WRITTEN BY:	Curt Winter	Engr.	*Curt Winter*	8/10/93
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Curt Winter	9/7/93	

REVISION HISTORY:

Rev. No.	Date	Page No.	Changed By	ECO No.	Description	Approved By
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
R	01/26/17	3, 4, 6, 9	D. Wiese	008536	Change EEx d IIB T3 to Ex db IIB T3 Gb. Update ATEX gas Certification number.	DAW
S	09/05/17	3, 5, 6, 10	D. Wiese	008780	Add standards issue dates. Add M44X & M46X to dust. Update dust cert numbers	DAW
T	02/26/18	3, 14, 65	D. Wiese	009053	Add models D & E; EnDat & Sin / Cos Encoder Conn diagrams; Sin / Cos Enc	DAW
U	05/19/23	various	D. Wiese	010313	Update to comply with latest EN/IEC standard, Lead seal special conditions, and 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

1.0) Certifications/ Special conditions for safe use

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-XXXX-8XXX, M43X-XXXX-9XXX, M43X-XXXX-DXXX, M43X-XXXX-EXXX, M44X-XXXX-8XXX, M44X-XXXX-9XXX, M44X-XXXX-DXXX, M44X-XXXX-EXXX, M46X-XXXX-8XXX, M46X-XXXX-9XXX, M46X-XXXX-DXXX and M46X-XXXX-EXXX are CE rated for use in the European Community complying with the ATEX directive. Specification Numbers: EN IEC 60079-0 / IEC 60079-0 and EN 60079-1 / IEC 60079-1. The ratings are as follows:

Ex db IIB T3 Gb

Ex	=	Equipment conforms to types of protection standardized by CENELEC.
db	=	Flameproof enclosure
IIB	=	Used in surface industries; gas group.
T3	=	Temperature class; maximum surface temperature 200° C
Gb	=	Equipment for explosive gas atmospheres, having a "high" level of protection, which is not a source of ignition in normal operation or during expected malfunctions.

CE 0539 ⟨Ex⟩ II 2 G

CE = CE marking
0539 = 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.

IECEx UL 16.0170X = IECEx Certification number.
DEMKO 16 ATEX 1817X = ATEX Certification number.

Special conditions for safe use:

- 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. The supplied lead seal is not sufficient for the protection method of the free end of the conductors. An ATEX/IECEx conduit sealing device(s) complying with the requirements of EN IEC 60079-0:2018/IEC 60079-0 Ed. 7 and EN 60079-1:2014/IEC 60079-1 Ed. 7 shall be supplied by the end user.
- 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 tie 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 lock nuts 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. A pulse-width-modulated (PWM) current amplitude, frequency and phase for operation of the rotor within its specification. The PWM switching frequency is specified at a minimum of 3 kHz.

- Flameproof joints are not intended to be repaired, contact Elwood Corp. for information.

M43X-XXXX-BXXX, M43X-XXXX-CXXX, M44X-XXXX-BXXX, M44X-XXXX-CXXX, M46X-XXXX-BXXX and M46X-XXXX-CXXX are CE rated for use in the European Community complying with the ATEX directive. Specification Numbers: : EN IEC 60079-0 / IEC 60079-0 and EN 60079-31 / IEC 60079-31 The ratings are as follows:

Ex tb IIIC T135°C Db IP6X (Models M43X & M46X)
Ex tb IIIC T115°C Db IP6X (Models M44X)

Ex = Equipment conforms to types of protection standardized by CENELEC.
tb = Protection by enclosure
IIIC = Used in surface industries; conductive dust group.
T135°C / T115°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 0539  II 2 D

CE = CE marking
0539 = Identification number of notified body.
 = Use of equipment in potentially explosive atmospheres.
II = Equipment group: for surface.
2 = Equipment category: present zone 1.
D = Dust.

IECEx UL 17.0076X = IEC Certification number.

DEMKO 17 ATEX 1923 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.

Special conditions for safe use continued:
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. The supplied lead seal is not sufficient for the protection method for the free end of the conductors. An ATEX/IECEx conduit sealing device(s) complying with the requirements of EN IEC 60079-0:2018/IEC 60079-0 Ed. 7 and EN 60079-31:2014/IEC 60079-31 Ed. 3 shall be supplied by the end user

- 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. A pulse-width-modulated (PWM) current amplitude, frequency and phase for operation of the rotor within its specification. The PWM switching frequency is specified at a minimum of 3 kHz.

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, 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. **All certifications and ratings are void if motor is opened or tampered with.**

2.0) 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.

2.1) 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 17-4 stainless steel as an option for harsh environments that will not require a rust inhibitor. 1.1)

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.

2.1) Motor Keyway Preparation Continued:

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.

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.

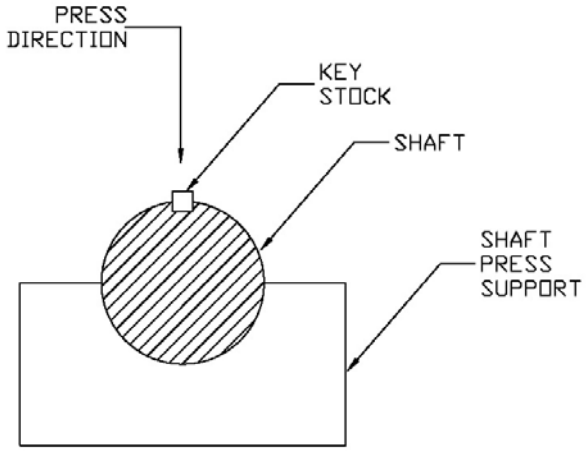


FIGURE (1) SHAFT KEY PRESS SUPPORT FIXTURE

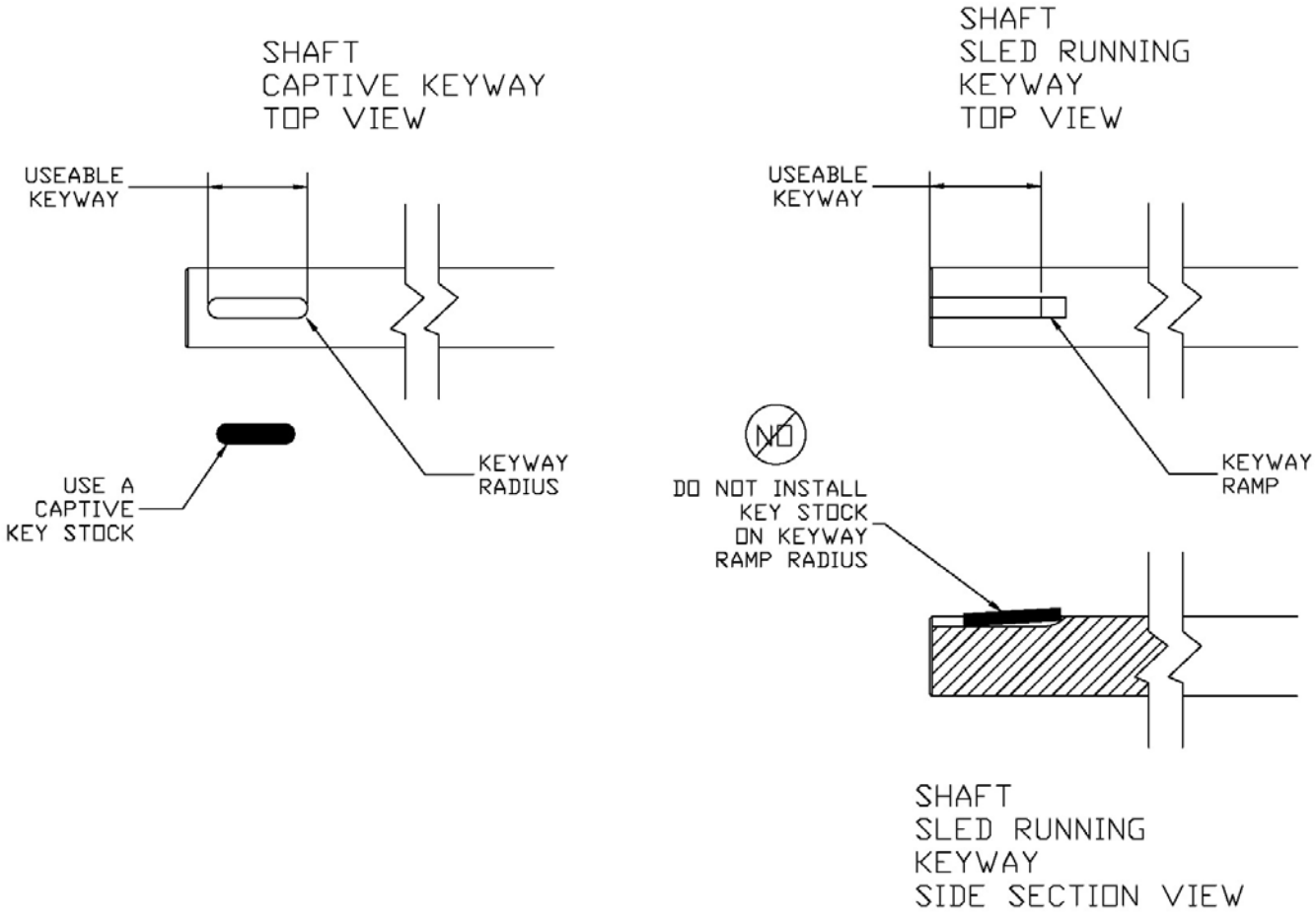


FIGURE (2) SHAFT KEYWAYS

3.0) 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 steel socket head screws that are a grade 8 minimum strength rating. Also use a 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.

3.1) 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.

3.2) 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.

3.2) Gearbox Mountings Continued:

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.

4.0) 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. Fitting thread sizes are: 1" NPT 11-1/2 threads per inch or ¾" NPT 14 threads per inch. 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 as is the use of approved NPT fittings for hazardous locations. ATEX / IECEx installations require a conduit sealing device with integral threads applied to the motor. These fittings must be Ex d or Ex tb rated where applicable and comply with the latest editions of IEC 60079-0/ EN 60079-0 and IEC 60079-1/ EN 60079-1 or IEC 60079-31/ EN 60079-31 where applicable (see 1.0 Special conditions for safe use).

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

The motor must be securely mounted to a machine frame and all safety guards in place before turning on

WARNING: Do not operate the motor in a hazardous location with any securing screws or covers removed, and do not remove any screws or covers while motor is in hazardous location. Do not open or attempt to open the motor, only a qualified Elwood employee can service this type of motor.

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.

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.

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.

9.0) Maintenance

Due to their construction, The "SX" Series motor are maintenance free. The bearings are the only components subject to wear and are provided with lifetime lubication (at least 20,000 operating hours at the specified maximum axial and radial forces; see Appendix F). The motors exterior surfaces are coated with a paint. If this motor is repainted and/or mounted in an enclosed area, the performance ratings could be degraded. Take care if excessive coats of paint on the motor. Do not paint over the nameplate or labeled information on the motor.

9.1) Repair

The flameproof joints are not intended to be repaired. 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. Contact Elwood at 800-558-9489 if repair is needed. When it is necessary to repair a Elwood "SX" Series motor, all non-Elwood parts such as gearing and pulleys are to be removed, as Elwood cannot guarantee that they will be removed correctly. Grease and dirt present at the connection flange of the motor should also be removed. The motor is to be packed in a manner to prevent damage during transport.

APPENDIX A

Wiring Interconnect Schematics

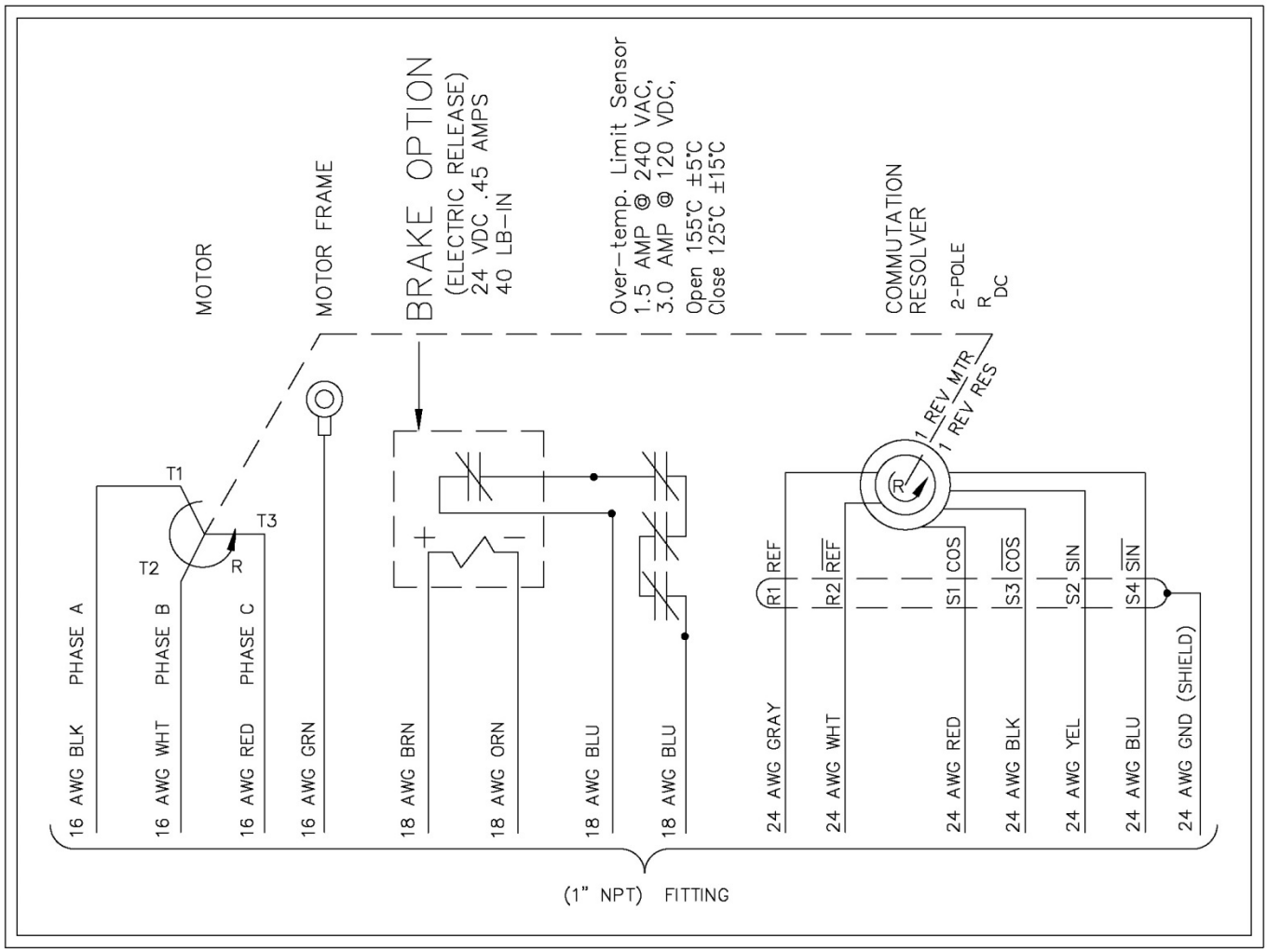
CONTENTS

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 2.2/01 Encoder
M43X & M44X	1	DSL Absolute Encoder
M43X & M44X	1	SIN / COS Encoder
M43X & M44X	1	EnDat 2.2/22 Encoder
M43X & M44X	1	EnDat 2.2/22 Single-Turn Encoder
M43X & M44X	1	DriveCliq Encoder
M43X & M44X	2	Single Resolver
M43X & M44X	2	Incremental Encoder
M43X & M44X	2	Absolute Encoder
M43X & M44X	2	EnDat 2.2/01 Encoder
M43X & M44X	2	SIN / COS Encoder
M43X & M44X	2	Dual Resolver
M43X & M44X	2	EnDat 2.2/22 Encoder
M43X & M44X	2	EnDat 2.2/22 Single-Turn Encoder
M43X & M44X	2	DriveCliq Encoder
M46X & M47X	1	Single Resolver
M46X & M47X	1	Incremental Encoder
M46X & M47X	1	Absolute Encoder
M46X & M47X	1	EnDat 2.2/01 Encoder
M46X & M47X	1	DSL Absolute Encoder
M46X & M47X	1	SIN / COS Encoder
M46X & M47X	1	EnDat 2.2/22 Encoder
M46X & M47X	1	EnDat 2.2/22 Single-Turn Encoder
M46X & M47X	1	DriveCliq Encoder
M46X & M47X	2	Single Resolver
M46X & M47X	2	Incremental Encoder
M46X & M47X	2	Absolute Encoder
M46X & M47X	2	EnDat 2.2/01 Encoder
M46X & M47X	2	SIN / COS Encoder
M46X & M47X	2	Dual Resolver
M46X & M47X	2	EnDat 2.2/22 Encoder
M46X & M47X	2	EnDat 2.2/22 Single-Turn Encoder
M46X & M47X	2	DriveCliq Encoder

Connection Diagram

M43X & M44X Motors

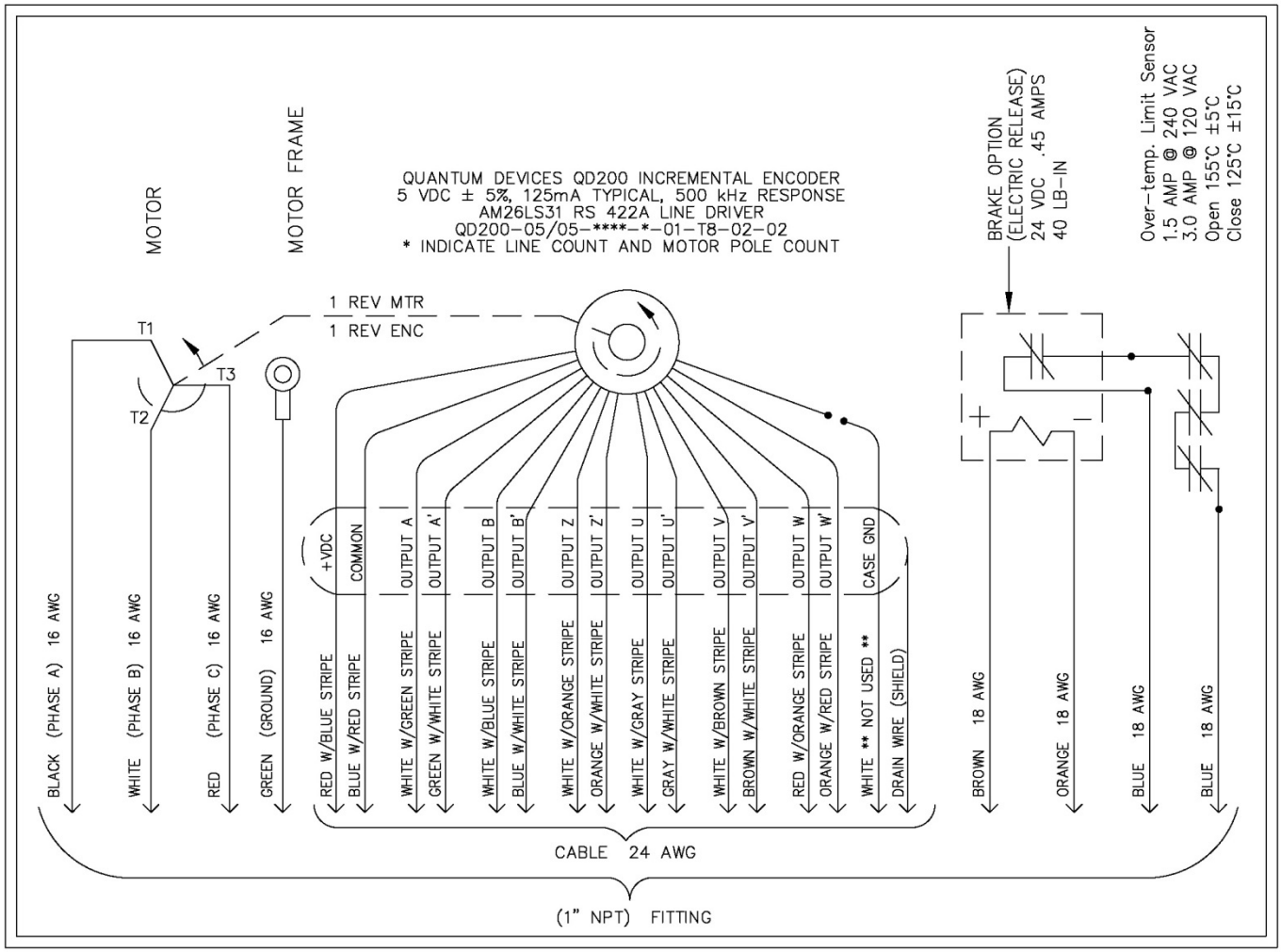
Single Resolver, One Leadwire Exit Fitting



Connection Diagram

M43X & M44X Motors

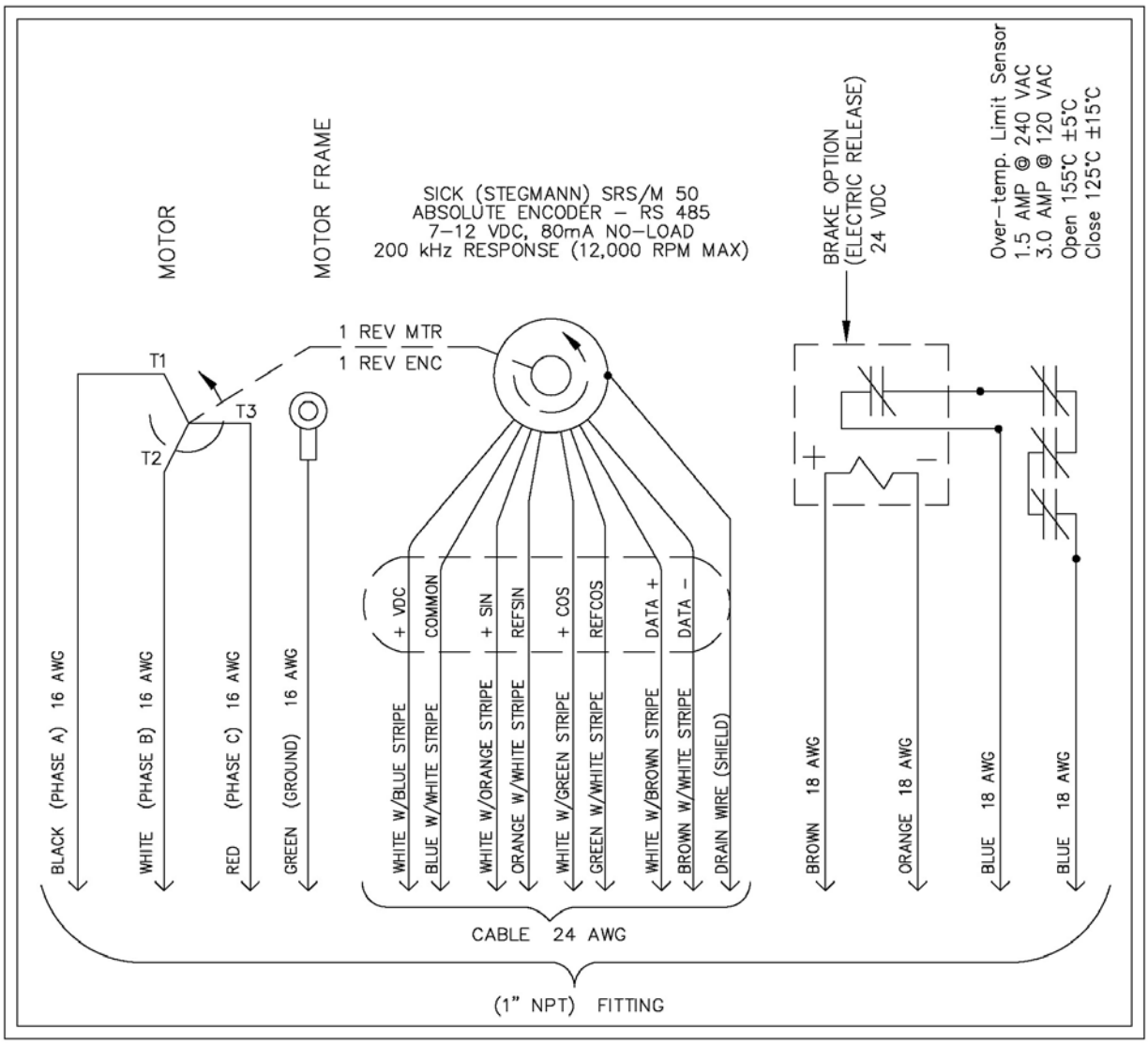
Incremental Encoder, One Leadwire Exit Fitting



Connection Diagram

M43X & M44X Motors

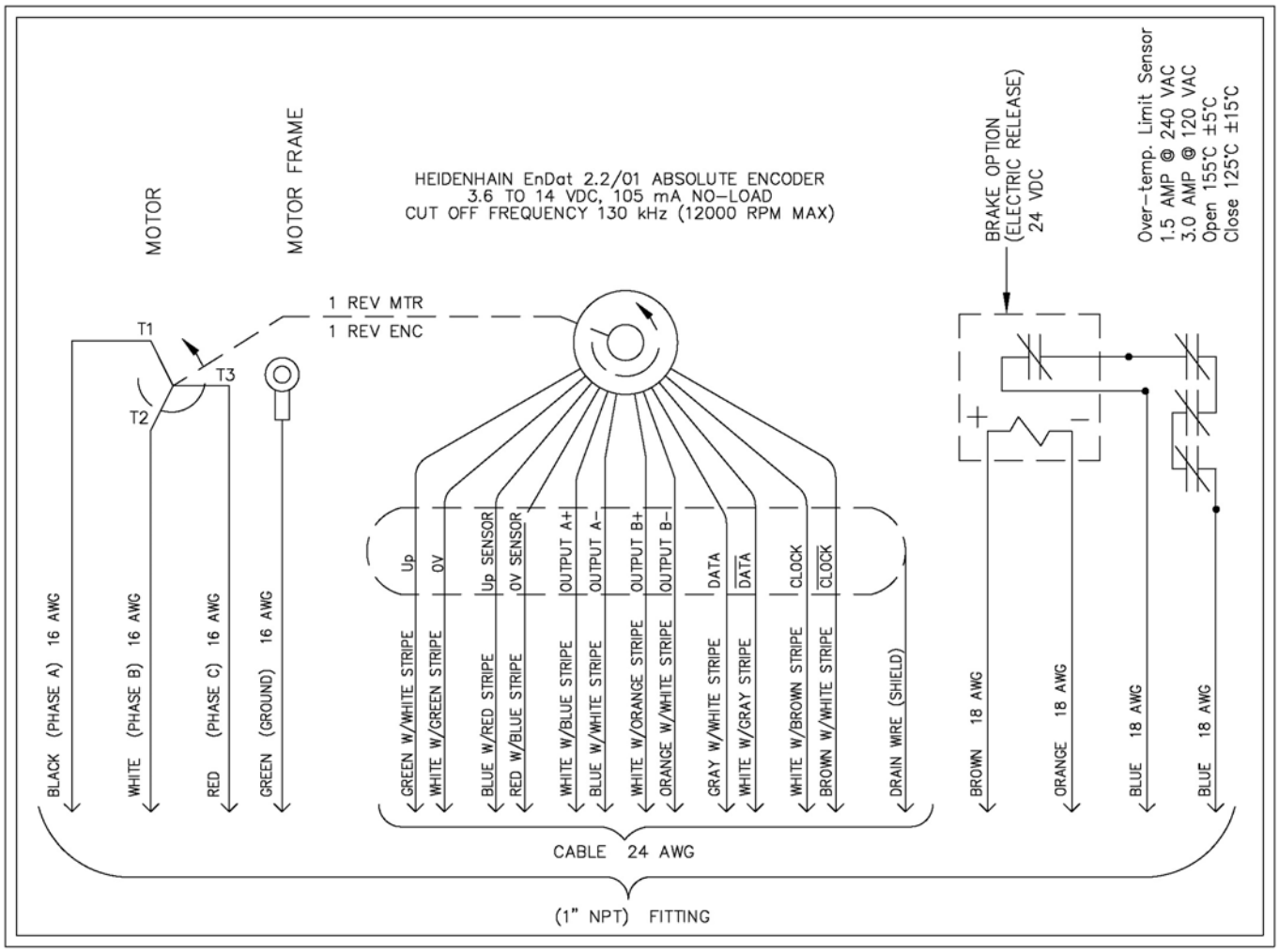
Absolute Encoder, One Leadwire Exit Fitting



Connection Diagram

M43X & M44X Motors

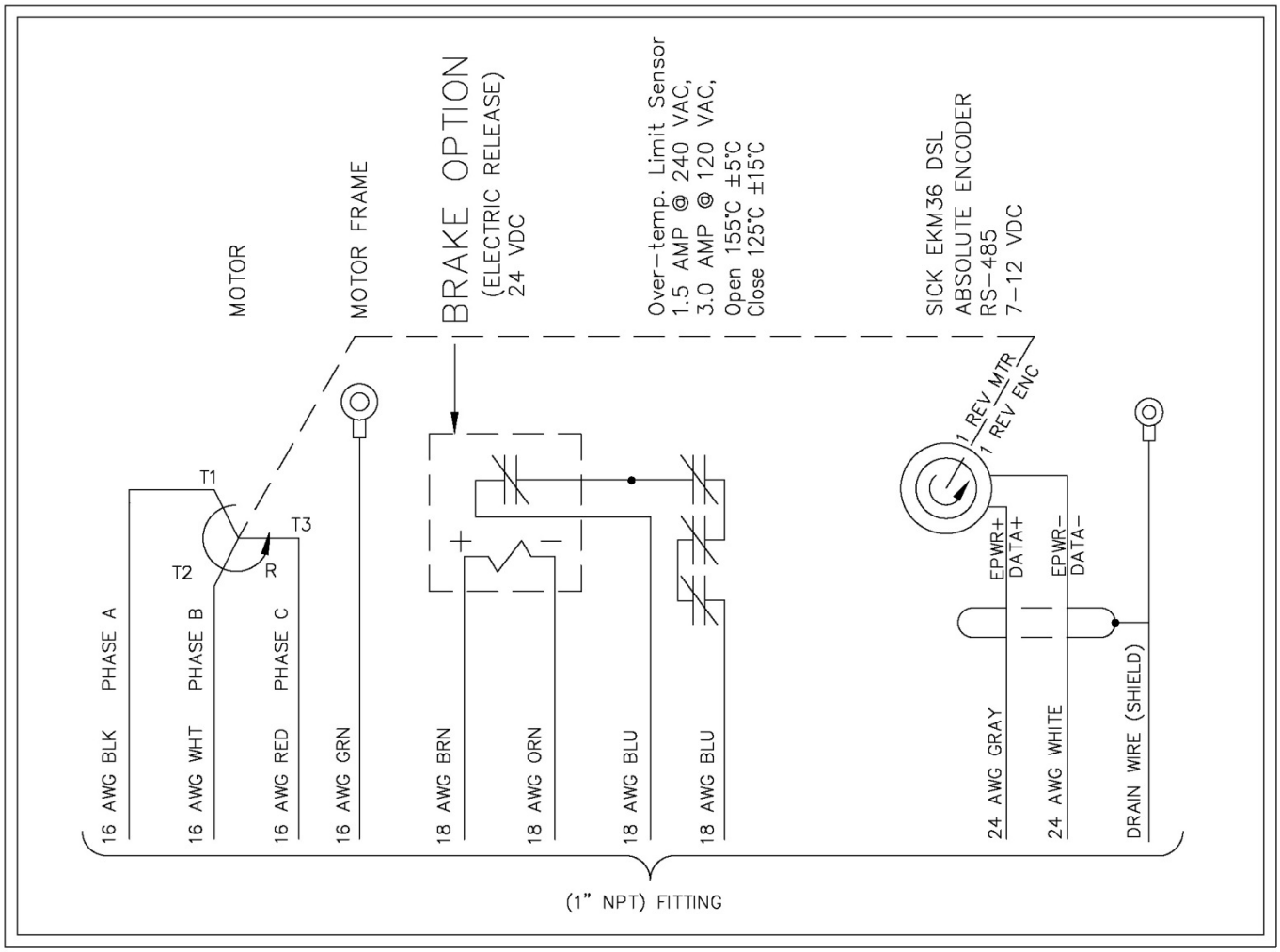
EnDat 2.2/01 Encoder, One Leadwire Exit Fitting



Connection Diagram

M43X & M44X Motors

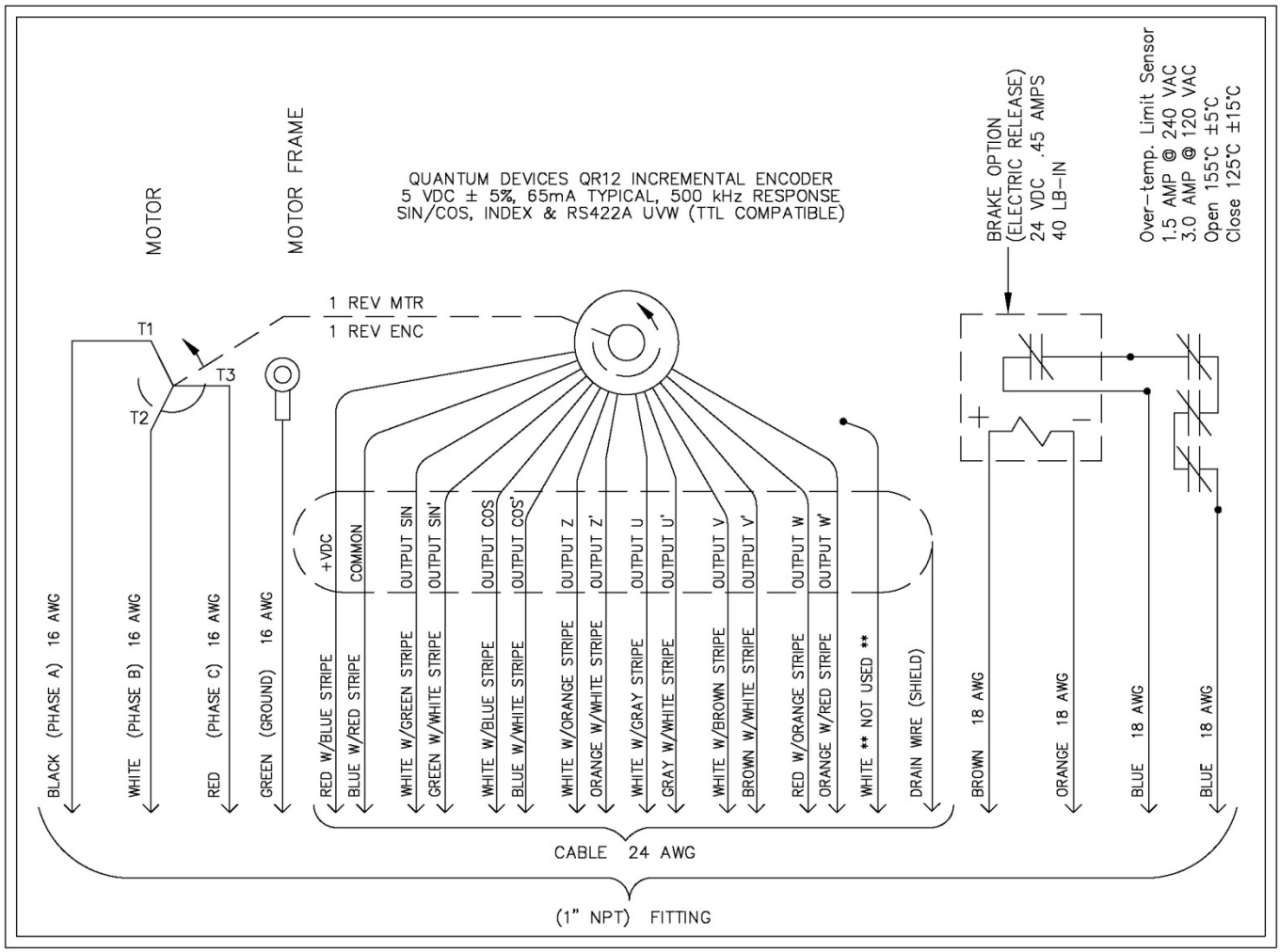
DSL Absolute Encoder, One Leadwire Exit Fitting



Connection Diagram

M43X & M44X Motors

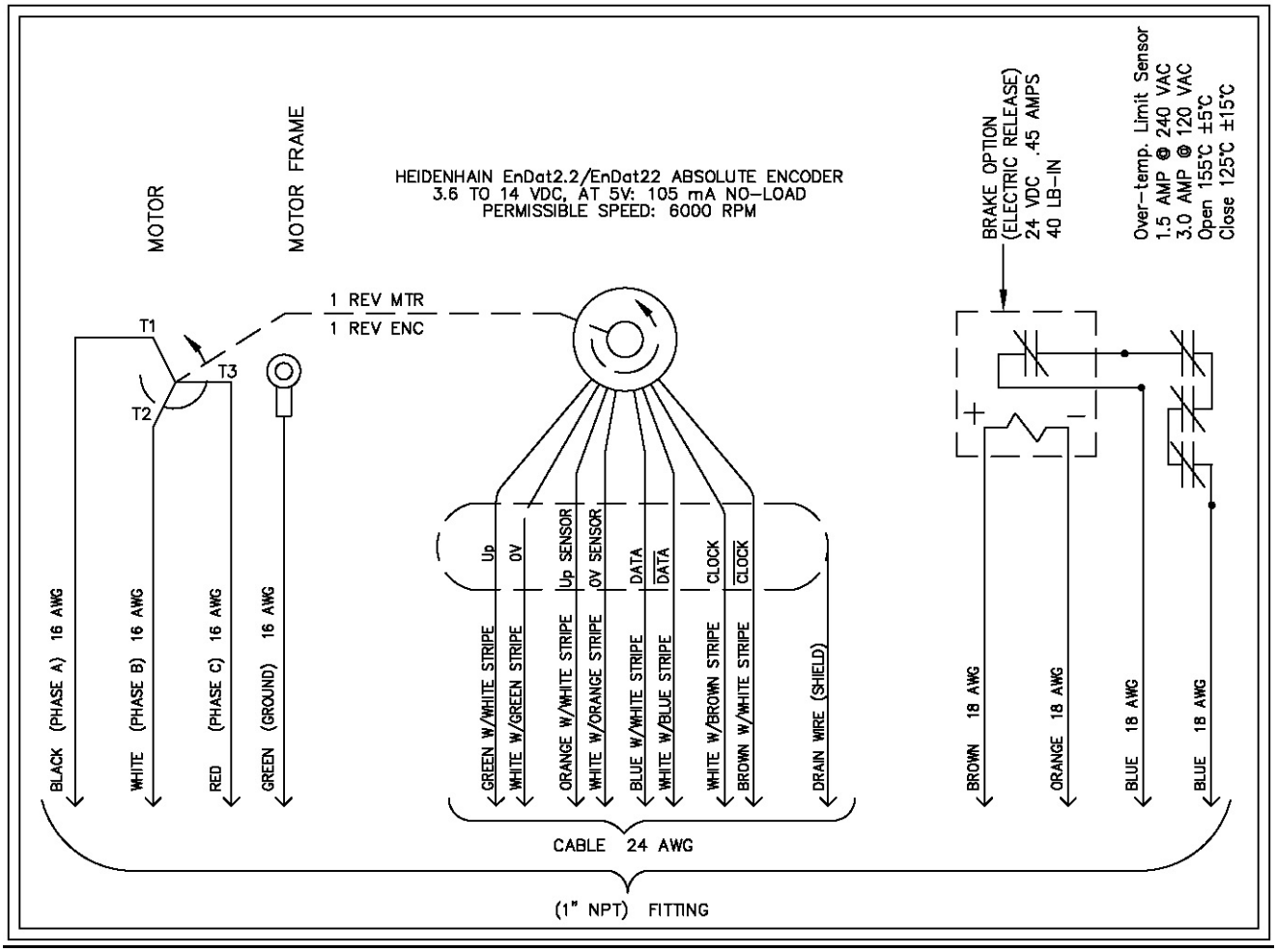
SIN / COS Encoder, One Leadwire Exit Fittings



Connection Diagram

M43X & M44X Motors

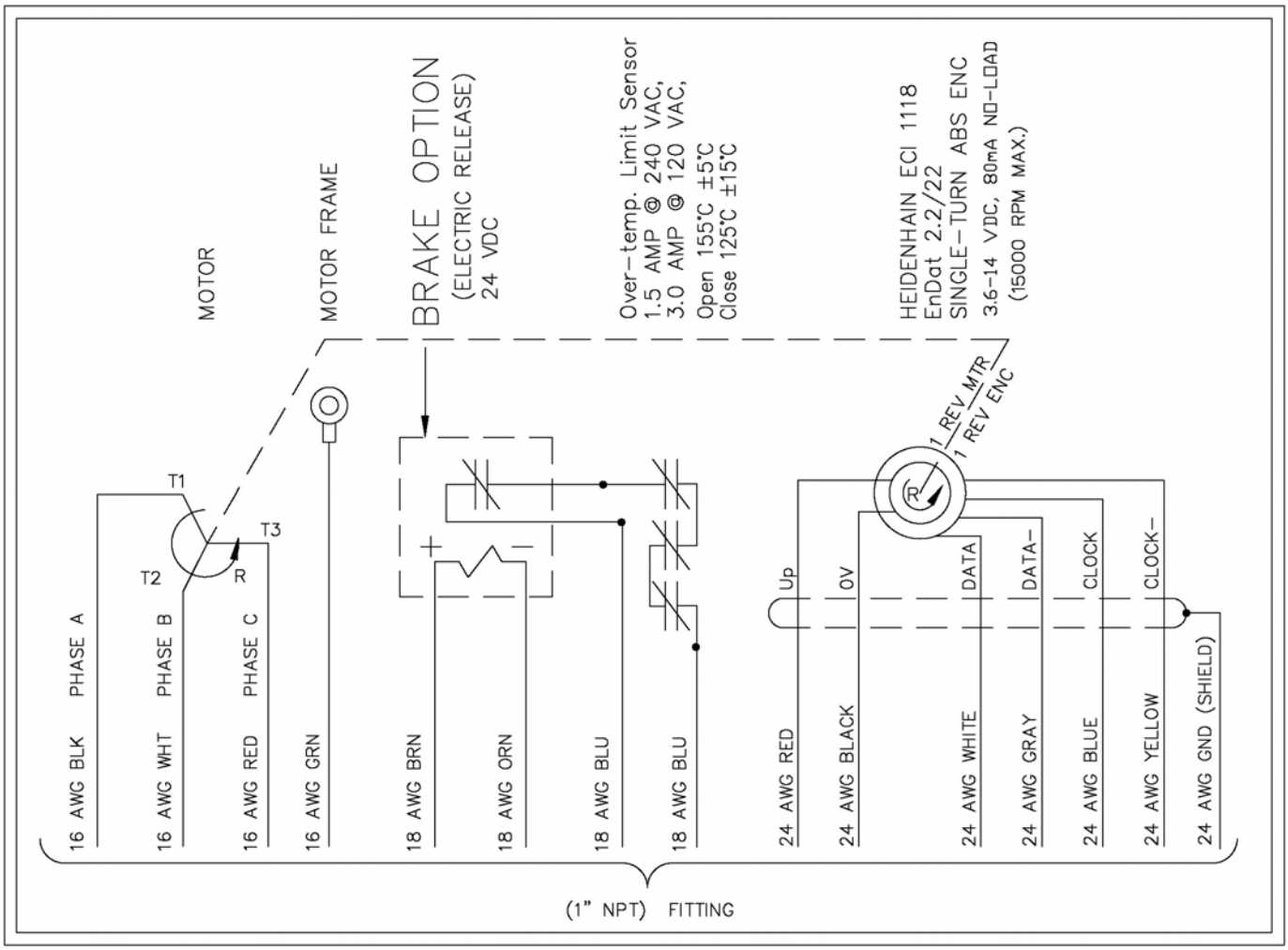
EnDat 2.2/22 Encoder, One Leadwire Exit Fitting



Connection Diagram

M43X & M44X Motors

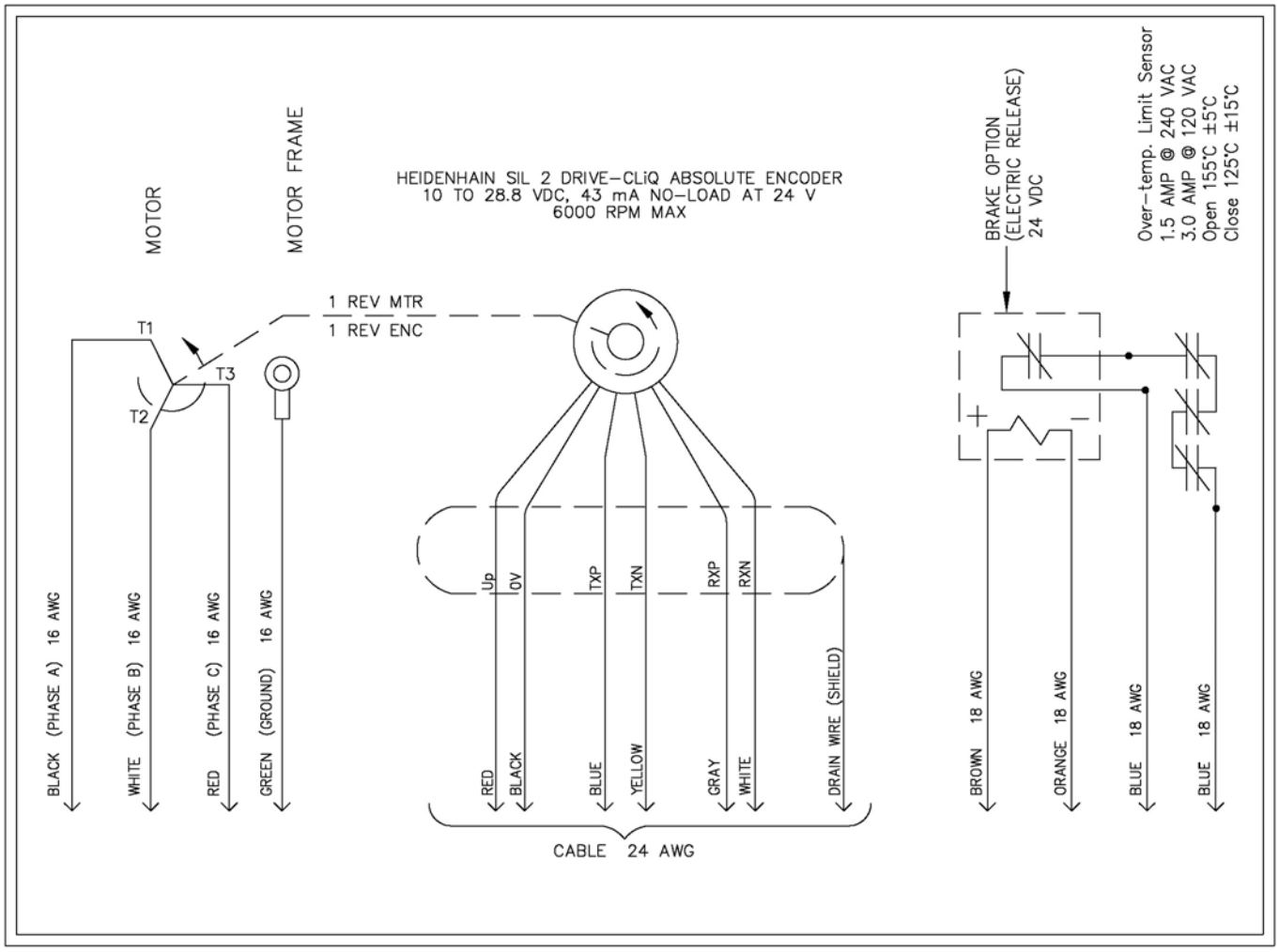
EnDat 2.2/22 Single-Turn Encoder, One Leadwire Exit Fitting



Connection Diagram

M43X & M44X Motors

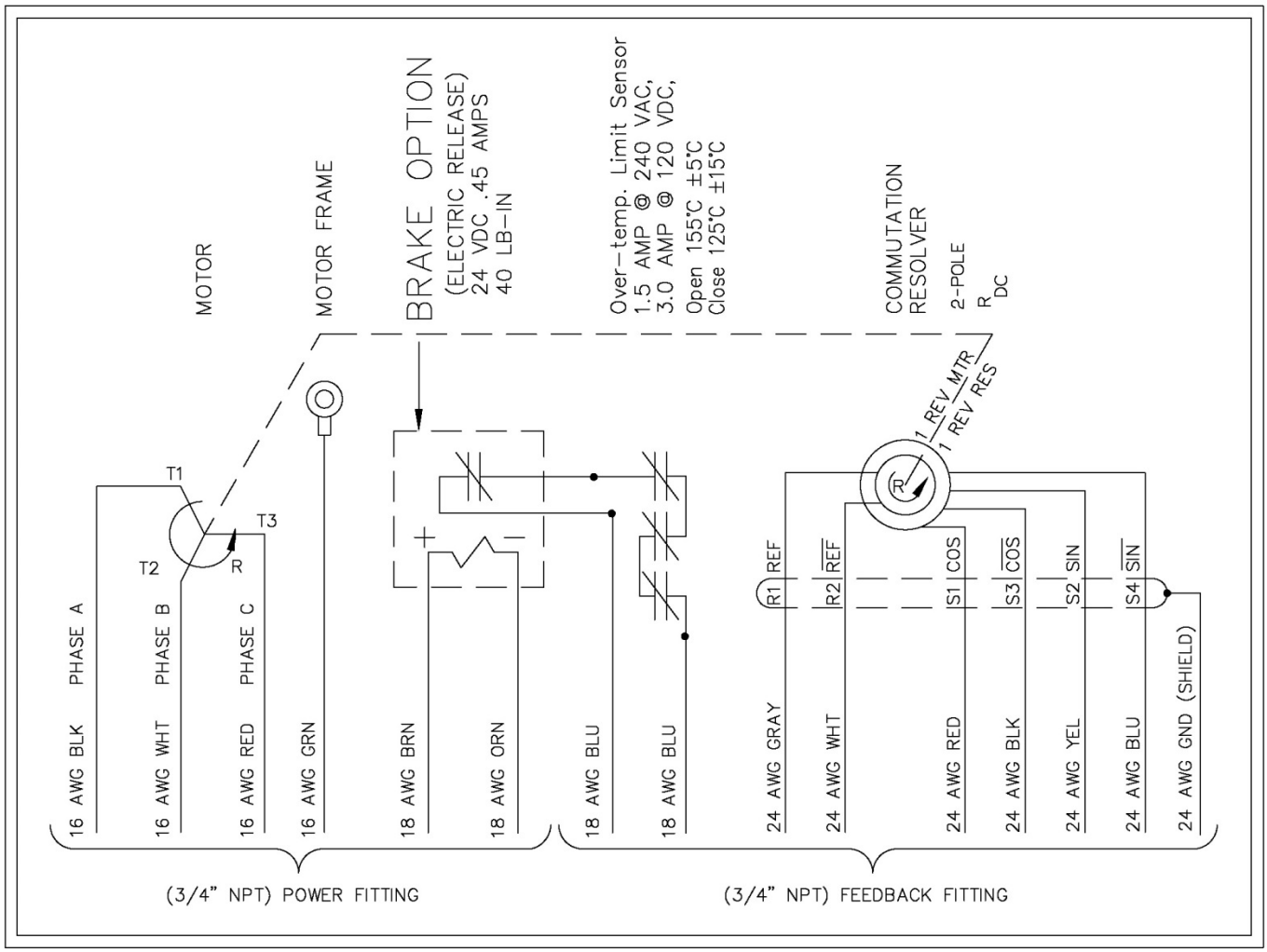
DriveCliq Encoder, One Leadwire Exit Fitting



Connection Diagram

M43X & M44X Motors

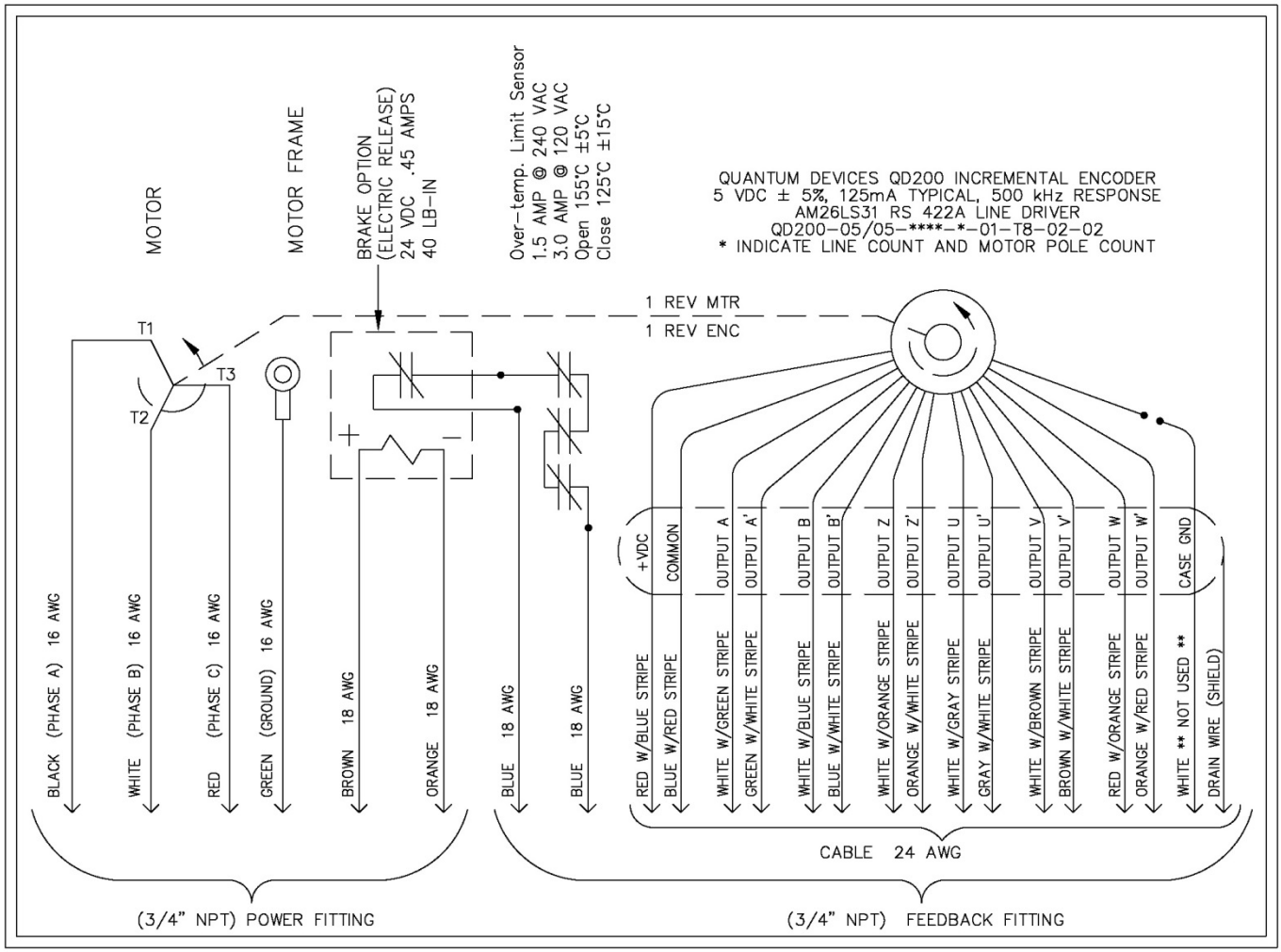
Single Resolver, Two Leadwire Exit Fittings



Connection Diagram

M43X & M44X Motors

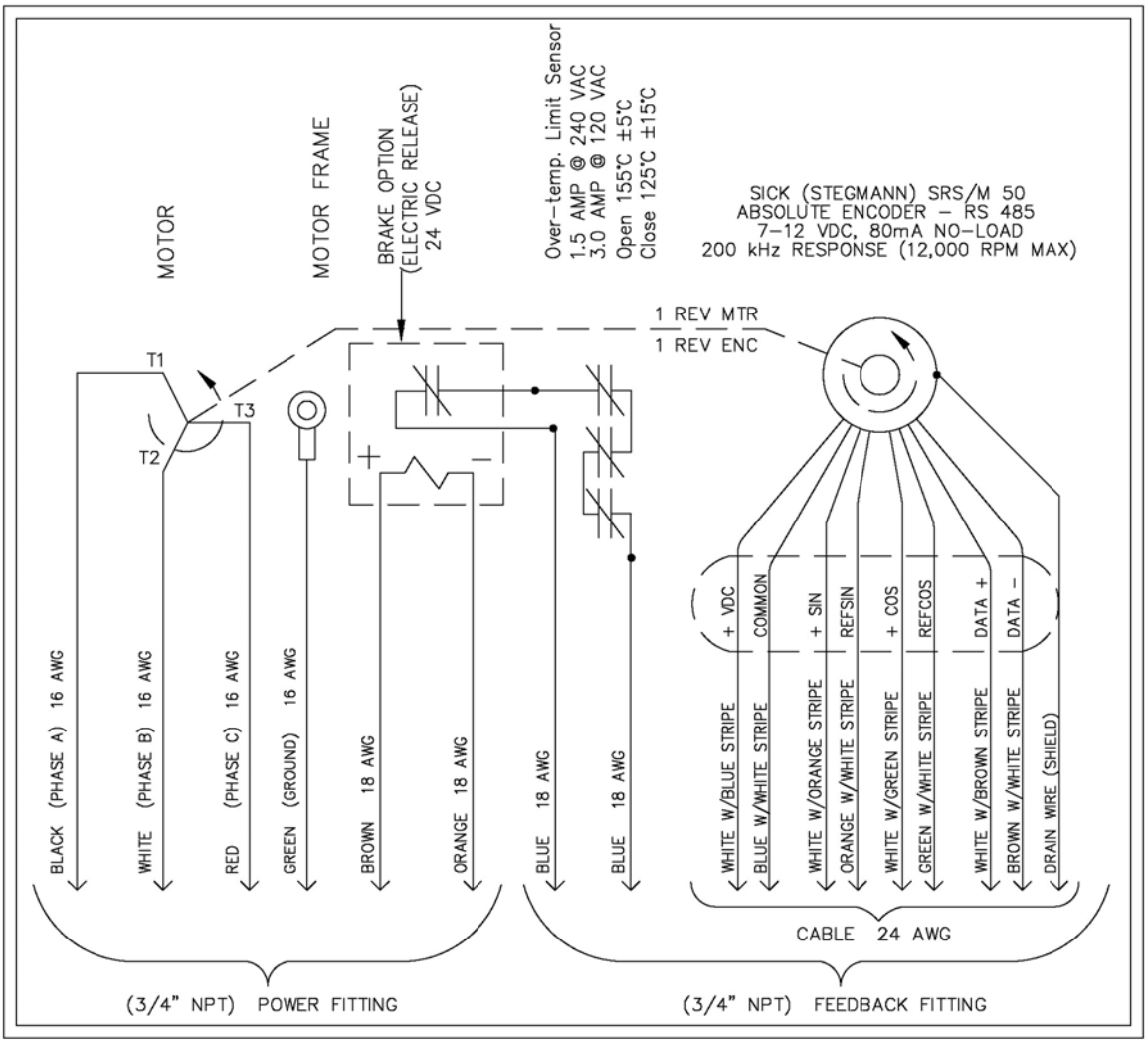
Incremental Encoder, Two Leadwire Exit Fittings



Connection Diagram

M43X & M44X Motors

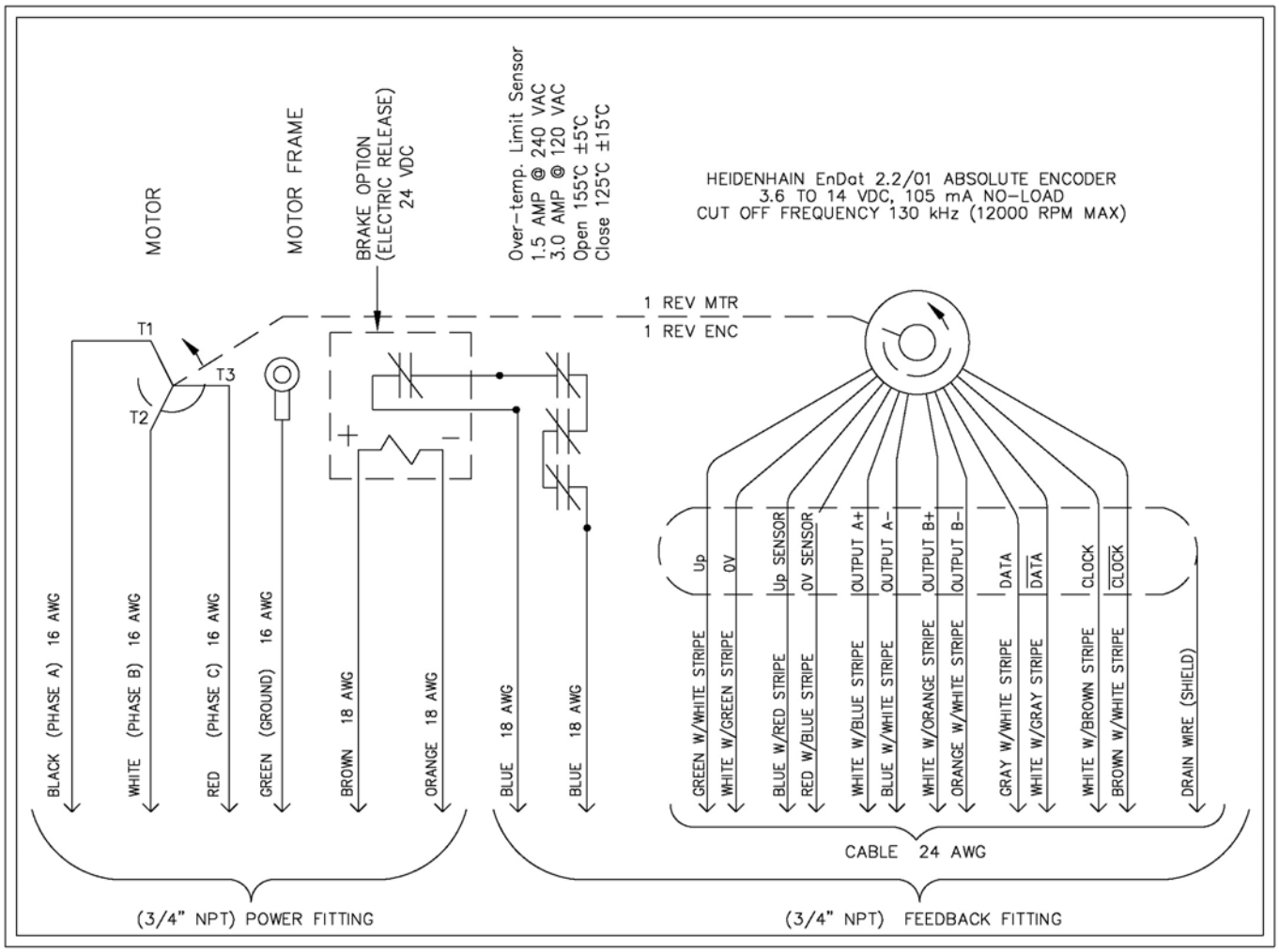
Absolute Encoder, Two Leadwire Exit Fittings



Connection Diagram

M43X & M44X Motors

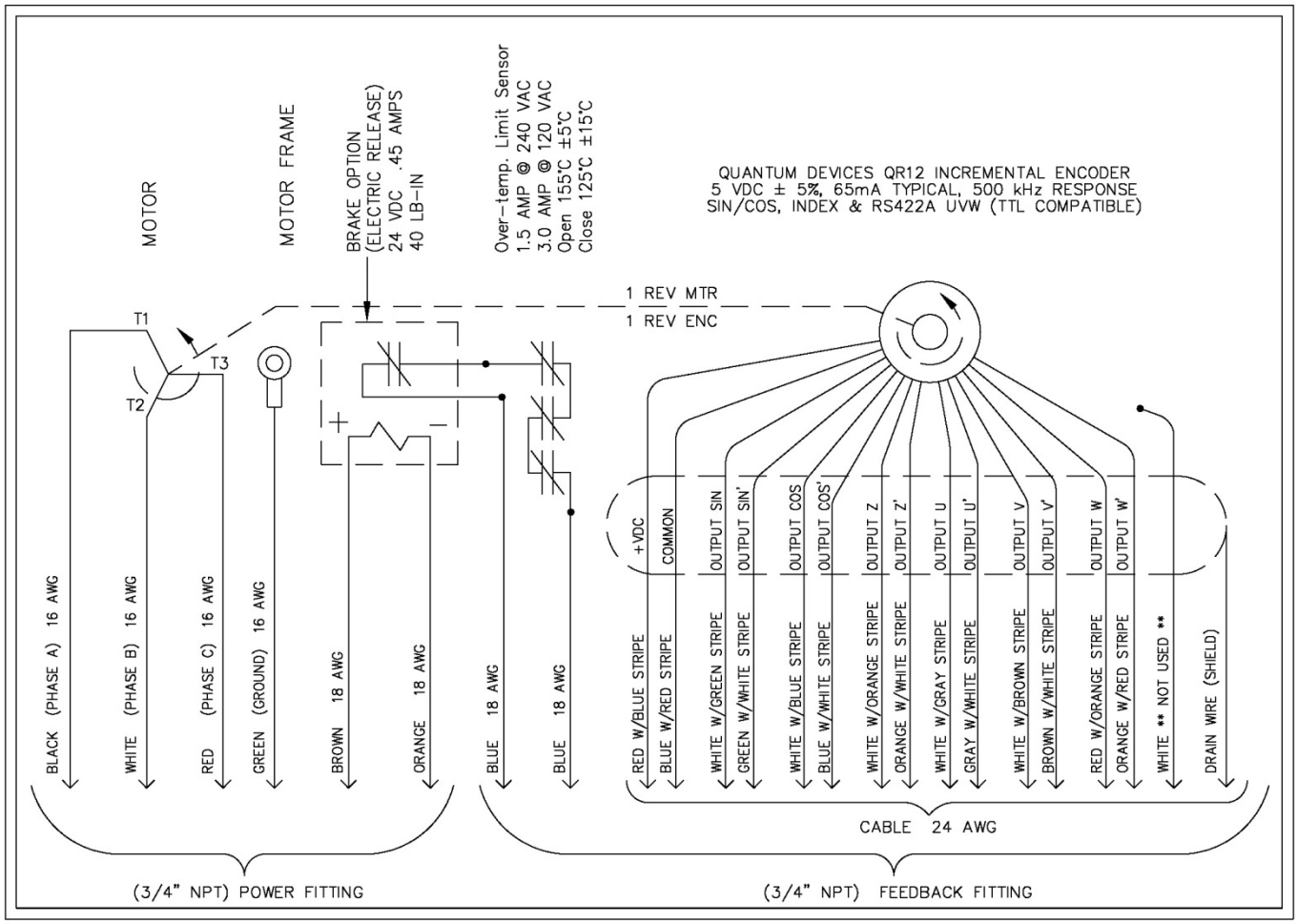
EnDat 2.2/01 Encoder, Two Leadwire Exit Fittings



Connection Diagram

M43X & M44X Motors

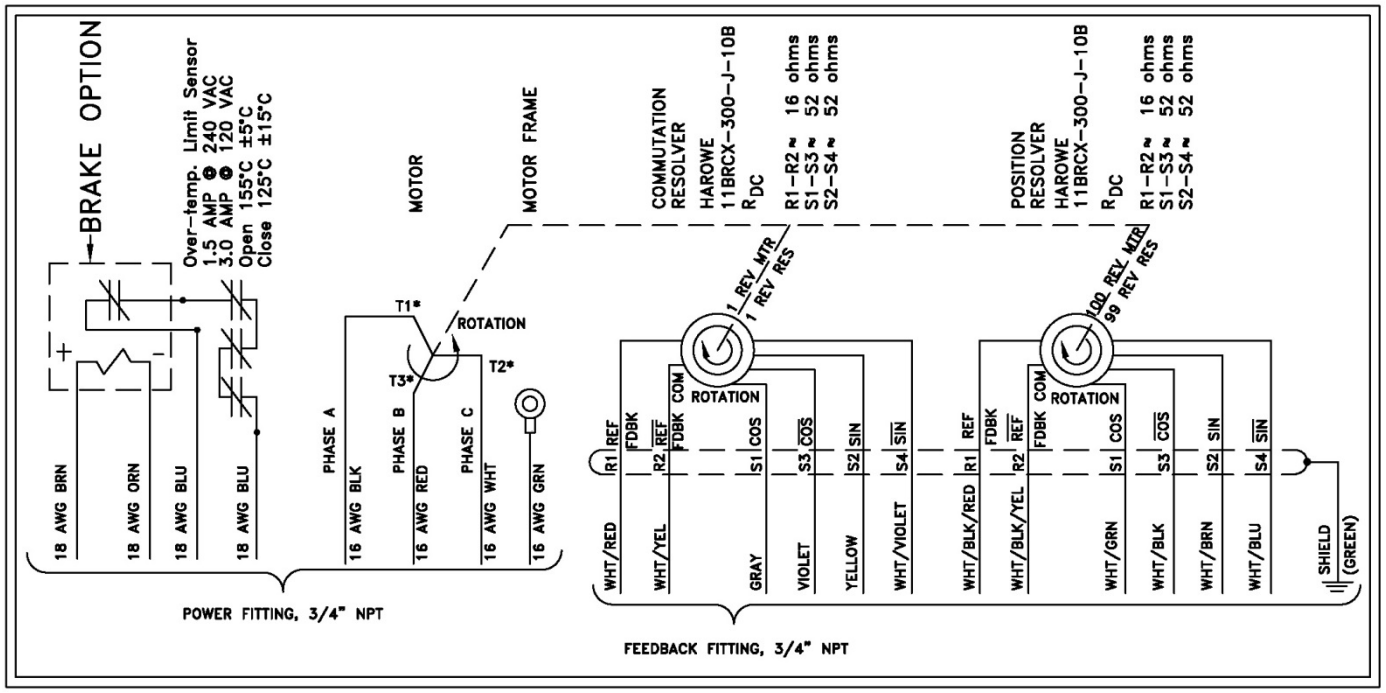
SIN / COS Encoder, Two Leadwire Exit Fittings



Connection Diagram

M43X & M44X Motors

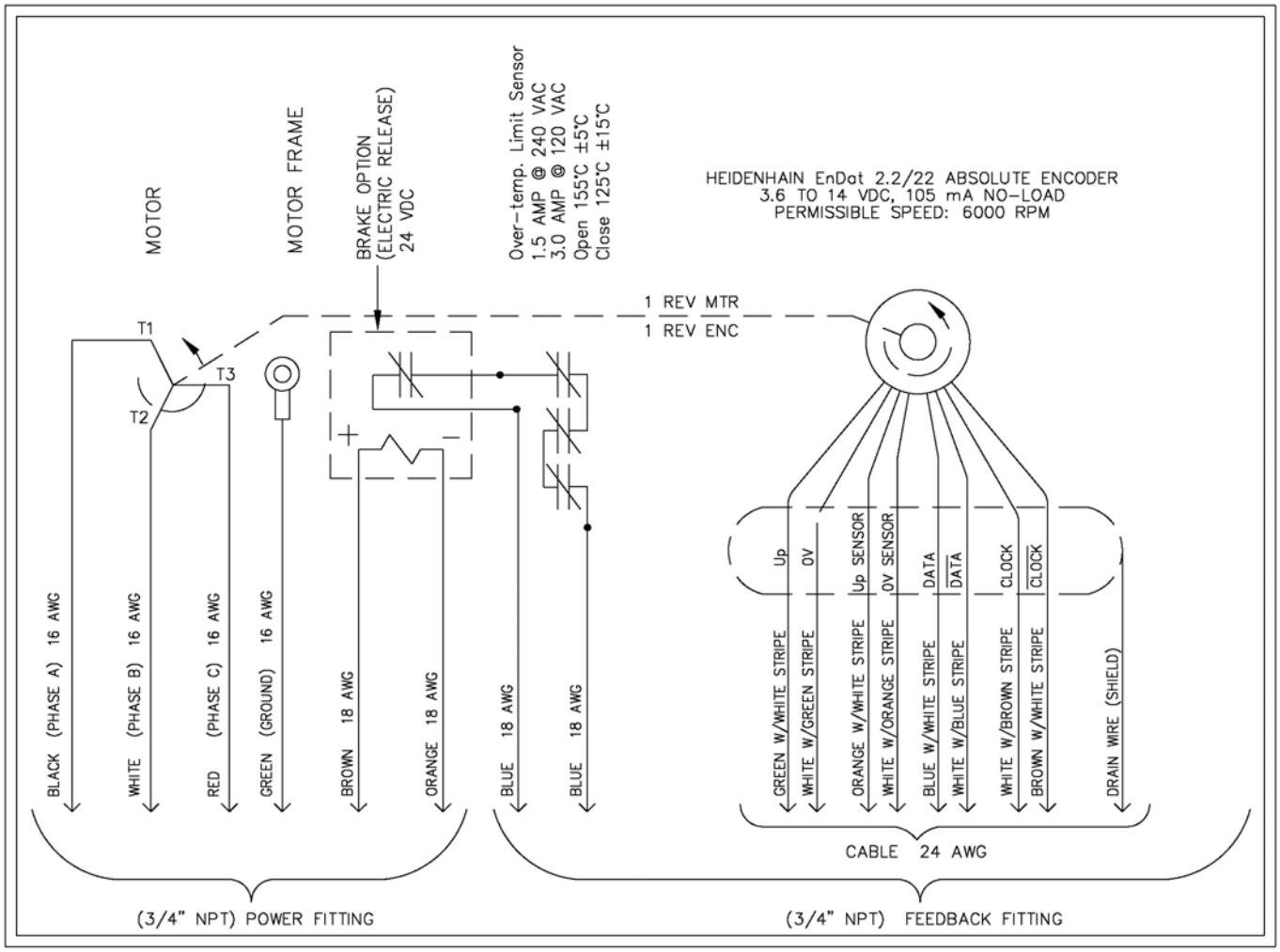
Dual Resolver, Two Leadwire Exit Fittings Connection Diagram



Connection Diagram

M43X & M44X Motors

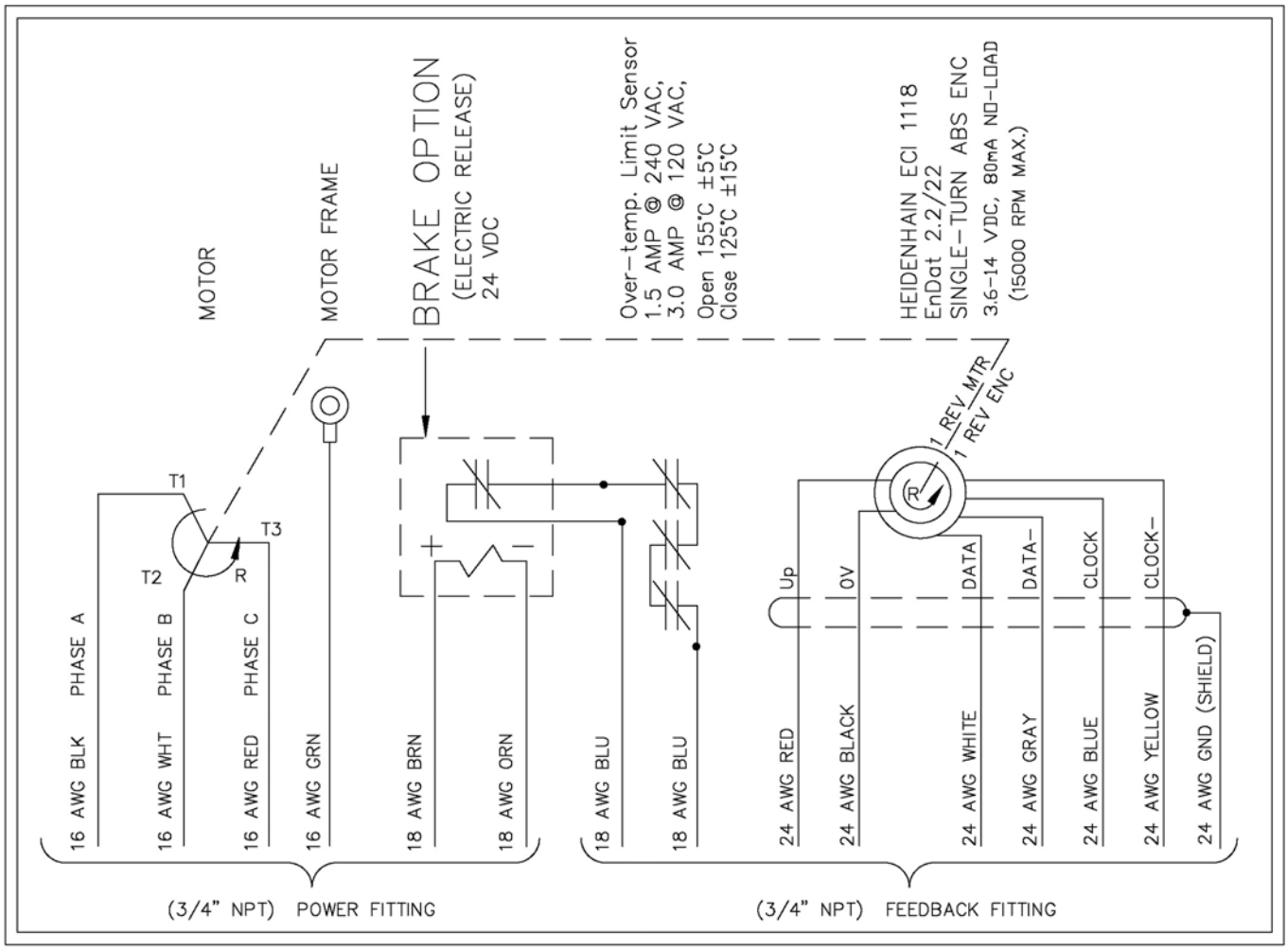
EnDat 2.2/22 Encoder, Two Leadwire Exit Fittings



Connection Diagram

M43X & M44X Motors

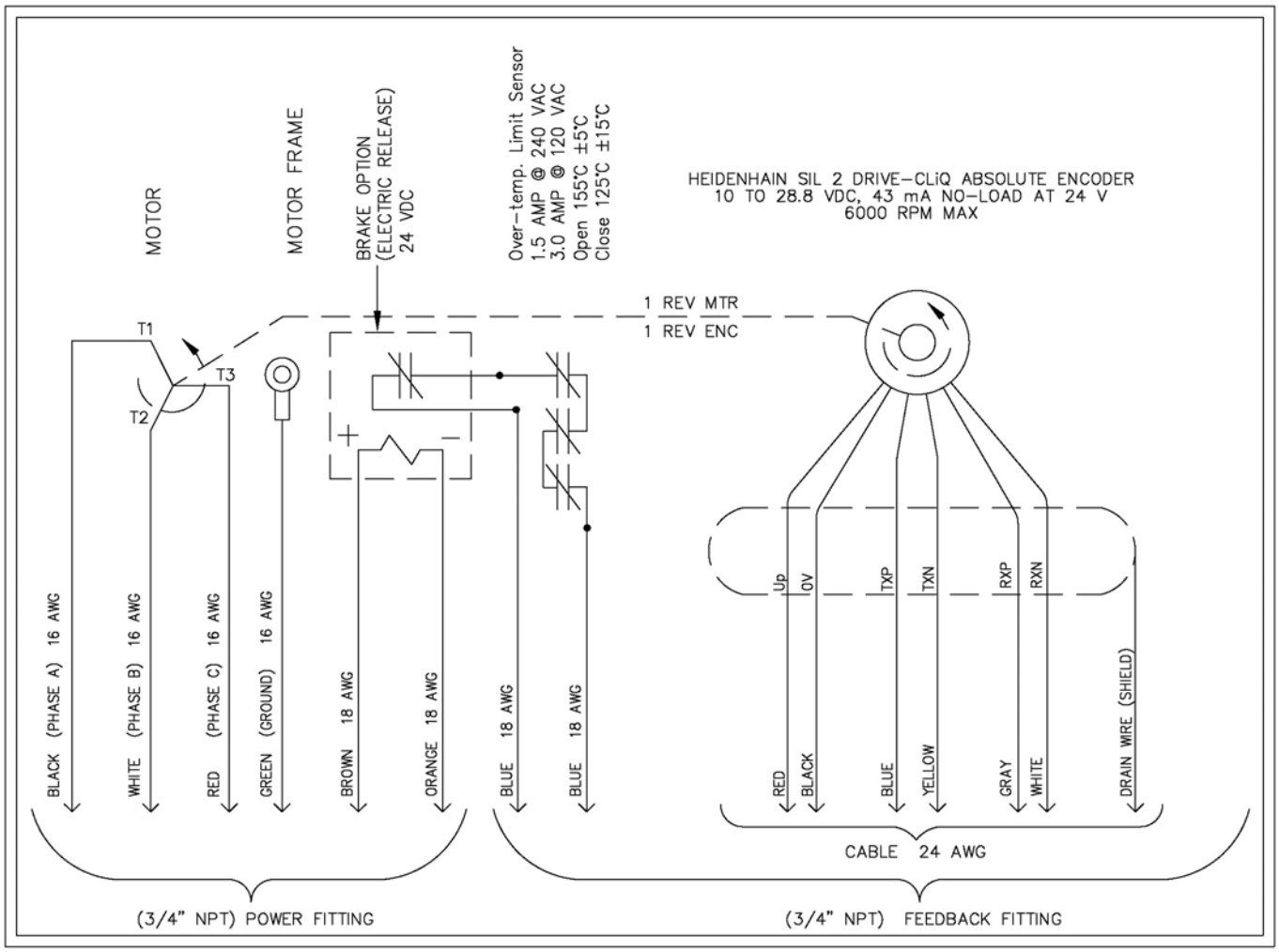
EnDat 2.2/22 Single-Turn Encoder, Two Leadwire Exit Fittings



Connection Diagram

M43X & M44X Motors

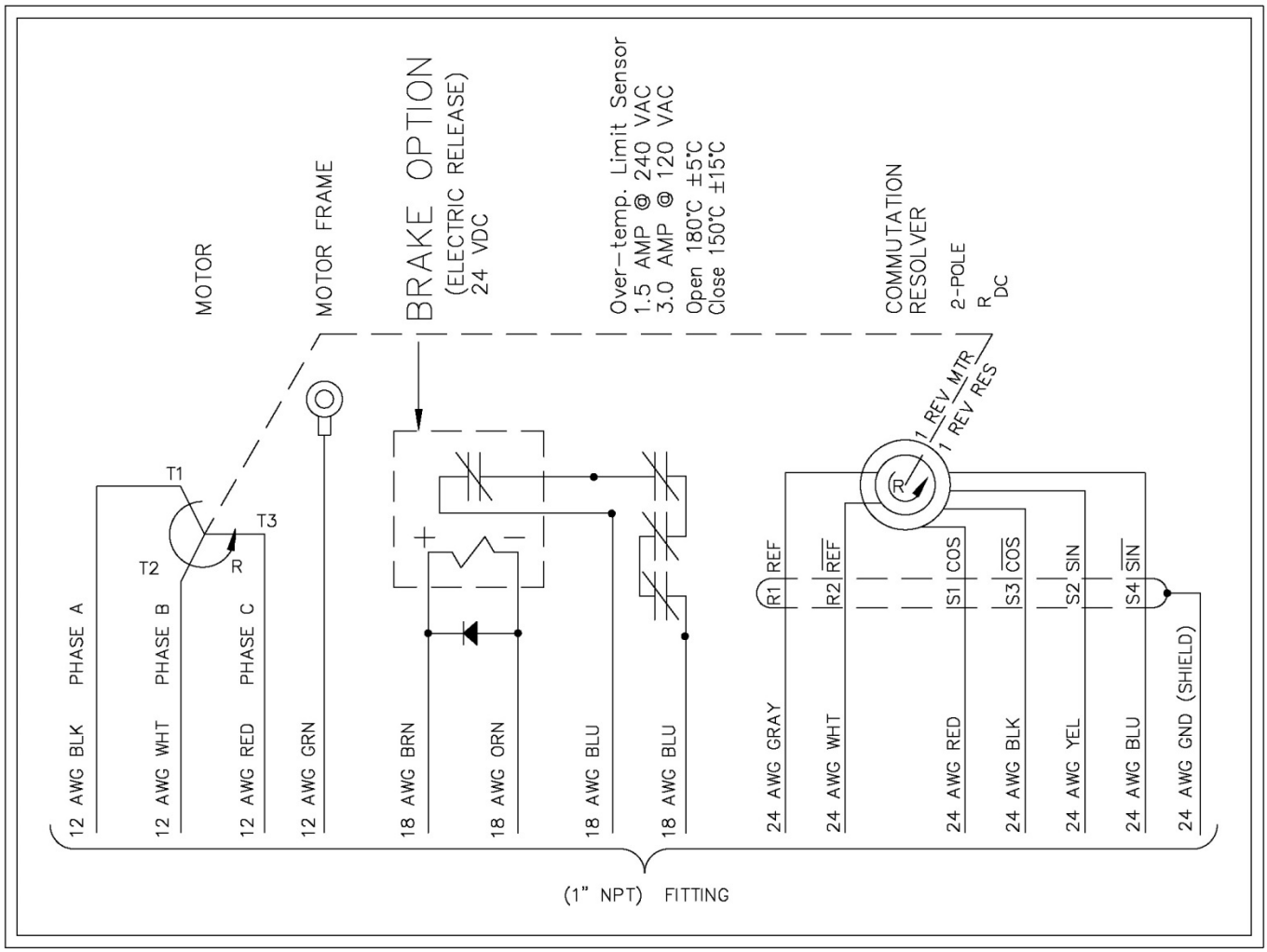
DriveClig Encoder, Two Leadwire Exit Fittings



Connection Diagram

M46X & M47X Motors

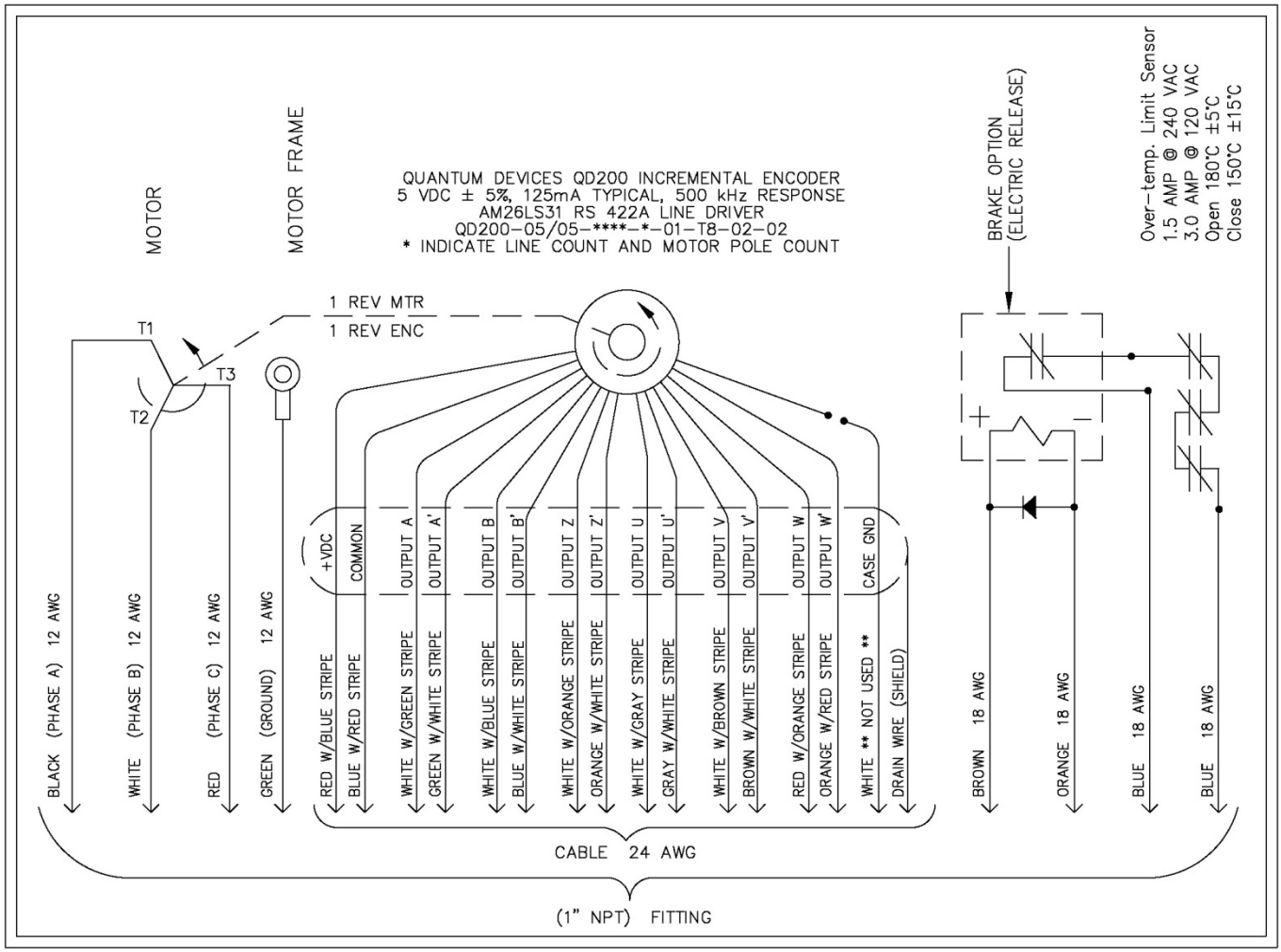
Single Resolver, One Leadwire Exit Fitting



Connection Diagram

M46X & M47X Motors

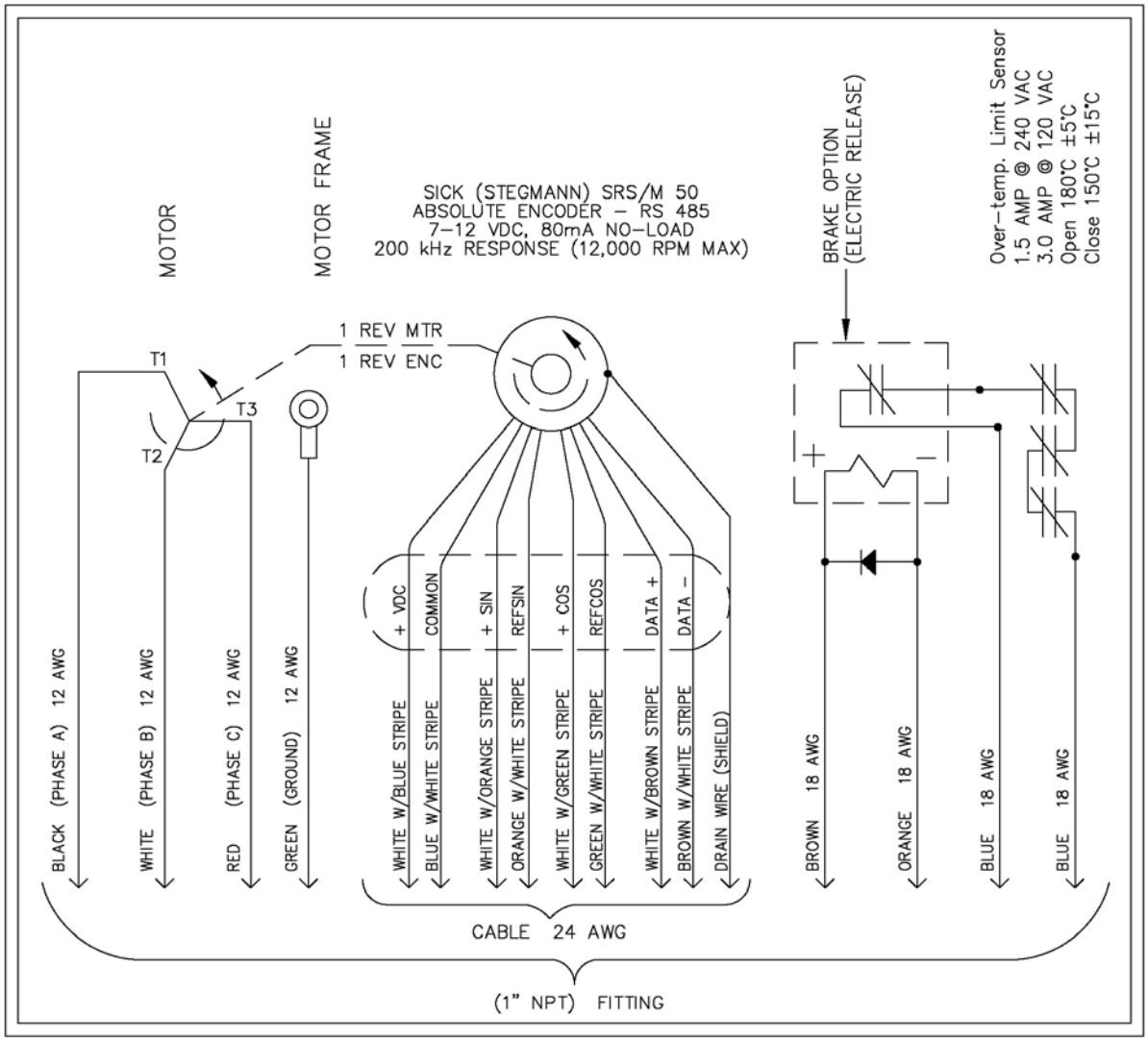
Incremental Encoder, One Leadwire Exit Fitting



Connection Diagram

M46X & M47X Motors

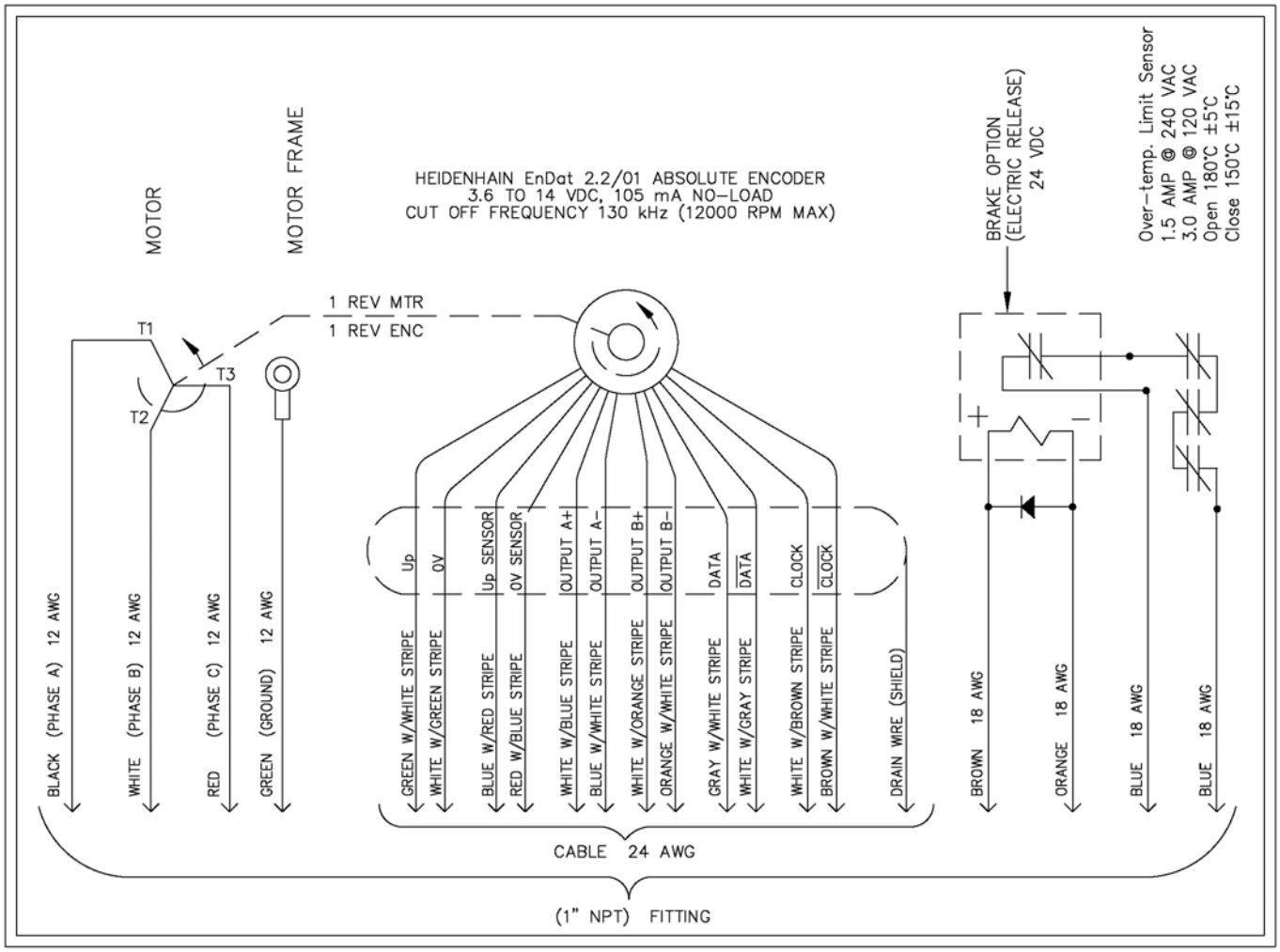
Absolute Encoder, One Leadwire Exit Fitting



Connection Diagram

M46X & M47X Motors

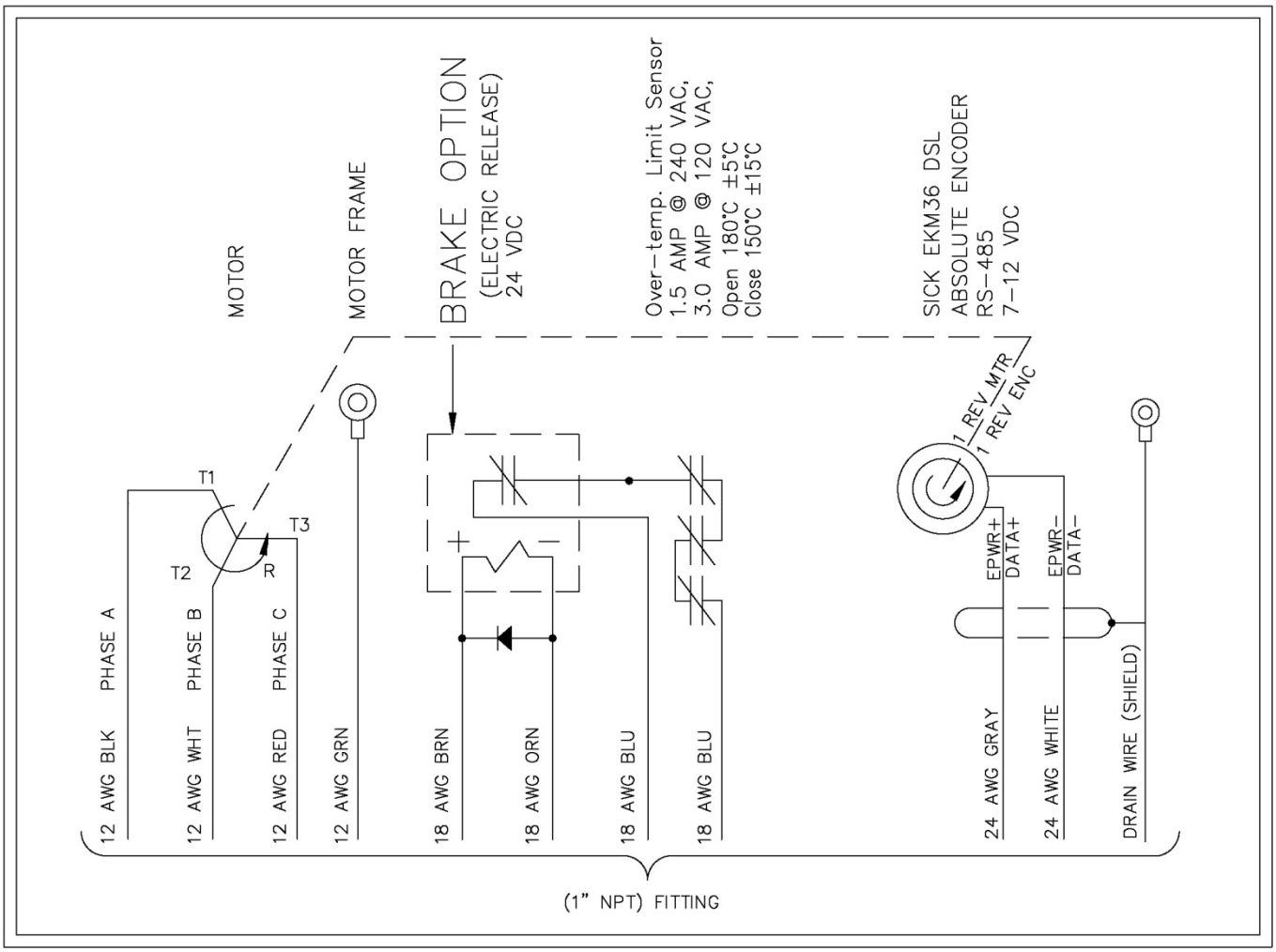
EnDat 2.2/01 Encoder, One Leadwire Exit Fitting



Connection Diagram

M46X & M47X Motors

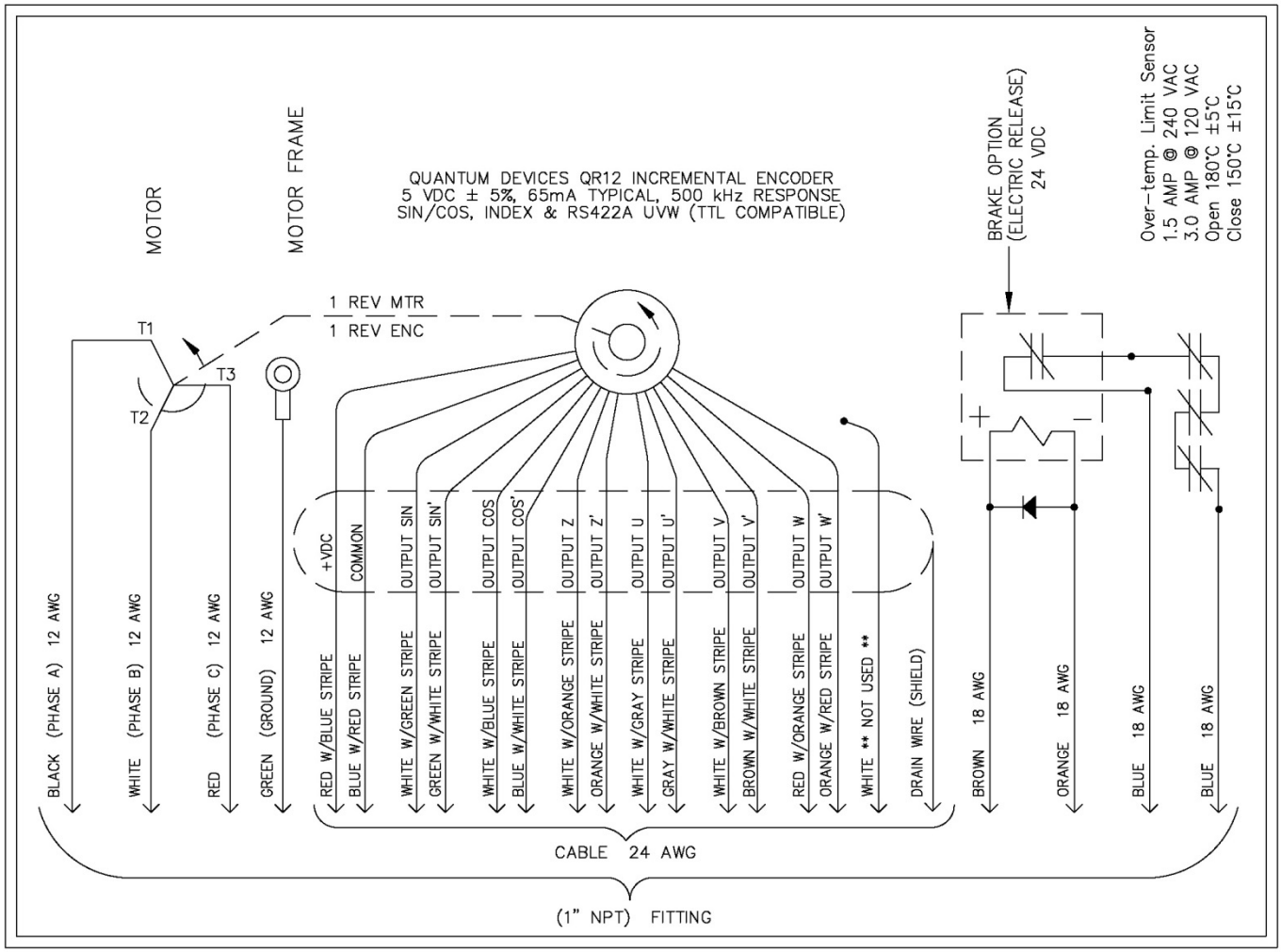
DSL Absolute Encoder, One Leadwire Exit Fitting



Connection Diagram

M46X & M47X Motors

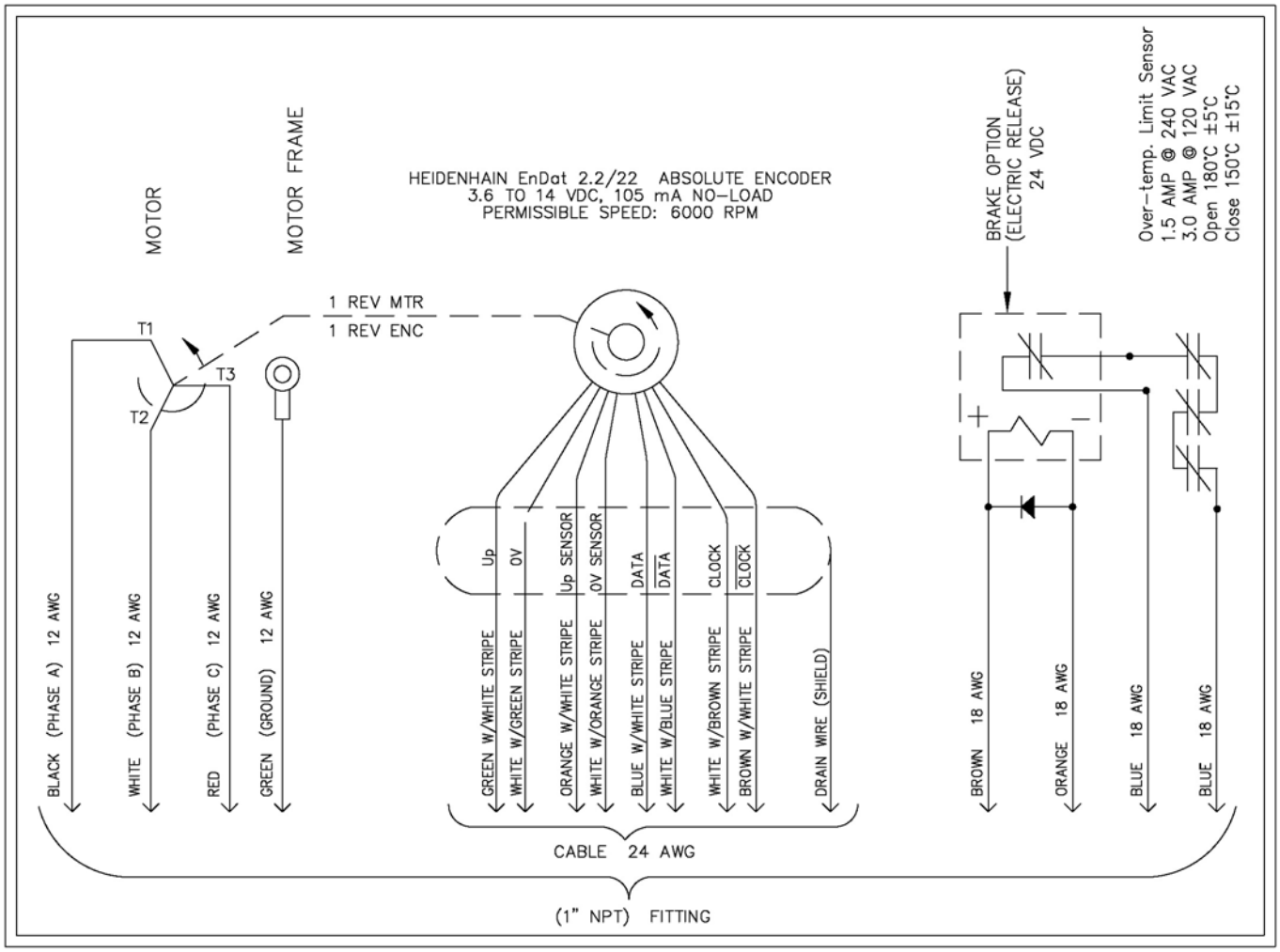
SIN / COS Encoder, One Leadwire Exit Fitting



Connection Diagram

M46X & M47X Motors

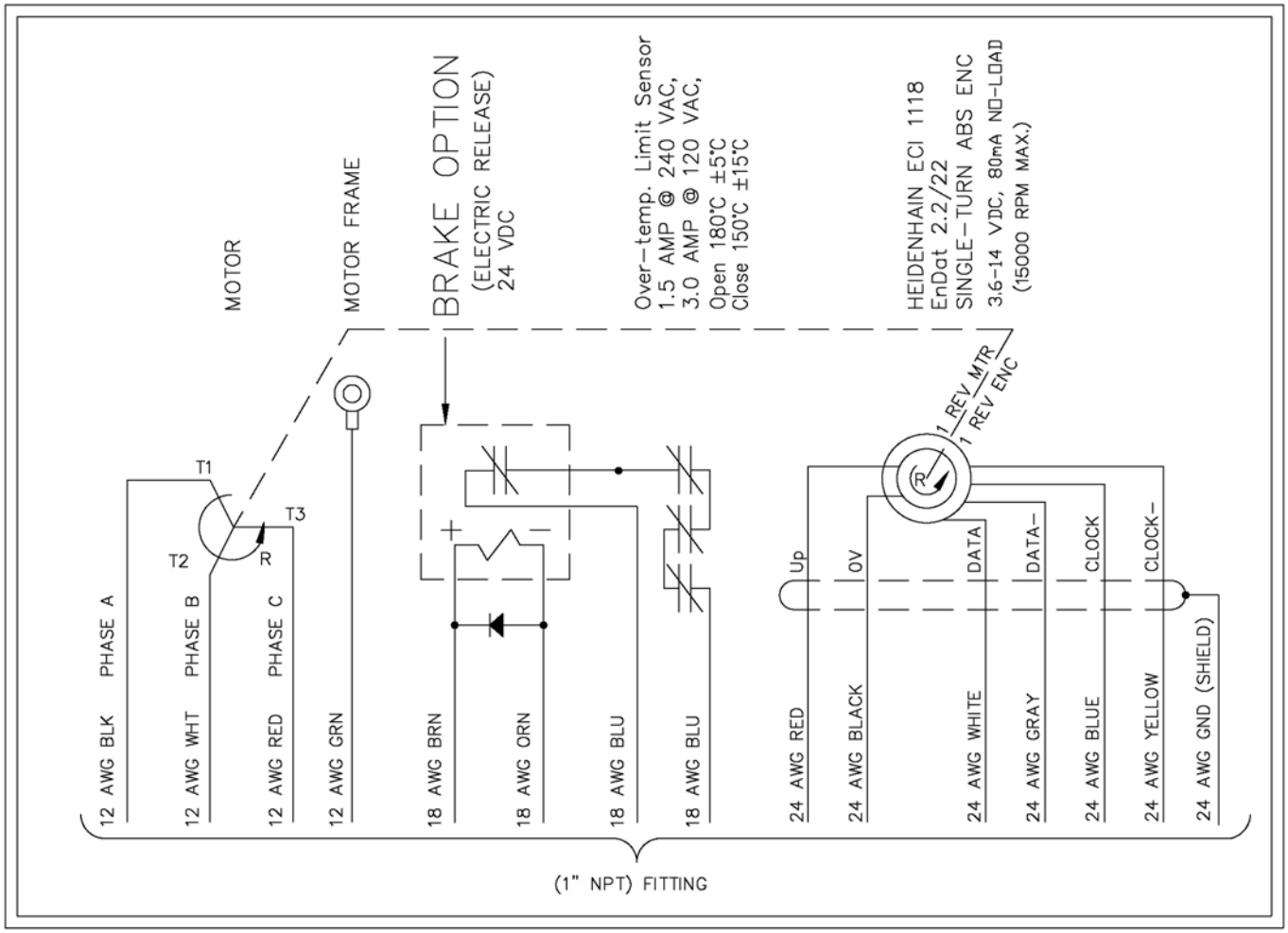
EnDat 2.2/22 Encoder, One Leadwire Exit Fitting



Connection Diagram

M46X & M47X Motors

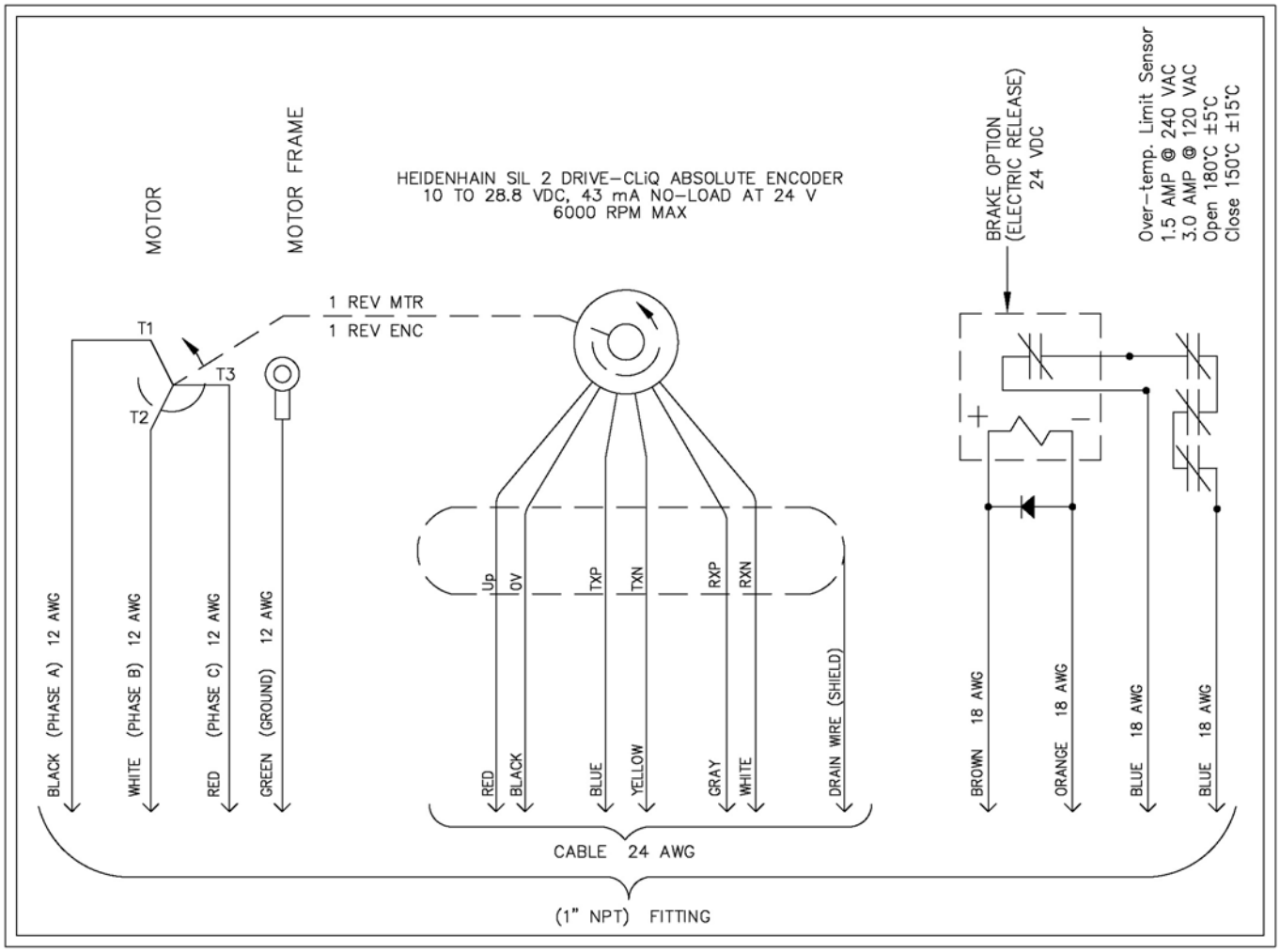
EnDat 2.2/22 Single-Turn Encoder, One Leadwire Exit Fitting



Connection Diagram

M46X & M47X Motors

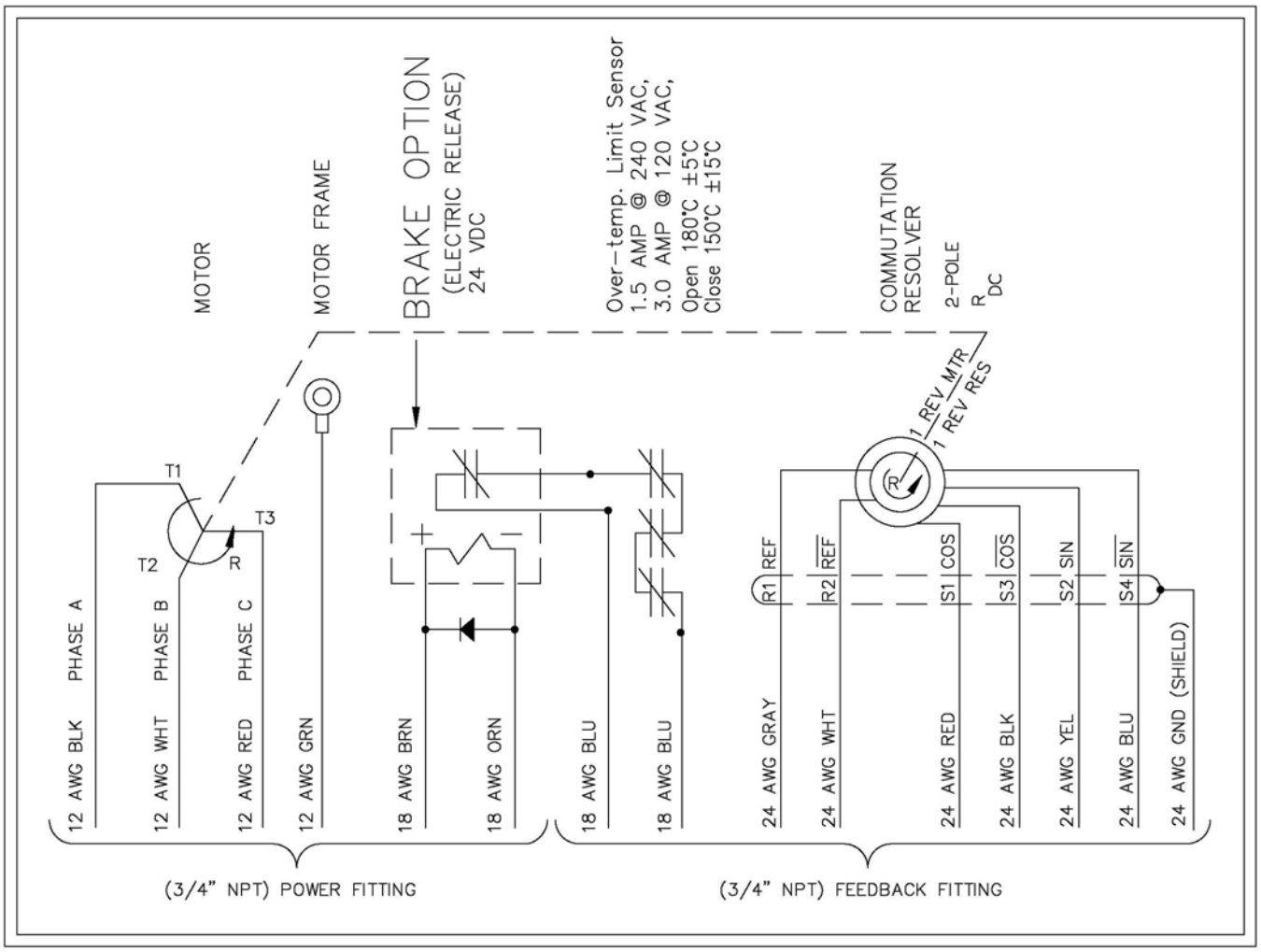
DriveCliQ Encoder, One Leadwire Exit Fitting



Connection Diagram

M46X & M47X Motors

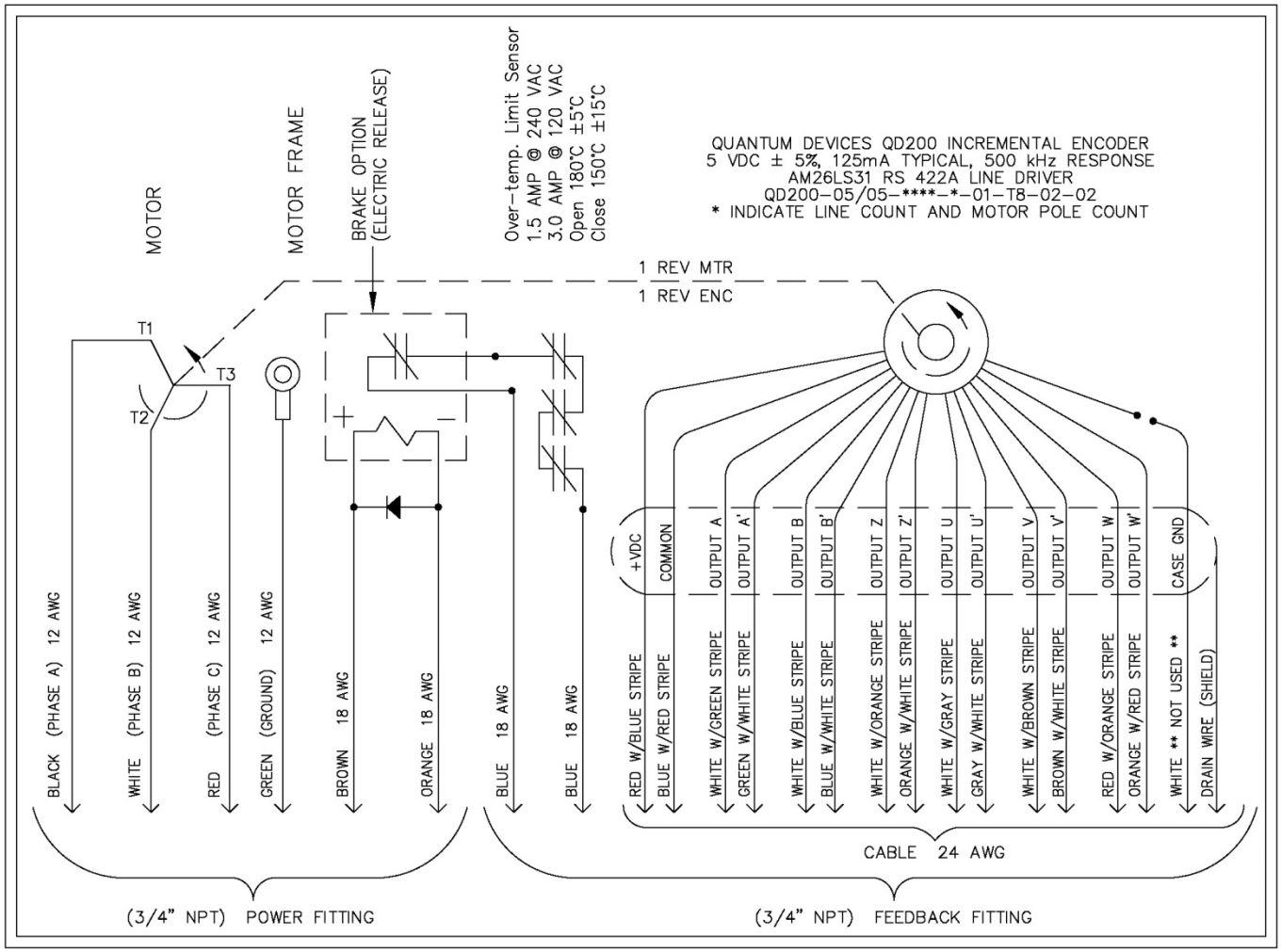
Single Resolver, Two Leadwire Exit Fittings



Connection Diagram

M46X & M47X Motors

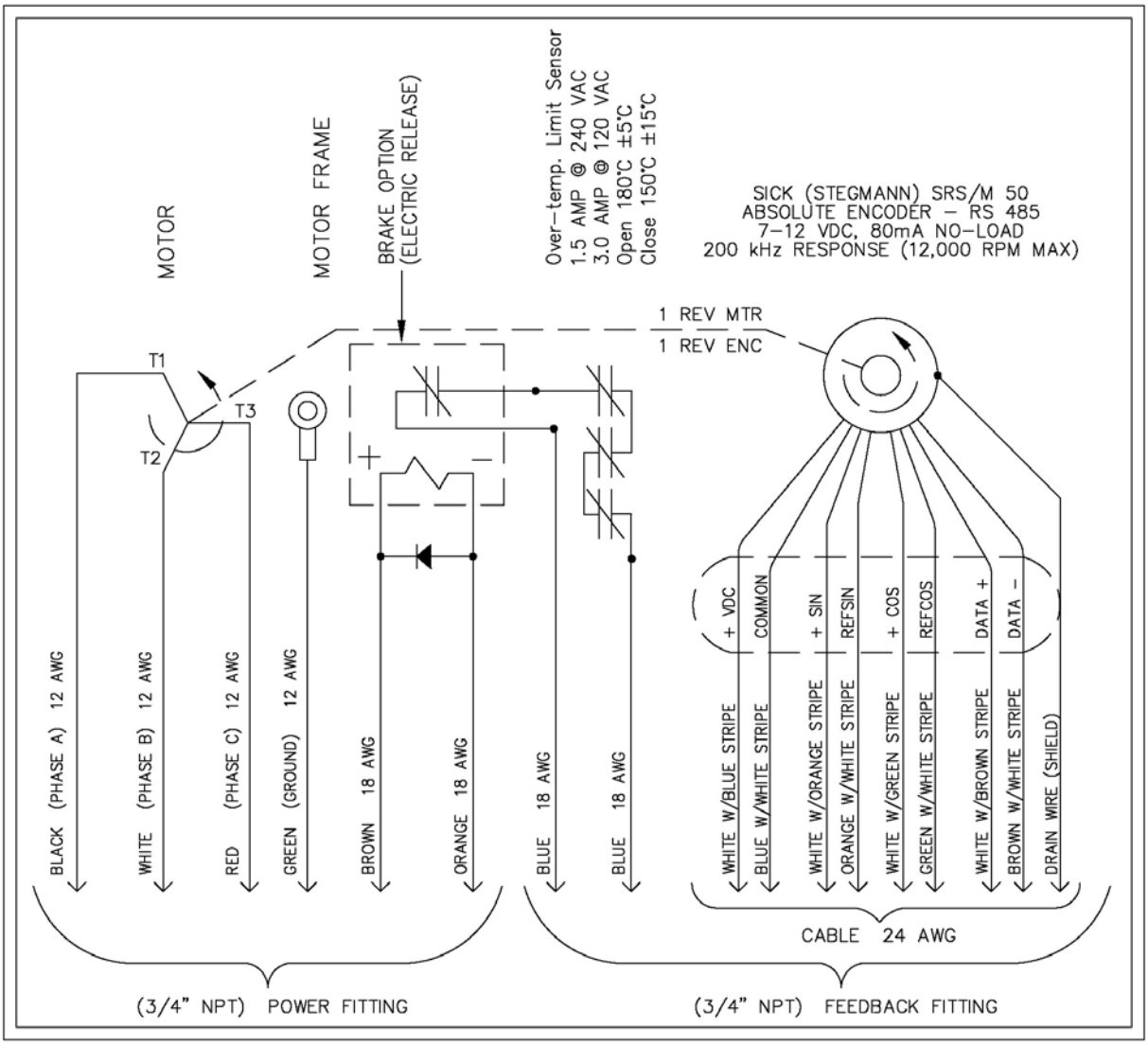
Incremental Encoder, Two Leadwire Exit Fittings



Connection Diagram

M46X & M47X Motors

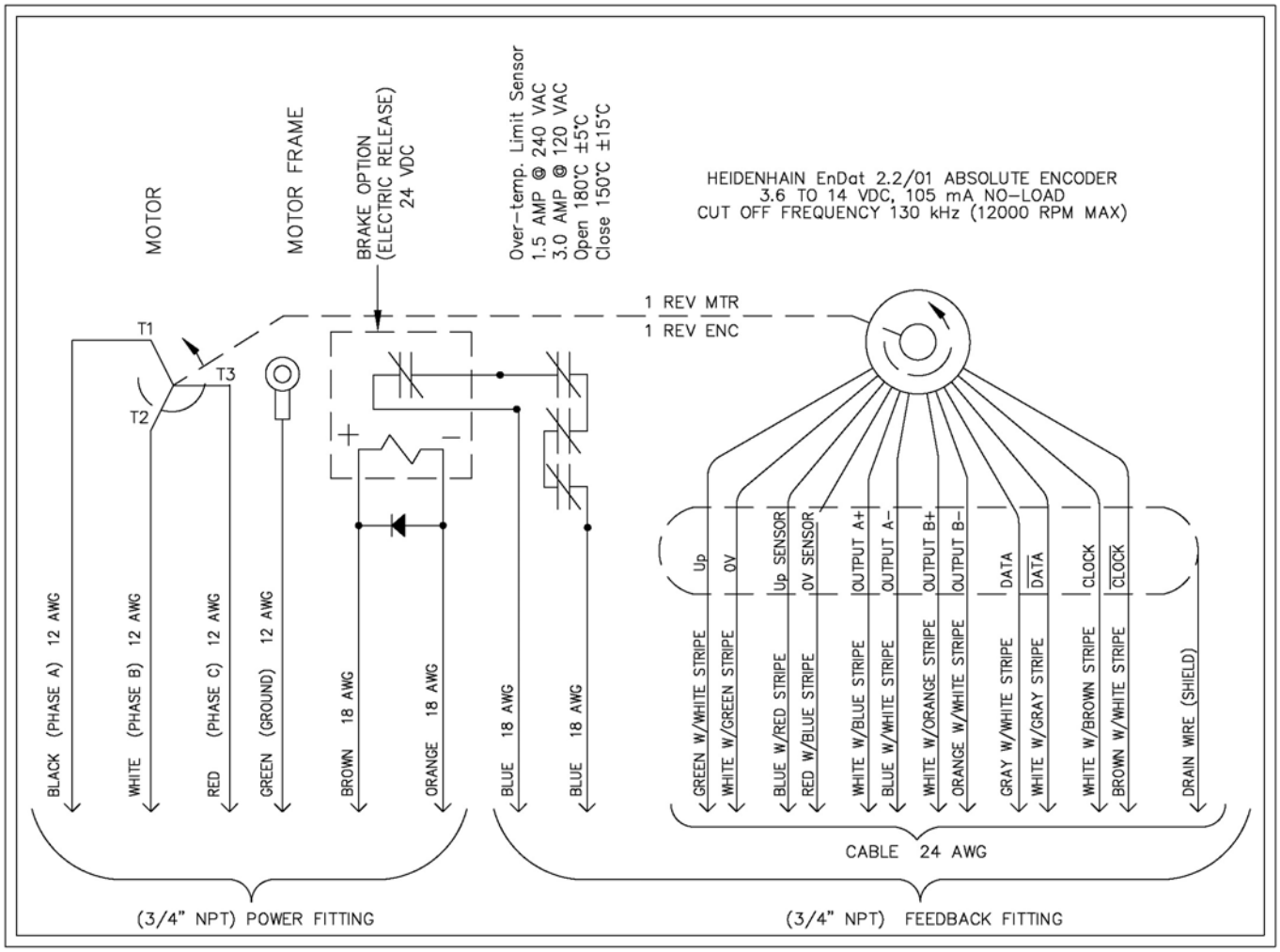
Absolute Encoder, Two Leadwire Exit Fittings



Connection Diagram

M46X & M47X Motors

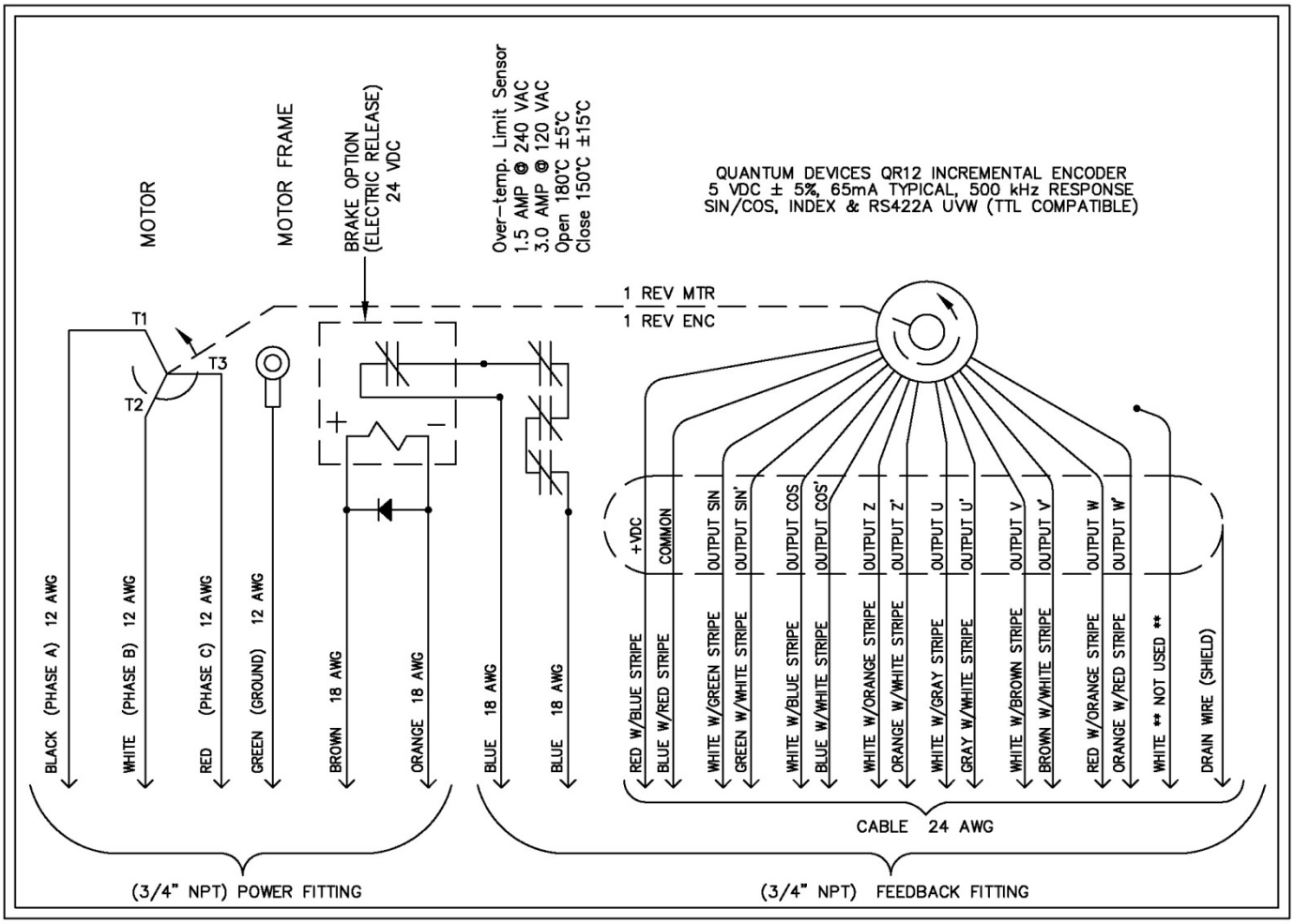
EnDat 2.2/01 Encoder, Two Leadwire Exit Fittings



Connection Diagram

M46X & M47X Motors

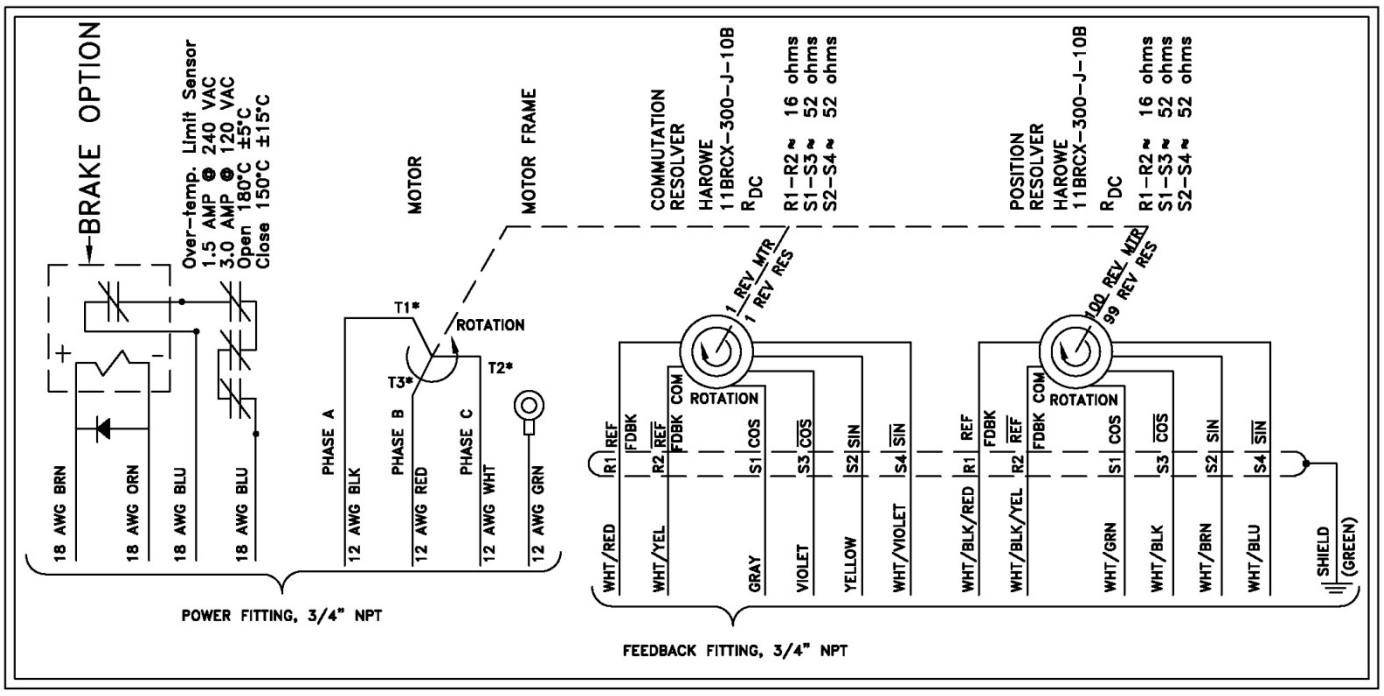
SIN / COS Encoder, Two Leadwire Exit Fittings



Connection Diagram

M46X & M47X Motors

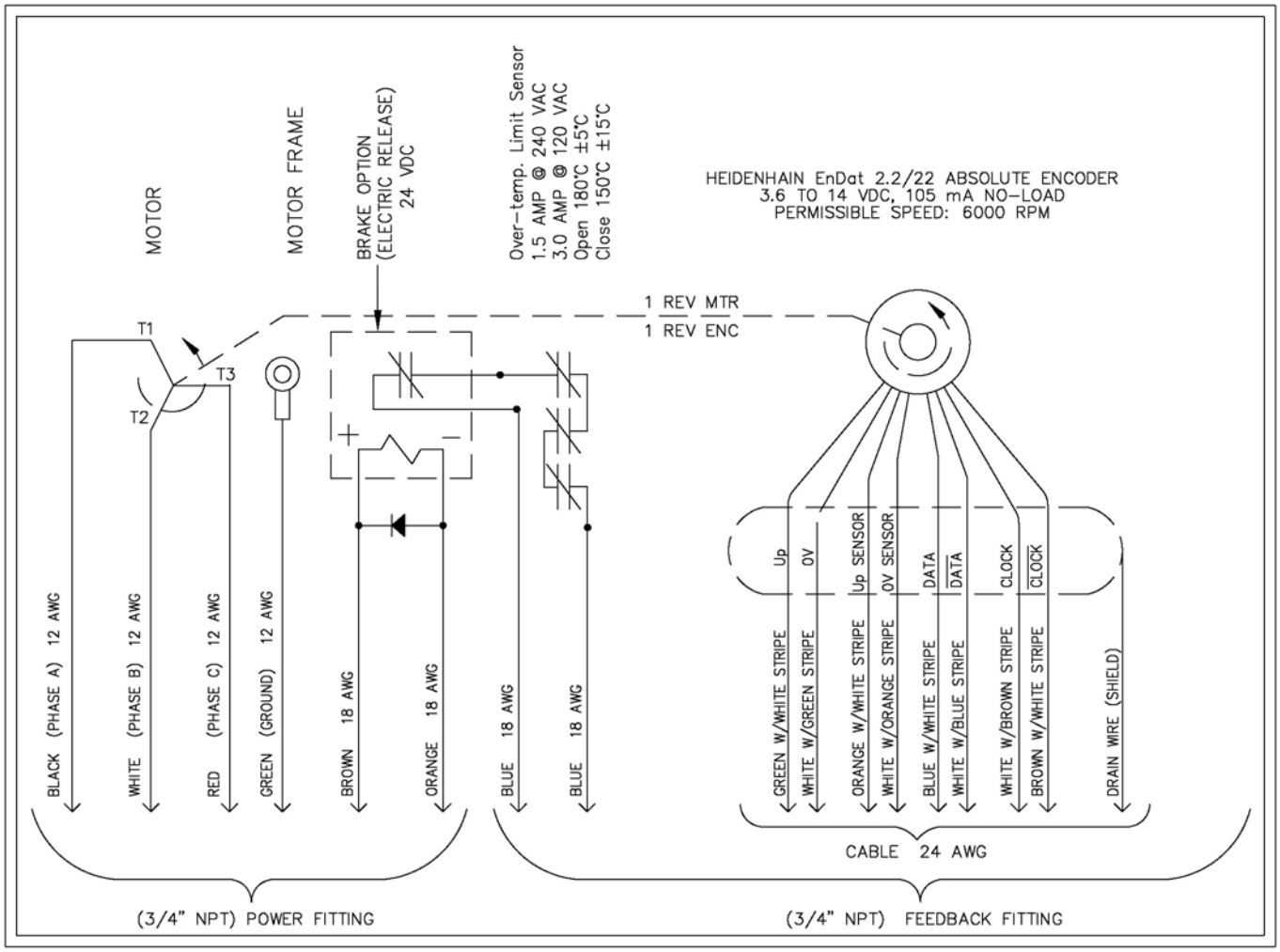
Dual Resolver, Two Leadwire Exit Fittings



Connection Diagram

M46X & M47X Motors

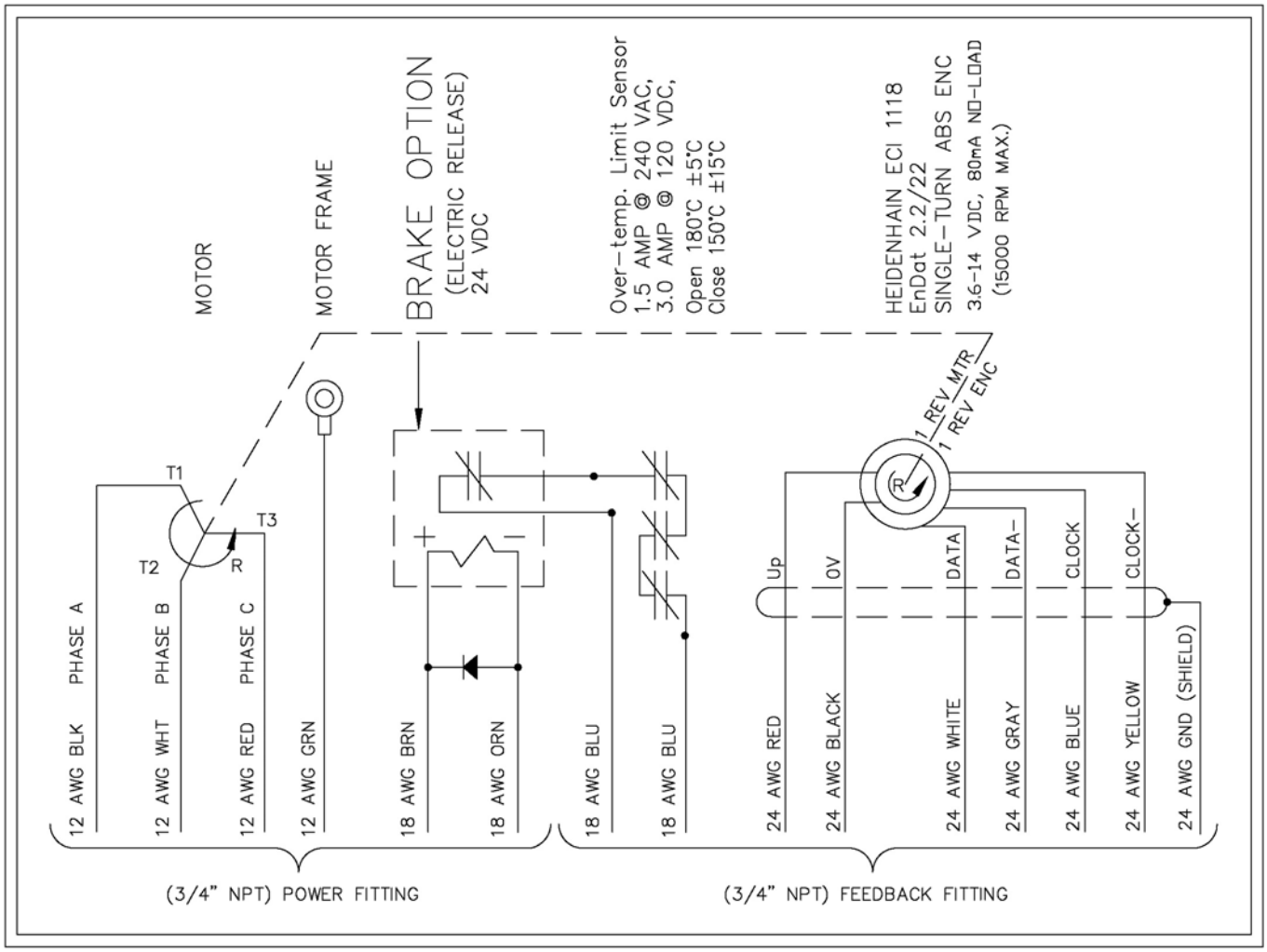
EnDat 2.2/22 Encoder, Two Leadwire Exit Fittings



Connection Diagram

M46X & M47X Motors

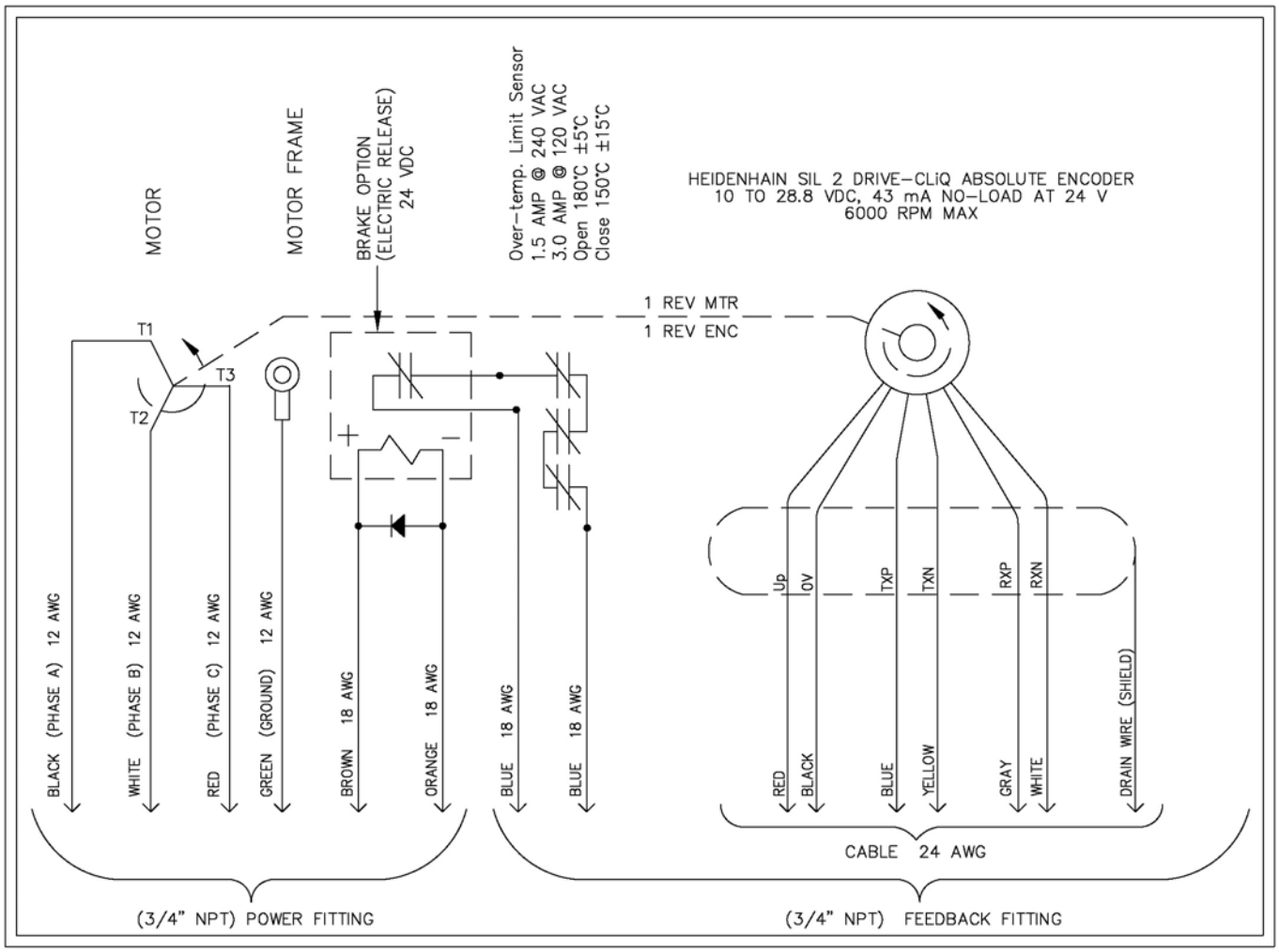
EnDat 2.2/22 Single-Turn Encoder, Two Leadwire Exit Fittings



Connection Diagram

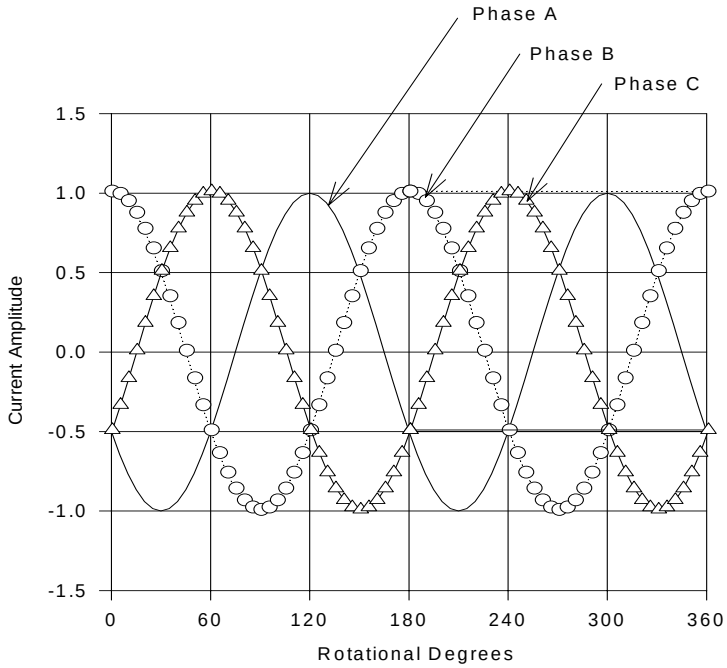
M46X & M47X Motors

DriveCliQ Encoder, Two Leadwire Exit Fittings

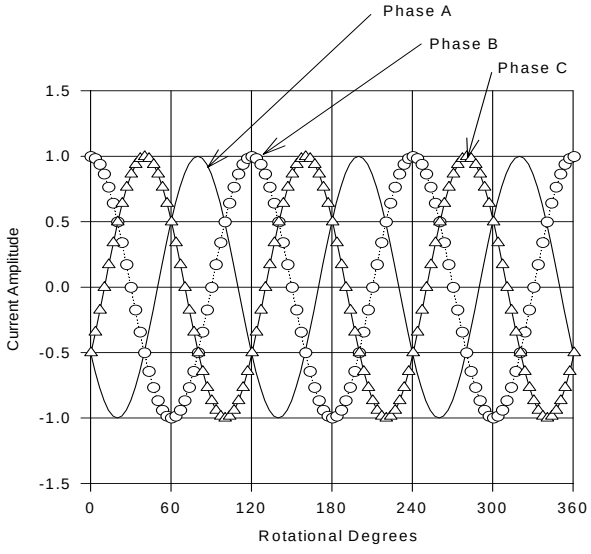


APPENDIX B
3-Phase Brushless PM Servo Motor
BEMF Sinusoidal Waveforms

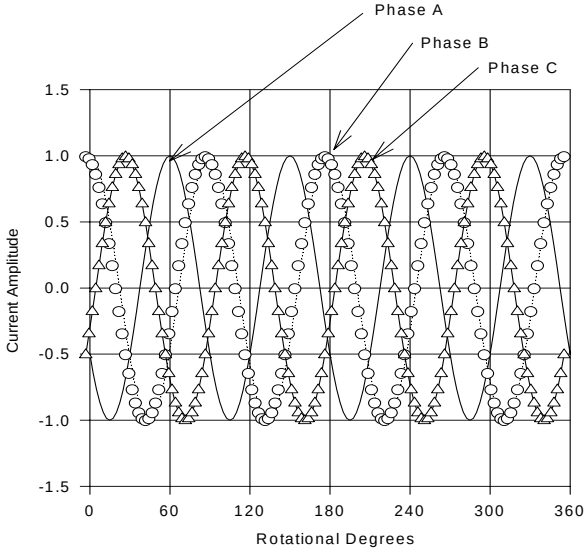
Sineusoidal Waveform
3-Phase Brushless PM 4-Pole, Servo Motor



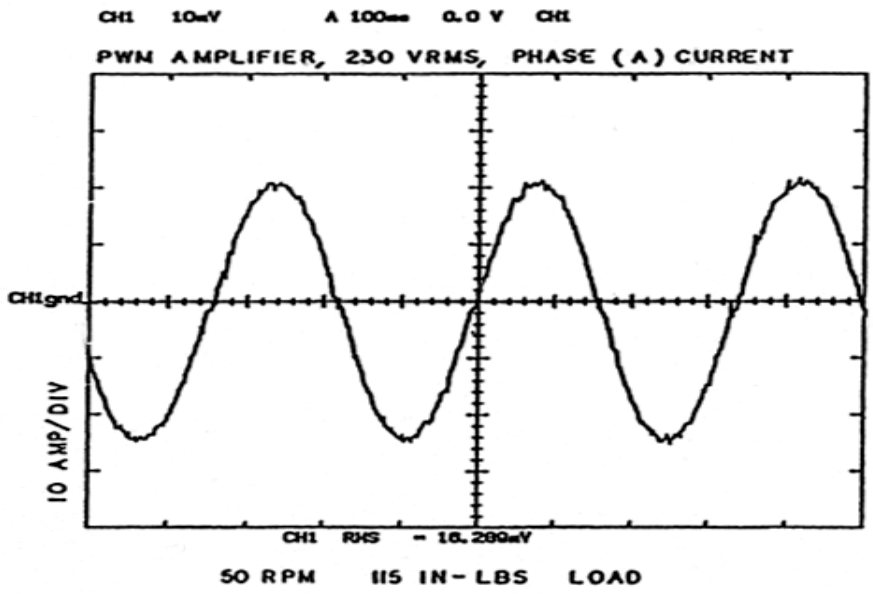
Sineusoidal Waveform
3-Phase Brushless PM 6-Pole, Servo Motor

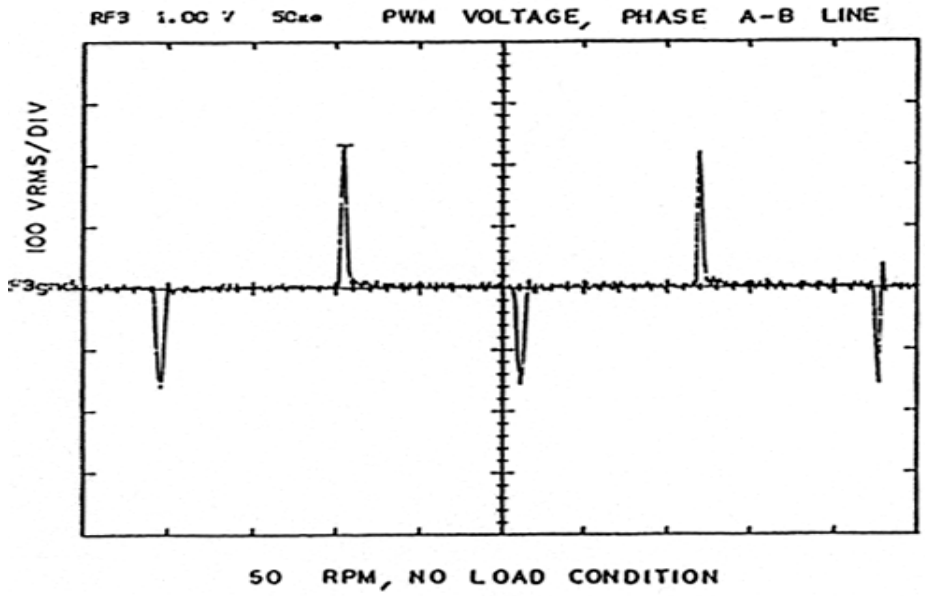


Sineusoidal Waveform
3-Phase Brushless PM 8-Pole, Servo Motor



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.

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

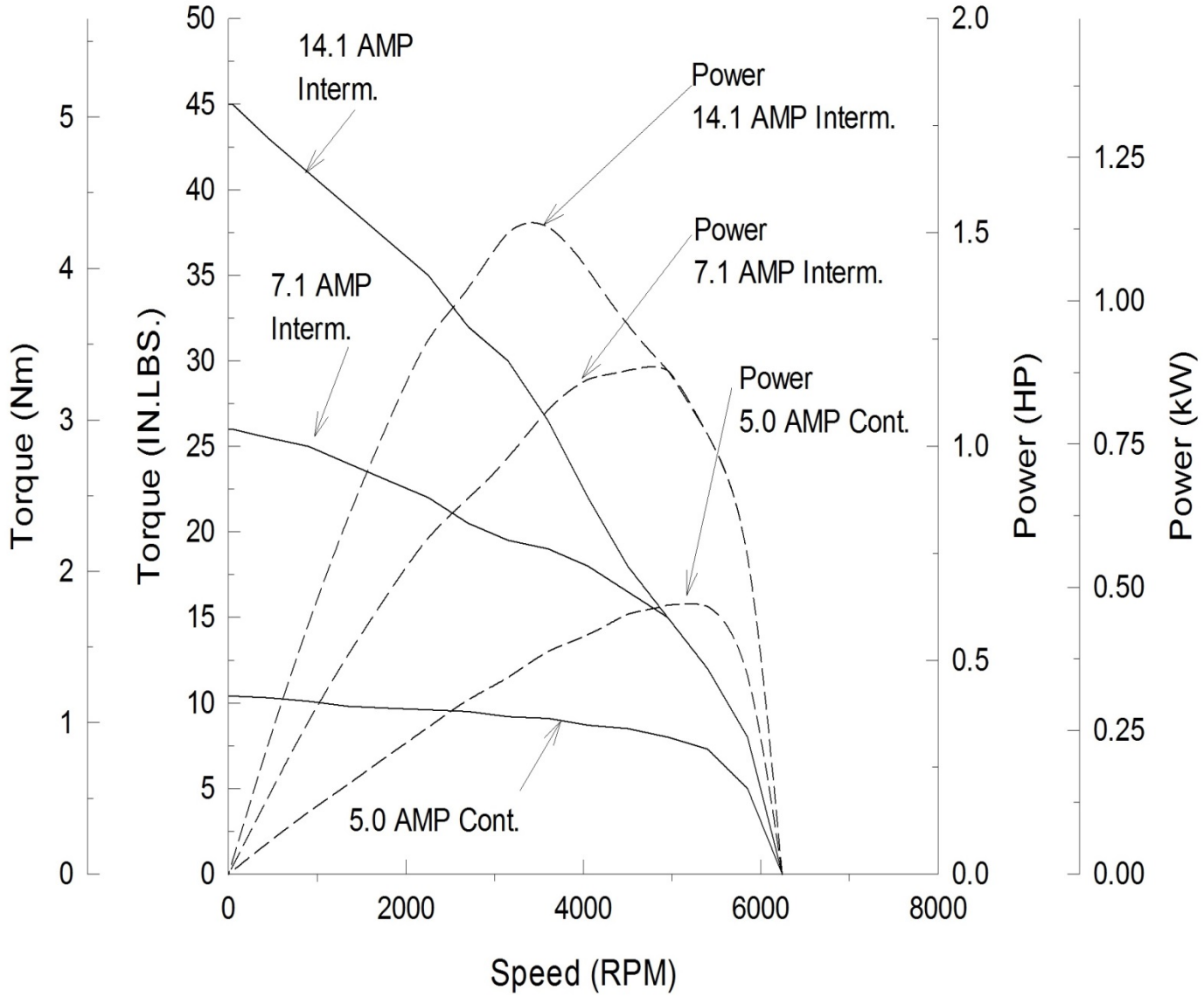
Example: Intermittent Stall Torque for a M444H Motor with a 14.14 Amp RMS Amplifier is shown below using Kt and I continuous stall current information from Appendix (E).

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

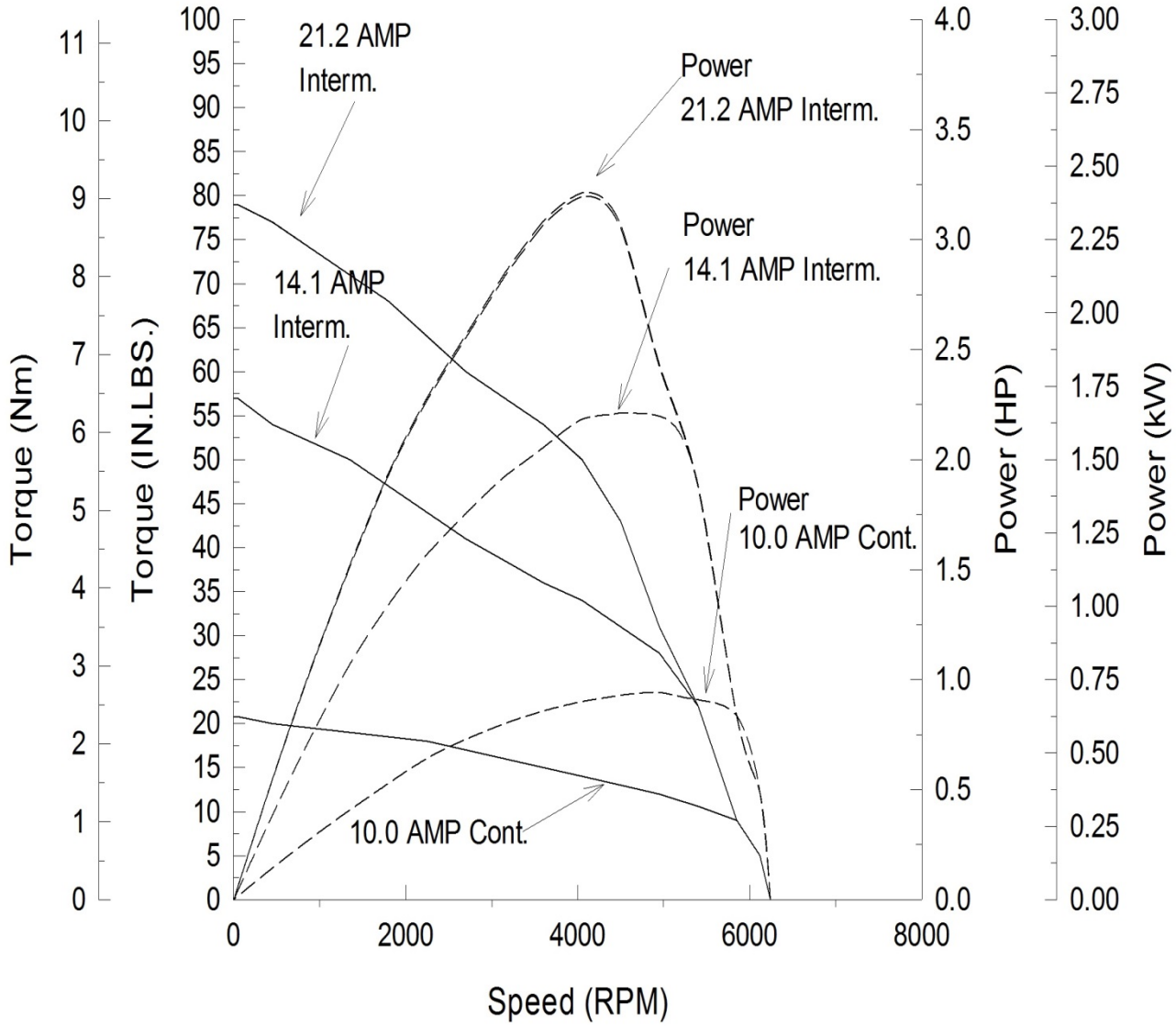
T int. stall = (6.64) * ((1+.068)-.068(14.14/9.31)) * (14.14) = 90.6 in lbs

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.

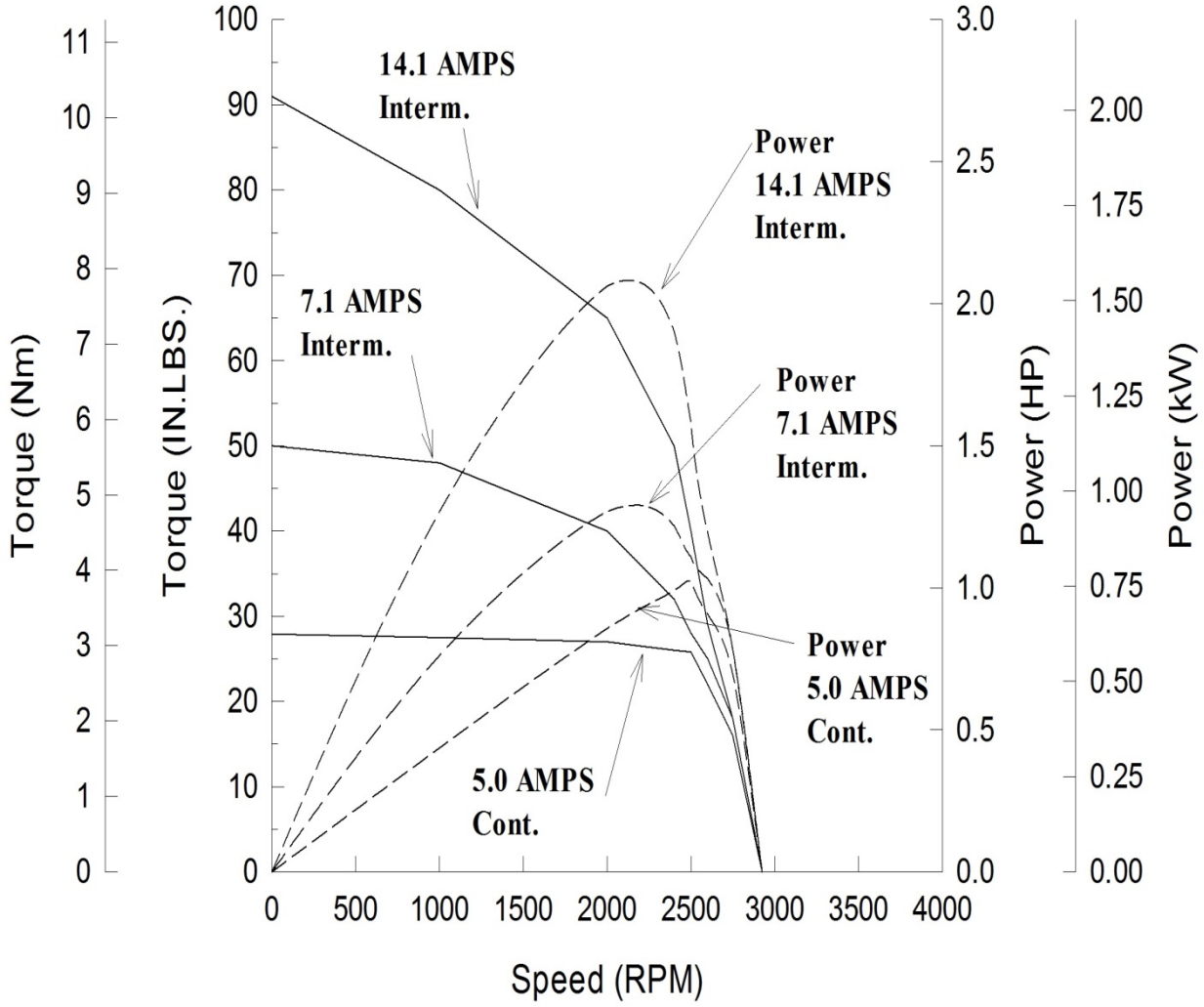
M431-NNN0-7207
Square Motor, Performance Curves
(40 C Ambient, RMS AMPS Max., 5/31/93)



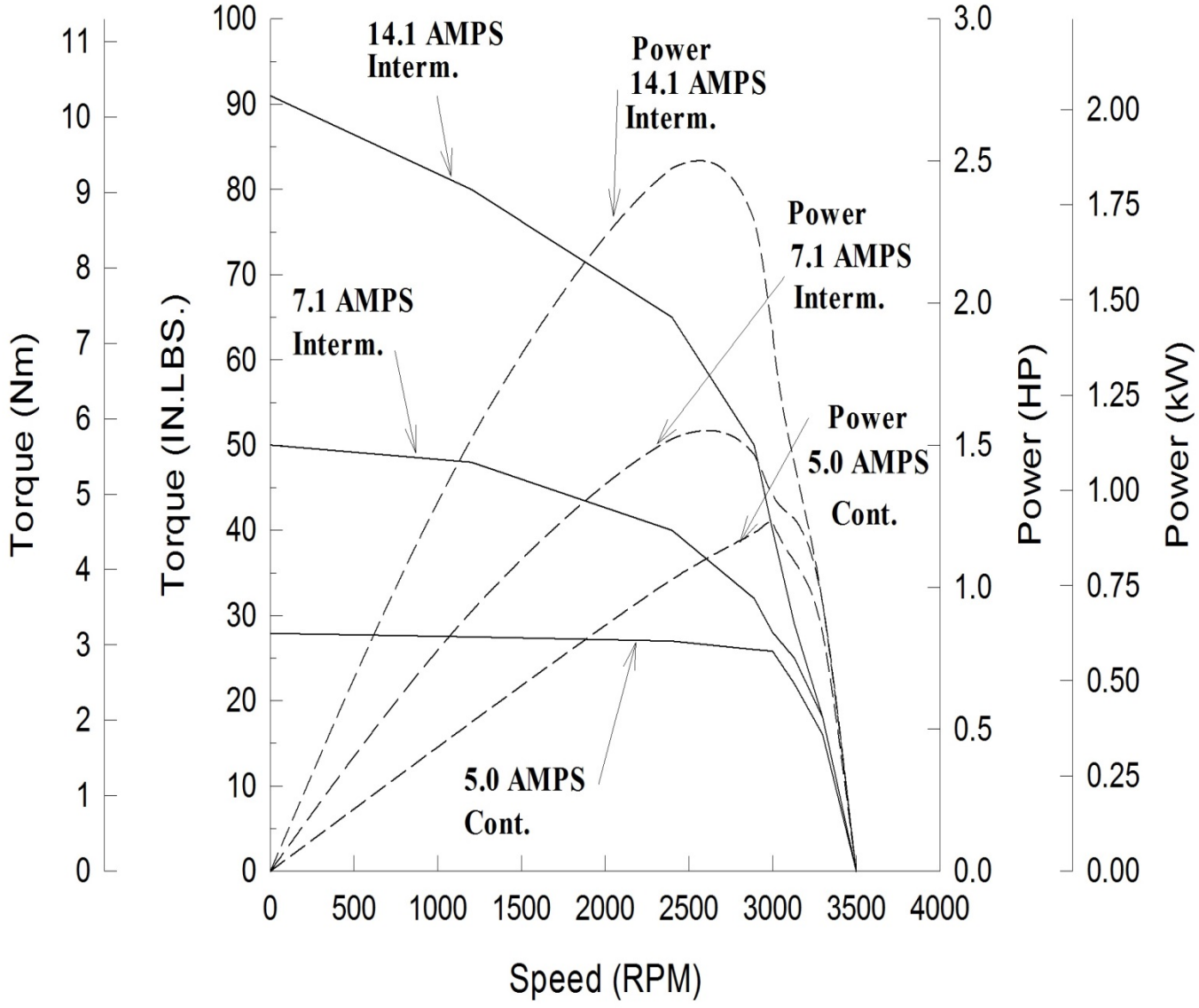
M432-NNN0-7207
Square Motor, Performance Curves
(40 C Ambient, Rms Amps Max., 230 Vrms, 5/31/93)



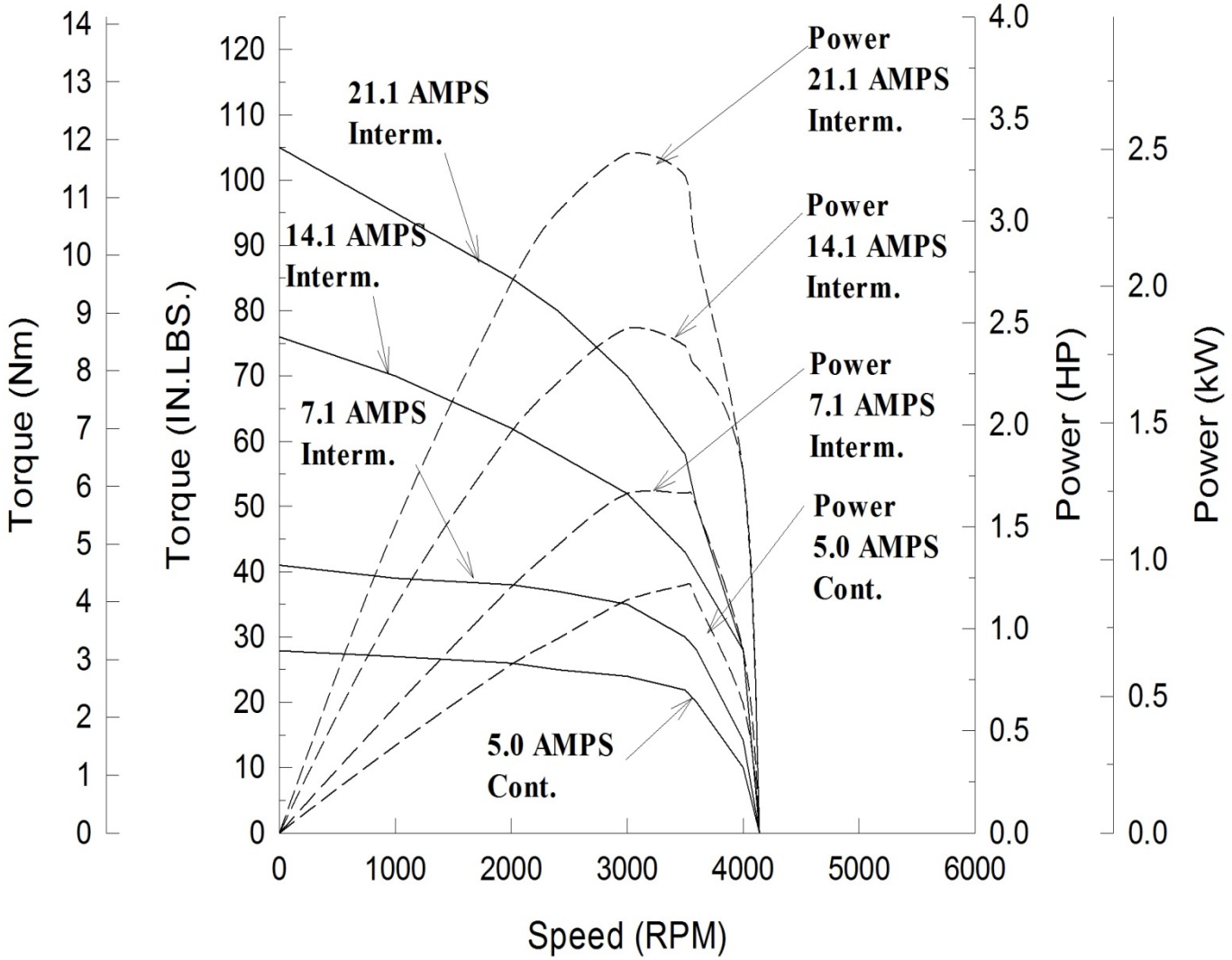
M433-FNN0-7207
Square Motor, Performance Curves
(40 C Ambient, Rms Amps Max., 230Vrms, 5/31/93)



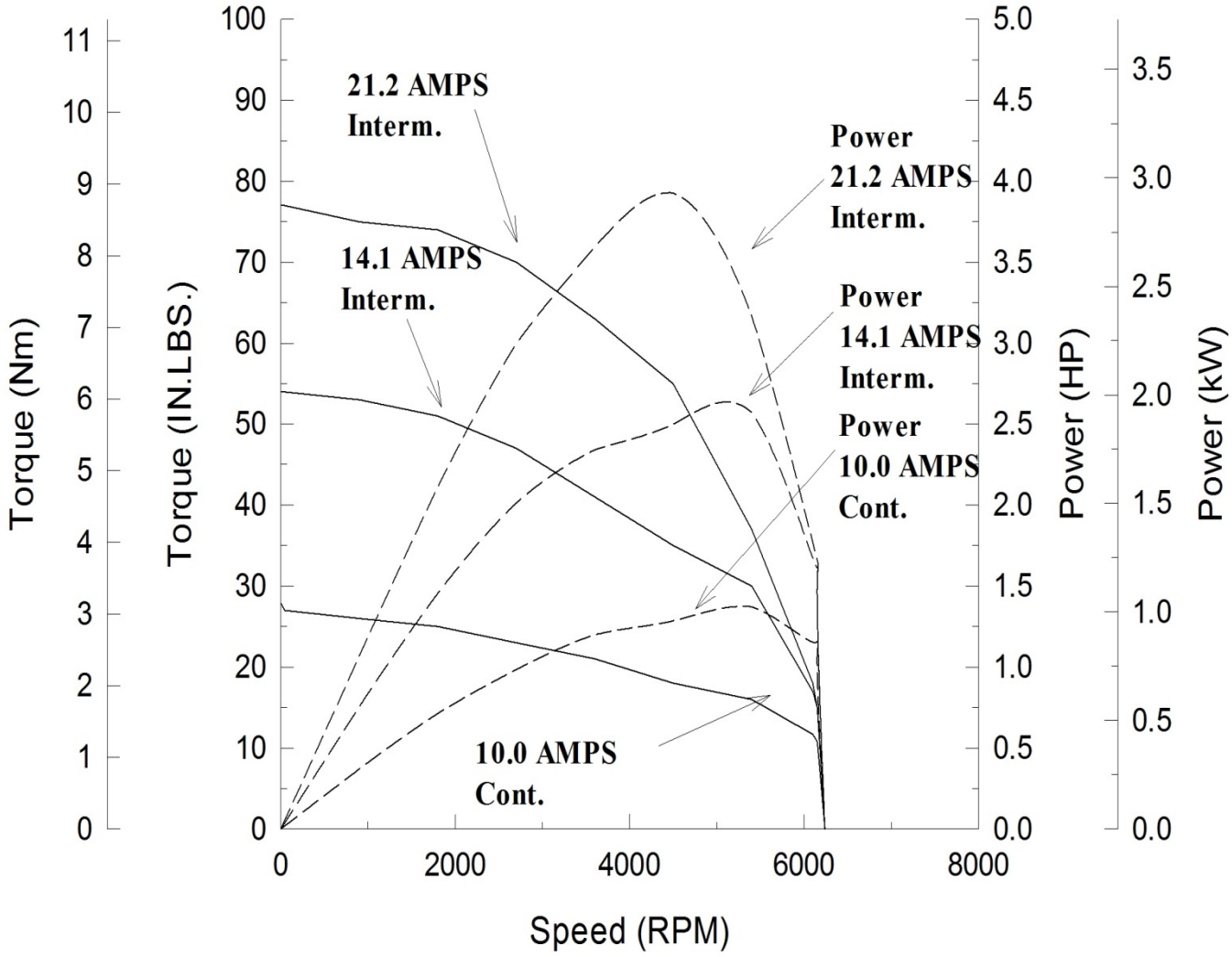
M433-HNN0-7207
Square Motor, Performance Curves
(40 C Ambient, RMS AMPS Max., 5/31/93)



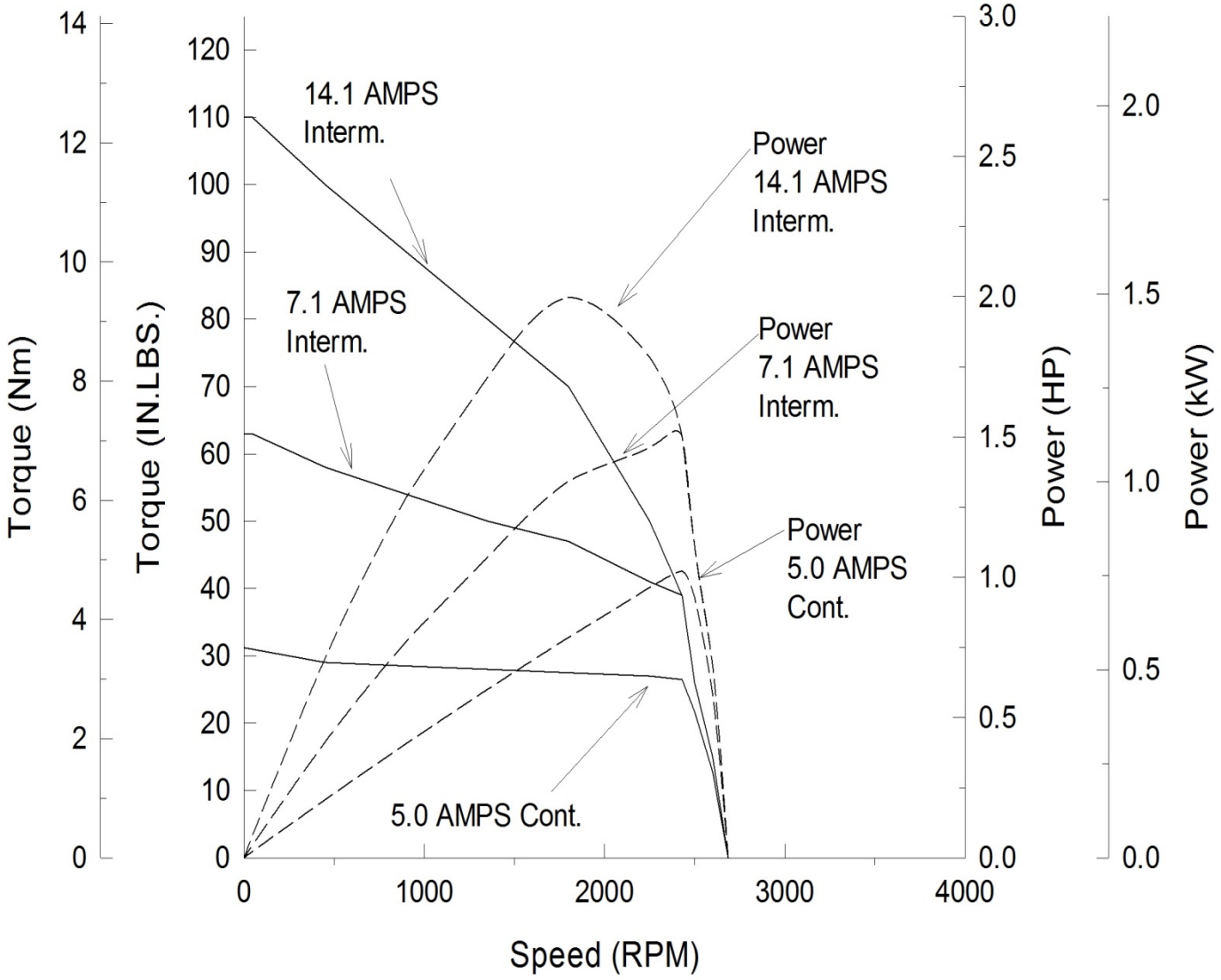
M433-JNN0-7207
Square Motor, Performance Curves
(40 C Ambient, Rms Amps Max., 230Vrms 5/31/93)



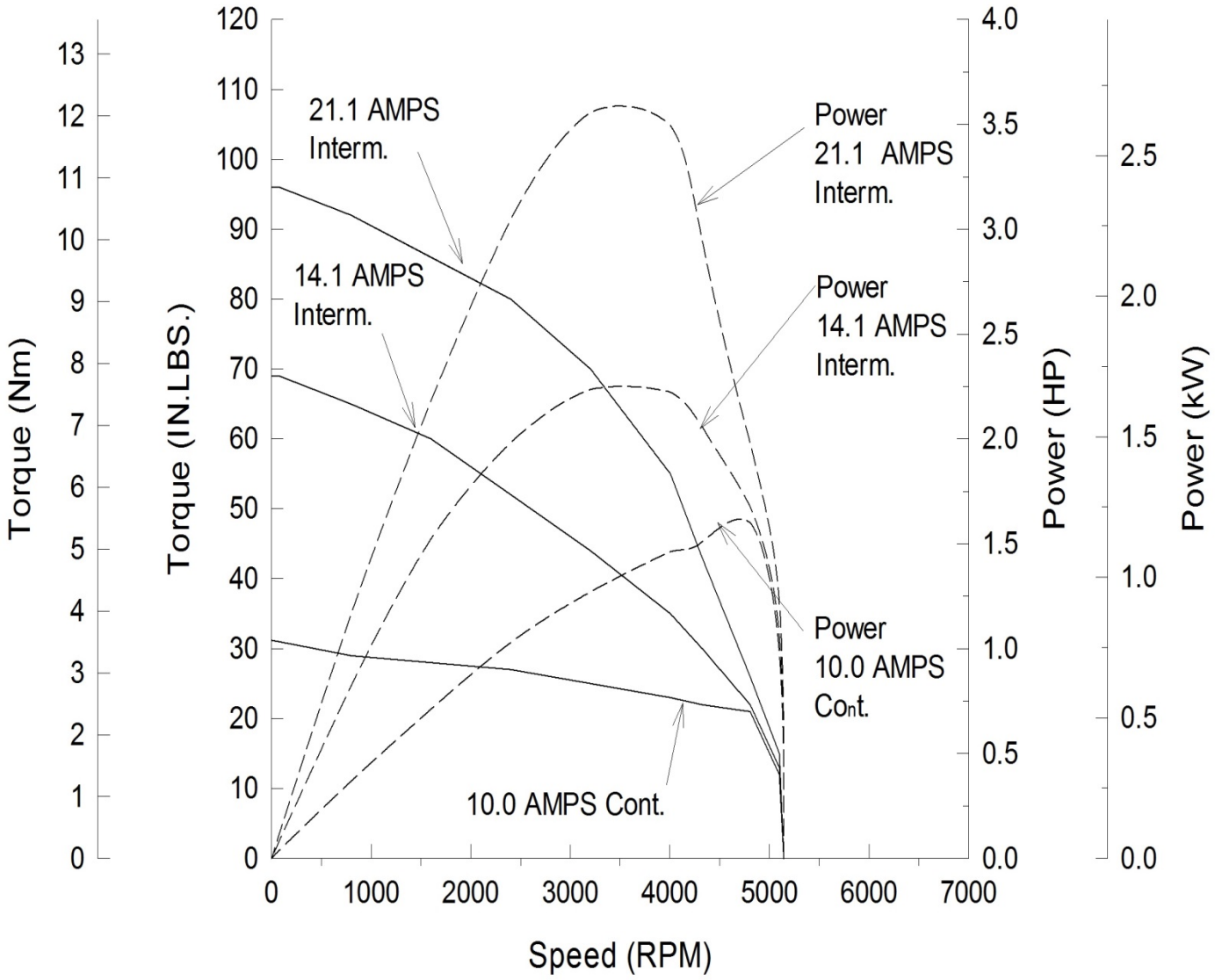
M433-MNN0-7207
Square Motor, Performance Curves
(40 C Ambient, RMS AMPS Max., 230 Vrms, 5/31/93)



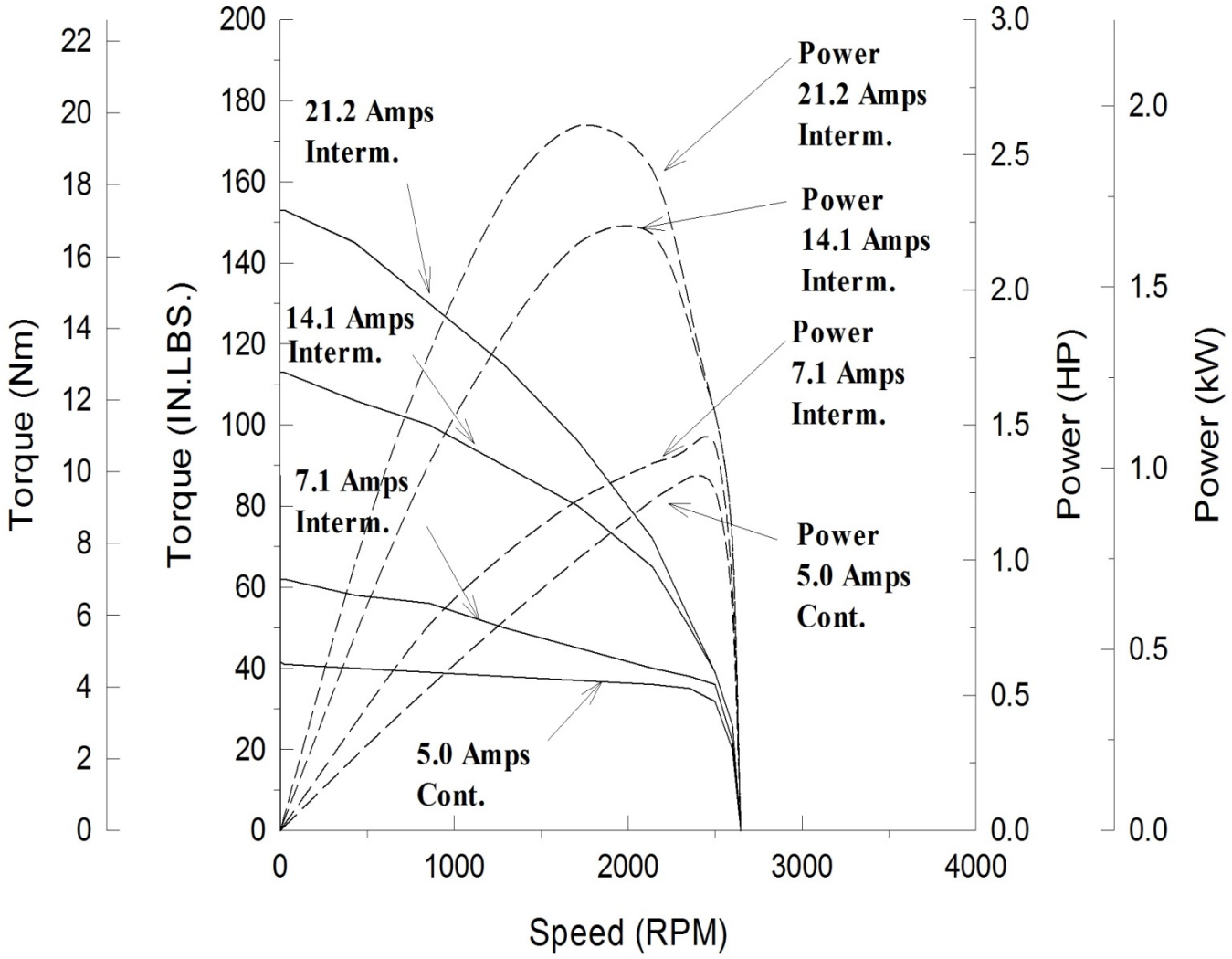
M442-ENN0-7207
Square Motor, Performance Curves
(40 C Ambient, Rms Amps Max.,230 Vrms 5/31/93)



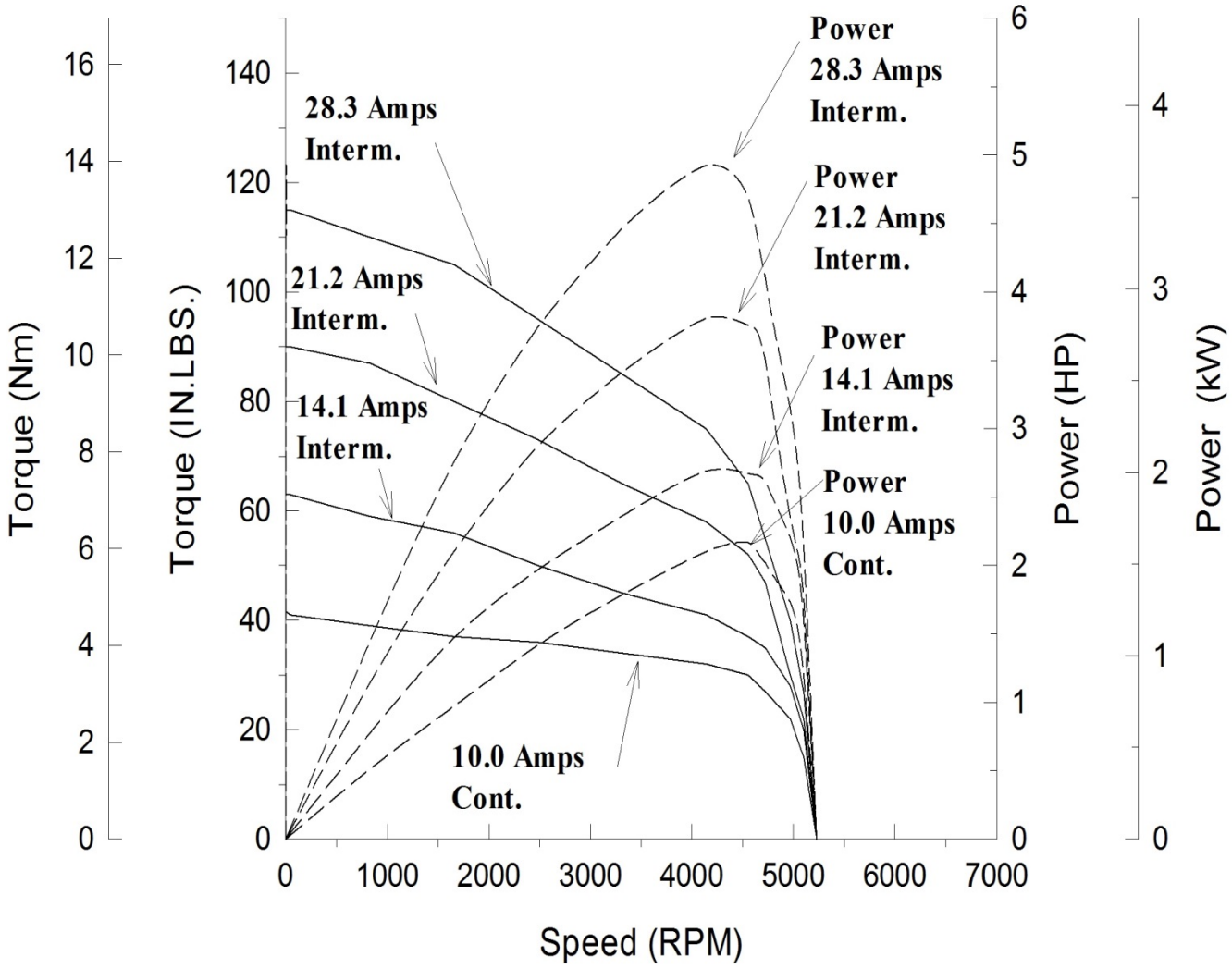
M442-KNN0-7207
Square Motor, Performance Curves
(40 C Ambient, Rms Amps Max.,230Vrms 5/31/93)



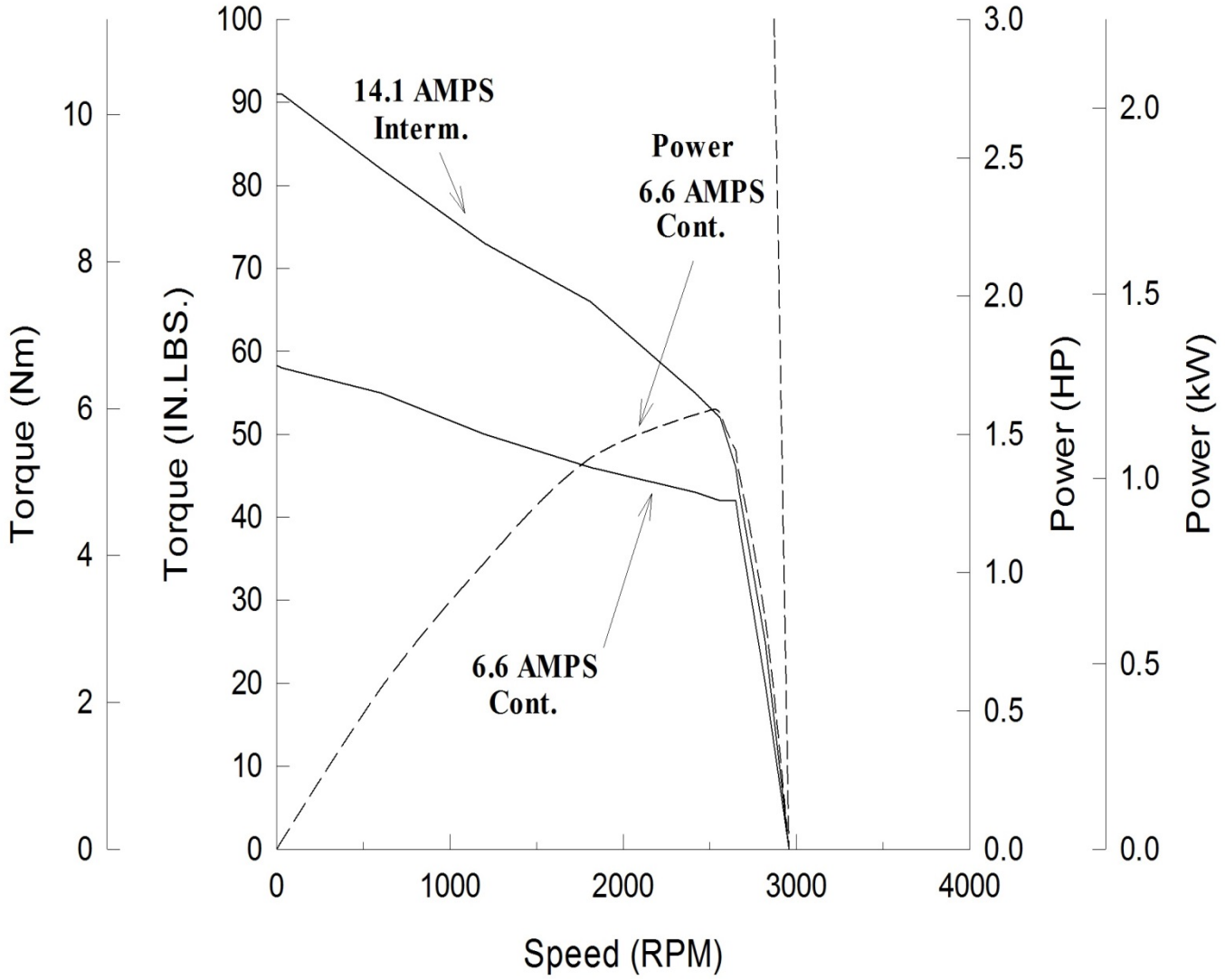
M443-ENN0-7207
Square Motor, Performance Curves
(40 C Ambient, Rms Amps Max., 230Vrms 5/31/93)

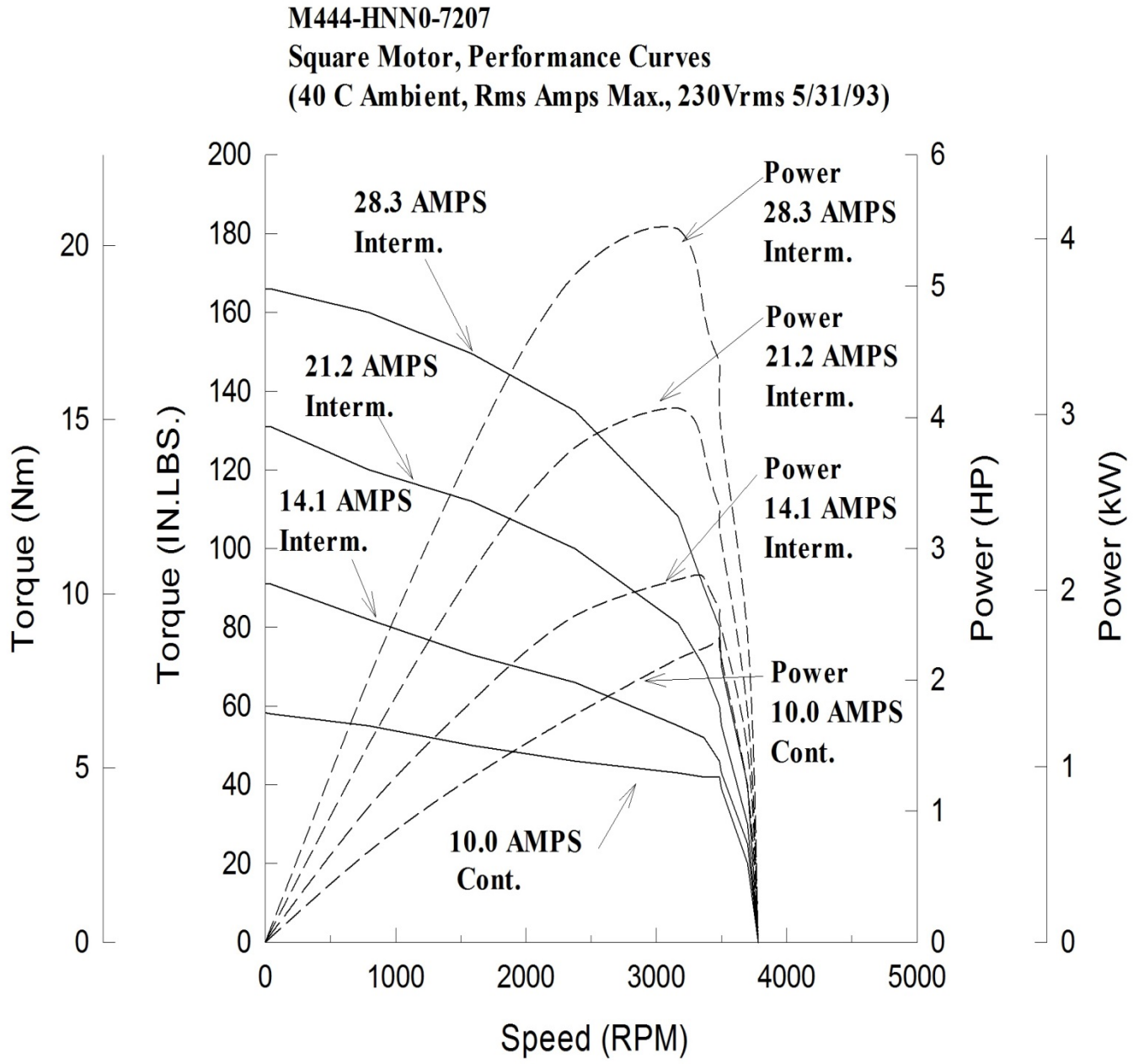


M443-KNN0-7207
Square Motor, Performance Curves
(40 C Ambient, Rms Amps Max., 230Vrms 5/31/93)

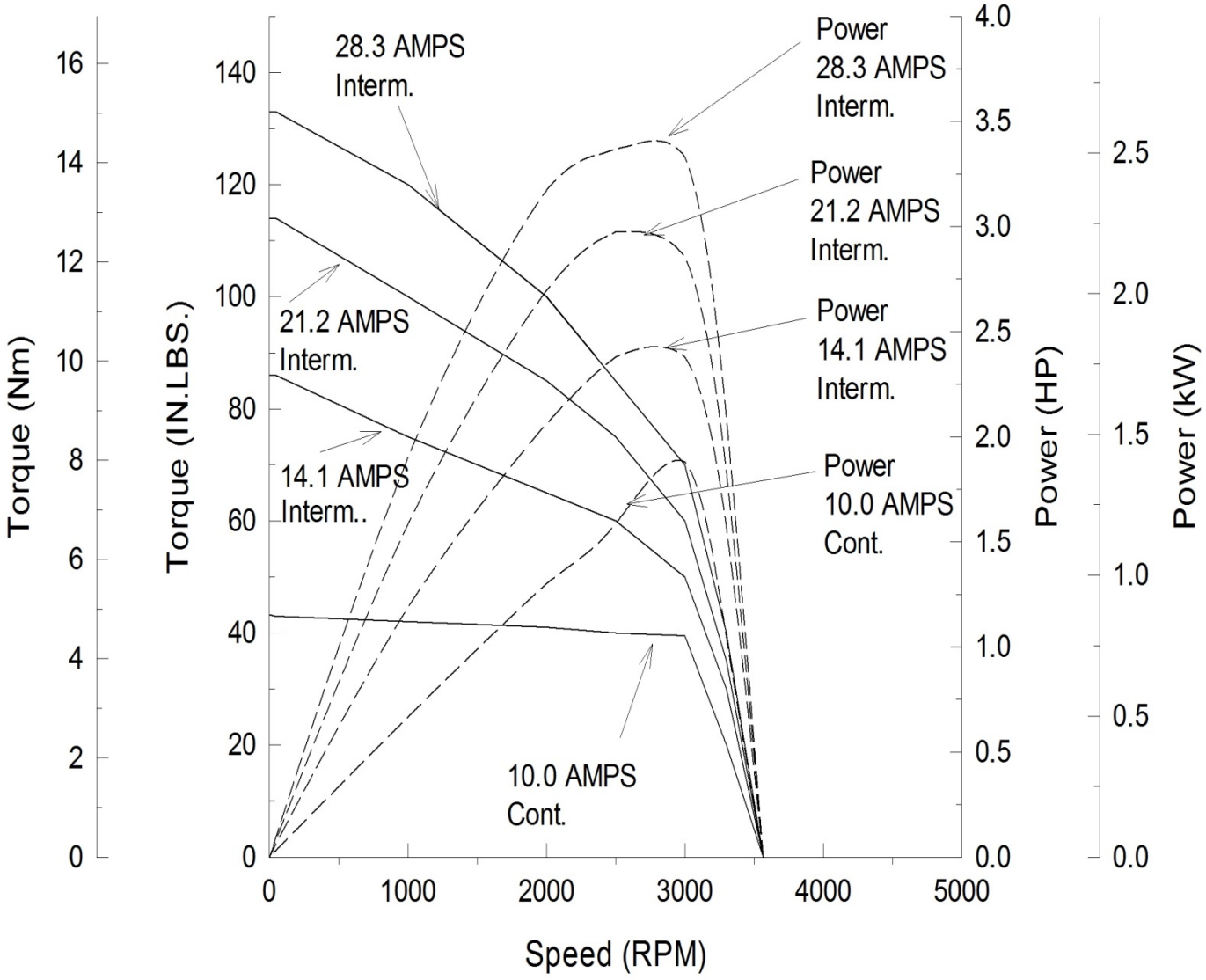


M444-ENN0-7207
Square Motor, Performance Curves
(40 C Ambient, Rms Amps Max., 230Vrms 5/31/93)

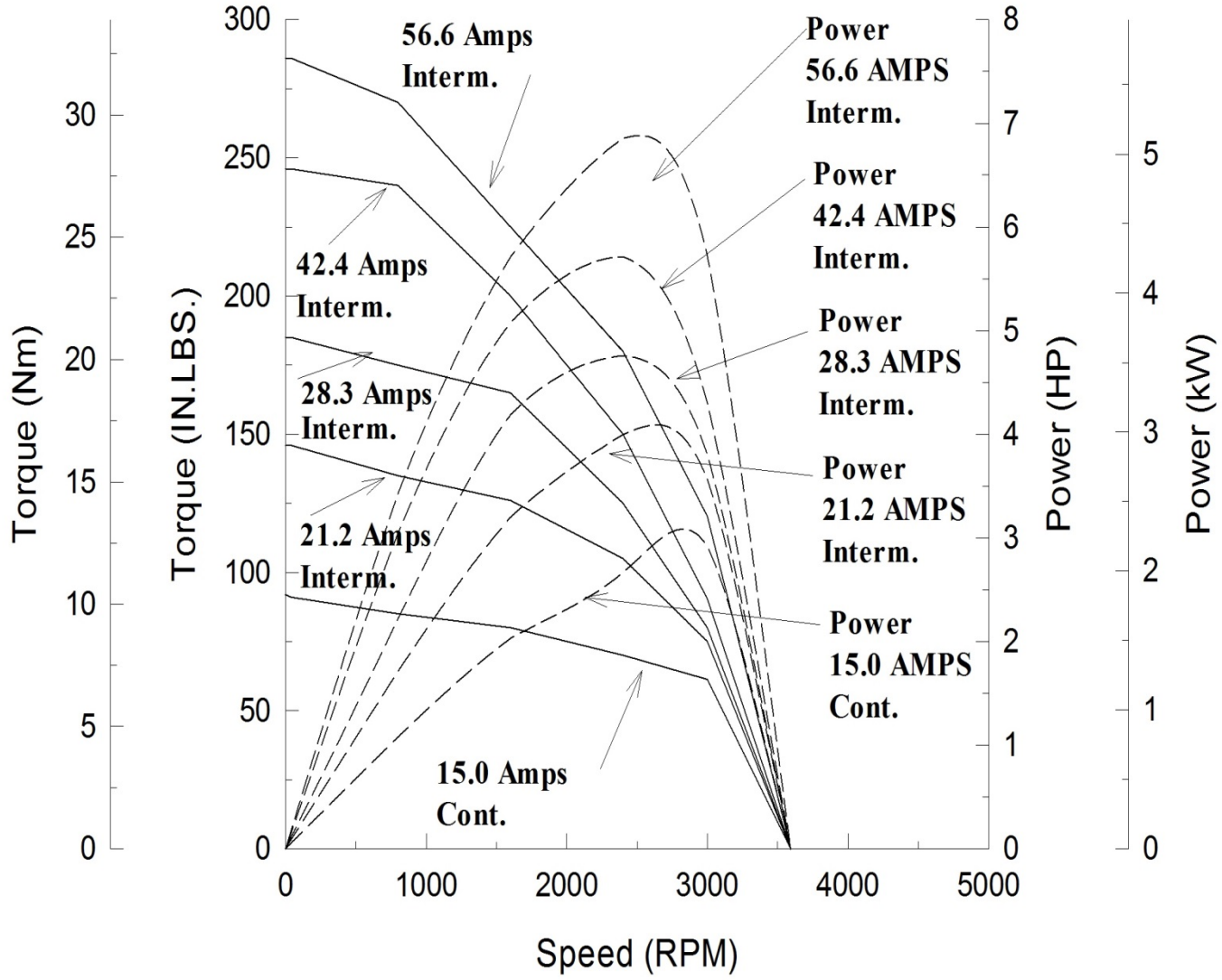


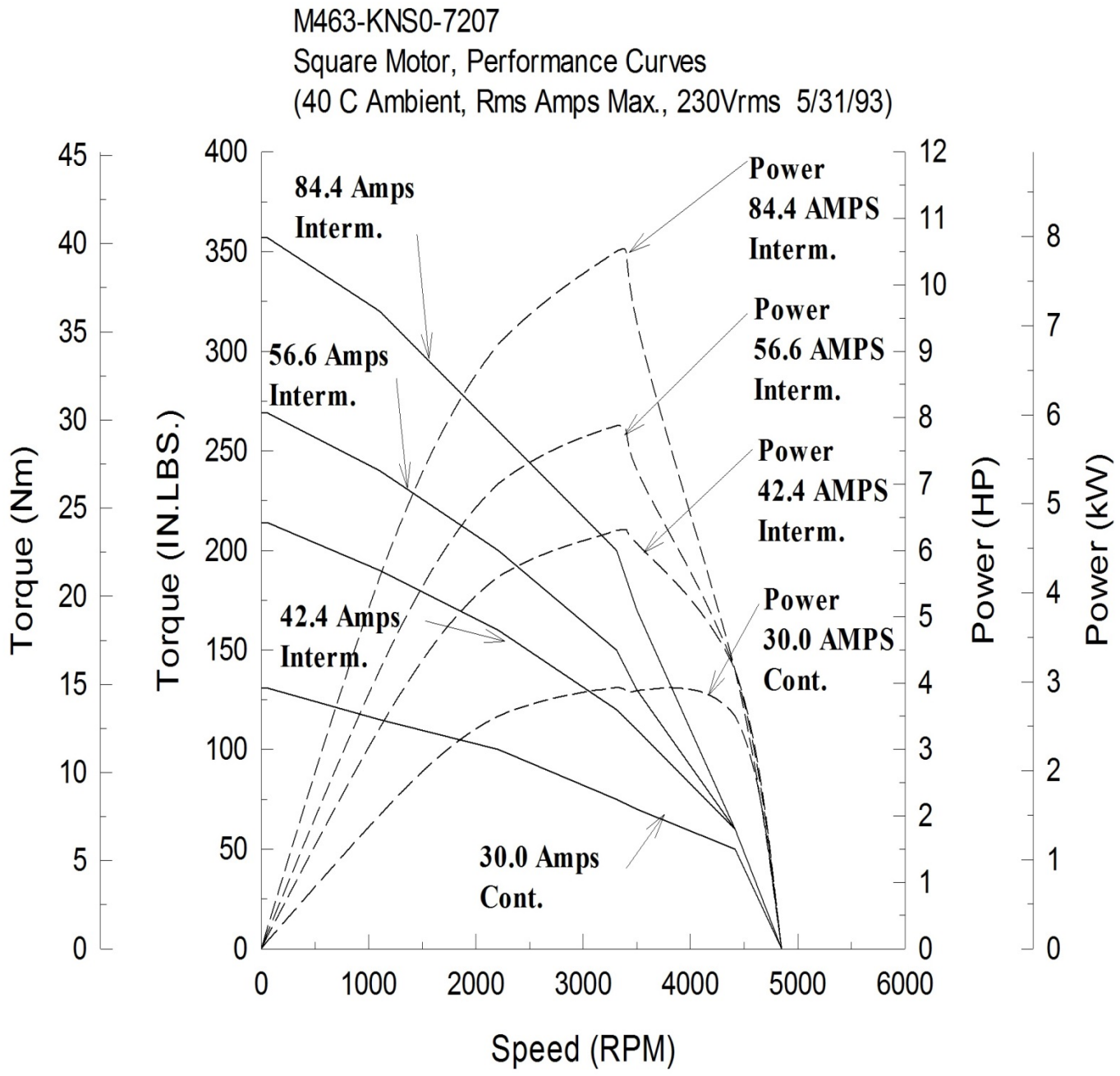


M461-GNS0-7207
Square Motor, Performance Curves
(40 C Ambient, Rms Amps Max.,230Vrms 5/31/93)

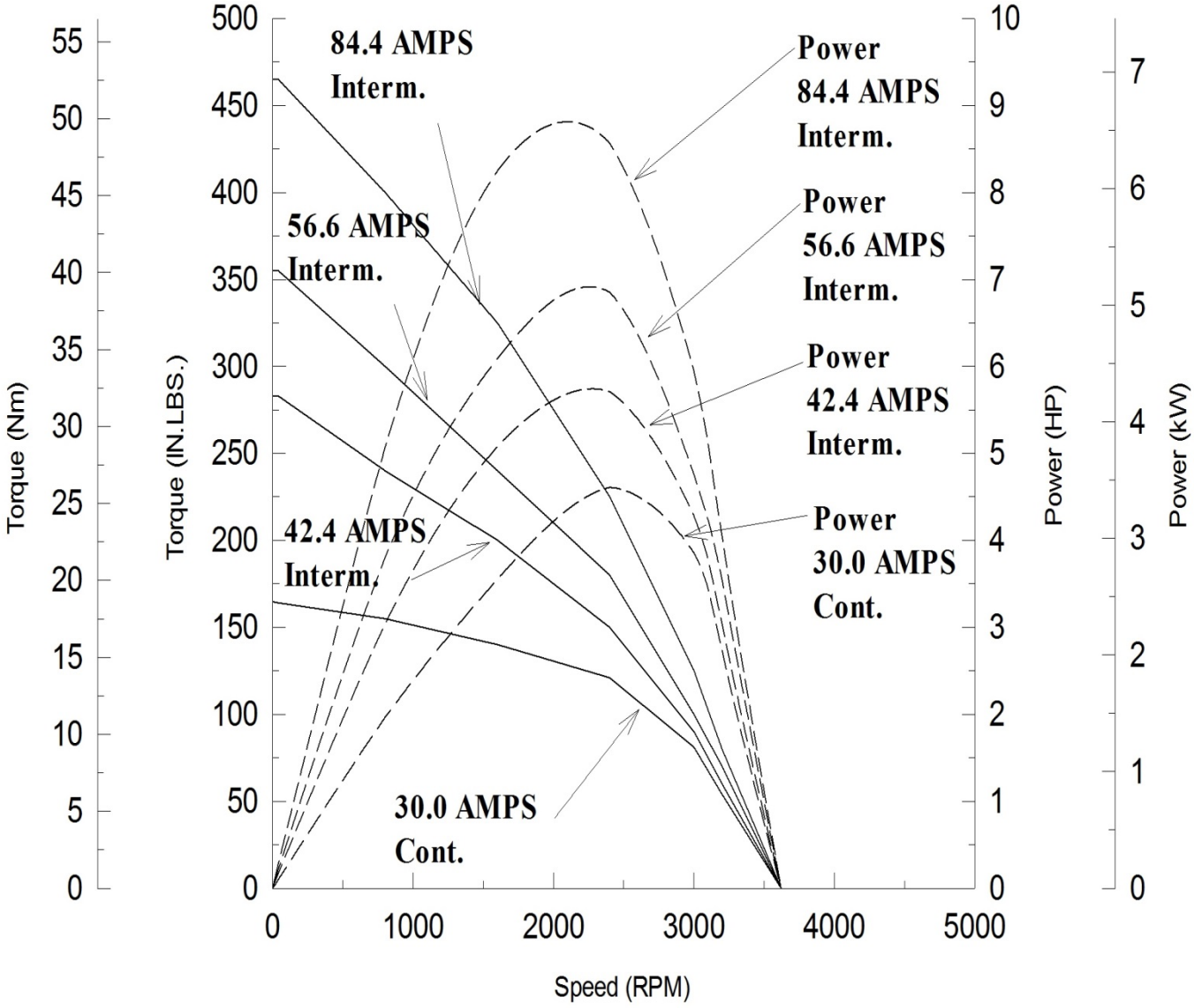


M462-GNS0-7207
Square Motor, Performance Curves
(40 C Ambient, Rms Amps Max., 230Vrms 5/31/93)





M464-GNS0-7207
Square Motor, Performance Curves
(40 C Ambient, RMS AMPS Max., 5/31/93)



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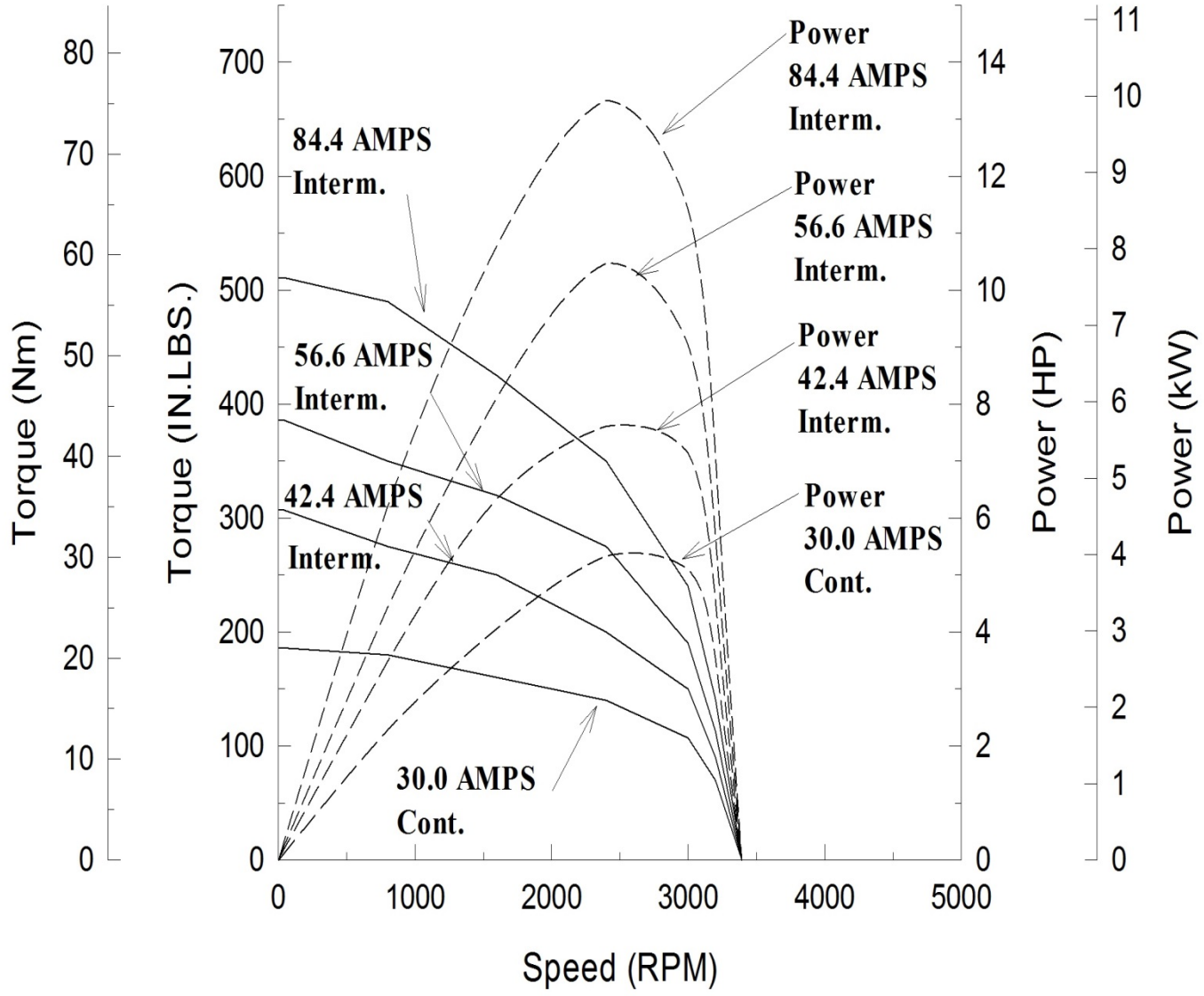
Square Motor, Performance Curves
(40 C Ambient, Rms Amps Max., 230Vrms 5/31/93)



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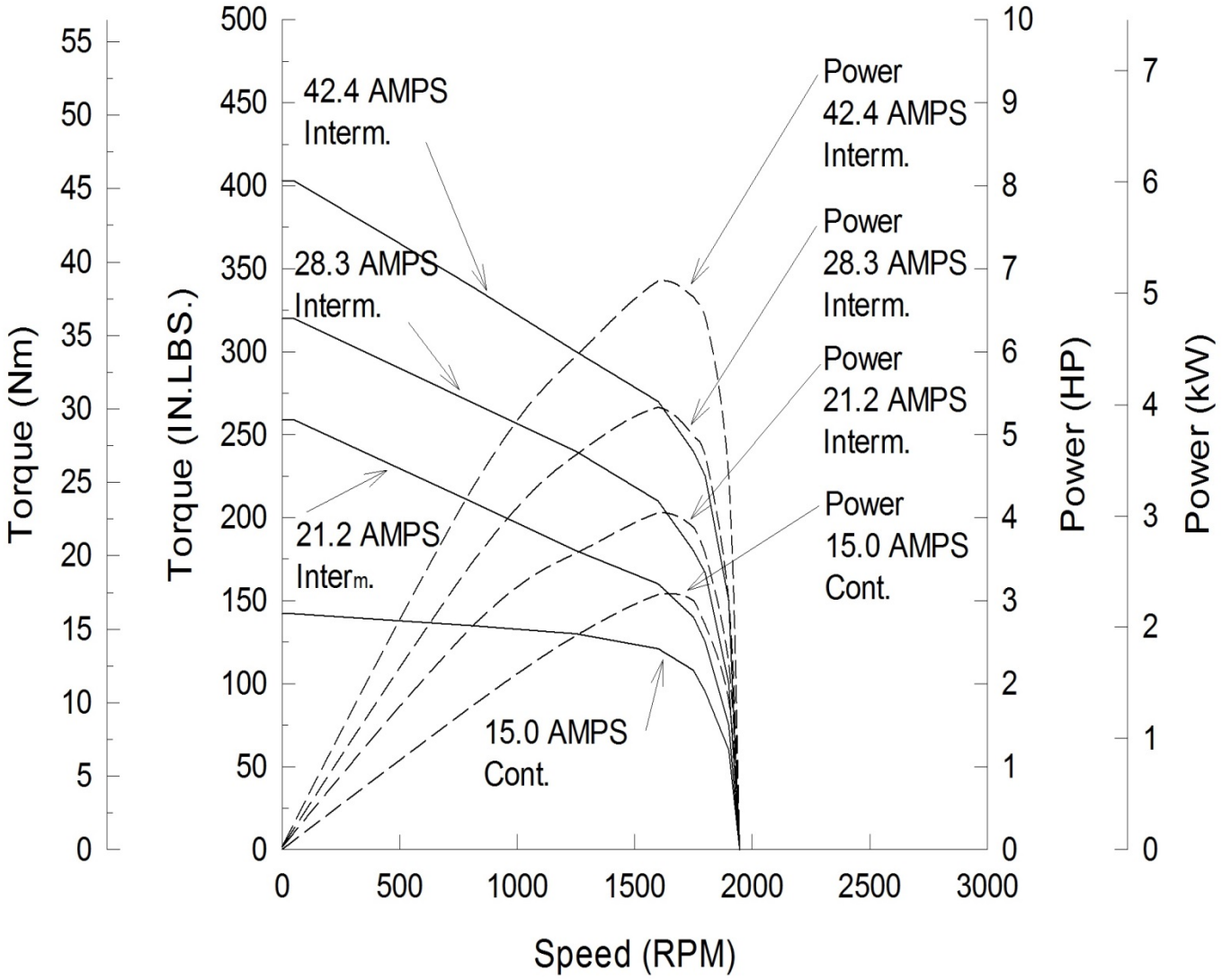
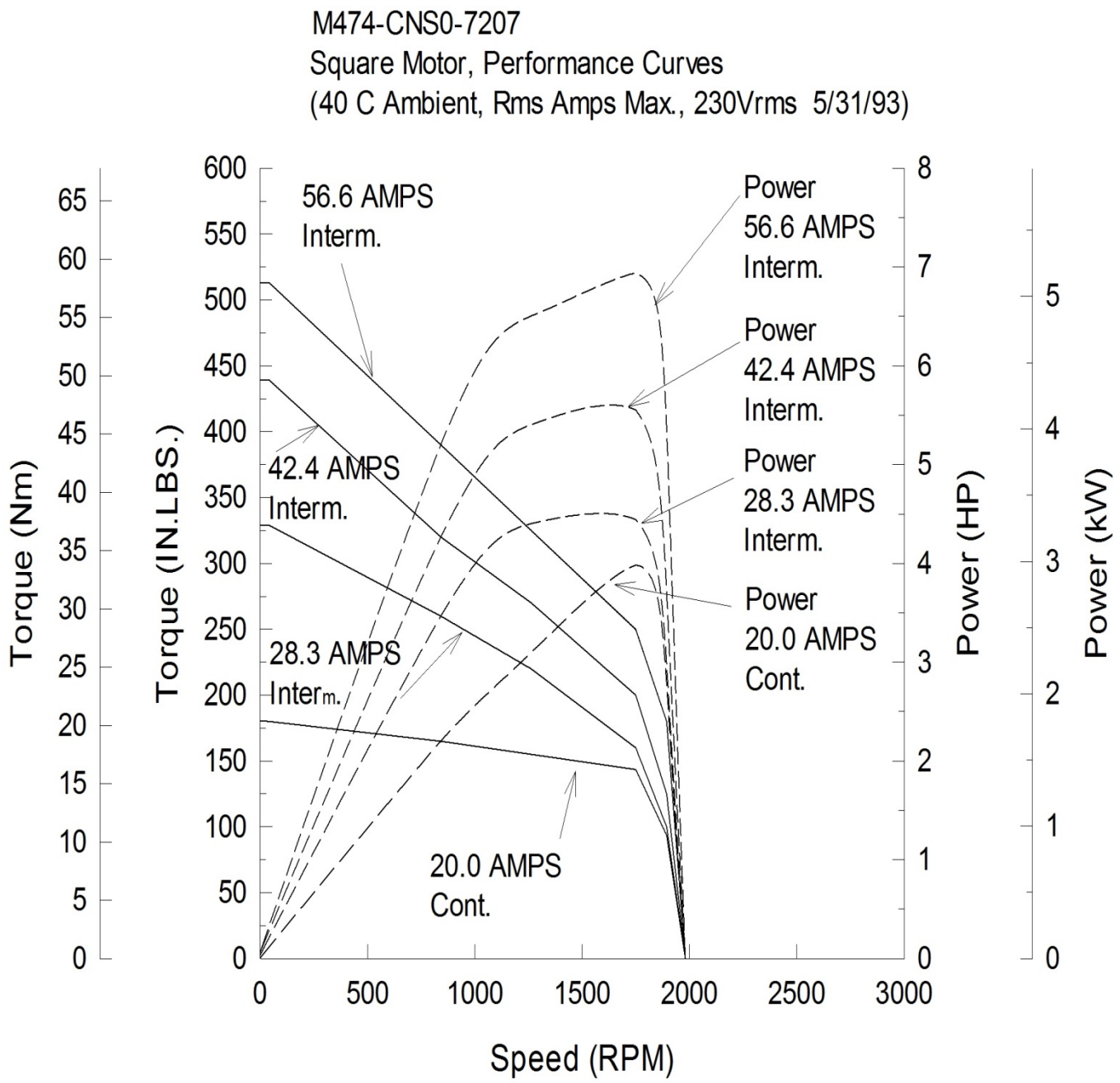
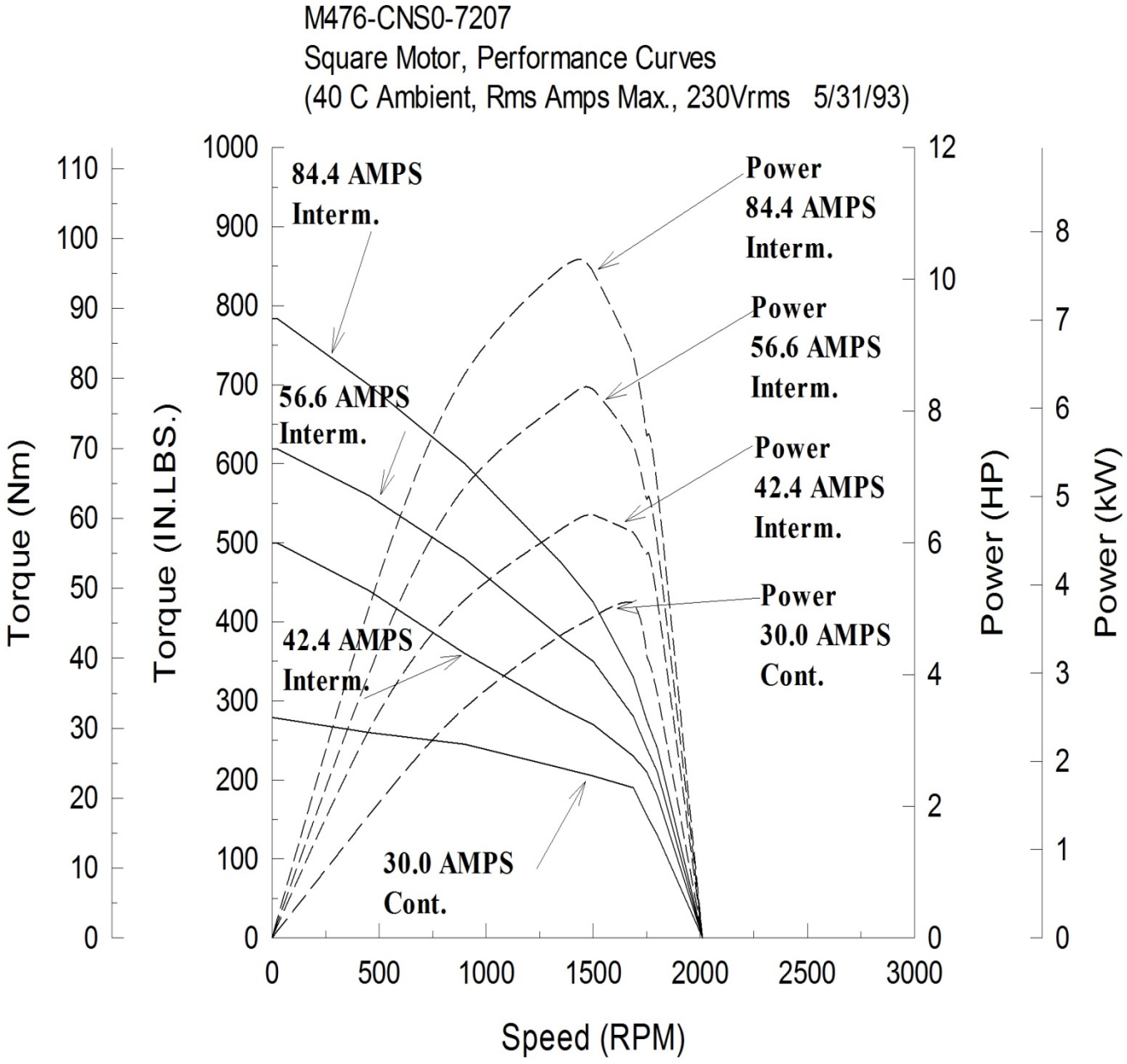
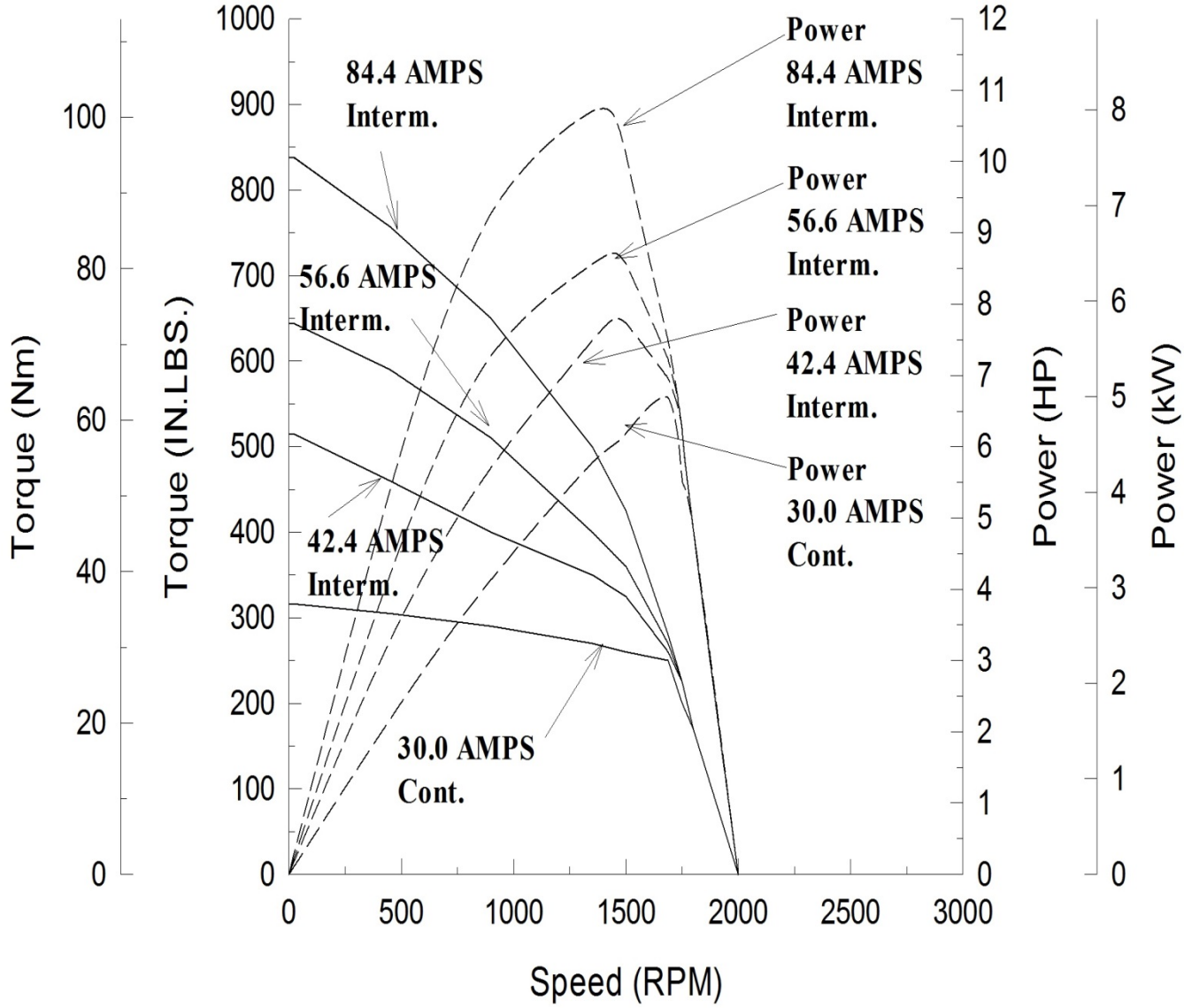
Square Motor, Performance Curves
(40 C Ambient, Rms Amps Max., 230Vrms 5/31/93)







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 (mA) Input	P (Watt) Input	R (Ohm) Input	E (V) Output	R (Ohm) Output
325-001-0012	Harowe	11BRW-300-M10B	5000	10.0	8.3	0.035	16	5.0	31
325-001-0020	Harowe	11BRCX-300-J10B	5000	7.0	10.9	0.047	16	6.65	52
325-003-0001	Harowe	21BRCX-611-TA42/10	4000	7.5	70	0.23	21	7.5	300
325-003-0004	Harowe	21BRCX-611-DB42/10	4000	7.0	58	0.15	28	7.0	160
325-003-0007	Harowe	21BRCX-501-A42/20	6600	7.5	55	0.20	31	7.8	93
325-004-0001	Servo-Tek	T4421WAB-R	N/A	N/A	N/A	N/A	N/A	1.0/KRPM	N/A
325-005-0002	Harowe	21BRCX-500-MA7	3000	10.0	17	0.08	250	8.8	114
325-005-0005	Harowe	21BRCX-500-H7A	5000	4.0	25	0.04	31	2.0	31
325-005-0008	Harowe	21BRCX-510-A7B/10-01	4000	6.0	20	0.08	38	2.0	110
325-005-0015	Tama-gawa	TS2640N321E64	10K	7.0	50	0.20	37.5	3.5	43.3
212-001-0063	Sick	SRS50	200K	5-12	80	.96 MAX	N/A	N/A	N/A
212-001-0064	Sick	SRM50	200K	5-12	80	.96 MAX	N/A	N/A	N/A
212-001-0066	Heiden-hain	EQN 425	130K	3.6-14	105	1.47 MAX	N/A	N/A	N/A
212-001-0067	Heiden-hain	EQN 1325	130K	3.6-14	105	1.47 MAX	N/A	N/A	N/A
212-001-0068	Sick	EKM36	75K	7-12	150	1.8 MAX	N/A	N/A	N/A
212-001-0071	Heiden-hain	EQN 437	8000K	3.6-14	105	1.47 MAX	N/A	N/A	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 (mA) Input	P (Watt) Input	R (Ohm) Input	E (V) Output	R (Ohm) Output
212-001-0072	Heiden-hain	EQN 436S	N/A	10-28.8	43	1.24 MAX	N/A	N/A	N/A
212-001-0073	Sick	SRM50S	200K	7-12	80	.96 MAX	N/A	N/A	N/A
212-001-0074	Sick	EKM36-2	75K	7-12	150	1.8 MAX	N/A	N/A	N/A
212-001-0075	Dynapar	AD36	10000K	5.0	100	0.05	N/A	N/A	N/A
212-001-0076	Sick	EKS36-2	75K	7-12	150	1.8 MAX	N/A	N/A	N/A
212-001-0078	Sick	SKM36S	65K	7-12	60	0.72 MAX	N/A	N/A	N/A
212-016-XXXX	QDI	QD200	500K	5.0	125	0.63	N/A	N/A	N/A
212-025-XXXX	QDI	QR200	500K	5.0	125	0.63	N/A	N/A	N/A
212-031-XXXX	QDI	QR12	500K	5.0	65	0.33	N/A	N/A	N/A
212-038-XX01	Heiden-hain	ECI 1118	N/A	3.6-14	80	0.52	N/A	N/A	N/A

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	11.7	25.8	22.5	21.9	16.2
	N-m	0.83	1.32	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	524	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	10.1	8.5	7.5	4.9
	N-m/Arms	0.55	0.55	1.14	0.96	0.84	0.55
BEMF Constant @ 25ºC	Vrms/kRPM	33.3	33.3	69.0	58.0	51.0	33.3
	Vrms/rad/sec	0.32	0.32	0.66	0.55	0.49	0.32
Mechanical Time Constant	msec	2.88	1.69	1.46	1.53	1.39	1.34
Mechanical Time Constant with Brake	msec	3.58	1.96	1.57	1.65	1.50	1.45
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	128.8
	N-m	4.46	6.84	6.93	6.89	10.99	14.56
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	7.96	15.9	8.0	6.0	8.4	8.9
	N-m/Arms	0.90	1.80	0.90	0.68	0.95	1.00
BEMF Constant @ 25ºC	Vrms/kRPM	54.4	108.8	54.4	41.0	57.6	60.5
	Vrms/rad/sec	0.52	1.04	0.52	0.39	0.55	0.58
Mechanical Time Constant	msec	6.29	3.18	3.35	2.55	1.99	2.30
Mechanical Time Constant with Brake	msec	10.29	4.42	4.65	3.26	2.43	2.83
Electrical Time Constant	msec	7.97	10.00	10.26	13.90	13.22	13.22
Thermal Time Constant	minutes	30	35	35	45	47	53
Thermal Time Constant with Brake	minutes	33	38	38	48	50	56
Stator Resistance (Line-to-Line) @ 25ºC	ohms	1.9	2.7	0.66	0.20	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	23.1	27.2	30.4
Motor Weight with Brake	lb	41.0	50.0	50.0	58.0	66.0	74.0
	kg	18.6	22.7	22.7	26.3	29.9	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	99.0	110.0
	kg	12.5	30.4	34.9	44.9	49.9
Motor Weight with Brake	lb	34.5	75.0	86.0	95.0	117.0
	kg	15.6	34.0	39.0	43.1	53.1
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	5.2	10.0	7.6	8.4	10.0	14.3
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	11.0	24.2	21.2	20.6	15.3
	N-m	0.78	1.24	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	524	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	7.5	7.8	13.8	12.5	10.5	7.3
	N-m/Arms	0.85	0.88	1.56	1.41	1.19	0.83
Torque Constant @ 25ºC	lb-in/Arms	9.7	9.7	20.5	17.0	14.3	9.7
	N-m/Arms	1.09	1.09	2.31	1.92	1.62	1.09
BEMF Constant @ 25ºC	Vrms/kRPM	66.0	66.0	140.0	116.0	98.0	66.0
	Vrms/rad/sec	0.63	0.63	1.34	1.11	0.94	0.63
Mechanical Time Constant	msec	3.56	2.21	1.85	1.99	1.83	1.53
Mechanical Time Constant with Brake	msec	4.42	2.55	2.00	2.15	1.97	1.65
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	62765	70754	69847	69847	69847	69847
Maximum Theoretical Acceleration at Maximum Current with Brake	rad/sec^2	50538	61283	64673	64673	64673	64673
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	19.23
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	16.8	15.9	11.9	16.9	18.2
	N-m/Arms	1.89	1.80	1.34	1.91	2.05
BEMF Constant @ 25ºC	Vrms/kRPM	114.5	108.8	81.0	115.3	124.2
	Vrms/rad/sec	1.09	1.04	0.77	1.10	1.19
Mechanical Time Constant	msec	6.51	3.19	3.06	2.35	2.37
Mechanical Time Constant with Brake	msec	10.66	4.43	3.92	2.86	2.92
Electrical Time Constant	msec	7.27	10.00	11.71	11.19	12.46
Thermal Time Constant	minutes	30	35	45	47	53
Thermal Time Constant with Brake	minutes	33	38	48	50	56
Stator Resistance (Line-to-Line) @ 25ºC	ohms	8.2	2.7	0.95	1.09	1.04
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	16631	21644	22224	21809	20327
Maximum Theoretical Acceleration at Maximum Current with Brake	rad/sec^2	10163	15584	17362	17894	16516
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	23.1	27.2	30.4
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

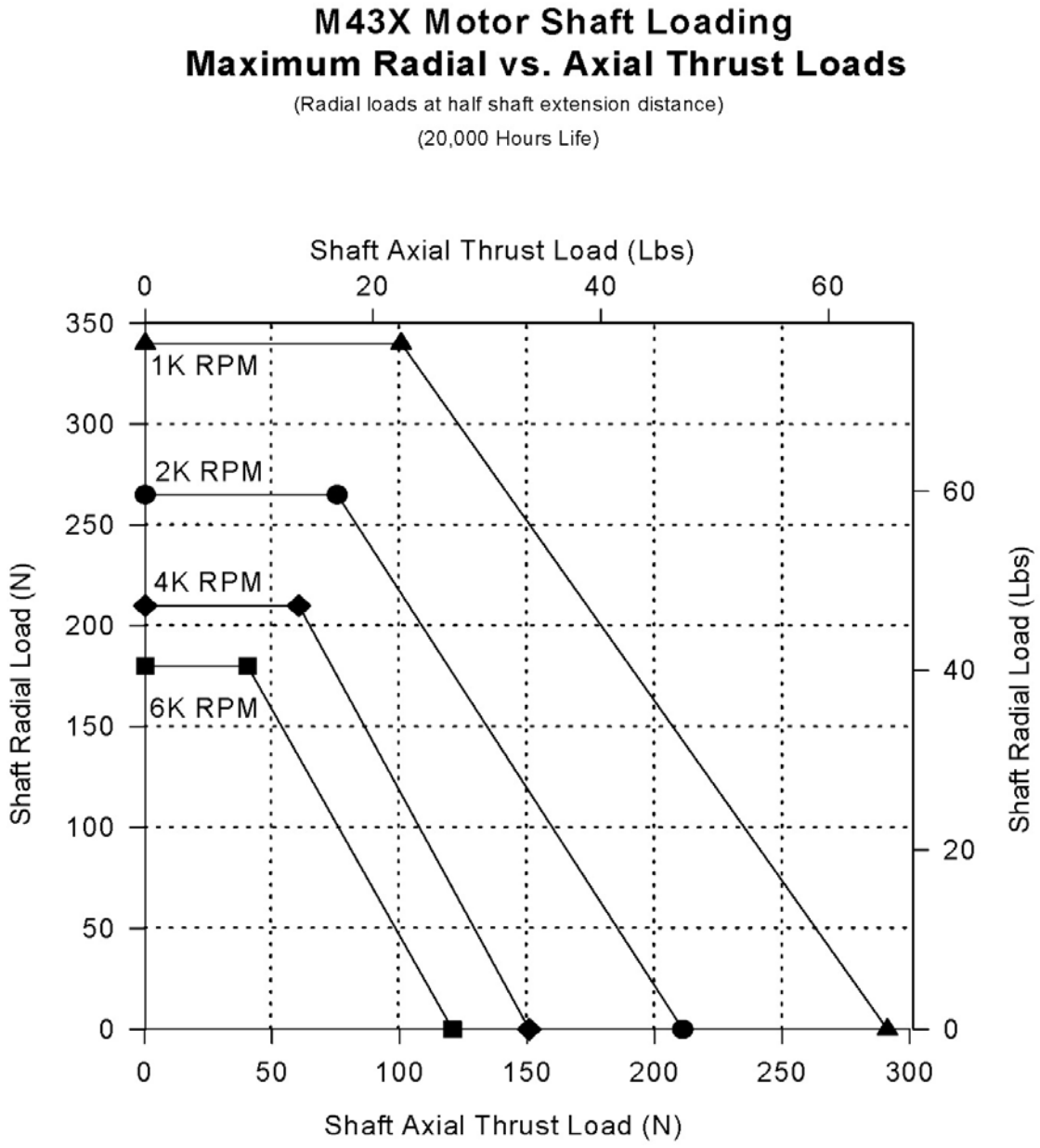
APPENDIX E (Continued)

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	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	99.0	110.0
	kg	12.5	30.4	34.9	44.9	49.9
Motor Weight with Brake	lb	34.5	75.0	86.0	95.0	117.0
	kg	15.6	34.0	39.0	43.1	53.1
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 F

Maximum Radial vs. Axial Shaft Loads

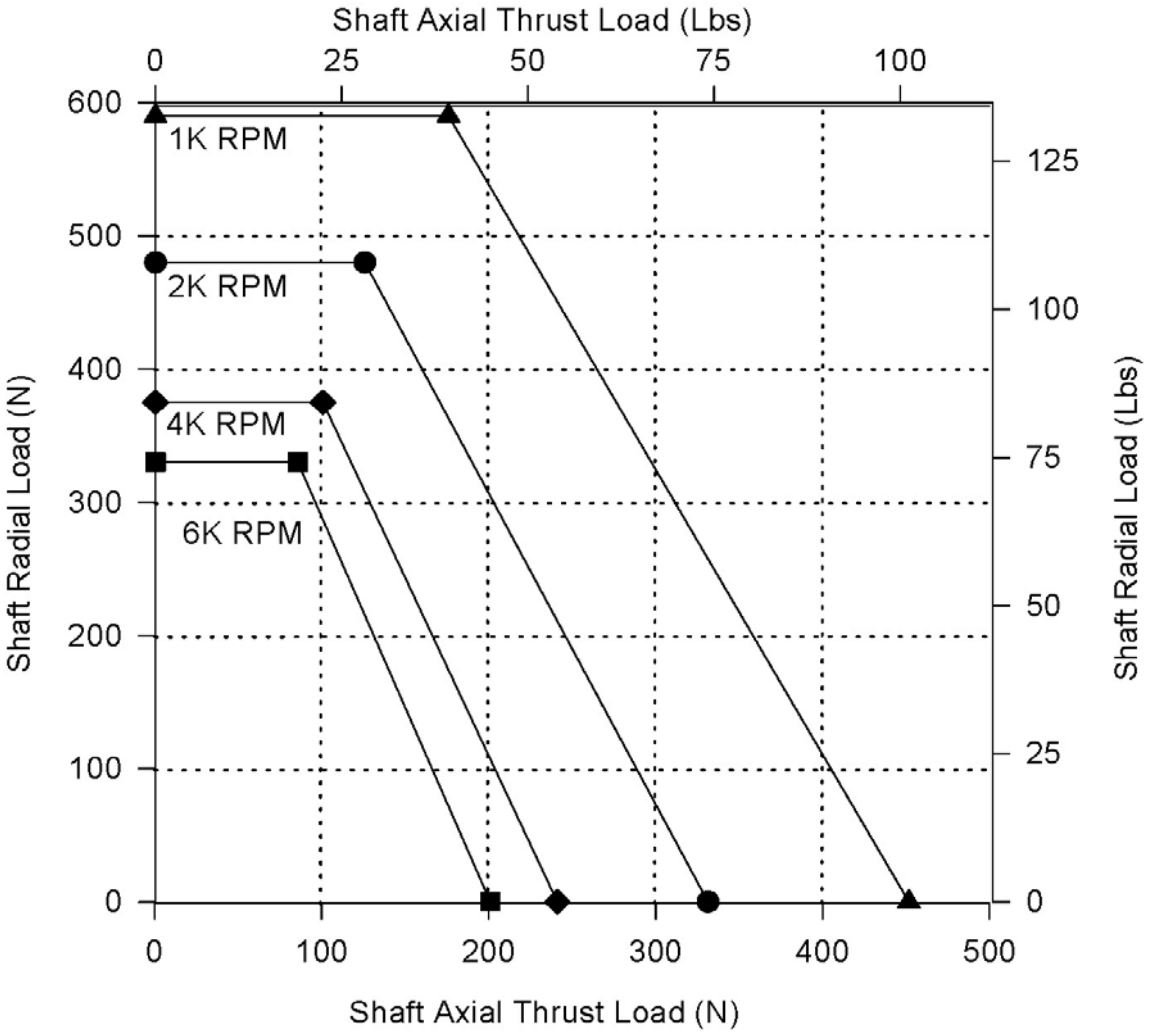


APPENDIX F (Continued)

M44X Motor Shaft Loading
Maximum Radial vs. Axial Thrust Loads

(Radial loads at half shaft extension distance)

(20,000 Hours Life)

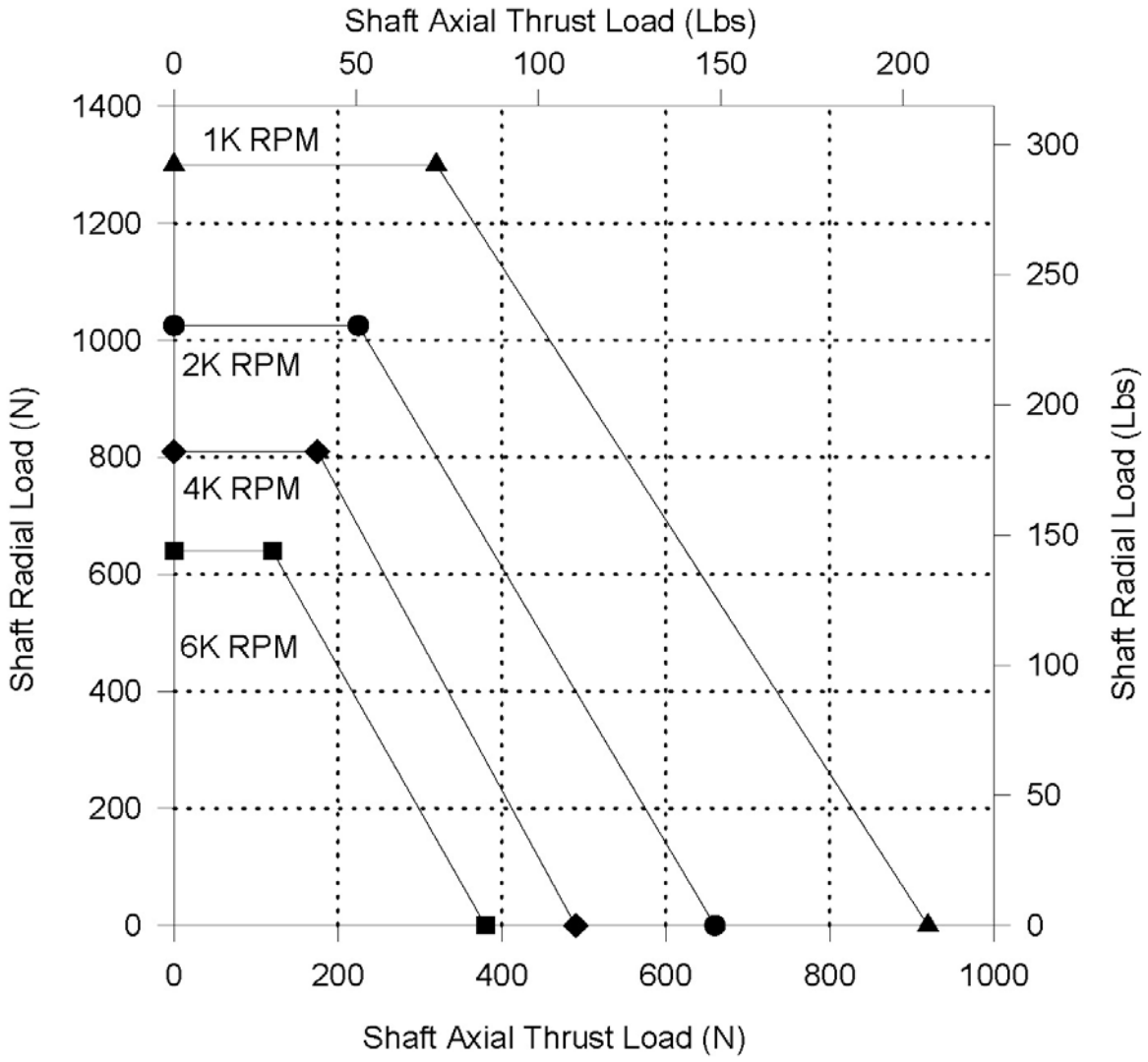


APPENDIX F (Continued)

M46X Motor Shaft Loading
Maximum Radial vs. Axial Thrust Loads

(Radial loads at half shaft extension distance)

(20,000 Hours Life)



APPENDIX F
(Continued)

M47X Motor Shaft Loading
Maximum Radial vs. Axial Thrust Loads

(Radial loads at half shaft extension distance)

(20,000 Hours Life)