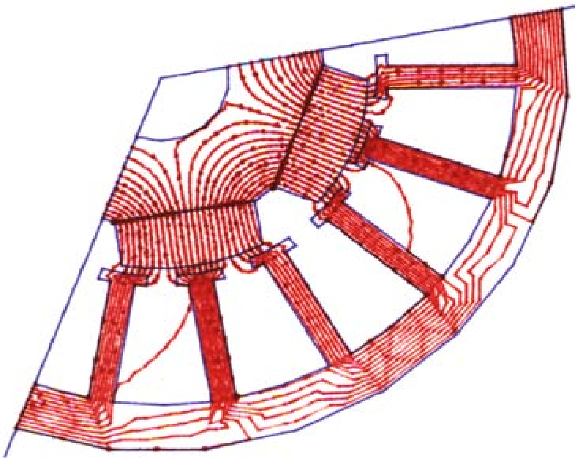
Stepper Motors



Introduction

This catalog is intended as a guide for the user to help select or specify a DC stepper motor. The size, weight and performance characteristics of the motors shown in the data sheets are examples of typical applications. Aeroflex can provide custom solutions if desired. This customization can include size variations, step angles, winding characteristics, performance characteristics and physical mounting requirements.

Stepper Motor Description

Stepper motors provide precise motion without the need for position feedback or commutation. Essentially the motor runs open loop. This type of motor has many advantages and disadvantages, which are discussed in the Application Considerations section of this document. The designer must weigh the pros and cons of the stepper motor in order to properly evaluate its use and implementation.

Stepper motors come in two basic configurations as used in most applications: permanent magnet and hybrid. Permanent magnet motors are configured just as the name implies – incorporating the use of permanent magnets. The hybrid design is a combination of permanent magnet and variable reluctance motor technologies. The hybrid motor usually has a rotor with teeth.

A stepper motor converts electrical pulses into incremental mechanical motion. Upon the application of electrical pulses in the proper sequence and polarity, the motor will rotate in the commanded direction. One energizing pulse results in one step at the output shaft of the motor. The frequency of the output steps is directly related to the frequency of the input electrical pulses.

Performance Considerations

When considering a stepper motor for an application there are several parameters that require evaluation. In many cases the designer is limited due to existing drive electronics and therefore must go down a limited path. Parameters to consider when evaluating stepper motors are as follows:

- Output step angle
- Pulse rate required
- Running Torque
- Powered holding torque
- Unpowered holding torque
- Size and power constraints
- Load, friction and inertia
- Redundancy
- Drive electronics

With respect to drive electronics, many variables exist. The designer must be aware of different drive techniques, such as unipolar and bipolar as well as how many phases are energized simultaneously.

Application Considerations

As with all designs, it is important to select the right components in order to be successful. Here are some trade-off points to consider:

1. Stepper motors tend to be less expensive than brushless DC motors. Steppers run open-loop; therefore expensive feedback devices in most cases are not needed. Control electronics are generally less expensive for steppers vs. brushless DC motors.
2. Steppers provide unpowered holding torque whereas brushless DC motors (depending upon motor detent torque) require continuous power or the use of an external brake.
3. Stepper motors do not incorporate brushes.

4. Stepper motor step angles are very accurate, even though they operate open-loop.
5. Stepper motors are limited by the step rate they can operate at.
6. Stepper motors will introduce disturbance torques and resonances into the system.

Explanation of Motor Terms

Running Torque - Generally termed "pull out torque". It is the torque that the motor can sustain without losing synchronous rotation with the pulse rate. Running torque will be influenced by the speed commanded, load factors and operating temperature.

Step Size (or Step Angle) – The physical angle between each step of the motor.

Maximum Step Rate – The number of steps per second the motor can reliably run at without missing steps without an external load or inertia.

Peak power - The Peak current squared multiplied by the motor resistance at +20°C. Use caution when discussing power for stepper motors. Duty cycle and pulse rate should be considered along with temperature when discussing power.

Motor Sizes – Stepper motors are commonly referred to their size by designations such as "Size 11". The size refers to the outer diameter of the motor. In the case of the "Size 11", the designer can assume the outer diameter of the motor is approximately 1.1 inches. Motor sizes from 10 mm on up can be tailored per customer applications

Km - Motor Constant - A figure of merit which characterizes the size of a motor with respect to the amount of torque vs. amount of power available. It is mathematically the peak torque divided by the square root of peak power or it is the torque constant (Kt) divided by the square root of motor resistance (R).

Detent – The rotor magnetic poles will align with the stator magnetic poles when no power is applied to the windings. This alignment, or detent, is what you feel when manually rotating the rotor shaft.

Poles – The number of poles in a stepper motor can be defined as the number of magnets. The number of poles is generally directly related to the step size of the motor.

Powered Holding Torque – With power applied to one winding (or several depending upon specification requirements), the motor will stay energized and hold position. Due to the increased magnetic attraction the rotor will have significantly more holding force compared to the unpowered state. This term relates to the amount of torque that would have to be applied to the rotor shaft to cause the shaft to move to the next rotor position.

Inertia - The moment of inertia about the axis of rotation.

Weight - The weight of the combined rotor and stator without leads.

Kt - Torque Constant - The amount of torque developed for a given current. The torque constant is independent of motor speed.

R - Motor Resistance - The +20°C resistance of each phase of the motor.