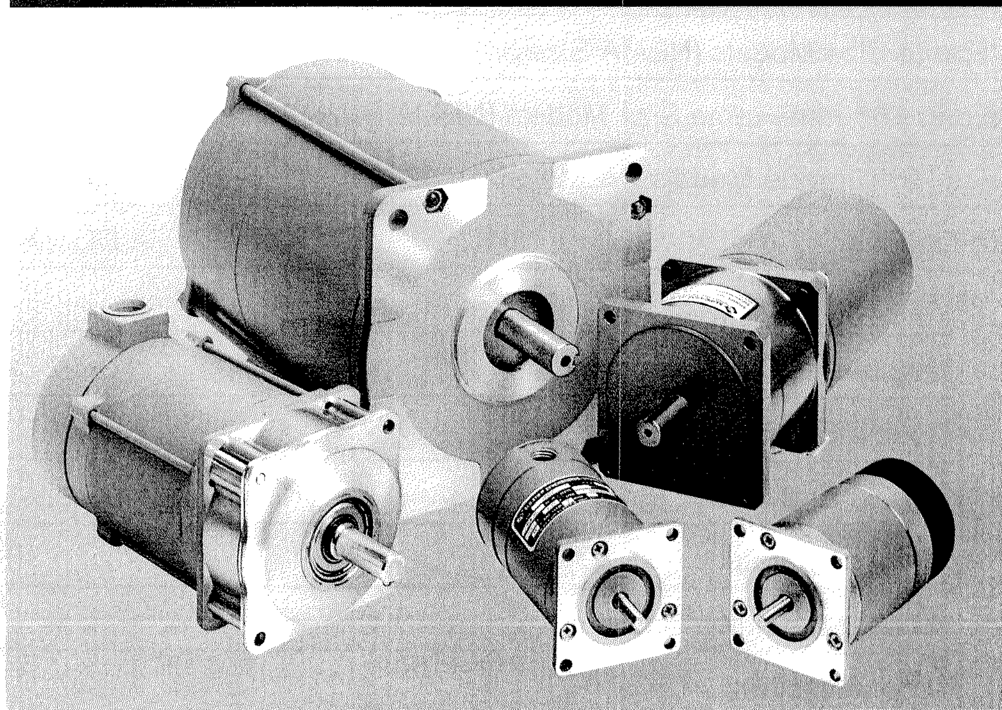
Superior Electric M092-FC09

Synchronous Stepping Motor

Superior Electric

SLO-SYN® DC STEP MOTORS, GEARMOTORS, AND AC SYNCHRONOUS MOTORS



Contents

Step motors are devices which position loads by operating in discrete increments, or steps, unlike other devices that operate at constant speeds. The stepping action is accomplished by switching the power to the motor windings so that the motor phases are energized in a specific sequence. Step motors are capable of very precise positioning without the use of complicated and expensive feedback devices, although feedback systems may be incorporated into step motor systems if position comparison is desired. Because of the simplified control needs and the freedom from expensive feedback requirements, step motors are viable alternatives to pneumatic, hydraulic and servo motor systems.

Characteristics of SLO-SYN DC Step Motors

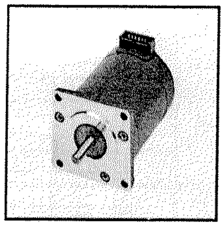
- *Brushless, permanent magnet motors*
- *Operate in full-step (1.8°) or half-step (0.9°) increments*
- *Can be microstepped to achieve increments as small as 0.0072°*
- *Offered with accuracies of ±3% and ±5% noncumulative*
- *Can be operated at rates to 20,000 steps per second (6000 rpm)*
- *Holding torque ratings from 60 to 5330 oz-in (42.4 to 3764 Ncm)*
- *Wide range of torque ratings, shaft configurations and frame sizes*
- *Easily adapted to different control types, including microprocessor based systems*
- *Class B insulation, operate at ambient temperatures from -40°C to +65°C (-40°F to +149°F)*
- *No brushes, ratchets or detents to wear out*
- *Lubricated-for-life ball bearings*

Underwriters Laboratories Recognition & Canadian Standards Association Certification

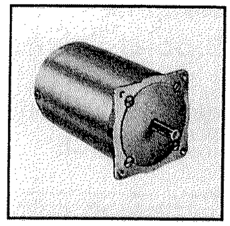
- *All M06 and M09 Series motors are recognized by UL, UL#E31544*
- *Motors in other series which meet UL requirements are identified with letter U suffix or are provided with a UL logo. Most standard motors, as well as double end motors, are eligible*
- *Most standard motors are listed by Canadian Standards Association, including all M06 and M09 Series Motors*

Comparison of Servomotors versus DC Step Motors

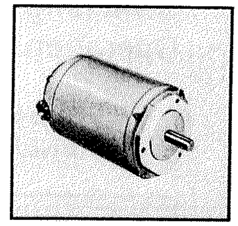
Too often, when a motion control system is being specified, the designer automatically assumes that a servomotor system must be



MO61 Motor



MO92 Motor



M111 and M112

used. The truth is that, in many cases, a well designed step motor system will perform the same function as well, and at lower cost. The following comparison of the outstanding characteristics of the two types of motors outlines some of the advantages of step motors for motion control.

Servomotor Characteristics

- *Require complex, expensive control systems*
- *Position sensing devices needed for feedback to control*
- *Relatively low torque for size*
- *Thermally inefficient*
- *Control system must be "tuned" to load; must be "retuned" if load is changed*
- *Brushes on DC servomotors subject to wear*

SLO-SYN DC Step Motor Characteristics

- *Relatively inexpensive*
- *Can be operated "open-loop" (no position feedback required)*
- *Noncumulative step error*
- *Simple control electronics can be used*
- *Brushless construction aids reliability*
- *Maintenance free*
- *Will not be damaged if stalled*
- *High torque for size*
- *Maintain position when at rest*

Typical Applications

- *Environmental Testing*
- *Silicon Crystal Growing*
- *Paper Packaging System*
- *Cut-To-Length of Metal, Plastic, Fabric, etc.*
- *Sheet Metal Fabrication*
- *Fiberglass Mass Production*
- *Aircraft and Aerospace Parts Machining*
- *Laser Positioning*
- *Brush Manufacturing*
- *Tire Manufacturing*
- *Radiation Testing Control*
- *Office Peripheral Equipment*
- *Pick-And-Place Automatic Loading and Unloading*
- *Grinding*
- *Metal Punching*
- *Rotary Table Control*
- *Welding*
- *Wire Harness Assembly*
- *Wrapping Machines*
- *XYZ Applications*

Switching Sequence For Operation From Bipolar Drives

FULL-STEP (TWO-PHASE ON) ENERGIZING SEQUENCE*

STEP	PHASE	
	A	B
1	+1	+1
2	+1	-1
3	-1	-1
4	-1	+1
1	+1	+1

HALF STEP PHASE ENERGIZING SEQUENCE*

STEP	PHASE	
	A	B
1	+1	+1
2	+1	—
3	+1	-1
4	—	-1
5	-1	-1
6	-1	—
7	-1	+1
8	—	+1
1	+1	+1

FULL-STEP (ONE PHASE ON) ENERGIZING SEQUENCE*

STEP	PHASE	
	A	B
1	+1	—
2	—	-1
3	-1	—
4	—	+1
1	+1	—

Switching Sequence For Operation From Unipolar Drives

FOUR STEP INPUT SEQUENCE (FULL-STEP MODE)*

STEP	SW1	SW2	SW3	SW4
1	ON	OFF	ON	OFF
2	ON	OFF	OFF	ON
3	OFF	ON	OFF	ON
4	OFF	ON	ON	OFF
5	ON	OFF	ON	OFF

EIGHT STEP INPUT SEQUENCE HALF-STEP MODE*

STEP	SW1	SW2	SW3	SW4
1	ON	OFF	ON	OFF
2	ON	OFF	OFF	OFF
3	ON	OFF	OFF	ON
4	OFF	OFF	OFF	ON
5	OFF	ON	OFF	ON
6	OFF	ON	OFF	OFF
7	OFF	ON	ON	OFF
8	OFF	OFF	ON	OFF
1	ON	OFF	ON	OFF

* Rotation is clockwise as viewed from label end of motor. For counterclockwise rotation, sequence should go from bottom to top of chart.

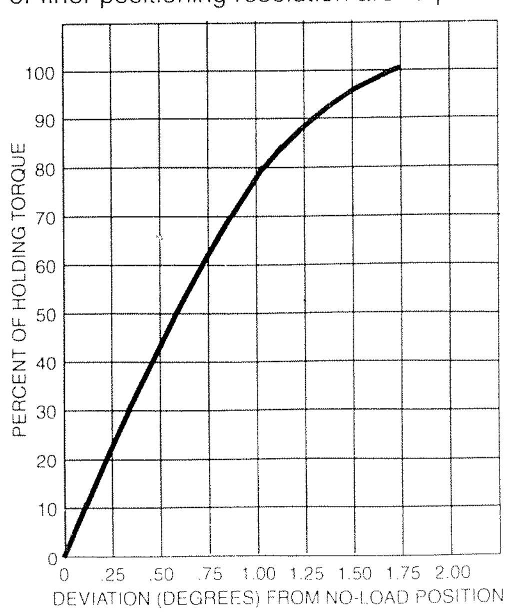
Microstepping

Microstepping is a method of step motor control that allows the rotor to be positioned at places other than the 1.8° or 0.9° locations provided by the full-step and half-step methods. Microstepping positions occur between these two angular points in the rotation of the rotor.

The most commonly used microstep increments are 1/5, 1/10, 1/16, 1/32, 1/125 and 1/250 of a full step. Microstep increments chosen by Superior Electric simplify control of both US and metric units of measurement, and also allow finer positioning resolution. While a full step of 1.8° will give a 0.001 inch resolution when the motor is driving through a lead screw which has a 0.2000 inch lead, resolutions of 0.000008 inch or less are theoretically possible using microstepping.

A major benefit of microstepping is that it reduces the amplitude of the resonance that occurs when the motor is operated at its natural frequency or at sub-harmonics of that frequency. The improved step response and reduced amplitude of the natural resonances result from the finer step angle.

Superior Electric drives offer microstepping, so the benefits of microstepping are available whenever smoother Step motor performance or finer positioning resolution are required.



SHAFT DEFLECTION

Shaft Deflection

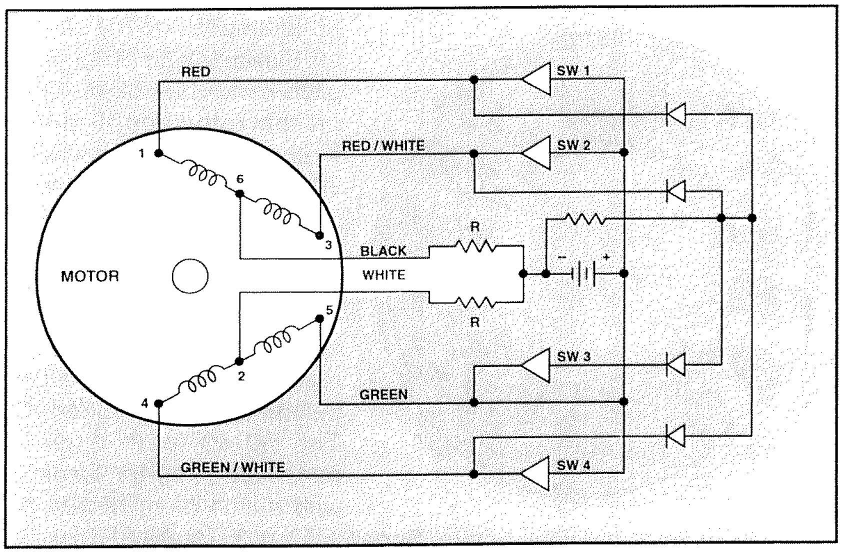
When a load is applied to a motor shaft, the shaft will deflect angularly from the no load position. The Shaft Deflection curve shows shaft deviation from the no load position vs. percent of rated holding torque. This curve is valid for all 1.8° step angle SLO-SYN Step Motors.

NOTE: Proper construction of the mechanism of the driven load is essential in order to accurately achieve a true versus theoretical position.

Transient Voltage Suppression

As current is switched through the motor windings during stepping, transient voltages are generated which can cause faulty operation and damage to the motor and drive components. To prevent these problems, some means of limiting or removing these transients must be provided. The most common means of accomplishing this employs shunting diodes as shown in the connection diagram.

Typical diodes for use in this circuit are 1N4002 and 1N4003 and similar types. Resistance may be varied between 0 and 50 ohms, as needed, to reduce transient voltages to an acceptable level. Capacitors can be used in place of the diodes. Capacitor ratings between 0.1 and 1.0 mfd. can be used, depending on the characteristics of the switches.



Note: Circuit shown is only for use with a unipolar drive
TYPICAL TRANSIENT VOLTAGE SUPPRESSION CIRCUIT

Holding and Residual Torque

The permanent magnet design of a SLO-SYN Step Motor provides a small residual torque which helps hold the motor shaft in position when the motor is not energized. If greater holding torque is required, one or both motor windings can be energized with dc voltage when the motor is not stepping. The Ratings and Specifications charts list residual torque values for each motor, as well as holding torque values with both one and two motor windings energized at rated voltage and current.

Optional Post Machining

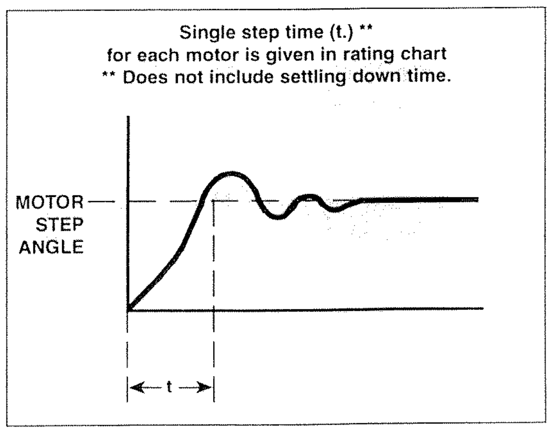
Motors in the M090 and larger frame sizes are available with optional post machining to provide closer shaft runout and mounting surface tolerances. The tolerances with standard machining and with optional post machining are given in the appropriate motor dimensional drawings. The second letter in the motor type number identifies the type of machining as well as the step accuracy of the motor. For example, the letter C in motor type number M091-FC09 signifies that the motor has optional post machining and provides ±3% step accuracy. The identifying letters that are used and the information that they convey are as follows:

Letter	Information
C	±3% accuracy[1], optional post machining
D	±5% accuracy[1], standard machining
F	±5% accuracy[1], standard machining
J	±5% accuracy[1], standard machining
S	±3% accuracy[1], standard machining
T	±5% accuracy[1], optional post machining

[1] Maximum positive or negative deviation from the rated angular motion per step, for any step in a complete revolution. Expressed as a percentage of the angle of a single step. Measured at no load with rated current applied to both motor windings (balanced to within 1%) and motor operated in the "two windings on" mode.

Step Response

When a step signal is given to a step motor, the motor shaft will rotate the specified angular distance within a measurable period of time which is called the step response time. This time is a function of the motor and of the characteristics of the electronic drive circuits. The step response times given in the Electrical Ratings charts were obtained under no-load conditions and do not include settling down time. The step response value only indicates single-step response time and is not an indicator of maximum motor speed.



STEP RESPONSE

Torque vs. Speed Characteristics

Many factors determine the torque vs. speed characteristics of a SLO-SYN Step Motor. These include the design of the drive system and the voltage supplied to the motor, as well as the inductance rating of the motor used.

Effects of Drive Design

Design of the drive which operates the motor is an important factor in determining the performance which will be obtained. The types of drives offered, and their effects on motor performance, are as follows:

NOTE: MH112 and MH172 motors are designed to operate only from four-terminal bipolar drives.

L/R Drives - This design was the basis for most older drives and is still used on some existing drives. It allows half- or full-step motor operation, but does not permit variable control of current level. L/R drives also require dropping resistors, which reduce motor efficiency. L/R drives provide satisfactory performance at lower stepping rates, but do not have good high speed capabilities. This is the most basic drive design, and it is typically the lowest in cost.

Constant Current Chopper Drives - These drives maintain relatively constant current to the motor at all speeds, and therefore offer good stepping performance at rates up to approximately 5000 steps per second. Although more costly and complex than L/R drives, they allow use of features such as closed-loop control, microstepping, current boost and stabilization in addition to improved motor performance.

Line Operated, High Voltage Chopper Drives - These drives deliver higher voltage to the motor for optimum high speed performance. They are also able to operate larger motors to provide high performance and excellent efficiency. Since they do not need bulky stepdown transformers, line operated drives are more compact than other chopper drives.

Effects of Motor Voltage

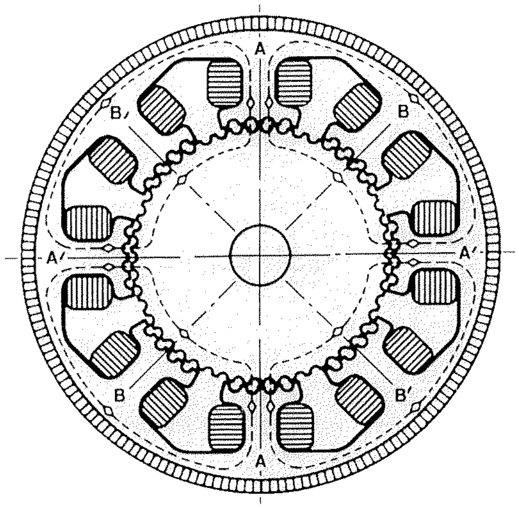
Motor performance at mid-range and high-range speeds can be unproved by increasing the voltage to the motor. However, the motor will operate at a high temperature when the voltage is increased, so some means of cooling may be necessary. In general, motor supply voltage does not affect operation at lower stepping rates.

Motor Inductance Effects

For a given supply voltage, a low inductance motor will give better performance at high speeds than a high inductance motor, but will operate at a high temperature. This is true because a lower inductance motor requires more current than does a high inductance model. High inductance motors yield higher maximum torque and operate cooler, but their top speed is limited and torque falls off more rapidly as speed rises than is the case with a lower inductance motor.

Construction of DC Step Motors

A SLO-SYN Step Motor is a brushless DC motor consisting of a rotor and a stator assembly. The illustration shows the internal construction and tooth alignment of the motor. A certain number of teeth, evenly spaced around the entire diameter, provide the incremental angular rotation that results in mechanical motion. Step motors are constructed with a 48-50 tooth pitch configuration as well as a 50-50 tooth pitch configuration. A 48-50 tooth pitch motor has 50 teeth on the rotor and a 48-tooth pitch on the stator. Similarly, a 50-50 tooth pitch motor has 50 teeth on the rotor and a 50-tooth pitch on the stator. While both motors deliver a 1.8° full step angle, the 48-50 tooth pitch motor gives much smoother operation and softer step-to-step motion with less resonance or mechanical instability at low speed. The 50-50 tooth pitch motor provides the user with a little more torque, but a much rougher running system. Superior Electric developed the 48-50 tooth pitch motor and holds a patent on this design. Both 48-50 and 50-50 tooth pitch motors are manufactured by Superior Electric.



Stepping Techniques

The terms full-step, half-step and microstep are commonly used in the discussion of step motors.

A standard 1.8° step motor has 2300 discrete positions in a full 360° revolution. Since 360° divided by 200 equals 1.8°, the motor shaft will advance 1.8° each time the motor is given a digital command to take one step. This is known as a full-step.

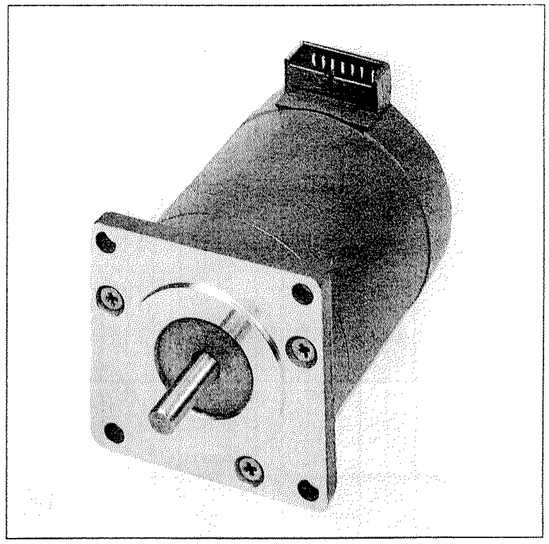
The term "half-step" implies a 0.9° step angle (half of a full 1.8° step), resulting from a different switching technique of the drive transistors that provide power to the motor windings.

The term "microstep" refers to a more sophisticated form of control which goes beyond the simple switching of power between phase A and phase B of the motor windings and takes control of the amount of current being sent to the individual windings. Microstepping permits the rotor and shaft to be positioned in places other than the natural 1.8° and 0.9° positions during motion.

SLO-SYN Step Motors, because of their basic nature as digital devices and reliable position and motion control actuator, have proven themselves for many years to be a very dependable source of motion control.

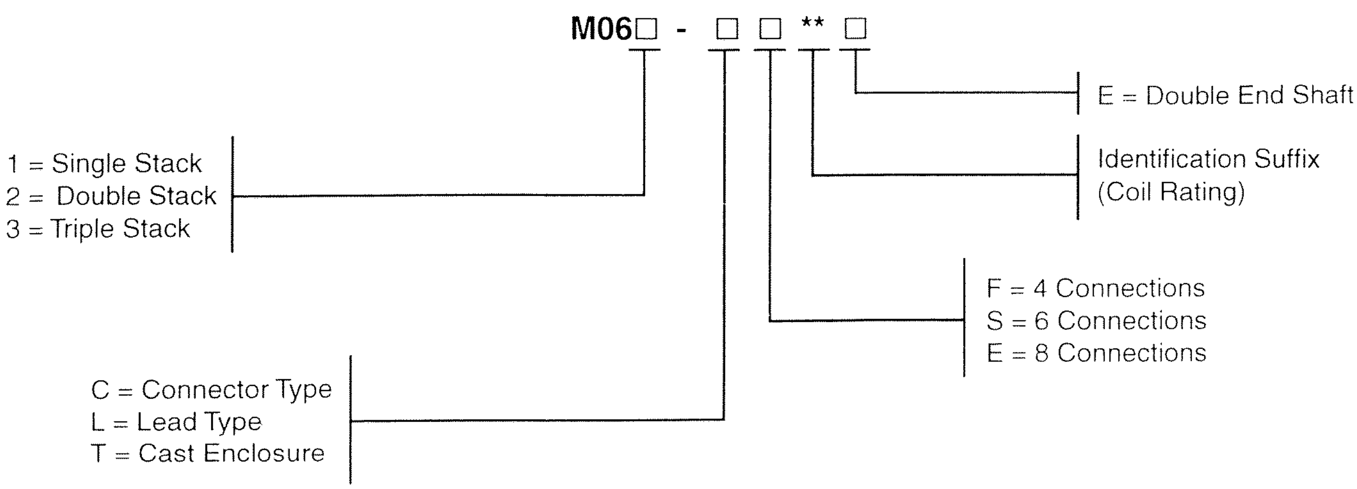
60mm Frame Size Models (NEMA Size 23D)

- *±3% step accuracy, noncumulative (all models)*
- *48-50 tooth pitch configuration give smooth operation, soft step motion, less resonance and instability*
- *Outstanding microstep performance characteristics*
- *Proprietary molding process yields improved rotor and stator insulation and increased mechanical integrity*
- *New loopless winding technique and internal circuit board virtually eliminate chance of interference between internal wiring and rotor/stator*
- ***Can withstand up to 2-1/2 times rated current (instantaneous) without demagnetization***
- *Holes in rear end bell for mounting encoder (double end shafts only)*
- *Excellent thermal properties and resistance to vibration*
- *Class B insulating materials*
- *Rated for operation in ambient temperatures from -40°C to +65°C (-40°F to +149°F)*



- *+100°C (212°F) maximum motor shell temperature*
- *Available with 4, 6 or 8 connections*
- *Can be supplied with leads, connector or cast enclosure*
- *Constructed to provide long life with no regular maintenance*

TYPE NUMBER EXPLANATION - M060 SERIES MOTORS



Refer to page DC-27 for available options

60MM (NEMA 23) RATINGS and SPECIFICATIONS

MOTOR TYPE 3% ACCURACY	CONNECTIONS NUMBER	CONNECTIONS TYPE	TYPICAL TIME FOR SINGLE STEP (mS) (1)	UNIPOLAR CONFIGURATION: NOMINAL DC VOLTS (3)	RATED AMPERES PER WINDING	NOMINAL RESISTANCE PER WINDING (25 C) OHMS (2)	NOMINAL INDUCTANCE PER PHASE (MILLI-HENRYS) (2) (4)	MINIMUM HOLDING TORQUE OZ-IN (Ncm) 2Ø ON	MINIMUM HOLDING TORQUE OZ-IN (Ncm) 1Ø ON	BIPOLAR CONNECTIONS: SERIES CONNECTION VOLTS	SERIES AMPERES	SERIES R	SERIES L	SERIES MINIMUM HOLDING TORQUE OZ-IN (Ncm) 2Ø ON	SERIES 1Ø ON	PARALLEL CONNECTION VOLTS	PARALLEL AMPERES	PARALLEL R	PARALLEL L	PARALLEL MINIMUM HOLDING TORQUE OZ-IN (Ncm) 2Ø ON	PARALLEL 1Ø ON
M061-CE02	8	CONN.	2.5	5	1	5	9.57	60 (42)	36 (25)	7	0.7	10	38.3	75 (53)	45 (32)	3.54	1.4	2.5	9.57	75 (53)	45 (32)
M061-LE02	8	LEADS	2.5	5	1	5	9.57	60 (42)	36 (25)	7	0.7	10	38.3	75 (53)	45 (32)	3.54	1.4	2.5	9.57	75 (53)	45 (32)
M061-CS02	6	CONN.	2.5	5	1	5	9.57	60 (42)	36 (25)	7	0.7	10	38.3	75 (53)	45 (32)	—	—	—	—	—	—
M061-LS02	6	LEADS	2.5	5	1	5	9.57	60 (42)	36 (25)	7	0.7	10	38.3	75 (53)	45 (32)	—	—	—	—	—	—
M061-CE08	8	CONN.	2	1.25	3.8	0.33	0.635	60 (42)	36 (25)	1.8	2.7	0.66	2.54	75 (53)	45 (32)	0.89	5.4	0.165	0.635	75 (53)	45 (32)
M061-LE08	8	LEADS	2	1.25	3.8	0.33	0.635	60 (42)	36 (25)	1.8	2.7	0.66	2.54	75 (53)	45 (32)	0.89	5.4	0.165	0.635	75 (53)	45 (32)
M061-CS08	6	CONN.	2	1.25	3.8	0.33	0.635	60 (42)	36 (25)	1.8	2.7	0.66	2.54	75 (53)	45 (32)	—	—	—	—	—	—
M061-LS08	6	LEADS	2	1.25	3.8	0.33	0.635	60 (42)	36 (25)	1.8	2.7	0.66	2.54	75 (53)	45 (32)	—	—	—	—	—	—
M061-FF-206	4	LEADS	—	—	—	—	—	—	—	6.3	1	6.3	24.8	75 (53)	—	—	—	—	—	—	—
M061-CS-301*	6	CONN.	7.5	11	0.44	22.5	38.4	53 (37)	32 (23)	15.6	0.3	45	154	65 (46)	39 (28)	—	—	—	—	—	—
M061-LS-301*	6	LEADS	7.5	11	0.44	22.5	38.4	53 (37)	32 (23)	15.6	0.3	45	154	65 (46)	39 (28)	—	—	—	—	—	—
M061-CS-302*	6	CONN.	4.2	5.5	0.88	6.2	9.57	53 (37)	32 (23)	7.7	0.6	12.4	38.3	65 (46)	39 (28)	—	—	—	—	—	—
M061-LS-302*	6	LEADS	4.2	5.5	0.88	6.2	9.57	53 (37)	32 (23)	7.7	0.6	12.4	38.3	65 (46)	39 (28)	—	—	—	—	—	—
M061-CS-311*	6	CONN.	12	20	0.22	91	126	47 (33)	28 (20)	28.3	0.16	182	504	58 (41)	35 (25)	—	—	—	—	—	—
M061-LS-311*	6	LEADS	12	20	0.22	91	126	47 (33)	28 (20)	28.3	0.16	182	504	58 (41)	35 (25)	—	—	—	—	—	—
M061-CF-408	4	CONN.	—	—	—	—	—	—	—	8	0.5	15.9	61	75 (53)	45 (32)	—	—	—	—	—	—
M061-LR-408	4	LEADS	—	—	—	—	—	—	—	8	0.5	15.9	61	75 (53)	45 (32)	—	—	—	—	—	—
M062-CS03	6	CONN.	3.5	5.3	1.6	3.3	8.28	100 (71)	60 (42)	7.5	1.13	6.6	33.12	125 (88)	75 (53)	—	—	—	—	—	—
M062-LS03	6	LEADS	3.5	5.3	1.6	3.3	8.28	100 (71)	60 (42)	7.5	1.13	6.6	33.12	125 (88)	75 (53)	—	—	—	—	—	—
M062-CS04	6	CONN.	2.8	4.2	1.9	2.2	5.89	100 (71)	60 (42)	5.9	1.34	4.4	23.56	125 (88)	75 (53)	—	—	—	—	—	—
M062-LS04	6	LEADS	2.8	4.2	1.9	2.2	5.89	100 (71)	60 (42)	5.9	1.34	4.4	23.56	125 (88)	75 (53)	—	—	—	—	—	—
M062-CE04	8	CONN.	2.8	4.2	1.9	2.2	5.89	100 (71)	60 (42)	5.9	1.34	4.4	23.56	125 (88)	75 (53)	3	2.7	1.1	5.89	125 (88)	75 (53)
M062-LE04	8	LEADS	2.8	4.2	1.9	2.2	5.89	100 (71)	60 (42)	5.9	1.34	4.4	23.56	125 (88)	75 (53)	3	2.7	1.1	5.89	125 (88)	75 (53)
M062-CS06	6	CONN.	—	2.6	3.1	0.88	2	100 (71)	60 (42)	3.9	2.2	1.76	8	125 (88)	75 (53)	—	—	—	—	—	—
M062-LS06	6	LEADS	—	2.6	3.1	0.88	2	100 (71)	60 (42)	3.9	2.2	1.76	8	125 (88)	75 (53)	—	—	—	—	—	—
M062-CE06	8	CONN.	—	2.6	3.1	0.88	2	100 (71)	60 (42)	3.9	2.2	1.76	8	125 (88)	75 (53)	1.9	4.4	0.44	2	125 (88)	75 (53)
M062-LE06	8	LEADS	—	2.6	3.1	0.88	2	100 (71)	60 (42)	3.9	2.2	1.76	8	125 (88)	75 (53)	1.9	4.4	0.44	2	125 (88)	75 (53)
M062-CS09	6	CONN.	2.2	1.65	4.7	0.35	0.8	100 (71)	60 (42)	2.3	3.3	0.7	3.2	125 (88)	75 (53)	—	—	—	—	—	—
M062-LS09	6	LEADS	2.2	1.65	4.7	0.35	0.8	100 (71)	60 (42)	2.3	3.3	0.7	3.2	125 (88)	75 (53)	—	—	—	—	—	—
M062-CE09	8	CONN.	2.2	1.65	4.7	0.35	0.8	100 (71)	60 (42)	2.3	3.3	0.7	3.2	125 (88)	75 (53)	1.2	6.65	0.175	0.8	125 (88)	75 (53)
M062-LE09	8	LEADS	2.2	1.65	4.7	0.35	0.8	100 (71)	60 (42)	2.3	3.3	0.7	3.2	125 (88)	75 (53)	1.2	6.65	0.175	0.8	125 (88)	75 (53)
M062-FF-206	4	LEADS	—	—	—	—	—	—	—	4.2	1.5	2.8	12.5	125 (88)	—	—	—	—	—	—	—
M062-CF-401	4	CONN.	—	—	—	—	—	—	—	6.6	1	6.6	33	125 (88)	75 (53)	—	—	—	—	—	—
M062-LF-401	4	LEADS	—	—	—	—	—	—	—	6.6	1	6.6	33	125 (88)	75 (53)	—	—	—	—	—	—
M063-CE06	8	CONN.	2.6	3.36	2.9	1.16	2.85	150 (106)	90 (64)	4.9	2.1	2.32	11.4	190 (134)	115 (81)	2.4	4.1	0.58	2.85	190 (134)	115 (81)
M063-LE06	8	LEADS	2.6	3.36	2.9	1.16	2.85	150 (106)	90 (64)	4.9	2.1	2.32	11.4	190 (134)	115 (81)	2.4	4.1	0.58	2.85	190 (134)	115 (81)
M063-CS06	6	CONN.	2.6	3.36	2.9	1.16	2.85	150 (106)	90 (64)	4.9	2.1	2.32	11.4	190 (134)	115 (81)	—	—	—	—	—	—
M063-LS06	6	LEAD	2.6	3.36	2.9	1.16	2.85	150 (106)	90 (64)	4.9	2.1	2.32	11.4	190 (134)	115 (81)	—	—	—	—	—	—
M063-CE09	8	CONN.	2.4	2.25	4.6	0.49	1.15	150 (106)	90 (64)	3.2	3.25	0.98	4.6	190 (134)	115 (81)	1.6	6.5	0.245	1.15	190 (134)	115 (81)
M063-LE09	8	LEADS	2.4	2.25	4.6	0.49	1.15	150 (106)	90 (64)	3.2	3.25	0.98	4.6	190 (134)	115 (81)	1.6	6.5	0.245	1.15	190 (134)	115 (81)
M063-CS09	6	CONN.	2.4	2.25	4.6	0.49	1.15	150 (106)	90 (64)	3.2	3.25	0.98	4.6	190 (134)	115 (81)	—	—	—	—	—	—
M063-LS09	6	LEADS	2.4	2.25	4.6	0.49	1.15	150 (106)	90 (64)	3.2	3.25	0.98	4.6	190 (134)	115 (81)	—	—	—	—	—	—
M063-FF-206	4	LEADS	—	—	—	—	—	—	—	5.4	1.5	3.6	14.5	190 (134)	—	—	—	—	—	—	—
M063-CF-401	4	CONN.	—	—	—	—	—	—	—	5.66	1	5.66	29	160 (113)	96 (68)	—	—	—	—	—	—
M063-LF-401	4	LEADS	—	—	—	—	—	—	—	5.66	1	5.66	29	160 (113)	96 (68)	—	—	—	—	—	—

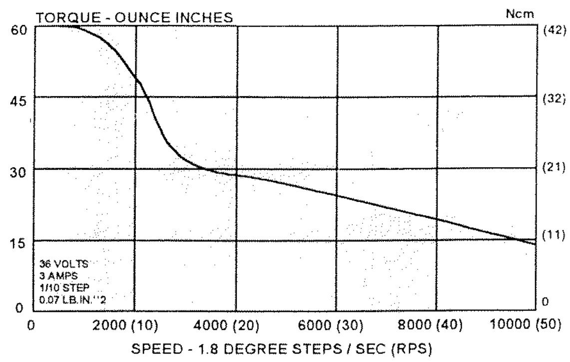
(1) With 24 volts drive.
(2) Values shown are for reference only and are correct to the best of our knowledge at the time of publication, but are subject to change without notice. Parameters to be used as part of a specification should be verified with the factory.
(3) Voltage shown is per phase at rated current at zero steps per second, with winding at 25°C. Resistance tolerance and winding temperature will influence voltage.
(4) Tolerance is ±20%. Measured at 1 kHz with a General Radio #1650B impedance bridge having a 1 volt rms open circuit sinusoidal signal. Rotor position preconditioned by energizing same phase, then deenergizing same phase during measurement without changing rotor position.
* These motors are obsolete and should not be used in a new application design. They can be provided to support existing systems.

MECHANICAL SPECIFICATIONS [1]

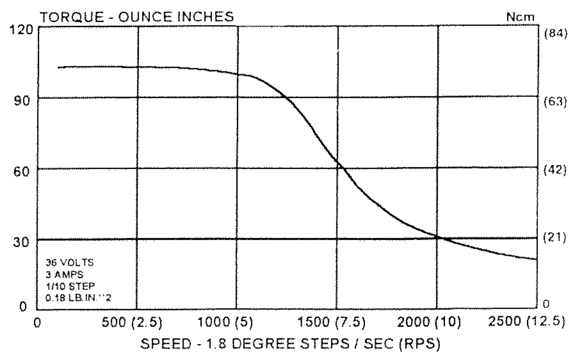
BASIC MOTOR SERIES	NOMINAL ROTOR INERTIA LB-IN² (kg-cm²)	MINIMUM RESIDUAL TORQUE OZ-IN (Ncm)	TYPICAL TORQUE TO INERTIA RATIO	MAXIMUM OVERHANG LOAD LBS (kg)	MAXIMUM THRUST LOAD LBS (kg)	APPROX. WEIGHT LBS. (kg)	
						NET	SHIPPING
M061	0.04 (0.12)	1.0 (0.71)	36×10^3 (36^3)	15 (6.8)	25 (11.3)	1.25 (0.57)	1.5 (0.68)
M062	0.08 (0.23)	1.4 (0.99)	30×10^3 (30^3)	15 (6.8)	25 (11.3)	2 (0.91)	2.5 (1.14)
M063	0.11 (0.32)	2.5 (1.77)	33×10^3 (33^3)	15 (6.8)	25 (11.3)	2.75 (1.25)	3.25 (1.48)

(1) Values shown are for reference information and are correct to the best of our knowledge at time of publication, but are subject to change without notice. Parameters to be used as part of a specification should be verified with the factory.

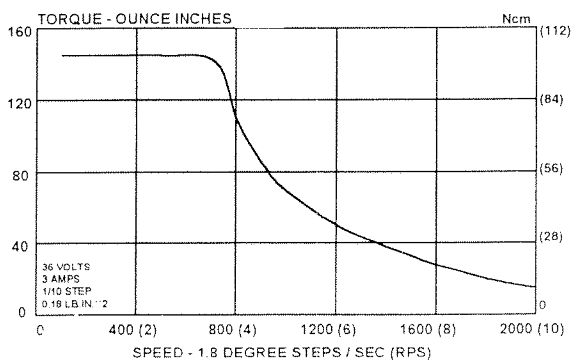
Typical Torque Versus Speed Characteristics



M061-C308 OR M061-LE08
MOTOR WITH SS2000MD4 3.0 AMP, 36 VDC
SLO-SYN MOTION CONTROL

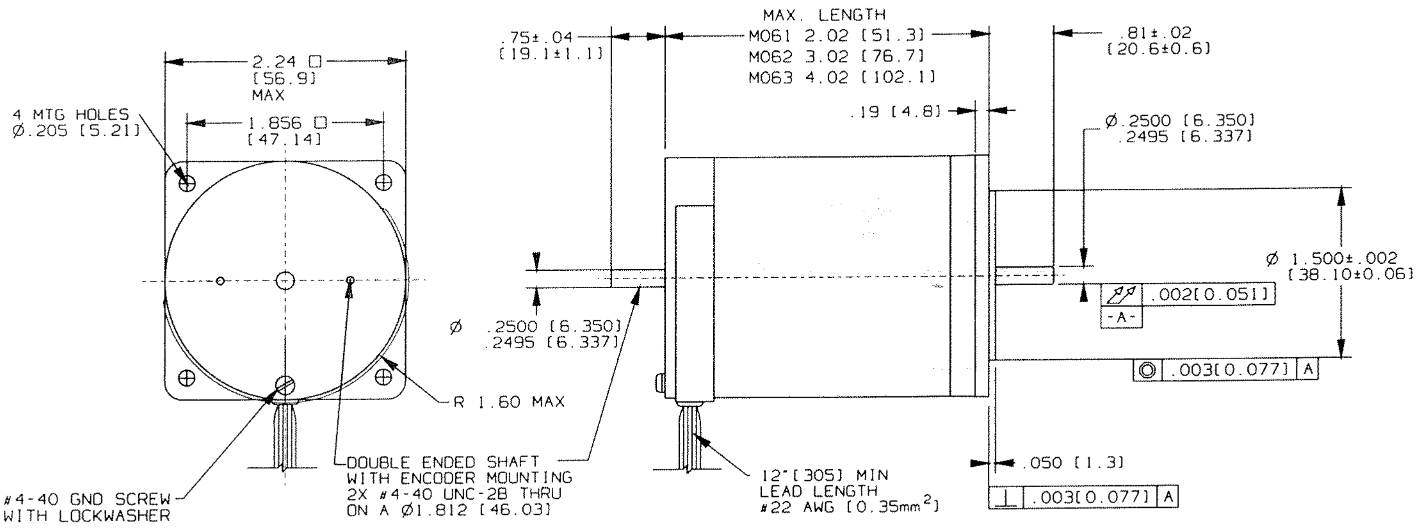


M062-CE09 OR M062-LE09
MOTOR WITH SS2000MD4 3.0 AMP, 36 VDC
SLO-SYN MOTION CONTROL

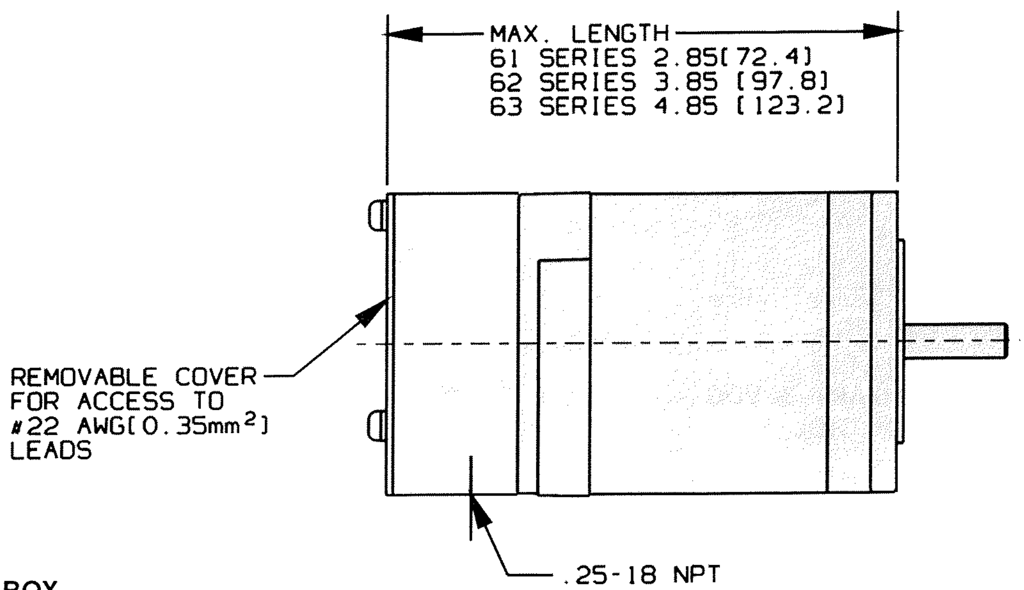


M063-CE09 OR M063-LE09 MOTOR WITH SS2000MD4
3.0 AMP, 36 VDC SLO-SYN MOTION CONTROL

DIMENSIONS, M060 SERIES MOTORS



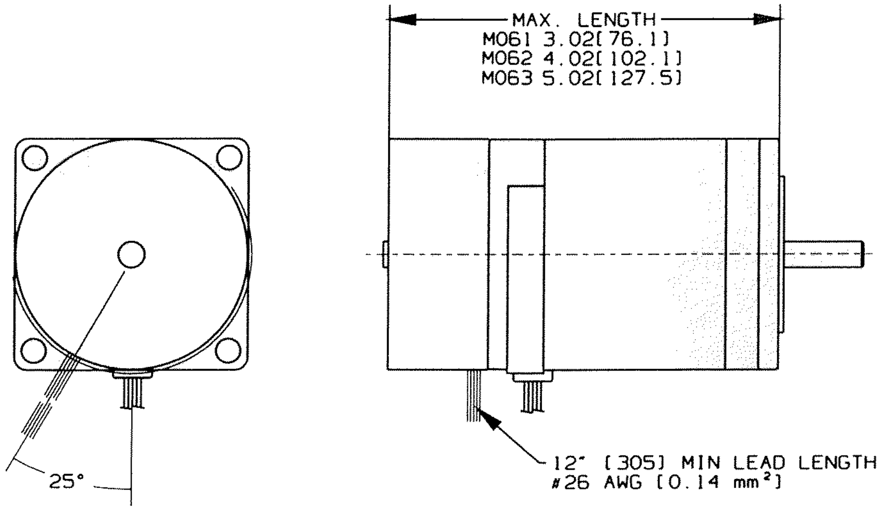
MODELS WITH LEADS



TERMINAL BOX

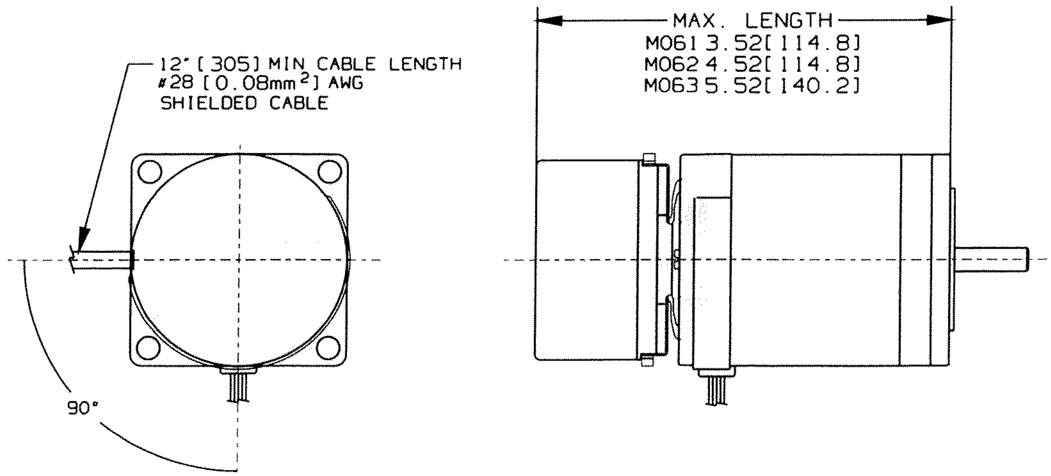
(See models with leads [above] for other dimensions)

DIMENSIONS, M060 SERIES MOTORS



ENCODER MODELS WITH LEADS
MO6C2XXX
MO6C4XXX
MO6C5XXX

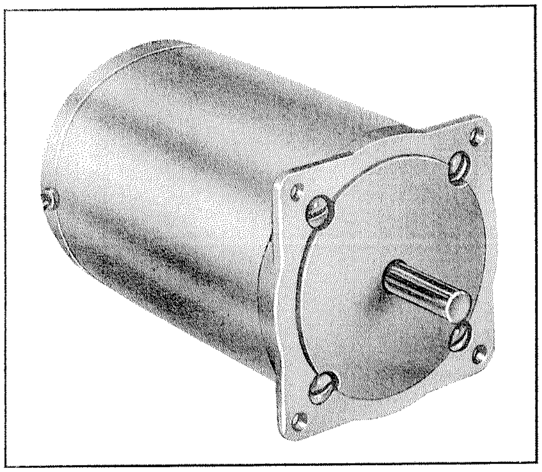
(See models with leads [page DC-9] for other dimensions)



ENCODER MODELS WITH LEADS
MO6C12

(See models with leads [page DC-9] for other dimensions)

90mm Frame Size Models (NEMA SIZE 34D)



- *Step angle of 1.8° (full step) or 0.9° (half step)*
- *48-50 tooth pitch configuration gives smooth operation, soft step motion, less resonance and instability*
- *Excellent microstep characteristics*
- *Available with ±5% or ±3% step accuracy, noncumulative*
- ***Can withstand up to 2-1/2 times rated current (instantaneous) without demagnetization***
- *Offered with connector, leads or cast terminal enclosure*
- *Can be supplied with 4, 6 or 8 connections*
- *Class B insulating materials*
- *Rated for operation in ambient temperatures from -40°C to +65°C (-40°F to +149°F)*
- *+100°C (+212°F) maximum motor shell temperature*
- *Constructed to provide long life with no regular maintenance*

TYPE NUMBER EXPLANATION - M090 SERIES MOTORS

M □ □ □ - F □ * * * * □

Frame Diameter			Identification Suffix + (Coil Rating)	
09 = 3.4"	1 = Single Stack	C = 6 Lead with optional post machining		C3A = Encoder
	2 = Double Stack	D = 6-Lead		E = Double End Shaft
	3 = Triple Stack	F = 4-Lead		

+ NOTE: Motors with 8000 suffixes (i.e. M091-FD-8009) are supplied with integral cast terminal boxes and 8 screw terminals. Motors with 8100 suffixes (i.e. M091-FD-8109) have 8 leads and no terminal boxes.

Refer to page DC-27 for available options.

90mm Frame Size Model (NEMA Size 34D) RATINGS and SPECIFICATIONS

MOTOR TYPE		CONNECTIONS		UNIPOLAR CONFIGURATION							BIPOLAR CONNECTIONS											
				TYPICAL TIME FOR SINGLE STEP (mS) (1)	NOMINAL DC VOLTS (3)	RATED AMPERES PER WINDING	NOMINAL RESISTANCE PER WINDING (25 C) OHMS (2)	NOMINAL INDUCTANCE PER PHASE (MILLI-HENRYS) (2) (4)	MINIMUM HOLDING TORQUE OZ-IN (Ncm)		SERIES CONNECTION				MINIMUM HOLDING TORQUE OZ-IN (Ncm)		PARALLEL CONNECTION				MINIMUM HOLDING TORQUE OZ-IN (Ncm)	
3% ACCURACY	5% ACCURACY	NUMBER	TYPE						2Ø ON	1Ø ON	VOLTS	AMPERES	R	L	2Ø ON	1Ø ON	VOLTS	AMPERES	R	L	2Ø ON	1Ø ON
—	M091-FD03	6	LEADS	8.5	5.3	1.6	3.3	16.5	150(106)	90(64)	7.25	1.1	6.6	66	180(127)	110(78)	—	—	—	—	—	—
M091-FC06	M091-FD06	6	LEADS	3.9	2.6	3.1	0.85	4.12	150(106)	90(64)	3.75	2.2	1.7	16.5	180(127)	110(78)	—	—	—	—	—	—
M091-FC09	M091-FD09	6	LEADS	3.1	1.7	4.7	0.36	1.5	150(106)	90(64)	2.4	3.3	0.72	6	180(127)	110(78)	—	—	—	—	—	—
—	M091-FF-206	4	LEADS	—	—	—	—	—	—	—	3	3	1	10.4	180(127)	—	—	—	—	—	—	—
—	M091-FF-401	4	TERM.	—	—	—	—	—	—	—	6.8	1	6.8	52	180(127)	110(78)	—	—	—	—	—	—
—	M091-FD-8106	8	LEADS	3.9	2.6	3.1	0.85	4.12	150(106)	90(64)	3.75	2.2	1.7	16.5	180(127)	110(78)	1.9	4.4	0.425	4.12	180(127)	110(78)
—	M091-FD-8009	8	TERM.	3.1	1.7	4.7	0.36	1.5	150(106)	90(64)	2.4	3.3	0.72	6	180(127)	110(78)	1.2	6.6	0.18	1.5	180(127)	110(78)
—	M091-FD-8109	8	LEADS	3.1	1.7	4.7	0.36	1.5	150(106)	90(64)	2.4	3.3	0.72	6	180(127)	110(78)	1.2	6.6	0.18	1.5	180(127)	110(78)
M092-FC08	M092-FD08	6	LEADS	4	3	4	0.75	3.56	300(212)	180(127)	4.2	2.8	1.5	14.24	370(261)	225(158)	—	—	—	—	—	—
M092-FC09	M092-FD09	6	LEADS	3.9	2.5	4.6	0.55	2.76	300(212)	180(127)	3.6	3.25	1.1	11.04	370(261)	225(158)	—	—	—	—	—	—
—	M092-FF-206	4	LEADS	—	—	—	—	—	—	—	4	4	1	11.5	370(261)	—	—	—	—	—	—	—
—	M092-FD-310	6	TERM.	3.9	1.56	6.8	0.23	1.28	300(212)	180(127)	2.2	4.8	0.46	5.12	370(261)	225(158)	—	—	—	—	—	—
—	M092-FD-335(5)*	6	TERM.	3.9	1.56	6.8	0.23	1.28	300(212)	180(127)	2.2	4.8	0.46	5.12	370(261)	225(158)	—	—	—	—	—	—
—	M092-FF-402	4	TERM.	—	—	—	—	—	—	—	3.4	2	1.7	16.6	325(229)	195(138)	—	—	—	—	—	—
—	M092-FD-8008	8	TERM.	4	3	4	0.075	3.56	300(212)	180(127)	4.2	2.8	1.5	14.24	370(261)	225(158)	2.1	5.7	0.375	3.56	370(261)	225(158)
—	M092-FD-8108	8	LEADS	4	3	4	0.75	3.56	300(212)	180(127)	4.2	2.8	1.5	14.24	370(261)	225(158)	2.1	5.7	0.375	3.56	370(261)	225(158)
—	M092-FD-8009	8	TERM.	3.9	2.5	4.6	0.55	2.76	300(212)	180(127)	3.6	3.25	1.1	11.04	370(261)	225(158)	1.8	6.5	0.275	2.76	370(261)	225(158)
—	M092-FD-8109	8	LEADS	3.9	2.5	4.6	0.55	2.76	300(212)	180(127)	3.6	3.25	1.1	11.04	370(261)	225(158)	1.8	6.5	0.275	2.76	370(261)	225(158)
—	M092-FD-8114*	8	TERM.	3.9	1.65	6.8	0.023	1.18	300(212)	180(127)	2.3	4.8	0.46	4.72	370(261)	225(158)	1.2	9.6	0.115	1.18	370(261)	225(158)
M093-FC07	M093-FD07	6	LEADS	6.3	4.3	3.5	1.22	7.87	450(318)	270(191)	6.1	2.5	2.44	31.48	550(388)	330(233)	—	—	—	—	—	—
M093-FC11	M093-FD11	6	LEADS	4.1	2.64	5.5	0.48	3.19	450(318)	270(191)	3.75	3.9	0.96	12.76	550(388)	330(233)	—	—	—	—	—	—
M093-FC14	M093-FD14	6	LEADS	3.4	2.27	7	0.324	2	450(318)	270(191)	3.2	5	0.648	8	550(388)	330(233)	—	—	—	—	—	—
—	M093-FF-206	4	LEADS	—	—	—	—	—	—	—	3.85	4	0.96	12.76	550(388)	—	—	—	—	—	—	—
—	M093-FD-301*	6	TERM.	3.4	1.54	11	0.14	0.85	450(318)	270(191)	2.2	7.8	0.28	3.4	550(388)	330(233)	—	—	—	—	—	—
—	M093-FD-315(5)*	6	TERM.	3.4	1.54	11	0.14	0.85	450(318)	270(191)	2.2	7.8	0.28	3.4	550(388)	330(233)	—	—	—	—	—	—
—	M093-FF-402	4	TERM.	—	—	—	—	—	—	—	4.5	3	1.5	16.9	550(388)	330(233)-	—	—	—	—	—	—
—	M093-FD-8007*	8	TERM.	6.3	4.3	3.5	1.22	7.87	450(318)	270(191)	6.1	2.5	2.44	31.48	550(388)	330(233)	3	4.95	0.61	7.87	550(388)	330(233)
—	M093-FD-8107*	8	LEADS	6.3	4.3	3.5	1.22	7.87	450(318)	270(191)	6.1	2.5	2.44	31.48	550(388)	330(233)	3	4.95	0.61	7.87	550(388)	330(233)
—	M093-FD-8011	8	TERM.	4.1	2.64	5.5	0.48	3.19	450(318)	270(191)	3.75	3.9	0.96	12.76	550(388)	330(233)	1.9	7.8	0.24	3.19	550(388)	330(233)
—	M093-FD-8014	8	TERM.	3.4	2.27	7	0.324	2	450(318)	270(191)	3.2	5	0.648	8	550(388)	330(233)	1.6	9.9	0.612	2	550(388)	330(233)

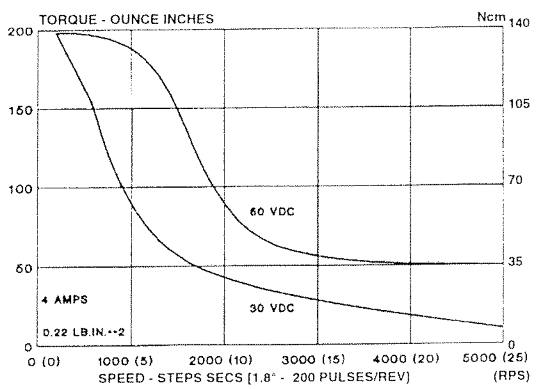
(1) With 24 volts drive.
(2) Values shown are for reference only and are correct to the best of our knowledge at the time of publication, but are subject to change without notice. Parameters to be used as part of a specification should be verified with the factory.
(3) Voltage shown is per phase at rated current at zero steps per second, with winding at 25°C. Resistance tolerance and winding temperature will influence voltage.
(4) Tolerance is ±20%. Measured at 1 kHz with a General Radio #1650B impedance bridge having a 1 volt rms open circuit sinusoidal signal. Rotor position preconditioned by energizing same phase, then deenergizing same phase during measurement without changing rotor position.
(5) Has double end shaft.
* These motors are obsolete and should not be used in a new application design. They can be provided to support existing systems.

MECHANICAL SPECIFICATIONS [1]

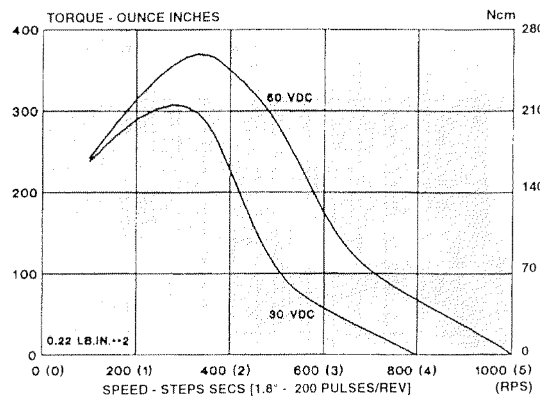
BASIC MOTOR SERIES	NOMINAL ROTOR INERTIA LB-IN^2 (kg-cm^2)	MINIMUM RESIDUAL TORQUE OZ-IN (Ncm)	TYPICAL TORQUE TO INERTIA RATIO	MAXIMUM OVERHANG LOAD LBS (kg)	MAXIMUM THRUST LOAD LBS (kg)	APPROX. WEIGHT LBS. (kg)	
						NET	SHIPPING
M091	0.23 (0.67)	2 (1.41)	15.6 x 10^3 (15.6^3)	25 (11.3)	50 (22.7)	3.25 (1.48)	4 (1.82)
M092	0.42 (1.23)	4 (2.82)	17.2 x 10^3 (17.2^3)	25 (11.3)	50 (22.7)	5.5 (2.5)	6.75 (3.1)
M093	0.64 (1.87)	7 (4.94)	16.8 x 10^3 (16.8^3)	25 (11.3)	50 (22.7)	7.75 (3.52)	9 (4.1)

(1) Values shown are for reference information and are correct to the best of our knowledge at time of publication, but are subject to change without notice. Parameters to be used as part of a specification should be verified with the factory.

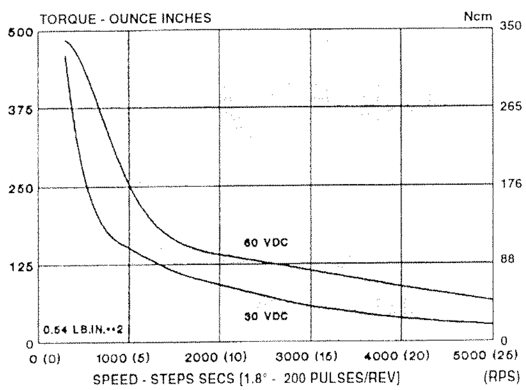
Typical Torque Versus Speed Characteristics



M091-FD-8009 OR M091-FD8109 MOTOR WITH SS2000MD7 4 AMP, 30 VDC/60 VDC SLO-SYN MOTION CONTROL - SERIES CONNECTION

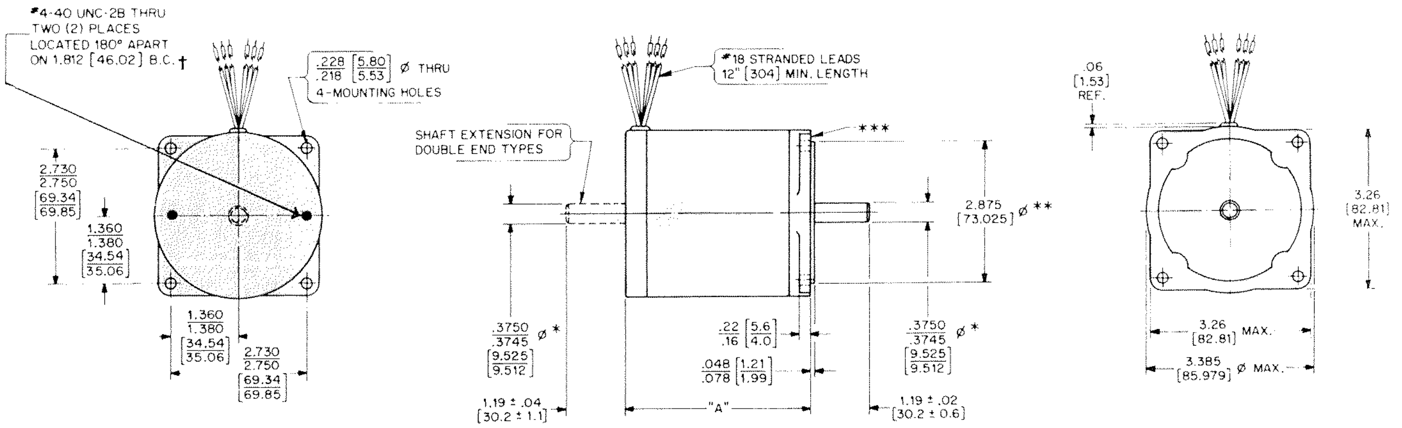


M092-FD-8009 OR M092-FD-8109 MOTOR WITH SS2000MD7 4 AMP, 30 VDC/60 VDC SLO-SYN MOTION CONTROL - SERIES CONNECTION



M093-FD-8014 OR M093-FD8114 MOTOR WITH SS2000MD7 5.0 AMP, 30 VDC/60 VDC SLO-SYN MOTION CONTROL - SERIES CONNECTION

DIMENSIONS, M090 SERIES MOTORS

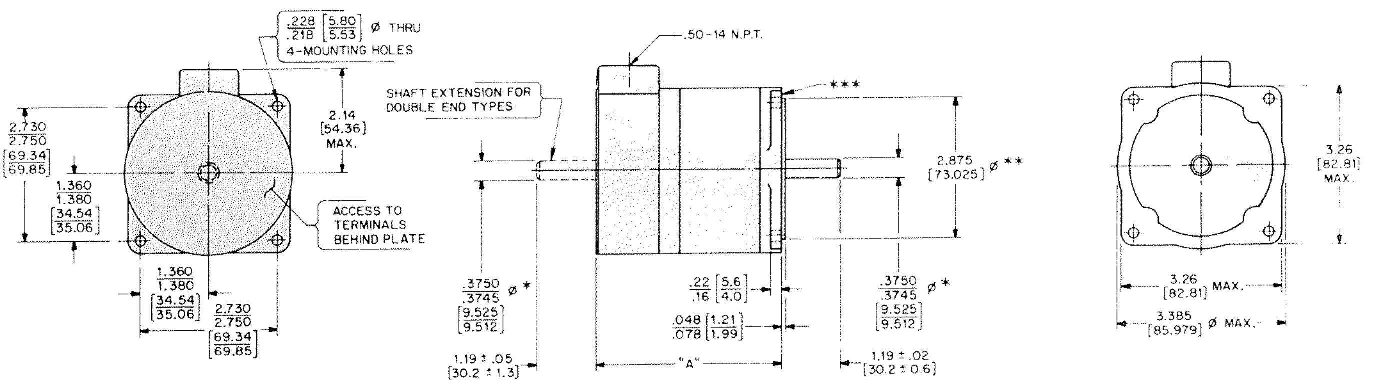


BASIC MOTOR TYPE	"A" MAX.	STANDARD MACHINING	OPTIONAL POST-MACHINING
M091	2.47 [62.74]	* SHAFT RUNOUT .002 [0.051] MAX. ** DIAMETER TOLERANCE ± .002 [0.051] DIAMETER CONCENTRIC TO SHAFT DIAMETER WITHIN .003 [0.077] T.I.R. *** SURFACE SQUARE TO SHAFT DIAMETER WITHIN .003 [0.077] T.I.R.	* SHAFT RUNOUT .001 [0.026] MAX. ** DIAMETER TOLERANCE ± .001 [0.026] DIAMETER CONCENTRIC TO SHAFT DIAMETER WITHIN .001 [0.026] T.I.R. *** SURFACE SQUARE TO SHAFT DIAMETER WITHIN .001 [0.026] T.I.R.
M092	3.72 [94.49]		
M093	5.10 [129.54]		

NOTES:--
1.- All dimensions apply before painting/plating.
2.-Dimensions in brackets are millimeters.

† Double ended shafts only

MODELS WITH LEADS

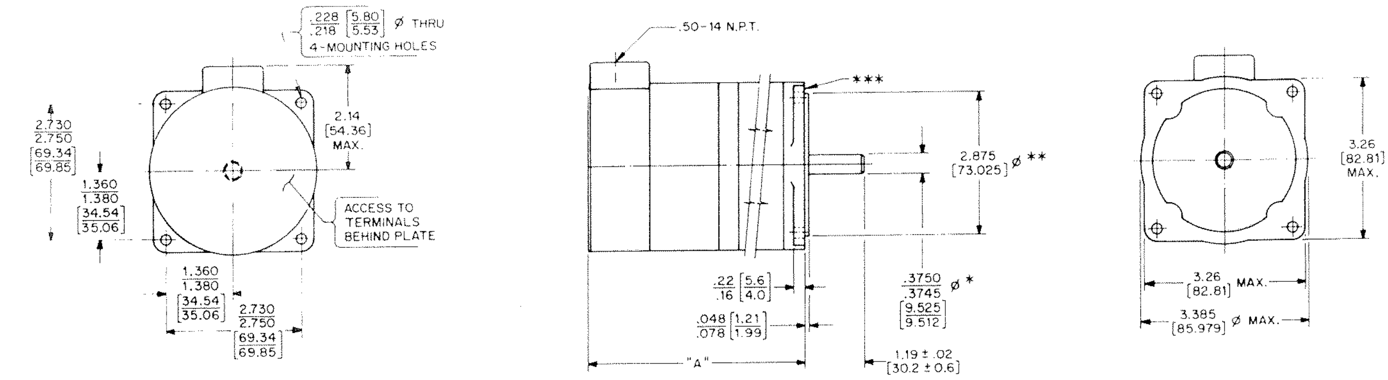


BASIC MOTOR TYPE	"A" MAX.	STANDARD MACHINING	OPTIONAL POST-MACHINING
M091	3.68 [93.47]	* SHAFT RUNOUT .002 [0.051] MAX. ** DIAMETER TOLERANCE ± .002 [0.051] DIAMETER CONCENTRIC TO SHAFT DIAMETER WITHIN .003 [0.077] T.I.R. *** SURFACE SQUARE TO SHAFT DIAMETER WITHIN .003 [0.077] T.I.R.	* SHAFT RUNOUT .001 [0.026] MAX. ** DIAMETER TOLERANCE ± .001 [0.026] DIAMETER CONCENTRIC TO SHAFT DIAMETER WITHIN .001 [0.026] T.I.R. *** SURFACE SQUARE TO SHAFT DIAMETER WITHIN .001 [0.026] T.I.R.
M092	4.93 [125.22]		
M093	6.30 [160.02]		

NOTES:--
1.- All dimensions apply before painting/plating.
2.-Dimensions in brackets are millimeters.

MODELS WITH CAST TERMINAL ENCLOSURE

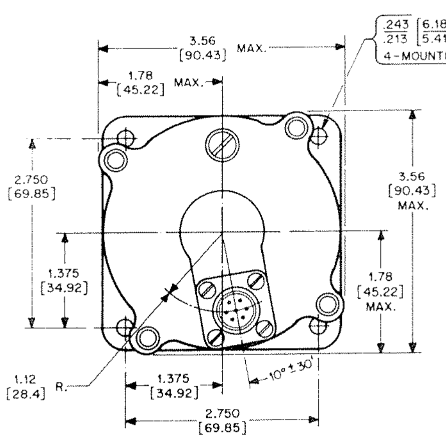
DIMENSIONS, M090 SERIES MOTORS

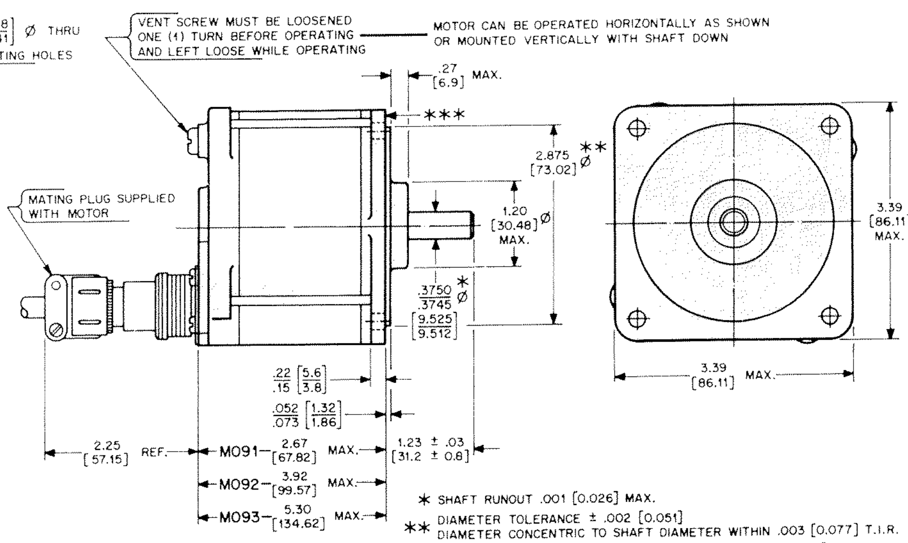


BASIC MOTOR TYPE	"A" MAX.	STANDARD MACHINING	OPTIONAL POST-MACHINING
M091	5.09 [129.29]	* SHAFT RUNOUT .002 [0.051] MAX. ** DIAMETER TOLERANCE ± .002 [0.051] DIAMETER CONCENTRIC TO SHAFT DIAMETER WITHIN .003 [0.077] T.I.R. *** SURFACE SQUARE TO SHAFT DIAMETER WITHIN .003 [0.077] T.I.R.	* SHAFT RUNOUT .001 [0.026] MAX. ** DIAMETER TOLERANCE ± .001 [0.026] DIAMETER CONCENTRIC TO SHAFT DIAMETER WITHIN .001 [0.026] T.I.R. *** SURFACE SQUARE TO SHAFT DIAMETER WITHIN .001 [0.026] T.I.R.
M092	6.34 [161.04]		
M093	7.71 [195.83]		

NOTES:--
1.- All dimensions apply before painting/plating.
2.- Dimensions in brackets are millimeters.

ENCODER MODELS





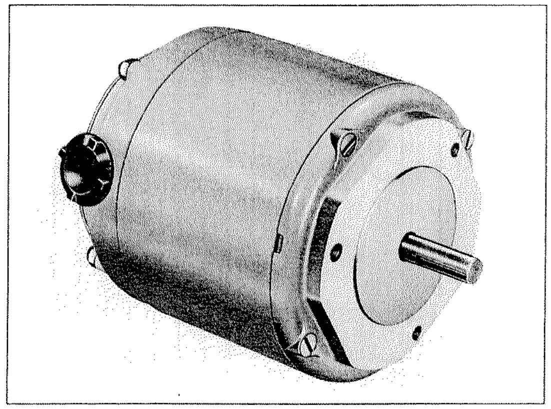
NOTES---
1 - Dimensions in brackets are millimeters.
2 - Tolerance on decimals ---
.XXX = ± 0.005 [0.13] unless otherwise specified.
.XX = ± 0.02 [0.6]
3 - Dimensions shown apply before painting or plating.
4 - This drawing shows only those features which are pertinent to the form, fit, and function of the motor.

* SHAFT RUNOUT .001 [0.026] MAX.
** DIAMETER TOLERANCE ± .002 [0.051] DIAMETER CONCENTRIC TO SHAFT DIAMETER WITHIN .003 [0.077] T.I.R.
*** SURFACE SQUARE TO SHAFT DIAMETER WITHIN .005 [0.127] T.I.R.

VISCOUS DAMPED MODELS (see page DC-27)

110mm Frame Size Models (NEMA Size 42)
165mm Frame Size Models (NEMA Size 66)

- *For full-step (1.8°), half-step (0.9°) or microstep operation*
- *±5% step accuracy, noncumulative*
- *Enclosed terminals for external connections*
- *Can be supplied with 4, 6 or 8 connections*
- *Class B insulating materials*
- ***Can withstand up to 2-1/2 times rated current (instantaneous) without demagnetization***
- *Operate in ambient temperatures from -40°C to +65°C (-40°F to +149°F)*
- *100°C (212°F) maximum motor shell temperature*



- *Shafts have flats (M111 models) or keyways (M112 and M172 models)*
- *Constructed to provide long life with no regular maintenance*
- *No ratchets, detents or gears to wear out*

TYPE NUMBER DESIGNATIONS
M111, M112, M113 AND M172 MOTORS

M □ □ □ - F □ ****

Frame Diameter
11 = 4.2"
12 = 4.2"
17 = 6.5"

1 = Single Stack
2 = Double Stack
3 = Triple Stack

D = 6 or 8 connections, round flange
F = 4 connections, square flange+
J = 6 or 8 connections, square flange, sealed against ingress of liquids or dust

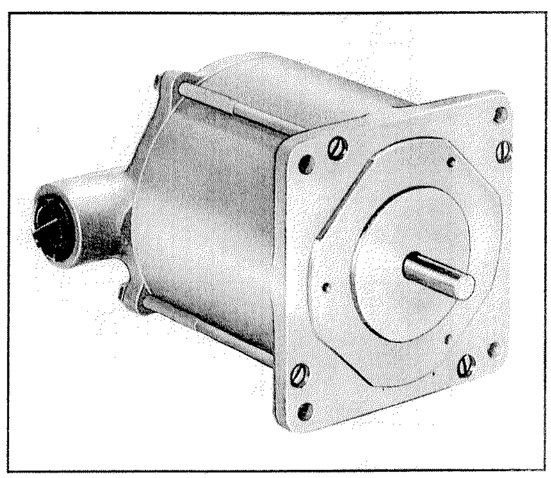
Identification Suffix (Coil Rating)

+ NOTE: Except the M111-FF401 which has a round flange.

Refer to page DC-27 for availble options.

Motors For "HAZARDOUS DUTY" Locations

The MX111-FF-401U, MX112-FF-401U and MX112-FF-401EU motors meet the specifications for motors operating in "Hazardous Duty" locations as defined by UL Class 1, Group D requirement. "Class 1" is designated as locations in which flammable gasses or vapors are, or may be, present in the air in quantities sufficient to cause explosions of ignitable mixtures. "Group D" includes atmospheres containing **gasoline, petroleum, naphtha, acetone, lacquer, solvent vapors or natural gas.**



MX111-FF-401U

110mm (NEMA Size 42) & 165mm (NEMA Size 66) RATINGS and SPECIFICATIONS

MOTOR TYPE 5% ACCURACY	CONNECTIONS		TYPICAL TIME FOR SINGLE STEP (mS) (1)	UNIPOLAR CONFIGURATION						BIPOLAR CONFIGURATION											
										SERIES CONNECTION						PARALLEL CONNECTION					
				NOMINAL DC VOLTS (3)	RATED AMPERES PER WINDING	NOMINAL RESISTANCE PER WINDING (25 C) OHMS (2)	NOMINAL INDUCTANCE PER PHASE (MILLI-HENRYS) (2) (4)	MINIMUM HOLDING TORQUE OZ-IN (Ncm)						MINIMUM HOLDING TORQUE OZ-IN (Ncm)						MINIMUM HOLDING TORQUE OZ-IN (Ncm)	
	NUMBER	TYPE						2Ø ON	1Ø ON	VOLTS	AMPERES	R	L	2Ø ON	1Ø ON	VOLTS	AMPERES	R	L	2Ø ON	1Ø ON
M111-FD12	6	TERM.	4.4	2.26	6.1	0.37	2.3	625 (441)	375 (265)	3.2	4.3	0.74	9.2	850 (600)	500 (353)	—	—	—	—	—	—
M111-FD16*	6	TERM.	4.4	1.7	8	0.21	1.1	625 (441)	375 (265)	2.4	5.7	0.42	4.4	850 (600)	500 (353)	—	—	—	—	—	—
M111-FF-206	4	TERM.	—	—	—	—	—	—	—	3.5	5	0.7	9.2	760 (537)	—	—	—	—	—	—	—
M111-FD-327*	6	TERM.	7	4.1	3.5	1.17	7.2	625 (441)	375 (265)	5.85	2.5	2.34	28.8	850 (600)	500 (353)	—	—	—	—	—	—
M111-FF-401	4	TERM.	—	—	—	—	—	—	—	4	3.4	1.14	17.7	850 (600)	500 (353)	—	—	—	—	—	—
MX111-FF-401	4	TERM.	—	—	—	—	—	—	—	4	3.4	1.14	17.7	850 (600)	500 (353)	—	—	—	—	—	—
M111-FD-8003*	8	TERM.	—	6.93	1.55	4.47	26.2	625 (441)	375 (265)	9.8	1.1	8.94	105	850 (600)	500 (353)	4.9	2.2	2.24	26.2	850 (600)	500 (353)
M111-FD-8007*	8	TERM.	7	4.1	3.5	1.17	7.2	625 (441)	375 (265)	5.85	2.5	2.34	28.8	850 (600)	500 (353)	2.93	5	0.585	7.2	850 (600)	500 (353)
M111-FD-8012	8	TERM.	4.4	2.26	6.1	0.37	2.3	625 (441)	375 (265)	3.2	4.3	0.74	9.2	850 (600)	500 (353)	1.6	8.63	0.185	2.3	850 (600)	500 (353)
M111-FD-8016*	8	TERM.	4.4	1.7	8	0.21	1.1	625 (441)	375 (265)	2.4	5.7	0.42	4.4	850 (600)	500 (353)	1.2	11.3	0.105	1.1	850 (600)	500 (353)
M112-FD08*	6	TERM.	7	5.8	3.8	1.53	14	1125 (794)	675 (477)	8.25	2.7	3.06	56	1390(981)	830 (586)	—	—	—	—	—	—
M112-FD12	6	TERM.	5.5	3.66	6.1	0.6	5.3	1125 (794)	675 (477)	5.2	4.3	1.2	21.2	1390(981)	830 (586)	—	—	—	—	—	—
M112-FJ12	6	TERM.	5.5	3.66	6.1	0.6	5.3	1125 (794)	675 (477)	5.2	4.3	1.2	21.2	1300(981)	830 (586)	—	—	—	—	—	—
M111-FF-206	4	TERM.	—	—	—	—	—	—	—	2.95	6	0.49	8.8	1390(981)	—	—	—	—	—	—	—
M112-FF-401	4	TERM.	—	—	—	—	—	—	—	1.95	4	0.49	8.8	950 (671)	675 (477)	—	—	—	—	—	—
MX112-FF-401U	4	TERM.	—	—	—	—	—	—	—	1.95	4	0.49	8.8	950 (671)	675 (477)	—	—	—	—	—	—
M112-FJ-326*	6	TERM.	6	1.52	15.2	0.1	0.88	1125 (794)	675 (477)	2.15	10.75	0.2	3.52	1390 (981)	830 (586)	—	—	—	—	—	—
M112-FJ-327*	6	TERM.	6	2.26	9.2	0.246	2.2	1125 (794)	675 (477)	3.2	6.5	0.492	8.8	1390 (981)	830 (586)	—	—	—	—	—	—
M112-FJ-335(5)*	6	TERM.	6	2.26	9.2	0.246	2.2	1125 (794)	675 (477)	3.2	6.5	0.492	8.8	1390 (981)	830 (586)	—	—	—	—	—	—
M112-FJ-344(5)*	6	TERM.	6	1.52	15.2	0.1	0.88	1125 (794)	675 (477)	2.215	10.75	0.2	3.52	1390 (981)	830 (586)	—	—	—	—	—	—
M112-FJ-8008*	8	TERM.	7	5.8	3.8	1.53	14	1125 (794)	675 (477)	8.25	2.7	3.06	56	1390 (981)	830 (586)	4.1	5.4	0.765	14	1390 (981)	830 (586)
M112-FD-8012*	8	TERM.	5.5	3.66	6.1	0.6	5.3	1125 (794)	675 (477)	5.2	4.3	1.2	21.2	1390 (981)	830 (586)	2.6	8.6	0.3	5.3	1390 (981)	830 (586)
M112-FJ-8012	8	TERM.	5.5	3.66	6.1	0.6	5.3	1125 (794)	675 (477)	5.2	4.3	1.2	21.2	1390 (981)	830 (586)	2.6	8.6	0.3	5.3	1390 (981)	830 (586)
M112-FJ-8018*	8	TERM.	6	2.1	9.2	0.242	2.1	1125 (794)	675 (477)	3	6.5	0.483	8.4	1390 (981)	830 (586)	1.5	13	0.12	2.1	1390 (981)	830 (586)
M112-FJ-8025*	8	TERM.	6	1.75	12.7	0.137	1	1125 (794)	675 (477)	2.5	9	0.274	4	1390 (981)	830 (586)	1.25	18	0.069	1	1390 (981)	830 (586)
M112-FJ-8030*	8	TERM.	6	1.52	15.2	0.1	0.88	1125 (794)	675 (477)	2.15	10.75	0.2	3.52	1390 (981)	830 (586)	1.1	21.5	0.05	0.88	1390 (981)	830 (586)
M113-FF-401	4	TERM.	—	—	—	—	—	—	—	4.5	6	0.75	17	2150(1518)	1290 (911)	—	—	—	—	—	—
M172-FD-306*	6	TERM.	24	2.35	15	0.15	1.98	2700 (1906)	1600 (1130)	3.3	10.6	0.3	7.92	3300(2330)	1980(1398)	—	—	—	—	—	—
M172-FD-308*	6	TERM.	24	1.45	20	0.075	1.06	2700 (1906)	1600 (1130)	2.1	14.1	0.15	4.24	3300(2330)	1980(1398)	—	—	—	—	—	—
M172-FF-401	4	TERM.	—	—	—	—	—	—	—	2.6	4	0.65	14.6	2000(1412)	1200 (847)	—	—	—	—	—	—
M172-FD-8030	8	TERM.	24	2.35	15	0.15	2.50	2700 (1906)	1600 (1130)	3.3	10.6	0.3	10.0	3300(2330)	1980(1398)	1.7	21.5	0.075	2.50	3300(2330)	1980 (1398)
M172-FD-8040*	8	TERM.	24	1.45	20	0.075	1.06	2700 (1906)	1600 (1130)	2.1	14.1	0.15	4.24	3300(2330)	1980(1398)	1	28.3	0.0375	1.06	3300(2330)	1980 (1398)

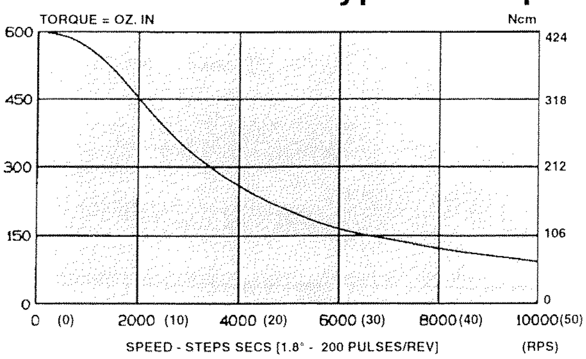
(1) With 24 volts drive.
(2) Values shown are for reference only and are correct to the best of our knowledge at the time of publication, but are subject to change without notice. Parameters to be used as part of a specification should be verified with the factory.
(3) Voltage shown is per phase at rated current at zero steps per second, with winding at 25°C. Resistance tolerance and winding temperature will influence voltage.
(4) Tolerance is ±20%. Measured at 1 kHz with a General Radio #1650B impedance bridge having a 1 volt rms open circuit sinusoidal signal. Rotor position preconditioned by energizing same phase, then deenergizing same phase during measurement without changing rotor position.
(5) Has double end shaft.
* These motors are obsolete and should not be used in a new application design. They can be provided to support existing systems.

MECHANICAL SPECIFICATIONS [1]

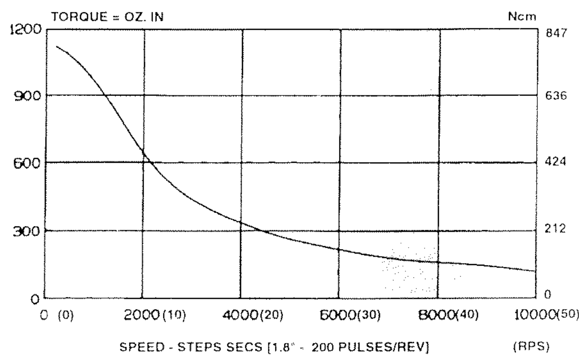
BASIC MOTOR SERIES	NOMINAL ROTOR INERTIA LB-IN^2 (kg-cm^2)	MINIMUM RESIDUAL TORQUE OZ-IN (Ncm)	TYPICAL TORQUE TO INERTIA RATIO	MAXIMUM OVERHANG LOAD LBS (kg)	MAXIMUM THRUST LOAD LBS (kg)	APPROX. WEIGHT LBS. (kg)	
						NET	SHIPPING
M111	1.34 (3.93)	6 (4.24)	11.2 x 10^3 (11.2^3)	25 (11.3)	50 (22.7)	8 (3.63)	9.25 (4.2)
MX111	1.34 (3.93)	6 (4.24)	11.2 x 10^3 (11.2^3)	25 (11.3)	50 (22.7)	9 (4.08)	10.25 (4.65)
M112-FD M112-FJ	2.75 (8.06)	12 (8.47)	9.8 x 10^3 (9.8^3)	25 (11.3)	50 (22.7)	16.7 (7.57)	16.5 (7.4)
MX112	2.75 (8.06)	12 (8.47)	9.8 X 103 (9.83)	25 (11.3)	50 (22.7)	16 (7.26)	18 (8.16)
M113	4.1 (12.0)	20 (14.12)	9.1 X 103 (9.13)	25 (11.3)	50 (22.7)	22 (10)	25 (11.4)
M172	21 (61.5)	50 (35.31)	3.1 x 103 (3.13)	50 (22.7)	100 (45.4)	50 (22.7)	56 (25.4)

(1) Values shown are for reference information and are correct to the best of our knowledge at time of publication, but are subject to change without notice. Parameters to be used as part of a specification should be verified with the factory.

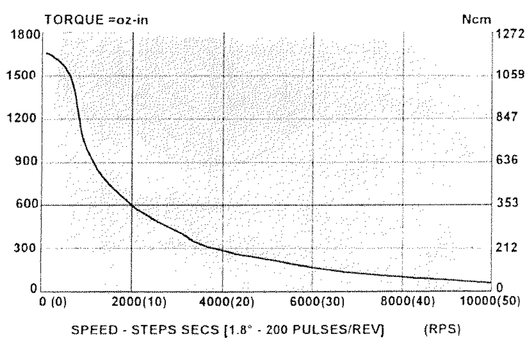
Typical Torque Versus Speed Characteristics



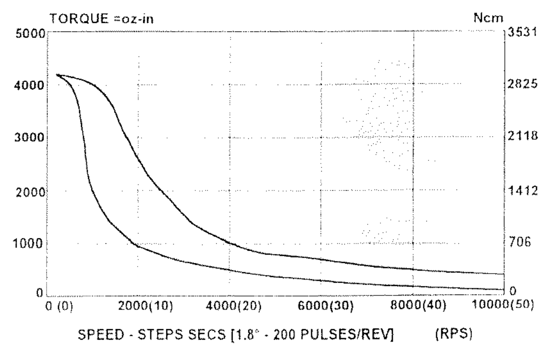
M111-FF206 MOTOR WITH SS2000D6
6 AMP, 180 VDC SLO-SYN MOTION CONTROL



M112-FF206 MOTOR WITH SS2000D6
6 AMP, 180 VDC SLO-SYN MOTION CONTROL

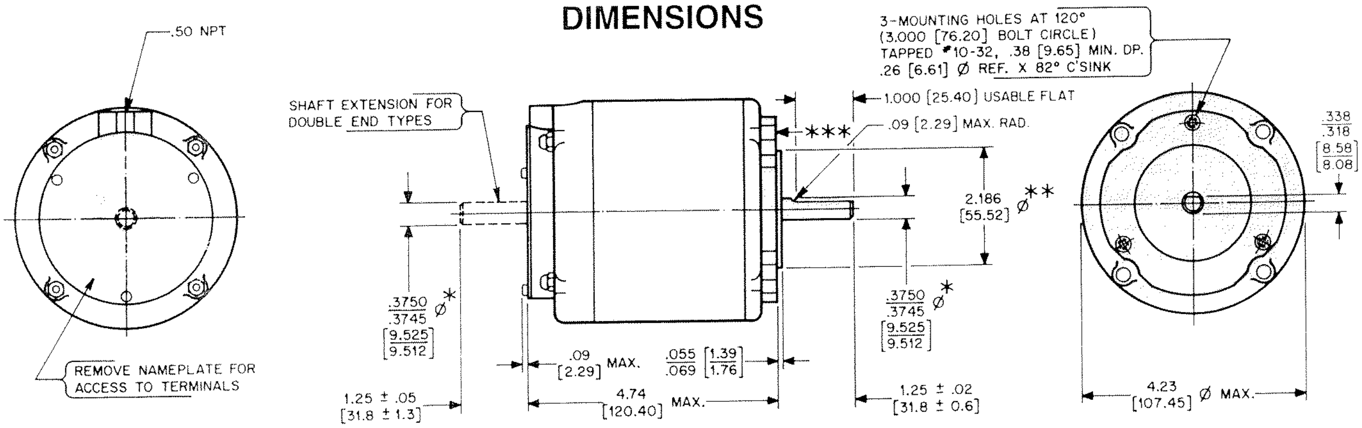


M113-FF-401 MOTOR WITH SS2000D6
6 AMP, 180 VDC SLO-SYN MOTION CONTROL



M172-FF-401 MOTOR WITH SS2000D12
8 AMP, 180 VDC SLO-SYN MOTION CONTROL

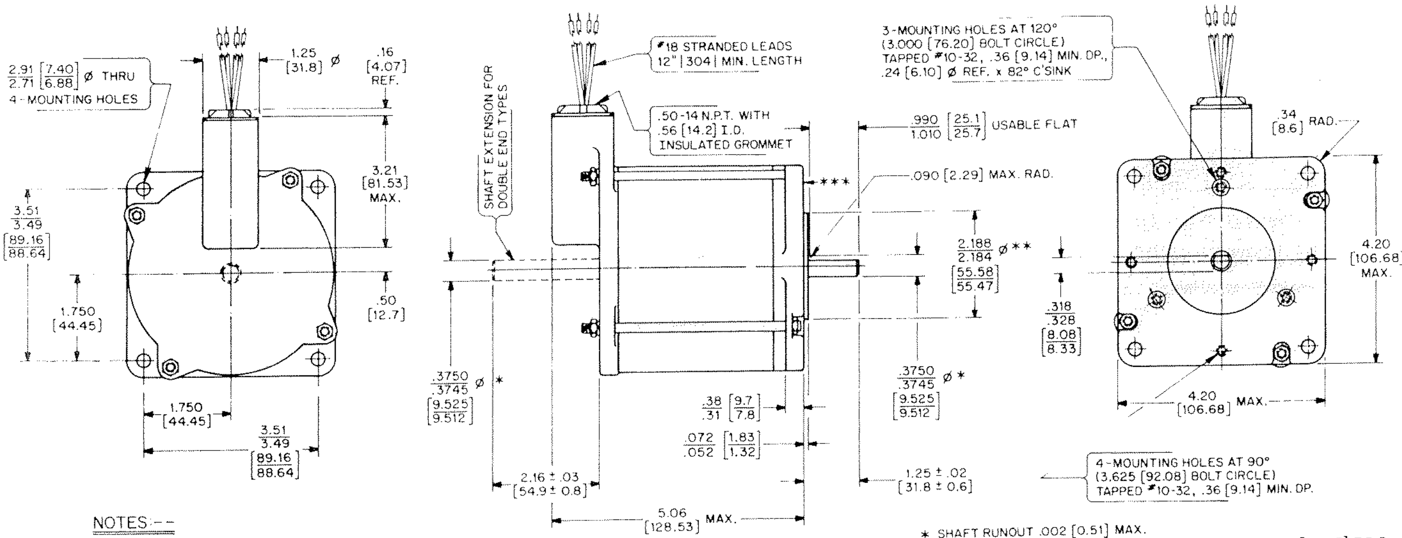
DIMENSIONS



NOTES ---
1 — Dimensions in brackets are millimeters.
2 — Tolerance on decimals ---
.XXX = ± 0.005 [0.13] unless otherwise specified.
3 — Dimensions shown apply before painting or plating.
4 — This drawing shows only those features which are pertinent to the form, fit, and function of the motor.

* SHAFT RUNOUT .002 [0.051] MAX.
** DIAMETER TOLERANCE ± .002 [0.051]
DIAMETER CONCENTRIC TO SHAFT DIAMETER WITHIN .003 [0.077] T.I.R.
*** SURFACE SQUARE TO SHAFT DIAMETER WITHIN .003 [0.077] T.I.R.

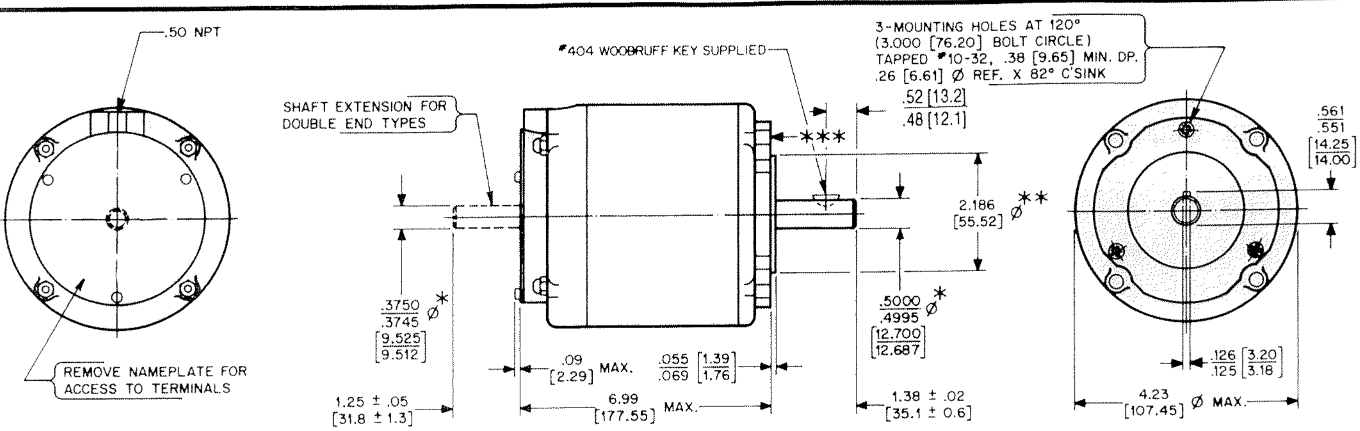
M111-FD MOTORS, STANDARD AND DOUBLE END



NOTES:--
1. - All dimensions apply before painting/plating.
2. - Dimensions in brackets are millimeters.

* SHAFT RUNOUT .002 [0.51] MAX.
** DIAMETER CONCENTRIC TO SHAFT DIAMETER WITHIN .003 [0.077] T.I.R.
*** SURFACE SQUARE TO SHAFT DIAMETER WITHIN .003 [0.077] T.I.R.

MX111-FF-401U MOTORS, STANDARD AND DOUBLE END

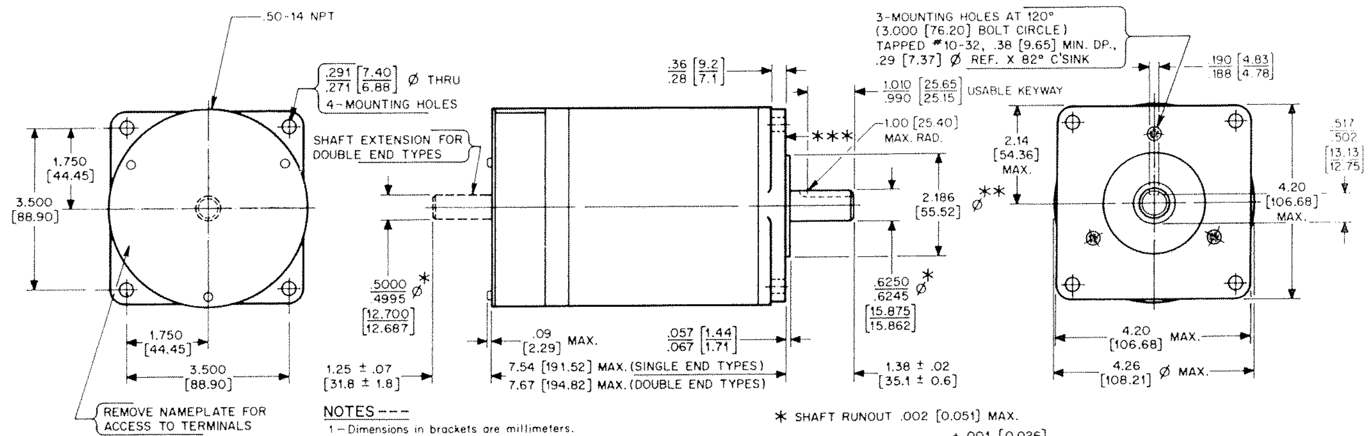


NOTES ---
1 — Dimensions in brackets are millimeters.
2 — Tolerance on decimals ---
.XXX = ± 0.005 [0.13] unless otherwise specified.
3 — Dimensions shown apply before painting or plating.
4 — This drawing shows only those features which are pertinent to the form, fit, and function of the motor.

* SHAFT RUNOUT .002 [0.051] MAX.
** DIAMETER TOLERANCE ± .002 [0.051]
DIAMETER CONCENTRIC TO SHAFT DIAMETER WITHIN .003 [0.077] T.I.R.
*** SURFACE SQUARE TO SHAFT DIAMETER WITHIN .003 [0.077] T.I.R.

M112-FD MOTORS, STANDARD AND DOUBLE END MODELS

DIMENSIONS



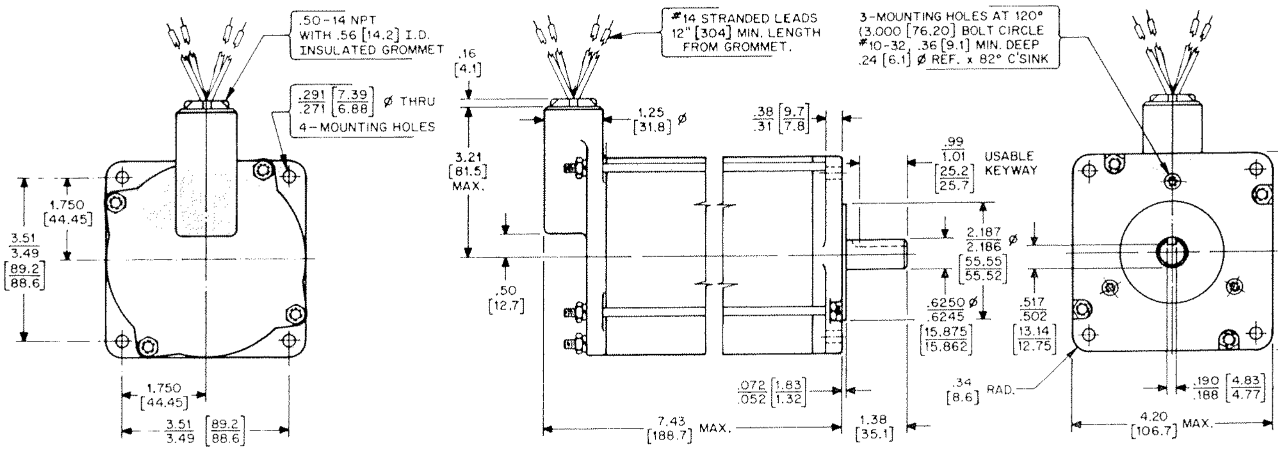
NOTES---
1 – Dimensions in brackets are millimeters.
2 – Tolerance on decimals ---
.XXX = ± 0.005 [0.13] unless otherwise specified.
3 – Dimensions shown apply before painting or plating.
4 – This drawing shows only those features which are pertinent to the form, fit, and function of the motor.

* SHAFT RUNOUT .002 [0.051] MAX.

** DIAMETER TOLERANCE +.001 [0.026] / −.000 [0.000]
DIAMETER CONCENTRIC TO SHAFT DIAMETER WITHIN .003 [0.077] T.I.R.

*** SURFACE SQUARE TO SHAFT DIAMETER WITHIN .003 [0.077] T.I.R.

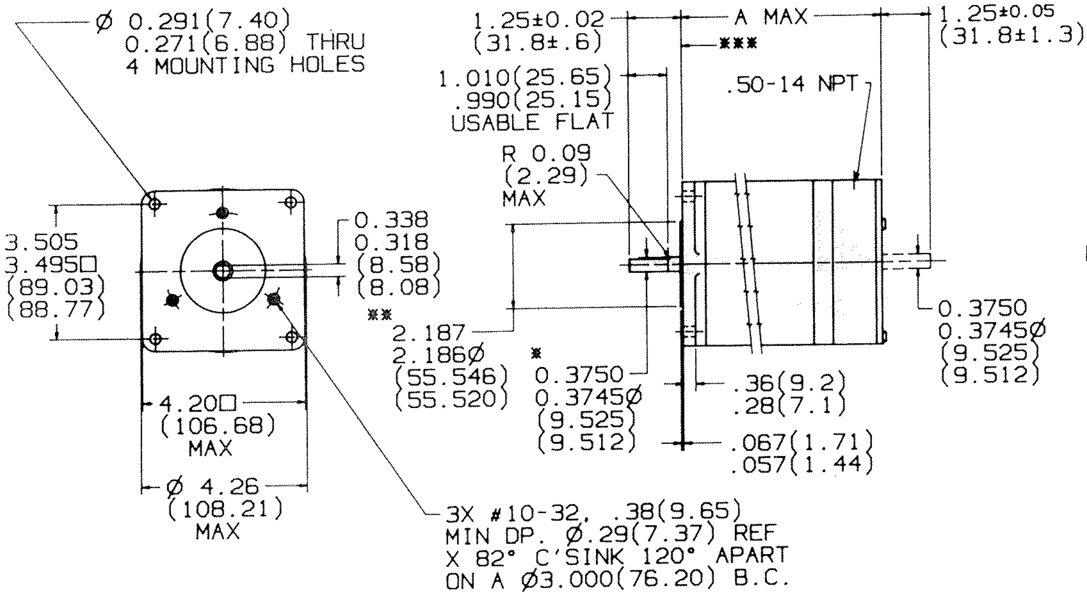
M112-FJ MOTORS, STANDARD AND DOUBLE END MODELS



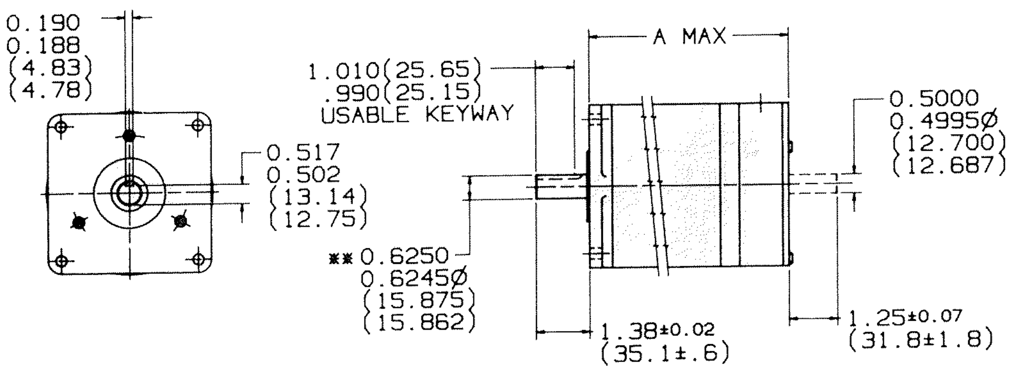
NOTES--
1 – Dimensions in brackets are millimeters.
2 – Tolerance on decimals ---
.XXX = ± 0.005 [0.13] unless otherwise specified.
3 – Dimensions shown apply before painting or plating.
4 – This drawing shows only those features which are pertinent to the form, fit, and function of the motor.

MX112-FF MOTORS, STANDARD AND DOUBLE END MODELS

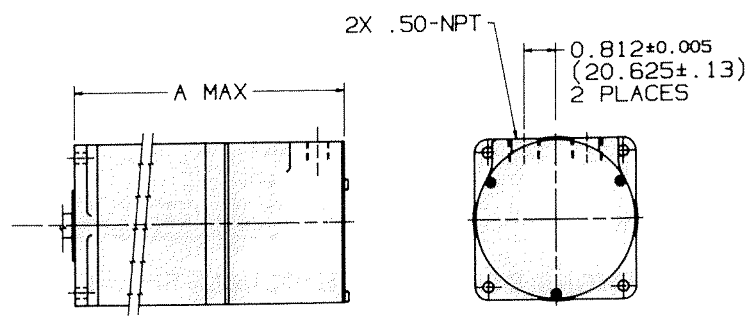
DIMENSIONS



M111 MODELS



M112
MH112
MODELS



MODEL	A MAX
M111,E	5.29 (134.37)
M112	7.54 (191.52)
M112E	7.67 (194.82)
MH112E	8.29 (210.57)
M111C	7.10 (180.34)
M112C	9.35 (237.49)
MH112C	10.16 (256.54)

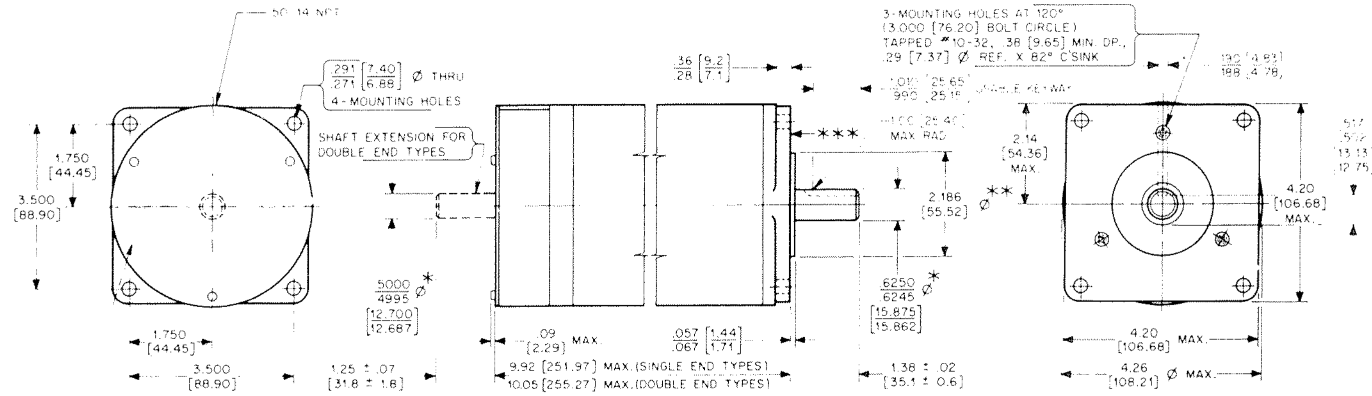
ENCODER MODELS

NOTES:

1. OTHER THAN THE DIMENSIONS SHOWN, THE PARAMETERS FOR M112 & MH112 MODELS ARE THE SAME AS THE M111 MODELS.
2. DIMENSIONS IN BRACKETS ARE IN MILLIMETERS.
3. TOLERANCES:
   * SHAFT RUNOUT .002(.051) MAX.
   ** DIAMETER CONCENTRIC TO SHAFT DIA WITHIN .003(.077) T.I.R.
   *** SURFACE SQUARE TO SHAFT DIA. WITHIN .003(.077) T.I.R.

M111-FF206 AND M112-FF206 MOTORS; STANDARD, DOUBLE END AND ENCODER MODELS

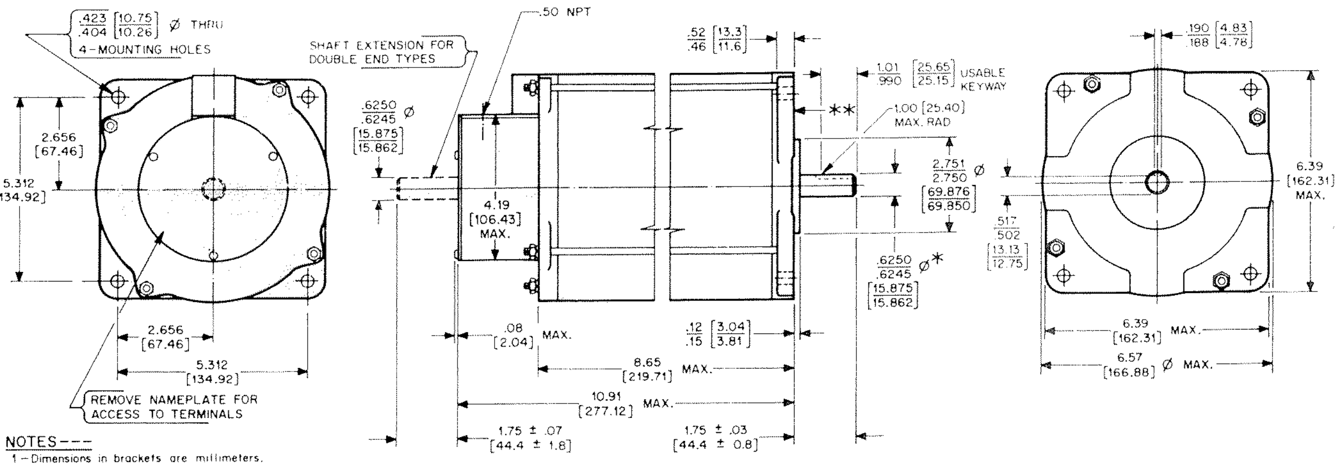
DIMENSIONS



NOTES---
1 - Dimensions in brackets are millimeters.
2 - Tolerance on decimals ---
.XXX = ± 0.005 [0.13] unless otherwise specified.
3 - Dimensions shown apply before painting or plating.
4 - This drawing shows only those features which are pertinent to the form, fit, and function of the motor.

* SHAFT RUNOUT .002 [0.051] MAX.
** DIAMETER TOLERANCE +.001 [0.026] -.000 [0.000]
DIAMETER CONCENTRIC TO SHAFT DIAMETER WITHIN .003 [0.077] T.I.R.
*** SURFACE SQUARE TO SHAFT DIAMETER WITHIN .003 [0.077] T.I.R.

M113-FF MOTORS, STANDARD AND DOUBLE END MODELS

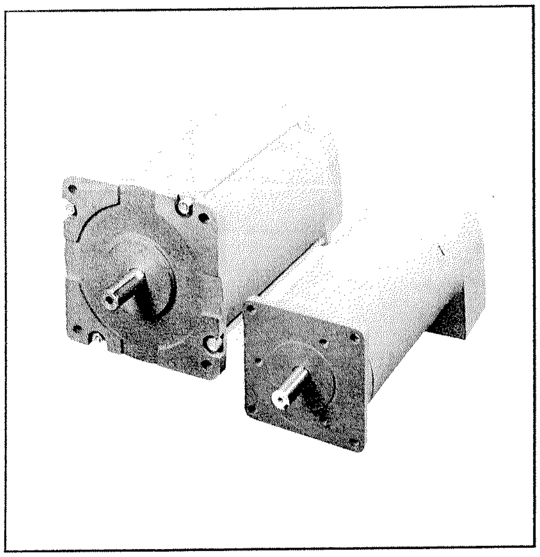


NOTES---
1 - Dimensions in brackets are millimeters.
2 - Tolerance on decimals ---
.XXX = ± 0.005 [0.13] unless otherwise specified.
3 - Dimensions shown apply before painting or plating.
4 - This drawing shows only those features which are pertinent to the form, fit, and function of the motor.

* SHAFT RUNOUT .002 [0.051] MAX.
** SURFACE SQUARE TO SHAFT DIAMETER WITHIN .005 [0.127] T.I.R.

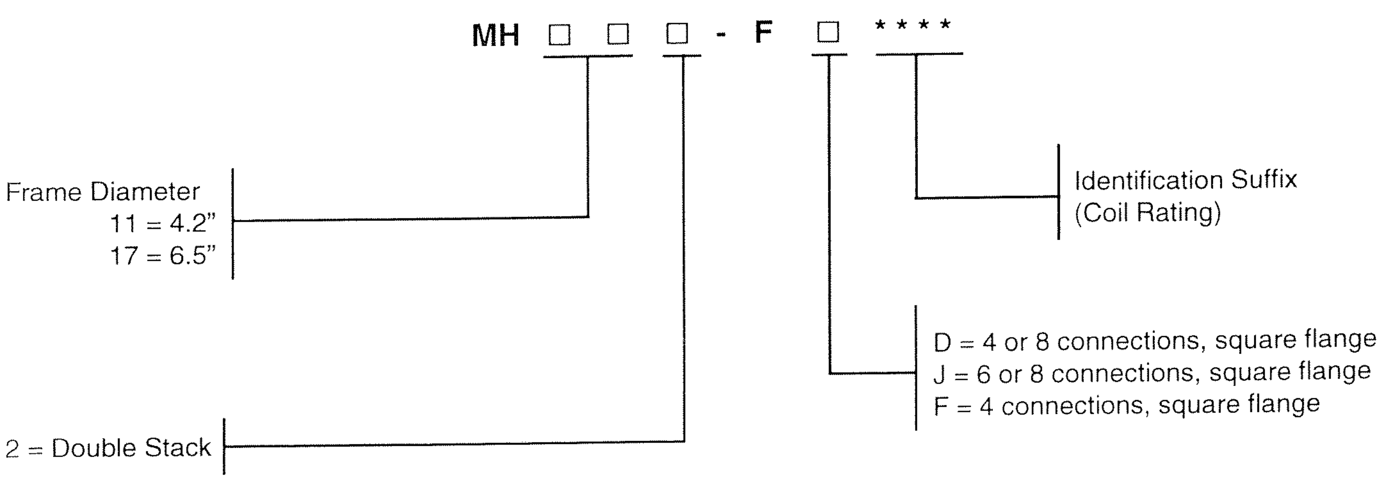
M172 MOTORS, STANDARD AND DOUBLE END MODELS

MH112 (NEMA Size 42) and MH172 (NEMA Size 66) Motors



- *Can be used for full step (1.8°), half step (0.9°) and microstep operation*
- *±5% step accuracy, noncumulative*
- *High power for machine tool and similar applications*
- *Offered with 4 or 8 connections for use with unipolar or bipolar chopper drives*
- *Have cast terminal enclosure*
- *Optimized magnetic structure gives motor torque 10% to 100% higher than competitive motors*
- *Have Class F insulation for higher allowable duty cycles*
- ***Can withstand up to 2-1/2 times rated current (instantaneous) without demagnetization***
- *Large diameter improves shaft stiffness*
- *Shaft has keyway for square key*
- *Have provisions for 4-hole mounting*

TYPE NUMBER EXPLANATION - MH SERIES MOTORS



Refer to page DC-27 for list of available options.

Specifications, MH112 and MH172 Motors

Motor Type 5% Accuracy	Connections		Thermal Resistance (°C/Watt)				Temperature	Limit	Series Connection						Parallel Connection					
	Number	Type	Typical Time For Single Step(mS) (1)	Winding to Frame	Frame To Air	Frame To Heat Sink	Winding	(°C) Frame	Volts	Ampere	R(ohms)	L(mH)	Minimum Holding Torque OZ-IN (Ncm) 1Ø ON	2Ø ON	Volts	Amperes	R(ohms)	L(mH)	Minimum Holding Torque OZ-IN (Ncm) 1Ø ON	2Ø ON
MH112-FJ8020	8	TERM.	3	0.8	1.87	4.1	155	125	3.8	7.1	0.532	11.92	1760 (1243)	2400 (1695)	1.9	14.1	0.133	2.98	1760 (1243)	2400 (1695)
MH112-FJ8030	8	TERM.	2.8	0.8	1.87	4.1	155	125	2.5	10.6	0.232	4.12	1760 (1243)	2400 (1695)	1.25	21.1	0.058	1.03	1760 (1243)	2400 (1695)
MH112-FJ4201	4	TERM.	—	0.8	1.87	4.1	155	125	3.2	4	0.8	16.8	1500 (1059)	2100 (1483)	—	—	—	—	—	—
MH112-FF206	4	TERM.	—	—	—	—	130	100	4.8	6	0.8	16.8	2000 (1412)	—	—	—	—	—	—	—
MH172-FD8030	8	TERM.	4.2	0.47	1.06	1.4	155	125	3.25	10.614	0.306	8.48	5330 (3764)	6800 (4801)	1.6	21.2	0.0765	2.12	5330 (3764)	6800 (4801)
MH172-FD8040*	8	TERM.	4	0.47	1.06	1.4	155	125	2.25	14.4	0.156	4.76	5330 (3764)	6800 (4801)	1.15	28.8	0.039	1.19	5330 (3764)	6800 (4801)
MH172-FD4201	4	TERM.	—	0.47	1.06	1.4	155	125	2.64	4	0.66	15.6	3000 (2118)	4200 (2966)	—	—	—	—	—	—

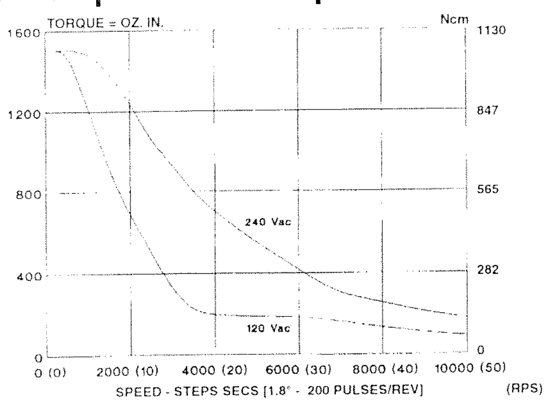
(1)
* These motors are obsolete and should not be used in a new application design. They can be provided to support existing systems.

MECHANICAL SPECIFICATIONS [1]

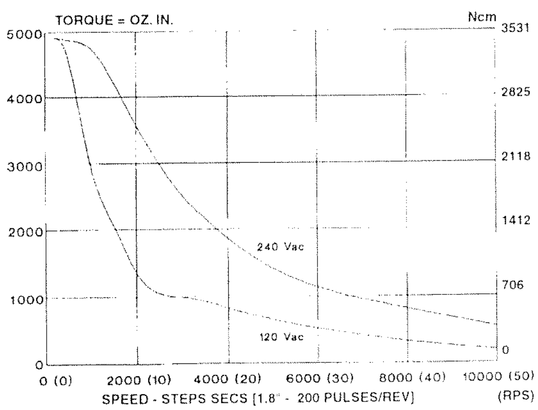
BASIC MOTOR SERIES	NOMINAL ROTOR INERTIA LB-IN² (kg-cm²)	MINIMUM RESIDUAL TORQUE OZ-IN (Ncm)	TYPICAL TORQUE TO INERTIA RATIO	MAXIMUM OVERHANG LOAD LBS (kg)	MAXIMUM THRUST LOAD LBS (kg)	APPROX. WEIGHT LBS. (kg)	
						NET	SHIPPING
MH112-8XXX	3.22 (9.42)	85 (60.02)	13.1×10^3	50 (22.7)	100 (45.4)	20.5 (9.3)	24 (10.9)
MH112-4XXX	3.22 (9.42)	85 (60.02)	11.2×10^3	50 (22.7)	100 (45.4)	20.5 (9.3)	24 (10.9)
MH172-8XXX	21.0 (61.5)	50 (35.31)	6.1×10^3	100 (45.4)	150 (68)	53 (24.1)	62 (28.1)
MH172-4XXX	21.0 (61.5)	50 (35.31)	3.4×10^3	100 (45.4)	150 (68)	53 (24.1)	62 (28.1)

(1) Values shown are for reference information and are correct to the best of our knowledge at time of publication, but are subject to change without notice. Parameters to be used as part of a specification should be verified with the factory.

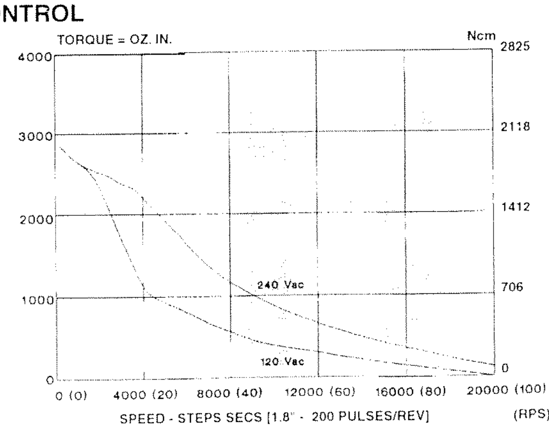
Typical Torque Versus Speed Characteristics



MH112-FJ-4201 OR MH112-FF206 MOTOR WITH SS2000D12 6 AMP, 180 VDC SLO-SYN MOTION CONTROL



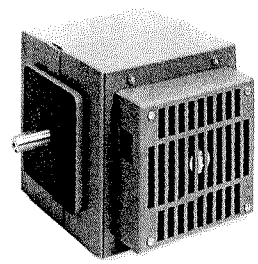
MH172-FD-8030 Motor with SS2000D12 12 AMP, 180 VDC SLO-SYN MOTION CONTROL - SERIES CONNECTION



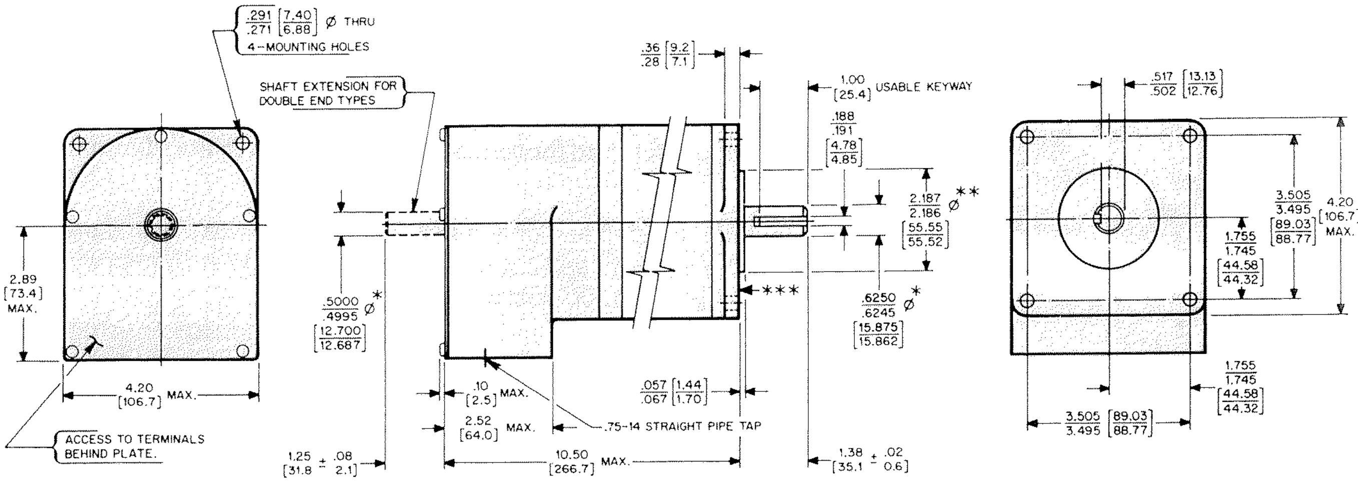
MH172-FD-8030 Motor with SS2000D12 12 AMP, 180 VDC SLO-SYN MOTION CONTROL - PARALLEL CONNECTION

Fan Kits

Motors of the MH Series can usually be operated at duty cycles up to 35% to 45% without exceeding their maximum temperature rating. If the duty cycle is greater than 45% or if the motor loading is too high, some additional means of cooling the motor may be required. Fan Kits FAN212, FAN112 and FAN172 are offered for this purpose. These two-piece kits bolt to the shells of the motors and can be installed in the field. Motors tested with these kits have exhibited operating temperatures of 130°F (55°C) or less after 900 hours of operation. This is well below the maximum motor shell temperature rating of 257°F (125°C). Order type FAN212 for an M112 motor, FAN112 for an MH112 motor or FAN172 for and MH172 motor.



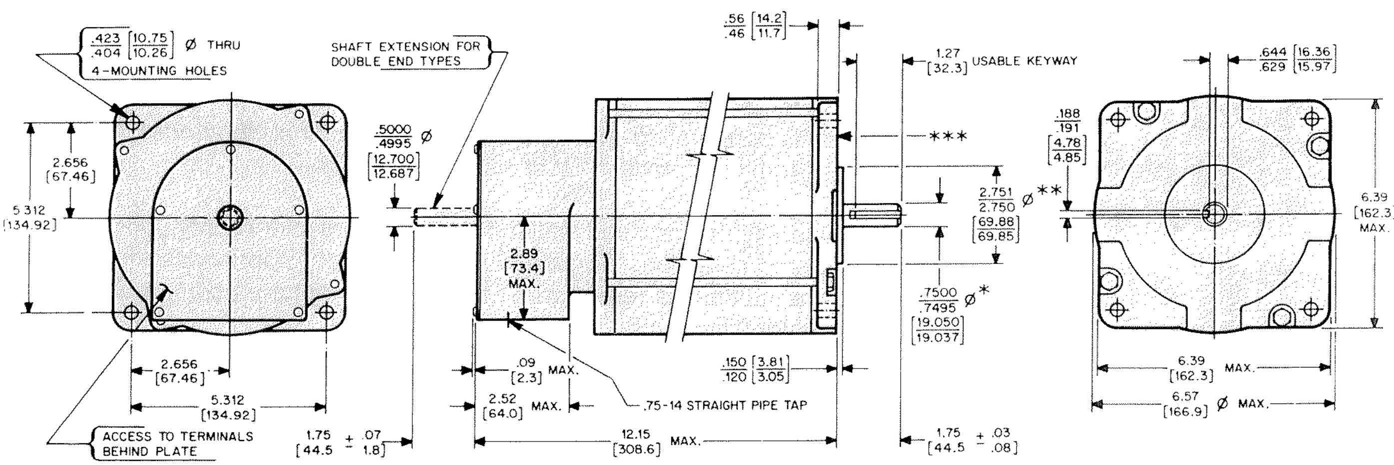
DIMENSIONS, MH112 AND MH172 SERIES MOTORS



Dimensions in brackets are millimeters.
Dimensions shown apply before painting.
This drawing shows only those features which are pertinent to the form, fit, and function of the motor.

* SHAFT RUNOUT .002 [0.051] MAX.
** DIAMETER CONCENTRIC TO SHAFT DIAMETER WITHIN .003 [0.077] T.I.R.
*** SURFACE SQUARE TO SHAFT DIAMETER WITHIN .003 [0.077] T.I.R.

MH112 MOTORS, STANDARD AND DOUBLE END MODELS

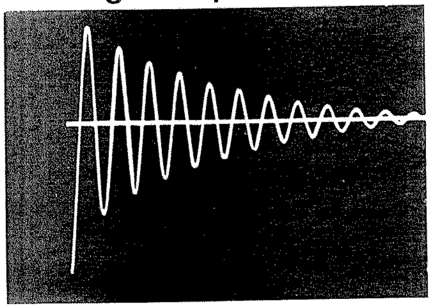


Dimensions in brackets are millimeters.
Tolerance on decimals ---
.XXX = ± .005 [0.13] unless otherwise specified.
.XX = ± .02 [0.6]
Dimensions shown apply before painting.
This drawing shows only those features which are pertinent to the form, fit, and function of the motor.

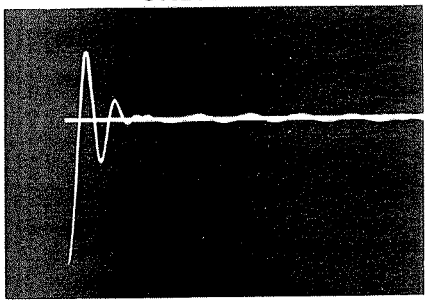
* SHAFT RUNOUT .002 [0.051] MAX.
** DIAMETER CONCENTRIC TO SHAFT DIAMETER WITHIN .005 [0.127] T.I.R.
*** SURFACE SQUARE TO SHAFT DIAMETER WITHIN .005 [0.127] T.I.R.

MH172 MOTORS, STANDARD AND DOUBLE END MODELS

Single Step Function



UNDAMPED



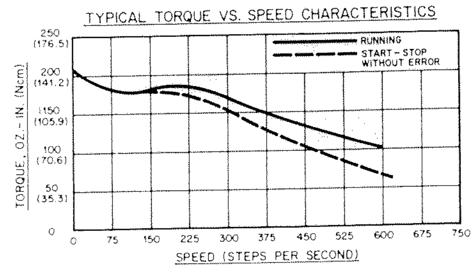
DAMPED

Available Options, All Models

Viscous Damped Motors - These motors have a unique fluid system that results in a step function that approaches critical damping. Properties of the internally contained silicon fluid are such that the overall speed of response and running characteristics are changed very little, but settling-down time is substantially reduced. A typical torque vs. speed curve for the M092-FC09D viscous damped motor is shown. **Viscous damped motors are only available in the 90mm frame size.**

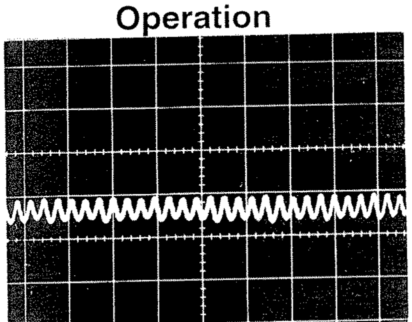
Step functions for both damped and undamped motors are shown. With damping, the typical time for the motor to settle down to within 0.1° is 17 milliseconds. Viscosity of the damping fluid is 1500 centistokes.

Viscous damped models can be operated over an ambient temperature range of 10°C to 35°C (50°F to 95°F). They can be mounted horizontally or vertically with the shaft facing down. A vent on the motor housing must be opened before operating a viscous damped motor.

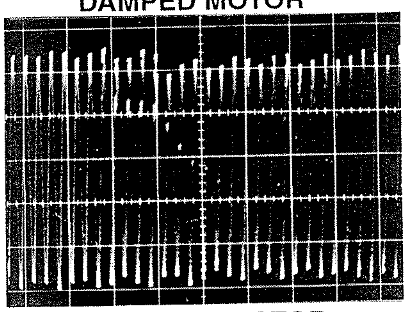


M092-FC09D

Continuous Stepping Operation



DAMPED MOTOR

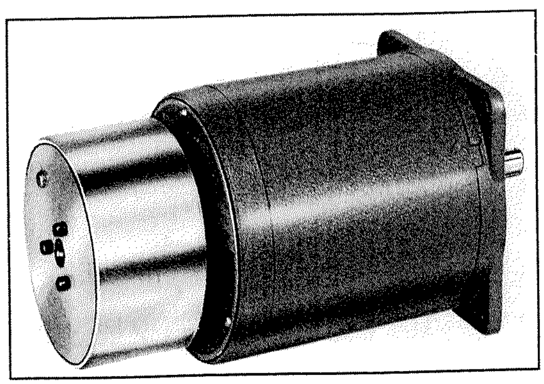


UNDAMPED MOTOR

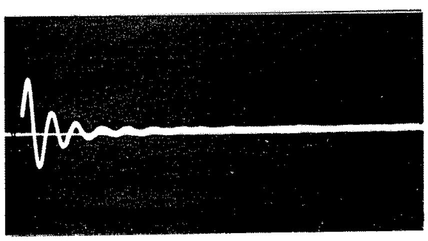
Lanchester Dampers - All stepper motors are subject to torsional vibrations or "resonance" when operated at their natural frequencies. Normally, these vibrations are minor in nature and the motors are seldom operated at the affected speeds. When inertial loads or operating speeds are such that torsional vibrations become excessive, they can be suppressed by adding dampers.

The curves compare typical damped and undamped motors under continuous stepping and single-step conditions. Torsional vibrations under continuous stepping conditions show a substantial reduction for the damped motor as compared with the undamped motor. The damped motor also shows improved step function characteristics, although settling time is not greatly reduced.

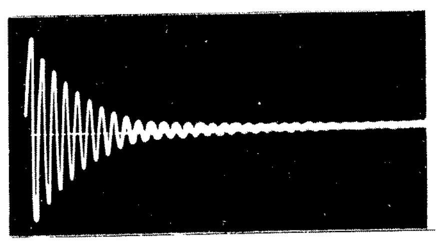
Motors having integrally mounted Lanchester dampers are available on special order. Dampers can also be supplied separately for addition to double-end motors in field use. Damper part numbers for specific motors are listed in the chart.



Single-Step Operation



DAMPED MOTOR

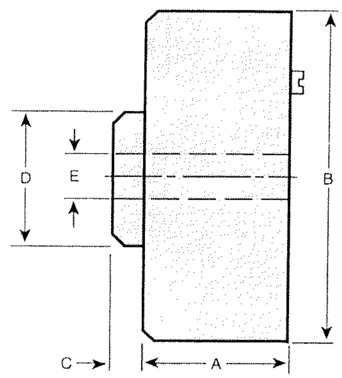


UNDAMPED MOTOR

BASIC MOTOR TYPE	DAMPER PART NUMBER	INERTIA (LB-IN²)
M061, M062, M063	131857-001	0.17
M091, M092, M093	131852-002	1.06
M111, M112-FD	131852-003	6.04
M112-FJ	131852-004	6.04
M172	131852-006	23.52

BASIC MOTOR TYPE	DIMENSIONS				
	A	B	C	D	E
M061, M062, M063	1.060 (26.92)	1.880 (47.75)	0.250 (6.35)	0.88 (22.4)	0.2505 - 0.2515 (6.363 - 6.388)
M091, M092, M093	1.4 (35.6)	2.8 (71.1)	0.250 (6.35)	1.125 (28.58)	0.3755 - 0.3765 (9.538 - 9.563)
M111, M112-FD	1.525 (38.74)	4.00 (101.6)	0.250 (6.35)	1.125 (28.58)	0.3755 - 0.3765 (9.538 - 9.563)
M112-FJ, M113-FJ	1.525 (38.74)	4.00 (101.6)	0.250 (6.35)	1.125 (28.58)	0.5005 - 0.5015 (12.713 - 12.738)
M172	1.650 (41.91)	5.969 (151.61)	0.50 (12.7)	1.75 (44.5)	0.6255 - 0.6265 (15.888 - 15.913)

(Dimensions in brackets are millimeters)



DIMENSIONS
LANCHESTER DAMPERS

Double End Shafts - These motors have an output shaft at both ends. Motors with double end shafts are used to mount an encoder on the motor shaft or to mount a knob for turning the motor shaft manually. Double end shaft models of the M060 and M090 Series are equipped with two drilled and tapped holes on the rear end bell for mounting encoders. Motors with shafts at both ends are identified with a letter E suffix added to the type number. For example, M063-CS06E.

NOTE: Double-end shafts are not available on motors that have a shaft mounted encoder.

High Temperature - These motors are constructed using Class H organic materials and have high temperature grease in the rotor bearings. They are rated for continuous duty in ambient temperatures as high as 115°C (239°F) and are identified with a letter H suffix. For Example: M091-FD09H. High temperature models are only available on special order. Consult factory for details.

Nuclear Radiation Resistant - A letter R suffix identifies a Nuclear Radiation Resistant model constructed using organic material and lubricating materials that have a high resistance to nuclear radiation. Operation in ambient temperatures to 100°C (212°F) is permissible. These motors can be supplied on special order. Consult the factory for availability.

Limited Vacuum - Constructed using Class B organic materials and high vacuum bearing lubricant to minimize "outgassing". They can be operated in vacuums to 10^{-8} Torr. The maximum permissible motor shell temperature is 100°C (212°F). Maximum pre-bakeout temperature is 180°C (356°F). Limited Vacuum motors have a letter V suffix added to the type number. Standard motors can be operated in vacuums up to 10^{-4} torr.

Shaft Modifications - A variety of motor output shaft modifications can be supplied. These include special flats and keyways, through holes and similar changes which may be needed to allow mounting of timing belts, pulleys or gears or to facilitate mounting the motor to the equipment being driven.

Electrical Modifications - Motors can be supplied with a number of electrical modifications, including nonstandard lead lengths, electrical connectors and special electrical windings.

Shaft Mounted Encoder - Superior Electric offers encoders which can be supplied as kits for mounting to existing double-end motors, or which can be supplied as an integral part of any standard M06 or M09 Series double-end motor. They can also be supplied on M111-FF and M112-FF 9 square flange) motors. The encoders are available with outputs of 200, 400, 500 or 1250 pulses-per-revolution with an optional zero reference pulse. Kits are offered for mounting on shafts 1/4 inch or 3/8 inch in diameter. Type numbers for ordering kits are shown in this section. Consult the factory for information on ordering a motor with an integral encoder.

Mechanical and electrical specifications, connections and output waveforms are as follows:

The complete Encloder Kit Model Number is specified as shown below:

EK **21** - ☐ - ☐ ☐

Encoder Kit

Encoder Body Diameter
(2.1 Inches)

Shaft Size
- 25 = 1/4" Dia.
- 38 = 3/8" Dia.

Lines Per Revolution
200, 400, 500, 1250

Number of Outputs
- 2 = Single-Ended (A, B Only)
- 3 = A, B and Index
- 6 = A, B, Index
  $\overline{A}$, $\overline{B}$, $\overline{\text{Index}}$ (With Differential Line Drivers)

Encoder Kit Specifications

Mechanical Specifications

Weight	2.1 ounces
Moment Of Inertia	2.6 x 10^{-4} oz-in -sec^2 maximum
Acceleration	100,000 radians per second
Bore Size	0.250" and 0.375"
Slew Speed	7000 rpm maximum
Strain Relief	withstands 10 lbs. pull on cable or wire bundle

Motor Interface

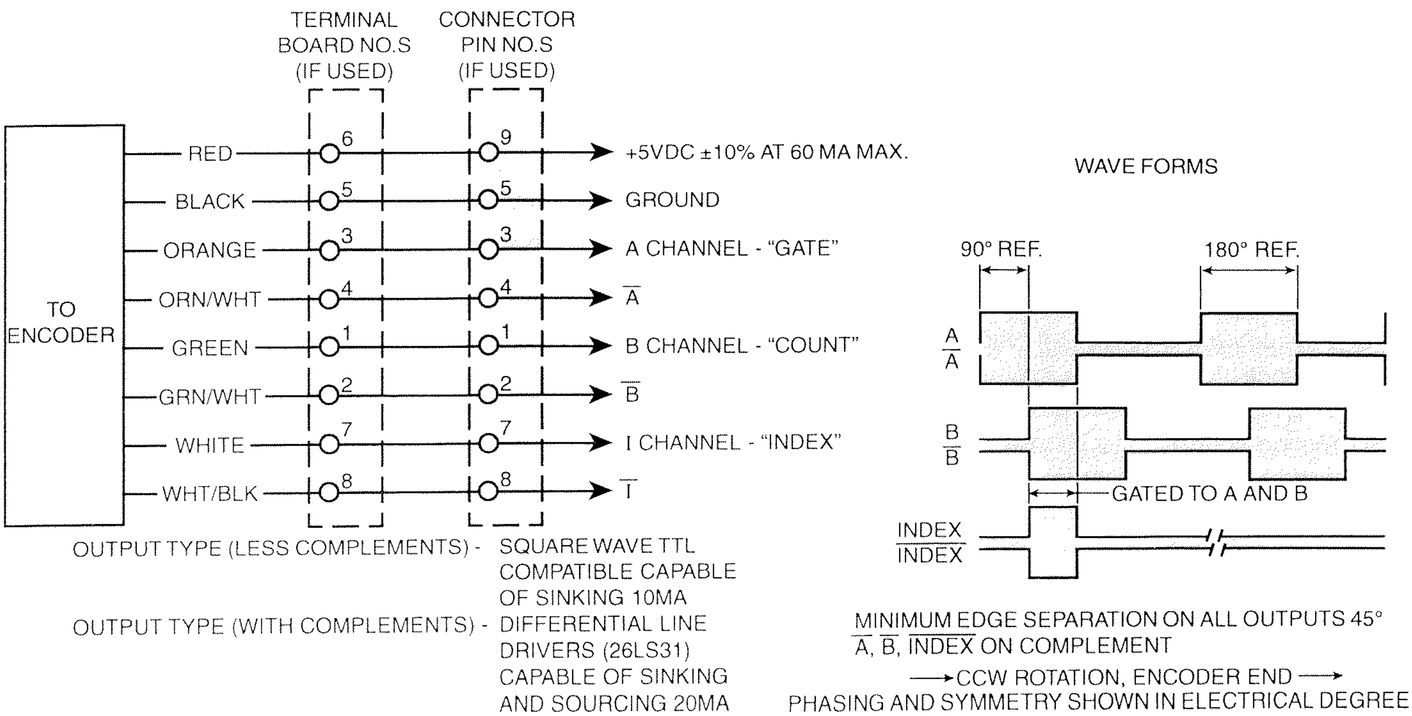
Mounting Holes	#4-40 at 180° on 1.812 diameter Bolt Circle
Perpendicularity	
Shaft To Mount	0.005" TIR
Shaft Endplay	
Dynamic Or Static	±0.010"
Shaft Finish	16 microinches or better. End must be chamfered or rounded
Shaft Tolerance	
1/4" Diameter	0.2495/0.2500 inch
3/8" Diameter	0.3745/0.3750 inch
Minimum Shaft	
Length	0.56 inch (usable at specified diameter)

Electrical Specifications

Code	Incremental
Cycles Per Revolution	200/400/500, as specified
Supply Voltage	5 Vdc 10% at 60mA maximum
Output Format	dual channel quadrature, minimum edge separation 45 °
Output Format	
Options	index and complementary outputs
Output Type	
Less Complements	square wave, TTL compatible, short circuit protected, capable of sinking 10mA
With Complements	square wave, TTL compatible, short circuit protected, capable of sinking and sourcing 20mA
Frequency Response	100 kHz (data and index)
Frequency Modulation	±0.5% maximum at 50 kHz
Encoder Accuracy	3.0 arc minutes maximum with zero shaft runout

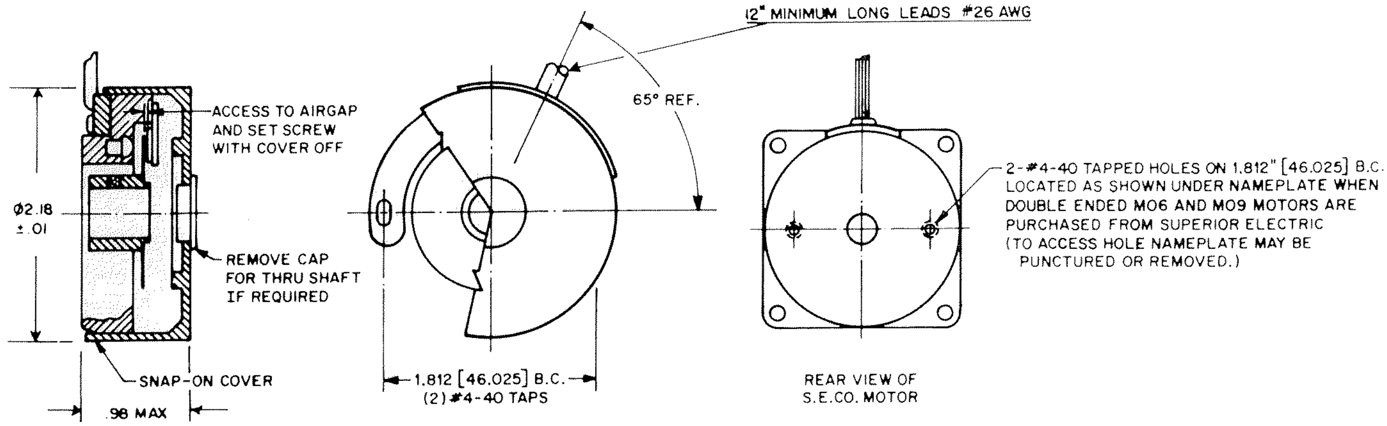
Environmental Specifications

Temperature	
Operating	-10°C to +100°C (+14°F to +176°F)
Storage	-20°C to 100°C (-4°F to +212°F)
Enclosure	unsealed housing, must be protected from harsh envir-onments



ENCODER CONNECTION DIAGRAM AND OUTPUT WAVEFORM

DIMENSIONS



ORDERING INFORMATION

The following diagram explains the Encoder Kit number system:

EK 21 - 25 - 200 - 2

- EK — Encoder Kit
- 21 — Encoder Body Diameter (2.1 inches)
- 25 — Shaft Size
  - 25 = 1/4 Inch Diameter
  - 38 = 3/8 Inch Diameter
- 200 — Lines Per Revolution: 200, 400, 500, 1250
- 2 — Number of Outputs
  - 2 = Single-Ended (A, B only)
  - 3 = A, B and Index
  - 6 = A, B, Index
    $\overline{A}$, $\overline{B}$, $\overline{Index}$
    (with Differential Line Drivers)

How To Select a DC Step Motor

Successful application of a step motor requires careful selection of the proper step motor control as well as the correct step motor. The first step in the selection process is a complete load analysis to determine the correct motor size and the amount of torque needed to drive the load. Since step motor systems are often used as ultra high performance positioning systems or motion controls, selection of the optimum motor/drive combination is of prime importance.

The torque versus speed performance of any step motor is dependent on the drive used to direct the motor. Torque and speed are directly related to voltage and current.

Voltage in a step motor system is used primarily to achieve speed and to overcome the back EMF (electro-magnetic force) generated by the motor. Higher voltage drives are capable of delivering higher speeds. Current is used to provide torque at the motor shaft. Superior Electric selected chopper drives for the Micro Series controls because of their ability to regulate the amount of current within the step motor to assure maximum performance.

One of the most important factors when choosing components for a step motor system is the proper calculation of inertia, which is the property of matter to resist a change in state. Because bodies at rest tend to remain at rest and bodies in motion tend to remain in motion, torque must be applied to the load to effect any change in motion, such as acceleration, deceleration, starting, stopping, etc.

The following information can be used to calculate the data needed to select the optimum components for the step motor system.

Selecting DC Step Motors

1. Leadscrew Mechanical System:

A. Leadscrew Shaft Inertia =
1. Shaft Diameter (D) = ____ Inches
2. Shaft Weight (W shaft) = ____ Pounds
   or
   Shaft Length (L) = ____ Inches
   Shaft Density (d) = ____ Lbs/in³
3. Shaft Inertia (J shaft)
   Calculation = ____ Lb-in²
   = W shaft x (D ÷2)²)÷ 2
   or
   -.098 x D⁴ x L x d

B. Reflected Load Inertia
1. Load Weight (W load) = ____ Pounds
2. Leadscrew Pitch (P) = ____ Rev/in
3. Efficiency (E) = ____ %
4. Load Inertia (J load)
   Calculation = ____ Lb-in²
   = (W load ÷ (E x P²))
   x (1÷(2 x PI)²)

C. Total Inertia
1. Add Leadscrew Shaft Inertia and Load Inertia = ____ Lb-in²
   J system = J shaft + J load

D. Friction
1. Friction Force = ____ Lb
   F force = u x W load
   u = Coefficient of Friction
2. Total Friction Torque = ____ Oz-in
   F total = (F force x 16) ÷
   (P x E x 2 x PI)

2. Pulley Mechanical System

A. Motor Pulley Inertia
1. Diameter (D pulley) = ____ Inches
2. Weight (W) if known = ____ Pounds
   or Calculate Weight:
   Length (L) = ____ Inches
   Density (d) = ____ Lb/in³
   W = PI x (D pulley ÷ 2)²
   x L x d = ____ Pounds
3. Pulley Inertia (J m pulley)
   Calculation
   = W x (D pulley ÷ 2)² ÷ 2 = ____ Lb/in²

B. Load Pulley Inertia
1. Diameter (D load) = ____ Inches
2. Weight (W) if known = ____ Pounds
   or Calculate Weight:
   Length (L) = ____ Inches
   Density (d) = ____ lb/in³
   W = PI x (D pulley ÷ 2)²
   x L x d = ____ Pounds
3. Pulley Inertia (J 1 pulley)
   Calculation
   = W x (D pulley ÷ 2)² ÷ 2 = ____ Lb/in²

C. External Load Driven by Load Pulley
1. Load Weight (W) = ____ Lbs
2. Load Inertia = ____ Lb-in²
   J load = W x (D load ÷2)²

D. Gear Ratio
   G = (D load)/(D pulley = ____

E. Total Inertia
   J system = J m pulley +
   (J 1 pulley) ÷ G² +
   (J load) ÷ G² = ____ Lb-in²

F. Total Friction Torque
   (F total) = ____ Oz-in

3. Cylindrical Mechanical System

A. Cylinder Inertia
1. Outer Diameter (OD) = ____ Inches
2. Inner Diameter (ID) = ____ Inches
   (= 0 if Solid)
3. Weight (W) = ____ Pounds
   or
   Length (L) = ____ Inches
   Density (d) = ____ Lb/in³
   W = π x [(OD ÷ 2)² -
   (ID ÷ 2)²] x L x d = ____ Pounds
4. Total Inertia (J system)
   = .5 x W x ((OD ÷ 2)² +
   (ID ÷ 2)²) = ____ Lb-in²
5. Total Friction Torque (F total)

Motion Calculations (Assuming Trapezoidal Move Profile)

1. Distance (X) = ____ Steps
2. Time (T) = ____ Seconds
3. Calculate Velocity (V)
   V = (1.5 x X) ÷ T = ____ Steps/Sec
4. Calculate Acceleration (A)
   A = (4.5 x X) ÷ T² = ____ Steps/Sec²
5. Torque Utilization Factor (UJ)
   (Usually 50%) = ____ %
6. Friction Utilization Factor (UF)
   (Usually 90%) = ____ %
7. Select Constant
   For 1.8 degree
   step angle
   K = 0.00131 = ____
   = ____ Lb-in²
8. Calculate Total Inertia
   (J total)
   Add Motor Inertia and the Total System Inertia
   J total = J motor + J system
   Note: If the Load Inertia is greater than ten times the Motor Inertia, then the motor is not applicable.
9. Calculate Required Torque
   = K (ACC) (J total) (100% ÷ UJ)
   + F total (100%/UF) = ____ Oz-in
10. Determine Torque Available at the required Velocity (V) from the Speed/Torque Curve = ____ Oz-in
11. If the value from Step 10 is greater than the value from Step 9, then the motor is applicable
12. Duty cycle considerations must be evaluated for proper motor selection

CONVERSION FACTORS			METRIC-DECIMAL EQIVALENTS		
INERTIA					
slug-ft² x 4600	=	lb-in²	1 inch	=	2.54 cm
lb-ft² x 144	=	lb-in²	1 cm	=	0.3937 Inch
oz-in² x 0.0625	=	lb-in²	1 pond (gm)	=	0.03527 oz.
lb-ft-sec² x 4600	=	lb-in²	1 oz.	=	28.35 pond (gm)
lb-in-sec² x 385	=	lb-in²	1 kp (kg)	=	2.205 pound
oz-in-sec² x 24	=	lb-in²	1 gm-cm	=	0.0139 oz-in
gm-cm² x .000342	=	lb-in²	1 kg-cm	=	1 kp-cm = 13.9 oz-in
kp-m-sec² x 33,500	=	lb-in²	1 hp	=	746 watts

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