



#### **Arduino SYS-STEM for Schools**



#### Training Methodology

SYS-STEM – Arduino SYS-STEM for Schools Erasmus + Key Action 2 Strategic partnership - 2019-1-ES01-KA201-064454





#### **MODULE 8**

#### DC Motor



SYS-STEM – Arduino SYS-STEM for Schools Erasmus + Key Action 2 Strategic partnership - 2019-1-ES01-KA201-064454





## ARDUINO DC MOTOR









- This unit will provide a description of the DC motor, L293D H-bridge, their connection, use and programming. An example of using a DC motor with an Arduino platform will also be shown;
- ▶ It will help to understand the operation of the DC motor and its use in real applications.





# **EXPECTED LEARNING OUTCOMES**

#### Knowledge

Upon completion of this unit, the student will be able to:

- Understand how DC motor and L293D Hbridge work
- Know the purpose of using DC motor and
   L293D H-bridge and in which situations they
   can be applied

#### Competences and Skills

Upon completion of this unit, the student will be able to:

Use a DC motor and L293D H-bridge on the Arduino platform





## **Description of the DC motor**

- DC motor is the most commonly used motor type in combination with the Arduino microcontroller platform
- DC motors usually have only two conductors, one positive and one negative
- If we connect these two wires directly to the battery, the motor will
- rotate. If we change the wires the motor will rotate in the opposite direction
- We cannot directly connect a DC motor to the output of an Arduino board, especially if the motors are higher power







## **Description of the DC motor**

- Direct connection of the DC motor to the output of the Arduino board could destroy the board and therefore the motor needs to be connected via a motor driver which can be performed by transistor circuits or integrated circuits
- Motors can be operated to:
  - they just rotate
  - their speed is controlled
  - their direction of rotation is controlled
- For lower power DC motors, the L293D integrated circuit, which is a double H-bridge with PWM, is most commonly used







## **Description of the DC motor**

- The H-bridge is used to control the direction of rotation
- PWM (pulse width modulation) is used to control the speed of rotation
- As the L293D chip is a double H-bridge with PWM, it is possible to connect 2 motors to it and control them in such a way that their direction and speed of rotation can be changed







- The working principle of the H-bridge is shown in the animation in the figure
- The direction of rotation of the DC motor can be controlled by changing the polarity of the motor input voltage. The usual technique for this is to use an H-bridge
- The H-bridge circuit contains four switches (usually transistors) with a motor in the center that forms an H-like layout
- By closing two, opposite diagonally, switches at the same time, a certain polarity of voltage is set on the motor. Changing the active switches changes the direction of rotation of the motorcal





# **Description of the PWM**

- The speed of a DC motor can be controlled by changing the amount of its input voltage. A common technique for this is to use PWM
- PWM is a technique in which the mean value of the motor input voltage is adjusted by sending a sequence of ON-OFF pulses from the microcontroller to the motor driver
- The mean voltage is proportional to the pulse width known as the "Duty Cycle"
- The longer the duty cycle, the higher the mean value of the voltage coming to the DC motor (high speed), and the lower the duty cycle the lower the mean value of the voltage coming to the DC motor (low speed)









# **Description of the L293D integrated circuit**

- Module pins:
  - 1 EN1 PWM pin for motor 1 speed
  - 2 IN1 pin 1 of motor 1 direction
  - 3 OUT1 pin of terminal 1 of motor 1
  - 4 GND (0V) power supply ground
  - 5 GND (0V) power supply ground
  - 6 OUT2 pin of terminal 2 of motor 1
  - 7 IN2 pin 2 of motor 1 direction
  - 8 +Vmotor motor supply voltage (between 4.5V and 36V)







# **Description of the L293D integrated circuit**

- Module pins:
  - 9 EN2 PWM pin for motor 2 speed
  - 10 IN3 pin 1 of motor 2 direction
  - 11 OUT3 pin of terminal 1 of motor 2
  - 12 GND (0V) power supply ground
  - 13 GND (0V) power supply ground
  - 14 OUT4 pin of terminal 2 of motor 2
  - 15 IN4 pin 2 of motor 2 direction
  - 16 +V chip supply voltage (5V)







# **Description of the L293D integrated circuit**

- Motor 1 (connected to OUT1 and OUT2) is controlled by the L293D chip as follows :
  - motor rotation to one side is possible if HIGH (5V) is applied to input IN1 and LOW (0V) is applied to input IN2 from the microcontroller
  - motor rotation to the other side is possible if LOW (0V) is applied to input IN1 and HIGH (5V) is applied to input IN2 from the microcontroller
  - if both inputs IN1 and IN2 are in the LOW (0V) or HIGH (5V) state then the motor does not rotate
  - the speed is adjusted by sending data from the Arduino platform from 0 to 255 (which gives a voltage of 0 to 5V) to the input EN1

<b>7</b>			
)	IN1	IN2	Spinning Direction
	Low(0)	Low(0)	Motor OFF
S	High(1)	Low(0)	Forward
t	Low(0)	High(1)	Backward
	High(1)	High(1)	Motor OFF





### **Description of example of using the DC motor**

- In the example below, the following will be realized :
  - One DC motor will be used which will be connected to the OUT1 and OUT2 outputs of the L293D motor driver. The motor power will be 6V. The Arduino platform will control the operation of the motor via PWM pin 9 which will be connected to EN1 input of L293D driver, and via pin 8 which will be connected to IN1 and 7 which will be connected to IN2 inputs of L293D driver. The program will implement starting the motor at maximum speed to one side and then to the other side. After that, the motor will accelerate from 0 to maximum and decelerate from maximum to 0.





#### **Example - Wiring diagram**







#### **Example - Wiring diagram on a breadboard**







# Example – Program code – Part 1/2

#### DC\_motor §

```
#define enA 9 // L293D motor driver "Enable 1" pin definition
#define in1 8 // L293D motor driver "In 1" pin definition
#define in2 7 // L293D motor driver "In 2" pin definition
void setup() {
    pinMode(enA, OUTPUT); // Initialize all motor control pins as output
    pinMode(in1, OUTPUT);
```

```
pinMode(in2, OUTPUT);
digitalWrite(in1, LOW); // Turn off the motor
digitalWrite(in2, LOW);
```

```
}
```

```
void loop() {
  directionControl(); // Call of direction control function
  delay(2000); // 2 second delay
  speedControl(); // Speed control function call
  delay(2000); // 2 second delay
```

```
}
```

```
void directionControl() { // Motor speed control function
   // Setting the motor to maximum speed (0(min) - 255(max))
   analogWrite(enA, 255);
   // Starting motor A in one direction
   digitalWrite(in1, HIGH);
   digitalWrite(in2, LOW);
   delay(2000);
   // Changing the direction of rotation of motor A to the other direction
   digitalWrite(in1, LOW);
   digitalWrite(in2, HIGH);
   delay(2000);
```





# Example – Program code – Part 2/2

```
// Stopping the motor
digitalWrite(in1, LOW);
digitalWrite(in2, LOW);
```

}

```
void speedControl() { // Motor speed control function
   // Turn on the motor
   digitalWrite(in1, LOW);
   digitalWrite(in2, HIGH);
```

```
// Accelerate from zero to maximum
for (int i = 0; i <= 255; i++) {
    analogWrite(enA, i);
    delay(20);
}
// Slow down from maximum to 0
for (int i = 255; i >= 0; i--) {
    analogWrite(enA, i);
    delay(20);
}
```

// Turn off the motor
digitalWrite(in1, LOW);
digitalWrite(in2, LOW);





#### **Example - Display of the connection on the breadboard**







## **Example - Demonstration of work**

- The example was tested in a classroom on a laboratory desk using a single DC motor connected to a 6V power supply
- The Arduino platform will control the operation of the engine by starting it at maximum speed in one direction and then in the other
- After that, the engine will accelerate from 0 to maximum and decelerate from maximum to 0
- Since the motor is not attached, care should be taken to move it around the table to avoid unwanted situations
- A demonstration of the operation of the example is shown on the next slide





#### **Example - Demonstration of work**









#### CONGRATULATIONS

You have completed SYS-STEM Module 8 DC Motor

SYS-STEM – Arduino SYS-STEM for Schools Erasmus + Key Action 2 Strategic partnership - 2019-1-ES01-KA201-064454