TECHNOCRATS ROBOTICS

VACATION TASKS

SET-2

Servo and Stepper Motors

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Servo Motor

A servo motor is an electrical device which can push or rotate an object with great precision. If you want to rotate and object at some specific angles or distance, then you use servo motor. It is just made up of simple motor which run through servo mechanism.

If motor is used is DC powered then it is called DC servo motor, and if it is AC powered motor then it is called AC servo motor. We can get a very high torque servo motor in a small and light weight packages. Doe to these features they are being used in many applications like toy car, RC helicopters and planes, Robotics, Machine etc.

Servo motors are rated in kg/cm (kilogram per centimeter) most hobby servo motors are rated at 3kg/cm or 6kg/cm or 12kg/cm. This kg/cm tells you how much weight your servo motor can lift at a particular distance. For example: A 6kg/cm Servo motor should be able to lift 6kg if the load is suspended 1cm away from the motors shaft, the greater the distance the lesser the weight carrying capacity.

The position of a servo motor is decided by electrical pulse and its circuitry is placed beside the motor.

Servo Mechanism

It consists of three parts:

- Controlled device
- Output sensor
- Feedback system

It is a closed loop system where it uses positive feedback system to control motion and final position of the shaft. Here the device is controlled by a feedback signal generated by comparing output signal and reference input signal.

Here reference input signal is compared to reference output signal and the third signal is produces by feedback system. And this third signal acts as input signal to control device. This signal is present as long as feedback signal is generated or there is difference between reference input signal and reference output signal. So the main task of servomechanism is to maintain output of a system at desired value at presence of noises.

Working principle of Servo Motors

A servo consists of a Motor (DC or AC), a potentiometer, gear assembly and a controlling circuit. First of all we use gear assembly to reduce RPM and to increase torque of motor. Say at initial position of servo motor shaft, the position of the potentiometer knob is such that there is no electrical signal generated at the output port of the potentiometer. Now an electrical signal is given to another input terminal of the error detector amplifier.

Now difference between these two signals, one comes from potentiometer and another comes from other source, will be processed in feedback mechanism and output will be provided in term of error signal. This error signal acts as the input for motor and motor starts rotating. Now motor shaft is connected with potentiometer and as motor rotates so the potentiometer and it will generate a signal.

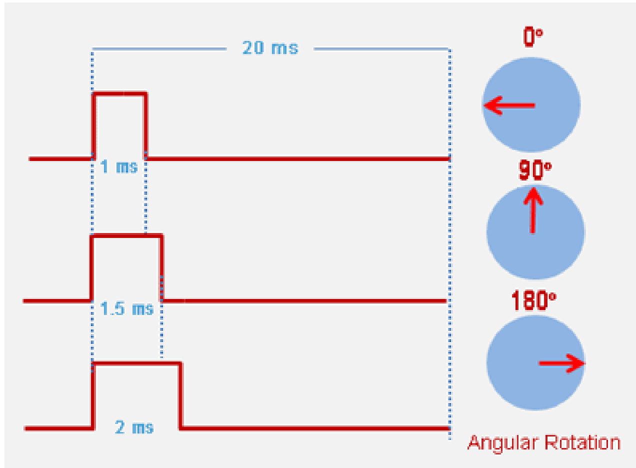
So as the potentiometer’s angular position changes, its output feedback signal changes. After sometime the position of potentiometer reaches at a position that the output of potentiometer is same as external signal provided. At this condition, there will be no output signal from the amplifier to the motor input as there is no difference between external applied signal and the signal generated at potentiometer, and in this situation motor stops rotating.

Controlling Servo Motor:

All motors have three wires coming out of them. Out of which two will be used for Supply (positive and negative) and one will be used for the signal that is to be sent from the MCU. Servo motor is controlled by PWM (Pulse with Modulation) which is provided by the control wires. There is a minimum pulse, a maximum pulse and a repetition rate. Servo motor can turn 90 degree from either direction form its neutral position.

The servo motor expects to see a pulse every 20 milliseconds (ms) and the length of the pulse will determine how far the motor turns. For example, a 1.5ms pulse will make the motor turn to the 90° position, such as if pulse is shorter than 1.5ms shaft moves to 0° and if it is longer than 1.5ms than it will turn the servo to 180°.

Servo motor works on PWM (Pulse width modulation) principle, means its angle of rotation is controlled by the duration of applied pulse to its Control PIN. Basically servo motor is made up of DC motor which is controlled by a variable resistor (potentiometer) and some gears. High speed force of DC motor is converted into torque by Gears. We know that WORK= FORCE X DISTANCE, in DC motor Force is less and distance (speed) is high and in Servo, force is High and distance is less. Potentiometer is connected to the output shaft of the Servo, to calculate the angle and stop the DC motor on required angle.



Servo motor can be rotated from 0 to 180 degree, but it can go up to 210 degree, depending on the manufacturing. This degree of rotation can be controlled by applying the Electrical Pulse of proper width, to its Control pin. Servo checks the pulse in every 20 milliseconds. Pulse of 1 ms (1 millisecond) width can rotate servo to 0 degree, 1.5ms can rotate to 90 degree (neutral position) and 2 ms pulse can rotate it to 180 degree.

All servo motors work directly with your +5V supply rails but we have to be careful on the amount of current the motor would consume, if you are planning to use more than two servo motors a proper servo shield should be designed.

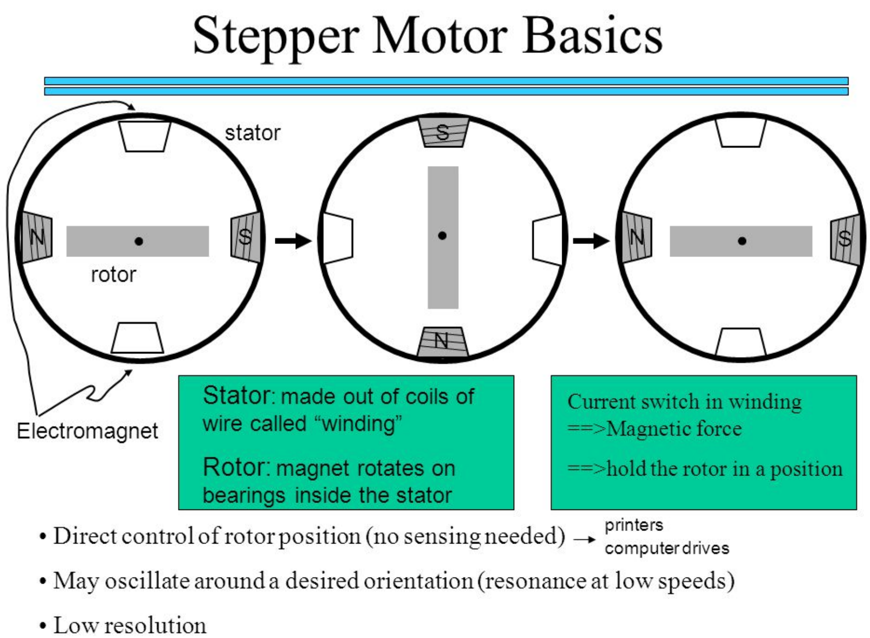
Code

```
// Include the Servo library
#include <Servo.h>
// Declare the Servo pin
int servoPin = 3;
// Create a servo object
Servo Servo1;
void setup() {
  // We need to attach the servo to the used pin number
  Servo1.attach(servoPin);
}
void loop(){
  // Make servo go to 0 degrees
  Servo1.write(0);
  delay(1000);
  // Make servo go to 90 degrees
  Servo1.write(90);
  delay(1000);
  // Make servo go to 180 degrees
  Servo1.write(180);
  delay(1000);
}
```

Stepper Motor

A large percentage of electromechanical linear motion applications—including ball and lead screw drives, rack and pinion drives, and linear actuators—use one of two motor technologies: servo or stepper. A servo motor is a closed-loop device, meaning it incorporates an encoder that monitors the actual motor position and feeds this information back to the drive, which compares it to the commanded position and makes any necessary adjustments.

A stepper motor, on the other hand, is primarily an open-loop device, without a feedback mechanism to ensure that the actual position matches the target position. For applications that don't require position feedback, stepper motors offer excellent performance at a lower price and with simpler control schemes than servo motors.



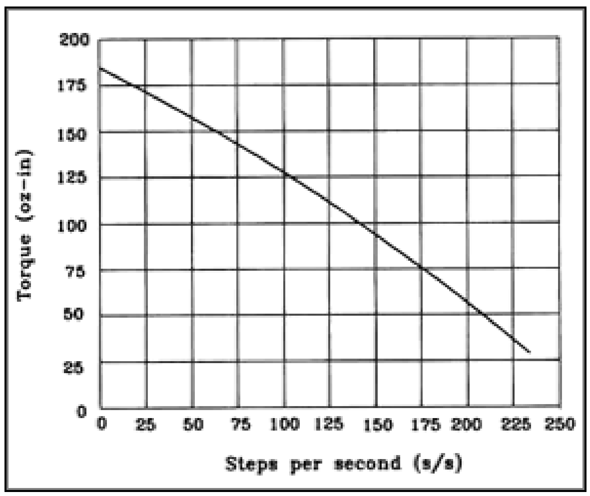
Basics of stepper motor construction

As their name implies, stepper motors move in discreet steps, known as the step angle, which usually ranges from 90 degrees (360° / 90° per step = 4 steps per revolution) to 0.75 degrees (360° /0.75° per step = 500 steps per revolution). Their basic construction consists of an outer stator and an inner rotor. The design of the rotor depends on the type of stepper motor being discussed, but the stator is similar between the various types of stepper motors, with uniform teeth around its perimeter and containing a specified number of poles. Poles are simply magnetic sections of the stator, and each pole has a winding that is connected to the pole opposite it on the stator. Thus, the opposing poles are magnetized with the opposite polarity when current is applied to the windings.

These pole pairs make up the winding phases, with most stepper motors being either 2-phase or 5-phase design. There can also be multiple pole pairs per phase; for example, a 2-phase stepper motor may have 3 pole pairs (6 poles) in each phase, for a total of 12 poles.

Stepper motor types

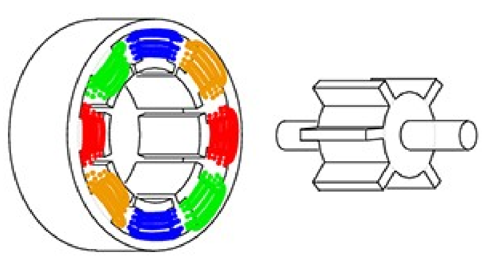
There are three general stepper motor designs: variable reluctance, permanent magnet, and hybrid. Regardless of the design, stepper motors have several performance characteristics in common. First, they produce high torque at low speeds, with maximum torque available when the rotor is stationary, making them good for applications that require holding a load in place. Second, a stepper motor's speed is directly related to the frequency of the input pulses, making it easy to achieve and control a wide range of running speeds. Stepper motors also have a noncumulative positioning error, so if the specified error is ± 5°, regardless of whether the motor completes one step or one hundred steps, its final position will be within ± 5° of the intended position.



The basic stepper motor speed-torque curve shows that maximum torque is achieved at standstill.

Variable reluctance

Variable reluctance steppers have a rotor made of soft iron. Both the stator and the rotor are toothed, but the rotor has fewer teeth than the stator to ensure that only one set of stator and rotor teeth aligns at any time. When the stator phases are energized, the iron rotor teeth align with the energized stator teeth, minimizing the reluctance (which is analogous to resistance in an electrical circuit) of the magnetic field.

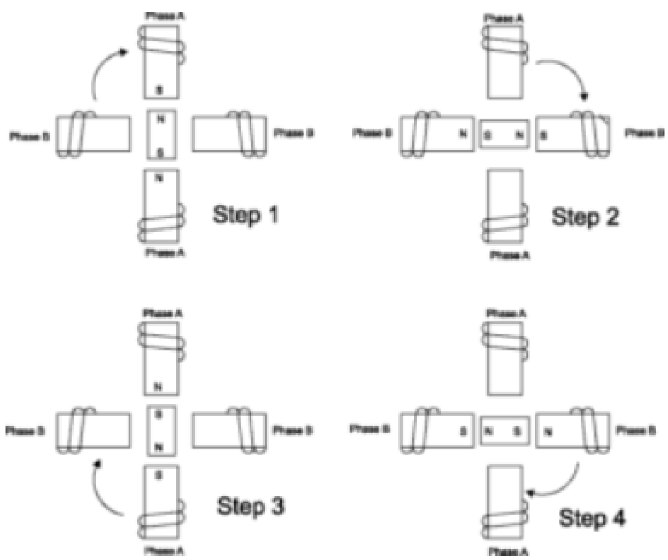


A variable reluctance stepper motor has an iron rotor with teeth that are attracted to the energized stator poles.

Variable reluctance designs produce moderate torque and have large step angles, but they do not experience detent torque since their rotors are passive (non-magnetized). In general, variable reluctance steppers are the least expensive type of stepper motor.

Permanent magnet

Permanent magnet steppers have permanent magnet rotors and operate when a stator phase (pair of opposite poles) is energized and an electromagnetic field is created. The N pole of the magnetic rotor is attracted to the S pole of the phase, and vice-versa, causing the rotor to turn.

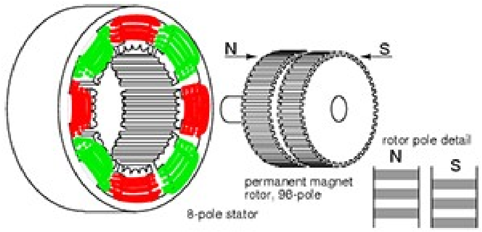


The basic function of a permanent magnet stepper motor.

Permanent magnet steppers have medium step angles and produce high torque. They also exhibit good holding torque when the rotor is stationary, without creating excess heat. When the coils are not energized, they exhibit residual torque (also referred to as detent torque) as a result of the magnetic flux between the rotor and stator. This is useful for holding a load in position with power off.

Hybrid

Hybrid stepper motors take features from both of the above designs, using a permanent magnet rotor with iron teeth. The rotor of a hybrid motor is typically two parts, with one part magnetized N and the other part magnetized S. The teeth of each rotor section are offset by ½ tooth pitch, so if each section has 50 teeth (poles), the rotor will be said to be 100-pole. The stator typically has two phases, which are offset by ¼ tooth pitch.



The rotor of a hybrid stepper motor is made of a permanent magnet with teeth to achieve a very small step angle.

In this example, the combined stator and rotor tooth designs results in 200 steps per revolution, giving the hybrid motor a small step angle, particularly when compared to variable reluctance or permanent magnet designs. Hybrid stepper motors also have higher torque capabilities and more holding and detent torque than other designs.

Application Considerations

As the speed-torque curve above shows, stepper motor torque drops off rapidly as speed increases. In addition, stepper motors draw full current regardless of their speed (whether at standstill or moving), which results in high heat generation. Although stepper motors are inherently open-loop, they can be operated in a closed-loop configuration with the addition of an encoder. However, this somewhat negates the low-cost and ease-of-use characteristics that make them a desirable choice for many applications.

Code

```
#include <Stepper.h>

int in1Pin = 12;
int in2Pin = 11;
int in3Pin = 10;
int in4Pin = 9;

Stepper motor(512, in1Pin, in2Pin, in3Pin, in4Pin);

void setup()
{
  pinMode(in1Pin, OUTPUT);
  pinMode(in2Pin, OUTPUT);
  pinMode(in3Pin, OUTPUT);
  pinMode(in4Pin, OUTPUT);

  // this line is for Leonardo's, it delays the serial interface
  // until the terminal window is opened
  while (!Serial);

  Serial.begin(9600);
```

```
  motor.setSpeed(20);
}

void loop()
{
  if (Serial.available())
  {
    int steps = Serial.parseInt();
    motor.step(steps);
  }
}
```