| Elwood Corporation – Motors Group | |
|---|---|
| TITLE: **PROCEDURE**<br>Installation & Operation Manual for the<br>"SX" Motors | PART NO. 307-700-0040, Rev. P<br>EDN 033300<br>PAGE 1 of 67 |

WRITTEN BY: Curt Winter (Name) | Engr. (Dept.) | *Curt Winter* (Signature) | 8/10/93 (Date)

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|---|---|---|---|---|---|---|
| A | 02/03/95 | 16 | LJE | 441-07 | Brake current was 1.46 A | C.W. |
| B | 04/03/96 | 11-16 | C. Winter | 9605-01 | Cable replaced, color codes | C.W. |
| C | 10/01/99 | All | C. Winter | 9941-03 | Redraw into Word document | C.W. |
| D | 11/19/01 | All | D. Moyer | 0147-01 | Change API Gettys to Gettys | DAM |
| E | 11/08/02 | various | D. Moyer | 0244-01 | Update to add encoder feedback | DAM |
| F | 08/05/03 | various | D. Moyer | 002718 | Update to add CE declaration of conformity and other minor changes. | DAM |
| G | 04/23/04 | various | D. Moyer | 003051 | Updated to add absolute encoder feedback | DAM |
| H | 11/23/05 | 3, 60 | D. Wiese | 003877 | Clarify ATEX cert; correct M44H 460V inductance | DAW |
| I | 04/10/06 | 61 | D. Wiese | 004102 | Update resistance and back Emf on M463K 460V | DAW |
| J | 09/10/08 | various | D. Wiese | 005104 | Update to clarify ATEX special condition; Stegmann voltage; Data sheets | DAW |
| K | 05/14/10 | 3, 4 | D. Wiese | 005651 | Add Class II, Groups E, F & G; Remove date from ATEX spec | DAW |
| L | 04/05/13 | All | D. Wiese | 006871 | Add ATEX dust description and information; update Appendix E; change Gettys to Elwood or Motors | DAW |
| M | 04/23/13 | 5 | D. Wiese | 006917 | Change "G" to "D"; Add Warnings | DAW |
| N | 06/18/13 | 5 | D. Wiese | 006995 | Add IECEx & ATEX dust cert numbers | DAW |
| P | 09/02/16 | 3, 5, 14, 19, 27, 58, 59, 61, 64 | D. Wiese | 008401 | Change from Ex to EEx. Add IECEx special conditions. Add DSL Encoder. Update data sheets | DAW |

## MANUAL CONTENTS



## APPENDIX CONTENTS

Note: Important! Read All Instructions Before Installing This Motor
Save These Instructions

Procedure, Installation, and Operation Manual

Elwood "SX" Series Hazardous Locations

Permanent Magnet AC Servo Motors

## Certifications:

*Motor can be ordered either UL Listed only or UL Listed and CE Certified. Part number of motor ordered determines which applies. See below for exceptions and ratings.*

M43X, M44X, M46X, and M47X series motors are UL Listed. The ratings are as follows:

Class I, Division 1, Groups C & D or Class II, Division 1, Groups E, F & G
File Number: E149083
Specification Number: UL 674

M43X, M44X, and M46X are CE rated for use in the European Community complying with the ATEX directive. Specification Numbers: EN60079-0 and EN60079-1 The ratings are as follows:

EEx d IIB T3

| | | |
|---|---|---|
| EEx | = | Equipment conforms to types of protection standardized by CENELEC. |
| d | = | Flameproof enclosure |
| IIB | = | Used in surface industries; gas group. |
| T3 | = | Temperature class; maximum surface temperature 200° C |

CE 0081 Ex II 2 G

| | | |
|---|---|---|
| CE | = | CE marking |
| 0081 | = | Identification number of notified body. |
| Ex | = | Use of equipment in potentially explosive atmospheres. |
| II | = | Equipment group: for surface. |
| 2 | = | Equipment category: present zone 1. |
| G | = | Gas. |

LCIE 03 ATEX 6236 X

LCIE 03 ATEX 6236 = Certification number.
X = Motors are manufactured with permanently connected unterminated conductors and therefore marked with the X to indicate the need for appropriate protection of the free end of the conductors. See page 10 of this manual for connection instructions.
If replacement of screws and/or locknuts that secure the front endbell to the stator assembly is necessary, they must be replaced with screws and locknuts having the following dimensions and minimum tensile strength:.

| Model | Dimension Screws | Material | Tensile strength | Dimensions Nuts | Material | Tensile strength |
|---|---|---|---|---|---|---|
| M43X | M4 x 0.7 x 16 | Steel | 174 KSI | M5 | Steel | 116 KSI |
| M44X | M5 x 0.8 x 16 | Steel | 174 KSI | M5 | Steel | 116 KSI |
| M46X | M5 x 0.8 x 25 | Steel | 174 KSI | M5 | Steel | 116 KSI |

If replacement of the bolts that secure the rear endbell and the motor cover to the stator assembly is necessary, they must be replaced with M5 x 0.8-6g tie bolts. The bolts must be made of steel and have a minimum tensile strength of 58 KSI.

If replacement of nuts that secure the motor cover to the stator assembly is necessary, they must be replaced with M5 x 0.8-6H lock nuts. The lock nuts must be made of steel and have a minimum tensile strength of 116 KSI.

The motors must be excited with 3-phase sinusoidal currents in proper relationship to the motor's generated voltage of back electromotive force at each rotor position. The PWM switching frequency is specified at a minimum of 3 kHz,

Do not open motor, serious injury may result if motor is opened by unauthorized personnel.

The approval applies to equipment without cable glands, When Mounting the flameproof enclosure in a hazardous area, only cable glands certified to EN60079-1 can be used.

M43X-XXXX-BXXX and M43X-XXXX-CXXX are CE rated for use in the European Community complying with the ATEX directive. Specification Numbers: IEC 60079-0:2007 ED.5 / EN 60079-0:2009 AND IEC 60079-31:2008 ED. 1 / EN 60079-31:2009. The ratings are as follows:

Ex tb IIIC T135°C Db IP6X

Ex = Equipment conforms to types of protection standardized by CENELEC.
tb = Protection by enclosure
IIIC = Used in surface industries; conductive dust group.
T135°C = Maximum surface temperature.
Db = Equipment for explosive dust atmospheres, having a "high" level of protection, which is not a source of ignition in normal operation or expected malfunctions.
IP6X = Degree of protection of enclosure; ingress of dust totally prevented.

CE 0081 Ex II 2 D

CE = CE marking
0081 = Identification number of notified body.
Ex = Use of equipment in potentially explosive atmospheres.
II = Equipment group: for surface.
2 = Equipment category: present zone 1.
D = Dust.

IECEx LCIE 13.0024X = IEC Certification number.

LCIE 13 ATEX 3043 X = ATEX Certification number.

WARNING – DO NOT OPEN WHEN AN EXPLOSIVE ATMOSPHERE MAY BE PRESENT.

WARNING – DO NOT OPEN WHEN ENERGIZED.

**Special conditions for safe use:**

- Ambient operating temperature range: -25°C up to +40°C.
- Lead wire exiting the servomotor shall be protected against impact by fittings or conduit systems. The mounting shall guarantee the protection against light of the filling compound inside the threaded fittings welded to the motor enclosure.

1.0) Motor Visual Preparation

Remove the motor carefully from its shipping container, being careful not to damage the leadwires that extend from the connection fitting. Do not lay the motor on top of the leadwires, as it may damage the wires. Visually inspect the motor for any shipment damage; examine the motor frame, front output shaft, frontbell flange & mounting pilot, mounting holes, and leadwires from the connection fitting exit of the motor. Leadwires should be free of nicks, cuts, or cracked insulation which exposes bare wire. If damage is suspected, the carrier should be notified immediately.

WARNING: The "SX" Series motor has been constructed to very tight tolerances for hazardous location ratings. Do not open or attempt to open the motor, only a qualified Elwood employee can service this type of motor. Do not operate the motor in a hazardous location with any securing screws or covers removed. Do not remove any screws or cover or disassemble the motor while in a hazardous location.

1.1) Motor Keyway Preparation:

A MIL-C-16173 grade 4 rust inhibitor has been applied to the drive shaft to protect the shaft before installation. This can be removed with a solvent such as kerosene, WD-40, or diesel fuel. Elwood can produce the drive shaft from passivated #416 or 17-4 stainless steel as an option for harsh environments that will not require a rust inhibitor.

The output shaft may have a sled runner or captive keyway provided. Metric shaft captive keyways have a (P9) press fit tolerance. Support the underside of the shaft diameter with a radius fixture (figure #1) and use a controlled press device when pressing a key into the shaft. Never use a hammer to impact press fit a key into a shaft. Metric keys usually have a full radius on each end of the key to match the captive keyway in the shaft.

English and NEMA shafts usually have an open sled runner or an open profile milled keyway. English and NEMA keys are usually cut square on each end. Do not press the squared cut end of a key into the radius of a profiled milled keyway or sled running keyway as shown in (figure #2). Do not use loose fitting keys in the keyways.

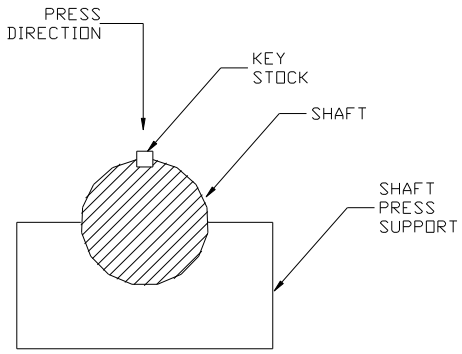



FIGURE (1) SHAFT KEY PRESS SUPPORT FIXTURE

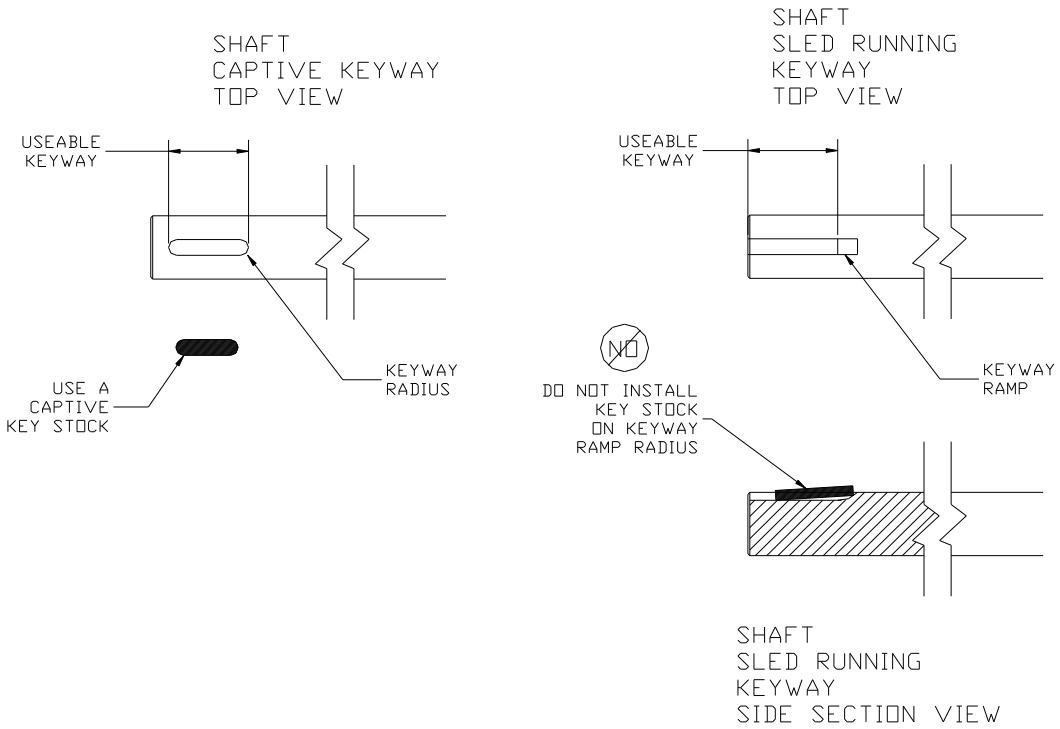



FIGURE (2) SHAFT KEYWAYS

1.1) Motor Keyway Preparation Continued:

Elwood recommends having a keyway in gears, pulleys, or other devices to match the motor shaft keyway and installed key. Installation of a gear may be performed before or after mounting the motor to the machine; depending if the gear will pass through the pilot diameter hole. Some proper gear mounting applications are to heat expand and slide the gear onto the shaft/key for a shrink fit hold. Another is to slide the gear onto the shaft/key and screw a set screw perpendicular through the gear and on top of the key. We recommend using a thread locking adhesive on the set screw to prevent the screw from backing out. Another is to slide the gear onto the shaft/key and match drill and press fit a pin into the gear and shaft. Snap rings and other holding devices can be included in the design. Do not press fit a gear or device in the axial direction onto the shaft. Elwood can perform this operation at the factory with proper support of the feedback side of the shaft. Never use a hammer to impact press fit any device onto a shaft, pressing or impacting in the axial direction will brinell damage the bearings in the motor. Consult machine design technical reference information for your particular requirements.

2.0) Frontbell Flange Mounting:

All motors include a mounting pilot for centering the motor on a machine. Visually inspect the pilot and flange to be free of nicks, burrs, or upsets which may cause improper mating or alignment after mounting. A motor typically has a DIN IEC-B5 or NEMA type D frontbell mounting flange with four through holes for bolting the motor to the machine frame. Preferred bolting fasteners are stainless steel socket head screws that are a grade 8 minimum strength rating. Also use a stainless steel split washer and then a flat washer under each head of the screws when mounting the motor.

A NEMA C-face mounting pattern is also available and has tapped holes into the frontbell flange, therefore requiring the bolting fastener to pass through the machine frame and screw into this frontbell. It is recommended to have at least five threads of engagement into the frontbell flange.

The Elwood "SX" motors may be mounted in the vertical or horizontal positions. When mounted in the horizontal position, the leadwire fittings may point up, down, or to either side.

2.1) Mounting Clearance and Ventilation:

Allow sufficient clearance around the motor for heat transfer ventilation. Do not enclose the motor unless forced air is blown across the motor for cooling. Fans blowing air across the motor will improve its performance. Keep other heat producing devices away from the motor.

2.2) Gearbox Mountings:

The Elwood "SX" Series motors can be provided with reduced shaft and frontbell runout tolerances per DIN-N 42955 standards to mount with gearboxes. An output shaft option is offered without a keyway for clamp-on gear pinions use in gearboxes. Elwood recommends using low backlash servo gearboxes with our motors.

Elwood uses single row double shielded ball bearings in the motors that are designed for radial loads. The ball bearings can be damaged with excessive axial loads from angular cut pinnion gears. Shaft mounted spur cut pinion gears inserted into a planetary gearbox is recommended. Consult the Applications Department if axial loads are expected to be applied to the motor.

WARNING: Some gearboxes require a low viscosity oil to be poured into the gearbox after assembled to the motor. Elwood recommends a face o-ring design in the rear flange of the gearbox for proper sealing between the gearbox and motor. Elwood can put an o-ring design into the frontbell of the motor if the gearbox does not offer an o-ring design in the rear flange. This face o-ring design is preferred because it allows a secure metal to metal contact of the gearbox and motor, while compressing a o-ring for sealing. Do not use flat gaskets between the gearbox and motor, they flex and move and could potentially leak. Using flat gaskets would not maintain runout tolerances of the shaft with respect to the gearbox. Incorrect lubrication of the gearbox would result in damage to the gearbox. Consult your gearbox manufacturer for more information.

3.0) Leadwire Connections and NPT (National Pipe Thread) Fittings

The Elwood "SX" Series motor has aluminum male NPT fittings located on the side or rear of the feedback housing assembly of the motors. The motors will have one or two male NPT fittings in any combination on the side or rear of the motor. Two fittings are used to separate the power and feedback signal leadwires for higher current draw motors. All NPT fittings have potting compound around the leadwires inside the fittings. Do not tamper with the potting. All NPT fittings will have a hex for the user to secure with a wrench when connecting NPT fittings for hazardous locations to the motor. Do not use a pipe wrench on the fitting hex or on the motor. Do not screw conduit to the motor unless the fitting hex is supported with a wrench as the required torque to connect conduit may damage the motor construction. Be careful not to damage insulation or put sharp radius bends in the leadwires when passing through the conduit. Leadwires are color coded for identification as shown on the motor electrical interconnection schematic drawings in Appendix A. Standard leadwire lengths are 36", consult the factory for custom lengths. Connection to the motor leadwires is the user's responsibility, and to use approved NPT fittings for hazardous locations. The motor must be securely mounted to a machine frame and all safety guards in place before turning on. Fitting thread sizes are: 1" NPT 11-1/2 threads per inch or ¾" NPT 14 threads per inch.

WARNING: The "SX" Series motor has been constructed to very tight tolerances for hazardous location ratings. Do not open or attempt to open the motor, only a qualified Elwood employee can service this type of motor. Do not operate the motor in a hazardous location with any securing screws or covers removed, and do not remove any screws or cover or disassemble the motor while in a hazardous location.

WARNING: Incorrect motor and/or feedback wiring can cause improper or runaway motor operations.

WARNING: Dangerous voltages and currents are present with servo motors. Only qualified personnel should install, set-up, and operate machinery with these motors.

4.0) Repainting the Motors

The Elwood "SX" Series motors exterior surfaces will be black color anodized, bare aluminum metal or a high temperature epoxy paint. If this motor is repainted and/or mounted in an enclosed area, the performance ratings could be degraded. Please take care of excessive coats of paint on the motor. Do not paint over the nameplate or labeled information on the motor.

5.0) Amplifiers/Drives for the "SX" Motors

The Elwood "SX" Series 3-phase wye-connected stator rare earth permanent magnet rotor servo motors must be excited with 3-phase sinusoidal currents, which are in the proper relationship to the motor's generated voltage or back electromotive force (BEMF) at each rotor position. A pulse-width-modulated (PWM) current amplifier drive is required to insure the ability to control the current amplitude, frequency, and phase for operation of the rotor within its specifications. The PWM switching frequency is specified at a minimum of 3 KHz. See Appendix B for examples of BEMF sinusoidal waveforms that the users amplifiers will need to control.

WARNING: Do not install the drive amplifier in a hazardous location.

Performance torque and speed curves for these motors with above described amplifiers are in Appendix C. The performance curves in Appendix C are based on a 3-phase, (230 Vrms) 207 to 253 Vrms main line input voltage at 47 to 63 HZ frequency. The 460 Vrms motors will have two times the winding turns of the 230 Vrms rated motors. The 460 Vrms motors will have torque and speed curve performance slightly derated to the 230 Vrms motors. These motor windings have special coatings for voltage spike protection. The winding coatings use up some of the winding slot fill, and require a reduction in winding copper, thus reducing the torque capabilities of the motor. The 460 Vrms motor will have approximately half the current draw, four time the resistance and four times the inductance as a 230 Vrms motor.

Performance will vary if the motors are driven by an amplifier that has the ability to change the commutation angle excitation between the stator and rotor, referred to as: torque angle control, or phase advance. Performance operation for these motors must be within curves in Appendix C to insure safe motor surface temperatures. Intermittent operations are defined in Appendix C. Specifications for commutation and feedback resolvers or encoders inside these motors are in Appendix D. The data sheets for 230 Vrms and 460 Vrms motors are in Appendix E.

5.0) Amplifiers/Drives for the "SX" Motors (Continued)

Some amplifier setups require information on the number of motor magnet poles to operate. Below are a quick reference chart for number of magnet poles of the "SX" Series motors, and the equation for commutation frequency. The nameplate will have frequency and RPM information provided for the customer.

| Part Number No. | Magnet Poles |
|---|---|
| M43X-XXNX-XXXX | 6 |
| M44X-XXNX-XXXX | 6 |
| M46X-XXSX-XXXX | 6 |
| M47X-XXSX-XXXX | 8 |

Chart (1) Part Number/No. Magnet Poles

See the "SX" Series part number flow chart for definition of the digits for the above chart.

$$\text{Motor Commutation Frequency} = \frac{\text{Motor Magnet \# Poles}}{120} * \text{Motor Speed (RPM)} = f = \frac{(P) * (RPM)}{120}$$

Equation (1) Frequency/Magnet Pole Equation

6.0) Over Temperature Limiting Device

The Elwood "SX" Series motors have over temperature limit (OTL) sensors in a series electrical path of the three phase windings. One is also supplied on the brake in series with the windings if the brake option is ordered. The OTL will mechanically open if the motor windings or brake over heats, thus opening the OTL series circuit path to the amplifier. The amplifier used to drive this motor should require a person to reset the system after inspection of the entire machine, motor, and drive electronics for possible causes of overheating. The motor OTL is an automatic resetting device and should be connected directly into a power disabling or latched (locked-out) type circuit that requires manual resetting. Do not override the OTL sensors from the amplifiers, caution must be observed when applying these motors to machinery to prevent possible accidental injury that could result when the thermal overload device automatically resets allowing the motor to restart. The OTL load ratings are on the interconnect schematic drawings in Appendix A.

WARNING: The "SX" Motor can operate with motor surface temperatures that can burn personnel upon contact. Do not touch the motor during operation.

7.0) Before Starting

Refer to user's amplifier's installation, connection, and operation manuals. Before attempting to start, check all connections, grounds, and fuses. Insure that all keys, pulleys, and mechanical linkages are securely fastened and aligned.

Proper guards should be provided to prevent hazards to personnel while rotation of motor shaft and associated mechanics. The inertia matching of the motor and machine application should be reviewed before starting. System inertia mismatch may produce unstable operations.

WARNING: The "SX" Series motor has been constructed to very tight tolerances for hazardous location ratings. Do not open or attempt to open the motor, only a qualified Elwood employee can service this type of motor. Do not operate the motor in a hazardous location with any securing screws or covers removed. Do not remove any screws or cover or disassemble the motor while in a hazardous location.

8.0) Starting

The motor and machine should be tested in an unloaded state. If the system does not start promptly and run smoothly, disconnect at once. Check for mechanical jambs and electrical connections. Disconnect the pulley or load transferring device from the motor. Elwood has an Application Engineering and a Customer Quality Service department to assist in your problems. If one is not using an Gettys amplifier and has system problems, please consult with that amplifier vendor for troubleshooting.

# APPENDIX A

## Wiring Interconnect Schematics

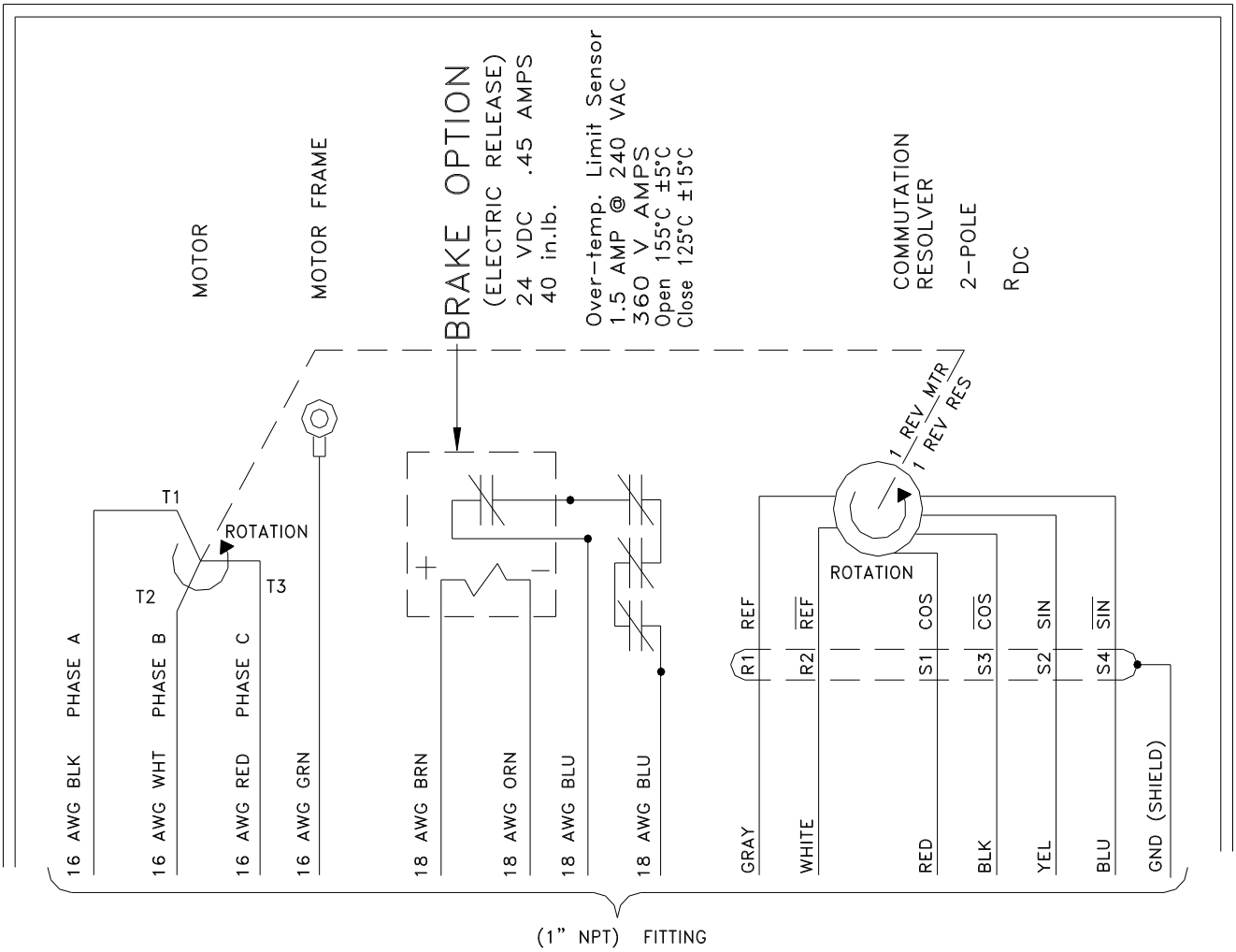
## CONTENTS

| XP, Square Motor Frame Size | Number of Leadwire Exit Fittings | Feedback Package |
|---|---|---|
| M43X & M44X | 1 | Single Resolver |
| M43X & M44X | 1 | Incremental Encoder |
| M43X & M44X | 1 | Absolute Encoder |
| M43X & M44X | 1 | EnDat Encoder |
| M43X & M44X | 1 | DSL Absolute Encoder |
| M43X & M44X | 2 | Single Resolver |
| M43X & M44X | 2 | Incremental Encoder |
| M43X & M44X | 2 | Absolute Encoder |
| M43X & M44X | 2 | Dual Resolver |
| M46X & M47X | 1 | Single Resolver |
| M46X & M47X | 1 | Incremental Encoder |
| M46X & M47X | 1 | Absolute Encoder |
| M46X & M47X | 1 | DSL Absolute Encoder |
| M46X & M47X | 2 | Single Resolver |
| M46X & M47X | 2 | Incremental Encoder |
| M46X & M47X | 2 | Absolute Encoder |
| M46X & M47X | 2 | Dual Resolver |

## Connection Diagram

## M43X & M44X Motors

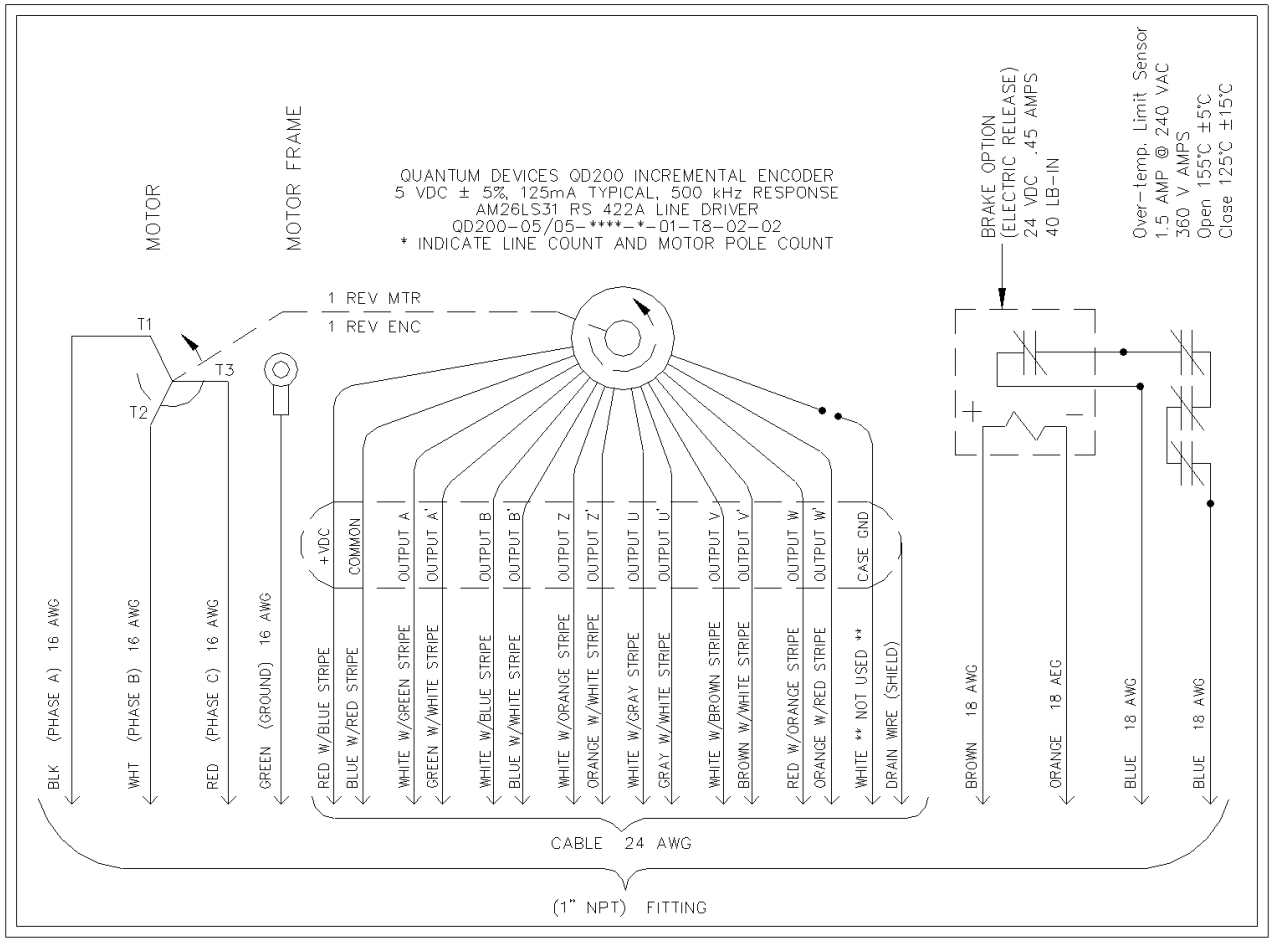
## Single Resolver, One Leadwire Exit Fitting



## Connection Diagram

## M43X & M44X Motors

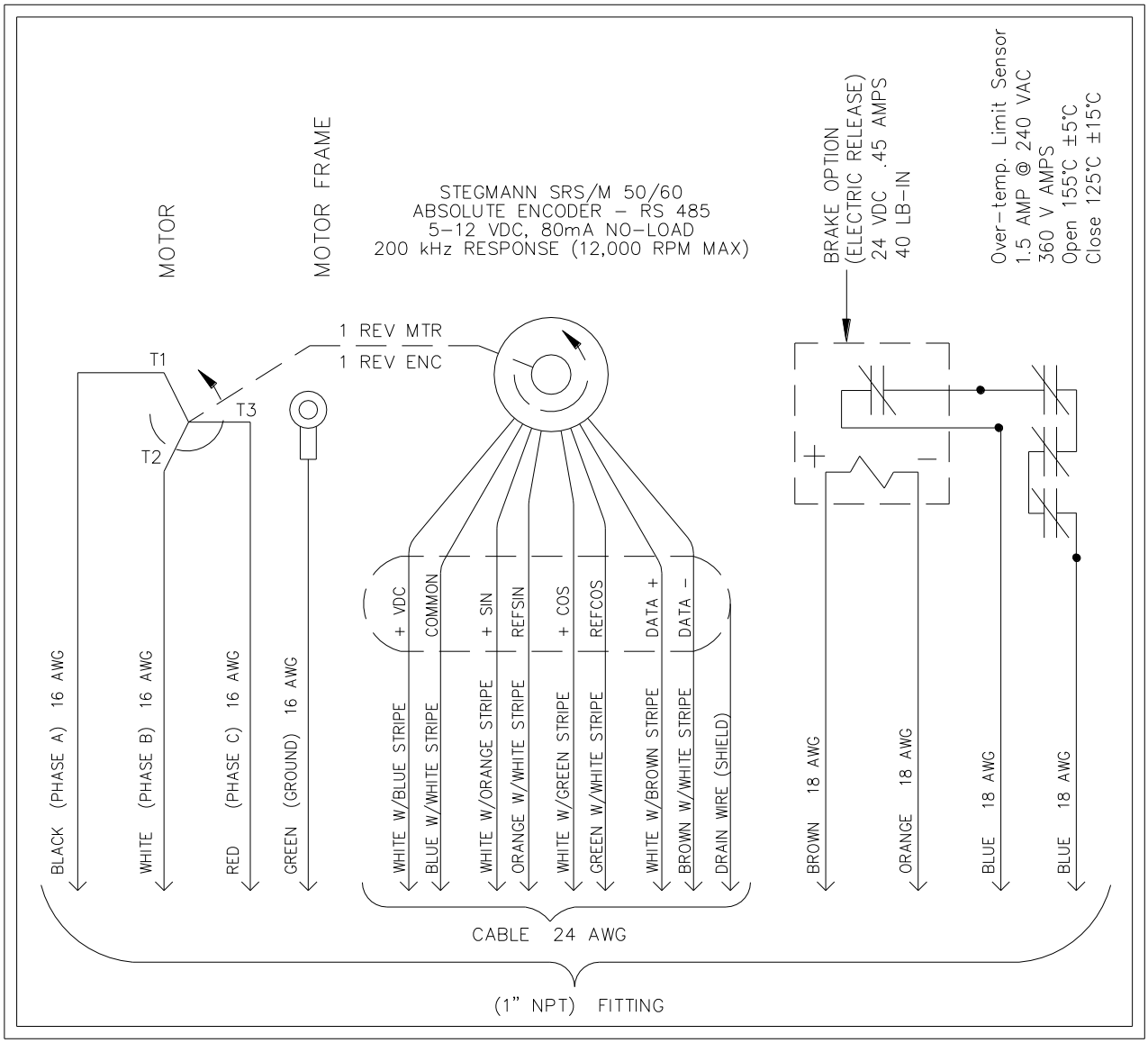
## Incremental Encoder, One Leadwire Exit Fitting



Connection Diagram

M43X & M44X Motors

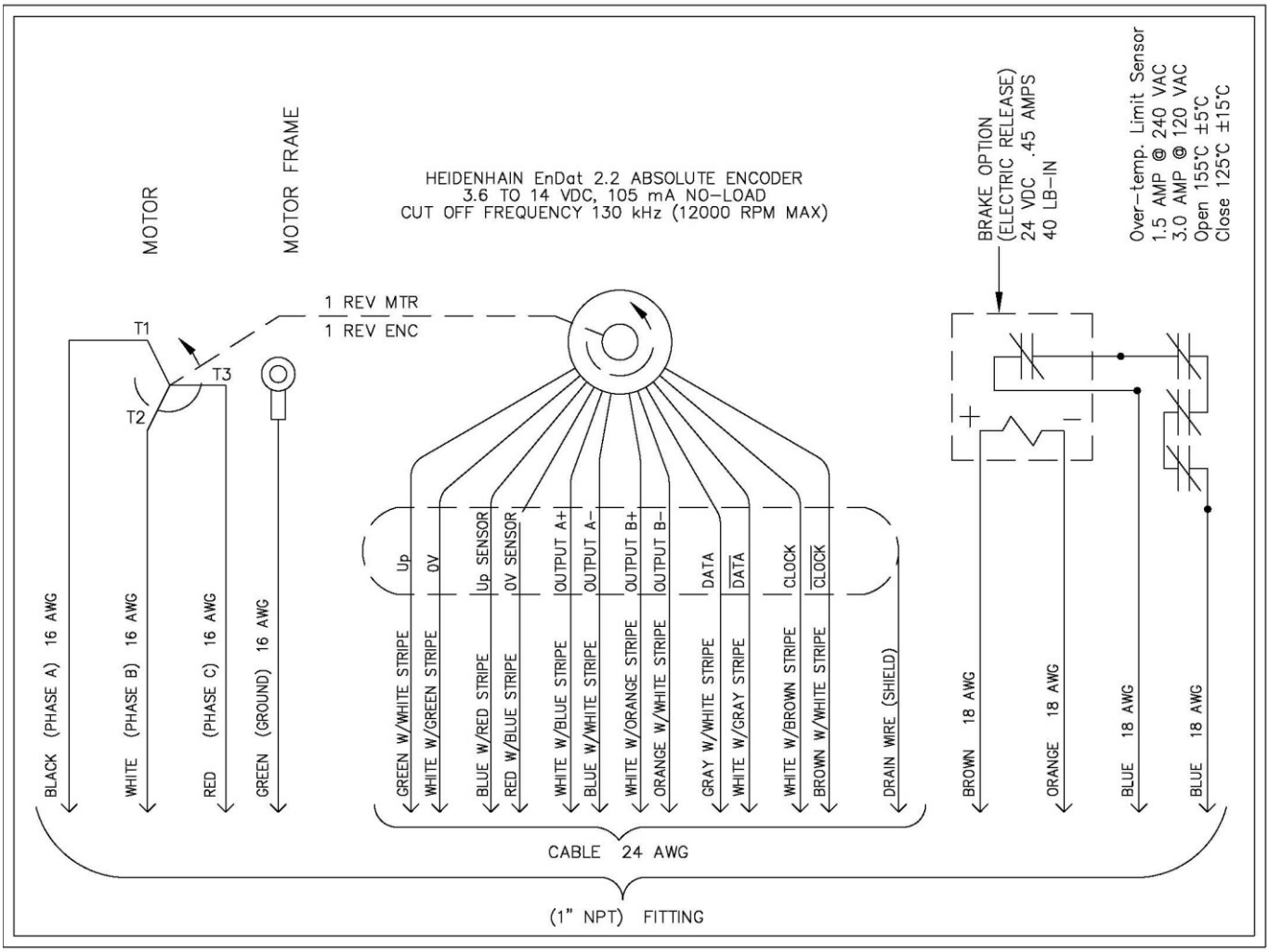
Absolute Encoder, One Leadwire Exit Fitting



Connection Diagram

M43X & M44X Motors

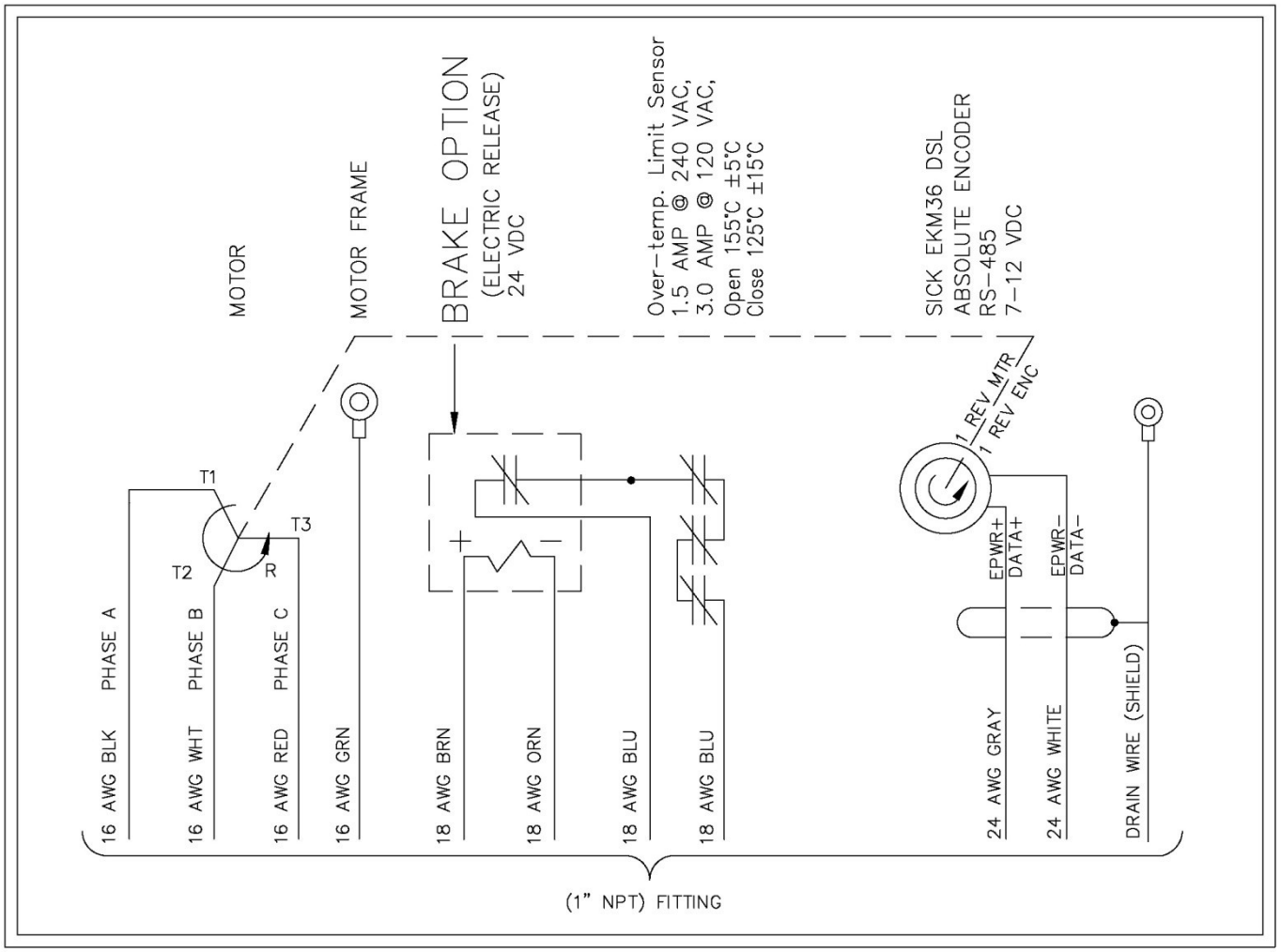
EnDat Encoder, One Leadwire Exit Fitting



Connection Diagram

M43X & M44X Motors

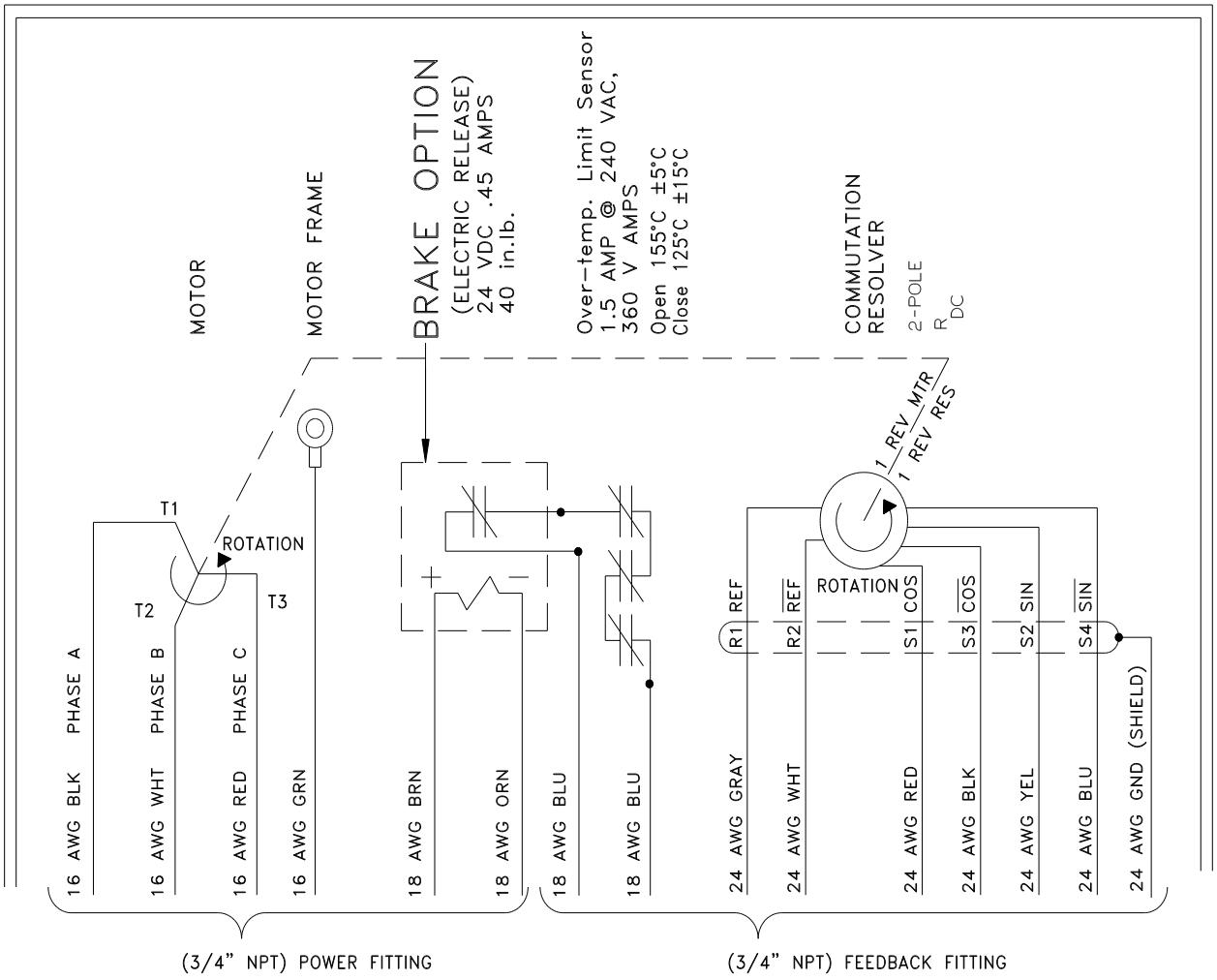
DSL Absolute Encoder, One Leadwire Exit Fitting



## Connection Diagram

## M43X & M44X Motors

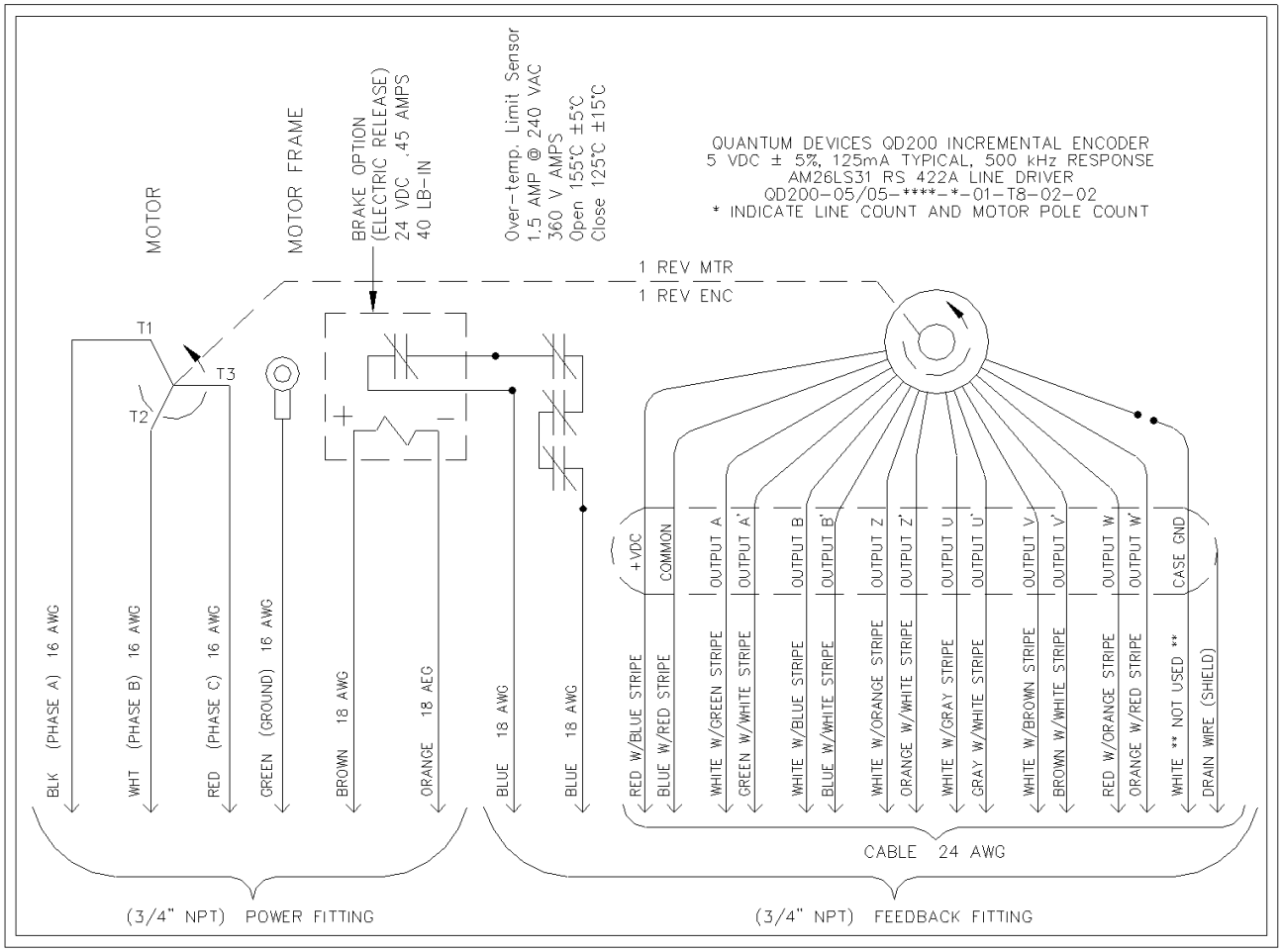
## Single Resolver, Two Leadwire Exit Fittings



## Connection Diagram

## M43X & M44X Motors

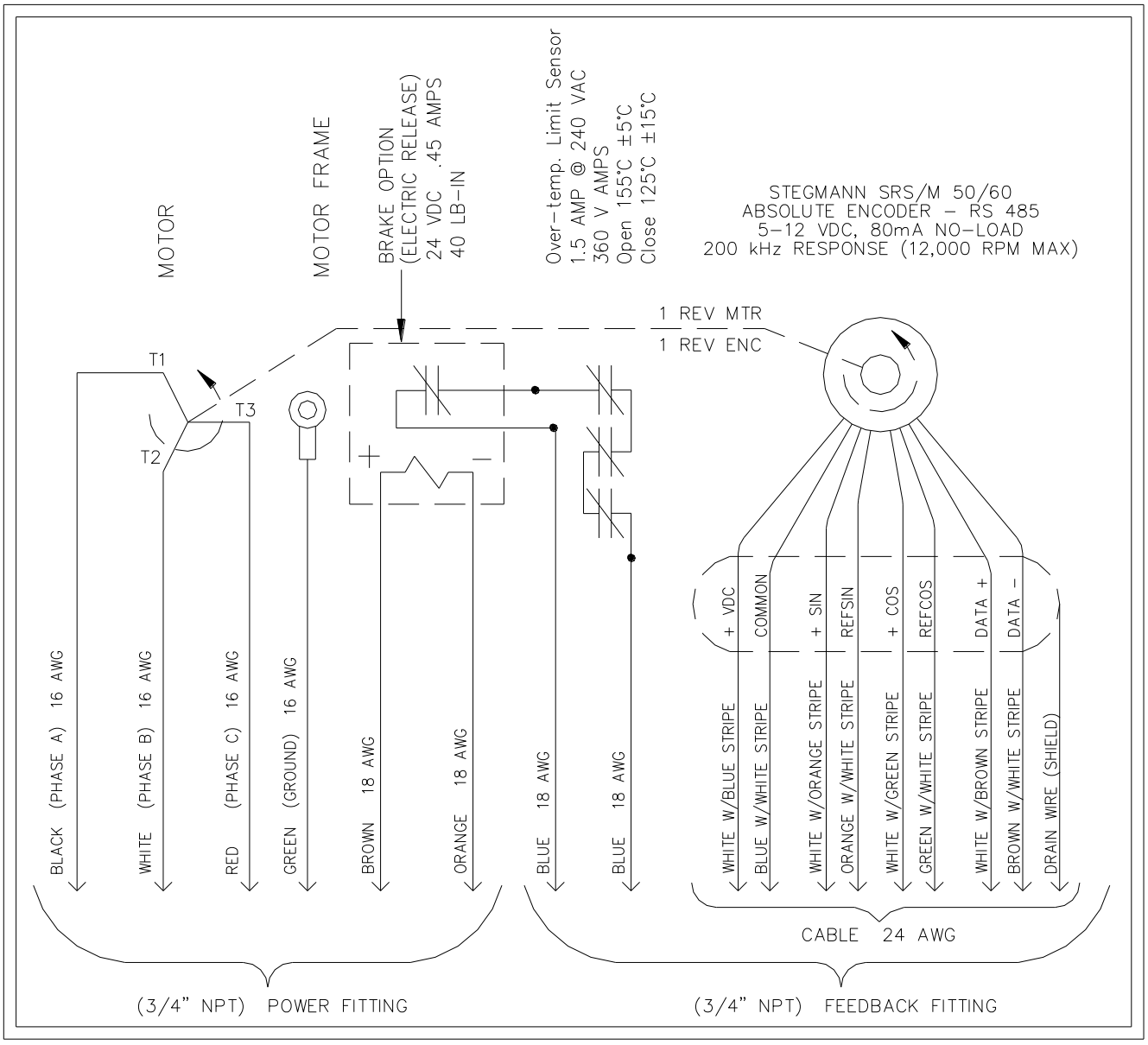
## Incremental Encoder, Two Leadwire Exit Fittings



## Connection Diagram

## M43X & M44X Motors

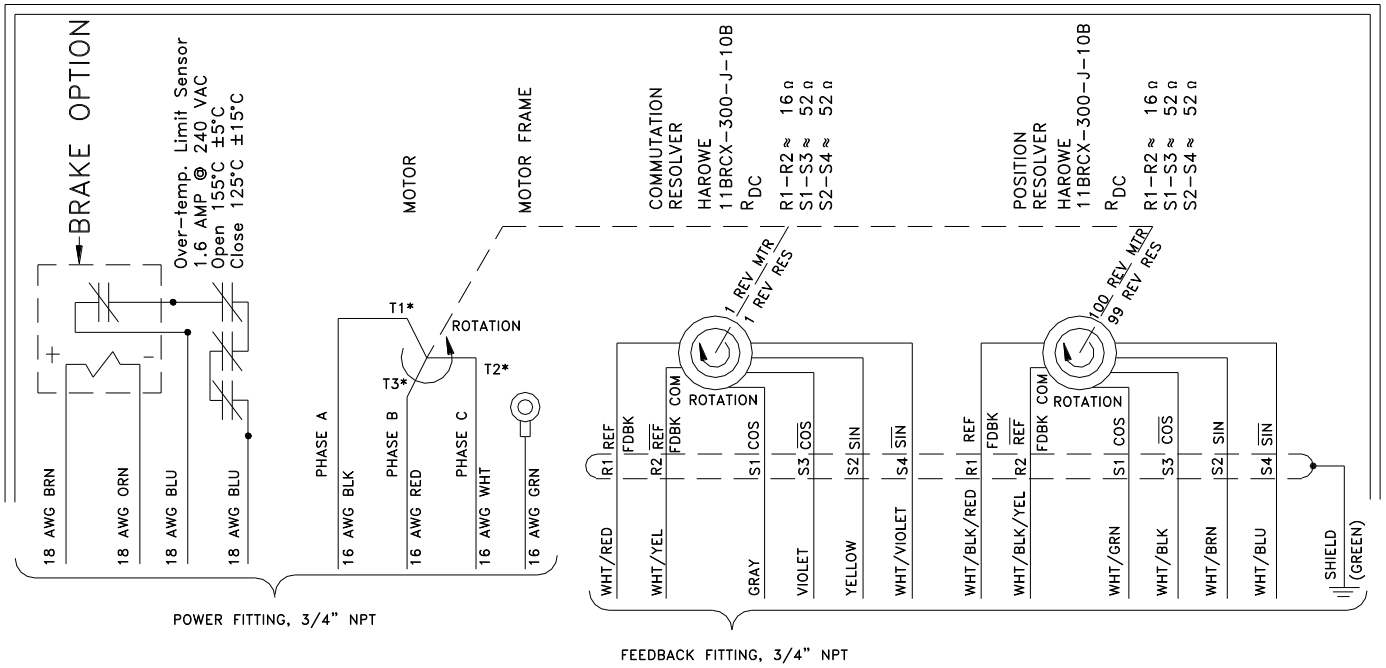
## Absolute Encoder, Two Leadwire Exit Fittings



## Connection Diagram

## M43X & M44X Motors

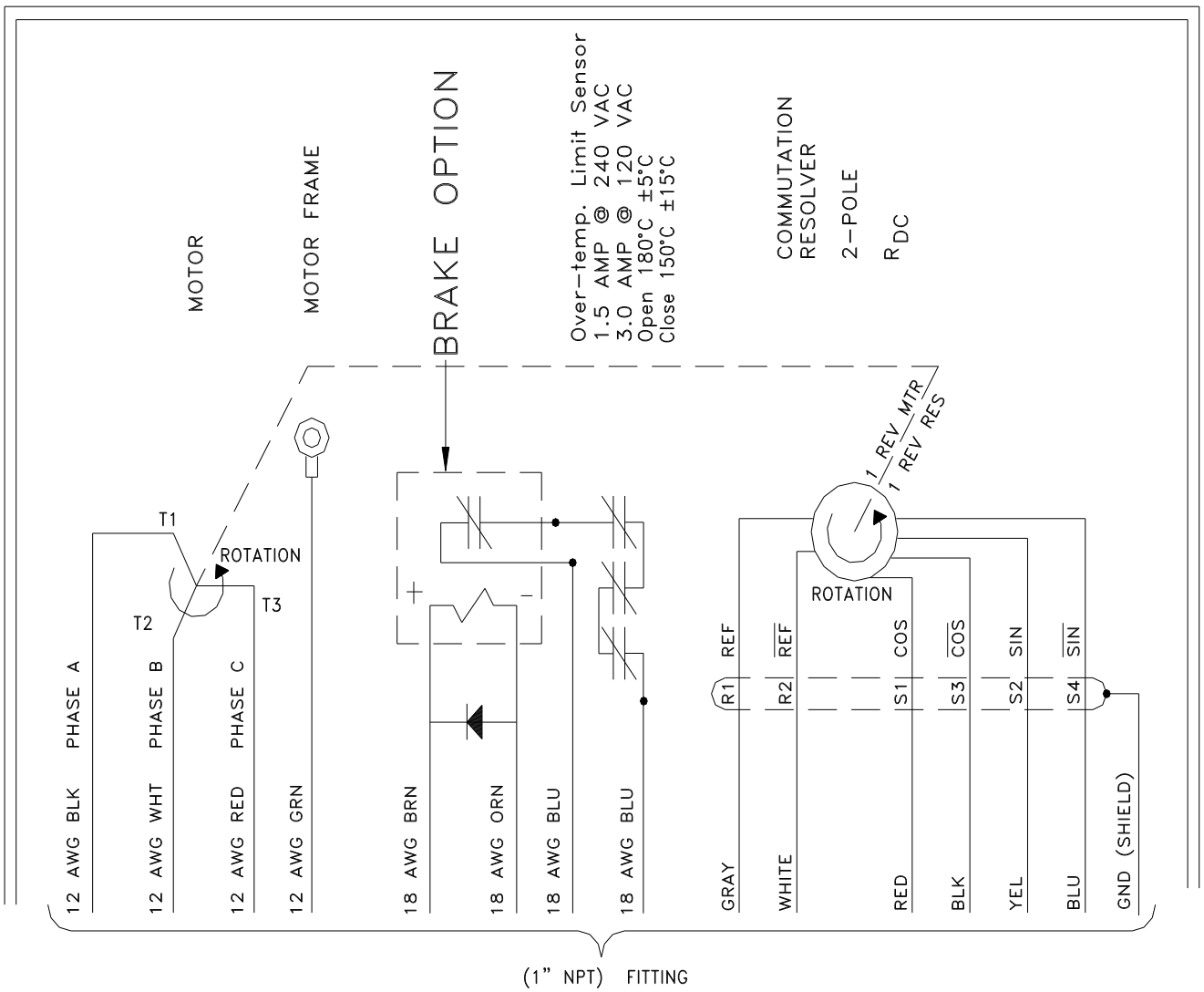
## Dual Resolver, Two Leadwire Exit Fittings



## Connection Diagram

## M46X & M47X Motors

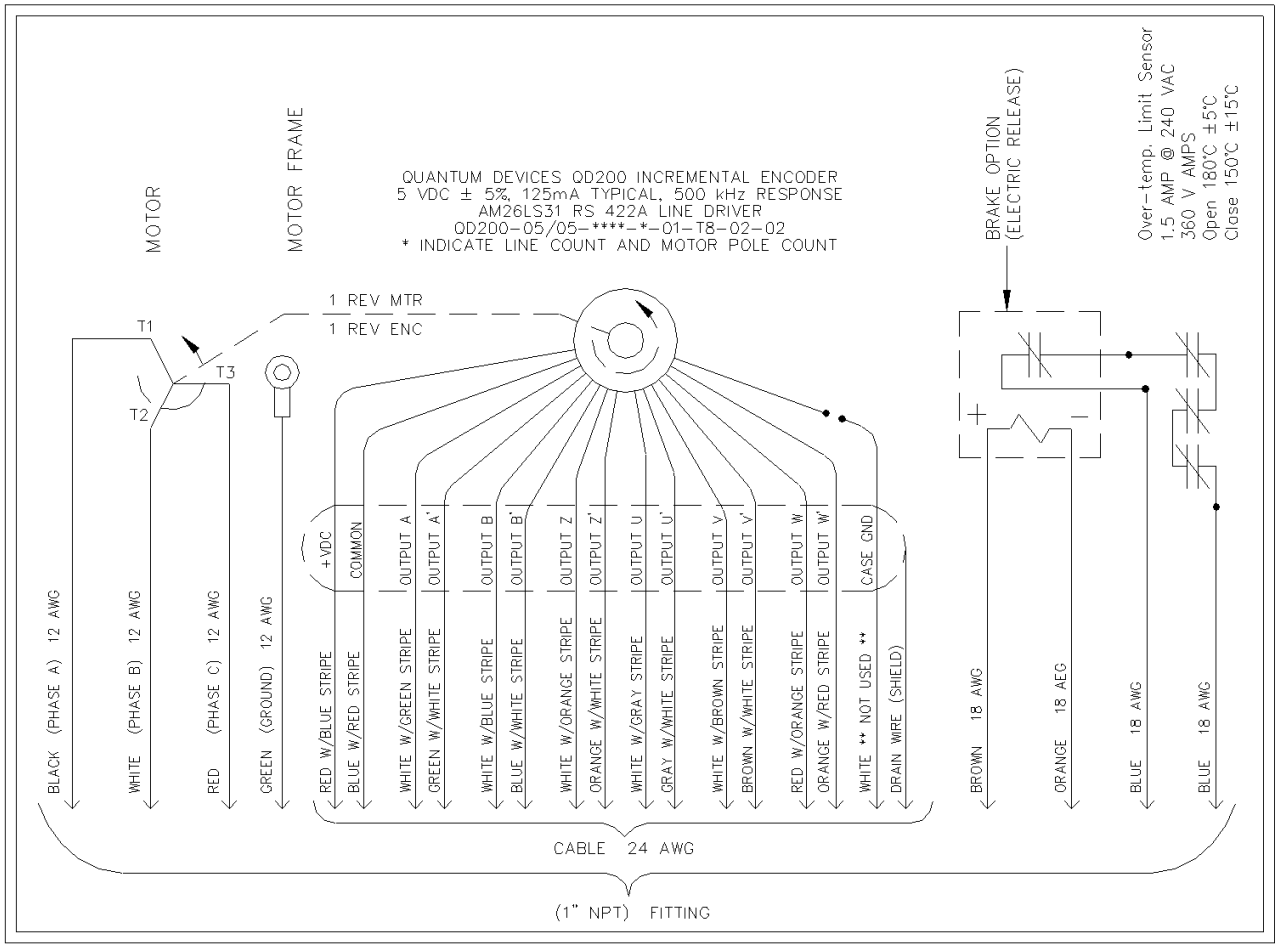
## Single Resolver, One Leadwire Exit Fitting



Connection Diagram

M46X & M47X Motors

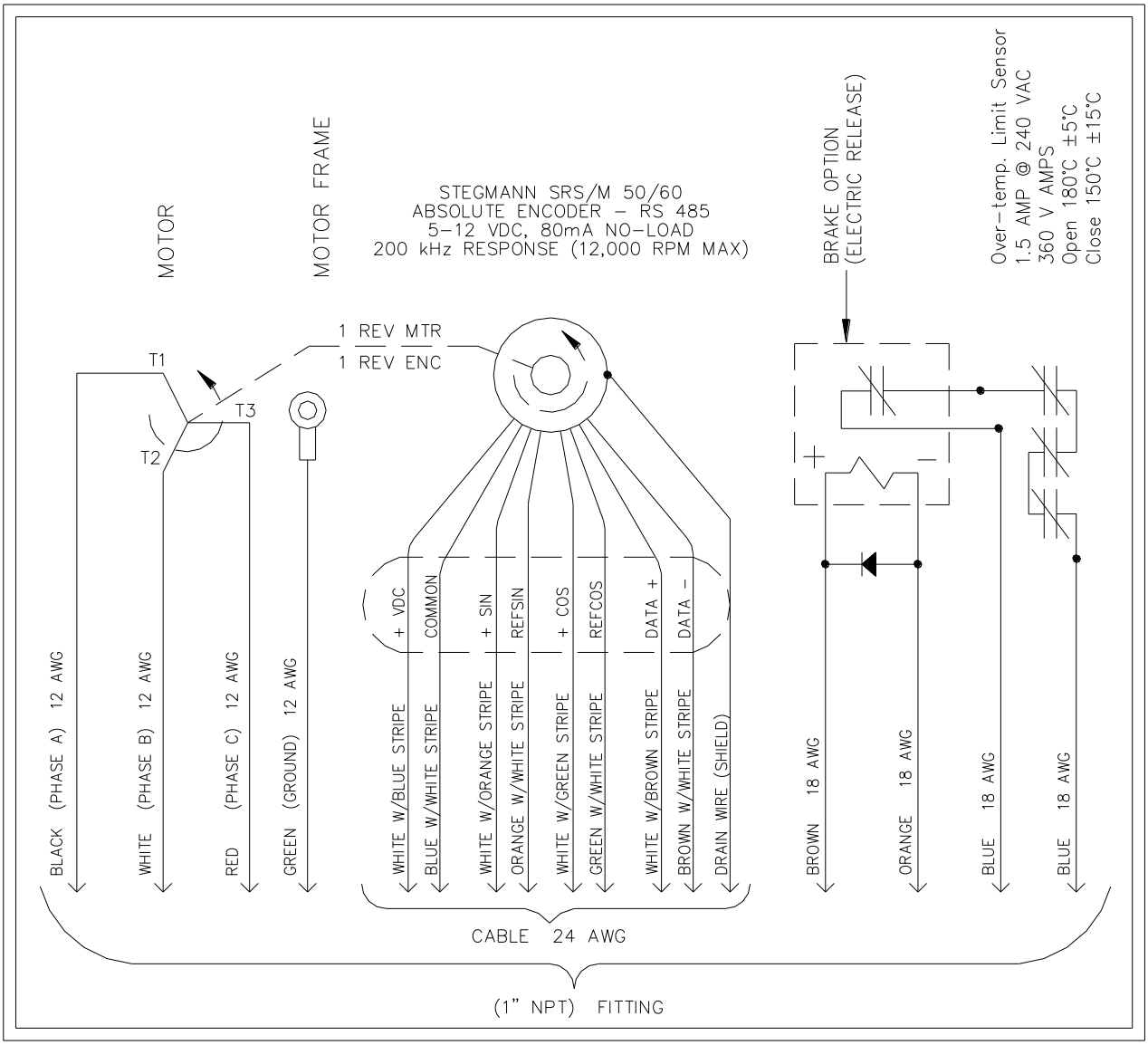
Incremental Encoder, One Leadwire Exit Fitting



Connection Diagram

M46X & M47X Motors

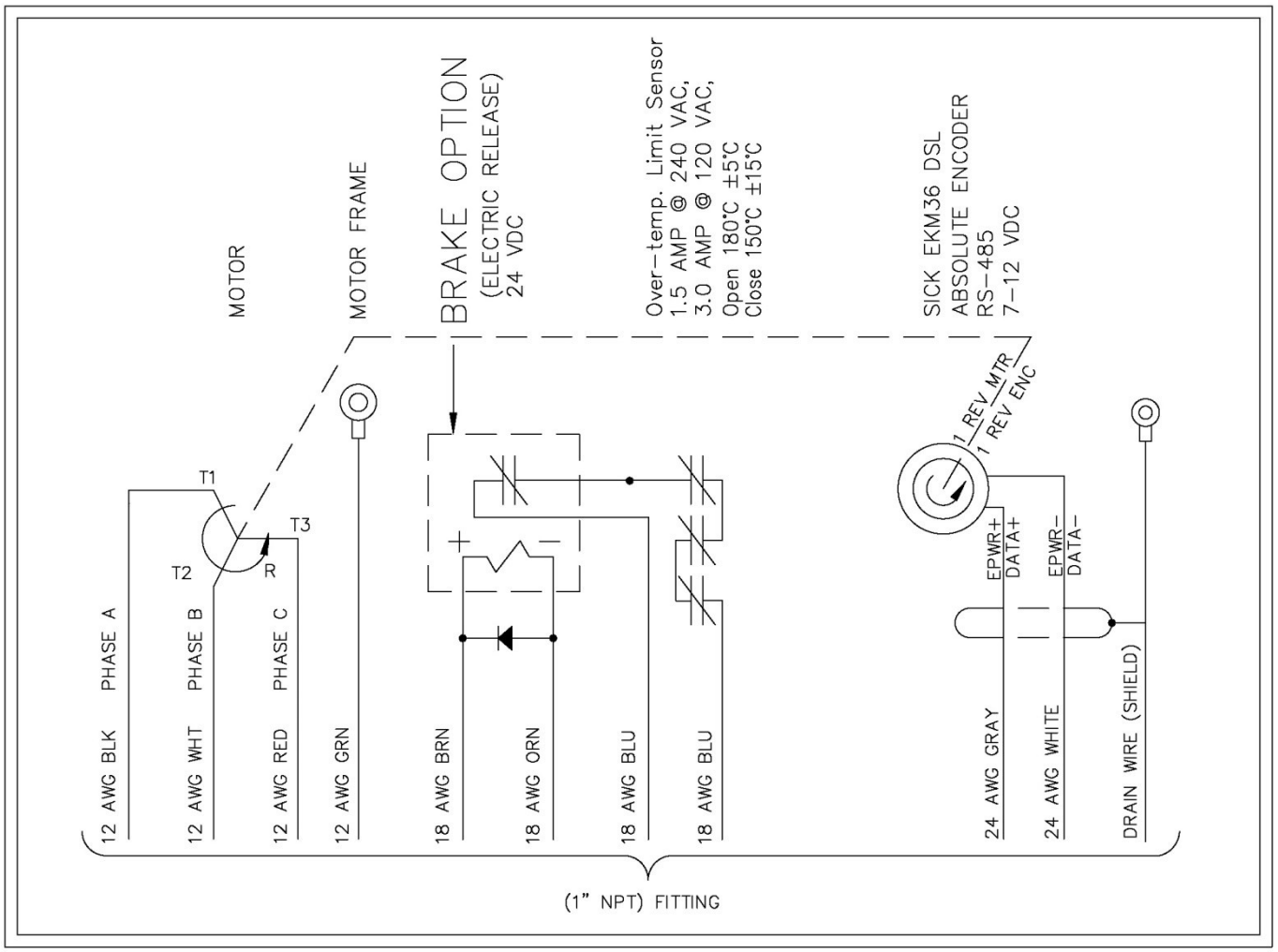
Absolute Encoder, One Leadwire Exit Fitting



Connection Diagram

M46X & M47X Motors

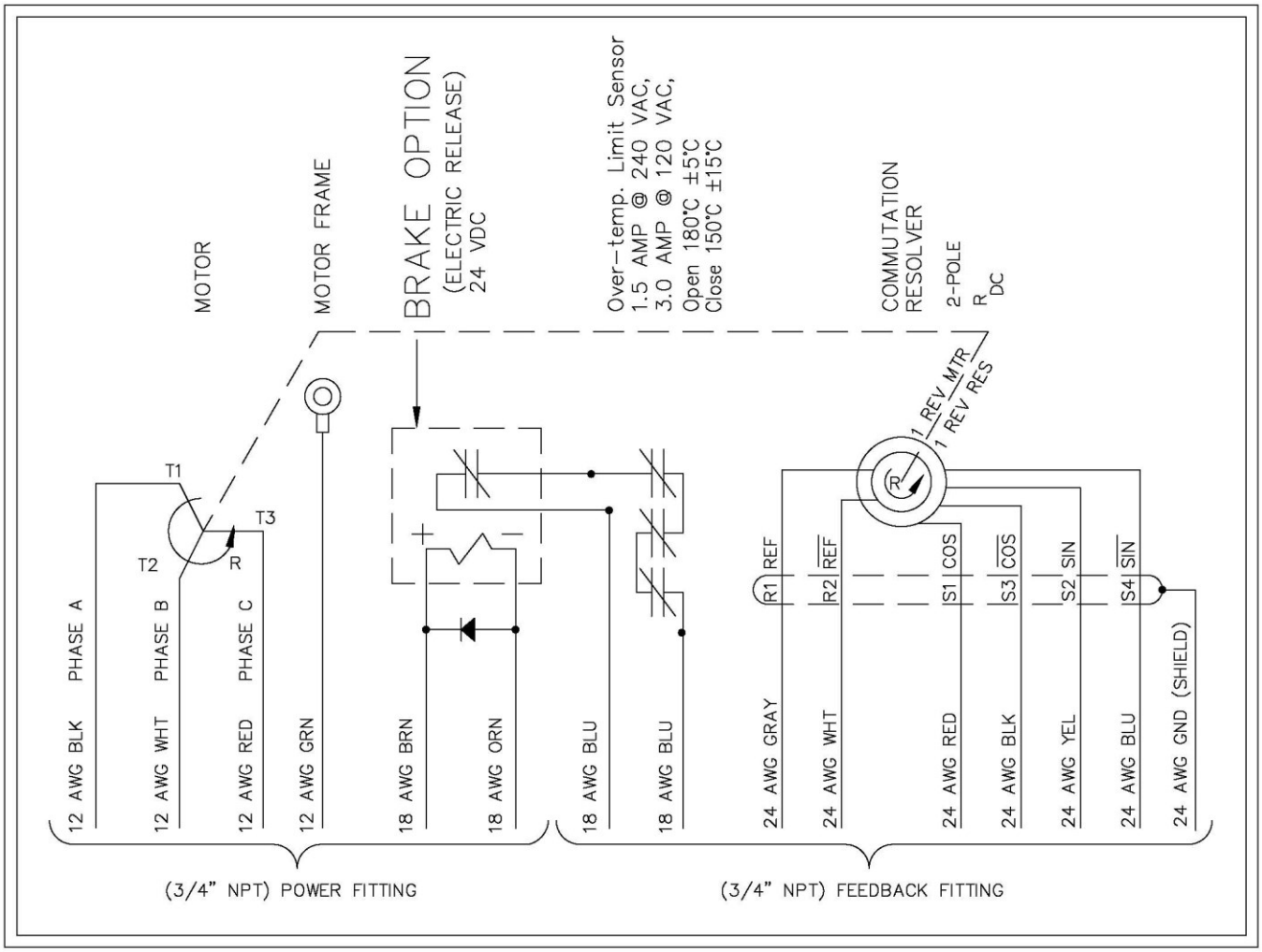
DSL Absolute Encoder, One Leadwire Exit Fitting



## Connection Diagram

## M46X & M47X Motors

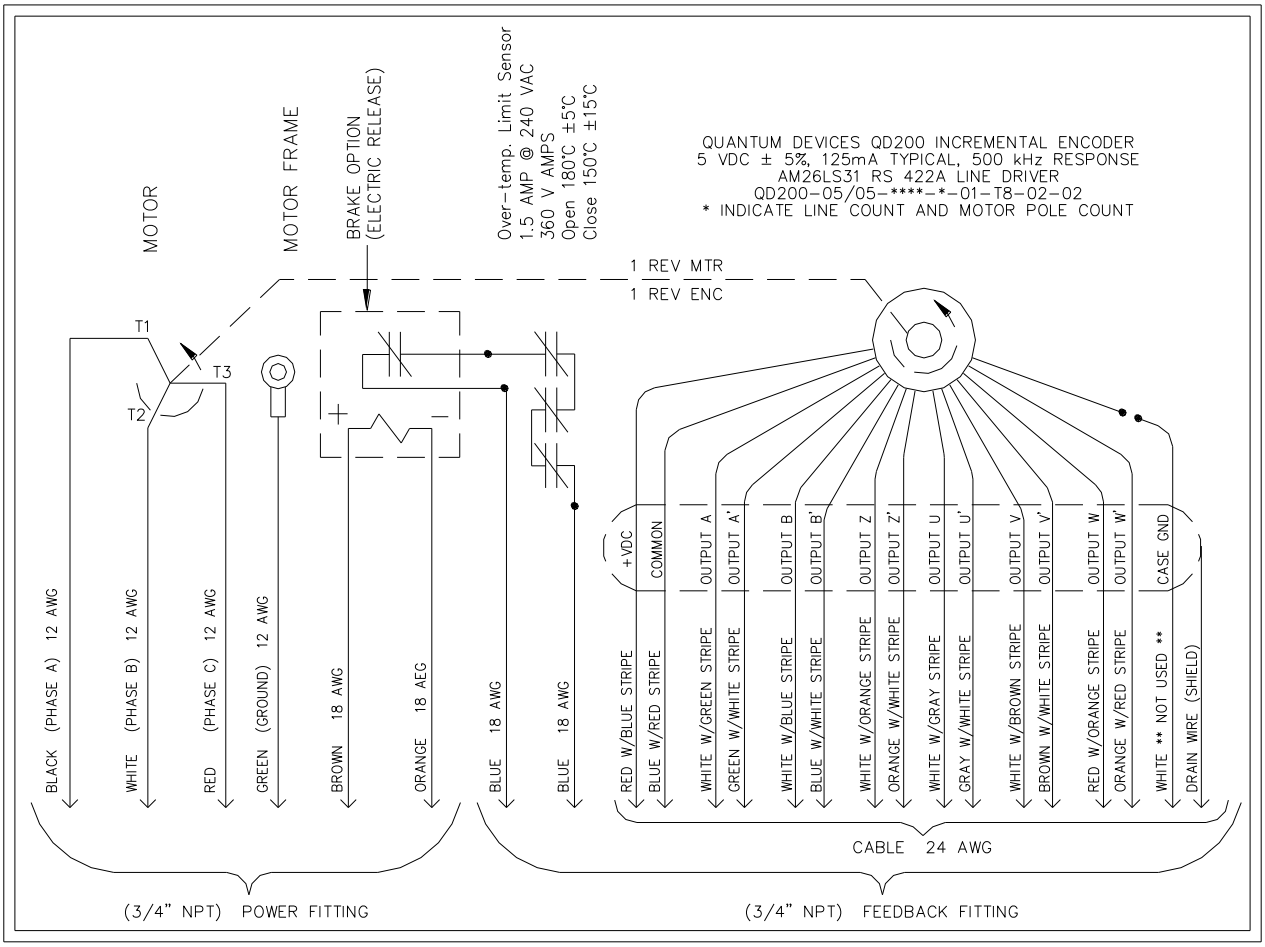
## Single Resolver, Two Leadwire Exit Fittings



## Connection Diagram

## M46X & M47X Motors

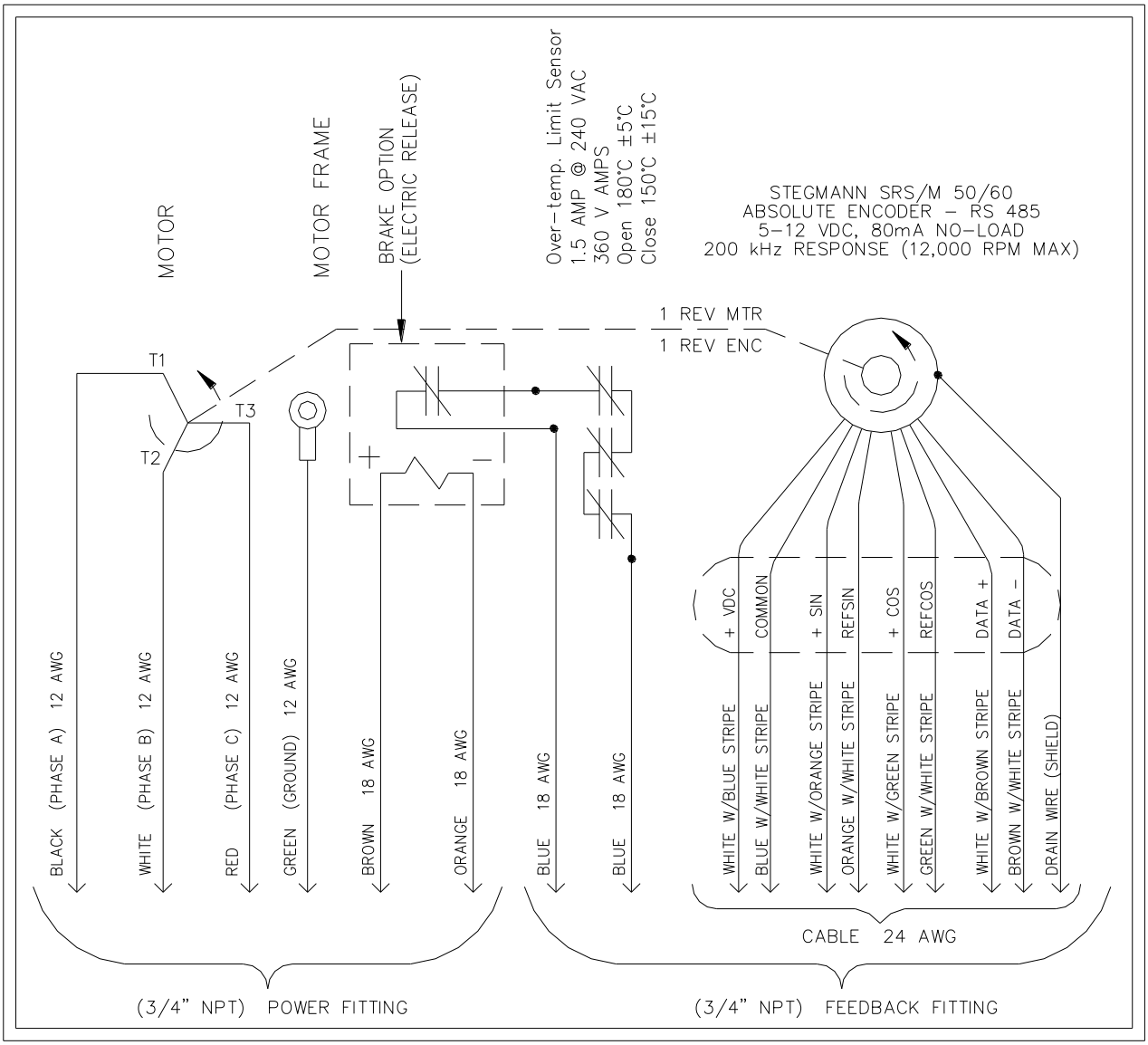
## Incremental Encoder, Two Leadwire Exit Fittings



Connection Diagram

M46X & M47X Motors

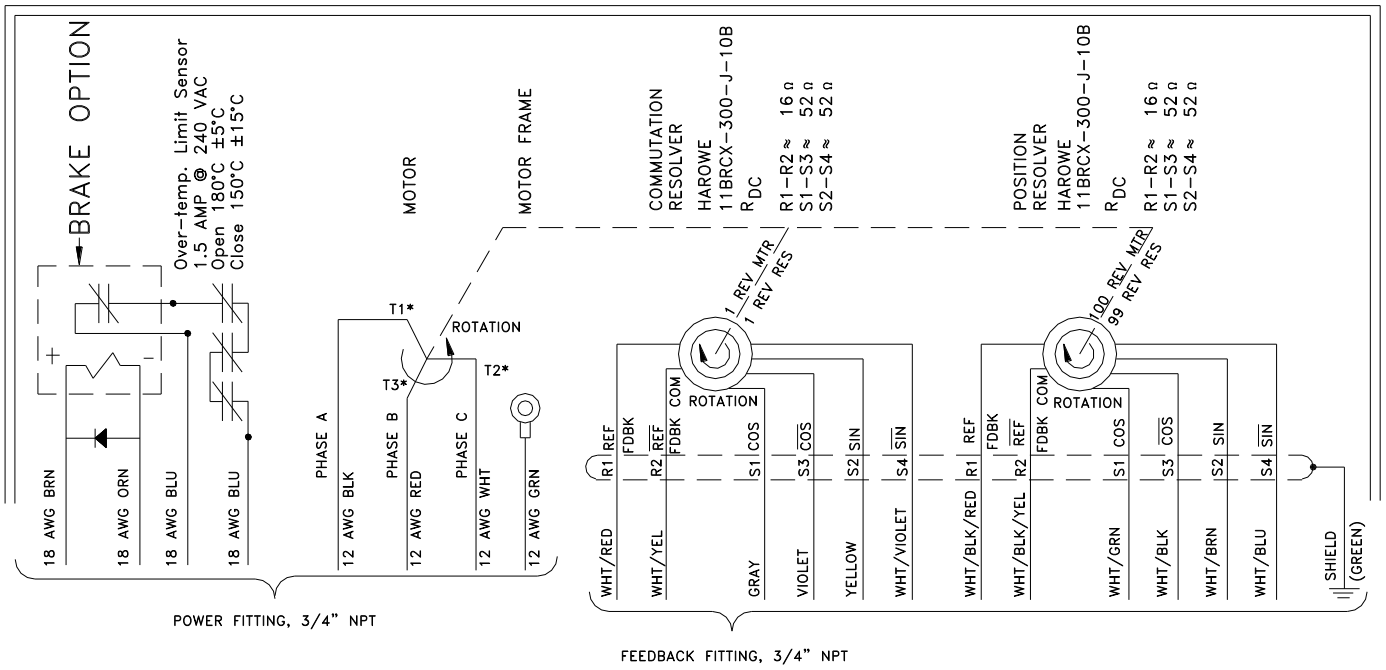
Absolute Encoder, Two Leadwire Exit Fittings



## Connection Diagram

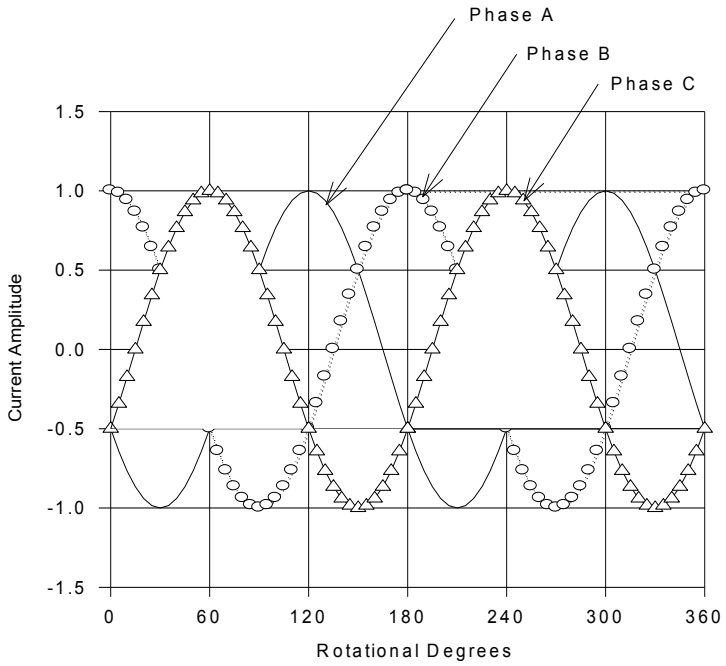
## M46X & M47X Motors

## Dual Resolver, Two Leadwire Exit Fittings

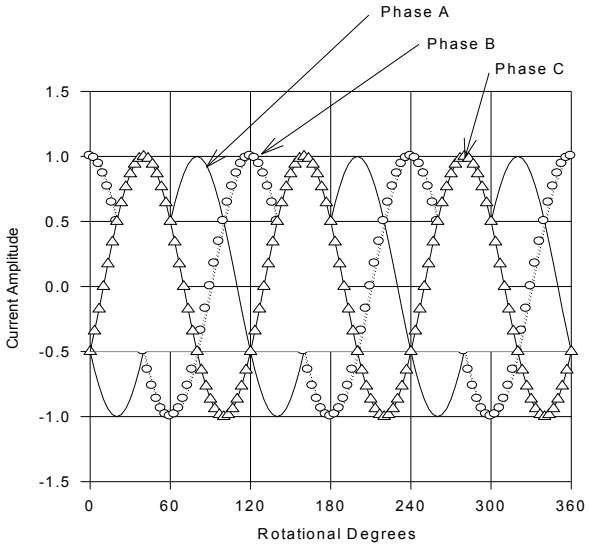


# APPENDIX B
## 3-Phase Brushless PM Servo Motor
## BEMF Sinusoidal Waveforms

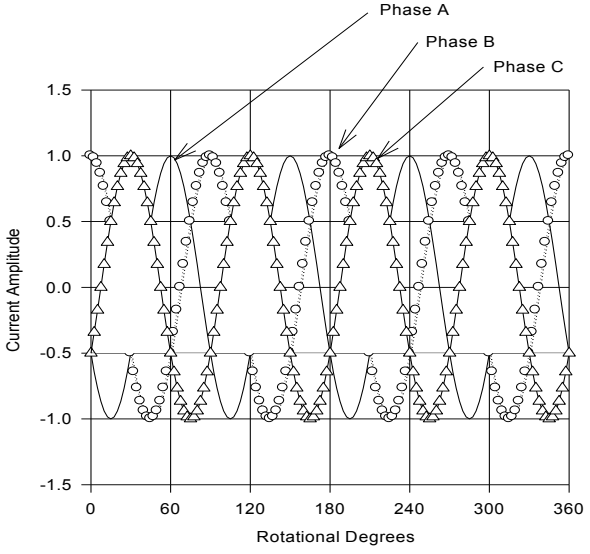
**Sineusoidal Waveform**
**3-Phase Brushless PM 4-Pole, Servo Motor**



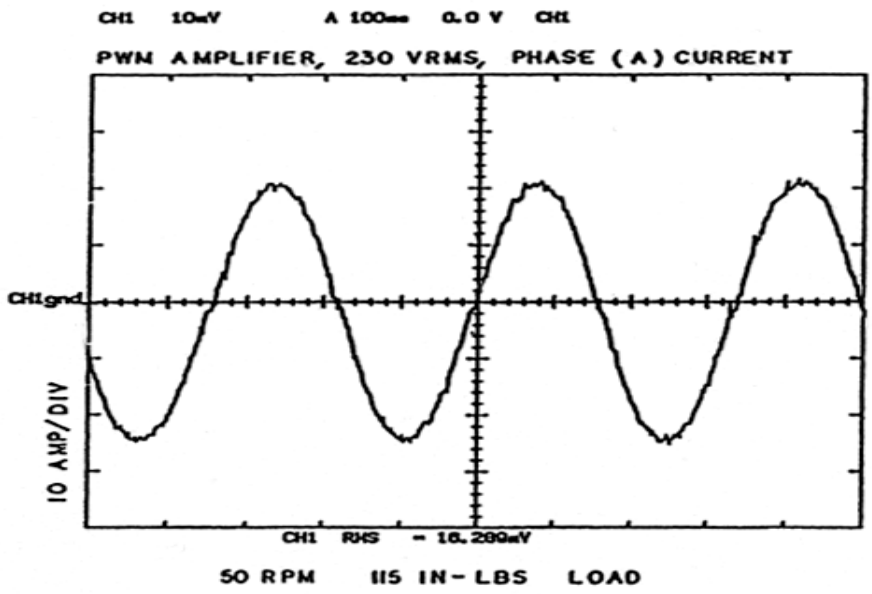

**Sineusoidal Waveform**
**3-Phase Brushless PM 6-Pole, Servo Motor**

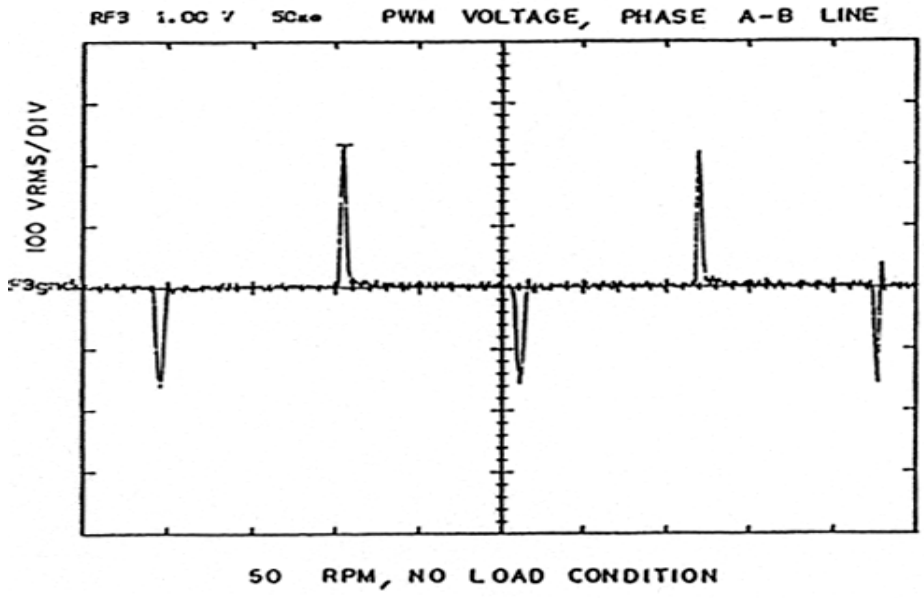



**Sineusoidal Waveform**
**3-Phase Brushless PM 8-Pole, Servo Motor**



APPENDIX B (Continued)
Phase A Sinusoidal Current
Waveform Plot from a
M462-GXSX-7XXX Motor



## APPENDIX C
## Elwood "SX" Series Servo Motor
## Performance Torque and Speed Curves

| Frame Size | Part Number Series |
|---|---|
| 3.4" | M431-NXNX-XXXX |
| | M432-NXNX-XXXX |
| | M433-FXNX-XXXX |
| | M433-HXNX-XXXX |
| | M433-JXNX-XXXX |
| | M433-MXNX-XXXX |
| 4.3" | M442-EXNX-XXXX |
| | M442-KXNX-XXXX |
| | M443-EXNX-XXXX |
| | M443-KXNX-XXXX |
| | M444-EXNX-XXXX |
| | M444-HXNX-XXXX |
| 6.0" | M461-GXSX-XXXX |
| | M462-GXSX-XXXX |
| | M463-KXSX-XXXX |
| | M464-GXSX-XXXX |
| | M465-GXSX-XXXX |
| 7.0" | M471-HXSX-XXXX |
| | M473-CXSX-XXXX |
| | M474-CXSX-XXXX |
| | M476-CXSX-XXXX |
| | M477-CXSX-XXXX |

See the "SX" Series part number flow chart in our catalog for definition of the digits for the above chart. Serial numbers on the nameplates were defined with five sequential numbers, a dash, and then a week and year date four number date manufacture code. Now there is an impact stamped serial number from UL for our motors and a four number date manufacture code in the S.N. field on the nameplate

Example: S/N 12345-0193 for (serial number - week #1, 1993). Motors built before 2001
Example: UL S/N: BV476059 S.N. Field: 0621 – week #21 of 2006

Note: The maximum continuous-duty torque and speed curves shown, are based upon the motor windings operating at 10% below 155°C for the (M43X & M44X) motors, and 10% below 180°C for the (M46X & M47X) motors. The motor can also operate at the maximum intermittent torque and speed curve for 5 seconds during every 60 second cycle at no load condition. All torque and speed curves are specific characteristics based on amplifiers, as described in Section (5.0).

APPENDIX C (Continued)

Elwood "SX" Series Servo Motor

Performance Torque and Speed Curves

Maximum Linear Torque

The torque constant Kt (in-lbs/amp) is derated per the below equations when the motor is used above its rated continuous stall current. The Kt torque/current relationship changes as more current is applied, and the torque output to current input is limited by the motor's magnetic circuit degree of saturation. Torque is produced at current levels above stall ratings, but is derated in a non-linear relationship. The below equations show a simplified linear relationship for application calculations for intermittent torques.

Derate Kt Equations (above stall current)

KTDF = Kt Derate Factor = ( (1+z) - z (I int. / I stall) )

I int. = Intermittent Current (Amps RMS)

I stall = Continuous rated Stall Current (Amps RMS)

z = Derate Constant

| Motor Series | = | M43X, | M44X, | M46X, | M47X |
|---|---|---|---|---|---|
| z constant value | = | .056 | .068 | .108 | .120 |

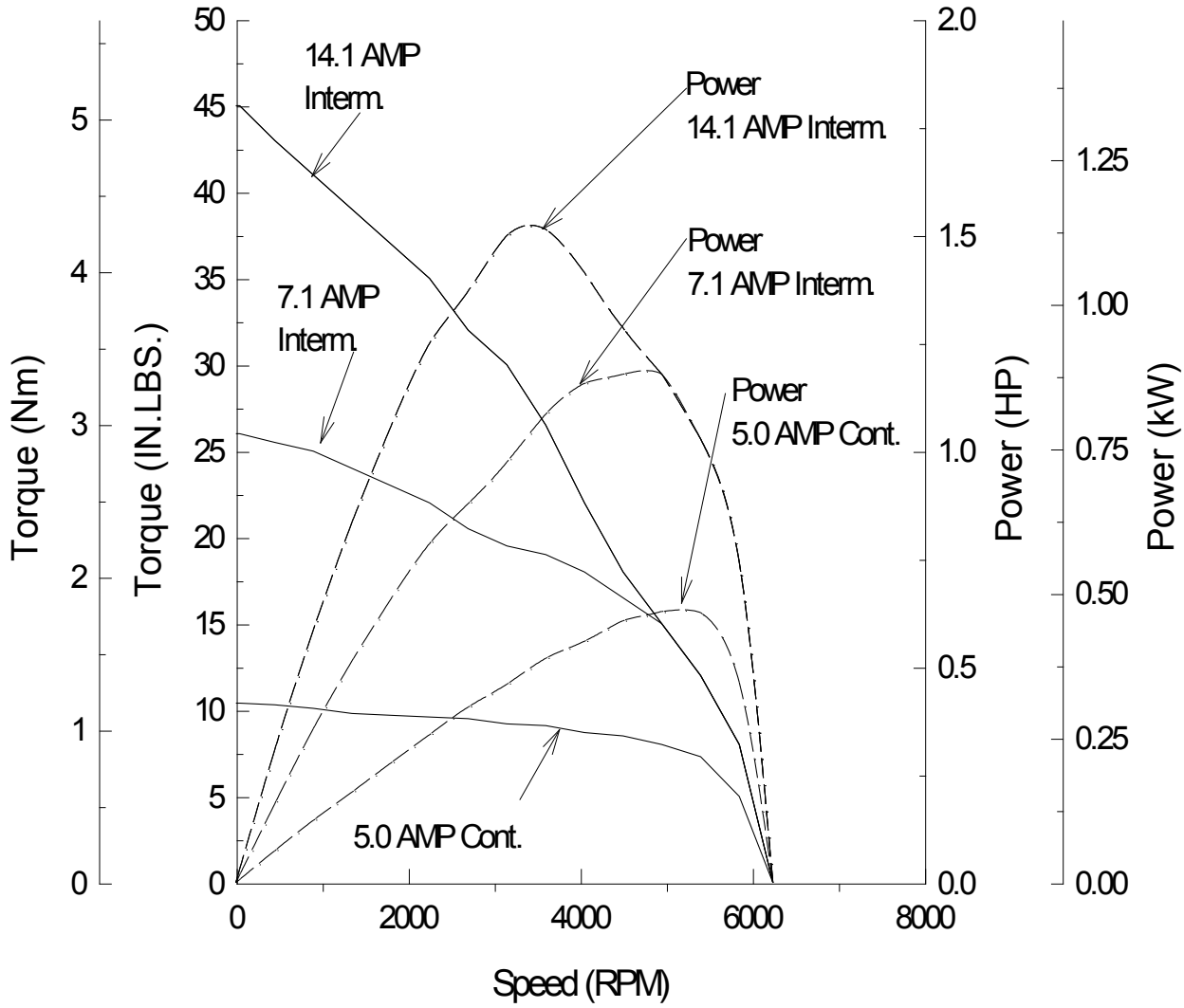
Example: Intermittent Stall Torque for a M444H Motor with a 14.14 Amp RMS Amplifier is shown below using Kt and I continuous stall current information from Appendix (E).

T int. stall = (Kt) * (KTDF) * (I int.)

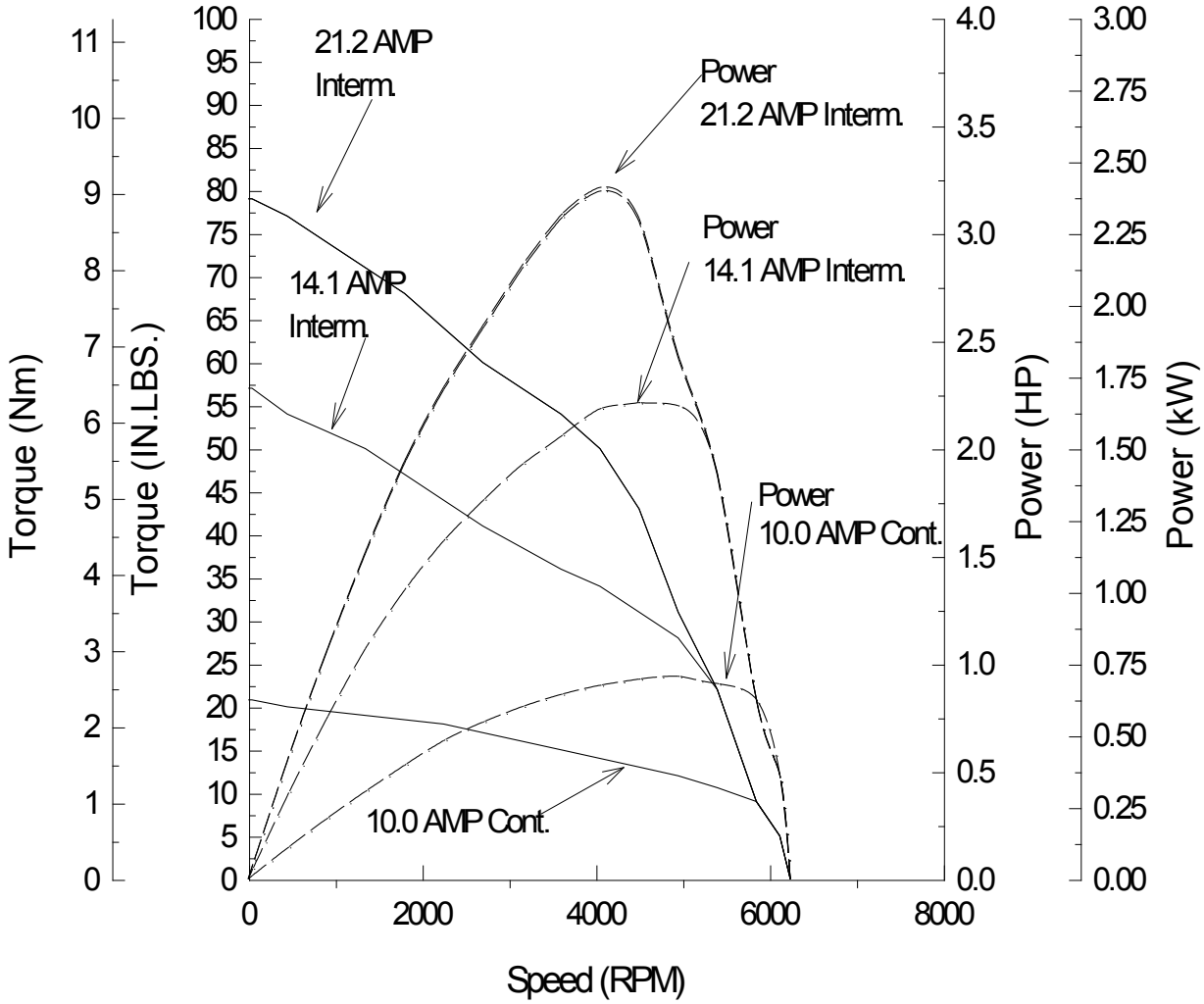
T int. stall = (6.64) * ((1+.068)-.068(14.14/9.31)) * (14.14) = 90.6 in lbs

Warning: Do not apply current above the maximum current rating values. Excessive currents may demagnetize the flux energy within the permanent magnet in the motor, or damage the motor wiring.

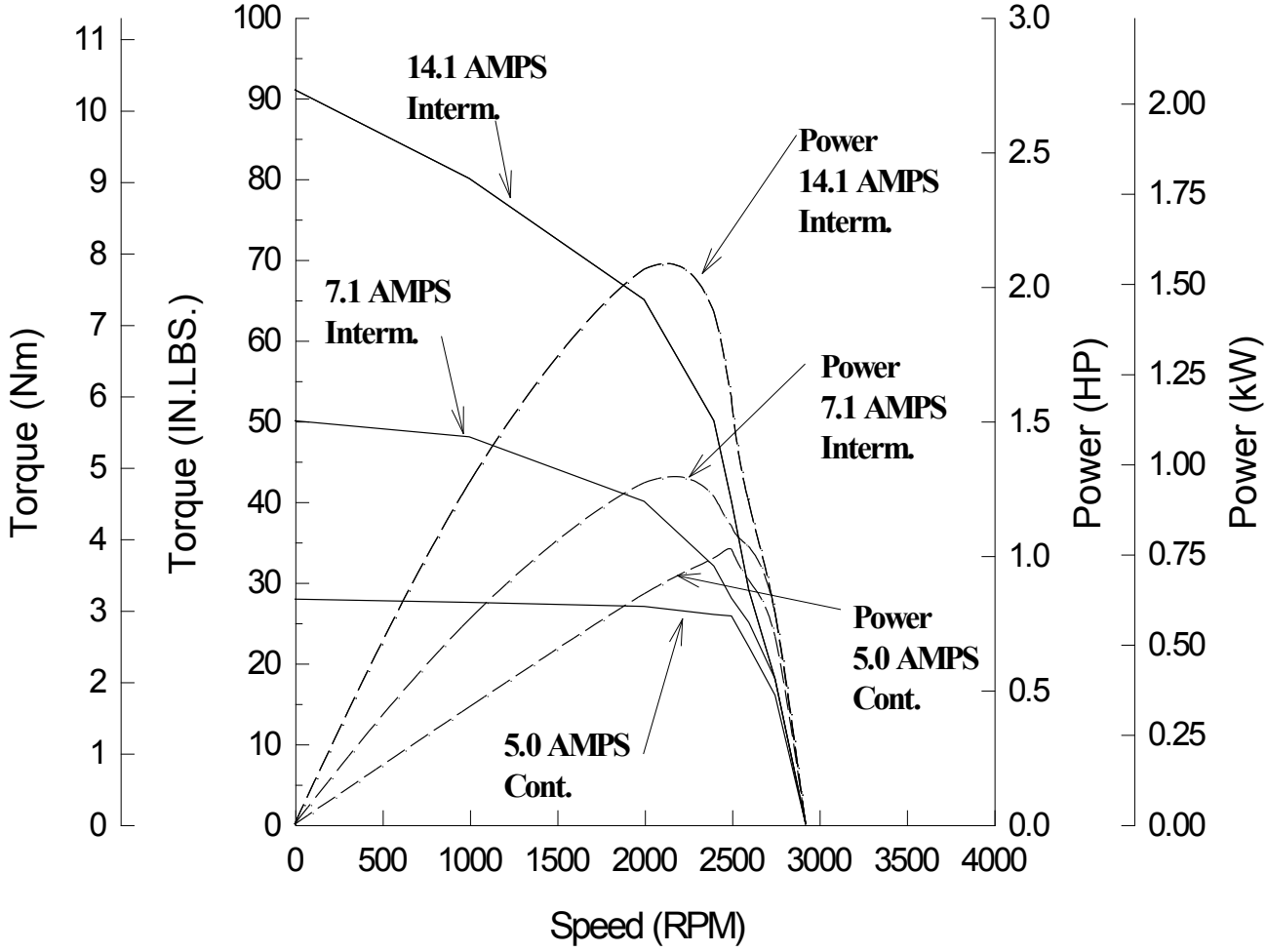
M431-NNN0-7207
Square Motor, Performance Curves
(40 C Ambient, Rms Amps Max., 230 Vrms, 5/31/93)



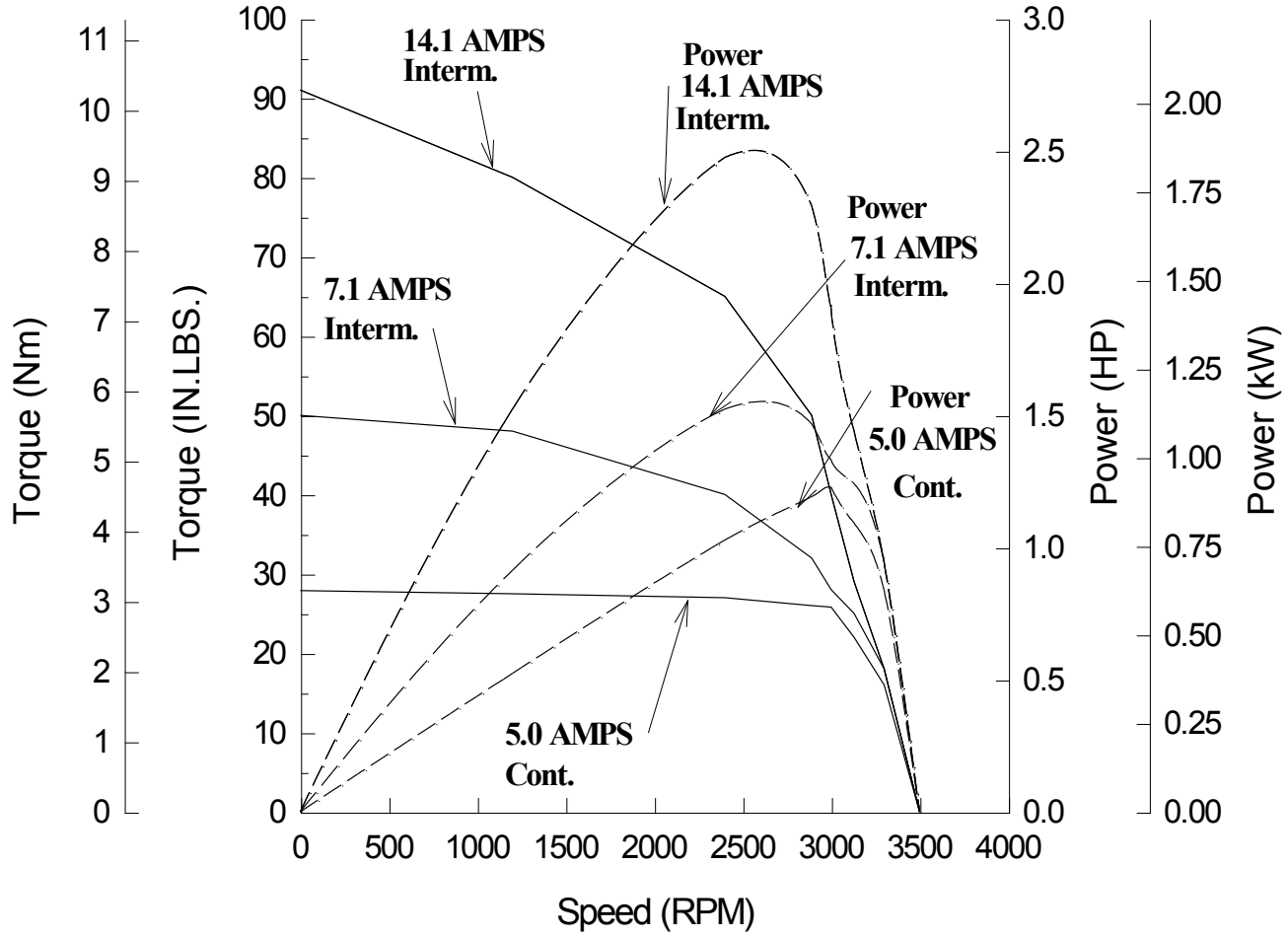
M432-NNN0-7207
Square Motor, Performance Curves
(40 C Ambient, Rms Amps Max., 230 Vrms, 5/31/93)



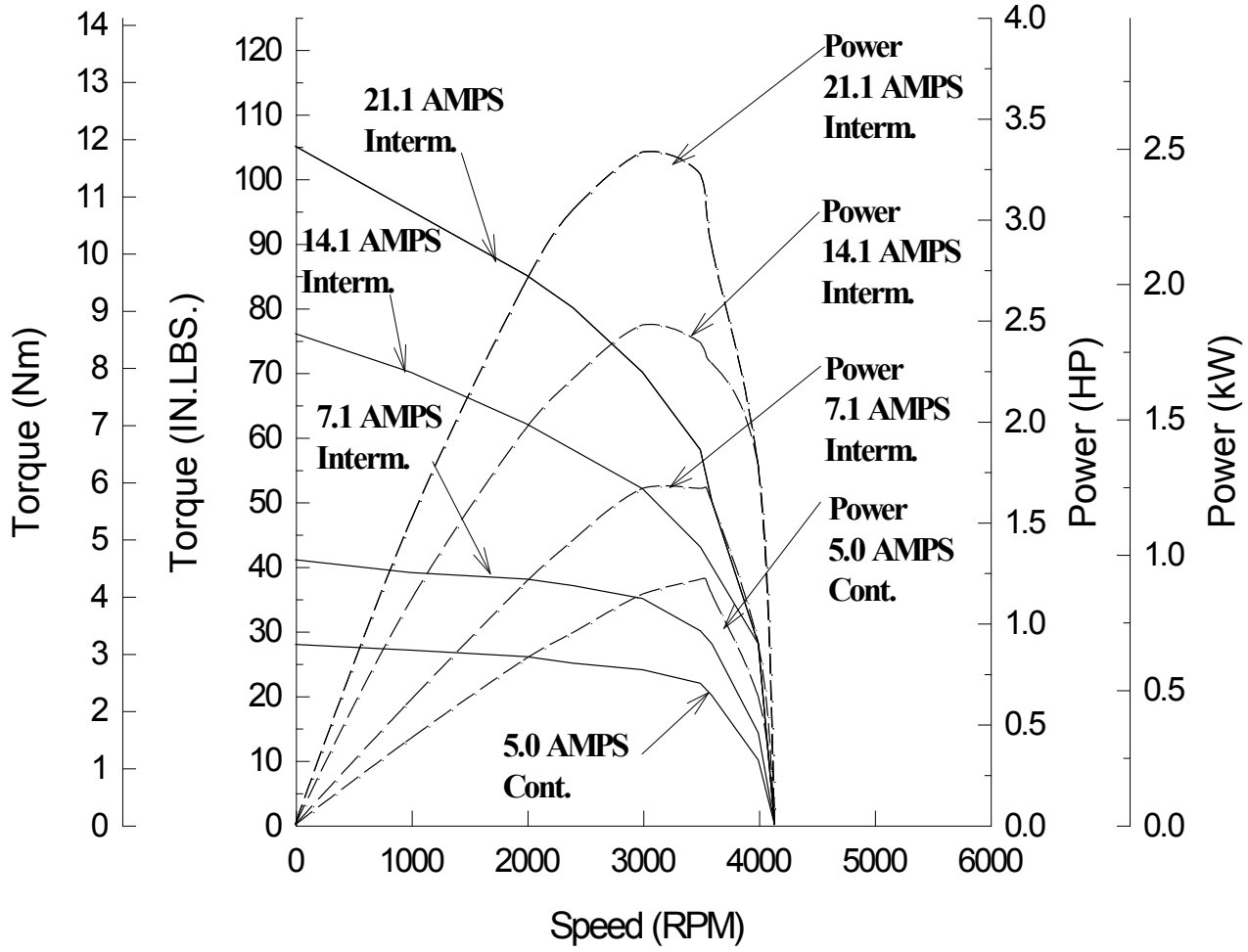
**M433-FNN0-7207**
**Square Motor, Performance Curves**
**(40 C Ambient, Rms Amps Max., 230Vrms, 5/31/93)**



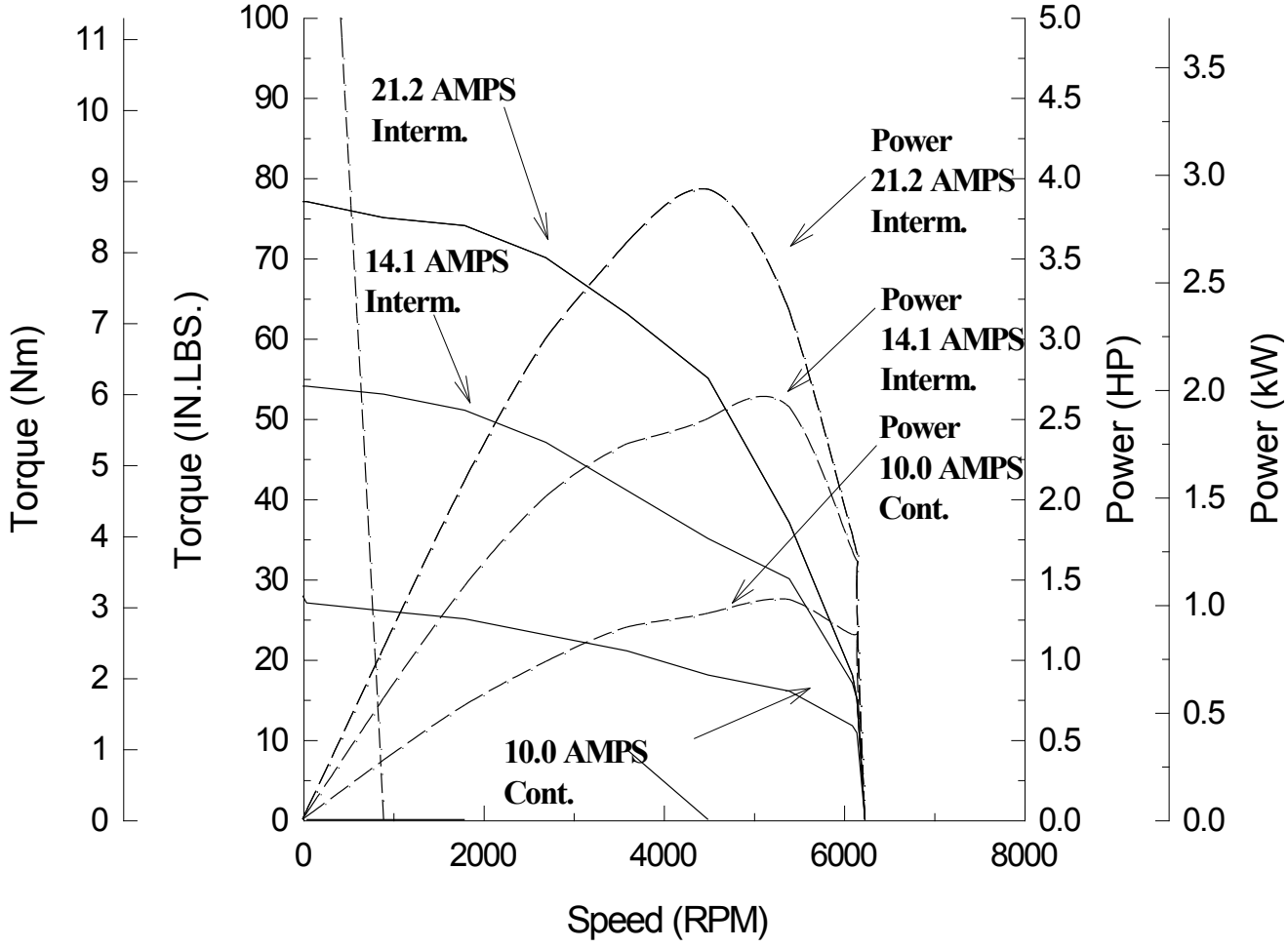
**M433-HNN0-7207**
**Square Motor, Performance Curves**
**(40 C Ambient, RMS AMPS Max., 5/31/93)**



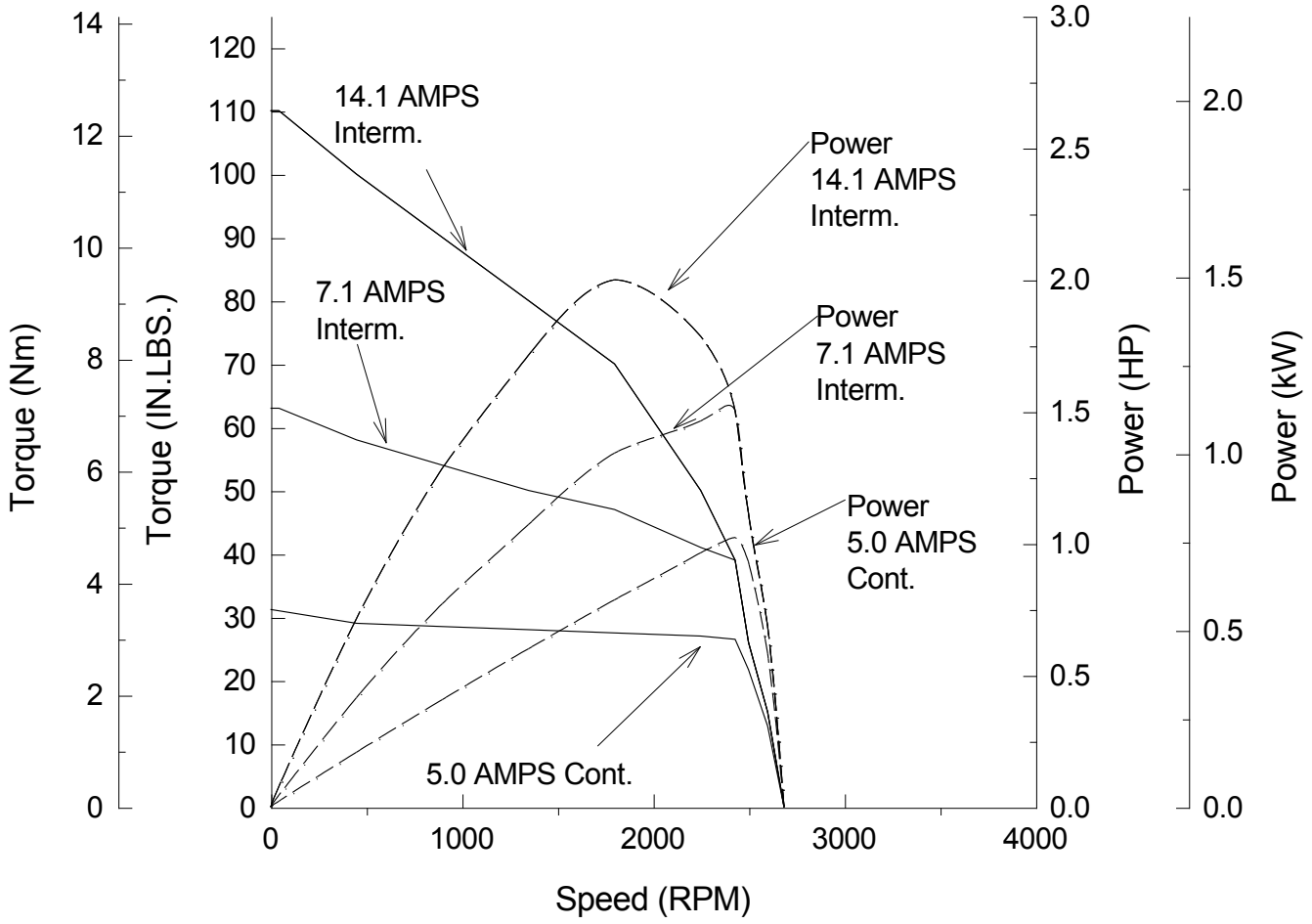
**M433-JNN0-7207**
**Square Motor, Performance Curves**
**(40 C Ambient, Rms Amps Max., 230Vrms 5/31/93)**



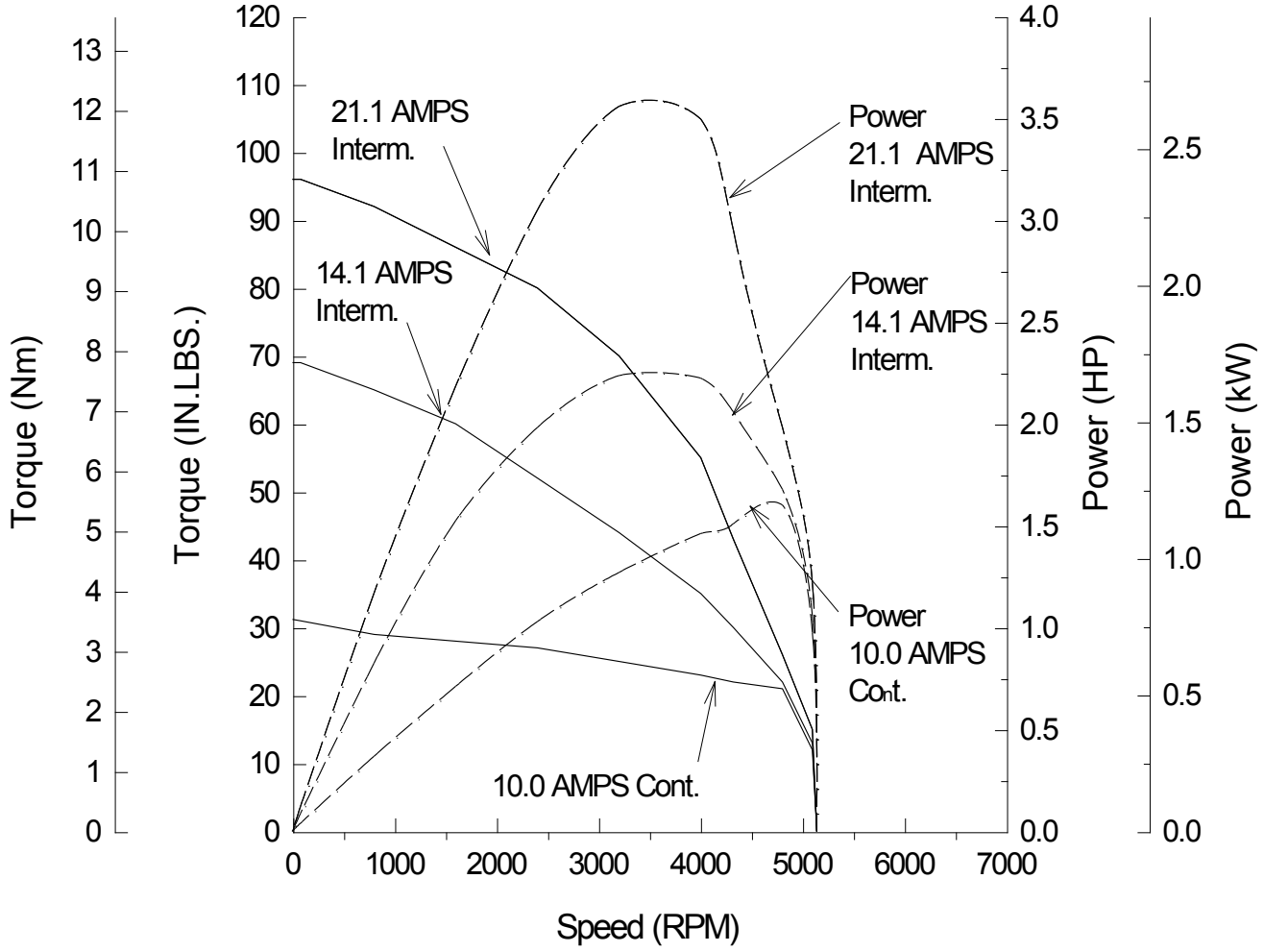
**M433-MNN0-7207**
**Square Motor, Performance Curves**
**(40 C Ambient, RMS AMPS Max., 230 Vrms, 5/31/93)**



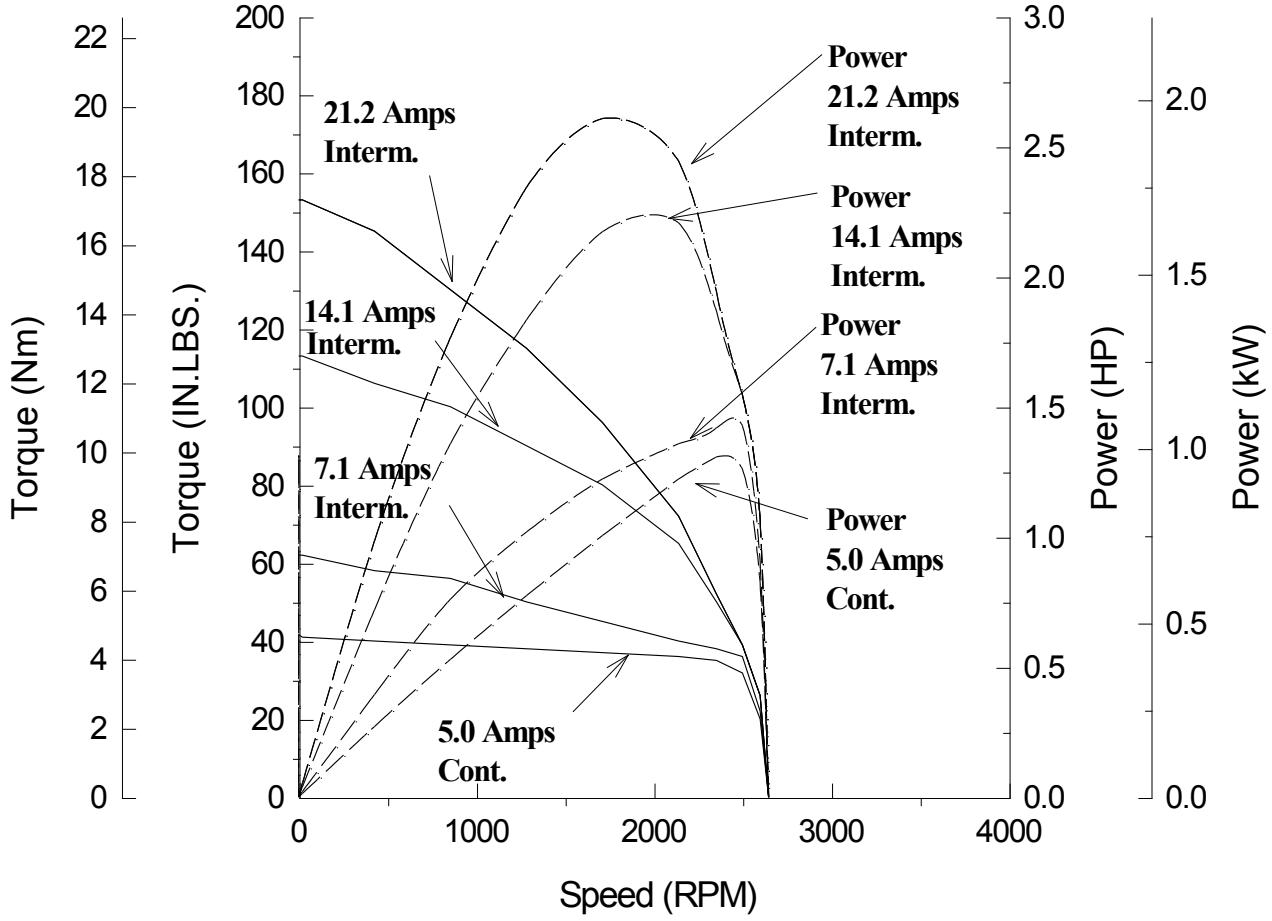
M442-ENNO-7207
Square Motor, Performance Curves
(40 C Ambient, Rms Amps Max.,230 Vrms 5/31/93)



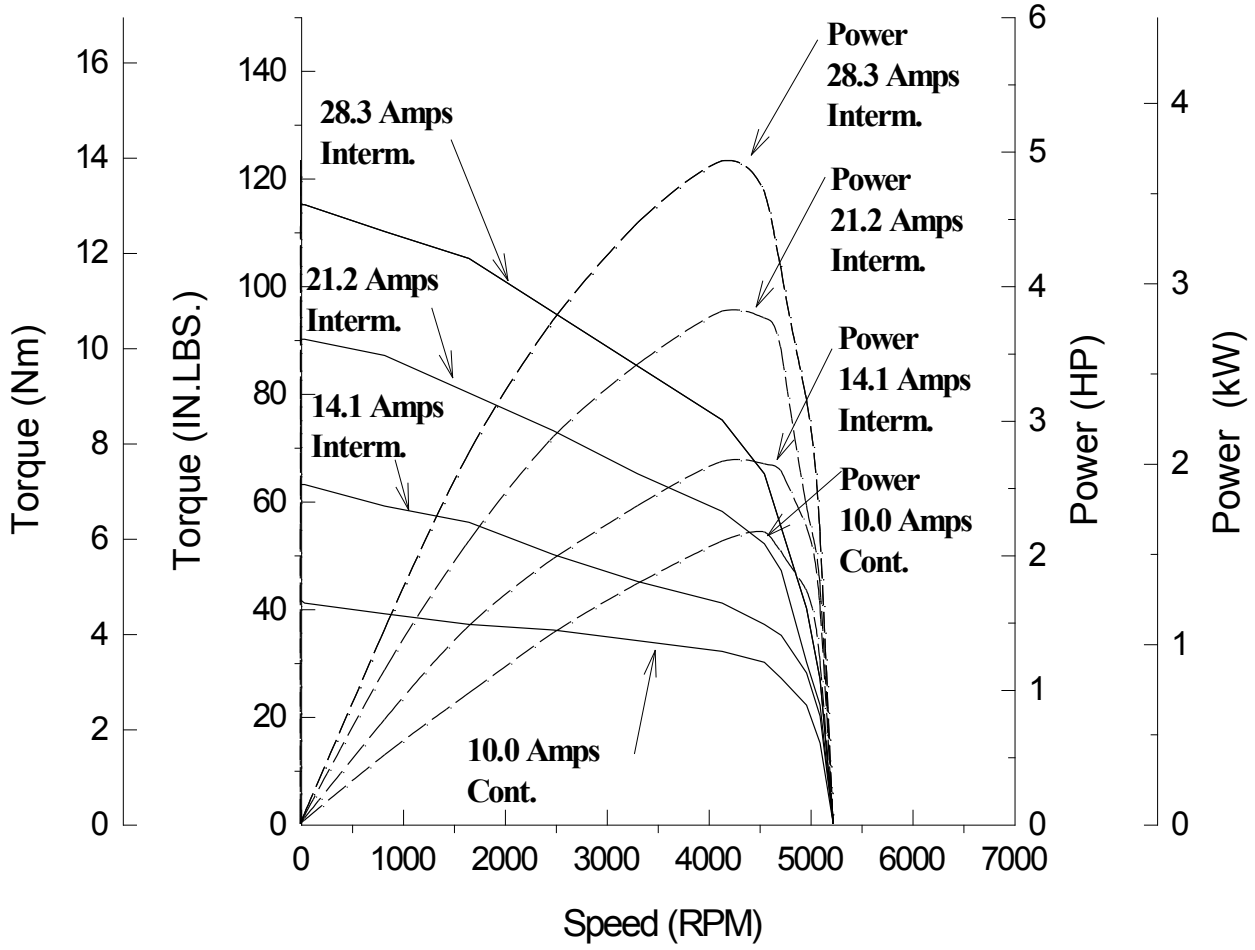
M442-KNNO-7207
Square Motor, Performance Curves
(40 C Ambient, Rms Amps Max.,230Vrms 5/31/93)



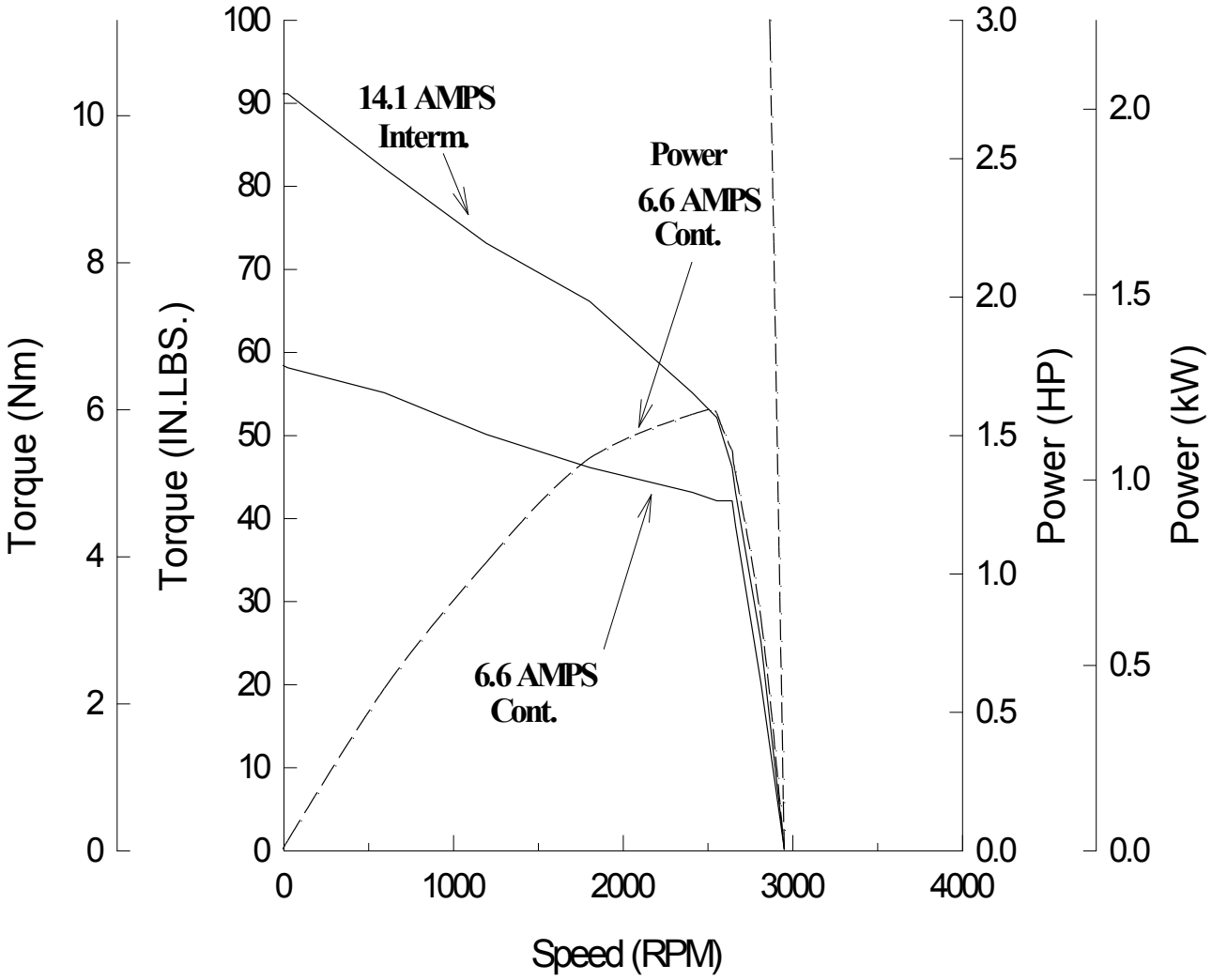
**M443-ENNO-7207**
**Square Motor, Performance Curves**
**(40 C Ambient, Rms Amps Max., 230Vrms 5/31/93)**



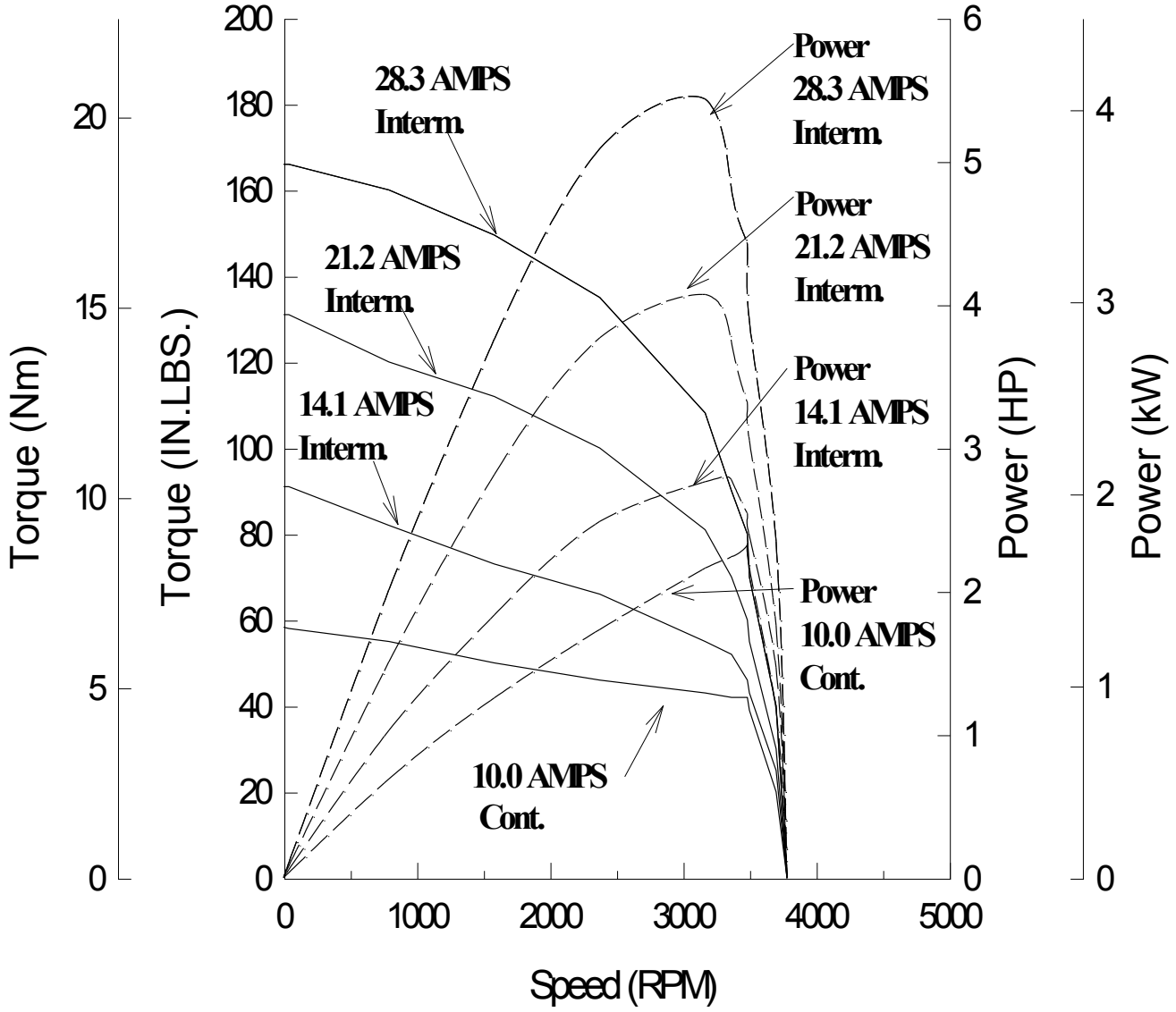
**M443-KNNO-7207**
**Square Motor, Performance Curves**
**(40 C Ambient, Rms Amps Max., 230Vrms 5/31/93)**



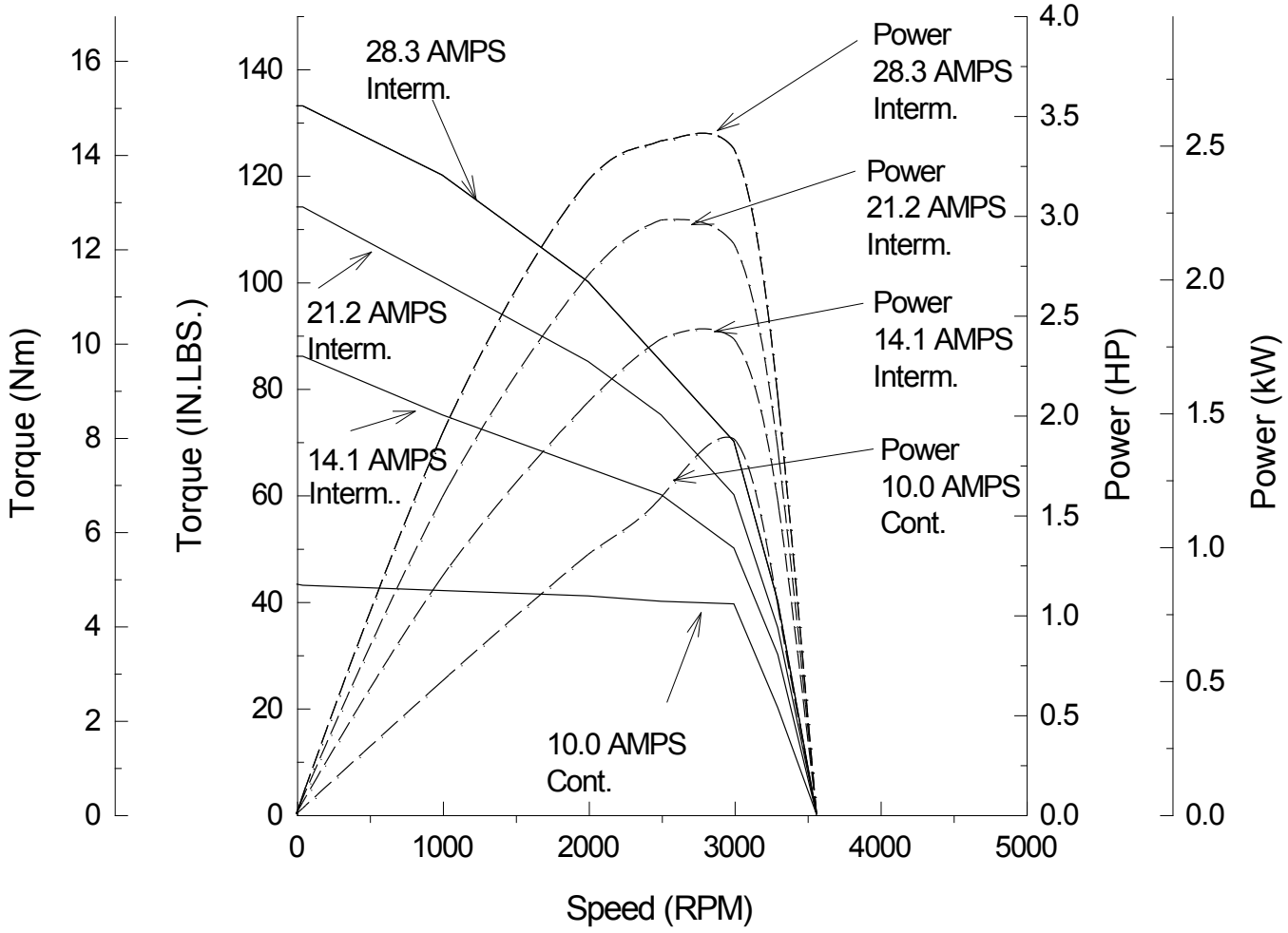
**M444-ENN0-7207**
**Square Motor, Performance Curves**
**(40 C Ambient, Rms Amps Max., 230Vrms 5/31/93)**



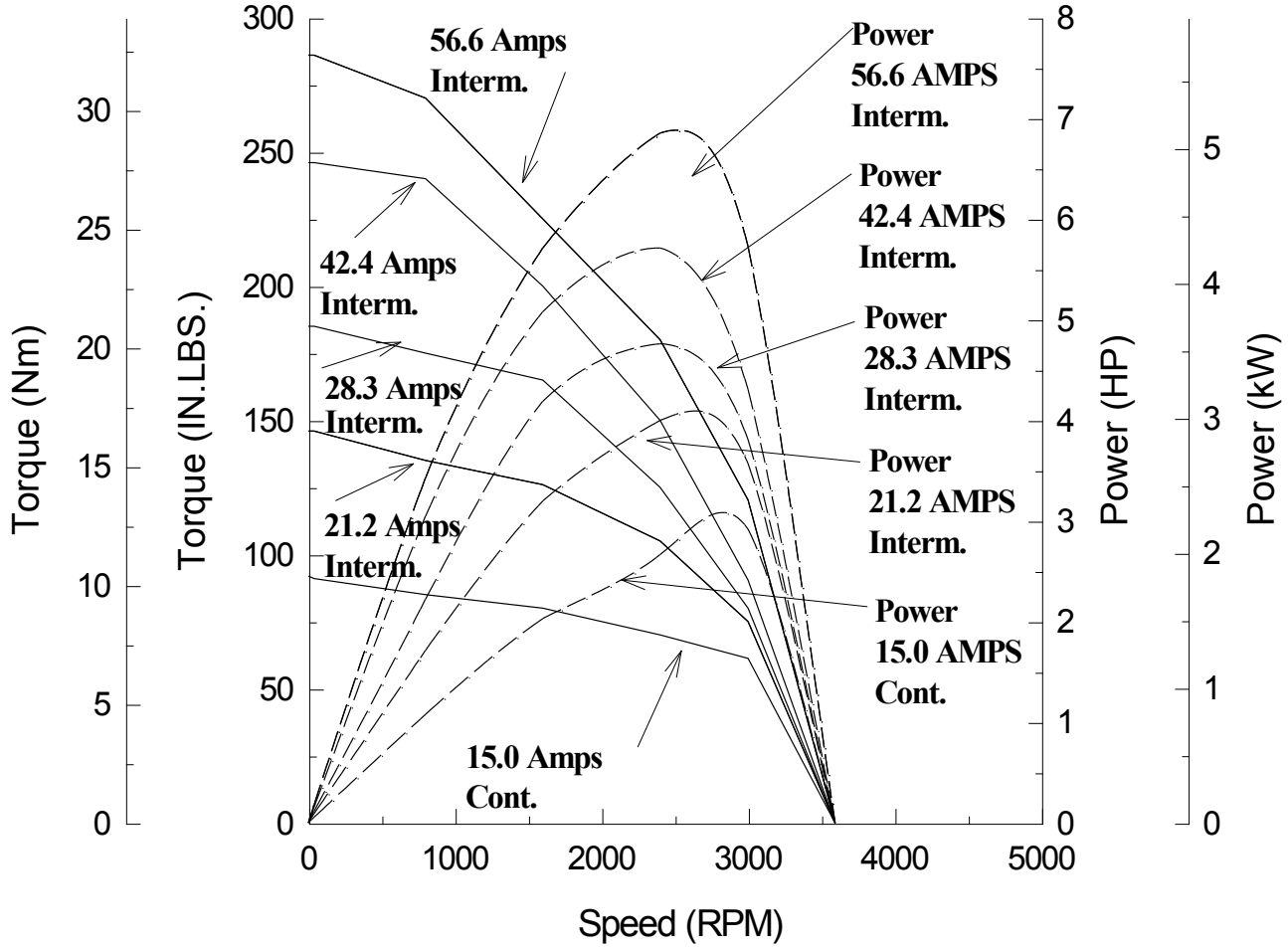
**M444-HNN0-7207**
**Square Motor, Performance Curves**
**(40 C Ambient, Rms Amps Max., 230Vrms 5/31/93)**

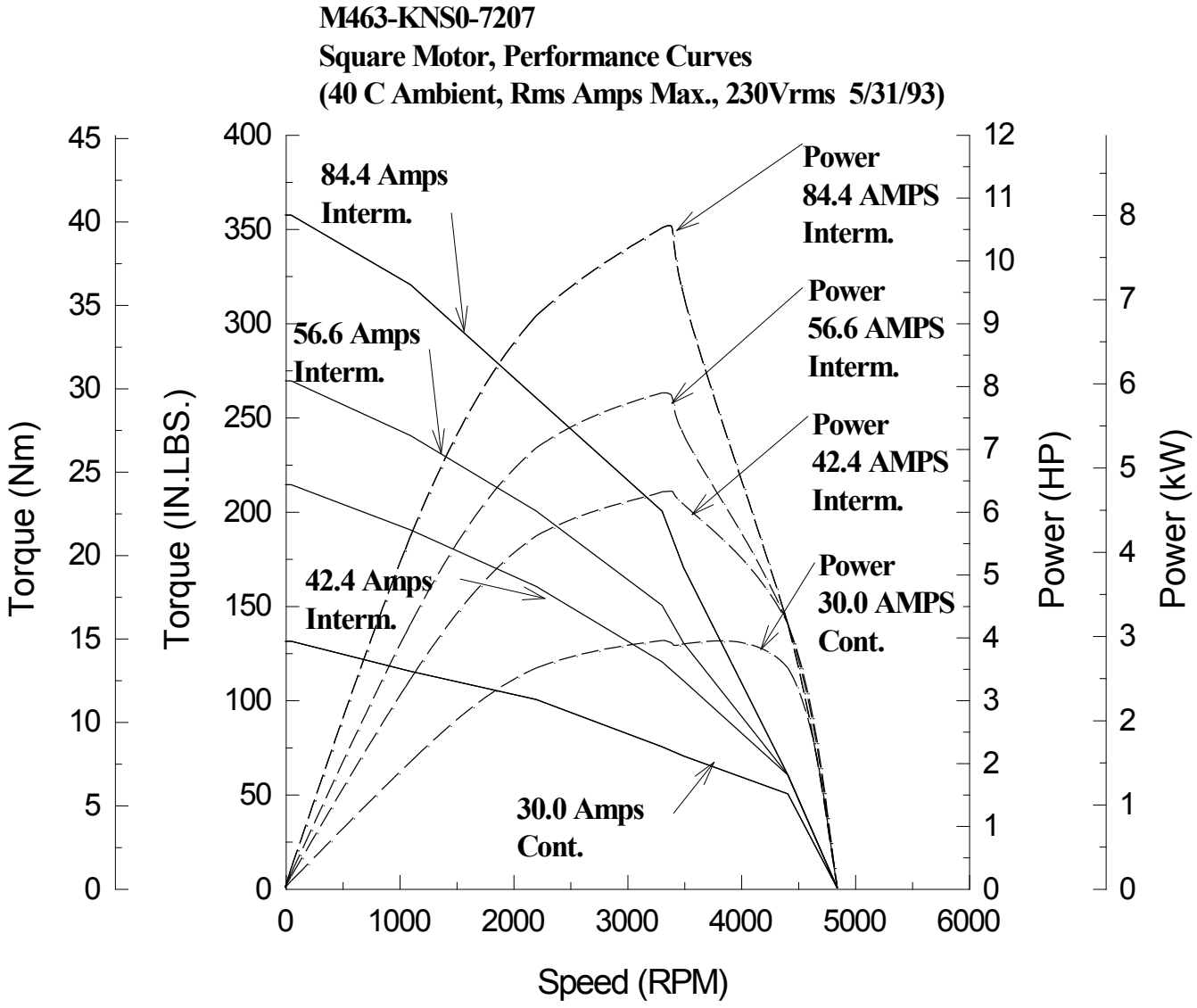


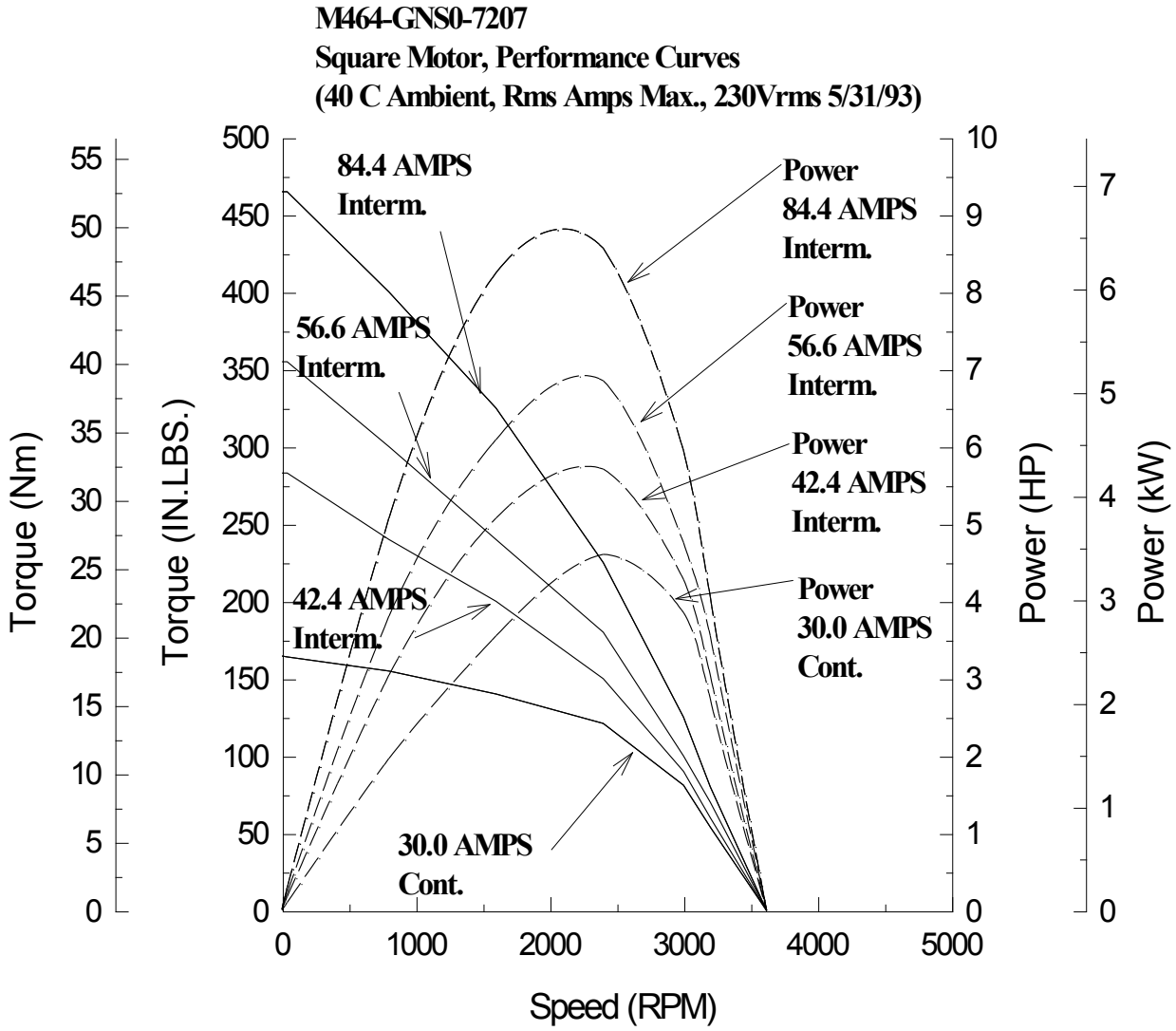
M461-GNS0-7207
Square Motor, Performance Curves
(40 C Ambient, Rms Amps Max.,230Vrms 5/31/93)



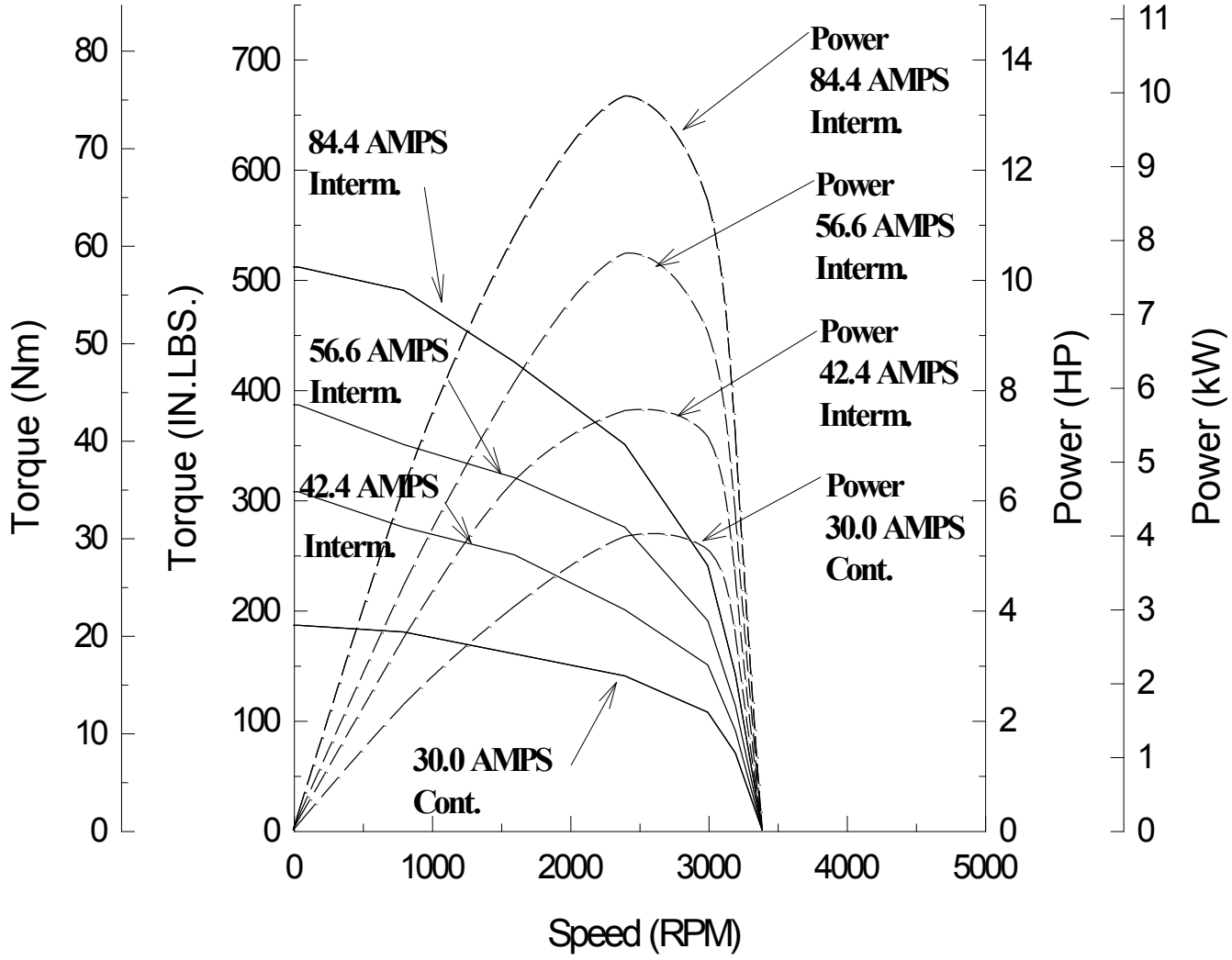
**M462-GNS0-7207**
**Square Motor, Performance Curves**
**(40 C Ambient, Rms Amps Max., 230Vrms 5/31/93)**



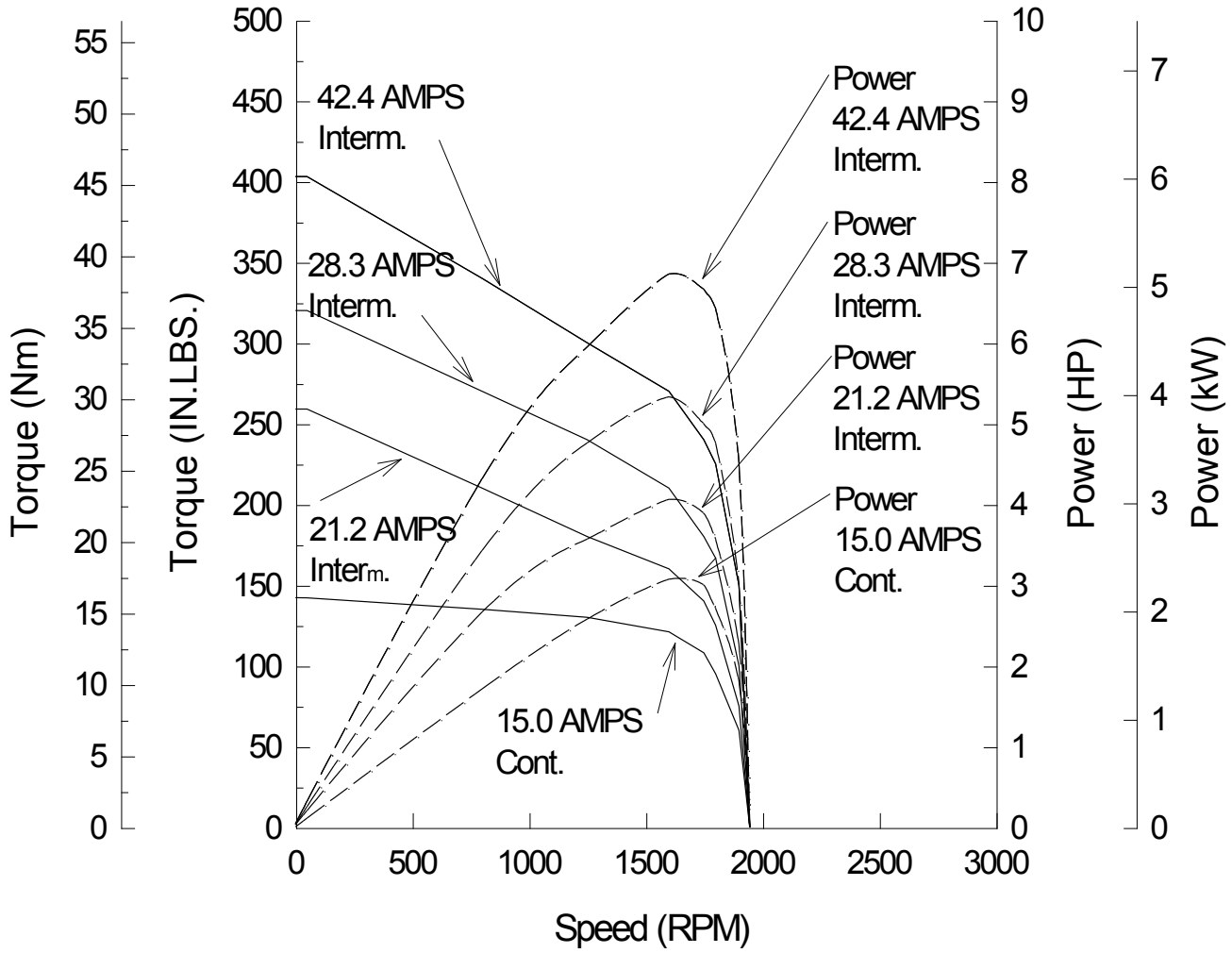




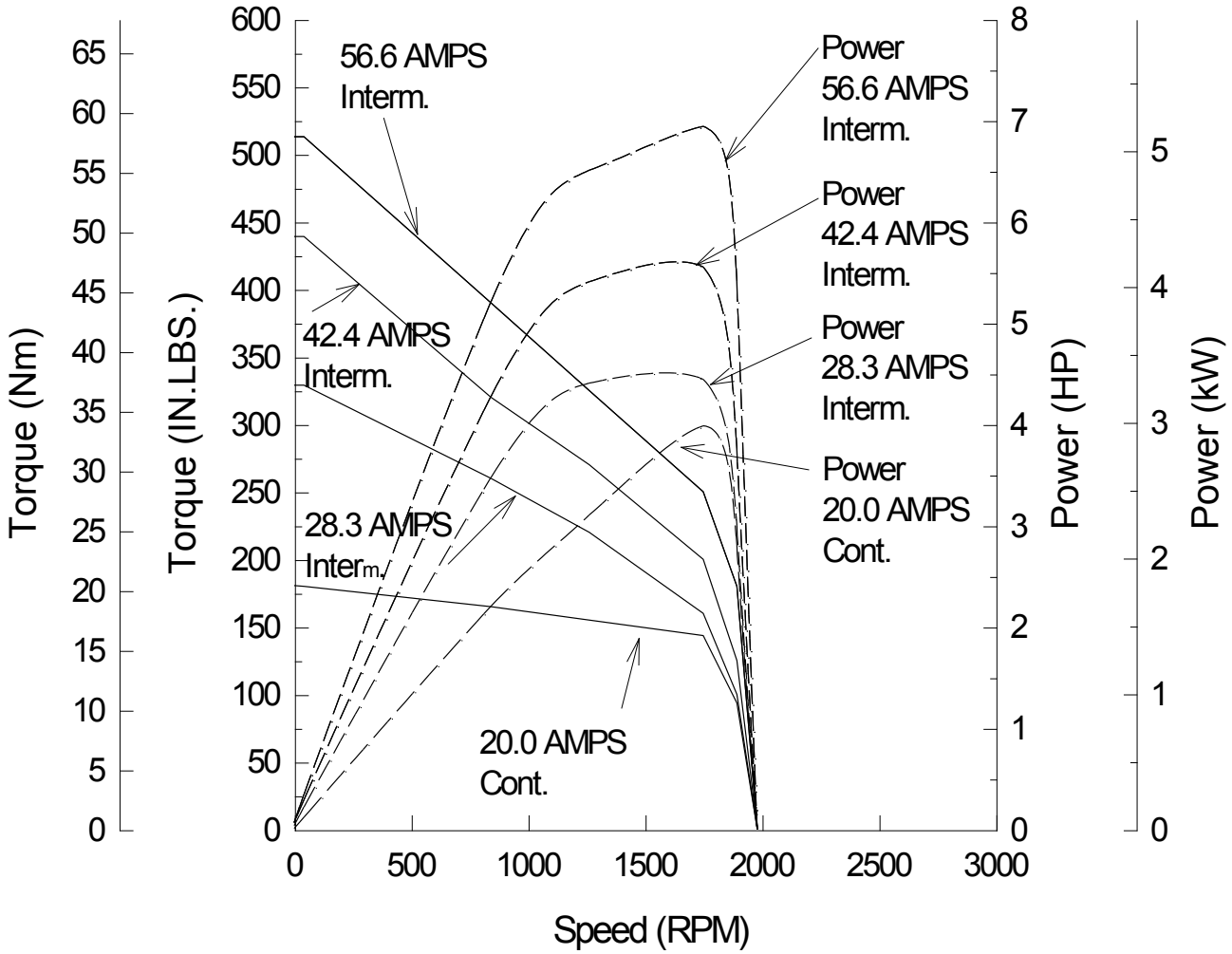
**M465-GNS0-7207**
**Square Motor, Performance Curves**
**(40 C Ambient, Rms Amps Max., 230Vrms 5/31/93)**

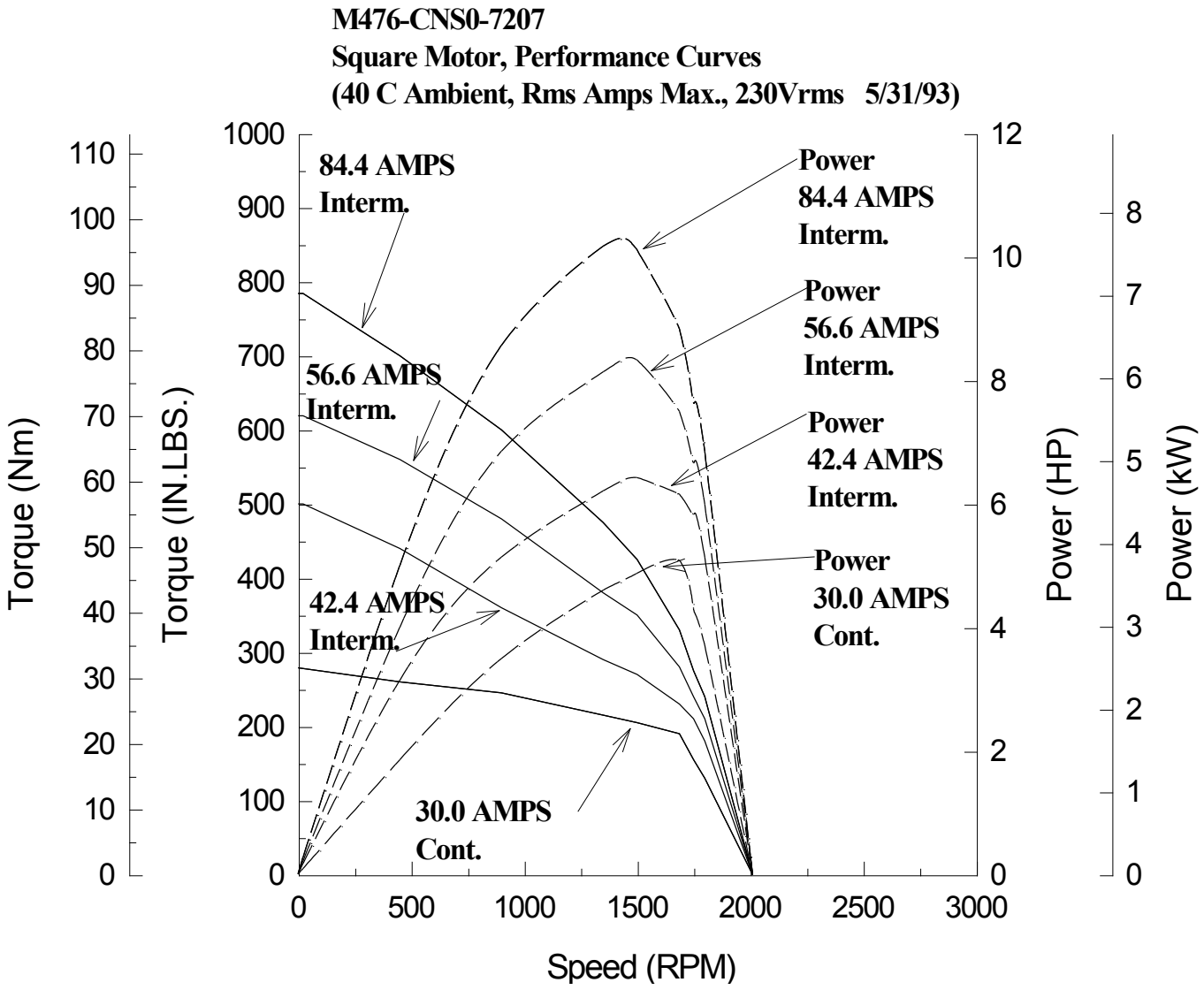


M473-CNS0-7207
Square Motor, Performance Curves
(40 C Ambient, Rms Amps Max., 230Vrms 5/31/93)

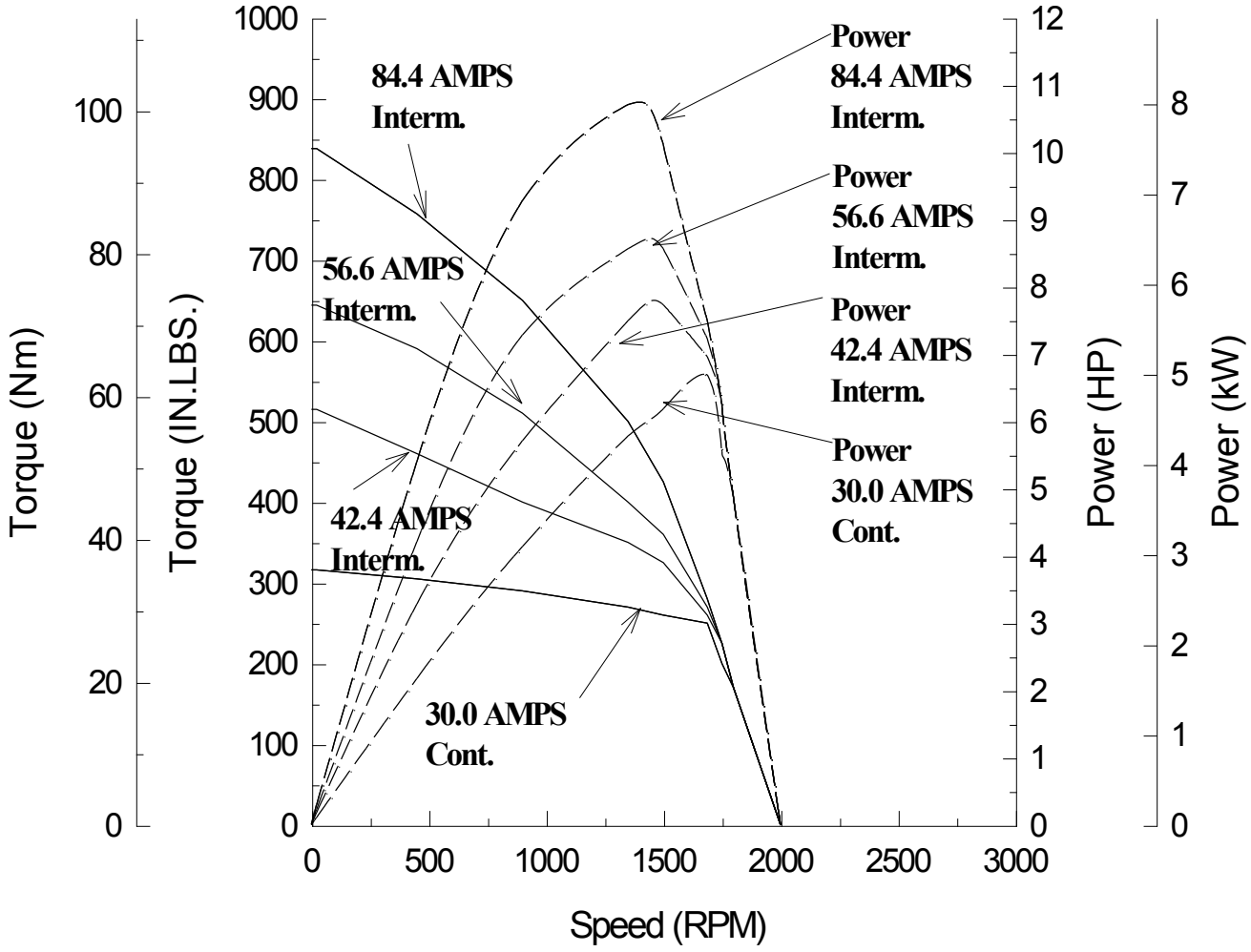


M474-CNS0-7207
Square Motor, Performance Curves
(40 C Ambient, Rms Amps Max., 230Vrms 5/31/93)





**M477-CNS0-7207**
**Square Motor, Performance Curves**
**(40 C Ambient, Rms Amps Max., 230Vrms 5/31/93)**



## APPENDIX D
## Elwood "SX" Series Servo Motor
## Commutation/Position Feedback Resolver, Encoder, or Tachsyn

| Elwood P/N | Manf. Name | Manf. P/N | Freq (Hz) | E (V) Input | I (Amp) Input | P (Watt) Input | R (Ohm) Input | E (V) Output | R (Ohm) Output |
|---|---|---|---|---|---|---|---|---|---|
| 325-001-0001 | Litton Clifton | 11-BHW-03F/A004 | 400 | 12.0 | .0091 | .0247 | 158 | 21.0 | 1100 |
| 325-001-0002 | Harowe | 11-BRW-300-B10 | 400 | 12.0 | .0109 | .055 | 850 | 21.0 | 197 |
| 325-001-0003 | Singer/ Kearfott | CR41095010-0 | 2500 | 12.0 | .0058 | .017 | 505 | 6.0 | N/A |
| 325-001-0004 | Harowe | 11BHW-01DQ/A001 | 2500 | 10.0 | .004 | .081 | 370 | 5.0 | 90 |
| 325-001-0005 | Harowe | 11BRCT-300-M10A | 2500 | 11.8 | .07 | .35 | 9.5 | 12.0 | 13.6 |
| 325-001-0008 | Litton Clifton | HSC-11-F-08/B651 | 400 | 22.0 | .0178 | .088 | 170 | 23.2 | 190 |
| 325-001-0012 | Harowe | 11BRW-300M-10B | 5000 | 10.0 | .0083 | .035 | 16 | 5.0 | 31 |
| 325-001-0015 | Harowe | 11BRCX-300-B10A | 400 | 7.5 | .04 | .19 | 5.7 | 8.0 | 18.5 |
| 325-001-0018 | Harowe | 11BRCT-300-S10A/5 | 5000 | 5.0 | .007 | .012 | 11. | 2.5 | 21.7 |
| 325-001-0019 | Harowe | 11BRW-300-J10C | 5000 | 7.0 | .011 | .047 | 16 | 6.65 | 52 |
| 325-001-0020 | Harowe | 11BRCX-300-J10B | 5000 | 7.0 | .011 | .047 | 16 | 6.65 | 52 |
| 325-001-0021 | Singer/ Kearfott | 05088GR41095006 | 400 | 11.8 | .009 | .035 | N/A | 22.5 | N/A |
| 325-002-0001 | Litton Clifton | 11-NLS-1DD-605/10 | 400 | 12.6 | .092 | .23 | 13.6 | 23.5 | 80 |
| 325-002-0003 | Litton Clifton | 11-NLS-1DD-B605/3 | 400 | 12.6 | .092 | .23 | 13.6 | 23.5 | 80 |
| 325-003-0001 | Litton Clifton | JSMB-21-B-06J | 4000 | 7.5 | .07 | .225 | 25 | 7.5 | 450 |
| 325-003-0004 | Litton Clifton | JSMB-21-B-05J | 4000 | 7.5 | .058 | .26 | 25 | 7.5 | 360 |
| 325-003-0007 | Harowe | 21BRCX-501-A42/20 | 6600 | 7.5 | .055 | .20 | 31 | 7.8 | 93 |
| 325-004-0001 | Servo-Tek | T4421WAB | N/A | N/A | N/A | N/A | N/A | 1.0/ KRPM | N/A |
| 325-004-0002 | SWEO | 9018951 | N/A | N/A | N/A | N/A | N/A | 1.7/ KRPM | N/A |

## APPENDIX D (Continued)

### Elwood "SX" Series Servo Motor
### Commutation/Position Feedback Resolver, Encoder, or Tachsyn

| Elwood P/N | Manf. Name | Manf. P/N | Freq (Hz) | E (V) Input | I (Amp) Input | P (Watt) Input | R (Ohm) Input | E (V) Output | R (Ohm) Output |
|---|---|---|---|---|---|---|---|---|---|
| 325-004-0003 | Servo-Tek | T6621WAC | N/A | N/A | N/A | N/A | N/A | 1.5/ KRPM | N/A |
| 325-005-0002 | Harowe | 21BRCX-500-MA7 | 3000 | 10 | .017 | .17 | 250 | 8.8 | 114 |
| 325-005-0003 | Harowe | 21BRCX-501-H42/20 | 5000 | 4 | .025 | .04 | 30 | 2.0 | 35 |
| 325-005-0005 | Harowe | 21BRCX-500-H7 | 3000 | 4 | .025 | .04 | 31 | 2.0 | 31 |
| 325-005-0008 | Harowe | 21BRCX-510-A7B-10 | 3000 | 6 | .02 | .08 | 38 | 2.0 | 110 |
| 325-005-0015 | Tama-gawa | TS2640N321E64 | 10000 | 7 | .05 | .20 | 37.5 | 3.5 | 43.3 |
| 325-005-0016 | LTN | RE-21-1-A04 | 5000 | 7 | .04 | .28 | 90 | 3.5 | 62 |
| 325-005-0017 | LTN | RE-21-1-V24 | 3000 | 10 | .06 | .60 | 58 | 8 | 252 |
| 325-005-0018 | LTN | RE-21-1-V39 | 5000 | 7 | .04 | .28 | 90 | 3.5 | 62 |
| 212-001-0063 / 0064 | Sick | SRS/M 50/60 | 200k | 5-12 | .08 | .96 MAX | N/A | N/A | N/A |
| 212-016-XXXX | QDI | QD200-05/05-****-*-01-T8-02-02 | 500k | 5 | .125 | .63 | N/A | N/A | N/A |
| 212-025-XXXX | QDI | QD200-05/05-****-*-01-T8-02-02 | 500k | 5 | .125 | .63 | N/A | N/A | N/A |
| 212-001-0066 / 0067 | Heiden-hain | EQN 425 / EQN 1325 | 130K | 3.6-14 | .105 | 1.47 MAX | N/A | N/A | N/A |
| 212-001-0068 | Sick | EKM36 | 75k | 7-12 | .15 | 1.8 MAX | N/A | N/A | N/A |

X - indicates operating temp, encoder line count, and motor pole count
* - indicates encoder line count and motor pole count

**See wiring interconnect schematic drawings shipped with the motor for resolver resistance values. Consult factory for feedback devise specification drawings if additional information is required.**

# APPENDIX E

## Elwood M43X "SX" Series Servo Motor
## 230 Vrms, Data Sheet Specifications

| | UNITS | M431N | M432N | M433F | M433H | M433J | M433M |
|---|---|---|---|---|---|---|---|
| Rated Ambient Temperature | ºC | 40 | 40 | 40 | 40 | 40 | 40 |
| | ºF | 104 | 104 | 104 | 104 | 104 | 104 |
| Maximum Winding Temperature ±5ºC (±9ºF) [Sensor Trip Point] | ºC | 155 | 155 | 155 | 155 | 155 | 155 |
| | ºF | 311 | 311 | 311 | 311 | 311 | 311 |
| Number of Motor Poles | --- | 6 | 6 | 6 | 6 | 6 | 6 |
| Continuous Torque (Stall) | lb-in | 10.4 | 20.8 | 28.0 | 28.0 | 28.0 | 28.0 |
| | N-m | 1.17 | 2.35 | 3.16 | 3.16 | 3.16 | 3.16 |
| Continuous Current (Stall) | Arms | 2.8 | 5.2 | 4.1 | 4.5 | 5.1 | 7.4 |
| Maximum Current | Arms | 11.8 | 22.1 | 17.2 | 19.1 | 21.5 | 31.6 |
| Maximum Continuous Power | HP | 0.64 | 0.92 | 1.02 | 1.07 | 1.22 | 1.29 |
| | kW | 0.48 | 0.69 | 0.76 | 0.80 | 0.91 | 0.96 |
| Torque @ Maximum Power | lb-in | 7.3 | 11.2 | 25.8 | 22.5 | 21.9 | 16.2 |
| | N-m | 0.83 | 1.27 | 2.91 | 2.54 | 2.48 | 1.83 |
| Current @ Maximum Power | Arms | 2.5 | 4.7 | 3.7 | 4.1 | 4.6 | 5.7 |
| Speed @ Maximum Power | RPM | 5500 | 5000 | 2500 | 3000 | 3500 | 5000 |
| | rad/sec | 576 | 545 | 262 | 314 | 367 | 524 |
| Maximum Continuous No Load Speed | RPM | 6500 | 6500 | 3000 | 3500 | 4500 | 6500 |
| | rad/sec | 681 | 681 | 314 | 367 | 471 | 681 |
| Rotor Inertia | lb-in-sec^2 | 0.000620 | 0.001100 | 0.001500 | 0.001500 | 0.001500 | 0.001500 |
| | kg-m^2 | 0.000070 | 0.000124 | 0.000169 | 0.000169 | 0.000169 | 0.000169 |
| Rotor Inertia with Brake | lb-in-sec^2 | 0.000770 | 0.001270 | 0.001620 | 0.001620 | 0.001620 | 0.001620 |
| | kg-m^2 | 0.000087 | 0.000143 | 0.000183 | 0.000183 | 0.000183 | 0.000183 |
| Torque Constant @ Maximum Winding Temperature | lb-in/Arms | 3.7 | 3.98 | 6.9 | 6.2 | 5.5 | 3.8 |
| | N-m/Arms | 0.42 | 0.45 | 0.78 | 0.70 | 0.62 | 0.42 |
| Torque Constant @ 25ºC | lb-in/Arms | 4.9 | 4.9 | 9.4 | 8.5 | 6.6 | 4.4 |
| | N-m/Arms | 0.55 | 0.55 | 1.06 | 0.96 | 0.75 | 0.50 |
| BEMF Constant @ 25ºC | Vrms/kRPM | 35.0 | 35.0 | 74.0 | 61.0 | 51.0 | 35.0 |
| | Vrms/rad/sec | 0.33 | 0.33 | 0.71 | 0.58 | 0.49 | 0.33 |
| Mechanical Time Constant | msec | 2.87 | 1.69 | 1.57 | 1.53 | 1.56 | 1.49 |
| Mechanical Time Constant with Brake | msec | 3.58 | 1.96 | 1.70 | 1.65 | 1.69 | 1.61 |
| Electrical Time Constant | msec | 1.38 | 1.79 | 2.24 | 2.98 | 1.69 | 2.34 |
| Thermal Time Constant | minutes | 30 | 30 | 30 | 30 | 30 | 30 |
| Thermal Time Constant with Brake | minutes | 33 | 33 | 33 | 33 | 33 | 33 |
| Stator Resistance (Line-to-Line) @ 25ºC | ohms | 5.5 | 2.0 | 4.4 | 3.5 | 2.5 | 1.1 |
| Stator Inductance (Line-to-Line) @ 25ºC | mH | 7.6 | 3.5 | 9.9 | 10.4 | 4.2 | 2.5 |
| Maximum Theoretical Acceleration at Maximum Current | rad/sec^2 | 71034 | 80074 | 79048 | 79048 | 79048 | 79048 |
| Maximum Theoretical Acceleration at Maximum Current with Brake | rad/sec^2 | 57196 | 69356 | 73192 | 73192 | 73192 | 73192 |
| Static Friction | lb-in | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| | N-m | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| Motor Weight | lb | 11.0 | 14.0 | 17.5 | 17.5 | 17.5 | 17.5 |
| | kg | 5.0 | 6.4 | 8.0 | 8.0 | 8.0 | 8.0 |
| Motor Weight with Brake | lb | 15.0 | 17.5 | 21.0 | 21.0 | 21.0 | 21.0 |
| | kg | 6.8 | 8.0 | 9.5 | 9.5 | 9.5 | 9.5 |
| Brake Holding Torque | lb-in | 40 | 40 | 40 | 40 | 40 | 40 |
| | N-m | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 |
| Brake Voltage | Vdc | 24 | 24 | 24 | 24 | 24 | 24 |
| Brake Current | A | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 |

## APPENDIX E (Continued)

### Elwood M44X "SX" Series Servo Motor
### 230 Vrms, Data Sheet Specifications

| | UNITS | M442E | M442K | M443E | M443K | M444E | M444H |
|---|---|---|---|---|---|---|---|
| Rated Ambient Temperature | ºC | 40 | 40 | 40 | 40 | 40 | 40 |
| | ºF | 104 | 104 | 104 | 104 | 104 | 104 |
| Maximum Winding Temperature ±5ºC (±9ºF) [Sensor Trip Point] | ºC | 155 | 155 | 155 | 155 | 155 | 155 |
| | ºF | 311 | 311 | 311 | 311 | 311 | 311 |
| Number of Motor Poles | --- | 6 | 6 | 6 | 6 | 6 | 6 |
| Continuous Torque (Stall) | lb-in | 31.2 | 31.2 | 41.5 | 41.5 | 58.3 | 58.3 |
| | N-m | 3.52 | 3.52 | 4.69 | 4.69 | 6.59 | 6.59 |
| Continuous Current (Stall) | Arms | 3.5 | 6.3 | 4.9 | 9.6 | 7.0 | 9.3 |
| Maximum Current | Arms | 14.7 | 26.5 | 20.8 | 40.9 | 29.8 | 39.5 |
| Maximum Continuous Power | HP | 1.04 | 1.58 | 1.26 | 1.90 | 1.76 | 2.21 |
| | kW | 0.77 | 1.18 | 0.94 | 1.41 | 1.31 | 1.65 |
| Torque @ Maximum Power | lb-in | 26.2 | 22.1 | 31.8 | 26.5 | 44.4 | 39.8 |
| | N-m | 2.96 | 2.50 | 3.60 | 3.00 | 5.01 | 4.50 |
| Current @ Maximum Power | Arms | 3.1 | 5.6 | 4.4 | 8.7 | 6.3 | 8.4 |
| Speed @ Maximum Power | RPM | 2500 | 4500 | 2500 | 4500 | 2500 | 3500 |
| | rad/sec | 262 | 471 | 262 | 471 | 262 | 367 |
| Maximum Continuous No Load Speed | RPM | 3000 | 5500 | 3000 | 5500 | 3000 | 4500 |
| | rad/sec | 314 | 576 | 314 | 576 | 314 | 471 |
| Rotor Inertia | lb-in-sec^2 | 0.003600 | 0.003600 | 0.004500 | 0.004500 | 0.005600 | 0.005600 |
| | kg-m^2 | 0.000406 | 0.000406 | 0.000508 | 0.000508 | 0.000632 | 0.000632 |
| Rotor Inertia with Brake | lb-in-sec^2 | 0.003750 | 0.003750 | 0.004650 | 0.004650 | 0.005750 | 0.005750 |
| | kg-m^2 | 0.000423 | 0.000423 | 0.000525 | 0.000525 | 0.000649 | 0.000649 |
| Torque Constant @ Maximum Winding Temperature | lb-in/Arms | 9.0 | 5.0 | 8.5 | 4.3 | 8.3 | 6.3 |
| | N-m/Arms | 1.02 | 0.56 | 0.96 | 0.49 | 0.94 | 0.71 |
| Torque Constant @ 25ºC | lb-in/Arms | 10.2 | 5.3 | 10.3 | 5.2 | 10.1 | 7.2 |
| | N-m/Arms | 1.15 | 0.60 | 1.17 | 0.59 | 1.14 | 0.82 |
| BEMF Constant @ 25ºC | Vrms/kRPM | 69.7 | 36.4 | 70.7 | 35.8 | 69.0 | 49.5 |
| | Vrms/rad/sec | 0.67 | 0.35 | 0.68 | 0.34 | 0.66 | 0.47 |
| Mechanical Time Constant | msec | 2.57 | 2.35 | 2.02 | 1.92 | 1.66 | 1.53 |
| Mechanical Time Constant with Brake | msec | 2.68 | 2.45 | 2.09 | 1.99 | 1.70 | 1.57 |
| Electrical Time Constant | msec | 3.75 | 3.01 | 3.39 | 3.17 | 4.94 | 3.70 |
| Thermal Time Constant | minutes | 30 | 30 | 35 | 40 | 40 | 40 |
| Thermal Time Constant with Brake | minutes | 33 | 33 | 38 | 43 | 43 | 43 |
| Stator Resistance (Line-to-Line) @ 25ºC | ohms | 4.3 | 1.1 | 2.6 | 0.6 | 1.6 | 0.8 |
| Stator Inductance (Line-to-Line) @ 25ºC | mH | 16.0 | 3.4 | 8.7 | 2.0 | 8.0 | 3.0 |
| Maximum Theoretical Acceleration at Maximum Current | rad/sec^2 | 36701 | 36701 | 39147 | 39147 | 44162 | 44162 |
| Maximum Theoretical Acceleration at Maximum Current with Brake | rad/sec^2 | 35233 | 35233 | 37885 | 37885 | 43010 | 43010 |
| Static Friction | lb-in | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 |
| | N-m | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 |
| Motor Weight | lb | 21.0 | 21.0 | 24.0 | 24.0 | 29.0 | 29.0 |
| | kg | 9.5 | 9.5 | 10.9 | 10.9 | 13.2 | 13.2 |
| Motor Weight with Brake | lb | 24.0 | 24.0 | 29.0 | 29.0 | 32.0 | 32.0 |
| | kg | 10.9 | 10.9 | 13.2 | 13.2 | 14.5 | 14.5 |
| Brake Holding Torque | lb-in | 40 | 40 | 40 | 40 | 40 | 40 |
| | N-m | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 |
| Brake Voltage | Vdc | 24 | 24 | 24 | 24 | 24 | 24 |
| Brake Current | A | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 |

## APPENDIX E (Continued)

### Elwood M46X "SX" Series Servo Motor
### 230 Vrms, Data Sheet Specifications

| | UNITS | M461G | M462C | M462G | M463K | M464G | M465G |
|---|---|---|---|---|---|---|---|
| Rated Ambient Temperature | ºC | 40 | 40 | 40 | 40 | 40 | 40 |
| | ºF | 104 | 104 | 104 | 104 | 104 | 104 |
| Maximum Winding Temperature ±5ºC (±9ºF) [Sensor Trip Point] | ºC | 180 | 180 | 180 | 180 | 180 | 180 |
| | ºF | 356 | 356 | 356 | 356 | 356 | 356 |
| Number of Motor Poles | --- | 6 | 6 | 6 | 6 | 6 | 6 |
| Continuous Torque (Stall) | lb-in | 43.1 | 91.9 | 91.9 | 131.0 | 164.6 | 187.0 |
| | N-m | 4.88 | 10.38 | 10.38 | 14.81 | 18.60 | 21.13 |
| Continuous Current (Stall) | Arms | 6.85 | 6.3 | 13.5 | 26.1 | 24.5 | 26.0 |
| Maximum Current | Arms | 29.1 | 26.5 | 57.0 | 110.8 | 104.0 | 110.3 |
| Maximum Continuous Power | HP | 1.88 | 1.68 | 2.92 | 3.38 | 3.86 | 5.11 |
| | kW | 1.40 | 1.25 | 2.18 | 2.52 | 2.88 | 3.81 |
| Torque @ Maximum Power | lb-in | 39.5 | 60.5 | 61.3 | 60.9 | 97.3 | 128.9 |
| | N-m | 4.46 | 6.84 | 6.93 | 6.89 | 10.99 | 14.57 |
| Current @ Maximum Power | Arms | 6.2 | 5.6 | 12.1 | 23.5 | 22.1 | 23.4 |
| Speed @ Maximum Power | RPM | 3000 | 1750 | 3000 | 3500 | 2500 | 2500 |
| | rad/sec | 314 | 183 | 314 | 367 | 262 | 262 |
| Maximum Continuous No Load Speed | RPM | 4000 | 2000 | 4000 | 5500 | 4000 | 4000 |
| | rad/sec | 419 | 209 | 419 | 576 | 419 | 419 |
| Rotor Inertia | lb-in-sec^2 | 0.01100 | 0.01800 | 0.01800 | 0.02500 | 0.03200 | 0.03900 |
| | kg-m^2 | 0.00124 | 0.00203 | 0.00203 | 0.00282 | 0.00361 | 0.00440 |
| Rotor Inertia with Brake | lb-in-sec^2 | 0.01800 | 0.02500 | 0.02500 | 0.03200 | 0.03900 | 0.04800 |
| | kg-m^2 | 0.00203 | 0.00282 | 0.00282 | 0.00361 | 0.00440 | 0.00542 |
| Torque Constant @ Maximum Winding Temperature | lb-in/Arms | 6.3 | 14.7 | 6.8 | 5.0 | 6.7 | 7.2 |
| | N-m/Arms | 0.71 | 1.66 | 0.77 | 0.57 | 0.76 | 0.81 |
| Torque Constant @ 25ºC | lb-in/Arms | 7.7 | 14.5 | 7.6 | 5.6 | 7.6 | 8.1 |
| | N-m/Arms | 0.87 | 1.64 | 0.86 | 0.64 | 0.85 | 0.91 |
| BEMF Constant @ 25ºC | Vrms/kRPM | 52.5 | 99.3 | 52.1 | 38.6 | 52.0 | 55.2 |
| | Vrms/rad/sec | 0.50 | 0.95 | 0.50 | 0.37 | 0.50 | 0.53 |
| Mechanical Time Constant | msec | 6.52 | 3.49 | 3.50 | 2.44 | 2.21 | 2.52 |
| Mechanical Time Constant with Brake | msec | 10.66 | 4.84 | 4.86 | 3.12 | 2.69 | 3.10 |
| Electrical Time Constant | msec | 7.97 | 10.00 | 10.26 | 15.44 | 13.22 | 13.22 |
| Thermal Time Constant | minutes | 30 | 35 | 35 | 40 | 47 | 53 |
| Thermal Time Constant with Brake | minutes | 33 | 38 | 38 | 43 | 50 | 56 |
| Stator Resistance (Line-to-Line) @ 25ºC | ohms | 1.9 | 2.7 | 0.66 | 0.18 | 0.23 | 0.25 |
| Stator Inductance (Line-to-Line) @ 25ºC | mH | 14.9 | 27.0 | 6.8 | 2.8 | 3.0 | 3.2 |
| Maximum Theoretical Acceleration at Maximum Current | rad/sec^2 | 16631 | 21644 | 21644 | 22224 | 21809 | 20327 |
| Maximum Theoretical Acceleration at Maximum Current with Brake | rad/sec^2 | 10163 | 15584 | 15584 | 17362 | 17894 | 16515 |
| Static Friction | lb-in | 5 | 5 | 5 | 5 | 5 | 5 |
| | N-m | 0.56 | 0.56 | 0.56 | 0.56 | 0.56 | 0.56 |
| Motor Weight | lb | 35.0 | 44.0 | 44.0 | 51.0 | 60.0 | 67.0 |
| | kg | 15.9 | 20.0 | 20.0 | 23.2 | 27.3 | 30.5 |
| Motor Weight with Brake | lb | 41.0 | 50.0 | 50.0 | 58.0 | 66.0 | 74.0 |
| | kg | 18.6 | 22.7 | 22.7 | 26.4 | 30.0 | 33.6 |
| Brake Holding Torque | lb-in | 100 | 100 | 100 | 100 | 100 | 100 |
| | N-m | 11.3 | 11.3 | 11.3 | 11.3 | 11.3 | 11.3 |
| Brake Voltage | Vdc | 24 | 24 | 24 | 24 | 24 | 24 |
| Brake Current | A | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 |

## APPENDIX E (Continued)

### Elwood M47X "SX" Series Servo Motor
### 230 Vrms, Data Sheet Specifications

| | UNITS | M471H | M473C | M474C | M476C | M477C |
|---|---|---|---|---|---|---|
| Rated Ambient Temperature | ºC | 40 | 40 | 40 | 40 | 40 |
| | ºF | 104 | 104 | 104 | 104 | 104 |
| Maximum Winding Temperature ±5ºC (±9ºF) [Sensor Trip Point] | ºC | 180 | 180 | 180 | 180 | 180 |
| | ºF | 356 | 356 | 356 | 356 | 356 |
| Number of Motor Poles | --- | 8 | 8 | 8 | 8 | 8 |
| Continuous Torque (Stall) | lb-in | 59.5 | 142.2 | 180.6 | 278.9 | 316.4 |
| | N-m | 6.72 | 16.07 | 20.40 | 31.51 | 35.75 |
| Continuous Current (Stall) | Arms | 8.8 | 11.3 | 15.1 | 23.1 | 26.1 |
| Maximum Current | Arms | 37.4 | 48.1 | 63.8 | 97.9 | 110.5 |
| Maximum Continuous Power | HP | 2.31 | 3.01 | 3.99 | 4.89 | 5.71 |
| | kW | 1.72 | 2.24 | 2.97 | 3.65 | 4.26 |
| Torque @ Maximum Power | lb-in | 44.1 | 108.3 | 143.5 | 181.2 | 239.8 |
| | N-m | 4.99 | 12.24 | 16.22 | 20.48 | 27.10 |
| Current @ Maximum Power | Arms | 7.9 | 10.2 | 13.6 | 20.8 | 20.8 |
| Speed @ Maximum Power | RPM | 3300 | 1750 | 1750 | 1700 | 1500 |
| | rad/sec | 346 | 183 | 183 | 178 | 157 |
| Maximum Continuous No Load Speed | RPM | 4000 | 2000 | 2000 | 2000 | 2000 |
| | rad/sec | 419 | 209 | 209 | 209 | 209 |
| Rotor Inertia | lb-in-sec^2 | 0.01515 | 0.04544 | 0.06590 | 0.09088 | 0.10603 |
| | kg-m^2 | 0.00171 | 0.00513 | 0.00744 | 0.01026 | 0.01197 |
| Rotor Inertia with Brake | lb-in-sec^2 | 0.01590 | 0.05810 | 0.07300 | 0.10300 | 0.11400 |
| | kg-m^2 | 0.00180 | 0.00656 | 0.00824 | 0.01163 | 0.01287 |
| Torque Constant @ Maximum Winding Temperature | lb-in/Arms | 6.7 | 12.5 | 12.0 | 12.1 | 12.1 |
| | N-m/Arms | 0.76 | 1.42 | 1.35 | 1.36 | 1.37 |
| Torque Constant @ 25ºC | IN-LBS/AMP | 8.6 | 14.1 | 13.8 | 13.6 | 13.7 |
| | Nm/AMP | 0.97 | 1.59 | 1.56 | 1.54 | 1.55 |
| BEMF Constant @ 25ºC | Vrms/kRPM | 58.8 | 96.2 | 94.5 | 93.1 | 93.6 |
| | Vrms/rad/sec | 0.56 | 0.92 | 0.90 | 0.89 | 0.89 |
| Mechanical Time Constant | msec | 7.12 | 3.30 | 3.65 | 2.96 | 2.54 |
| Mechanical Time Constant with Brake | msec | 7.47 | 4.23 | 4.05 | 3.36 | 2.73 |
| Electrical Time Constant | msec | 3.64 | 5.21 | 5.18 | 5.83 | 6.31 |
| Thermal Time Constant | minutes | 35 | 40 | 45 | 55 | 60 |
| Thermal Time Constant with Brake | minutes | 38 | 43 | 48 | 58 | 63 |
| Stator Resistance (Line-to-Line) @ 25ºC | ohms | 1.8 | 0.84 | 0.60 | 0.35 | 0.26 |
| Stator Inductance (Line-to-Line) @ 25ºC | mH | 6.5 | 4.4 | 3.1 | 2.0 | 1.6 |
| Maximum Theoretical Acceleration at Maximum Current | rad/sec^2 | 16655 | 13270 | 11618 | 13009 | 12652 |
| Maximum Theoretical Acceleration at Maximum Current with Brake | rad/sec^2 | 15867 | 10379 | 10488 | 11479 | 11768 |
| Static Friction | lb-in | 10 | 10 | 10 | 10 | 10 |
| | N-m | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 |
| Motor Weight | lb | 27.5 | 67.0 | 77.0 | 88.0 | 110.0 |
| | kg | 12.5 | 30.5 | 35.0 | 40.0 | 50.0 |
| Motor Weight with Brake | lb | 34.5 | 75.0 | 86.0 | 95.0 | 117.0 |
| | kg | 15.7 | 34.1 | 39.1 | 43.2 | 53.2 |
| Brake Holding Torque | lb-in | 354 | 354 | 354 | 354 | 354 |
| | N-m | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 |
| Brake Voltage | Vdc | 24 | 24 | 24 | 24 | 24 |
| Brake Current | A | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 |

## APPENDIX E (Continued)

### Elwood "SX" Series Servo Motor
### 460 Vrms, Description

The "SX" M4XX servo motor series that have 460 Vac rated windings will have two times the winding turns as the 230 Vac rated motors. Therefore 2X times the BEMF of a 230 Vac motor.

The 460 Vac motor will have torque and speed curve performance slightly derated to the 230 Vac motors. The 460 Vac motor will have approximately half the current draw, four times the resistance and four times the inductance as a 230 Vac motor. The 460 Vac motor windings have special coatings for voltage spike protection. The winding coatings use up some of the winding slot fill and require a reduction in winding copper, thus reducing the torque capabilities of the motor.

## APPENDIX E (Continued)

### Elwood M43X "SX" Series Servo Motor
### 460 Vrms, Data Sheet Specifications

| | UNITS | M431N | M432N | M433F | M433H | M433J | M433M |
|---|---|---|---|---|---|---|---|
| Rated Ambient Temperature | ºC | 40 | 40 | 40 | 40 | 40 | 40 |
| | ºF | 104 | 104 | 104 | 104 | 104 | 104 |
| Maximum Winding Temperature ±5ºC (±9ºF) [Sensor Trip Point] | ºC | 155 | 155 | 155 | 155 | 155 | 155 |
| | ºF | 311 | 311 | 311 | 311 | 311 | 311 |
| Number of Motor Poles | --- | 6 | 6 | 6 | 6 | 6 | 6 |
| Continuous Torque (Stall) | lb-in | 9.8 | 19.5 | 26.3 | 26.3 | 26.3 | 26.3 |
| | N-m | 1.10 | 2.21 | 2.97 | 2.97 | 2.97 | 2.97 |
| Continuous Current (Stall) | Arms | 1.3 | 2.5 | 1.9 | 2.1 | 2.5 | 3.6 |
| Maximum Current | Arms | 5.6 | 10.4 | 8.1 | 9.0 | 10.4 | 15.4 |
| Maximum Continuous Power | HP | 0.60 | 0.87 | 0.96 | 1.01 | 1.15 | 1.21 |
| | kW | 0.45 | 0.65 | 0.72 | 0.75 | 0.85 | 0.90 |
| Torque @ Maximum Power | lb-in | 6.9 | 10.5 | 24.2 | 21.2 | 20.6 | 15.3 |
| | N-m | 0.78 | 1.19 | 2.74 | 2.39 | 2.33 | 1.72 |
| Current @ Maximum Power | Arms | 1.2 | 2.2 | 1.7 | 1.9 | 2.2 | 3.3 |
| Speed @ Maximum Power | RPM | 5500 | 5000 | 2500 | 3000 | 3500 | 5000 |
| | rad/sec | 576 | 545 | 262 | 314 | 367 | 524 |
| Maximum Continuous No Load Speed | RPM | 6500 | 6500 | 3000 | 3500 | 4500 | 6500 |
| | rad/sec | 681 | 681 | 314 | 367 | 471 | 681 |
| Rotor Inertia | lb-in-sec^2 | 0.000620 | 0.001100 | 0.001500 | 0.001500 | 0.001500 | 0.001500 |
| | kg-m^2 | 0.000070 | 0.000124 | 0.000169 | 0.000169 | 0.000169 | 0.000169 |
| Rotor Inertia with Brake | lb-in-sec^2 | 0.000770 | 0.001270 | 0.001620 | 0.001620 | 0.001620 | 0.001620 |
| | kg-m^2 | 0.000087 | 0.000143 | 0.000183 | 0.000183 | 0.000183 | 0.000183 |
| Torque Constant @ Maximum Winding Temperature | lb-in/Arms | 7.4 | 8.0 | 13.7 | 12.4 | 10.7 | 7.2 |
| | N-m/Arms | 0.84 | 0.90 | 1.55 | 1.40 | 1.21 | 0.82 |
| Torque Constant @ 25ºC | lb-in/Arms | 9.1 | 9.1 | 20.5 | 16.9 | 13.3 | 8.8 |
| | N-m/Arms | 1.02 | 1.02 | 2.31 | 1.91 | 1.51 | 0.99 |
| BEMF Constant @ 25ºC | Vrms/kRPM | 68.0 | 69.0 | 145.0 | 122.0 | 98.0 | 69.0 |
| | Vrms/rad/sec | 0.65 | 0.66 | 1.38 | 1.17 | 0.94 | 0.66 |
| Mechanical Time Constant | msec | 3.83 | 2.31 | 1.86 | 1.63 | 1.62 | 1.70 |
| Mechanical Time Constant with Brake | msec | 4.75 | 2.67 | 2.01 | 1.76 | 1.75 | 1.83 |
| Electrical Time Constant | msec | 1.12 | 1.41 | 2.70 | 2.27 | 2.56 | 2.91 |
| Thermal Time Constant | minutes | 30 | 30 | 30 | 30 | 30 | 30 |
| Thermal Time Constant with Brake | minutes | 33 | 33 | 33 | 33 | 33 | 33 |
| Stator Resistance (Line-to-Line) @ 25ºC | ohms | 27.2 | 9.9 | 22.8 | 18.4 | 12.0 | 4.7 |
| Stator Inductance (Line-to-Line) @ 25ºC | mH | 30.4 | 14.0 | 61.5 | 41.7 | 30.7 | 13.6 |
| Maximum Theoretical Acceleration at Maximum Current | rad/sec^2 | 66772 | 75270 | 74305 | 74305 | 74305 | 74305 |
| Maximum Theoretical Acceleration at Maximum Current with Brake | rad/sec^2 | 53764 | 65194 | 68801 | 68801 | 68801 | 68801 |
| Static Friction | lb-in | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| | N-m | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 |
| Motor Weight | lb | 11.0 | 14.0 | 17.5 | 17.5 | 17.5 | 17.5 |
| | kg | 5.0 | 6.4 | 8.0 | 8.0 | 8.0 | 8.0 |
| Motor Weight with Brake | lb | 15.0 | 17.5 | 21.0 | 21.0 | 21.0 | 21.0 |
| | kg | 6.8 | 8.0 | 9.5 | 9.5 | 9.5 | 9.5 |
| Brake Holding Torque | lb-in | 40 | 40 | 40 | 40 | 40 | 40 |
| | N-m | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 |
| Brake Voltage | Vdc | 24 | 24 | 24 | 24 | 24 | 24 |
| Brake Current | A | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 |

## APPENDIX E (Continued)

### Elwood M44X "SX" Series Servo Motor
### 460 Vrms, Data Sheet Specifications

| | UNITS | M442E | M442K | M443E | M443K | M444E | M444H |
|---|---|---|---|---|---|---|---|
| Rated Ambient Temperature | ºC | 40 | 40 | 40 | 40 | 40 | 40 |
| | ºF | 104 | 104 | 104 | 104 | 104 | 104 |
| Maximum Winding Temperature ±5ºC (±9ºF) [Sensor Trip Point] | ºC | 155 | 155 | 155 | 155 | 155 | 155 |
| | ºF | 311 | 311 | 311 | 311 | 311 | 311 |
| Number of Motor Poles | --- | 6 | 6 | 6 | 6 | 6 | 6 |
| Continuous Torque (Stall) | lb-in | 29.3 | 29.3 | 39.1 | 39.1 | 54.2 | 54.2 |
| | N-m | 3.31 | 3.31 | 4.41 | 4.41 | 6.13 | 6.13 |
| Continuous Current (Stall) | Arms | 1.6 | 2.9 | 2.3 | 4.6 | 3.3 | 4.4 |
| Maximum Current | Arms | 6.8 | 12.3 | 9.8 | 19.5 | 14.0 | 18.7 |
| Maximum Continuous Power | HP | 0.98 | 1.48 | 1.19 | 1.78 | 1.64 | 2.06 |
| | kW | 0.73 | 1.11 | 0.89 | 1.33 | 1.22 | 1.53 |
| Torque @ Maximum Power | lb-in | 24.6 | 20.8 | 29.9 | 24.9 | 41.3 | 37.0 |
| | N-m | 2.78 | 2.35 | 3.38 | 2.82 | 4.66 | 4.18 |
| Current @ Maximum Power | Arms | 1.5 | 2.6 | 2.1 | 4.1 | 2.9 | 3.9 |
| Speed @ Maximum Power | RPM | 2500 | 4500 | 2500 | 4500 | 2500 | 3500 |
| | rad/sec | 262 | 471 | 262 | 471 | 262 | 367 |
| Maximum Continuous No Load Speed | RPM | 3000 | 5000 | 3000 | 5500 | 3000 | 4500 |
| | rad/sec | 314 | 524 | 314 | 576 | 314 | 471 |
| Rotor Inertia | lb-in-sec^2 | 0.003600 | 0.003600 | 0.004500 | 0.004500 | 0.005600 | 0.005600 |
| | kg-m^2 | 0.000406 | 0.000406 | 0.000508 | 0.000508 | 0.000632 | 0.000632 |
| Rotor Inertia with Brake | lb-in-sec^2 | 0.003750 | 0.003750 | 0.004650 | 0.004650 | 0.005750 | 0.005750 |
| | kg-m^2 | 0.000423 | 0.000423 | 0.000525 | 0.000525 | 0.000649 | 0.000649 |
| Torque Constant @ Maximum Winding Temperature | lb-in/Arms | 18.3 | 10.1 | 17.0 | 8.5 | 16.4 | 12.3 |
| | N-m/Arms | 2.07 | 1.14 | 1.92 | 0.96 | 1.86 | 1.39 |
| Torque Constant @ 25ºC | lb-in/Arms | 20.4 | 13.0 | 20.7 | 10.5 | 19.6 | 14.5 |
| | N-m/Arms | 2.30 | 1.47 | 2.34 | 1.18 | 2.22 | 1.64 |
| BEMF Constant @ 25ºC | Vrms/kRPM | 139.4 | 89.0 | 141.4 | 71.6 | 134.0 | 99.0 |
| | Vrms/rad/sec | 1.33 | 0.85 | 1.35 | 0.68 | 1.28 | 0.95 |
| Mechanical Time Constant | msec | 2.69 | 3.05 | 2.14 | 2.09 | 1.73 | 1.82 |
| Mechanical Time Constant with Brake | msec | 2.80 | 3.18 | 2.21 | 2.16 | 1.78 | 1.87 |
| Electrical Time Constant | msec | 3.52 | 1.87 | 3.19 | 2.96 | 4.89 | 3.17 |
| Thermal Time Constant | minutes | 30 | 30 | 35 | 40 | 40 | 40 |
| Thermal Time Constant with Brake | minutes | 33 | 33 | 38 | 43 | 43 | 43 |
| Stator Resistance (Line-to-Line) @ 25ºC | ohms | 18.2 | 7.3 | 10.9 | 2.7 | 6.5 | 3.8 |
| Stator Inductance (Line-to-Line) @ 25ºC | mH | 64.0 | 13.6 | 34.8 | 8.0 | 31.8 | 12.0 |
| Maximum Theoretical Acceleration at Maximum Current | rad/sec^2 | 34499 | 34499 | 36799 | 36799 | 41071 | 41071 |
| Maximum Theoretical Acceleration at Maximum Current with Brake | rad/sec^2 | 33119 | 33119 | 35612 | 35612 | 39999 | 39999 |
| Static Friction | lb-in | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 | 1.3 |
| | N-m | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 | 0.15 |
| Motor Weight | lb | 21.0 | 21.0 | 24.0 | 24.0 | 29.0 | 29.0 |
| | kg | 9.5 | 9.5 | 10.9 | 10.9 | 13.2 | 13.2 |
| Motor Weight with Brake | lb | 24.0 | 24.0 | 29.0 | 29.0 | 32.0 | 32.0 |
| | kg | 10.9 | 10.9 | 13.2 | 13.2 | 14.5 | 14.5 |
| Brake Holding Torque | lb-in | 40 | 40 | 40 | 40 | 40 | 40 |
| | N-m | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 | 4.5 |
| Brake Voltage | Vdc | 24 | 24 | 24 | 24 | 24 | 24 |
| Brake Current | A | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 | 0.45 |

## APPENDIX E (Continued)

### Elwood M46X "SX" Series Servo Motor
### 460 Vrms, Data Sheet Specifications

| | UNITS | M461G | M462G | M463K | M464G | M465G |
|---|---|---|---|---|---|---|
| Rated Ambient Temperature | ºC | 40 | 40 | 40 | 40 | 40 |
| | ºF | 104 | 104 | 104 | 104 | 104 |
| Maximum Winding Temperature ±5ºC (±9ºF) [Sensor Trip Point] | ºC | 180 | 180 | 180 | 180 | 180 |
| | ºF | 356 | 356 | 356 | 356 | 356 |
| Number of Motor Poles | --- | 6 | 6 | 6 | 6 | 6 |
| Continuous Torque (Stall) | lb-in | 39.3 | 83.6 | 119.2 | 149.8 | 170.1 |
| | N-m | 4.44 | 9.45 | 13.47 | 16.92 | 19.22 |
| Continuous Current (Stall) | Arms | 3.1 | 5.7 | 11.9 | 11.1 | 11.8 |
| Maximum Current | Arms | 13.1 | 24.2 | 50.4 | 47.1 | 50.0 |
| Maximum Continuous Power | HP | 1.71 | 2.66 | 3.08 | 3.51 | 4.65 |
| | kW | 1.28 | 1.98 | 2.30 | 2.62 | 3.47 |
| Torque @ Maximum Power | lb-in | 35.9 | 55.9 | 55.5 | 88.5 | 117.2 |
| | N-m | 4.06 | 6.31 | 6.27 | 10.00 | 13.25 |
| Current @ Maximum Power | Arms | 2.8 | 5.1 | 10.7 | 10.0 | 10.7 |
| Speed @ Maximum Power | RPM | 3000 | 3000 | 3500 | 2500 | 2500 |
| | rad/sec | 314 | 314 | 367 | 262 | 262 |
| Maximum Continuous No Load Speed | RPM | 4000 | 4000 | 5500 | 4000 | 4000 |
| | rad/sec | 419 | 419 | 576 | 419 | 419 |
| Rotor Inertia | lb-in-sec^2 | 0.01100 | 0.01800 | 0.02500 | 0.03200 | 0.03900 |
| | kg-m^2 | 0.00124 | 0.00203 | 0.00282 | 0.00361 | 0.00440 |
| Rotor Inertia with Brake | lb-in-sec^2 | 0.01800 | 0.02500 | 0.03200 | 0.03900 | 0.04800 |
| | kg-m^2 | 0.00203 | 0.00282 | 0.00361 | 0.00440 | 0.00542 |
| Torque Constant @ Maximum Winding Temperature | lb-in/Arms | 12.7 | 14.7 | 10.0 | 13.5 | 14.4 |
| | N-m/Arms | 1.43 | 1.66 | 1.13 | 1.52 | 1.63 |
| Torque Constant @ 25ºC | lb-in/Arms | 15.4 | 14.5 | 11.0 | 15.1 | 16.2 |
| | N-m/Arms | 1.74 | 1.64 | 1.25 | 1.71 | 1.83 |
| BEMF Constant @ 25ºC | Vrms/kRPM | 105.0 | 99.3 | 75.5 | 103.4 | 110.4 |
| | Vrms/rad/sec | 1.00 | 0.95 | 0.72 | 0.99 | 1.05 |
| Mechanical Time Constant | msec | 7.10 | 3.49 | 3.28 | 2.43 | 2.54 |
| Mechanical Time Constant with Brake | msec | 11.62 | 4.85 | 4.20 | 2.96 | 3.13 |
| Electrical Time Constant | msec | 7.27 | 10.00 | 11.71 | 12.08 | 13.09 |
| Thermal Time Constant | minutes | 30 | 35 | 40 | 47 | 53 |
| Thermal Time Constant with Brake | minutes | 33 | 38 | 43 | 50 | 56 |
| Stator Resistance (Line-to-Line) @ 25ºC | ohms | 8.2 | 2.7 | 0.95 | 1.01 | 0.99 |
| Stator Inductance (Line-to-Line) @ 25ºC | mH | 59.6 | 27.0 | 11.1 | 12.2 | 13.0 |
| Maximum Theoretical Acceleration at Maximum Current | rad/sec^2 | 15134 | 19696 | 20224 | 19846 | 18497 |
| Maximum Theoretical Acceleration at Maximum Current with Brake | rad/sec^2 | 9249 | 14181 | 15800 | 16284 | 15029 |
| Static Friction | lb-in | 5 | 5 | 5 | 5 | 5 |
| | N-m | 0.56 | 0.56 | 0.56 | 0.56 | 0.56 |
| Motor Weight | lb | 35.0 | 44.0 | 51.0 | 60.0 | 67.0 |
| | kg | 15.9 | 20.0 | 23.2 | 27.3 | 30.5 |
| Motor Weight with Brake | lb | 41.0 | 50.0 | 58.0 | 66.0 | 74.0 |
| | kg | 18.6 | 22.7 | 26.4 | 30.0 | 33.6 |
| Brake Holding Torque | lb-in | 100 | 100 | 100 | 100 | 100 |
| | N-m | 11.3 | 11.3 | 11.3 | 11.3 | 11.3 |
| Brake Voltage | Vdc | 24 | 24 | 24 | 24 | 24 |
| Brake Current | A | 0.67 | 0.67 | 0.67 | 0.67 | 0.67 |

## APPENDIX E (Continued)

### Elwood M47X "SX" Series Servo Motor
### 460 Vrms, Data Sheet Specifications

| | UNITS | M471H | M473C | M474C | M476C | M477C |
|---|---|---|---|---|---|---|
| Rated Ambient Temperature | ºC | 40 | 40 | 40 | 40 | 40 |
| | ºF | 104 | 104 | 104 | 104 | 104 |
| Maximum Winding Temperature ±5ºC (±9ºF) [Sensor Trip Point] | ºC | 180 | 180 | 180 | 180 | 180 |
| | ºF | 356 | 356 | 356 | 356 | 356 |
| Number of Motor Poles | --- | 8 | 8 | 8 | 8 | 8 |
| Continuous Torque (Stall) | lb-in | 59.5 | 142.2 | 180.6 | 278.9 | 316.4 |
| | N-m | 6.72 | 16.07 | 20.40 | 31.51 | 35.75 |
| Continuous Current (Stall) | Arms | 4.0 | 5.2 | 6.9 | 10.5 | 13.1 |
| Maximum Current | Arms | 17.0 | 22.0 | 29.3 | 44.5 | 55.3 |
| Maximum Continuous Power | HP | 2.31 | 3.01 | 3.99 | 4.89 | 5.71 |
| | kW | 1.72 | 2.24 | 2.97 | 3.65 | 4.26 |
| Torque @ Maximum Power | lb-in | 44.1 | 108.3 | 143.5 | 181.2 | 239.8 |
| | N-m | 4.99 | 12.24 | 16.22 | 20.48 | 27.10 |
| Current @ Maximum Power | Arms | 3.6 | 4.6 | 6.2 | 9.4 | 10.4 |
| Speed @ Maximum Power | RPM | 3300 | 1750 | 1750 | 1700 | 1500 |
| | rad/sec | 346 | 183 | 183 | 178 | 157 |
| Maximum Continuous No Load Speed | RPM | 4000 | 2000 | 2000 | 2000 | 2000 |
| | rad/sec | 419 | 209 | 209 | 209 | 209 |
| Rotor Inertia | lb-in-sec^2 | 0.01515 | 0.04544 | 0.06590 | 0.09088 | 0.10603 |
| | kg-m^2 | 0.00171 | 0.00513 | 0.00744 | 0.01026 | 0.01197 |
| Rotor Inertia with Brake | lb-in-sec^2 | 0.01590 | 0.05810 | 0.07300 | 0.10300 | 0.11400 |
| | kg-m^2 | 0.00180 | 0.00656 | 0.00824 | 0.01163 | 0.01287 |
| Torque Constant @ Maximum Winding Temperature | lb-in/Arms | 14.9 | 27.4 | 26.2 | 26.6 | 24.2 |
| | N-m/Arms | 1.68 | 3.09 | 2.96 | 3.00 | 2.74 |
| Torque Constant @ 25ºC | IN-LBS/AMP | 17.2 | 28.1 | 27.7 | 27.2 | 27.4 |
| | Nm/AMP | 1.94 | 3.18 | 3.12 | 3.08 | 3.09 |
| BEMF Constant @ 25ºC | Vrms/kRPM | 117.6 | 192.4 | 189.0 | 186.2 | 187.2 |
| | Vrms/rad/sec | 1.12 | 1.84 | 1.80 | 1.78 | 1.79 |
| Mechanical Time Constant | msec | 7.07 | 3.35 | 3.36 | 2.89 | 2.69 |
| Mechanical Time Constant with Brake | msec | 7.42 | 4.28 | 3.72 | 3.27 | 2.89 |
| Electrical Time Constant | msec | 3.33 | 4.73 | 5.15 | 5.47 | 5.96 |
| Thermal Time Constant | minutes | 35 | 40 | 45 | 55 | 60 |
| Thermal Time Constant with Brake | minutes | 38 | 43 | 48 | 58 | 63 |
| Stator Resistance (Line-to-Line) @ 25ºC | ohms | 7.8 | 3.7 | 2.4 | 1.5 | 1.1 |
| Stator Inductance (Line-to-Line) @ 25ºC | mH | 26.0 | 17.5 | 12.4 | 8.2 | 6.6 |
| Maximum Theoretical Acceleration at Maximum Current | rad/sec^2 | 15156 | 12076 | 10572 | 11838 | 12652 |
| Maximum Theoretical Acceleration at Maximum Current with Brake | rad/sec^2 | 14439 | 9445 | 9544 | 10446 | 11768 |
| Static Friction | lb-in | 10 | 10 | 10 | 10 | 10 |
| | N-m | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 |
| Motor Weight | lb | 27.5 | 67.0 | 77.0 | 88.0 | 110.0 |
| | kg | 12.5 | 30.5 | 35.0 | 40.0 | 50.0 |
| Motor Weight with Brake | lb | 34.5 | 75.0 | 86.0 | 95.0 | 117.0 |
| | kg | 15.7 | 34.1 | 39.1 | 43.2 | 53.2 |
| Brake Holding Torque | lb-in | 354 | 354 | 354 | 354 | 354 |
| | N-m | 40.0 | 40.0 | 40.0 | 40.0 | 40.0 |
| Brake Voltage | Vdc | 24 | 24 | 24 | 24 | 24 |
| Brake Current | A | 0.62 | 0.62 | 0.62 | 0.62 | 0.62 |