# Welcome

Electrical Training Week 2
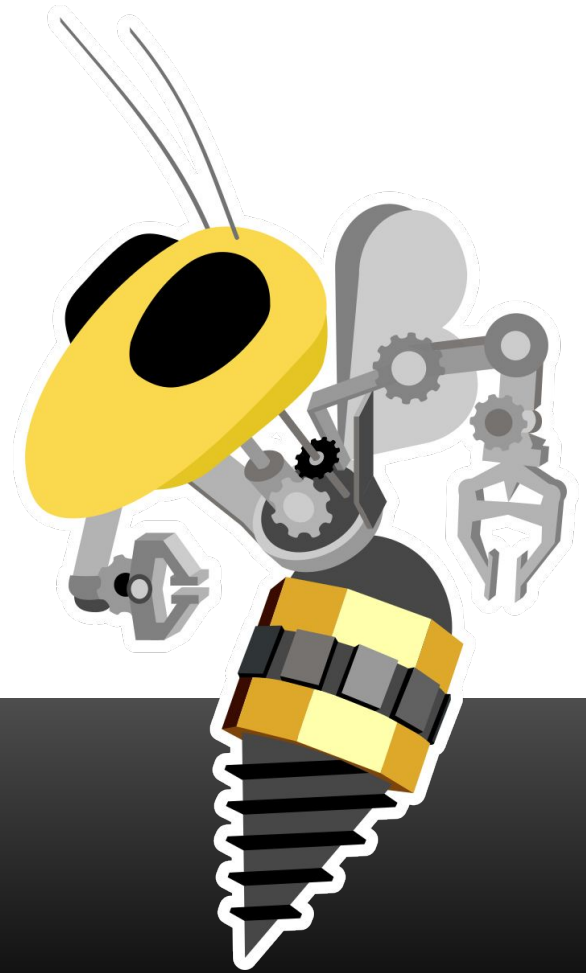
# Last Week!

- Electricity Basics
- Prototyping and Lab

# Agenda

- Motors
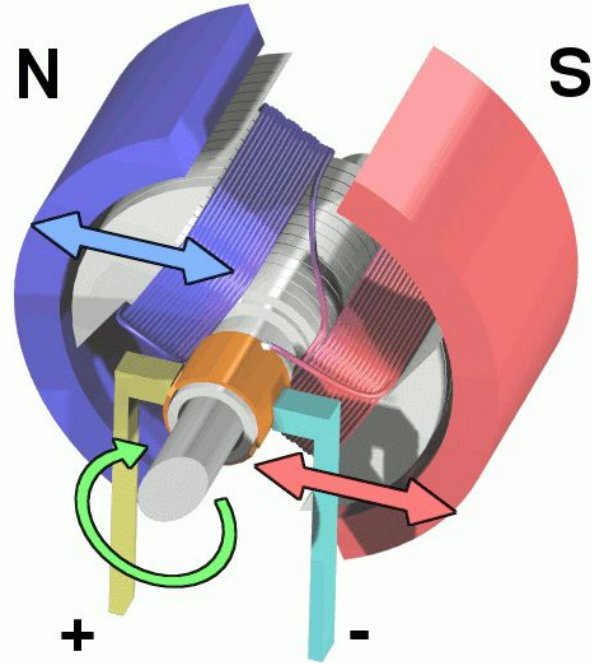- Motor Controllers
- Datasheets

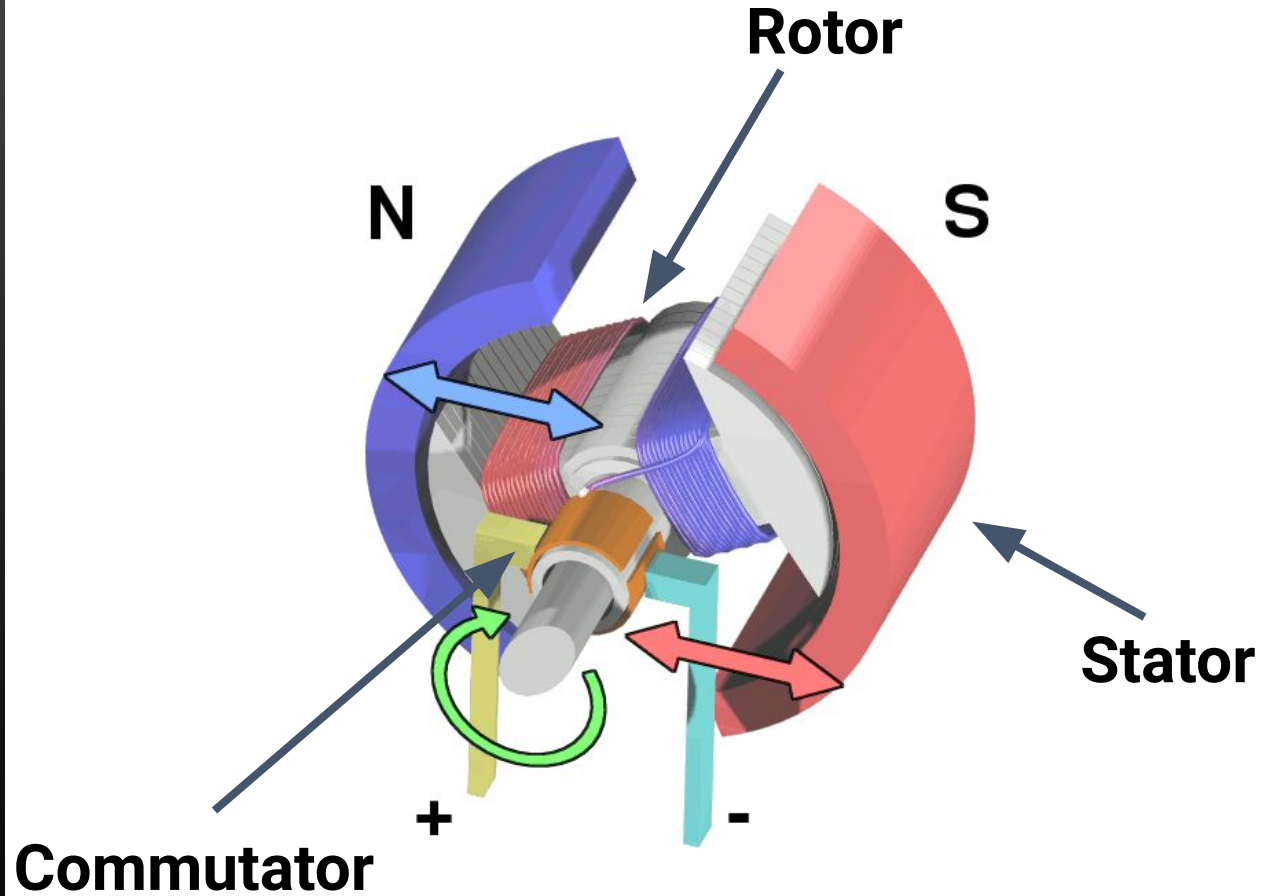# Motors

You know, those things that spin and make robots move
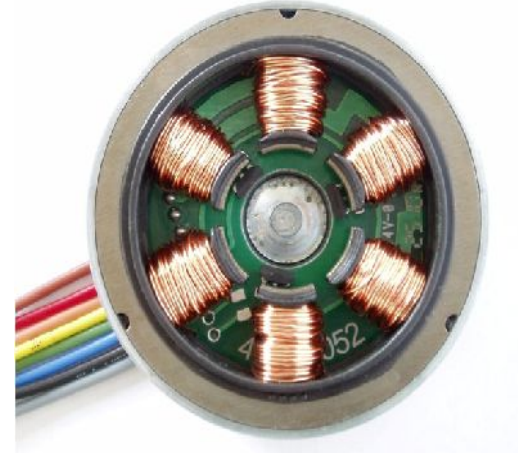
# Brushed DC Motors

*A.k.a DC Motors*



- Electromagnets attached to axle
- Permanent magnets attached to body

RoboJackets
Competitive Robotics at Georgia Tech

Let's Slow it Down

Rotor

N          S

Commutator

Stator

+          -

# Brushless DC Motors

*A.k.a BLDC Motors*
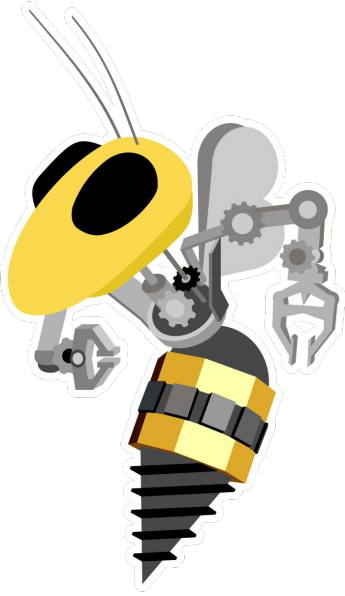


Brushless DC Motor
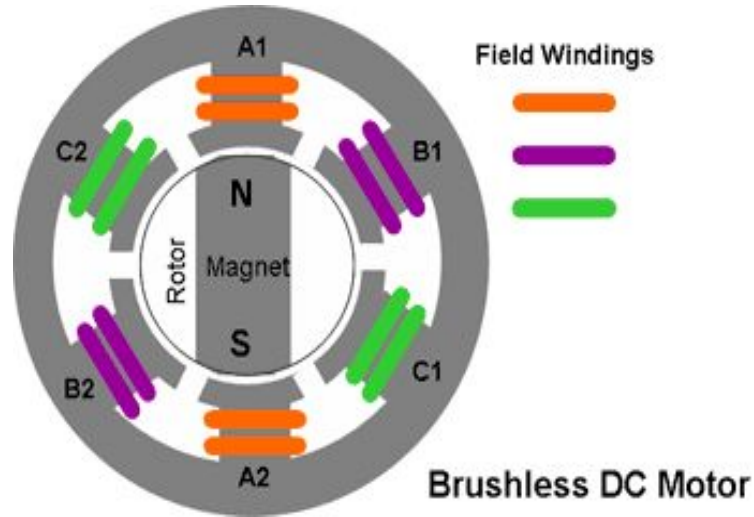
- Permanent magnet on rotor
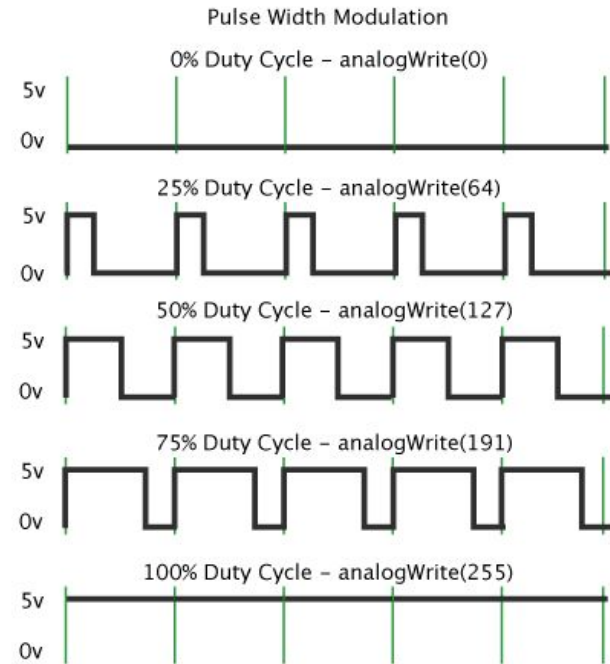- Array of electromagnetic coils on stator
- No commutator

# Motor Controllers

How does one make a motor spin

RoboJackets
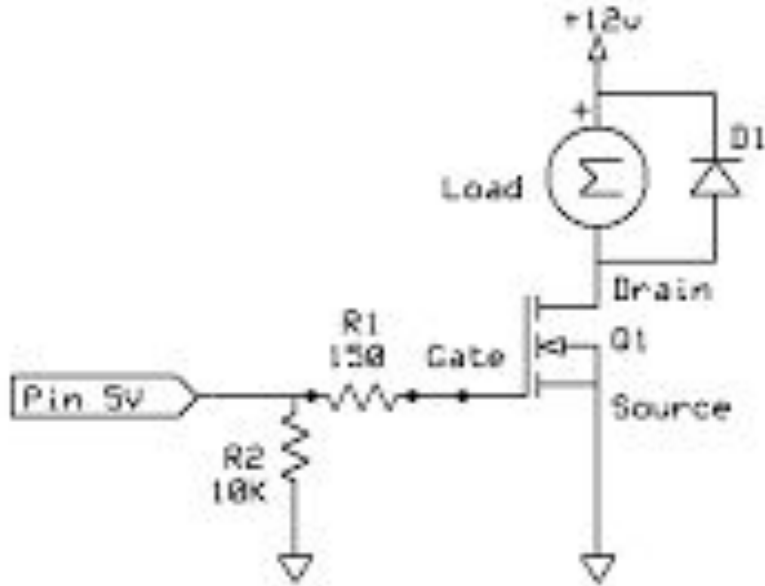Competitive Robotics at Georgia Tech

# Controlling a DC Motor

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

Pulse Width Modulation

0% Duty Cycle – analogWrite(0)

25% Duty Cycle – analogWrite(64)

50% Duty Cycle – analogWrite(127)

75% Duty Cycle – analogWrite(191)

100% Duty Cycle – analogWrite(255)

# Unipolar Control

Low-side driver (sink current)

+12v

Load Σ    D1

R1
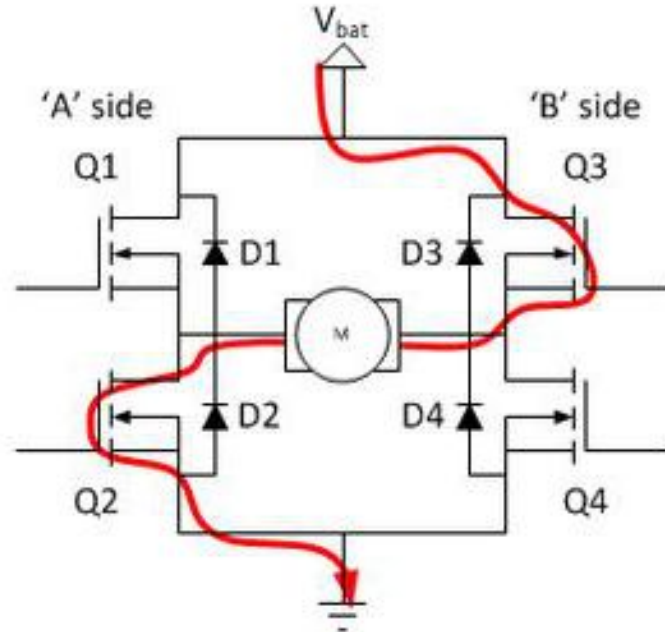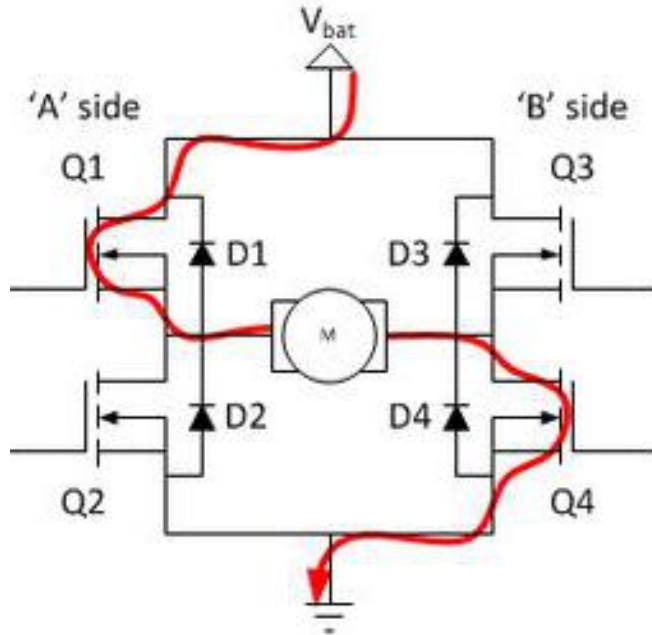150    Gate    Drain    Q1
Pin 5v    Source
R2
10K

R1 limits gate current
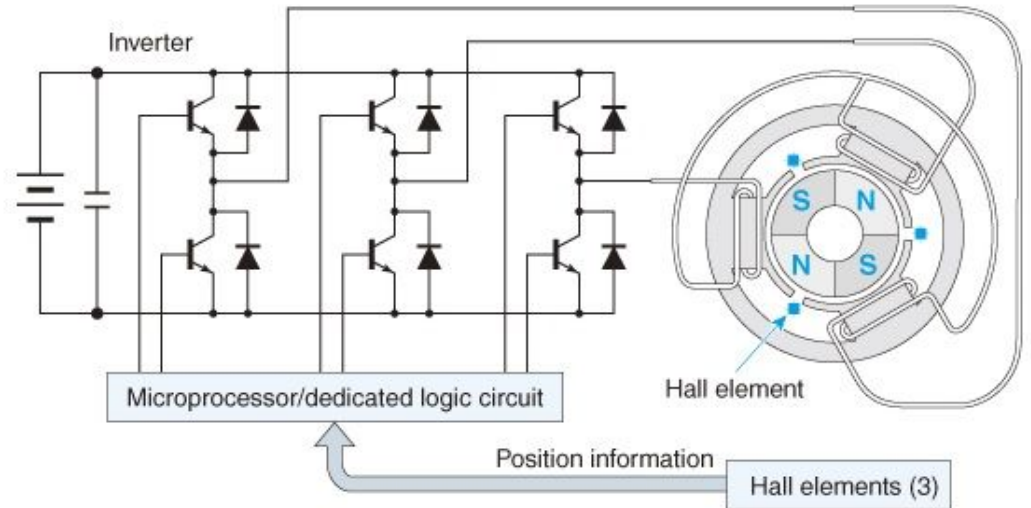R2 is pull-down in case pin
high-impedance
D1 is flyback protection (Schottky)
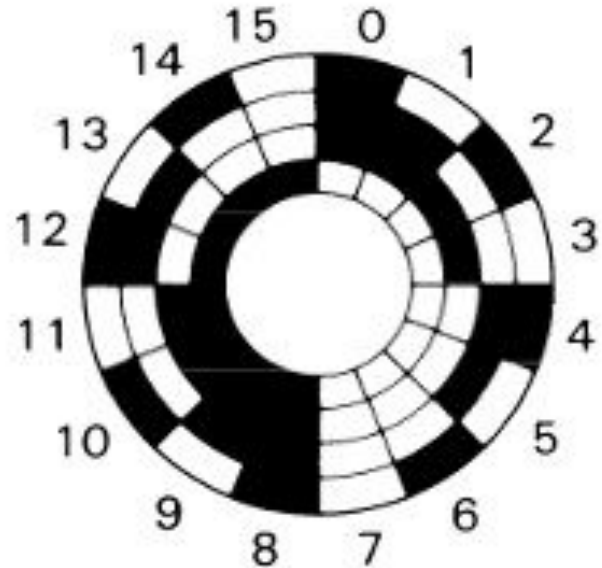Q1 is N-channel MOSFET

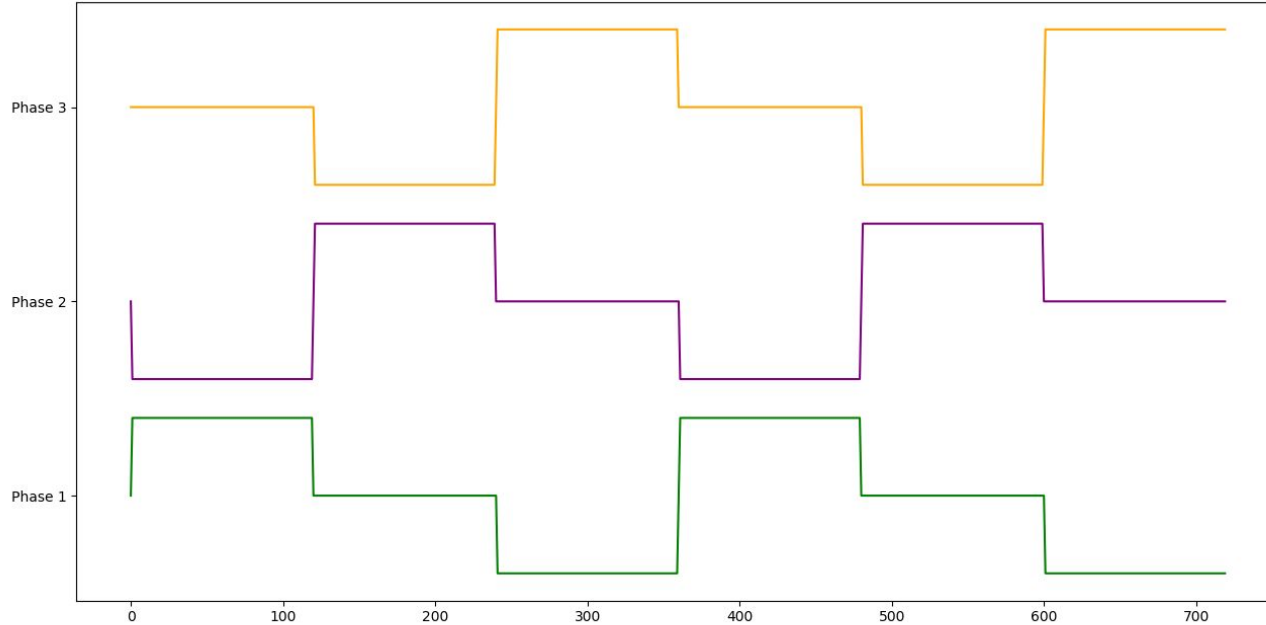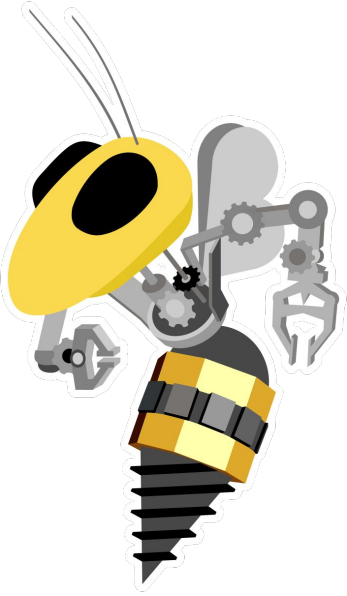# H-Bridge

# Brushless Motor Control

# 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

# Lab Setup

- Configure: Tools -> Board -> Arduino/Genuino Uno
- Plug in Arduino
- Choose Port: Tools -> Port
- Follow the Lab 2 Guide