

Kollmorgen Brushless Motor Amplifier EB-20X Series Motors Installation and Service Manual

Edition: September 2020, Revision B

Part Number: EB-8902

Original Document



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

KOLLMORGEN[®]

Because Motion Matters™

Record of Document Revisions

Revision	Date	Remarks
1	05/1990	Initial Release
2	10/2004	Update corporate identity and 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	4
1.1	Amplifier and Power Supply Ratings.....	5
2.	WIRING	6
2.1	TYPICAL AMPLIFIER	7
2.1.1.	OUTLINE DIMENSIONS.....	7
2.1.2.	FRONT VIEW.....	8
2.1.3.	SIDE VIEW.....	8
2.2	TYPICAL POWER SUPPLY	9
2.2.1.	OUTLINE DIMENSIONS.....	9
2.2.2.	FRONT VIEW.....	10
2.2.3.	SIDE VIEW.....	10
2.3	SYSTEM WIRING	11
2.4	TYPICAL MOTOR WIRING	13
2.5	GROUNDING.....	14
2.6	INPUTS	14
2.7	PRELIMINARY CHECKS.....	14
2.7.1.	CHECK AC INPUT VOLTAGE.....	15
2.7.2.	CHECK DC OUTPUT VOLTAGE	15
2.7.3.	ZERO SYSTEM RESOLVER.....	15
2.8	3-PHASE POWER TRANS.....	16
3.	MOTOR DATA PACKAGE	18
3.1	MODEL NUMBER.....	18
3.2	EB-20X.....	19
3.2.1.	EB-20X-11.....	19
3.3	EB-202	20
3.3.1.	SPECIFICATIONS CD-26716.....	20
3.3.2.	PERFORMANCE CURVES	22
3.4	EB-204	25
3.4.1.	SPECIFICATIONS CD-26717.....	25
3.4.2.	PERFORMANCE CURVES	27
3.5	EB-206	30
3.5.1.	SPECIFICATIONS CD-26718.....	30
3.5.2.	PERFORMANCE CURVES	32
3.6	TYPICAL CURRENT AND VOLTAGE (WAVE FORMS AT MOTOR))35	
3.6.1.	CURRENT PHASE C.....	35
3.6.2.	VOLTAGE LINE A-C.....	35
3.7	INTERMITTENT DUTY OPERATION.....	35
4.	TYPICAL AMPLIFIER DATA PACKAGE.....	39
4.1	TYPICAL AMPLIFIER SPECIFICATIONS.....	39
5	INDEX.....	40

1 INTRODUCTION

This installation and service manual is a general document and is applicable to a typical amplifier needed to properly control the EB-20X motor series. Since servo amplifiers drive motors of varying sizes with different operating characteristics (voltage and current, internal resistance, inductance, rotor inertia, etc.), these amplifiers must vary with the specific motor. Consult the manufacturer of the amplifier to assure operation per the motor's nameplate data.

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

Typical amplifiers are 3-phase sine wave, pulse-width modulated type. They are fully 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's 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. Brushless motors have 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's magnetic field. A brushless resolver is used as the feedback device and is mounted internally as part of the overall motor construction.

Benefits resulting from the typical amplifier and brushless motor construction are:

- Lower rotor inertia permits 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 horsepower 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 _{RMS} (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 V _{RMS} (L-L), Nominal ±10%
	Continuous Current (A _{RMS} /Phase)	Intermittent Current (5 sec. max., 30% duty cycle) (A _{RMS} /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.

See the Typical Motor Wiring section for the correct method of wiring the motor stator. Connect the BROWN, RED, and WHITE leads to the points identified as Ma, Mb, and Mc on the power terminal block. Connect the green/yellow lead to the ground point of the same terminal block.

Bring the 3-phase 230 input power through a customer supplied circuit breaker and connect it to points identified as L_a, L_b, and L_c on the power terminal block mounted on the power supply. The system is not AC line phase sensitive. (See the System Wiring section). Connect the 325 VDC output, the 115 VAC 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. To access the control terminal strips to wire the typical amplifier, review the wiring diagrams and:

1. Wire the typical amplifier control terminal strips per the system-wiring diagram. The wiring should be neatly dressed so it does not 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 prevents 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 wiring diagram.
4. Neatly dress the wire cable so it enters the amplifier chassis and does not interfere with the front cover. Dress signal cables separately - 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 on their connectors.

The following precautions are also recommended:

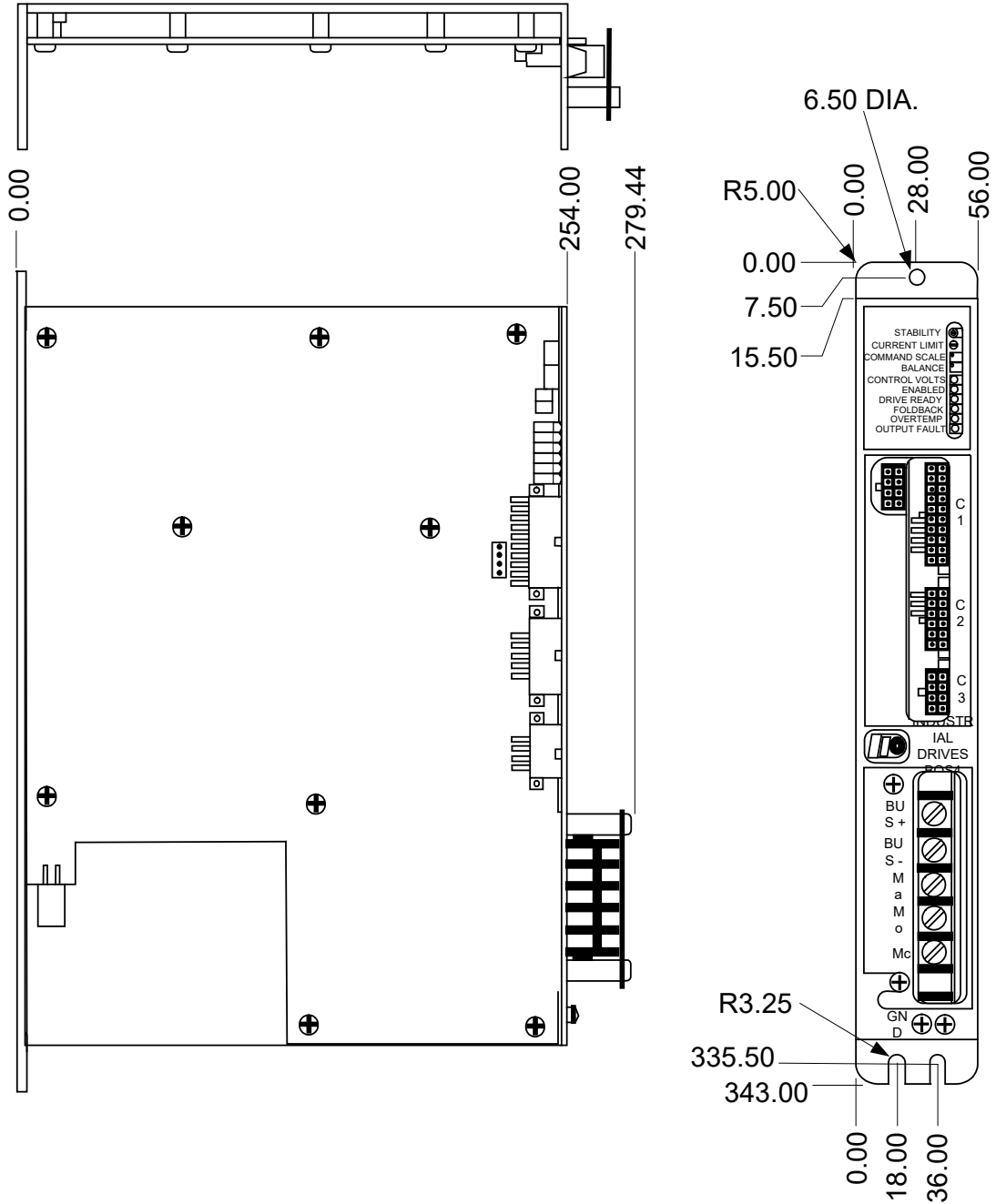
1. Twist all AC leads to minimize electromagnetic emissions and pick-up. Maintain the shield over resolver leads.
2. Avoid running signal leads near power leads, armature leads, or other sources of electromagnetic noise.
3. Minimize lead lengths as much as practical.
4. Double-check all interface wiring.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

CAUTION

Motor and resolver phasing are critical for proper operation.

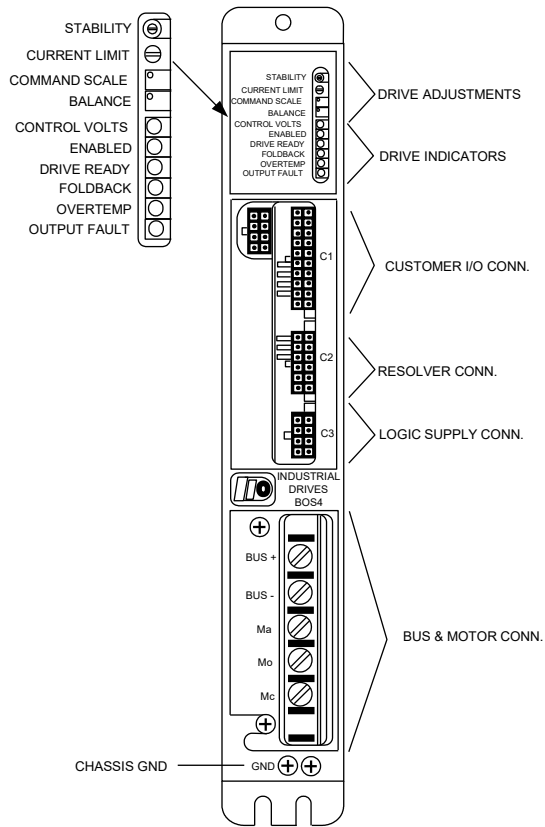
2.1 TYPICAL AMPLIFIER

2.1.1. OUTLINE DIMENSIONS

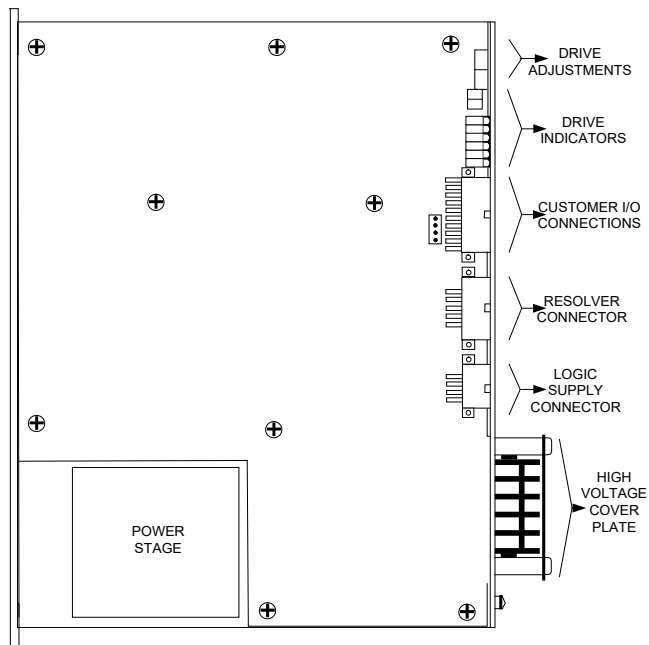


A-84471

2.1.2. FRONT VIEW

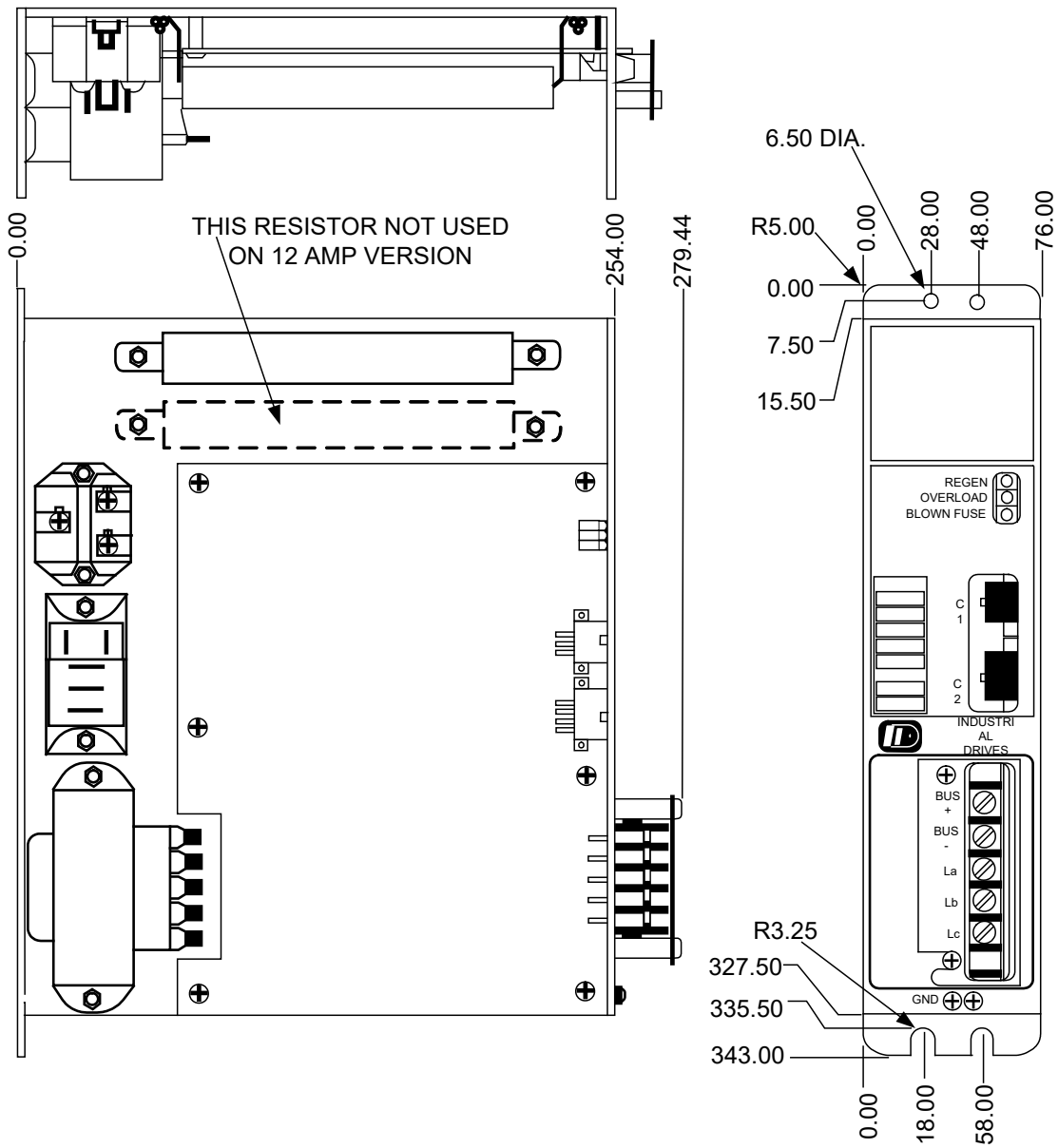


2.1.3. SIDE VIEW



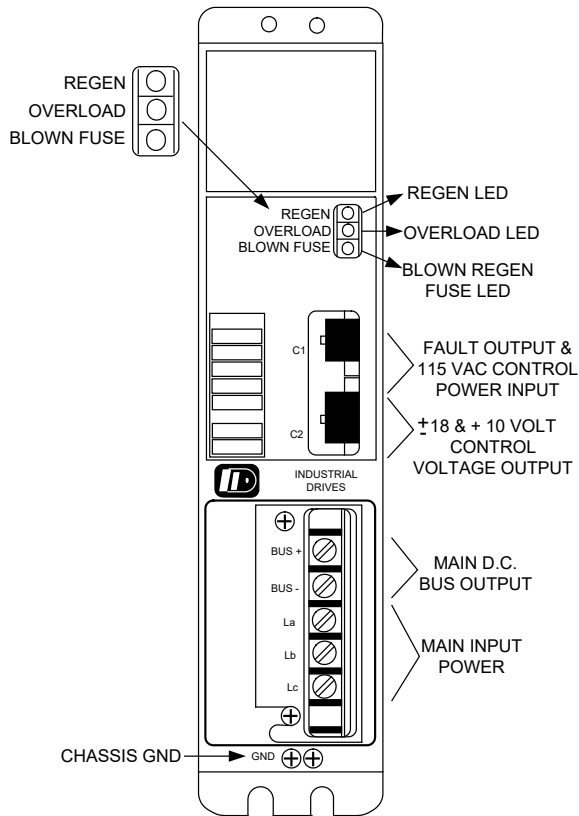
2.2 TYPICAL POWER SUPPLY

2.2.1. OUTLINE DIMENSIONS

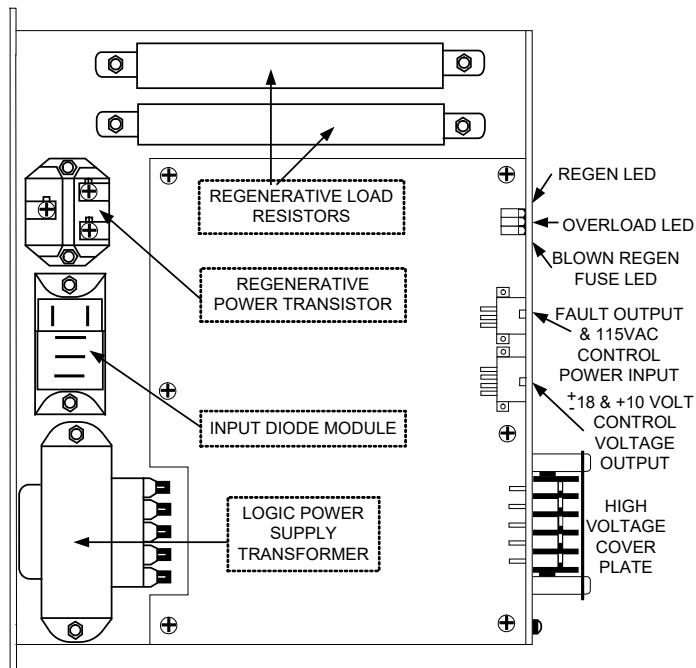


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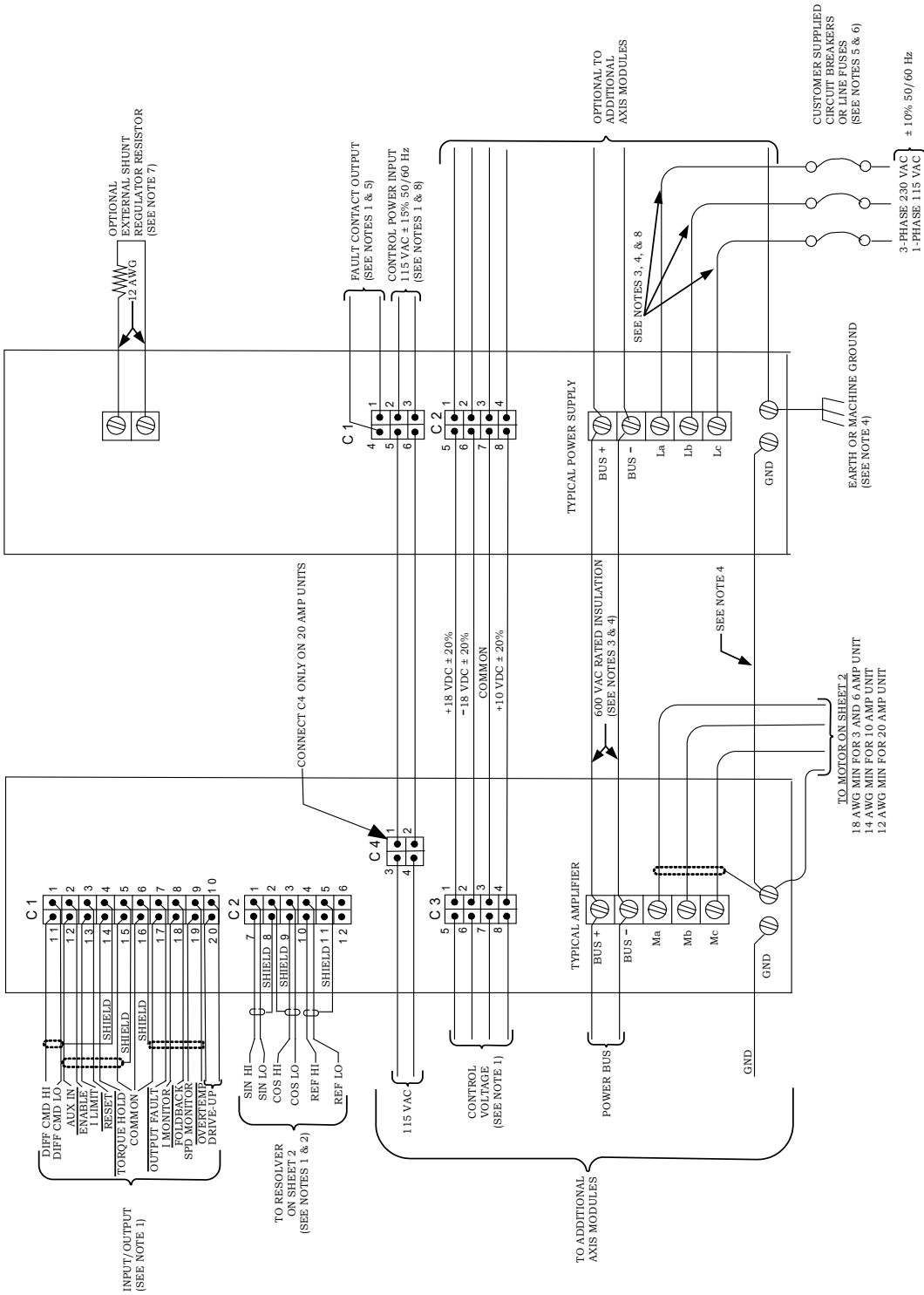
2.2.2. FRONT VIEW



2.2.3. SIDE VIEW



2.3 SYSTEM WIRING



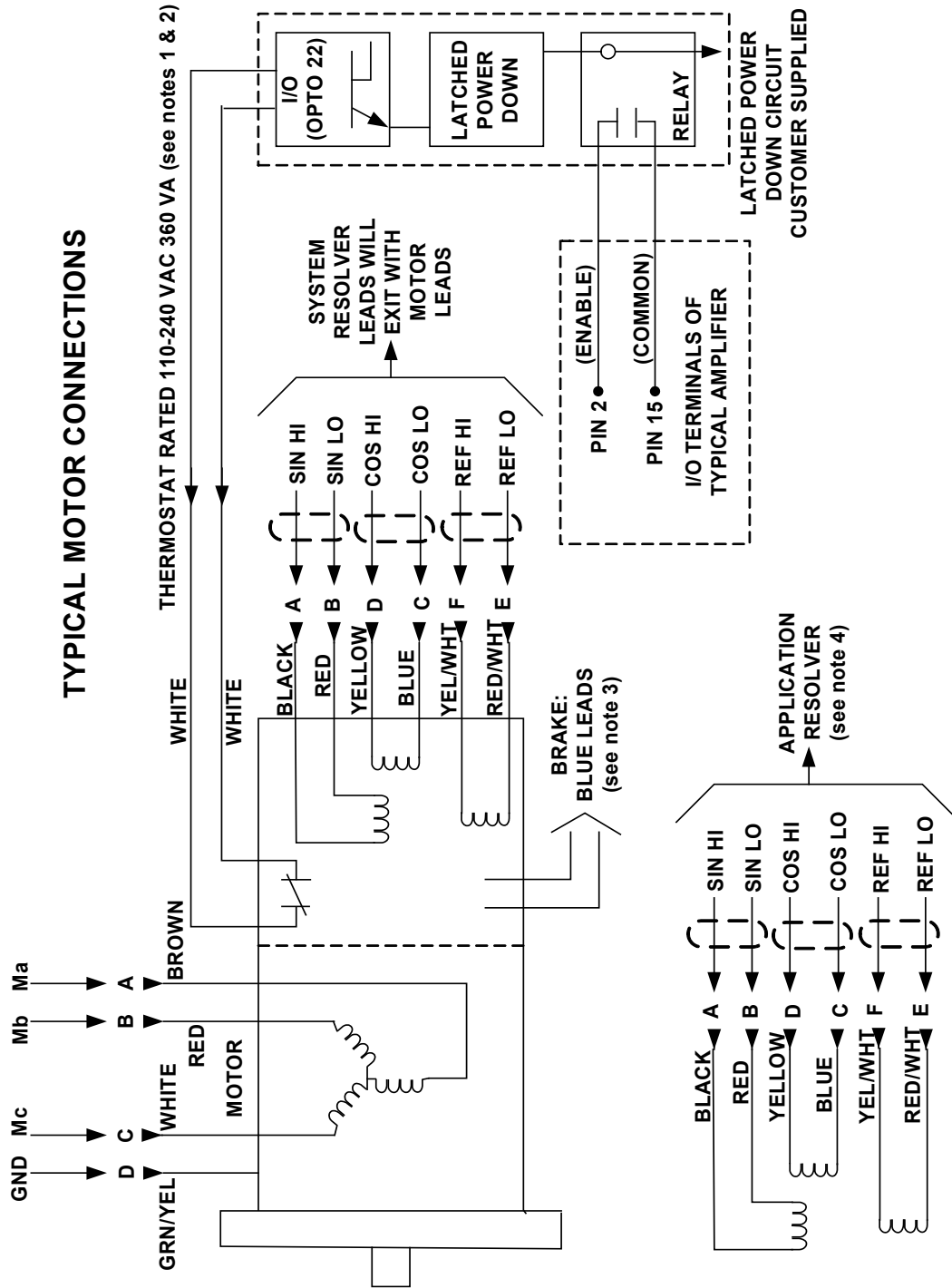
*Notes are on the following page.

Notes for System Wiring

1. All signal and control wire must be 22-18 AWG wire. If 16 AWG is desired, use Molex #39-00-0078 crimp pins (not supplied) instead of the parts supplied.
2. Resolver must be wired with three (3) sets of 2-conductor shielded pairs as shown. Thermostat wiring must be a twisted pair.
3. Caution, 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 is dependent on application. For total axis currents less than 9-amps, use 16 AWG. For total axis currents greater than 20-amps, use 10 AWG.
5. Wire the power supply fault contact (rated 115 VAC 1 amp) to drop main 3-phase power (L_a, L_b, L_c) in fault conditions. (This contact is normally open, closed on power-up (approx. 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 (maintain electrical isolation for this voltage rating).
8. All AC lines should be twisted cables.

2. 4 TYPICAL MOTOR WIRING



*Notes are on the following page.

Notes for Typical Motor Wiring

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. Energize the brake before switching the motor on and while it is in operation. For proper operation, use an electrical interlock circuit to ensure that the brake is not engaged while the motor is energized.

Model	Holding VDC	Holding ADC
EB-20X-X-XX-B2	90	0.09
EB-20X-X-XX-B3	24	0.52

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

2.5 GROUNDING

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

2.6 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 is an indication that it is in the 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 off power from the amplifier to limit the surface temperature of the motor and prevent ignition in hazardous atmospheres.

The remote inhibit disables the amplifier without removing the main power. When a contact is closed between pins (2 and 15) D common, the amplifier is placed in drive-up or ready-to-operate mode. Opening the contact places the amplifier in the inhibit, or non-operable mode. These pins (2 and 15) are connected through the latched power down circuit to the motor thermostat (see B-84470). The motor thermostat is an automatic resetting device that is 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 a manual reset. This prevents inadvertent restart of the motor when it cools down below the thermostats set value.

2.7 PRELIMINARY CHECKS

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

2.7.1. CHECK 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 to check the 3-phase secondary line-to-line voltage. The voltage should be approximately $230 V_{RMS} \pm 10\%$. Remove power and close the circuit breaker or replace the fuses in the secondary of the large 3-phase isolation transformer.

2.7.2. CHECK DC OUTPUT VOLTAGE

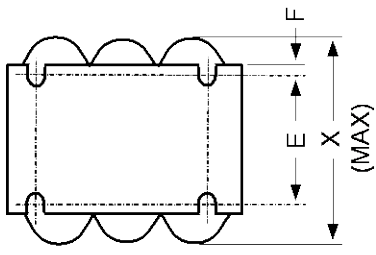
Do not apply the 115 VAC. Apply power to the large 3-phase transformer only. With a DC voltmeter, monitor the 325 VDC bus bars of the power supply and amplifier units. The voltage from the power supply should be approximately $\pm 325 VDC \pm 10\%$. Remove power.

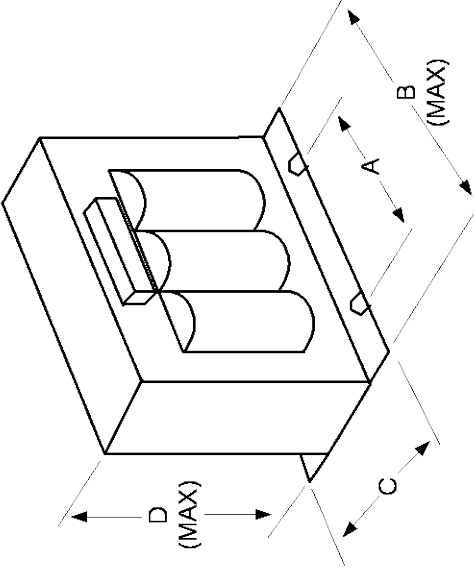
2.7.3. ZERO SYSTEM RESOLVER

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

2.8 3-PHASE POWER TRANS

	DWG. # A-84469	SH 1 OF 2	ISSUE 1
--	--------------------------	-----------	------------





DASH	X	A	B	C	D	E	F
001		8.5	12.5	6.5	7.0	4.88	
002							
003							
004		10.75	15.88	9.75	9.06	7.5	1.13
005							
006	9.50	12.0	15.25	8.5	13.5	7.25	5/8
007	13.5	14.0	20.75	11 ¹ / ₁₆	13.0	7 ³ / ₁₆	2 ¹ / ₃₂
008		12.0	16.0	8.5	15.5	6.87	.782
009							
010							
011		19.0	21.0	8.25	16.5	6.5	0.87
012							
013							
014							

EXAMPLE: IR3 - 230 / 7.5 - 16 - 00 ----- OPEN CONSTRUCTION

3 PHASE TRANSFORMER 240/480 VAC RMS PRIMARY

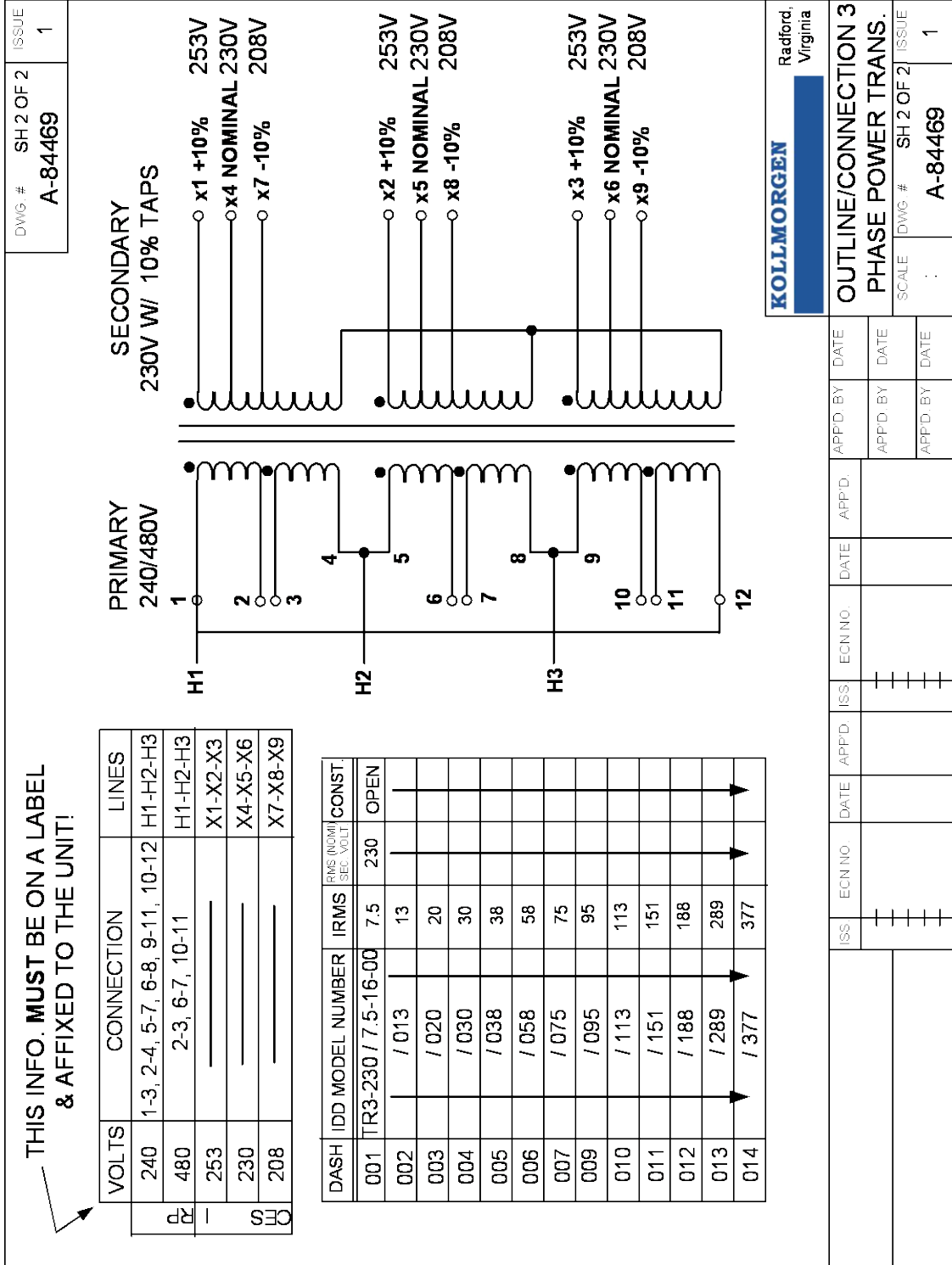
→ 240/480 PRIMARY

→ IRMS

→ 230 VRMS SECONDARY

KOLLMORGEN Radford, Virginia		OUTLINE/CONNECTION 3 PHASE POWER TRANS.	
ISS	ECN NO.	DATE	ISS
---	---	---	---
APP'D.	ECN NO.	DATE	APP'D.
---	---	---	---
APP'D. BY	DATE	APP'D. BY	DATE
---	---	---	---
APP'D. BY	DATE	APP'D. BY	DATE
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	DWG. #	SH 1 OF 2	ISSUE
	A-84469		1

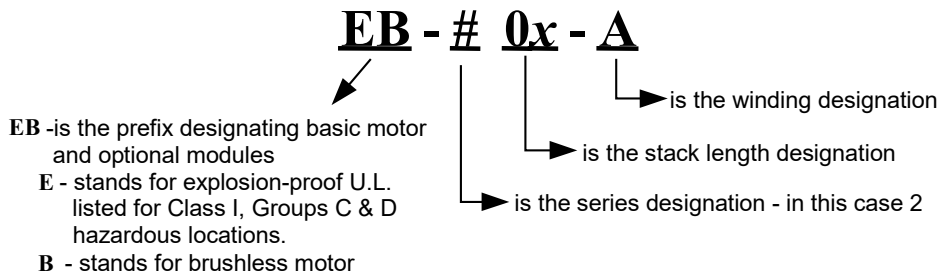


3. MOTOR DATA PACKAGE

Typical product features are:

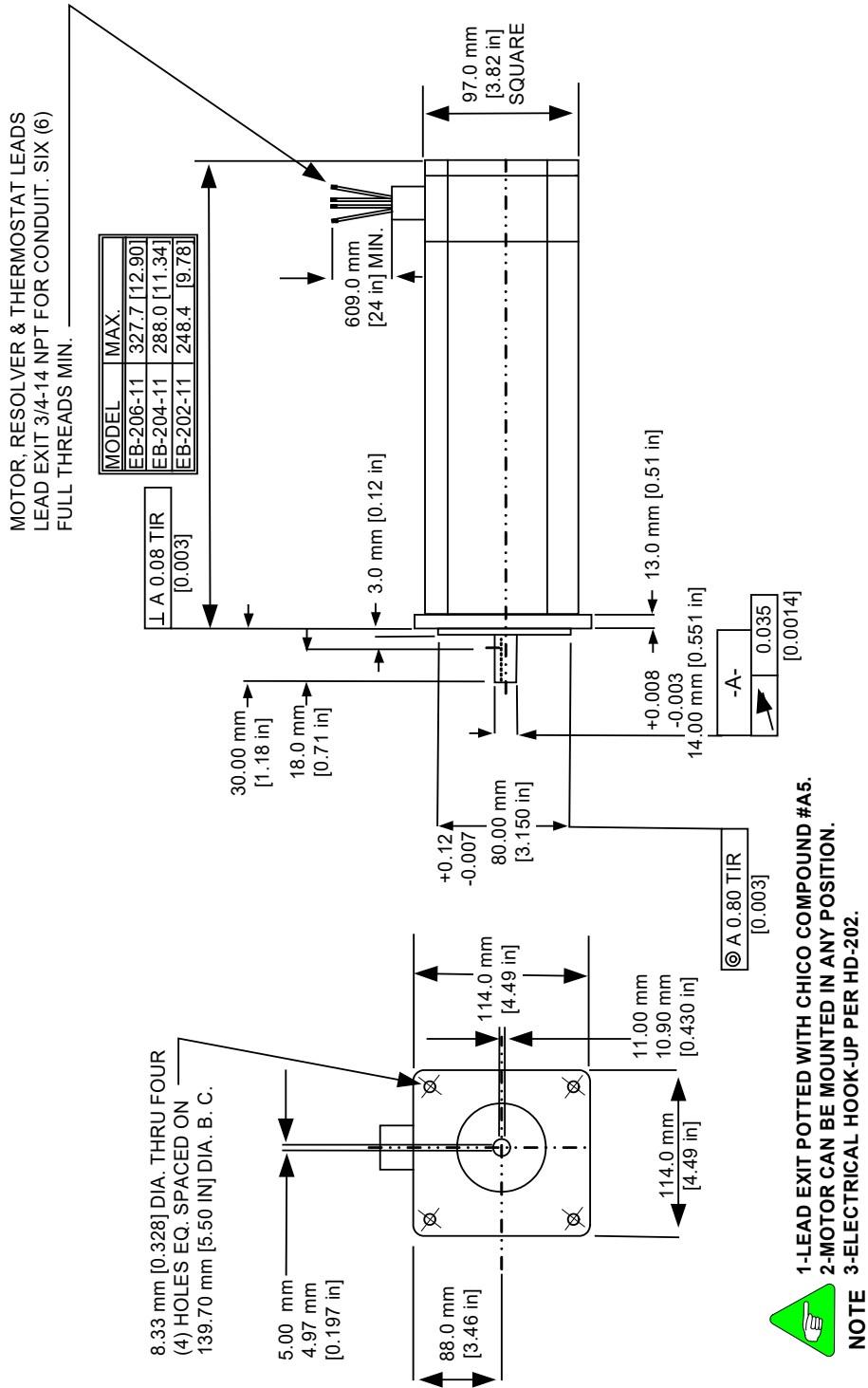
- UL listed explosion-proof for Class I, Groups C & D hazardous locations
- Neodymium-Iron-Boron magnets
- Aluminum end bells
- Frameless, shaft-mounted resolver
- Rugged construction

3.1 MODEL NUMBER



3.2 EB-20X

3.2.1. EB-20X-11



A-43083

3.3 EB-202

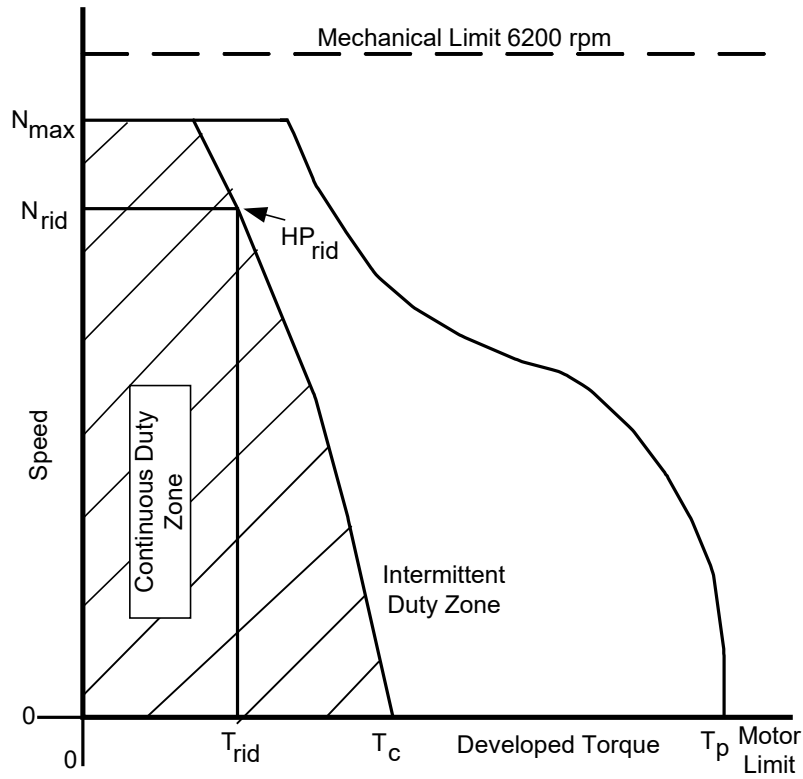
3.3.1. SPECIFICATIONS CD-26716

Specification	Tol	Symbol	Units	A	B	C
*Continuous Torque (stall) at 40° C Ambient	Nom.	T _C	lb-ft	13.0	12.8	12.8
			N-m	17.63	17.36	17.36
Cont. Line Current	Nom.	I _C	A _{RMS}	10.0	20.0	15.0
†Max. Speed	Nom.	N max.	rpm	2000	4000	3000
*Peak Torque	Nom.	T _P	lb-ft	37.7	36.7	36.5
			N-m	51.2	49.8	49.5
Peak Line Current	Nom.	I _P	A _{RMS}	30.5	61.4	45
129.2†Theoretical Acceleration	Nom.	∞m	rad/sec ²	48681	48417	48945
†Horsepower	Rated	H _P rtd	H _P	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 _{RMS}	230	230	230
*Torque Sensitivity	± 10%	K _T	lb-ft / A _{RMS}	1.302	0.629	0.854
			N-m / A _{RMS}	1.765	0.853	1.158
Back EMF (line-to-line)	± 10%	K _B	V/krpm	106.8	51.6	70.0
Max. line-to-line volts	Max.	V max	V _{RMS}	250	250	250
DC Res at 25° C (line-to-line)	± 10%	R _M	ohms	1.548	0.382	0.674
Inductance (line-to-line)	± 30%	L _M	mH	32	9.0	14.0
Time Constant at 25° C	Mech.	Nom.	T _M	ms	0.77	0.81
	Elec.	Nom.	T _E	ms	20.7	23.6
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 ²	0.000758
		kg m ²	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 ωZ 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.



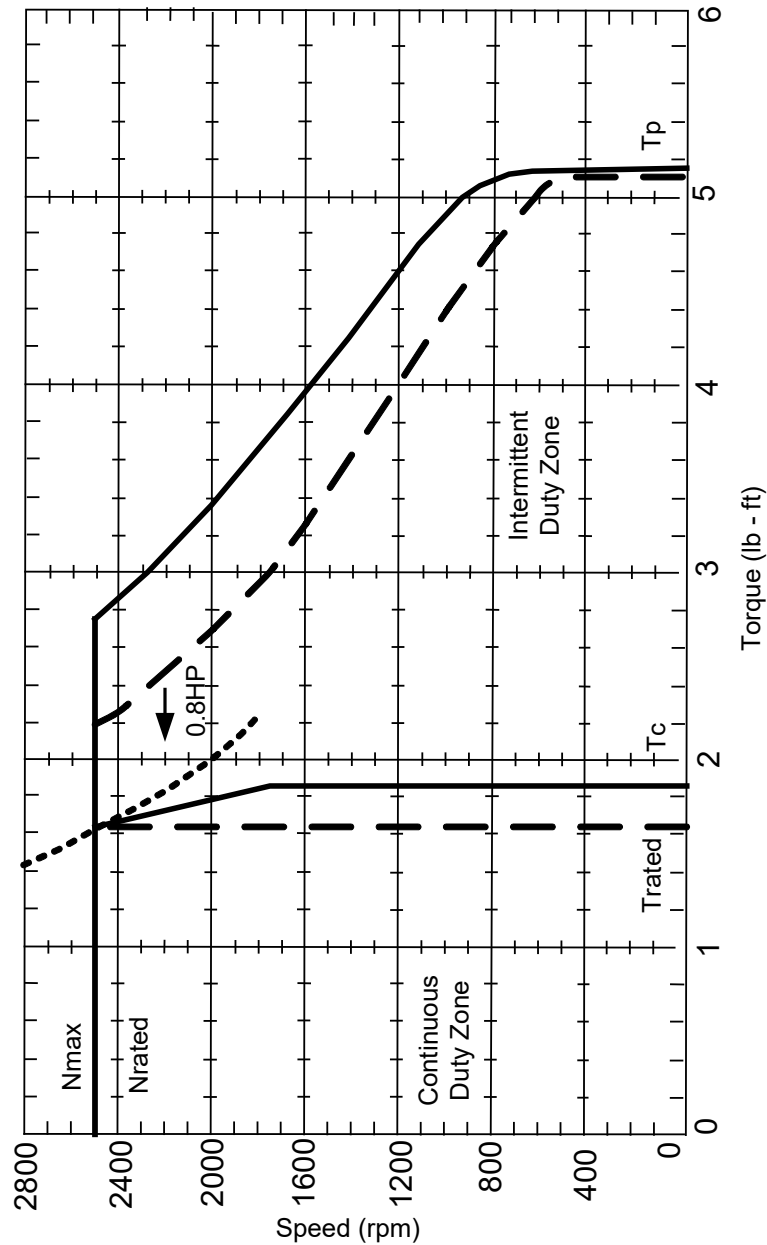
3.3.2. PERFORMANCE CURVES

3.3.2.1. EB-202-A PC-26721

NOTE

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

Motor EB-202-A
Drive BDS4-230/3
Test T3-1339

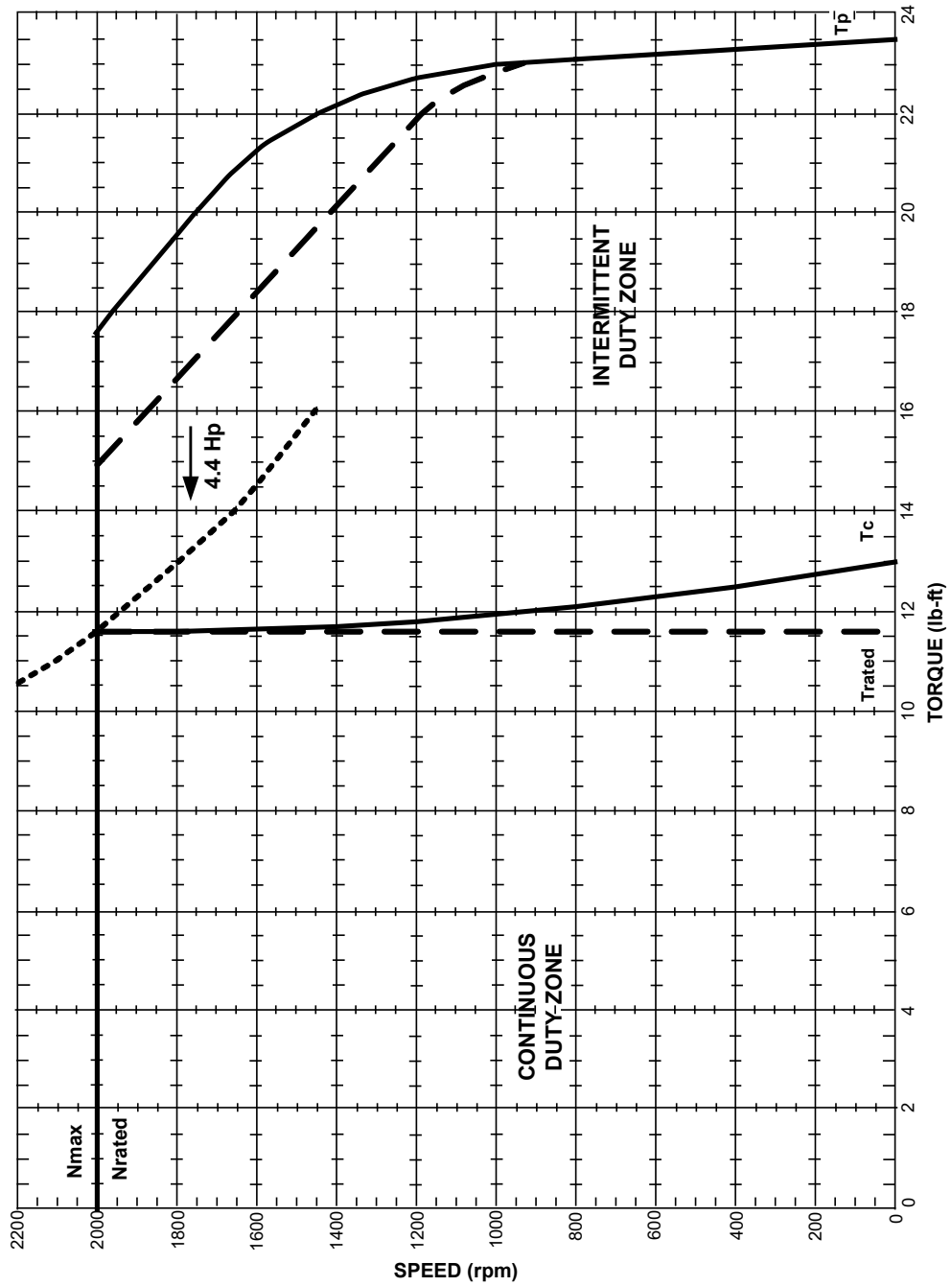


3.3.2.2. EB-202-B PC-26722

NOTE

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

Motor EB-202-B
 Drive BDS4-230/3
 Test Calculated

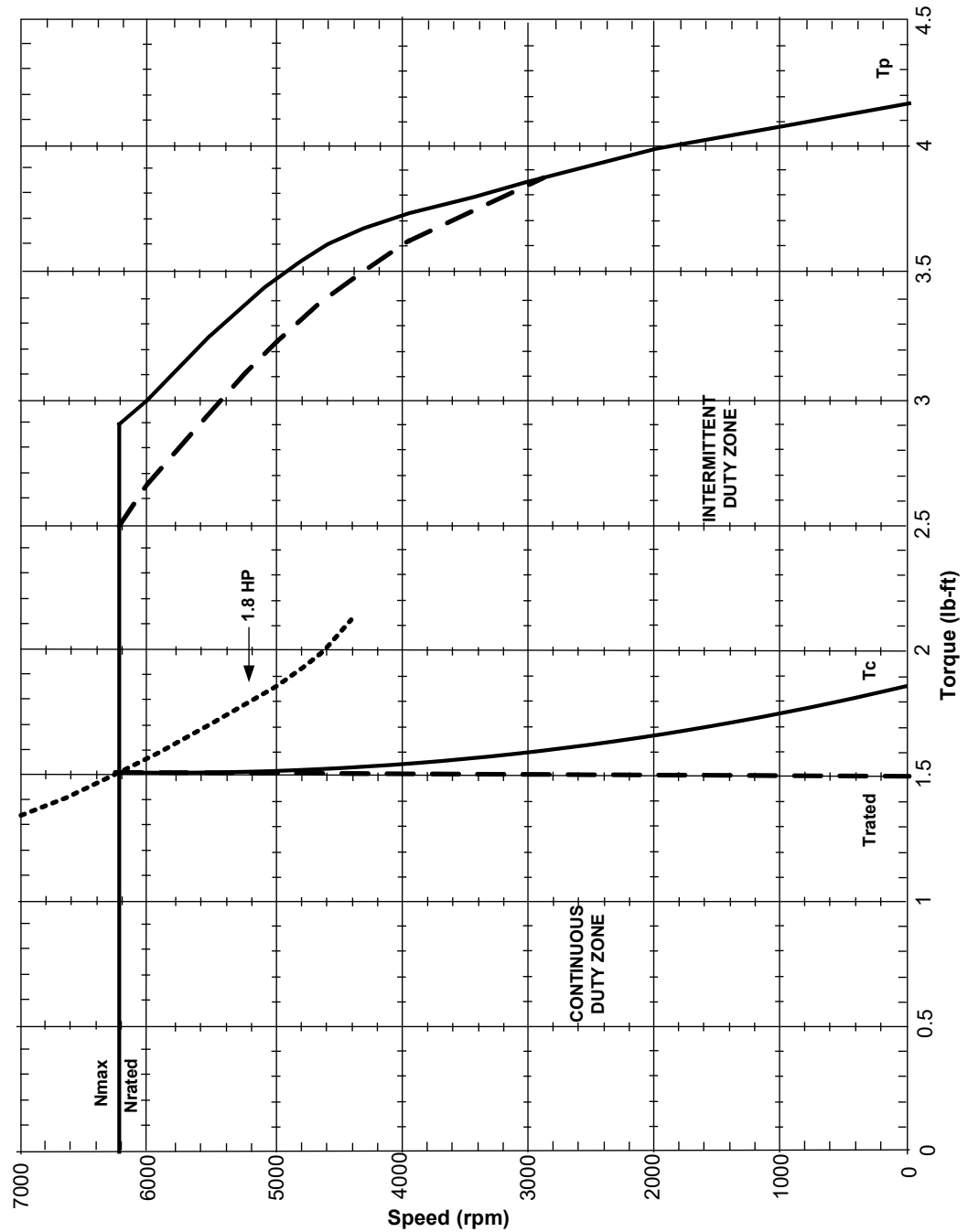


3.3.2.3. EB-202-C PC-26723

NOTE

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

Motor EB-202-C
 Drive BDS4-230/6
 Test Calculated



3.4 EB-204

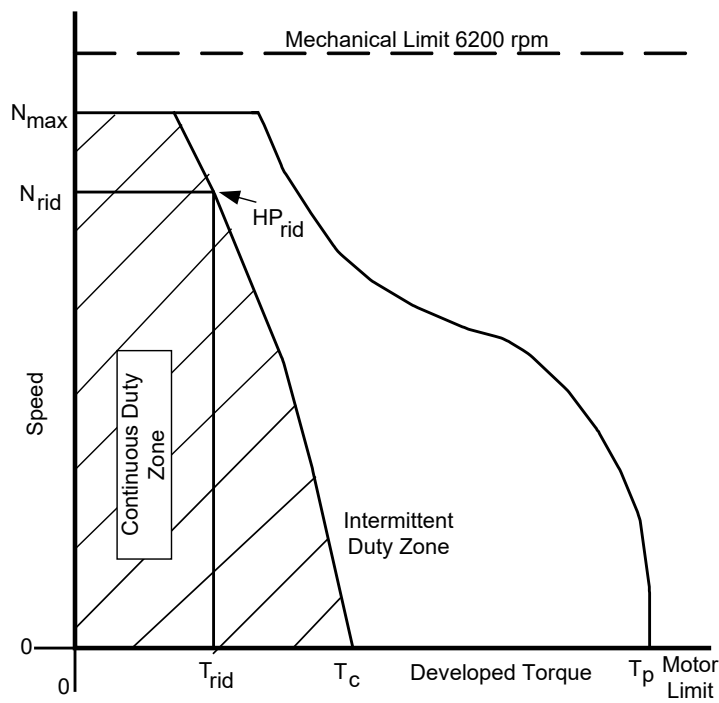
3.4.1. SPECIFICATIONS CD-26717

Specification	Tol	Symbol	Units	A	B	C
*Continuous Torque (stall) at 40° C Ambient	Nom.	T _C	lb-ft	3.60	3.60	3.60
			N-m	4.88	4.88	4.88
Cont. Line Current	Nom.	I _C	A _{RMS}	2.9	5.80	10.0
†Max. Speed	Nom.	N max.	rpm	1900	3600	6200
*Peak Torque	Nom.	T _P	lb-ft	9.43	10.33	8.95
			N-m	12.80	14.00	12.14
Peak Line Current	Nom.	I _P	A _{RMS}	8.10	17.4	26.1
129.2†Theoretical Acceleration	Nom.	∞m	rad/sec ²	73961	81020	70196
†Horsepower	Rated	H _P rtd	H _P	1.20	2.30	3.70
†Speed	Rated	N rtd	rpm	1900	3600	6200
†Torque	Rated	T rtd	lb-ft	3.20	3.41	3.13
			N-m	4.34	4.62	4.25
Volts (line to line)	Rated	V rtd	V _{RMS}	230	230	230
*Torque Sensitivity	± 10%	K _T	lb-ft / A _{RMS}	1.226	0.625	0.361
			N-m / A _{RMS}	1.662	0.848	0.490
Back EMF (line-to-line)	± 10%	K _B	V/krpm	100.5	51.2	29.6
Max. line-to-line volts	Max.	V max	V _{RMS}	250	250	250
DC Res at 25° C (line-to-line)	± 10%	R _M	ohms	9.46	2.48	0.786
Inductance (line-to-line)	± 30%	L _M	mH	133	38	12
Time Constant at 25° C	Mech.	Nom.	T _M	ms	0.888	0.896
	Elec.	Nom.	T _E	ms	14.06	15.32
System Performance Curve				26724	26725	26719

*At ultimate winding temperature - for ambient data, multiply by 1.06.

†	Symbol	Units	Value
Rotor Inertia	J_M	lb ft sec ²	0.0001275
		kg m ²	0.0001729
Weight	Wt	lb	18
		kg (f)	8.2
Static Friction	T_F	lb-ft	0.005
		N-m	0.007
Thermal Time Constant Peak	TCTP	Minutes	20
Viscous Damping $\propto Z$ Source	F_1	lb-ft/krpm	0.005
		N-m/krpm	0.007

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



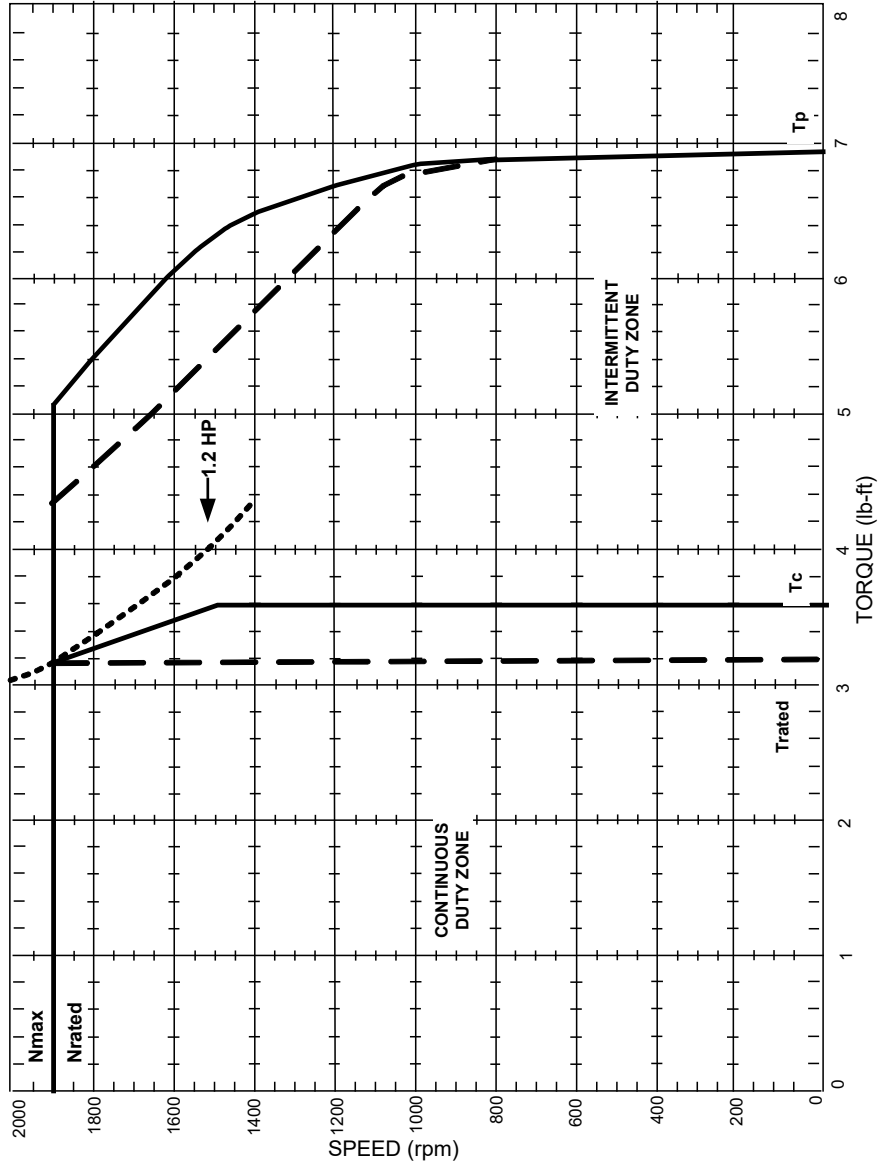
3.4.2. PERFORMANCE CURVES

3.4.2.1. EB-204-A PC-26724

NOTE

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

Motor EB-204-A
 Drive BDS4-230/3
 Test Calculated

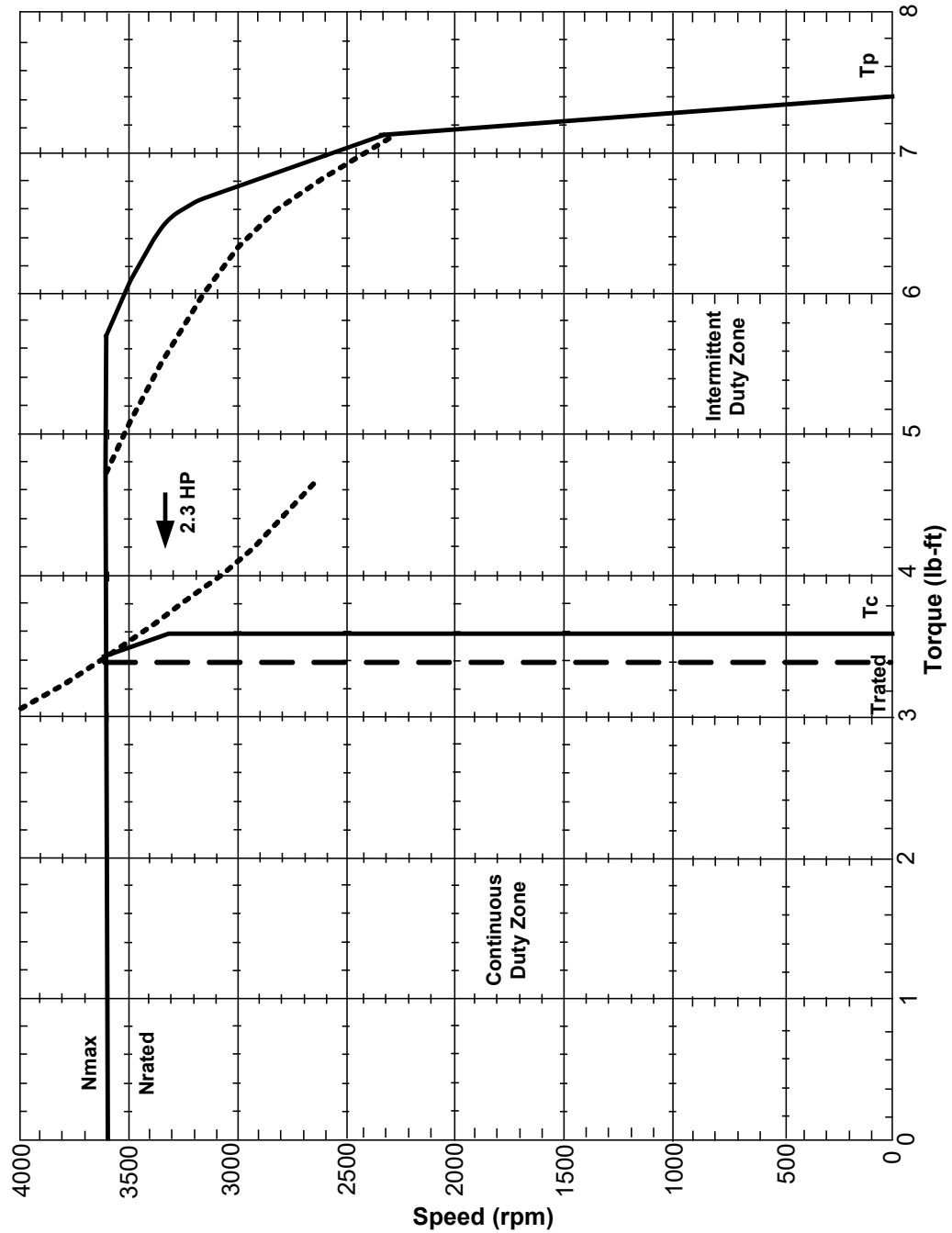


3.4.2.2. EB-204-B PC-26725

NOTE

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

Motor EB-204-B
 Drive BDS4-230/6
 Test T3-1393

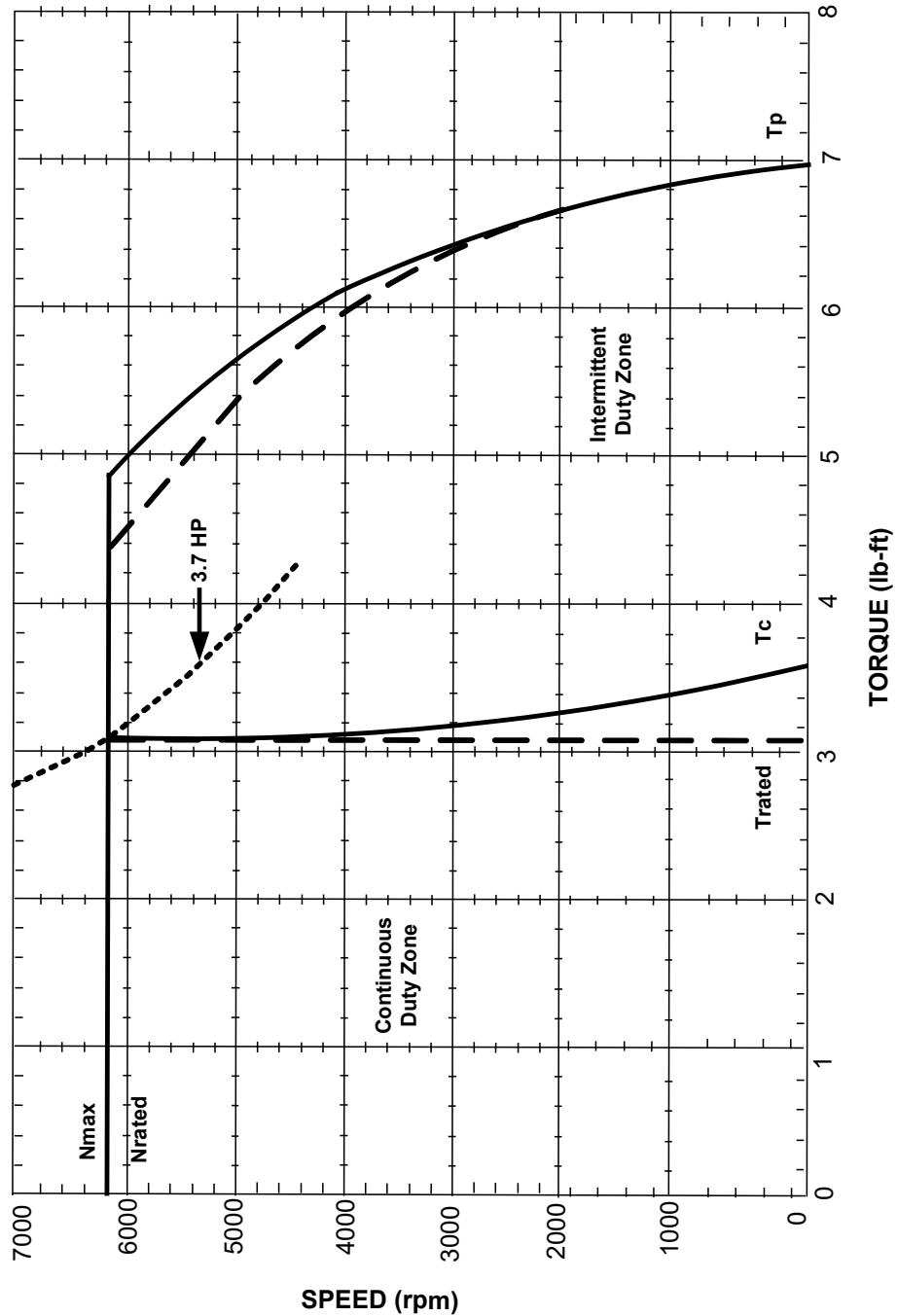


3.4.2.3. EB-204-C PC-26719

NOTE

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

Motor EB-204-C
 Drive BDS4-230/10
 Test T3-1396



3.5 EB-206

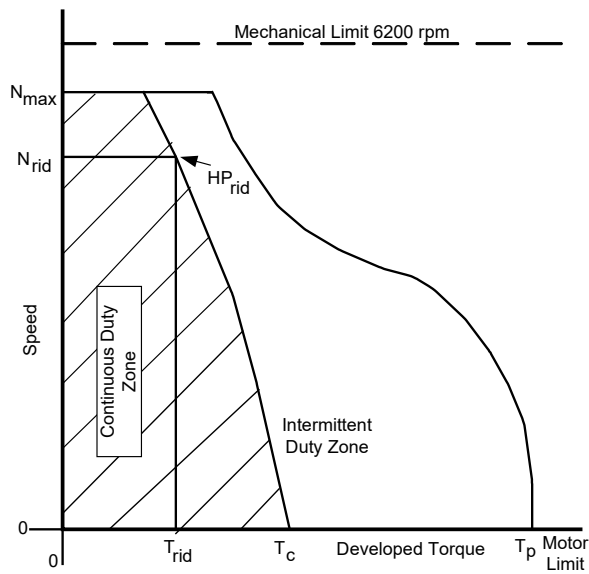
3.5.1. SPECIFICATIONS CD-26718

Specification	Tol	Symbol	Units	A	B	C
*Continuous Torque (stall) at 40° C Ambient	Nom.	T _C	lb-ft	4.60	4.60	4.75
			N-m	6.24	6.24	6.44
Cont. Line Current	Nom.	I _C	A _{RMS}	2.9	5.80	10.0
†Max. Speed	Nom.	N max.	rpm	1400	2800	4900
*Peak Torque	Nom.	T _P	lb-ft	14.03	14.03	12.54
			N-m	19.03	19.03	17.0
Peak Line Current	Nom.	I _P	A _{RMS}	9.3	18.6	28.7
129.2†Theoretical Acceleration	Nom.	∞m	rad/sec ²	75715	75715	67674
†Horsepower	Rated	H _P rtd	H _P	1.20	2.50	3.80
†Speed	Rated	N rtd	rpm	1400	2800	4900
†Torque	Rated	T rtd	lb-ft	4.5	4.6	4.06
			N-m	6.1	6.24	5.5
Volts (line to line)	Rated	V rtd	V _{RMS}	230	230	230
*Torque Sensitivity	± 10%	K _T	lb-ft / A _{RMS}	1.588	0.794	0.460
			N-m / A _{RMS}	2.153	1.077	0.624
Back EMF (line-to-line)	± 10%	K _B	V/krpm	130.2	65.1	37.7
Max. line-to-line volts	Max.	V max	V _{RMS}	250	250	250
DC Res at 25° C (line-to-line)	± 10%	R _M	ohms	8.82	2.32	0.78
Inductance (line-to-line)	± 30%	L _M	mH	130	32	14
Time Constant at 25° C	Mech.	Nom.	T _M	ms	0.717	0.754
	Elec.	Nom.	T _E	ms	14.74	13.79
System Performance Curve				26726	26460	26720

*At ultimate winding temperature - for ambient data, multiply by 1.06.

†	Symbol	Units	Value
Rotor Inertia	J_M	lb ft sec ²	0.0001853
		kg m ²	0.0002512
Weight	Wt	lb	21
		kg (f)	9.5
Static Friction	T_F	lb-ft	0.005
		N-m	0.007
Thermal Time Constant Peak	TCTP	Minutes	22
<i>Viscous Damping ∞Z Source</i>	F_1	lb-ft/krpm	0.008
		N-m/krpm	0.011

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



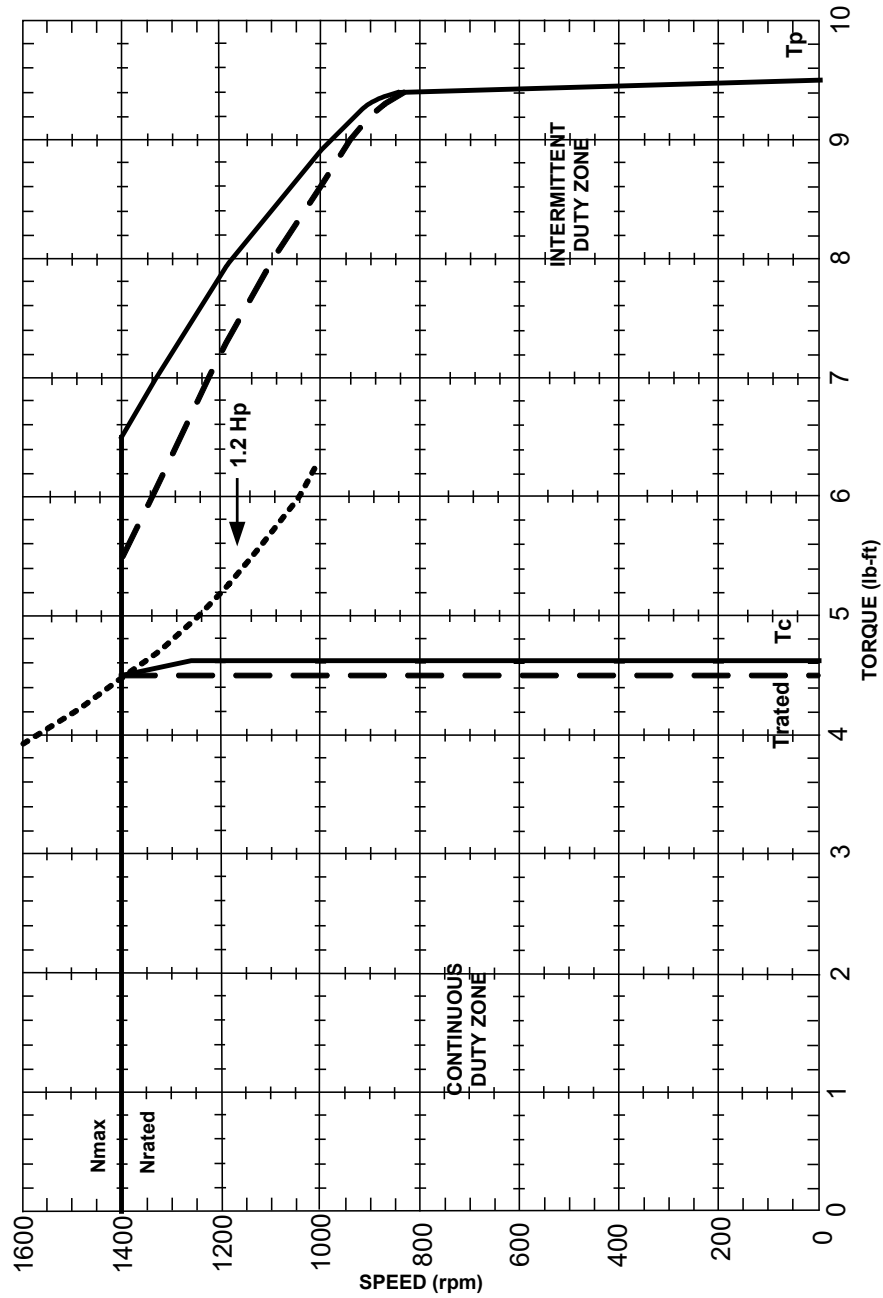
3.5.2. PERFORMANCE CURVES

3.5.2.1. EB-206-A PC-26726

NOTE

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

Motor EB-206-A
 Drive BDS4-230/3
 Test Calculated

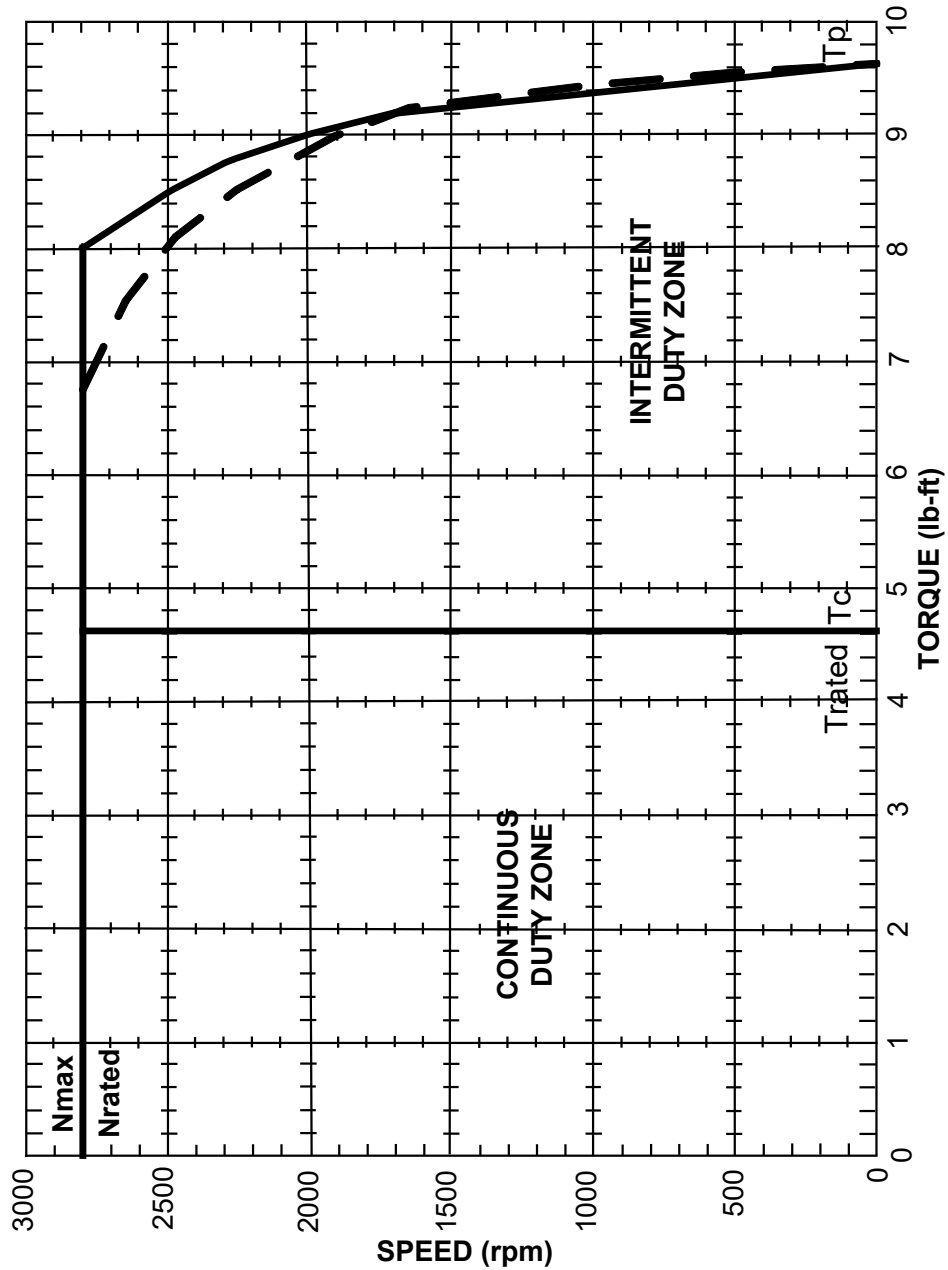


3.5.2.2. EB-206-B PC-26460

NOTE

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

Motor EB-206-B
 Drive BDS4-230/6
 Test T3-1394

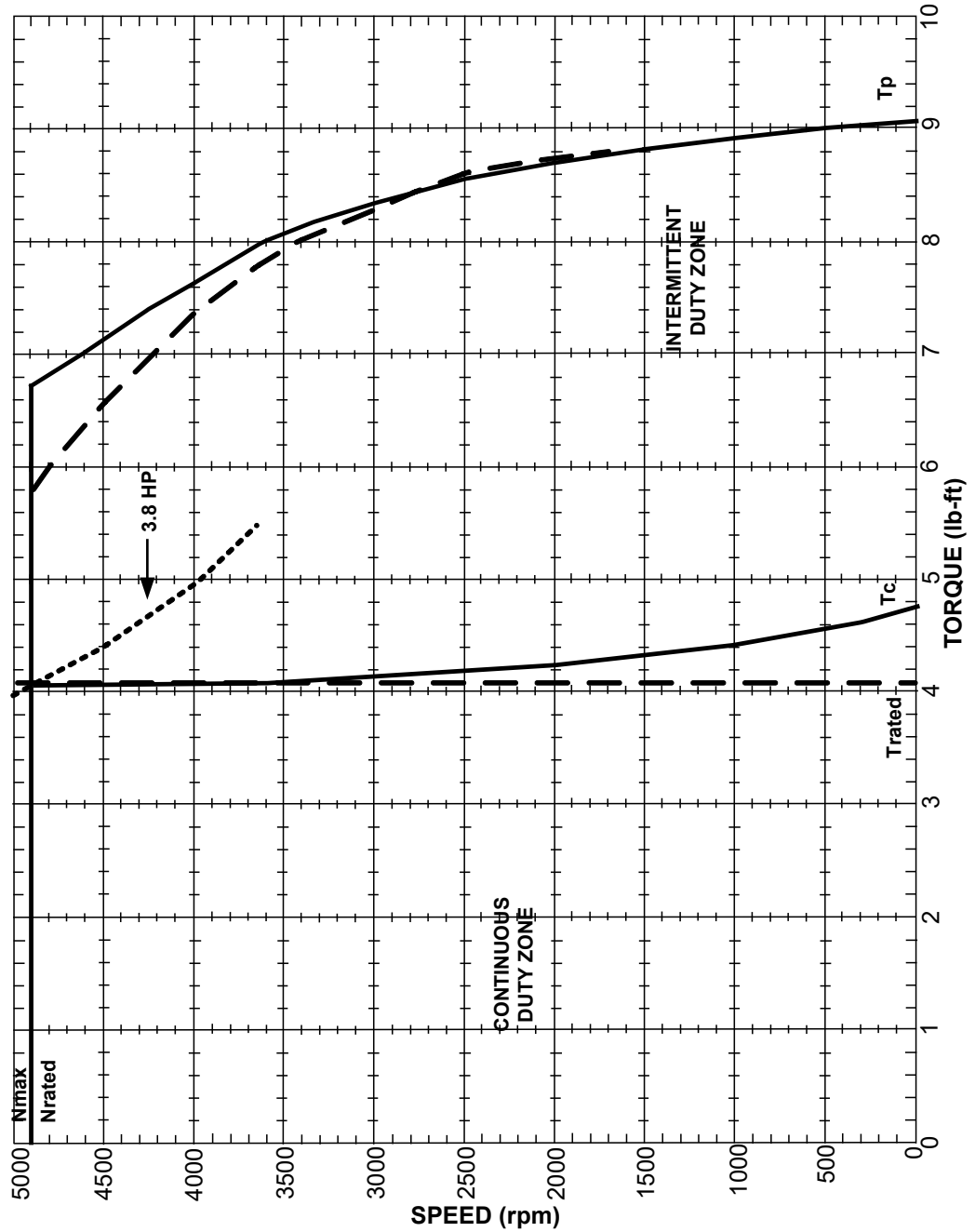


3.5.2.3. EB-206-C PC-26720

NOTE

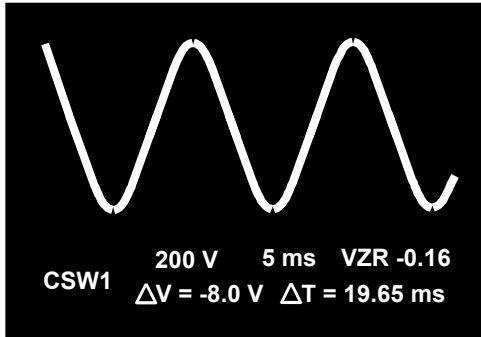
Do not operate this motor outside the parameters shown on this performance curve.

Motor EB-206-C
 Drive BDS4-230/10
 Test T3-1397

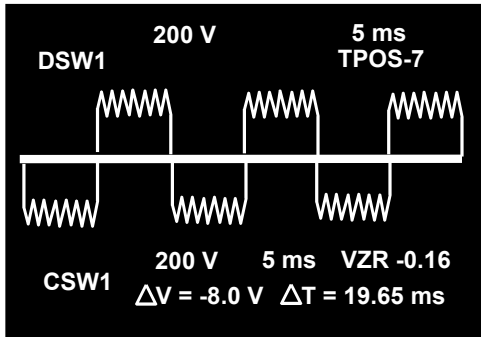


3.6 TYPICAL CURRENT AND VOLTAGE (WAVE FORMS AT MOTOR)

3.6.1. CURRENT PHASE C



3.6.2. VOLTAGE LINE A-C



The EB-206-C is illustrated at 1500 rpm, 4.4 lb-ft.

3.7 INTERMITTENT DUTY OPERATION

If a motor operates intermittently, it is not necessary that the peak load torques 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.

(EQ1) 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 (TC). This is not always a good assumption. For cases where torque values significantly exceed TC, the following equation is used:

$$\frac{T_{OUT}}{T_C} = \sqrt{\frac{1 - e^{-t_{ON}/\text{Duty Cycle} * TCTP}}{1 - e^{-t_{ON}/TCTP}}}$$

where duty cycle = $t_{ON}/(t_{ON} + t_{OFF})$

T_{OUT} = output torque

T_C = continuous torque at operating speed

t_{ON} = time on

TCTP = thermal time constant for peak power of motor

The next equation expresses operating torques 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:

$$(EQ-2) \quad T_{OFF} = -TCTP \ln \left[1 - \frac{(1 - e^{-t_{ON}/TCTP}) T_{OUT}^2}{T_C^2} \right] - t_{ON}$$

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

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

$$(EQ-3) \quad \begin{aligned} T_R \text{ Actual Above Ambient} &= \left(\frac{T_{OUT}}{T_C} \right)^2 \\ T_R \text{ Rated Above Ambient} &= \left(\frac{T_{OUT}}{T_C} \right)^2 \end{aligned}$$

$$(EQ-4) \quad \begin{aligned} T_R \text{ Rated} &= T_R \text{ Ultimate} (1 - e^{-t}) \\ \text{where TR Rated} &= \text{time}/TCTP \\ \text{Substitute 3) into 4) and obtain:} \end{aligned}$$

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:

$$(EQ-5) \quad T_{MAX} = -TCTP \ln \left[1 - \left(\frac{T_{OUT}}{T_C} \right)^2 \right]$$

where: t = max on time

TCTP = thermal time constant for peak power of motor

T_C = continuous torque of the motor at the operating speed

T_{OUT} = 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_{OUT} approaches T_c , t approaches infinity. This is expected since we can theoretically operate the motor indefinitely at continuous torque without exceeding its thermal limits. EQ5 with EQ2 define the motor's operating time limits.

Example #1

An EB-206-C has the torque vs. speed performance characteristics described in the performance curve labeled EB-206-C PC 26720. The motor is operating intermittently at 4900 rpm with a torque of 6.6 lb-ft.

FIND:

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

GIVEN: $T_{OUT} = 6.6$ lb-ft

From the performance curve, the continuous torque at 4900 rpm is obtained.
 $T_c = 4.0$ lb-ft

From Specifications CD-26718 for the EB-206-C motor:
 $TCTP = 22$ min.

- (a) The maximum ON time is found from EQ5:

$$T_{MAX} = -TCTP \ln \left[1 - \left(\frac{T_{OUT}}{T_c} \right)^2 \right]$$

$TCTP = 22$ min., $T_c = 4.0$ lb-ft, $TOUT = 6.6$ lb-ft

$$T_{MAX} = -22 \text{ min} \ln \left[1 - \left(\frac{4.4}{6.6} \right)^2 \right]$$

$$\begin{aligned} t_{MAX} &= -22 \text{ min.} \ln [0.6327] \\ t_{MAX} &= -22 \text{ min.} \ln(-0.4578) \\ t_{MAX} &= 10.0 \text{ min.} \end{aligned}$$

This says that if the motor has an ON time greater than 10 minutes, it exceeds its thermal limits.

- (b) The required OFF time for a given ON time is found from EQ2.

$$T_{OFF} = - TCTP \ln \left[1 - \frac{(1 - e^{-t_{ON}/TCTP}) T_{OUT}^2}{T_c^2} \right] - t_{ON}$$

$$\begin{aligned} t_{ON} &= 4 \text{ seconds} \\ TCTP &= 22 \text{ min.} \cdot 60 \text{ sec/min} = 1320 \text{ seconds} \\ t_{OUT} &= 6.6 \text{ lb-ft} \\ T_c &= 4.0 \text{ lb-ft} \end{aligned}$$

$$T_{\text{OFF}} = -1320 \text{ sec } 1n \left[1 - \frac{(1 - e^{-4/1320}) 6.6^2}{(4.0)^2} \right] - 4 \text{ sec}$$

$$t_{\text{OFF}} = -1320 \text{ seconds } 1n 0.99176 - 4 \text{ seconds}$$

$$t_{\text{OFF}} = 7.0 \text{ seconds}$$

For the EB-206-C motor operating at the load point in this example, an ON time of 4 seconds must be followed by an OFF time of 7.0 seconds so the motor does not exceed its thermal limits.

Example #2

The motor of Example #1 is running at 2500 rpm with an intermittent operating torque of 8.6 lb-ft.

FIND:

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

GIVEN: $T_{\text{OUT}} = 8.6 \text{ lb-ft}$

From the performance curve EB-206-A PC-26726,
 $T_C = 4.1 \text{ lb-ft}$ at 2500 rpm.

From Specifications CD-26718, $TCTP = 22 \text{ min}$.

- (a) Using EQ5 and the values above:
 $t_{\text{MAX}} = 5.6 \text{ min}$.
- (b) Using EQ2 and an On time of 4 seconds, an OFF time is:
 $t_{\text{OFF}} = 13.7 \text{ seconds}$

Example #3

The motor in Example 1 is running at 1000 rpm with an intermittent operating torque of 8.9 lb-ft.

FIND:

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

GIVEN: $t_{\text{OUT}} = 8.9 \text{ lb-ft}$

From the performance curve EB-206-A PC-26726,
 $T_C = 4.4 \text{ lb-ft}$ at 1000 rpm.

From Specifications CD-26718, $TCTP = 22 \text{ min}$.

- (a) Using EQ5 and the values above:
 $t_{\text{MAX}} = 6.2 \text{ min}$.
 $t_{\text{ON}} = 4 \text{ sec}$
- (b) Using EQ2 and the values above:
 $t_{\text{OFF}} = 12.4 \text{ sec}$

NOTE

The applications engineers at Kollmorgen will assist in the proper sizing of the motor and amplifier based on the application's 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

The product features are:

- 30 microprocessor synthesized sine-wave control
- Three AC current loops – fully integrating velocity loop
- OK to Enable or Drive-Up relay
- Inhibit function
- Current monitor

4.1 TYPICAL AMPLIFIER SPECIFICATIONS

Amplifier Specifications		
Input Power to Amplifier	230 VRMS L-L 30 (±15%)	
	Isolation Transformer Not Required	
	115 VAC 10 Control Power (+10%, -15%)	
Output Power to Motor	Power Supply DC Bus	325 VDC nominal, no load
	Output at rated load%	230 VRMS L-L, Nominal ±15% Pulse Width Modulated
	Cont. Current (ARMS/Phase)	Intermittent Current (5 sec. max., 25% duty cycle)
	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.

5 INDEX

- 3 Phase Power Trans..... 17
- Amplifier
 - ambient temperature40
 - continuous current40
 - cooling40
 - input power to amplifier40
 - isolation transformer40
 - output at rated load.....40
 - power supply DC bus40
 - power supply settings6
 - Ratings.....6
 - specifications40
 - switching frequency40
 - typical.....5
- CD-2671621, 22
- CD-2671726, 27
- CD-2671831, 32
- Cooling6
- EB 206.....31
- EB-20221
 - performance curves23, 24, 25
 - Specifications21, 22
- EB-20426
 - performance curves28, 29, 30
 - Specifications26, 27
- EB-206
 - performance curves33, 34, 35
 - Specifications31, 32
- EB-20x.....20
 - amplifier data package40
 - bus5
 - Introduction5
- Equation 136
- Equation 237
- Equation 337
- Equation 437
- Equation 537
- Example 138
- Example 239
- Example 339
- Grounding.....15
- Input Power6
- Intermittent Duty Operation36
- Model Number.....19
- motor5
- Motor
 - data package19
- Outline & Dimensions.....10
- Outline Dimensions8
- Output Power6
- PC-2646034

- PC-26719.....30
- PC-26720.....35
- PC-2672123
- PC-2672224
- PC-26723.....25
- PC-2672428
- PC-26725.....29
- PC-26726.....33
- Performance Curves23, 28, 33
 - EB-202-A23
 - EB-202-B24
 - EB-202-C25
 - EB-204-A28
 - EB-204-B29
 - EB-204-C30
 - EB-206-A33
 - EB-206-B34
 - EB-206-C35
 - PC-2646034
 - PC-2671930
 - PC-2672035
 - PC-2672123
 - PC-2672224
 - PC-2672325
 - PC-2672428
 - PC-2672529
 - PC-2672633
- Power Supply
 - Ratings6
- Preliminary Checks16
 - AC Input Voltage16
 - DC Output Voltage16
 - zero system resolver16
- Rating
 - Power Supply6
- Signal Inputs
 - Modes of Operation.....15
- Specifications
 - CD-2671621, 22
 - CD-2671726, 27
 - CD-2671831, 32
 - EB-20221, 22
 - EB-20426, 27
 - EB-20631, 32
- Switching Frequency6
- System Wiring.....12
- Temperature
 - ambient.....6
 - operating6
- Wave Forms.....36
 - current phase C36

voltage line A-C36
Wiring
input power6

National Code..... 6
typical motor 14
typical power supply 11

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