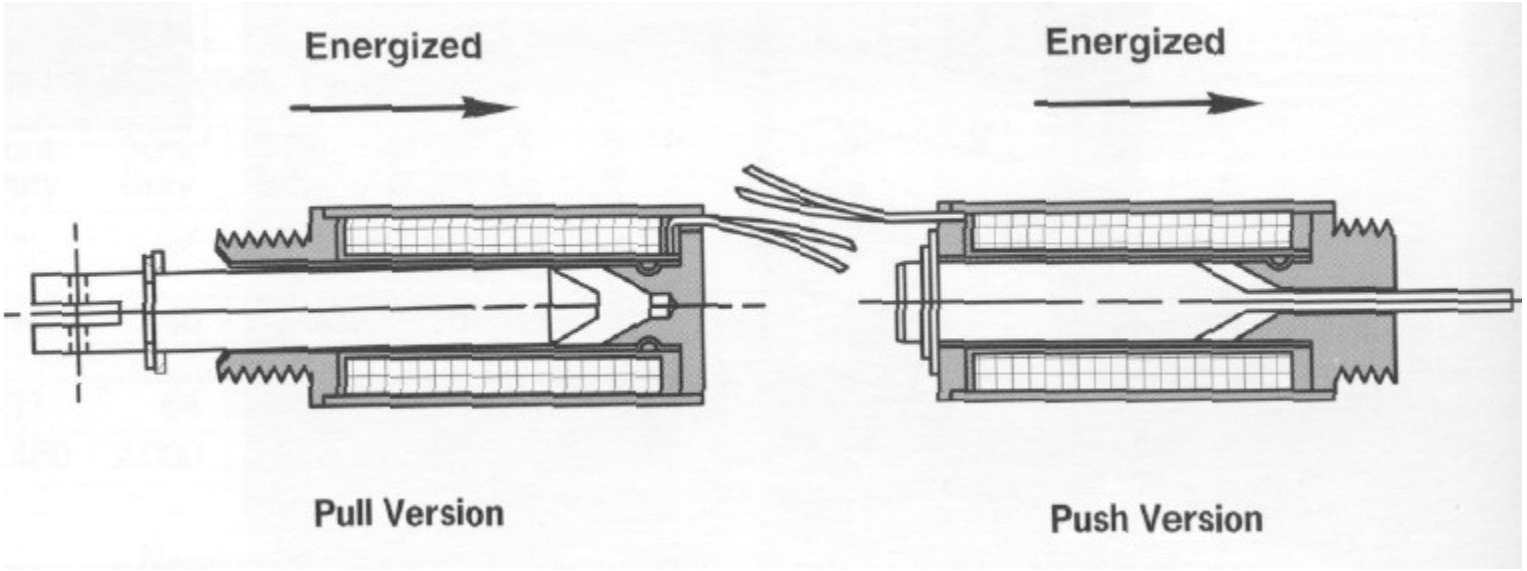
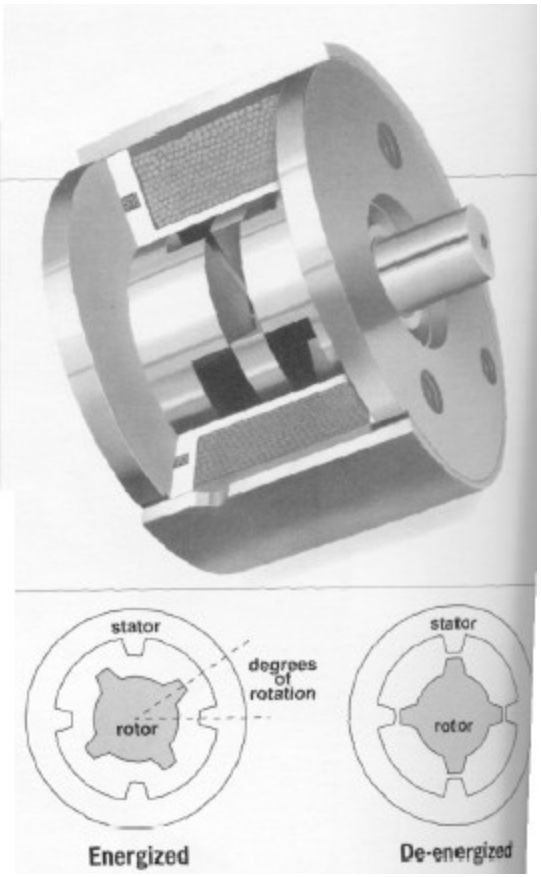
Electric Solenoids



Force $\propto$ stroke^{-1}

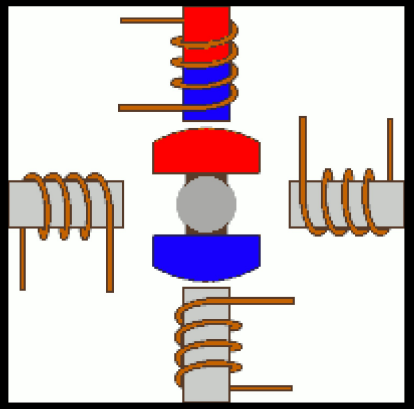
Electric Rotary Actuator (solenoid)

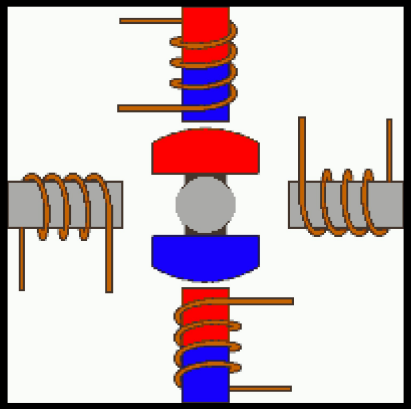


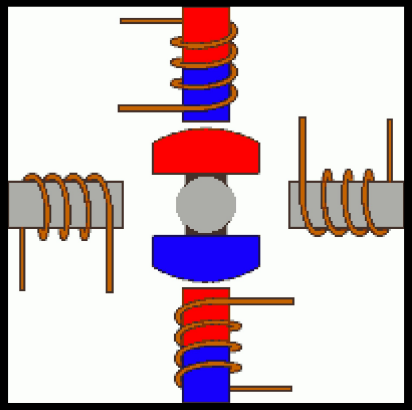
Electric Rotary Actuators (motors)

- DC motors
- AC motors
  - stepper (2-phase synchronous)
  - brushless (3-phase synchronous)
  - induction

Step Motors







Step Motors

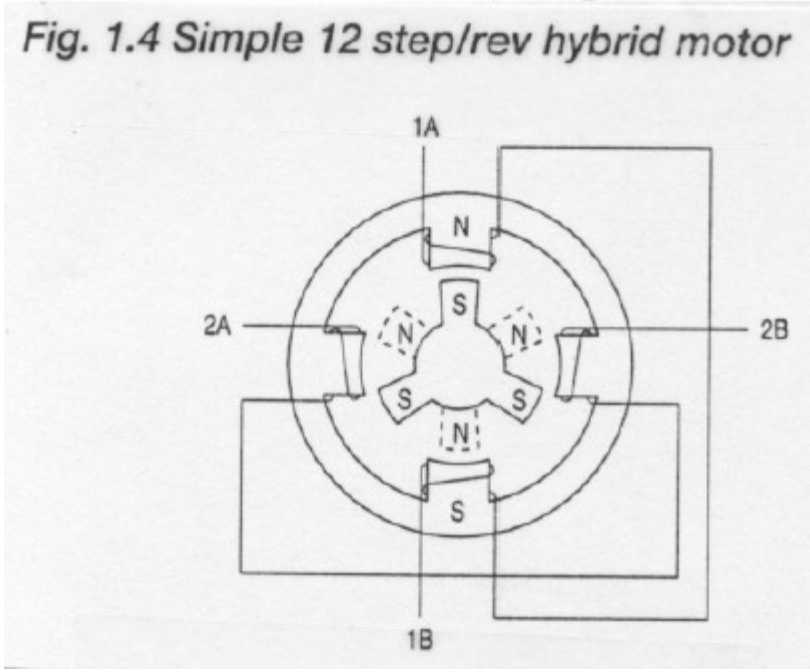
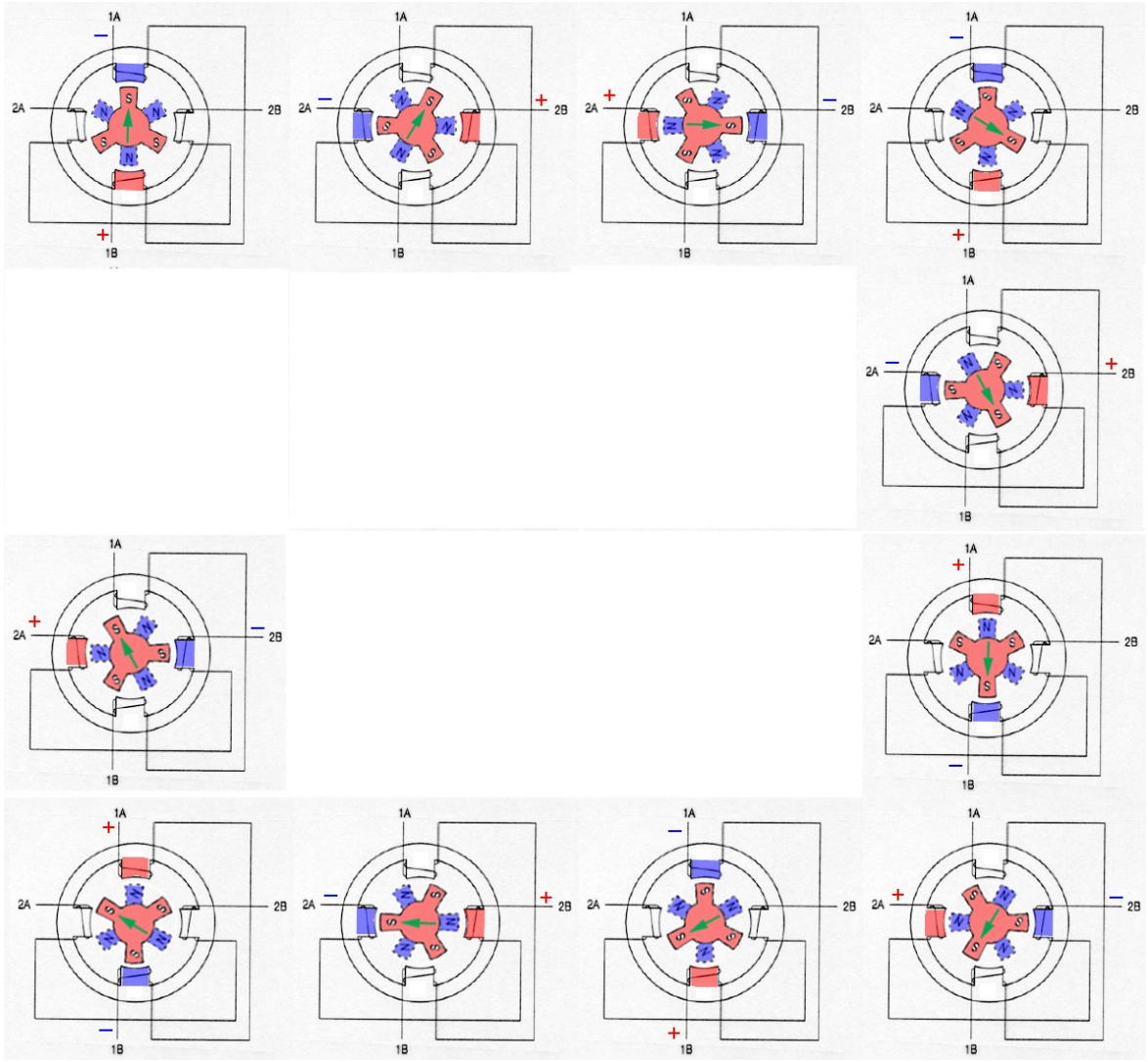
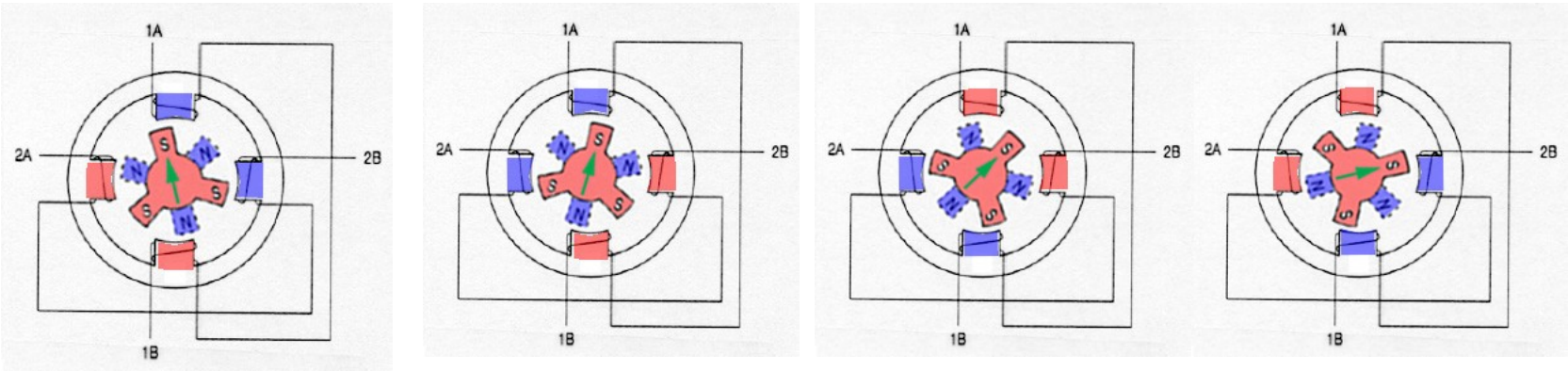


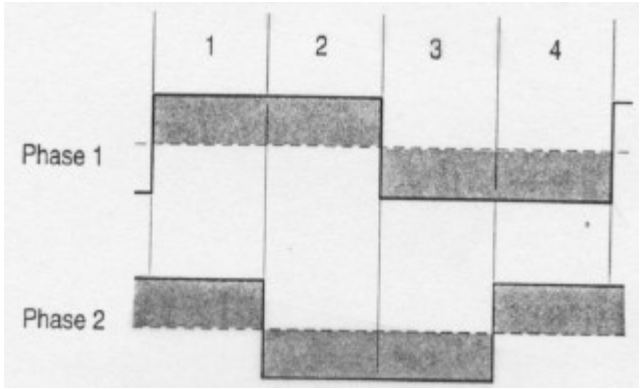
Fig. 1.4 Simple 12 step/rev hybrid motor

Step Motor
12 step/rev, 1 phase on

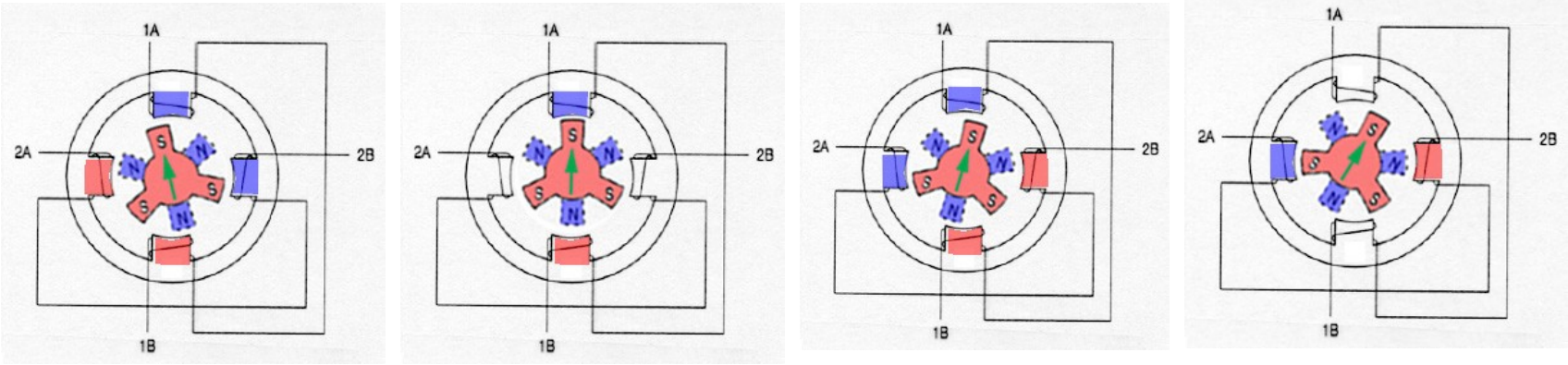


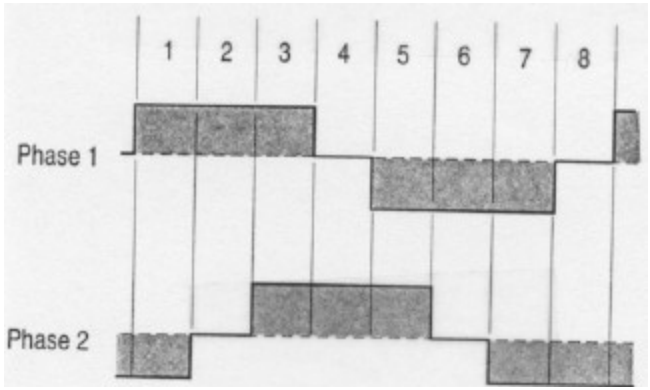
Step Motor
12 step/rev, 2 phase on



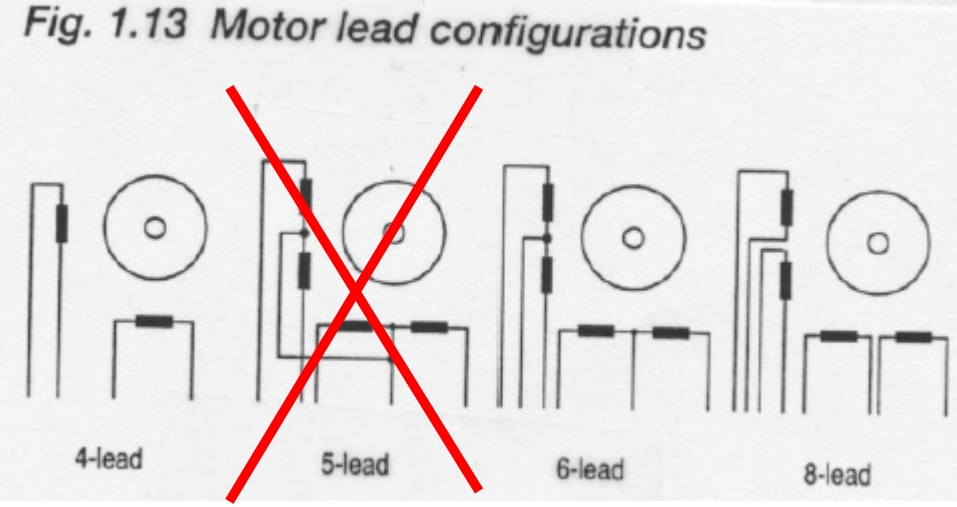


Step Motor
12 step/rev, half-stepping





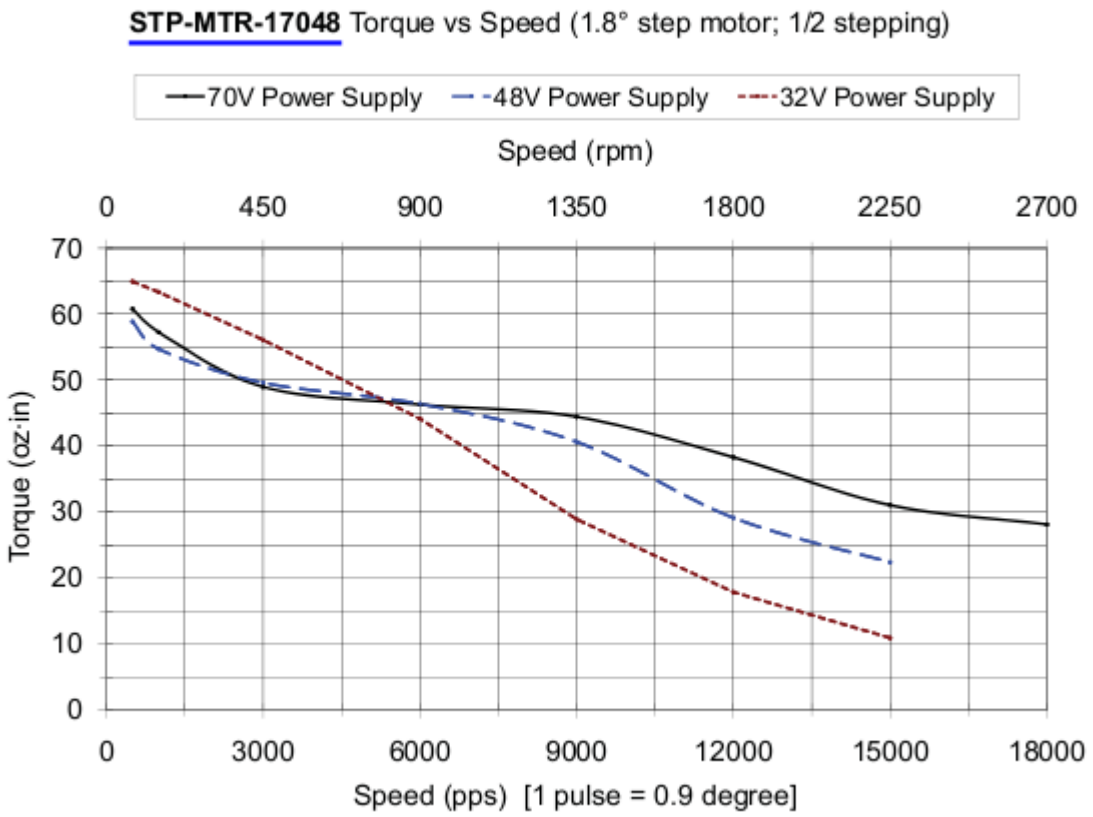
Step Motors



Selecting Step Motors

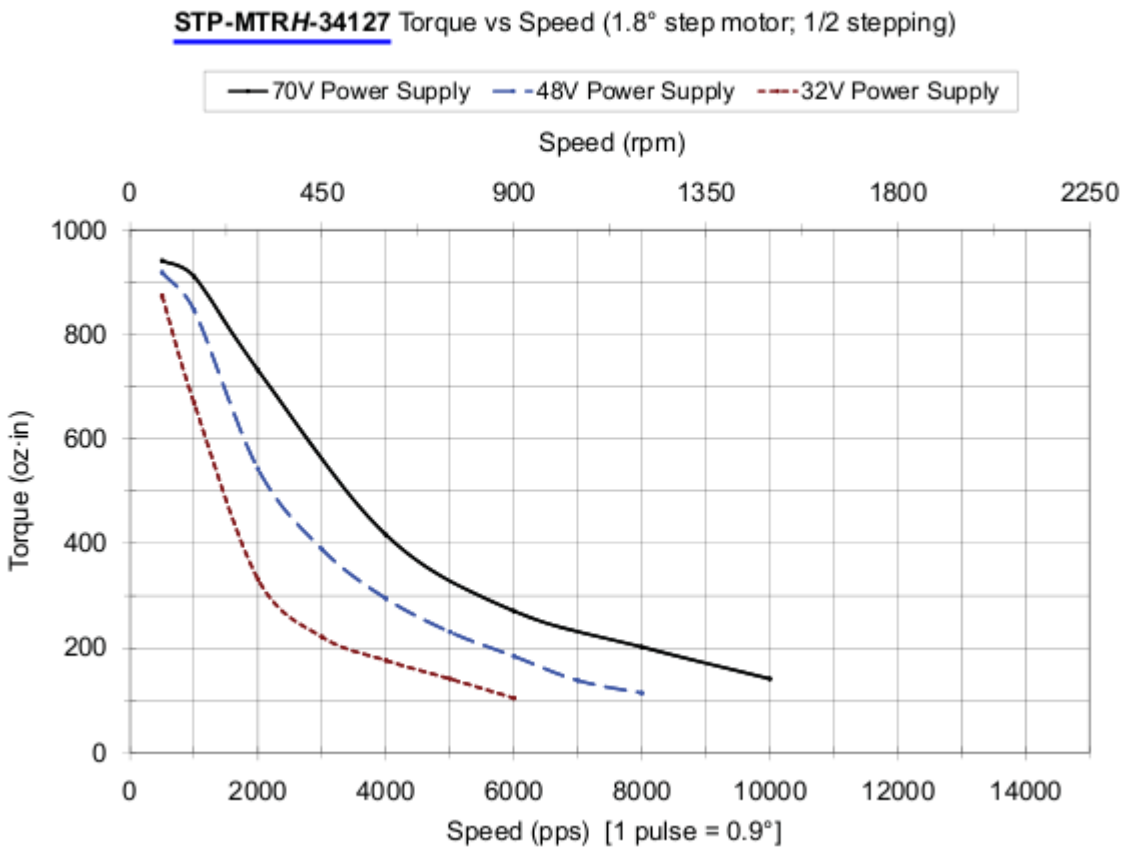
- Torque
- Speed
- Size, shaft configuration

Torque/Speed



$20 motor

Torque/Speed



$160 motor

Step Motor Drives

- Resolution (full, half, microstepping)
- Current Limit (resistor or digital)
- AC powered or DC powered
- Pulse/Direction or Indexing

Resolution

- Full step/Half step
- Microstepping
  - x2,x4,x5,x8,x10,x16,x25,x32,x50,x64,x125,x128,x250, x256 common choices
- Max step frequency
  - PLC: 7kHz pulse rate => 2100 RPM at x1, 8.2RPM at x256 (1.8deg motor)
  - Compumotor 6104: 2MHz pulse rate => 2300RPM at x256
- Resonance problems