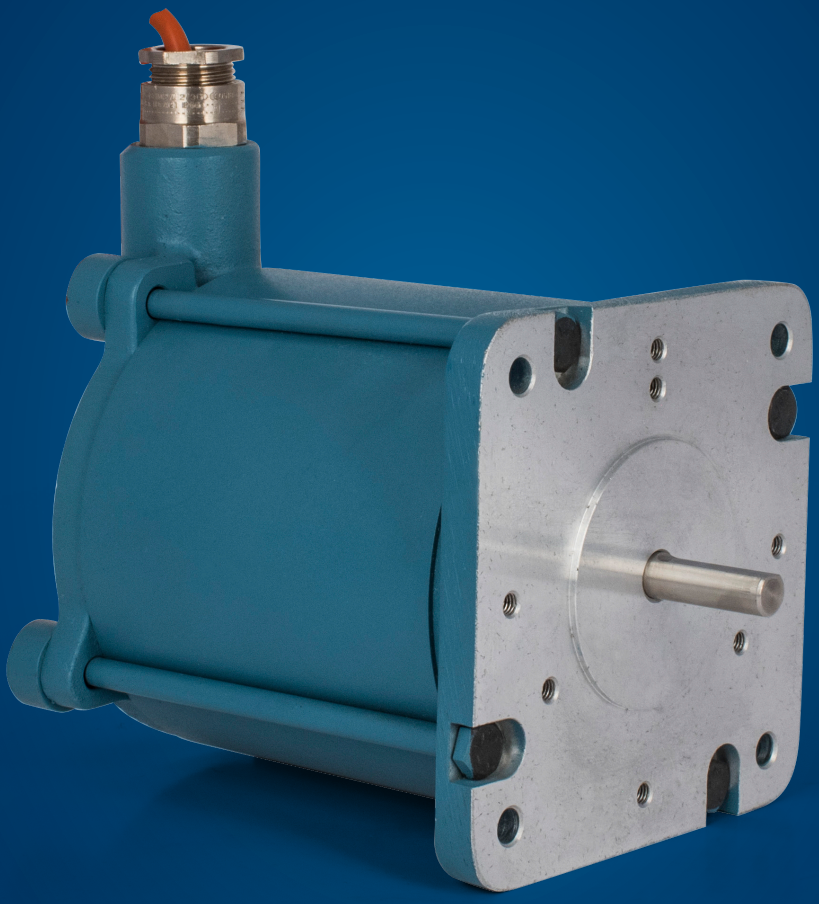
Kollmorgen AC Synchronous Motor

Selection Guide



X Series Synchronous Motor

KOLLMORGEN

A REGAL REXNORD BRAND

Kollmorgen: Your Partner, In Motion.

Every solution comes from a real understanding of the challenges facing machine designers and users.

Innovators consistently rate Kollmorgen as one of their best motion systems manufacturing partners. Whether you are looking for classic servo motors, direct-drive servo motors, stepper motors, drives & amplifiers, gearing, actuation, or multi-axis motion controllers, Kollmorgen is one of the few companies in the world that actually designs and manufactures all of these products.

Our customers are leaders in many industries such as Aerospace & Defense, Printing, Packaging & Converting, Food & Beverage Processing, Medical Imaging, In Vitro Diagnostics & Laboratory Automation, Pharmaceutical Manufacturing, Material Forming and Cutting, Oil & Gas, and Robotics. Kollmorgen is also a leader in Warehouse Automation, including complete AGV systems, software, awareness and autonomy.

Our Automation Solutions can be found on Mars and in space, ships and submarines, O&G drilling and metrology, surgical robots and laser eye surgery, even inside artificial hearts. These are just a few applications that demand high-performance and high-quality while satisfying their specific needs.

Because motion matters, it's our focus: Motion can distinctly differentiate a specific machine and deliver a marketplace advantage by increasing its performance and dramatically improving Overall Equipment Effectiveness (OEE).

High-performance motion can make your customer's machine more reliable and energy-efficient, enhance accuracy and improve operator safety. Motion also represents endless possibilities for innovation.

We've always understood this potential, and thus have kept motion at our core and in our Vision, Mission & Values, relentlessly developing products that offer precise control of torque, velocity and position accuracy in machines that rely on complex motion.

KOLLMORGEN
A REGAL REXNORD BRAND

Removing the Barriers of Design, Sourcing, and Time

At Kollmorgen, we know that OEM engineers can achieve a lot more when obstacles aren't in the way. So, we clear obstacles in three important ways:

Integrating Standard and Custom Products

The optimal solution is often not clear-cut. Our application expertise allows us to modify standard products or develop totally custom solutions across our whole product portfolio so that designs can take flight.

Providing Motion Solutions, Not Just Components

As companies reduce their supplier base and focus their engineering manpower on the product design, they need a total system supplier with a wide range of integrated solutions. Kollmorgen offers complete solutions as well as motion subsystems that combine programming software, engineering services and best-in-class motion components.

Global Footprint

With direct sales, engineering support, manufacturing facilities, and distributors spanning the Americas, Europe, the Middle East, and Asia, we're close to OEMs worldwide. Our proximity helps speed delivery and lend support where and when they're needed.

Financial and Operational Stability

Kollmorgen is part of Regal Rexnord. A key driver in the growth of all Regal Rexnord segments is the Regal Rexnord Business System, which relies on the principle of "kaizen" – or continuous improvement. Using world-class tools, cross-disciplinary teams of exceptional people evaluate processes and develop plans that result in superior performance.

Kollmorgen: Your partner. In Motion.

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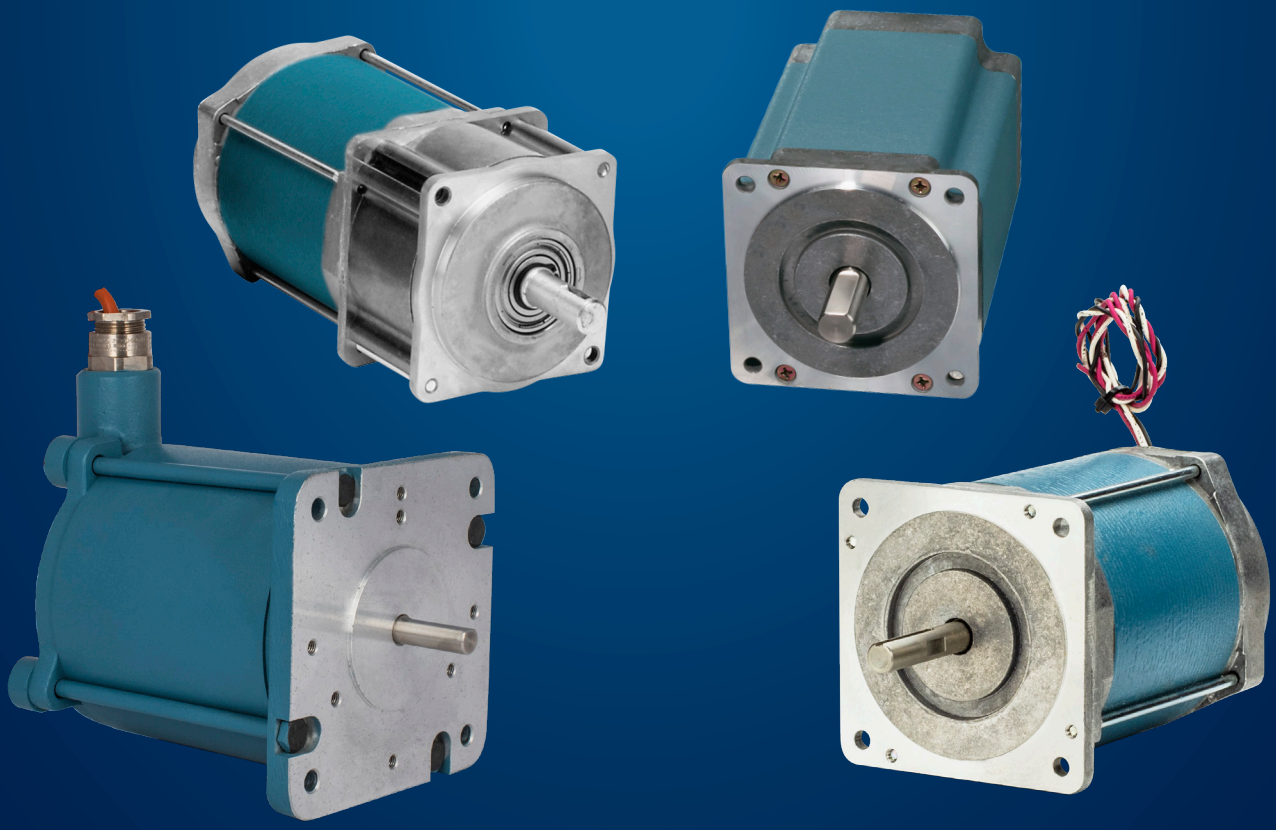
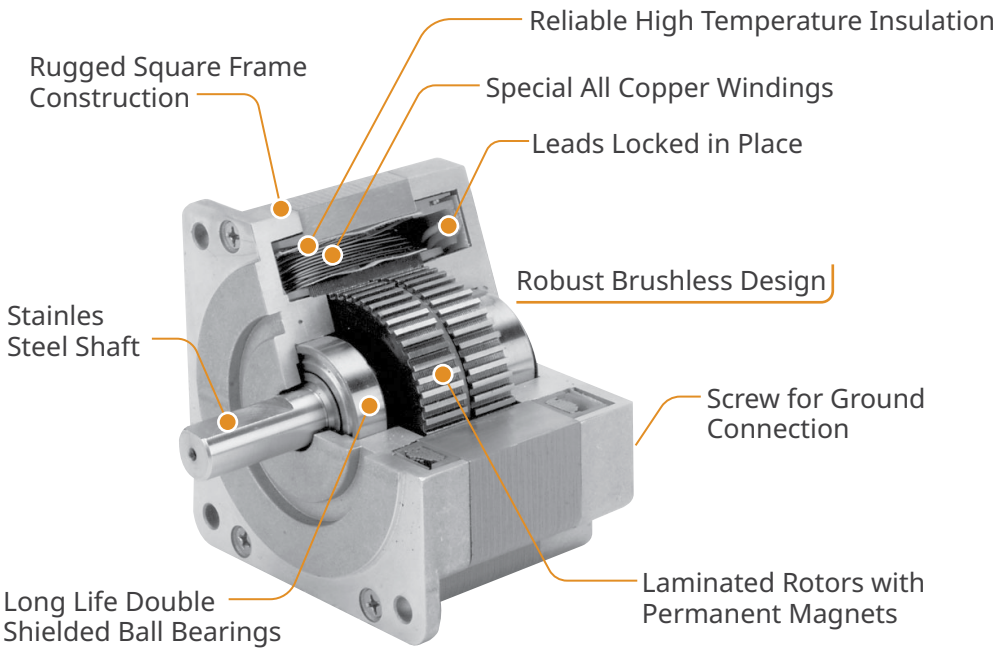
AC Synchronous Motors

Kollmorgen AC synchronous motors are high pole count motors that naturally turn at slower speeds (72 or 60 rpm). They only need a resistor – capacitor (RC) network to operate from single-phase AC utility power. For loads that operate at 72 rpm or slower, they are very cost effective and simple to use. Other motor technologies (induction, DC, servo and stepper motors) either need gear reducers, or electronic drives to match the speed of Kollmorgen synchronous motors. The cost of just the gear reduction or the cost of the electronic drive will usually exceed the total cost of the Kollmorgen synchronous motor. For even slower speeds planetary gear reducers are offered. Kollmorgen synchronous motors produce very low speeds with only modest gear reductions.





Performance Features

- 72 rpm motor speed (with 60 Hz voltage)
- 60 rpm motor speed (with 50 Hz voltage)
- Constant speed does not vary with the load
- 120 volt or 240 volt AC models
- Torques: 70 to 1,500 oz-in (0.50-10.6 Nm)
- Gear reducers with ratios up to 125:1 and torques up to 5,000 oz-in (36.7 Nm)
- UL and CE hazardous duty versions
- Fast starting, stopping, or reversing
- Can be stalled indefinitely without overheating

Typical Applications

Due to their ease of use and inherent slow speeds, Kollmorgen AC synchronous motors are used in a wide variety of applications including:

- Stirring
- Valve operation
- Metering pumps
- Cryogenic pumps
- Simple position & process controls
- Linear actuators
- Edge guides
- Variable transformers
- Dampers
- Conveyor systems
- Table lifts
- Remote control of switches, antennas, etc.

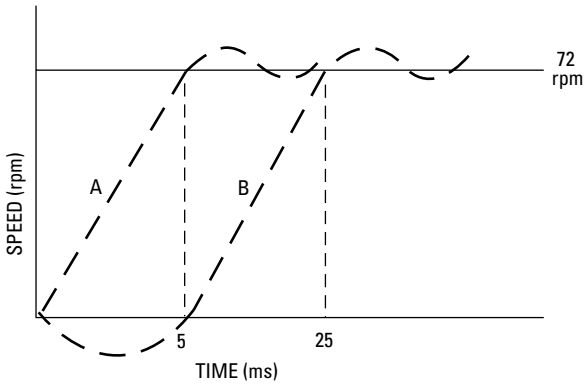
AC Synchronous Motors

AC Synchronous Motor Technology

Starting and Stopping

Rapid starting, stopping and reversing are among the advantages of Kollmorgen AC synchronous motors. The motors will start within 1-1/2 cycles of the applied frequency and will stop within 5 mechanical degrees. As shown in the typical starting curve, these motors will start and reach its full synchronous speed within 5 to 25 milliseconds. Curve A shows the motor starting in the correct direction. The motor may also momentarily start in the wrong direction, then quickly reverse and rotate in the correct direction (Curve B).

Typical Starting Characteristics for a 72 rpm Motor



Phase-Shifting Network

The KS series and hazardous duty motors use a two-phase winding design. They are usually operated from single-phase AC power using a phase shifting network consisting of one or two resistors and a capacitor. These motors can also be operated directly from a two-phase power source. The SS240 – SS450 series use a three phase winding design. They can be driven directly from three-phase voltage or can be operated from single-phase power using only a phase shifting capacitor.
Ratings and part numbers for the phase-shifting components are shown in the motor charts. Be sure to select the correct components for the frequency of the AC power source, since the components needed for 50 hertz operation may be different from those required for operation at 60 hertz.

Temperature

All Kollmorgen AC synchronous motors are rated for continuous duty at a maximum ambient temperature of 40C (104∞F). Motor shell temperature must not be allowed to exceed 100∞C (212∞F) measured with a thermocouple. The minimum ambient temperature at which the motors may be operated is -40∞C (-40∞F), (EEx -20 C (-4∞F)).

Starting and Running Current

It is not necessary to consider high starting currents when designing a control system for a Kollmorgen synchronous motor, since starting and operating current are, for all practical purposed, identical.

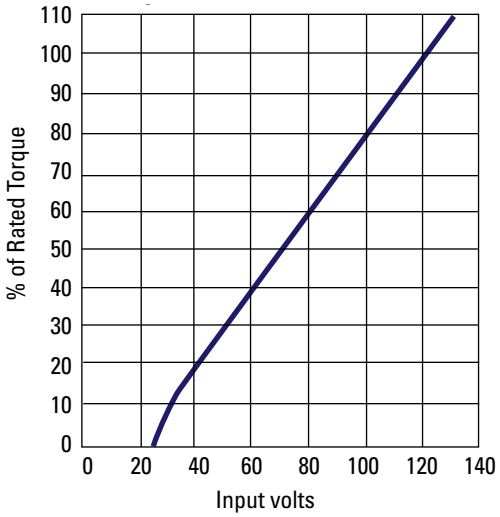
Stalling

If a motor becomes stalled, it will not overheat and will continue to draw only rated current. However, if the motor is stalled by running up against a stop, it will vibrate against the stop. Operating the motor continuously in this manner may eventually cause bearing failure.

Torque Versus Voltage

As indicated in the curve, the torque output of a Kollmorgen motor is approximately proportional to the applied input voltage. For intermittent operation, this characteristic can be used to provide increased torque by increasing the voltage. For example, assume that an application has a torque requirement of 200 ounce-inches (141 N-cm). Normally, a 240 ounce-inch (169 N-cm) Kollmorgen motor would be adequate, but this application is subject to wide voltage fluctuations and, therefore the 40 ounce-inch (28 N-cm) safety margin may be insufficient. The recommended practice is to use a motor having a higher torque rating. However, a larger motor may not fit in the available space. In this case, a step-up transformer could be used to increase the voltage to the 240 ounce-inch motor by approximately 10 %. Because operation at a higher voltage will cause a greater temperature rise, care must be taken to assure motor shell temperature does not exceed 10∞C (212∞F).

Typical Torque Versus Voltage for a Synchronuos Motor



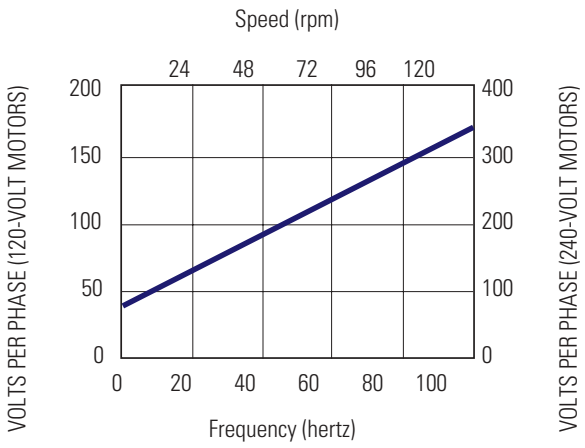
Speed Versus Frequency

The speed of a synchronous motor is directly proportional to the applied frequency, as shown in the Speed vs. Frequency chart. However, because the winding impedance is also a function of frequency it is necessary to adjust the voltage, to provide a constant current and torque at different excitation frequencies. The voltage required at a specific frequency can be obtained from the Voltage vs. Frequency curve. When a two-phase motor is operated from a two-phase source or a three-phase motor is operated from a three-phase source, it is only necessary to change the voltage and frequency to obtain the desired synchronous speed. When operating from a single-phase source it is necessary to change the values of the phase shifting components at each new frequency to provide the required phase shift.

Speed Versus Frequency

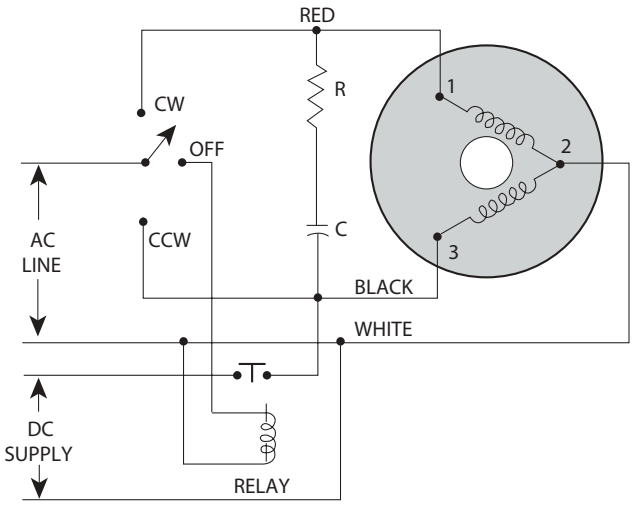
Frequency (Hertz)	Speed 72 rpm at 60 Hertz Models
10	12
20	24
30	36
40	48
50	60
60	72
70	84
80	96

Typical Voltage Versus Frequency for a Kollmorgen Motor



Holding Torque

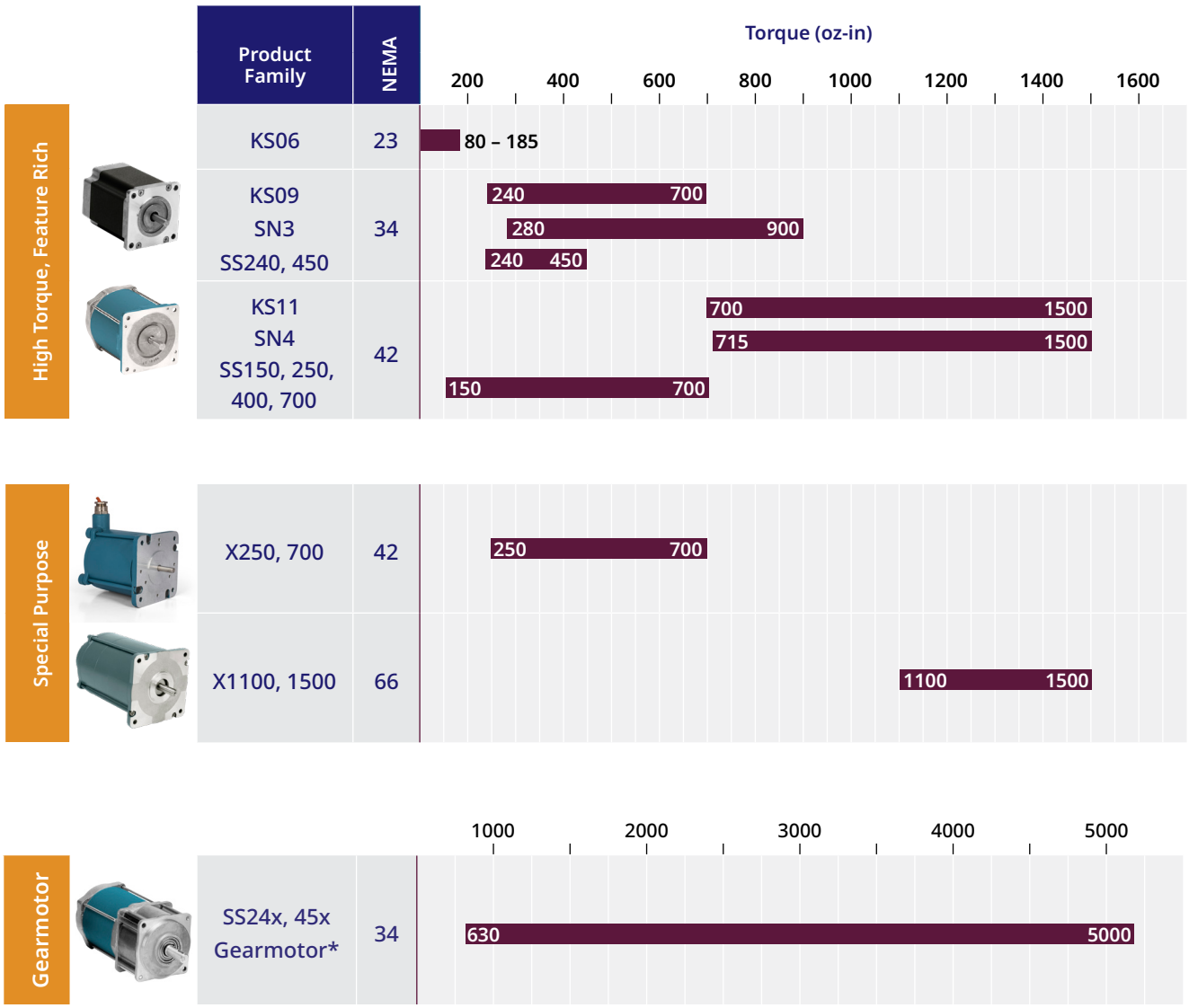
The permanent magnet construction of a Kollmorgen motor provides a small residual torque which helps hold the motor shaft in position when the motor is de-energized. When additional holding torque is required, DC current can be applied to one winding when the ac input is removed. DC current can also be applied to both windings if more holding torque is needed. The diagrams show typical connections for applying DC current to increase holding torque. Contact customer support for voltage, current and holding torque specifications.



AC Synchronous Motor Overview

Kollmorgen offers a comprehensive range of AC synchronous motor products including continous torque, high torque and hybrid options to meet a wide range of application requirements. For products not included in this catalog go to www.kollmorgen.com for information about other Kollmorgen synchronous motor products.

Flagship Products



*SS24x/SS45x Gearmotors carry either a 5pc or 25pc MOQ depending on the gear ratio.

Product Family	NEMA	Phases	Options			Family Features
			Leaded	Terminal Box	Rear Shaft	
KS06	23	1Ø	·	·	·	» 1Ø and 3Ø (SS240, 450 models only) » 72 rpm motor speed (with 60 Hz voltage) » 60 rpm motor speed (with 50 Hz voltage) » 120 volt or 240 volt AC models » Torques: 80 – 1800 oz-in (0.56 – 12.7 Nm) » Fast starting, stopping, or reversing » Can be stalled indefinitely without overheating » Gearmotor option (KS09 only)
KS09 SN3 SS240, 450	34	1Ø 3Ø	·	·	·	
KS11 SN4 SS150, 250, 400, 700	42	1Ø	·	·	·	
X250, 700	42	1Ø	·		·	» 1Ø models » X models meet UL Class 1, Group D hazardous duty requirements » 60 and 50 Hz models (72 and 60 rpm respectively) » 120 volt or 240 volt AC models » Torques: 250 – 1500 oz-in (1.77 – 10.6 Nm) » Fast starting, stopping, or reversing » Can be stalled indefinitely without overheating
X1100, 1500	66	1Ø	·		·	
SS240, 450 Gearmotor*	34	3Ø	·	·	·	» All the features of the SS240, 450 series » Gear reducers with ratios up to 125:1 » Torques: 634 - 5000 oz-in (4.48 – 35.3 Nm)

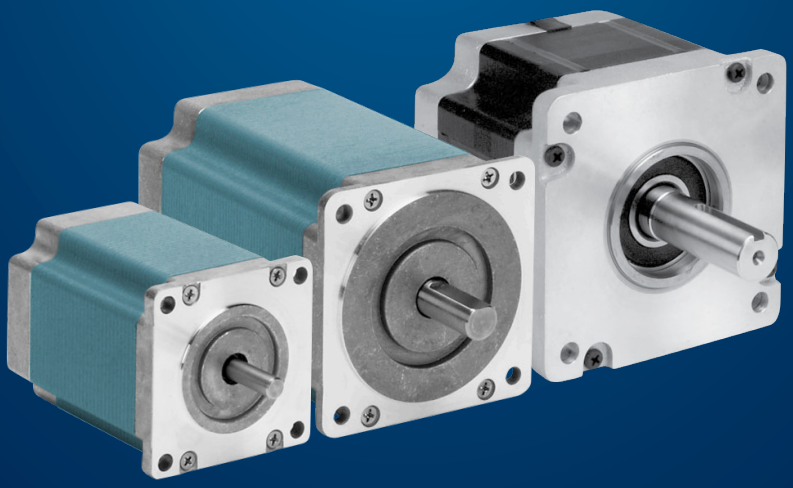
*SS24x/SS45x Gearmotors carry either a 5pc or 25pc MOQ depending on the gear ratio.

KS Synchronous Motors

Our high pole count motors naturally turn at slower speeds (72 or 60 rpm). They only need a resistor-capacitor (RC) network to operate from single-phase AC utility power. These motors provide the highest torque in an AC synchronous motor for loads that operate at 72 rpm or slower. They are available in three frame sizes.

Features

- Latest high torque construction
- Motor torque up to 1,500 oz-in (1059 N-cm)
- 72 rpm at 60 Hz, 60 rpm at 50 Hz
- 120 and 240 volt AC versions
- RRC network for smoother operation
- Leaded or terminal box connections
- Gearboxes available on KS09, NEMA 34 motors
- KS06, KS09, KS11 Series - High Torque - NEMA 23, 34, 42



KS Series Synchronous Motor Nomenclature

KS L 06 2 T1 Y _

KS Series

Termination
L Leaded
T Terminal box

Frame Size
06 NEMA size 23
09 NEMA size 34
11 NEMA size 42

Number of Stacks
1 1 stack
2 2 stacks
3 3 stacks

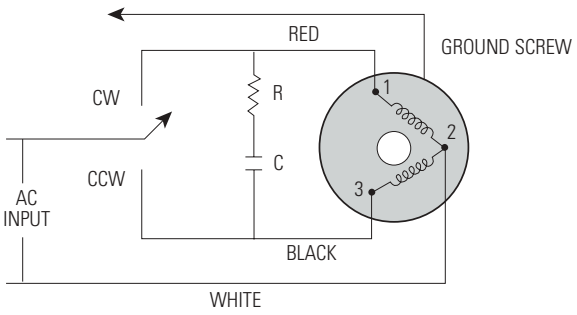
Options
E Rear shaft
Gxx Gearbox + Ratio (KS09 only)
(omit for no options)

Frequency
W 60 Hz
X 50 Hz
Y 50/60 Hz

Voltage
T1 120 Vac
T2 240 Vac

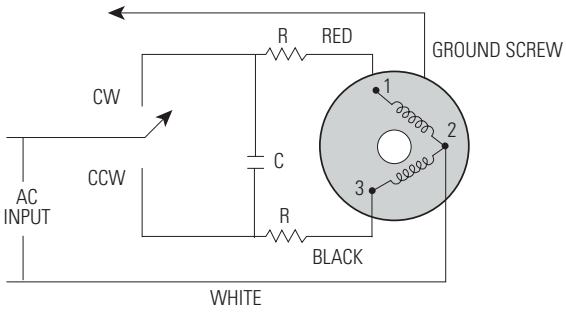
Single-Phase KS Motor Connection Diagrams

R/C Connection
Single-Phase Operation



NOTE:
1 - Direction or rotation is determined when viewed from end opposite mounting surface.

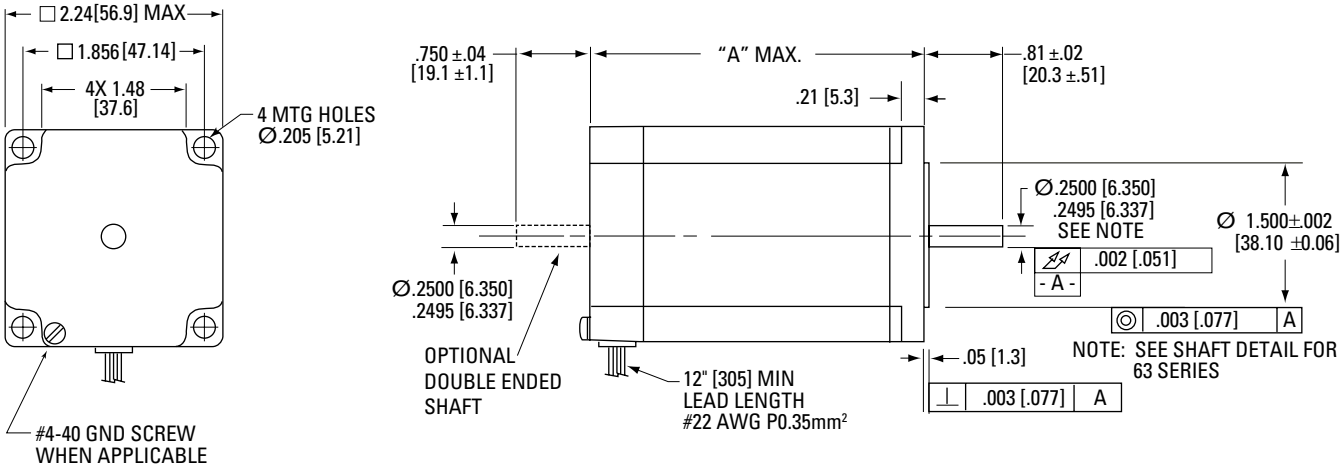
R/R/C Connection
Single-Phase Operation



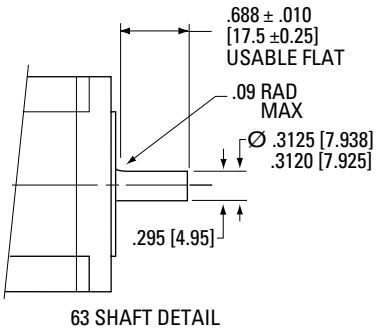
2 - Number in diagrams represent terminal connection when motors are supplied with terminal boards.

KS06 Series AC Synchronous Motors

KSL06 Outline Drawings



KSx063 Shaft Detail

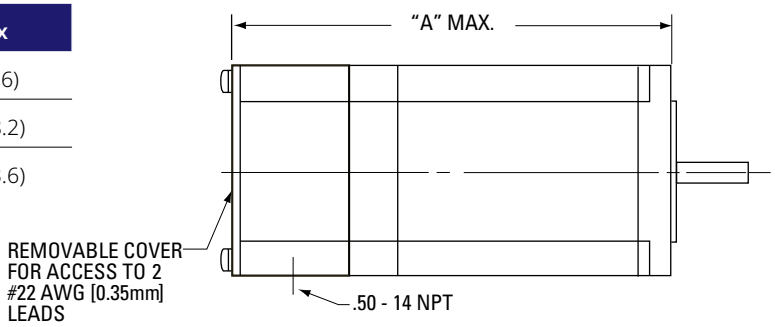


Model	"A" Max
KSL061	2.21 (56.1)
KSL062	3.06 (77.7)
KSL063	4.06 (103.1)

Dimensions in inches [mm]

KST06 Outline Drawing

Model	"A" Max
KST061	3.41 (86.6)
KST062	4.26 (108.2)
KST063	5.26 (133.6)



Dimensions in inches [mm]

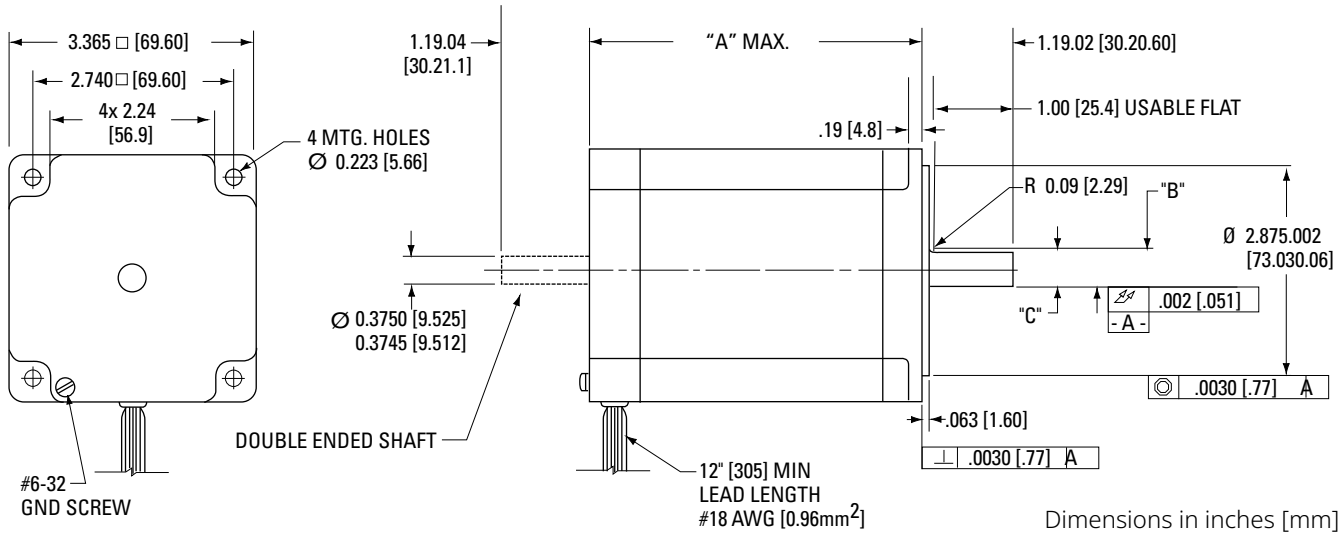
KS06 Performance Data

Model	Min. Torque	Load Inertia[2]	Line Current	Weight	Shaft Loading		Wiring Diag.	Phase Shifting Components				
					Radial Force	Axial Force		Resistor			Capacitor (240 Vac)	
	oz-in (Nm)	oz-in-s^2 (kg-m^2 x 10^{-3})	A (RMS/Ø)	lb (kg)	lb (N)	lb (N)		Resistor part no.	Ohms	Watts	Capacitor part no.	µF
60 Hz, 120 Vac, 72 RPM												
KSx061T1Y[1]	70 (0.49)	0.021 (1.5)	0.25	1.6 (0.73)	15 (67)	25 (111)	R/R/C	201052-034	600	12	201053-068	1.5
KSx061T1Y	80 (0.56)	0.028 (2)	0.25	1.6 (0.73)	15 (67)	25 (111)	R/C	201052-033	1000	12	201053-038	2
KSx062T1Y	140 (0.99)	0.084 (5.9)	0.35	2.3 (1.04)	15 (67)	25 (111)	R/C	201052-035	600	25	201053-044	3
KSx063T1Y	185 (1.31)	0.17 (12)	0.4	3.2 (1.45)	15 (67)	25 (110)	R/C	201052-049	400	50	201053-076	5
60 Hz, 240 Vac, 72 RPM												
KSx062T2Y	140 (0.99)	0.095 (6.7)	0.15	2.3 (1.04)	15 (67)	25 (111)	R/R/C	201052-036	1100	25	201053-063	0.75
KSx063T2Y	185 (1.31)	0.11 (7.6)	0.2	3.2 (1.45)	15 (67)	25 (111)	R/R/C	201052-050	1000	25	201053-063	0.75
50 Hz, 240 Vac, 60 RPM												
KSx062T2Y	140 (0.99)	0.095 (6.7)	0.15	2.3 (1.04)	15 (67)	25 (111)	R/R/C	201052-036	1100	25	201053-063	0.75
KSx063T2Y	185 (1.31)	0.11 (7.6)	0.2	3.2 (1.45)	15 (67)	25 (111)	R/R/C	201052-050	1000	25	201053-070	1

1. Using RRC phase shifting arrangement to achieve very smooth operation.
2. This is the maximum rigidly attached load inertia the motor will reliably start. If the load is attached to the motor with a 5° flex coupling, the motor will start loads up to seven times listed.

KS09 Series AC Synchronous Motors

KSL09 Outline Drawing

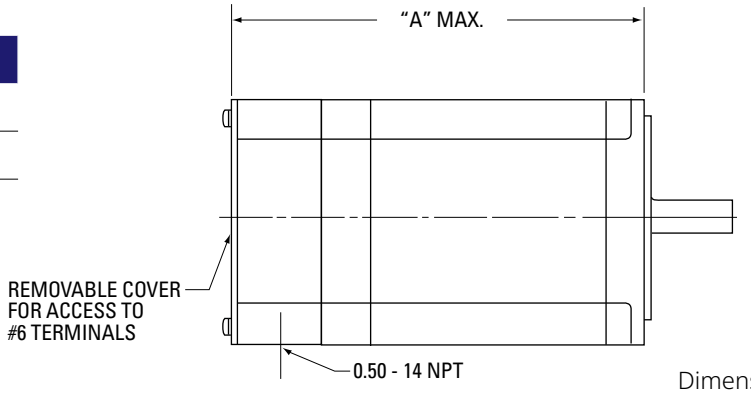


Dimensions in inches [mm]

Model	"A" Max	"B" Dia.	"C" Flat
KSL091	2.57 (65.1)	0.3750 (9.525) 0.3745 (9.512)	0.328 (8.33)
KSL092	3.77 (95.6)		
KSL093	4.97 (126.0)	0.5000 (12.700) 0.4995 (12.687)	0.450 (11.43)

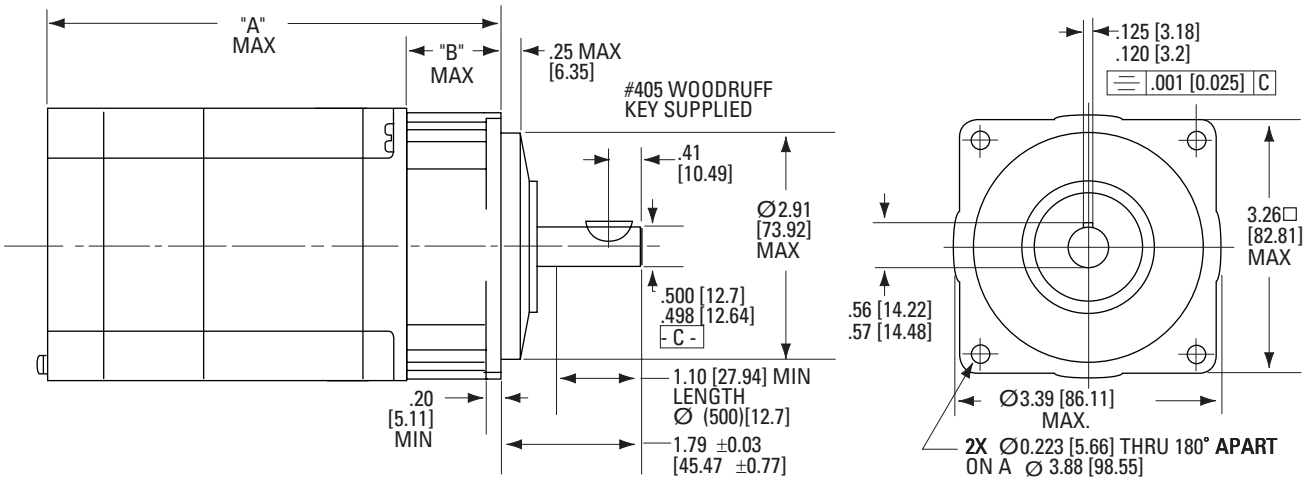
KST09 Outline Drawing

Model	"A" Max
KST091	3.90 (100)
KST092	5.10 (130)
KST093	6.30 (161)



Dimensions in inches [mm]

KS09 Gearmotor Outline Drawing



Motor Series	Gearbox		Leaded Motors		Terminal Box Motors	
	Ratio	"B" Max	Series	"A" Max	Series	"A" Max
KSx091	3:1 thru 5:1	1.19 (30.2)	KSL091	3.76 (96)	KST091	5.09 (129)
	9:1 thru 25:1	1.81 (46.0)		4.38 (111)		5.71 (145)
	27:1 thru 125:1	2.38 (60.5)		4.95 (126)		6.28 (160)
KSx092	3:1 thru 5:1	1.19 (30.2)	KSL092	4.96 (126)	KST092	6.29 (160)
	9:1 thru 25:1	1.81 (46.0)		5.58 (142)		6.91 (176)
	27:1 thru 125:1	2.38 (60.5)		6.15 (156)		7.48 (190)
KSx093	3:1 thru 5:1	1.19 (30.2)	KSL093	6.16 (156)	KST093	7.49 (190)
	9:1 thru 25:1	1.81 (46.0)		6.78 (172)		8.11 (206)
	27:1 thru 125:1	2.38 (60.5)		7.35 (187)		8.68 (220)

KS09 Series AC Synchronous Motors

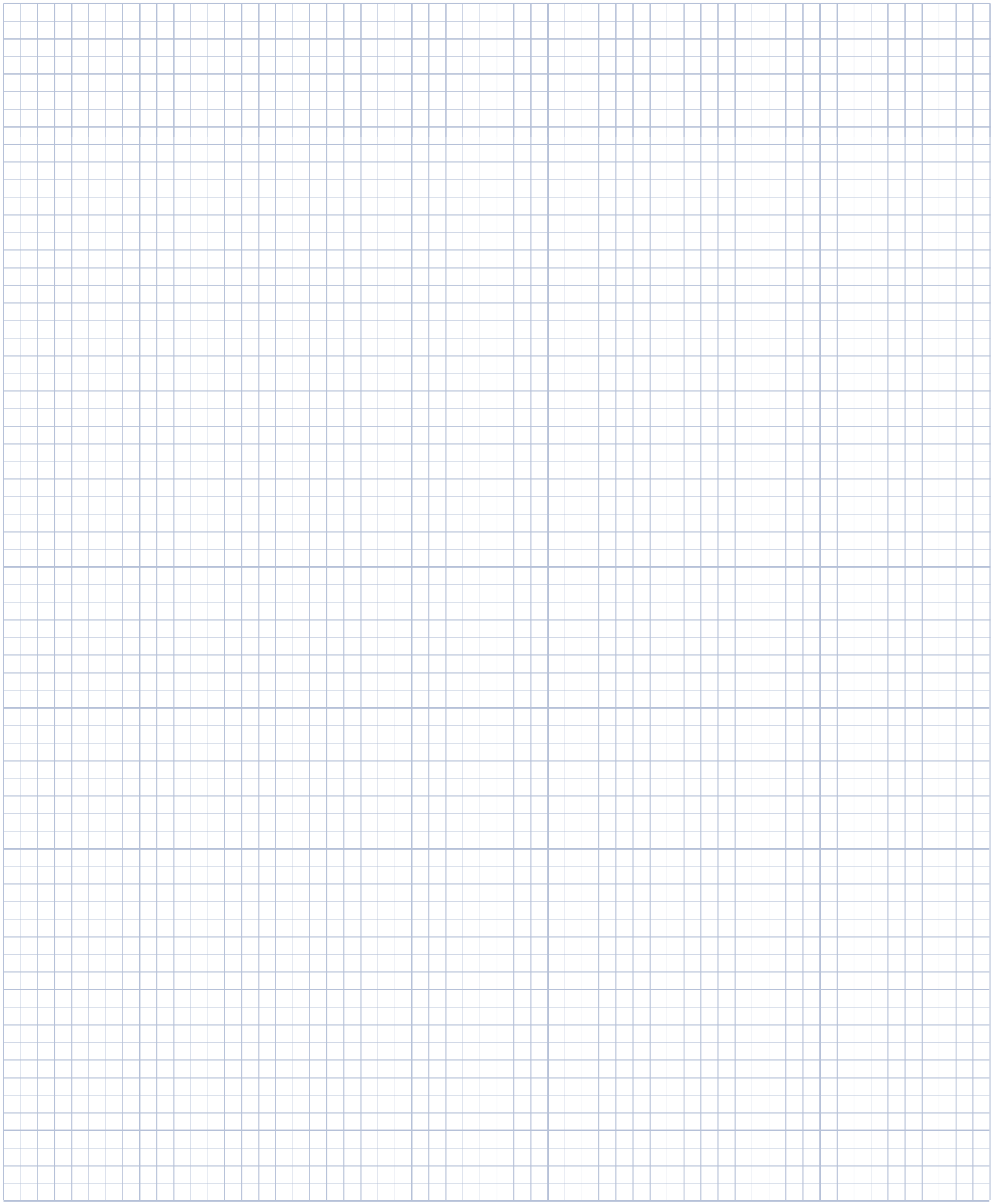
KS09 Performance Data

Model	Min. Torque	Load Inertia*	Line Current	Weight	Shaft Loading		Wiring Diag.	Phase Shifting Components				
					Radial Force	Axial Force		Resistor			Capacitor (240 Vac)	
	oz-in (Nm)	oz-in-s^2 (kg-m^2 x 10^{-3})	A (RMS/Ø)	lb (kg)	lb (N)	lb (N)		Resistor part no.	Ohms	Watts	Capacitor part no.	µF
60 Hz, 120 Vac, 72 RPM												
KSx091T1Y	240 (1.69)	0.17 (12)	0.5	3.8 (1.73)	25 (111)	50 (222)	R/C	201052-037	300	50	201053-076	5
KSx092T1Y	450 (3.18)	0.33 (23)	0.6	6.2 (2.82)	25 (111)	50 (222)	R/C	201052-041	250	50	201053-069	6
KSx093T1Y	700 (4.94)	0.54 (38)	1.0	8.7 (3.95)	25 (111)	50 (222)	R/C	201052-027	150	100	201053-074	11
60 Hz, 240 Vac, 72 RPM												
KSx091T2Y	240 (1.69)	0.17 (12)	0.25	3.8 (1.73)	25 (111)	50 (222)	R/R/C	201052-039	900	50	201053-070	1
KSx092T2Y	450 (3.18)	0.37 (26)	0.35	6.2 (2.82)	25 (111)	50 (222)	R/C	201052-045	1000	100	201053-072	2
KSx093T2Y	700 (4.94)	0.58 (41)	0.5	8.7 (3.95)	25 (111)	50 (222)	R/C	201052-047	600	100	201053-073	3
50 Hz, 240 Vac, 60 RPM												
KSx091T2Y	240 (1.69)	0.18 (13)	0.25	3.8 (1.73)	25 (111)	50 (222)	R/R/C	201052-039	900	50	201053-075	1.5
KSx092T2Y	450 (3.18)	0.33 (23)	0.35	6.2 (2.82)	25 (111)	50 (222)	R/R/C	201052-043	600	50	201053-071	1.75
KSx093T2Y	700 (4.94)	0.58 (41)	0.5	8.7 (3.95)	25 (111)	50 (222)	R/R/C	201052-046	400	100	201053-073	3

* This is the maximum rigidly attached load inertia the motor will reliably start. If the load is attached to the motor with a 5° flex coupling, the motor will start loads up to seven times listed.

Notes

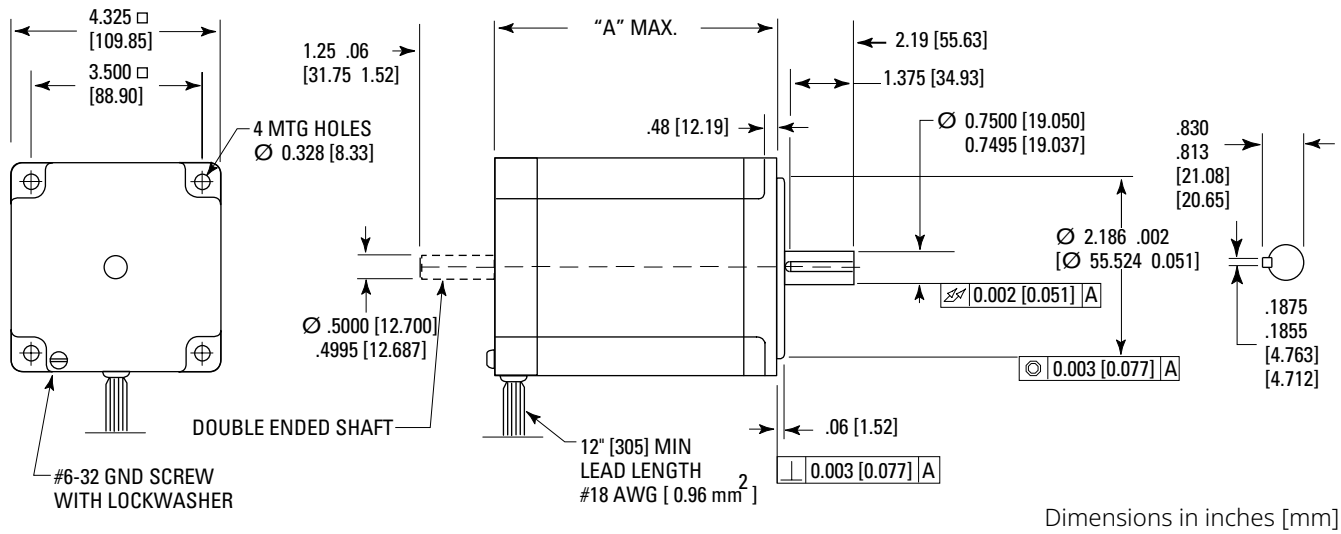
KS — Motor Series
L — Termination
09 — Frame Size
2 — Stack Length
T1 — Voltage
Y — Frequency
— Options



0.125 inch divisions

KS11 Series AC Synchronous Motors

KSL11 Outline Drawing

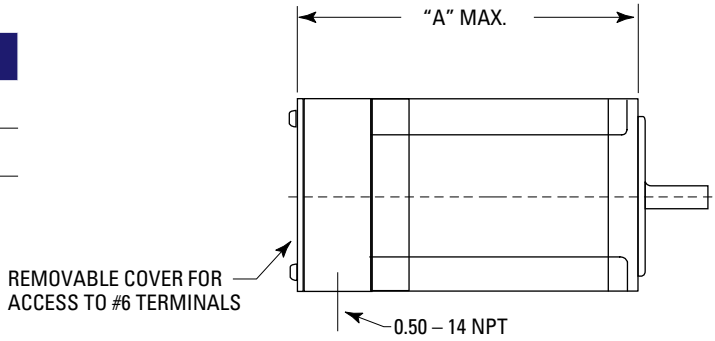


Dimensions in inches [mm]

Model	"A" Max
KSL111	3.89 (98.81)
KSL112	5.91 (150.1)
KSL113	7.92 (201.2)

KST11 Outline Drawing

Model	"A" Max
KST111	5.20 (132.1)
KST112	7.22 (183.4)
KST113	9.23 (234.4)



Dimensions in inches [mm]

KS11 Performance Data

Model	Min. Torque	Load Inertia*	Line Current	Weight	Shaft Loading		Wiring Diag.	Phase Shifting Components				
					Radial Force	Axial Force		Resistor			Capacitor (240 Vac)	
	oz-in (Nm)	oz-in-s^2 (kg-m^2 x 10^{-3})	A (RMS/Ø)	lb (kg)	lb (N)	lb (N)		Resistor part no.	Ohms	Watts	Capacitor part no.	µF
60 Hz, 120 Vac, 72 RPM												
KSx111T1W	700 (4.94)	0.28 (20)	1.2	11.0 (5.0)	75 (333)	130 (578)	R/C	201052-045	100	100	201053-032	12.5
KSx112T1W	1100 (7.77)	0.54 (38)	1.7	18.4 (8.3)	75 (333)	130 (578)	R/C	201052-101	75	100	201053-081	20
KSx113T1W	1500 (10.59)	0.62 (44)	2.1	25.7 (11.7)	75 (333)	130 (578)	R/C	201052-104	50	200	201053-081	20
60 Hz, 240 Vac, 72 RPM												
KSx111T2W	700 (4.94)	0.37 (26)	0.6	11.0 (5.0)	75 (333)	130 (578)	R/C	201052-028	500	100	201053-030	3
KSx112T2W	1100 (7.77)	0.75 (53)	0.9	18.4 (8.3)	75 (333)	130 (578)	R/C	201052-102	200	100	201053-030	3
KSx113T2W	1500 (10.59)	0.71 (50)	1.3	25.7 (11.7)	75 (333)	130 (578)	R/C	201052-105	200	200	201053-029	6
50 Hz, 240 Vac, 60 RPM												
KSx111T2X	700 (4.94)	0.21 (15)	0.6	11.0 (5.0)	75 (333)	130 (578)	R/C	201052-041	250	50	201053-030	3
KSx112T2X	1100 (7.77)	0.75 (53)	0.7	18.4 (8.3)	75 (333)	130 (578)	R/C	201052-103	250	100	201053-028	4
KSx113T2X	1500 (10.59)	1.12 (79)	1.4	25.7 (11.7)	75 (333)	130 (578)	R/C	201052-106	150	200	201053-082	7.5

* This is the maximum rigidly attached load inertia the motor will reliably start. If the load is attached to the motor with a 5° flex coupling, the motor will start loads up to seven times listed.

SN Synchronous Motors

SN series 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.

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

- 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 and Benefits of SN Synchronous Motors

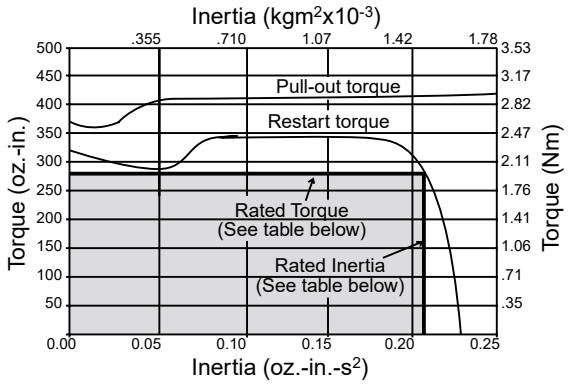
With rated torques to 1500 oz-in. (93.75 lb-in.), 10,5 Nm, POWERSYNC provides the highest rated output torque range in the industry	Optimized magnetics provide maximum performance in a small envelope, reducing space required for the motor. Exceptionally high torques provide unparalleled application freedom 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, 120V ac, 60 Hz	For North American use
60 RPM, 120V ac, 50 Hz	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

SN Series Synchronous Motor Performance Overview

RPM	Voltage	Frequency	Rated Torque oz-in. (Nm)	Rated Inertia oz-in-s² (kg-cm²)
72	120 V_{AC}	60 Hz	280 - 1500 (1.98 - 10.59)	0.21 - 0.92 (14.8 - 64.9)
60	120 V_{AC}	50 Hz	375 - 1400 (2.64 - 10.17)	0.29 - 1.3 (20.5 - 91.8)

SN Series AC Synchronous Motors

SN Series Motor Performance Specifications



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 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.

SN3 & SN4 60 Hz, 120 V, Single Phase, 72 rpm

Model[1]	Rated Torque[2,3]	Rated Inertia[2,3]	Rotor Inertia	Max. Pull-out Torque	Current @ 80% Pull-out Torque	Weight	Shaft Loading		Phase Shifting Components		
							Max. Radial Force[4]	Max. Axial Force[4]	Resistor		Capacitor (370 VAC)
	oz-in (Nm)	oz-in-s² (kg-cm2)	oz-in-s² (kg-cm2)	oz-in (Nm)	Arms/phase	lb (kg)	lb	lb	Ohms	Watts	µF
SN31H	280 (1.98)	0.21 (14.8)	0.0202 (1.4)	410 (2.9)	0.38	5.0 (2.27)	65	305	200	50	6.0
SN32H	480 (3.39)	0.29 (20.5)	0.038 (2.7)	690 (4.87)	0.47	8.4 (3.81)	65	305	200	50	10.0
SN33H	690 (4.87)	0.53 (37.4)	0.0567 (4.0)	1015 (7.17)	0.78	11.9 (5.39)	110	305	100	100	10.0
SN34H	900 (6.36)	0.53 (37.4)	0.075 (5.3)	1520 (10.73)	1.43	15.1 (6.84)	110	305	50	100	17.5
SN41H	715 (5.05)	0.40 (28.2)	0.0783 (5.5)	1045 (7.38)	0.8	11 (4.98)	125	404	100	100	12.5
SN42H	1200 (8.47)	0.82 (57.9)	0.1546 (10.9)	1580 (11.16)	1.19	18.4 (8.34)	110	404	75	100	20.0
SN43H	1500 (10.59)	0.92 (64.9)	0.2293 (16.2)	2000 (14.12)	1.5	25.7 (11.64)	110	404	50	100	20.0

SN3 & SN4 50 Hz, 120 V, Single Phase, 60 rpm

Model[1]	Rated Torque[2,3]	Rated Inertia[2,3]	Rotor Inertia	Max. Pull-out Torque	Current @ 80% Pull-out Torque	Weight	Shaft Loading		Phase Shifting Components		
							Max. Radial Force[4]	Max. Axial Force[4]	Resistor		Capacitor (370 VAC)
	oz-in (Nm)	oz-in-s² (kg-cm2)	oz-in-s² (kg-cm2)	oz-in (Nm)	Arms/phase	lb (kg)	lb	lb	Ohms	Watts	µF
SN31H	375 (2.64)	0.29 (20.5)	0.0202 (1.4)	490 (3.46)	0.34	5.0 (2.27)	65	305	150	25	2.0
SN32H	600 (4.24)	0.52 (36.7)	0.038 (2.7)	870 (6.14)	0.64	8.4 (3.81)	65	305	100	50	4.0
SN33H	800 (5.65)	0.60 (42.3)	0.0567 (4.0)	1120 (7.91)	0.67	11.9 (5.39)	110	305	100	50	4.0
SN34H	990 (6.99)	0.53 (37.4)	0.075 (5.3)	1565 (11.05)	1.1	15.1 (6.84)	110	305	75	100	6.5
SN41H	700 (4.94)	0.53 (37.4)	0.0783 (5.5)	1060 (7.49)	0.71	11 (4.98)	125	404	100	50	4.0
SN42H	1020 (7.22)	1.16 (81.9)	0.1546 (10.9)	1575 (11.12)	0.93	18.4 (8.34)	110	404	100	100	6.5
SN43H	1440 (10.17)	1.30 (91.8)	0.2293 (16.2)	2000 (14.12)	1.6	25.7 (11.64)	110	404	50	225	10.5

Notes:
1. See page 25 for full nomenclature options
2. Rated Torque and Inertia are maximum values. The Rated Torque is the combination of load torque and friction torque. The Rated Inertia is a combination of the load inertia and the motor's Rotor Inertia
3. Rated Torque and Inertia denote restart conditions with a stiff coupling of 0.3 arc-sec/oz-in. minimum
4. See page 30 for shaft load and bearing fatigue life charts

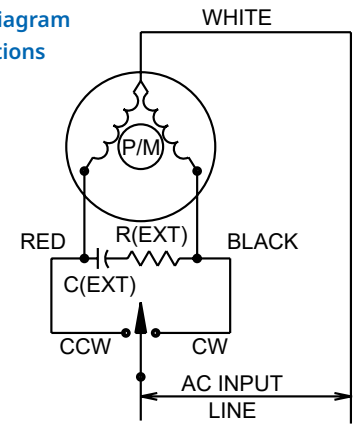
SN Series Motor Phase R-C Phase Shift Networks

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

SN3 & SN4 60 Hz, 120 V, Single Phase, 72 rpm

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



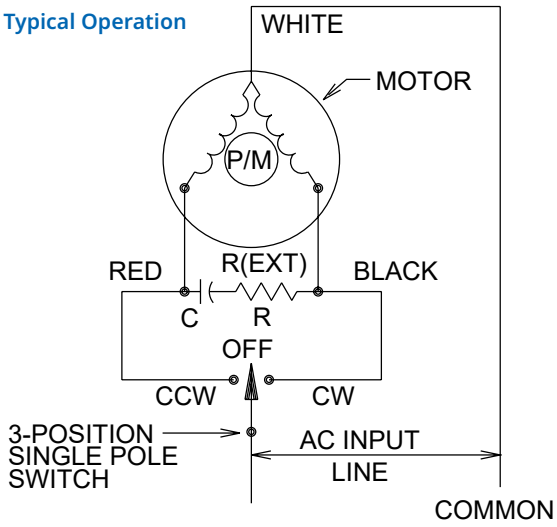
SN3 & SN4 50 Hz, 120 V, Single Phase, 60 rpm

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

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 to the right shows the connection diagram for AC synchronous motors.

Typical Operation

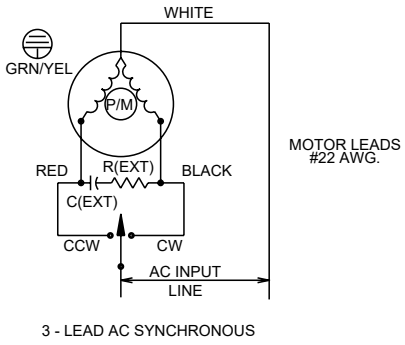


SN Series AC Synchronous Motors

SN Series Synchronous Motor 3 Lead Connection Information

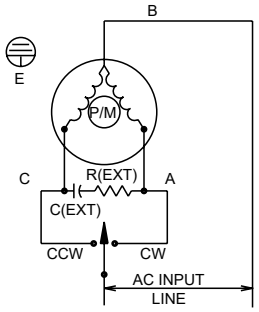
For all motor terminations refer to the following AC synchronous motor connection diagram to assure that proper connections are made. Consult our application engineers for assistance if necessary.

Flying Leads



3 - LEAD AC SYNCHRONOUS

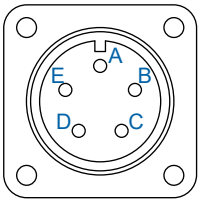
MS Connector



3 - LEAD AC SYNCHRONOUS

3-Lead Connection

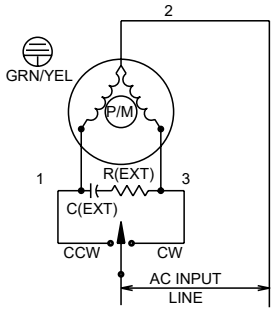
MS Connector Pinout	Lead Color
A	Black
B	White
C	Red
D	–
E	Green/Yellow



MS Connector MS3102R14S-5P

Mating Plug Type
MS3106F14S-5S

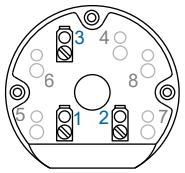
Terminal Board



3 - LEAD AC SYNCHRONOUS

3-Lead Connection

Terminal Number	Lead Color
1	Red
2	White
3	Black



Terminal Board

SN Series Synchronous Motor Nomenclature

SN 4 3 H C Y – L E K – M2 – 01

SN Series
SN Standard construction

Frame Size
3 NEMA 34 (3.38 in.) square frame
4 NEMA 42 (4.325 in.) square frame

Stack Length
1 1 stack
2 2 stacks
3 3 stacks
4 4 stacks - NEMA 34 only

Mounting
H Heavy duty NEMA
S Special, contact customer support

Construction/Connection Style
R Regular/leadwire
C System MS connector
L Splashproof to terminal board via conduit connector: 1/2 in. NPS pipe thread
M Splashproof to terminal board via conduit connect: metric PG11 pipe thread - NEMA 34 metric PG13.5 pipe thread - NEMA 42
S Special, contact customer support

Windings/Leads
Y 3 leads

Rotor Type
L Laminated

Shaft Configuration (Diameter & Length)
N Single
D Double (R or C construction only)
E Double ended for encoder (R or C construction only)
S Special, contact customer support

Shaft Modifications
K Straight key
S Special, contact customer support

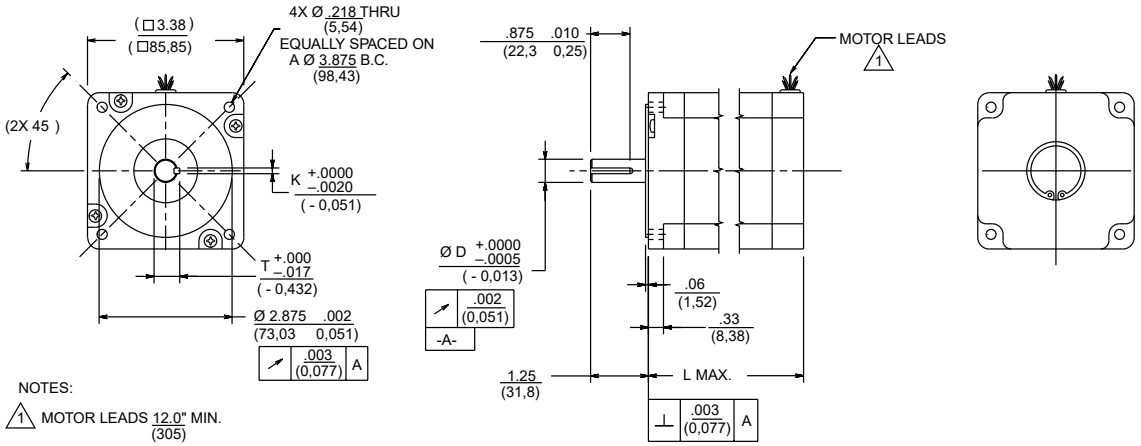
Encoder Option
NS No feedback
M2 Encoder mounting provision (must use construction C or R and shaft configuration E)
SS Special, contact customer support

Special Sequence
00 Standard motor without shaft seal
01 Standard motor with shaft seal
Other numbers will be assigned for special motors

SN Series NEMA 34 Motors

SN Series NEMA 34 Dimensional Drawings

R- Construction Leadwire Hookup



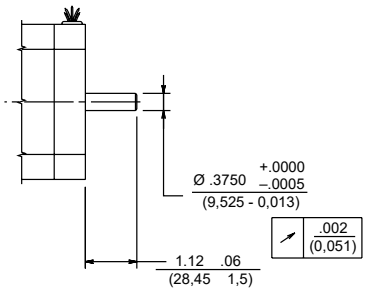
NOTES:

1 MOTOR LEADS 12.0" MIN. (305)

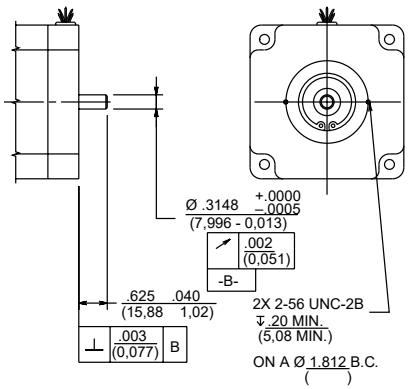
MOTOR*	D	K	T	L MAX.
31HR	.5000 (12,70)	.1250 (3,175)	.555 (14,09)	3.13 (79,5)
32HR	.5000 (12,70)	.1250 (3,175)	.555 (14,09)	4.65 (118,1)
33HR	.6250 (15,875)	.1875 (4,763)	.705 (17,91)	6.17 (156,7)
34HR	.6250 (15,875)	.1875 (4,763)	.705 (17,91)	7.68 (195,1)

Dimensions in in./mm (metric dimensions for reference only.

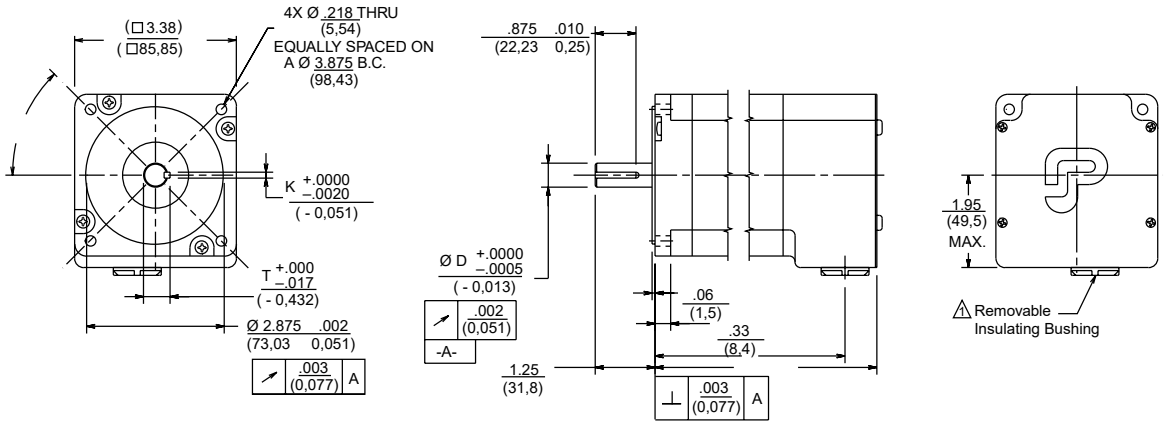
D- Construction Double Shaft Option



M2- Construction Encoder Mounting Provision



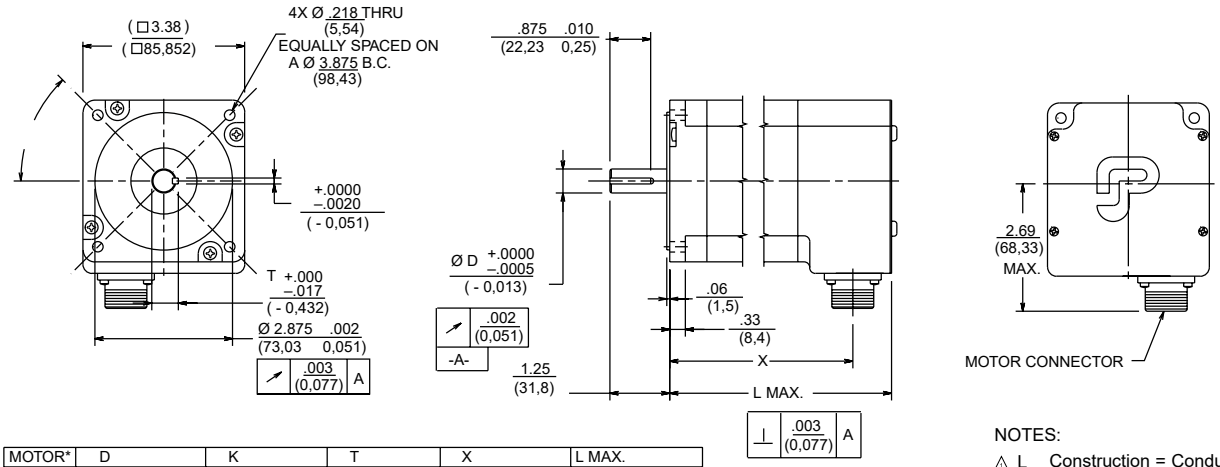
L-, M- Splashproof Construction / Terminal Board Connection



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)

Dimensions in in./mm (metric dimensions for reference only.

C/System- Splashproof Construction / MS Connector



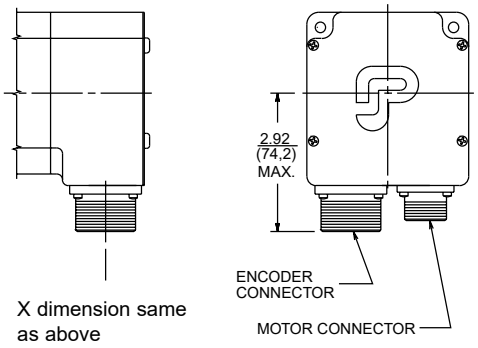
MOTOR*	D	K	T	X	L MAX.
31HR	.5000 (12,70)	.1250 (3,175)	.555 (14,09)	3.56 (90,42)	4.44 (112,8)
32HR	.5000 (12,70)	.1250 (3,175)	.555 (14,09)	5.07 (128,78)	5.96 (151,4)
33HR	.6250 (15,875)	.1875 (4,763)	.705 (17,91)	6.59 (167,39)	7.48 (189,9)
34HR	.6250 (15,875)	.1875 (4,763)	.705 (17,91)	8.11 (205,99)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

NOTES:

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

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

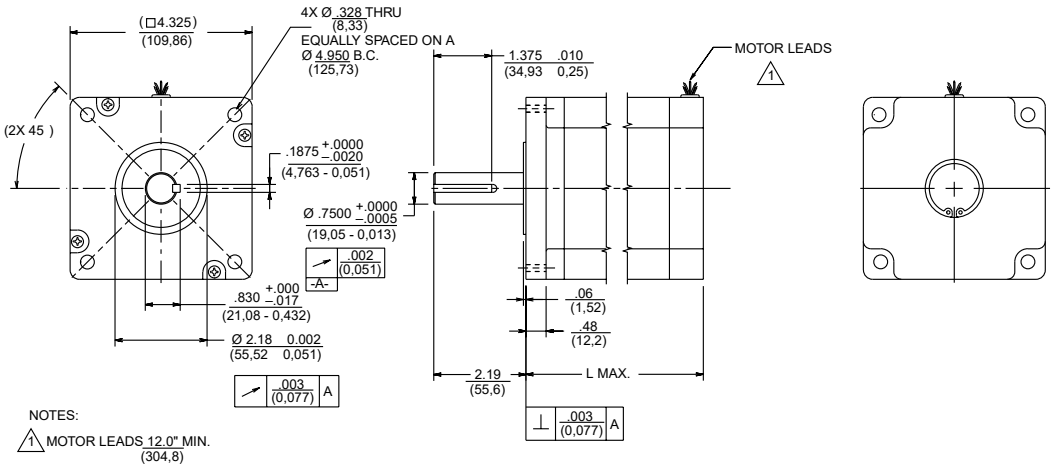
Encoder Splashproof Mounting Provision



SN Series NEMA 42 Motors

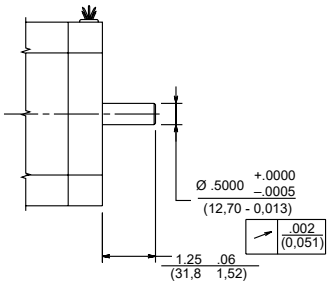
SN Series NEMA 42 Dimensional Drawings

R- Construction Leadwire Hookup



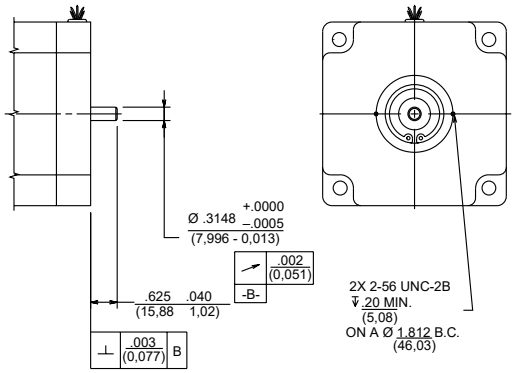
MOTOR*	L MAX.
41HR	3.89 (98,8)
42HR	5.91 (150,1)
43HR	7.92 (201,2)

R- Construction Double Shaft Option

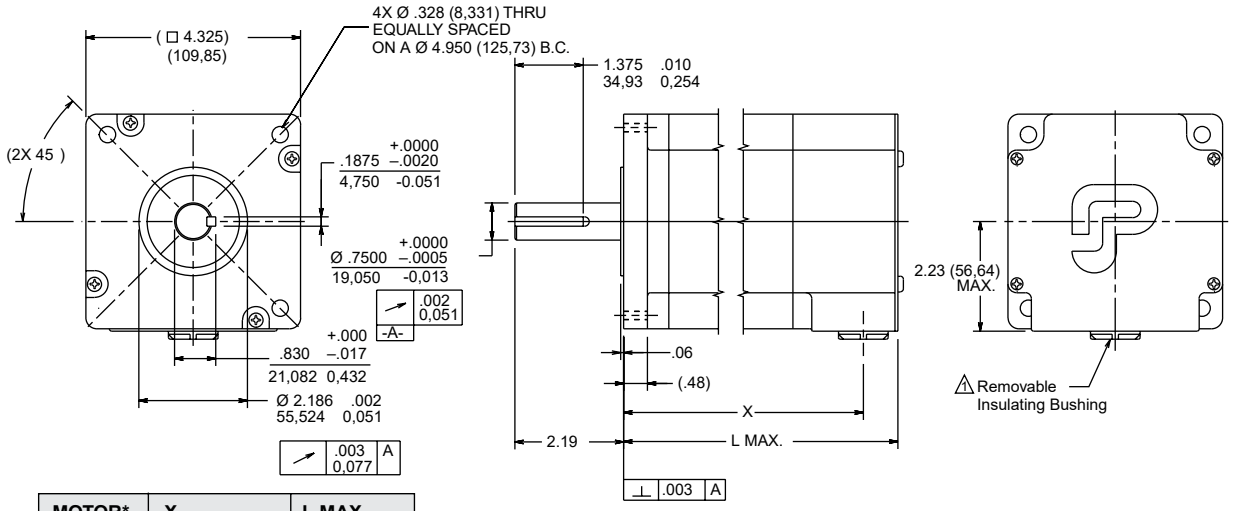


M2- Construction Encoder Mounting Option

See the Encoder Options on pags 32-33 for details

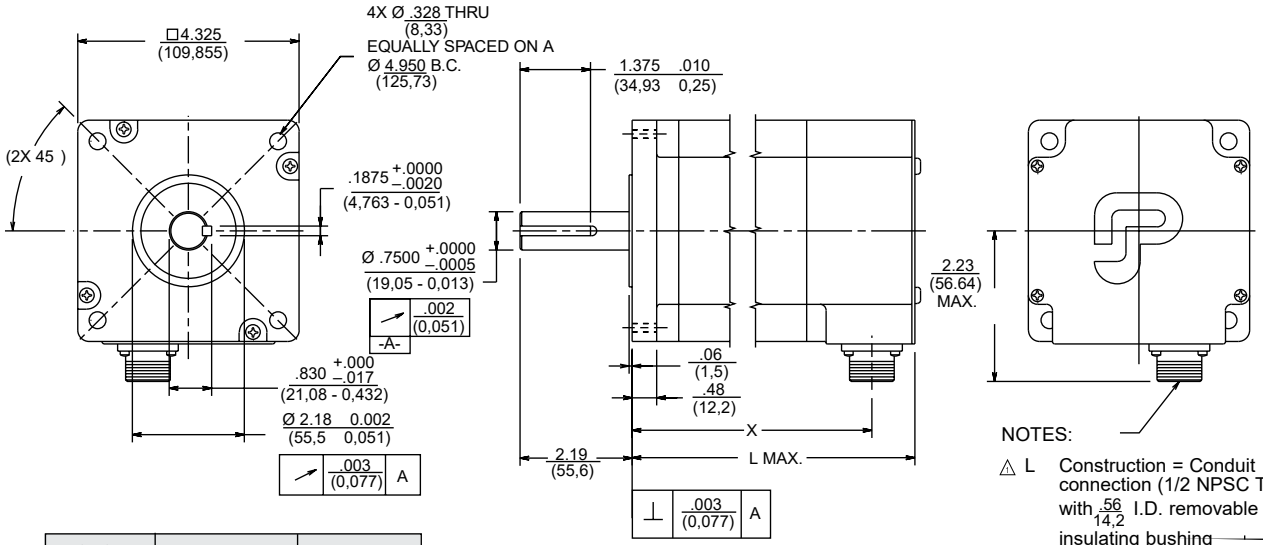


L-, M- Splashproof Construction / Terminal Board Connection



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)

C/System- Splashproof Construction / MS Connector



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)

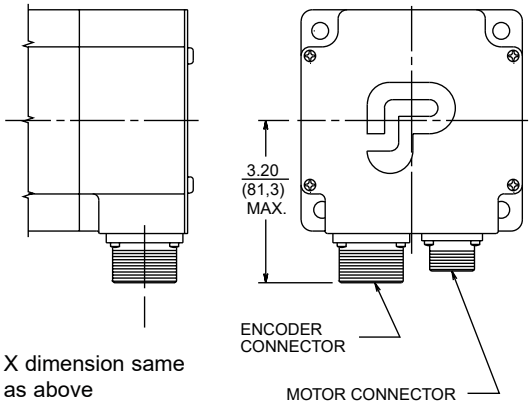
NOTES:

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

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

Encoder Splashproof Mounting Option

See the Encoder Options on pages 32-33 for details



SN Series Technical Data

Shaft Load and Bearing Fatigue Life

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. Kollmorgen uses heavy duty, long life bearings to assure you the maximum useful life from every AC synchronous motor you purchase.

Shaft Loading

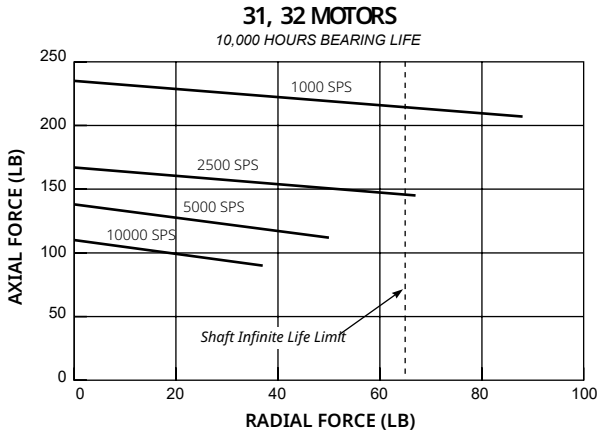
The maximum radial fatigue load ratings reflect the following assumptions:

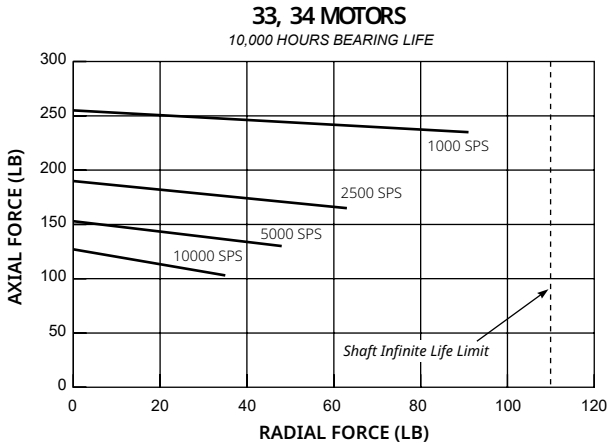
1. Motors are operated at 1* rated torque
2. Fully reversed radial load applied in the center of the keyway extension
3. Infinite life with 99% reliability
4. Safety factory = 2

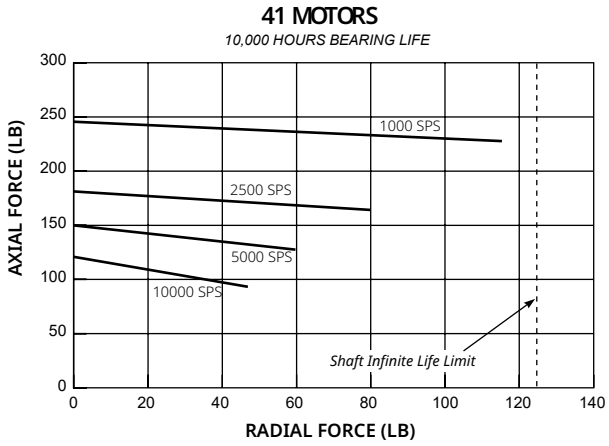
Motor	Max. Radial Force (Lb.)	Max. Axial Force (Lb.)
31, 32	65	305
33, 34	110	305
41	125	404
42, 43	110	404

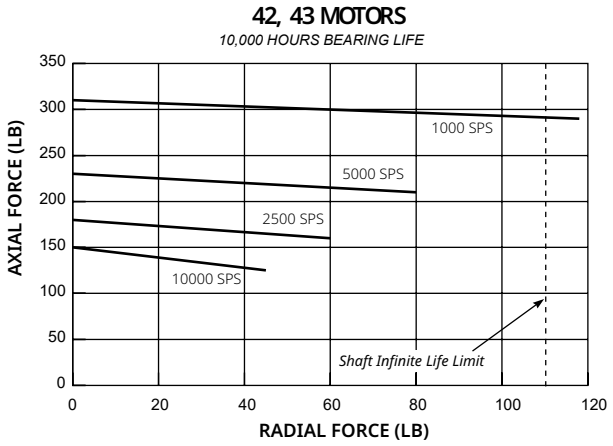
Bearing Fatigue Life (L_{10})

Note: SPS = Speed, Full Steps Per Second





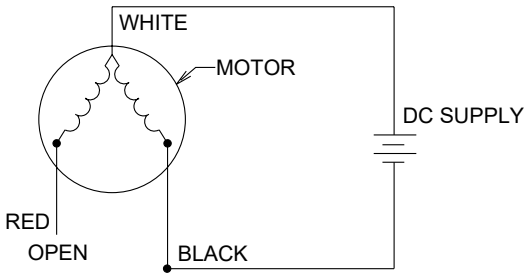




Holding Torque

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)
SN31HXYY-LXK-XX-XX	72	120	60	0.53	45
SN32HXYY-LXK-XX-XX	72	120	60	0.92	35
SN33HXYY-LXK-XX-XX	72	120	60	1.12	36
SN34HXYY-LXK-XX-XX	72	120	60	1.76	28
SN41HXYY-LXK-XX-XX	72	120	60	1.27	27
SN42HXYY-LXK-XX-XX	72	120	60	2.22	22
SN43HXYY-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

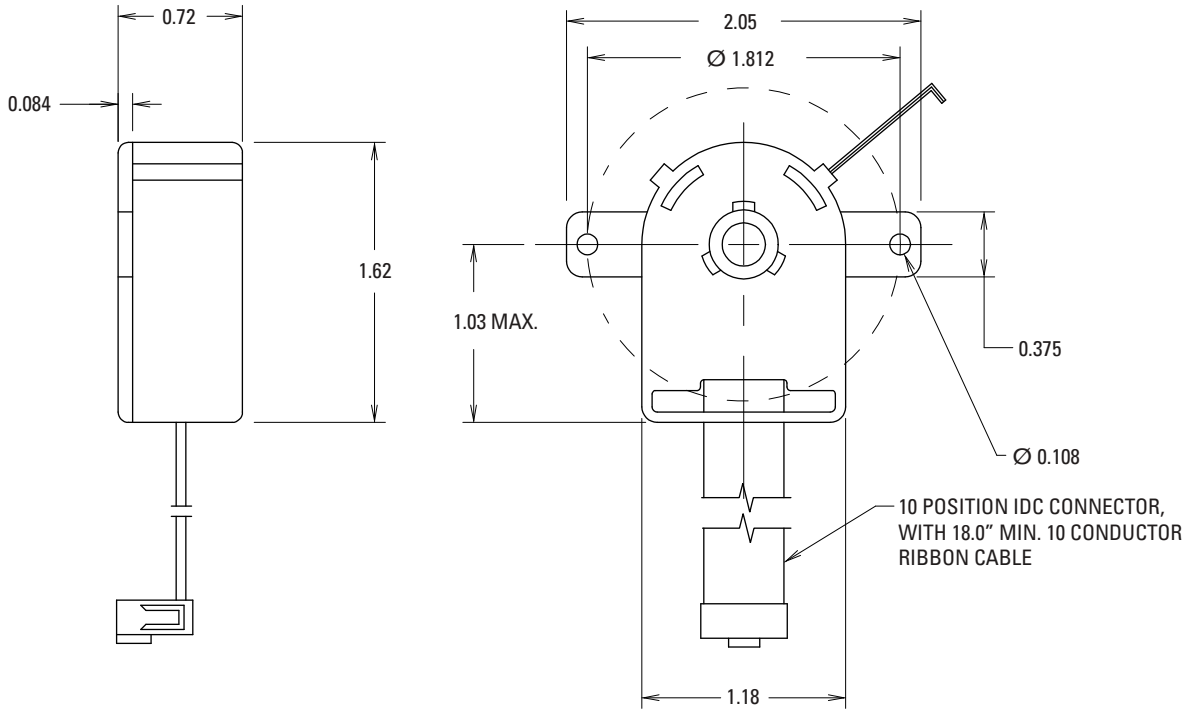
SN Series Encoder Options

SN Encoder Options

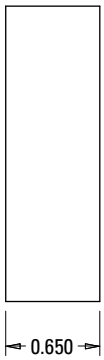
Enconder Specifications

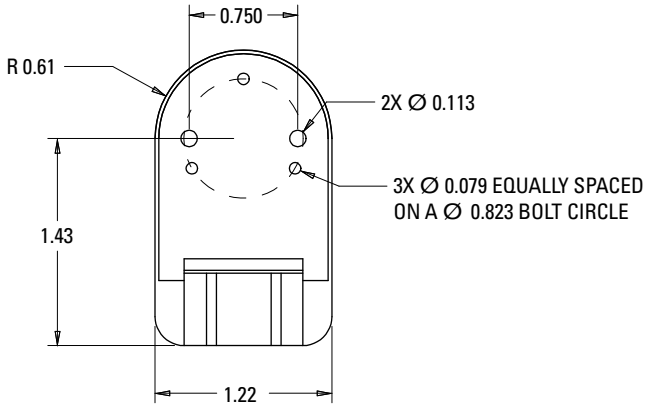
Parameter	Code	
	PD	PF
Type	Optical Incremental	
Supply Voltage	5 VDC ±10%	
Lines per Revolution	500	1000
Output Format	Dual Channel Quadrature with Index (Z)	
Output Type	Differential Line Drive (with compliments)	
Output Frequency (kHz)	100	
Operating Temperature (°C)	-40 to 100	
Storage Temperature (°C)	-40 to 100	

PD Encoder Dimensional Drawings

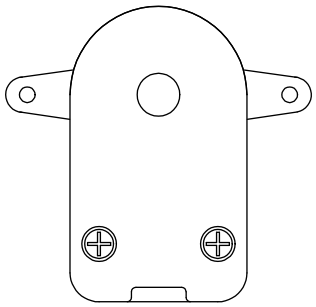


PF Encoder Dimensional Drawings



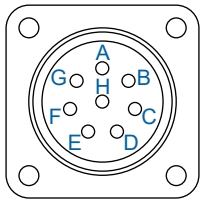


(BASE ONLY)



(WITH COVER AND
MOUNTING OPTION G)

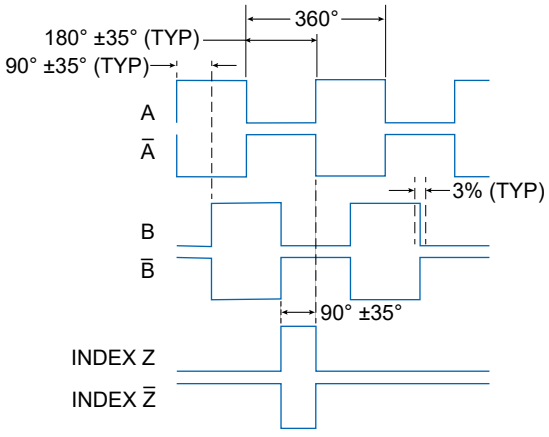
Color	Function	MS Connector
Brown	N/C	–
Red	+5 V	G
Orange	GROUND	H
Yellow	N/C	–
Green	$\bar{A}$	A
Blue	A	B
Violet	$\bar{B}$	C
Gray	B	D
White	Z (Index)	E
Black	$\bar{Z}$ (Index)	F



MS Connector
MS3102E20-7P

Mating Plug Type
MS3106F20-7S

PD, PF Encoder Phase Diagram



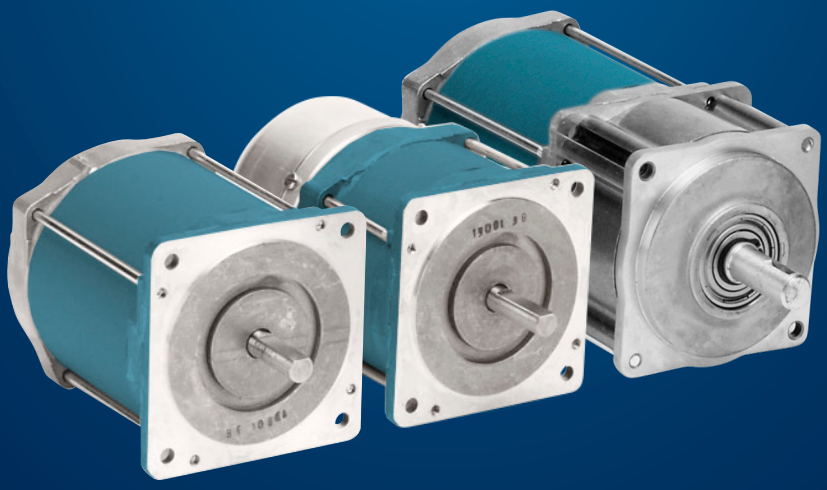
OUTPUT FORMAT FOR CCW ROTATION VIEWED
FROM ENCODER END

SS Synchronous Motors

Our high pole count motors naturally turn at slower speeds (72 or 60 rpm). They only need a capacitor (C) network to operate from single-phase, 120VAC or 240VAC utility power. These motors provide the highest torque in an AC synchronous motor for loads that operate at 72 rpm or slower. They are available in two frame sizes.

Features

- Latest high torque construction
- Motor torque up to 700 oz-in (4.94 Nm)
- 72 rpm at 60 Hz, 60 rpm at 50 Hz
- 120 and 240 volt AC versions
- Leaded or terminal box connections
- Gearboxes available on NEMA 34 offerings – SS240, SS450 Series
- SS240, SS450 Series – NEMA Size 34
- SS150, SS250, SS400, SS700 Series – NEMA Size 42



SS Series Synchronous Motor Nomenclature

SS 24 1 LE G60

SS Series

Minimum Running Torque

NEMA Size 34

24	240 oz-in
45	450 oz-in

NEMA Size 42

15	150 oz-in
25	250 oz-in
40	400 oz-in
70	700 oz-in

Voltage

0	120 Vac NEMA 42
1	120 Vac NEMA 34
2	240 Vac

Gearbox (NEMA 34 Only)

GXX where XX = reducer ratio

Rear Shaft Option

(blank)	No Rear Shaft
E	Rear shaft extension

Options

NEMA Size 34

L	Leads
T	Terminal box
(blank)	Connector on leads
C	Covered capacitor
CT	Capacitor in terminal box

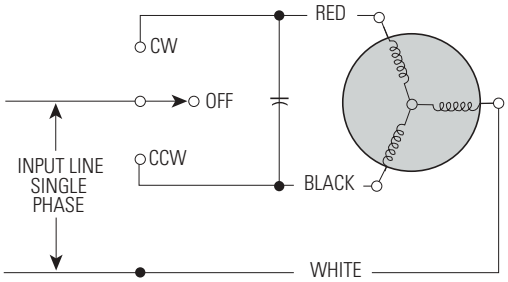
NEMA Size 42

B	Terminal board (SS15x, 25x, 40x)
(blank)	Connector on leads (SS15x, 25x, 40x)
(blank)	Terminal board (SS70x only)

SS Motor Connection Diagrams

C Connection

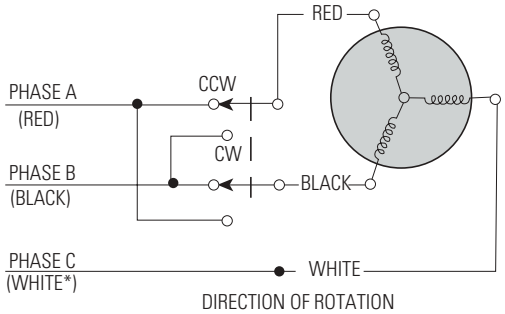
Single-Phase Operation



DIRECTION OF ROTATION
DETERMINED WHEN VIEWED
FROM NAMEPLATE END OF MOTOR.

3∅ Connection

Three-Phase Operation



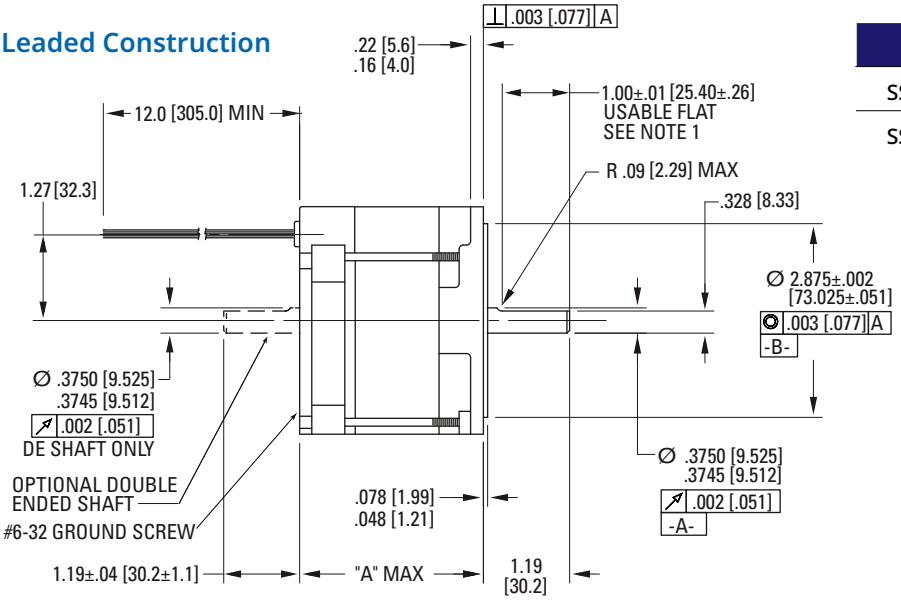
DIRECTION OF ROTATION
DETERMINED WHEN VIEWED
FROM NAMEPLATE END OF MOTOR.

* — WHITE IS NOT "NEUTRAL"

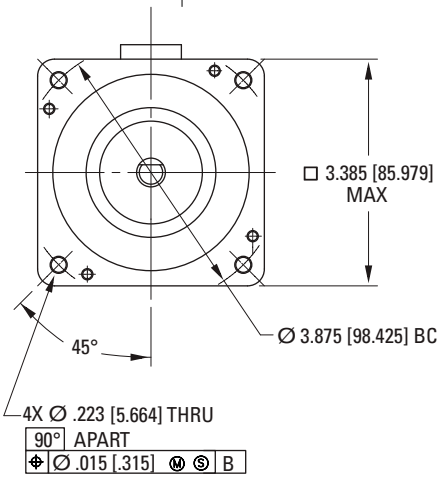
SS Series NEMA 34 Motors

SS240 and SS450 NEMA 34 Outline Drawings

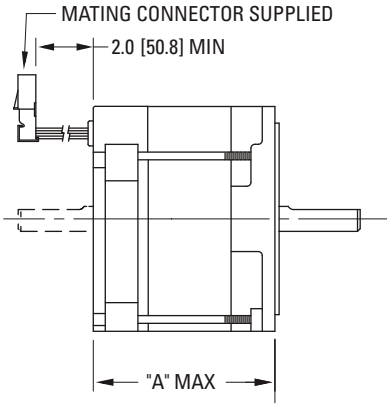
Leaded Construction



Model	"A" Max
SS241L / SS242L	2.72 (69.9)
SS451L / SS452L	4.32 (110)

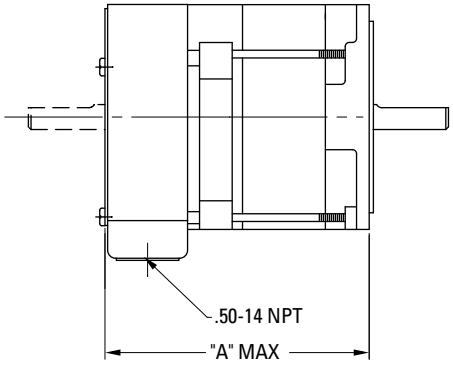


Leaded Plug Construction



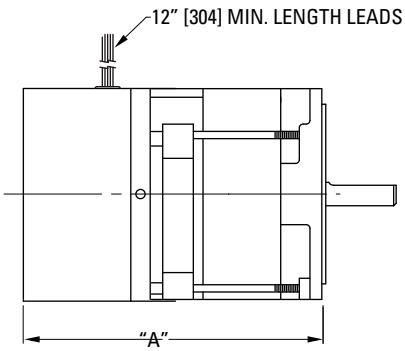
Model	"A" Max
SS241_	2.72 (69.1)
SS242_	
SS451_	4.32 (110)
SS452_	

Terminal Box Construction



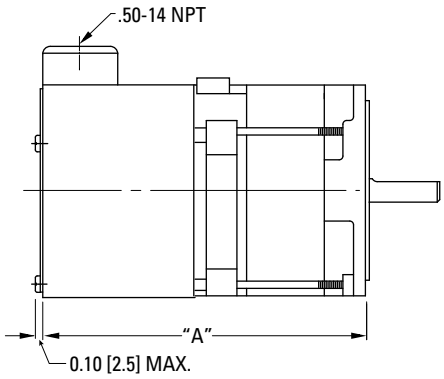
Model	"A" Max
SS241T	4.05 (103)
SS242T	
SS451T	5.65 (144)
SS452T	

Covered Capacitor



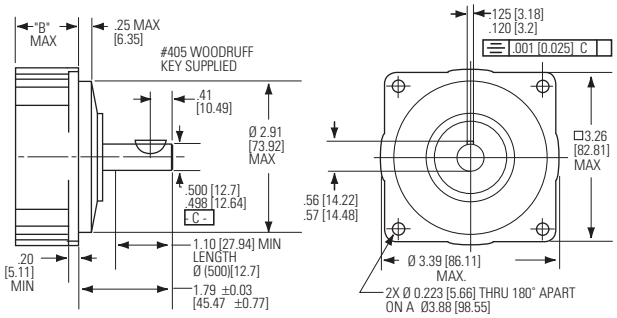
Model	"A" Max
SS241C	4.69 (119)
SS242C	
SS451C	6.29 (160)
SS452C	

Capacitor in Terminal Box



Model	"A" Max
SS241CT	5.48 (139)
SS242CT	
SS451CT	7.08 (180)
SS452CT	

Gearbox Construction



Motor Series	Gearbox	
	Ratio	"B" Max
SS240	3:1 thru 5:1	1.19 (30.2)
	9:1 thru 25:1	1.81 (46.0)
	27:1 thru 125:1	2.38 (60.5)
SS450	3:1 thru 5:1	1.19 (30.2)
	9:1 thru 25:1	1.81 (46.0)
	27:1 thru 125:1	2.38 (60.5)

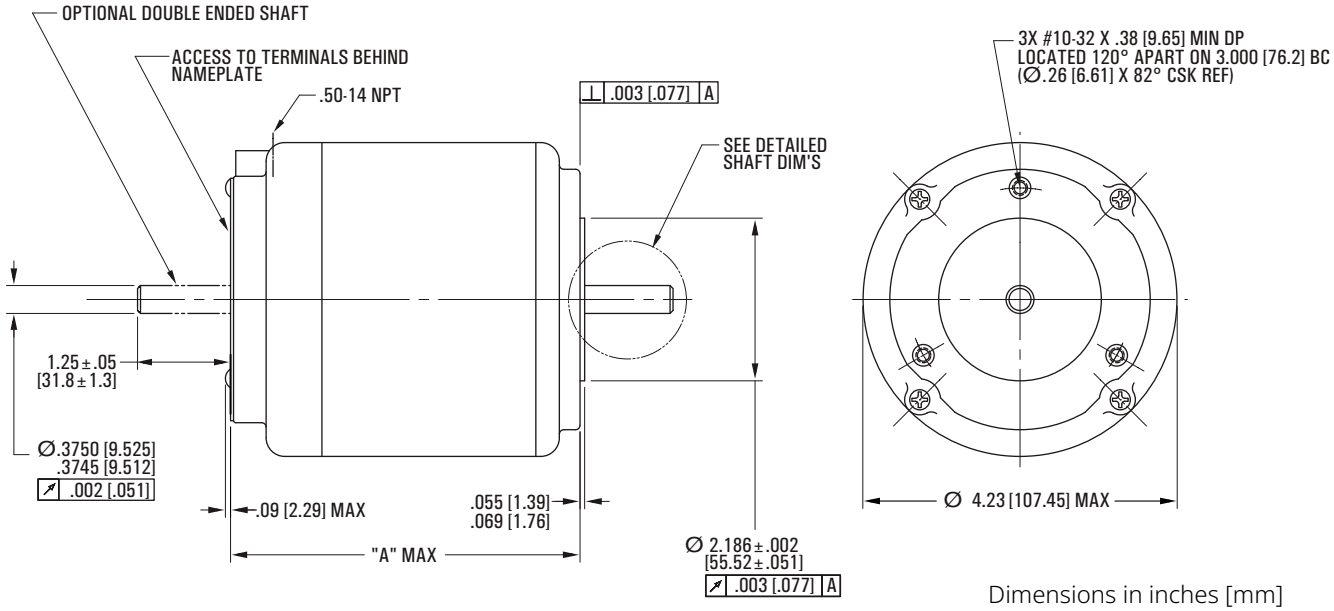
SS24x and SS45x NEMA 34 Performance Data

Model	Min. Torque	Load Inertia*	Line Current	Weight	Shaft Loading		Wiring Diagram	Phase Shifting Capacitor (250 Vac)	
					Radial Force	Axial Force			
	oz-in (Nm)	oz-in-s² (kg-cm²)	A (RMS/Ø)	lb (kg)	lb (N)	lb (N)		Kit No.	µF
60 Hz, 120 Vac, 1Ø, 72 RPM									
SS241	240 (1.69)	0.10 (7.3)	0.4	4.1 (1.9)	25 (111)	50 (222)	C	201053-037	7
SS451	450 (3.18)	0.23 (16)	0.8	6.5 (2.9)	25 (111)	50 (222)	C	201053-042	14
60 Hz, 240 Vac, 1Ø, 72 RPM									
SS242	240 (1.69)	0.10 (7.3)	0.2	4.1 (1.9)	25 (111)	50 (222)	C	201053-038	2
SS452	450 (3.18)	0.31 (22)	0.3	6.5 (2.9)	25 (111)	50 (222)	C	201053-044	3
60 Hz, 208 - 240 Vac, 3Ø, 72 RPM									
SS242	240 (1.69)	0.10 (7.3)	0.2	4.1 (1.9)	25 (111)	50 (222)	3Ø	N/A	N/A
SS452	450 (3.18)	0.18 (13)	0.3	6.5 (2.9)	25 (111)	50 (222)	3Ø	N/A	N/A
50 Hz, 240 Vac, 1Ø, 60 RPM									
SS242	240 (1.69)	0.041 (2.9)	0.4	4.1 (1.9)	25 (111)	50 (222)	C	201053-038	2
SS452	450 (3.18)	0.084 (5.9)	0.8	6.5 (2.9)	25 (111)	50 (222)	C	201053-061	4
50 Hz, 208 Vac, 3Ø, 60 RPM									
SS242	240 (1.69)	0.17 (12)	0.2	4.1 (1.9)	25 (111)	50 (222)	3Ø	N/A	N/A
SS452	450 (3.18)	0.18 (13)	0.3	6.5 (2.9)	25 (111)	50 (222)	3Ø	N/A	N/A

* This is the maximum rigidly attached load inertia the motor will reliably start. If the load is attached to the motor with a 5° flex coupling, the motor will start loads up to seven times listed.

SS Series NEMA 42 Motors

SS150, SS250, SS400, SS700 NEMA 42 Outline Drawings



Dimensions in inches [mm]

Model	"A" Max	Shaft Figure
SS150	4.74 (120.4)	1
SS250		
SS400	6.62 (168.1)	2
SS700	6.99 (177.5)	3

SS150, SS250, SS400, SS700 Shaft Details

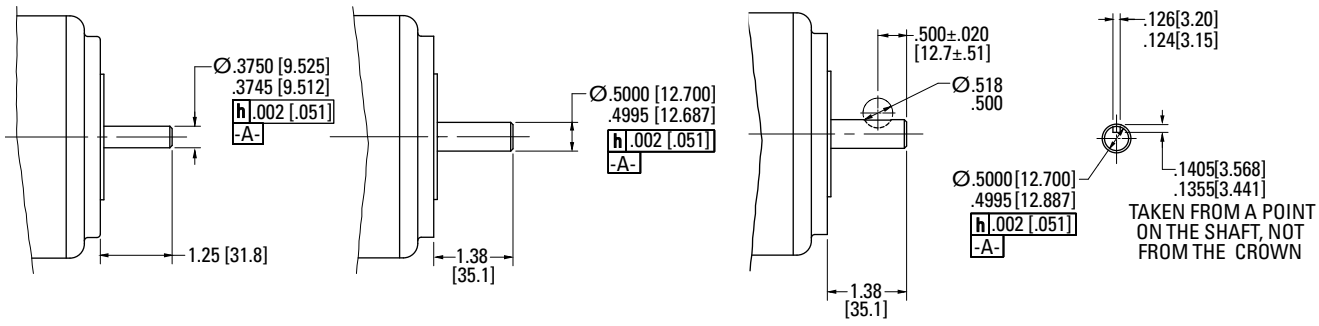


FIGURE 1 FIGURE 2 FIGURE 3

Dimensions in inches [mm]

SS 15x, 25x, 40x, 70x NEMA 42 Performance Data

Model	Min. Torque	Load Inertia*	Line Current	Weight	Shaft Loading		Wiring Diag.	Phase Shifting Components				
					Radial Force	Axial Force		Resistor			Capacitor (330 Vac)	
	oz-in (Nm)	oz-in-s² (kg-cm²)	A (RMS/Ø)	lb (kg)	lb (N)	lb (N)		Resistor part no.	Ohms	Watts	Capacitor part no.	µF
60 Hz, 120 Vac, 1Ø, 72 RPM												
SS150B	150 (1.06)	0.062 (4.4)	0.45	8.0 (3.6)	25 (111)	50 (222)	C	201052-007	250	25	201053-005	3.75
SS250B	250 (1.77)	0.12 (8.8)	0.6	8.0 (3.6)	25 (111)	50 (222)	C	201052-013	150	50	201053-010	6.5
SS400B	400 (2.82)	0.18 (13.2)	0.6	12.3 (5.6)	25 (111)	50 (222)	C	201052-013	150	50	201053-010	6.5
SS700	700 (4.94)	0.42 (30)	1.1	15.5 (7.0)	25 (111)	50 (222)	C	201052-027	150	100	201053-032	12.5
60 Hz, 240 Vac, 1Ø, 72 RPM												
SS152B	150 (1.06)	0.062 (4.4)	0.2	8.0 (3.6)	25 (111)	50 (222)	C	201052-030	1000	25	201053-023	1
SS252B	250 (1.77)	0.12 (8.8)	0.4	8.0 (3.6)	25 (111)	50 (222)	C	201052-015	500	50	201053-036	2
SS402B	400 (2.82)	0.18 (13.2)	0.4	12.3 (5.6)	25 (111)	50 (222)	C	201052-015	500	50	201053-012	1.75
SS702	700 (4.94)	0.42 (30)	0.55	15.5 (7.0)	25 (111)	50 (222)	C	201052-028	500	100	201053-030	3
50 Hz, 240 Vac, 1Ø, 60 RPM												
SS152B	150 (1.06)	0.074 (5.2)	0.2	8.0 (3.6)	25 (111)	50 (222)	C	201052-030	1000	25	201053-034	1.5
SS252B	250 (1.77)	0.15 (10.5)	0.40	8.0 (3.6)	25 (111)	50 (222)	C	201052-015	500	50	201053-030	3
SS402B	400 (2.82)	0.21 (14.6)	0.40	12.3 (5.6)	25 (111)	50 (222)	C	201052-015	500	50	201053-035	2.5
SS702	700 (4.94)	0.51 (36)	0.55	15.5 (7.0)	25 (111)	50 (222)	C	201052-028	500	100	201053-028	4

* This is the maximum rigidly attached load inertia the motor will reliably start. If the load is attached to the motor with a 5° flex coupling, the motor will start loads up to seven times listed.

X Series Hazardous Duty AC Synchronous Motors

UL, File E32246
Class I, Divisions 1 & 2, Group D

These hazardous-duty synchronous motors provide torque up to 1,500 oz-in (1059 N-cm) and are available in NEMA 42 and 66 frame sizes (110 mm and 170 mm). They run at 72 rpm with a 120 Vac or 240 Vac, 60 Hz power supply, or 60 rpm with a 240 Vac, 50 Hz power supply.

Features

» NEMA Sizes 42 and 66
» Motor torque up to 1,500 oz-in (1059 N-cm)
» 72 rpm at 60 Hz, 60 rpm at 50 Hz
» 120 and 240 volt AC versions
» UL Listed versions meet Class I, Division 1&2, Group D requirements
» UL Listed versions have a conduit connection
» Leaded connections

General Specifications

Phases	1Ø
Operating Temperature	-20°C to +40°C
Insulation Class	Class B, 130°C
Insulation Voltage Rating	240 Vac
Insulation Resistance	100 Megohms

X250

X1100

X Series Hazardous Duty AC Synchronous Motor Nomenclature

X 25 2 _

X Series
X Meets UL Class 1, Group D requirements

Minimum Running Torque

24x	240 oz-in
25x	250 oz-in
45x	450 oz-in
70x	700 oz-in
110x	1100 oz-in
150x	1500 oz-in

Options
Contact customer support for option availability
Omit for no options

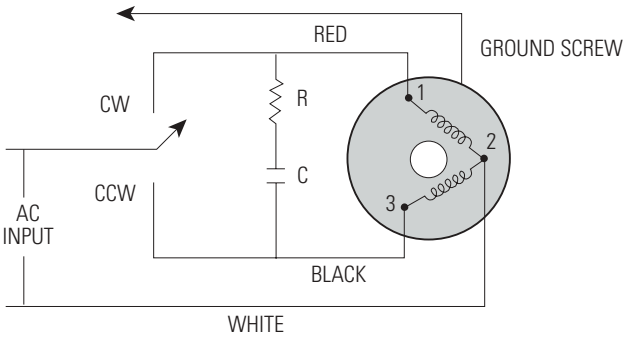
Voltage

0 or 1	120 Vac (model dependent)
2	240 Vac

X Series Connection Information

Connection Diagram

R/C Connection

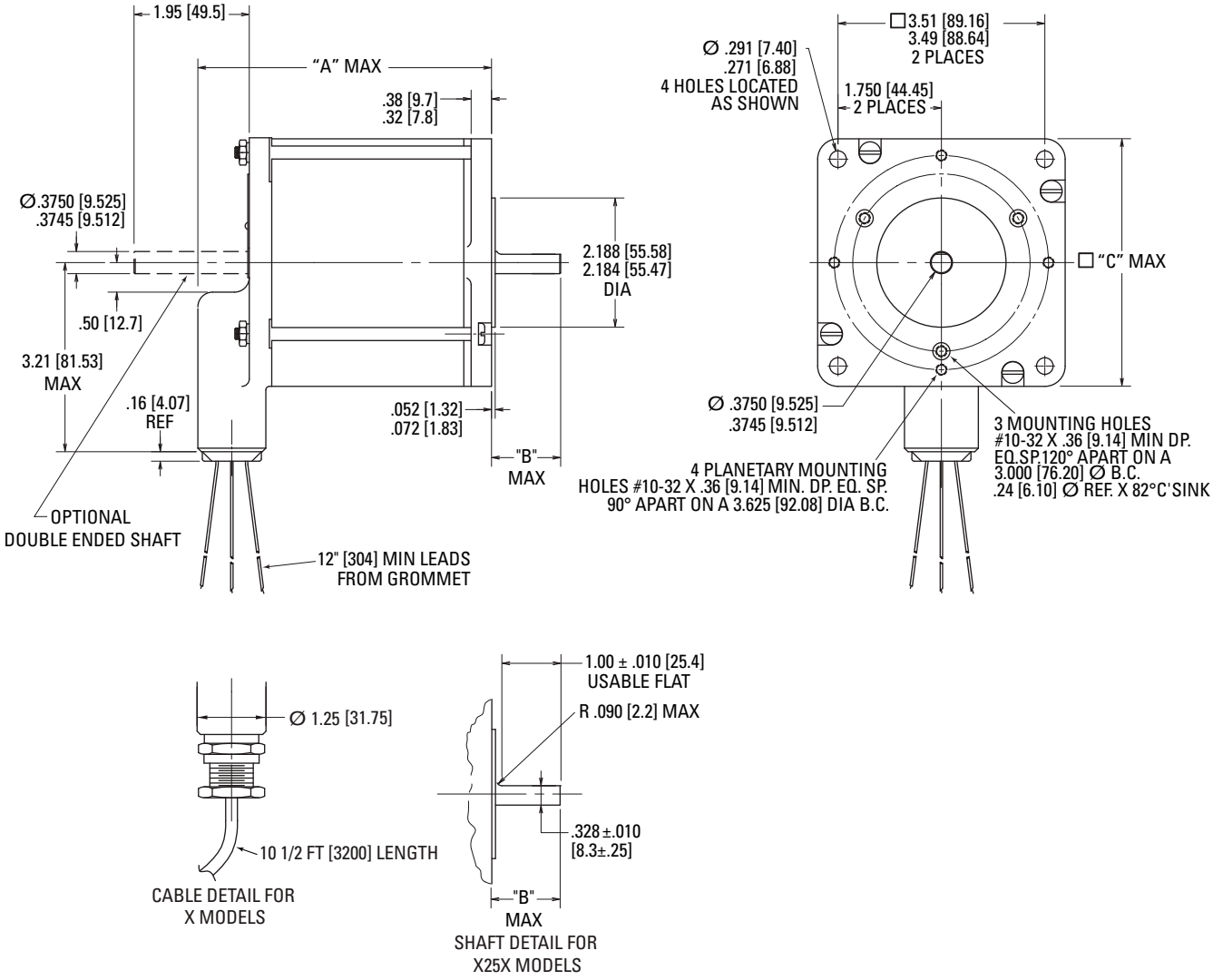


NOTE:
1 - Direction or rotation is determined when viewed from end opposite mounting surface.

Single-Phase Operation

X Series Hazardous Duty AC Synchronous Motors

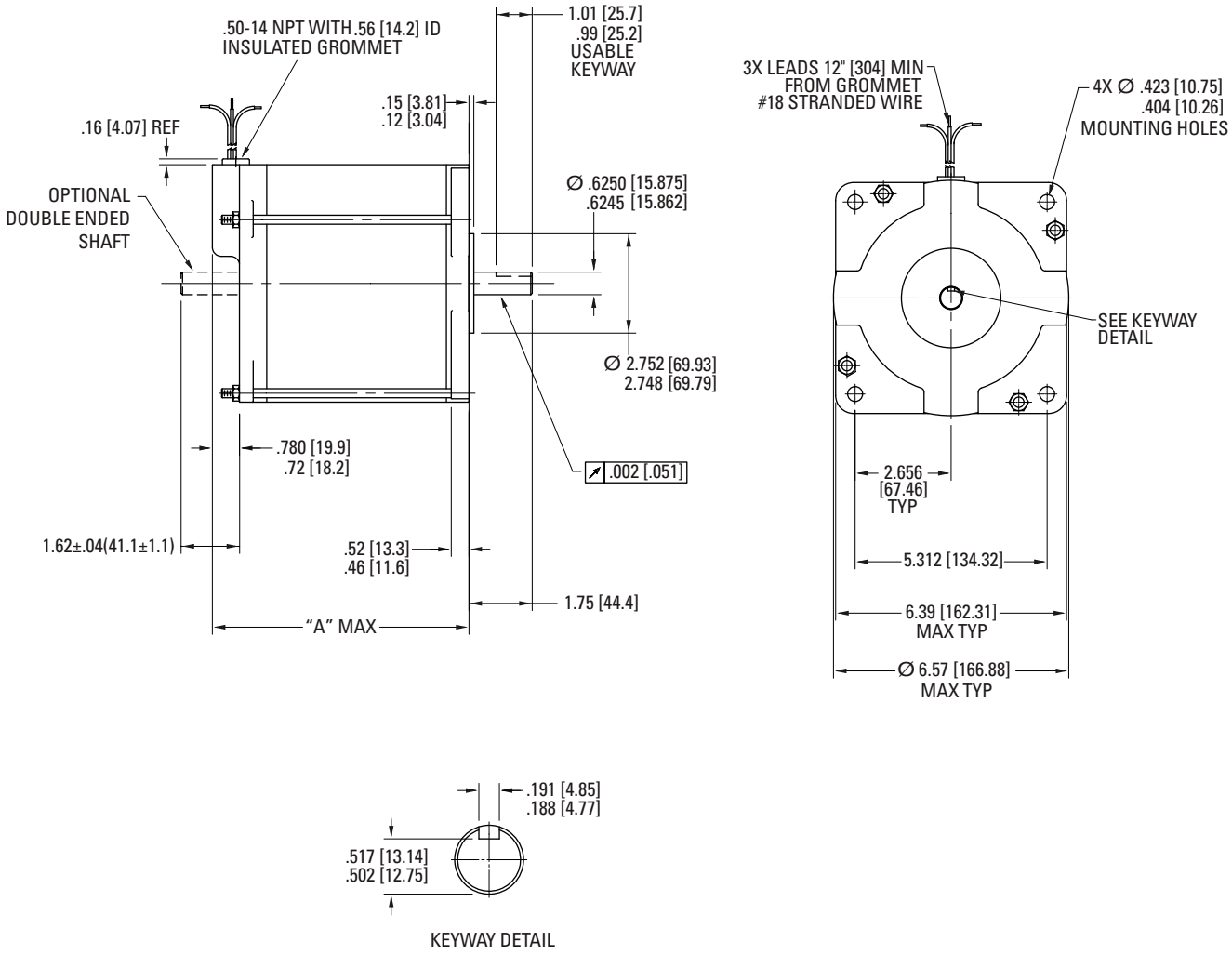
X 25x, 70x Outline Drawings



Model	"A" Max	"B" Max	"C" Max
X250 / X252	5.06 (129)	1.17 (29.7)	4.20 (107)
X700	7.45 (189)	1.38 (35.1)	4.20 (107)

Dimensions in inches [mm]

X 110x, 150x Outline Drawings



KEYWAY DETAIL

Model	"A" Max
X1100 / X1102	7.1 (180)
X1500 / X1502	8.41 (214)

Dimensions in inches [mm]

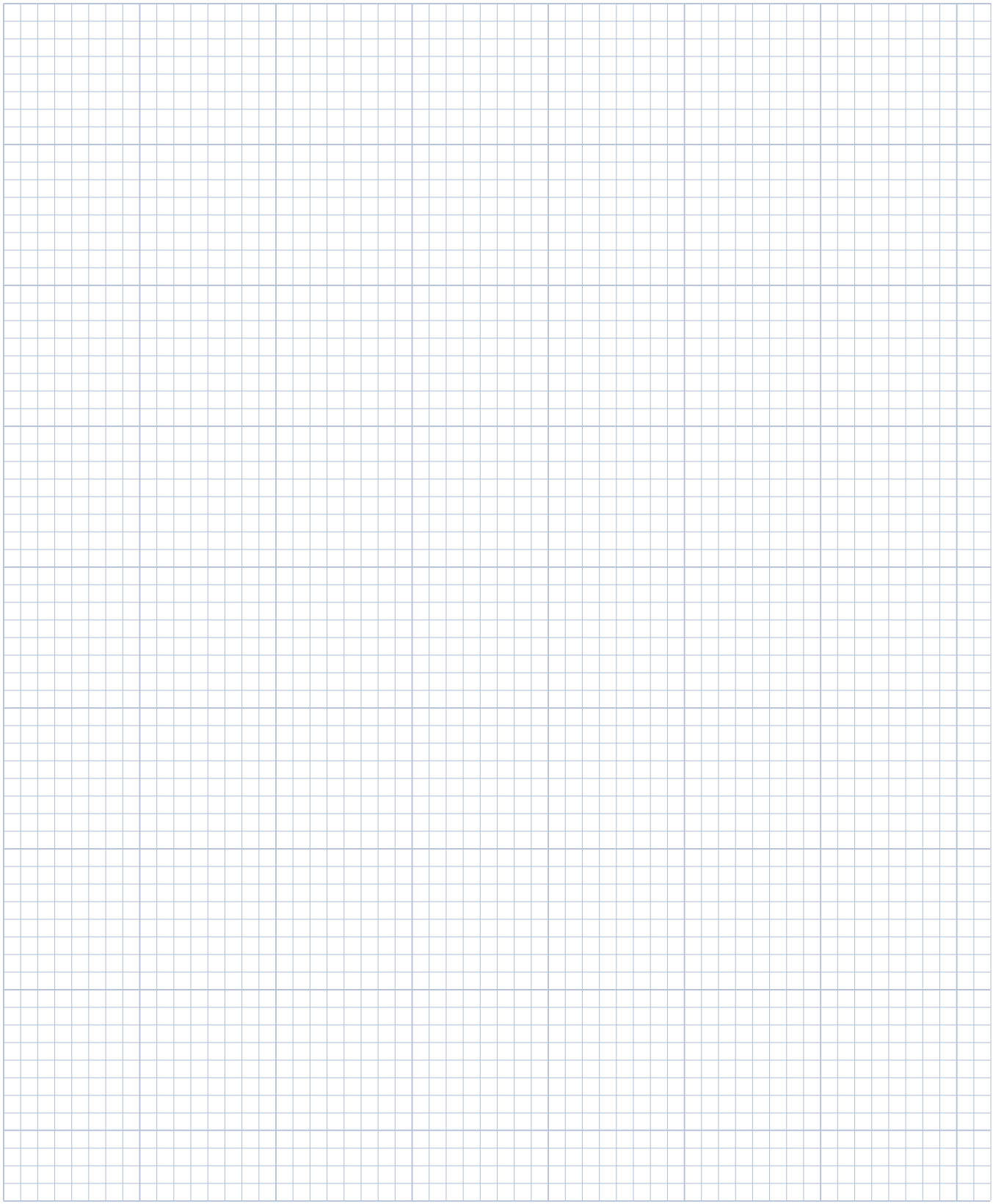
X Series Hazardous Duty AC Synchronous Motors

X Series 25x, 70x, 110x, 150x Performance Data

Model	Rated Torque	Load Inertia*	Line Current	Weight	Shaft Loading		Wiring Diag.	Phase Shifting Components				
					Radial Force	Axial Force		Resistor			Capacitor (330 Vac)	
	oz-in (Nm)	oz-in-s² (kg-cm²)	A (RMS/Ø)	lb (kg)	lb (N)	lb (N)		Resistor part no.	Ohms	Watts	Capacitor part no.	µF
60 Hz, 120 Vac, 1Ø, 72 RPM												
X250	250 (1.77)	0.12 (8.8)	0.60	9.0 (4.1)	25 (111)	50 (222)	R/C	201052-013	150	50	201053-010	6.5
X700	700 (4.94)	0.43 (30)	1.1	n/a	n/a	n/a	R/C	201052-027	150	100	201053-032	12.5
X1100	1100 (7.77)	0.37 (26)	3.0	36 (16)	50 (222)	100 (445)	R/C	201052-025	100	160	201053-026	17.5
X1500	1800 (10.6)	0.50 (35)	3.0	42 (19)	50 (222)	100 (445)	R/C	201052-020	55	375	201053-014	30
60 Hz, 240 Vac, 1Ø, 72 RPM												
X252	250 (1.77)	0.12 (8.8)	0.4	9.0 (4.1)	25 (111)	50 (222)	R/C	201052-015	500	50	201053-012	1.75
X702	700 (4.94)	0.43 (30)	0.6	n/a	n/a	n/a	R/C	201052-028	500	100	20153-030	3
X1102	1100 (7.77)	0.37 (26)	1.5	36 (16)	50 (222)	100 (445)	R/C	201052-026	400	160	201053-028	4
X1502	1800 (10.6)	0.50 (35)	1.5	42 (19)	50 (222)	100 (445)	R/C	201052-018	250	200	201053-016	8
50 Hz, 240 Vac, 1Ø, 60 RPM												
X252	250 (1.77)	0.12 (8.8)	0.4	9.0 (4.1)	25 (111)	50 (222)	R/C	201052-015	500	50	201053-012	1.75
X702	700 (4.94)	0.43 (30)	0.6	n/a	n/a	n/a	R/C	201052-028	500	100	201053-028	4
X1102	1100 (7.77)	0.37 (26)	1.5	36 (16)	50 (222)	100 (445)	R/C	201052-026	400	160	201053-029	6
X1502	1800 (10.6)	0.50 (35)	1.5	42 (19)	50 (222)	100 (445)	R/C	201052-018	250	200	201053-019	9

* This is the maximum rigidly attached load inertia the motor will reliably start. If the load is attached to the motor with a 5° flex coupling, the motor will start loads up to seven times listed.

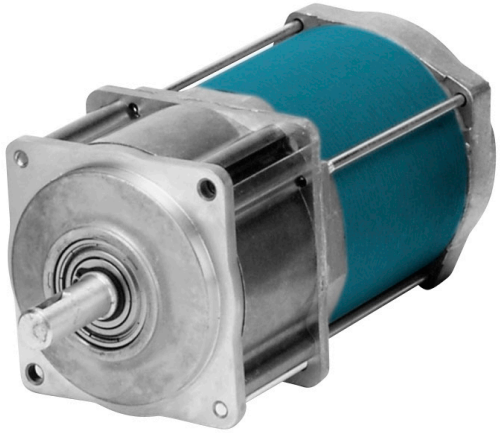
Notes



0.125 inch divisions

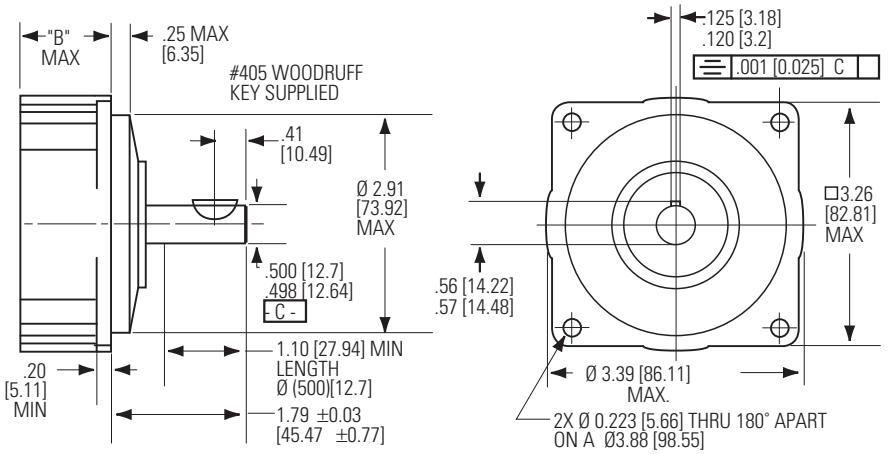
AC Synchronous Gearmotors and Gearbox Kits

Kollmorgen gearmotors mate NEMA 34 AC synchronous motors with step-down gearboxes for applications where slow shaft speeds or high torque are needed. The rugged gearbox developed for Kollmorgen gearmotors has been designed to allow high output torque ratings, while providing long life. The gearboxes are permanently lubricated and no scheduled maintenance is needed. Gearbox efficiency is 88% to 68% depending on the number of stages. The output shaft of the gear assembly is provided with a standard Woodruff key for easy and positive coupling to the load.



- Ratios from 3:1 to 125:1
- Up to 5000 oz-in (35.3 Nm) torque
- Typical output shaft backlash is 2 degrees
- Maintenance free
- Kits for field installation to NEMA 34 motors
- 5 or 25 piece MOQ depending on the gear ratio

SS Size 34 Gearmotor Outline Drawings



Dimensions in inches [mm]

SS Size 34 Gearmotor Perfomance Data

Gearmotor Model Number		Gear Ratio	Speed (rpm)		Minimum Torque	Maximum Riddidly Attached Load Inertia		
						1Ø, 60 Hz	1Ø, 50 Hz	3Ø
120 V	240 V		@ 60 Hz	@ 50 Hz	oz-in (Nm)	oz-in-s² (kg-m²)	oz-in-s² (kg-m²)	oz-in-s² (kg-m²)
SS241LG3	SS242LG3	3:1	24	20	634 (4.48)	0.79 (0.0056)	0.30 (0.0021)	0.793 (0.0056)
SS241LG4	SS242LG4	4:1	18	15	845 (5.96)	1.44 (0.0102)	0.57 (0.0040)	1.44 (0.0102)
SS241LG5	SS242LG5	5:1	14.4	12	1060 (7.46)	2.27 (0.0160)	0.89 (0.0063)	2.27 (0.0160)
SS241LG9	SS242LG9	9:1	8	6.667	1660 (11.7)	6.16 (0.0435)	2.29 (0.0162)	6.16 (0.0435)
SS241LG12	SS242LG12	12:1	6	5	2220 (15.7)	11.3 (0.0798)	4.40 (0.0311)	11.3 (0.0798)
SS241LG15	SS242LG15	15:1	4.8	4	2770 (19.6)	17.8 (0.126)	7.01 (0.0495)	17.8 (0.126)
SS241LG16	SS242LG16	16:1	4.5	3.75	2960 (20.9)	20.1 (0.142)	7.86 (0.0555)	20.1 (0.142)
SS241LG20	SS242LG20	20:1	3.6	3	3700 (26.1)	31.6 (0.223)	1.25 (0.00880)	31.6 (0.223)
SS241LG25	SS242LG25	25:1	2.88	2.4	4620 (32.6)	49.4 (0.349)	19.5 (0.138)	49.4 (0.349)
SS241LG27	SS242LG27	27:1	2.667	2.222	4410 (31.1)	49.0 (0.346)	18.2 (0.129)	49.0 (0.346)
SS241LG36	SS242LG36	36:1	2	1.667	5000 (35.3)	89.8 (0.634)	35.0 (0.247)	89.8 (0.634)
SS241LG45	SS242LG45	45:1	1.6	1.333	5000 (35.3)	141 (0.998)	55.7 (0.393)	141 (0.998)
SS241LG48	SS242LG48	48:1	1.5	1.25	5000 (35.3)	160 (1.13)	(625) 4.42)	160 (1.13)
SS241LG60	SS242LG60	60:1	1.2	1	5000 (35.3)	251 (1.77)	991 (7.00)	251 (1.77)
SS241LG64	SS242LG64	64:1	1.125	0.938	5000 (35.3)	284 (2.01)	1110 (7.85)	284 (2.01)
SS241LG75	SS242LG75	75:1	0.96	0.8	5000 (35.3)	393 (2.77)	1550 (10.9)	393 (2.77)
SS241LG100	SS242LG100	100:1	0.72	0.6	5000 (35.3)	698 (4.93)	2760 (19.5)	698 (4.93)
SS241LG125	SS242LG125	125:1	0.576	0.48	5000 (35.3)	1090 (7.70)	4310 (30.4)	1090 (7.70)
SS451LG3	SS452LG3	3:1	24	20	1190 (8.40)	1.77 (0.0125)	0.62 (0.0044)	1.44 (0.0102)
SS451LG4	SS452LG4	4:1	18	15	1580 (11.2)	3.19 (0.0225)	1.15 (0.0081)	2.61 (0.0184)
SS451LG5	SS452LG5	5:1	14.4	12	1980 (14.0)	5.00 (0.0353)	1.80 (0.0127)	4.08 (0.0288)
SS451LG9	SS452LG9	9:1	8	6.667	3120 (22.0)	13.9 (0.0983)	4.87 (0.0344)	11.3 (0.0800)
SS451LG12	SS452LG12	12:1	6	5	4160 (29.4)	25.1 (0.177)	9.01 (0.0636)	20.5 (0.145)
SS451LG15	SS452LG15	15:1	4.8	4	5000 (35.3)	39.3 (0.278)	14.2 (0.100)	32.1 (0.227)
SS451LG16	SS452LG16	16:1	4.5	3.75	5000 (35.3)	44.6 (0.315)	16.0 (0.113)	36.4 (0.257)
SS451LG20	SS452LG20	20:1	3.6	3	5000 (35.3)	69.9 (0.494)	25.2 (0.178)	57.1 (0.404)
SS451LG25	SS452LG25	25:1	2.88	2.4	5000 (35.3)	109 (0.771)	39.4 (0.279)	89.3 (0.631)
SS451LG27	SS452LG27	27:1	2.667	2.222	5000 (35.3)	111 (0.781)	38.7 (0.274)	90.1 (0.636)

Note: 5 or 25 piece MOQ depending on the gear ratio

AC Synchronous Gearmotors and Gearbox Kits

Field Installable NEMA Size 34 Gearhead Kits

Gearbox Ratio	Kit Part Number	"B" Body Length	Typical Input Shaft Lost Motion	Typical Output Shaft Backlash	Reflected Moment of Inertia	Efficiency %
		in (mm)	Degrees	Degrees	oz-in-s^2 (kg-cm^2)	
3:1	220763-003	1.19 (30.2)	6	2	0.00435 (0.307)	85
4:1	220763-004		7		0.00144 (0.102)	
5:1	220763-005		8		0.00086 (0.061)	
9:1	220763-009	1.81 (46.0)	43	2	0.00476 (0.336)	77
12:1	220763-012		61		0.00170 (0.120)	
15:1	220763-015		81		0.000991 (0.070)	
16:1	220763-016		58		0.00153 (0.108)	
20:1	220763-020		65		0.00095 (0.067)	
25:1	220763-025		73		0.00091 (0.064)	
27:1	220763-027	2.38 (60.5)	109	2	0.00473 (0.334)	68
36:1	220763-036		110		0.00170 (0.120)	
45:1	220763-045		112		0.000991 (0.070)	
48:1	220763-048		113		0.00153 (0.108)	
60:1	220763-060		115		0.00095 (0.067)	
64:1	220763-064		116		0.00153 (0.108)	
75:1	220763-075		118		0.00091 (0.064)	
100:1	220763-100		124		0.00091 (0.064)	
125:1	220763-125		130		0.00091 (0.064)	

Notes:
1. Maximum shaft loading for all gearhead kits is 150 lb (667 N) Radial, 100 lb (445 N) Axial
2. 5 or 25 piece MOQ depending on the gear ratio

Phase Shifting Components

Capacitor Kits

PHASE SHIFTING COMPONENT DIMENSIONS

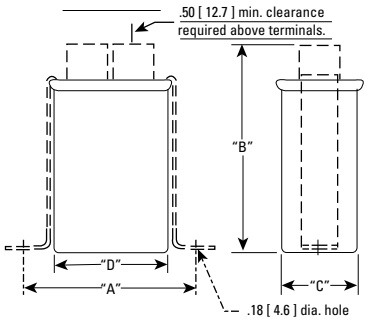


FIGURE C1

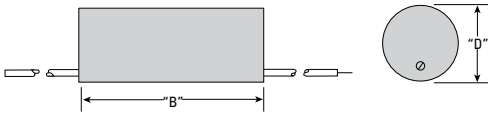
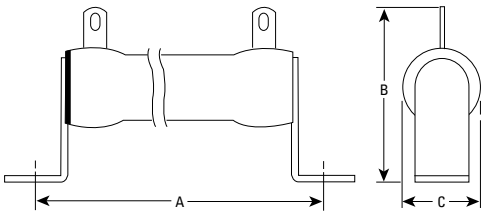


FIGURE C2

Kit Number	Figure	µfd	VAC	A		B		C		D	
				in	mm	in	mm	in	mm	in	mm
201053-010	C1	6.5	330	2.66	67.6	4.14	105	1.31	33	2.16	55
201053-012	C1	1.75	660	2.66	67.6	3.77	96	1.31	33	2.16	55
201053-014	C1	30	330	3.41	86.6	7.56	192	1.91	49	2.91	74
201053-016	C1	8	660	3.41	86.6	5.81	148	1.91	49	2.91	74
201053-019	C1	9	660	4.16	105.7	5.81	148	1.97	50	3.66	93
201053-026	C1	17.5	330	3.41	86.6	4.84	123	1.91	49	2.91	74
201053-028	C1	4	660	2.66	67.6	3.7	94	1.31	33	2.16	55
201053-029	C1	6	660	2.66	67.6	4.83	123	1.31	33	2.16	55
201053-030	C1	3	660	2.66	67.6	4.08	104	1.31	33	2.16	55
201053-032	C1	12.5	330	2.66	67.6	6.08	154	1.31	33	2.16	55
201053-037	C2	7.5	250	-	-	2.0	51	-	-	1.10	28
201053-038	C2	2	250	-	-	2.0	51	-	-	0.66	17
201053-041	C2	2.5	250	-	-	2.0	51	-	-	0.67	17
201053-042	C2	14	250	-	-	2.5	64	-	-	1.15	29
201053-044	C2	3	250	-	-	2.0	51	-	-	0.68	17
201053-061	C2	4	250	-	-	2.0	51	-	-	0.81	21
201053-063	C1	0.75	370	2.66	67.6	2.79	71	1.31	33	2.16	55
201053-068	C2	1.5	250	-	-	2.0	51	-	-	0.66	17
201053-069	C2	6	250	-	-	2.0	51	-	-	1.10	28
201053-070	C1	1	370	2.66	67.6	2.79	71	1.31	33	2.16	55
201053-071	C1	1.75	370	2.66	67.6	2.79	71	1.31	33	2.16	55
201053-072	C1	2	370	2.66	67.6	2.79	71	1.31	33	2.16	55
201053-073	C1	3	370	2.66	67.6	2.79	71	1.31	33	2.16	55
201053-074	C2	11	250	-	-	2.0	51	-	-	1.30	33
201053-075	C1	1.5	370	2.66	67.6	2.79	71	1.31	33	2.16	55
201053-076	C2	5	250	-	-	2.0	51	-	-	1.10	28
201053-081	C1	20	330	3.41	86.6	6.09	155	1.91	49	2.91	74
201053-082	C1	7.5	660	3.41	86.6	5.81	148	1.91	49	2.91	74

Resistor Kits



Kit Number	ohms	watts	A		B		C	
			in	mm	in	mm	in	mm
201052-013	150	50	4.88	124	1.44	37	1	25.4
201052-015	500	50	4.88	124	1.44	37	1	25.4
201052-018	250	200	11.5	292	2.75	70	1.13	28.7
201052-020	55	375	11.5	292	2.69	68.3	1.25	31.8
201052-025	100	160	9.38	238	2.5	64	1.13	28.7
201052-026	400	160	9.38	238	2.5	64	1.13	28.7
201052-027	150	100	5.88	150	2.76	70	1.38	35
201052-028	500	100	5.88	150	2.76	70	1.38	35
201052-033	1,000	12	2.5	64	0.94	24	0.32	8.1
* 201052-034	600	12	2.5	64	0.94	24	0.32	8.1
201052-035	600	25	3	76	1.94	50	0.75	19
* 201052-036	1,100	25	3	76	1.94	50	0.75	19
201052-037	300	50	4.88	124	1.44	37	1	25.4
* 201052-039	900	50	4.88	124	1.44	37	1	25.4
201052-041	250	50	4.88	124	1.44	37	1	25.4
* 201052-043	600	50	4.88	124	1.44	37	1	25.4
201052-045	1,000	100	5.88	150	2.76	70	1.38	35
* 201052-046	400	100	5.88	150	2.76	70	1.38	35
201052-047	600	100	5.88	150	2.76	70	1.38	35
201052-049	400	50	4.88	124	1.44	37	1	25.4
* 201052-050	1,000	25	3	76	1.94	50	0.75	19
201052-101	75	100	5.88	150	2.76	70	1.38	35
201052-102	200	100	5.88	150	2.76	70	1.38	35
201052-103	250	100	5.88	150	2.76	70	1.38	35
201052-104	50	200	11.5	292	2.75	70	1.13	28.7
201052-105	200	200	11.5	292	2.75	70	1.13	28.7
201052-106	150	200	11.5	292	2.75	70	1.13	28.7

* Kit contains two resistors. Dimensions shown are for one resistor.

AC Sychronous Motor Application Guide

Parallel Motor Operation

Two or more Kollmorgen motors may be operated simultaneously from the same power source, if the total current requirement does not exceed the current capability of the supply. However, due to the motor starting characteristics, mechanical synchronization of the motors is not practical. One motor may achieve running speed within 5 milliseconds while a second motor, because of its at rest position, may require 25 milliseconds to achieve running speed.

Starting High Inertia Loads

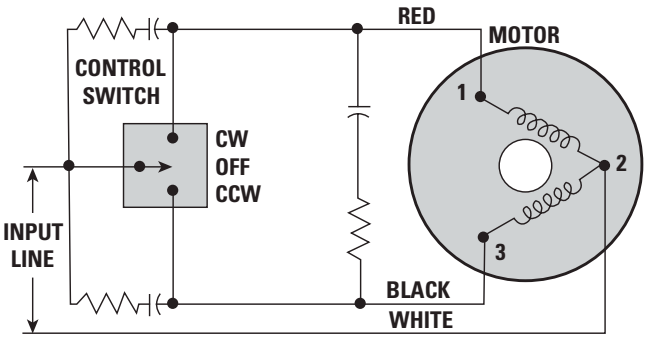
The motor charts show the maximum load inertia that each motor model can start. Inertial loads as high as five to ten times these ratings can be started if a flexible coupling is used between the motor shaft and the load. The coupling should allow approximately 5° of shaft rotation before the full load is applied to the shaft. Rubber couplings are often used, as are chain drives with sufficient slack to allow the necessary shaft motion. Timing belts are also used, and in most cases will provide adequate flexing while providing smooth and quiet transmission of power.

Effects of Speed Reduction Gearing on Torque and Inertia

The combination of reduction gearing and a Kollmorgen motor provides increased torque as well as a lower operating speed. Output speed is decreased and torque increased by the factor of the gear ratio used minus losses due to gear train inefficiency. Gear losses are typically around 10% per mesh. Step-down gearing offers even greater gains in inertial load rating, since the inertia moving capability increases by the square of the gear ratio. Timing belts and pulleys can be used in place of gears for speed reduction and will provide the added benefit of flexible coupling.

Switch Contact Protection

In some applications it may be desirable to protect the switch contacts from arcing and from transient voltages generated during switching. The most common method is the addition of resistors and capacitors across the switch contacts as shown in the diagram. Recommended values of the components are: resistor, 330 ohm, 1 watt; capacitor, 0.1 mfd, 250 Vac.



SWITCH PROTECTION NETWORK FOR AC OPERATION OF STANDARD MODELS

Temperature Considerations

The motors are rated for a maximum free-air ambient temperature of 40° C (104°F). However, it is possible to operate in higher ambient temperatures or above rated voltages if the motors are mounted on metal plates or are forced-air cooled. Do not exceed the maximum motor case temperature of 100° C (212° F).

Coupling Motor to Load

Because of the extremely fast starting and stopping characteristics of a Kollmorgen AC synchronous motor, couplings, pulleys or other devices should be well secured to the motor shaft with the key provided, roll-pins, or set-screws.

If a coupling is to be press-fitted to the shaft, the motor must be held by the shaft (not by the gearbox or the motor case) when pressing the coupling in place. This will prevent damage to the motor bearings. The force used in pressing must not exceed the thrust force limit of the gearbox (100 pounds).

Selecting an AC Synchronous Motor

To select a synchronous motor first determine the torque and moment of inertia characteristics of the load, as presented to the motor. The following examples show how to calculate these requirements in both standard U.S. and metric units. If additional information or technical assistance is needed, contact Kollmorgen customer support. A representative will be pleased to help you select the best motor for your application. Once the requirements of the application including input voltage and frequency are known, refer to the rating shown on the motor charts and select the motor which best suits these requirements.

Torque

Torque (oz-in) = Fr

Where F = Force (in ounces) required to drive the load
r = Radius (in inches)

Force can be measured using a pull type spring scale. The scale may be attached to a string that is wrapped around a pulley or a hand wheel attached to the scale. If the scale reading is in pounds, it must be converted into ounces to obtain a torque rating in ounce-inches.

For example: A 4" diameter pulley requires a 2 pound pull on the scale to rotate it.

F = 2 pounds x 16 = 32 ounces
r = 4" / 2 = 2"
Torque = 32 x 2 = 64 oz-in

Torque (Nm) = Fr

Where F = Force (N) required to drive the load
r = 0.05 m
Toque = 1.5 x 0.05 = 0.075 Nm

Force can be measured using a pull type spring scale. If the scale reading is calibrated in Kilograms, the scale reading must be multiplied by 9.8067 to obtain newtons. The scale should be attached to a string that is wrapped around a pulley or a hand wheel which is then attached to the load.

For example: A 10 cm diameter pulley requires a 1.5 newton (0.153 kg) pull on the scale to rotate it.

F = 1.5 newtons
r = 0.05 m
Torque = 1.5 x 0.05 = 0.075 Nm

Gears and Pulleys

When the load is driven through gears or pulleys, the required motor torque is changed by the overall ratio.

For example, if the load is 90 ounce-inches (0.636 Nm) and the step-down ratio is 3:1, the required torque would be 30 ounce-inches (0.212 Nm).

Load inertia presented to the motor is changed by the square of the ratio. For example, with a load inertia of 16 oz-in-s^2 (0.113 kg-m) and a 2:1 step-down ratio, the effective inertia would be 4 oz-in-s^2 (0.0308 kg-m^2) plus the inertia of the first gear or pulley.

Inertia

Moment of Inertia (oz-in-s^2)

$(\text{oz-in-s}^2) = \frac{Wr^2}{772.2}$ for a disk, or

$\frac{Wr^2}{772.2}(r_1 - r_2)$ for a cylinder

Where: W = Weight in ounces
r = Radius (in inches)

For eample: A load is an 8" diameter solid gear weighing 8 ounces.

W = 8 oz
r = 8"/ 2 = 4"

Moment Of Inertia = $\frac{8 \times (4)^2}{772.2} = 0.166$ oz-in-s^2

Moment Of Inertia (kg-m^2)

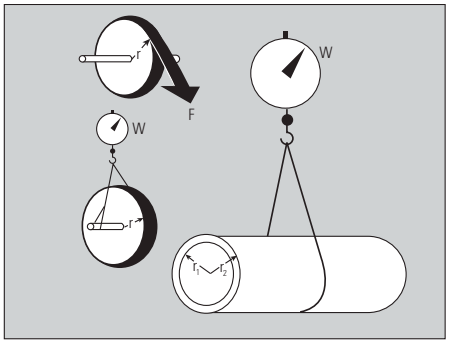
$J = \frac{Wr^2}{196134}$ for a disk, or $J = \frac{(r_1^2 - r_2^2)}{196134}$ for a cylinder

Where W = newtons
r = cm

For eample: A load is 20 cm diameter solid gear weighing 0.25 newtons.

W = .25 newtons
r = 10 cm

Moment Of Inertia = $\frac{.25 \times 10^2}{196134} = 0.0001275$ kg-m^2



More Expertise for a More Successful Machine

Our global engineering, service and support network provides deep knowledge of all the major industries that rely on advanced motion control and automation technology. We offer world-class engineering expertise, self-service design tools, personalized field service, and easy access to our design, application and manufacturing centers in strategic locations across the globe.

About Kollmorgen

Kollmorgen, a Regal Rexnord brand, has more than 100 years of motion experience, proven in the industry's highest-performing, most reliable motors, drives, linear actuators, AGV (Automated Guided Vehicle) control solutions, and automation control platforms. We deliver breakthrough solutions that combine exceptional performance, reliability and ease of use, giving machine builders an irrefutable marketplace advantage.

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