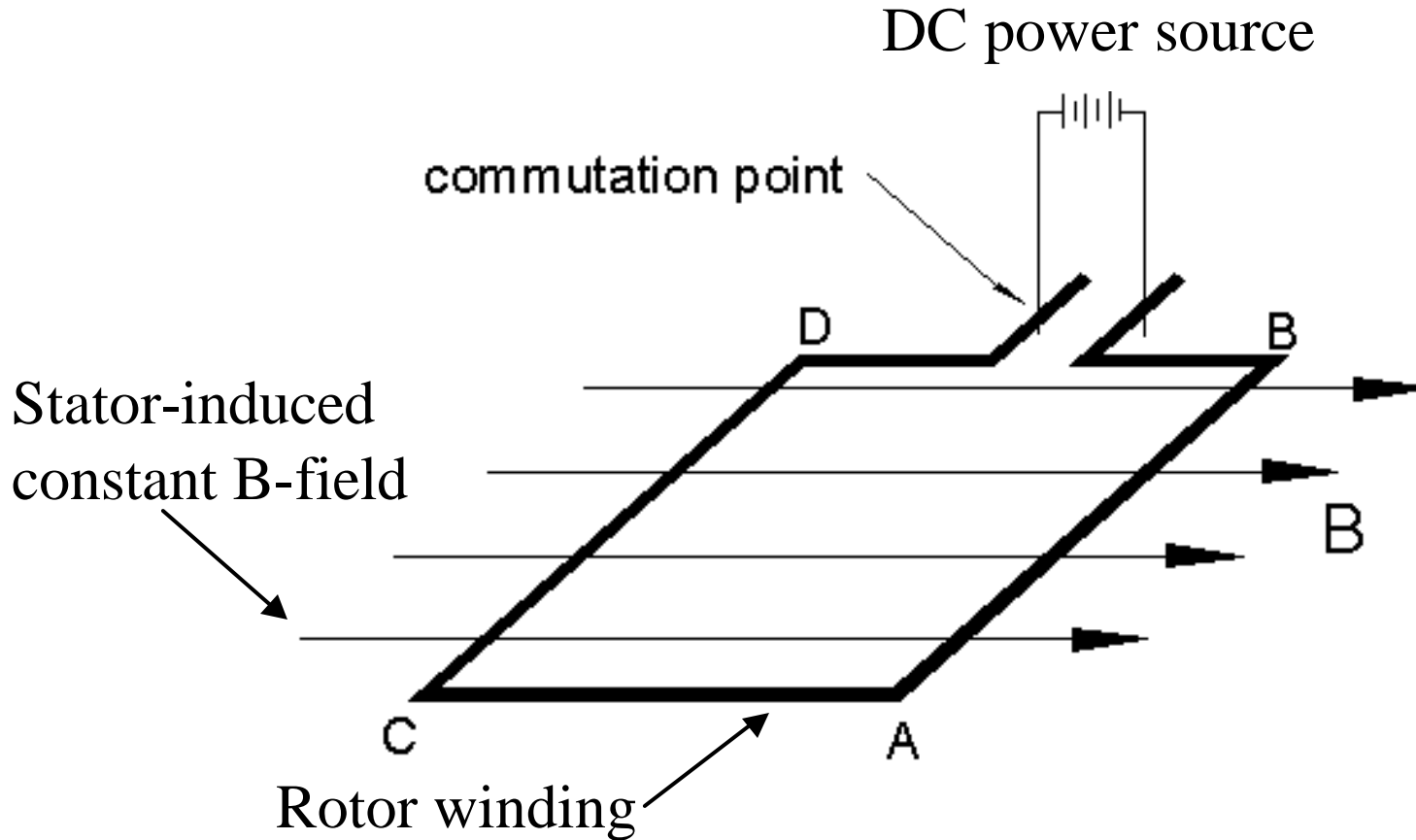


- Motors
 - DC motors
 - Stepper motors
- Motor-driving Electronics
- RC Servos



- DC motors are distinguished by their ability to operate from direct current (not as evident as it might appear)
- The Parts
 - **Rotor** – The rotating center portion. Term may also refer to the winding that is on the rotor.
 - **Stator** – The static (stationary) windings around the rotor. In many small motors, the stator can be replaced with permanent magnets (not as efficient).
 - **Commutator** – The brush connection to the winding on the rotor.



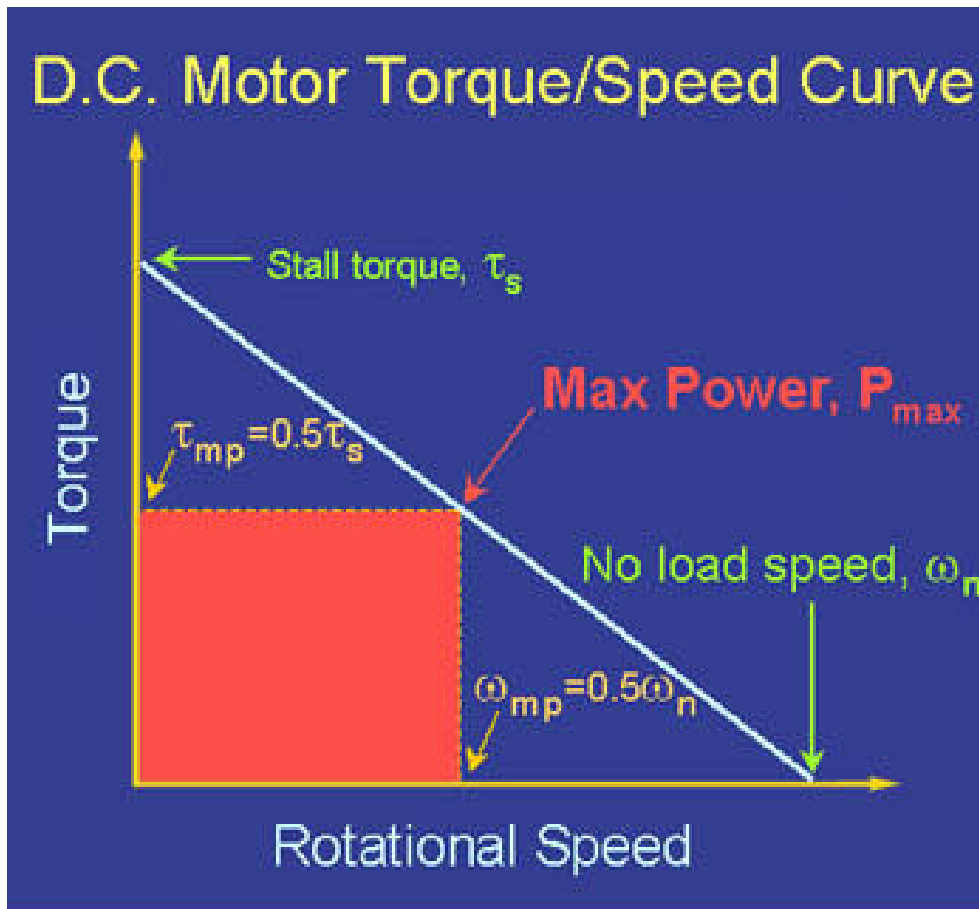


Graphic from application note by MicroMo Electronics at http://www.micromo.com/03application_notes.asp



- Speed varies with applied voltage
 - $\text{RPM} = (1000 * V_a) / K_e$
- Torque varies with current
 - $\text{Torque} = K_t * I$
- Polarity determines direction of rotation
- Requires an external positional encoder to close feedback loop.

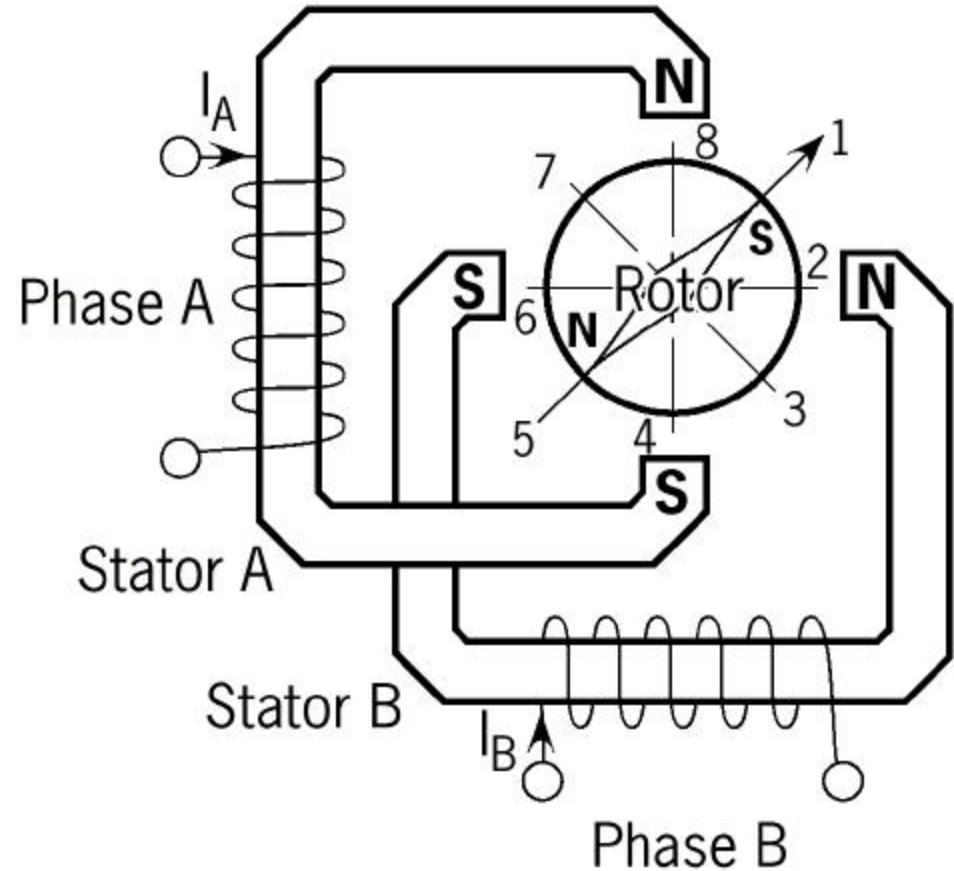




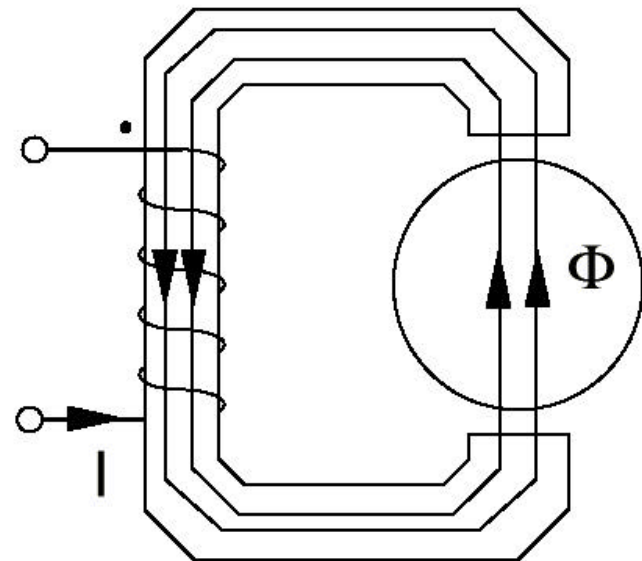
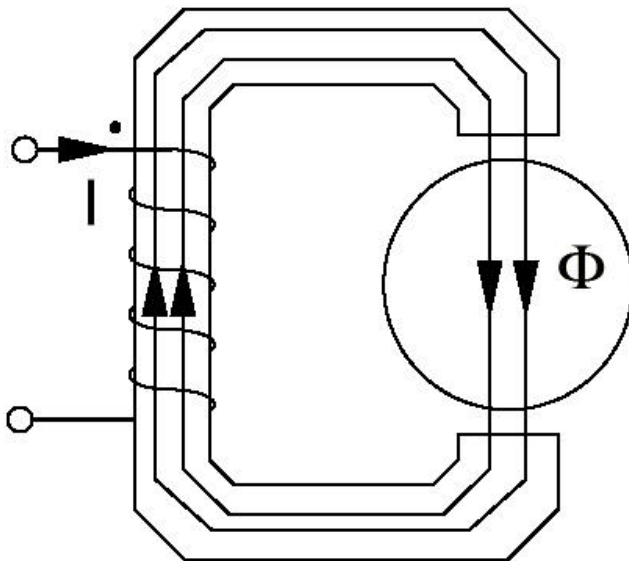
- Can be thought of as a DC motor without a commutator
- Active windings are on the stator instead of the rotor. Rotor is often a permanent magnet.
- Multiple wires give access to stator coils (typically two coils)
- Requires control electronics for sequencing coils. This replaces the commutator.
- Excellent “Open-Loop” Servo



- Power to the two coils must be properly sequenced (phased) to achieve rotor rotation
- Rotation is synchronous to the drive sequence, which means high rotational precision is possible



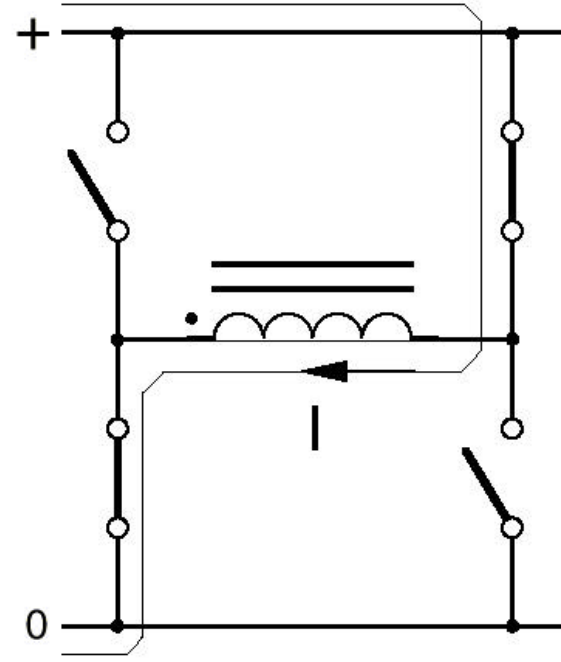
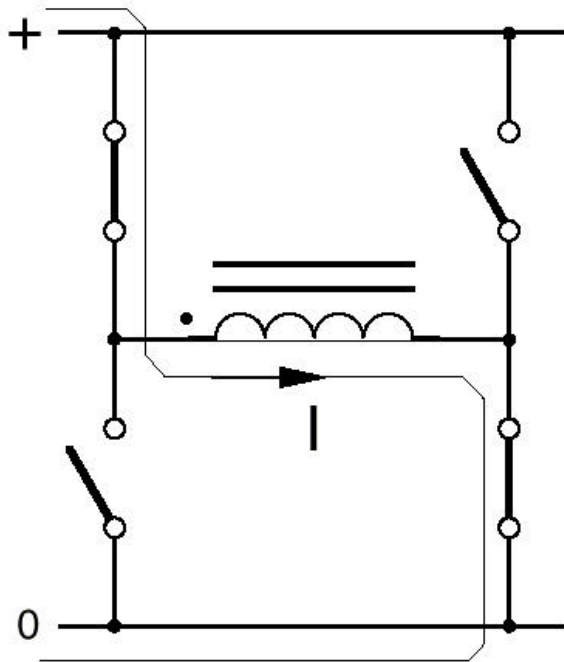
- Reversing current flow in the stator windings causes B field to change direction and rotor to move



Graphic from Stepper Motor Application Notes available at: http://www.ericsson.com/microe/apn_ind.html



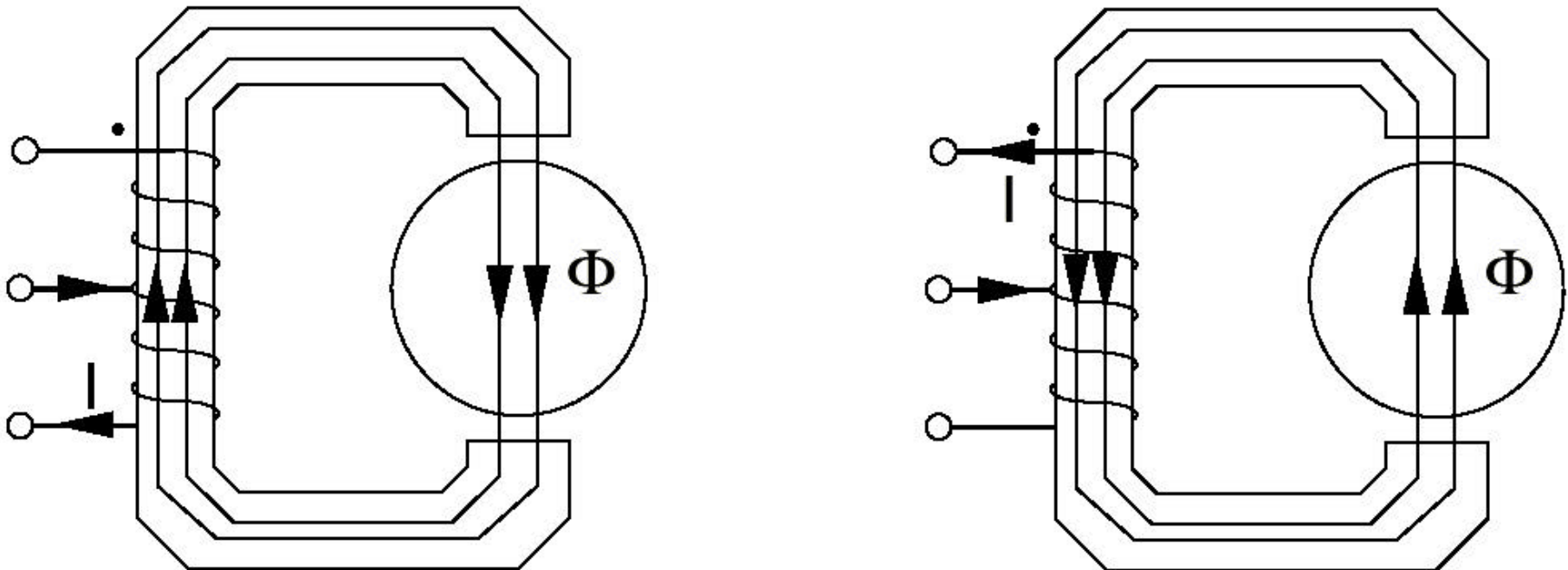
H-Bridge Bipolar drive



Graphic from Stepper Motor Application Notes available at: http://www.ericsson.com/microe/apn_ind.html



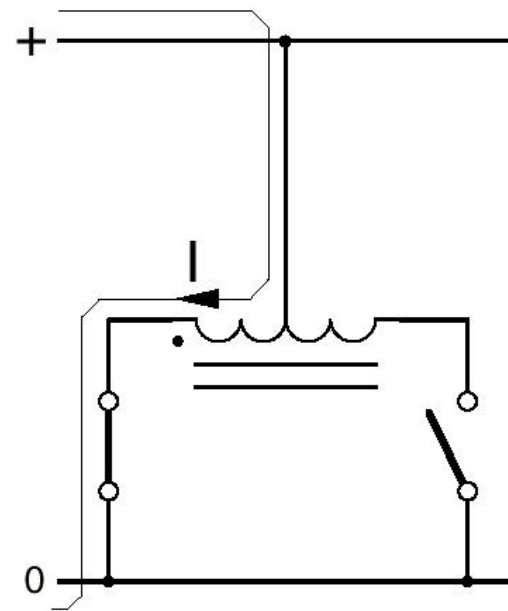
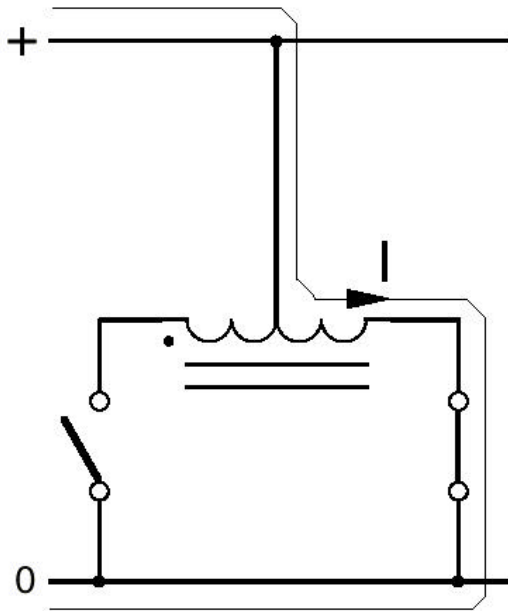
Unipolar Stepper Motor



Graphic from Stepper Motor Application Notes available at: http://www.ericsson.com/microe/apn_ind.html



Unipolar drive



Graphic from Stepper Motor Application Notes available at: http://www.ericsson.com/microe/apn_ind.html



- Wave-Drive – One phase energized at any instant
- Full-Step Drive – Two phases energized at any instant
- Half-Step Drive – One then two phases, every-other-step
- Micro-stepping – Continuously varying current between phases
- Brushless DC Motor – Closed-loop controlled special case.



Wave-Stepping Sequence

Unipolar motor

Bipolar motor

Graphics from: <http://eio.com/jasstep.htm>



Full/Half-Stepping Sequence

Graphics from: <http://eio.com/jasstep.htm>



- Single Direction
 - NPN transistor, MOSFET, or power driver IC
 - ON/OFF control or PWM to control speed, torque, delivered power
 - 2N2222 for small motors ($I < 200\text{mA}$)
 - ULN2003/ULN2803 7/8-channel power driver ($I < 800\text{mA}/\text{chip}$)
 - TIP120 for larger motors ($I < 5\text{A}$)
- Bi-Directional
 - Need reversible power, an H-Bridge Driver
 - LMD18200: single H-bridge high-power motor driver. Up to 55V 3A. Accepts enable, brake, and direction inputs
 - LM18293: dual H-bridge motor driver. $I < 400\text{mA}$. May be used for both stepper motors and DC motors



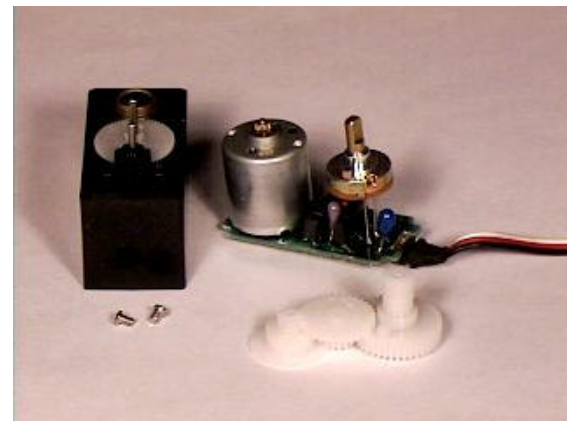
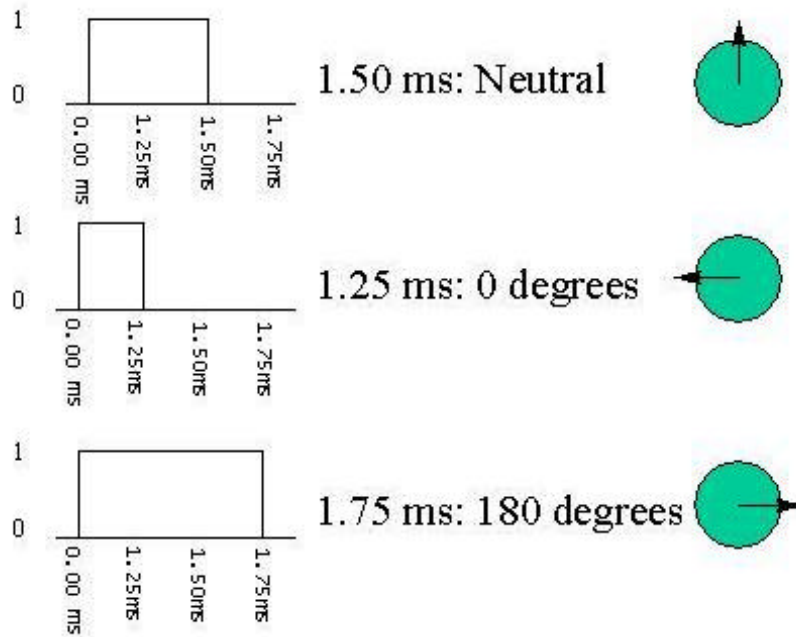
- Unipolar Drive
 - Can use 4 to 8 NPN transistors or MOSFETs, or power driver IC
 - Must provide sequencing logic/signals to make motor operate
 - Could do microstepping using PWM
 - 2N2222 for small motors ($I < 200\text{mA}$)
 - ULN2003/ULN2803 7/8-channel power driver ($I < 800\text{mA}/\text{chip}$)
 - TIP120 for larger motors ($I < 5\text{A}$)
- Bipolar Drive
 - Needs reversible power for two coils (Dual H-Bridge Driver)
 - LM18293: dual H-bridge motor driver. $I < 400\text{mA}$. May be used for both stepper motors and DC motors
 - UCN5408, MC3479, etc: dual H-bridge driver plus sequencing logic for stepping the motor. Accepts STEP, DIR inputs.



- Servos made for Radio-Control applications can be commanded by your AVR!
- RC-Servos are:
 - Cheap (typically \$10, range \$5-50)
 - Strong (typically 42 oz-in or 3.1 kg/cm)
 - Small (typically 1.6”x0.8”x1.4”)
 - Have built in control electronics, gearing, mount holes
 - 3-wire interface (Ground , Power, Control)
 - Operate on 4-6V
 - Commanded to a position by pulse width



- “Closed-loop” position commanding by pulse width



- DC Motors:
 - <http://lancet.mit.edu/motors/index.html>
 - http://www.micromo.com/03application_notes.asp
 - <http://www.instantweb.com/o/oddparts/acsi/motortut.htm> (Document still under development)
- Stepper Motors:
 - http://www.ericsson.com/microe/apn_ind.html
 - <http://www.st.com/stonline/books/pdf/docs/1679.pdf>
 - <http://www.thomsonind.com/airpax/airpax.htm>
- RC Servos
 - <http://www.google.com> (keywords: RC servo)
 - <http://www.towerhobbies.com>

