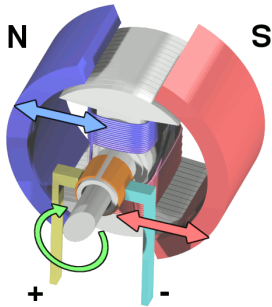# Autonomous Navigation for Flying Robots

Lecture 4.1:
Motors and Controllers
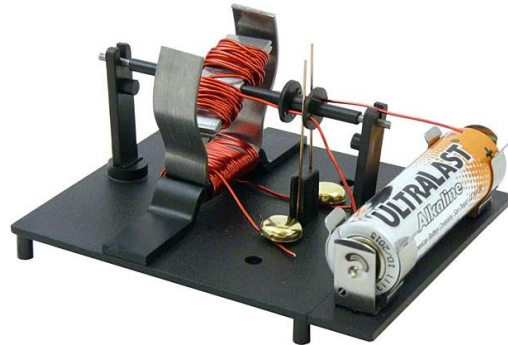
Jürgen Sturm

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DC Motors

- Stationary permanent magnet
- Electromagnet on axis induces torque
- Split ring + brushes switch direction of current
- Maybe you built one in school

CC BY SA by Wapcaplet
http://en.wikipedia.org/wiki/File:Electric_motor_cycle_2.png

http://www.hometrainingtools.com/dc-motor-kit/p/EL-KIT02/

http://www.seeedstudio.com/depot/bitcraze-m-64.html?ref=side
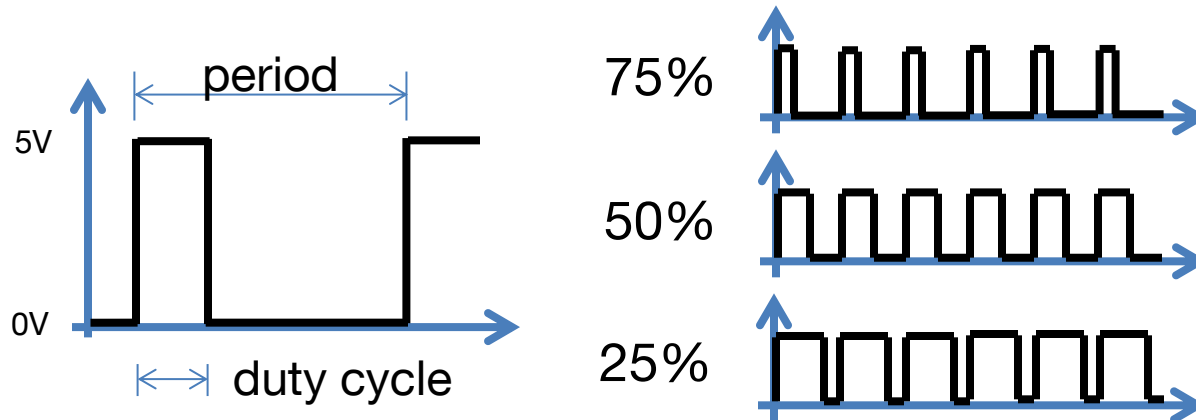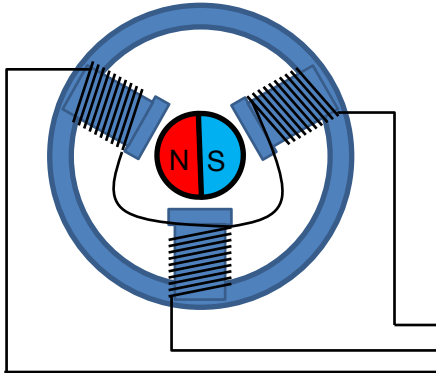
Control of DC Motors

- More power = faster rotation
- How to modulate power using a digital signal?
- Pulse width modulation (PWM)
- Duty cycle = proportion of on time vs. period

Brushless Motors

- Electromagnets are stationary
- Permanent magnets on the axis (either inside or outside)
- Three coils (or more)
- No brushes (less maintenance, higher efficiency)

https://www.hobbyking.com/hobbyking/store/
__25556__AX_2810Q_750KV_Brushless_Quadcopter_Motor.html

Brushless Controllers

- Typically one microcontroller per motor
- Generates PWM signal for the three motor phases
- AC signal converter (MOSFET) to convert PWM to analogue output
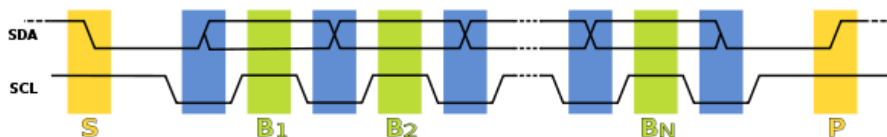- Measure motor position/speed using back-EMF
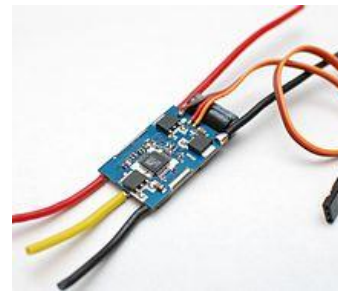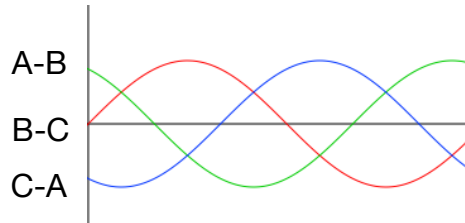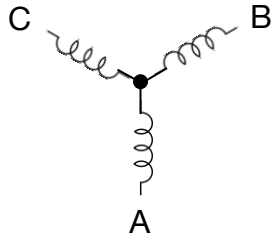
http://en.wikipedia.org/wiki/File:ESC_35A.jpg

I²C Protocol

- Serial data line (SDA) + serial clock line (SCL)
- All devices connected in parallel
- 7-10 bit address, 100-3400 kbit/s speed
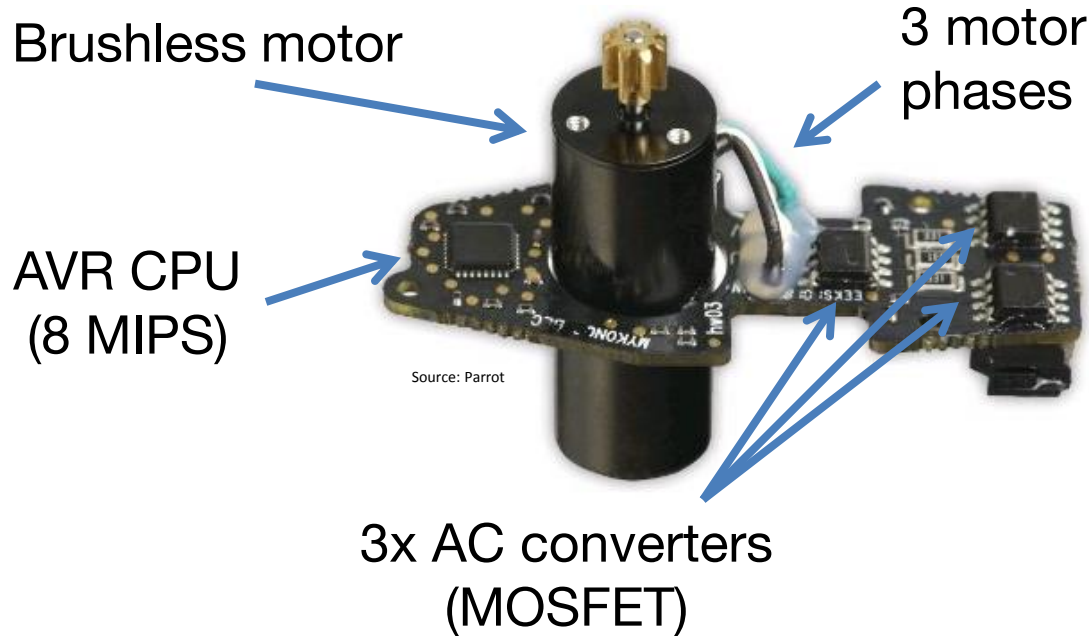- Communication between motor controller and autopilot

http://en.wikipedia.org/wiki/File:I2C.svg
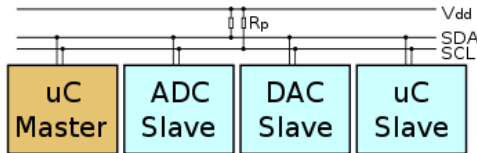
http://en.wikipedia.org/wiki/File:I2C_data_transfer.svg

Example: Parrot Ardrone

Brushless motor

3 motor phases

AVR CPU
(8 MIPS)

Source: Parrot

1:8.75 gears

http://droneflyers.com/category/ar_drone/

3x AC converters
(MOSFET)

Lessons Learned

- DC motors
- Brushless motors
- Motor controllers
- Ardrone example
- Next: How do we generate suitable control signals