Stepper Motors

Physics review:

- Electric fields and magnetic fields are the same thing.
- Nature is lazy. Things seek lowest energy states.
  - iron core vs. magnet
  - magnetic fields tend to line up

Stepper Motors

- "variable reluctance" stepper motor
  - Direct control of rotor position (no sensing needed)
  - May oscillate around a desired orientation
  - Low resolution

Increased Resolution

- Half stepping
  - More teeth on rotor or stator
  - Increased resolution
  - Printers, computer drives, machining

Half stepping
Increased Resolution

More teeth on rotor or stator

Half stepping

Stepper Motors

30 degree per step permanent magnet motor. Motor winding number 1 is distributed between the top and bottom stator pole, while motor winding number 2 is distributed between the left and right motor poles. The rotor is a permanent magnet with 6 poles, 3 south and 3 north, arranged around its circumference.

Stepper Motor Basics

Note the following:
1. This 6-pole rotor turns in a direction opposite the rotation of the stator field; a two-pole rotor inside the exact same stator would rotate with the field.
2. This illustration is based on half-step control, where alternate half steps involve one and two motor windings.
3. It takes three complete cycles of the control system to turn this 6-pole rotor one revolution. A two-pole rotor would turn a full revolution per control system cycle.
Stepper Motor Basics

- Each step may only be a few degrees
- Step rate limited by motor inertia
- Example
  - One step equals 6 degrees
  - One step per millisecond

\[
\frac{6^\circ}{10^{-3} \text{ sec}} \times \frac{\text{rev}}{360^\circ} \times \frac{60 \text{ sec}}{\text{min}} = 100 \text{rpm}
\]
Step Motor Precautions

Stepper motors are simple rugged devices and are generally immune from:

A. Stall Condition- when the motor shaft is locked and the drivers continue to attempt to rotate it, the motor current is actually reduced, preventing damage. Stall's from operation at the natural resonance's step rates will similarly not result in damage.

B. High Currents - as long as the motor DOES NOT overheat it takes extremely high current to damage the magnets. A step motor can be driven with high current or high voltage power drives, provided that it is not allowed to over heat.
Step Motor Precautions

Most stepping motors can withstand 100 degree C. temperatures without damage. Excessive heat will melt insulating materials and cause the motor to freeze up beyond repair.

Factors that must be considered include duty cycle, thermal time constant, heat conduction (sinking) to the system, ambient temperatures and air flow. As a rule of thumb (ROT) if you can hold onto the motor, than it isn't too hot.