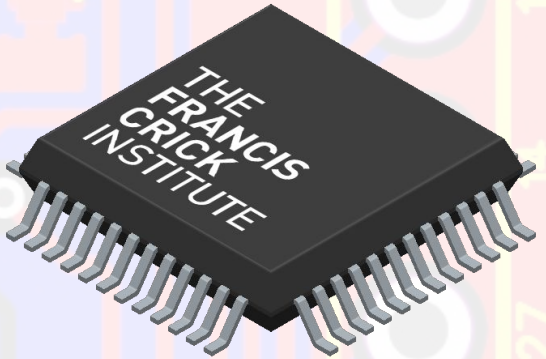
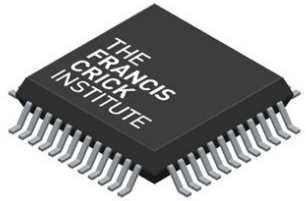


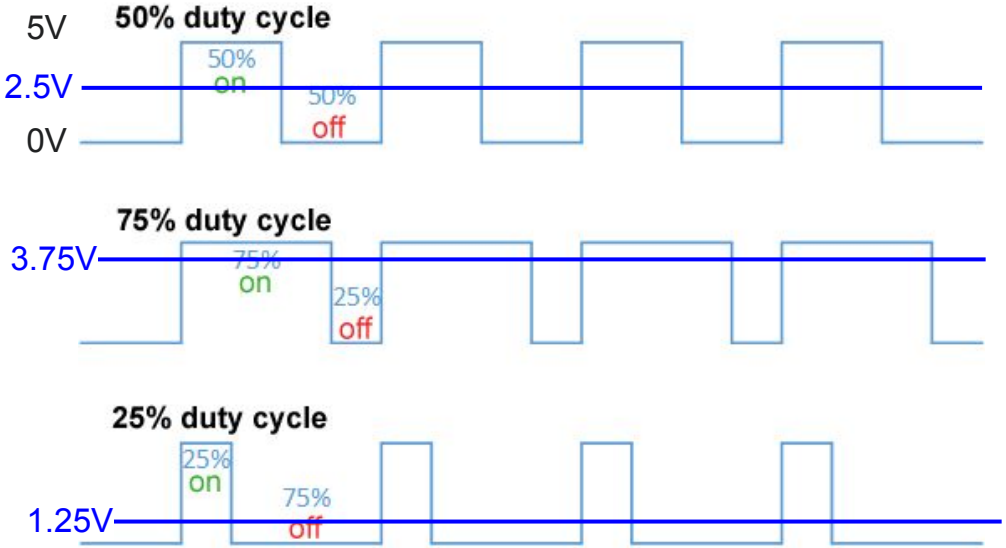
Microcontrollers (2022)

Session 3

Pulse Width Modulation (PWM)

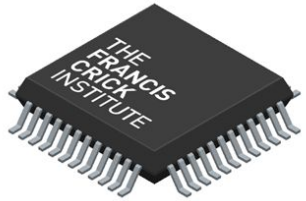


The average value of **voltage** fed to the **load** is controlled by turning the switch between supply and load on and off at a **fast rate**.



That is what we use to perform gradual control of actuators such as DC motors, Servo motors, Brightness levels on LEDs …

Pulse Width Modulation (PWM)



There are only certain pins that can do PWM

In the Arduino environment, the function to control PWM pins is called `analogWrite(Pin_number, dutyCycle)` (duty cycle has 8 bits and ranges 0-255 values)

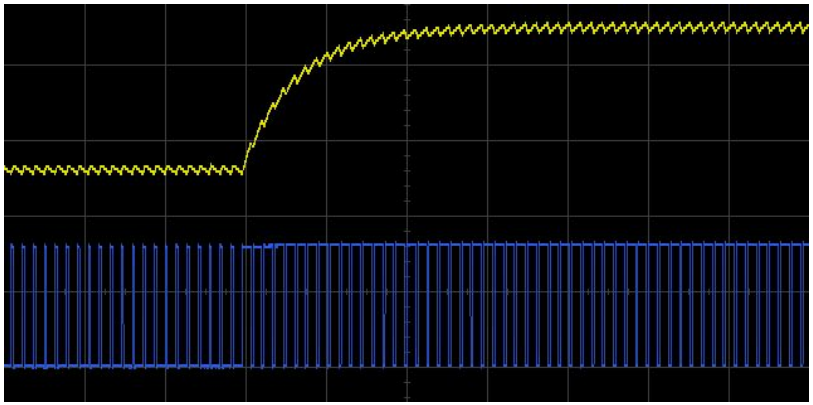
In ESP32…

The `ledcWrite(Pin_number, dutyCycle)` is usually the function used in the ESP32 context.

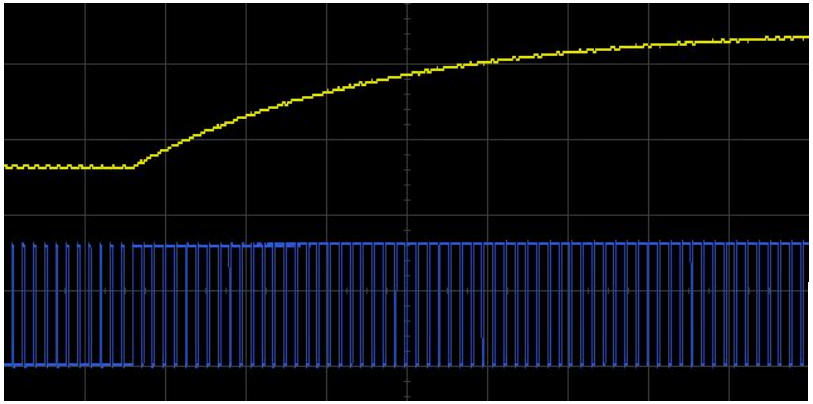
Or downloading the ESP32_anlaogWrite library

https://github.com/erropix/ESP32_AnalogWrite

Pulse Width Modulation (PWM)



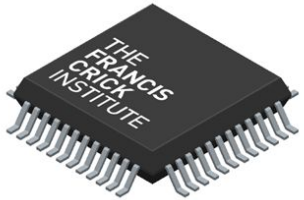
PWM Filtered by 1K Resistor & 10µF Capacitor



PWM Filtered by 1K Resistor & 47µF Capacitor

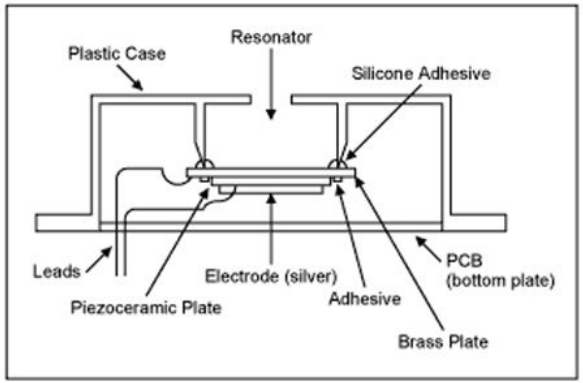
https://www.xtronical.com/the-dacaudio-library-download-and-installation/

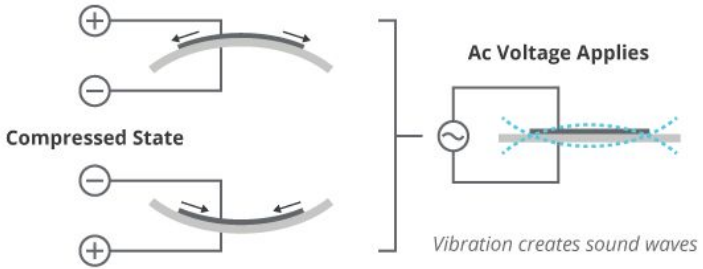
PWM Audio



- https://github.com/lbernstone/Tone32
- https://www.xtronical.com/the-dacaudio-library-download-and-installation/

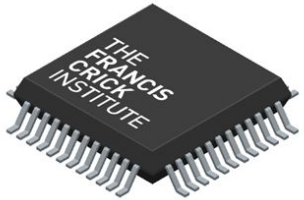
Pulse Width Modulation (PWM): Sound examples



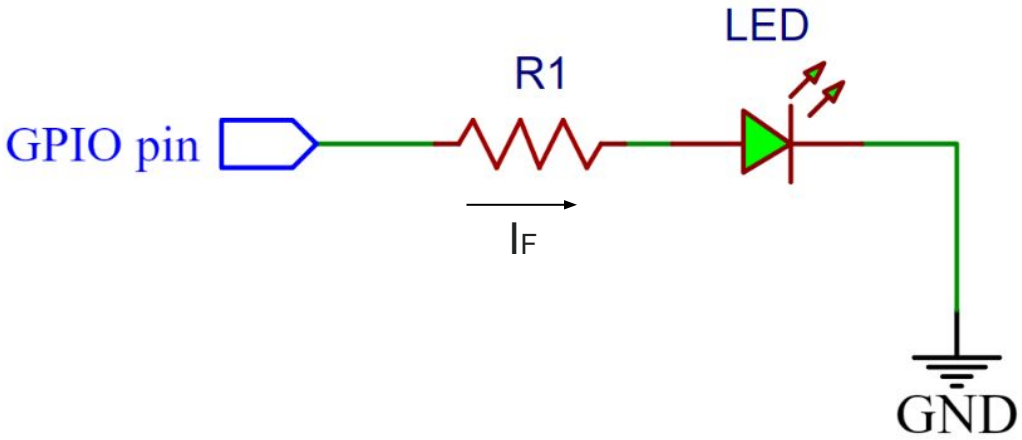


File->Examples->06.Sensors->Knock

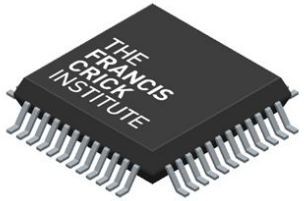
For some applications 20 or 40 mA is enough…



… for example to blink an LED:

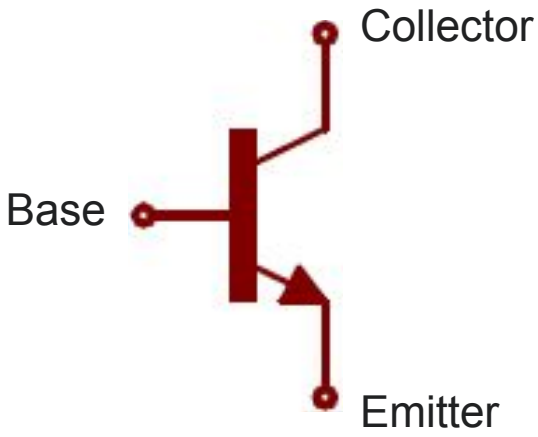


How to commutate a higher power ?

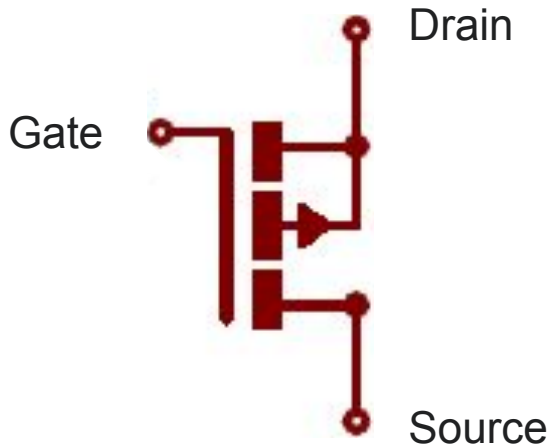


We have **current** and **voltage** controlled devices:

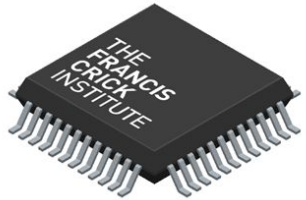
Current controlled devices:
BJT Transistors



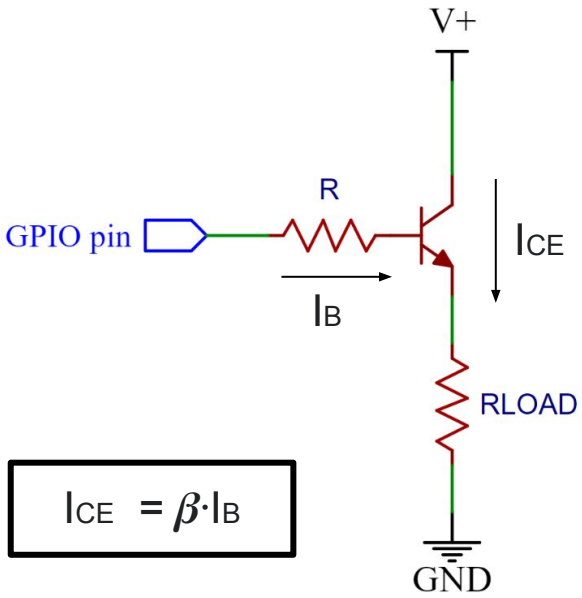
Voltage controlled devices:
FET Transistors



How to commutate a higher power ?



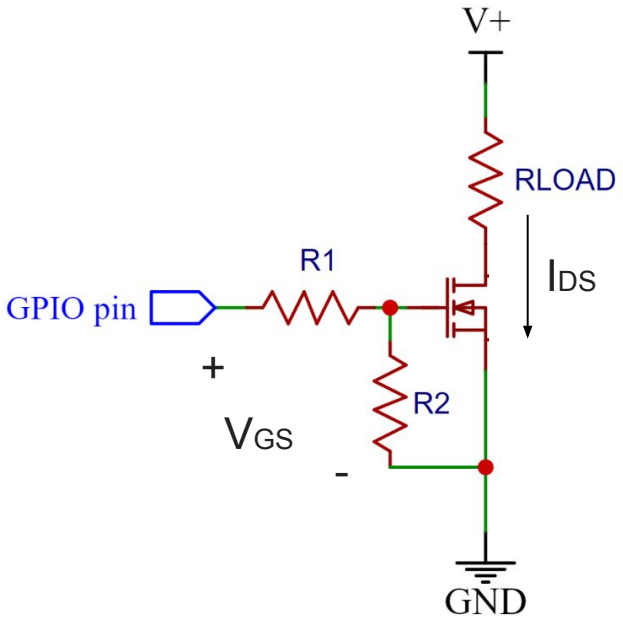
Current controlled devices: **BJT**
Transistors (“Intermediate power”)



$I_{CE} = \beta \cdot I_B$

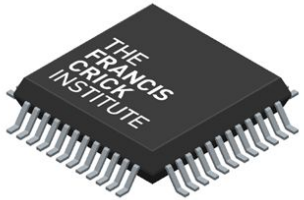
β can be 50, 100 or more

Voltage controlled devices:
FET Transistors (“Higher power”)

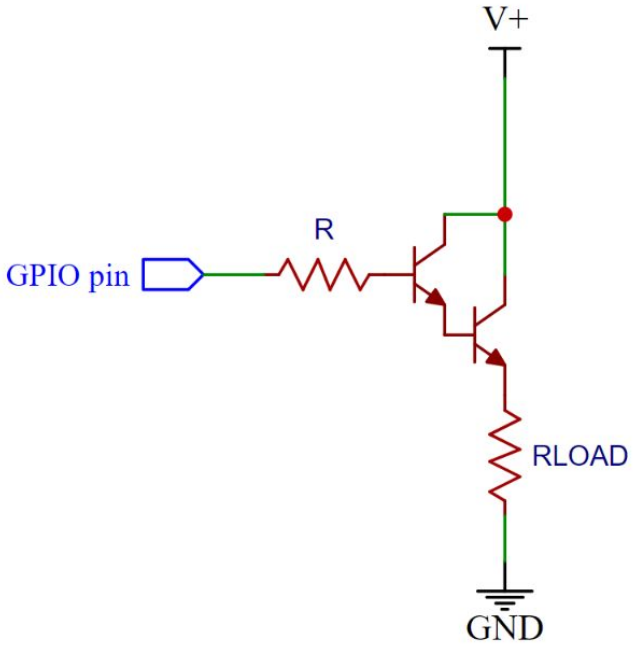


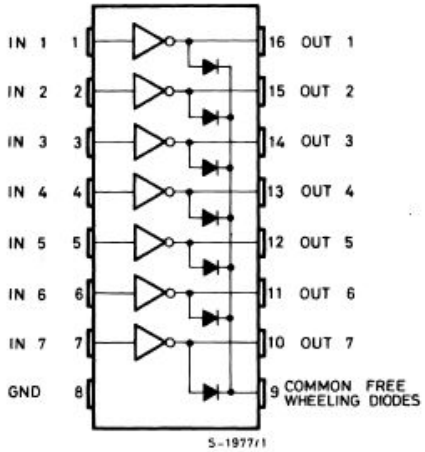
R_{LOAD} will be a valve, LED …

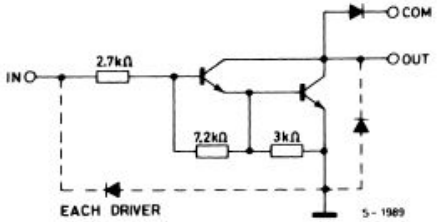
Darlington array



Cascade of two **BJT** Transistors

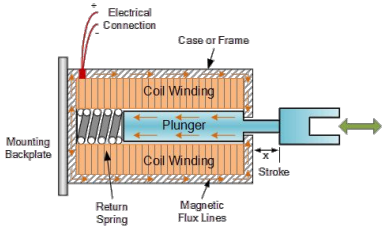






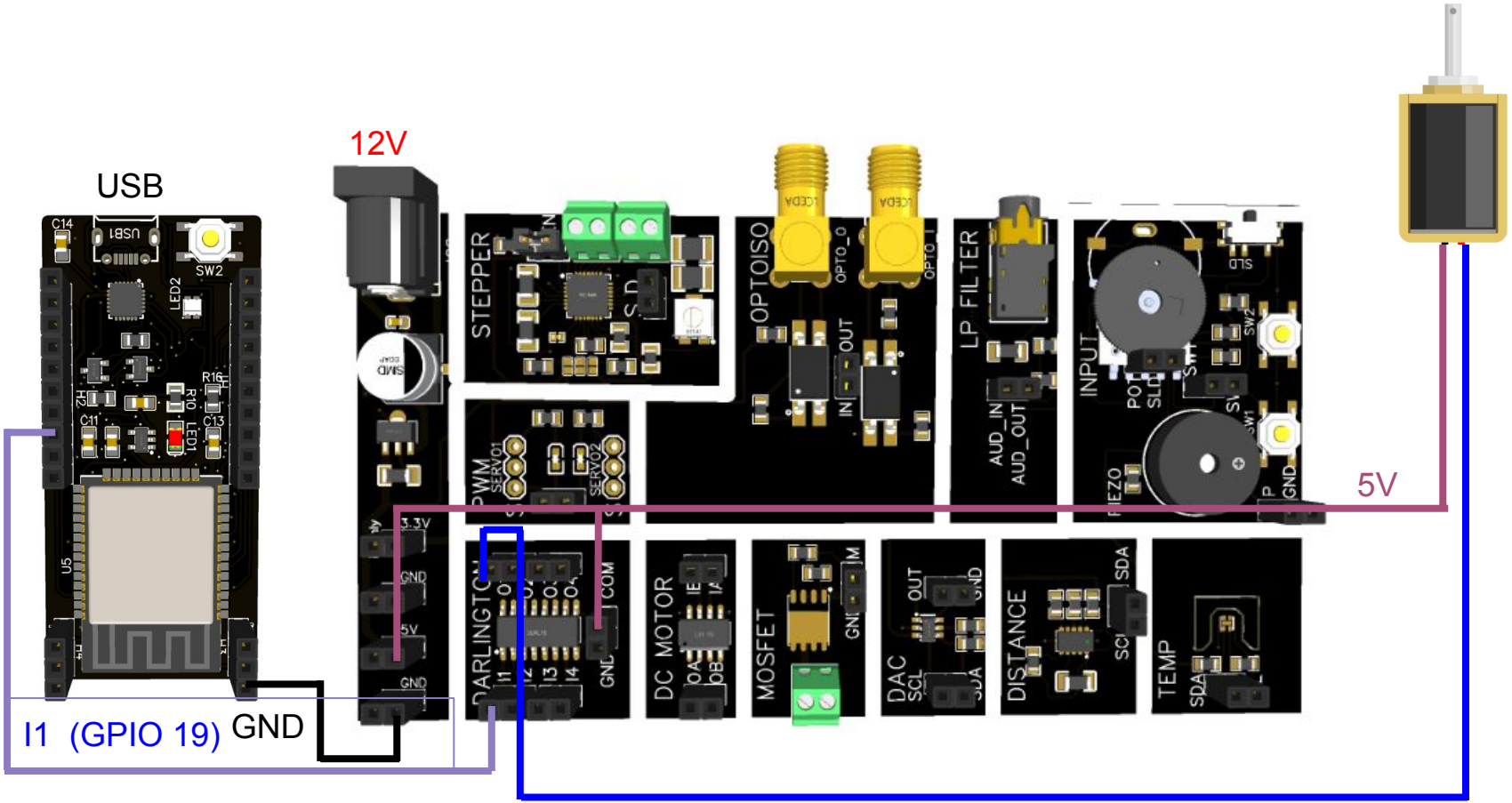
ULN2003 (each driver)

100 mA per channel **at 3.3V**
140 mA per channel **at 5V**

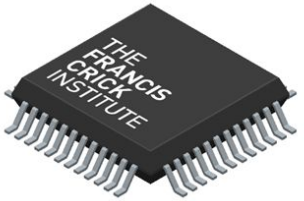


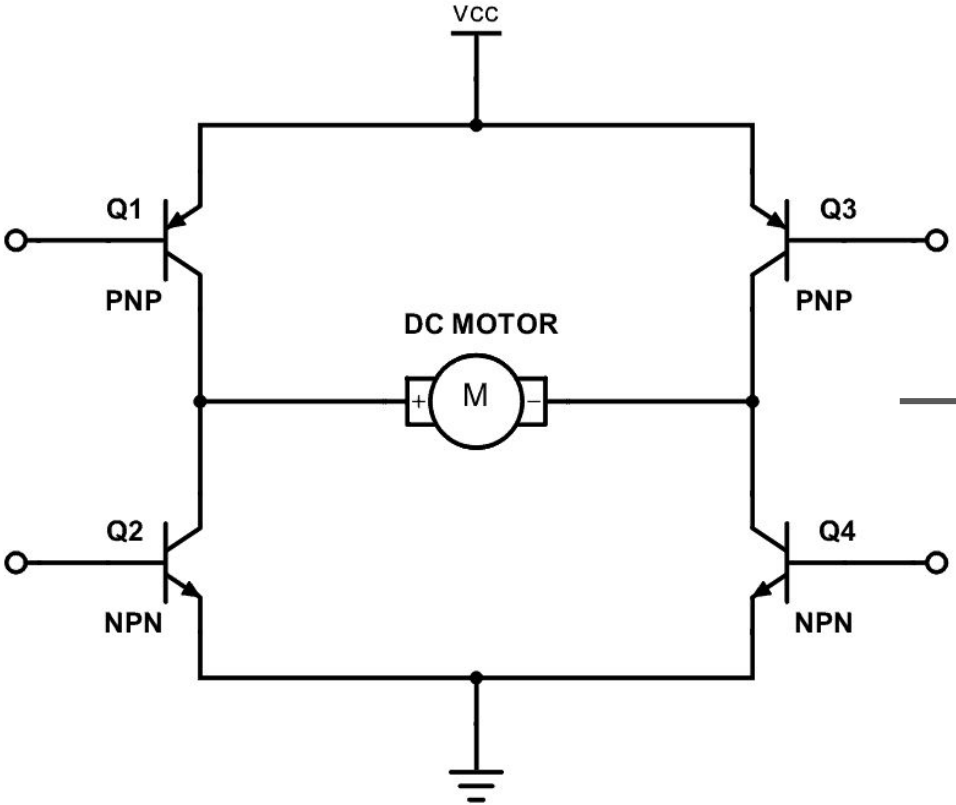
electronics-tutorials

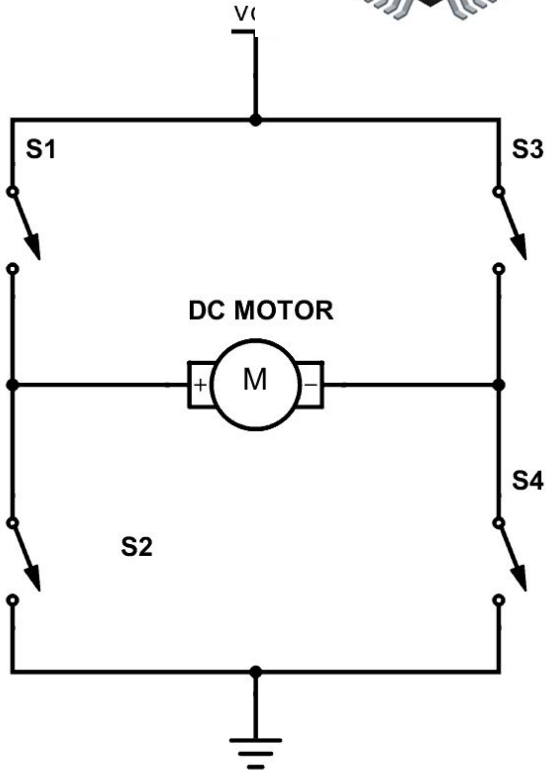
Valve control (Example 302)



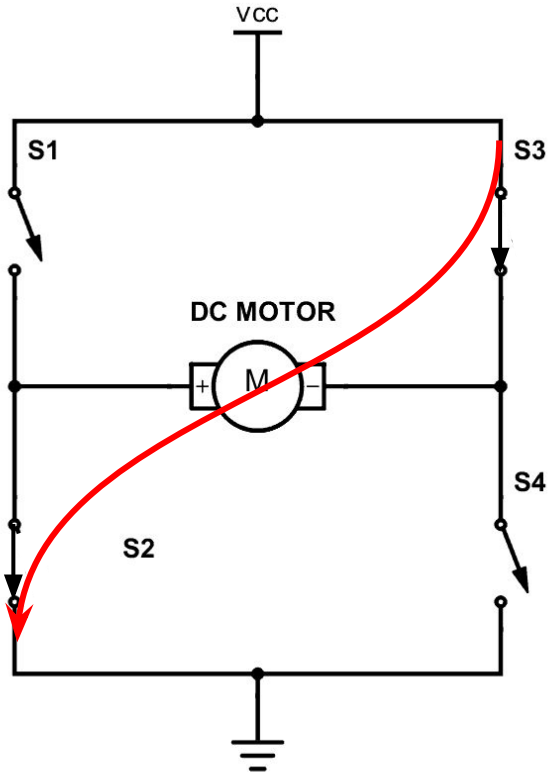
How to control DC motors: H-bridge

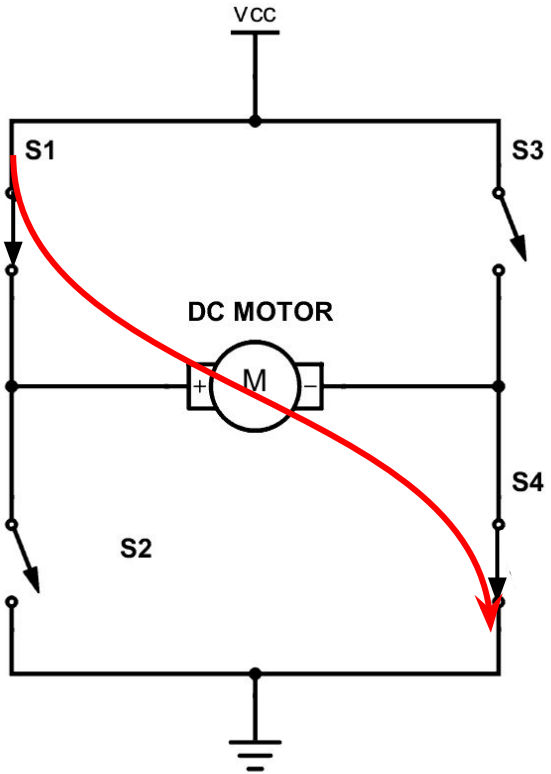


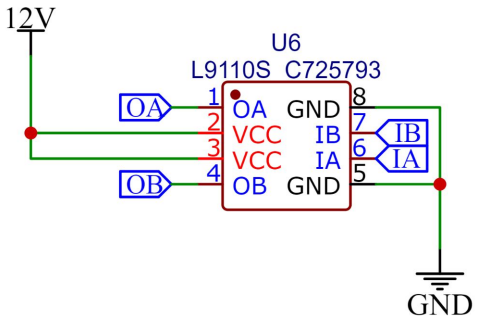




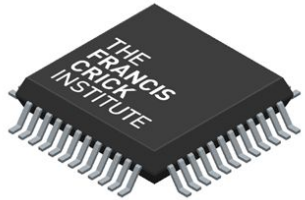
How to control DC motors: H-bridge







Making if/else structures more compact



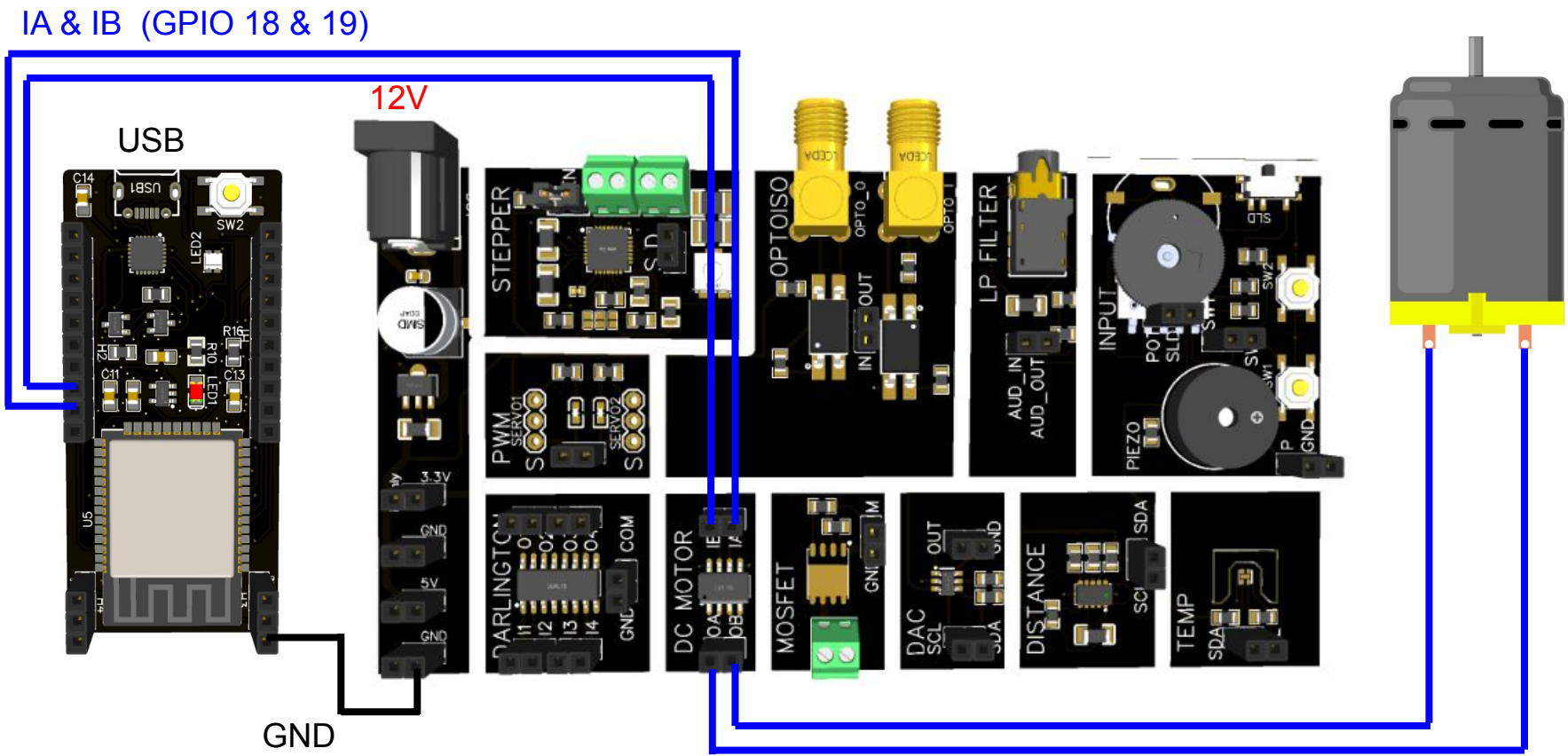

```
switch (var)
{
  case 1:
    // statements
    break;
  case 2:
    // statements
    break;
  case n:
    // statements
    break;
  default:
    // statements
    break;
}
```

var value

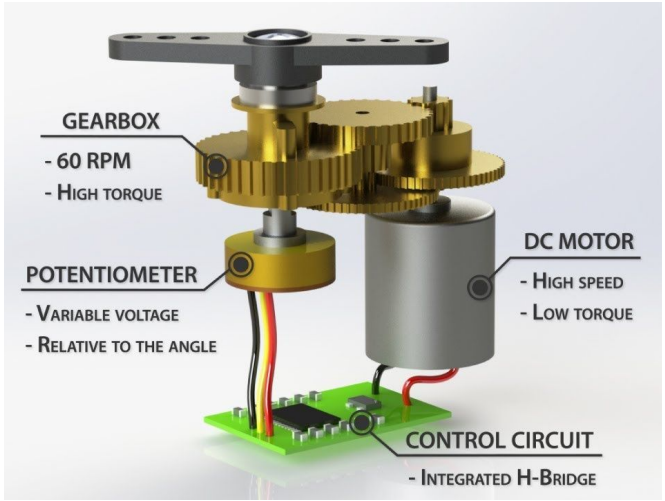
Equivalent to else (for any other condition)

https://www.arduino.cc/reference/tr/language/structure/control-structure/switchcase/

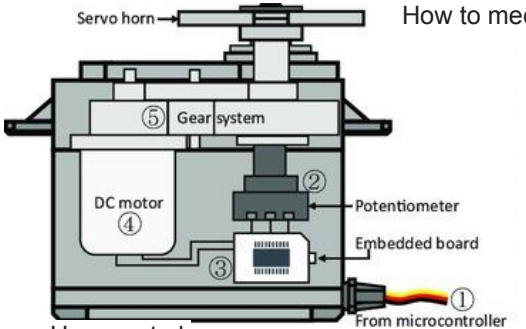
DC motor control (Example 303)



Servo motors

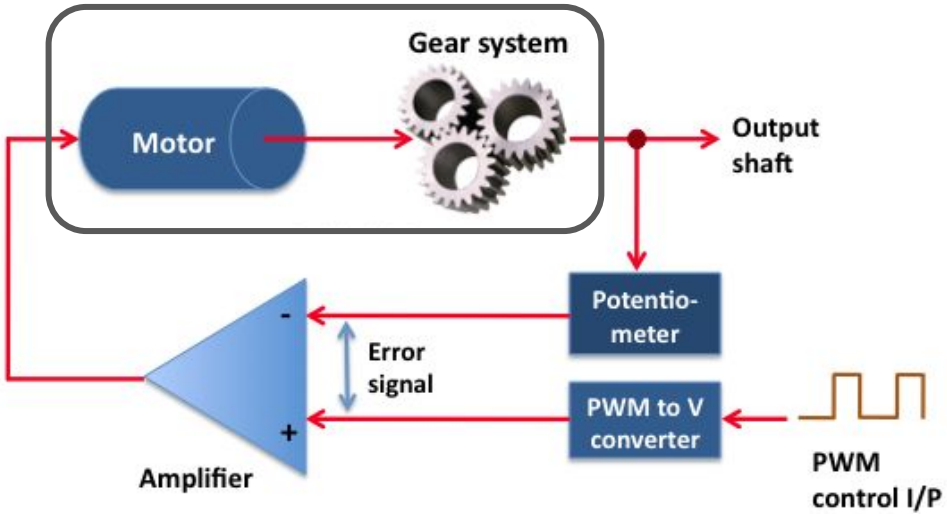


How to mechatronics



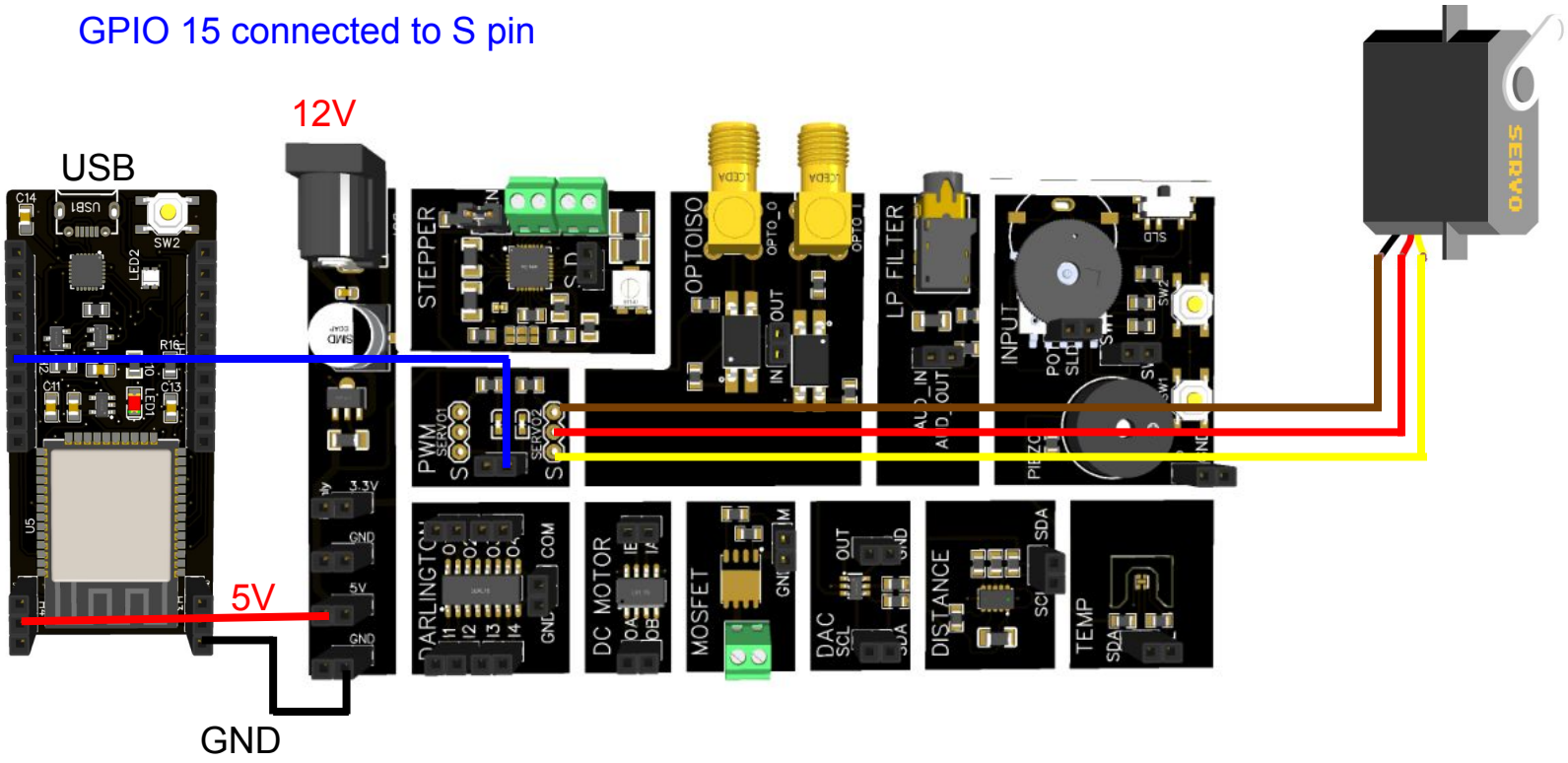
Hwang et al.

Position control system embedded on the motor

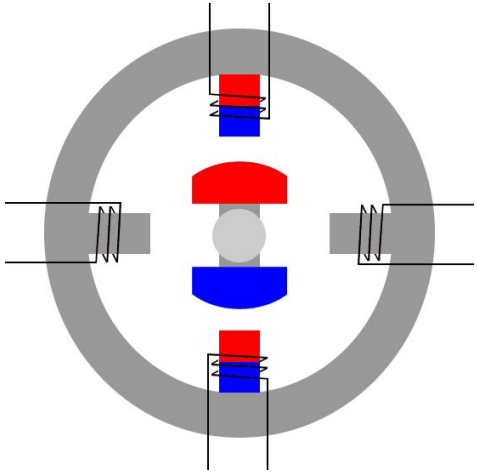


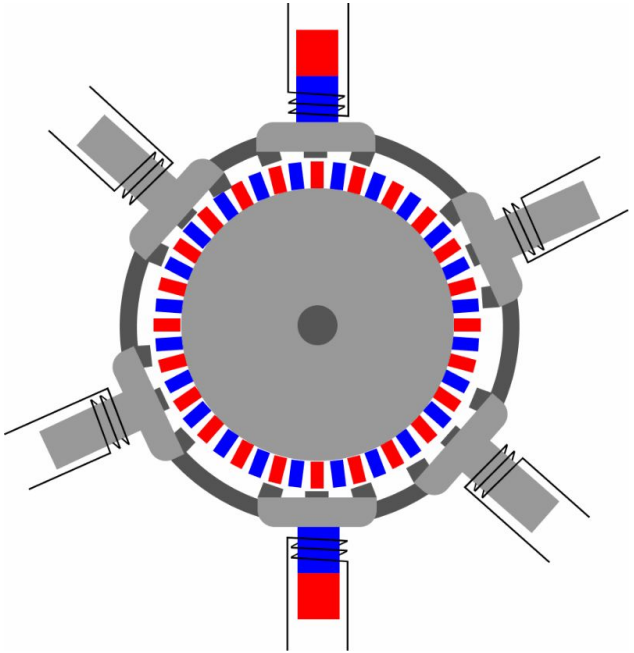
Embedded lab

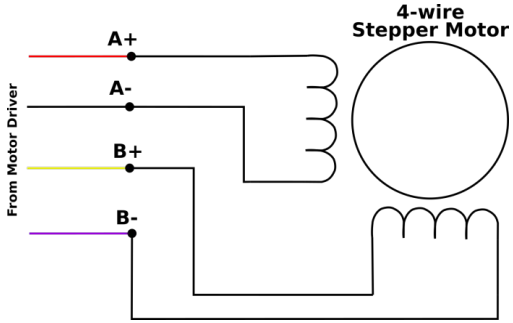
Servo motor control (Example 304)



Stepper motors

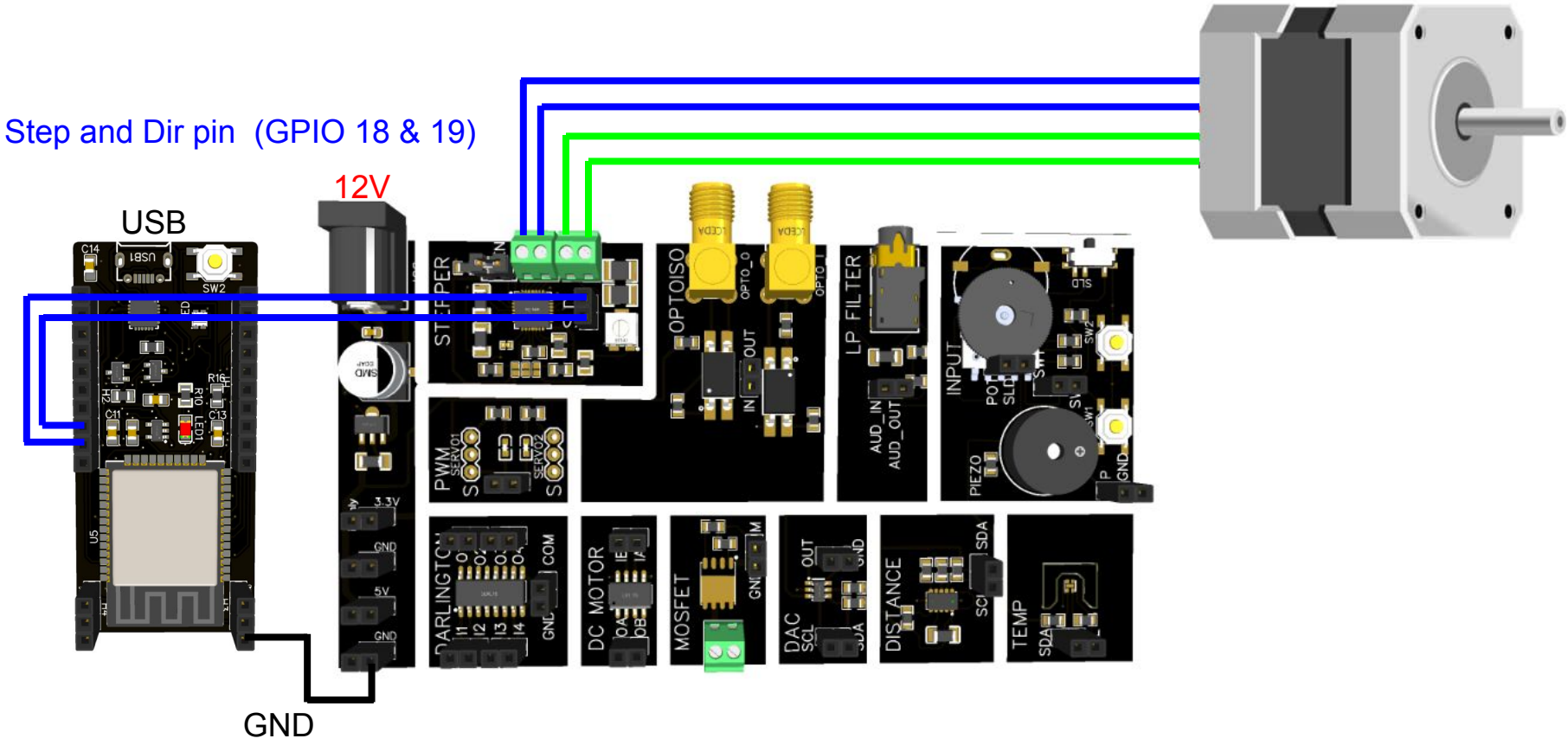




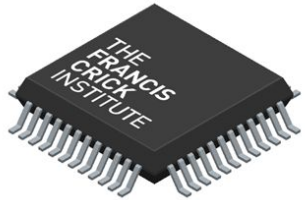


DrufelCNC

Stepper motor control (Examples on 305)



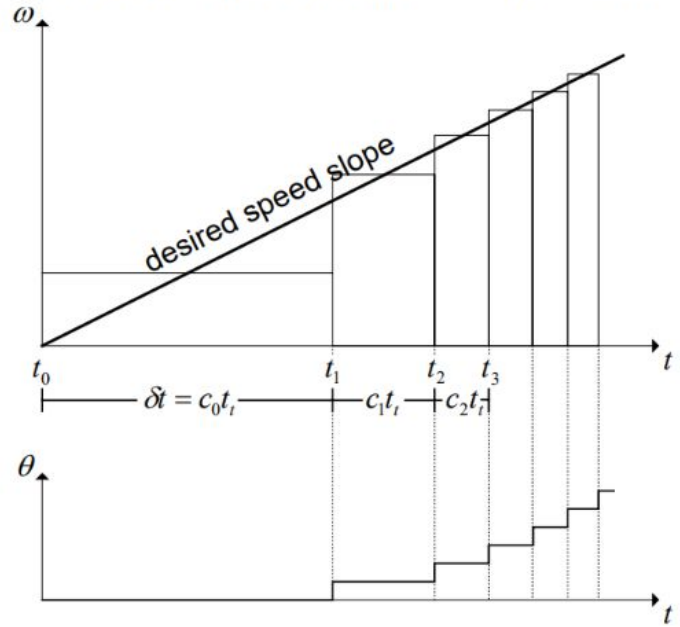
Stepper motors: microstepping and acceleration



MS1	MS2	MS3	Microstep Resolution
Low	Low	Low	Full step
High	Low	Low	Half step
Low	High	Low	Quarter step
High	High	Low	Eighth step
High	High	High	Sixteenth step

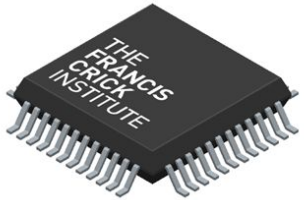
Pololu

Figure 2-6. Speed profile vs. stepper motor pulses/speed



Atmel (AVR): “Linear speed control of stepper motors”

Proposed exercises



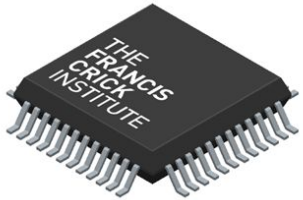
Use the Piezo as a user input

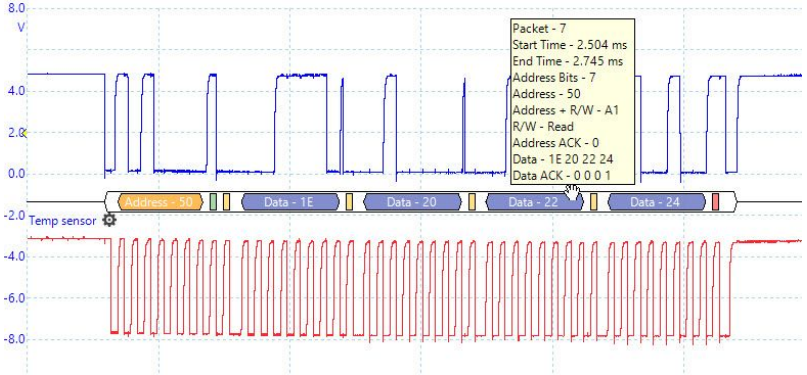
Control the LED brightness using the potentiometer

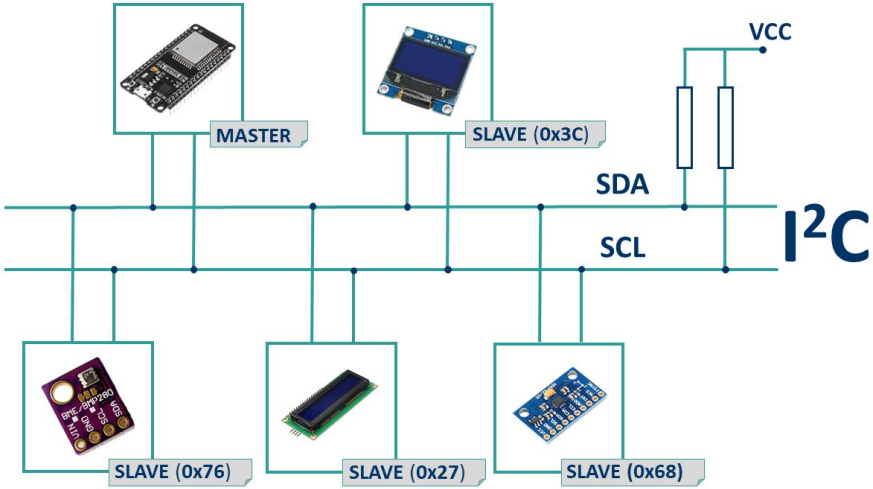
Control the DC motor speed using the potentiometer and the direction using one switch

Control the position of a stepper using a potentiometer and the same but having two/three velocities selected with a button or direction changed with a button.

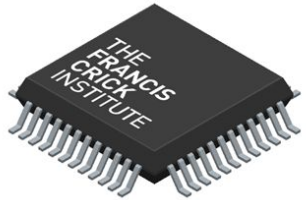
I2C (Inter-Integrated Circuit, eye-squared-C)







Our Sensors



- **SHT4x** 4th Generation, High-Accuracy, Ultra-Low-Power, 16-bit Relative Humidity and Temperature Sensor
- **VL53L0X** Time-of-Flight Ranging Sensor