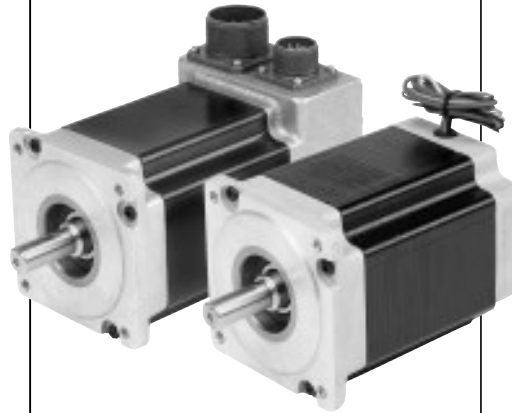


POWERSYNC SYNCHRONOUS MOTORS



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

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

Runs cooler than other AC synchronous motors

Rugged "housingless" square frame

Sealed per NEMA and IP65

Outer bearing races won't turn—front locked (in steel insert) and rear held by O-ring

Selection of terminations
Special shaft configurations available

Easy to apply

Precise speed control

72 RPM, 120V ac, 60 Hz

60 RPM, 120V ac, 50 Hz

Standard NEMA mounting

Motors (unloaded) reach synchronous speed in as little as 2 milliseconds. Ask us about response time at your load

BENEFITS

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

Longer, more reliable motor life—backed by a two year warranty

Efficient use of volume for optimal magnetic design

For splashproof requirements

Long life bearings—also prevents axial shaft movement for encoder applications

Match your requirements

Simple, economical control components (resistor and capacitor)

Synchronous speed for a broad range of applications

For North American use

For international requirements

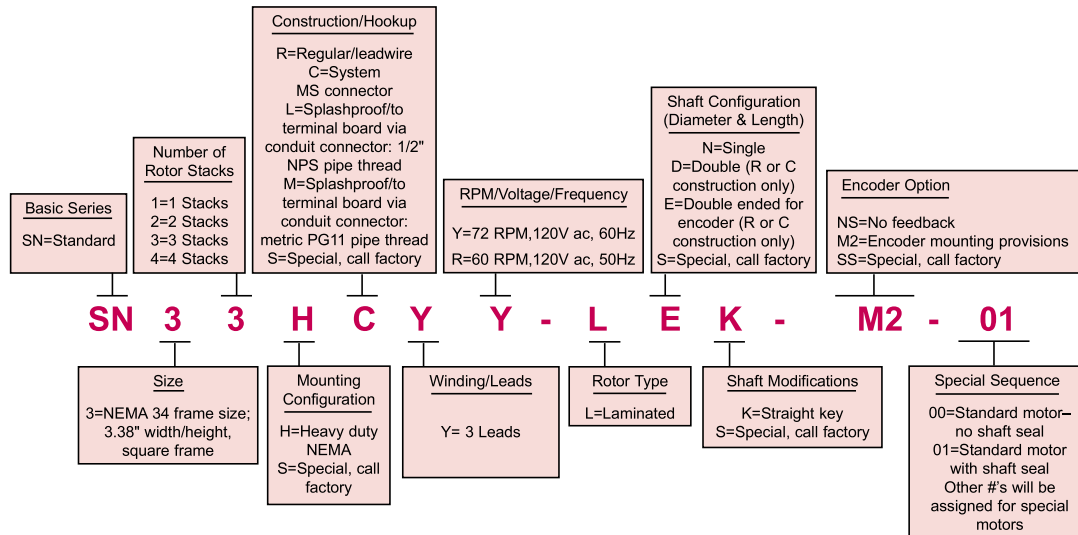
Widely recognized standard

Fast response for on-off, precisely timed events

POWERSYNC™

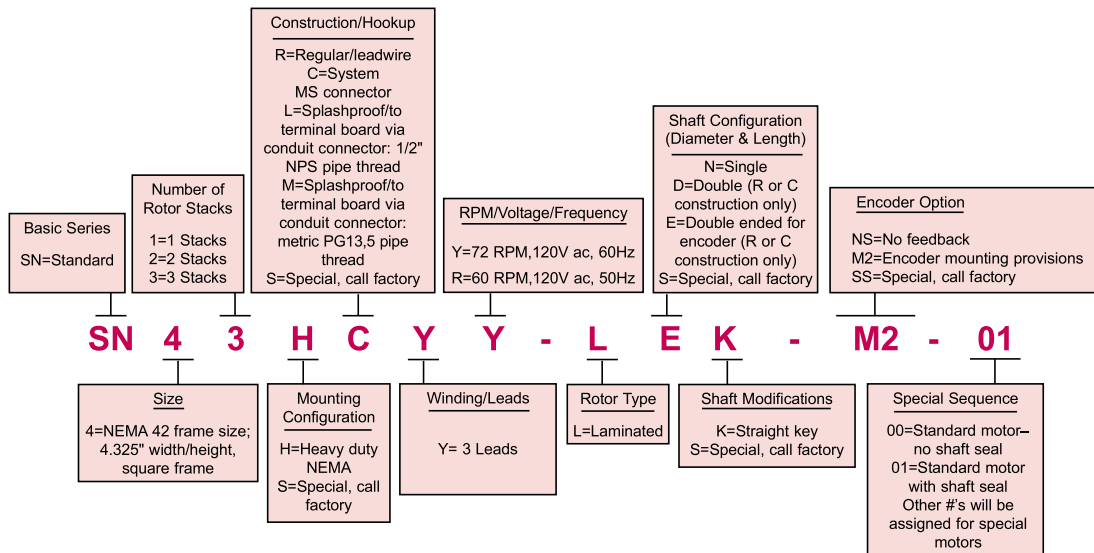
NEMA 34 & 42 Frame (3.38" & 4.325" Square)

MODEL NUMBER CODE - NEMA 34 FRAME



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, encoder mounting provisions and a shaft seal.

MODEL NUMBER CODE - NEMA 42 FRAME



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, encoder mounting options and a shaft seal.

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 83 to verify coded information prior to ordering.
- If you are not familiar with these motors, start with "Selection Overview" on page 85. The Motor Sizing & Selection section starting on page 95 will help you determine the key performance criteria in your application. You can then select the AC synchronous motor most appropriate for your needs.

Product Overview	82
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Features & Benefits	82
Selection Overview	85
NEMA 34 Frame Motors	
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Typical Performance Curves	86-87
Dimensions	88-89
NEMA 42 Frame Motors	
Model Number Code	83
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Motor Sizing & Selection	95-97
Other Sizing Considerations	98-100

POWERSYNC™

SELECTION OVERVIEW

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	120V ac	60Hz	280-1500 (1,98 - 10,58)	.21-.92 (1,48 - 6,49)	86
60	120V ac	50Hz	375-1440 (2,64 - 10,17)	.29-1.3 (2,05 - 9,18)	87

For assistance in selecting a motor, see page 83.

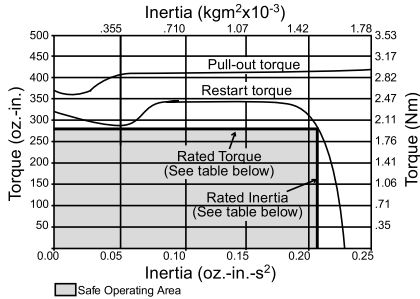
POWERSYNC™

Ratings and Characteristics

72 RPM, 120 Vac, 60 Hz

Typical Performance Curve

also see p.97



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 [△]	Rated Torque [△] oz-in (Nm)	Rated Inertia [△] oz-in-s² (kgm²x10⁻³)	Max. Pull-out Torque [△] oz-in (Nm)	RMS per Phase Current @ 80% Pull-out (Amps)	Detent Torque [△] oz-in (Nm)	Thermal Res. [△] (°C/watt)	Phase Res. (Ohms)	Phase Ind. (mH)	Rotor Inertia [△] 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)

[△] An "X" in the Model Number Code indicates an undefined option. See page 83.

[△] 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 95.

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

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

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

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

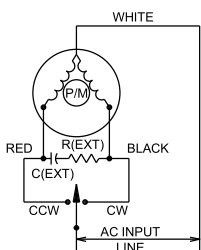
R-C PHASE SHIFT NETWORKS

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. 100. The resistors and capacitors are standard and are readily available from electronic component suppliers.

For 72RPM, 120V ac, 60 Hz

Model Number	Resistor		Capacitor	
	(Ohms)	(Watts)	(µf)	(rated Vac)
SN31HXYY-LXK-XX-XX	200	50	6	370
SN32HXYY-LXK-XX-XX	200	50	10	370
SN33HXYY-LXK-XX-XX	100	100	10	370
SN34HXYY-LXK-XX-XX	50	100	17.5	370
SN41HXYY-LXK-XX-XX	100	100	12.5	370
SN42HXYY-LXK-XX-XX	75	100	20	370
SN43HXYY-LXK-XX-XX	50	100	20	370

Schematic Diagram All Constructions



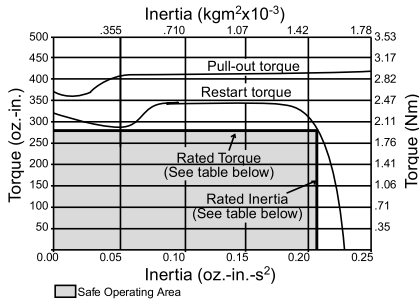
POWERSYNC™

Ratings and Characteristics

60 RPM, 120 Vac, 50 Hz

Typical Performance Curve

also see p.97



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 [△]	Rated Torque [△] oz-in [△] (Nm)	Rated Inertia [△] oz-in-s² [△] (kgm²x10⁻³)	Max. Pull-out Torque [△] oz-in (Nm)	RMS per Phase Current @ 80% Pull-out (Amps)	Detent Torque [△] oz-in (Nm)	Thermal Res. [△] (°C/watt)	Phase Res. (Ohms)	Phase Ind. (mH)	Rotor Inertia [△] 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)

[△] An "X" in the Model Number Code indicates an undefined option. See page 83.

[△] 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 95.

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

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

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

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

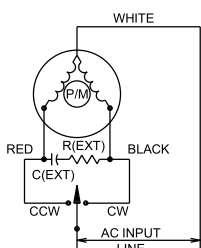
R-C PHASE SHIFT NETWORKS

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. 100. The resistors and capacitors are standard and are readily available from electronic component suppliers.

For 60RPM, 120V ac, 50 Hz

Model Number	Resistor		Capacitor	
	(Ohms)	(Watts)	(µf)	(rated Vac)
SN31HXYR-LXK-XX-XX	150	25	2	2.75
SN32HXYR-LXK-XX-XX	100	50	4	4.75
SN33HXYR-LXK-XX-XX	100	50	4	4.75
SN34HXYR-LXK-XX-XX	75	100	6.5	7.38
SN41HXYR-LXK-XX-XX	100	50	4	4.75
SN42HXYR-LXK-XX-XX	100	100	6.5	7.38
SN43HXYR-LXK-XX-XX	50	225	10.5	11.38

Schematic Diagram All Constructions



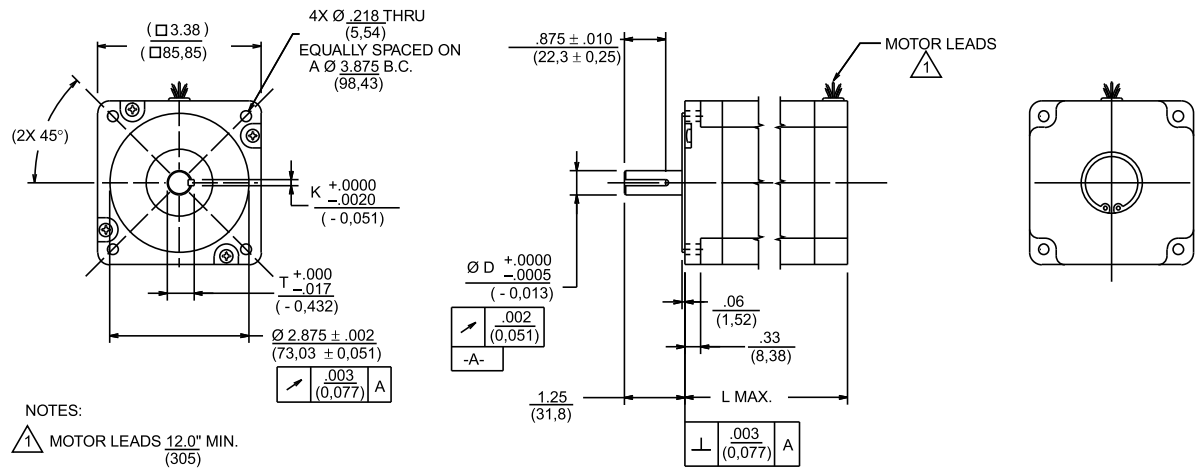
DIMENSIONS . . . POWERSYNC™

in. (metric dimensions for ref. only)
mm

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.83

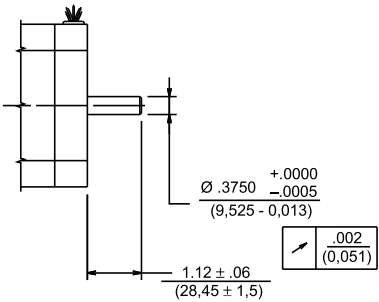


MOTOR*	D	K	T	L MAX.
31HR	.5000 (12,70)	.1250 (3,175)	.555 (14,09)	3.13 (79,5)
32HR	.5000 (12,70)	.1250 (3,175)	.555 (14,09)	4.65 (118,1)
33HR	.6250 (15,875)	.1875 (4,763)	.705 (17,91)	6.17 (156,7)
34HR	.6250 (15,875)	.1875 (4,763)	.705 (17,91)	7.68 (195,1)

*See Model Number Code, p 83.

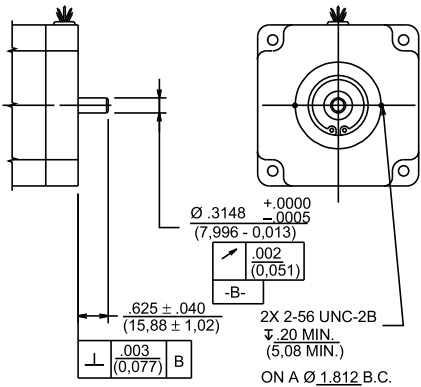
LEADWIRE HOOKUP DOUBLE SHAFT CONFIGURATION

Model Number Code designation D (Shaft Configuration), p. 83



LEADWIRE HOOKUP ENCODER MOUNTING PROVISION

Model Number Code designation M2 (Encoder Mounting Option), p.83



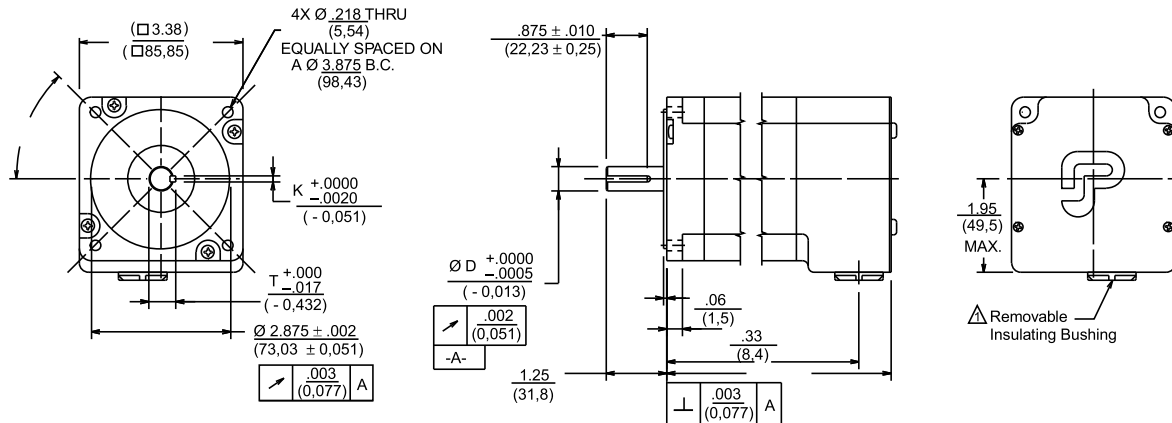
DIMENSIONS . . . POWERSYNC™

in. (metric dimensions for ref. only)
mm

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 83

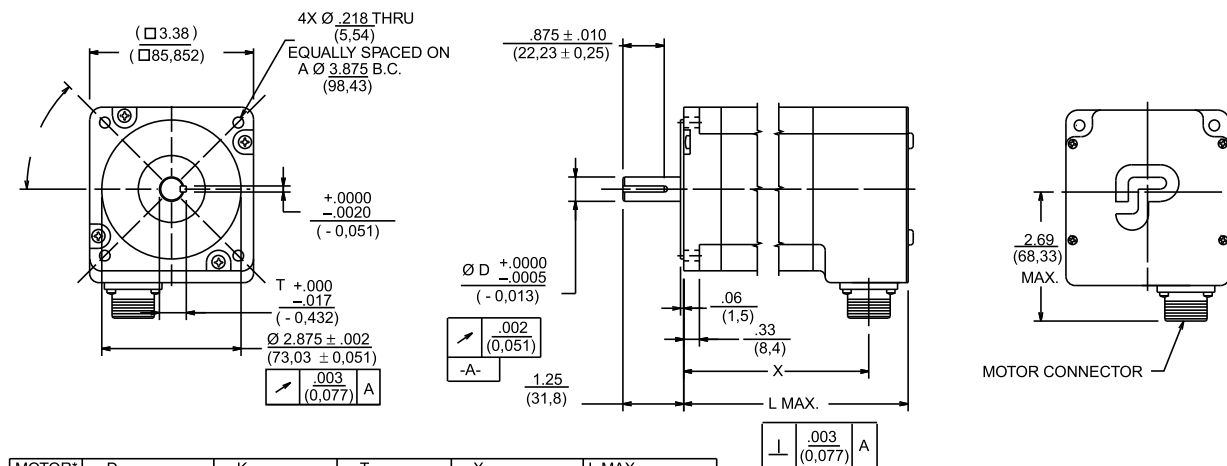


MOTOR*	D	K	T	X	L MAX.
31HR	.5000 (12,70)	.1250 (3,175)	.555 (14,09)	3.70 (93,9)	4.44 (112,8)
32HR	.5000 (12,70)	.1250 (3,175)	.555 (14,09)	5.22 (132,6)	5.96 (151,4)
33HR	.6250 (15,875)	.1875 (4,763)	.705 (17,91)	6.74 (171,20)	7.48 (189,9)
34HR	.6250 (15,875)	.1875 (4,763)	.705 (17,91)	8.25 (209,6)	8.99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

*See Model Number Code, p 83.

SPLASHPROOF CONSTRUCTION/MS CONNECTOR(S)— ENCODER OPTION

Model Number Code designation C/System (Construction/Hookup) and Encoder Mounting Option, p 83



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)

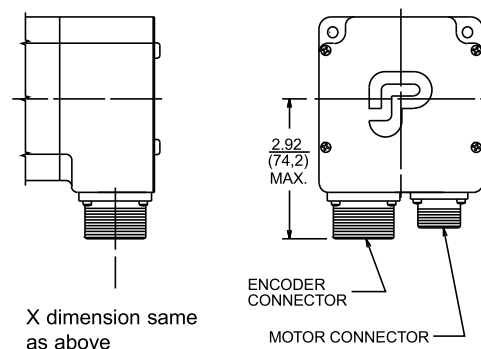
*See Model Number Code, p 83.

NOTES:

△ L Construction = Conduit connection (1/2 NPSC TAP) with $\frac{56}{14,2}$ I.D. removable insulating bushing

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

ENCODER MOUNTING OPTION



X dimension same as above

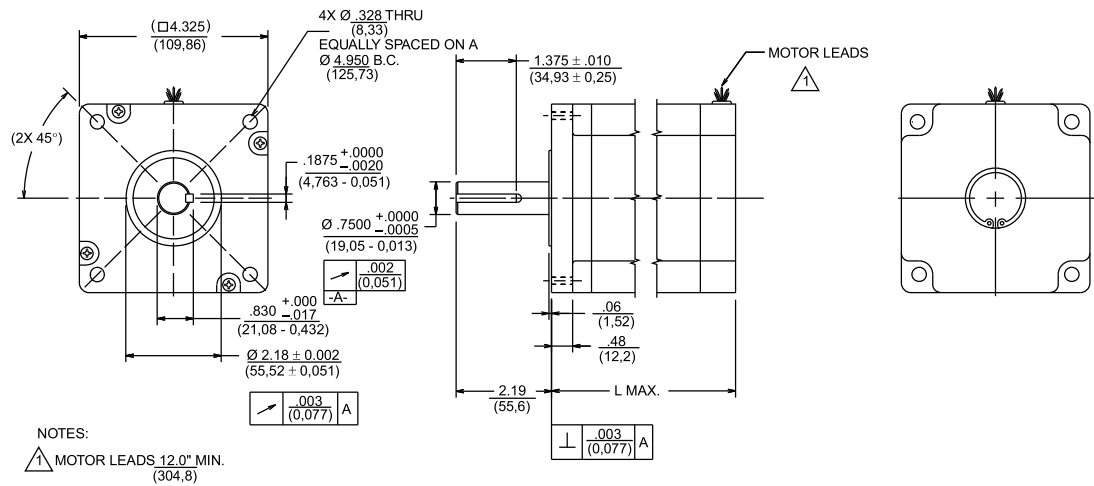
DIMENSIONS . . . POWERSYNC™

in. (metric dimensions for ref. only)
mm

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. 83

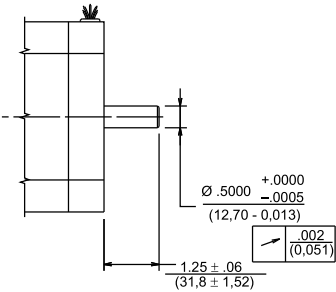


MOTOR*	L MAX.
41HR	3.89 (98,8)
42HR	5.91 (150,1)
43HR	7.92 (201,2)

* See Model Number Code, p.83

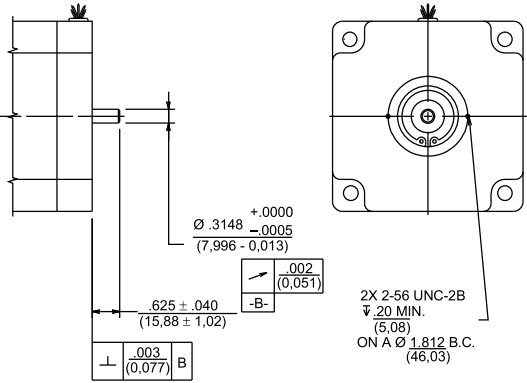
LEADWIRE HOOKUP
DOUBLE SHAFT CONFIGURATION

Model Number Code designation D (Shaft Configuration), p. 83
Available on R construction only.



LEADWIRE HOOKUP
ENCODER MOUNTING PROVISION

Model Number Code designation M2 (Encoder Mounting Option), p.83



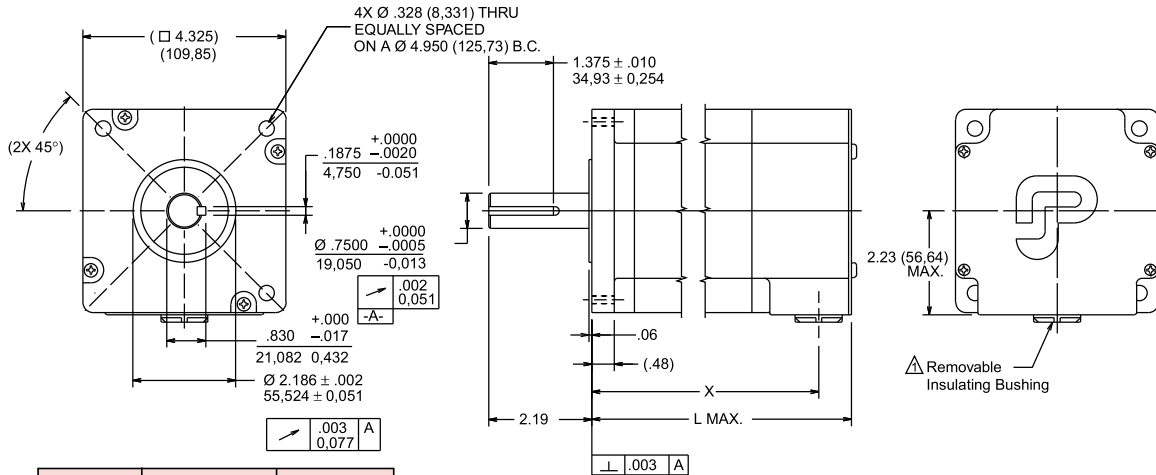
DIMENSIONS . . . POWERSYNC™

in. (metric dimensions for ref. only)
mm

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. 83.

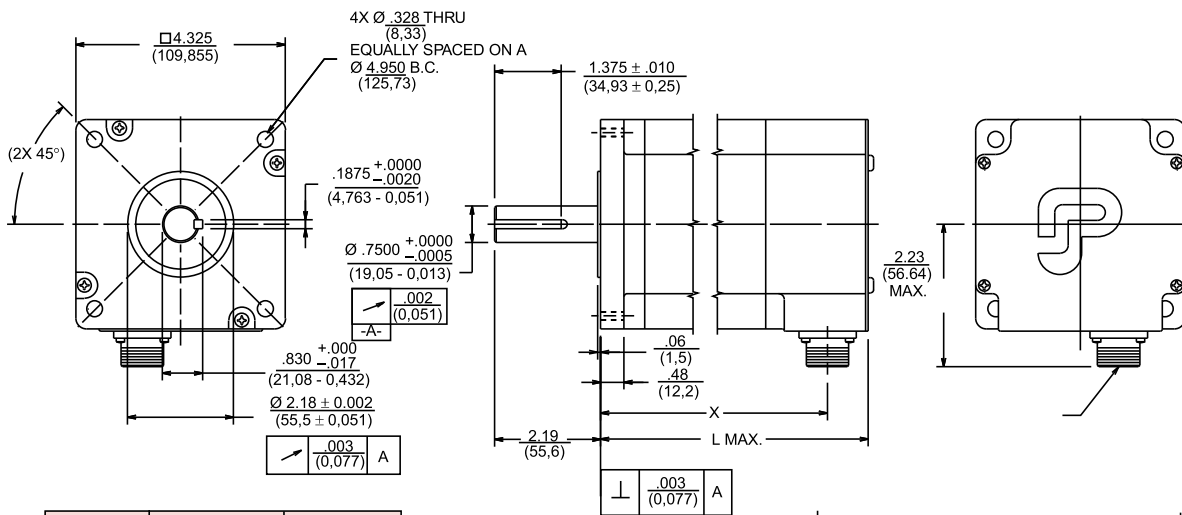


MOTOR*	X	L MAX.
41HR	4.46 (113,3)	3.89 (98.9)
42HR	6.48 (164,6)	5.91 (150,1)
43HR	8.49 (215,7)	7.92 (201,2)

* See Model Number Code, p.83

SPLASHPROOF CONSTRUCTION/MS CONNECTOR(S)—ENCODER OPTION

Model Number Code designation C/System (Construction/Hookup) and Encoder Mounting Option, p. 83.



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.83

ENCODER MOUNTING OPTION

NOTES:

- △ L Construction = Conduit
connection (1/2 NPSC TAP)
with $\frac{.56}{14.2}$ I.D. removable
insulating bushing

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

X dimension same as above

3.20
(81.3)
MAX.

ENCODER CONNECTOR

MOTOR CONNECTOR

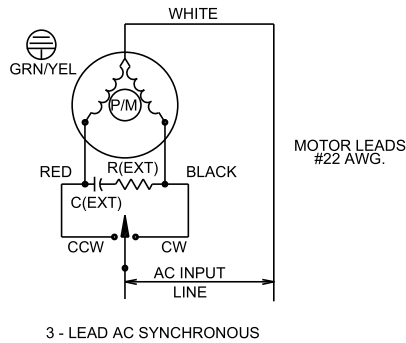
POWERSYNC™ TECHNICAL DATA

MOTOR POWER CONNECTIONS

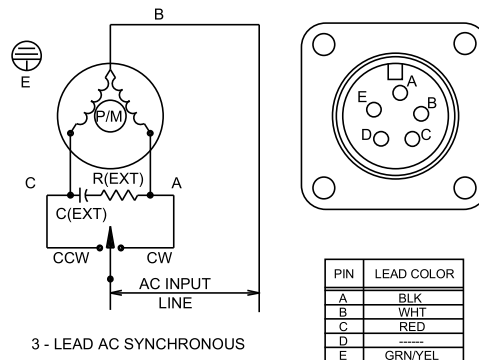
- Connection options: Flying Leads, MS Connectors, Terminal Board

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.

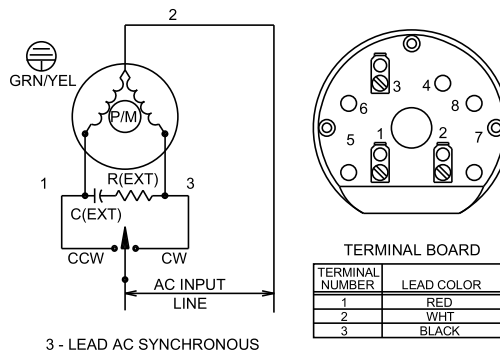
FLYING LEADS



MS CONNECTOR



TERMINAL BOARD

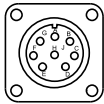


ENCODER OPTIONS...POWERSYNC™

NEMA 34 AND NEMA 42 ENCODER MOUNTING OPTIONS

Encoder factory installed (inside).
See NEMA 34 drawing, p. 89 and
NEMA 42 drawing, p. 91.

Encoder factory installed (outside on rear
end bell). See NEMA 34 drawing, p. 88
and NEMA 42 drawing, p. 90.



ENCODER CONNECTOR △

PIN	FUNCTION
A	CHANNEL A
B	CHANNEL A
C	CHANNEL B
D	CHANNEL B
E	CHANNEL Z
F	CHANNEL Z
G	+ 5 VDC
H	5 VDC RTN

MOTOR FEEDBACK CONNECTOR
CA3102E20-7P-A206-F80-F0

SUGGESTED MATING CONNECTOR	
PAC SCI P.N.	CANNON P.N.
CZ00008	MS3106A20-7S-621

NOTE:
△ NEMA 34, NEMA 42
SYSTEM CONSTRUCTION

SHAFT LOAD AND BEARING FATIGUE LIFE (L₁₀)...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

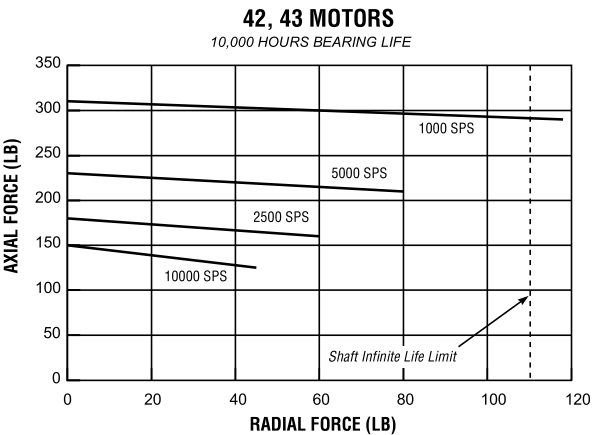
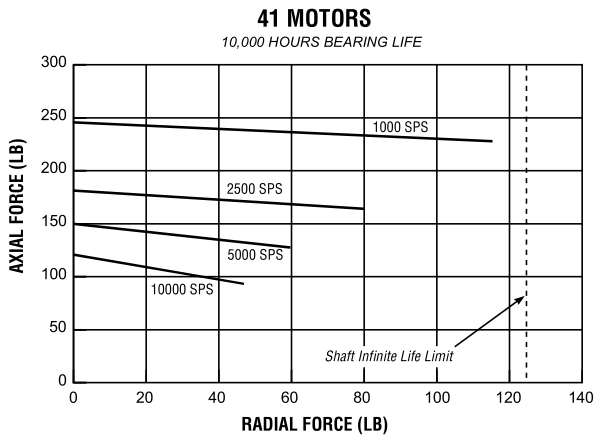
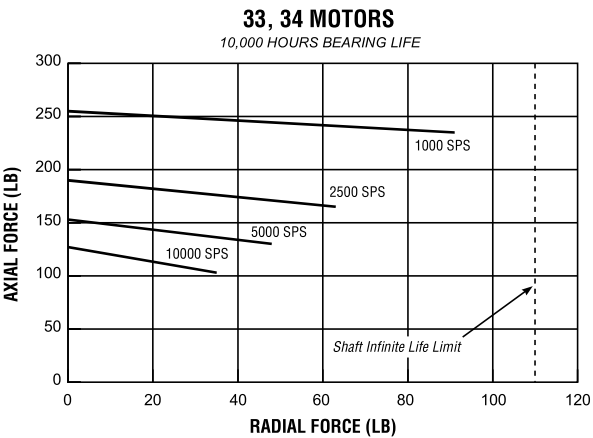
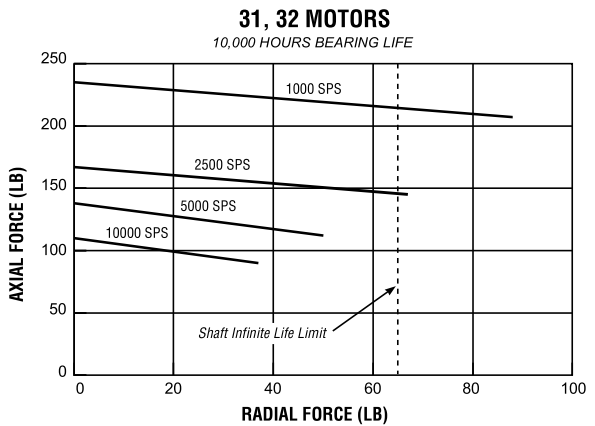
The maximum radial fatigue load ratings reflect the following assumptions:

- 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 (L₁₀)

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:

- Inertia, J (oz-in-s², kgm² 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.
- 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.
- 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.

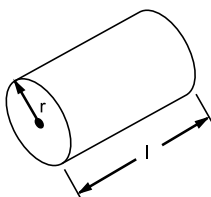
SOLID CYLINDER

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.

$$\text{For known weight and radius: } J_L = \frac{1}{2} W r^2 = (0.0013) W r^2$$

$$\text{For known density, radius, and length: } J_L = \frac{1}{2} \pi \rho l r^4 = (0.0041) \rho l r^4$$

where: J_L = inertia (oz-in-s²)
 W = weight (oz)
 r = radius (in)
 l = length (in)
 ρ = density of material (oz/in³)
 g = gravitational constant (386 in/s²)



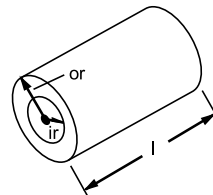
HOLLOW CYLINDER

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.

$$\begin{aligned} \text{For known weight and radii: } J_L &= \frac{1}{2} \frac{W}{g} (o r^2 + i r^2) \\ &= (0.0013) (o r^2 + i r^2) W \end{aligned}$$

$$\begin{aligned} \text{For known density, radii, and length: } J_L &= \frac{\pi \rho l}{2} (o r^4 - i r^4) \\ &= (0.0041) (o r^4 - i r^4) \rho l \end{aligned}$$



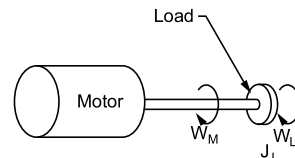
where: J_L = inertia (oz-in-s²)
 W = weight (oz)
 $o r$ = outside radius (in)
 $i r$ = inside radius (in)
 l = length (in)
 ρ = density of material (oz/in³)
 g = gravitational constant (386 in/s²)

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.



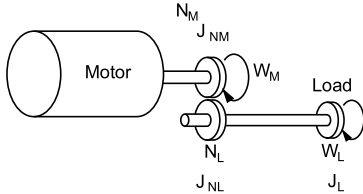
Speed: $W_M = W_L$
Torque: $T_L = T_M$
Inertia: $J_T = J_L + J_M$

where: W_M = motor speed (rpm)
 W_L = load speed (rpm)
 J_T = total system inertia (oz-in-s²)
 J_L = load inertia (oz-in-s²)
 J_M = motor inertia (oz-in-s²)
 T_L = load torque at motor shaft (oz-in)
 T_T = load torque (oz-in)

MOTOR SIZING & SELECTION (CONT.)

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

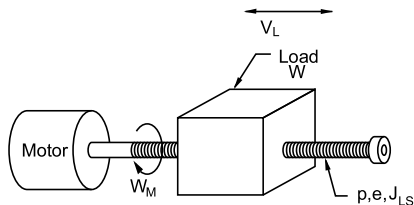
where: w_M = motor speed (rpm)
 w_L = load speed (rpm)
 N_M = number of motor gear teeth
 N_L = number of load gear teeth
 T_L = load torque reflected to motor shaft (oz-in)
 T' = load torque (oz-in)—not reflected
 J_T = total system inertia (oz-in-s²)
 J_L = load inertia (oz-in-s²)
 J_M = motor inertia (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: $T_L = \frac{1}{2\pi} \frac{F_L}{pe} + \frac{1}{2\pi} \frac{F_{PL}}{p} \times 0.2 \Delta$
 $= (0.159)F_L/pe + (0.032)F_{PL}/p$
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)

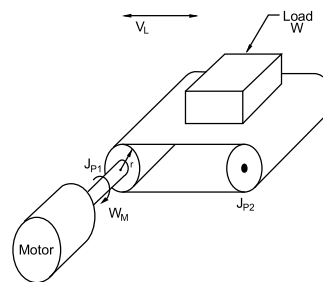
COEFFICIENTS OF FRICTION

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: $T_F = F_F r$

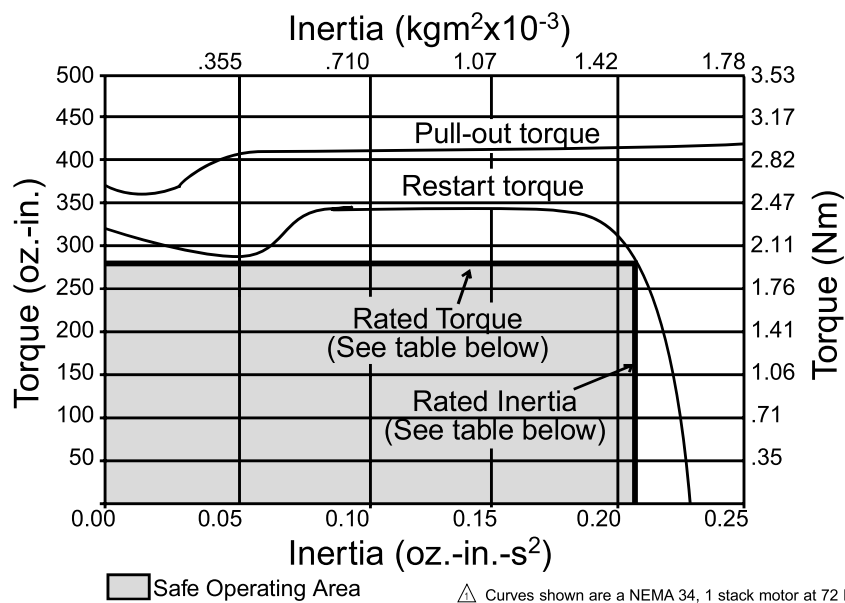
where: w_M = motor speed (rpm)
 v_L = linear load speed (in/min)
 r = pulley radius (in)
 T_L = load torque reflected to motor shaft (oz-in)
 T_F = friction torque (oz-in)
 F_L = load force (oz)
 J_T = total system inertia (oz-in-s²)
 J_M = motor inertia (oz-in-s²)
 J_P = pulley inertia(s) (oz-in-s²)
 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 86 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 (120V ac) and frequency (60 or 50 Hz). For assistance, see the Selection Overview on page 85.
- 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



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.

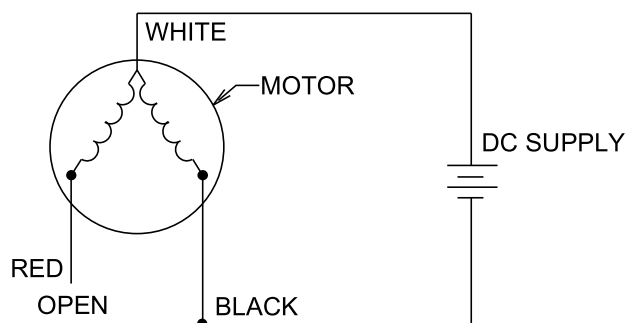
Residual Torque When power is removed from the motor, there is some residual torque present. This is called the motor's detent torque and is shown in the catalog ratings table. This torque should not be used for holding a load in situations requiring safety. This parameter is inherent to the motor design 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 99 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.

ADDITIONAL HOLDING TORQUE



Motor	Speed (RPM)	Voltage (V rms)	Freq (Hz)	Holding Torque Current	DC Supply Voltage (Volts)
SN31HXYX-LXK-XX-XX	72	120	60	0.53	45
SN32HXYX-LXK-XX-XX	72	120	60	0.92	35
SN33HXYX-LXK-XX-XX	72	120	60	1.12	36
SN34HXYX-LXK-XX-XX	72	120	60	1.76	28
SN41HXYX-LXK-XX-XX	72	120	60	1.27	27
SN42HXYX-LXK-XX-XX	72	120	60	2.22	22
SN43HXYX-LXK-XX-XX	72	120	60	3.03	21
SN31HXYR-LXK-XX-XX	60	120	50	0.42	57
SN32HXYR-LXK-XX-XX	60	120	50	0.78	41
SN33HXYR-LXK-XX-XX	60	120	50	1.07	37
SN34HXYR-LXK-XX-XX	60	120	50	1.65	30
SN41HXYR-LXK-XX-XX	60	120	50	1.01	33
SN42HXYR-LXK-XX-XX	60	120	50	1.81	27
SN43HXYR-LXK-XX-XX	60	120	50	2.31	28

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 its 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

