Choosing a Motor Controller

Developed by Ludor Engineering

A Trainers Toolkit To Foster STEM Skills Using Microcontroller Applications

Co-funded by the Erasmus+ Programme of the European Union

Project No. 2019-1-RO01-KA202-063965

This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Choosing a Motor Controller

Content

- Introduction
- Motors
- Selecting motor drivers
- Microcontrollers
- Summary

Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

Introduction

Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

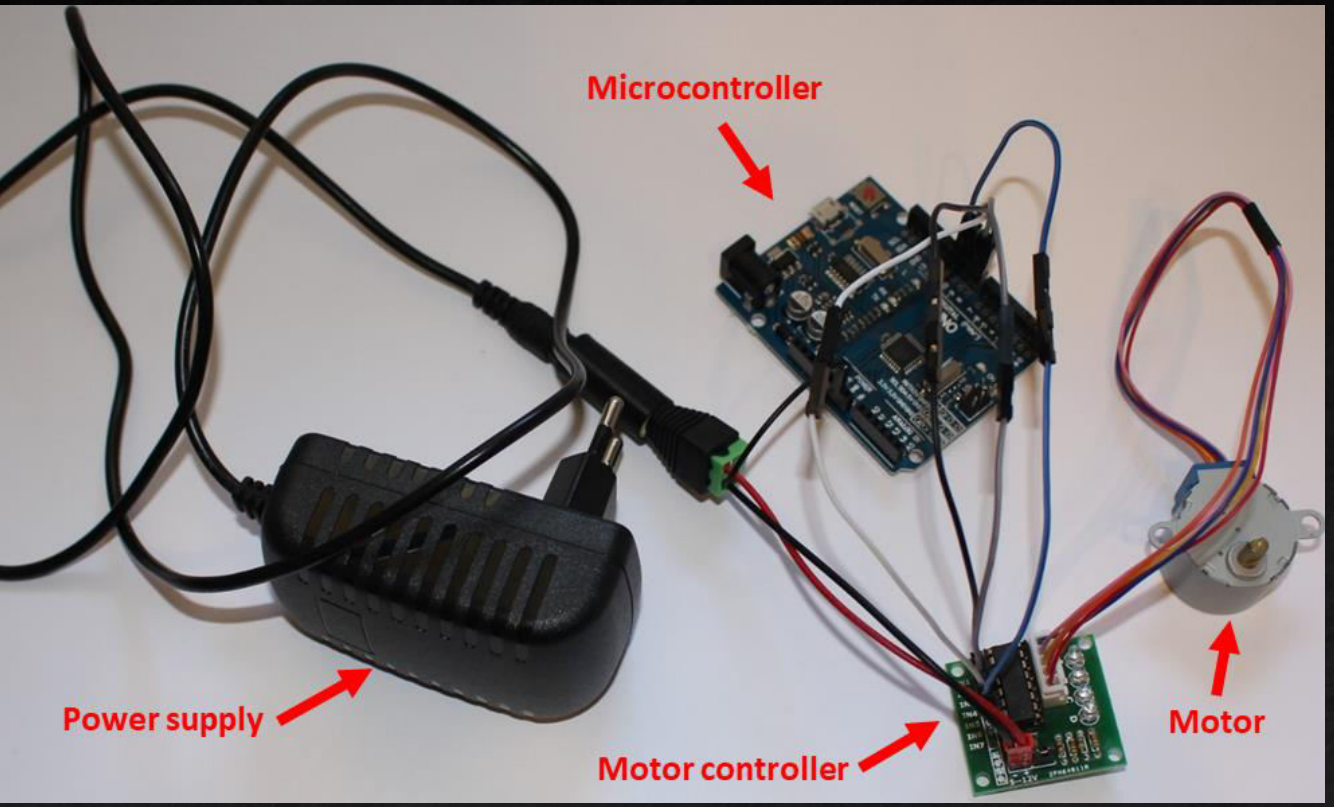
Introduction

- Electric motors are employed in many microcontroller applications where various motor parameters (start and stop, rotation direction, speed, etc.) need to be controlled.
- It is very important to select the right motor controlling method in order to cope with the application requirements and to avoid damaging the components.

Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

Introduction



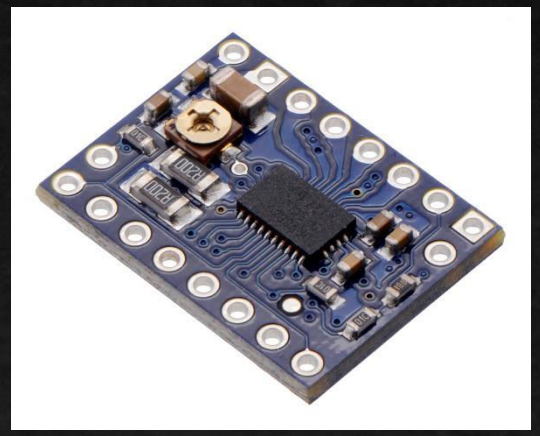
- The main principle in controlling a motor with a microcontroller lies with the motor driver - an electronic component that takes control signals from microcontroller and provide the necessary drive current to the motor from the power supply.
- DC motors need a much higher current than what a microcontroller can usually deliver so these two should never be connected directly.

Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

Motor controller vs. motor driver

- The terms motor controller and motor driver are used rather interchangeably despite often being strictly incorrect.
- A motor driver is an electronic component which can convert an input signal into movement of the motor without itself being able to issue instructions (or control) the motor. A motor controller can actively control and drive the motor itself. It controls the motor through the driver unit.
- Sometimes controller and driver are separate units, sometimes they are integrated.



DRV8880 stepper motor driver.
Source: www.robofun.ro/

ZD10LCD 10A stepper motor controller.
Source: www.zikodrive.com/

Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

Motors

Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

Introduction

- Three kinds of electric motors are commonly used in microcontroller applications:
  - DC motors
  - RC Servo motors
  - Stepper motors.
- They are selected depending on the specific application requirements:
  - positional accuracy
  - availability of drive power
  - torque
  - acceleration
  - cost

Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

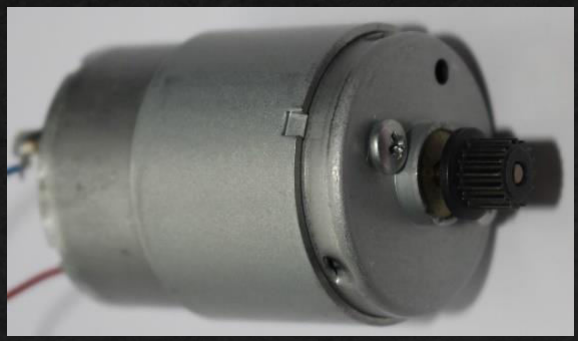
Co-funded by the Erasmus+ Programme of the European Union

DC Motors

- DC motors convert direct current electrical energy into mechanical energy

Controlling DC motors

- the rotation direction can be reversed by simply reversing the polarity of the voltage
- the speed can be controlled by controlling the input voltage to the motor



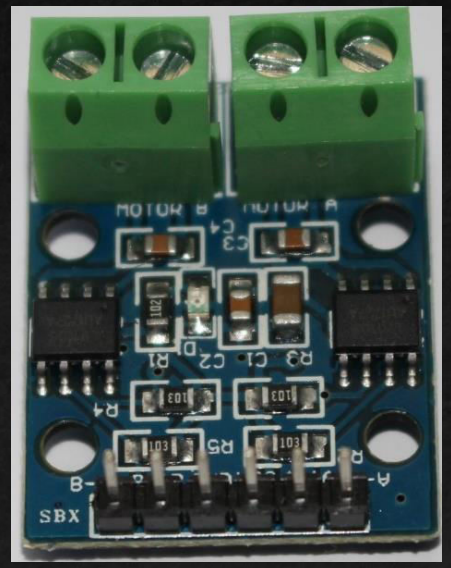
Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

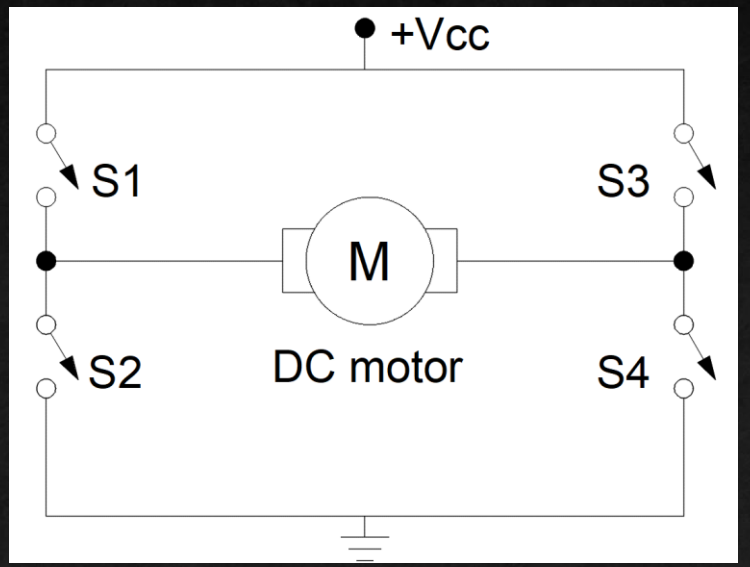
Direct control of DC Motors

- Depending on application, some motor actions and parameters can be controlled without a driver, by:
  - connecting the power supply directly through a switch – start/stop the motor
  - using a potentiometer – control speed
  - using a H-bridge, a simple electronic circuit allowing to change the direction of current flowing through the motor, thus changing the rotation direction of a DC motor.

Potentiometer



H-bridge



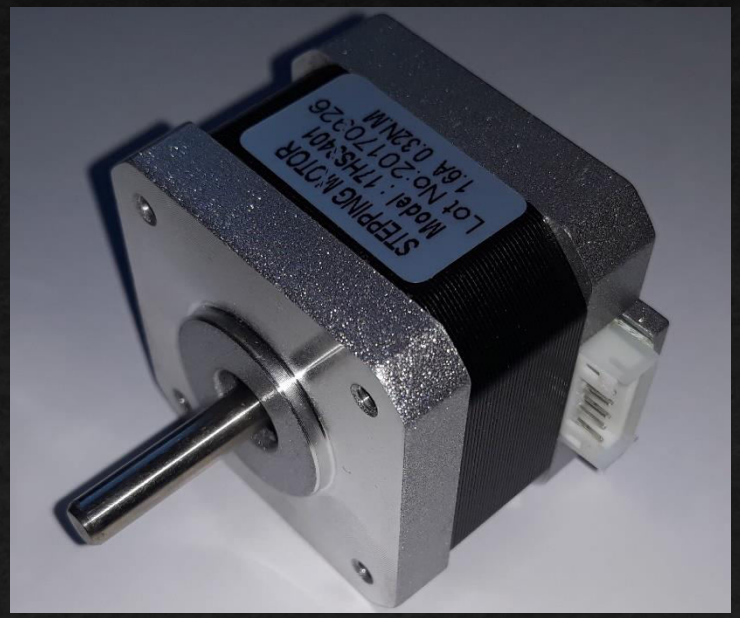
H-bridge schematics

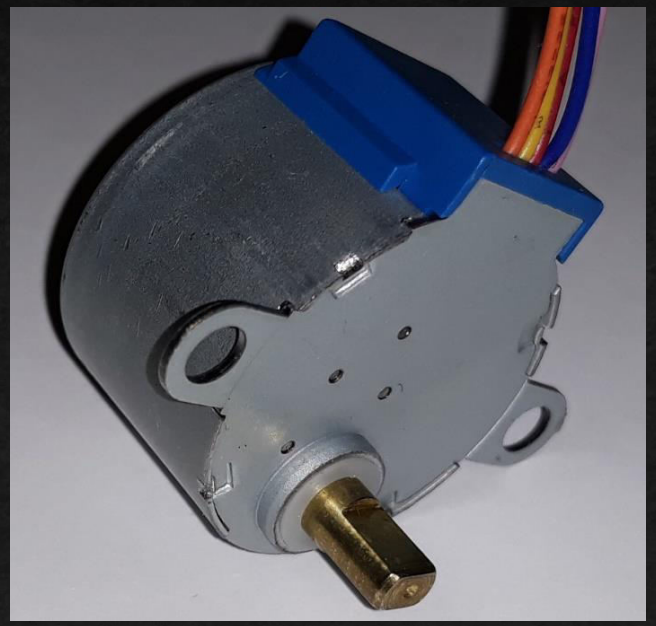
Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

Stepper Motors

- Are brushless DC motors that convert digital pulses into mechanical shaft rotation.
- Every full rotation is divided into a number of steps and the motor must be sent a separate pulse for each step. The stepper motor can only take one step at a time and each step is the same size.

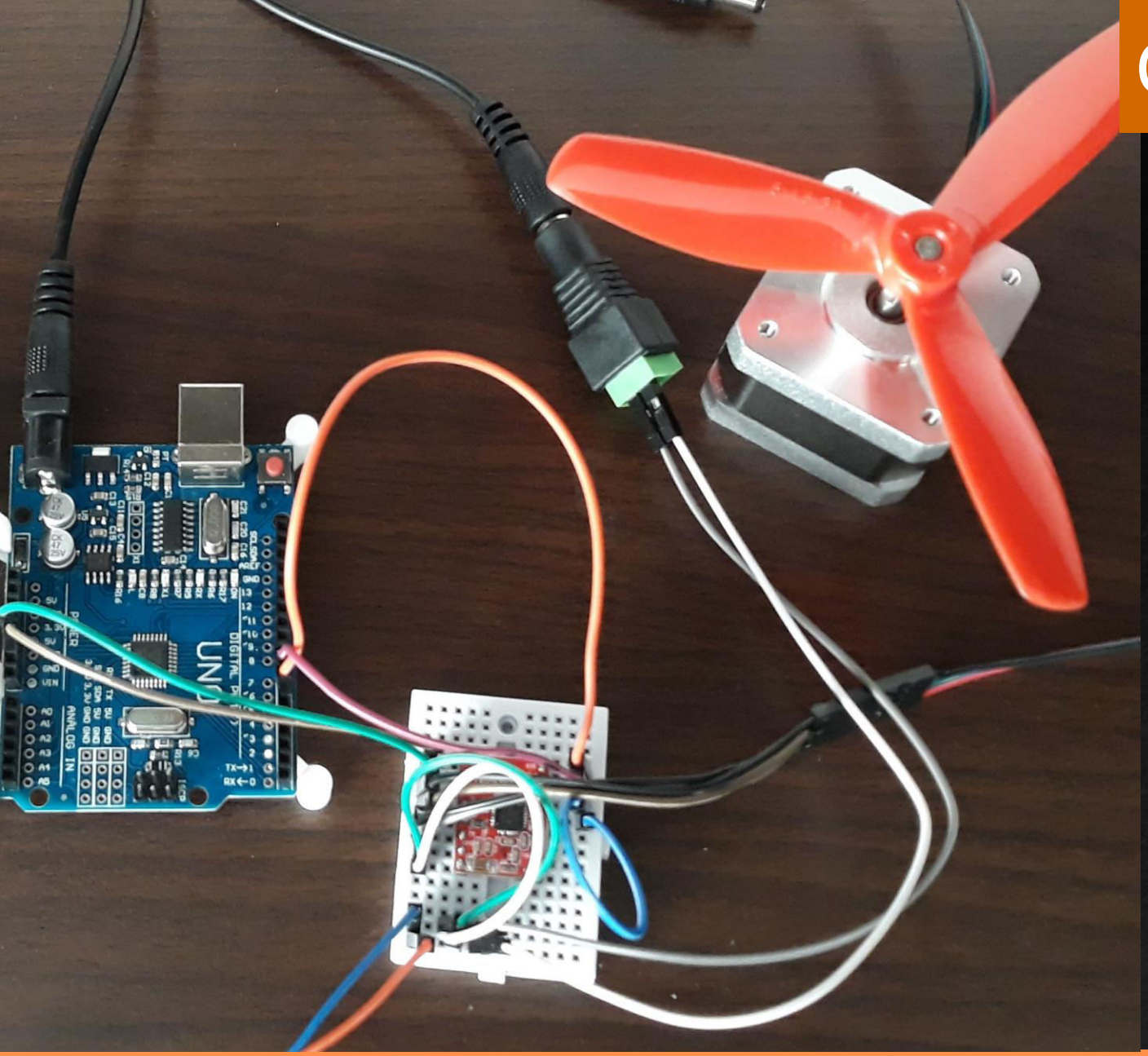




Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

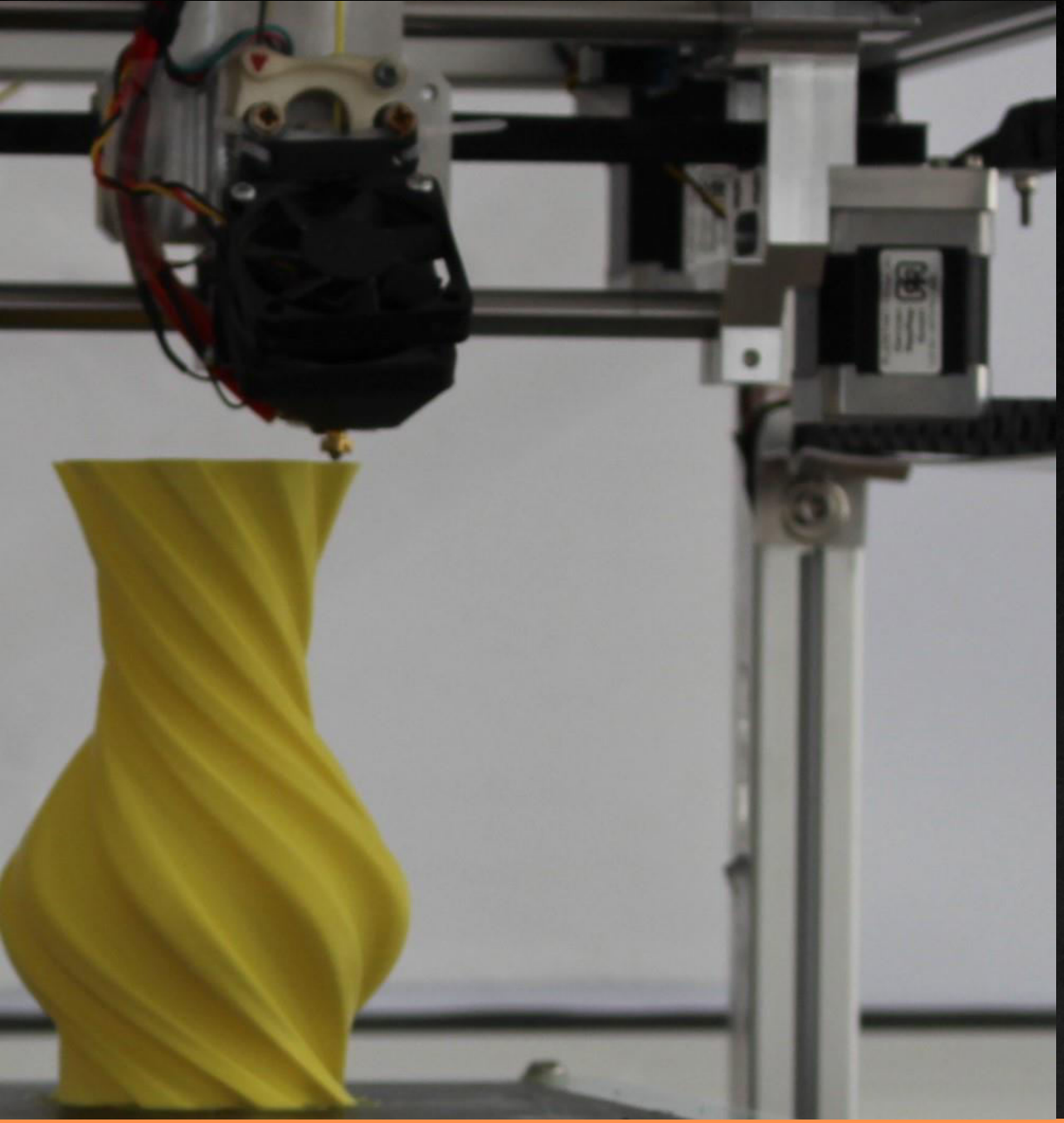
Controlling Stepper Motors



- The speed of rotation can be controlled by controlling the frequency of the input pulses.
- The rotation direction can be reversed by switching the polarity of one coil or swapping the coils.
- The motor's position can be controlled without any feedback mechanism because each pulse causes the motor to rotate a precise angle. However, they do not have the ability to communicate their position, they can only move the commanded number of steps from their current position.

Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union



Methods for Controlling Stepper Motors

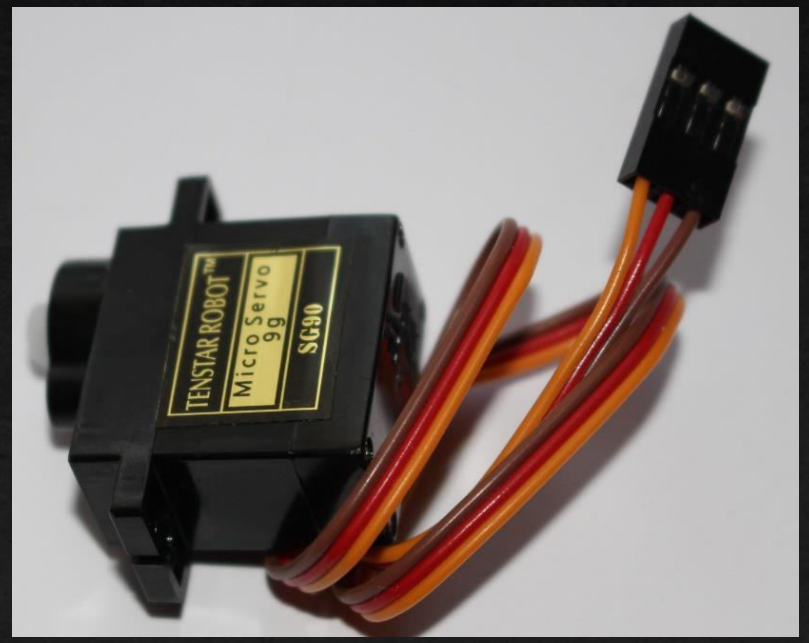
- Stepper Motor Drivers
  - A4988 and DRV8825 are typical example of economical drivers but many others are available, having various costs and performances.
- H-bridge driver
  - Not recommended because don’t have a method for limiting the current value, are more difficult to connect to an Arduino (they require more pins) and to be controlled (more calculations required for the Arduino).

Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

Servo Motors

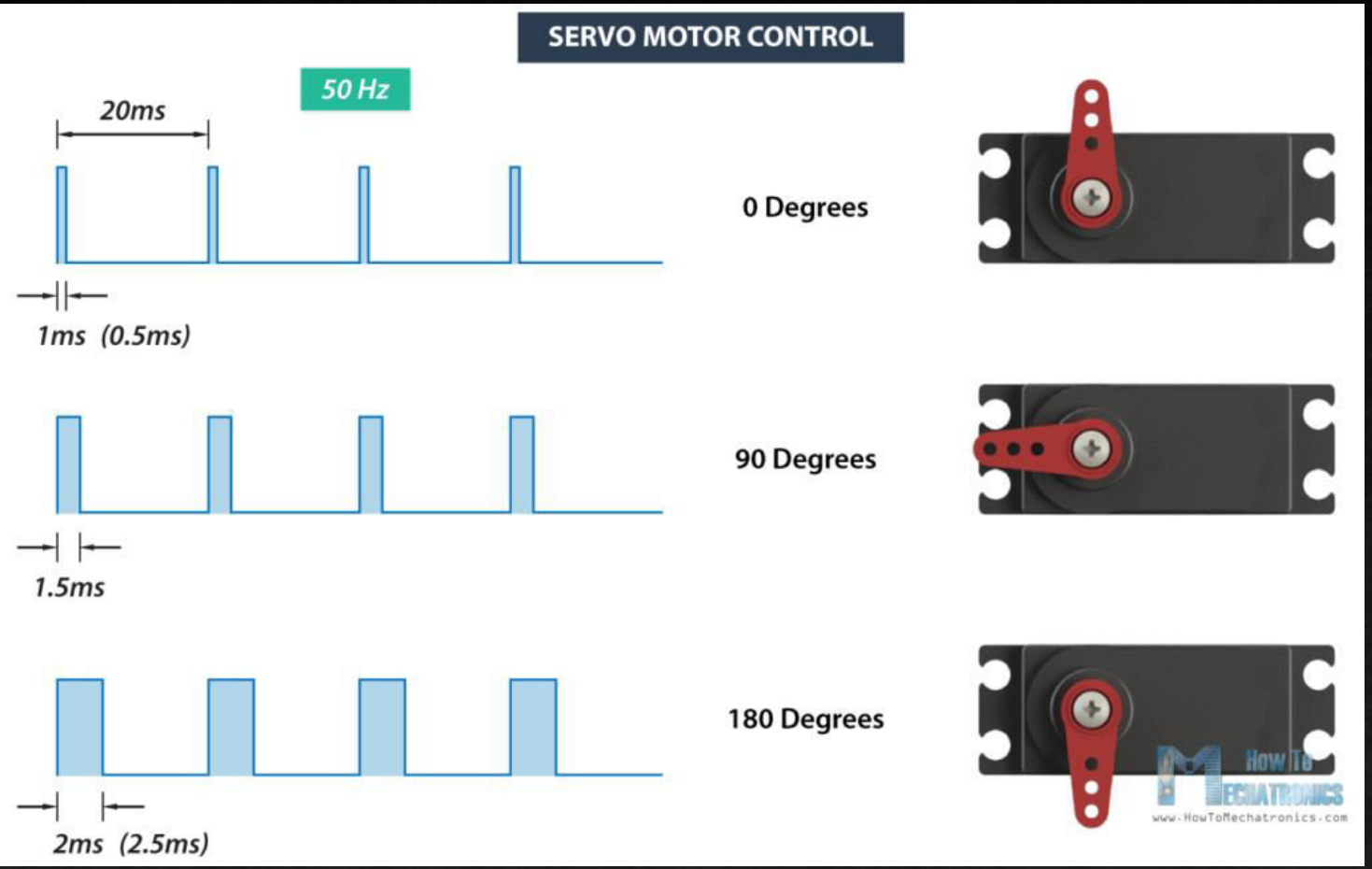
- Are electrical devices that allows for precise control of angular position.
- Are composed of an electric motor coupled to a sensor for position feedback.
- Have 3 wires: power (usually red), ground (usually brown or black), and signal (usually white or orange).



Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

Controlling Servo Motors



- Servo motors are controlled using electrical pulse of adjustable width, or pulse width modulation (PWM), through the signal wire.
- Usually, sending a 1ms 5V pulse turns the servo to 0° and sending a 2ms 5V pulse turns it to 180° with the pulse lengths in the middle scaling linearly.

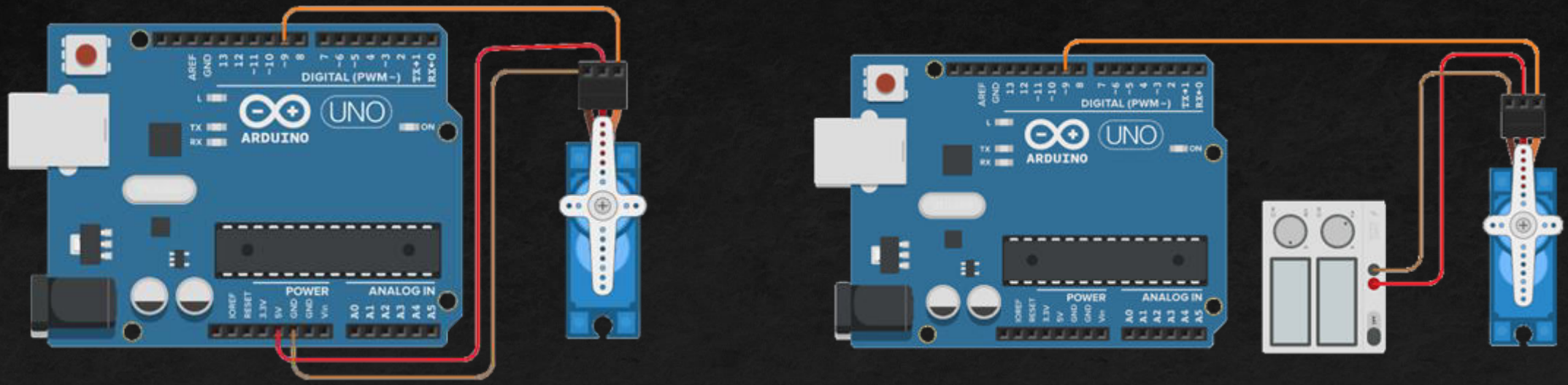
Source: https://howtomechatronics.com/

Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

Controlling Servo Motors using microcontrollers

- The microcontrollers can easily control servo motors through PWM, turning them exactly in the desired position.
- The servo's signal wire need to be connected to the microcontroller's digital output that generate the pulse
- Small servos can be directly powered by microcontroller but if the current required by servo is bigger than what this can provide, a separate power supply for the servo must be used.



Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

Selecting motor drivers

Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

Important when selecting a motor driver

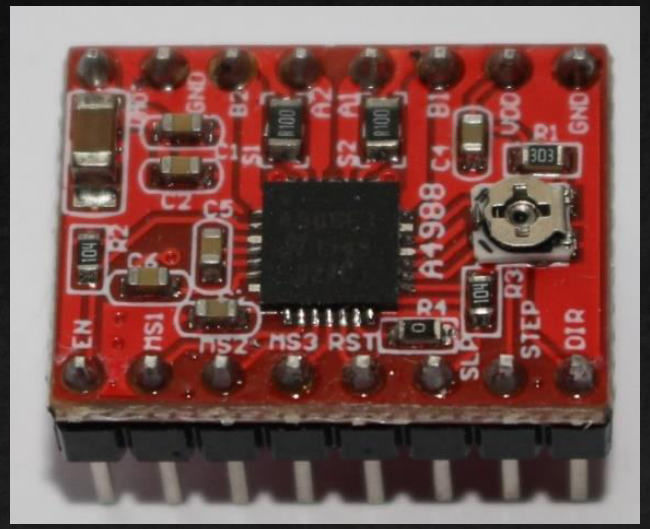
- Compatible Motors
  - Each type of motor needs its own type of motor controller so it is necessary to choose the controller according to your motor.
- Interface
  - The motor driver and its interface should be selected according to the given application.
- Voltage and Current
  - The motor driver must have a voltage range suitable for the application and enough current handling capacity.
  - It is best to choose a driver which has more power than the motor rating in order to avoid damaging it and to ensure full mechanical performance range from the motor.

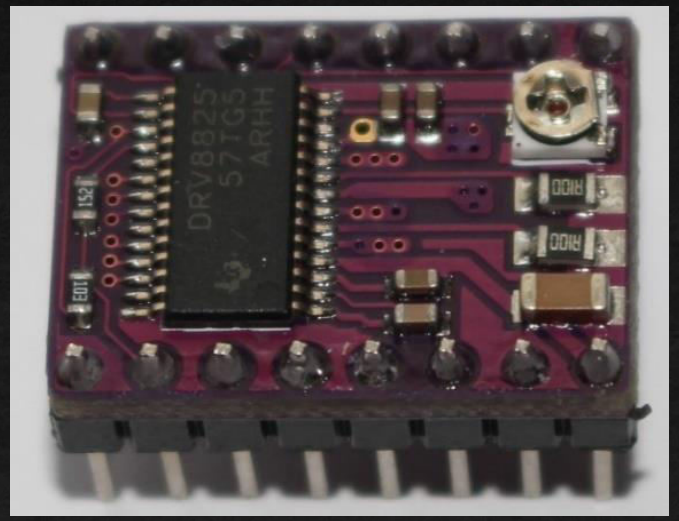
Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

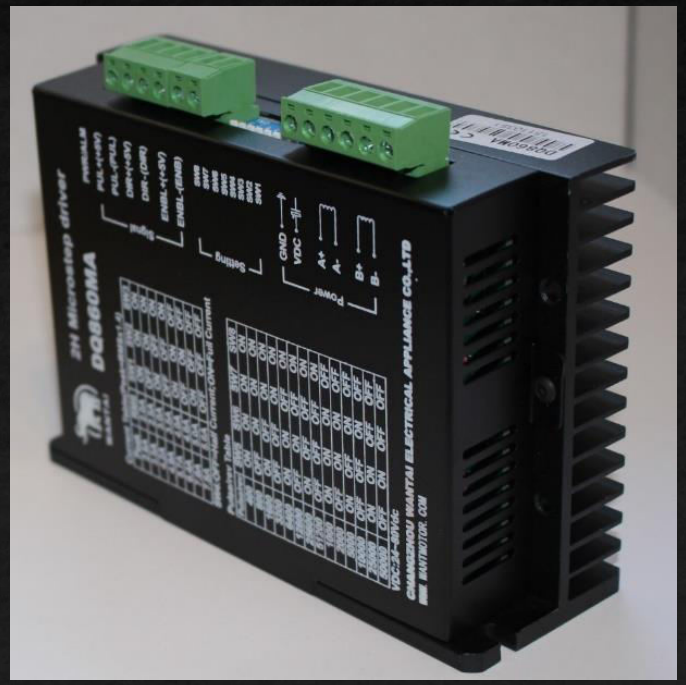
Co-funded by the Erasmus+ Programme of the European Union

Choosing a stepper motor driver

- Choose a stepper motor driver that can comfortably supply the current required by the motor.
- Economical stepper drivers such as A4988 and the DRV8825 can only supply around 2 amps. If the motor requires a higher current, a more expensive commercial stepper driver have to be used.







Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

Choosing a DC or a servo motor driver

Motor parameter	Requirements for the controller
Nominal voltage (V)	The voltage range must match the motor’s nominal voltage.
Current (A)	Must supply current equal to or above the motor's continuous current consumption under load. Make sure that controller’s maximum current rating is about double that of the motor's continuous operating current.
Control method	The control method must be appropriate for the motor.

Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.
Co-funded by the Erasmus+ Programme of the European Union

Choosing a stepper motor driver

Motor parameter	Requirements for the controller
Unipolar or bipolar?	Must be accordingly or be able to control both types.
Nominal voltage (V)	The voltage range must match the motor's nominal voltage.
Current per coil (A)	Must supply current (per coil) accordingly.
Control method	The control method must be appropriate for the motor.

Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

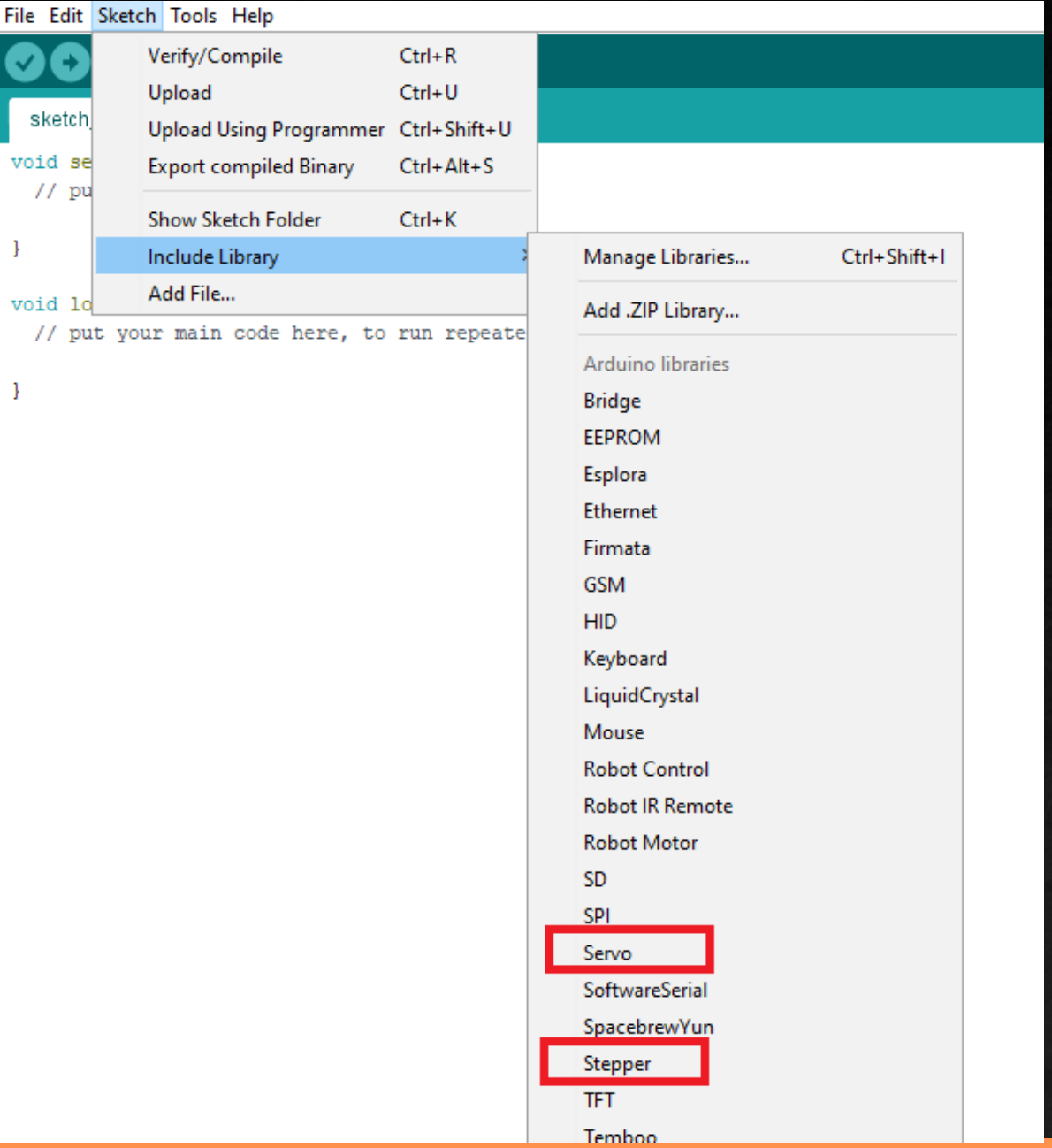
Co-funded by the Erasmus+ Programme of the European Union

Microcontrollers

Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

Controlling motors with Arduino - libraries

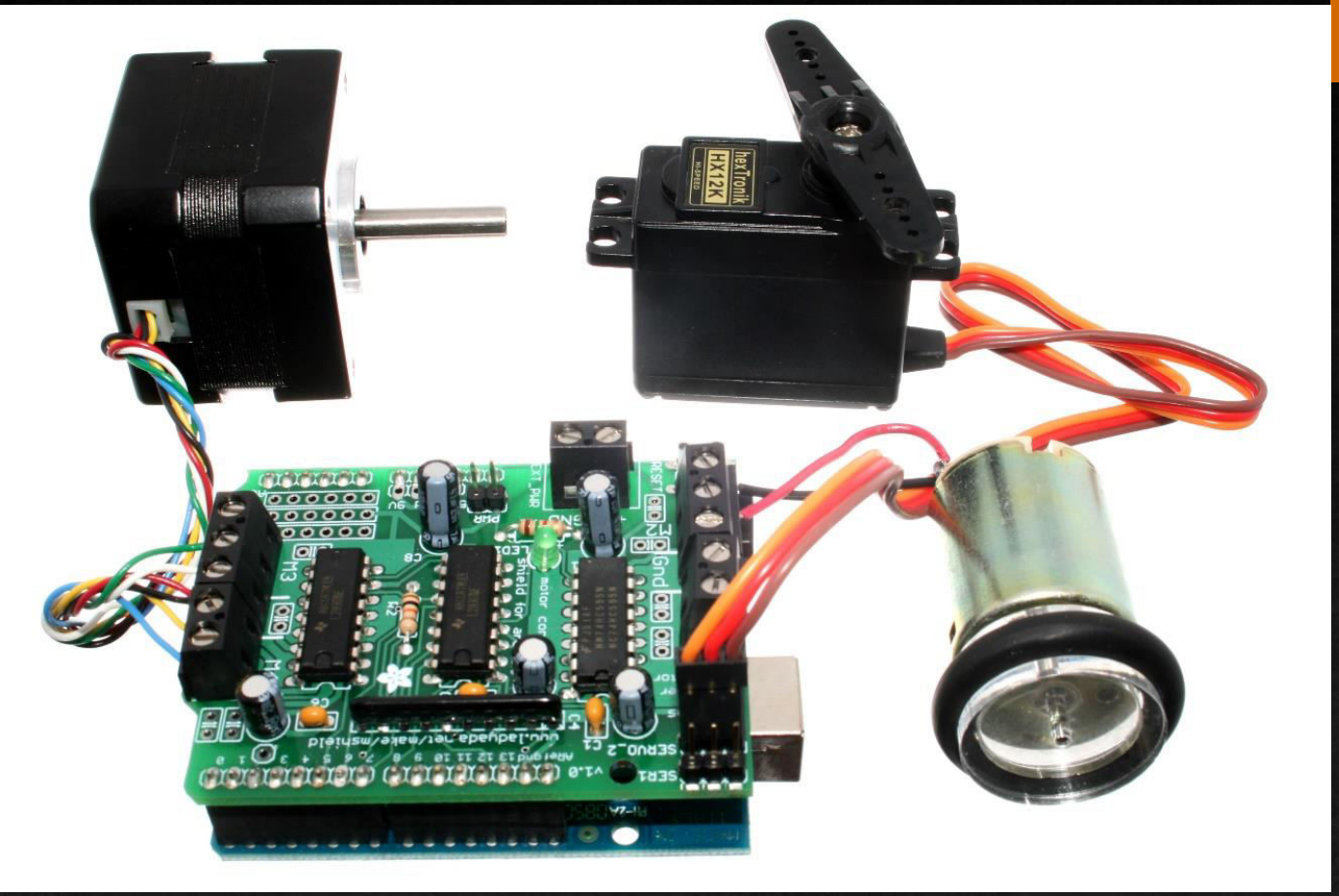


- Arduino IDE has built-in libraries that makes it very easy to control both stepper and servo motors
  - "Stepper.h" - allows for controlling unipolar or bipolar stepper motors
  - "Servo.h" - allows for controlling RC (hobby) servo motors
- There are also many libraries available for adding in Arduino IDE in order to facilitate the use of various motor drivers and H-bridge.

Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

Controlling motors with Arduino - shields



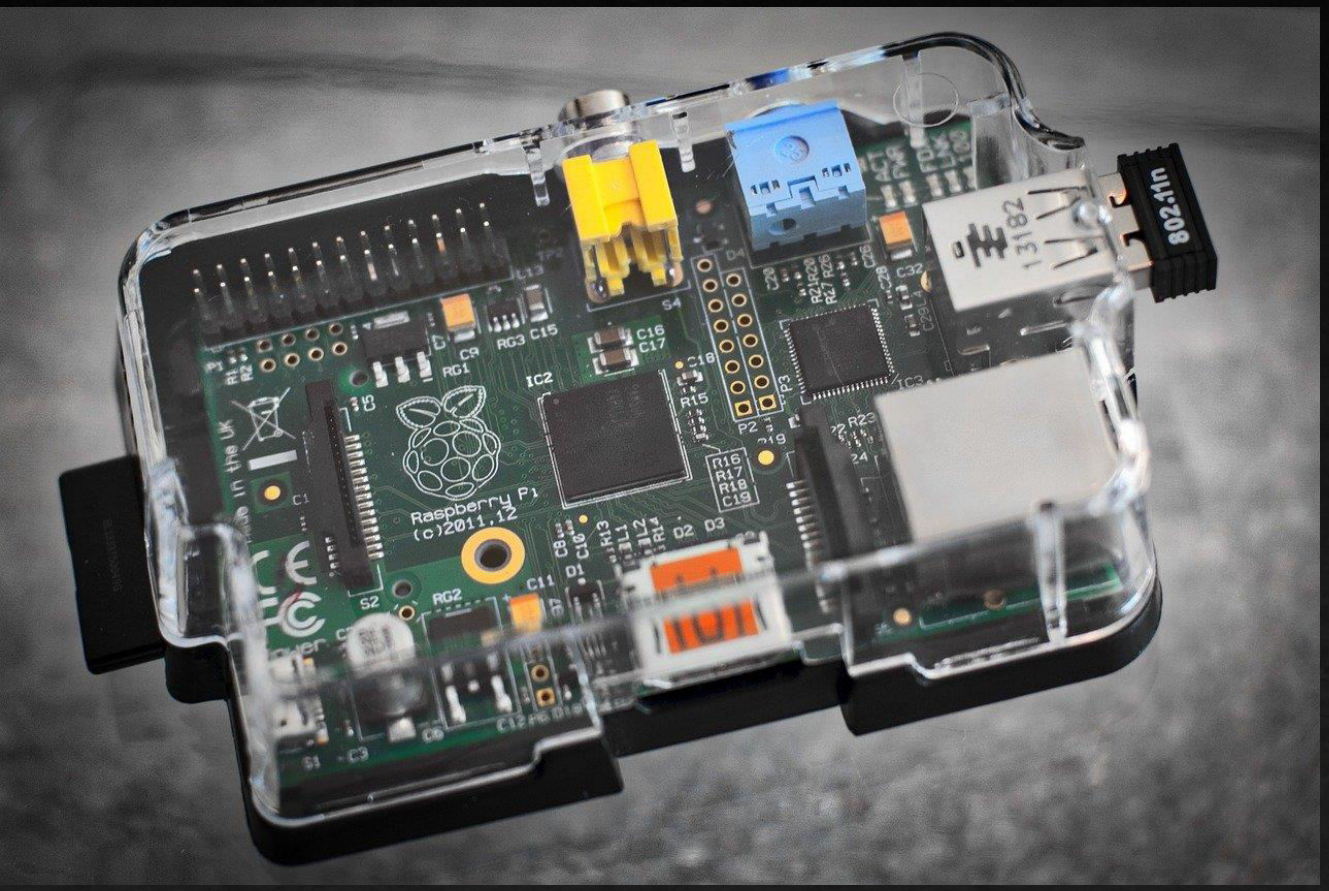
- Shields are boards that can be plugged on Arduino to extend its capabilities.
- Arduino Motor Shield allows Arduino to drive DC and stepper motors. More on https://store.arduino.cc/arduino-motor-shield-rev3

oomlout, Adafruit Motor Shield on Arduino - ARSH-02-MS (3725118122), CC BY-SA 2.0

Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

Controlling motors with Raspberry Pi - libraries

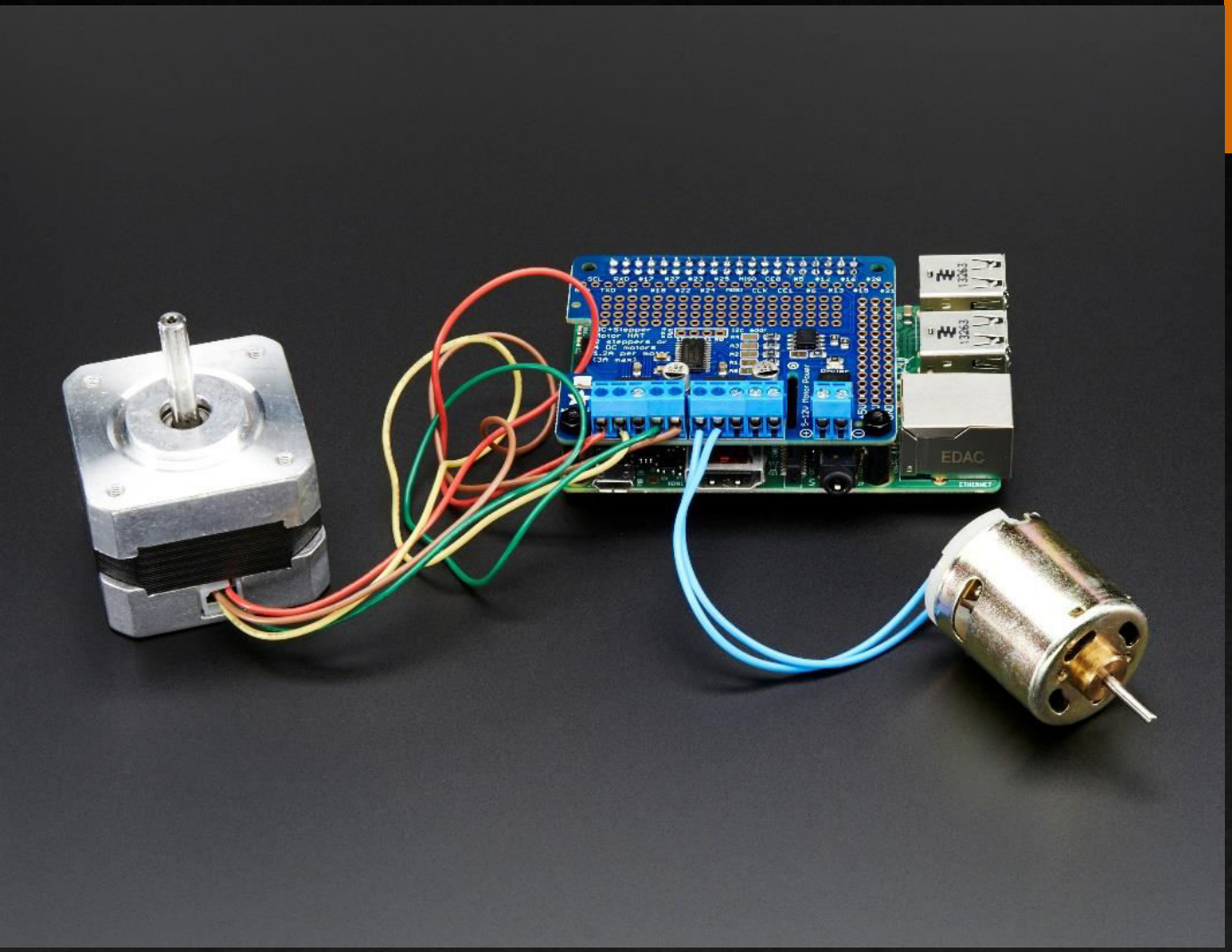


- Raspberry Pi Motor Library : A Python 3 library for motors and servos to connect to a Raspberry Pi.
- There are also many libraries available for installing on Raspberry Pi in order to facilitate the use of various motors.

Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

Controlling motors with Raspberry Pi - HATs



- A HAT (Hardware Attached on Top) is an add-on board for Raspberry Pi
- Adafruit 16-Channel PWM/Servo HAT allows Raspberry Pi to control multiple servos simultaneously
- Adafruit DC and Stepper Motor HAT allows driving up to 4 DC or 2 Stepper motors with full PWM speed control.

Source: https://learn.adafruit.com/

Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

Useful links

- DC Motors: The Basics https://itp.nyu.edu/physcomp/lessons/dc-motors/dc-motors-the-basics/
- https://www.robotshop.com/community/tutorials/show/how-to-make-a-robot-lesson-5-choosing-a-motor-controller
- FIND THE RIGHT MOTOR CONTROLLER FOR YOUR MOTOR … https://www.zikodrive.com/ufaqs/find-right-motor-controller-motor/
- DC Motor Control with an Arduino https://core-electronics.com.au/tutorials/dc-motors-with-arduino.html
- How To Control A Motor with the Raspberry Pi https://core-electronics.com.au/tutorials/how-to-control-a-motor-with-the-raspberry-pi.html
- Introduction to Motor Driver: H-Bridge Topology and Direction control https://components101.com/articles/what-is-motor-driver-h-bridge-topology-and-direction-control
- Controlling Stepper Motors https://itp.nyu.edu/physcomp/lessons/dc-motors/stepper-motors/
- How To Control a Stepper Motor with A4988 Driver and Arduino - https://howtomechatronics.com/tutorials/arduino/how-to-control-stepper-motor-with-a4988-driver-and-arduino/
- How Servo Motors Work & How To Control Servos using Arduino https://howtomechatronics.com/how-it-works/how-servo-motors-work-how-to-control-servos-using-arduino/
- Stepper Motor Drivers https://www.pololu.com/category/120/stepper-motor-drivers

Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union

Choosing a Motor Controller

Topic Summary

Here is what we learned

- **Motor selection skills:**
  Determine the kind of motor needed for a microcontroller application

- **Knowledge about electric motors:**
  What are and how work DC, servo and stepper motors

- **Knowledge about controlling motors :**
  What are the methods, the hardware and the software involved in the control of motors for microcontrollers applications

Project No. 2019-1-RO01-KA202-063965
This project has been funded with support from the European Commission. The content reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

Co-funded by the Erasmus+ Programme of the European Union