Motor Fundamentals

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Overview

Motors come in many different types, shapes, and sizes. Most of the motors used in motion control can be divided into two categories: stepper motors and servo motors. This document describes these two types of motors.

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1. Stepper Motors

Stepper motors are less expensive and typically easier to use than a servo motor of a similar size. They are called stepper motors because they move in discrete steps. Controlling a stepper motor requires a stepper drive and a controller (For more information about stepper drives, see the related link, Stepper Motor Drives below). You control a stepper motor by providing the drive with a step and direction signal. The drive then interprets these signals and drives the motor. Stepper motors can be run in an open loop configuration (no feedback) and are good for low-cost applications. In general, a stepper motor will have high torque at low speeds, but low torque at high speeds. Movement at low speeds is also choppy unless the drive has microstepping capability (for more information on microstepping see the microstep section of the Stepper Motor Switching Sequence link below). At higher speeds, the stepper motor is not as choppy, but it does not have as much torque. When idle, a stepper motor has a higher holding torque than a servo motor of similar size, since current is continuously flowing in the stepper motor windings. For information about how stepper motors work, see the following links:

See Also:
Types of Stepper Motors
Types of Stepper Motors (detailed)
Stepper Motor Theory of Operation
Selecting the Proper Size Stepper Motor
Linear Stepper Motors

2. Advantages of Stepper Motors

Some of the advantages of stepper motors over servo motors are as follows:

- Low cost
- Can work in an open loop (no feedback required)
- Excellent holding torque (eliminated brakes/clutches)
- Excellent torque at low speeds
- Low maintenance (brushless)
- Very rugged - any environment
- Excellent for precise positioning control
- No tuning required

3. Disadvantages of Stepper Motors

Some of the disadvantages of stepper motors in comparison with servo motors are as follows:

- Rough performance at low speeds unless you use microstepping For more information about microstepping, see the Stepper Motor Switching Sequence link below)
- Consume current regardless of load
- Limited sizes available
- Noisy
- Torque decreases with speed (you need an oversized motor for higher torque at higher speeds)
- Stepper motors can stall or lose position running without a control loop
  See Also:
  Stepper Motor Switching Sequence

4. Servo Motors

One of the main differences between servo motors and stepper motors is that servo motors, by definition, run using a control loop and require feedback of some kind. A control loop uses feedback from the motor to help the motor get to a desired state (position, velocity, and so on). There are many different types of control loops. Generally, the PID (Proportional, Integral, Derivative) control loop is used for servo motors. For more information, see the related link, PID Controller: Theory and Practice.

When using a control loop such as PID, you may need to tune the servo motor. Tuning is the process of making a motor respond in a desirable way. Tuning a motor can be a very difficult and tedious process, but is also an advantage in that it lets the user have more control over the behavior of the motor. For more information about tuning servo motors see the related link, Basics of Tuning Servos Using PID.

Since servo motors have a control loop to check what state they are in, they are generally more reliable than stepper motors. When a stepper motor misses a step for any reason, there is no control loop to compensate in the move. The control loop in a servo motor is constantly checking to see if the motor is on the right path and, if it is not, it makes the necessary adjustments.

In general, servo motors run more smoothly than stepper motors except when microstepping is used. Also, as speed increases, the torque of the servo remains constant, making it better than the stepper at high speeds (usually above 1000 RPM). For information about how servo motors work see the related link below.

See Also:
Servo Motor Overview

5. Advantages of Servo Motors

Some of the advantages of servo motors over stepper motors are as follows:

- High intermittent torque
- High torque to inertia ratio
- High speeds

- Work well for velocity control
- Available in all sizes
- Quiet

6. Disadvantages of Servo Motors

Some of the disadvantages of servo motors compared with stepper motors are as follows:

- More expensive than stepper motors
- Cannot work open loop - feedback is required
- Require tuning of control loop parameters
- More maintenance due to brushes on brushed DC motors