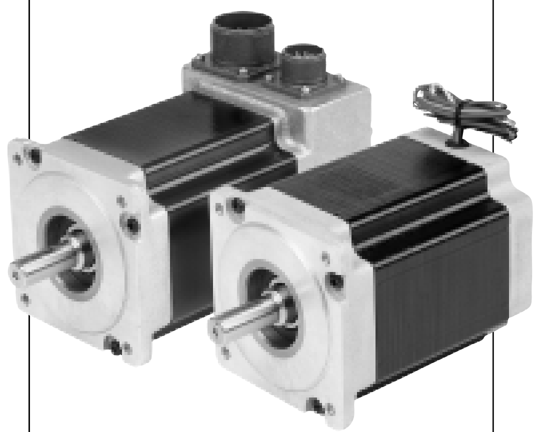
POWERSYNC SYNCHRONOUS MOTORS

OBJY2



Pacific Scientific synchronous motors deliver bidirectional motion for low velocity, constant speed motor drives. These motors are driven economically from standard AC line voltage and the synchronous speed is related to the line frequency.

Synchronous motor components are identical to those in Pacific Scientific step motors except for high impedance, serially connected stator windings designed for direct operation from AC line voltage.

Synchronous motors are often used rather than geared AC induction motors. The desired speed is easily accomplished by gearing up or down from the synchronous speed using a gear box or simple timing belt and pulleys.

Agency Approval

All NEMA 34 and 42 Frame synchronous motors are UL recognized; Class B motor insulation (File 103510).

Typical Application

- Automatic antennas
- Carousel rotation
- Conveyor systems
- Dispensing machines
- Door openers
- Fluid metering
- Labeling machines
- Packaging machines
- Pumps; medical, process and fuel
- Sorting machines
- Test equipment
- Timing belt drives

FEATURES	BENEFITS
With rated torques to 1500 oz-in. (93.75 lb-in.), 10,5 Nm, POWERSYNC provides the highest rated output torque range in the industry	Optimized magnetics provide maximum performance in a small envelope, reducing space required for the motor. Exceptionally high torques provide unparalleled application freedom for AC synchronous motors
Runs cooler than other AC synchronous motors	Longer, more reliable motor life— backed by a two year warranty
Rugged “housingless” square frame	Efficient use of volume for optimal magnetic design
Sealed per NEMA and IP65	For splashproof requirements
Outer bearing races won’t turn— front locked (in steel insert) and rear held by O-ring	Long life bearings— also prevents axial shaft movement for encoder applications
Selection of terminations Special shaft configurations available	Match your requirements
Easy to apply	Simple, economical control components (resistor and capacitor)
Precise speed control	Synchronous speed for a broad range of applications
72 RPM, 120 Vac, 60 Hz and 240 Vac, 60 Hz models	For North American use
60 RPM, 120 Vac, 50 Hz and 240 Vac, 50 Hz models	For international requirements
Standard NEMA mounting	Widely recognized standard
Motors (unloaded) reach synchronous speed in as little as 2 milliseconds. Ask us about response time at your load	Fast response for on-off, precisely timed events

POWERSYNC™
NEMA 34 & 42 Frame
(3.38" & 4.325" Square)

MODEL NUMBER CODE - NEMA 34 FRAME

SN 3 3 H C Y Y - L E K - PD - 01

- **Basic Series** (SN): SN=Standard
- **Size** (3): 3=NEMA 34 frame size; 3.38" width/height, square frame
- **Number of Rotor Stacks** (3): 1=1 Stacks, 2=2 Stacks, 3=3 Stacks, 4=4 Stacks
- **Mounting Configuration** (H): H=Heavy duty NEMA; S=Special, call factory
- **Construction/Hookup** (C): R=Regular/leadwire; C=System MS connector; L=Splashproof/to terminal board via conduit connector: 1/2" NPS pipe thread; M=Splashproof/to terminal board via conduit connector: metric PG11 pipe thread; S=Special, call factory
- **Winding/Leads** (Y): Y= 3 Leads
- **RPM/Voltage/Frequency** (Y): Y=72 RPM,120V ac, 60Hz; Z=72 RPM, 240V ac, 60Hz; R=60 RPM,120V ac, 50Hz; W=60 RPM, 240V ac, 50Hz
- **Rotor Type** (L): L=Laminated
- **Shaft Configuration (Diameter & Length)** (E): N=Single; D=Double (R construction only); E=Double ended for encoder (req'd. for all motors with encoders); S=Special, call factory
- **Shaft Modifications** (K): K=Straight key; S=Special, call factory
- **Encoder Option** (PD): NS=No feedback; M2=Encoder mtg. provisions; PH=Encoder 200ppr w/line driver; PK=Encoder 400ppr w/line driver; PD=Encoder 500ppr w/line driver; PF=Encoder 1000ppr w/line driver; PG=Encoder 1024ppr w/line driver; SS=Special, call factory
- **Special Sequence** (01): 00=Standard motor– no shaft seal; 01=Standard motor with shaft seal; Other #'s will be assigned for special motors

The example model number above indicates a standard NEMA 34 frame motor with a three stack rotor. This motor is equipped with a heavy-duty front end bell and shaft, and a sealed-system rear end bell with MS connectors. It operates at 72 RPM with 120V ac, 60 Hz input voltage. It has a three lead winding, a straight keyway and a shaft seal. The encoder specified is 500ppr with line driver output.

MODEL NUMBER CODE - NEMA 42 FRAME

SN 4 3 H C Y Y - L E K - PD - 01

- **Basic Series** (SN): SN=Standard
- **Size** (4): 4=NEMA 42 frame size; 4.325" width/height, square frame
- **Number of Rotor Stacks** (3): 1=1 Stacks, 2=2 Stacks, 3=3 Stacks
- **Mounting Configuration** (H): H=Heavy duty NEMA; S=Special, call factory
- **Construction/Hookup** (C): R=Regular/leadwire; C=System MS connector; L=Splashproof/to terminal board via conduit connector: 1/2" NPS pipe thread; M=Splashproof/to terminal board via conduit connector: metric PG13,5 pipe thread; S=Special, call factory
- **Winding/Leads** (Y): Y= 3 Leads
- **RPM/Voltage/Frequency** (Y): Y=72 RPM,120V ac, 60Hz; Z=72 RPM, 240V ac, 60Hz; R=60 RPM,120V ac, 50Hz; W=60 RPM, 240V ac, 50Hz
- **Rotor Type** (L): L=Laminated
- **Shaft Configuration (Diameter & Length)** (E): N=Single; D=Double (R construction only); E=Double ended for encoder (req'd. for all motors with encoders); S=Special, call factory
- **Shaft Modifications** (K): K=Straight key; S=Special, call factory
- **Encoder Option** (PD): NS=No feedback; M2=Encoder mtg. provisions; PH=Encoder 200ppr w/line driver; PK=Encoder 400ppr w/line driver; PD=Encoder 500ppr w/line driver; PF=Encoder 1000ppr w/line driver; PG=Encoder 1024ppr w/line driver; SS=Special, call factory
- **Special Sequence** (01): 00=Standard motor– no shaft seal; 01=Standard motor with shaft seal; Other #'s will be assigned for special motors

The example model number above indicates a standard NEMA 42 frame motor with a three stack rotor. This motor is equipped with a heavy-duty front end bell and shaft, and a sealed-system rear end bell with MS connectors. It operates at 72 RPM with 120V ac, 60 Hz input power. It has a three lead winding, a straight keyway and a shaft seal. The encoder specified is 500ppr with line driver output.

HOW TO ORDER

Review the Motor Model Number Code to assure that all options are designated. Call your nearest Pacific Scientific Motor Products Distributor to place orders and for application assistance. If you need to identify your Distributor, call the Motor Products Division at (815) 226-3100.

INDEX

How to use this section

- If you're already familiar with AC synchronous motors and their application, refer to the appropriate Ratings and Characteristics tables in the Index and the available options. See the Model Number Code on page 89 to verify coded information prior to ordering.

- If you are not familiar with these motors, start with "Selection Overview" on page 91. The Motor Sizing & Selection section starting on p. 163 will help you determine the key performance criteria in your application. You can then select the AC synchronous motor most appropriate for your needs.

POWERSYNC™
AC SYNCRHONOUS MOTORS

RPM	Voltage	Frequency	Rated torque oz-in. (Nm)	Rated inertia oz-in-s^2 (kgm^2 x 10^{-3})	Page
72	120Vac	60Hz	280-1500 (1,98 -10,58)	.21-.92 (1,48 - 6,49)	**92**
72	240Vac	60Hz	450-1360 (3,18 - 9,6)	.23-1.13 (1,62 - 7,98)	**93**
60	120Vac	50Hz	375-1440 (2,64 -10,17)	.29-1.3 (2,05 - 9,18)	**94**
60	240Vac	50Hz	360-1430 (2,53 -10,1)	.29-1.64 (2,05 -11,58)	**95**

For assistance in selecting a motor, see page 89.

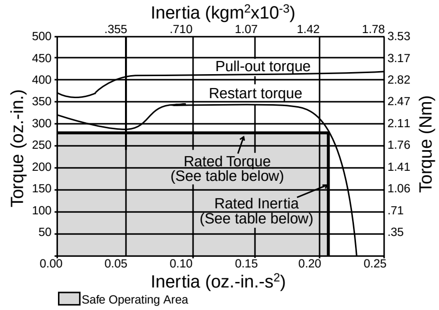
POWERSYNC™

Ratings and Characteristics

72 RPM, 120 Vac, 60 Hz

Typical Performance Curve

also see p.105



PULL-OUT Torque Curve The maximum friction load, at a particular inertial load, that can be applied to the shaft of an AC synchronous motor (running at constant speed) and not cause it to lose synchronism.

RESTART Torque Curve The maximum friction load, at a particular inertial load, that can be applied to the shaft of an AC synchronous motor without causing it to lose synchronism when accelerating to a constant speed from standstill.

For 72RPM, 120V ac, 60 Hz

NEMA Frame Size (in)	Model Number (1)	Rated (2) Torque (3) oz-in (Nm)	Rated (2) Inertia (3) oz-in-s² (kgm²x10⁻³)	Max. Pull-out Torque oz-in (Nm)	RMS per Phase Current @ 80% Pull-out (Amps)	Detent (4) Torque oz-in (Nm)	Thermal Res. (5) (°C/watt)	Phase Res. (Ohms)	Phase Ind. (mH)	Rotor Inertia (6) oz-in-s² (kgm²x10⁻³)	Weight lbs (kg)
34	SN31HXYY-LXK-XX-XX	280 (1,98)	0.21 (1,48)	410 (2,9)	0.38	18 (0,13)	2.7	86	601	0.0202 (0,14)	5 (2,27)
34	SN32HXYY-LXK-XX-XX	480 (3,39)	0.29 (2,05)	690 (4,87)	0.47	36 (0,25)	2	38	383	0.038 (0,27)	8.4 (3,81)
34	SN33HXYY-LXK-XX-XX	690 (4,87)	0.53 (3,74)	1015 (7,17)	0.78	54 (0,38)	1.6	32	362	0.0567 (0,4)	11.9 (5,39)
34	SN34HXYY-LXK-XX-XX	900 (6,36)	0.53 (3,74)	1520 (10,73)	1.43	57 (0,4)	1.3	16	191	0.075 (0,53)	15.1 (6,84)
42	SN41HXYY-LXK-XX-XX	715 (5,05)	0.4 (2,82)	1045 (7,38)	0.8	42 (0,3)	1.9	21	334	0.0783 (0,55)	11 (4,98)
42	SN42HXYY-LXK-XX-XX	1200 (8,47)	0.82 (5,79)	1580 (11,16)	1.19	84 (0,59)	1.3	9.5	198	0.1546 (1,09)	18.4 (8,34)
42	SN43HXYY-LXK-XX-XX	1500 (10,59)	0.92 (6,49)	2000 (14,12)	1.46	106 (0,75)	1	7.2	148	0.2293 (1,62)	25.7 (11,64)

(1) An "X" in the Model Number Code indicates an undefined option. See page 89.

(2) Rated Torque and Inertia are maximum values. The rated torque is the combination of load torque and friction torque. The motor will accelerate and run at synchronous speed, delivering the rated torque value while moving an inertia up to the rated inertia value. Rated inertia is a combination of the load inertia and the motor's rotor inertia. For assistance in motor selection, see page 103.

(3) Rated Torque and Rated Inertia denote restart conditions with a stiff coupling of .3 arc sec/oz-in. minimum.

(4) Detent torque is the maximum torque that can be applied to an unenergized step motor without causing continuous rotating motion.

(5) Thermal resistance from motor winding to ambient with motor hanging in still air, unmounted.

(6) Small signal inductance as measured with impedance bridge at 1kHz, 1 amp.

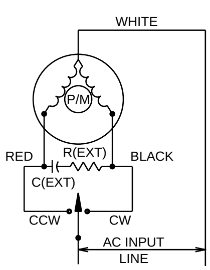
R-C PHASE SHIFT NETWORKS

A phase shift network is required and values have been selected to eliminate reversing torque and motor oscillations during motor startup. The network is placed in the circuit as shown in the diagram below. It is important to use the recommended values for the resistor and capacitor which vary with each motor, see p. 108. For your convenience, R-C phase shift network kits are available from Pacific Scientific. The resistors and capacitors are standard and also readily available from electronic component suppliers.

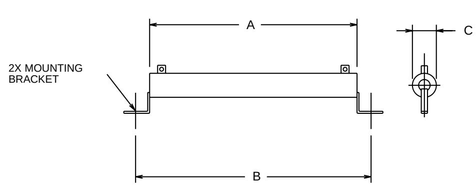
For 72RPM, 120V ac, 60 Hz

Model Number	Resistor		Resistor Dim.			Capacitor		Capacitor Dim.						Kit Number
	(Ohms)	(Watts)	A	B	C	(µf)	(rated Vac)	Fig.	A	B	C	K	J	
SN31HXYY-LXK-XX-XX	200	50	4.0	4.75	.56	6	370	2	2.16	1.31	2.88	-	-	SNRC31-60-120
SN32HXYY-LXK-XX-XX	200	50	4.0	4.75	.56	10	370	2	2.16	1.31	3.88	-	-	SNRC32-60-120
SN33HXYY-LXK-XX-XX	100	100	6.5	7.38	.75	10	370	2	2.16	1.31	3.88	-	-	SNRC33-60-120
SN34HXYY-LXK-XX-XX	50	100	6.5	7.38	.75	17.5	370	1	-	-	2.88	1.75	1.88	SNRC34-60-120
SN41HXYY-LXK-XX-XX	100	100	6.5	7.38	.75	12.5	370	2	2.16	1.31	3.88	-	-	SNRC41-60-120
SN42HXYY-LXK-XX-XX	75	100	6.5	7.38	.75	20	370	1	-	-	3.88	1.75	1.88	SNRC42-60-120
SN43HXYY-LXK-XX-XX	50	100	6.5	7.38	.75	20	370	1	-	-	3.88	1.75	1.88	SNRC43-60-120

Schematic Diagram All Constructions



Resistor



Capacitor

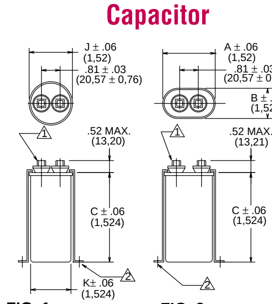


FIG. 1 FIG. 2

Notes:

(1) All blades are .031 x .250. (0,787 x 6,35)

(2) Foot Brackets.

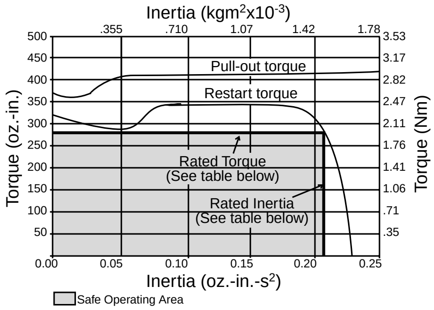
POWERSYNC™

Ratings and Characteristics

72 RPM, 240 Vac, 60 Hz

Typical Performance Curve

also see p.105



PULL-OUT Torque Curve The maximum friction load, at a particular inertial load, that can be applied to the shaft of an AC synchronous motor (running at constant speed) and not cause it to lose synchronism.

RESTART Torque Curve The maximum friction load, at a particular inertial load, that can be applied to the shaft of an AC synchronous motor without causing it to lose synchronism when accelerating to a constant speed from standstill.

For 72RPM, 240V ac, 60 Hz

NEMA Frame Size (in)	Model Number [1]	Rated [2] Torque [3] oz-in (Nm)	Rated [2] Inertia [3] oz-in-s² (kgm²x10⁻³)	Max. Pull-out Torque oz-in (Nm)	RMS per Phase Current @ 80% Pull-out (Amps)	Detent [4] Torque oz-in (Nm)	Thermal Res. [5] (°C/watt)	Phase Res. (Ohms)	Phase Ind. (mH)	Rotor Inertia [6] oz-in-s² (kgm²x10⁻³)	Weight lbs (kg)
34	SN31HXYZ-LXK-XX-XX [7] [8]	450 (3,18)	0.23 (1,62)	560 (3,95)	0.38	18 (0,13)	2.7	141	1058	0.0202 (0,14)	5 (2,27)
34	SN32HXYZ-LXK-XX-XX	655 (4,62)	0.41 (2,89)	850 (6,0)	0.35	36 (0,25)	2	134	1177	0.038 (0,27)	8.4 (3,81)
34	SN33HXYZ-LXK-XX-XX	745 (5,26)	0.41 (2,89)	955 (6,74)	0.28	54 (0,38)	1.6	119	1174	0.0567 (0,4)	11.9 (5,39)
34	SN34HXYZ-LXK-XX-XX	970 (6,84)	0.45 (3,18)	1535 (10,84)	0.64	57 (0,4)	1.3	45	588	0.075 (0,53)	15.1 (6,84)
42	SN41HXYZ-LXK-XX-XX	700 (4,94)	0.53 (3,74)	1000 (7,06)	0.38	42 (0,3)	1.9	84	1342	0.0783 (0,55)	11 (4,98)
42	SN42HXYZ-LXK-XX-XX	1040 (7,34)	1.1 (7,76)	1520 (10,73)	0.63	84 (0,59)	1.3	56	1100	0.1546 (1,09)	18.4 (8,34)
42	SN43HXYZ-LXK-XX-XX	1360 (9,6)	1.13 (7,98)	2150 (15,18)	0.87	106 (1,62)	1	21	485	0.2293 (1,62)	25.7 (11,64)

[1] An "X" in the Model Number Code indicates an undefined option. See page 89.

[2] Rated Torque and Inertia are maximum values. The rated torque is the combination of load torque and friction torque. The motor will accelerate and run at synchronous speed, delivering the rated torque value while moving an inertia up to the rated inertia value. Rated inertia is a combination of the load inertia and the motor's rotor inertia. For assistance in motor selection, see page 103.

[3] Rated Torque and Rated Inertia denote restart conditions with a stiff coupling of .3 arc sec/oz-in. minimum.

[4] Detent torque is the maximum torque that can be applied to an unenergized step motor without causing continuous rotating motion.

[5] Thermal resistance from motor winding to ambient with motor hanging in still air, unmounted.

[6] Small signal inductance as measured with impedance bridge at 1kHz, 1 amp.

[7] Motor has a continuous duty rating if mounted to a 10" x 10" x 1/4" aluminum heat sink in a 40°C ambient.

[8] Motor has an intermittent duty rating unmounted in a 40°C ambient. A maximum duty cycle of 75% is allowed, with a maximum on-time of 150 seconds and zero current during the off-time.

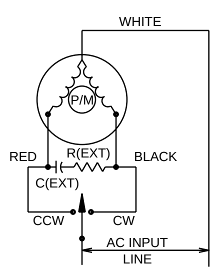
R-C PHASE SHIFT NETWORKS

A phase shift network is required and values have been selected to eliminate reversing torque and motor oscillations during motor startup. The network is placed in the circuit as shown in the diagram below. It is important to use the recommended values for the resistor and capacitor which vary with each motor, see p. 108. For your convenience, R-C phase shift network kits are available from Pacific Scientific. The resistors and capacitors are standard and also readily available from electronic component suppliers.

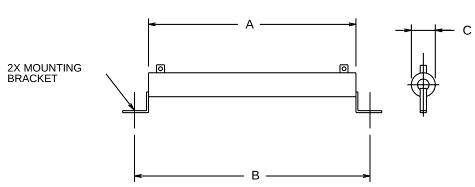
For 72RPM, 240V ac, 60 Hz

Model Number	Resistor (Ohms)		Resistor Dim. (Watts)	A	B	Capacitor C	(µf)	(rated Vac)	Fig.	Capacitor Dim. A	B	C	K	Kit Number J
SN31HXYZ-LXK-XX-XX	500	100	6.5	7.38	0.75	3	370	2	2.16	1.31	2.12	-	-	SNRC31-60-240
SN32HXYZ-LXK-XX-XX	500	100	6.5	7.38	0.75	3	370	2	2.16	1.31	2.12	-	-	SNRC32-60-240
SN33HXYZ-LXK-XX-XX	500	50	4	4.75	0.56	2	660	2	2.16	1.31	2.12	-	-	SNRC33-60-240
SN34HXYZ-LXK-XX-XX	250	100	6.5	7.38	0.75	5	370	2	2.16	1.31	2.12	-	-	SNRC34-60-240
SN41HXYZ-LXK-XX-XX	500	100	6.5	7.38	0.75	3	370	2	2.16	1.31	2.12	-	-	SNRC41-60-240
SN42HXYZ-LXK-XX-XX	200	200	10.5	11.38	1.12	3	370	2	2.16	1.31	2.12	-	-	SNRC42-60-240
SN43HXYZ-LXK-XX-XX	200	200	10.5	11.38	1.12	6	370	2	2.16	1.31	2.88	-	-	SNRC43-60-240

Schematic Diagram All Constructions



Resistor



Capacitor

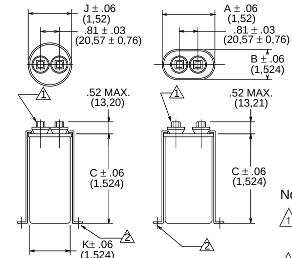


FIG. 1 FIG. 2

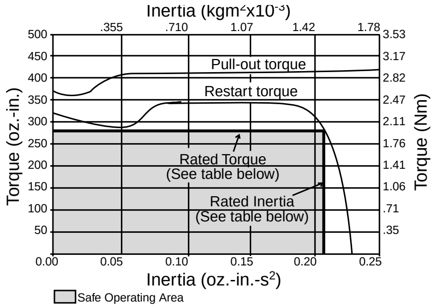
Notes:

[1] All blades are .031 x .250. (0,787 x 6,35)

[2] Foot Brackets.

POWERSYNC™
Ratings and Characteristics
60 RPM, 120 Vac, 50 Hz

Typical Performance Curve
also see p.105



PULL-OUT Torque Curve The maximum friction load, at a particular inertial load, that can be applied to the shaft of an AC synchronous motor (running at constant speed) and not cause it to lose synchronism.

RESTART Torque Curve The maximum friction load, at a particular inertial load, that can be applied to the shaft of an AC synchronous motor without causing it to lose synchronism when accelerating to a constant speed from standstill.

For 60RPM, 120V ac, 50 Hz

NEMA Frame Size (in)	Model Number (1)	Rated (2) Torque (3) oz-in (Nm)	Rated (2) Inertia (3) oz-in-s² (kgm²x10⁻³)	Max. Pull-out Torque oz-in (Nm)	RMS per Phase Current @ 80% Pull-out (Amps)	Detent (4) Torque oz-in (Nm)	Thermal Res. (5) (°C/watt)	Phase Res. (Ohms)	Phase Ind. (mH)	Rotor Inertia (6) oz-in-s² (kgm²x10⁻³)	Weight lbs (kg)
34	SN31HXYR-LXK-XX-XX	375 (2,64)	0.29 (2,05)	490 (3,46)	0.34	18 (0,13)	2.7	136	990	0.0202 (0,14)	5 (2,27)
34	SN32HXYR-LXK-XX-XX	600 (4,24)	0.52 (3,67)	870 (6,14)	0.64	36 (0,25)	2	53	493	0.038 (0,27)	8.4 (3,81)
34	SN33HXYR-LXK-XX-XX	800 (5,65)	0.6 (4,23)	1120 (7,91)	0.67	54 (0,38)	1.6	35	417	0.0567 (0,4)	11.9 (5,39)
34	SN34HXYR-LXK-XX-XX	990 (6,99)	0.53 (3,74)	1565 (11,05)	1.1	57 (0,4)	1.3	18	226	0.075 (0,53)	15.1 (6,84)
42	SN41HXYR-LXK-XX-XX	700 (4,94)	0.53 (3,74)	1060 (7,49)	0.71	42 (0,3)	1.9	33	513	0.0783 (0,55)	11 (4,98)
42	SN42HXYR-LXK-XX-XX	1020 (7,22)	1.16 (8,19)	1575 (11,12)	0.93	84 (0,59)	1.3	15	300	0.1546 (1,09)	18.4 (8,34)
42	SN43HXYR-LXK-XX-XX	1440 (10,17)	1.3 (9,18)	2000 (14,12)	1.6	106 (0,75)	1	12	267	0.2293 (1,62)	25.7 (11,64)

(1) An "X" in the Model Number Code indicates an undefined option. See page 89.

(2) Rated Torque and Inertia are maximum values. The rated torque is the combination of load torque and friction torque. The motor will accelerate and run at synchronous speed, delivering the rated torque value while moving an inertia up to the rated inertia value. Rated inertia is a combination of the load inertia and the motor's rotor inertia. For assistance in motor selection, see page 103.

(3) Rated Torque and Rated Inertia denote restart conditions with a stiff coupling of .3 arc sec/oz-in. minimum.

(4) Detent torque is the maximum torque that can be applied to an unenergized step motor without causing continuous rotating motion.

(5) Thermal resistance from motor winding to ambient with motor hanging in still air, unmounted.

(6) Small signal inductance as measured with impedance bridge at 1kHz, 1 amp.

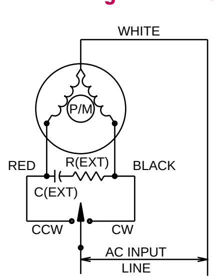
R-C PHASE SHIFT NETWORKS

A phase shift network is required and values have been selected to eliminate reversing torque and motor oscillations during motor startup. The network is placed in the circuit as shown in the diagram below. It is important to use the recommended values for the resistor and capacitor which vary with each motor, see p. 108. For your convenience, R-C phase shift network kits are available from Pacific Scientific. The resistors and capacitors are standard and also readily available from electronic component suppliers.

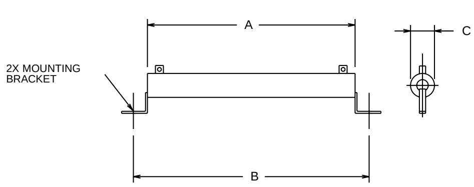
For 60RPM, 120V ac, 50 Hz

Model Number	Resistor (Ohms)	Resistor (Watts)	Resistor Dim. A	Resistor Dim. B	Resistor Dim. C	Capacitor (µf)	Capacitor (rated Vac)	Fig.	Capacitor Dim. A	Capacitor Dim. B	Capacitor Dim. C	Capacitor Dim. K	Capacitor Dim. J	Kit Number
SN31HXYR-LXK-XX-XX	150	25	2	2.75	0.56	5	370	2	2.16	1.31	2.12	-	-	SNRC31-50-120
SN32HXYR-LXK-XX-XX	100	50	4	4.75	0.56	10	370	2	2.16	1.31	3.88	-	-	SNRC32-50-120
SN33HXYR-LXK-XX-XX	100	50	4	4.75	0.56	10	370	2	2.16	1.31	3.88	-	-	SNRC33-50-120
SN34HXYR-LXK-XX-XX	75	100	6.5	7.38	0.75	20	370	1	-	-	3.88	1.75	1.88	SNRC34-50-120
SN41HXYR-LXK-XX-XX	100	50	4	4.75	0.56	10	370	2	2.16	1.31	3.88	-	-	SNRC41-50-120
SN42HXYR-LXK-XX-XX	100	100	6.5	7.38	0.75	20	370	1	-	-	3.88	1.75	1.88	SNRC42-50-120
SN43HXYR-LXK-XX-XX	50	225	10.5	11.38	1.12	20	370	1	-	-	3.88	1.75	1.88	SNRC43-50-120

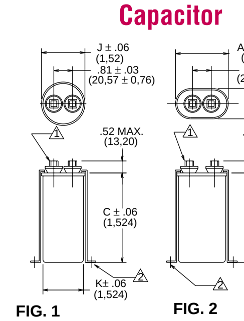
Schematic Diagram All Constructions



Resistor

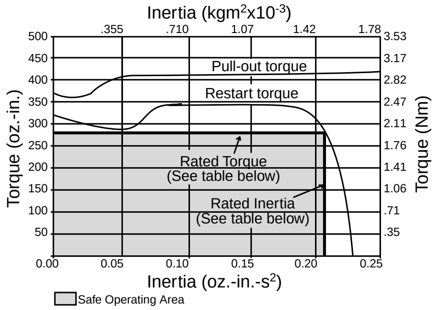


Capacitor



Notes:
(1) All blades are .031 x .250. (0,787 x 6,35)
(2) Foot Brackets.

Typical Performance Curve
also see p.105



PULL-OUT Torque Curve The maximum friction load, at a particular inertial load, that can be applied to the shaft of an AC synchronous motor (running at constant speed) and not cause it to lose synchronism.

RESTART Torque Curve The maximum friction load, at a particular inertial load, that can be applied to the shaft of an AC synchronous motor without causing it to lose synchronism when accelerating to a constant speed from standstill.

For 60RPM, 240V ac, 50 Hz

NEMA Frame Size (in)	Model Number [1]	Rated [2] Torque [3] oz-in (Nm)	Rated [2] Inertia [3] oz-in-s² (kgm²x10⁻³)	Max. Pull-out Torque oz-in (Nm)	RMS per Phase Current @ 80% Pull-out (Amps)	Detent [4] Torque oz-in (Nm)	Thermal Res. [5] (°C/watt)	Phase Res. (Ohms)	Phase Ind. (mH)	Rotor Inertia [6] oz-in-s² (kgm²x10⁻³)	Weight lbs (kg)
34	SN31HXYW-LXK-XX-XX [7] [8]	360 (2,53)	0.29 (2,05)	500 (3,53)	0.43	18 (0,13)	2.7	146	1129	0.0202 (0,14)	5 (2,27)
34	SN32HXYW-LXK-XX-XX	600 (4,24)	0.5 (3,53)	825 (5,83)	0.29	36 (0,25)	2	143	1345	0.038 (0,27)	8.4 (3,81)
34	SN33HXYW-LXK-XX-XX	700 (4,94)	0.52 (3,67)	995 (7,03)	0.32	54 (0,38)	1.6	203	2162	0.0567 (0,4)	11.9 (5,39)
34	SN34HXYW-LXK-XX-XX	1015 (7,18)	0.51 (3,6)	1460 (10,31)	0.52	57 (0,4)	1.3	67	809	0.075 (0,53)	15.1 (6,84)
42	SN41HXYW-LXK-XX-XX	775 (5,47)	0.31 (2,19)	1115 (7,87)	0.38	42 (0,3)	1.9	113	1480	0.0783 (0,55)	11 (4,98)
42	SN42HXYW-LXK-XX-XX	1150 (8,12)	1.08 (7,62)	1650 (11,65)	0.49	84 (0,59)	1.3	57	1130	0.1546 (1,09)	18.4 (8,34)
42	SN43HXYW-LXK-XX-XX	1430 (10,1)	1.64 (11,58)	2200 (15,54)	0.96	106 (0,75)	1	32	729	0.2293 (1,62)	25.7 (11,64)

[1] An "X" in the Model Number Code indicates an undefined option. See page 89.

[2] Rated Torque and Inertia are maximum values. The rated torque is the combination of load torque and friction torque. The motor will accelerate and run at synchronous speed, delivering the rated torque value while moving an inertia up to the rated inertia value. Rated inertia is a combination of the load inertia and the motor's rotor inertia. For assistance in motor selection, see page 103.

[3] Rated Torque and Rated Inertia denote restart conditions with a stiff coupling of .3 arc sec/oz-in. minimum.

[4] Detent torque is the maximum torque that can be applied to an unenergized step motor without causing continuous rotating motion.

[5] Thermal resistance from motor winding to ambient with motor hanging in still air, unmounted.

[6] Small signal inductance as measured with impedance bridge at 1kHz, 1 amp.

[7] Motor has a continuous duty rating if mounted to a 10" x 10" x 1/4" aluminum heat sink in a 40°C ambient.

[8] Motor has an intermittent duty rating unmounted in a 40°C ambient. A maximum duty cycle of 75% is allowed, with a maximum on-time of 150 seconds and zero current during the off-time.

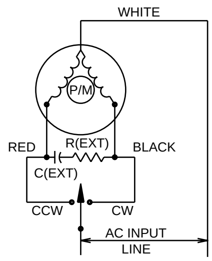
R-C PHASE SHIFT NETWORKS

A phase shift network is required and values have been selected to eliminate reversing torque and motor oscillations during motor startup. The network is placed in the circuit as shown in the diagram below. It is important to use the recommended values for the resistor and capacitor which vary with each motor, see p. 108. For your convenience, R-C phase shift network kits are available from Pacific Scientific. The resistors and capacitors are standard and also readily available from electronic component suppliers.

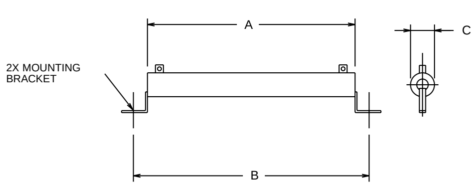
For 60RPM, 240V ac, 50 Hz

Model Number	Resistor		Resistor Dim.			Capacitor		Capacitor Dim.						Kit Number
	(Ohms)	(Watts)	A	B	C	(µf)	(rated Vac)	Fig.	A	B	C	K	J	
SN31HXYW-LXK-XX-XX	500	100	6.5	7.38	0.75	6	370	2	2.16	1.31	2.88	-	-	SNRC31-50-240
SN32HXYW-LXK-XX-XX	500	50	4	4.75	0.56	3	370	2	2.16	1.31	2.12	-	-	SNRC32-50-240
SN33HXYW-LXK-XX-XX	250	50	4	4.75	0.56	2	660	2	2.16	1.31	2.12	-	-	SNRC33-50-240
SN34HXYW-LXK-XX-XX	250	100	6.5	7.38	0.75	5	370	2	2.16	1.31	2.12	-	-	SNRC34-50-240
SN41HXYW-LXK-XX-XX	250	50	4	4.75	0.56	3	370	2	2.16	1.31	2.12	-	-	SNRC41-50-240
SN42HXYW-LXK-XX-XX	250	100	6.5	7.38	0.75	4	370	2	2.16	1.31	2.12	-	-	SNRC42-50-240
SN43HXYW-LXK-XX-XX	150	225	10.5	11.38	1.12	7.5	370	2	2.16	1.31	2.88	-	-	SNRC43-50-240

Schematic Diagram All Constructions



Resistor



Capacitor

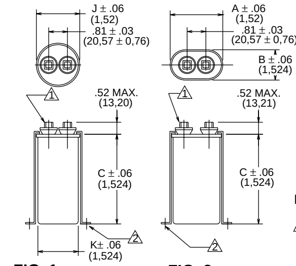


FIG. 1 FIG. 2

Notes:

[1] All blades are .031 x .250. (0,787 x 6,35)

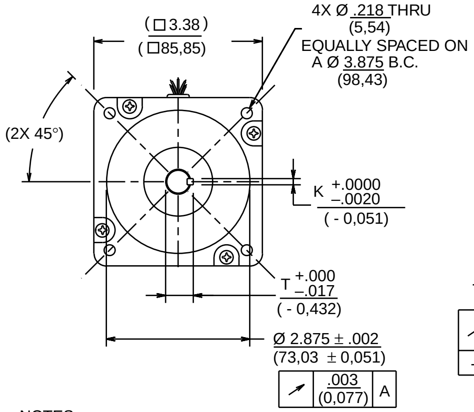
[2] Foot Brackets.

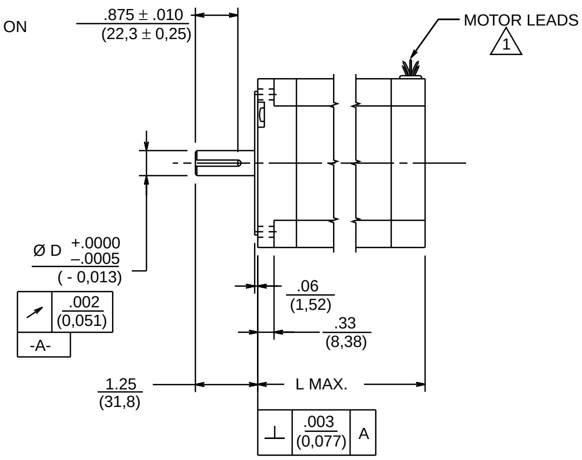
in. / mm (metric dimensions for ref. only)

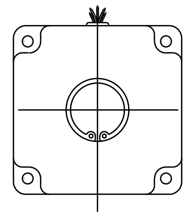
NEMA 34 FRAME: All motors have a heavy duty NEMA front end bell and large diameter shaft to support the higher output torques

LEADWIRE HOOKUP - ENCODER OPTIONS

Model Number Code designation R (Construction/Hookup), p.89







NOTES:

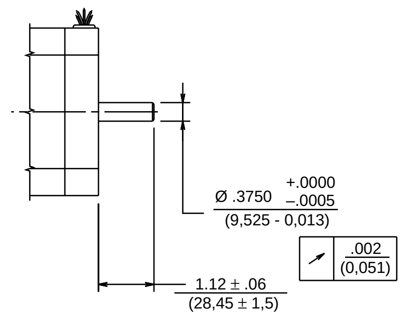
1 MOTOR LEADS 12.0" MIN. (305)

MOTOR*	D	K	T	L MAX.
31HR	.5000 (12,70)	.1250 (3,175)	.555 (14,09)	3.13 (79,5)
32HR	.5000 (12,70)	.1250 (3,175)	.555 (14,09)	4.65 (118,1)
33HR	.6250 (15,875)	.1875 (4,763)	.705 (17,91)	6.17 (156,7)
34HR	.6250 (15,875)	.1875 (4,763)	.705 (17,91)	7.68 (195,1)

*See Model Number Code, p 89.

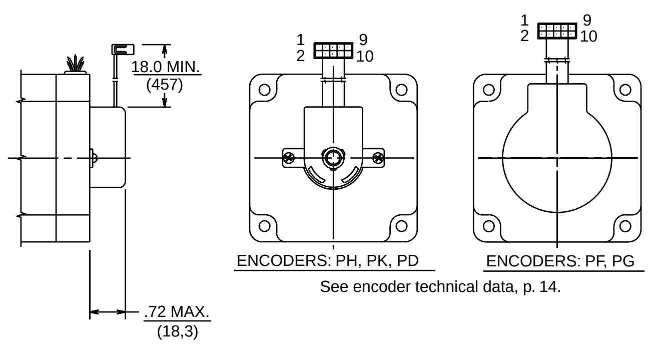
LEADWIRE HOOKUP
DOUBLE SHAFT CONFIGURATION

Model Number Code designation D (Shaft Configuration), p. 89



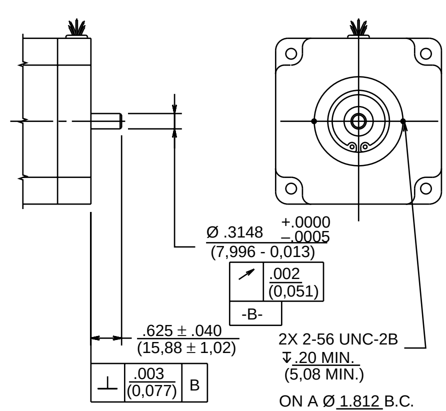
LEADWIRE HOOKUP
FACTORY INSTALLED ENCODER

Model Number Code designation E (Encoder Option), p. 89
See encoder technical data, p. 101



LEADWIRE HOOKUP
ENCODER MOUNTING PROVISION

Model Number Code designation M2 (Encoder Option), p.89

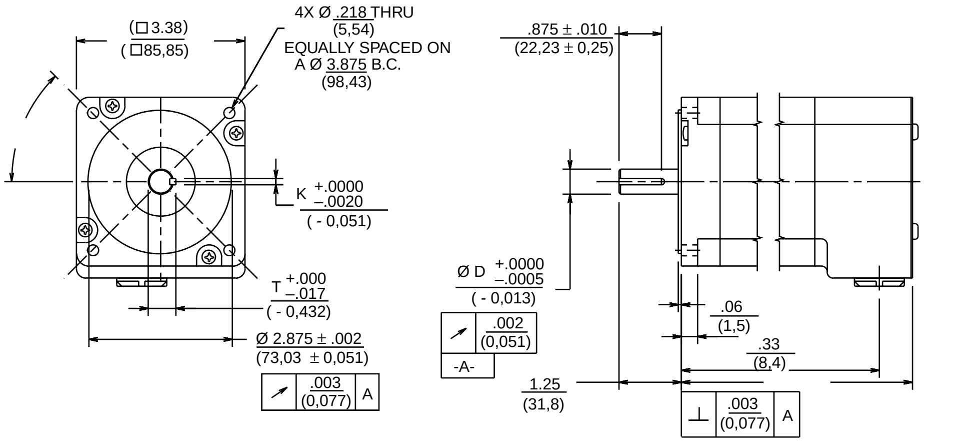


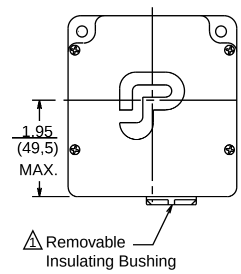
in./mm (metric dimensions for ref. only)

NEMA 34 FRAME: All motors have a heavy duty NEMA front end bell and large diameter shaft to support the higher output torques

SPLASHPROOF CONSTRUCTION/TERMINAL BOARD CONNECTIONS

(via English or Metric thread for conduit) Model Number Code designation L or M (Construction/Hookup), p 89





⚠ Removable Insulating Bushing

⚠ L Construction = Conduit connection (1/2 NPS TAP) with .56/14,2 I.D. removable insulating bushing

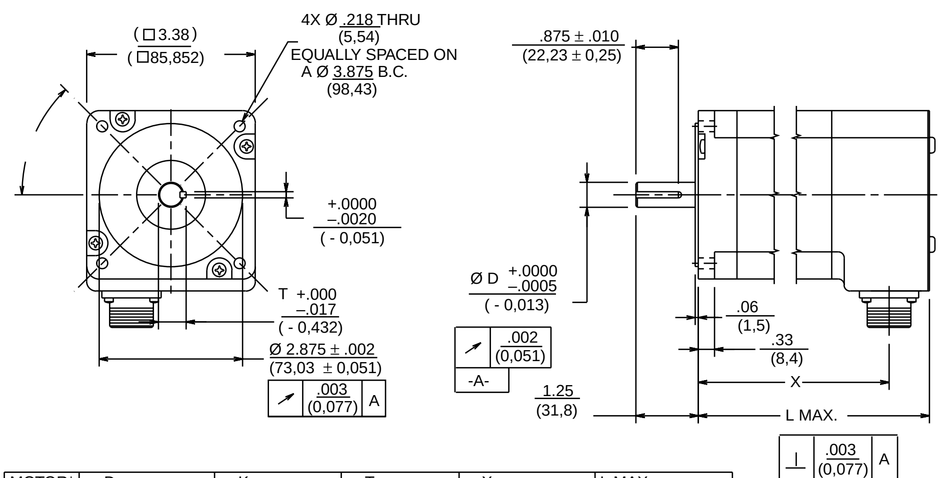
M Construction = Conduit connection (PG 11 TAP). (No insulating bushing supplied)

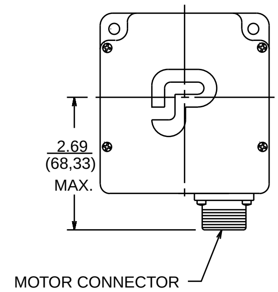
MOTOR*	D	K	T	X	L MAX.
31HR	.5000 (12,70)	.1250 (3,175)	.555 (14,09)	3.70 (93,9)	4.44 (112,8)
32HR	.5000 (12,70)	.1250 (3,175)	.555 (14,09)	5.22 (132,6)	5.96 (151,4)
33HR	.6250 (15,875)	.1875 (4,763)	.705 (17,91)	6.74 (171,20)	7.48 (189,9)
34HR	.6250 (15,875)	.1875 (4,763)	.705 (17,91)	8.25 (209,6)	8.99 (228,4)

*See Model Number Code, p 89.

SPLASHPROOF CONSTRUCTION/MS CONNECTOR(S)— ENCODER OPTION

Model Number Code designation C/System (Construction/Hookup) and Px (Encoder Option), p 89



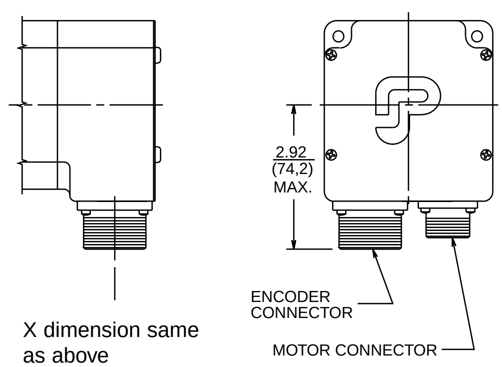


MOTOR*	D	K	T	X	L MAX.
31HR	.5000 (12,70)	.1250 (3,175)	.555 (14,09)	3.56 (90,42)	4.44 (112,8)
32HR	.5000 (12,70)	.1250 (3,175)	.555 (14,09)	5.07 (128,78)	5.96 (151,4)
33HR	.6250 (15,875)	.1875 (4,763)	.705 (17,91)	6.59 (167,39)	7.48 (189,9)
34HR	.6250 (15,875)	.1875 (4,763)	.705 (17,91)	8.11 (205,99)	8.99 (228,4)

*See Model Number Code, p 89.

ENCODER OPTION

Factory installed, see Model Number Code Px (Encoder Option), p. 89 and encoder technical data, p. 101



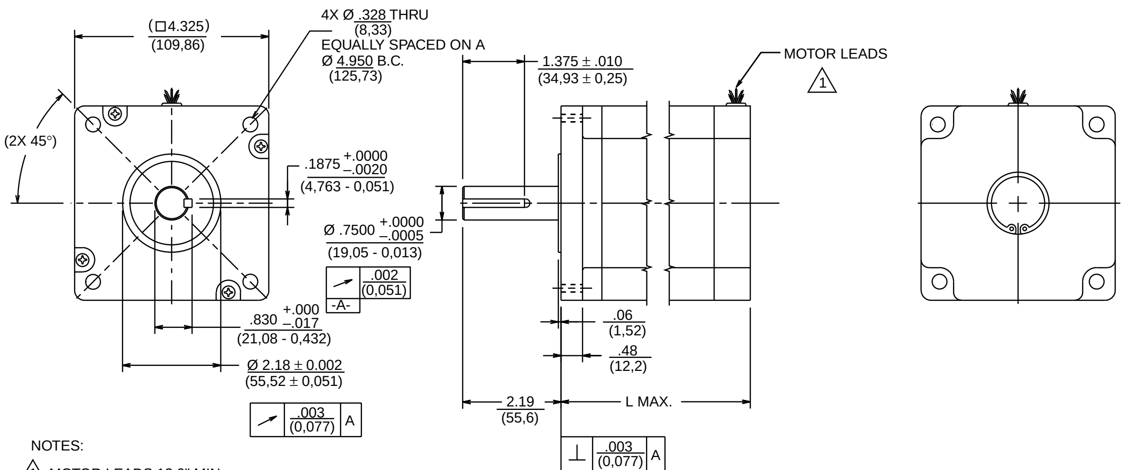
X dimension same as above

in. / mm (metric dimensions for ref. only)

NEMA 42 FRAME: All motors have a heavy duty NEMA front end bell and large diameter shaft to support the higher output torques

LEADWIRE HOOKUP

Model Number Code designation R (Construction/Hookup), p. 89



NOTES:

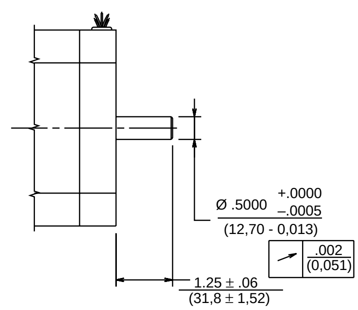
1 MOTOR LEADS 12.0" MIN. (304,8)

MOTOR*	L MAX.
41HR	3.89 (98,8)
42HR	5.91 (150,1)
43HR	7.92 (201,2)

* See Model Number Code, p.89

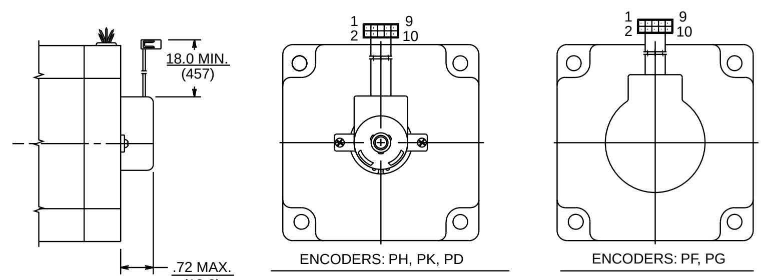
LEADWIRE HOOKUP
DOUBLE SHAFT CONFIGURATION

Model Number Code designation D (Shaft Configuration), p. 89
Available on R construction only.



LEADWIRE HOOKUP
FACTORY INSTALLED ENCODER

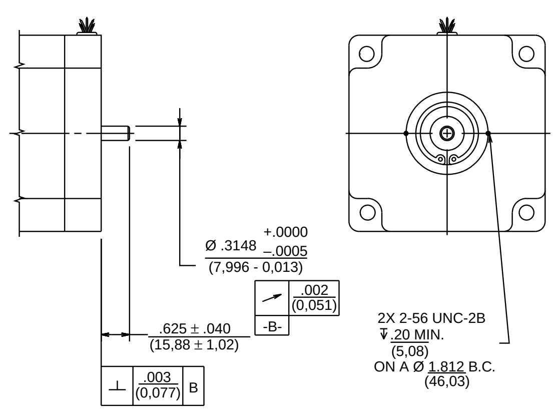
Model Number Code designation E (Encoder Option), p. 89
See encoder technical data, p. 101



See encoder technical data, p. 14.

LEADWIRE HOOKUP
ENCODER MOUNTING PROVISION

Model Number Code designation M2 (Encoder Option), p.89



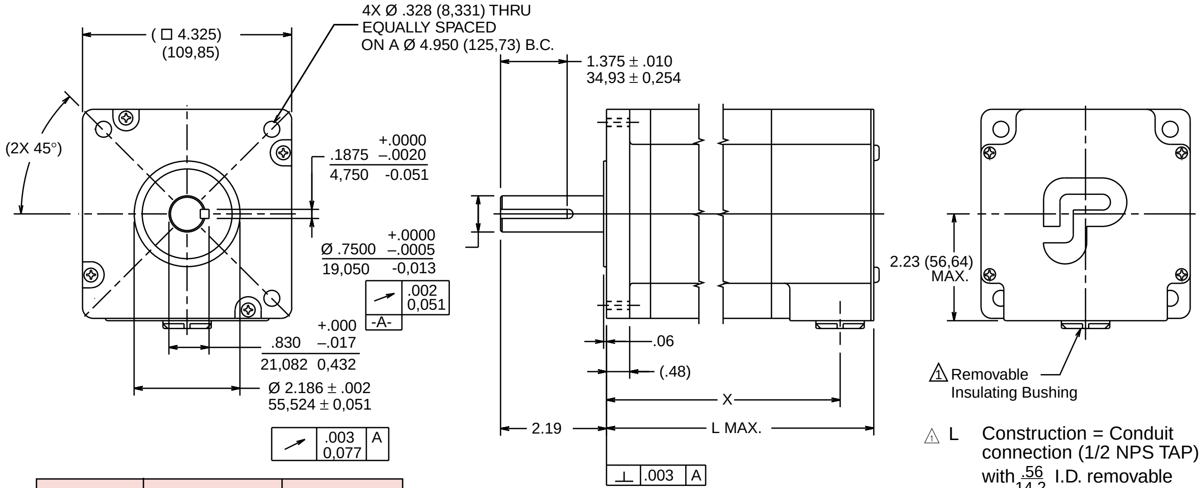
DIMENSIONS . . . POWERSYNC™

in./mm (metric dimensions for ref. only)

NEMA 42 FRAME: All motors have a heavy duty NEMA front end bell and large diameter shaft to support the higher output torques

SPLASHPROOF CONSTRUCTION/TERMINAL BOARD CONNECTIONS

(via English or Metric thread for conduit) Model Number Code designation L or M (Construction/Hookup), p. 89.



MOTOR*	X	L MAX.
41HR	4.46 (113,3)	3.89 (98.9)
42HR	6.48 (164,6)	5.91 (150,1)
43HR	8.49 (215,7)	7.92 (201,2)

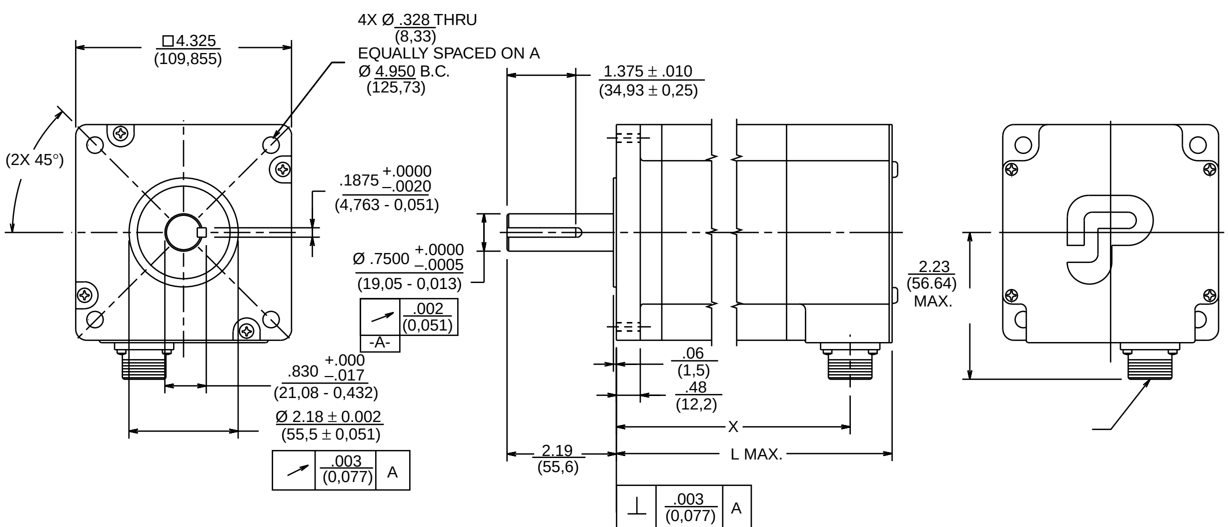
* See Model Number Code, p.89

⚠ L Construction = Conduit connection (1/2 NPS TAP) with .56/14,2 I.D. removable insulating bushing

M Construction = Conduit connection (PG 13, 5 TAP). (No insulating bushing supplied)

SPLASHPROOF CONSTRUCTION/MS CONNECTOR(S)— ENCODER OPTION

Model Number Code designation C/System (Construction/Hookup) and Px (Encoder Option), p. 89.

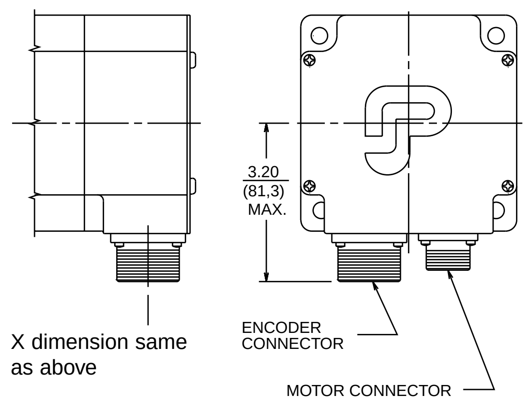


MOTOR*	X	L MAX.
41HR	4.32 (109,7)	5.20 (132,1)
42HR	6.33 (160,8)	7.22 (183,4)
43HR	8.35 (212,1)	9.23 (234,4)

* See Model Number Code, p.89

ENCODER OPTION

Factory installed, see Model Number Code Px (Encoder Option), p. 89 and encoder technical data, p. 101

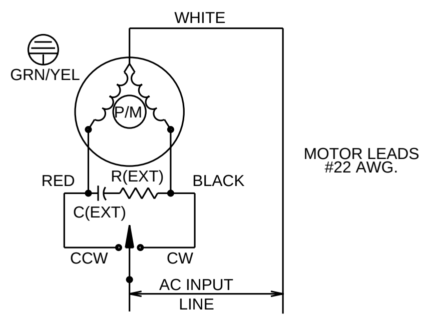


MOTOR POWER CONNECTIONS

• Connection options: Flying Leads, MS Connectors, Terminal Board

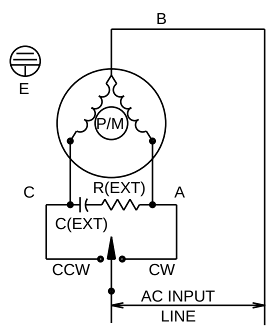
For all motor terminations refer to the following AC synchronous motor connection diagram to assure that proper connections are made. Consult our application engineers for assistance if necessary.

FLYING LEADS

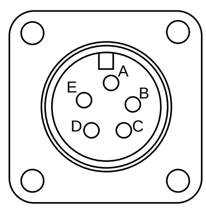


3 - LEAD AC SYNCHRONOUS

MS CONNECTOR

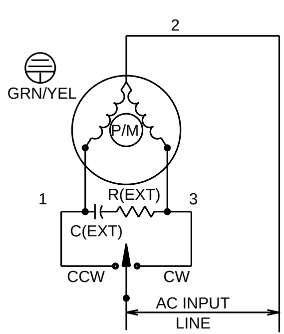


3 - LEAD AC SYNCHRONOUS

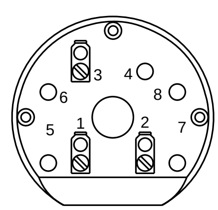


PIN	LEAD COLOR
A	BLK
B	WHT
C	RED
D	------
E	GRN/YEL

TERMINAL BOARD



3 - LEAD AC SYNCHRONOUS



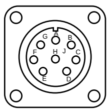
TERMINAL BOARD

TERMINAL NUMBER	LEAD COLOR
1	RED
2	WHT
3	BLACK

ENCODER OPTIONS...**POWERSYNC™**

NEMA 34 AND NEMA 42 ENCODER OPTIONS

Encoder factory installed (inside). See NEMA 34 drawing, p. 97 and NEMA 42 drawing, p. 99.



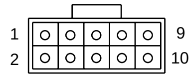
ENCODER CONNECTOR △1

PIN	FUNCTION
A	CHANNEL A
B	CHANNEL $\overline{A}$
C	CHANNEL B
D	CHANNEL $\overline{B}$
E	CHANNEL Z
F	CHANNEL $\overline{Z}$
G	+ 5 VDC
H	5 VDC RTN

MOTOR FEEDBACK CONNECTOR
MS3102E20-7P

SUGGESTED MATING CONNECTOR	
PAC SCI P.N.	MS P.N.
CZ00008	MS3106F20-7S

Encoder factory installed (outside on rear end bell). See NEMA 34 drawing, p. 96 and NEMA 42 drawing, p. 98.



ENCODER CONNECTOR △2

PIN	FUNCTION
1	N/C
2	+5V
3	GROUND
4	N/C
5	$\overline{A}$
6	A
7	$\overline{B}$
8	B
9	$\overline{Z}$
10	Z

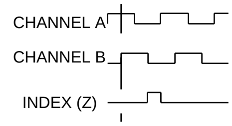
MODELS Px

MATING CONNECTOR NOT OFFERED SUGGESTED MFR. PART NUMBERS
BERG 65692-001

ENCODER OUTPUT

ENCODER OUTPUT

FOR CW DIRECTION OF ROTATION WHEN VIEWED FROM MOTOR DRIVE SHAFT END. (COMPLEMENTS NOT SHOWN) MIN. EDGE SEPARATION 45°. INDEX GATED TO A AND B.



PARAMETER △3	LINE DRIVER (Px)				
TYPE	INCREMENTAL				
ENCODER OPTION	PH	PK	PD	PF	PG
PULSES PER REVOLUTION	200	400	500	1000	1024
SUPPLY VOLTAGE	+5V ± 10% @ 165 mA MAX.				
OUTPUT FORMAT	DUAL CHANNEL QUADRATURE AND INDEX W/ COMPLEMENTS				
OUTPUT TYPE	23LS31 TTL DIFFERENTIAL LINE DRIVER, SHORT CIRCUIT PROTECTED				
FREQUENCY RESPONSE	100 kHz				
ROTOR INERTIA (ADDED)	8×10^{-6} oz-in-s^2 for PH, PK and PD 110.4×10^{-6} oz-in-s^2 for PF and PG				

NOTE:

△1 NEMA 34, NEMA 42 SYSTEM CONSTRUCTION

△2 NEMA 34, REGULAR CONSTRUCTION ONLY.

△3 TYPICAL @ 25° C

SHAFT LOAD AND BEARING FATIGUE LIFE (L_{10})...POWERSYNC™

The **POWERSYNC** H-mount configuration has a heavy duty NEMA front end bell and a large diameter shaft to support the higher torque outputs.

Bearings are the only wearing component in an AC synchronous motor. PacSci uses heavy duty, long life bearings to assure you the maximum useful life from every AC synchronous motor you purchase.

SHAFT LOADING

The maximum radial fatigue load ratings reflect the following assumptions:

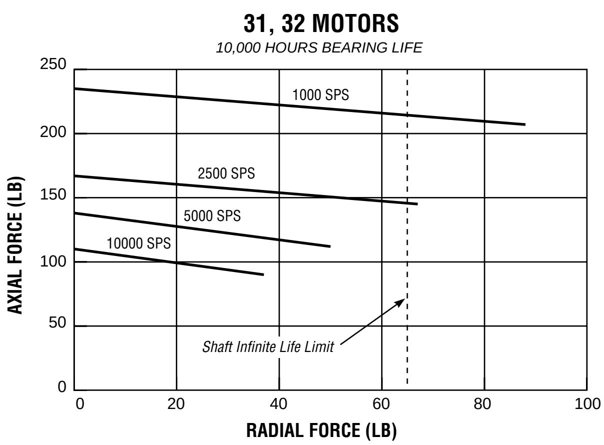
1. Motors are operated at 1 * rated torque
2. Fully reversed radial load applied in the center of the keyway extension
3. Infinite life with 99% reliability
4. Safety factory = 2

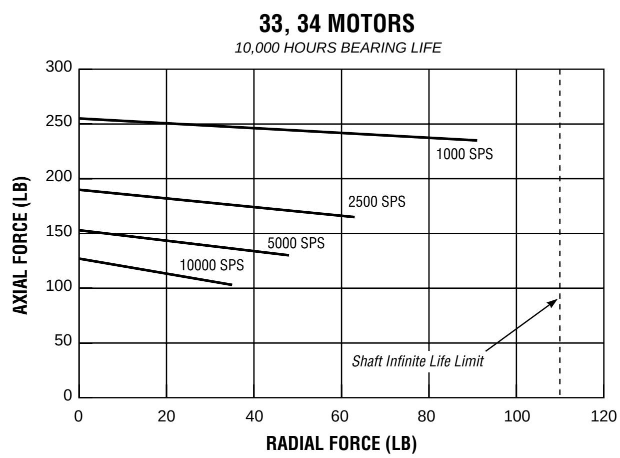
Motor	Max. Radial Force (Lb.)	Max. Axial Force (Lb.)
31, 32	65	305
33, 34	110	305
41	125	404
42, 43	110	404

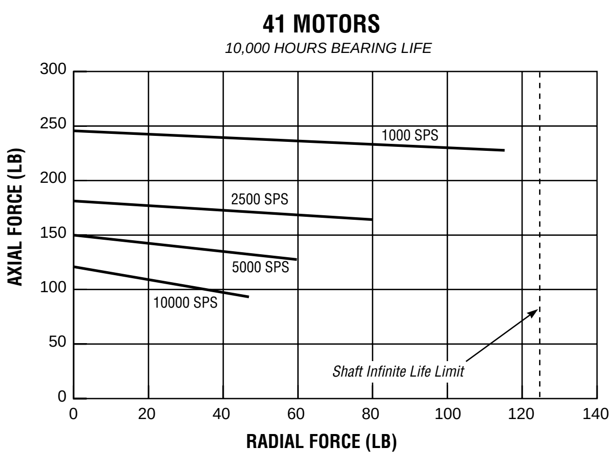
BEARING FATIGUE LIFE (L_{10})

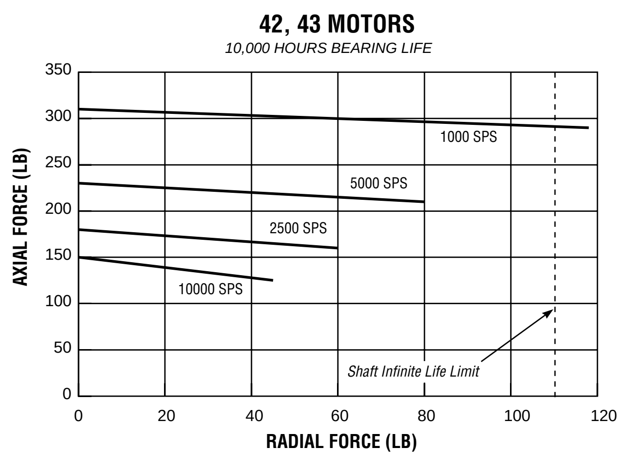
See Model Number Codes on page 4 for clarification.

Note: SPS = Speed, Full Steps Per Second









POWERSYNC™ MOTOR SIZING & SELECTION

Use this procedure to select a motor.

DETERMINE THE LOAD

Three load parameters, defined at the motor shaft, must be determined. If there is a mechanical linkage between the load and the motor shaft, e.g. gears or belts and pulleys, the effect of these mechanics must be taken into account. The three parameters are:

a. Inertia, J (oz-in-s^2, kgm^2 x 10^{-3}). Inertia is the resistance of an object to change in velocity, i.e., the resistance to accelerate or decelerate. Inertia can be calculated or measured. Inertia is an important parameter since it defines the torque required to accelerate the load.

b. Friction Torque, T_F (oz-in, lb-in., or Nm). This is the torque required to overcome the contact between mechanical components that resists motion of these components relative to each other. Friction torque is independent of speed. It can be calculated but is usually measured using a torque wrench placed at the drive shaft point.

c. Load Torque, T_L (oz-in. lb-in., or Nm). This is any torque required by the load and is separate from the friction torque.

MOTION CONTROL MECHANICS

Typical mechanical drive systems for motion control can be divided into four basic categories; direct drive, gear drive, leadscrew drive, and tangential drive. The following describes each one of the categories and provides the relevant formulas for calculating the various load parameters. In all instances, the formulas reflect all parameters back to the motor shaft. This means that all load parameters are transformed to the equivalent load parameters "seen" by the motor. Reflecting all parameters back to the motor shaft eases the calculations necessary to properly size the motor.

CALCULATING THE INERTIA OF A CYLINDER

Inertia can be seen as the resistance of an object to being accelerated or decelerated. In motion control applications, inertia is an important parameter since it is a major part in the definition of the torque required to accelerate and decelerate the load.

SOLID CYLINDER

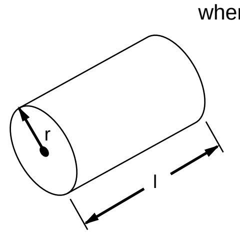
The inertia of a solid cylinder can be calculated if either its weight and radius or its density, radius, and length are known. Lead screws, Rotary Tables and Solid Pulley's can be viewed as solid cylinders when performing this calculation.

For known weight and radius: $J_L = \frac{1}{2}\frac{Wr^2}{g} = (0.0013)Wr^2$

For known density, radius, and length:

$$J_L = \frac{1}{2}\frac{\pi l p r^4}{g} = (0.0041)lpr^4$$

where:
- J_L = inertia (oz-in-s^2)
- W = weight (oz)
- r = radius (in)
- l = length (in)
- p = density of material (oz/in^3)
- g = gravitational constant (386 in/s^2)



HOLLOW CYLINDER

The inertia of a hollow cylinder can be calculated if its weight, inside radius, and outside radius are known or if its density, inside radius, outside radius, and length are known.

The densities of some commonly used materials are given in the table below

For known weight and radii:

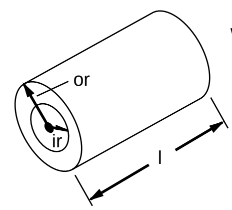
$$J_L = \frac{1W}{2\,g}(or^2 + ir^2)$$

$$= (0.0013)\,(or^2 + ir^2)W$$

For known density, radii, and length:

$$J_L = \frac{\pi l p}{2\,g}(or^4 - ir^4)$$

$$= (0.0041)\,(or^4 - ir^4)lp$$



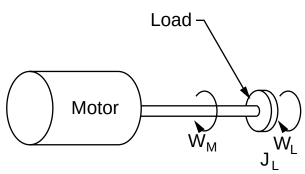
where:
- J_L = inertia (oz-in-s^2)
- W = weight (oz)
- or = outside radius (in)
- ir = inside radius (in)
- l = length (in)
- p = density of material (oz/in^3)
- g = gravitational constant (386 in/s^2)

MATERIAL DENSITIES

Material	oz/in^3
Aluminum	1.536
Brass	4.800
Bronze	4.720
Copper	5.125
Steel (cold rolled)	4.480
Plastic	0.640
Hard Wood	0.464
Soft Wood	0.288

DIRECT DRIVE LOAD

For direct drive loads, the load parameters do not have to be reflected back to the motor shaft since there are no mechanical linkages involved. The inertia of loads connected directly to the motor shaft can be calculated using the Solid and Hollow Cylinder examples.



Speed: $W_M = W_L$

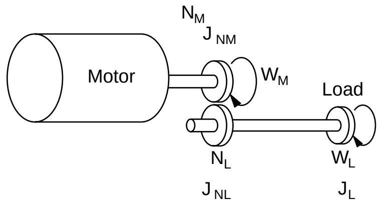
Torque: $T_L = T'$

Inertia: $J_T = J_L + J_M$

where:
- W_M = motor speed (rpm)
- W_L = load speed (rpm)
- J_T = total system inertia (oz-in-s^2)
- J_L = load inertia (oz-in-s^2)
- J_M = motor inertia (oz-in-s^2)
- T_L = load torque at motor shaft (oz-in)
- T' = load torque (oz-in)

GEAR DRIVEN LOAD

Load parameters in a gear driven system have to be reflected back to the motor shaft. The inertia of the gears have to be included in the calculations. The gear inertias can be calculated using the equations shown for the inertia of a Solid or Hollow Cylinder.



Speed: $w_M = w_L(N_L/N_M)$

Torque: $T_L = T'(N_M/N_L)$

Inertia: $J_T = (N_M/N_L)^2\,(J_L + J_{NL}) + J_M + J_{NM}$

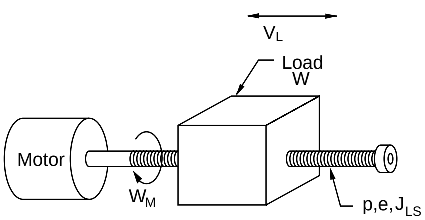
where:
- w_M = motor speed (rpm)
- w_L = load speed (rpm)
- N_M = number of motor gear teeth
- N_L = number of load gear teeth
- T_L = load torque reflected to motor shaft (oz-in)
- T' = load torque (oz-in)–not reflected
- J_T = total system inertia (oz-in-s²)
- J_L = load inertia (oz-in-s²)
- J_M = motor inertia (oz-in-s²)
- J_{NM} = motor gear inertia (oz-in-s²)
- J_{NL} = load gear inertia (oz-in-s²)

LEADSCREW DRIVEN LOAD

For this type of drive system, the load parameters have to be reflected back to the motor shaft. The inertia of the leadscrew has to be included and can be calculated using the equations for inertia of a solid cylinder. For precision positioning applications, the leadscrew is sometimes preloaded to eliminate or reduce backlash. If preloading is used, the preload torque must be included since it can be a significant term. The leadscrew's efficiency must also be considered in the calculations. The efficiencies of various types of leadscrews are shown here.

TYPICAL LEADSCREW EFFICIENCIES

Type	Efficiency
Ball-nut	0.90
Acme with plastic nut	0.65
Acme with metal nut	0.40



Speed: $w_M = v_L p$

Torque: $T_L = \frac{1}{2\pi}\frac{F_L}{pe} + \frac{1}{2\pi}\frac{F_{PL}}{p} \times 0.2$ ⚠

$= (0.159)F_L/pe + (0.032)F_{PL}/p$

Inertia: $J_T = \frac{W}{g}\left(\frac{1}{2\pi p}\right)^2 \frac{1}{e} + J_{LS} + J_M$

$= (6.56 \times 10^{-5})W/ep^2 + J_{LS} + J_M$

Friction: $F_F = uW$

$T_F = \frac{1}{2\pi}\frac{F_F}{pe} = (0.159)F_F/pe$

where:
- w_M = motor speed (rpm)
- v_L = linear load speed (in/min)
- p = lead screw pitch (revs/in)
- e = lead screw efficiency
- T_L = load torque reflected to motor shaft (oz-in)
- T_F = friction torque (oz-in)
- F_L = load force (oz)
- F_{PL} = preload force (oz)
- J_T = total system inertia (oz-in-s²)
- J_M = motor inertia (oz-in-s²)
- J_{LS} = lead screw inertia (oz-in-s²)
- W = load weight (oz)
- F_F = frictional force (oz)
- u = coefficient of friction
- g = gravitational constant (386 in/s²)

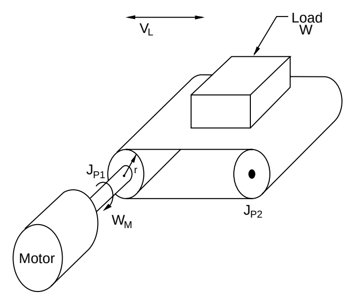
COEFFICIENTS OF FRICTION

Steel on steel	0.580
Steel on steel (lubricated)	0.150
Teflon on steel	0.040
Ball bushing	0.003

⚠ For certain applications, the frictional drag torque due to preloading should also be considered as part of the total torque requirement. Since optimum preloading is one-third of operating load, it is common practice to use 0.2 as the preload torque coefficient for the ball screw to obtain a maximum figure for preload frictional drag torque. At higher than optimum preloading, the preload frictional drag will add to the torque requirements, since it is a constant.

TANGENTIALLY DRIVEN LOAD

For this type of drive system, the load parameters have to be reflected back to the motor shaft. A tangential drive can be a rack and pinion, timing belt and pulley, or chain and sprocket. The inertia of the pulleys, sprockets, or pinion gears must be included in the calculations. These inertia's can be calculated using the equations shown for the inertia of a Solid or Hollow Cylinder.



Speed: $w_M = \frac{1}{2\pi}\frac{V_L}{r} = (0.159)v_L/r$

Torque: $T_L = F_L r$

Inertia: $J_T = \frac{W}{g}r^2 + J_{P1} + J_{P2} + J_M$

$= (0.0026)Wr^2 + J_{P1} + J_{P2} + J_M$

Friction: $T_F = F_F r$

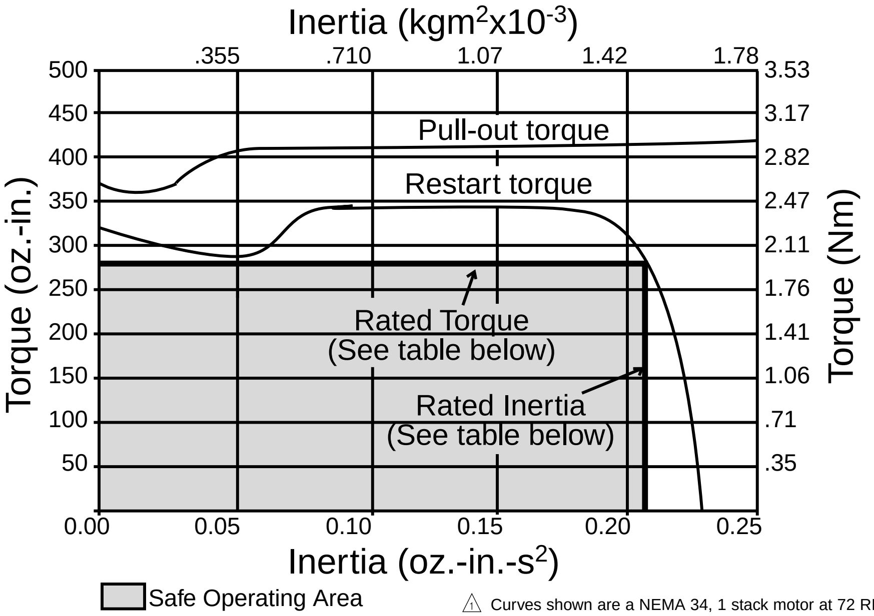
where:
- w_M = motor speed (rpm)
- v_L = linear load speed (in/min)
- r = pulley radius (in)
- T_L = load torque reflected to motor shaft (oz-in)
- T_F = friction torque (oz-in)
- F_L = load force (oz)
- J_T = total system inertia (oz-in-s²)
- J_M = motor inertia (oz-in-s²)
- J_P = pulley inertia(s) (oz-in-s²)
- W = load weight including belt (oz)
- F_F = frictional force (oz)
- g = gravitational constant (386 in/s²)

POWERSYNC™ MOTOR SIZING & SELECTION

After the load characteristics (torque and inertia) are determined, the motor can be selected. See the ratings and characteristics tables beginning on page 92 for reference. The data in the Rated Torque and Rated Inertia columns reflect the motors ability to stay in synchronism under external load conditions not exceeding these values. In the Typical Performance Curve below, the same Rated Torque and Rated Inertia values define the motors safe operating area. Once the load characteristics have been determined, proceed as follows:

- Find the ratings and characteristics table that reflects the desired motor on the basis of your synchronous speed (72 or 60 RPM), Voltage (120 or 240V ac) and frequency (60 or 50 Hz). For assistance, see the Selection Overview on page 91.
- In the ratings and characteristics table, find the motor with the Rated Torque and Rated Inertia combination that are slightly above the required torque and inertia load characteristics. This assures that the load characteristics are within the motors safe operating area.

TYPICAL PERFORMANCE CURVE ⚠



⚠ Curves shown are a NEMA 34, 1 stack motor at 72 RPM, 120 Vac, 60 Hz

This typical performance curve shows the Pull-out torque, Restart (pull-in) torque, Rated torque and Rated Inertia. These terms are defined as follows.

- Pull-out torque. The maximum friction load, at a particular inertial load, that can be applied to the shaft of an AC synchronous motor (running at constant speed) and not cause it to lose synchronism.
- Restart (Pull-in) torque. The maximum friction load, at a particular inertial load, that can be applied to the shaft of an AC synchronous motor without causing it to lose synchronism when accelerating to a constant speed from standstill.
- Rated torque. The maximum frictional torque that the motor can accelerate from standstill to synchronous speed.
- Rated inertia. The maximum inertial load the motor can accelerate from standstill to synchronous speed.

OTHER SELECTION CONSIDERATIONS… **POWERSYNC™**

It is worthwhile to review these points to determine if they apply to your particular application.

Temperature

The insulation class for POWERSYNC motors is NEMA class B (maximum of 130°C inside the motor). This rating is established by hanging the motor in still air, locking the rotor and energizing the windings. The recommended maximum room temperature is 40°C. If the motor is subjected to 40°C room temperature, the motor housing temperature could reach 100°C.

Vibration

With all Synchronous Motors, there is some vibration that exists while the motor is running. This becomes less noticeable when the motor is loaded and flexible couplings or belts are used to connect the load. Vibration insulators can also be used between the motor and the mounting bracket.

Starting

A low speed AC synchronous motor is an appropriate solution to a variety of demanding applications including those which require six or more starts per minute. The motor has no significant current rise on starting and hence no additional heat rise with repeated starts. The motors will start within 1.5 cycles of the applied frequency and will reach synchronous speed within 2 to 25 milliseconds at 60 Hz.

The extremely high torque and small frame size of the POWERSYNC motors often lends the motor as a suitable substitute for gearmotors. The advantages include concentric shaft and omission of gear backlash. Additionally, starting times of gearmotors will be slightly greater due to gearing backlash.

Two or more POWERSYNC motors may be operated simultaneously from the same power source, if the total current required by the motors does not exceed the current capacity of the supply. However, since the at rest position of the motors is indeterminant, mechanical synchronization of two or more motors may never be achieved because of the starting time differential that may exist between motors.

Stalling

Low speed motors will not overheat if stalled because starting, full load and no load currents are essentially the same. However, prolonged operation against a solid stop will eventually cause bearing fatigue and probable failure. Stall torque cannot be measured in the conventional manner because there is no average torque delivered when the rotor is not in synchronization with the apparent rotation of the stator magnetic field.

Residual Torque

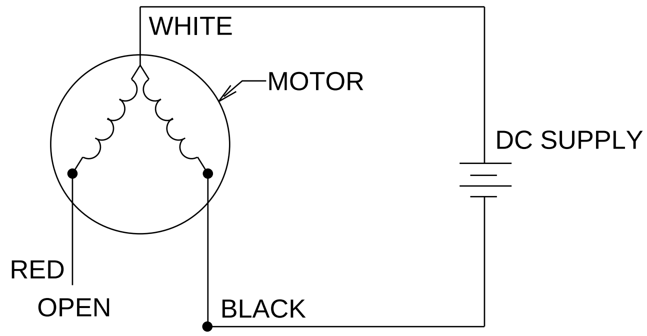
When power is removed from the motor, there is some residual torque present. This is called the motor's detent torque and is shown in the catalog ratings table. This torque should not be used for holding a load in situations requiring safety. This parameter is inherent to the motor design and may vary as much as 50%.

Holding Torque

When using an AC synchronous motor on any system with a “potential” type loading, like gravity, it may be desirable to have the motor hold in a position while waiting to rotate. This can be done by using a DC power supply attached to one or both motor phases. The figure on page 107 shows a typical connection diagram.

HOLDING TORQUE... **POWERSYNC™**

Attach a DC power supply across the neutral line and one of the phase wires (there are only 3 wires, Neutral, Phase A and Phase B). Make sure the voltage and current values do not exceed those shown in the table below. These values will provide holding torque approximately 1.15 times the specified pull-out torque rating.

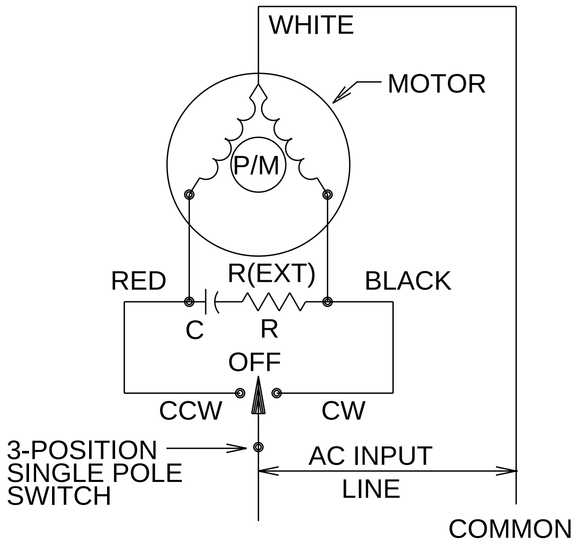


Motor	Speed (RPM)	Voltage (V rms)	Freq (Hz)	Holding Torque Current	DC Supply Voltage (Volts)
SN31HXYY-LXK-XX-XX	72	120	60	0.53	45

R-C PHASE SHIFT NETWORK...**POWERSYNC™**

R-C Network- Resistor and capacitor networks are specific to each motor offering. Reference the data contained in the data table for values and specifications. Deviations from recommended capacitor or resistor values can reduce forward torque and permit the motor to exhibit some of it's forward torque in the reverse mode (vibration). This scenario is less of a problem if the load is substantially frictional. Other values can be recommended by the factory for specific applications. Capacitor and resistor values have been selected to provide the highest possible torque without sacrificing smooth operation throughout the safe operating area. Capacitor and resistor values may be adjusted by the factory to accommodate specific application needs. The figure below shows the connection diagram for AC synchronous motors.

TYPICAL OPERATION



CONVERSION TABLES

ROTARY INERTIA CONVERSION TABLE

(To convert from A to B, multiply by entry in table)

B A	gm-cm^2	oz-in^2	gm-cm-s^2	Kg-cm^2	lb-in^2	oz-in-s^2	lb-ft^2	Kg-cm-s^2	lb-in-s^2	lb-ft-s^2 or slug-ft^2
gm-cm^2	1	5.46 x 10^{-3}	1.01 x 10^{-3}	10^{-3}	3.417 x 10^{-4}	1.41 x 10^{-5}	2.37 x 10^{-6}	1.01 x 10^{-6}	8.85 x 10^{-7}	7.37 x 10^{-8}
oz-in^2	182.9	1	.186	.182	.0625	2.59 x 10^{-3}	4.34 x 10^{-4}	1.86 x 10^{-4}	1.61 x 10^{-4}	1.34 x 10^{-5}
gm-cm-s^2	980.6	5.36	1	.9806	.335	1.38 x 10^{-2}	2.32 x 10^{-3}	10^{-3}	8.67 x 10^{-4}	7.23 x 10^{-5}
Kg-cm^2	1000	5.46	1.019	1	.3417	1.41 x 10^{-2}	2.37 x 10^{-3}	1.019 x 10^{-3}	8.85 x 10^{-4}	7.37 x 10^{-5}
lb-in^2	2.92 x 10^{3}	16	2.984	2.926	1	4.14 x 10^{-2}	6.94 x 10^{-3}	2.98 x 10^{-3}	2.59 x 10^{-3}	2.15 x 10^{-4}
oz-in-s^2	7.06 x 10^{4}	386.08	72.0	70.615	24.13	1	.1675	7.20 x 10^{-2}	6.25 x 10^{-2}	5.20 x 10^{-3}
lb-ft^2	4.21 x 10^{5}	2304	429.71	421.40	144	5.967	1	.4297	.3729	3.10 x 10^{-2}
Kg-cm-s^2	9.8 x 10^{5}	5.36 x 10^{3}	1000	980.66	335.1	13.887	2.327	1	.8679	7.23 x10^{-2}
lb-in-s^2	1.129 x 10^{6}	6.177 x 10^{3}	1.152 x 10^{3}	1.129 x 10^{3}	386.08	16	2.681	1.152	1	8.33 x 10^{-2}
lb-ft-s^2 or slug-ft^2	1.355 x 10^{7}	7.41 x 10^{4}	1.38 x 10^{4}	1.35 x 10^{4}	4.63 x 10^{3}	192	32.17	13.825	12	1

TORQUE CONVERSION TABLE

(To convert from A to B, multiply by entry in table)

B A	dyne-cm	gm-cm	oz-in	Kg-cm	lb-in.	N-m	lb-ft	Kg-m
dyne-cm	1	1.019 x 10^{-3}	1.416 x 10^{-5}	1.0197 x 10^{-6}	8.850 x 10^{-7}	10^{-7}	7.375 x 10^{-8}	1.019 x 10^{-8}
gm-cm	980.665	1	1.388 x 10^{-2}	10^{-3}	8.679 x 10^{-4}	9.806 x 10^{-5}	7.233 x 10^{-5}	10^{-5}
oz-in.	7.061 x 10^{4}	72.007	1	7.200 x 10^{-2}	6.25 x 10^{-2}	7.061 x 10^{-3}	5.208 x 10^{-3}	7.200 x 10^{-4}
Kg-cm	9.806 x 10^{5}	1000	13.877	1	.8679	9.806 x 10^{-2}	7.233 x 10^{-2}	10^{-2}
lb-in	1.129 x 10^{6}	1.152 x 10^{3}	16	1.152	1	.112	8.333 x10^{-2}	1.152 x 10^{-2}
N-m	10^{7}	1.019 x10^{4}	141.612	10.197	8.850	1	.737	.101
lb-ft	1.355 x 10^{7}	1.382 x 10^{4}	192	13.825	12	1.355	1	.138
Kg-m	9.806 x10^{7}	10^{5}	1.388 x 10^{3}	100	86.796	9.806	7.233	1

CONVERSION FACTORS

LENGTH

TO OBTAIN	MULTIPLY NUMBER OF	BY
cm	inches	2.540
cm	feet	30.48
inches	cm	.3937
inches	feet	12.0
feet	cm	3.281 x 10^{-2}
feet	inches	8.333 x 10^{-2}

MASS

TO OBTAIN	MULTIPLY NUMBER OF	BY
gm	oz	28.35
gm	lb	453.6
gm	slug	1.459 x 10^{-4}
oz	gm	3.527 x 10^{-2}
oz	lb	16.
oz	slug	514.7
lb	gm	2.205 x 10^{-3}
lb	oz	6.250 x 10^{-2}
lb	slug	32.17
slug*	gm	6.853 x 10^{-5}
slug	oz	1.943 x 10^{-3}
slug	lb	3.108 x 10^{-2}

*1 slug mass goes at 1 ft/sec^2 when acted upon by 1 lb force.

POWER

TO OBTAIN	MULTIPLY NUMBER OF	BY
H.P.	(oz-in.) (deg./sec)	1.653 x 10^{-7}
H.P.	(oz-in.) (RPM)	9.917 x 10^{-7}
H.P.	(#ft) (deg./sec)	3.173 x 10^{-5}
H.P.	(#ft) (RPM)	1.904 x 10^{-4}
H.P.	watts	1.341 x 10^{-3}
Watts	(oz-in.) (deg./sec)	1.232 x 10^{-4}
Watts	(oz-in.) (RPM)	7.395 x 10^{-4}
Watts	(#ft) (deg./sec)	2.366 x 10^{-2}
Watts	(#ft) (RPM)	.1420
Watts	H.P.	745.7

TORQUE TO INERTIA RATIO

TO OBTAIN	MULTIPLY NUMBER OF	BY
rad/sec^2	oz-in./gm-cm^2	7.062 x 10^{4}
rad/sec^2	oz-in./oz-in^2	386.1

TORQUE GRADIENT

TO OBTAIN	MULTIPLY NUMBER OF	BY
#ft/rad	oz-in./degree	0.2984
dyne-cm/rad	oz-in./degree	4.046 x 10^{6}

FORCE

TO OBTAIN	MULTIPLY NUMBER OF	BY
dyne	gm*	980.7
dyne	oz	2.780 x 10^{4}
dyne	lb	4.448 x 10^{5}
gm*	dyne	1.020 x 10^{-3}
oz	dyne	3.597 x 10^{-5}
lb	dyne	2.248 x 10^{-6}

* used as force units

ROTATION

TO OBTAIN	MULTIPLY NUMBER OF	BY
degrees/sec.	RPM	6.
degrees/sec.	rad/sec.	57.30
RPM	degrees/sec.	.1667
RPM	rad/sec.	9.549
rad/sec.	degrees/sec.	1.745 x 10^{-2}
rad/sec.	RPM	.1047

MECHANISM EFFICIENCIES

Acme-screw w/brass Nut	~0.35-0.65
Acme-screw w/plastic Nut	~0.50-0.85
Ball-screw	~0.85-0.95
Preloaded Ball screw	~0.75-0.85
Spur or Bevel gears	~0.90
Timing Belts	~0.96-0.98
Chain & Sprocket	~0.95-0.98
Worm gears	~0.45-0.85

MATERIAL DENSITIES

MATERIALS	lb/in^3	gm/cm^3
Aluminum	0.096	2.66
Brass	0.300	8.30
Bronze	0.295	8.17
Copper	0.322	8.91
Plastic	0.040	1.11
Steel	0.280	7.75
Hard Wood	0.029	0.80

FRICTION COEFFICIENTS $F_{fr}=\mu W_L$

MATERIALS	μ	MECHANISM	μ
Steel on Steel	~0.58	Ball Bushings	<0.001
Steel on Steel (greased)	~0.15	Linear Bearings	<0.001
Aluminum on Steel	~0.45	Dove-tail Slides	~0.2
Copper on Steel	~0.30	Gibb Ways	~0.5
Brass on Steel	~0.35		
Plastic on Steel	~0.15-0.25		