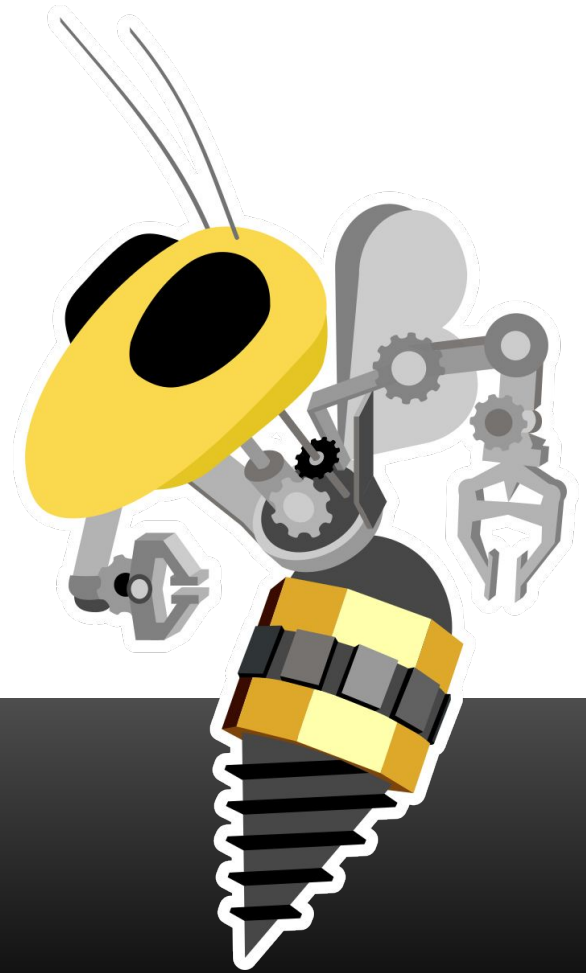


# Welcome

Electrical Training Week 2

**ROBOJACKETS**  
COMPETITIVE ROBOTICS AT GEORGIA TECH

[www.robojackets.org](http://www.robojackets.org)



# Last Week!

- Electricity Basics
- Prototyping and Lab

# Agenda

- Motors
- Motor Controllers
- Datasheets

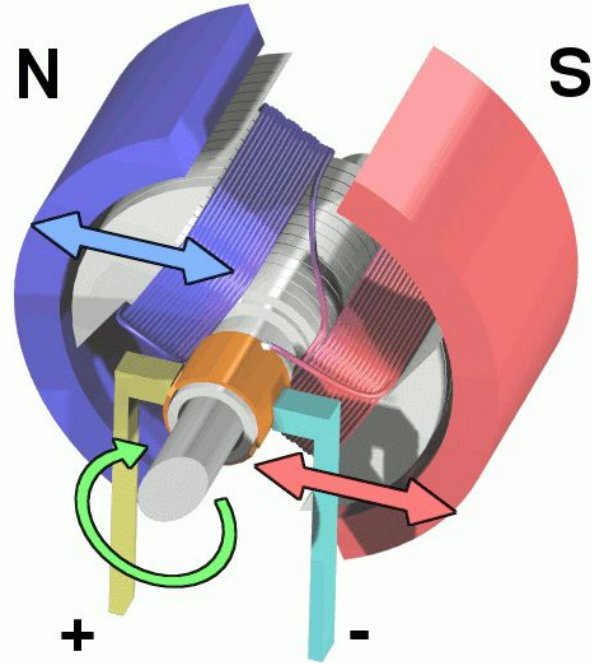


# Motors

You know, those things that spin and make robots move

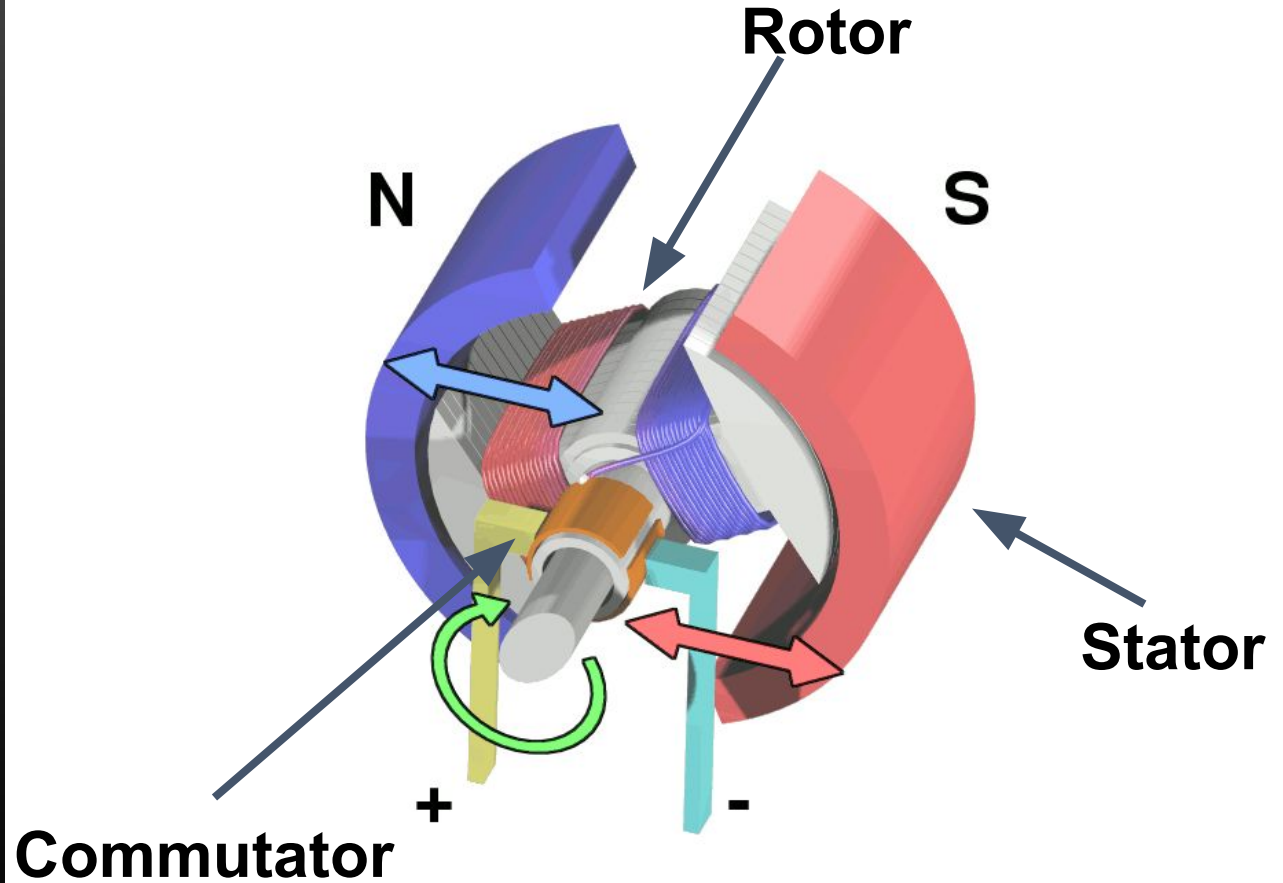
# Brushed DC Motors

*A.k.a DC Motors*

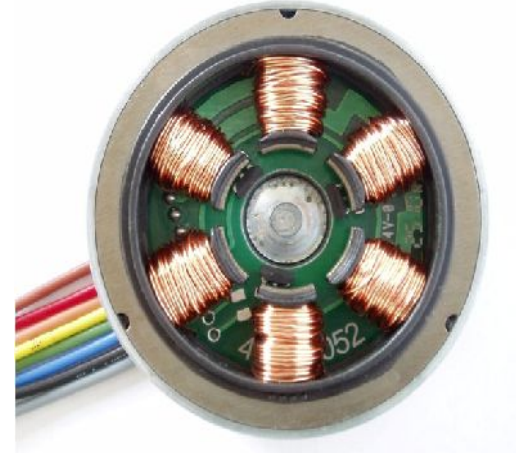
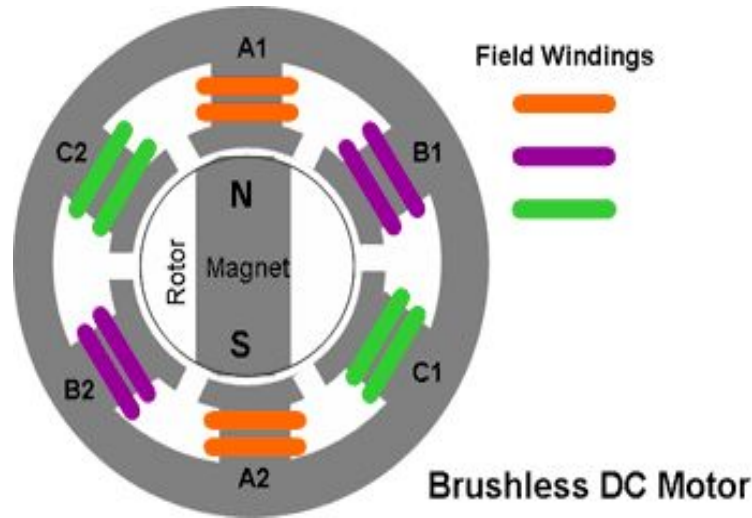


- Electromagnets attached to axle
- Permanent magnets attached to body

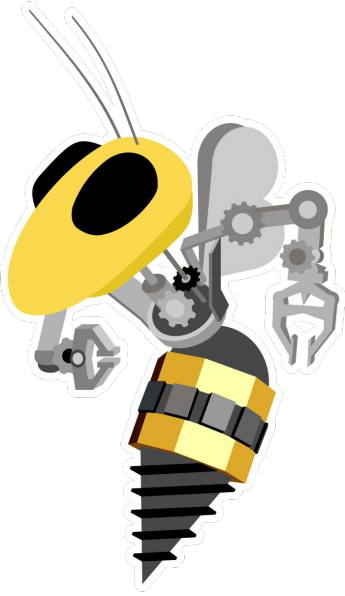
# Let's Slow it Down



# Brushless DC Motors



- Permanent magnet on rotor
- Array of electromagnetic coils on stator
- No commutator



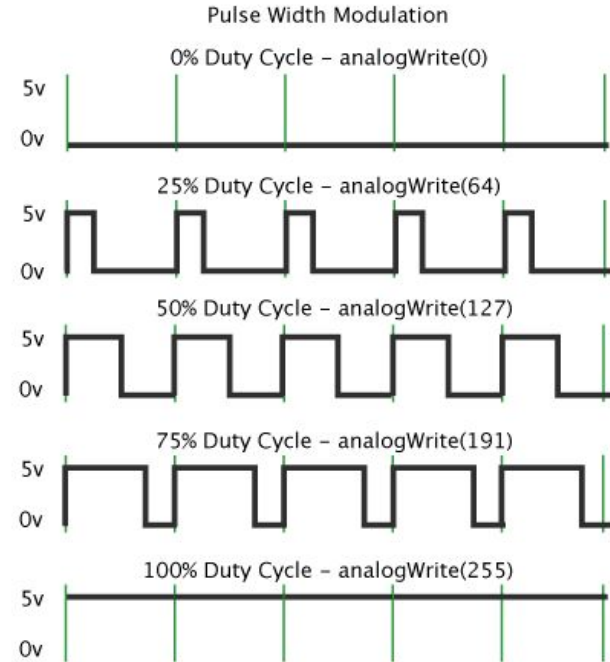
# Motor Controllers

How does one make a motor spin...

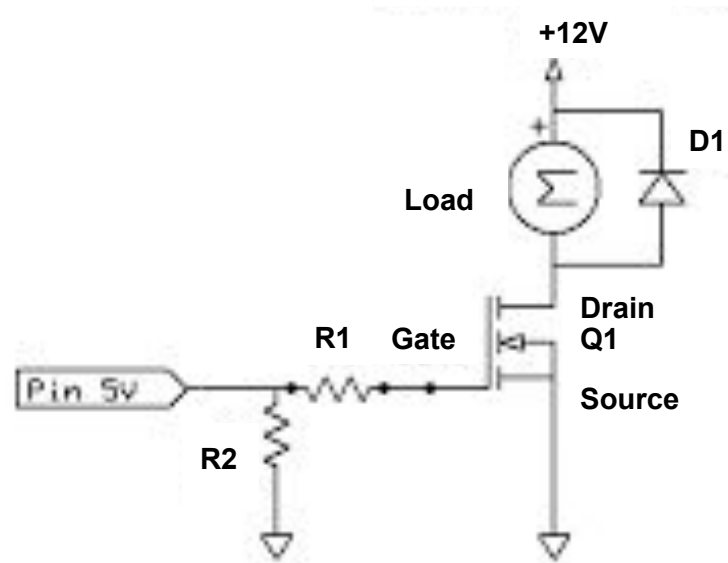


# Controlling a DC Motor

- Speed
  - Proportional to Voltage across brushes
  - Controlled with PWM
- Torque
  - Proportional to current drawn by motor
  - Cannot be directly controlled



# Unipolar Control



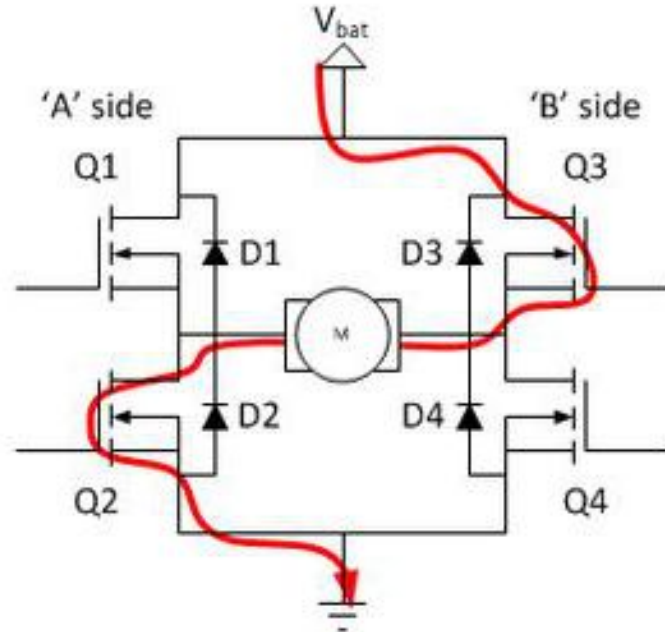
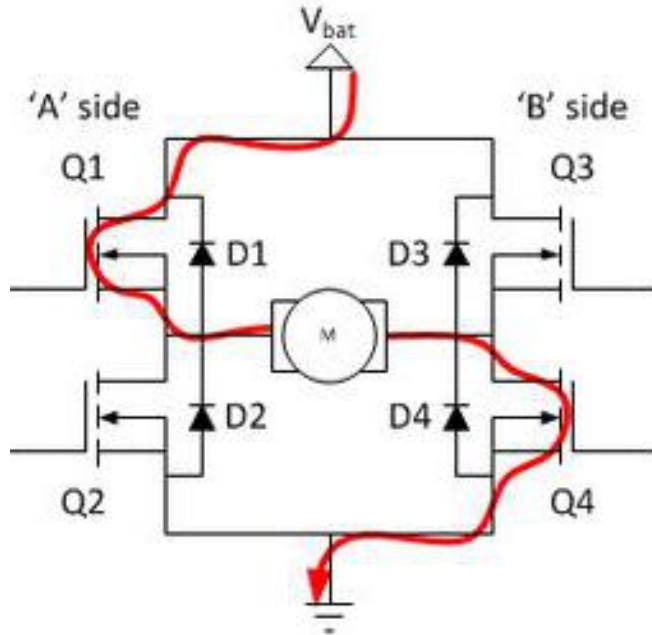
R1 limits gate current

R2 is pull-down in case pin high-impedance

D1 is flyback protection (Schottky)

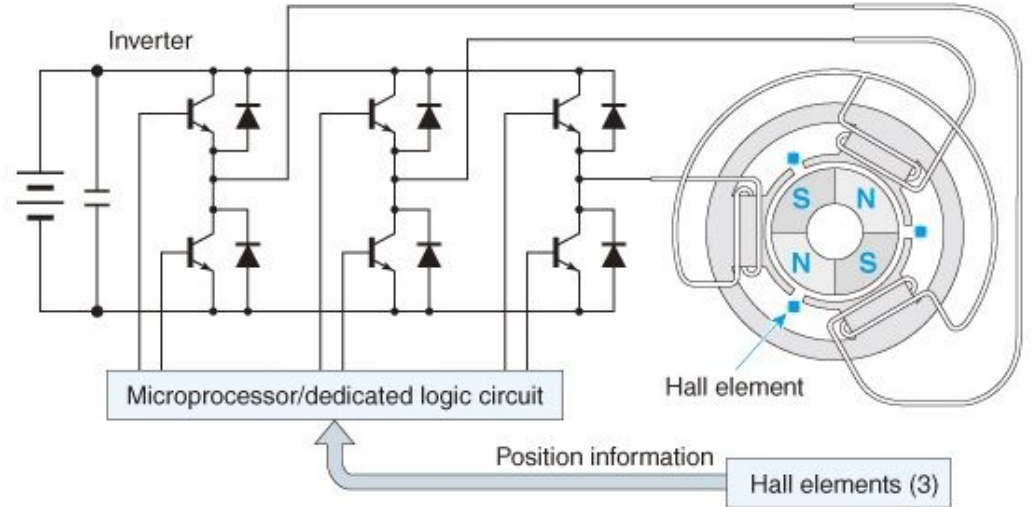
Q1 is N-channel MOSFET

# H-Bridge



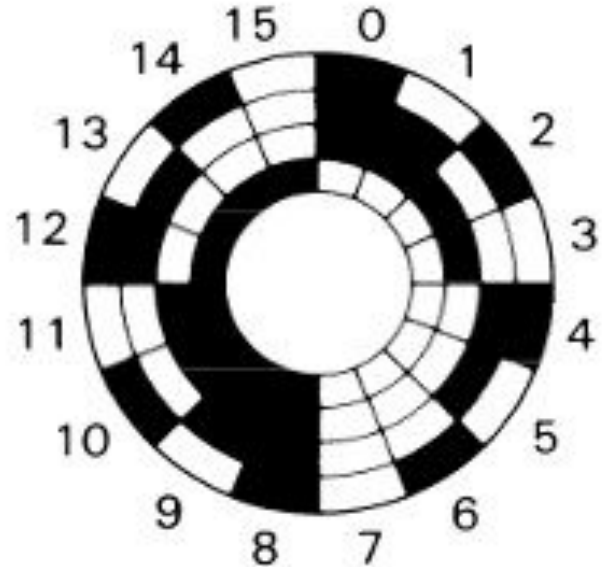
# Brushless Motor Control

Closed loop control

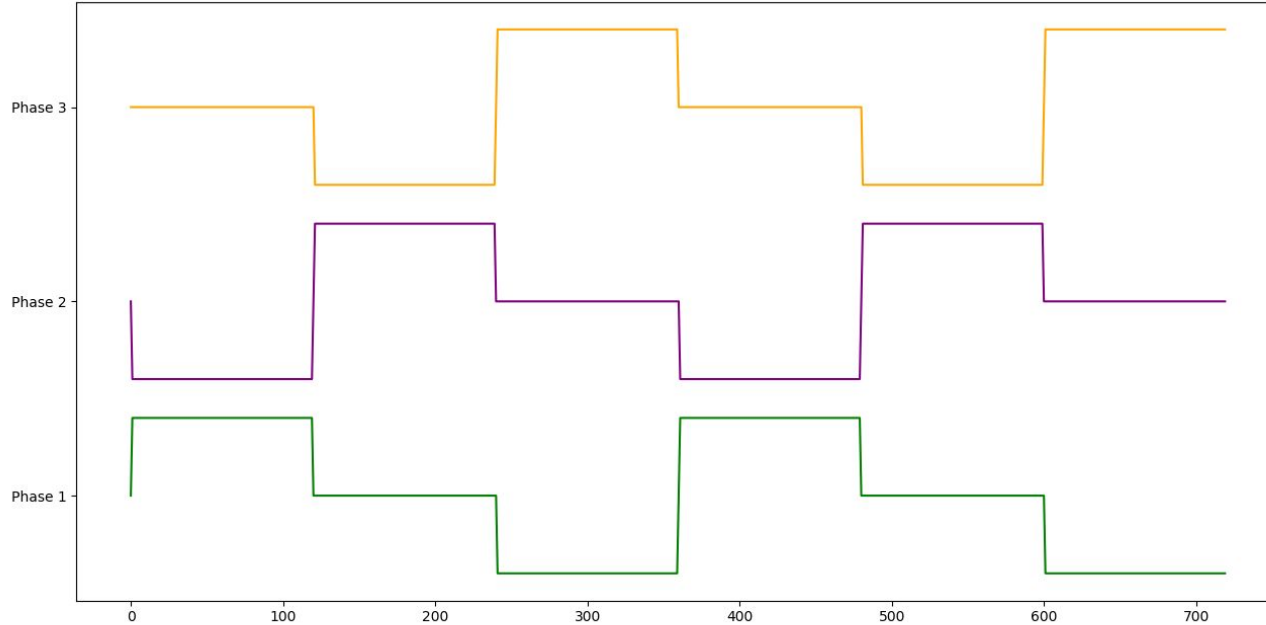


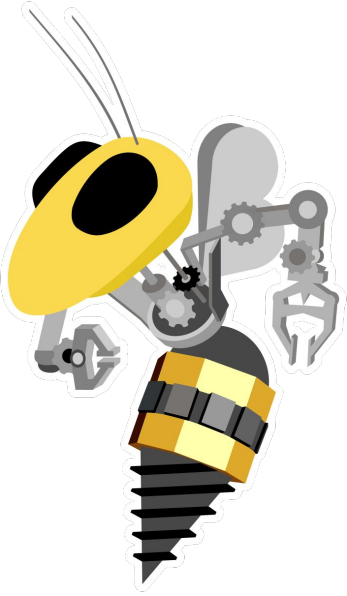
# Encoders

- Measures speed (or position) of motor
- Absolute and Incremental
- Direction measurement happens through phase shift (quadrature)



# Timing Diagram





# Lab

Controlling DC Motors with Arduino