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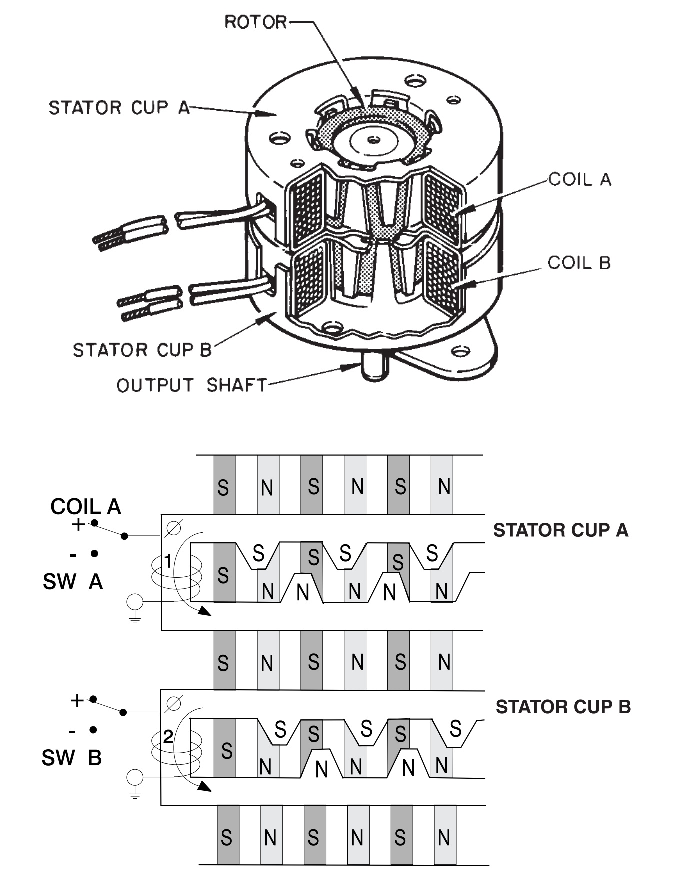
The stepper motor is a device used to convert electrical pulses into discrete mechanical rotational movements.

The Thomson Airpax Mechatronics stepper motors described in this guide are 2-phase permanent magnet (PM) motors which provide discrete angular movement every time the polarity of a winding is changed.

CONSTRUCTION

In a typical motor, electrical power is applied to two coils. Two stator cups formed around each of these coils, with pole pairs mechanically displaced by 1/2 a pole pitch, become alternately energized North and South magnetic poles. Between the two stator-coil pairs, the displacement is 1/4 of a pole pitch.

The permanent magnet rotor is magnetized with the same number of pole pairs as contained by the stator-coil section.



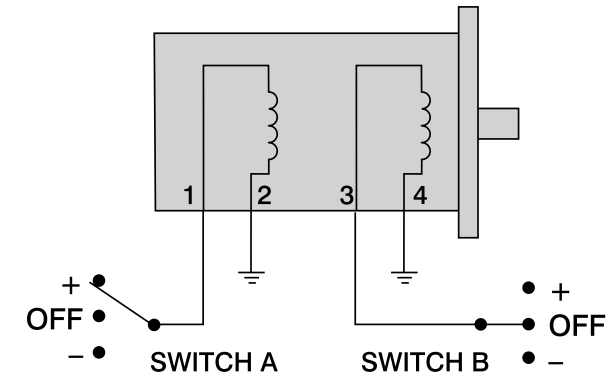
LAYOUT DIAGRAM OF STEP PER MOTOR SHOWING A GIVEN STATOR POLARITY AND ROTOR POSITION.

Figure 1: Cutaway 2∅ — Permanent Magnet Stepper Motor.

Interaction between the rotor and stator (opposite poles attracting and likes repelling) causes the rotor to move 1/4 of a pole pitch per winding polarity change. A 2-phase motor with 12 pole pairs per stator-coil section would thus move 48 steps per revolution or 7.5° per step.

ELECTRICAL INPUT

The normal electrical input is a 4-step switching sequence as is shown in Figure 2.



CW ROTATION ↓

STEP	COIL A	COIL B
1	+	OFF
2	OFF	+
3	–	OFF
4	OFF	–
1	+	OFF

CCW ROTATION ↑

Figure 2: Schematic — 4-Step Switching Sequence.

Continuing the sequence causes the rotor to rotate forward. Reversing the sequence reverses the direction of rotation. Thus, the stepper motor can be easily controlled by a pulse input drive which can be a 2-flip-flop logic circuit operated either open or closed loop. Operated at a fixed frequency, the electrical input to the motor is a 2-phase 90° shifted square wave as shown below in Fig. 3.

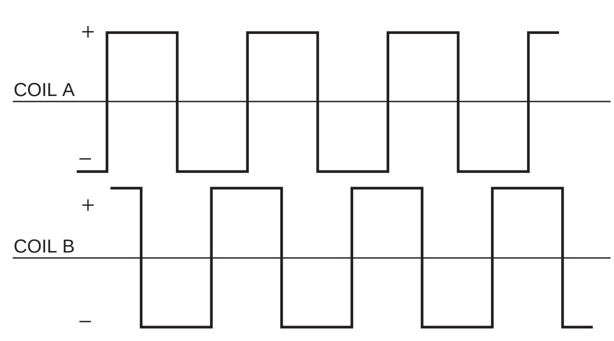


Figure 3: Voltage Wave Form — Fixed Frequency — 4-Step Sequence.

Since each step of the rotor can be controlled by a pulse input to a drive circuit, the stepper motor used with modern digital circuits, microprocessors and transistors provides accurate speed and position control along with long life and reliability.

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STEP ANGLE

Step angles for steppers are available in a range from .72° to 90°. Standard step angles for Thomson Airpax steppers are:

3.6º — 100 steps per rev.
7.5° — 48 steps per rev.
15° — 24 steps per rev.
18° — 20 steps per rev.

A movement of any multiple of these angles is possible. For example, six steps of a 15° stepper motor would give a movement of 90°.

ACCURACY

A 7.5° stepper motor, either under a load or no load condition, will have a step-to-step accuracy of 6.6% or 0.5º. This error is non-cumulative so that even after making a full revolution, the position of the rotor shaft will be 360º ± 0.5º.

The step error is noncumulative. It averages out to zero within a 4-step sequence which corresponds to 360 electrical degrees. A particular step characteristic of the 4-step is to sequence repeatedly using the same coil, magnetic polarity and flux path. Thus, the most accurate movement would be to step in multiples of four, since electrical and magnetic imbalances are eliminated. Increased accuracy also results from movements which are multiples of two steps. Keeping this in mind, positioning applications should use 2 or 4 steps (or multiples thereof) for each desired measured increment, wherever possible.

TORQUE

The torque produced by a specific stepper motor depends on several factors:

1/ The Step Rate
2/ The Drive Current Supplied to the Windings
3/ The Drive Design

HOLDING TORQUE

At standstill (zero steps/sec and rated current), the torque required to deflect the rotor a full step is called the *holding torque*. Normally, the holding torque is higher than the running torque and, thus, acts as a strong brake in holding a load. Since deflection varies with load, the higher the holding torque the more accurate the position will be held. Note in the curve below in Fig. 4, that a 2-step deflection corresponding to a phase displacement of 180, results in zero torque. A 1-step plus or minus displacement represents the initial lag that occurs when the motor is given a step command.

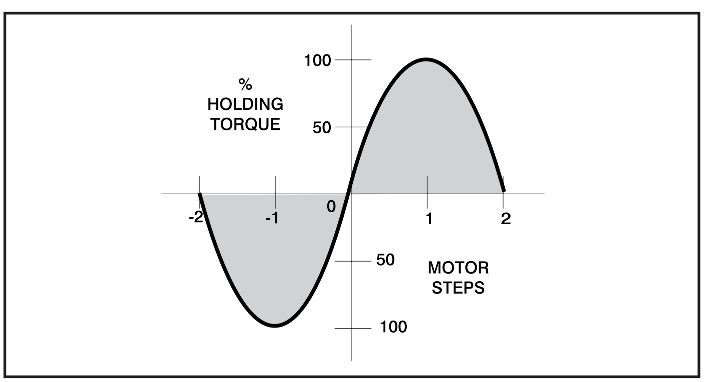

Figure 4: Torque Deflection.

RESIDUAL TORQUE

The non-energized detent torque of a permanent magnet stepper motor is called *residual torque*. A result of the permanent magnet flux and bearing friction, it has a value of approximately 1/10 the holding torque. This characteristic of PM steppers is useful in holding a load in the proper position even when the motor is de-energized. The position, however, will not be held as accurately as when the motor is energized.

DYNAMIC TORQUE

A typical torque versus step rate (speed) characteristic curve is shown in Figure 5.

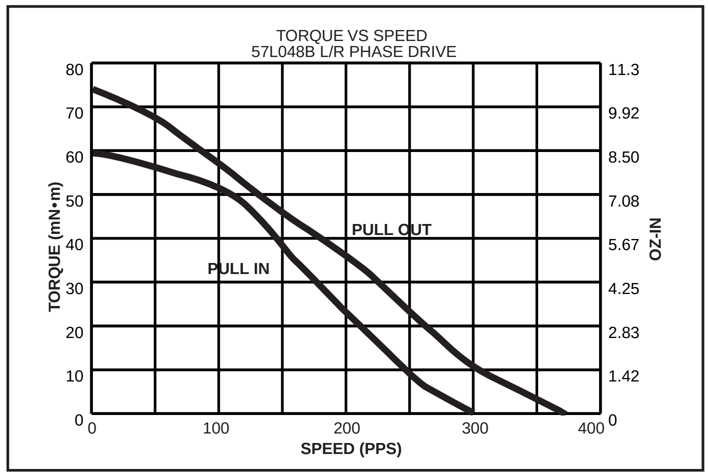

Figure 5: Torque/Speed — (Thomson Airpax 57L048B L/R Stepper).

The *PULL IN* curve shows what torque load the motor can start and stop without loss of a step when started and stopped at a constant step or pulse rate.

The *PULL OUT* curve is the torque available when the motor is slowly accelerated to the operating rate. It is thus the actual dynamic torque produced by the motor.

The difference between the *PULL IN* and *PULL OUT* torque curves is the torque lost due to accelerating the motor rotor inertia.

The torque/speed characteristic curves are key to selecting the right motor and control drive method for a specific application.

Note: In order to properly analyze application requirements, the load torque must be defined as being either *Frictional* and/*or Inertial*. (See Handy Formula Section in this engineering guide on pages 12 and 13 for resolving the load torque values. Also, an additional “Application Notes” section is located on pages 10 and 11.)

Use the *PULL IN* curve if the control circuit provides no acceleration and the load is frictional only.

Example: Frictional Torque Load.
Using a torque wrench, a frictional load is measured to be 25 mN•m (3.54 oz-in). It is desired to move this load 67.5° in .06 sec or less.

Solution:

1. If a 7.5° motor is used, then the motor would have to take nine steps to move 67.5°.
   A rate of $v = \frac{9}{.06}$ = 150 steps/sec or higher is thus required.
2. Referring to Fig. 6, the maximum *PULL IN* error rate with a torque of 25 mN•m is 185 steps/sec. (It is assumed no acceleration control is provided.)
3. Therefore, a 57L048B motor could be used at 150 steps per second — allowing a safety factor.

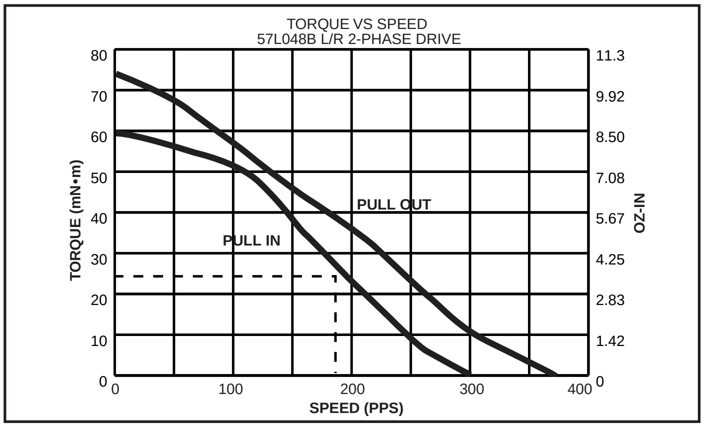

Figure 6: Torque/Speed — Frictional Load.

Use the *PULL OUT* curve, in conjunction with a Torque = Inertia x Acceleration equation (T= Jα), when the load is inertial and/or acceleration control is provided.

In this equation, acceleration or ramping $\alpha = \frac{\Delta v}{\Delta t}$ is in radians/sec^2.

RAMPING

Acceleration control or *ramping* is normally accomplished by gating on a voltage controlled oscillator (VCO) and associated charging capacitor. Varying the RC time constant will give different ramping times. A typical VCO acceleration control frequency plot for an incremental movement with equal acceleration and deceleration time would be as shown in Fig. 7.

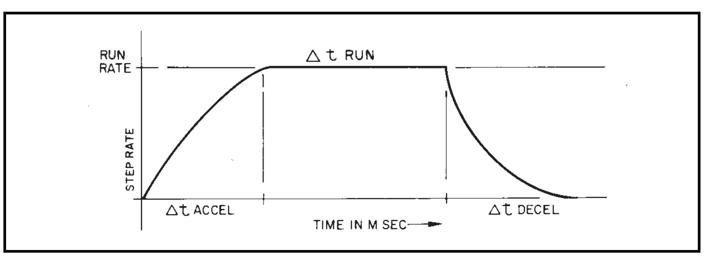

Figure 7: Step Rate/Time.

Acceleration also may be accomplished by changing the timing of the input pulses (frequency). For example, the frequency could start at a 1/4 rate, go to a 1/2 rate, 3/4 rate and finally the running rate.

A. Applications where:
Ramping acceleration or deceleration control time is allowed.

$$T_J(\text{Torque mN}\cdot\text{m}) = J_T \times \frac{\Delta v}{\Delta t} \times K$$

Where J_T = Rotor Interia (g•m^2) plus Load Inertia (g•m^2)

Δv = Step rate change

Δt = Time allowed for acceleration in seconds

$K = \frac{2\pi}{\text{steps/rev}}$ (converts steps/sec to radians/sec)

K = .13 for 7.5° — 48 steps/revolution
K = .26 for 15° — 24 steps/revolution
K = .314 for 18° — 20 steps/revolution

In order to solve an application problem using acceleration ramping, it is usually necessary to make several estimates according to a procedure similar to the one used to solve the following example:

Example: Frictional Torque Plus Inertial Load with Acceleration Control. An assembly device must move 4 mm in less than 0.5 sec. The motor will drive a lead screw through a gear ratio. The lead screw and gear ratio were selected so that 100 steps of a 7.5° motor = 4 mm. The total Inertial Load (rotor + gear + screw) = 25 x 10^{-4} g•m^2. The Frictional Load = 15 mN•m

Solution:

1. Select a stepper motor *PULL OUT* curve which allows a torque in excess of 15 mN•m at a step rate greater than

$$v = \frac{100 \text{ steps}}{0.5 \text{ sec}} = 200 \text{ steps/sec}$$

Referring to Fig. 8, determine the maximum possible rate (vF) with the frictional load only.

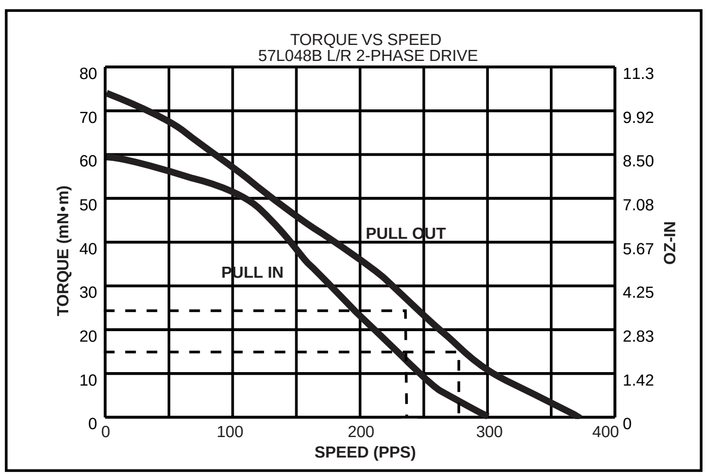

Figure 8: Torque/Speed — Friction Plus Inertia.
(Thomson Airpax 57L048B L/R Stepper).

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2. Make a first estimate of a working rate (a running rate less than the maximum) and determine the torque available to accelerate the inertia (excess over T_F).

$$T_1 - T_F = 23 - 15 = 8 \text{ mN}\bullet\text{m}$$

(torque available for acceleration at 240 steps/sec)

3. Using a 60% safety factor

$8 \text{ mN}\bullet\text{m} \times .6 = 4.8 \text{ mN}\bullet\text{m}$,

calculate Δt to accelerate. (Refer to Fig. 7).

From the $T_J = J_T \times \frac{\Delta v}{\Delta t} \times K$ equation,

$$4.8 \text{ mN m} = \frac{25 \times 10^{-4} \times 240 \times .13}{\Delta t}$$

Therefore, to accelerate $\Delta t = .016$ sec.

Note: The same amount of time is allowed to decelerate.

4. The number of steps used to accelerate and decelerate,

$$N_A + N_D = \frac{v}{2} \Delta t \times 2$$

or

$$N_A + N_D = v\Delta t$$

$$= 240\ (.016) = 4 \text{ steps}$$

5. The time to move at the run rate

$$\Delta t_{run} = N_T - (N_A + N_D) = \frac{100-4}{240} = .4 \text{ sec}$$

Where N_T = Total move of 100 steps

6. The total time to move is thus

$$\Delta t_{run} + \Delta t_{accel} + Dt_{decel}$$

$$.4 + .016 + .016 = .43 \text{ sec}$$

This is the first estimate. You may make the motor move slower if more safety is desired, or faster if you want to optimize it. At this time, you may wish to consider a faster motor drive combination as will be discussed on page 8.

B. Applications where:
No ramping acceleration or deceleration control time is allowed.

Even though no acceleration time is provided, the stepper motor can lag a maximum of two steps or 180 electrical degrees. If the motor goes from zero steps/sec to v steps/sec, the lag time Δt would be

$$\frac{2}{v} \text{ sec}$$

Thus, the torque equation for no acceleration or deceleration is:

$$\textbf{T (Torque mN}\bullet\textbf{m)} = J_T \times \frac{v^2}{2} \times K$$

Where:

J_T = Rotor Inertia ($g\bullet m^2$) plus Load Inertia ($g\bullet m^2$)

v = steps/sec rate

$$K = \frac{2\pi}{\text{step/rev}}$$

("K" values as shown in application A on page 4)

Example: Friction Plus Inertia – No Acceleration Ramping.
A tape capstan is to be driven by a stepper motor. The frictional drag torque (T_F) is 15.3 mN•m and the inertia of the capstan is 10 x 10^{-4} $g\bullet m^2$. The capstan must rotate in 7.5° increments at a rate of 200 steps per second.

Solution:
Since a torque greater than 15.3 mN•m at 200 steps per second is needed, consider a 57L048B motor.

The Total Inertia = Motor Rotor Inertia + Load Inertia.

$$J_T = J_R + J_L$$

$$= (34 \times 10^{-4} + 10 \times 10^{-4})\ g\bullet m^2$$

$$= 44 \times 10^{-4}\ g\bullet m^2$$

1. Since there is no acceleration ramping, use the equation:

$$T_J = J_T \times \frac{v^2}{2} \times K \quad (K = .13)$$

$$T_J = 44 \times 10^{-4} \times \frac{200^2}{2} \times .13$$

$$T_J = 11.4 \text{ mN}\bullet\text{m}$$

2. Total Torque $= T_F + T_J$

$$= 15.3 + 11.4$$

$$= 26.7 \text{ mN}\bullet\text{m}$$

3. Refer to the *PULL OUT* curve Fig. 9, at speed of 200 pulses per second, where the available torque is 35 mN•m. Therefore, the 57L048B motor can be selected with a safety factor.

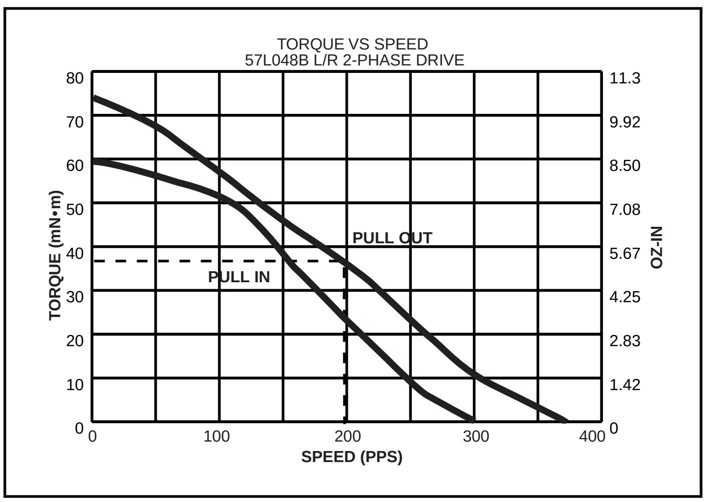

Figure 9: Torque/Speed — Friction Plus Inertia. (Thomson Airpax 57L048B L/R Stepper).

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STEP FUNCTION - SINGLE STEP

When a single step of a motor is made, a typical response is as shown in Figure 10.

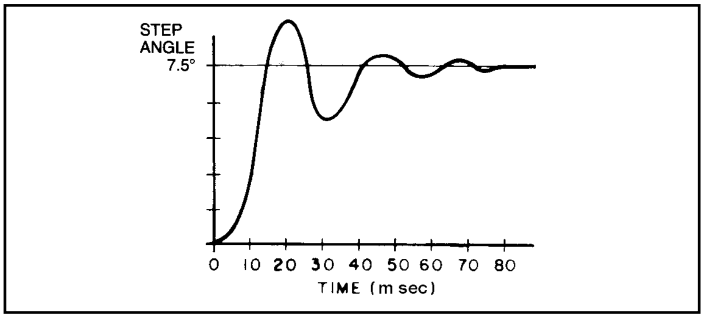


Figure 10: Single Step Response.

The actual response for a given motor is a function of the power input provided by the drive and the load. Increasing the frictional load or adding external damping can thus modify this response, if it is required.

Mechanical dampers (e.g., slip pads or plates), or devices such as a fluid coupled flywheel can be used, but add to system cost and complexity. Electronic damping also can be accomplished. Step sequencing is altered to cause braking of the rotor, thus minimizing overshoot.

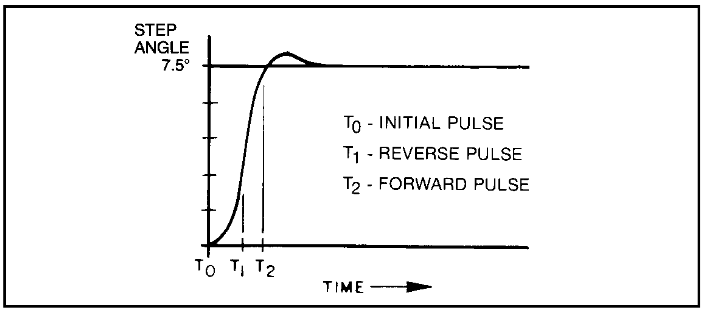


Figure 11: Electronically Damped Response.

STEP FUNCTION - MULTIPLE STEPPING

Multiple stepping can offer several alternatives. A 7.5° motor moving 12 steps (90º), or a 15° motor moving six steps (90º) to give a 90° output move would have less overshoot, be stiffer, and relatively more accurate than a motor with a 90° step angle. Also, the pulses can be timed to shape the velocity of the motion; slow during start, accelerate to maximum velocity, then decelerate to stop with minimum ringing.

RESONANCE

If a stepper motor is operated no load over the entire frequency range, one or more natural oscillating resonance points may be detected, either audibly or by vibration sensors. Some applications may be such that operation at these frequencies should be avoided. External damping, added inertia, or a microstepping drive can be used to reduce the effect of resonance. A permanent magnet stepper motor, however, will not exhibit the instability and loss of steps often found in variable reluctance stepper motors, since the PM has a higher rotor inertia and a stronger detent torque.

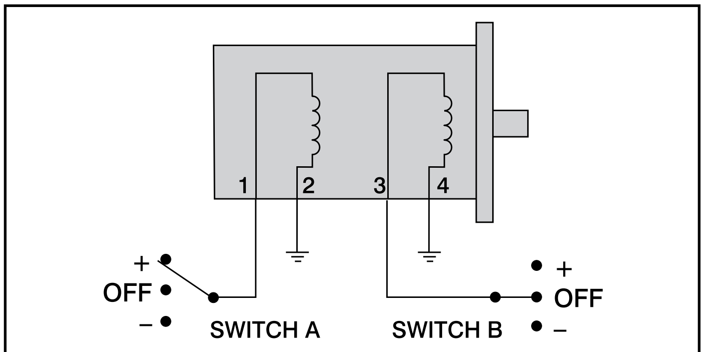
DRIVE METHODS

The normal drive method is the 4-step sequence shown in Fig. 2, (page 2); however, the following methods are also possible.

WAVE DRIVE

Energizing only one winding at a time, as indicated in Fig. 12 is called *Wave Excitation*. It produces the same increment as the 4-step sequence.

Since only one winding is on, the hold and running torque with rated voltage applied will be reduced 30%. Within limits, the voltage can be increased to bring output power back to near rated torque value. The advantage of this type of drive is increased efficiency, while the disadvantage is decreased step accuracy.



CW ROTATION / CCW ROTATION

STEP	COIL A	COIL B
1	+	OFF
2	OFF	+
3	–	OFF
4	OFF	–
1	+	OFF

Figure 12: Schematic — Wave Drive Switching Sequence.

HALF STEP

It is also possible to step the motor in an 8-step sequence to obtain a half step — such as a 3.75° step from a 7.5° motor, as in Fig. 13.

For applications utilizing this, you should be aware that the holding torque will vary for every other step, since only one winding will be energized for a step position; but, on the next step two windings are energized. This gives the effect of a strong step and a weak step. Also, since the winding and flux conditions are not similar for each step when 1/2 stepping, accuracy will not be as good as when full stepping.

CW ROTATION / CCW ROTATION

STEP	COIL A	COIL B
1	+	+
2	+	OFF
3	+	-
4	OFF	-
5	-	-
6	-	OFF
7	-	+
8	OFF	+
1	+	+

Figure 13: Half Step or 8-Step Switching Sequence.

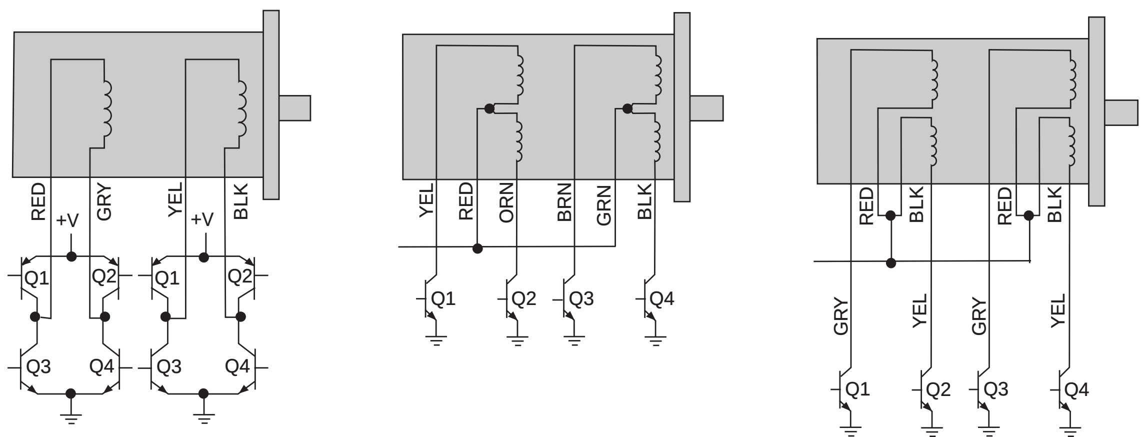
BIPOLAR AND UNIPOLAR OPERATION

All Thomson Airpax stepper motors are available with either 2-coil *Bipolar*, or 4-coil *Unipolar* windings.

The stator flux with a Bipolar winding is reversed by reversing the current in the winding. It requires a push-pull Bipolar drive as shown in Fig. 14. Care must be taken to design the circuit so that the transistors in series do not short the power supply by coming on at the same time. Properly operated, the Bipolar winding gives the optimum motor performance at low-to-medium step rates.

A Unipolar winding has two coils wound on the same bobbin (one bobbin resides in each stator half) per stator half. Flux is reversed in each coil bobbin assembly by sequentially grounding ends of each half of the coil winding. The use of a Unipolar winding, sometimes called a *bifilar winding*, allows the drive circuit to be simplified. Not only are half as many power switches required (4 vs. 8), but the timing is not as critical to prevent a current short through two transistors as is possible with a Bipolar drive.

For a Unipolar motor to have the same number of turns per winding as a Bipolar motor, the wire diameter must be decreased and the resistance increased. As a result, Unipolar motors have 30% less torque at low step rates. However, at higher rates the torque outputs are equivalent.



BIPOLAR

UNIPOLAR

Normal 4-Step Sequence (CW ROTATION / CCW ROTATION)

Bipolar:

Step	Q_1-Q_4	Q_2-Q_3	Q_5-Q_8	Q_6-Q_7
1	ON	OFF	ON	OFF
2	ON	OFF	OFF	ON
3	OFF	ON	OFF	ON
4	OFF	ON	ON	OFF
1	ON	OFF	ON	OFF

Unipolar:

Step	Q_1	Q_2	Q_3	Q_4
1	ON	OFF	ON	OFF
2	ON	OFF	OFF	ON
3	OFF	ON	OFF	ON
4	OFF	ON	ON	OFF
1	ON	OFF	ON	OFF

1/2 Step 8-Step Sequence (CW ROTATION / CCW ROTATION)

Bipolar:

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

Unipolar:

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

Wave Drive 4-Step Sequence (CW ROTATION / CCW ROTATION)

Bipolar:

1	ON	OFF	OFF	OFF
2	OFF	OFF	OFF	ON
3	OFF	ON	OFF	OFF
4	OFF	OFF	ON	OFF
1	ON	OFF	OFF	OFF

Unipolar:

1	ON	OFF	OFF	OFF
2	OFF	OFF	OFF	ON
3	OFF	ON	OFF	OFF
4	OFF	OFF	ON	OFF
1	ON	OFF	OFF	OFF

Figure 14: Schematic Bipolar and Unipolar Switching Sequence. Direction of Rotation Viewed from Shaft End.

HIGHER PERFORMANCE

A motor operated at a fixed rated voltage has a decreasing torque curve as the frequency or step rate increases. This is due to the fact that the rise time of the coil limits the percentage of power actually delivered to the motor. This effect is governed by the inductance to resistance ratio of the circuit (L/R).

Compensation for this effect can be achieved by either increasing the power supply voltage to maintain a constant current as the frequency increases, or by raising the power supply voltage and adding a series resistor in the L/4R drive circuit (See Fig. 15). Note that as the L/R is changed, more total power is used by the system.

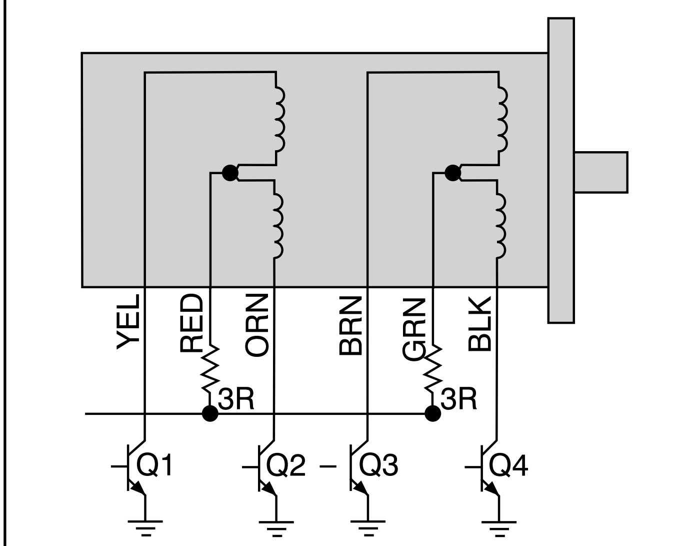


Figure 15: L/4R Drive

The series resistors, R, are selected for the L/R ratio desired. For L/4R they are selected to be three times the motor winding resistance with a wattage rating = (current per winding)^2 x R.

The power supply voltage is increased to four times motor rated voltage so as to maintain rated current to the motor. The power supplied will thus be four times that of a L/R drive.

Note, the Unipolar motor which has a higher coil resistance, thus has a better L/R ratio than a Bipolar motor.

To minimize power consumption, various devices such as a bi-level power supply or chopper drive may be used.

BI-LEVEL DRIVE

The bi-level drive allows the motor at zero steps/sec to hold at a lower than rated voltage. When stepping, it runs at a higher than rated voltage. It is most efficient when operated at a fixed stepping rate. The high voltage may be switched on through the use of a current sensing resistor, or by a circuit (See Fig. 16) which uses the inductively generated turnoff current spikes to control the voltage.

At zero steps/sec the windings are energized with the low voltage. As the windings are switched according to the 4-step sequence, the suppression diodes D_1, D_2, D_3 and D_4 are used to turn on the high voltage supply transistors S_1 and S_2.

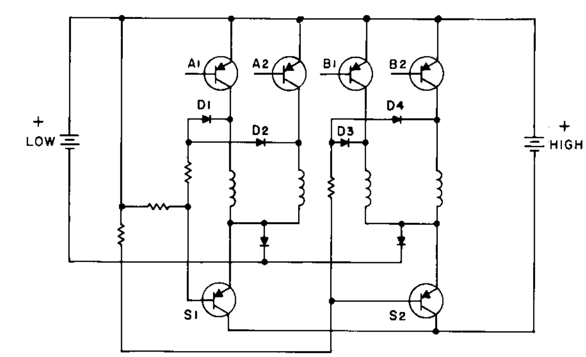


Figure 16: Unipolar Bi-Level Drive.

CHOPPER DRIVE

A chopper drive maintains an average current level through the use of a current sensor, which turns on a high voltage supply until an upper current value is reached. It then turns off the voltage until a low level limit is sensed, when it turns on again. A chopper is best for fast acceleration and variable frequency applications. It is more efficient than a constant current amplifier regulated supply. The V+ in the chopper shown in Fig. 17 typically would be five to six times the motor voltage rating.

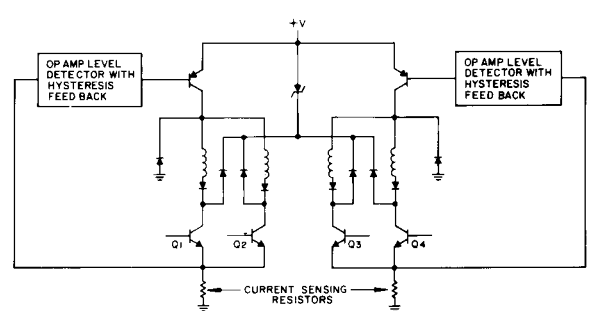


Figure 17: Unipolar Chopper Drive.

VOLTAGE SUPPRESSION

Whenever winding current is turned off, a high voltage inductive spike will be generated, which can damage the drive circuit. The normal method used to suppress these spikes is to put a diode across each winding. This, however, will reduce the torque output of the motor, unless the voltage across the switching transistors is allowed to build up to at least twice the supply voltage. The higher this voltage, the faster the induced field, and current will collapse, and thus the better performance. For this reason, a zener diode or series resistor is usually added as shown in Figure 18.

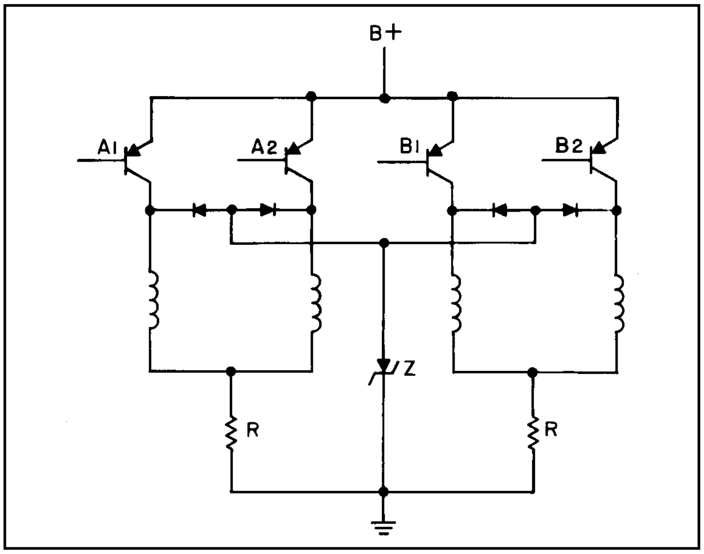


Figure 18: Voltage Suppression Circuit.

PERFORMANCE LIMITATIONS

Increasing the voltage to a stepper motor at standstill or low stepping rates will produce a proportionally higher torque until the magnetic flux paths within the motor saturate. As the motor nears saturation, it becomes less efficient and thus does not justify the additional power input.

The maximum speed a stepper motor can be driven is limited by hysteresis and eddy current losses. At some rate, the heating effects of these losses limit any further effort to get more speed or torque output by driving the motor harder.

TORQUE MEASUREMENT

The output torque of a stepper motor and drive can best be measured by using a bridge type strain gage coupled to a magnetic particle brake load. A simple pulley and pull spring scale also can be used, but is difficult to read at low and high step rates.

MOTOR HEATING AND TEMPERATURE RISE

Operating continuous duty at rated voltage and current will give an approximate 40°C motor winding a temperature rise. If the motor is mounted on a substantial heat sink, however, more power may be put into the windings. If it is desired to push the motor harder, a maximum motor winding temperature of 100°C should be the upper limit. Motor construction can be upgraded to allow for a winding temperature of 120°C (60°C rise).

SUMMARY OF KEY TORQUE EVALUATIONS

The torque-speed characteristic curves are key to selecting the right motor and the control drive method for a specific application.

Define your application load.

Use the PULL IN curve if the control circuit provides no acceleration and the load is frictional only.

Use the PULL OUT curve, in conjunction with a Torque = Inertia x Acceleration equation (T = Jα), when the load is inertial and/or acceleration control is provided.

When acceleration ramping control is provided, use the PULL OUT curve and this torque equation:

$$T_J \text{ (Torque mN}\bullet\text{m)} = J_T \times \frac{\Delta V}{\Delta t} \times K$$

When no acceleration ramping control is provided, use the PULL OUT curve and this torque equation:

$$T \text{ (Torque mN}\bullet\text{m)} = J_T \times \frac{v^2}{2} \times K$$

Motor Selection Guidelines

1. **Based on frictional torque and speed, make a first estimate motor selection.**
2. **Use torque equations and motion plot to evaluate.**
3. **If necessary, select another motor and/or modify the drive.**
4. **Secure prototype and test.**

Formula for determining temperature rise of a motor (using coil resistance) is:

Motor T rise °C =

$$\frac{R\ hot}{R\ cold}\ (234.5 + T\ amb\ cold) - (234.5 + T\ amb\ hot)$$

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Applying a stepper motor can be relatively easy or it can be complex. As a designer gains experience, the versatility and ways to use a stepper motor become more obvious. These application notes should be an aid to you in gaining this experience.

SELECTION GUIDE

The following elements should be considered in selecting a stepper motor:

1. Frictional torque required in mN•m
2. Load inertia in g•m^2
3. Move required in degrees
4. Time to complete move in sec
5. Number of steps and step angle in movement
6. Step rate in steps per sec
7. Acceleration - Deceleration time in sec
8. Power available
9. Drive System (Unipolar and/or Bipolar)
10. Size; Weight; Shaft and Mounting considerations

The importance of any of the above elements will, of course, depend on system and budget considerations. Some apply only to positioning type applications. Other considerations should be taken into account for fixed speed or variable speed applications. These might include:

1. RPM required
2. Maximum/Minimum pulse rate required
3. Pulse or frequency source accuracy
4. Allowable velocity variations
5. Resonance

OPEN LOOP

The features of a stepper motor make it an ideal open loop device for providing precise pulse-to-step movements in a variety of positioning applications from printer paper feeds to small clocks. Most applications are open loop. When operated open loop, always assume worst case values in calculating loads. If you measure average values, allow at least a 20% safety factor. Some applications run open loop with a periodic verification. For example, an electronic typewriter may be character advanced open loop with the line return end position verified by a sensor.

Variable speed or fixed speed applications such as chart drives or reagent pumps take advantage of the fact that variations in torque do not effect the output speed, which is as accurate as the pulse source. For applications such as these you should avoid running at certain frequencies because of resonance.

CLOSED LOOP

Various devices such as optical encoders or magnetic Hall effect sensors may be used to close the control loop in order to obtain the maximum torque and/or acceleration from a given stepper motor.

In a typical closed loop system, a 2-quadrature track encoder capable of detecting direction could be used to sense that a step has been made before allowing the next pulse to step the motor.

Obviously, the closed loop system will be more complicated and expensive than open loop, but it will have the ability to handle a wide variation in load conditions with optimum acceleration and reliability. Closed loop operation also can be used to stabilize resonance in variable speed applications.

A more detailed analysis of both open and closed loop performance is beyond the scope of this guide; however, it can be obtained by referring to the proceedings from *Incremental Motion Control Systems and Devices, University of Illinois*, 1972 to 1998 issues.

LOAD COUPLING, GEARS AND PULLEYS, LEAD SCREWS

Other than the added inertia of the coupling, a properly aligned direct coupling will present the load as it is.

Gears, however, will increase or decrease the load by the gear ratio as is shown in the *Handy Formula Section (pages 12-13)*. It is not recommended to gear up, such as to make a 30° movement with a 15° stepper motor. The torque reflected to the motor in this case would be twice the frictional load torque and the inertia would be four times the inertia load.

It would be better to take two motor steps to get the 30° movement, or if the motor load were high, take four motor steps of 7.5° and gear down 2:1 speed torque curve permitting. In this instance, the motor would see only 1/2 the frictional load and 1/4 the inertial load.

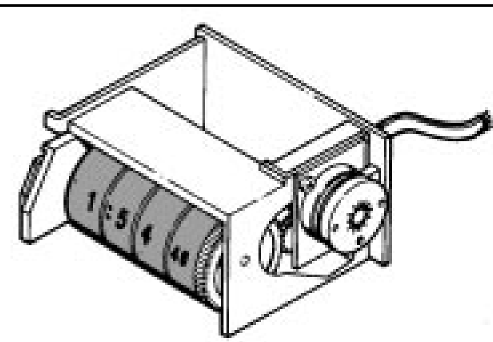
Equations using lead screws also are given in the *Handy Formula Section*. Note how the load to the motor is reduced when the lead of the screw is small.

The following examples show how three typical systems were designed.

1. FIXED SPEED APPLICATION

A stepper motor being run at a fixed speed is in reality a synchronous motor running on square waves.

Typical applications running at fixed frequencies are timing devices, recorders, meters and clocks.



One such system, a DC operated clock, uses a small stepper motor and drive with signal pulses supplied by a 240 Hz crystal oscillator module. The 240 Hz signal generates the equivalent of 60 Hz 2-phase operation. When operated at this pulse rate, a 15° stepper rotates at 600 RPM and will be as accurate as the crystal rate.

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2. POSITIONING TYPE APPLICATION

A computer peripheral type serial character printer is a typical positioning application. The stepper motor is used to advance the paper for line feed.

The printer prints either six or eight lines per inch.

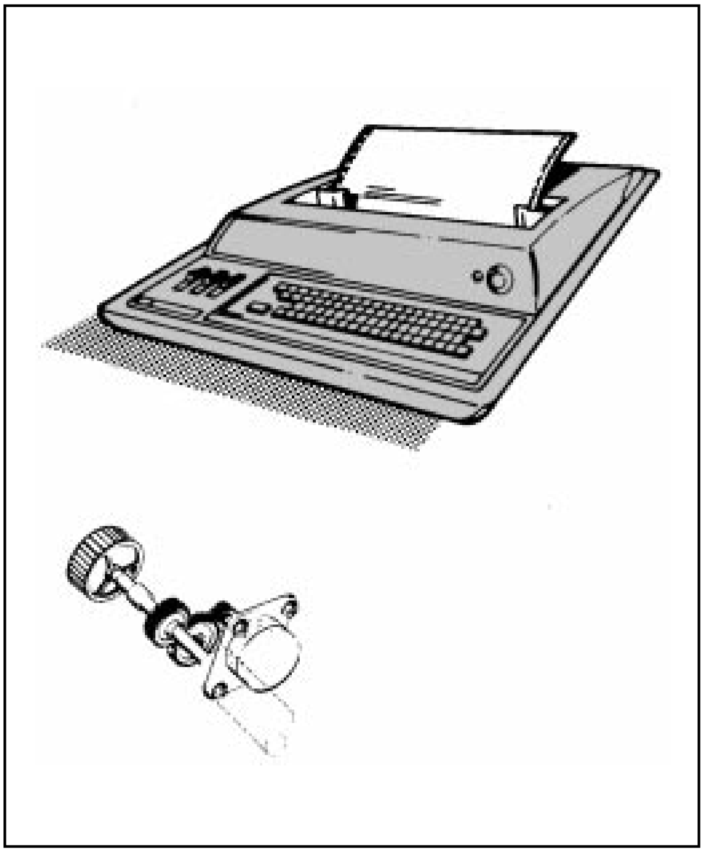
A 4.5:1 gear ratio is used between the paper roller and the motor. A 7.5° stepper motor taking eight steps per incremental movement will advance the paper at six lines per inch. A simple control logic change makes the motor take six steps per movement giving eight lines per inch.

The reflected frictional load to the motor is 22% of the frictional load of the roller and paper and only 5% of the inertial load because of the gear ratio.

Since the motor always takes at least six pulses to move a line, the timing of the pulses is spaced or ramped so as to accelerate and decelerate the motor in the fastest time with minimum ringing.

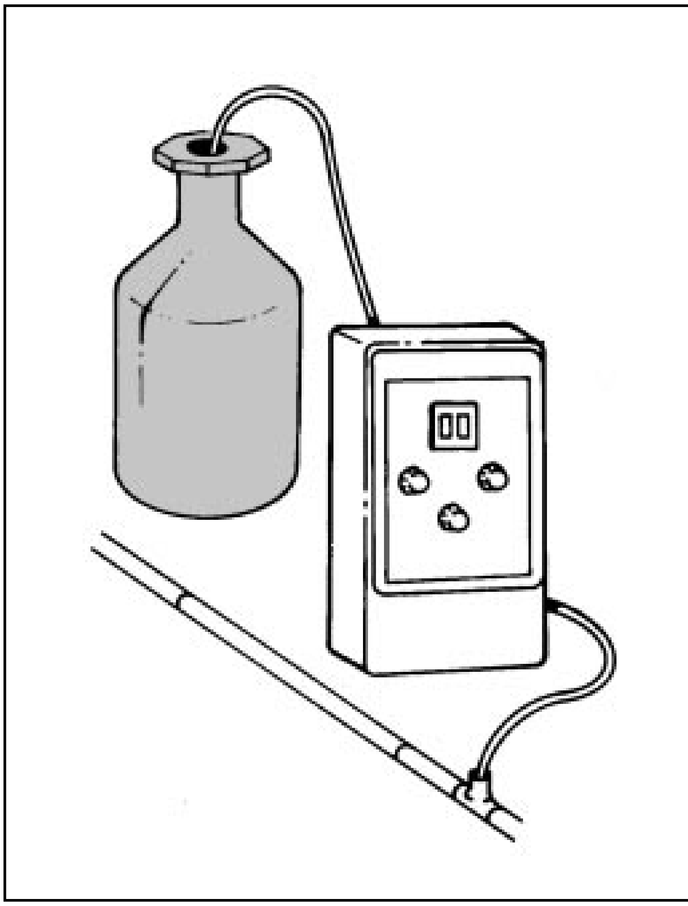
In order to get the maximum line feed rate, the motor is driven by a a bi-level supply which puts five times rated voltage on the motor when stepping and drops down to 25% rated voltage when not being stepped. This allows maximum input power during stepping and minimum dissipation during standstill.

Additionally, the accuracy of the spacing between lines is optimum, since the motor is stepped in multiples of four or two.



3. VARIABLE SPEED APPLICATION

Many variable speed applications use DC motors with the speed of the motor being controlled by velocity feedback devices. Since problems of life, noise and complexity of feedback servo make the use of a DC motor unsatisfactory, it is more advantageous to use stepper motors in applications such as a reagent pump.



Reagent pumps are used to dispense various solutions at preselected rates. A crystal oscillator is used as the base frequency. Sub-multiples of this frequency are obtained by dividing the base frequency to get the desired feed rates.

A 4:1 ratio pulley and belt couple the 7.5° stepper motor to the pump. The stepper motor was selected on the basis of the maximum running rate torque required with a 50% safety factor. Since the feed rates are fixed by the crystal, torque load variations within the range have no effect on the rate the fluid is dispensed.

The relative low shaft speed of the motor and the absence of brushes provide the long motor life required of the pump. Also, the stepper motor has the ability to be pulsed from very low rates to very high rates, thus giving the pump a possible flow rate range of 1000:1. A practical open loop DC system speed range is only about 10:1.

Primary units in this guide are metric (SI – the International System of units):

Length - m - (meter)
Mass - g - (gram)
Force - mN - (millinewton)
Torque - mN•m - (millinewton meter)
Inertia - g•m^2 - (gram meter^2)

In this system, mass is always in kilograms or grams. Force, or weight, is always in newtons or millinewtons.

Force (or weight) = Mass x Acceleration

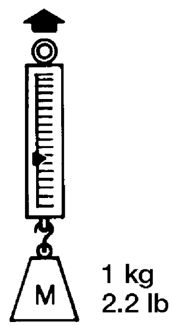
$$F = ma$$

when a = 9.81 m/sec^2 (acceleration due to gravity), then F would be the weight in newtons.

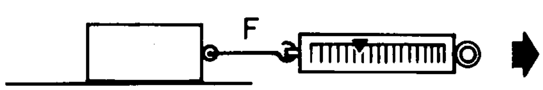
How to measure Mass or Force.

A spring scale reading of 1 kg means that you are measuring a mass of 1 kg.

A spring scale reading of 2.2 lb also is measuring a mass of 1 kg.



If you use that same spring scale to measure a force, the 1 kg reading must be multiplied by 9.8 to give a force of 9.8 newtons.



The reading of 2.2 lb is a force and is equal to 9.8 newtons.

If the same scale is used to measure torque (T = FR) at a one meter radius, the reading of

1 kilogram x 1 meter = 1 kgm

must be multiplied by 9.8 to give a torque of 9.8 newton meters (N•m).

	Given Unit				Units Used in this Manual (Metric SI)
Length	1 inch	=	2.54 cm	=	2.54 X 10^{-2}m
Force	1 oz	=		=	278 mN
	1 lb	=	4.45 N	=	4,450 mN
	1 g•cm	=		=	9.8 mN
Mass	1 lb	=		=	454g
	1oz	=		=	28.4g
	1kg	=		=	1,000g
	1 slug	=	14.6 kg	=	14,600g
Inertia	1 g•cm^2	=		=	10^{-4} g•m^2
	1 oz-in-sec^2	=		=	7.06 g•m^2
	1 slug ft^2	=		=	.29 g•m^2
Torque	1 oz-in	=	72.01 g•cm	=	7.06 mN•m
	1 lb-ft	=		=	1.356 x N•m
	1 g•cm	=		=	9.8 x 10^{-2} mN•m
			10.2 g•cm	=	1 mN•m
			141.6 oz-in	=	1 N•m

1. Torque (mN•m) = Force (mN) x Radius (m)

Torque = FR

2. Torque required to accelerate inertial load

$$\mathbf{T\ (mN{\bullet}m) = J\ \alpha}$$

J = Inertia in g•m^2

α = Acceleration in radians/sec^2

EXAMPLE:
If a rotor inertia plus load inertia = J = 2 x 10^{-3} g•m^2, and the motor is to be accelerated at 6,000 radians per sec, what torque is required?

$T = J\alpha = 2 \times 10^{-3} \times 6000$
$T = 12$ mN•m

For stepper motors, α can be converted to radians/sec^2 from steps/sec^2.

$$\alpha\ \text{(radians/sec)} = \frac{\Delta v\ \text{(steps/sec)}}{\Delta t\ \text{(accel. time)}} \times \frac{2\pi}{\text{steps/rev}}$$

$$\mathbf{TORQUE = J\ \frac{\Delta v}{\Delta t} \times \frac{2\pi}{steps/rev}}$$

EXAMPLE:
For a 48-step per revolution motor accelerating from zero to steps/sec running rate v in Δt seconds.

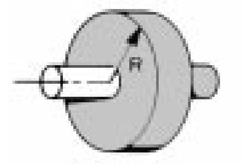
$$\text{TORQUE} = J\ \frac{v}{\Delta t} \times \frac{\pi}{24}$$

If no *acceleration time* is provided, then a maximum 2-step lag can occur.

Δt (sec) $= \dfrac{2 \text{ (steps)}}{v \text{ (steps/sec)}}$ giving the following equation.

$$\textbf{TORQUE} = J \frac{V^2}{2} \times \frac{2\pi}{\text{steps/rev}}$$

3. Moment of Inertia



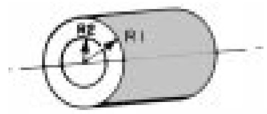
Disc or shaft

M = Mass in grams

R = Radius in meters

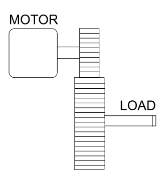
$$J\ (g \bullet m^2) = \frac{MR^2}{2}$$

Cylinder



$$J\ (g \bullet m^2) = \frac{M^2}{2}\ (R^2_1 + R^2_2)$$

4. Reflected loads when using gears or pulleys

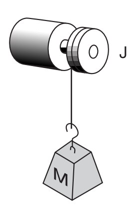


$$\textbf{Torque required of motor} = \frac{\text{Load Torque}}{GR}$$

$$\text{gear or pulley ratio GR} = \frac{\text{motor shaft revolutions}}{\text{load shaft revolutions}}$$

$$\textbf{Inertia reflected to motor} = \frac{\text{Load intertia}}{(GR)^2}$$

5. Equivalent Inertial Load
For a pulley and weight or a rack and pinion



J eqv. $(g \bullet m^2) = MR^2$

M = Mass of load in grams
R = Radius of pulley in meters

6. Total Load
Note: Be sure to include all load components.

J_T = Rotor Inertia + all J Loads

T_F = Frictional and Forces

Note: In the pulley example above, the total load would be:

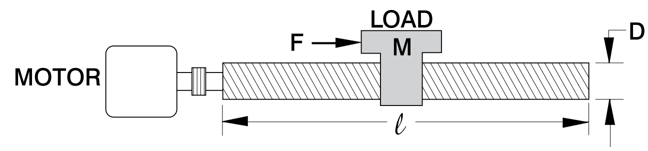
J_T = J rotor + J pulley + J eqv.

T_F = T frictional + Load Weight x Radius

Total T = $J_T\ \alpha + T_F$

The load weight = mass x 9.8 millinewtons.

7. Axial Force of Lead Screw



$$F = \frac{2\pi \times T}{L} \times \text{eff.}$$

F (mN) when T = Torque in mN•m

L = Lead of screw in meters

F (oz) when T = Torque in oz-in

L = Lead of screw in inches

efficiency = from .9 for ballnut to .3 for Acme

Inertia of lead screw load

J = J rotor + J steel screw + J reflected

$$\text{J steel screw} = D^4 \times \backslash \times \frac{\pi}{32} \times \text{Density}$$

Density for steel = 7.83 x 106 g/m³

then:

$$J\ (g \bullet m^2) = D^4\ \backslash \times 7.7 \times 10^5$$

The reflected inertia of the load is:

$$\textbf{J reflected}\ (g \bullet m^2) = M\ (\text{load})\ L^2 \times .025$$

Total Torque Load from lead screw (T) in mN•m

T = (J rotor + J screw + J reflected) α + T friction

8. Motor watts output

Watts out = Torque output x speed in radians/sec

1 watt = 1 Nm/sec

For a given output Torque (mN•m) and converting v (steps/sec) to radians/sec

$$\textbf{Watts out} = \textbf{Torque}\ (mN \bullet m) \times v \frac{(\text{motor step angle})}{57.3} \times 10^{-3}$$

If the speed is in RPM then:

Watts out = 1.05×10^{-4} x torque (mN•m) x RPM

9. Steps/sec to RPM

$$\textbf{RPM} = \frac{v\ (\text{steps/sec}) \times 60}{\text{motor steps/rev}}$$

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Permanent Magnet Stepper And Geared Motors

Thomson Airpax Mechatronics manufactures permanent magnet (PM) stepper motors. They have a stator construction that consists of bobbin wound coils surrounded by a "claw tooth" pole configuration and a rotor assembly that includes a multi-pole ring magnet.

- Standard Industry configuration for drop-in replacement
- Motor sizes from ϕ15mm to ϕ60mm, with step angles ranging from 3.6° to 18°
- Simple mechanical construction with proven design characteristics
- Self-lubricating sintered bronze bearings
- Ideal for high volume production

Permanent magnet motors also are available with gear reductions, which provide the following advantages:

- Higher motor output torque (35.3 mN•m/5 oz-in to 13.56 mN•m/10 lb-ft) with compact gear train packages
- Gearboxes adaptable to 26mm, 35mm, 42mm & 57mm frame size motors
- Available in wide range of gear and pinion materials for optimum cost and performance
- Standard Industry configuration for drop-in replacement
- Reduces impact of load inertia
- Full utilization of the maximum motor power

Thomson Airpax Mechatronics motor products are ideally suited for applications such as:

- Computer Peripherals
- Office Automation
- HVAC
- Medical
- Instrumentation
- Communications

Call or E-Mail and discuss your application with an expert

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motorinfo@snet.net

Europe: (44) 1276-691622
info@tammail.com

Asia: (65) 7474-888
airpax@tamsales.com.sg

Application Chart

The applications for Permanent Magnet, Hybrid, Value Added (Gear-Train & DLA) Stepper Motors and Brushless DC Motors are virtually unlimited. Listed here are some typical motion control applications where reliability, repeatability, and controllability are most important.

	PM Stepper & Hybrid Stepper	Geared Stepper	Digital Linear Actuator (DLA)	Brushless DC Motor (BLDC)
COMPUTER PERIPHERAL				
Disk Drive	■			■
Ink Jet/Laser Printers	■			■
Thermal/Dot Matrix Printers	■			
Plotter	■		■	
Page/Document Scanner	■	■		
OFFICE AUTOMATION				
Copy Machine	■			■
Facsimile Machine	■			
Typewriter/Printer	■		■	
Identification/Smart Card	■			
Bar-Code Machine	■	■		■
Mail Handling System	■			■
HVAC				
Valves	■	■	■	
Dampers	■	■	■	■
Thermostats	■			
GAMING				
Slot Machine	■			
MEDICAL				
Peristaltic Pump	■	■		
Fluid Metering	■	■		■
Pipette	■		■	
Blood Analyzer	■	■	■	■
INSTRUMENTATION				
Chart Recorder	■	■		
Camera, Optical Scope	■	■	■	
Buoy		■		
Security Camera	■	■	■	■
Laser Alignment		■		■
Robotics	■	■	■	■
Telecommunications	■	■	■	
Satellite Antenna	■	■		■

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Permanent Magnet Stepper Motor

SERIES	Holding Torque (Min.) (mN•m/oz-in)	Step Angle (Degrees)	Steps/Rev	DC Operating Voltage	Resistance/Windings Ω Unipolar 5 Vdc	Resistance/Windings Ω Unipolar 12 Vdc	Page for full Specs
15M020D	3.33/.55	18	20	5	40	–	**17**
26M048B	7.0/0.99	7.5	48	5 or 12	20	110	**18**
26M024B	5.5/0.78	15	24	5 or 12	20	110	**19**
35M048B	17.4/2.6	7.5	48	5 or 12	12.5	72	**20**
35M024B	16.2/.2.3	15	24	5 or 12	12.5	72	**20**
35M020B	13.4/1.9	18	20	5 or 12	12.5	72	**20**
35L048B	25.0/3.5	7.5	24	5 or 12	11.0	64	**21**
35L024B	21.1/3.0	15	24	5 or 12	11.0	64	**21**
35L020B	17.7/2.5	18	20	5 or 12	11.0	64	**21**
42M048C	73.4/10.4	7.5	48	5 or 12	9.1	52.4	**22**
42M100B	33/4.8	3.6	100	5 or 12	12.5	75	**23**
57L048B	113/16.0	7.5	48	5 or 12	6.3	36	**24**
57M024B	55/7.8	15	24	5 or 12	6.3	36	**24**
57M048B	74/10.5	7.5	48	5 or 12	6.3	36	**24**
60L048B	198/28	7.5	48	5 or 12	4.6	26.0	**25**
60L024B	141/20	15	24	5 or 12	4.6	26.0	**25**
4SQ	65/9.2	1.8	200	12	–	74.0	**26**
4SHG (46mm)	388/55	1.8	200	6 to 12	7 Ω @ 6 Vdc	104 Ω @ 24 Vdc	**27**
4SHG (56mm)	600/85	1.8	200	6 to 12	4.7 Ω @ 6 Vdc	79 Ω @ 24 Vdc	**27**

Permanent Magnet Stepper Motor with Gear Trains

SERIES	Gear Train Rating (Running) (mN•m/oz-in)	Gear Train Rating (Static) (mN•m/oz-in)	Shape of Gear Box	DC Operating Voltage	Resistance/Windings Ω Unipolar 5 Vdc	Resistance/Windings Ω Unipolar 12Vdc	Page for full Specs
26M048B-V	70.6/10	141.2/20	Football	5 or 12	20.0	110.0	**28**
35M048B-X	35.3/5	141.2/20	Pear	5 or 12	12.5	72.0	**29**
42M048C-R	706/100	1.06 N•m/150	Round	5 or 12	9.1	52.4	**30**
42M048C-Z	1.4 N•m/200	2.12 N•m/300	Pear	5 or 12	9.1	52.4	**31**

Digital Linear Actuator

SERIES	Linear Travel Per Step mm/in	Maximum Force	Min. Holding Force (Unenergized)	DC Operating Voltage	Resistance/Windings Ω Unipolar 5 Vdc	Resistance/Windings Ω Unipolar 12Vdc	Page for full Specs
K & L 92100	.25/.001 .05/.002 .10/.004	12.5 N/45 oz	16.68 N/60 oz @ .025 mm/.001"	5 or 12	15.0	84.0	**34-35**
K & L 92200	.25/.001 .05/.002 .76/.003	20.9 N/75 oz	11.1 N/40 oz @ .025 mm/.001"	5 or 12	10.0	58.0	**36-37**
L92400	.025/.001 .05/.002	88 N/20 lb	88 N/20 lb @ .025 mm/.001"	5 or 12	4.3	25.0	**38-39**

The L/R torque/speed curves are intended as guides for motor selection and are considered to be typical. Improved performance can be achieved through the use of various drive methods (several approaches are described on pages 8 and 9 of this engineering guide) or by using high-energy magnet materials. For more specific recommendations to cover your application — contact one of our experienced sales engineers.

Note: Inductance is measured using an LRC bridge with L_S scale and internal 1 KC oscillator..

All above data as well as data shown on proceeding pages are specified at room temperature, with operating voltage at the motor leads.

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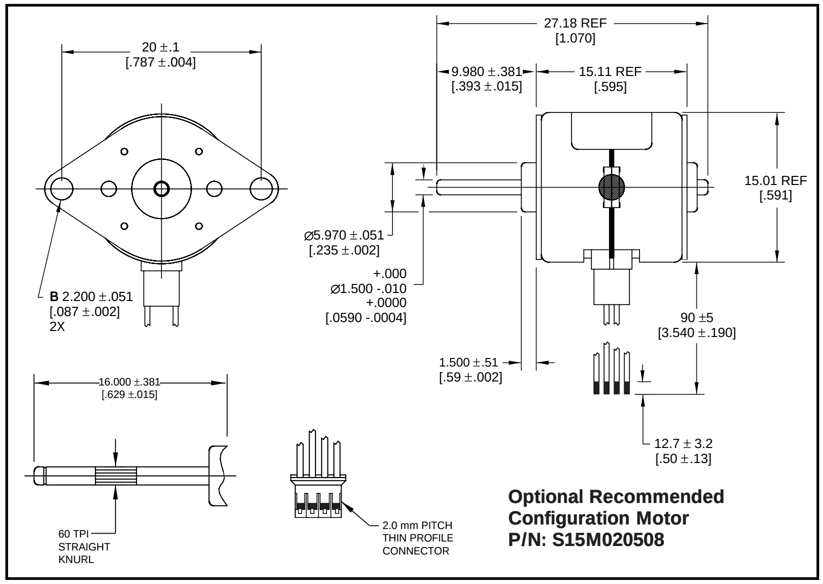
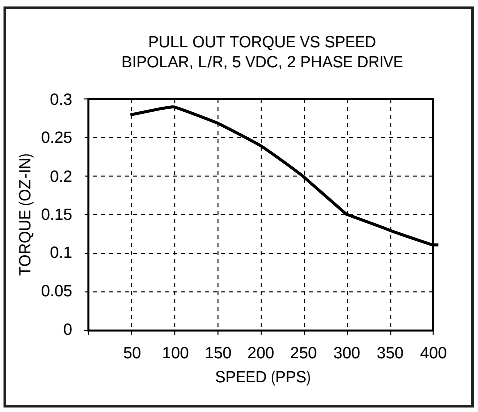
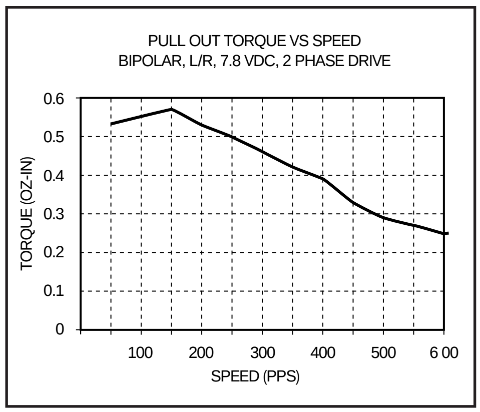
THOMSON AIRPAX MECHATRONICS

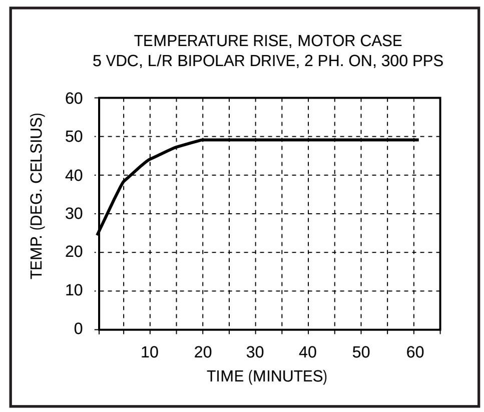
Series 15M020D Stepper Motors

Dimensions: mm/inches





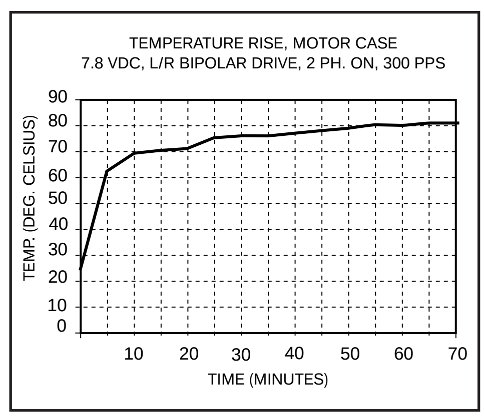




Specifications

Part Number	15M020D1B
DC Operating Voltage	5
Res. per Winding Ω	40 ± 10%
Ind. per Winding mH	14 ± 20%
Holding Torque mN•m/oz-in†	3.88/.55
Detent Torque mN•m/oz-in	1.62/.23
Step Angle	18°
Step Angle Tolerance†	± 1.5°
Steps per Rev.	20
Max Operating Temp.	100°C
Ambient Temp Range	
Operating	-20°C to 70°C
Storage	-40°C to 85°C
Bearing Type	Bronze sleeve
Insulation Res. at 500Vdc	100 megohms
Dielectric Withstanding Voltage	400 ± 50 VRMS 60 Hz for 2 seconds
Weight g/oz	14 g/0.5 oz
Lead Wires	28 AWG, UL style 1429

† Measured with 2 phases energized.



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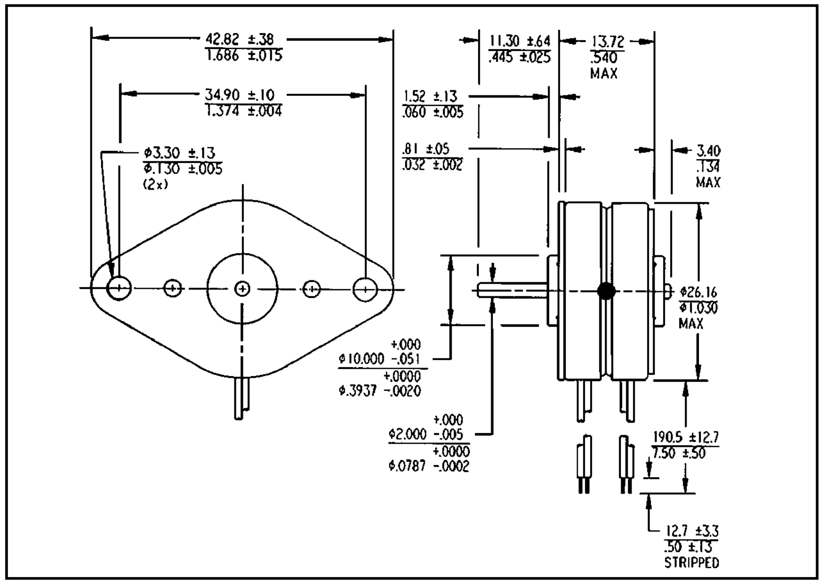
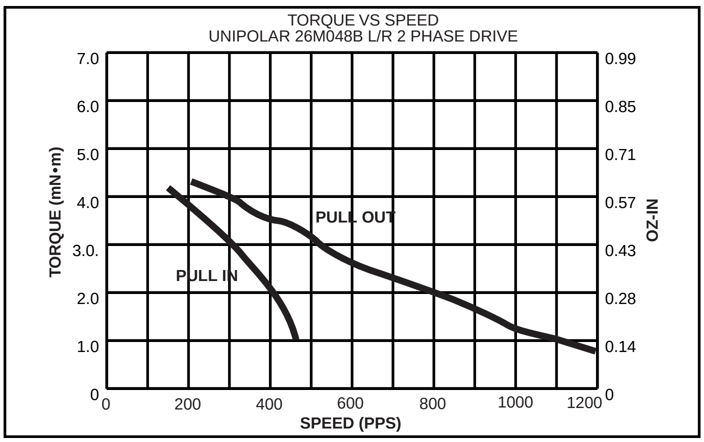
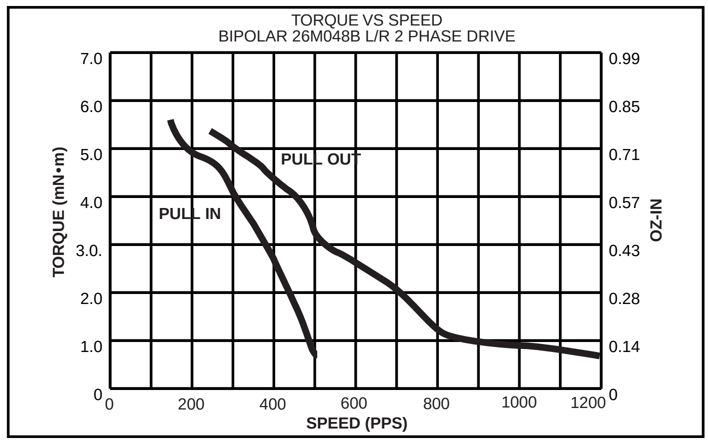
Dimensions: mm/inches







Specifications

NOTE: Refer to page 7 for switching sequence

Part Number	Unipolar		Bipolar	
	26M048B1U	26M048B2U	26M048B1B	26M048B2B
DC Operating Voltage	5	12	5	12
Res. per Winding Ω	19.6	110	19.8	108
Ind. per Winding mH	5.3	36.5	13.0	60.7
Holding Torque mN•m/oz-in†	9.2/1.3		10.6/1.5	
Rotor Moment of Inertia g•m²	1.1×10^{-4}			
Detent Torque mN•m/oz-in	0.85/0.12			
Step Angle	7.5°			
Step Angle Tolerance†	±.5°			
Steps per Rev.	48			
Max Operating Temp.	100°C			
Ambient Temp Range				
Operating	-20°C to 70°C			
Storage	-40°C to 85°C			
Bearing Type	Bronze sleeve			
Insulation Res. at 500Vdc	100 megohms			
Dielectric Withstanding Voltage	650 ±50 VRMS 60 Hz for 1 to 2 seconds			
Weight g/oz	28 g/1 oz			
Lead Wires	28 AWG			

† Measured with 2 phases energized.

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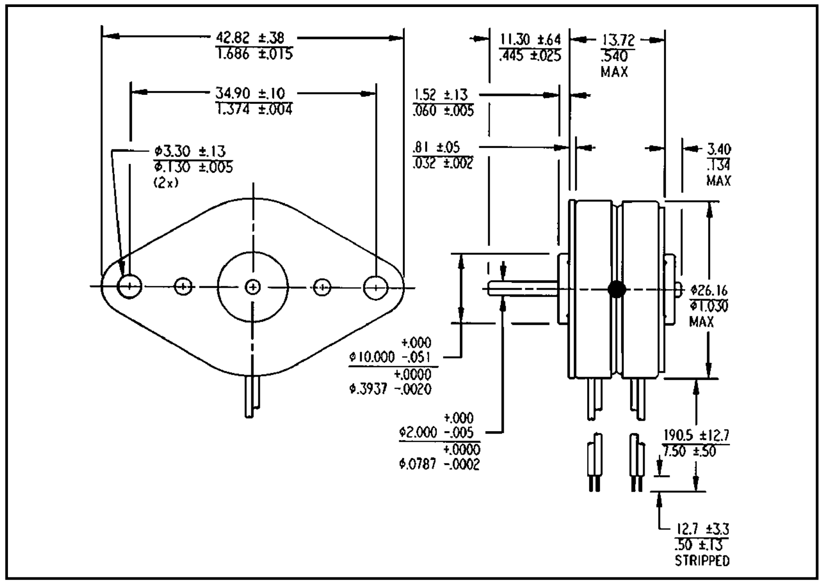
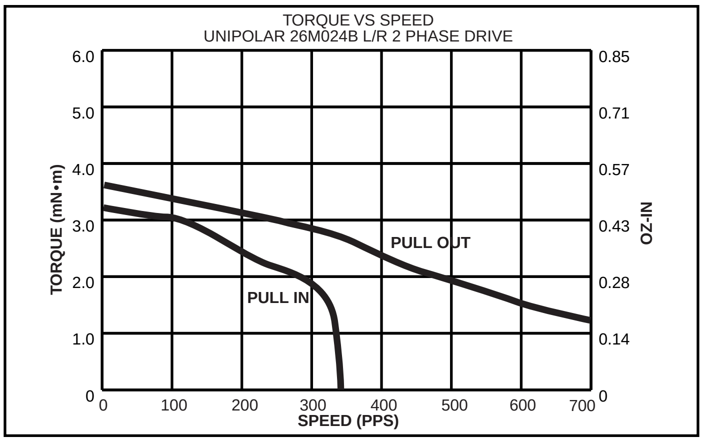
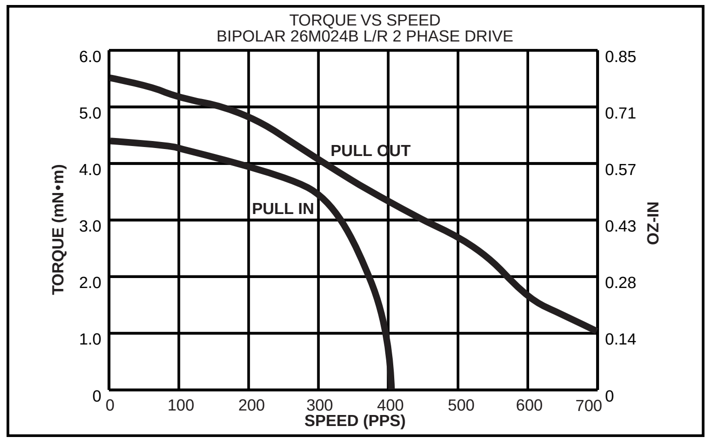
THOMSON AIRPAX MECHATRONICS

Series 26M024B Stepper Motors

Dimensions: mm/inches







Specifications

NOTE: Refer to page 7 for switching sequence

Part Number	Unipolar		Bipolar	
	26M024B1U	26M024B2U	26M024B1B	26M024B2B
DC Operating Voltage	5	12	5	12
Res. per Winding Ω	20.4	118	19.6	113
Ind. per Winding mH	6.4	33.8	13.8	72.9
Holding Torque mN•m/oz-in†	4.9/0.7		7.1/1.0	
Rotor Moment of Inertia g•m²	1.1×10^{-4}			
Detent Torque mN•m/oz-in	1.06/0.15			
Step Angle	15°			
Step Angle Tolerance†	±1°			
Steps per Rev.	24			
Max Operating Temp.	100°C			
Ambient Temp Range				
Operating	-20°C to 70°C			
Storage	-40°C to 85°C			
Bearing Type	Bronze sleeve			
Insulation Res. at 500Vdc	100 megohms			
Dielectric Withstanding Voltage	650 ±50 VRMS 60 Hz for 1 to 2 seconds			
Weight g/oz	28 g/1 oz			
Lead Wires	28 AWG			

† Measured with 2 phases energized.

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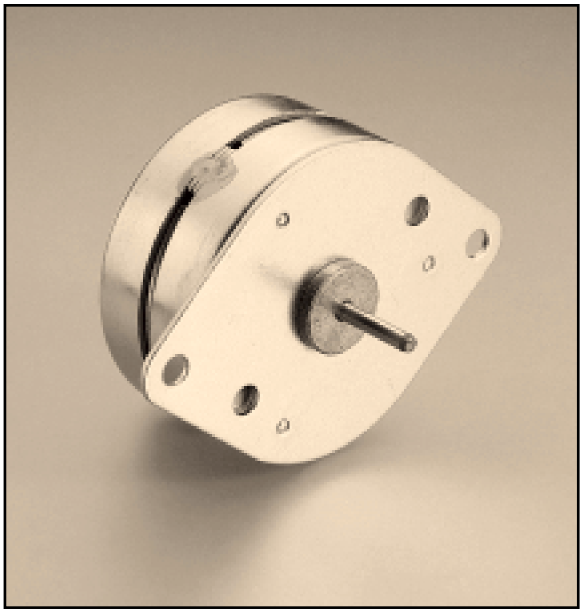
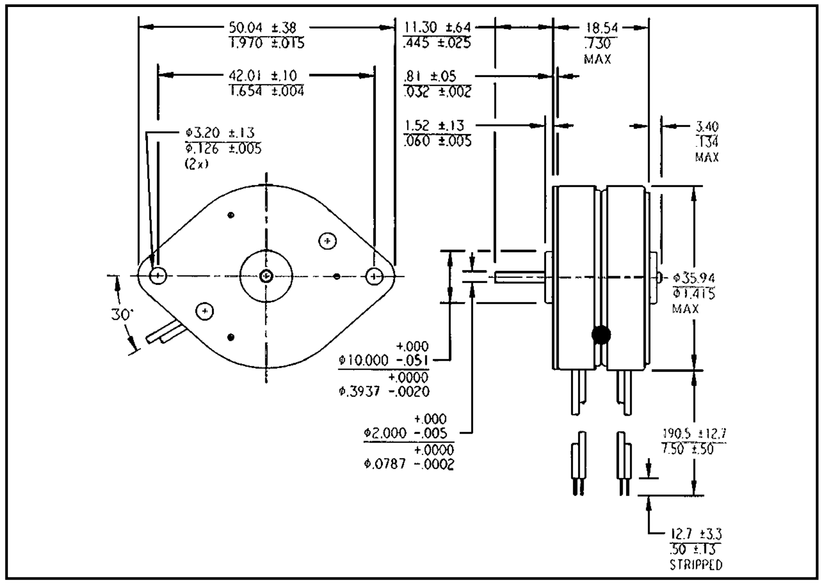
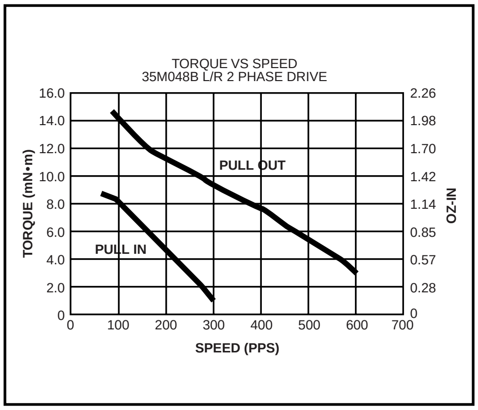
THOMSON AIRPAX MECHATRONICS

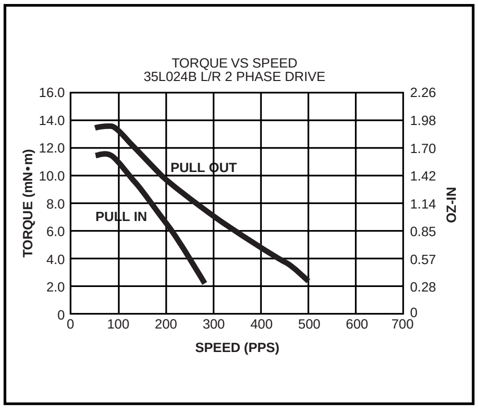
Series 35M048B, 35M024B & 35M020B Stepper Motors

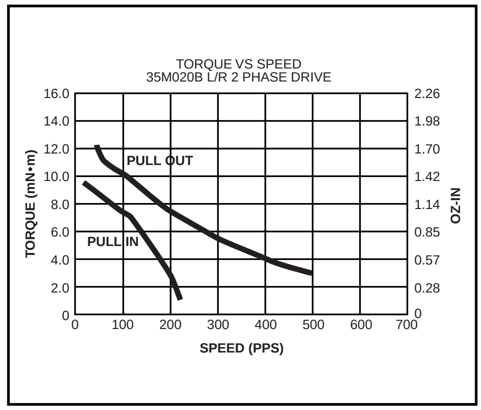


Dimensions: mm/inches









Specifications

NOTE: Refer to page 7 for switching sequence

Part Number	35M048B1U	35M048B2U	35M024B1U	35M024B2U	35M020B1U	35M020B2U
DC Operating Voltage	5	12	5	12	5	12
Res. per Winding Ω	12.5	72	12.5	72	12.5	72
Ind. per Winding mH	7.8	36	7	34	6.6	30
Holding Torque mN•m/oz-in†	18.4/2.6		16.93/2.4		13.4/1.9	
Rotor Moment of Inertia g•m²	2 x 10^{-4}		2 x 10^{-4}		2 x 10^{-4}	
Detent Torque mN•m/oz-in	1.8/0.26		1.8/0.26		1.8/0.26	
Step Angle	7.5°		15.0°		18.0°	
Step Angle Tolerance†	±.5°		±1°		±1.2°	
Steps per Rev.	48		24		20	
Max Operating Temp.	100°C					
Ambient Temp Range						
Operating	-20°C to 70°C					
Storage	-40°C to 85°C					
Bearing Type	Bronze sleeve					
Insulation Res. at 500Vdc	100 megohms					
Dielectric Withstanding Voltage	650 ±50 VRMS 60 Hz for 2 seconds					
Weight g/oz	79/2.8					
Lead Wires	26 AWG					

† Measured with 2 phases energized.

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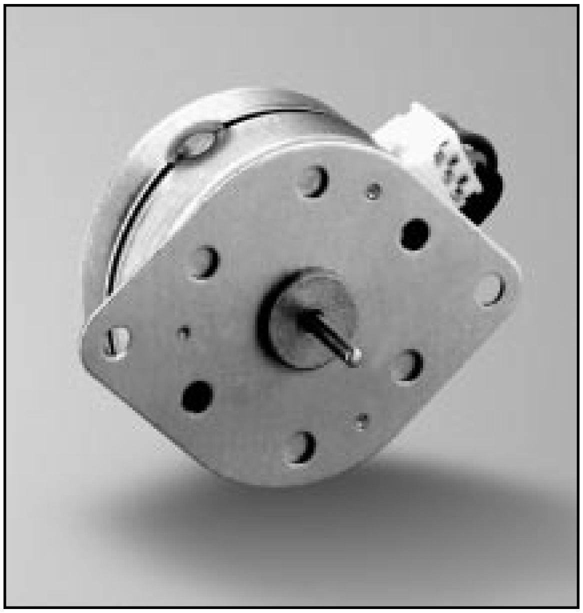
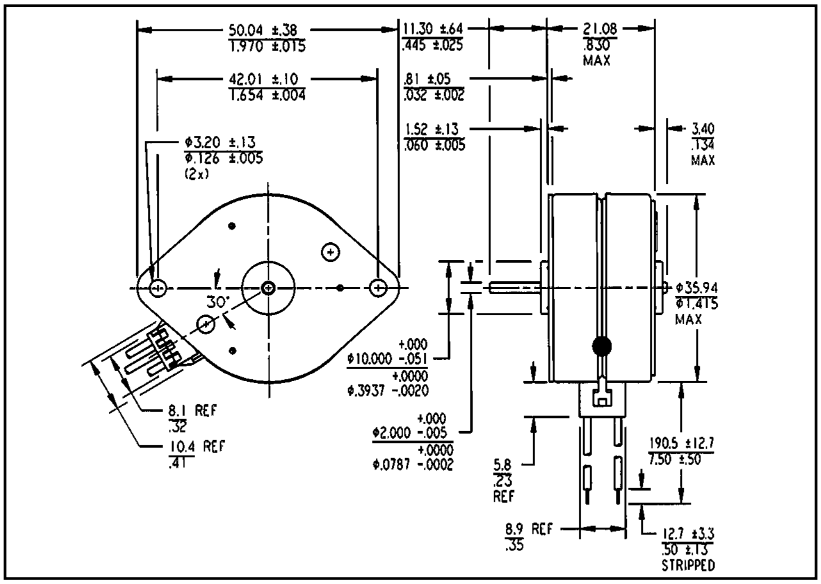
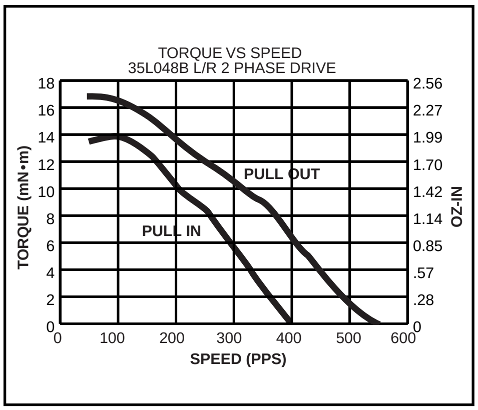
THOMSON AIRPAX MECHATRONICS

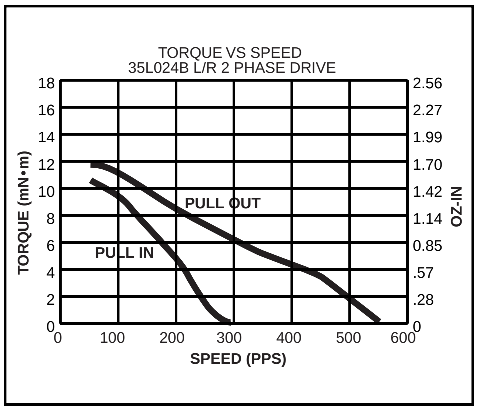
Series 35L048B, 35L024B & 35L020B Stepper Motors

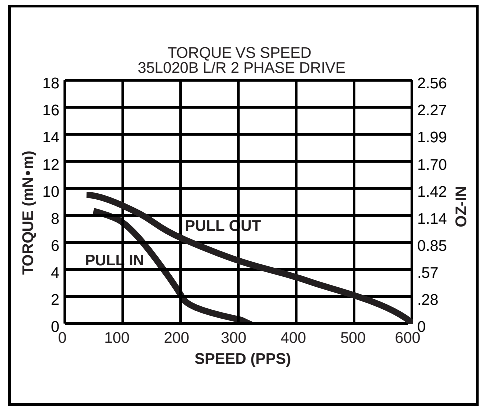


Dimensions: mm/inches









Specifications

NOTE: Refer to page 7 for switching sequence

Part Number	35L048B1U	35L048B2U	35L024B1U	35L024B2U	35L020B1U	35L020B2U
DC Operating Voltage	5	12	5	12	5	12
Res. per Winding Ω	11	64	11	64	11	64
Ind. per Winding mH	7	38	7	34	7	30
Holding Torque mN•m/oz-in†	27.5/3.9		21.1/3.0		17.7/2.5	
Rotor Moment of Inertia g•m²	4.0 x 10^{-4}		4.0 x 10^{-4}		4.0 x 10^{-4}	
Detent Torque mN•m/oz-in	2.5/.36		2.5/.36		2.5/.36	
Step Angle	7.5°		15.0°		18.0°	
Step Angle Tolerance†	±.5°		±1°		±1.2°	
Steps per Rev.	48		24		20	
Max Operating Temp.	100°C					
Ambient Temp Range						
Operating	-20°C to 70°C					
Storage	-40°C to 85°C					
Bearing Type	Bronze sleeve					
Insulation Res. at 500Vdc	100 megohms					
Dielectric Withstanding Voltage	650 ±50 VRMS 60 Hz for 2 seconds					
Weight g/oz	88/3.1					
Lead Wires	26 AWG					

† Measured with 2 phases energized.

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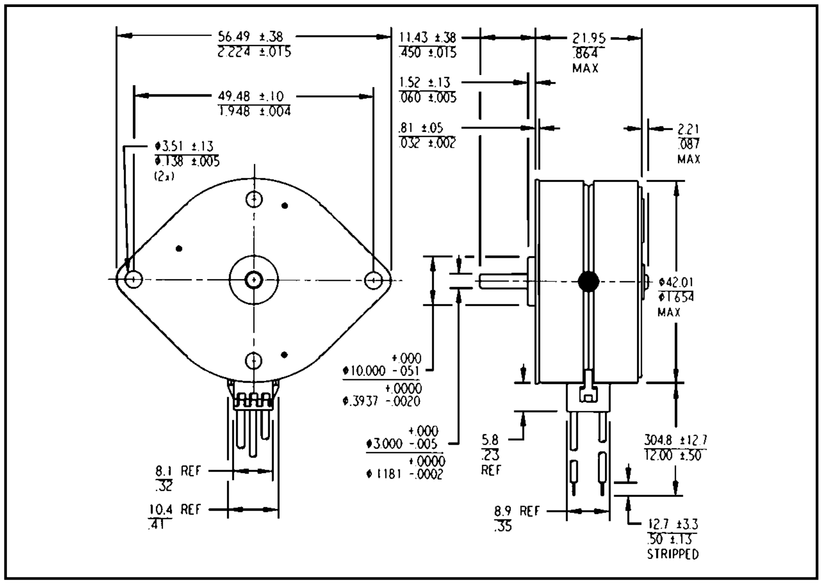
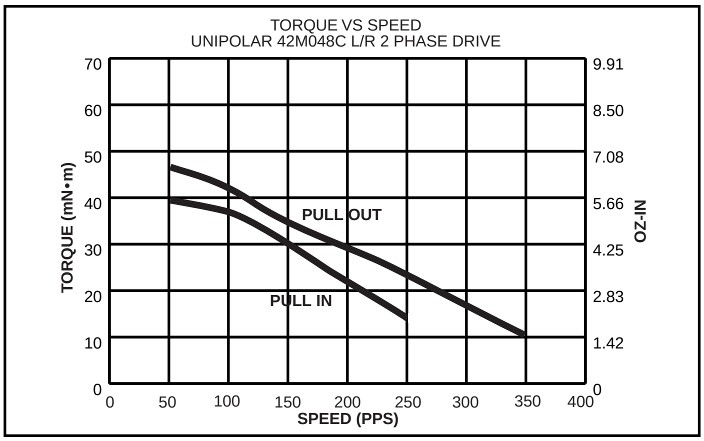
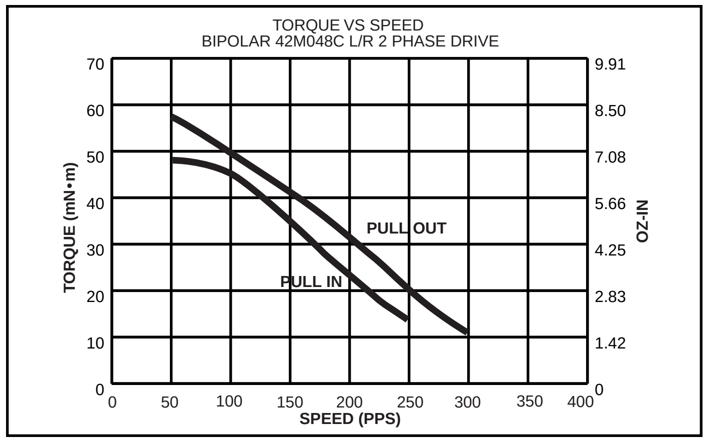
THOMSON AIRPAX MECHATRONICS

Dimensions: mm/inches







Specifications

NOTE: Refer to page 7 for switching sequence

Part Number	Unipolar		Bipolar	
	42M048C1U	42M048C2U	42M048C1B	42M048C2B
DC Operating Voltage	5	12	5	12
Res. per Winding Ω	9.1	52.4	9.1	52.4
Ind. per Winding mH	7.5	46.8	14.3	77.9
Holding Torque mN•m/oz-in†	73.4/10.4		87.5/12.4	
Rotor Moment of Inertia g•m²	12.5×10^{-4}			
Detent Torque mN•m/oz-in	9.2/1.3			
Step Angle	7.5°			
Step Angle Tolerance†	±.5°			
Steps per Rev.	48			
Max Operating Temp.	100°C			
Ambient Temp Range				
Operating	-20°C to 70°C			
Storage	-40°C to 85°C			
Bearing Type	Bronze sleeve			
Insulation Res. at 500Vdc	100 megohms			
Dielectric Withstanding Voltage	650 ±50 VRMS 60 Hz for 1 to 2 seconds			
Weight g/oz	144/5.1			
Lead Wires	26 AWG			

† Measured with 2 phases energized.

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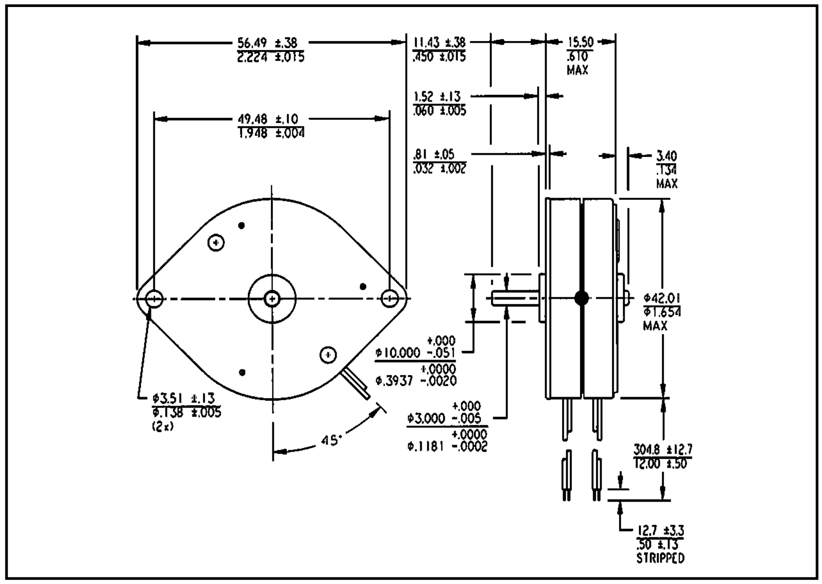
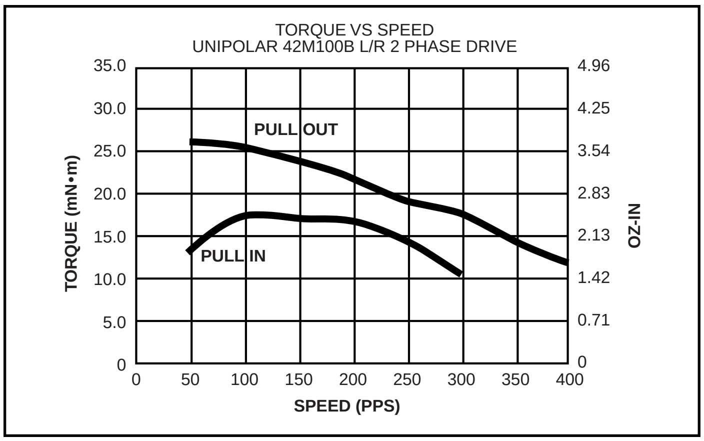
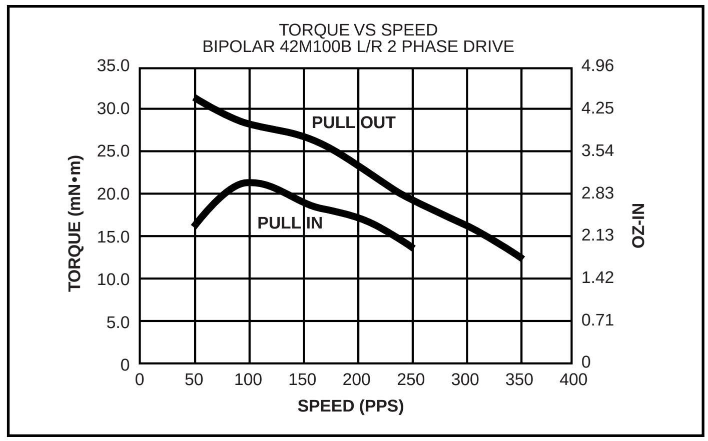
Series 42M100B Stepper Motors

Dimensions: mm/inches







Specifications at the Rotor

NOTE: Refer to page 7 for unipolar switching sequence

Part Number	Unipolar		Bipolar	
	42M100B1U	42M100B2U	42M100B1B	42M100B2B
DC Operating Voltage	5	12	5	12
Res. per Winding Ω	12.5	75	12.5	75
Ind. per Winding mH	6.6	37.7	11.3	62.1
Holding Torque mN•m/oz-in†	45.2/6.4		49.4/7.0	
Rotor Moment of Inertia g•m²	11.8×10^{-4}			
Detent Torque mN•m/oz-in	5.0/0.7			
Step Angle	3.6°			
Step Angle Tolerance†	±0.25°			
Steps per Rev.	100			
Max Operating Temp.	100°C			
Ambient Temp Range				
Operating	-20°C to 70°C			
Storage	-40°C to 85°C			
Bearing Type	Bronze sleeve			
Insulation Res. at 500Vdc	100 megohms			
Dielectric Withstanding Voltage	650 ±50 VRMS 60 Hz for 1 to 2 seconds			
Weight g/oz	88/31			
Lead Wires	28 AWG			

† Measured with 2 phases energized.

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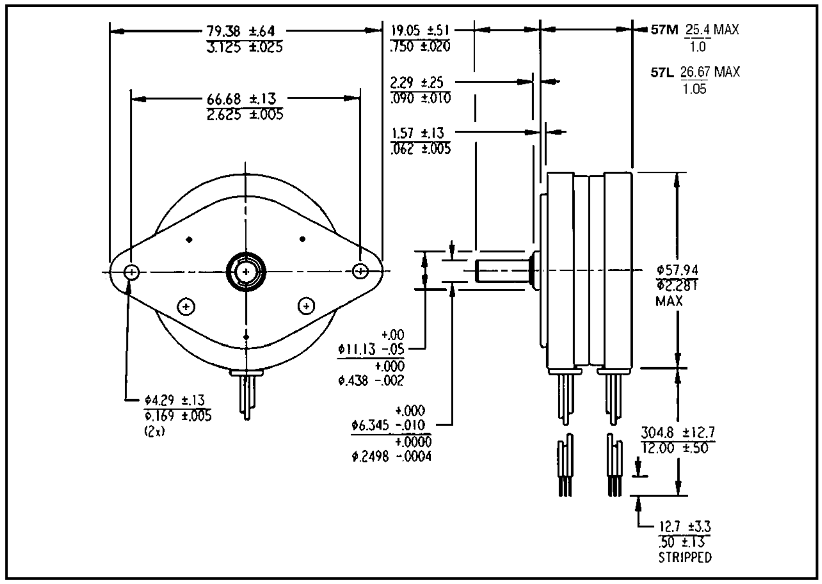
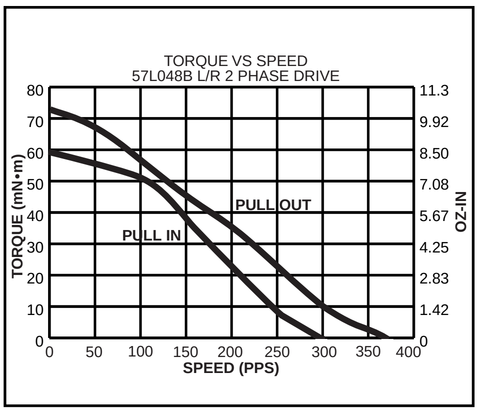
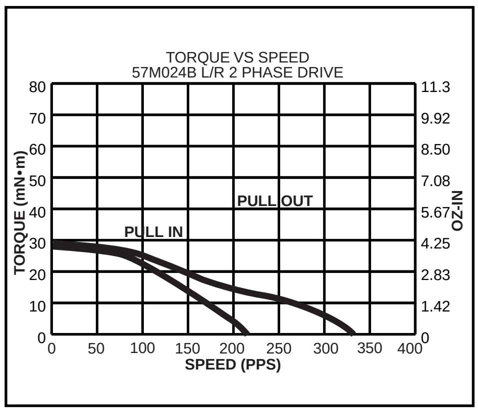
THOMSON AIRPAX MECHATRONICS

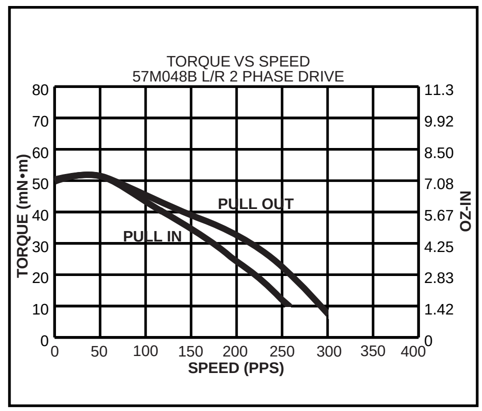
Series 57L048B, 57M024B & 57M048B Stepper Motors

Dimensions: mm/inches









Specifications

NOTE: Refer to page 7 for switching sequence

Part Number	57L048B1U	57L048B2U	57M024B1U	57M024B2U	57M048B1U	57M048B2U
DC Operating Voltage	5	12	5	12	5	12
Res. per Winding Ω	6.3	36	6.3	36	6.3	36
Ind. per Winding mH	7.0	38	4.5	24	5.0	26
Holding Torque mN•m/oz-in†	205/25.0		55/7.8		74/10.5	
Rotor Moment of Inertia g•m²	3.4 x 10^{-3}		3.1 x 10^{-3}		3.1 x 10^{-3}	
Detent Torque mN•m/oz-in	9.9/1.4		9.9/1.4		9.9/1.4	
Step Angle	7.5°		15.0°		7.5°	
Step Angle Tolerance†	±.5°		±1°		±.5°	
Steps per Rev.	48		24		48	
Max Operating Temp.	100°C					
Ambient Temp Range						
Operating	-20°C to 70°C					
Storage	-40°C to 85°C					
Bearing Type	Bronze sleeve					
Insulation Res. at 500Vdc	100 megohms					
Dielectric Withstanding Voltage	650 ± 50 VRMS 60 Hz for 2 seconds					
Weight g/oz	281/9.9		239/8.4		239/8.4	
Lead Wires	26 AWG		26 AWG		26 AWG	

† Measured with 2 phases energized.

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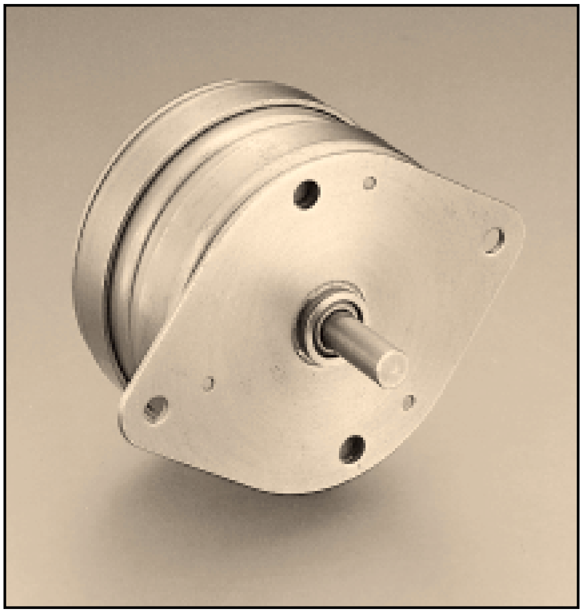
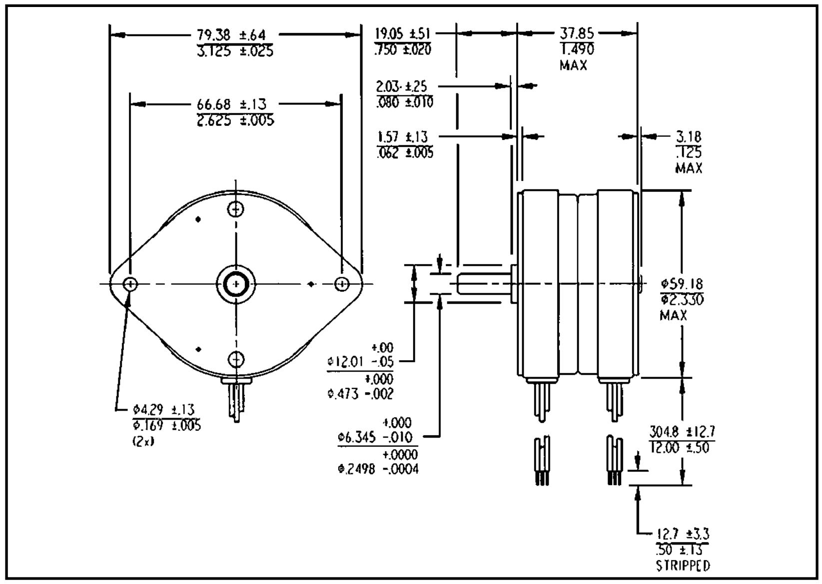
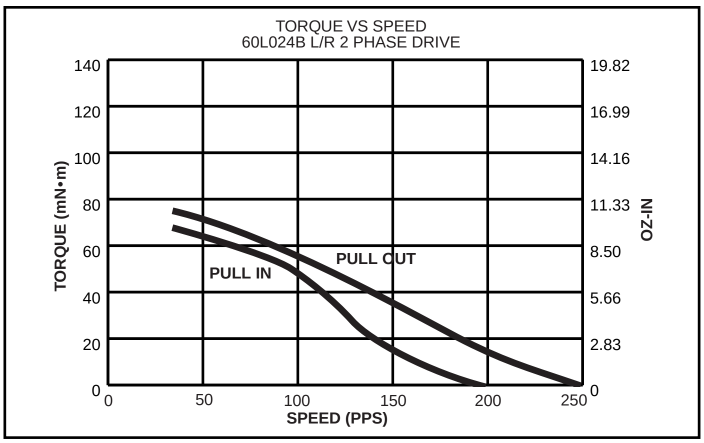
THOMSON AIRPAX MECHATRONICS

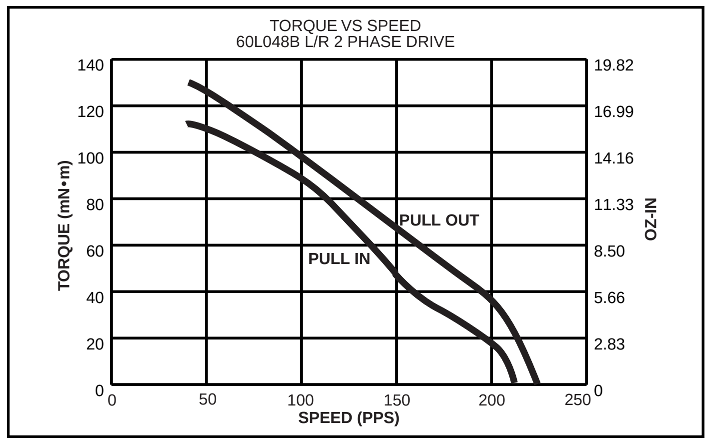
Series 60L048B & 60L024B Stepper Motors



Dimensions: mm/inches







Specifications

NOTE: Refer to page 7 for switching sequence

Part Number	60L048B1U	60L048B2U	60L024B1U	60L024B2U
DC Operating Voltage	5	12	5	12
Res. per Winding Ω	4.6	26	4.6	26
Ind. per Winding mH	6.0	33	5.4	29
Holding Torque mN•m/oz-in†	198/28		141/20	
Rotor Moment of Inertia g•m²	9.5 x 10^{-3}		9.5 x 10^{-3}	
Detent Torque mN•m/oz-in	21.2/3.0		21.2/3.0	
Step Angle	7.5°		15°	
Step Angle Tolerance†	±.5°		±1.0°	
Steps per Rev.	48		24	
Max Operating Temp.	100°C			
Ambient Temp Range				
Operating	-0°C to 60°C			
Storage	-40°C to 85°C			
Bearing Type	Bronze sleeve			
Insulation Res. at 500Vdc	100 megohms			
Dielectric Withstanding Voltage	650 ±50 VRMS 60 Hz for 2 seconds			
Weight g/oz	440/15.5			
Lead Wires	24 AWG			

† Measured with 2 phases energized.

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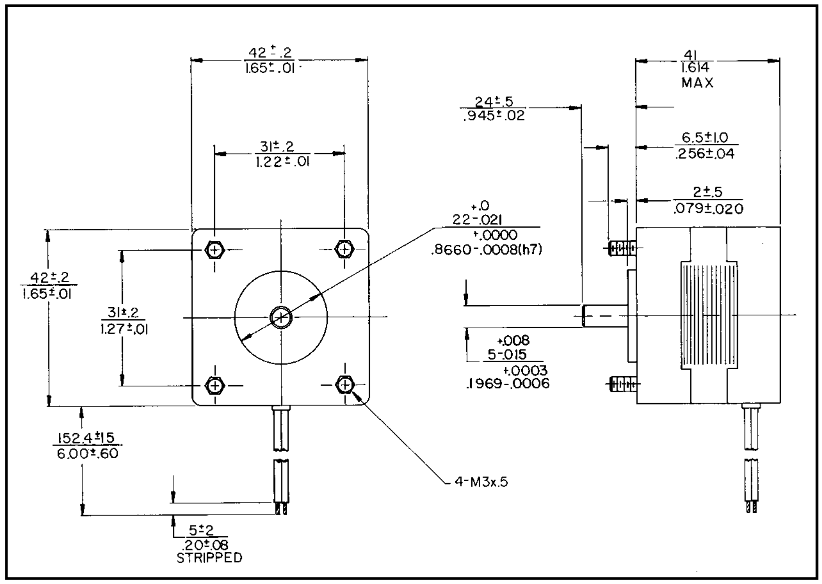
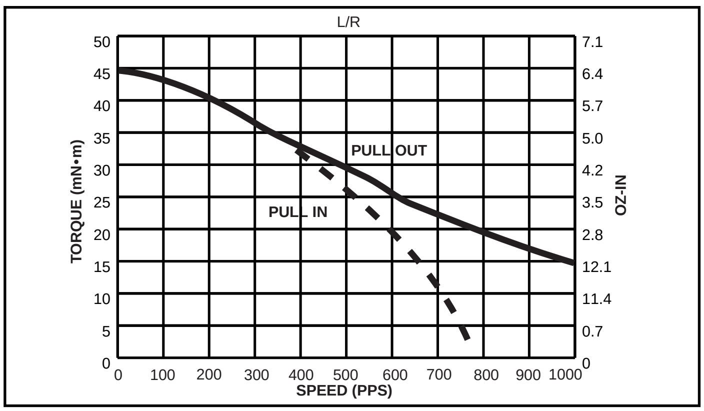
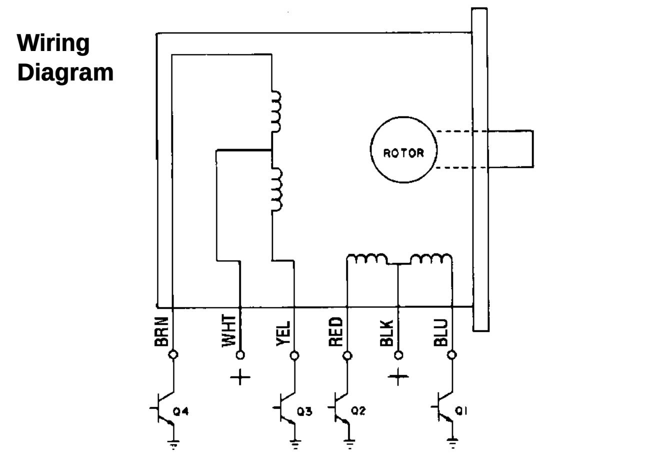
THOMSON AIRPAX MECHATRONICS

Dimensions: mm/in







NOTE: Refer to page 7 for unipolar switching sequence

Specifications

Part Number	4SQ - 120B34S
DC Operating Voltage	12
Res. per Winding Ω	5
Ind. per Winding mH	26
Holding Torque mN•m/oz-in†	65/9.2
Rotor Moment of Inertia g•m²	1.9 x 10^{-3}
Detent Torque mN•m/oz-in	8.5/01.2
Step Angle	1.8°
Step Angle Tolerance†	±5%
Steps per Rev.	200
Max. Radial Load†† kg/lb	4/8.8
Max. Axial Load kg/lb	8/17.6
Max. Temp. Rise	55°C
Ambient Temp Range	
Operating	-20°C to +50°C
Storage	-20°C to +60°C
Bearing Type	Bal, Double Shielded
Insulation Res. at 500Vdc	50 megohms
Dielectric Withstanding Voltage	500 Vac for 60 Sec
Weight g/oz	195/7

NOTE: Unless otherwise indicated all values shown are typical. Other windings available on special order. Consult Thomson Airpax for availability of motors with 3.6° step angle.

† Measured with 2 phases energized. †† Measured at 10mm from mounting plate surface

Catalog P/N Construction

Example 1. Single Shaft Extension

4SQ – 060 BA 34 S

- S — Single Shaft Extension
- 34 — 34 mm/1.3 Length
- BA — Aluminum End Bells
- 060 — 6 Volts
- 4SQ — Basic Motor

Example 2. Double Shaft Extension

4SQ – 120 BF 34 W

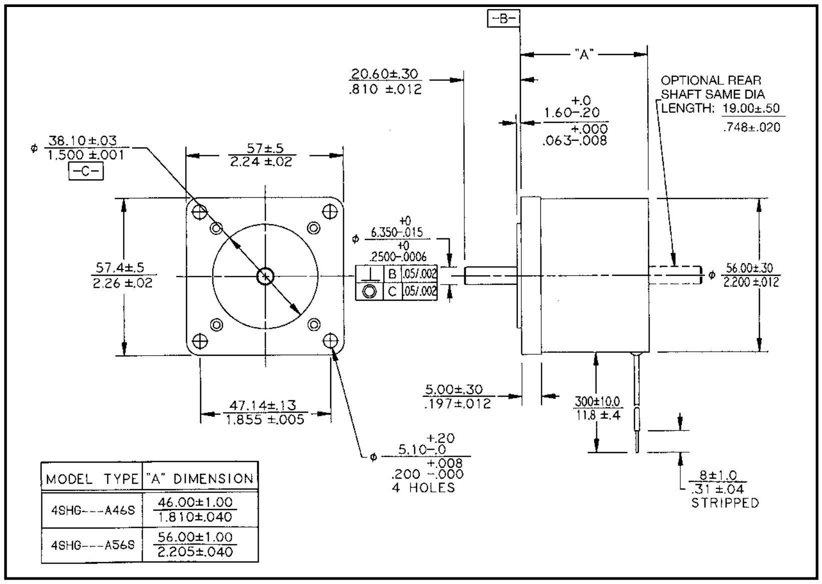
- W — Double Shaft Extension
- 34 — 34 mm/1.3 Length
- BF — Steel End Bells
- 120 — 12 Volts
- 4SQ — Basic Motor

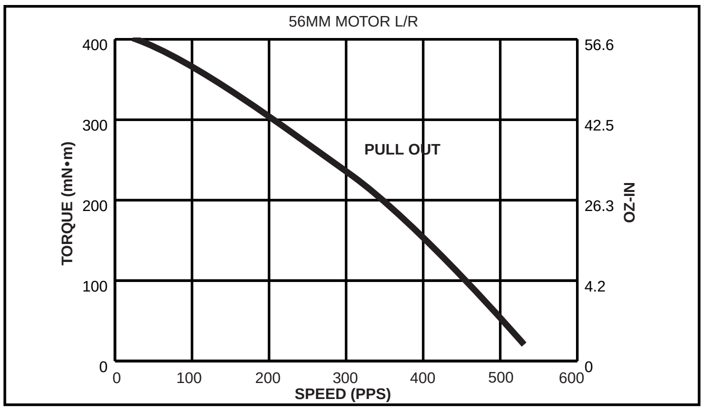
For information or to place an order in North America: 1 (203) 271-6444 Asia: (65) 7474-888

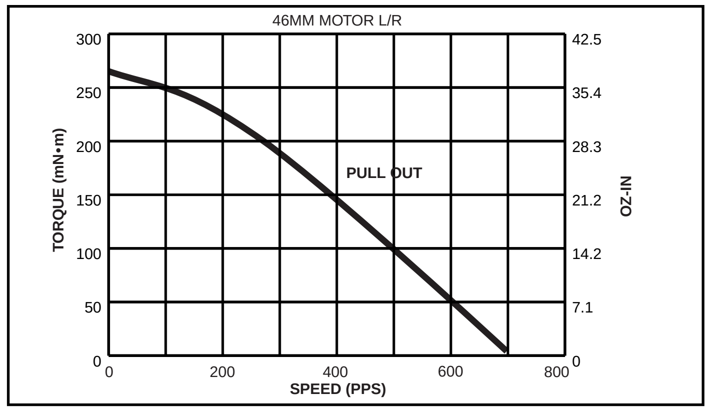
THOMSON AIRPAX MECHATRONICS

Series 4SHG Stepper Motors 1.8° *Not available for sale in Europe*

Dimensions: mm/inches







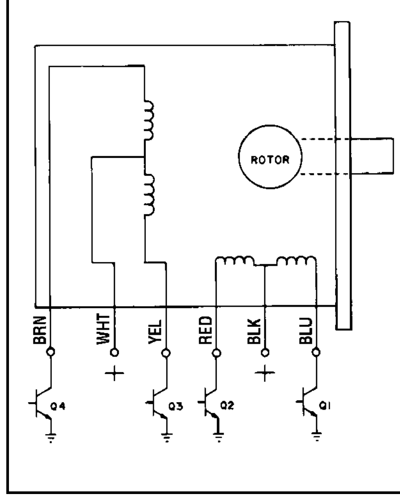
Specifications

NOTE: Refer to page 7 for unipolar switching sequence

Part Number	(46 mm)			(56 mm)		
(For optional Rear Shaft, Remove Suffix "S" and Replace with Suffix "W")	4SHG 060A46S	4SHG 120A46S	4SHG 240A46S	4SHG 060A56S	4SHG 120A56S	4SHG 240A56S
DC Operating Voltage	6	12	24	6	12	24
Res. per Winding Ω	7	27	104	4.7	20.5	79
Ind. per Winding mH	8.6	30	89	9	45	150
Holding Torque mN•m/oz-in†	388/55	388/55	353/50	600/85	600/85	600/85
Rotor Moment of Inertia g•m²	1 x 10^{-2}			1.67 x 10^{-2}		
Detent Torque mN•m/oz-in	49.4/7					
Step Angle	1.8°					
Step Angle Tolerance†	±5%					
Steps per Rev.	200					
Max. Radial Load†† kg/lb	7/15.4					
Max. Axial Load kg/lb	12/26.4					
Max Temp. Rise	80°C					
Ambient Temp Range Operating	-20°C to 50°C					
Storage	-20°C to 60°C					
Bearing Type	Ball, Double Shielded					
Insulation Res. at 500Vdc	50 megohms					
Dielectric Withstanding Voltage	500 Vac for 60 seconds					
Weight g/oz	450/16			610/21.5		

† Measured with 2 phases energized. †† Measured at 10mm from mounting plate surface

Wiring Diagram

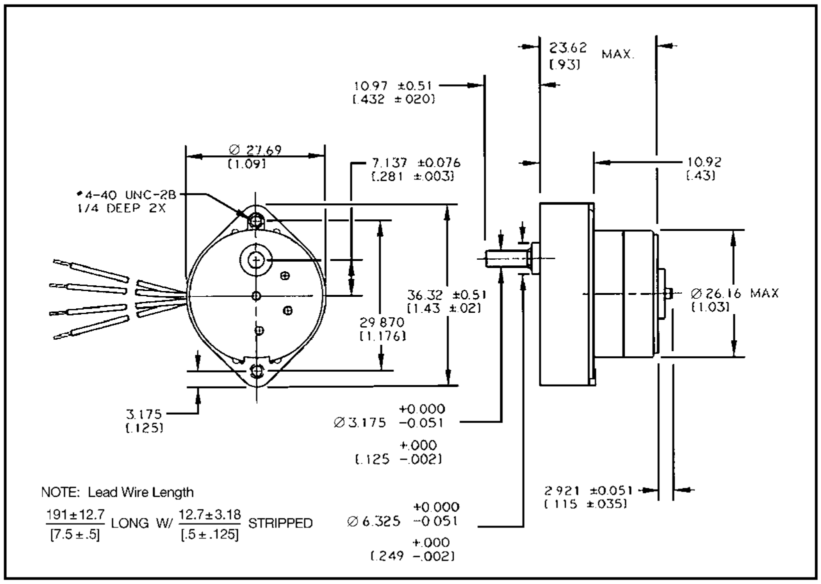


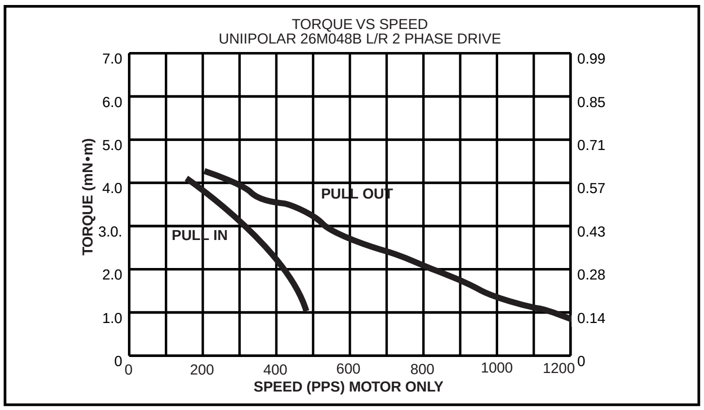
For information or to place an order in North America: 1 (203) 271-6444 Asia: (65) 7474-888

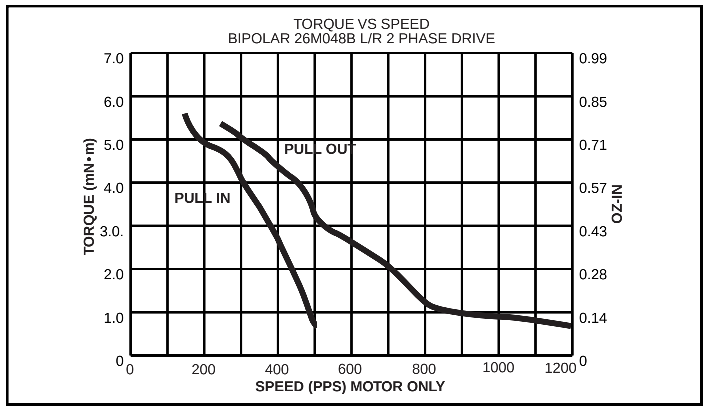
Series 26M048B Stepper Motors With Gear Trains (Type V)

Gear Train Rating: 141.2mN•m/20 oz-in static
70.6mN•m/10 oz-in running

Dimensions: mm/in







Specifications (Motor Only)

Part Number	Unipolar		Bipolar	
	26M048B1U	26M048B2U	26M048B1B	26M048B2B
DC Operating Voltage	5	12	5	12
Res. per Winding Ω	19.6	110	19.8	108
Ind. per Winding mH	5.3	36.5	13.0	60.7
Holding Torque mN•m/oz-in†	9.2/1.3		10.6/1.5	
Rotor Moment of Inertia g•m²	1.1×10^{-4}			
Detent Torque mN•m/oz-in	0.85/0.12			
Step Angle	7.5°			
Step Angle Tolerance†	±.5°			
Steps per Rev.	48			
Max Operating Temp.	100°C			
Ambient Temp Range				
Operating	-20°C to 70°C			
Storage	-40°C to 85°C			
Bearing Type	Bronze sleeve			
Insulation Res. at 500Vdc	100 megohms			
Dielectric Withstanding Voltage	650±50 VRMS 60 Hz for 1 to 2 seconds			
Weight g/oz	57.2/2			
Lead Wires	28 AWG			

† Measured with 2 phases energized.

Available Gear Train Reductions

Part Suffix	Gear Ratio	Output Step Angle	Output Speed RPM @100 PPS	Running Torque @ 100 PPS mN•m/oz-in
-V11	2:1	3.75°	62.50	8.9/1.16
-V16	5:1	1.5°	25.00	17.01/2.41
-V19	7.5:1	1.00°	16.66	21.08/3.00
-V21	10:1	.75°	12.50	28.24/4.00
-V24	15:1	.5°	8.33	35.30/5.00
-V27	20:1	.375°	6.25	46.88/6.64
-V31	30:1	.25°	4.17	70.6/10.00
-V37	60:1	.125°	2.09	112.96/16.00

How to Order

1. List Series 26M048B.
2. Add suffix -V11 to V37 for desired gear ratio.

Examples of Part Numbers

26M048B 2U -V11
- -V11: 2:1
- 2U: Unipolar 12 Vdc
- 26M048B: Basic Series

26M048B 1B V31
- V31: 30:1
- 1B: Bipolar 5 Vdc
- 26M048B: Basic Series

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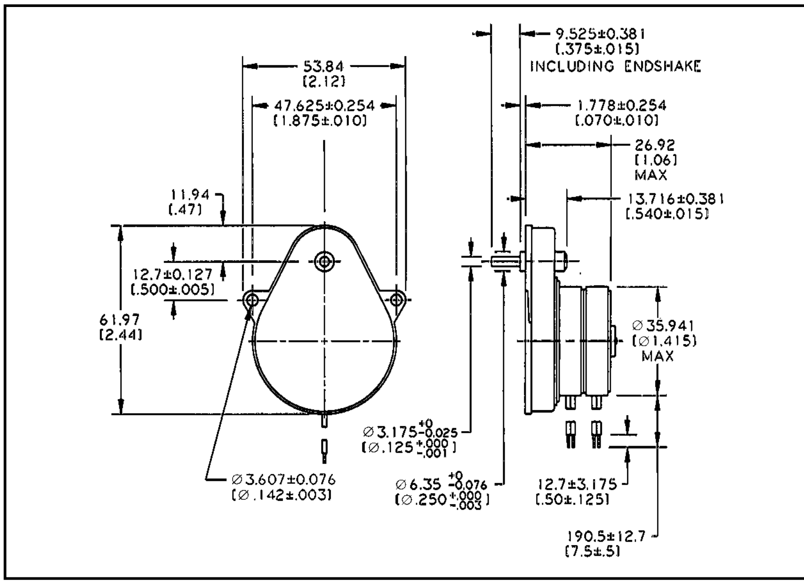
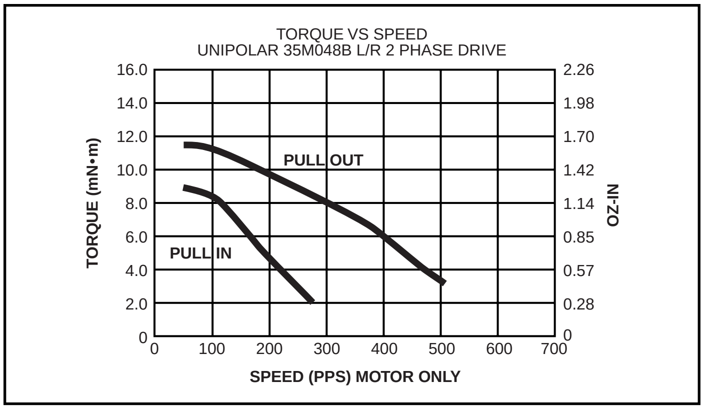
THOMSON AIRPAX MECHATRONICS

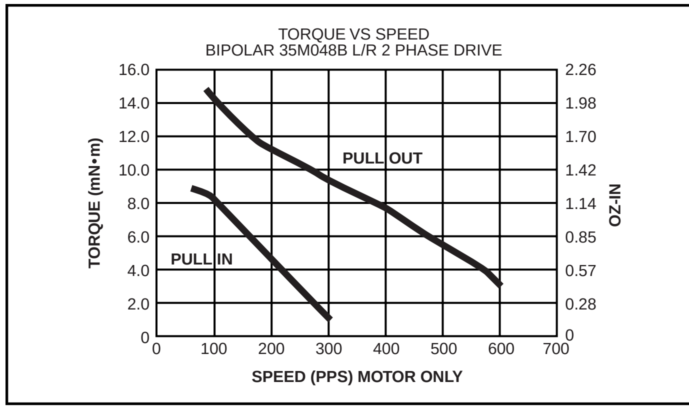
Series 35M048B Stepper Motors With Gear Trains (Type X)

Gear Train Rating: 141.2mN•m/20 oz-in static
35.3mN•m/5.0 oz-in running

Dimensions: mm/in







Specifications (Motor Only)

Part Number	Unipolar		Bipolar	
	35M048B1U	35M048B2U	35M048B1B	35M048B2B
DC Operating Voltage	5	12	5	12
Res. per Winding Ω	12.5	72	12.5	72
Ind. per Winding mH	7.8	36	16.4	86.0
Holding Torque mN•m/oz-in†	18.4/2.6		10.6/1.5	
Rotor Moment of Inertia g•m²	2×10^{-4}			
Detent Torque mN•m/oz-in	1.8/0.26			
Step Angle	7.5°			
Step Angle Tolerance†	±.5°			
Steps per Rev.	48			
Max Operating Temp.	100°C			
Ambient Temp Range				
Operating	-20°C to 70°C			
Storage	-40°C to 85°C			
Bearing Type	Bronze sleeve			
Insulation Res. at 500Vdc	100 megohms			
Dielectric Withstanding Voltage	650±50 VRMS 60 Hz for 1 to 2 seconds			
Weight g/oz	142/5			
Lead Wires	26 AWG			

† Measured with 2 phases energized.

Available Gear Train Reductions

Part Suffix	Gear Ratio	Output Step Angle	Output Speed RPM @ 240 PPS	Running Torque @240 PPS mN•m/oz-in
-X24	15:1	.500°	20	35.3/5.0 MAX††
-X27	20:1	.375°	15	
-X31	30:1	.250°	10	
-X37	60:1	.1250°	5	
-X39	75:1	.1000°	4	
-X45	150:1	.0500°	2	
-X52	300:1	.0250°	1	
-X64	1350:1	.0055°	.222	

†† Higher ratings available.

How to Order

1. List Series 35M048B.
2. Add suffix -X24 to -X64 for desired gear ratio.

Examples of Part Numbers

35M048B 2U -X24
- -X24: 15:1
- 2U: Unipolar 12 Vdc
- 35M048B: Basic Series

35M048B 1B -X31
- -X31: 30:1
- 1B: Bipolar 5 Vdc
- 35M048B: Basic Series

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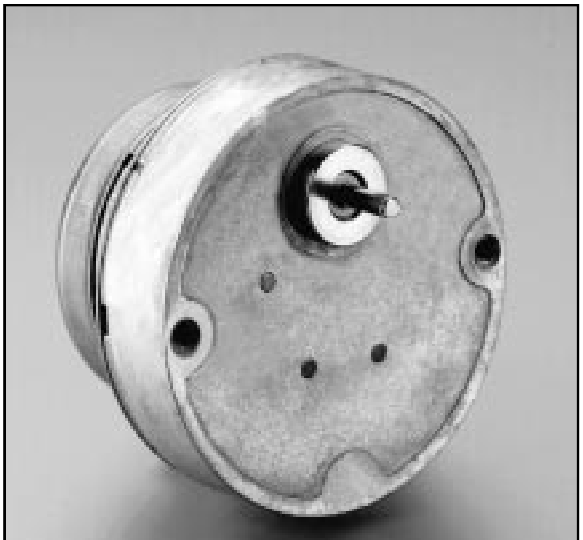
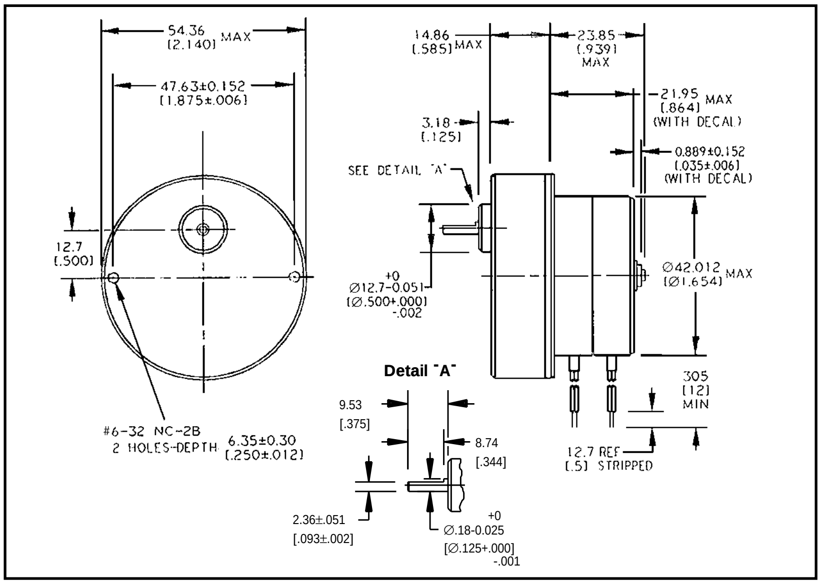
THOMSON AIRPAX MECHATRONICS

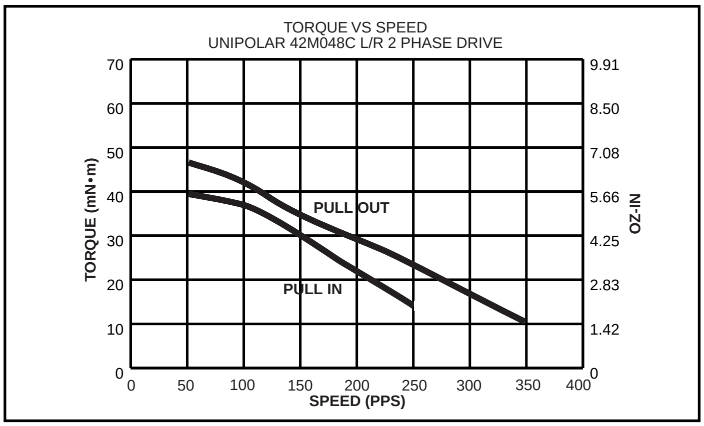
Series 42M048C Stepper Motors With Gear Trains (Type R)

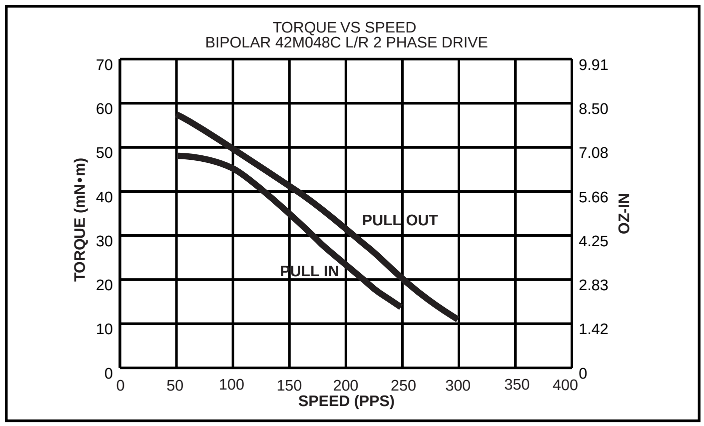


Gear Train Rating: 1.06 N•m/150 oz-in static
0.706 N•m/100 oz-in running

Dimensions: mm/inches







Specifications (Motor Only)

Part Number	Bipolar		Unipolar	
	42M048C1B	42M048C2B	42M048C1U	42M048C2U
DC Operating Voltage	5	12	5	12
Res. per Winding Ω	9.1	52.4	9.1	52.4
Ind. per Winding mH	14.3	77.9	7.5	46.8
Holding Torque mN•m/oz-in†	87.5/12.4		73.4/10.4	
Rotor Moment of Inertia g•m²	12.5 x 10^{-4}			
Step Angle	7.5°			
Step Angle Tolerance†	±0.5°			
Steps per Rev.	48			
Max Operating Temp.	100°C			
Ambient Temp Range Operating / Storage	-20°C to 70°C / -40°C to 85°C			
Bearing Type	Bronze sleeve			
Insulation Res. at 500Vdc	100 megohms			
Weight g/oz	312/11.0			
Lead Wires	No. 26 AWG			

† Measured with 2 phases energized.

Available Gear Train Reductions

Part Suffix	Gear Ratio	Output Step Angle	Output Speed RPM @240 PPS	Running Torque @ 240 PPS N•m/oz-in
-R12	2.5:1	3.00°	50	0.078/11
-R16	5:1	1.50°	25	0.155/22
-R21	10:1	.75°	12.5	0.318/45
-R24	15:1	.50°	8.33	0.473/67
-R27	20:1	.375°	6.25	0.635/90
-R31	30:1	.25°	4.17	0.706/100 max
-R36	50:1	.15°	2.5	0.706/100 max
-R39	75:1	.10°	1.67	0.706/100 max

How to Order

1. List Series 42M048C.
2. Add suffix -R12 to -R39 for round diecast.

Example of Part Numbers

42M048C | 2U | -R24

-R24: 15:1 (round)
42M048C: Basic Series
2U: Unipolar 12 Vdc

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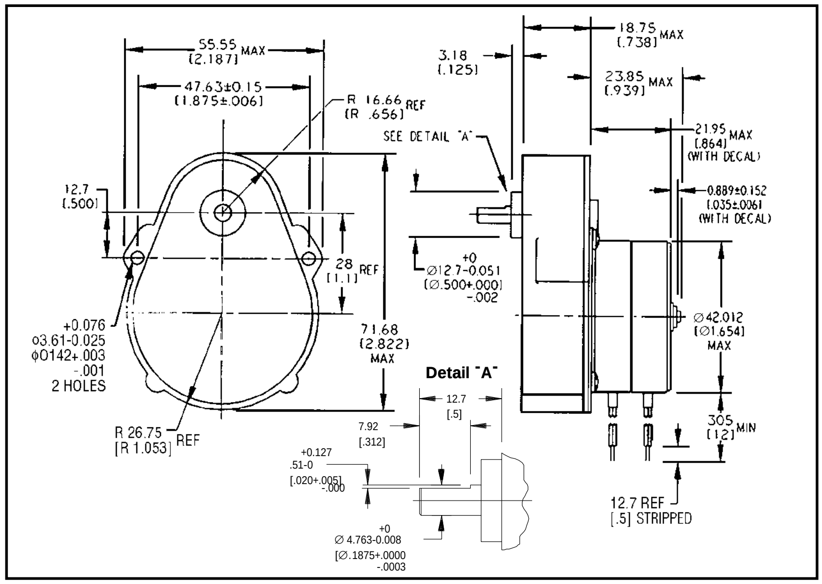
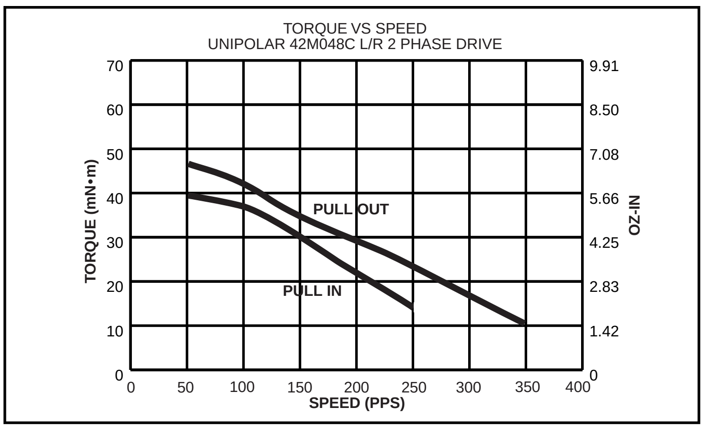
THOMSON AIRPAX MECHATRONICS

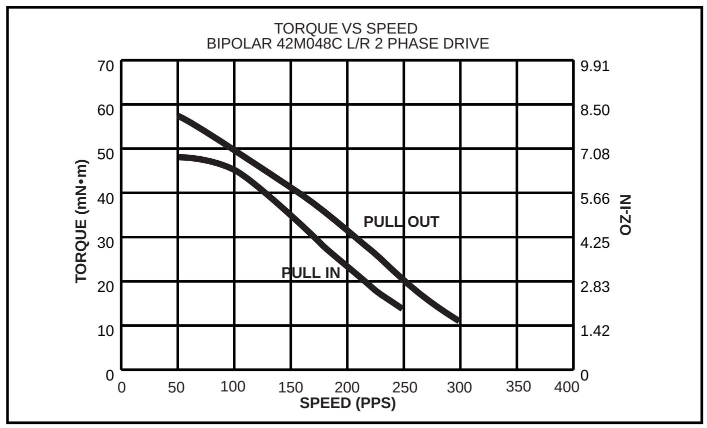
Series 42M048C Stepper Motors With Gear Trains (Type Z)

Gear Train Rating: 2.12 N•m/300 oz-in static
1.41 N•m/200 oz-in running

Dimensions: mm/inches







Specifications (Motor Only)

Part Number	Bipolar		Unipolar	
	42M048C1B	42M048C2B	42M048C1U	42M048C2U
DC Operating Voltage	5	12	5	12
Res. per Winding Ω	9.1	52.4	9.1	52.4
Ind. per Winding mH	14.3	77.9	7.5	46.8
Holding Torque mN•m/oz-in†	87.5/12.4		73.4/10.4	
Rotor Moment of Inertia g•m²	12.5 x 10^{-4}			
Step Angle	7.5°			
Step Angle Tolerance†	±0.5°			
Steps per Rev.	48			
Max Operating Temp.	100°C			
Ambient Temp Range				
Operating	-20°C to 70°C			
Storage	-40°C to 85°C			
Bearing Type	Bronze sleeve			
Insulation Res. at 500Vdc	100 megohms			
Weight g/oz	312/11.0			
Lead Wires	No. 26 AWG			

† Measured with 2 phases energized.

Available Gear Train Reductions

Part Suffix	Gear Ratio	Output Step Angle	Output Speed RPM @ 240 PPS	Running Torque @240 PPS N•m/oz-in
-Z16	5:1	1.50°	25	0.155/22
-Z21	10:1	.75°	12.5	0.318/45
-Z24	15:1	.50°	8.33	0.473/67
-Z27	20:1	.375°	6.25	0.635/90
-Z31	30:1	.25°	4.17	0.953/135
-Z36	50:1	.15°	2.5	1.412/200 max

How to Order

1. List Series 42M048C.
2. Add suffix -Z16 to -Z36 for pear diecast gearbox.

Example of Part Numbers

42M048C | 1U | -Z24

- Basic Series (42M048C)
- Unipolar 5 Vdc (1U)
- 15:1 (pear) (-Z24)

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THOMSON AIRPAX MECHATRONICS

Step Angle: The nominal angle that the motor shaft rotates for each winding polarity change.

Step Accuracy: The per step deviation from the nominal step angle of an unloaded motor. May be expressed as a percent or in degrees.

Holding Torque: The torque required to deflect the rotor a full step with the motor energized and in a standstill condition.

Residual Torque: The non-energized detent torque due to the effects of the permanent magnet and bearing friction.

Pull Out Torque: The maximum torque load that the motor can drive, at a fixed frequency, without losing synchronism.

Pull In Torque: The maximum torque load the motor can start and stop with, at a fixed frequency, without loss of a step.

Pull In Rate: The stepping rate at which a motor with no external load inertia can start and stop without losing a step.

Ramping: A control method used to vary the pulse rate to accelerate from zero steps per second to the running rate, or from any step rate to a different rate — whether it is accelerating or decelerating.

Torque-To-Inertia Ratio: The holding torque of a motor divided by the rotor inertia. This ratio is sometimes used to relate the step response of one motor size or design to another.

Step Response: The motor shaft rotational response to a step command related to time.

Overshoot: The amount the motor shaft may rotate beyond the step angle before it comes to rest at the step angle position.

Drive: The switching circuitry which controls the stepper motor.

Pulse Rate: The rate, pulses per second, at which pulses are fed to a drive. In most cases, the pulse rate is the stepping rate or running rate.

Introduction to Digital Linear Actuators

Thomson Airpax Mechatronics manufactures digital linear actuators (DLA's). These are modified rotary stepper motors, with rotors that include a molded thread that mates to an externally threaded shaft (lead screw). Rotary motion is converted to linear movement, with the travel per step determined by the pitch of the lead screw and step angle of the motor.

- High linear resolution in a complete solution package
- Ideal for fast and precise positioning
- Available in three package sizes based on our ϕ26mm, ϕ35mm and ϕ57mm stepper motors
- Available in linear travel per step .001" (.025mm) to .004" (182mm)
- Available with output force up to 20 lb (89 Newtons)

Thomson Airpax Mechatronics DLA products are ideally suited for applications such as:

- Computer Peripherals
- HVAC
- Instrumentation
- Office Automation
- Medical

Call or E-Mail and discuss your application with an expert

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motorinfo@snet.net

Europe: (44) 1276-691622
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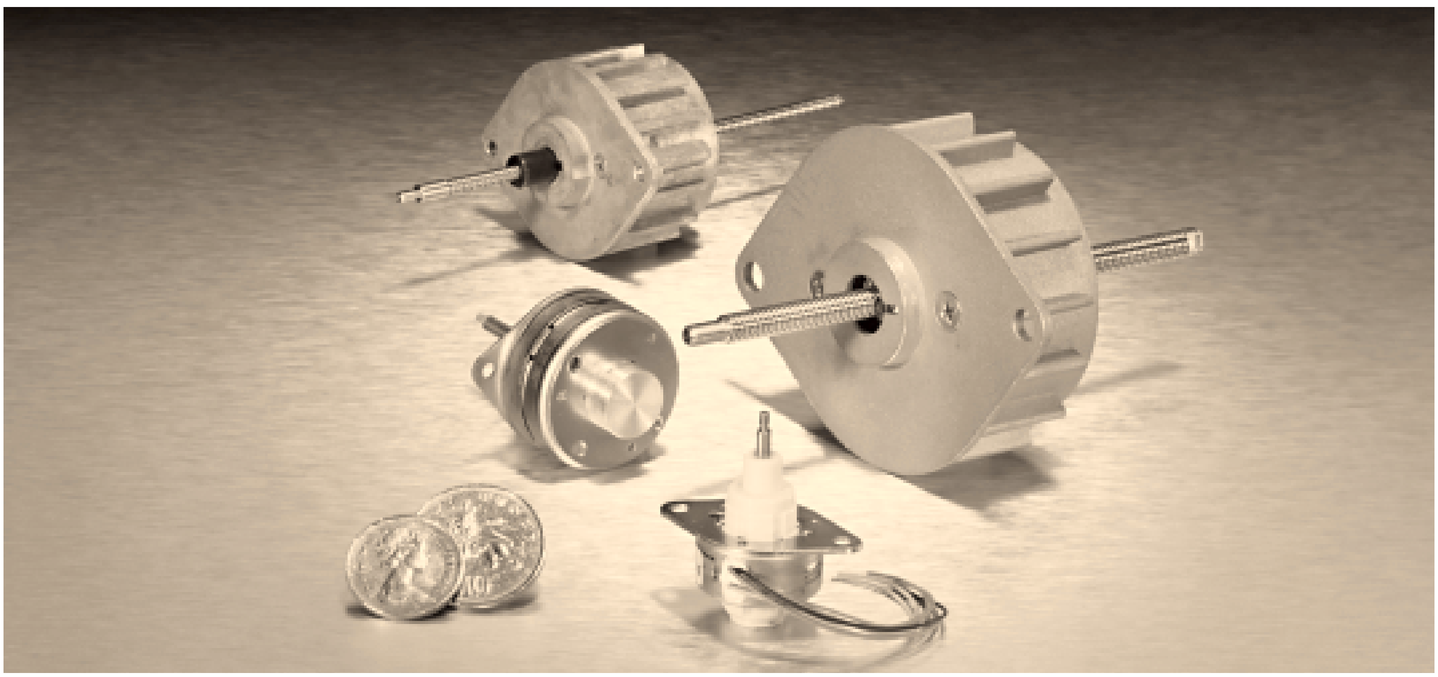
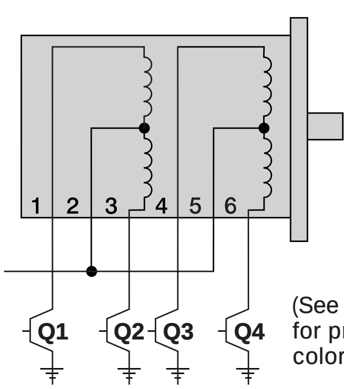
airpax@tamsales.com.sg



Standard Switching Sequence for Linear Actuators – Unipolar Drive 5Vdc and 12Vdc



(See chart for proper color codes)

OUT ↓ / IN ↑

Q1	Q2	Q3	Q4
ON	OFF	ON	OFF
ON	OFF	OFF	ON
OFF	ON	OFF	ON
OFF	ON	ON	OFF

Unipolar Drive

Note: Chart sequence repeats after four pulses. For outward thrust, use switching from top of chart to bottom. For inward thrust, use switching from bottom of chart to top.

Lead Wire Color Codes

Series	Q1	Q2	Q3	Q4	+V
92100 5V & 12V	YEL	ORN	BLK	BRN	RED (2) GRN (5)
92200 5V	GRN	GRY	BLU	WHT	RED
92200 12V	YEL	BLK	ORN	BRN	RED
92400 5V	GRN	GRY	BLU	WHT	RED
92400 12V	YEL	BLK	ORN	BRN	RED

Series 92100 Digital Linear Actuators

The Series 92100 bidirectional linear actuator is a stepper motor that has been modified by incorporating a pre-loaded ball bearing and an internally threaded rotor with a lead screw shaft. Energizing the unit's coil in proper sequence will cause the threaded shaft to move out or back into the rotor in linear increments of .001", .002" or .004" per pulse.

The actuator shaft will remain in position when power is removed. The actuator shaft of the Series K92100 has a maximum travel of 1/2". Maximum travel of the Series L92100 shaft is 1 7/8". The *Linear Force Chart* shows typical forces available vs. pulse rates. "K" units contain an integral anti-rotational shaft feature. "L" units require an external means of preventing shaft rotation.

These devices are particularly useful for applications, such as valve actuators, variable displacement pumps, etc., where rapid movement to a particular linear position is required. Actuators for applications requiring different step increments, force outputs or extended travel can be provided on a special basis. Please supply us with complete specifications of your requirements.

Specifications

Part Number	DC Operating Voltage	Maximum Travel	Linear Travel Per Step	Maximum Force	Minimum Holding Force (Unenergized)
K92111-P1	5	0.5" (12.7mm)	.001" (.025mm)	45 oz (12.5N)	60 oz (16.68N)
K92111-P2	12				
L92111-P1	5	1.875" (47.6mm)			
L92111-P2	12				
K92121-P1	5	0.5" (12.7mm)	.002" (.05mm)	26 oz (7.23N)	40 oz (11.13N)
K92121-P2	12				
L92121-P1	5	1.875" (47.6mm)			
L92121-P2	12				
K92141-P1	5	0.5" (12.7mm)	.004" (.10mm)	16 oz (4.45N)	7 oz (1.95N)
K92141-P2	12				
L92141-P1	5	1.875" (47.6mm)			
L92141-P2	12				

Note: Shaft Options Series K92100
Add Suffix-S1 for #4-40 NC-2A Threaded Tip
Add Suffix-S2 for #2-56 NC-2A Threaded Tip

Unipolar Drive		
Max Pull-in Rate (Steps/Sec)	380	
Max Pull-out Rate (Steps/Sec)	650	
Power Consumption:	3.5 Watts	
Insulation Resistance:	20MΩ	
Bearings:	Radial Ball	
Weight:	1.5 oz. (42.5 gr.)	
Operating Temp. Range:	-20ºC to 70ºC	
Storage Temp. Range:	-40ºC to 85ºC	
Coil Data	-P1 (5Vdc)	-P2 (12Vdc)
Resistance Per Phase:	15Ω	84Ω
Inductance Per Phase:	5mH	29mH

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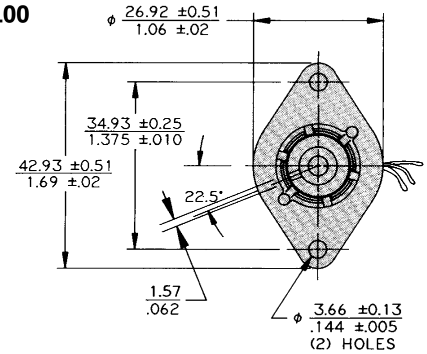
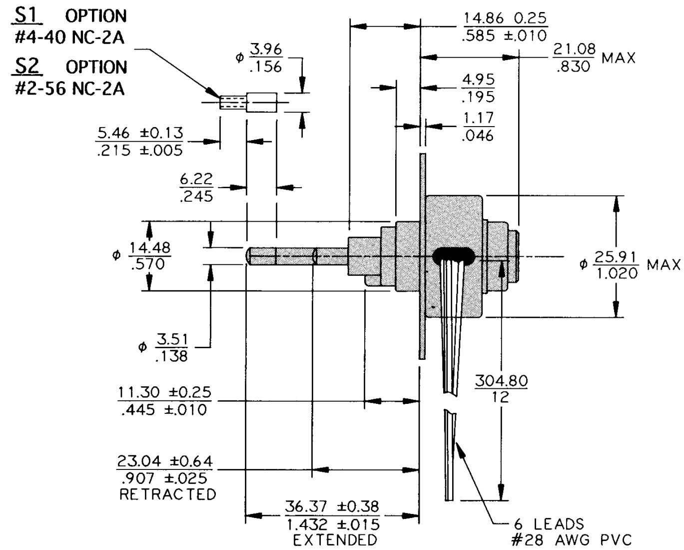
THOMSON AIRPAX MECHATRONICS

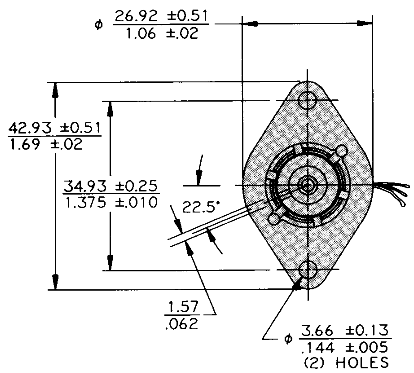
Dimensions: mm/in

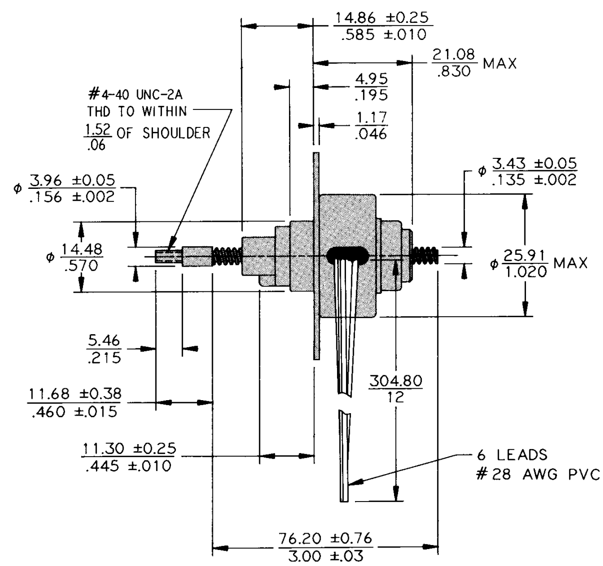
Series K92100



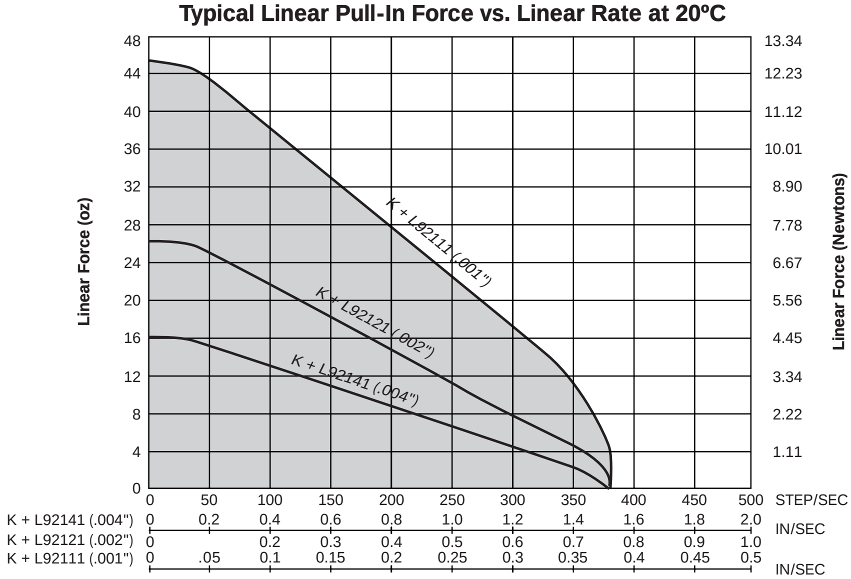


Series L92100





Typical Linear Pull-In Force vs. Linear Rate at 20ºC



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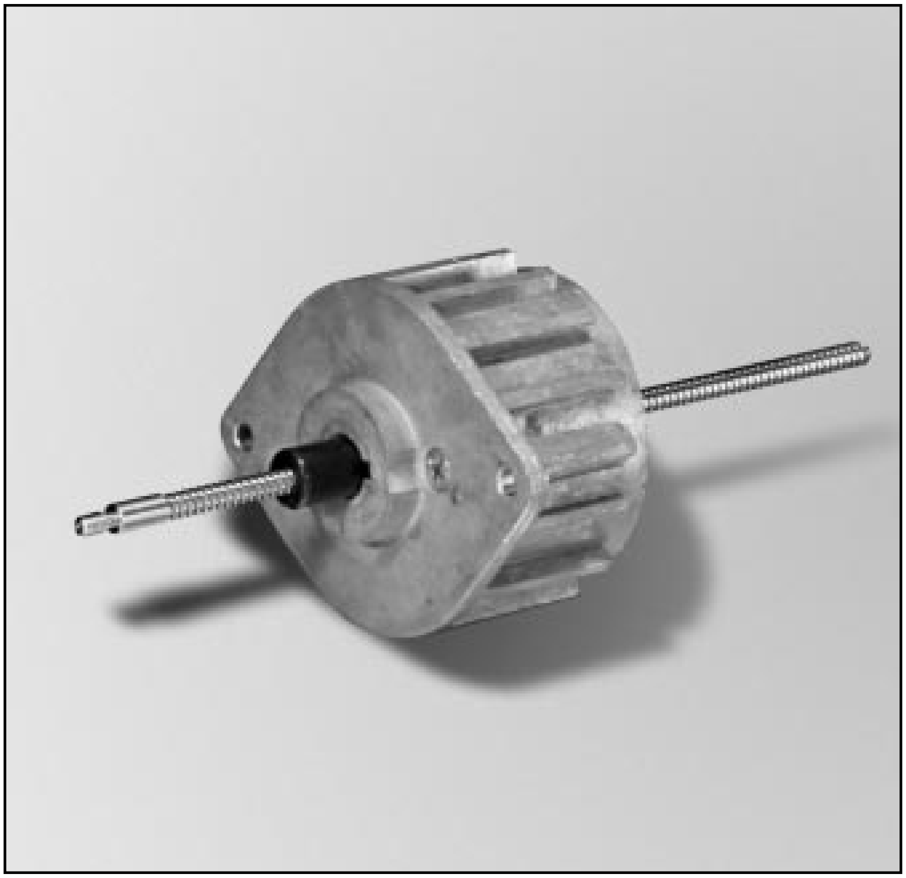
THOMSON AIRPAX MECHATRONICS

Series K92200 & L92200 Digital Linear Actuators



Series 92200 Digital Linear Actuators

The Series 92200 bidirectional linear actuator is a stepper motor that has been modified by incorporating an internally threaded rotor and fitting it with a lead screw shaft. Energizing the unit's coils in proper sequence will cause the threaded shaft to move out of or back into the rotor in linear increments of .001", .002", or .003" per pulse. The actuator shaft will remain in position when power is removed.

Series 92200 is rated with a maximum linear force of 75 ounces. The actuator shaft has a maximum travel of 0.875" for the "K" unit and 2.5" for the "L" unit. The *Linear Force Graph* shows typical forces available vs. pulse rates. "K" units contain an integral anti-rotational shaft feature. "L" units require an external means of preventing shaft rotation.

Use this actuator wherever precise response and precision movements are essential. Typical applications include valve actuation and variable displacement pump regulation in process control situations and medical equipment. Unique step increment, force output or travel needs can be handled on a special basis.

Please supply us with complete specifications of your requirements.

Specifications

Part Number	DC Operating Voltage	Maximum Travel	Linear Travel Per Step	Maximum Force	Minimum Holding Force (Unenergized)
K92211-P1	5	.875" (22.2mm)	.001" (.025mm)	75 oz (20.9N)	40 oz (11.1N)
K92211-P2	12				
L92211-P1	5	2.5" (63.5mm)			
L92211-P2	12				
K92221-P1	5	.875" (22.2mm)	.002" (.05mm)	55 oz (15.3N)	20 oz (5.6N)
K92221-P2	12				
L92221-P1	5	2.5" (63.5mm)			
L92221-P2	12				
K92231-P1	5	.875" (22.2mm)	.003" (.076mm)	32 oz (8.9N)	8 oz (2.2N)
K92231-P2	12				
L92231-P1	5	2.5" (63.5mm)			
L92231-P2	12				

Note: Part number without suffix will be supplied with #4-40 NC-2A Threaded
Part number with suffix -S1 will be supplied with #2-56 NC-2A Threaded

Unipolar Drive Max Pull-in Rate (Steps/Sec) Max Pull-out Rate (Steps/Sec)	425 700	
Power Consumption:	5 Watts	
Insulation Resistance:	20 MΩ	
Bearings:	Radial Ball	
Weight:	7 oz. (198 gr.)	
Operating Temp. Range:	-20ºC to 70ºC	
Storage Temp. Range:	-40ºC to 85ºC	
Coil Data	-P1 (5Vdc)	-P2 (12Vdc)
Resistance Per Phase:	10Ω	58Ω
Inductance Per Phase:	5.2mH	30mH

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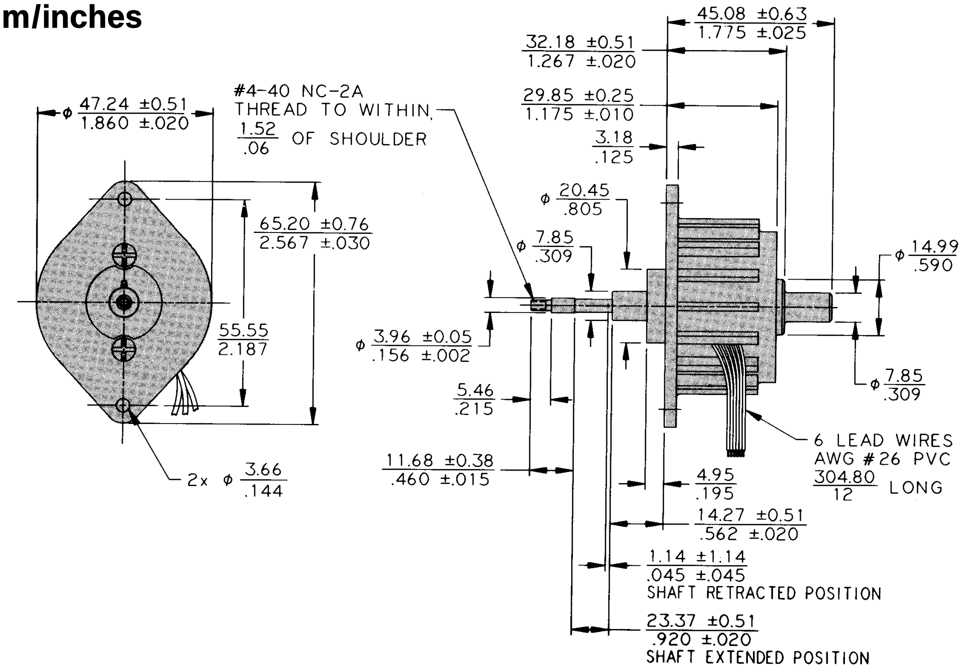
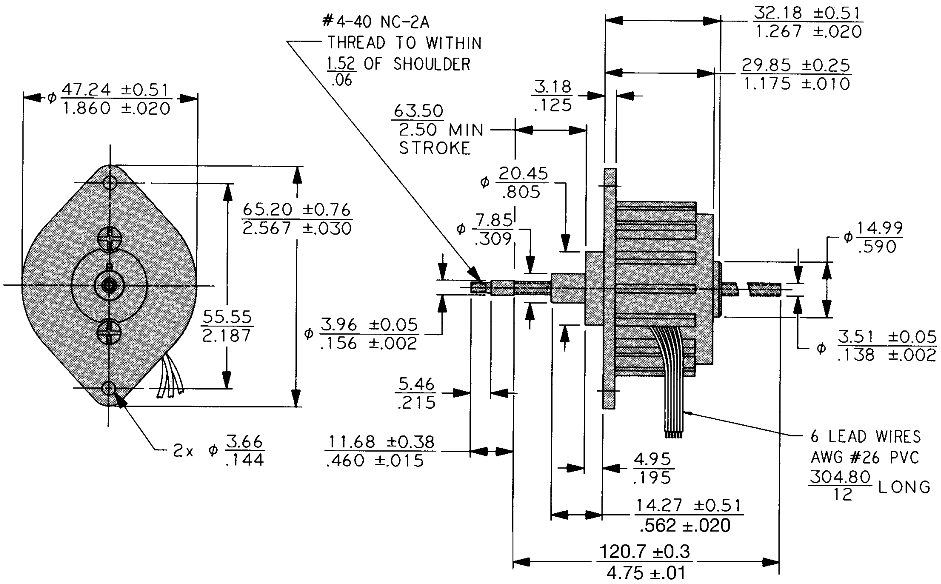
THOMSON AIRPAX MECHATRONICS

Dimensions: mm/inches

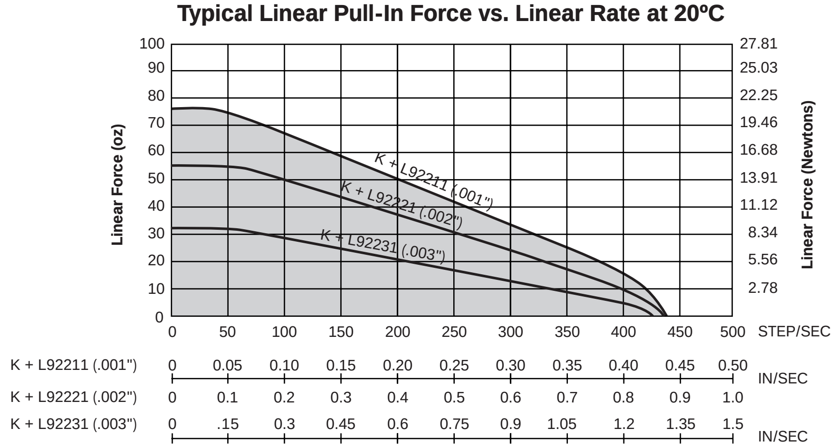
Series K92200



Series L92200



Typical Linear Pull-In Force vs. Linear Rate at 20ºC



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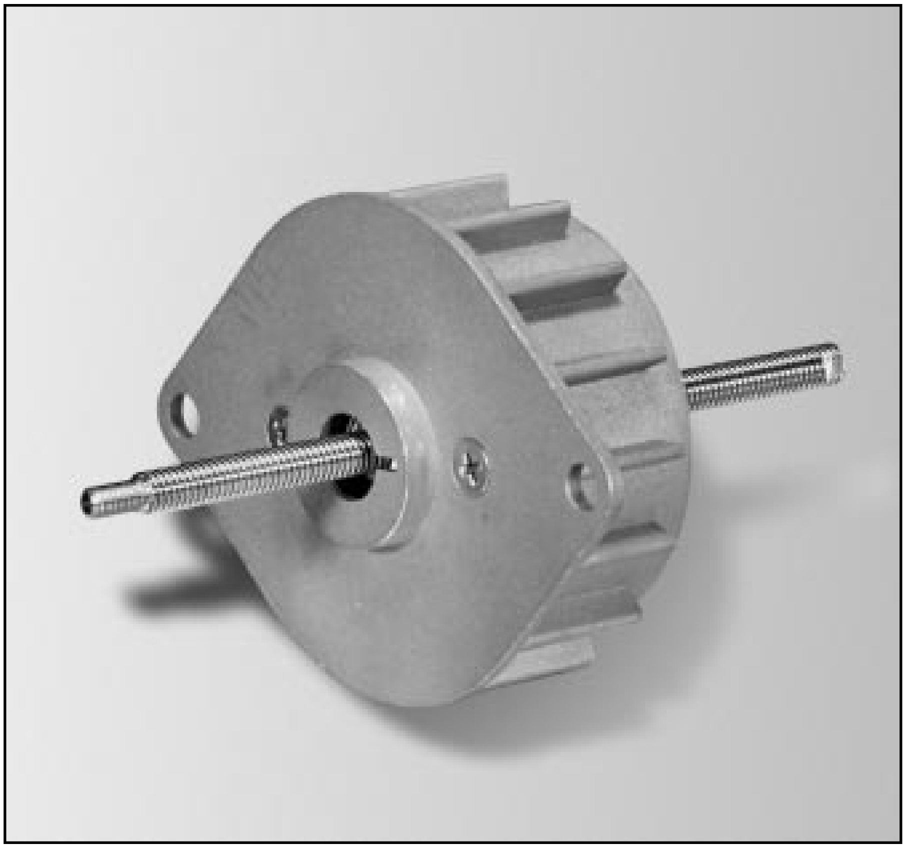
THOMSON AIRPAX MECHATRONICS



Series 92400 Digital Linear Actuators

The Series 92400 bidirectional linear actuator is a stepper motor that has been modified by incorporating an internally threaded rotor and fitting it with a lead screw shaft. Energizing the unit's coils in proper sequence will cause the threaded shaft to move out of or back into the rotor in precise linear increments of .001" or .002" per pulse. The actuator shaft will remain in position when power is removed.

Series 92400 is rated with a maximum linear force of 20 pounds. The actuator shaft has a maximum travel of 3". This unit needs an external means for preventing shaft rotation. The *Linear Force Graph* charts typical forces available vs. pulse rates.

This actuator is ideal for exact response and precision movements. Typical applications include valve actuation and variable displacement pump regulation in process control situations and in medical equipment, and pneumatic valve control in air brake systems. Unique step increment, force output or travel needs can be handled on a special basis.

Please supply us with complete specifications of your requirements.

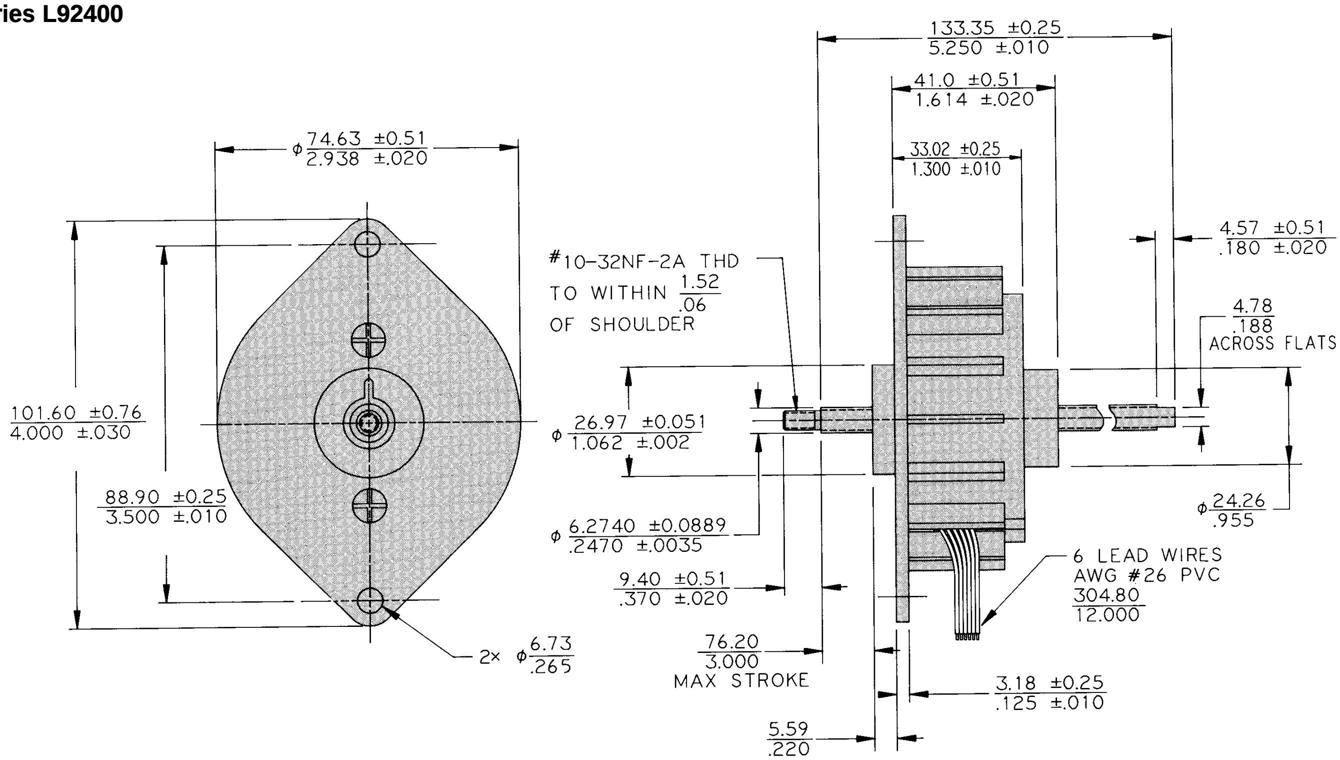
Specifications

Part Number	DC Operating Voltage	Maximum Travel	Linear Travel Per Step	Maximum Force	Minimum Holding Force (Unenergized)
L92411-P1	5	3" (76.2mm)	.001" (.025mm)	20 lb (88N)	>20 lb (88N)
L92411-P2	12				
L92421-P1	5	3" (76.2mm)	.001" (.025mm)	16 lb (71N)	>16 lb (71N)
L92421-P2	12				

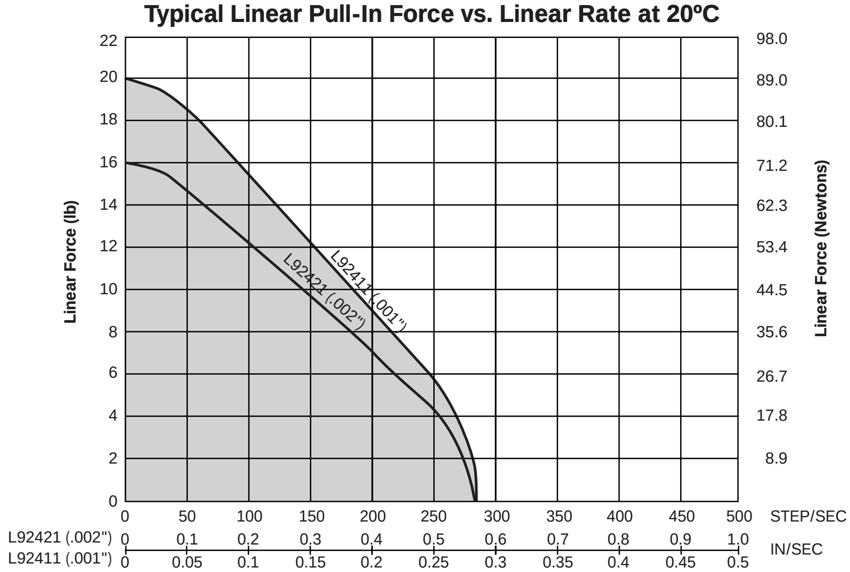
Unipolar Drive Max Pull-in Rate (Steps/Sec) Max Pull-out Rate (Steps/Sec)	275 450	
Power Consumption:	12Watts	
Insulation Resistance:	20 MΩ	
Bearings:	Radial Ball	
Weight:	1 lb (0.45 Kilo)	
Operating Temp. Range:	-20ºC to 70ºC	
Storage Temp. Range:	-40ºC to 85ºC	
Coil Data	-P1 (5Vdc)	-P2 (12Vdc)
Resistance Per Phase:	4.3Ω	25Ω
Inductance Per Phase:	5mH	25mH

Dimensions: mm/in

Series L92400



Typical Linear Pull-In Force vs. Linear Rate at 20ºC



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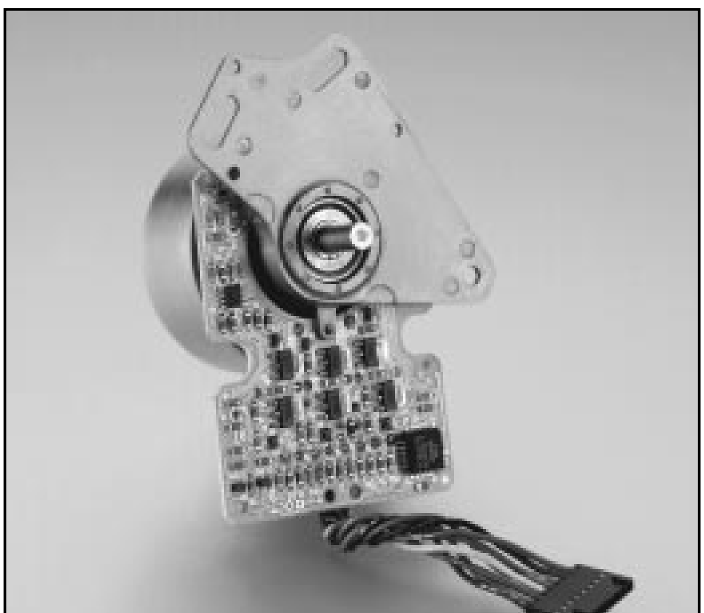
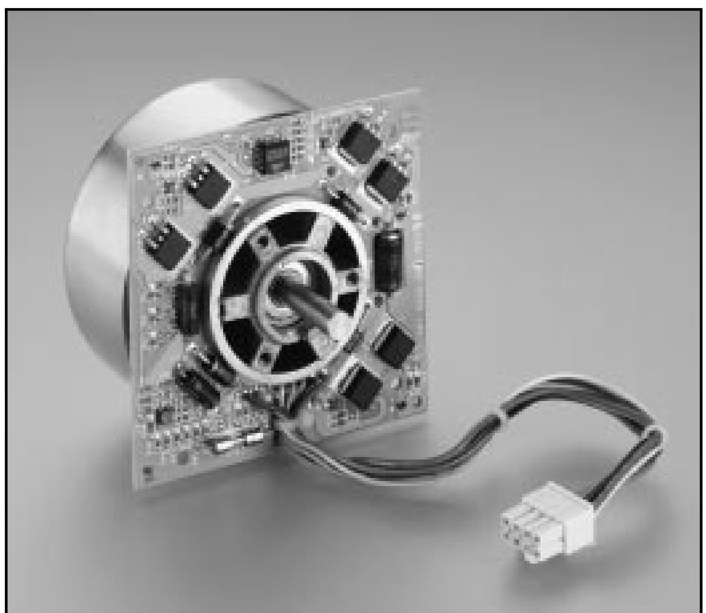


Series 58MD036000



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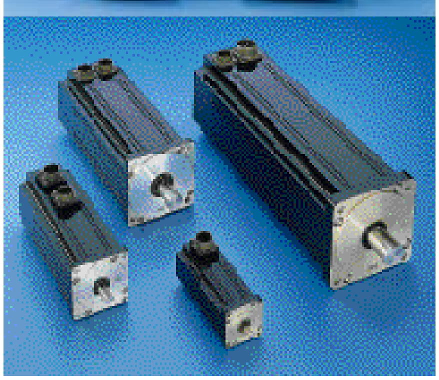

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HEADQUARTERS (North America)
THOMSON AIRPAX MECHATRONICS LLC
7 McKee Place
Cheshire, CT 06410 USA
E-mail: motorinfo@snet.net
Phone: 1-203-271-6444
Fax: 1-203-271-6400

EUROPE
THOMSON AIRPAX MECHATRONICS (UK) LIMITED
9 Farnborough Business Centre
Eelmoor Road, Farnborough
Hants GU14 7QN Great Britain
E-mail: info@tammail.com
Phone: (44) 1276-691622
Fax: (44) 1276-691420

ASIA
THOMSON AIRPAX MECHATRONICS PTE LTD.
Block 3015A, Ubi Road 1
#07-08 Kampong Ubi Industrial Estate
Singapore 408705
E-mail: airpax@tamsales.com.sg
Phone: (65) 7474-888
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THOMSON INDUSTRIES, INC.
2 Channel Drive
Port Washington, NY 11050 USA
E-mail: litrequest@thomsonmail.com
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