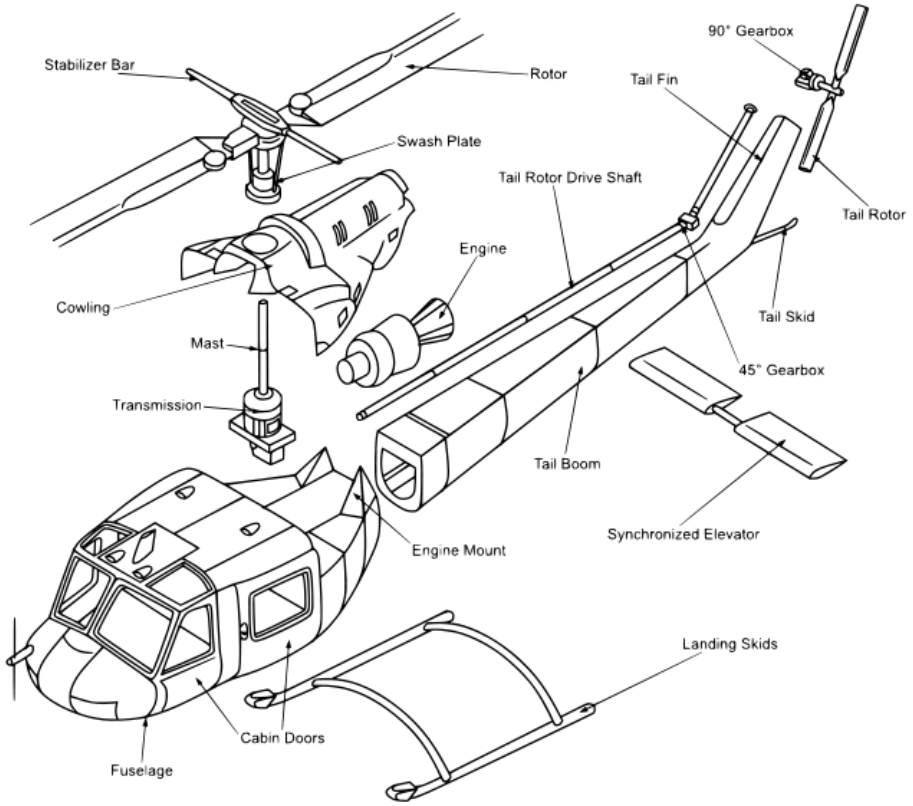
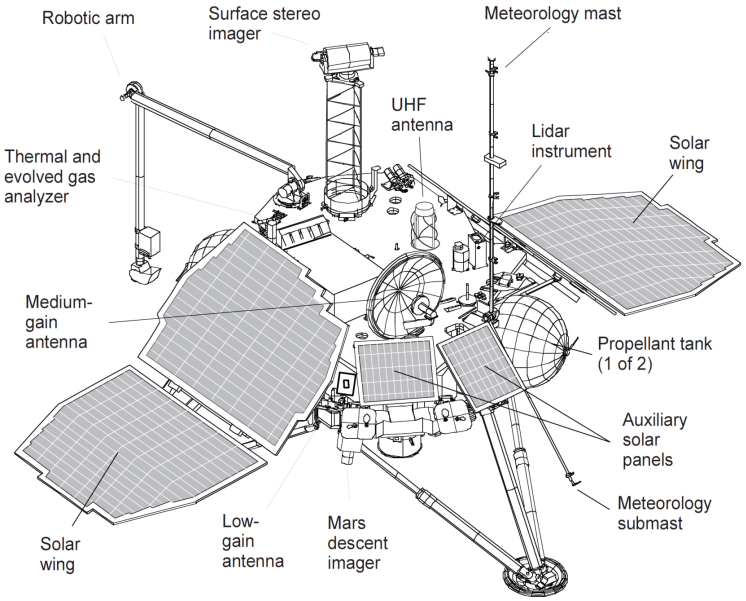
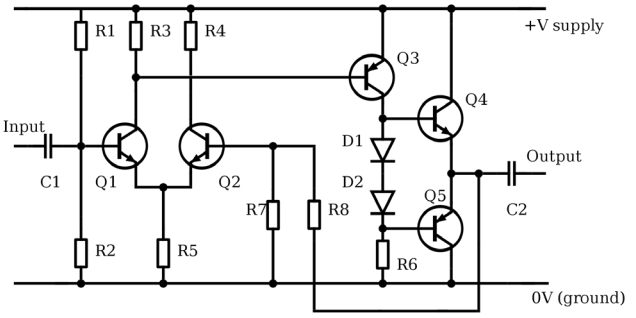




Lecture 7 – Microcontrollers

Andrés Faíña (anfv@itu.dk)



News

You can take an Arduino kit until March 25

- Sign up after the lab
- Practice different circuits at home
- Arduino Kit Guide is a recommended lecture

From March 25, take Arduinos boards, shields, sensors and hardware, but no Arduino kits

Add your project group to the Google docs document (LearnIT)

The auto-focus of the laser cutter is broken

- use manual focus, ask TAs

Preferably, use PMMA (acrylic) instead of POM

Startup programme presentation (Vlad)

Overview

DC/DC converters

Servos

Ultrasound sensors

Digital communications
- Accelerometers / IMU (I2C)

Stable voltage

Issues
- Input voltage can vary
  - Batteries
  - Noise
- Load conditions (e.g., I=0 to 400mA)

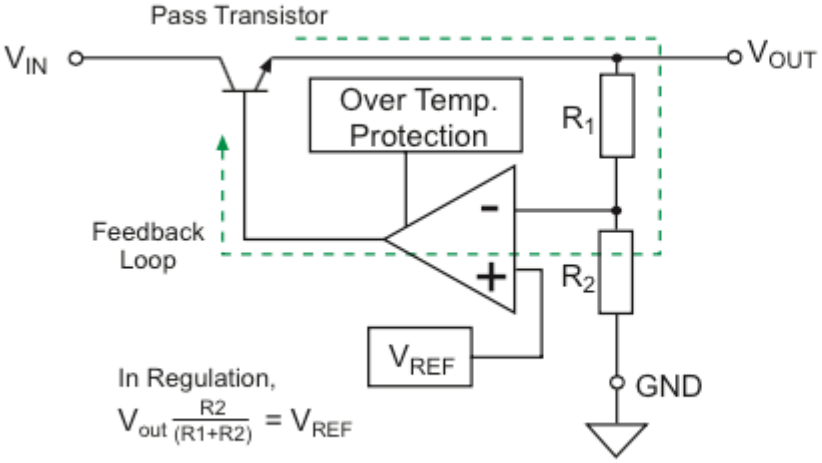
How can we have a fixed voltage output?
- Linear regulators
- DC/DC converters

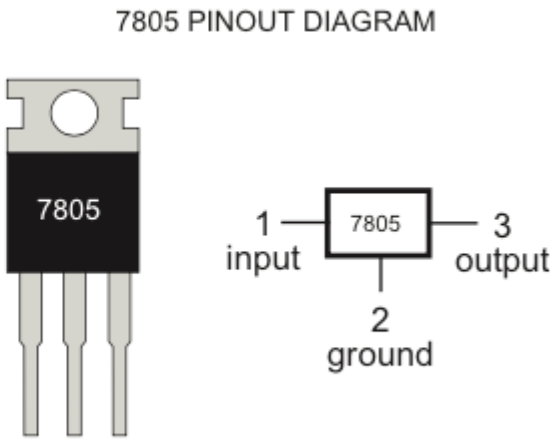
Linear regulators

Use a transistor and a fixed voltage reference to keep constant the output voltage

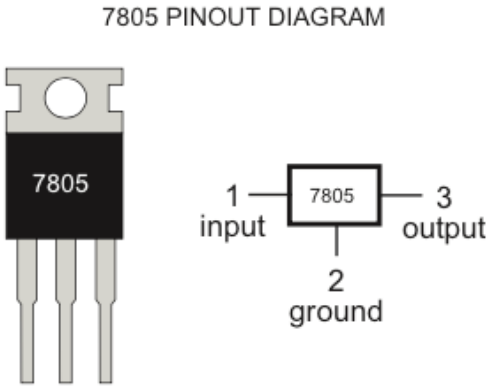
Cons:

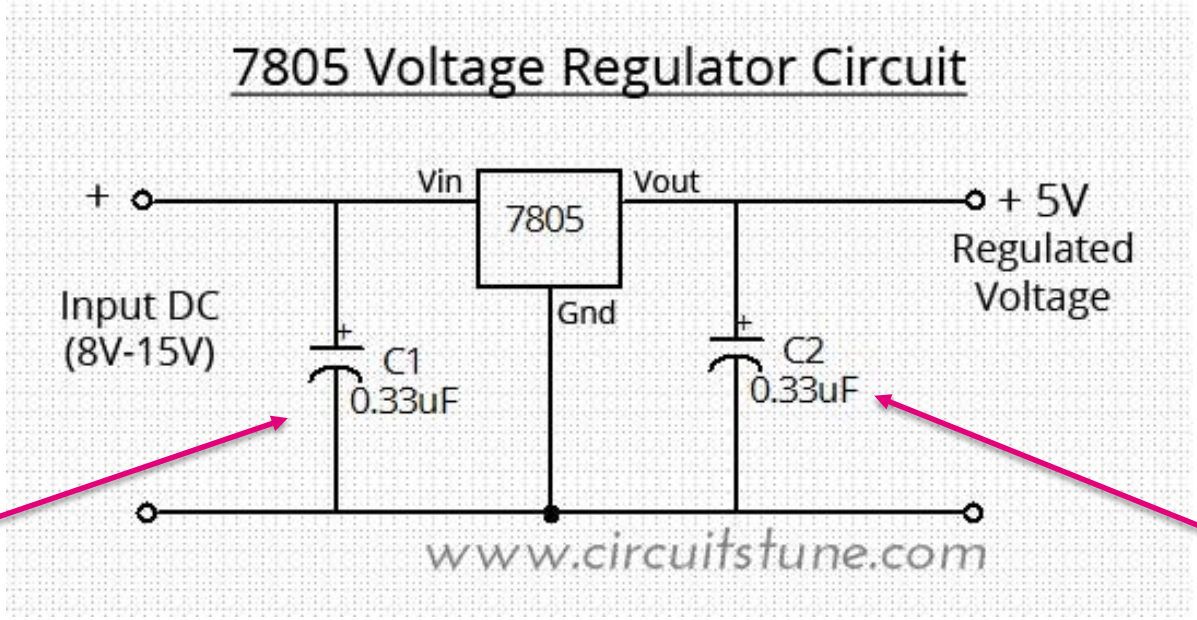
- Generate heat, specially if Vin >>> Vout or I is high
- Only decreases the voltage (Vout < Vin)





An example: 7805





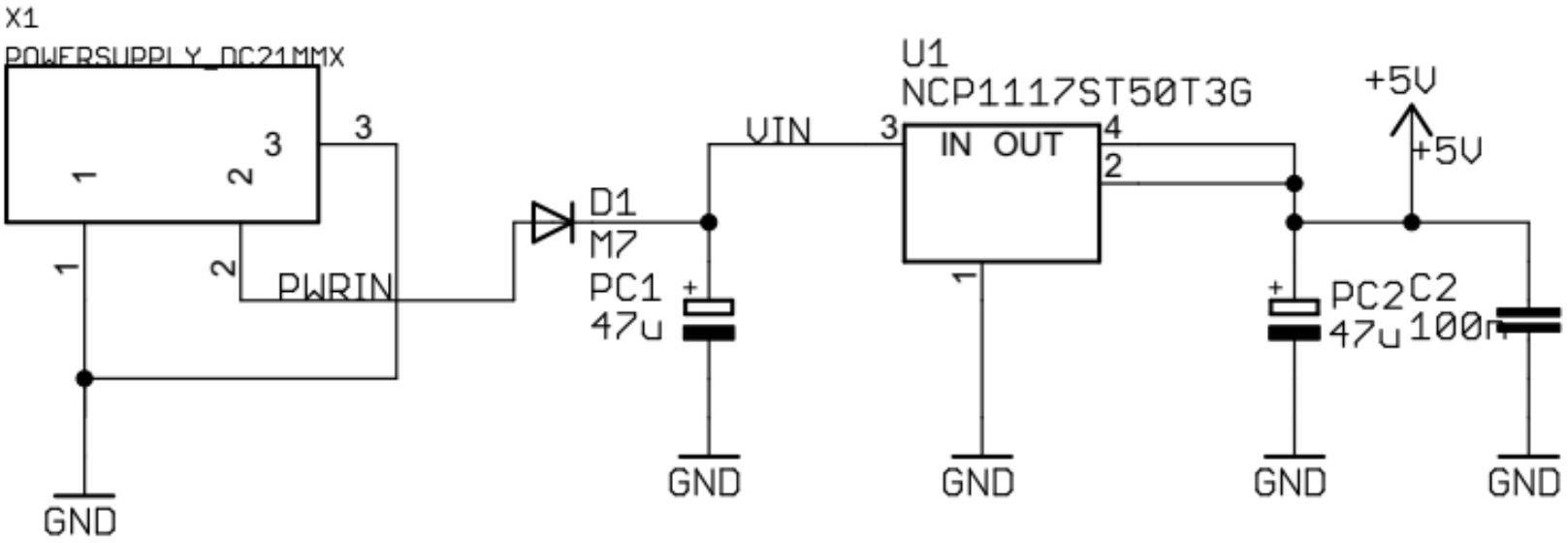
Input capacitor

Output capacitor

Always place two capacitors! (stability)

Where are the two resistors?

Example II: Arduino Uno schematics



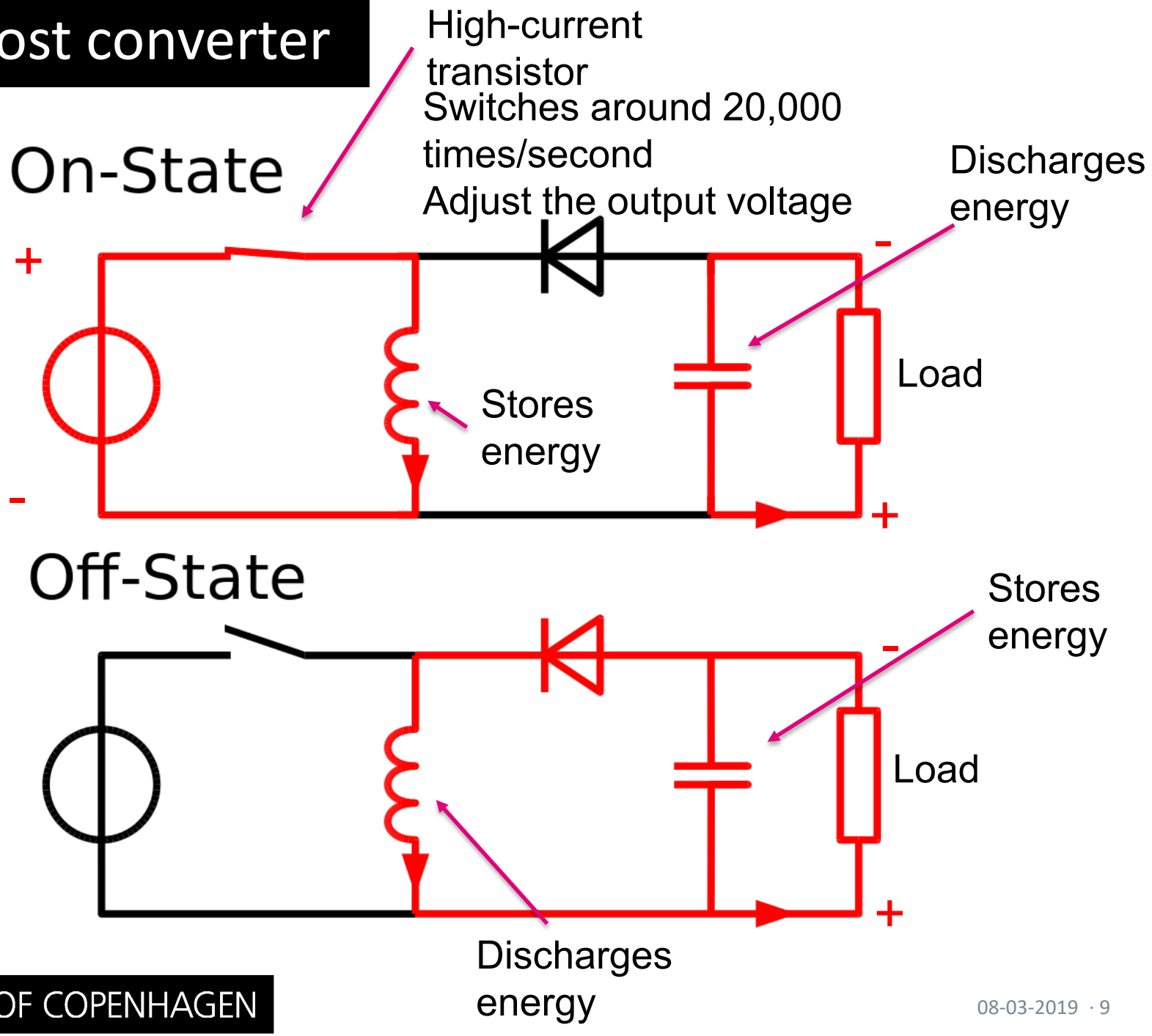
DC / DC converters

Convert DC voltage to another voltage

- Almost no looses of energy
- Noisy (no suitable for precise analog measurements)

- Different types
- Boost:
  - Steps up voltage (Vin < Vout)
- Buck:
  - Steps down voltage (Vin > Vout)
- Buck-boost:
  - Output voltage is higher or smaller than the input

Buck-Boost converter

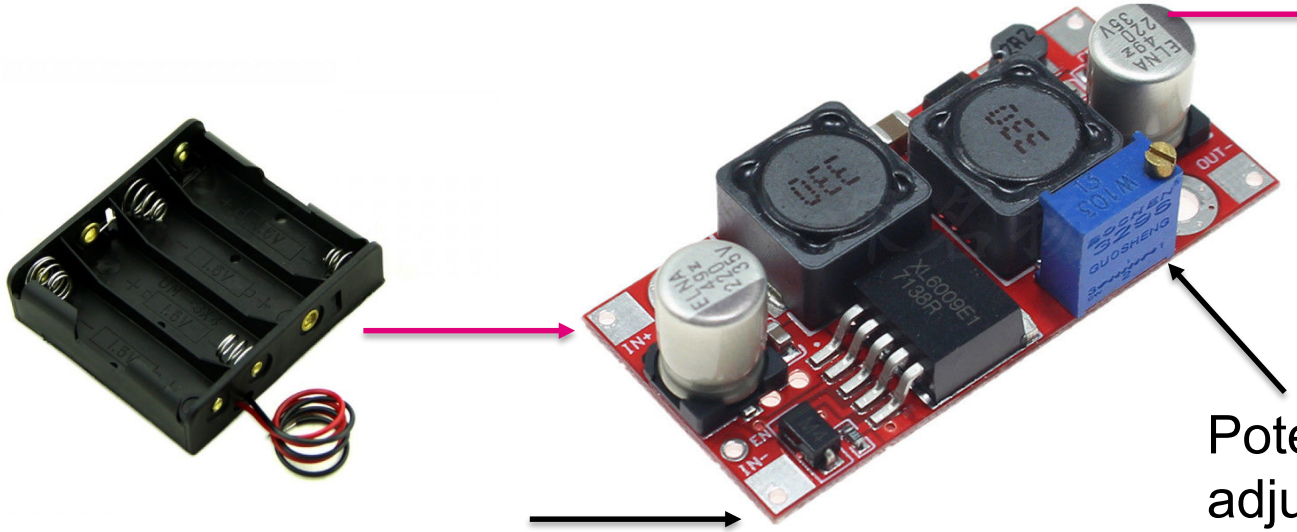


Buck-Boost available at REAL

5-6V

Buck-Boost

12V



GND2
Not connected to GND1!

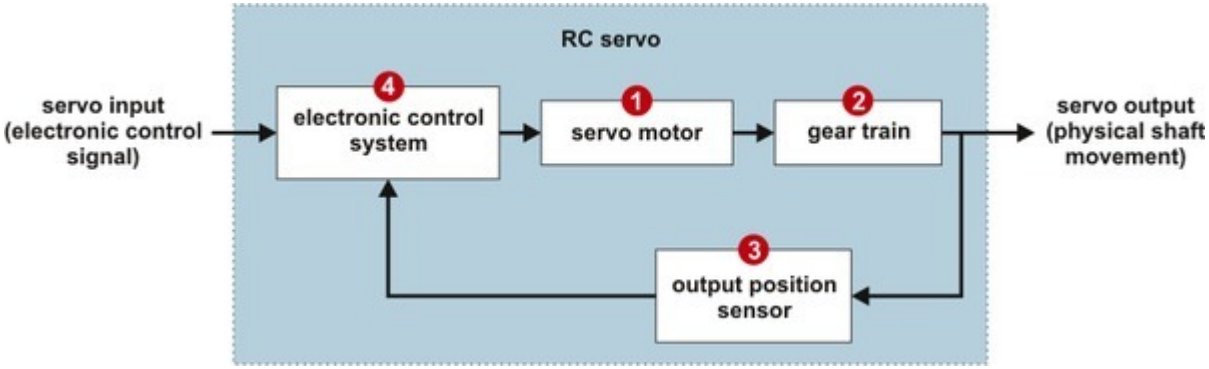
Potentiometer to adjust the output voltage

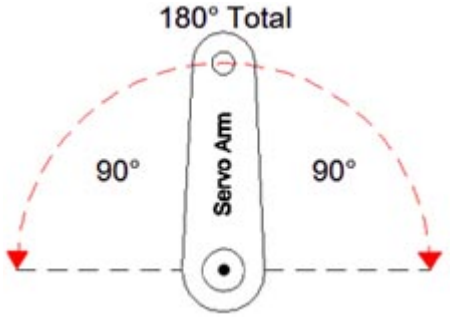
GND1
Not connected to GND2!

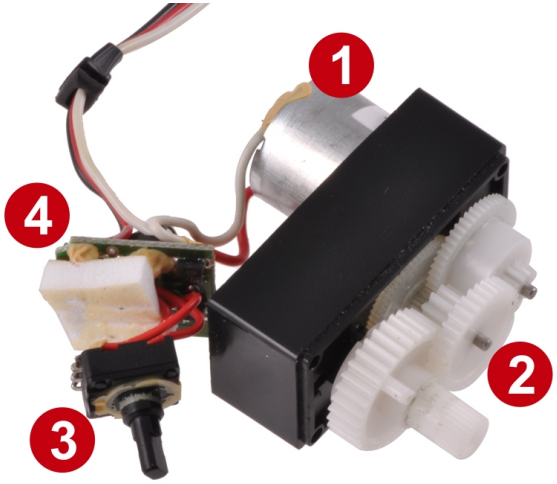
DC motors

How to reach a specific position with a DC motor?

RC servos


RC servo
servo input (electronic control signal)
4
electronic control system
1
servo motor
2
gear train
servo output (physical shaft movement)
3
output position sensor

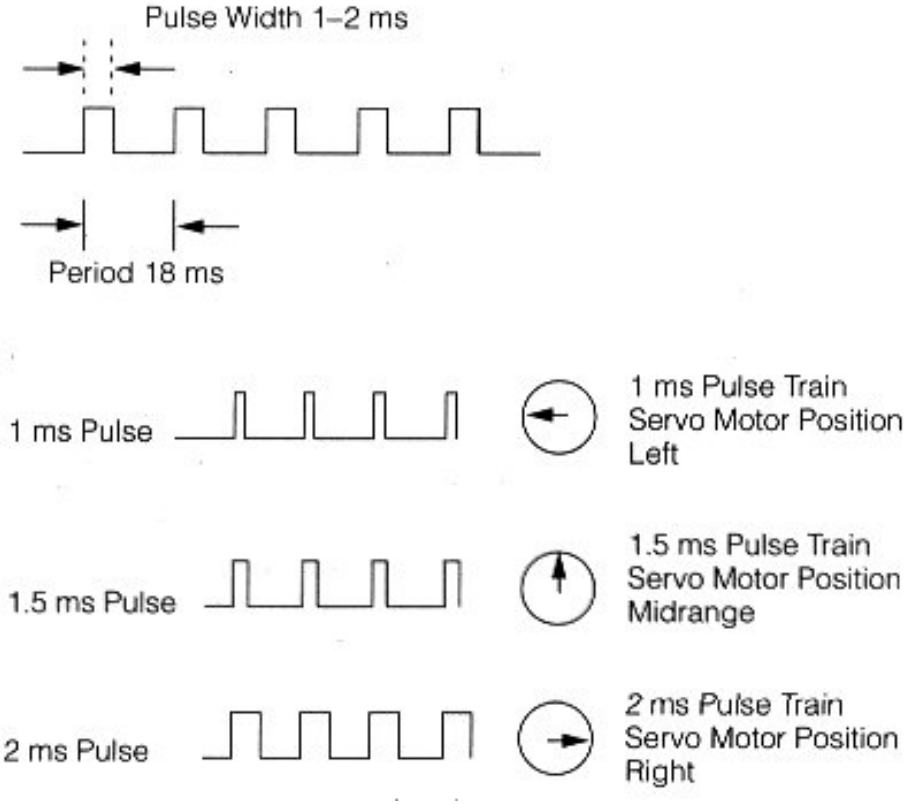

180° Total
90°
Servo Arm
90°


1
2
3
4


QUARTER SCALE
HiTEC
HS-755HB

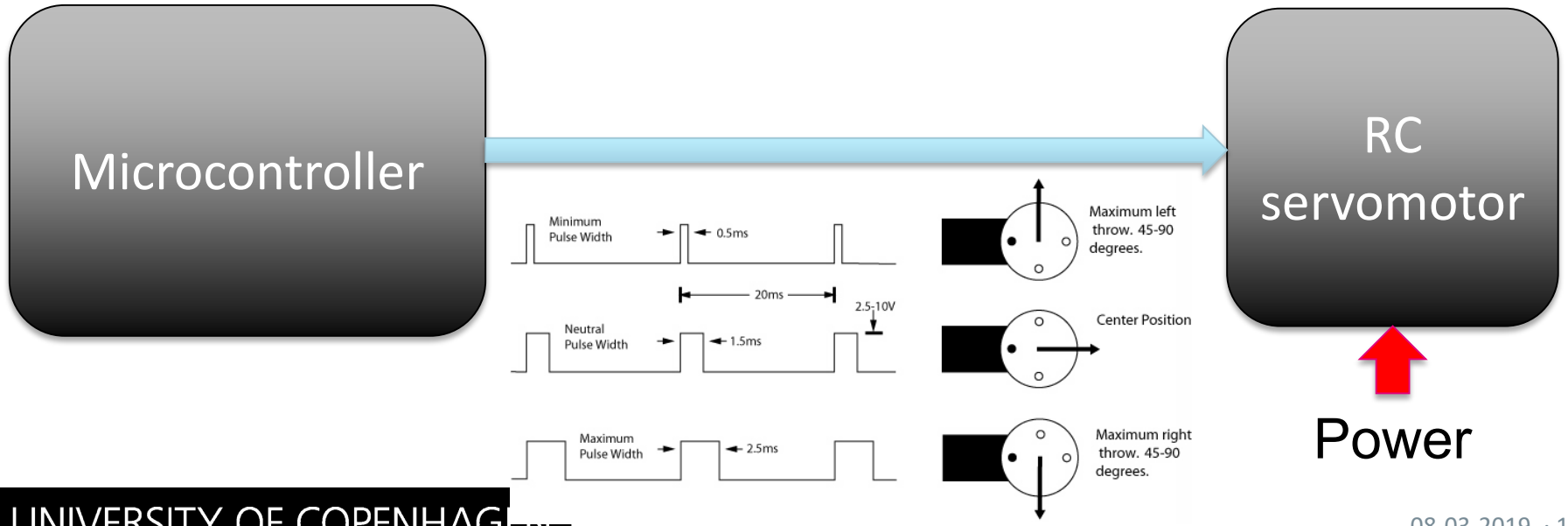
RC Servos

n


Pulse Width 1–2 ms
Period 18 ms
1 ms Pulse
1 ms Pulse Train
Servo Motor Position
Left
1.5 ms Pulse
1.5 ms Pulse Train
Servo Motor Position
Midrange
2 ms Pulse
2 ms Pulse Train
Servo Motor Position
Right

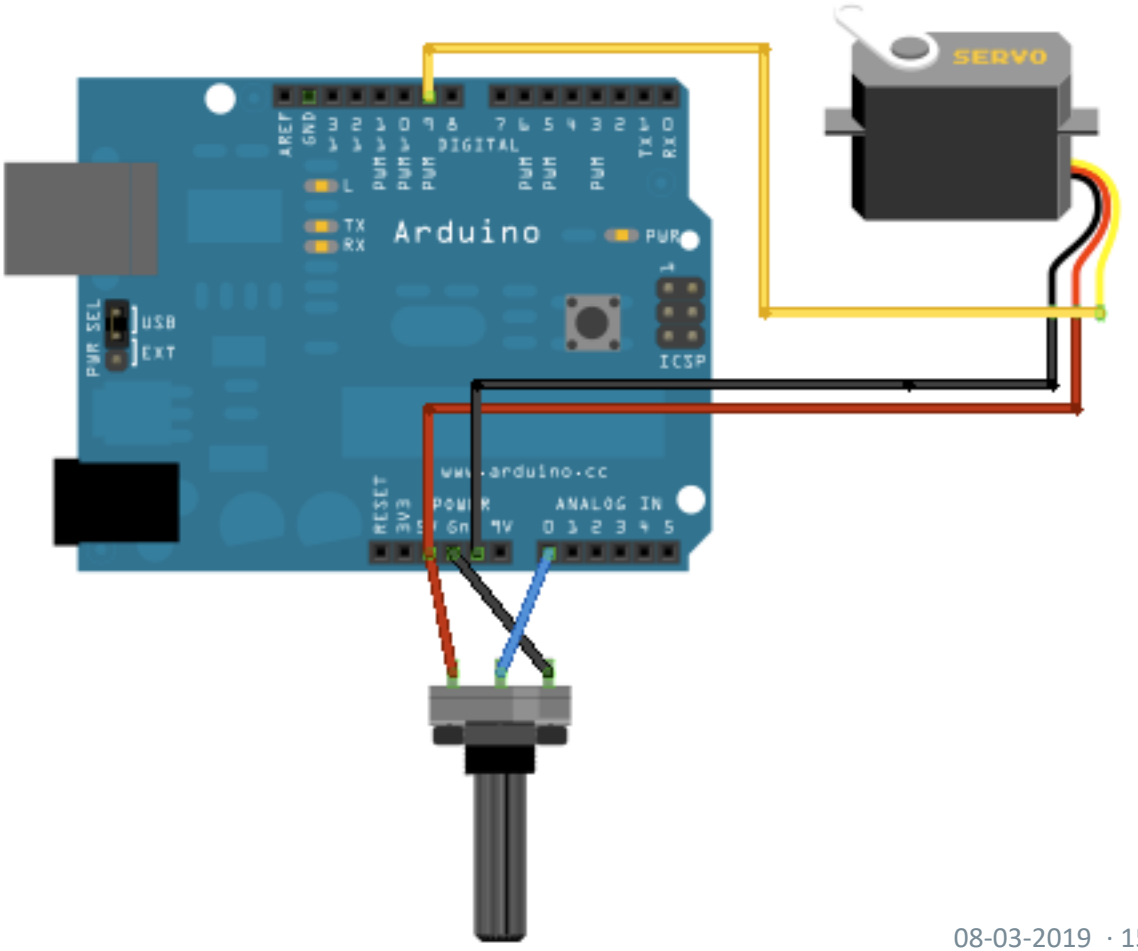
Servomotor- Control

- Microcontroller sets a target
- Servomotor tries to reach the target
  - Calculates the error
  - Calculates the output (voltage)
  - Applies the voltage to the motor



Exercise #1 - Moving a servo

Control the position la servo with a potentiometer
Use servo library



Questions? (Servos)

Connect a RC servo to an Arduino

Try to move it to different positions setting a target with a potentiometer

Keep one position and apply a force to the shaft

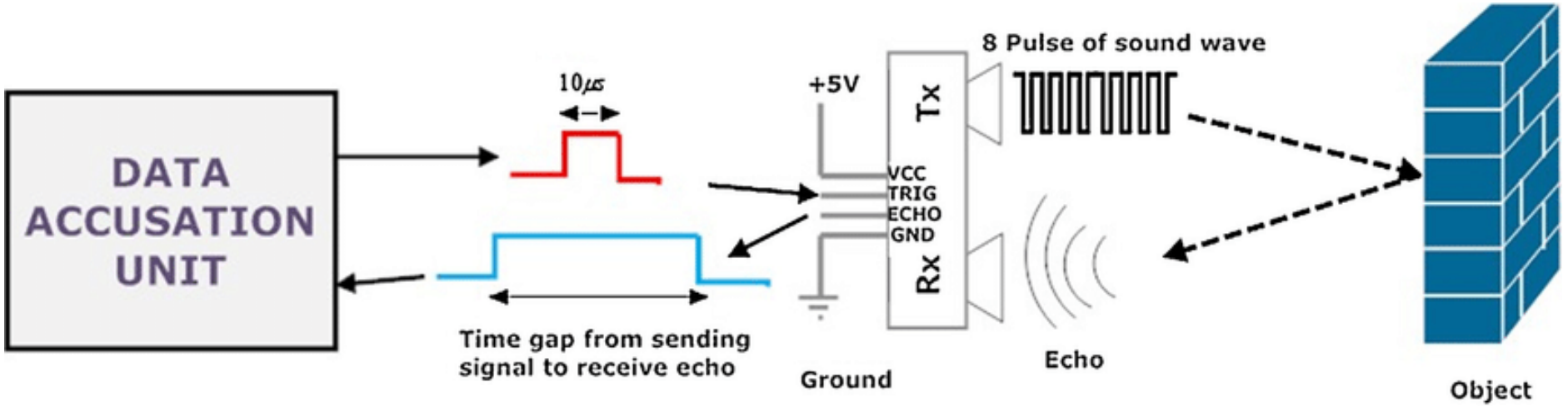
- Does the servo keep the position?
- What happens if you remove the force?
- What happens if you apply more force?

But be gentle when applying the force!

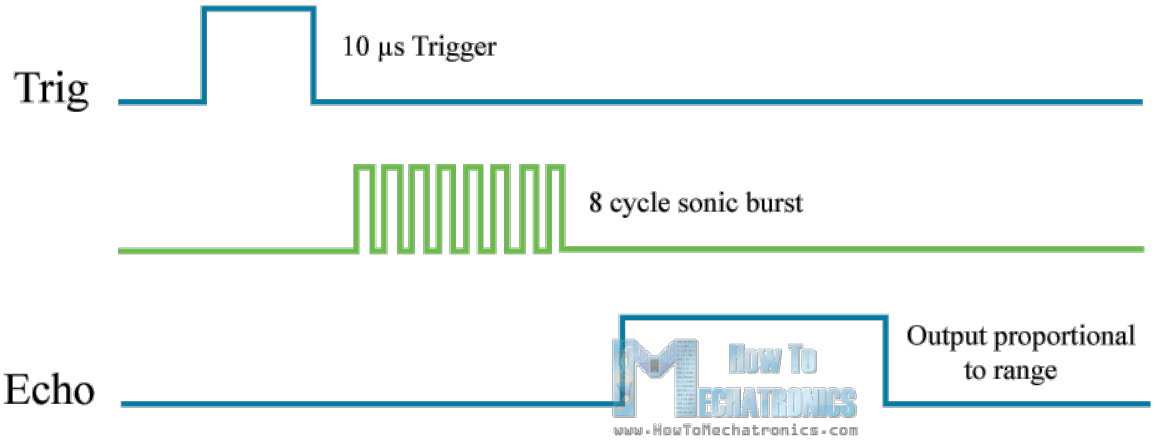
Ultrasound sensors

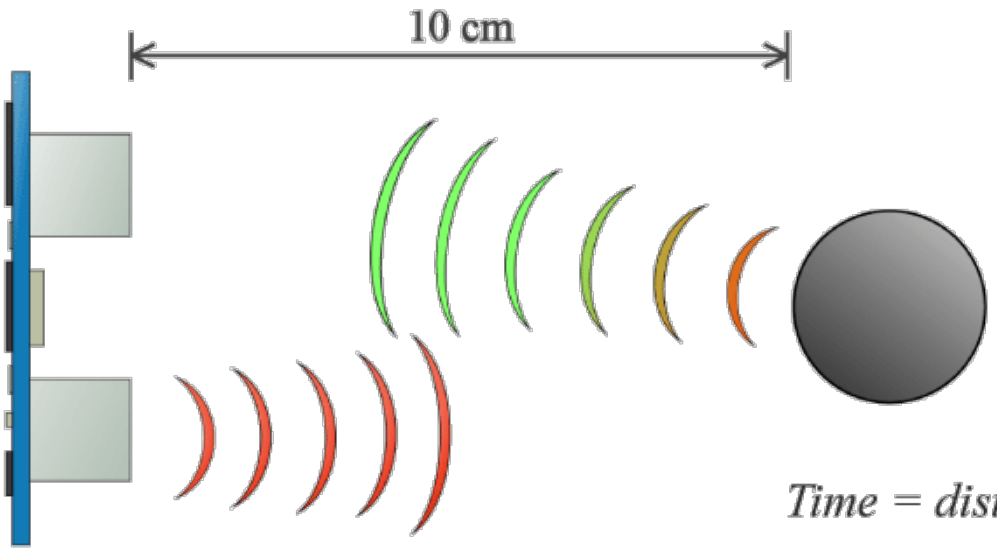
Similar to reflective optosensors

- Use sound (instead of light)
- Measure the time of flight (instead intensity of light)



Working principle





speed of sound:

$$v = 340\ m/s$$

$$v = 0{,}034\ cm/\mu s$$

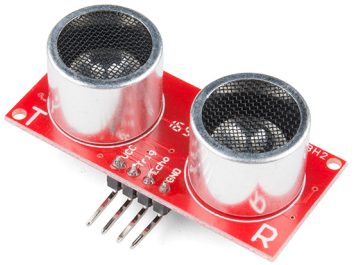
Time = distance / speed:

$$t = s / v = 10 / 0{,}034 = 294\ \mu s$$

Distance:

$$s = t \cdot 0{,}034 / 2$$

Ultrasound sensor - HC-SR04



https://www.sparkfun.com/products/13959

http://howtomechatronics.com/tutorials/arduino/ultrasonic-sensor-hc-sr04/

Place the sensors in front of a white obstacle

Start with a distance of 0cm and note the value of the sensor, move the object (or the sensor) 10cm backwards at a time and note the values

Now plot the data (e.g. in Excel) and use it to answer the following questions:

- Can you use the sensors to distinguish black from white?
- Can you use the IR/US light sensors to measure distance?
- Does the angle between sensor and object matter?
- Does the material of the object matter?

Digital protocols

The ucontrollers can communicate with other devices through digital protocols

Features:

- Multi-master or 1master multi-slaves
- Easy to implement (low number of lines)
- Medium speeds (400kHz to 5MHz)

Types:

- Uart (serial)
- SPI
- I2C
- USB
- CAN

USART - Universal Synchronous Asynchronous Receiver Transceiver (Serial)

We have a serial port between the Arduino and our computer

Try to print a message or a number

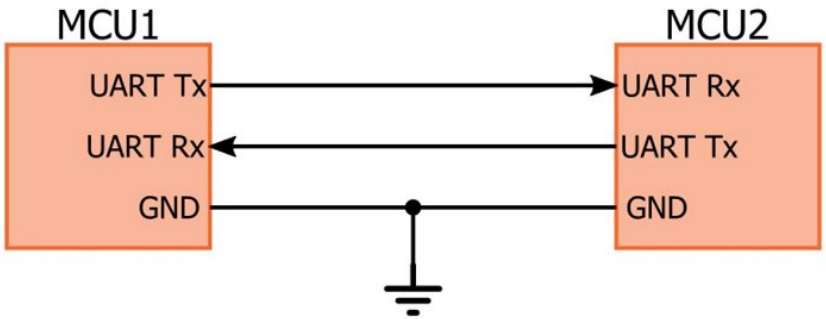
Open Serial monitor

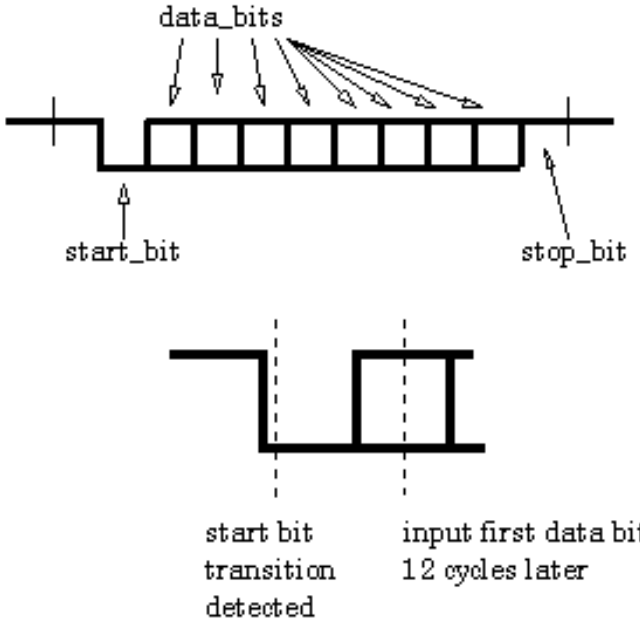
2 lines:

Rx

Tx

TX are RX are crossed over!





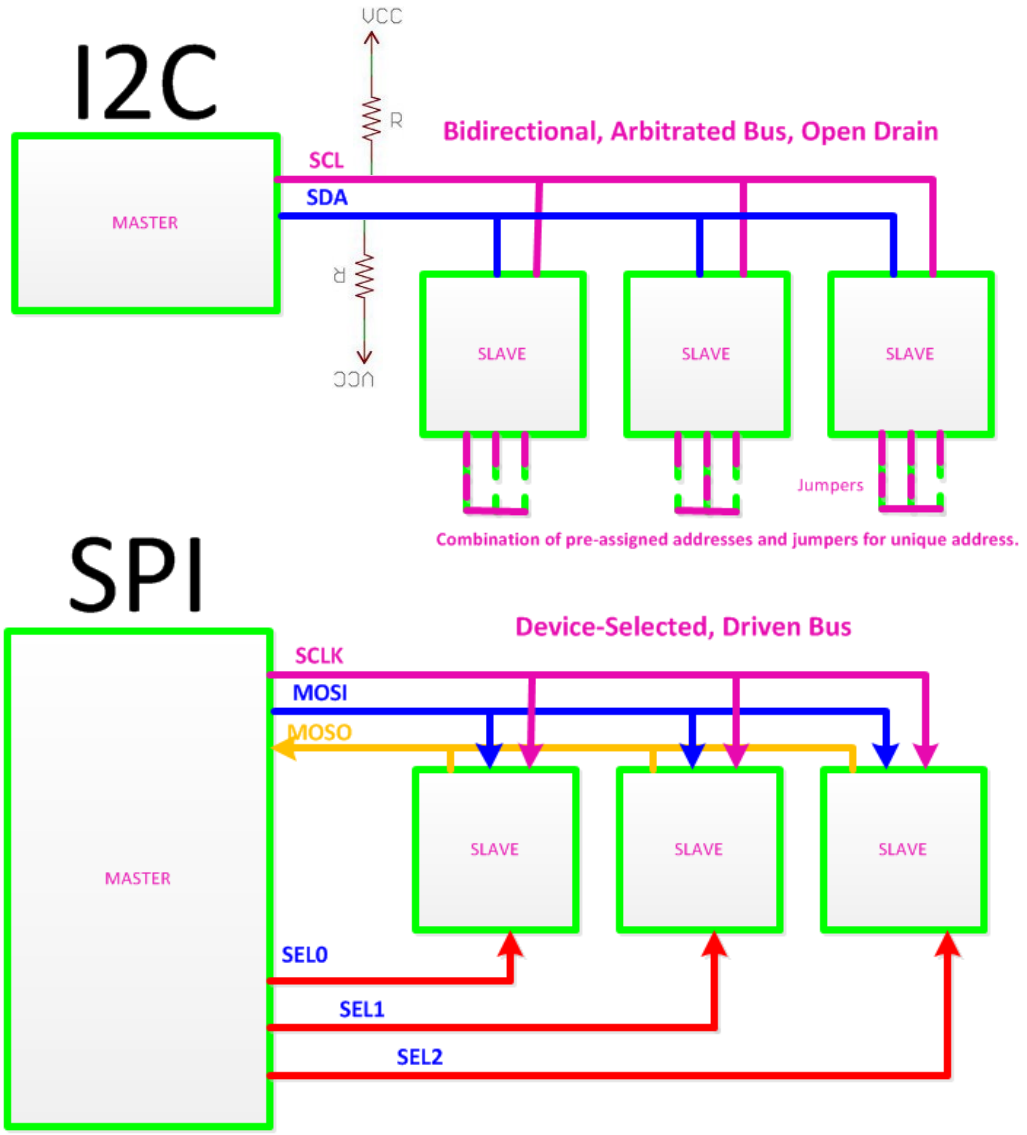
SPI / I2C (Wire or TWI)

I2C

- Only 2 lines (SDA, SCL)
  - with pull up resistors!
- Slaves have addresses
- up to 400kHz
- Multimaster

SPI

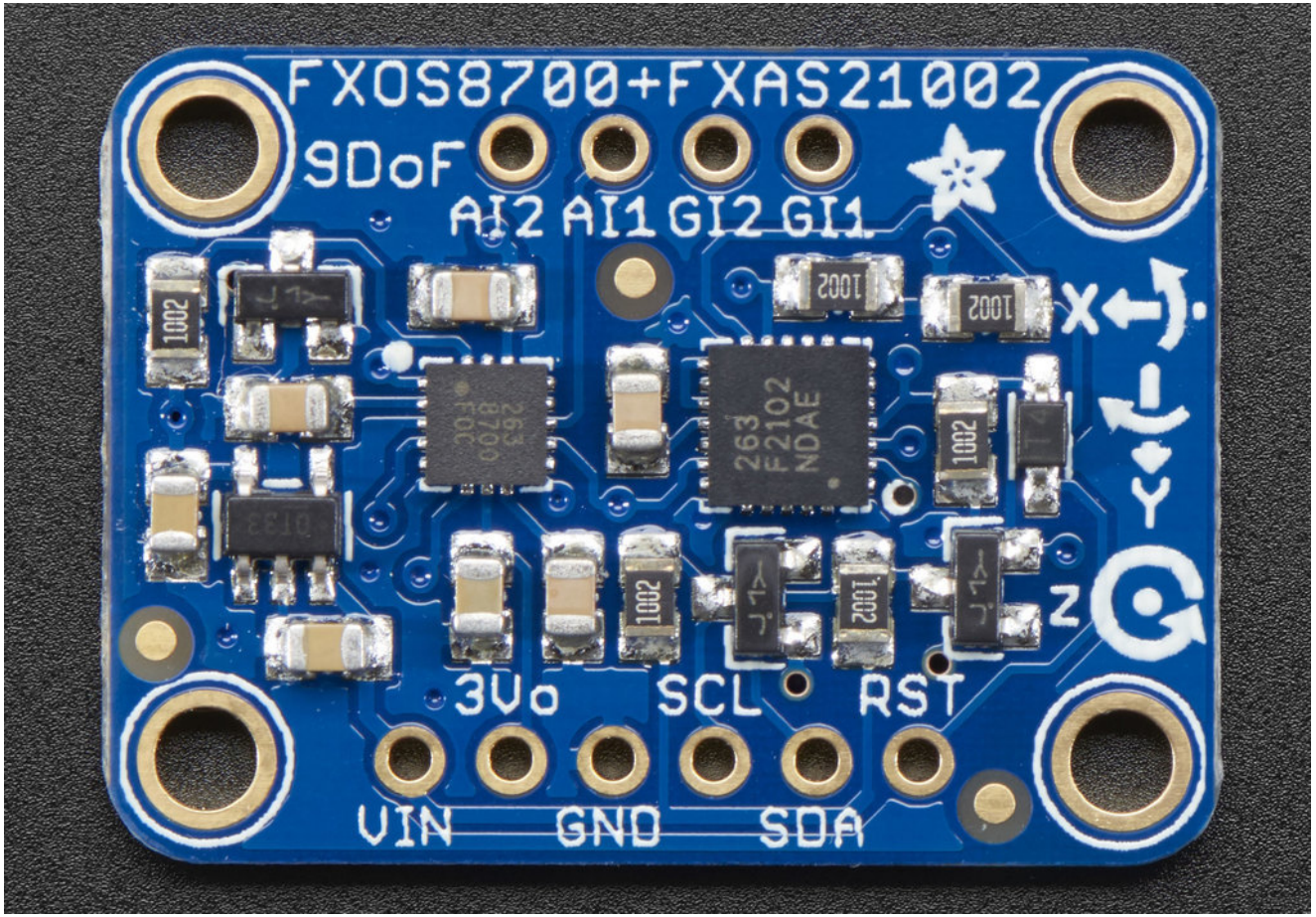
- 3 lines and 1 CS per slave (MOSI, MISO, SCLK)
- Slaves not need addresses
- up to 14MHz
- 1 master



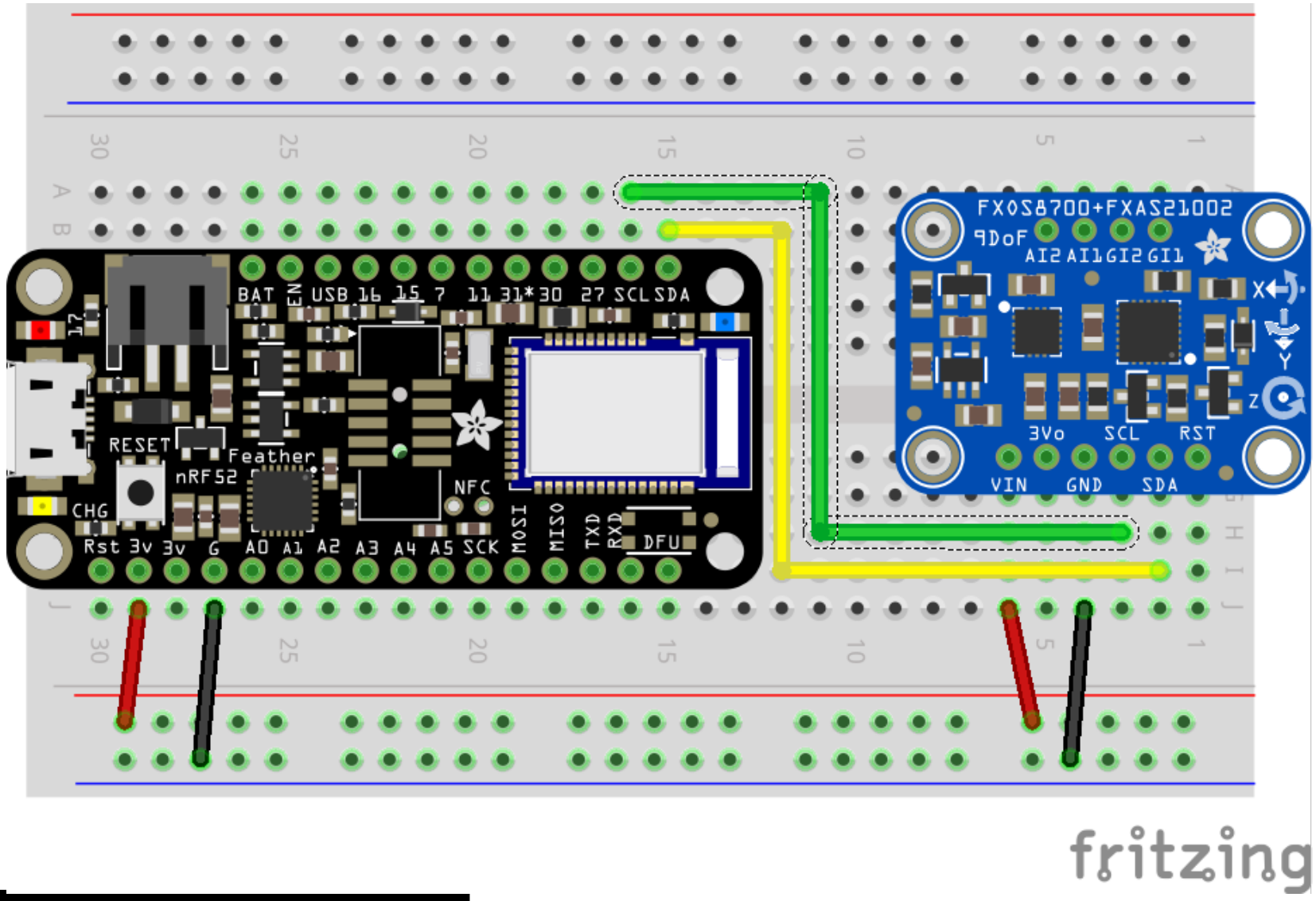
An example: FXOS8700

An 3-Axis accelerometer and magnetometer

What protocol does it employ?

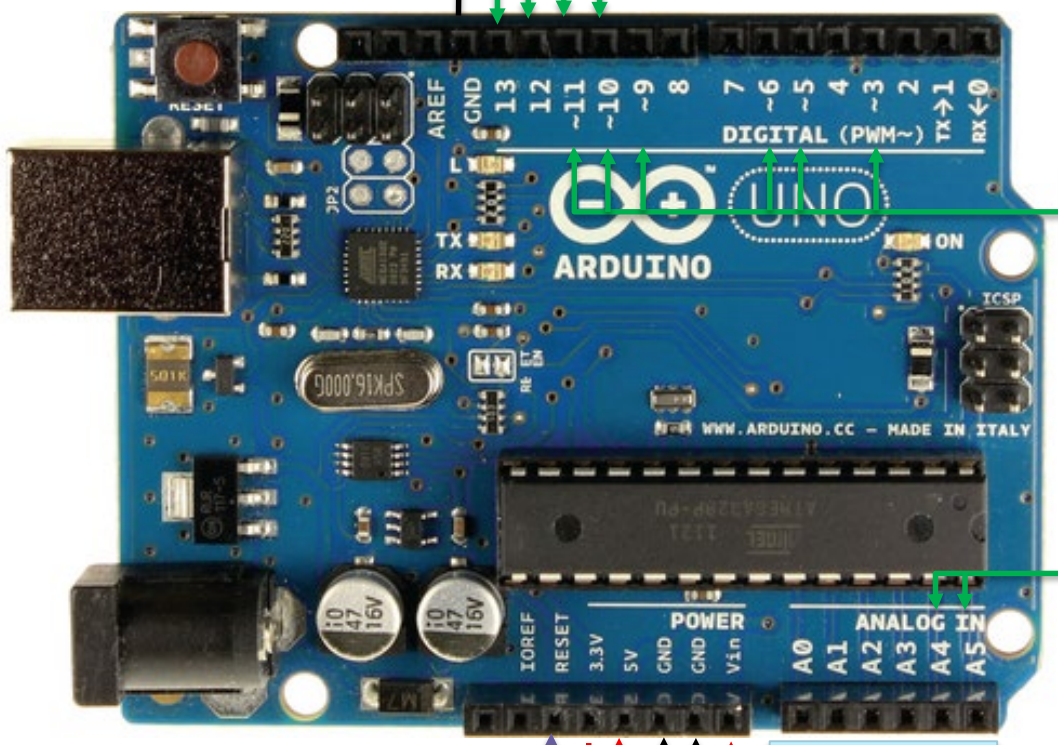


Wiring the FXOS8700



fritzing

Arduino - Headers



Digital Inputs/Outputs

SPI

10 (SS)
11 (MOSI)
12 (MISO)
13 (SCK)

PWM

I2C (Wire)

A4 (SDA)
A5 (SCL)

Digital Inputs/ Outputs

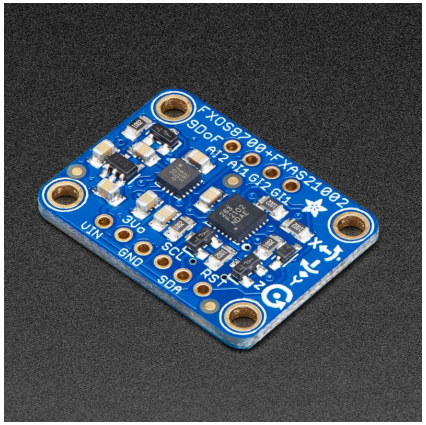
Reset

Analog Inputs

9dof IMU: I2C communications

NXP Precision 9DoF Breakout

https://learn.adafruit.com/nxp-precision-9dof-breakout?view=all



Mandatory assignment

There is no MA today

Use the lab time to

- ask questions
- try buck-boost converters
- explore advanced sensors/actuators
  - Ultrasounds
  - Accelerometers
  - Pressure
  - LCD
  - Servos
  - finish the previous MAs

Ready?

Let´s program!

Andrés Faíña, 4D26
anfv@itu.dk

Where to find electric components?

Components:

- Sensors
- Shields
- Breakout boards

Distributors:

- RS Components (*www.rs-components.com/*)
- Mouser (*www.mouser.dk/*)
- TME (https://www.tme.eu/en/)

DIY shops (with tutorials and libraries):

- Adafruit (*https://www.adafruit.com/*)
- Sparkfun (*https://www.sparkfun.com/*)

Breadboards

How to Use a Breadboard

https://learn.sparkfun.com/tutorials/how-to-use-a-breadboard