

# keyestudio

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## ARDUINO super learning kit



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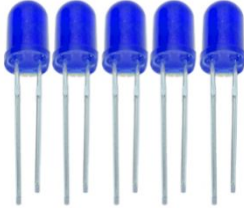
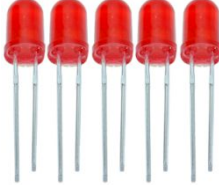
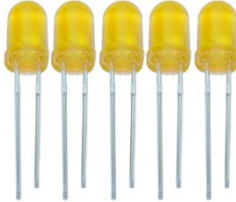

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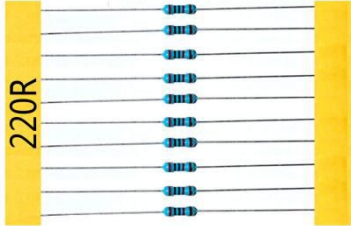




## 1. Introduction

Keystudio super learning kit is suitable for Arduino enthusiasts. This kit includes 32 projects with detailed tutorials, starting from the basics to more complex projects. Different from other kits, it adds some functional modules, such as RFID, temperature and humidity module. There is connection diagram and code for each project, making it easy for you to learn.







## 2. Component list

No.	Product Name	Quantity	Picture
1	LED - Blue	5	
2	LED - Red	5	
3	LED - Yellow	5	
4	LED - RGB	1	




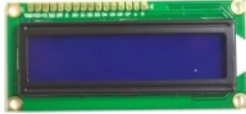


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5	220 $\Omega$ resistor	8	
6	10K $\Omega$ resistor	5	
7	1K $\Omega$ resistor	5	
8	10K $\Omega$ Pot	1	
9	Buzzer (active)	1	
10	Buzzer (passive)	1	

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11	Large button switch	4	
12	Ball tilt sensor	2	
13	Photo Resistor	3	
14	Flame sensor	1	
15	1x LM35 Temp Sensor	1	
16	IC 74HC595N 16-pin DIP	1	







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17	7-seg LED 1x module	1	
18	7-seg LED 4x module	1	
19	8*8 LED Matrix	1	
20	2x16 LCD display	1	
21	IR receiver	1	
22	IR remote control	1	

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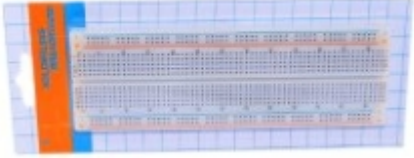

23	Servo Motor	1	
24	Stepper driver module	1	
25	Stepper Motor	1	
26	Joystick module	1	
27	Relay module	1	
28	PIR Motion Sensor	1	

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29	Analog Gas Sensor	1	
30	ADXL345 Three Axis Acceleration Module	1	
31	HC-SR04 Ultrasonic Sensor	1	
32	DS3231 Clock Module	1	
33	DHT11 Temperature and Humidity Sensor	1	
34	Soil humidity sensor	1	



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35	rc522 RFID module	1	
36	RFID card	1	
37	RFID key	1	
38	Pin headers	40	
39	830-hole Breadboard	1	
40	Dupont connector wires	10	

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41	Jumper Wire	30	
42	6-cell AA Battery pack	1	
43	USB cable	1	

## 3. Project list

- Project 1: Hello World
- Project 2: LED blinking
- Project 3: PWM
- Project 4: Traffic light
- Project 5: LED chasing effect
- Project 6: Button-controlled LED
- Project 7: Active buzzer
- Project 8: Passive buzzer
- Project 9: RGB LED
- Project 10: Photo resistor
- Project 11: Flame sensor
- Project 12: LM35 temperature sensor

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- Project 13: Tilt switch
- Project 14: IR remote control
- Project 15: Analog value reading
- Project 16: 74HC595
- Project 17: 1-digit LED segment display
- Project 18: 4-digit LED segment display
- Project 19: 8\*8 LED matrix
- Project 20: 1602 LCD
- Project 21: 9g servo control
- Project 22: Stepper Motor
- Project 23: PIR Motion Sensor
- Project 24: Analog Gas Sensor
- Project 25: ADXL345 Three Axis Acceleration Module
- Project 26: HC-SR04 Ultrasonic Sensor
- Project 27: Joystick Module
- Project 28: 5V Relay Module
- Project 29: DS3231 Clock Module
- Project 30: DHT11 Temperature and Humidity Sensor
- Project 31: Soil Humidity Sensor
- Project 32: RC522 RFID module

## 4. Project details

### Project 1: Hello World

#### Introduction

As for starters, we will begin with something simple. In this project, you only need an Arduino and a USB cable to start the "Hello World!" experiment. This is a communication test of your Arduino and PC, also a primer project for you to have your first try of the Arduino world!

#### Hardware required

Arduino board \*1  
USB cable \*1

#### Sample program

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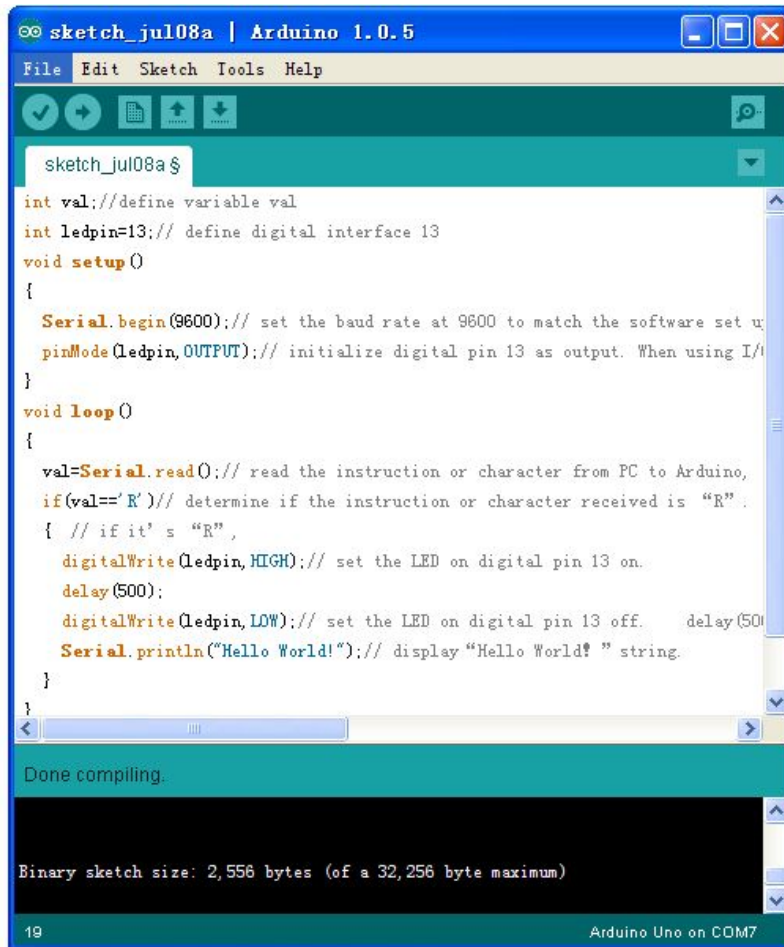
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After installing driver for Arduino, let's open Arduino software and compile code that enables Arduino to print "Hello World!" under your instruction. Of course, you can compile code for Arduino to continuously echo "Hello World!" without instruction. A simple If () statement will do the instruction trick. With the onboard LED connected to pin 13, we can instruct the LED to blink first when Arduino gets an instruction and then print "Hello World!".

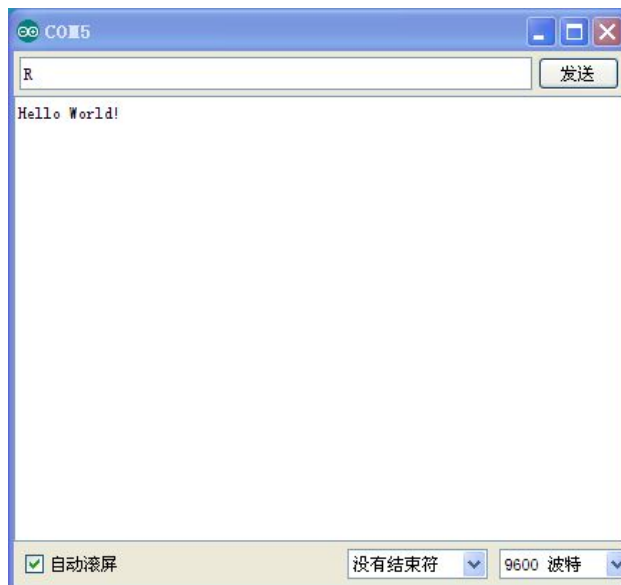
```
////////////////////////////////////
int val;//define variable val
int ledpin=13;// define digital interface 13
void setup()
{
  Serial.begin(9600);// set the baud rate at 9600 to match the software set up. When connected to
  a specific device, (e.g. bluetooth), the baud rate needs to be the same with it.
  pinMode(ledpin,OUTPUT);// initialize digital pin 13 as output. When using I/O ports on an
  Arduino, this kind of set up is always needed.
}
void loop()
{
  val=Serial.read();// read the instruction or character from PC to Arduino, and assign them to
  Val.
  if(val=='R')// determine if the instruction or character received is "R".
  { // if it's "R",
    digitalWrite(ledpin,HIGH);// set the LED on digital pin 13 on.
    delay(500);
    digitalWrite(ledpin,LOW);// set the LED on digital pin 13 off.    delay(500);
    Serial.println("Hello World!");// display"Hello World! "string.
  }
}
////////////////////////////////////
```

## Result

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Click serial port monitor, Input R, LED 13 will blink once, PC will receive information from Arduino: Hello World



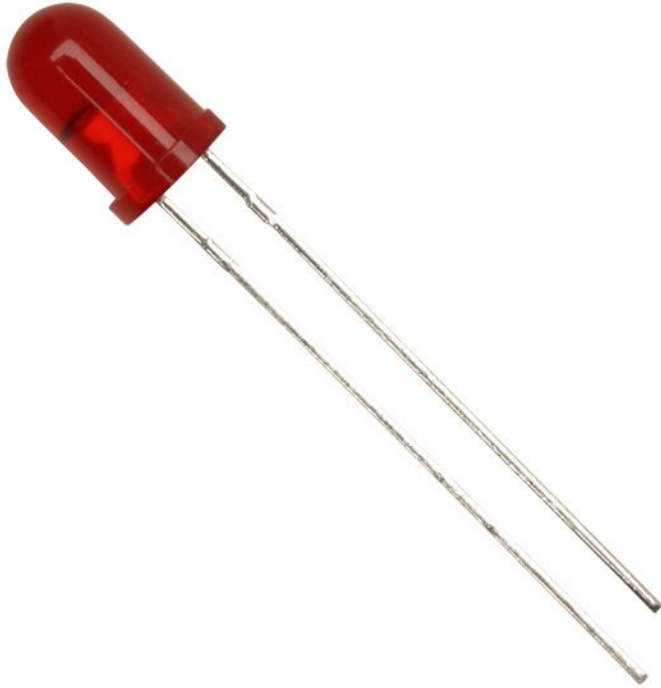
After you choosing the right port, the experiment should be easy for you!

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## Project 2: LED blinking



### Introduction

Blinking LED experiment is quite simple. In the "Hello World!" program, we have come across LED. This time, we are going to connect an LED to one of the digital pins rather than using LED13, which is soldered to the board. Except an Arduino and an USB cable, we will need extra parts as below:

### Hardware required

Red M5 LED\*1

220Ω resistor\*1

Breadboard\*1

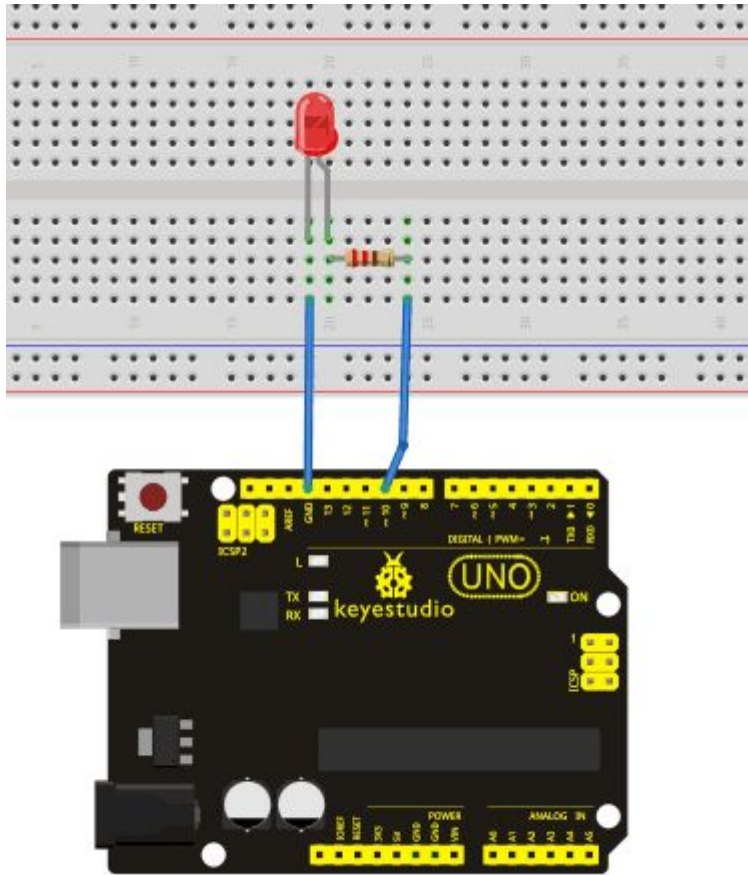
Breadboard jumper wires

### Circuit connection

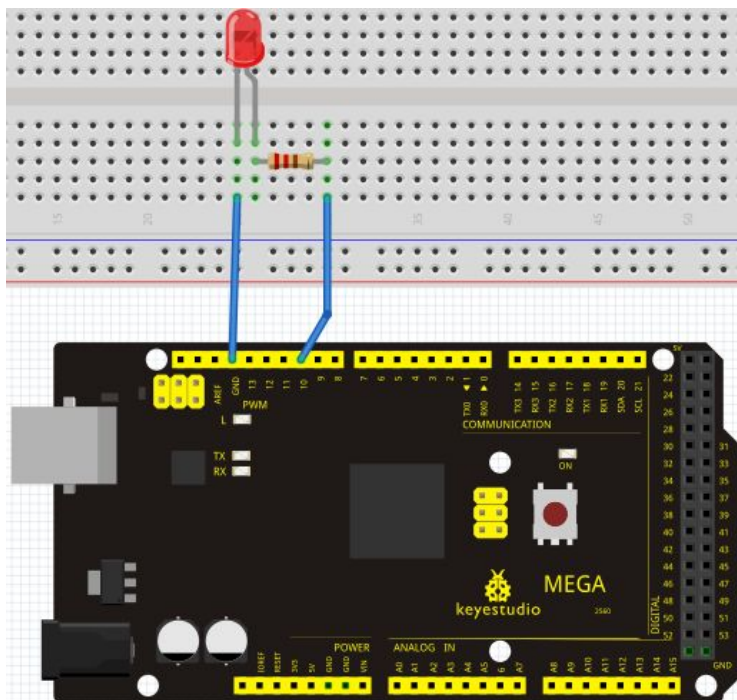
We follow below diagram from the experimental schematic link. Here we use digital pin 10. We connect LED to a 220 ohm resistor to avoid high current damaging the LED.

Connection for UNO R3:

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Connection for 2560 R3:



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## Sample program

```
////////////////////////////////////  
int ledPin = 10; // define digital pin 10.  
void setup()  
{  
pinMode(ledPin, OUTPUT); // define pin with LED connected as output.  
}  
void loop()  
{  
digitalWrite(ledPin, HIGH); // set the LED on.  
delay(1000); // wait for a second.  
digitalWrite(ledPin, LOW); // set the LED off.  
delay(1000); // wait for a second  
}  
////////////////////////////////////
```

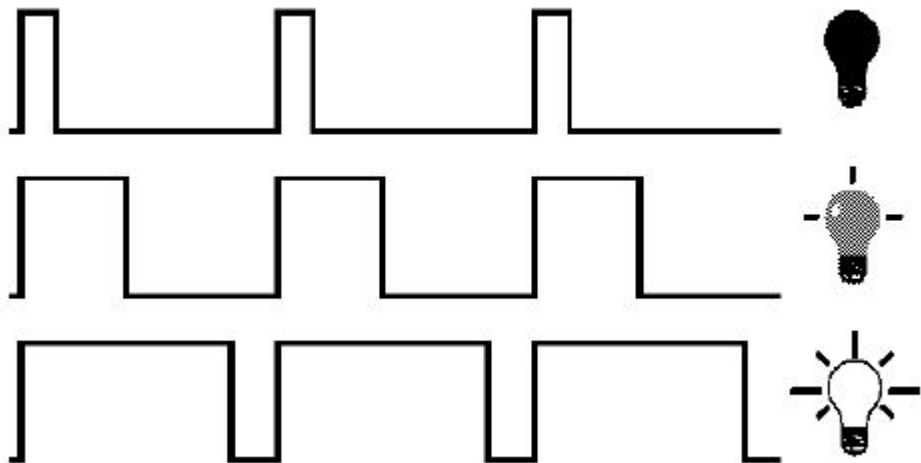
## Result

After downloading this program, in the experiment, you will see the LED connected to pin 10 turning on and off, with an interval approximately one second.

The blinking LED experiment is now completed. Thank you!

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## Project 3: PWM

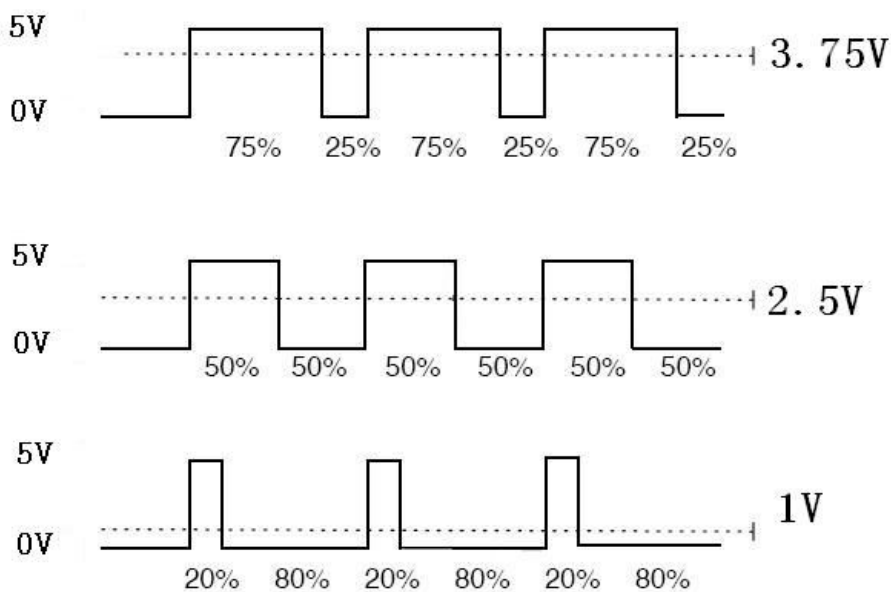




# keystudio

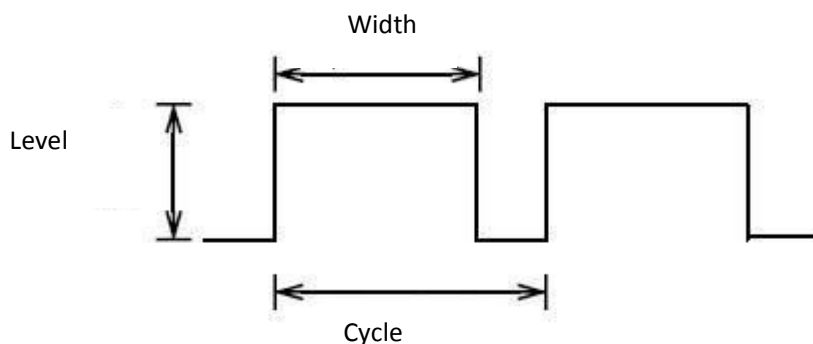
## Introduction

PWM, short for Pulse Width Modulation, is a technique used to encode analog signal level into digital ones. A computer cannot output analog voltage but only digital voltage values such as 0V or 5V. So we use a high resolution counter to encode a specific analog signal level by modulating the duty cycle of PMW. The PWM signal is also digitalized because in any given moment, fully on DC power supply is either 5V (ON), or 0V (OFF). The voltage or current is fed to the analog load (the device that uses the power) by repeated pulse sequence being ON or OFF. Being on, the current is fed to the load; being off, it's not. With adequate bandwidth, any analog value can be encoded using PWM. The output voltage value is calculated via the on and off time. Output voltage = (turn on time/pulse time) \* maximum voltage value



PWM has many applications: lamp brightness regulating, motor speed regulating, sound making, etc.

The following are the three basic parameters of PMW:



1. The amplitude of pulse width (minimum / maximum)
2. The pulse period (The reciprocal of pulse frequency in 1 second)

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3. The voltage level (such as: 0V-5V)

There are 6 PWM interfaces on Arduino, namely digital pin 3, 5, 6, 9, 10, and 11. In previous experiments, we have done "button-controlled LED", using digital signal to control digital pin, also one about potentiometer. This time, we will use a potentiometer to control the brightness of the LED.

## Hardware required

Potentiometer\*1

Red M5 LED\*1

220Ω resistor

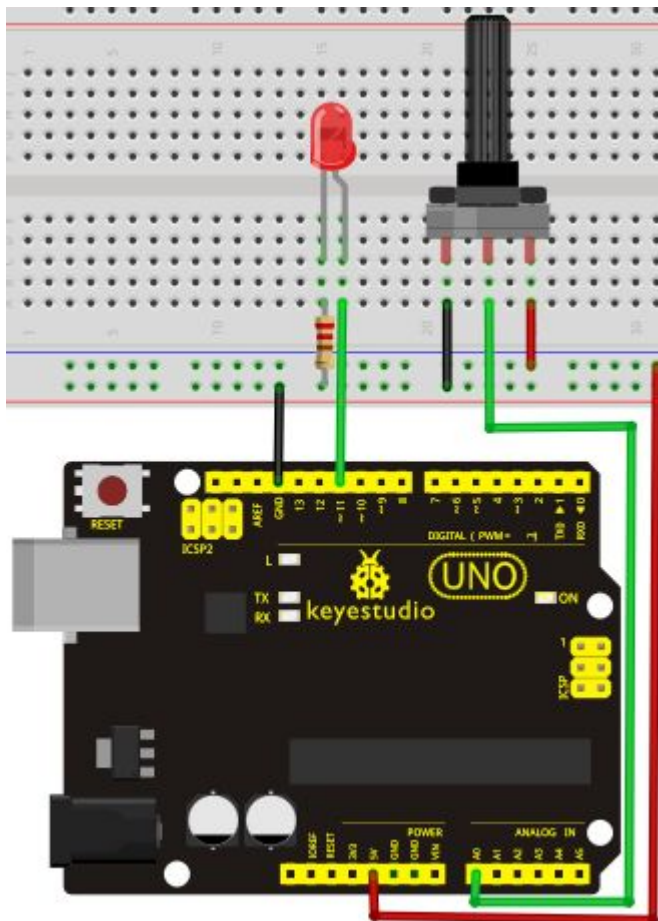
Breadboard\*1

Breadboard jumper wires

## Circuit connection

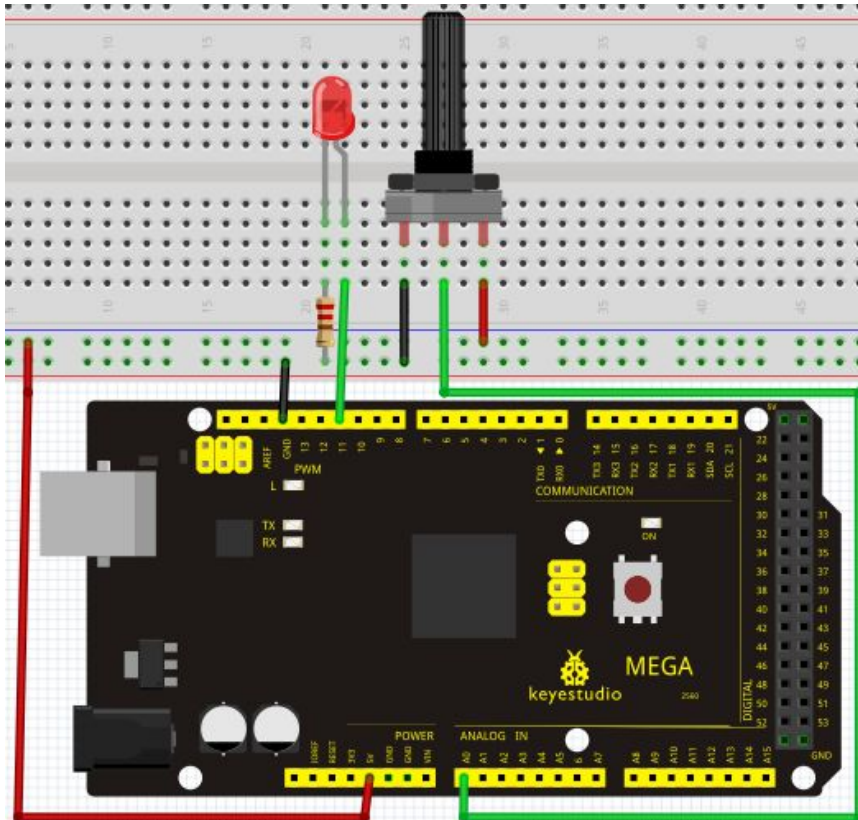
The input of potentiometer is analog, so we connect it to analog port, and LED to PWM port. Different PWM signal can regulate the brightness of the LED.

Connection for UNO R3:



Connection for 2560 R3:

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## Sample program

In the program compiling process, we will use the analogWrite (PWM interface, analog value) function. In this experiment, we will read the analog value of the potentiometer and assign the value to PWM port, so there will be corresponding change to the brightness of the LED. One final part will be displaying the analog value on the screen. You can consider this as the "analog value reading" project adding the PWM analog value assigning part. Below is a sample program for your reference.

```
////////////////////////////////////
```

```
int potpin=0;// initialize analog pin 0
int ledpin=11;//initialize digital pin 11 (PWM output)
int val=0;// Temporarily store variables' value from the sensor
void setup()
{
  pinMode(ledpin,OUTPUT);// define digital pin 11 as "output"
  Serial.begin(9600);// set baud rate at 9600
  // attention: for analog ports, they are automatically set up as "input"
}
void loop()
{
  val=analogRead(potpin);// read the analog value from the sensor and assign it to val
```

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```
Serial.println(val);// display value of val
analogWrite(ledpin,val/4);// turn on LED and set up brightness ( maximum output of PWM is 255)
delay(10);// wait for 0.01 second
}
////////////////////////////////////
```



## Result

After downloading the program, when we rotate the potentiometer knob, we can see changes of the displaying value, also obvious change of the LED brightness on the breadboard.

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## Project 4: Traffic light



### Introduction

In the previous program, we have done the LED blinking experiment with one LED. Now, it's time to up the stakes and do a bit more complicated experiment-traffic lights. Actually, these two experiments are similar. While in this traffic lights experiment, we use 3 LEDs with different color other than 1 LED.

### Hardware required

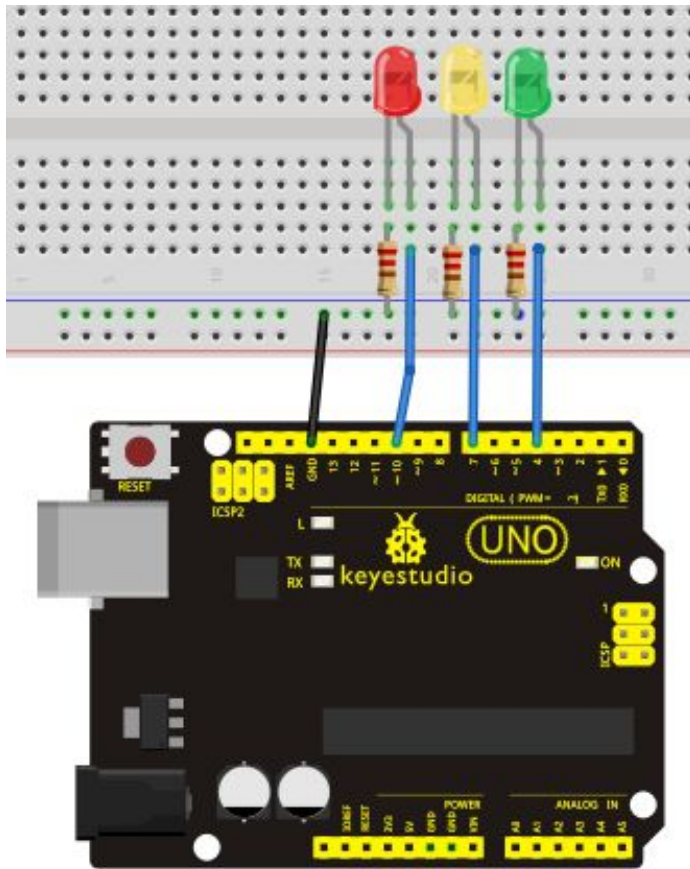
- Arduino board \*1
- USB cable \*1
- Red M5 LED\*1
- Yellow M5 LED\*1
- Green M5 LED\*1
- 220Ω resistor \*3
- Breadboard\*1
- Breadboard jumper wires

### Circuit connection

Connection for UNO R3:

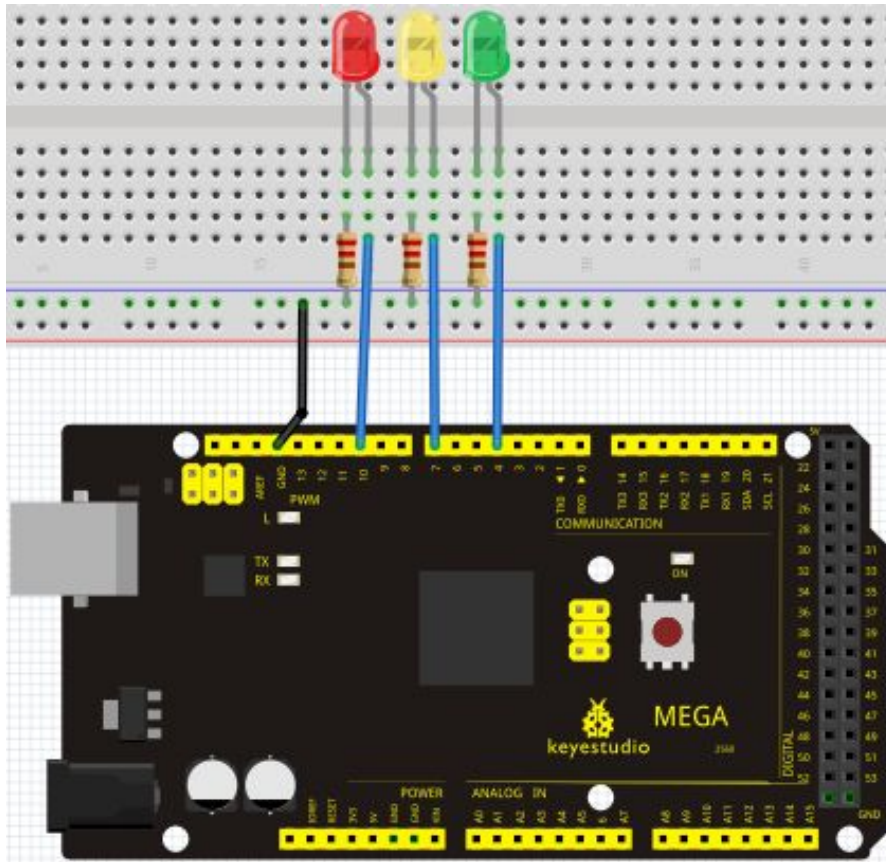
# keyestudio

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Connection for 2560 R3:

# keystudio



## Sample program

Since it is a simulation of traffic lights, the blinking time of each LED should be the same with those in traffic lights system. In this program, we use Arduino delay () function to control delay time, which is much simpler than C language.

```
////////////////////////////////////  
int redled =10; // initialize digital pin 8.  
int yellowled =7; // initialize digital pin 7.  
int greenled =4; // initialize digital pin 4.  
void setup()  
{  
pinMode(redled, OUTPUT); // set the pin with red LED as "output"  
pinMode(yellowled, OUTPUT); // set the pin with yellow LED as "output"  
pinMode(greenled, OUTPUT); // set the pin with green LED as "output"  
}  
void loop()  
{  
digitalWrite(greenled, HIGH); // turn on green LED  
delay(5000); // wait 5 seconds  
digitalWrite(greenled, LOW); // turn off green LED  
for(int i=0;i<3;i++) // blinks for 3 times
```

# keystudio

---

```
{
delay(500);// wait 0.5 second
digitalWrite(yellowled, HIGH);// turn on yellow LED
delay(500);// wait 0.5 second
digitalWrite(yellowled, LOW);// turn off yellow LED
}
delay(500);// wait 0.5 second
digitalWrite(redled, HIGH);// turn on red LED
delay(5000);// wait 5 second
digitalWrite(redled, LOW);// turn off red LED
}
////////////////////////////////////
```

## Result

When the uploading process is completed, we can see traffic lights of our own design.

Note: this circuit design is very similar with the one in LED chase effect.

The green light will be on for 5 seconds, and then off., followed by the yellow light blinking for 3 times, and then the red light on for 5 seconds, forming a cycle. Cycle then repeats.

Experiment is now completed, thank you.

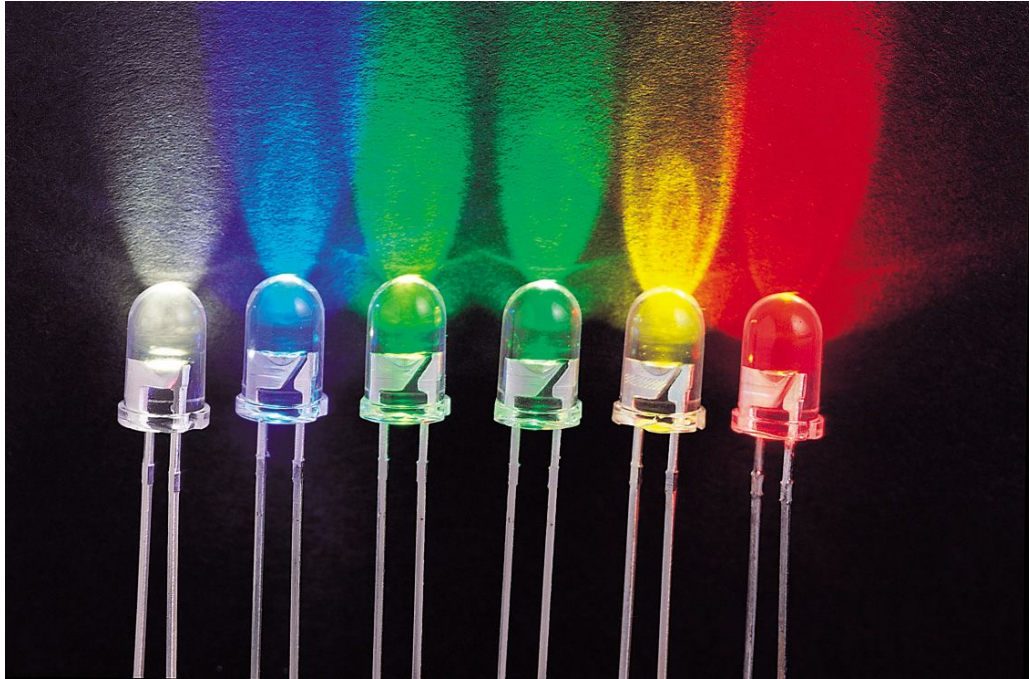
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## Project 5: LED chasing effect



### Introduction

We often see billboards composed of colorful LEDs. They are constantly changing to form various effects. In this experiment, we compile a program to simulate chase effect.

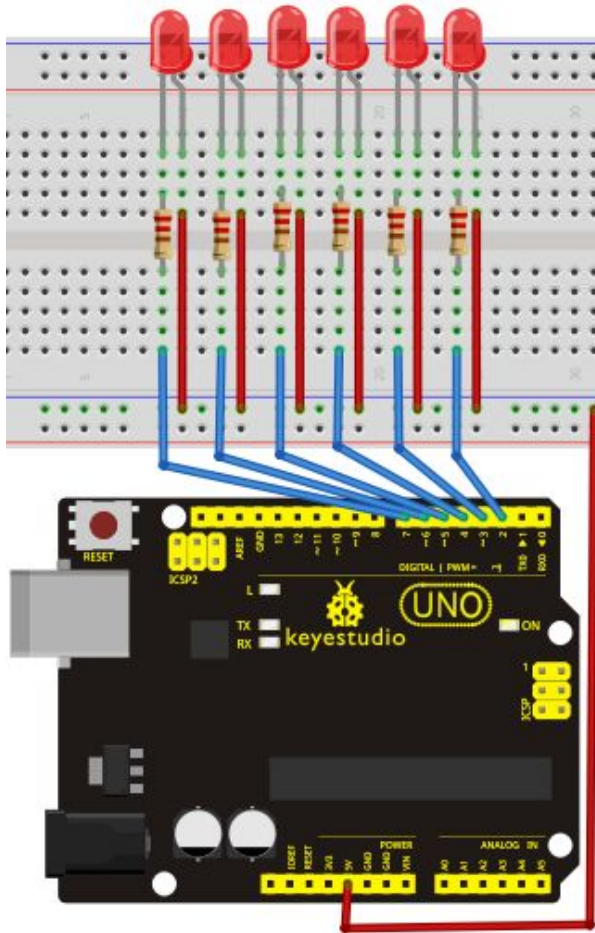
### Hardware required

Led \*6  
220Ω resistor \*6  
Breadboard jumper wires

### Circuit connection

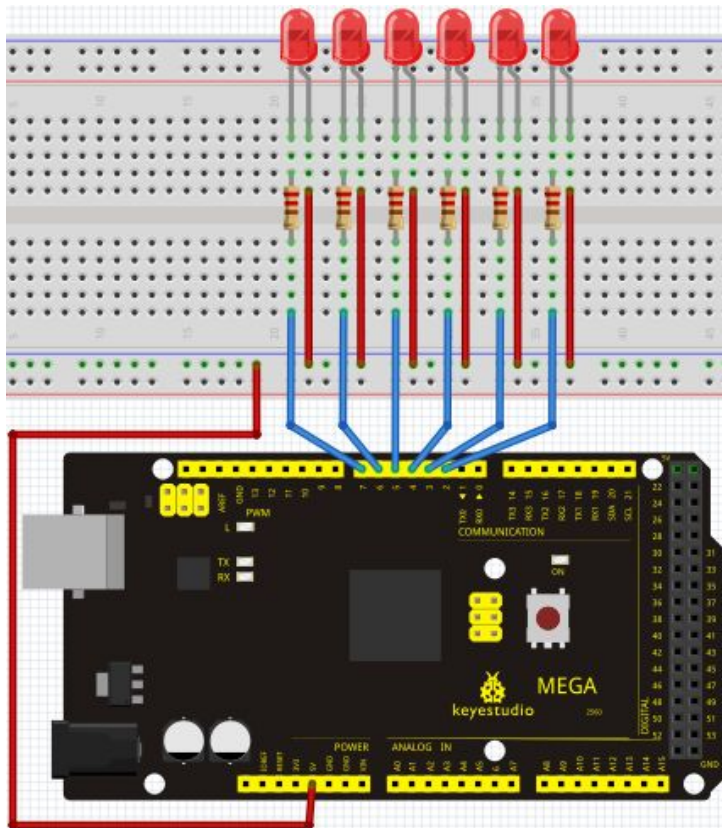
Connection for UNO R3:

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Connection for 2560 R3:

# keystudio



## Sample program

```
////////////////////////////////////  
int BASE = 2 ; // the I/O pin for the first LED  
int NUM = 6; // number of LEDs  
  
void setup()  
{  
  for (int i = BASE; i < BASE + NUM; i ++)  
  {  
    pinMode(i, OUTPUT); // set I/O pins as output  
  }  
}  
  
void loop()  
{  
  for (int i = BASE; i < BASE + NUM; i ++)  
  {  
    digitalWrite(i, LOW); // set I/O pins as "low", turn off LEDs one by one.  
    delay(200); // delay  
  }  
  for (int i = BASE; i < BASE + NUM; i ++)
```

# keystudio

---

```
{
  digitalWrite(i, HIGH);    // set I/O pins as "high", turn on LEDs one by one
  delay(200);              // delay
}
}
```

////////////////////////////////////

## Result

You can see the LEDs blink by sequence.

\*\*\*\*\*

## Project 6: Button-controlled LED



### Introduction

I/O port means interface for INPUT and OUTPUT. Up until now, we have only used its OUTPUT function. In this experiment, we will try to use the input function, which is to read the output value of device connecting to it. We use 1 button and 1 LED using both input and output to give you a better understanding of the I/O function. Button switches, familiar to most of us, are a switch value (digital value) component. When it's pressed, the circuit is in closed (conducting) state.

### Hardware required

- Button switch\*1
- Red M5 LED\*1

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220Ω resistor\*1

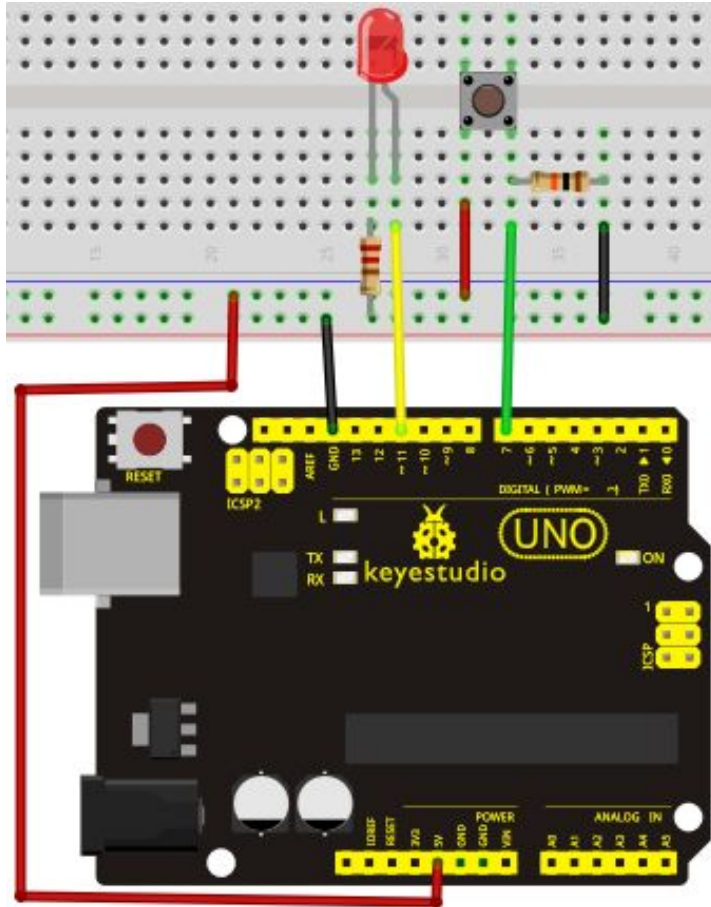
10KΩ resistor\*1

Breadboard\*1

Breadboard jumper wires

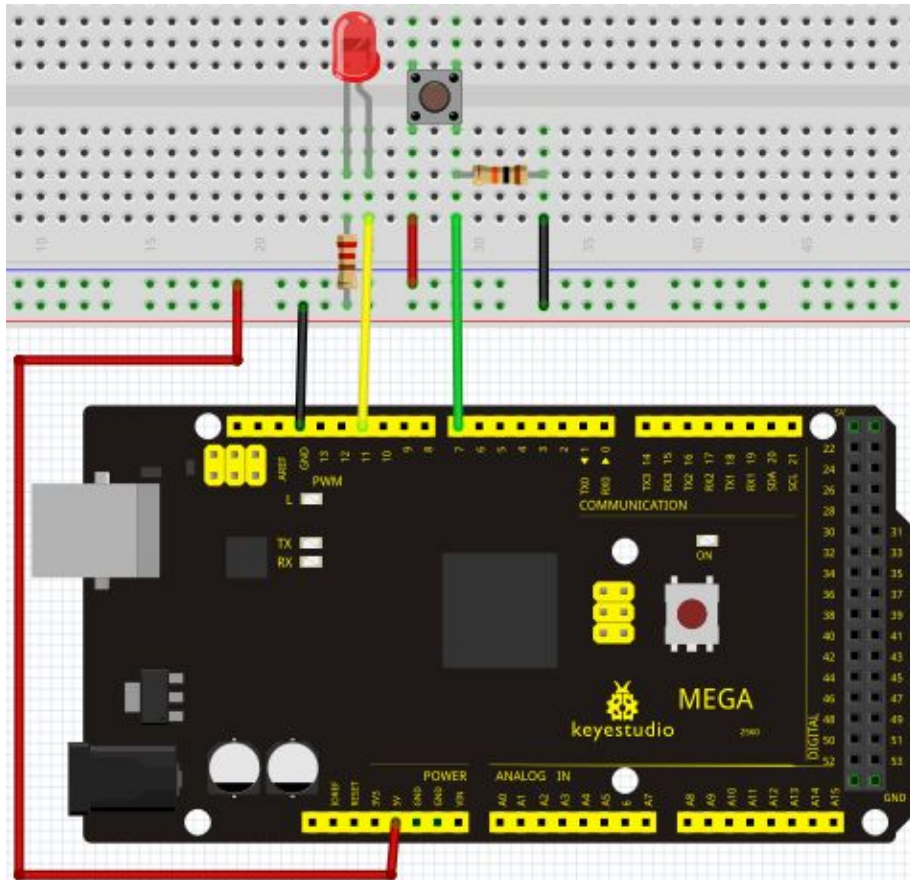
## Circuit connection

Connection for UNO R3:



Connection for 2560 R3:

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## Sample program

Now, let's begin the compiling. When the button is pressed, the LED will be on. After the previous study, the coding should be easy for you. In this program, we add a statement of judgment. Here, we use an if () statement.

Arduino IDE is based on C language, so statements of C language such as while, switch etc. can certainly be used for Arduino program.

When we press the button, pin 7 will output high level. We can program pin 11 to output high level and turn on the LED. When pin 7 outputs low level, pin 11 also outputs low level and the LED remains off.

```
////////////////////////////////////
```

```
int ledpin=11;// initialize pin 11
int inpin=7;// initialize pin 7
int val;// define val
void setup()
{
pinMode(ledpin,OUTPUT);// set LED pin as “output”
pinMode(inpin,INPUT);// set button pin as “input”
}
void loop()
```

# keystudio

---

```
{
val=digitalRead(inpin);// read the level value of pin 7 and assign it to val
if(val==LOW)// check if the button is pressed, if yes, turn on the LED
{ digitalWrite(ledpin,LOW);}
else
{ digitalWrite(ledpin,HIGH);}
}
////////////////////////////////////
```

## Result

When the button is pressed, LED is on, otherwise, LED remains off. After the above process, the button controlled LED experiment is completed. The simple principle of this experiment is widely used in a variety of circuit and electric appliances. You can easily come across it in your every day life. One typical example is when you press a certain key of your phone, the backlight will be on.

\*\*\*\*\*

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## Project 7: Active buzzer



### Introduction

Active buzzer is widely used on computer, printer, alarm, electronic toy, telephone, timer etc as a sound making element. It has an inner vibration source. Simply connect it with 5V power supply, it can buzz continuously.

### Hardware required

Buzzer\*1  
Key \*1  
Breadboard\*1  
Breadboard jumper wires

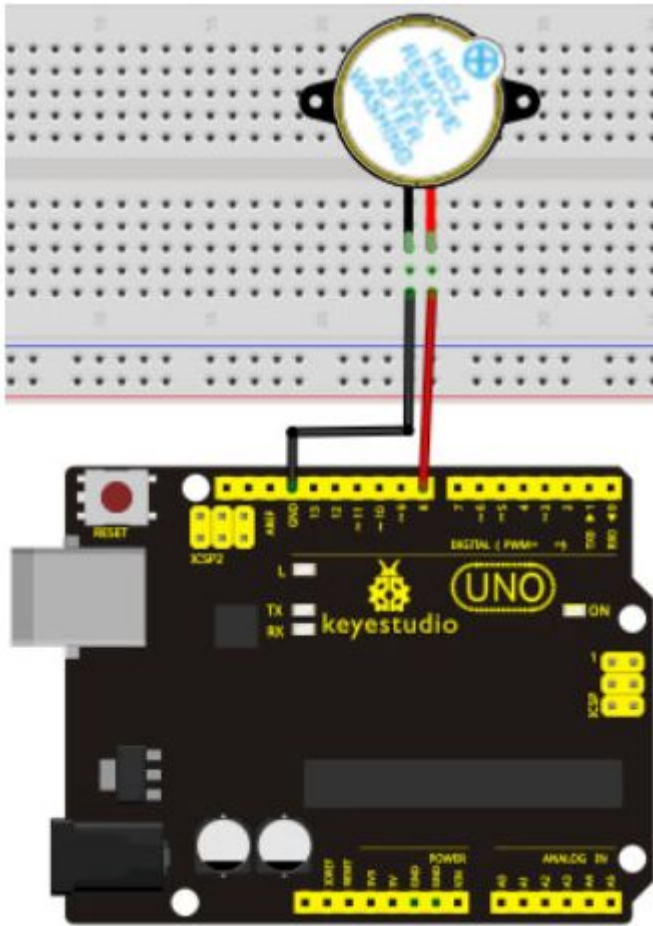
### Circuit connection

Connection for UNO R3:



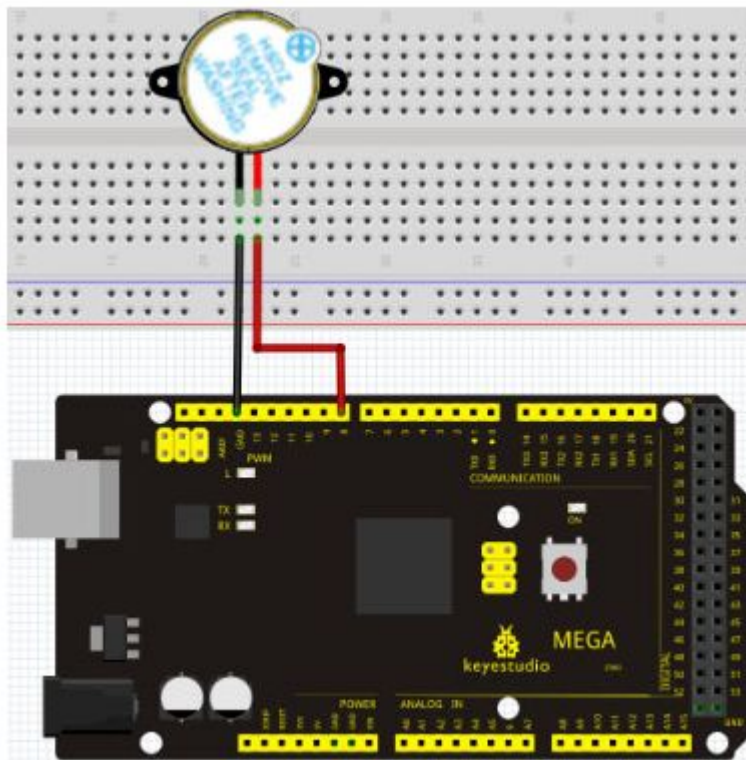
# keystudio

---



Connection for 2560 R3:

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When connecting the circuit, pay attention to the positive & the negative poles of the buzzer. In the photo, you can see there are red and black lines. When the circuit is finished, you can begin programming.

## Sample program

Program is simple. You control the buzzer by outputting high/low level.

```
////////////////////////////////////  
int buzzer=8;// initialize digital IO pin that controls the buzzer  
void setup()  
{  
  pinMode(buzzer,OUTPUT);// set pin mode as “output”  
}  
void loop()  
{  
  digitalWrite(buzzer, HIGH); // produce sound  
}  
////////////////////////////////////
```

## Result

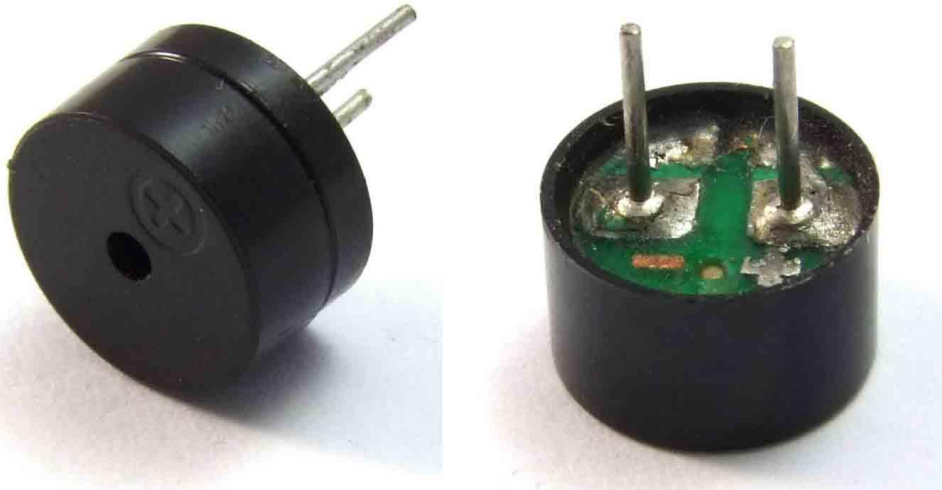
After downloading the program, the buzzer experiment is completed. You can see the buzzer is ringing.

\*\*\*\*\*

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## Project 8: Passive buzzer



### Introduction

We can use Arduino to make many interactive works of which the most commonly used is acoustic-optic display. All the previous experiment has something to do with LED. However, the circuit in this experiment can produce sound. Normally, the experiment is done with a buzzer or a speaker while buzzer is simpler and easier to use. The buzzer we introduced here is a passive buzzer. It cannot be actuated by itself, but by external pulse frequencies. Different frequencies produce different sounds. We can use Arduino to code the melody of a song, which is actually quite fun and simple.

### Hardware required

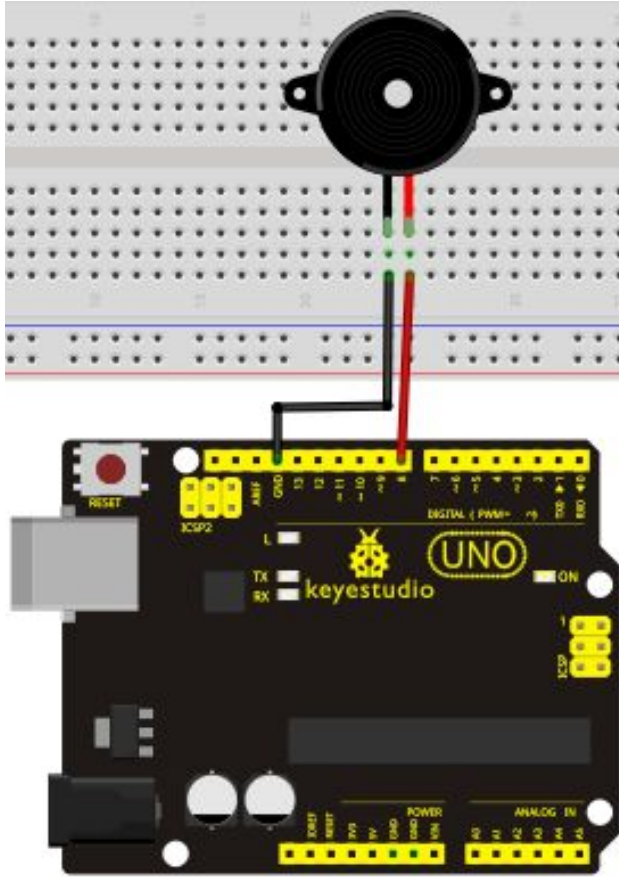
Passive buzzer\*1  
Key \*1  
Breadboard\*1  
Breadboard jumper wires

### Circuit connection

Connection for UNO R3:

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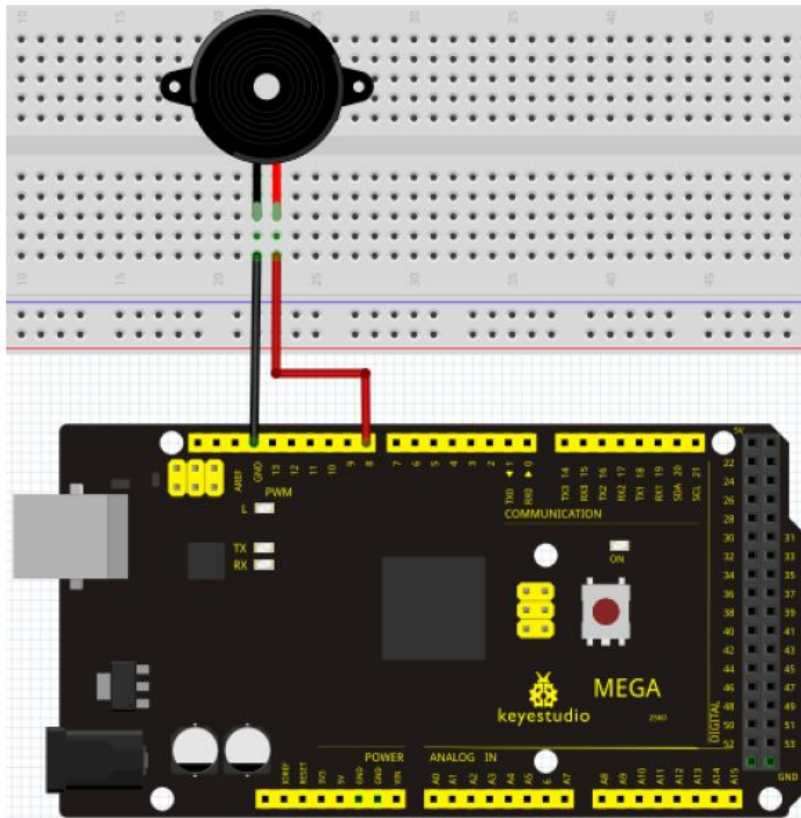
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Connection for 2560 R3:

# keystudio

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## Sample program

```
////////////////////////////////////  
int buzzer=8;// select digital IO pin for the buzzer  
void setup()  
{  
pinMode(buzzer,OUTPUT);// set digital IO pin pattern, OUTPUT to be output  
}  
void loop()  
{ unsigned char i,j;//define variable  
while(1)  
{ for(i=0;i<80;i++)// output a frequency sound  
{ digitalWrite(buzzer,HIGH);// sound  
delay(1);//delay 1ms  
digitalWrite(buzzer,LOW);//not sound  
delay(1);//ms delay  
}  
for(i=0;i<100;i++)// output a frequency sound  
{ digitalWrite(buzzer,HIGH);// sound  
digitalWrite(buzzer,LOW);//not sound  
delay(2);//2ms delay  
}
```

# keystudio

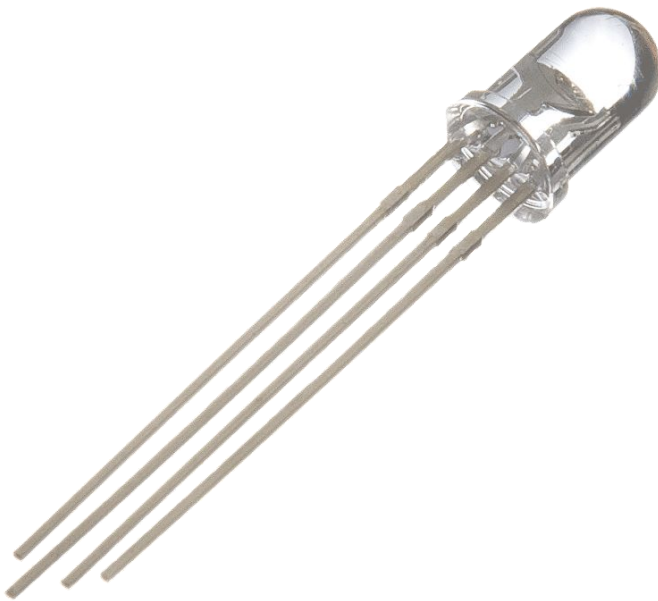
---

```
}  
}  
}  
////////////////////////////////////
```

After downloading the program, buzzer experiment is finished.

\*\*\*\*\*

## Project 9: RGB LED



### Introduction

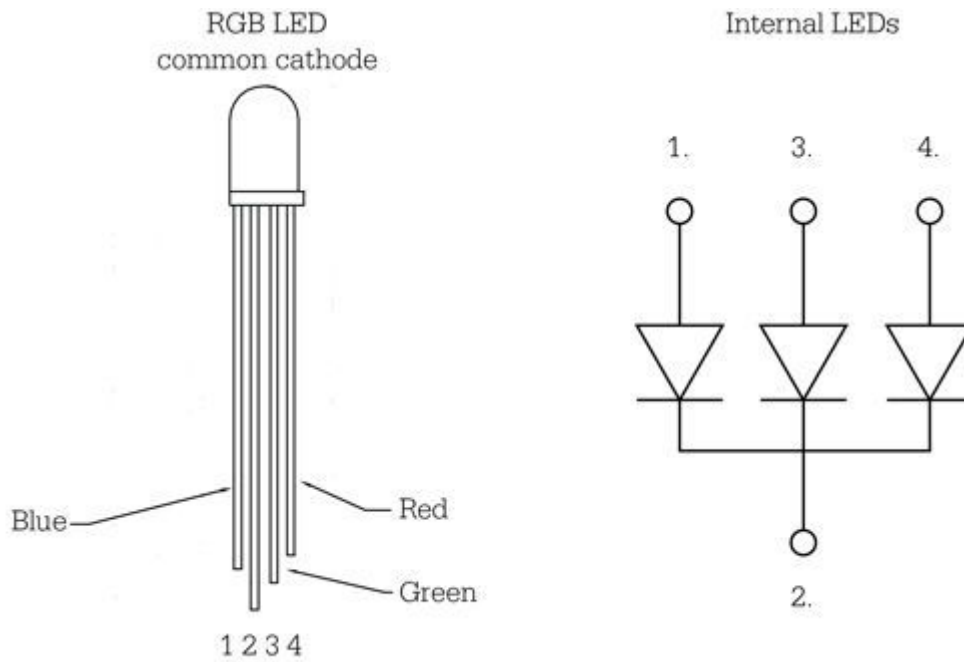
Tricolor principle to display various colors

PWM controlling ports to display full color

Can be driven directly by Arduino PWM interfaces

# keystudio

---



## Hardware Required

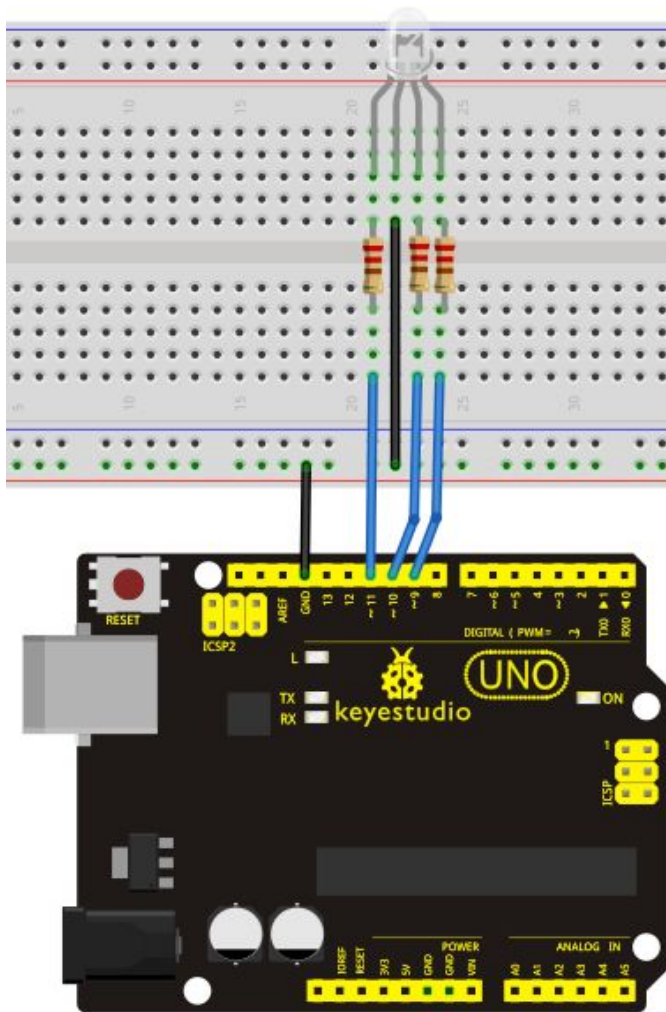
- Arduino controller \* 1
- USB cable \* 1
- RGB LED \* 1

## Circuit connection

Connection for UNO R3:

# keystudio

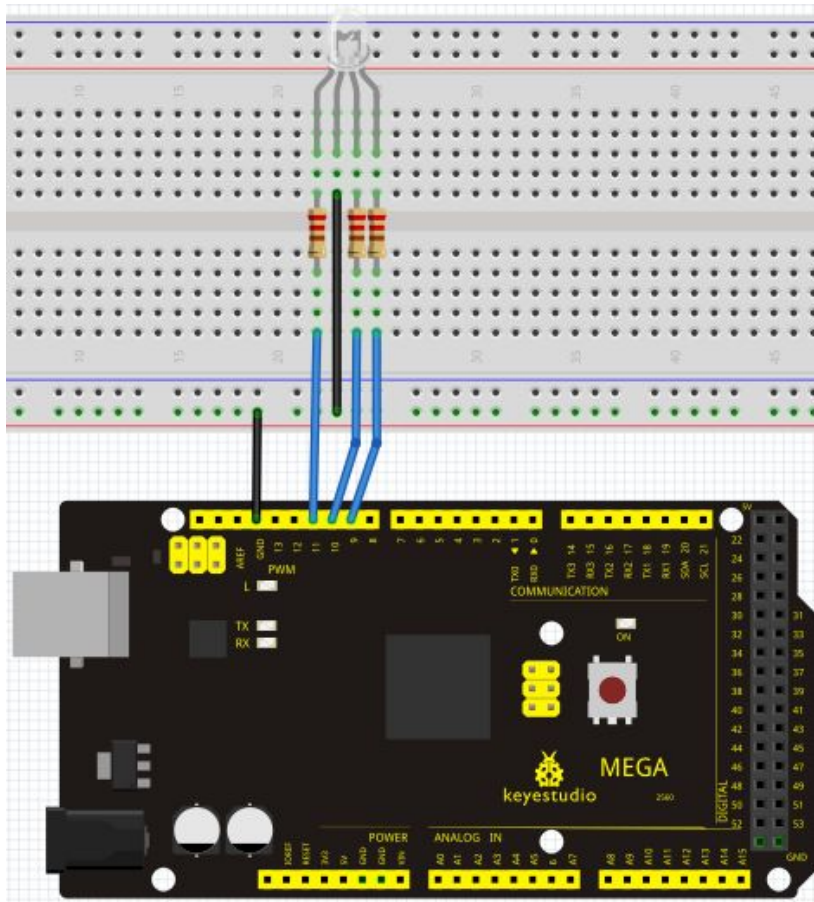
---



Connection for 2560 R3:



# keyestudio



## Sample program

```
////////////////////////////////////  
int redpin = 11; //select the pin for the red LED  
int bluepin =10; // select the pin for the blue LED  
int greenpin =9; // select the pin for the green LED
```

```
int val;
```

```
void setup() {  
  pinMode(redpin, OUTPUT);  
  pinMode(bluepin, OUTPUT);  
  pinMode(greenpin, OUTPUT);  
  Serial.begin(9600);  
}
```

```
void loop()  
{  
for(val=255; val>0; val--)
```


# keystudio

---

```
{
  analogWrite(11, val);
  analogWrite(10, 255-val);
  analogWrite(9, 128-val);
  delay(1);
}
for(val=0; val<255; val++)
{
  analogWrite(11, val);
  analogWrite(10, 255-val);
  analogWrite(9, 128-val);
  delay(1);
}
Serial.println(val, DEC);
}
```

////////////////////////////////////

## Result

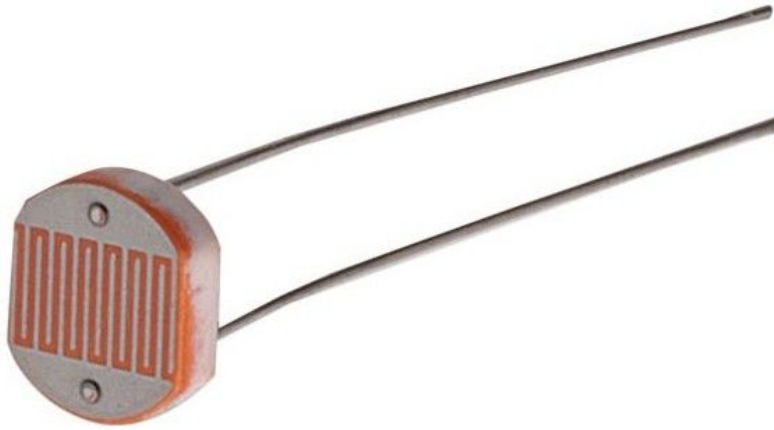
Directly copy the above code into arduino IDE, and click upload , wait a few seconds, you can see a full-color LED

\*\*\*\*\*

# keystudio

---

## Project 10: Photo resistor



### Introduction

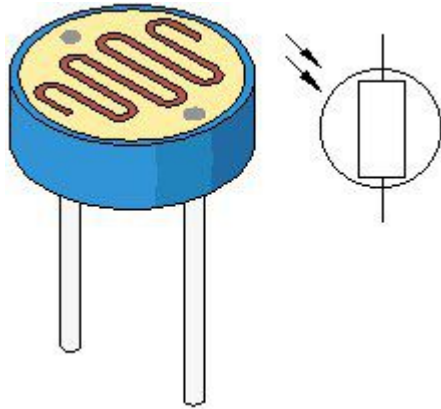
After completing all the previous experiments, we acquired some basic understanding and knowledge about Arduino application. We have learned digital input and output, analog input and PWM. Now, we can begin the learning of sensors applications.

Photo resistor (Photoresistor) is a resistor whose resistance varies according to different incident light strength. It's made based on the photoelectric effect of semiconductor. If the incident light is intense, its resistance reduces; if the incident light is weak, the resistance increases. Photoresistor is commonly applied in the measurement of light, light control and photovoltaic conversion (convert the change of light into the change of electricity).

Photo resistor is also being widely applied to various light control circuit, such as light control and adjustment, optical switches etc.

# keystudio

---



We will start with a relatively simple experiment regarding photoresistor application. Photoresistor is an element that changes its resistance as light strength changes. So we will need to read the analog values. We can refer to the PWM experiment, replacing the potentiometer with photoresistor. When there is change in light strength, there will be corresponding change on the LED.

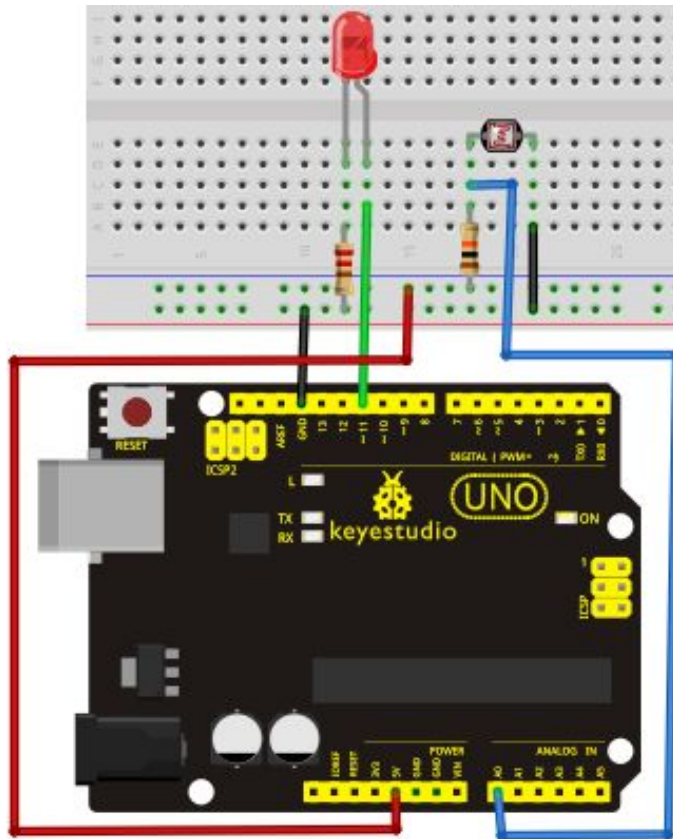
## Hardware required

Photo resistor\*1  
Red M5 LED\*1  
10K $\Omega$ resistor\*1  
220 $\Omega$ resistor\*1  
Bread board\*1  
Bread board jumper wires

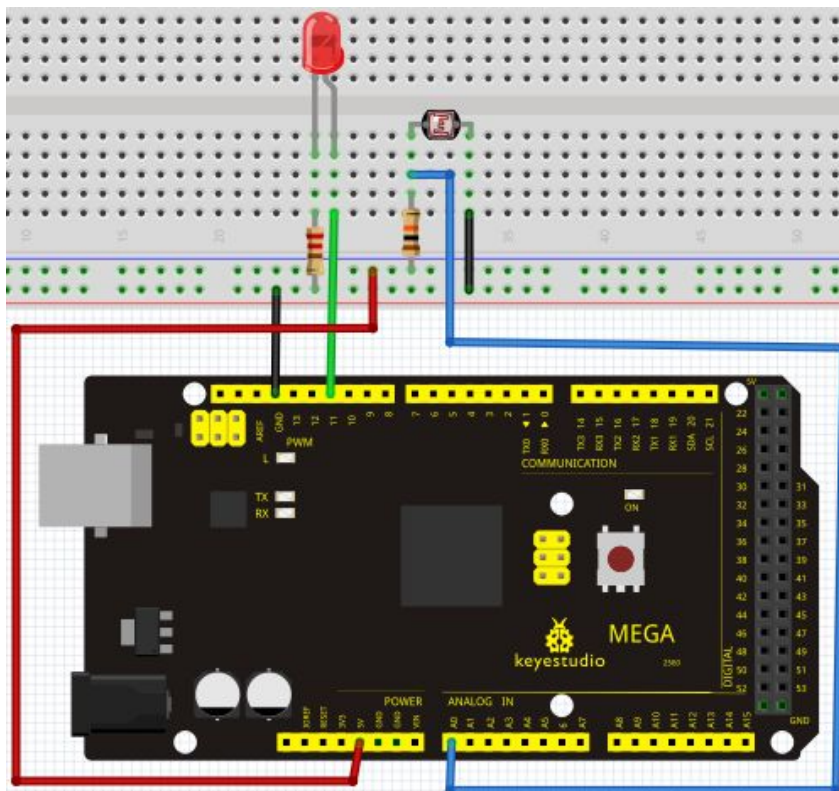
## Circuit connection

Connection for UNO R3:

# keyestudio



Connection for 2560 R3:



Sample program

# keystudio

---

After the connection, let's begin the program compiling. The program is similar to the one of PWM. For change detail, please refer to the sample program below.

```
////////////////////////////////////
int potpin=0;// initialize analog pin 0, connected with photovaristor
int ledpin=11;// initialize digital pin 11, output regulating the brightness of LED
int val=0;// initialize variable va
void setup()
{
pinMode(ledpin,OUTPUT);// set digital pin 11 as "output"
Serial.begin(9600);// set baud rate at "9600"
}
void loop()
{
val=analogRead(potpin);// read the analog value of the sensor and assign it to val
Serial.println(val);// display the value of val
analogWrite(ledpin,val);// turn on the LED and set up brightness ( maximum output value 255)
delay(10);// wait for 0.01
}
////////////////////////////////////
```

## Result

After downloading the program, you can change the light strength around the photovaristor and see corresponding brightness change of the LED. Photovaristors has various applications in our everyday life. You can make other interesting interactive projects base on this one.

\*\*\*\*\*

## Project 11: Flame sensor

### Introduction

Flame sensor (Infrared receiving triode) is specially used on robots to find the fire source. This sensor is of high sensitivity to flame. Below is a photo of it.

# keystudio

---



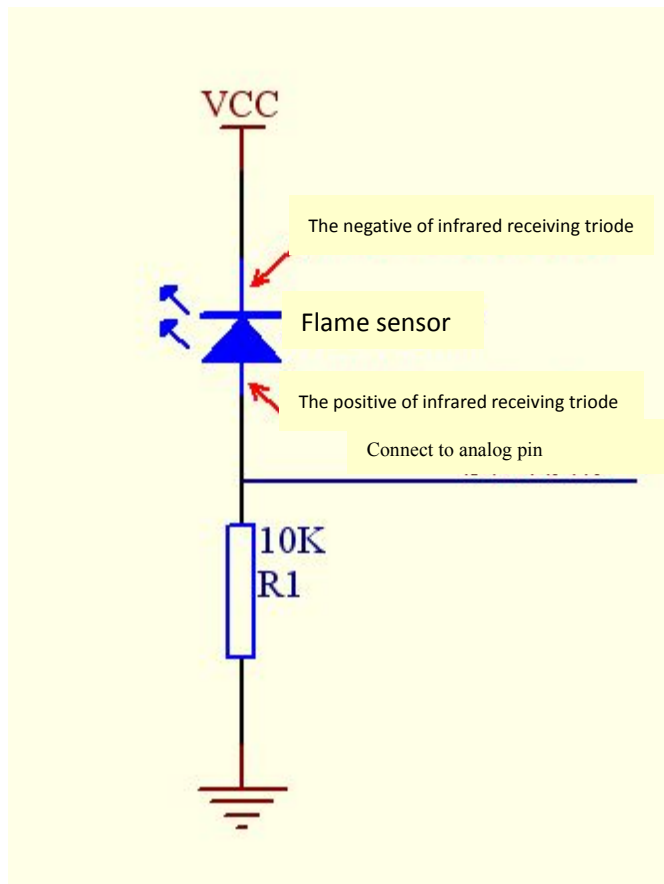
## Working principle:

Flame sensor is made based on the principle that infrared ray is highly sensitive to flame. It has a specially designed infrared receiving tube to detect fire, and then convert the flame brightness to fluctuating level signal. The signals are then input into the central processor and be dealt with accordingly.

## Sensor connection

The shorter lead of the receiving triode is for negative, the other one for positive. Connect negative to 5V pin, positive to resistor; connect the other end of the resistor to GND, connect one end of a jumper wire to a clip which is electrically connected to sensor positive, the other end to analog pin. As shown below:

# keystudio



## Hardware required

Flame sensor \*1

Buzzer \*1

10K resistor x1

Breadboard jumper wires

## Experiment connection

1) Connecting buzzer:

Connect the controller board, prototype board, breadboard and USB cable according to the Arduino tutorial. Connect the buzzer to digital pin 8.

2) Connecting flame sensor:

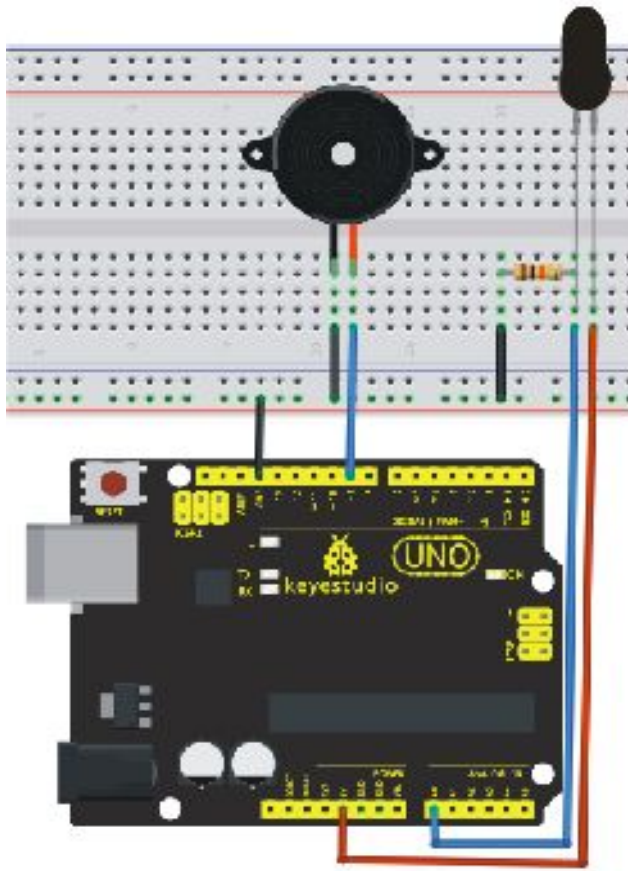
Connect the sensor to analog pin 0.

Connection for UNO R3:



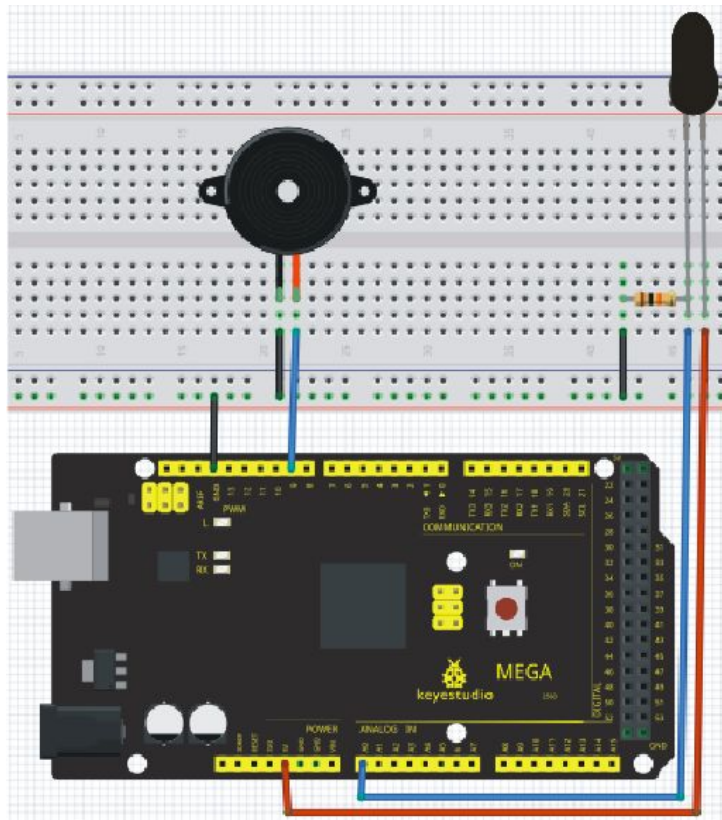
# keystudio

---



Connection for 2560 R3:

# keystudio



## Experiment principle

When it's approaching a fire, the voltage value the analog port reads differs. If you use a multimeter, you can know when there is no fire approaching, the voltage it reads is around 0.3V; when there is fire approaching, the voltage it reads is around 1.0V, the nearer the fire, the higher the voltage.

So in the beginning of the program, you can initialize voltage value  $i$  (no fire value); Then, continuously read the analog voltage value  $j$  and obtain difference value  $k=j-i$ ; compare  $k$  with 0.6V (123 in binary) to determine whether or not there is a fire approaching; if yes, the buzzer will buzz.

## Sample program

```
////////////////////////////////////  
int flame=0;// select analog pin 0 for the sensor  
int Beep=9;// select digital pin 9 for the buzzer  
int val=0;// initialize variable  
void setup()  
{  
  pinMode(Beep,OUTPUT);// set LED pin as "output"  
  pinMode(flame,INPUT);// set buzzer pin as "input"
```

# keystudio

---

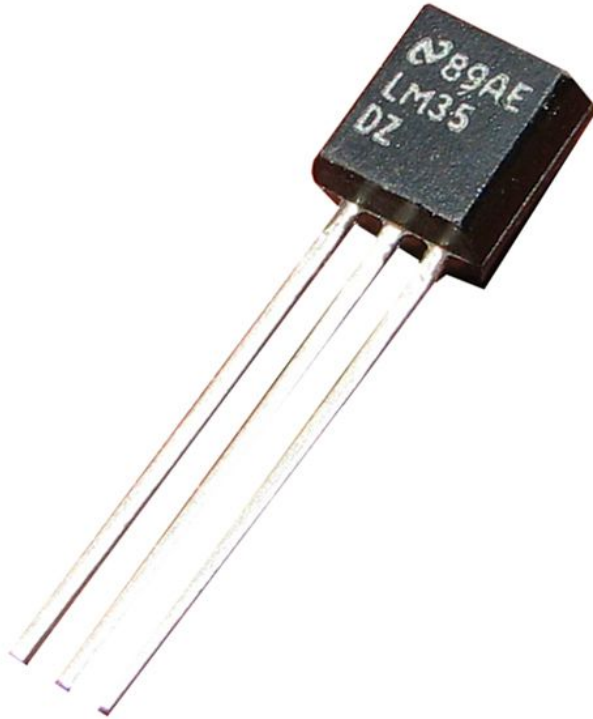
```
Serial.begin(9600);// set baud rate at "9600"
}
void loop()
{
  val=analogRead(flame);// read the analog value of the sensor
  Serial.println(val);// output and display the analog value
  if(val>=600)// when the analog value is larger than 600, the buzzer will buzz
  {
    digitalWrite(Beep,HIGH);
  }else
  {
    digitalWrite(Beep,LOW);
  }
  delay(500);
}
////////////////////////////////////////////////////////////////
```

## Result

This program can simulate an alarm when there is a fire. Everything is normal when there is no fire; when there is, the alarm will be set off immediately.

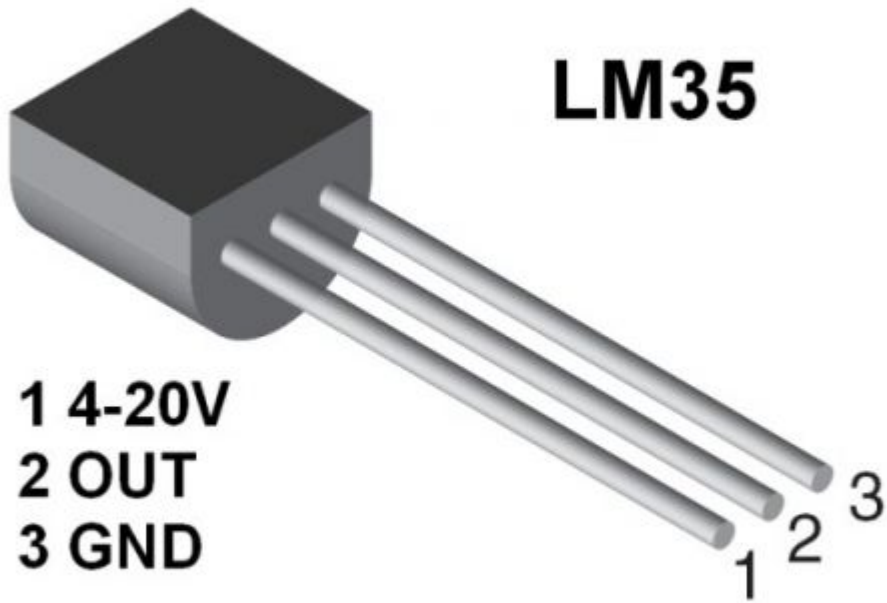
\*\*\*\*\*

## Project 12: LM35 temperature sensor



### Introduction

LM35 is a common and easy-to-use temperature sensor. It does not require other hardware. You just need an analog port to make it work. The difficulty lies in compiling the code to convert the analog value it reads to celsius temperature.



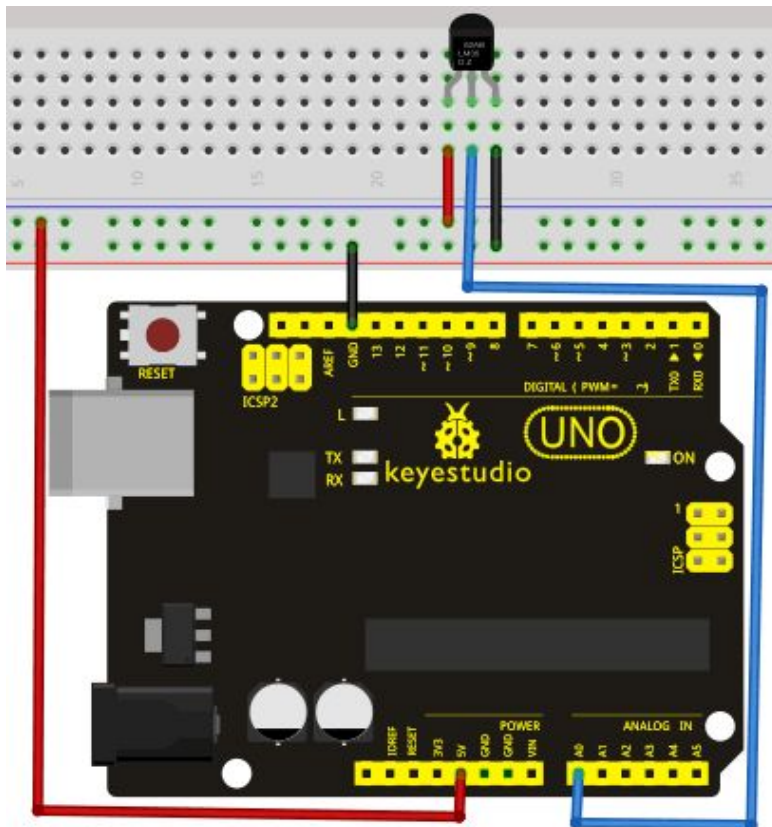
## **Hardware required**

LM35\*1  
Breadboard\*1  
Breadboard jumper wires

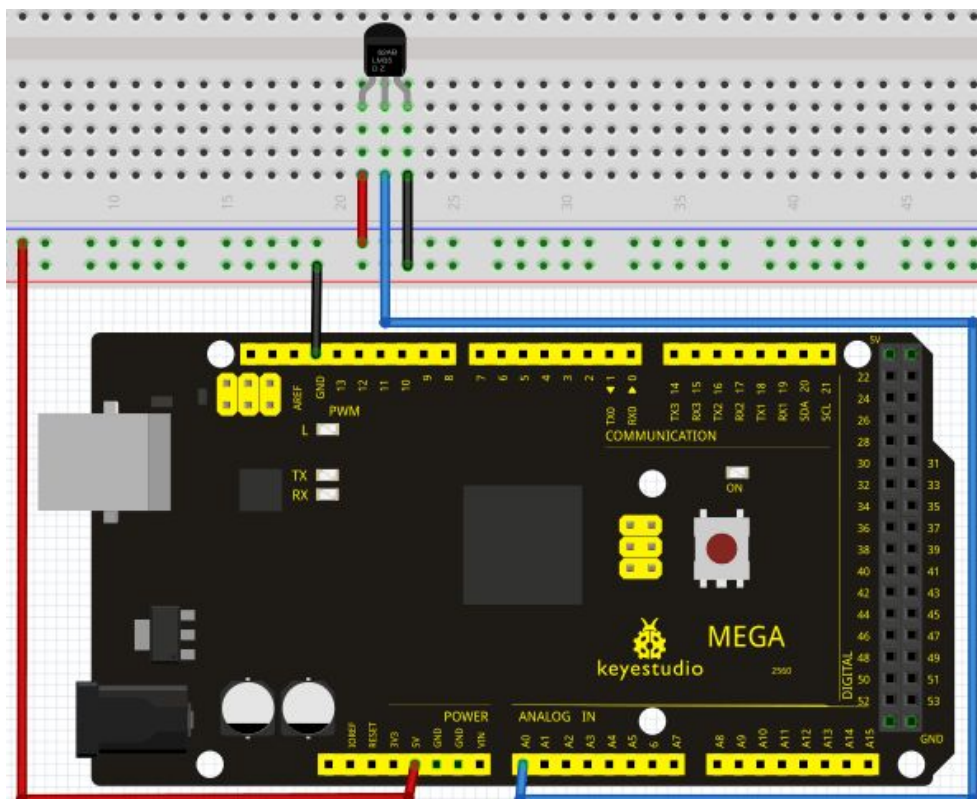
## **Circuit connection**

Connection for UNO R3:

# keystudio



Connection for 2560 R3:



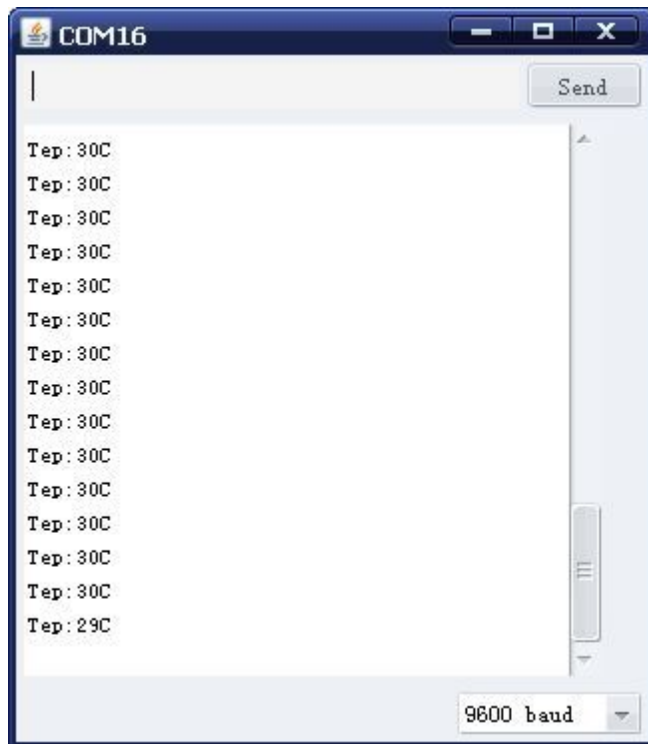
# keyestudio

## Sample program

```
////////////////////////////////////  
int potPin = 0; // initialize analog pin 0 for LM35 temperature sensor  
void setup()  
{  
Serial.begin(9600); // set baud rate at "9600"  
}  
void loop()  
{  
int val; // define variable  
int dat; // define variable  
val = analogRead(0); // read the analog value of the sensor and assign it to val  
dat = (125 * val) >> 8; // temperature calculation formula  
Serial.print("Tep:"); // output and display characters beginning with Tep  
Serial.print(dat); // output and display value of dat  
Serial.println("C"); // display "C" characters  
delay(500); // wait for 0.5 second  
}  
////////////////////////////////////
```

## Result

After downloading the program, you can open the monitoring window to see current temperature.



\*\*\*\*\*

## Project 13: Tilt switch



### Introduction

Tilt switch controlling the ON and OFF of LED

### Hardware required

Ball switch\*1

Led \*1

220 $\Omega$  resistor\*1

10K $\Omega$  resistor\*1

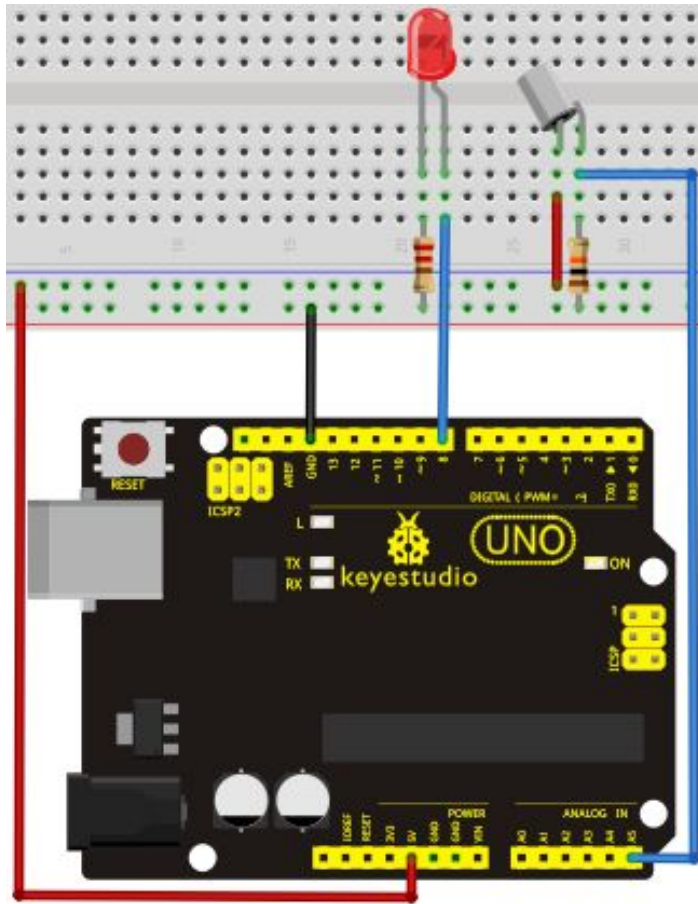
Breadboard jumper wires

### Circuit connection

Connection for R3:

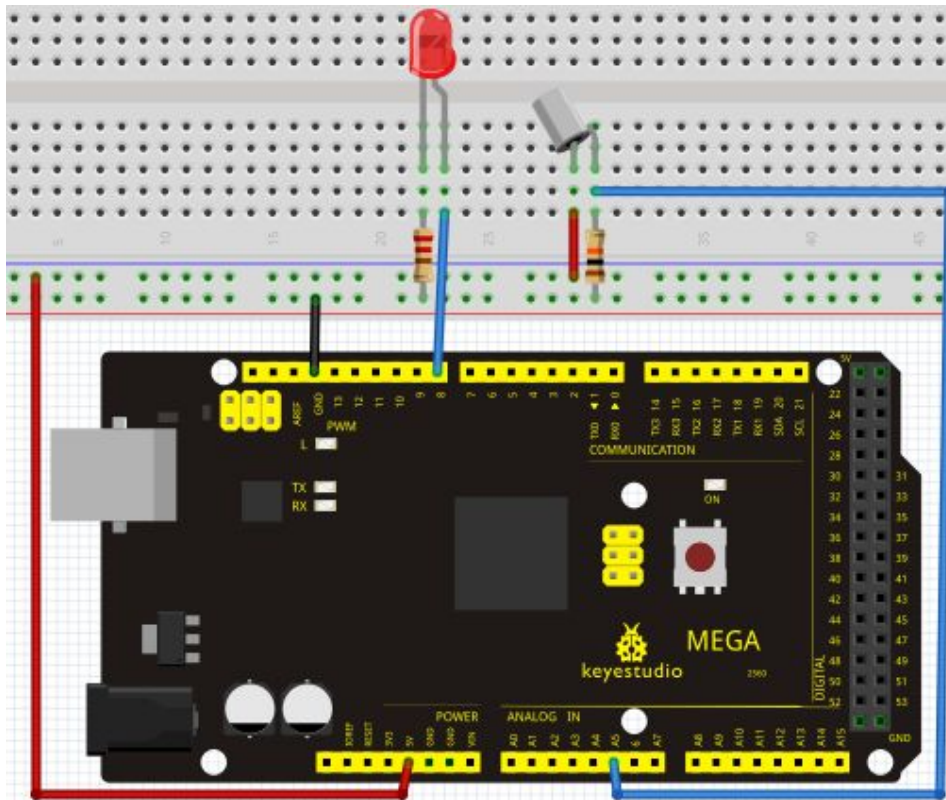


# keyestudio



Connection for 2560 R3:

# keystudio



Connect the controller board, shield, breadboard and USB cable according to Arduino tutorial. Connect the LED to digital pin 8, ball switch to analog pin 5.

## Experiment principle

When one end of the switch is below horizontal position, the switch is on. The voltage of the analog port is about 5V (1023 in binary). The LED will be on. When the other end of the switch is below horizontal position, the switch is off. The voltage of the analog port is about 0V (0 in binary). The LED will be off. In the program, we determine whether the switch is on or off according to the voltage value of the analog port, whether it's above 2.5V (512 in binary) or not.

## Sample program

```
////////////////////////////////////  
void setup()  
{  
  pinMode(8,OUTPUT);// set digital pin 8 as "output"  
}  
void loop()  
{  
  int i;// define variable i  
  while(1)
```

# keystudio

---

```
{
  i=analogRead(5);// read the voltage value of analog pin 5
  if(i>512)// if larger than 512 (2.5V)
  {
    digitalWrite(8,LOW);// turn on LED
  }
  else// otherwise
  {
    digitalWrite(8,HIGH);// turn off LED
  }
}
}
}
////////////////////////////////////
```

## Result

Hold the breadboard with your hand. Tilt it to a certain extent, the LED will be on.

If there is no tilt, the LED will be off.

The principle of this experiment can be applied to relay control.

Experiment completed.

Thank you!

\*\*\*\*\*

# keystudio

---

## Project 14: IR remote control



### Introduction

What is an infrared receiver?

The signal from the infrared remote controller is a series of binary pulse code. To avoid interference from other infrared signals during the wireless transmission, the signal is pre-modulate at a specific carrier frequency and then send out by a infrared emission diode. The infrared receiving device needs to filter out other wave and receive signal at that specific frequency and modulate it back to binary pulse code, known as demodulation.

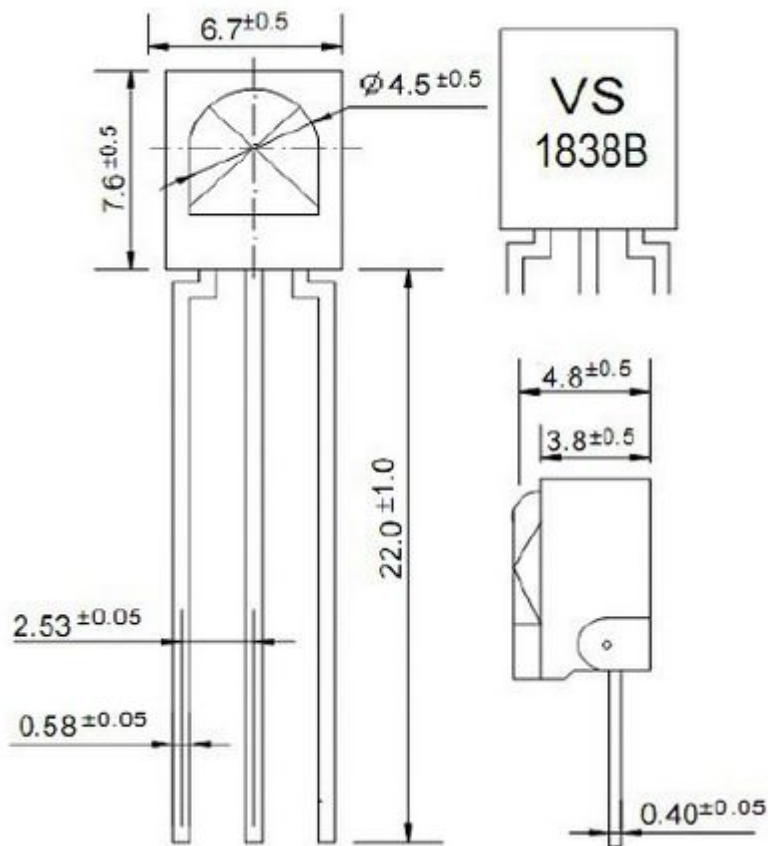
Working principal

The built-in receiver converts the light signal it received from the sender into feeble electrical signal. The signal will be amplified by the IC amplifier. After automatic gain control, band-pass filtering, demodulation, wave shaping, it returns to the original code. The code is then input to the code identification circuit by the receiver's signal output pin.

The pin and the connection of the infrared receiving head

Pin and wiring of infrared receiver

# keystudio



Infrared receiver has 3 pins.

When you use it, connect VOUT to analog pin, GND to GND, VCC to +5V.

## 2. Infrared remote control experiment

### Hardware required

Infrared remote controller \*1

Infrared receiver \*1

LED \*6

220 $\Omega$  resistor \*6

Multi-color breadboard wires

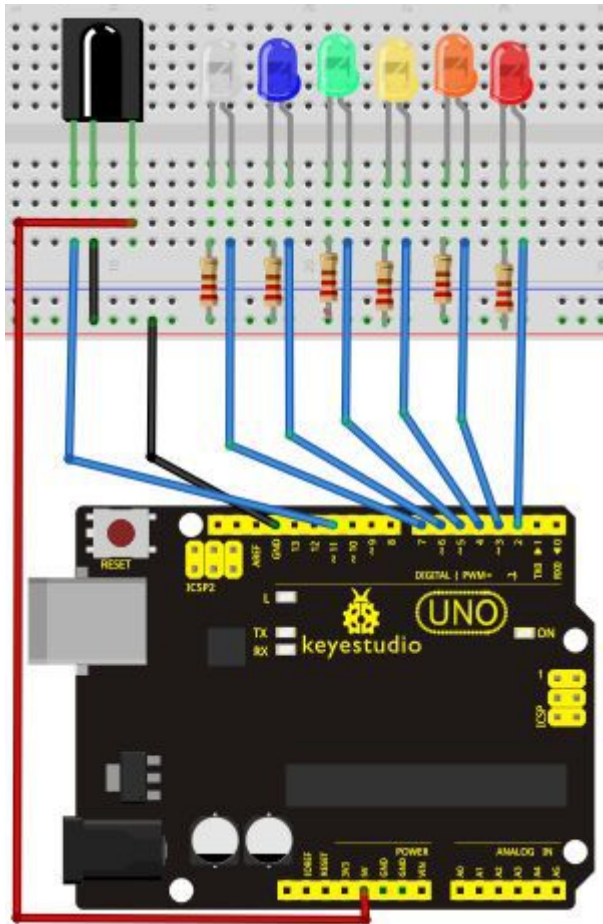
### Circuit connection

First, connect the controller board; then connect the infrared receiver as the above mentioned, connect VOUT to digital pin 11, connect the LEDs with resistors and connect the resistors to pin 2,3,4,5,6,7.

Connection for UNO R3:

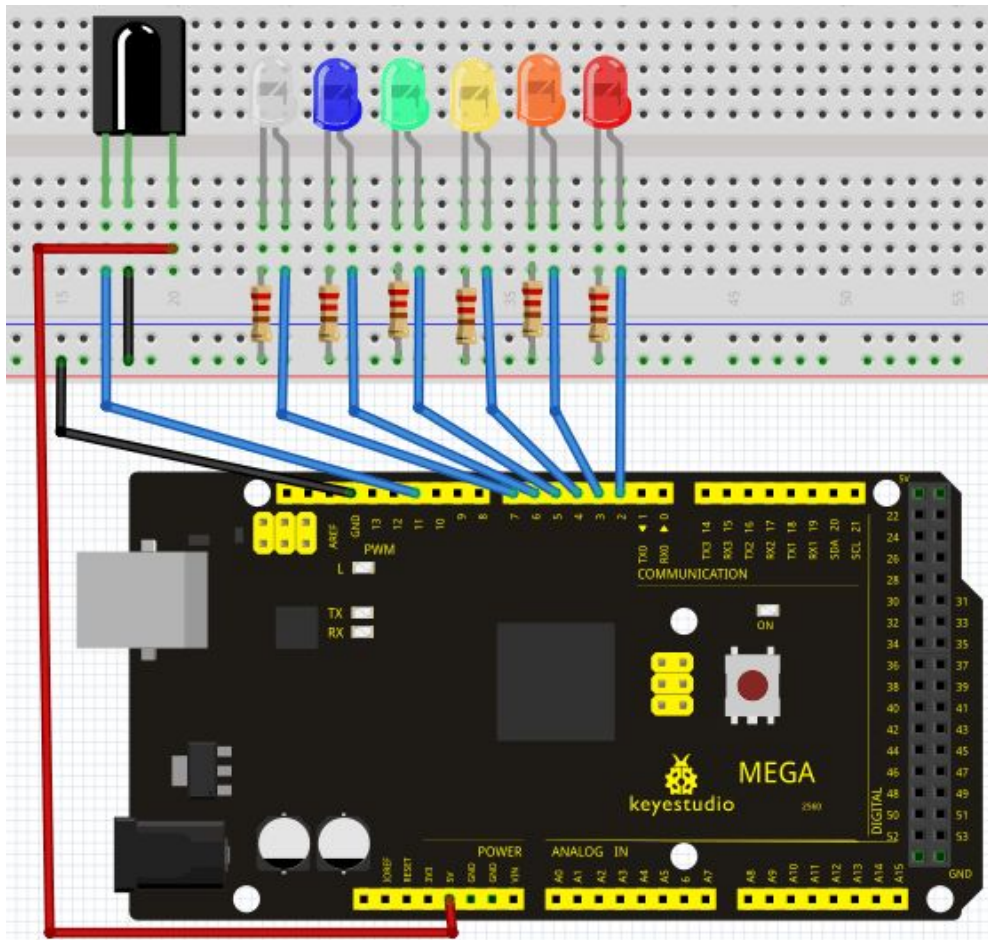
# keystudio

---



Connection for 2560 R3:

# keystudio



## Experimental principle

If you want to decode code of a remote controller, you must first know how it's coded. The coding method we use here is NEC protocol. Below is a brief introduction.

·NEC protocol:

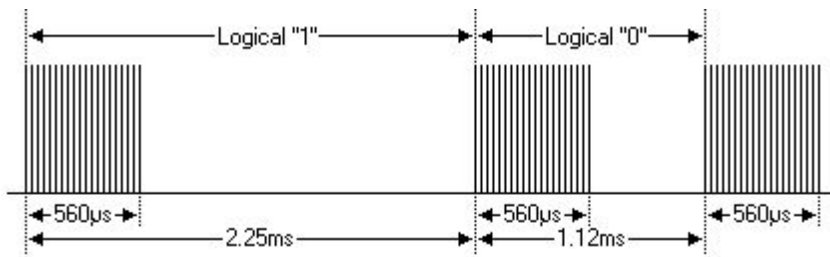
Features:

- (1) 8 bit address and 8 bit command length
- (2) address and command are transmitted twice for reliability
- (3) pulse distance modulation
- (4) carrier frequency of 38 KHZ
- (5) bit time of 1.125ms or 2.25ms

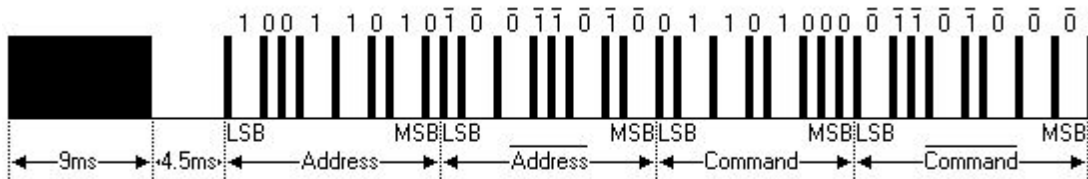
Protocol is as below:

- Definition of logical 0 and 1 is as below

# keystudio

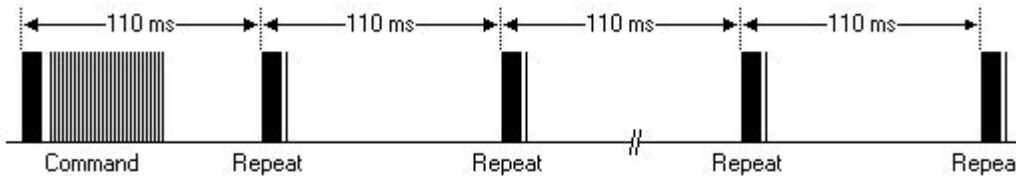


- Pulse transmitted when button is pressed and immediately released



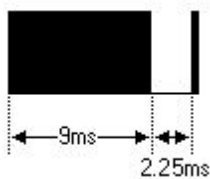
The picture above shows a typical pulse train of the NEC protocol. With this protocol the LSB is transmitted first. In this case Address \$59 and Command \$16 is transmitted. A message is started by a 9ms AGC burst, which was used to set the gain of the earlier IR receivers. This AGC burst is then followed by a 4.5ms space, which is then followed by the address and command. Address and Command are transmitted twice. The second time all bits are inverted and can be used for verification of the received message. The total transmission time is constant because every bit is repeated with its inverted length. If you are not interested in this reliability, you can ignore the inverted values, or you can expend the Address and Command to 16 bits each!

- Pulse transmitted when button is pressed and released after a period of time



A command is transmitted only once, even when the key on the remote control remains pressed. Every 110ms a repeat code is transmitted for as long as the key remains down. This repeat code is simply a 9ms AGC pulse followed by a 2.25ms space and a 560µs burst.

- Repeat pulse



Note: when the pulse enters the integrated receiver, there will be decoding, signal amplifying and wave shaping process. So you need to make sure the level of the output is just the opposite from



# keystudio

---

that of the signal sending end. That is when there is no infrared signal, the output end is in high level; when there is infrared signal, the output end is in low level. You can see the pulse of the receiving end in the oscilloscope. Try to better understand the program base on what you see.

## Sample program

```
////////////////////////////////////
#include <IRremote.h>
int RECV_PIN = 11;
int LED1 = 2;
int LED2 = 3;
int LED3 = 4;
int LED4 = 5;
int LED5 = 6;
int LED6 = 7;
long on1 = 0x00FFA25D;
long off1 = 0x00FFE01F;
long on2 = 0x00FF629D;
long off2 = 0x00FFA857;
long on3 = 0x00FFE21D;
long off3 = 0x00FF906F;
long on4 = 0x00FF22DD;
long off4 = 0x00FF6897;
long on5 = 0x00FF02FD;
long off5 = 0x00FF9867;
long on6 = 0x00FFC23D;
long off6 = 0x00FFB047;
IRrecv irrecv(RECV_PIN);
decode_results results;
// Dumps out the decode_results structure.
// Call this after IRrecv::decode()
// void * to work around compiler issue
//void dump(void *v) {
//  decode_results *results = (decode_results *)v
void dump(decode_results *results) {
  int count = results->rawlen;
  if (results->decode_type == UNKNOWN)
  {
    Serial.println("Could not decode message");
  }
  else
  {
    if (results->decode_type == NEC)
```

# keyestudio

---

```
{
  Serial.print("Decoded NEC: ");
}
else if (results->decode_type == SONY)
{
  Serial.print("Decoded SONY: ");
}
else if (results->decode_type == RC5)
{
  Serial.print("Decoded RC5: ");
}
else if (results->decode_type == RC6)
{
  Serial.print("Decoded RC6: ");
}
Serial.print(results->value, HEX);
Serial.print(" (");
Serial.print(results->bits, DEC);
Serial.println(" bits)");
}
Serial.print("Raw (");
Serial.print(count, DEC);
Serial.print("): ");
for (int i = 0; i < count; i++)
{
  if ((i % 2) == 1) {
    Serial.print(results->rawbuf[i]*USECPERTICK, DEC);
  }
  else
  {
    Serial.print(-(int)results->rawbuf[i]*USECPERTICK, DEC);
  }
  Serial.print(" ");
}
Serial.println("");
}

void setup()
{
  pinMode(RECV_PIN, INPUT);
  pinMode(LED1, OUTPUT);
  pinMode(LED2, OUTPUT);
  pinMode(LED3, OUTPUT);
}
```

# keystudio

---

```
pinMode(LED4, OUTPUT);
pinMode(LED5, OUTPUT);
pinMode(LED6, OUTPUT);
pinMode(13, OUTPUT);
Serial.begin(9600);
  irrecv.enableIRIn(); // Start the receiver
}
int on = 0;
unsigned long last = millis();

void loop()
{
  if (irrecv.decode(&results))
  {
    // If it's been at least 1/4 second since the last
    // IR received, toggle the relay
    if (millis() - last > 250)
    {
      on = !on;
//      digitalWrite(8, on ? HIGH : LOW);
      digitalWrite(13, on ? HIGH : LOW);
      dump(&results);
    }
    if (results.value == on1 )
      digitalWrite(LED1, HIGH);
    if (results.value == off1 )
      digitalWrite(LED1, LOW);
    if (results.value == on2 )
      digitalWrite(LED2, HIGH);
    if (results.value == off2 )
      digitalWrite(LED2, LOW);
    if (results.value == on3 )
      digitalWrite(LED3, HIGH);
    if (results.value == off3 )
      digitalWrite(LED3, LOW);
    if (results.value == on4 )
      digitalWrite(LED4, HIGH);
    if (results.value == off4 )
      digitalWrite(LED4, LOW);
    if (results.value == on5 )
      digitalWrite(LED5, HIGH);
    if (results.value == off5 )
```

# keystudio

```
digitalWrite(LED5, LOW);
if (results.value == on6 )
  digitalWrite(LED6, HIGH);
if (results.value == off6 )
  digitalWrite(LED6, LOW);
last = millis();
irrecv.resume(); // Receive the next value
}
}
```

////////////////////////////////////

Program function

Decode the coded pulse signal emitted by the remote controller; execute corresponding action according to the results of the decoding. In this way, you will be able to control your device with remote controller.

## Result



**Note:** add IRremote folder into installation directory \Arduino\compiler libraries, or you will not be able to compile.

Infrared remote library :<https://github.com/shirriff/Arduino-IRremote>

\*\*\*\*\*

## Project 15: Analog value reading



### Introduction

In this experiment, we will begin the learning of analog I/O interfaces. On an Arduino, there are 6 analog interfaces numbered from 0 to 5. These 6 interfaces can also be used as digital ones numbered as 14-19. After a brief introduction, let's begin our project. Potentiometer used here is a typical output component of analog value that is familiar to us.

### Hardware required

Potentiometer \*1

Breadboard\*1

Breadboard jumper wires

### Circuit connection

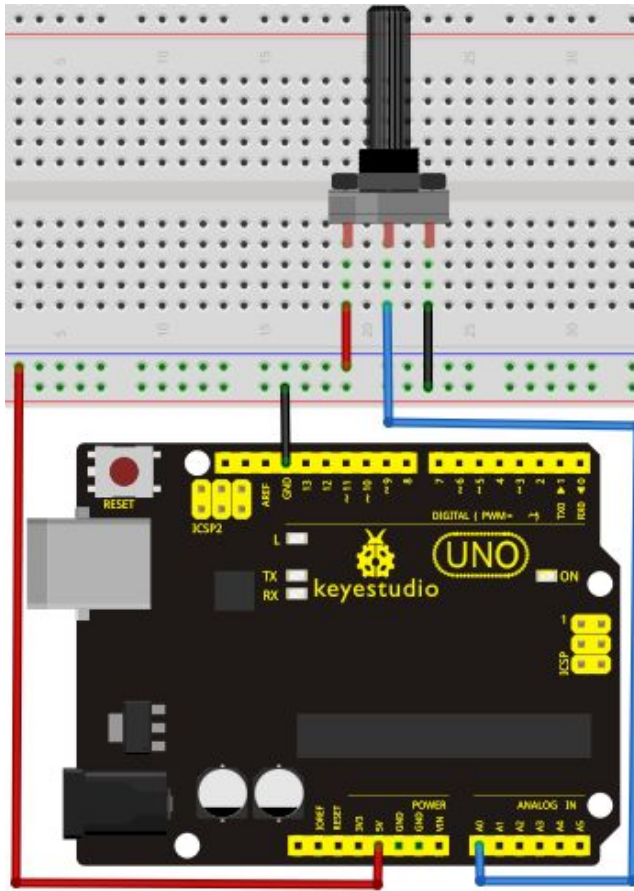
In this experiment, we will convert the resistance value of the potentiometer to analog ones and display it on the screen. This is an application we need to master well for our future experiments.

Connection circuit as below:

Connection for UNO R3:

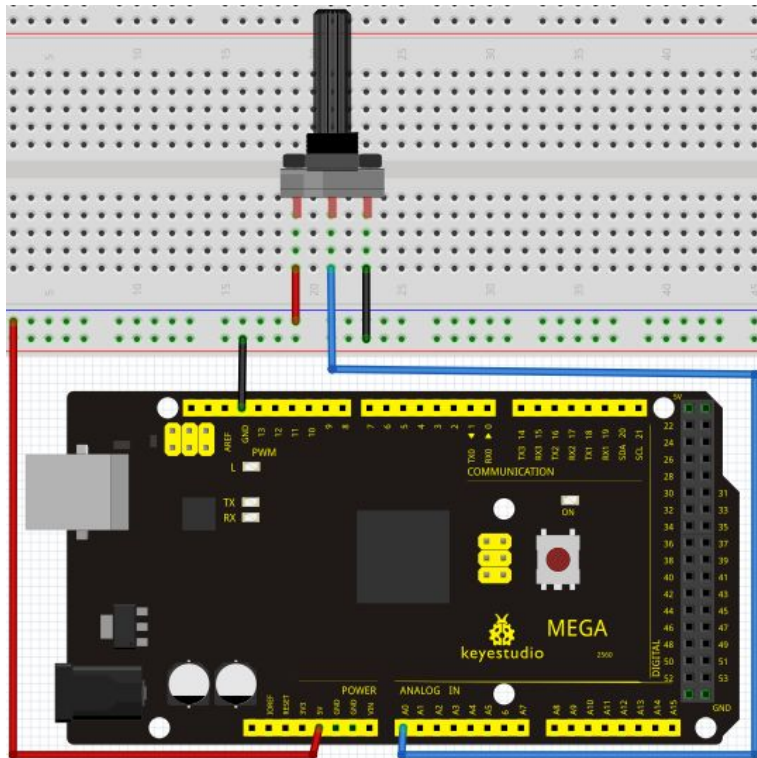
# keyestudio

---



Connection for 2560 R3:

# keyestudio



We use the analog interface 0.

The analog interface we use here is interface 0.

## Sample program

The program compiling is simple. An analogRead () Statement can read the value of the interface. The A/D acquisition of Arduino 328 is in 10 bits, so the value it reads is among 0 to 1023. One difficulty in this project is to display the value on the screen, which is actually easy to learn. First, we need to set the baud rate in voidsetup (). Displaying the value is a communication between Arduino and PC, so the baud rate of the Arduino should match the the one in the PC's software set up. Otherwise, the display will be messy codes or no display at all. In the lower right corner of the Arduino software monitor window, there is a button for baud rate set up. The set up here needs to match the one in the program. The statement in the program is Serial.begin(); enclosed is the baud rate value, followed by statement for displaying. You can either use Serial.print() or Serial.println() statement.

```
////////////////////////////////////
```

```
int potpin=0;// initialize analog pin 0
int ledpin=13;// initialize digital pin 13
int val=0;// define val, assign initial value 0
void setup()
{
pinMode(ledpin,OUTPUT);// set digital pin as "output"
Serial.begin(9600);// set baud rate at 9600
}
```

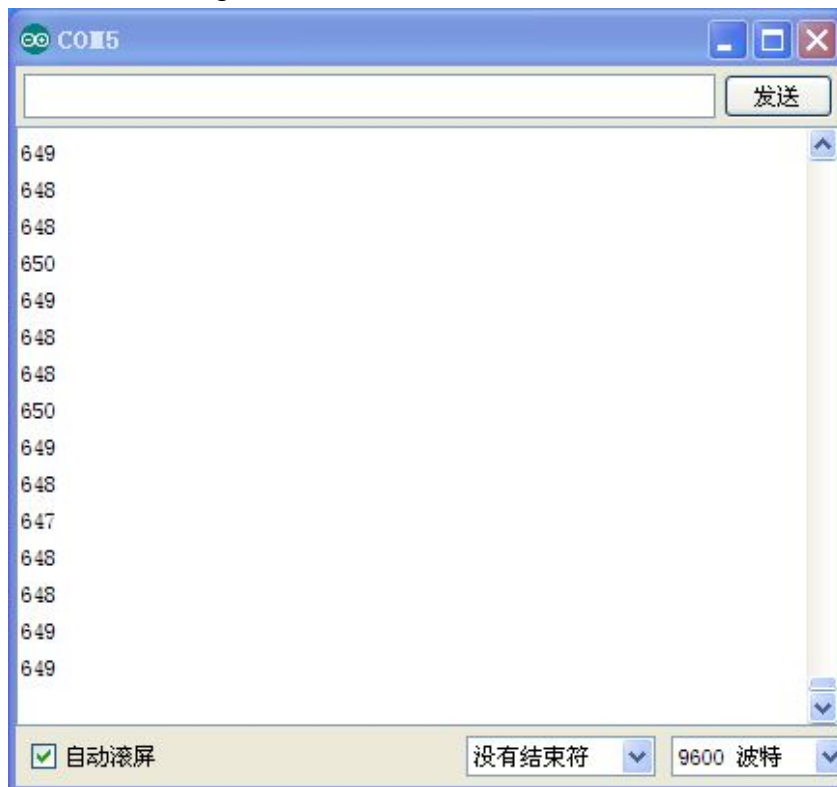
# keyestudio

```
void loop()
{
digitalWrite(ledpin,HIGH);// turn on the LED on pin 13
delay(50);// wait for 0.05 second
digitalWrite(ledpin,LOW);// turn off the LED on pin 13
delay(50);// wait for 0.05 second
val=analogRead(potpin);// read the analog value of analog pin 0, and assign it to val
Serial.println(val);// display val's value
}
////////////////////////////////////
```

## Result

The sample program uses the built-in LED connected to pin 13. Each time the device reads a value, the LED blinks.

Below is the analog value it reads.



When you rotate the potentiometer knob, you can see the displayed value changes. The reading of analog value is a very common function since most sensors output analog value. After calculation, we can have the corresponding value we need.

The experiment is now completed, thank you.

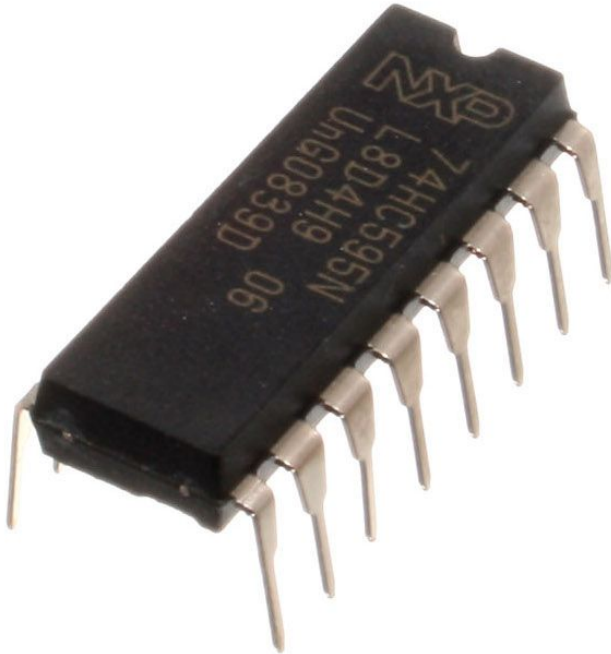
\*\*\*\*\*



# keystudio

---

## Project 16: 74HC595



### Introduction

To put it simply, 74HC595 is a combination of 8-digit shifting register, memorizer and equipped with tri-state output. Here, we use it to control 8 LEDs. You may wonder why use a 74HC595 to control LED? Well, think about how many I/O it takes for an Arduino to control 8 LEDs? Yes, 8. For an Arduino 168, it has only 20 I/O including analog ports. So, to save port resources, we use 74HC595 to reduce the number of ports it needs. Using 74HC595 enables us to use 3 digital I/O port to control 8 LEDs!

### Hardware required

74HC595 chip\*1

Red M5 LED\*4

Green M5 LED\*4

220Ω resistor\*8

Breadboard\*1

Breadboard jumper wires

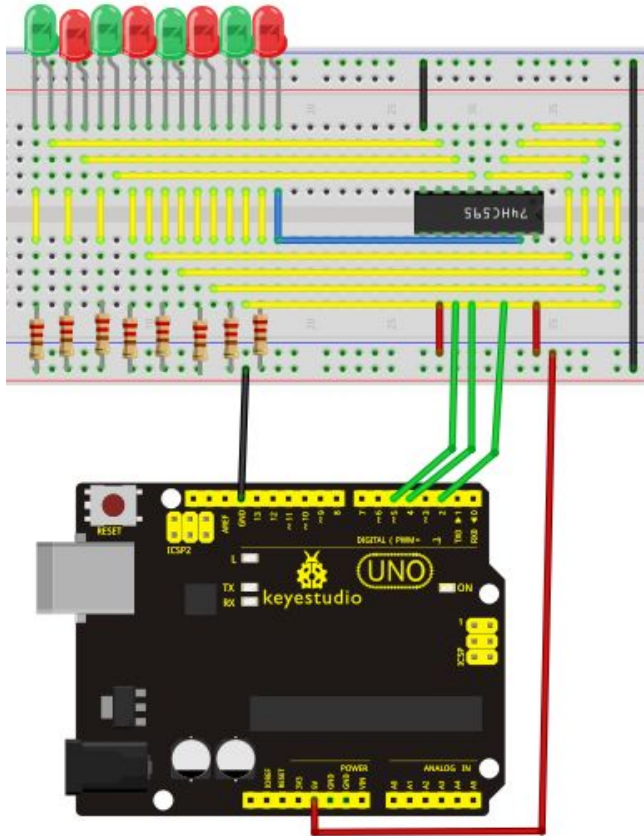
**Note:** for pin 13 OE port of 74HC595, it needs to be connected to GND

### Circuit connection

Connection for UNO R3:

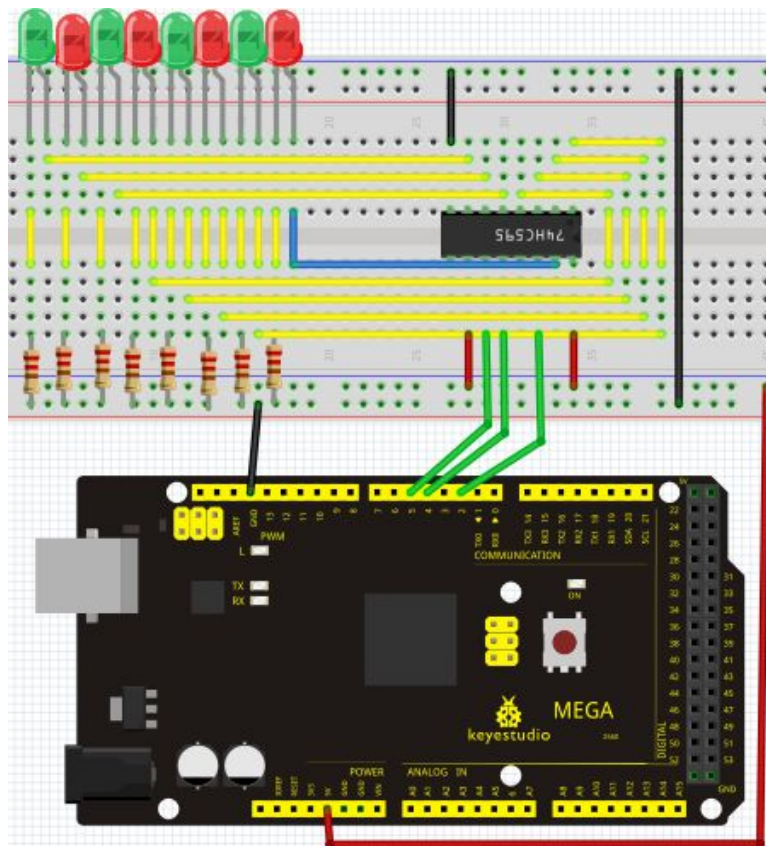
# keystudio

---



Connection for 2560 R3:

# keyestudio



The circuit may seem completed, but once you give it a good look, you will find it easy!

## Sample program

```
////////////////////////////////////  
int data = 2; // set pin 14 of 74HC595 as data input pin SI  
int clock = 5; // set pin 11 of 74hc595 as clock pin SCK  
int latch = 4; // set pin 12 of 74hc595 as output latch RCK  
int ledState = 0;  
const int ON = HIGH;  
const int OFF = LOW;  
void setup()  
{  
  pinMode(data, OUTPUT);  
  pinMode(clock, OUTPUT);  
  pinMode(latch, OUTPUT);  
}  
void loop()  
{  
  for(int i = 0; i < 256; i++)  
  {  
    updateLEDs(i);  
  }  
}
```

# keystudio

---

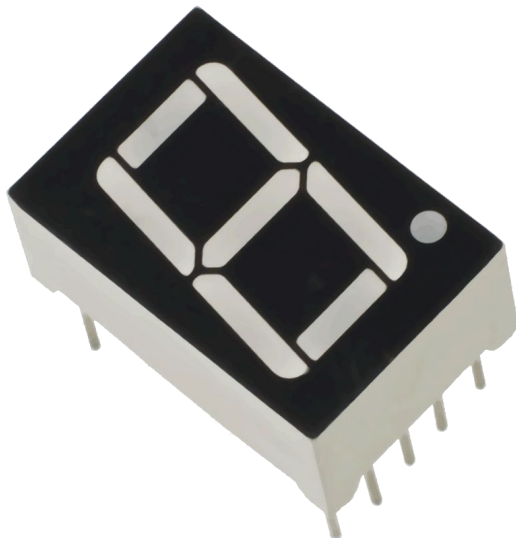
```
delay(500);
}
}
void updateLEDs(int value)
{
digitalWrite(latch, LOW);//
shiftOut(data, clock, MSBFIRST, ~value);// serial data "output", high level first
digitalWrite(latch, HIGH);// latch
}
////////////////////////////////////
```

## Result

After downloading the program, you can see 8 LEDs displaying 8-bit binary number.

\*\*\*\*\*

## Project 17: 1-digit LED segment display



## Introduction

LED segment displays are common for displaying numerical information. It's widely applied on displays of electromagnetic oven, full automatic washing machine, water temperature display, electronic clock etc. It is necessary that we learn how it works.

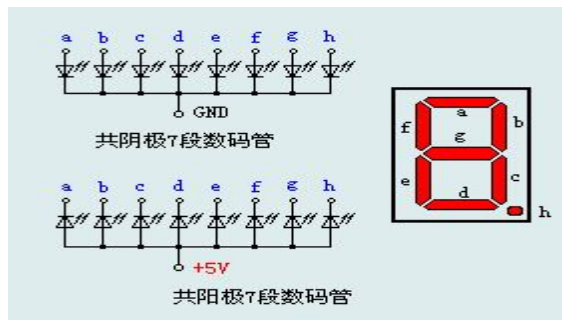
# keystudio

LED segment display is a semiconductor light-emitting device. Its basic unit is a light-emitting diode (LED). LED segment display can be divided into 7-segment display and 8-segment display according to the number of segments. 8-segment display has one more LED unit ( for decimal point display) than 7-segment one. In this experiment, we use a 8-segment display.

According to the wiring method of LED units, LED segment displays can be divided into display with common anode and display with common cathode. Common anode display refers to the one that combine all the anodes of LED units into one common anode (COM).

For the common anode display, connect the common anode (COM) to +5V. When the cathode level of a certain segment is low, the segment is on; when the cathode level of a certain segment is high, the segment is off. For the common cathode display, connect the common cathode (COM) to GND. When the anode level of a certain segment is high, the segment is on; when the anode level of a certain segment is low, the segment is off.

Common cathode 7-segment display



Common anode 7-segment display

Each segment of the display consists of an LED. So when you use it, you also need use a current-limiting resistor. Otherwise, LED will be burnt out. In this experiment, we use a common cathode display. As we mentioned above, for common cathode display, connect the common cathode (COM) to GND. When the anode level of a certain segment is high, the segment is on; when the anode level of a certain segment is low, the segment is off.

## Hardware required

Eight-segment display\*1

220Ω resistor\*8

Breadboard\*1

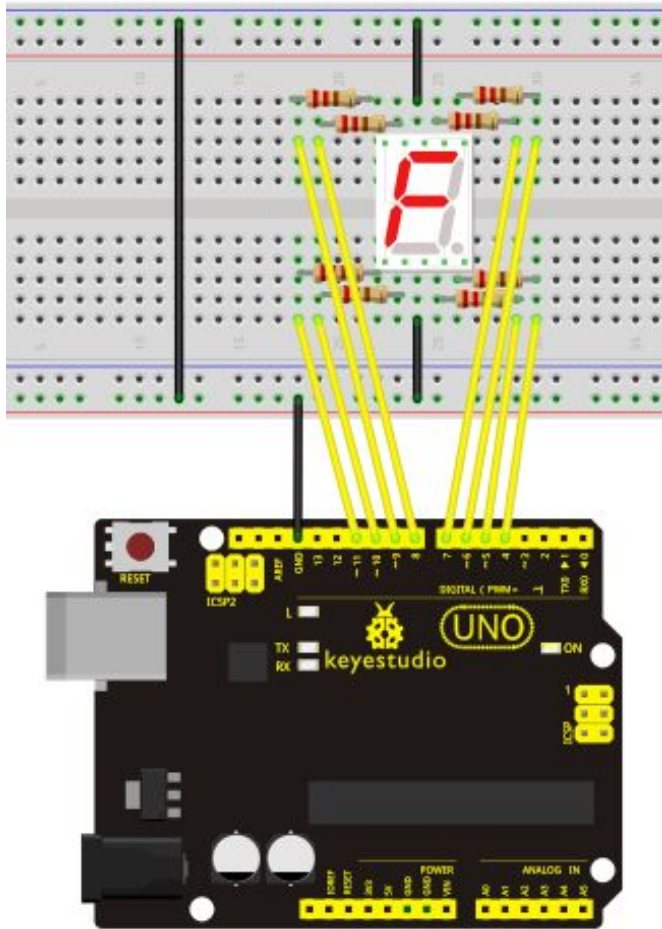
Breadboard jumper wires\*several

## Circuit connection

Connection for UNO R3:

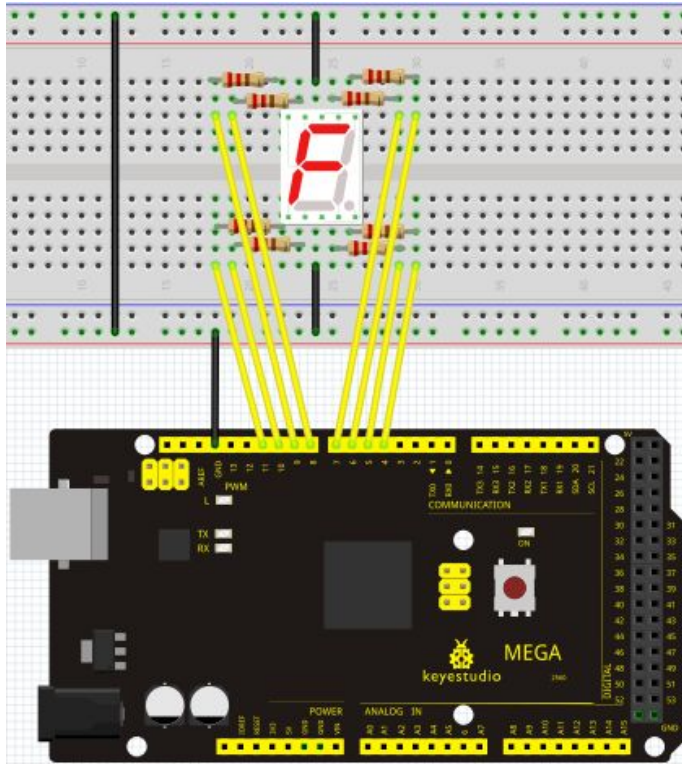
# keyestudio

---



Connection for 2560 R3:

# keyestudio



## Sample program

There are seven segments for numerical display, one for decimal point display. Corresponding segments will be turned on when displaying certain numbers. For example, when displaying number 1, b and c segments will be turned on. We compile a subprogram for each number, and compile the main program to display one number every 2 seconds, cycling display number 0 ~ 9. The displaying time for each number is subject to the delay time, the longer the delay time, the longer the displaying time.

```
////////////////////////////////////  
// set the IO pin for each segment  
int a=7;// set digital pin 7 for segment a  
int b=6;// set digital pin 6 for segment b  
int c=5;// set digital pin 5 for segment c  
int d=10;// set digital pin 10 for segment d  
int e=11;// set digital pin 11 for segment e  
int f=8;// set digital pin 8 for segment f  
int g=9;// set digital pin 9 for segment g  
int dp=4;// set digital pin 4 for segment dp  
void digital_0(void) // display number 5  
{  
  unsigned char j;  
  digitalWrite(a,HIGH);
```

# keystudio

---

```
digitalWrite(b,HIGH);
digitalWrite(c,HIGH);
digitalWrite(d,HIGH);
digitalWrite(e,HIGH);
digitalWrite(f,HIGH);
digitalWrite(g,LOW);
digitalWrite(dp,LOW);
}
void digital_1(void) // display number 1
{
unsigned char j;
digitalWrite(c,HIGH);// set level as "high" for pin 5, turn on segment c
digitalWrite(b,HIGH);// turn on segment b
for(j=7;j<=11;j++)// turn off other segments
digitalWrite(j,LOW);
digitalWrite(dp,LOW);// turn off segment dp
}
void digital_2(void) // display number 2
{
unsigned char j;
digitalWrite(b,HIGH);
digitalWrite(a,HIGH);
for(j=9;j<=11;j++)
digitalWrite(j,HIGH);
digitalWrite(dp,LOW);
digitalWrite(c,LOW);
digitalWrite(f,LOW);
}
void digital_3(void) // display number 3
{digitalWrite(g,HIGH);
digitalWrite(a,HIGH);
digitalWrite(b,HIGH);
digitalWrite(c,HIGH);
digitalWrite(d,HIGH);
digitalWrite(dp,LOW);
digitalWrite(f,LOW);
digitalWrite(e,LOW);
}
void digital_4(void) // display number 4
{digitalWrite(c,HIGH);
digitalWrite(b,HIGH);
digitalWrite(f,HIGH);
```



# keystudio

---

```
digitalWrite(g,HIGH);
digitalWrite(dp,LOW);
digitalWrite(a,LOW);
digitalWrite(e,LOW);
digitalWrite(d,LOW);
}
void digital_5(void) // display number 5
{
unsigned char j;
digitalWrite(a,HIGH);
digitalWrite(b, LOW);
digitalWrite(c,HIGH);
digitalWrite(d,HIGH);
digitalWrite(e, LOW);
digitalWrite(f,HIGH);
digitalWrite(g,HIGH);
digitalWrite(dp,LOW);
}
void digital_6(void) // display number 6
{
unsigned char j;
for(j=7;j<=11;j++)
digitalWrite(j,HIGH);
digitalWrite(c,HIGH);
digitalWrite(dp,LOW);
digitalWrite(b,LOW);
}
void digital_7(void) // display number 7
{
unsigned char j;
for(j=5;j<=7;j++)
digitalWrite(j,HIGH);
digitalWrite(dp,LOW);
for(j=8;j<=11;j++)
digitalWrite(j,LOW);
}
void digital_8(void) // display number 8
{
unsigned char j;
for(j=5;j<=11;j++)
digitalWrite(j,HIGH);
digitalWrite(dp,LOW);
```

# keystudio

---

```
}
void digital_9(void) // display number 5
{
  unsigned char j;
  digitalWrite(a,HIGH);
  digitalWrite(b,HIGH);
  digitalWrite(c,HIGH);
  digitalWrite(d,HIGH);
  digitalWrite(e, LOW);
  digitalWrite(f,HIGH);
  digitalWrite(g,HIGH);
  digitalWrite(dp,LOW);
}
void setup()
{
  int i;// set variable
  for(i=4;i<=11;i++)
  pinMode(i,OUTPUT);// set pin 4-11 as “output”
}
void loop()
{
  while(1)
  {
    digital_0();// display number 0
    delay(1000);// wait for 1s
    digital_1();// display number 1
    delay(1000);// wait for 1s
    digital_2();// display number 2
    delay(1000); // wait for 1s
    digital_3();// display number 3
    delay(1000); // wait for 1s
    digital_4();// display number 4
    delay(1000); // wait for 1s
    digital_5();// display number 5
    delay(1000); // wait for 1s
    digital_6();// display number 6
    delay(1000); // wait for 1s
    digital_7();// display number 7
    delay(1000); // wait for 1s
    digital_8();// display number 8
    delay(1000); // wait for 1s
    digital_9();// display number 9
```

# keystudio

---

```
delay(1000); // wait for 1s
}
}
////////////////////////////////////
```

## Result

LED segment display displays number 0 to 9.

\*\*\*\*\*

## Project 18: 4-digit LED segment display

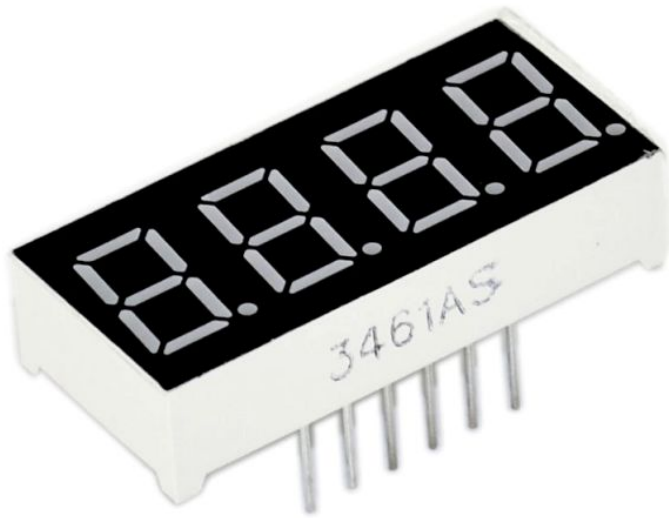
### Introduction

In this experiment, we use an Arduino to drive a common anode, 4-digit, 7-segment LED display. For LED display, current-limiting resistors are indispensable. There are two wiring method for Current-limiting resistor. One is to connect one resistor for each anode, 4 in totals for d1-d4 anode. An advantage for this method is that it requires fewer resistors, only 4. But it cannot maintain consistent brightness, 1 the brightest, 8, the least bright. Another method is to connect one resistor to each pin. It guarantees consistent brightness, but requires more resistors. In this experiment, we use 8 220Ω resistors (we use 220Ω resistors because no 100Ω resistor available. If you use 100Ω, the displaying will be brighter).

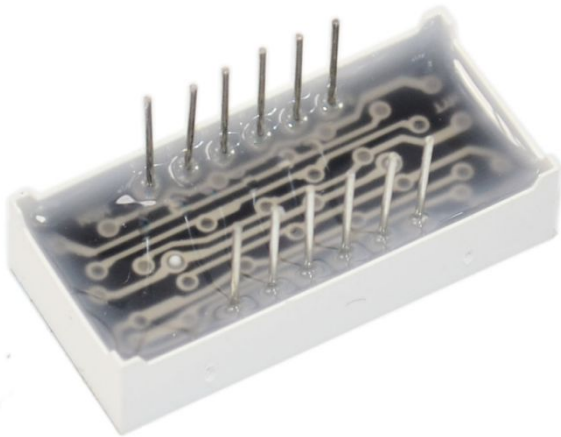
### Circuit connection

# keystudio

---

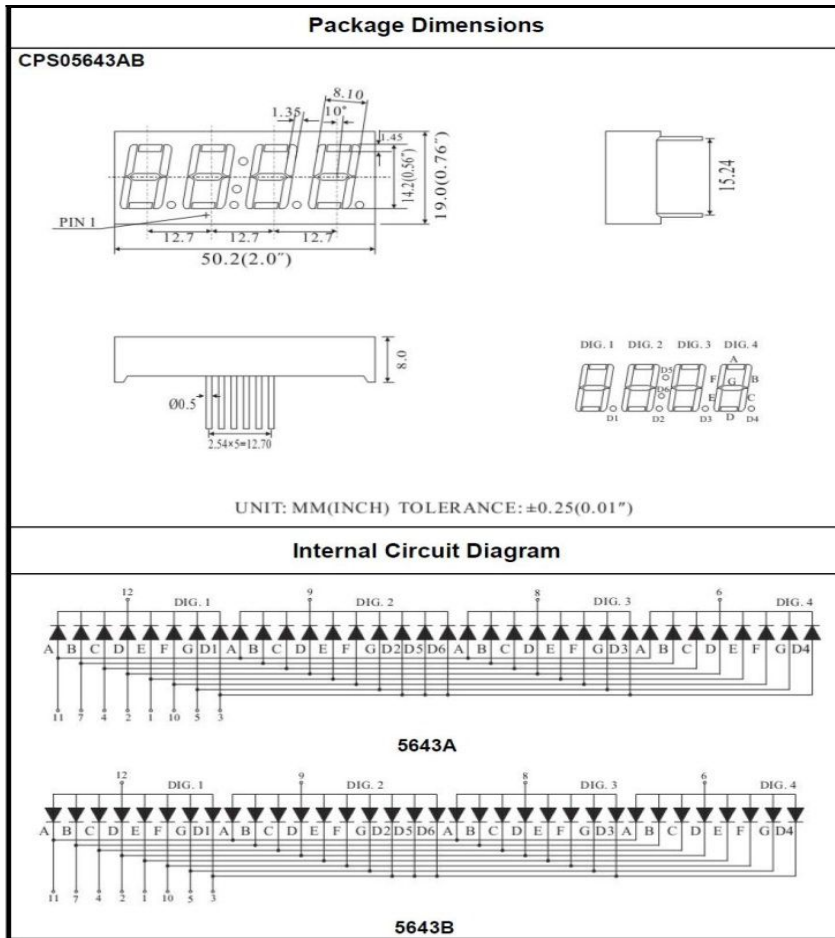


For 4-digit displays, there are 12 pins in total. When you place the decimal point downward , the pin on the lower left part is refer to as 1, the upper left part 12.



Manual for LED segment display

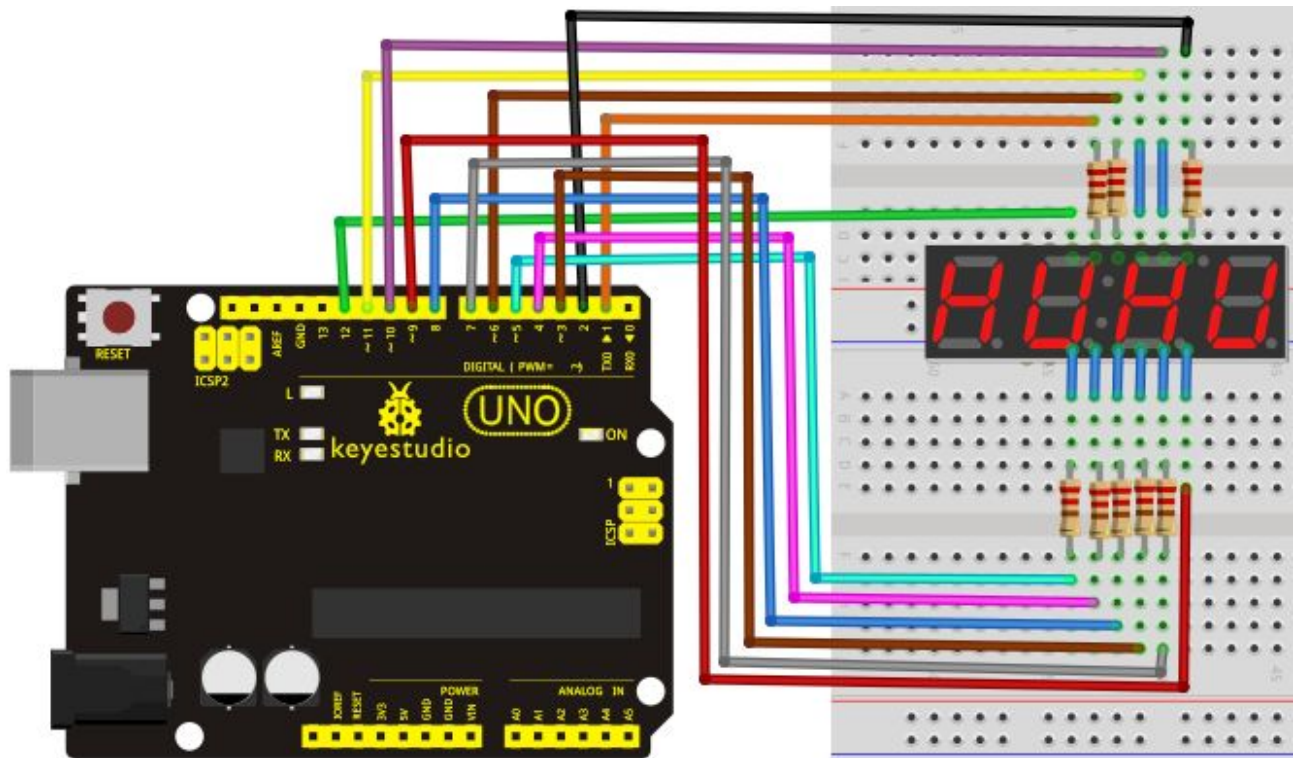
# keystudio



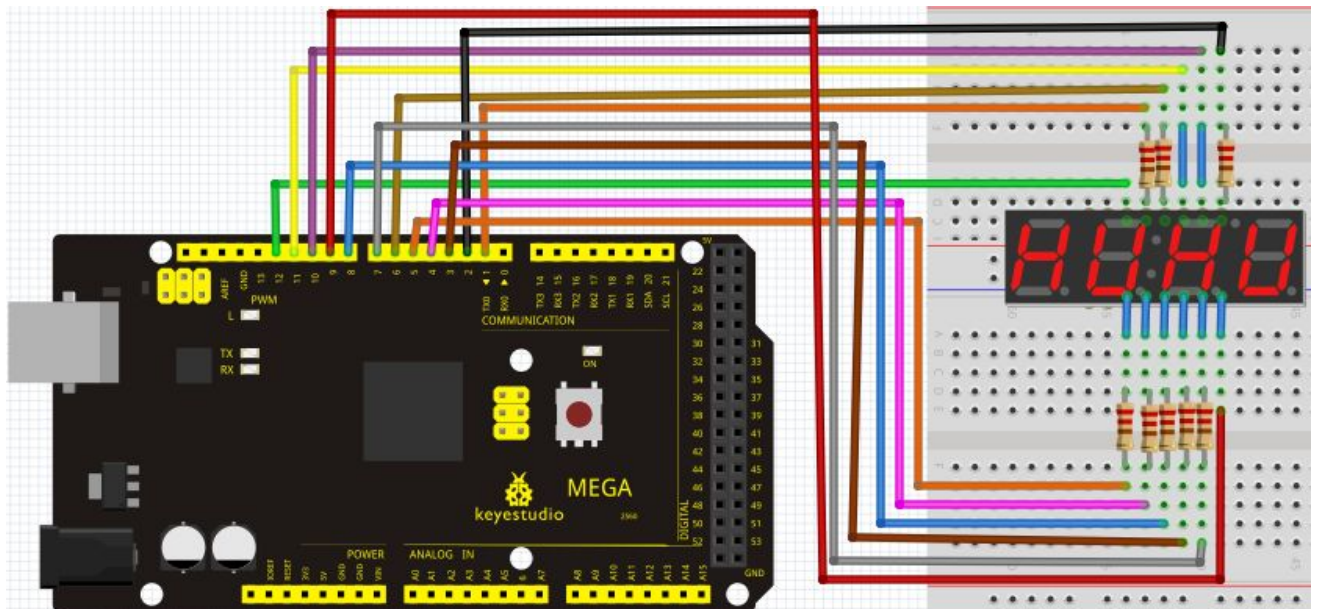
**Four Digits Displays Series**

Connection for UNO R3:

# keystudio



Connection for 2560 R3:



Sample Program

////////////////////////////////////

# keystudio

---

```
// display 1234
  // select pin for cathode
  int a = 1;
  int b = 2;
  int c = 3;
  int d = 4;
  int e = 5;
  int f = 6;
  int g = 7;
  int dp = 8;
  // select pin for anode
  int d4 = 9;
  int d3 = 10;
  int d2 = 11;
  int d1 = 12;
  // set variable
  long n = 1230;
  int x = 100;
  int del = 55; // fine adjustment for clock

void setup()
{
  pinMode(d1, OUTPUT);
  pinMode(d2, OUTPUT);
  pinMode(d3, OUTPUT);
  pinMode(d4, OUTPUT);
  pinMode(a, OUTPUT);
  pinMode(b, OUTPUT);
  pinMode(c, OUTPUT);
  pinMode(d, OUTPUT);
  pinMode(e, OUTPUT);
  pinMode(f, OUTPUT);
  pinMode(g, OUTPUT);
  pinMode(dp, OUTPUT);
}
/////////////////////////////////////////////////////////////////
void loop()
{
  Display(1, 1);
  Display(2, 2);
  Display(3, 3);
  Display(4, 4);
```

# keystudio

---

```
}
////////////////////////////////////
void WeiXuan(unsigned char n)//
{
    switch(n)
    {
    case 1:
        digitalWrite(d1,LOW);
        digitalWrite(d2, HIGH);
        digitalWrite(d3, HIGH);
        digitalWrite(d4, HIGH);
        break;
    case 2:
        digitalWrite(d1, HIGH);
        digitalWrite(d2, LOW);
        digitalWrite(d3, HIGH);
        digitalWrite(d4, HIGH);
        break;
    case 3:
        digitalWrite(d1,HIGH);
        digitalWrite(d2, HIGH);
        digitalWrite(d3, LOW);
        digitalWrite(d4, HIGH);
        break;
    case 4:
        digitalWrite(d1, HIGH);
        digitalWrite(d2, HIGH);
        digitalWrite(d3, HIGH);
        digitalWrite(d4, LOW);
        break;
    default :
        digitalWrite(d1, HIGH);
        digitalWrite(d2, HIGH);
        digitalWrite(d3, HIGH);
        digitalWrite(d4, HIGH);
        break;
    }
}
void Num_0()
{
    digitalWrite(a, HIGH);
```



# keystudio

---

```
digitalWrite(b, HIGH);
digitalWrite(c, HIGH);
digitalWrite(d, HIGH);
digitalWrite(e, HIGH);
digitalWrite(f, HIGH);
digitalWrite(g, LOW);
digitalWrite(dp,LOW);
}
void Num_1()
{
digitalWrite(a, LOW);
digitalWrite(b, HIGH);
digitalWrite(c, HIGH);
digitalWrite(d, LOW);
digitalWrite(e, LOW);
digitalWrite(f, LOW);
digitalWrite(g, LOW);
digitalWrite(dp,LOW);
}
void Num_2()
{
digitalWrite(a, HIGH);
digitalWrite(b, HIGH);
digitalWrite(c, LOW);
digitalWrite(d, HIGH);
digitalWrite(e, HIGH);
digitalWrite(f, LOW);
digitalWrite(g, HIGH);
digitalWrite(dp,LOW);
}
void Num_3()
{
digitalWrite(a, HIGH);
digitalWrite(b, HIGH);
digitalWrite(c, HIGH);
digitalWrite(d, HIGH);
digitalWrite(e, LOW);
digitalWrite(f, LOW);
digitalWrite(g, HIGH);
digitalWrite(dp,LOW);
}
void Num_4()
```

# keystudio

---

```
{
    digitalWrite(a, LOW);
    digitalWrite(b, HIGH);
    digitalWrite(c, HIGH);
    digitalWrite(d, LOW);
    digitalWrite(e, LOW);
    digitalWrite(f, HIGH);
    digitalWrite(g, HIGH);
    digitalWrite(dp,LOW);
}
void Num_5()
{
    digitalWrite(a, HIGH);
    digitalWrite(b, LOW);
    digitalWrite(c, HIGH);
    digitalWrite(d, HIGH);
    digitalWrite(e, LOW);
    digitalWrite(f, HIGH);
    digitalWrite(g, HIGH);
    digitalWrite(dp,LOW);
}
void Num_6()
{
    digitalWrite(a, HIGH);
    digitalWrite(b, LOW);
    digitalWrite(c, HIGH);
    digitalWrite(d, HIGH);
    digitalWrite(e, HIGH);
    digitalWrite(f, HIGH);
    digitalWrite(g, HIGH);
    digitalWrite(dp,LOW);
}
void Num_7()
{
    digitalWrite(a, HIGH);
    digitalWrite(b, HIGH);
    digitalWrite(c, HIGH);
    digitalWrite(d, LOW);
    digitalWrite(e, LOW);
    digitalWrite(f, LOW);
    digitalWrite(g, LOW);
    digitalWrite(dp,LOW);
}
```

# keystudio

---

```
}
void Num_8()
{
    digitalWrite(a, HIGH);
    digitalWrite(b, HIGH);
    digitalWrite(c, HIGH);
    digitalWrite(d, HIGH);
    digitalWrite(e, HIGH);
    digitalWrite(f, HIGH);
    digitalWrite(g, HIGH);
    digitalWrite(dp,LOW);
}
void Num_9()
{
    digitalWrite(a, HIGH);
    digitalWrite(b, HIGH);
    digitalWrite(c, HIGH);
    digitalWrite(d, HIGH);
    digitalWrite(e, LOW);
    digitalWrite(f, HIGH);
    digitalWrite(g, HIGH);
    digitalWrite(dp,LOW);
}
void Clear() // clear the screen
{
    digitalWrite(a, LOW);
    digitalWrite(b, LOW);
    digitalWrite(c, LOW);
    digitalWrite(d, LOW);
    digitalWrite(e, LOW);
    digitalWrite(f, LOW);
    digitalWrite(g, LOW);
    digitalWrite(dp,LOW);
}
void pickNumber(unsigned char n)// select number
{
    switch(n)
    {
        case 0:Num_0();
        break;
        case 1:Num_1();
        break;
    }
}
```

# keystudio

---

```
    case 2:Num_2();
    break;
    case 3:Num_3();
    break;
    case 4:Num_4();
    break;
    case 5:Num_5();
    break;
    case 6:Num_6();
    break;
    case 7:Num_7();
    break;
    case 8:Num_8();
    break;
    case 9:Num_9();
    break;
    default:Clear();
    break;
}
}
void Display(unsigned char x, unsigned char Number)// take x as coordinate and display number
{
    WeiXuan(x);
    pickNumber(Number);
    delay(1);
    Clear() ; // clear the screen
}
////////////////////////////////////
```

## Result

Download the above code to the controller board and see the result.

The experiment result displays 1234 on the display.

Note: if it's not displaying correctly, check the wiring.

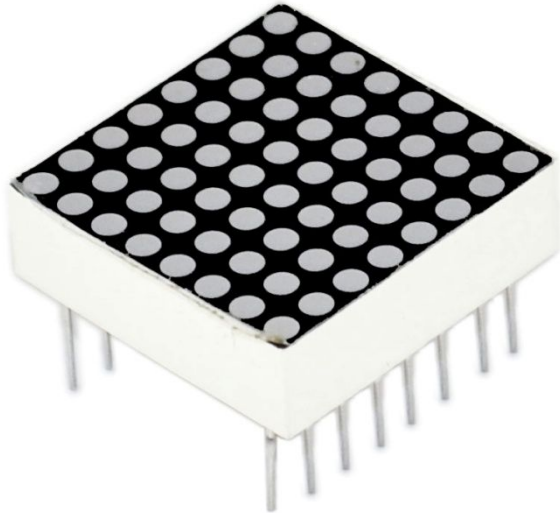
Thank you.

\*\*\*\*\*

# keystudio

---

## Project 19: 8\*8 LED matrix



### Introduction

#### Introduction

With low-voltage scanning, LED dot-matrix displays have advantages such as power saving, long service life, low cost, high brightness, wide angle of view, long visual range, waterproof, and numerous specifications. LED dot-matrix displays can meet the needs of different applications and thus have a broad development prospect. This time, we will conduct an LED dot-matrix experiment to experience its charm firsthand.

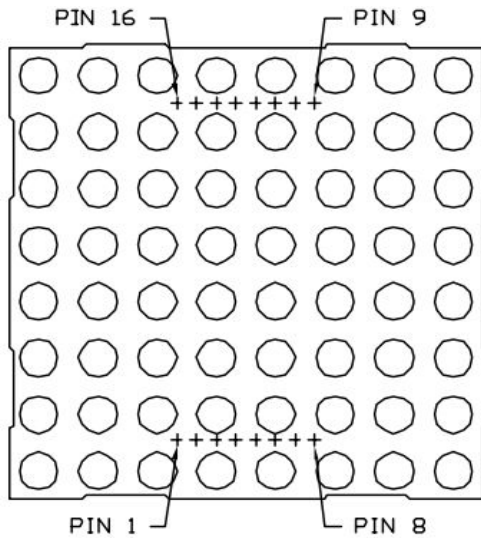
### Hardware required

- 1 \* Uno board
- 1 \* 8\*8 dot-matrix
- 8 \* Resistor (220 $\Omega$ )
- 1 \* Breadboard
- 2 \* 74HC595
- 1 \* USB cable
- Jumper wires

### Circuit connection

# keyestudio

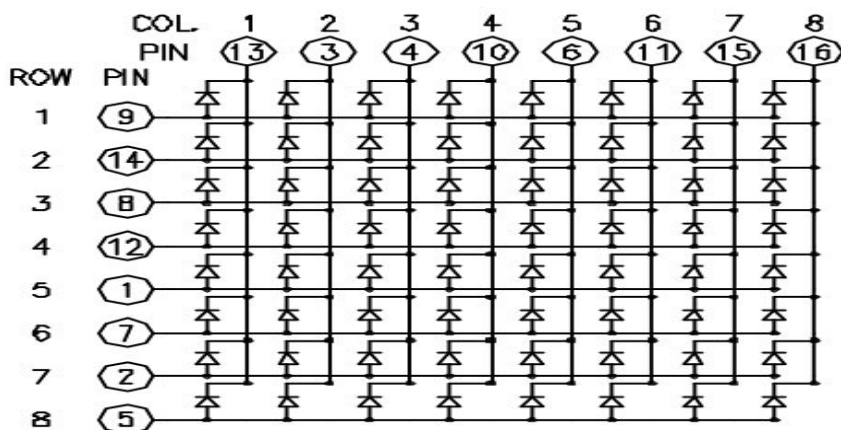
The external view of a dot-matrix is shown as follows:



The display principle of the 8\*8 dot-matrix:

The 8\*8 dot-matrix is made up of sixty-four LEDs, and each LED is placed at the cross point of a row and a column. When the electrical level of a certain row is 1 and the electrical level of a certain column is 0, the corresponding LED will light up. If you want to light the LED on the first dot, you should set pin 9 to high level and pin 13 to low level. If you want to light LEDs on the first row, you should set pin 9 to high level and pins 13, 3, 4, 10, 6, 11, 15 and 16 to low level. If you want to light the LEDs on the first column, set pin 13 to low level and pins 9, 14, 8, 12, 1, 7, 2 and 5 to high level.

The internal view of a dot-matrix is shown as follows:



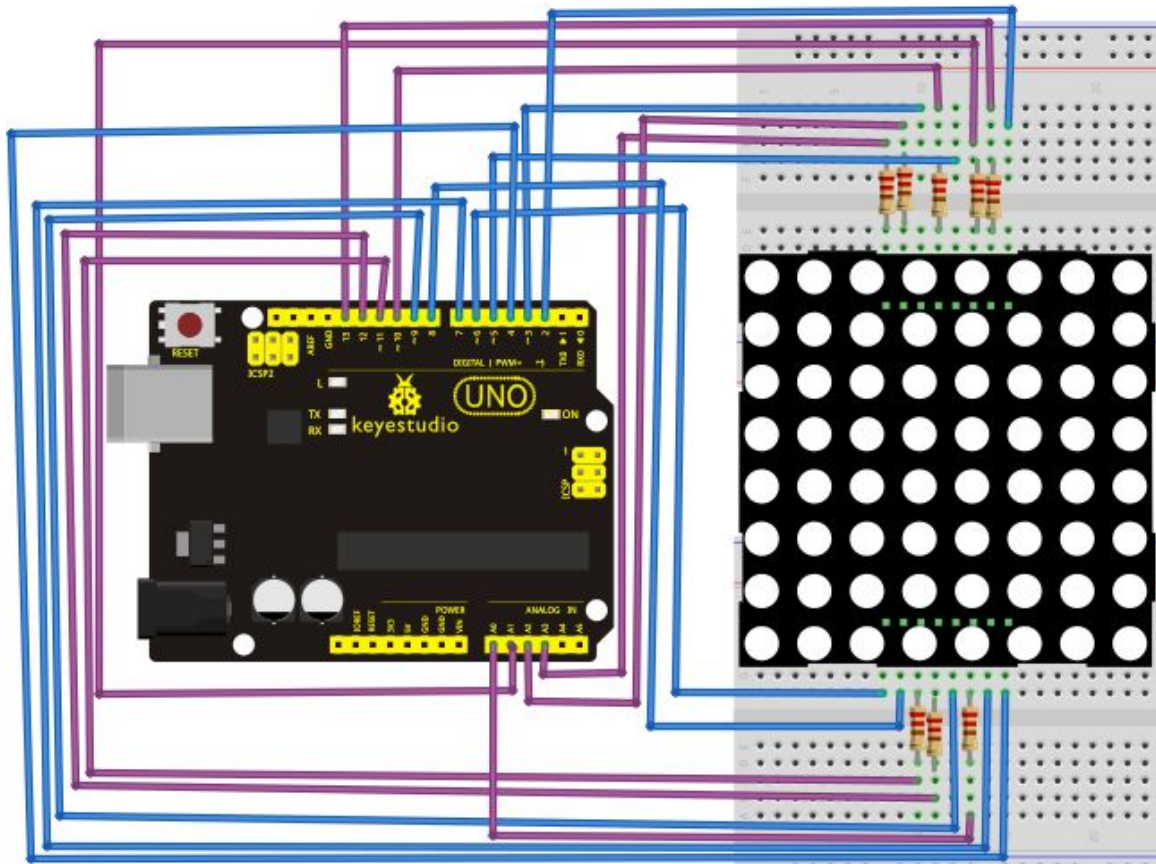
The principle of 74HC595 has been previously illustrated. One chip is used to control the rows of the dot-matrix while the other chip is used to control the columns.

Connect circuit as shown in the following diagram:

# keyestudio

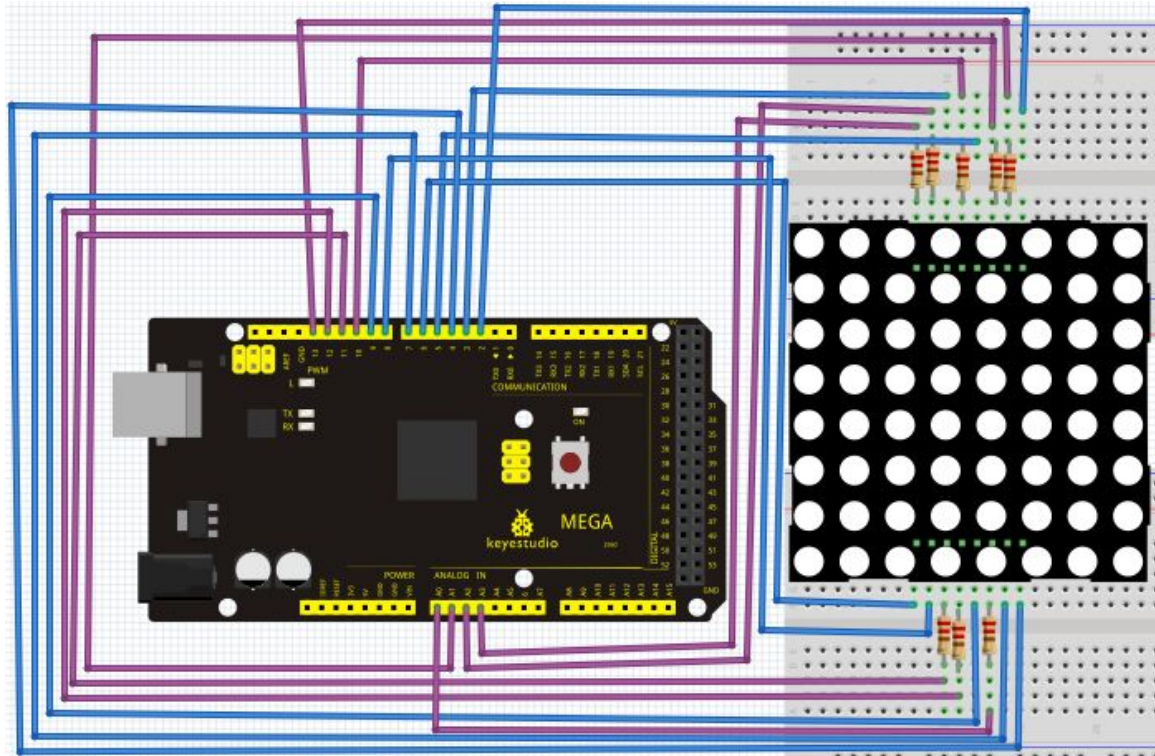
---

Connection for UNO R3:



Connection for 2560 R3:

# keyestudio



## Sample program for displaying “0”

```
////////////////////////////////////  
// set an array to store character of “0”  
unsigned char Text[]={0x00,0x1c,0x22,0x22,0x22,0x22,0x22,0x1c};  
void Draw_point(unsigned char x,unsigned char y)// point drawing function  
{ clear_();  
  digitalWrite(x+2, HIGH);  
  digitalWrite(y+10, LOW);  
  delay(1);  
}  
void show_num(void)// display function, call point drawing function  
{  
  unsigned char i,j,data;  
  for(i=0;i<8;i++)  
  {  
    data=Text[i];  
    for(j=0;j<8;j++)  
    {  
      if(data & 0x01)Draw_point(j,i);  
      data>>=1;  
    }  
  }  
}
```



# keystudio

---

```
    }  
  }  
  void setup(){  
  int i = 0 ;  
  for(i=2;i<18;i++)  
  {  
    pinMode(i, OUTPUT);  
  }  
  clear_();  
}  
void loop()  
{ show_num();  
}  
void clear_(void)// clear screen  
{for(int i=2;i<10;i++)  
  digitalWrite(i, LOW);  
  for(int i=0;i<8;i++)  
    digitalWrite(i+10, HIGH);  
}  
////////////////////////////////////
```

## Result

Burn the program into Uno board The dot-matrix will display 0.

\*\*\*\*\*

## Project 20: 1602 LCD



## Introduction

In this experiment, we use an Arduino to drive the 1602 LCD.

# keystudio

1602 LCD has wide applications. In the beginning, 1602 LCD uses a HD44780 controller. Now, almost all 1602 LCD module uses a compatible IC, so their features are basically the same.

1602LCD main parameters:

- Display capacity: 16 \* 2 characters.
- Chip operating voltage: 4.5 ~ 5.5V.
- Working current: 2.0mA (5.0V).
- Optimum working voltage of the module is 5.0V.
- Character size: 2.95 \* 4.35 (W \* H) mm.

Pin description of 1602 LCD

No.	Mark	Pin description	No.	Mark	Pin description
1	VSS	Power GND	9	D2	Date I/O
2	VDD	Power positive	10	D3	Date I/O
3	VL	LCD voltage bias signal	11	D4	Date I/O
4	RS	Select data/command(V/L)	12	D5	Date I/O
5	R/W	Select read/write(H/L)	13	D6	Date I/O
6	E	Enable signal	14	D7	Date I/O
7	D0	Date I/O	15	BLA	Back light power positive
8	D1	Date I/O	16	BLK	Back light power negative

Interface description:

1. two power sources, one for module power, another one for back light, generally use 5V. In this project, we use 3.3V for back light.
2. VL is the pin for adjusting contrast ratio; it usually connects a potentiometer(no more than 5K $\Omega$ ) in series for its adjustment. In this experiment, we use a 1K $\Omega$  resistor. For its connection, it has 2 methods, namely high potential and low potential. Here, we use low potential method; connect the resistor and then the GND.
3. RS is a very common pin in LCD. It's a selecting pin for command/data. When the pin is in high level, it's in data mode; when it's in low level, it's in command mode.
4. RW pin is also very common in LCD. It's a selecting pin for read/write. When the pin is in high level, it's in read operation; when it's in low level, it's in write operation.
5. E pin is also very common in LCD. Usually, when the signal in the bus is stabilized, it sends out a positive pulse requiring read operation. When this pin is in high level, the bus is not allowed to have any change.
6. D0-D7 is 8-bit bidirectional parallel bus, used for command and data transmission.
7. BLA is anode for back light; BLK, cathode for back light.

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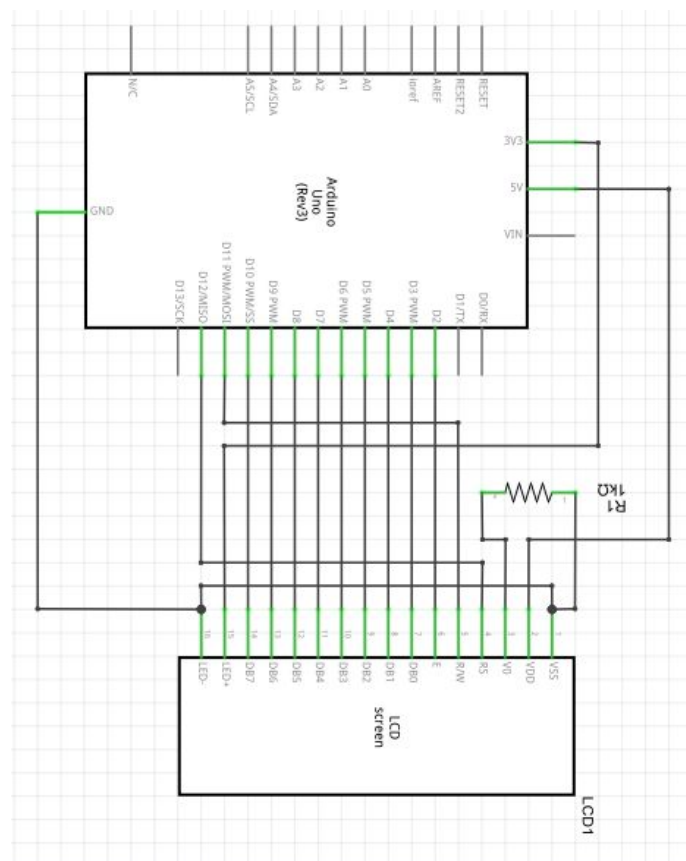
4 basic operations of 1602LCD:

Read status	input	RS=L, R/W=H, E=H	output	D0-D7=status word
Write command	input	RS=L, R/W=H, D0-D7=command code, E=high pulse	output	none
Read data	input	RS=H, R/W=H, E=H	output	D0-D7=data
Write data	input	RS=H, R/W=L, D0-D7=data, E=high pulse	output	none

## Connection & sample program

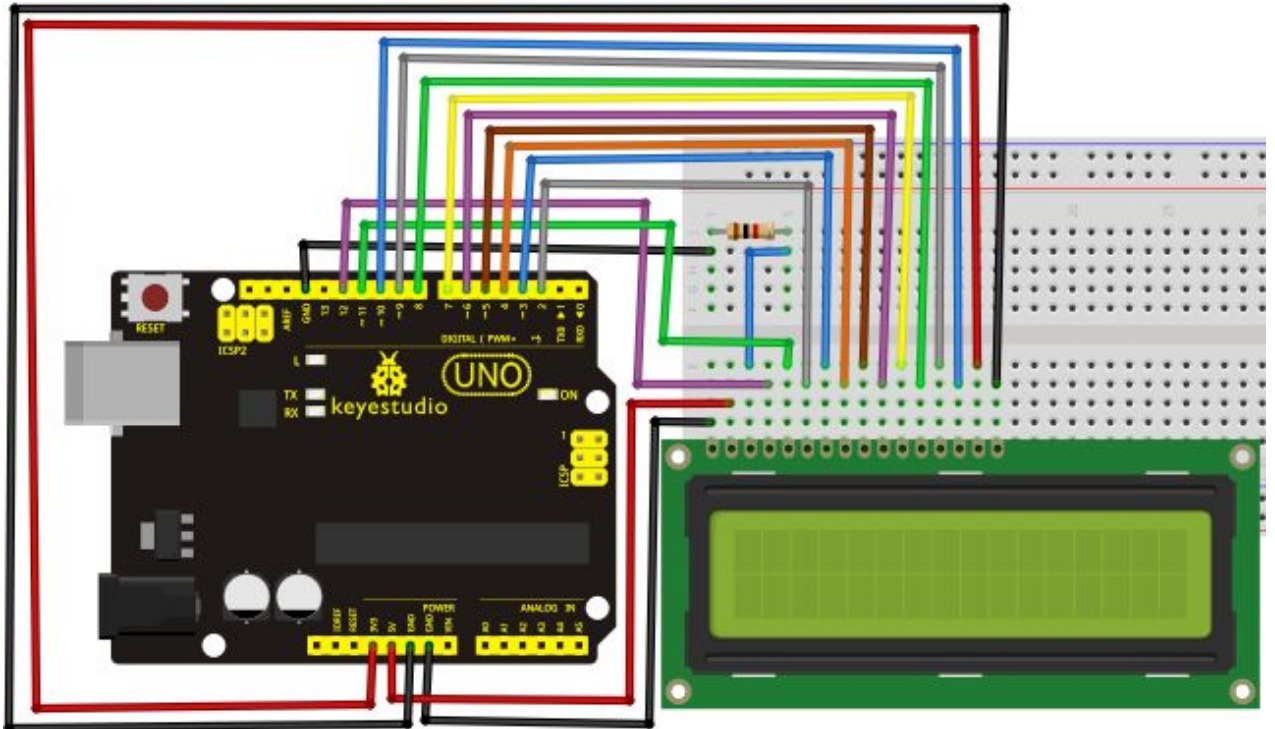
1602 can directly communicate with Arduino. According to the product manual, it has two connection methods, namely 8-bit connection and 4-bit connection.

### 8-bit connection method:

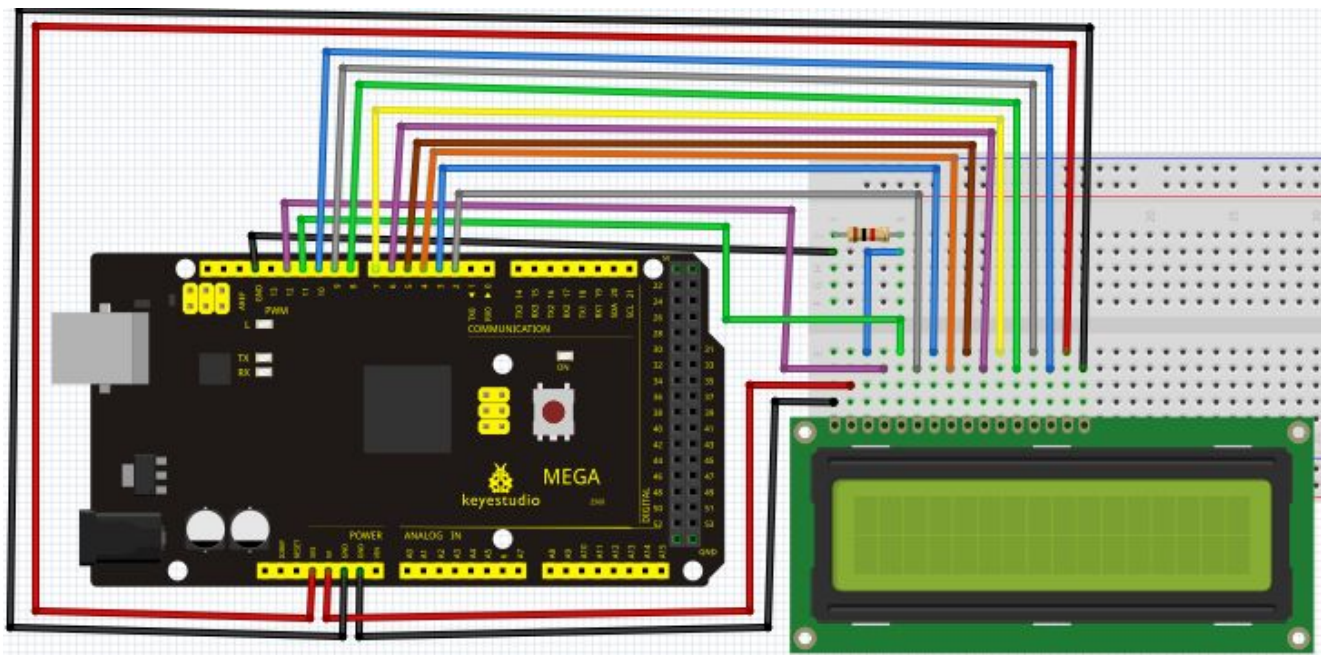


Connection for UNO R3:

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Connection for 2560 R3:



## Sample code A:

```
////////////////////////////////////  
int DI = 12;  
int RW = 11;
```

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---

```
int DB[] = {3, 4, 5, 6, 7, 8, 9, 10}; // use array to select pin for bus
int Enable = 2;

void LcdCommandWrite(int value) {
// define all pins
int i = 0;
for (i=DB[0]; i <= DI; i++) // assign value for bus
{
    digitalWrite(i,value & 01); // for 1602 LCD, it uses D7-D0( not D0-D7) for signal identification;
    here, it's used for signal inversion.
    value >>= 1;
}
digitalWrite(Enable,LOW);
delayMicroseconds(1);
digitalWrite(Enable,HIGH);
delayMicroseconds(1); // wait for 1ms
digitalWrite(Enable,LOW);
delayMicroseconds(1); // wait for 1ms
}

void LcdDataWrite(int value) {
// initialize all pins
int i = 0;
digitalWrite(DI, HIGH);
digitalWrite(RW, LOW);
for (i=DB[0]; i <= DB[7]; i++) {
    digitalWrite(i,value & 01);
    value >>= 1;
}
digitalWrite(Enable,LOW);
delayMicroseconds(1);
digitalWrite(Enable,HIGH);
delayMicroseconds(1);
digitalWrite(Enable,LOW);
delayMicroseconds(1); // wait for 1ms
}

void setup (void) {
int i = 0;
for (i=Enable; i <= DI; i++) {
    pinMode(i,OUTPUT);
}
}
```

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---

```
delay(100);
// initialize LCD after a brief pause
// for LCD control
LcdCommandWrite(0x38); // select as 8-bit interface, 2-line display, 5x7 character size
delay(64);
LcdCommandWrite(0x38); // select as 8-bit interface, 2-line display, 5x7 character size
delay(50);
LcdCommandWrite(0x38); // select as 8-bit interface, 2-line display, 5x7 character size
delay(20);
LcdCommandWrite(0x06); // set input mode
                        // auto-increment, no display of shifting
delay(20);
LcdCommandWrite(0x0E); // display setup
                        // turn on the monitor, cursor on, no flickering
delay(20);
LcdCommandWrite(0x01); // clear the scree, cursor position returns to 0
delay(100);
LcdCommandWrite(0x80); // display setup
                        // turn on the monitor, cursor on, no flickering

delay(20);
}

void loop (void) {
  LcdCommandWrite(0x01); // clear the scree, cursor position returns to 0
  delay(10);
  LcdCommandWrite(0x80+3);
  delay(10);
  // write in welcome message
  LcdDataWrite('W');
  LcdDataWrite('e');
  LcdDataWrite('l');
  LcdDataWrite('c');
  LcdDataWrite('o');
  LcdDataWrite('m');
  LcdDataWrite('e');
  LcdDataWrite(' ');
  LcdDataWrite('t');
  LcdDataWrite('o');
  delay(10);
  LcdCommandWrite(0xc0+1); // set cursor position at second line, second position
  delay(10);
}
```

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---

```
LcdDataWrite('g');
LcdDataWrite('e');
LcdDataWrite('e');
LcdDataWrite('k');
LcdDataWrite('-');
LcdDataWrite('w');
LcdDataWrite('o');
LcdDataWrite('r');
LcdDataWrite('k');
LcdDataWrite('s');
LcdDataWrite('h');
LcdDataWrite('o');
LcdDataWrite('p');
delay(5000);
LcdCommandWrite(0x01); // clear the screen, cursor returns to 0
delay(10);
LcdDataWrite('I');
LcdDataWrite(' ');
LcdDataWrite('a');
LcdDataWrite('m');
LcdDataWrite(' ');
LcdDataWrite('h');
LcdDataWrite('o');
LcdDataWrite('n');
LcdDataWrite('g');
LcdDataWrite('y');
LcdDataWrite('i');
delay(3000);
LcdCommandWrite(0x02); // set mode as new characters replay old ones, where there is no new
ones remain the same
delay(10);
LcdCommandWrite(0x80+5); // set cursor position at first line, sixth position
delay(10);
LcdDataWrite('t');
LcdDataWrite('h');
LcdDataWrite('e');
LcdDataWrite(' ');
LcdDataWrite('a');
LcdDataWrite('d');
LcdDataWrite('m');
LcdDataWrite('i');
LcdDataWrite('n');
```

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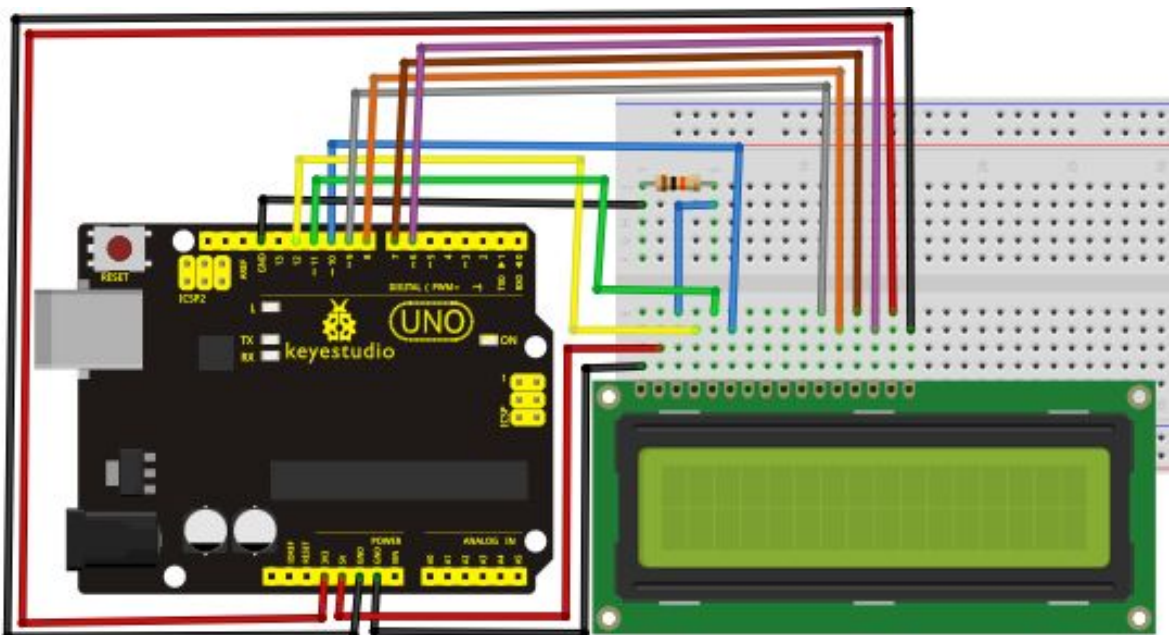
```
delay(5000);  
}  
////////////////////////////////////
```

## 4-bit connection method:

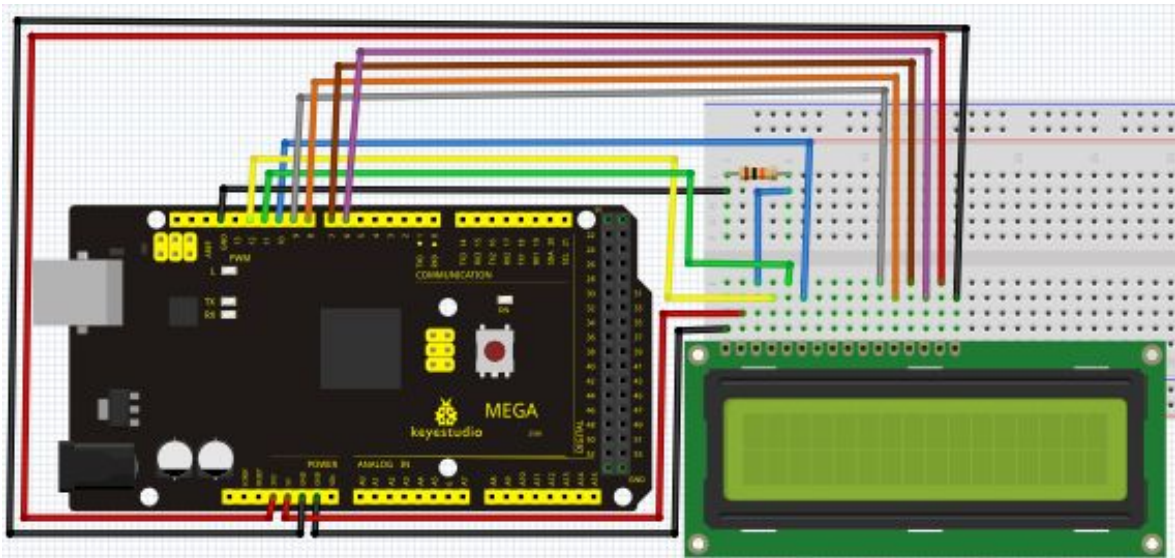
When using this module, 8-bit connection uses all the digital pins of the Arduino, leaving no pin for sensors. What then? We can use 4-bit connection.

Connection circuit:

Connection for UNO R3:



Connection for 2560 R3:





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---

After the connection, upload below code to the controller board and see how it goes.

**Sample code B:**

```
////////////////////////////////////
```

```
int LCD1602_RS=12;
int LCD1602_RW=11;
int LCD1602_EN=10;
int DB[] = { 6, 7, 8, 9};
char str1[]="Welcome to";
char str2[]="geek-workshop";
char str3[]="this is the";
char str4[]="4-bit interface";

void LCD_Command_Write(int command)
{
int i,temp;
digitalWrite( LCD1602_RS,LOW);
digitalWrite( LCD1602_RW,LOW);
digitalWrite( LCD1602_EN,LOW);

temp=command & 0xf0;
for (i=DB[0]; i <= 9; i++)
{
digitalWrite(i,temp & 0x80);
temp <<= 1;
}

digitalWrite( LCD1602_EN,HIGH);
delayMicroseconds(1);
digitalWrite( LCD1602_EN,LOW);

temp=(command & 0x0f)<<4;
for (i=DB[0]; i <= 10; i++)
{
digitalWrite(i,temp & 0x80);
temp <<= 1;
}

digitalWrite( LCD1602_EN,HIGH);
delayMicroseconds(1);
digitalWrite( LCD1602_EN,LOW);
}
```

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---

```
void LCD_Data_Write(int dat)
{
int i=0,temp;
digitalWrite( LCD1602_RS,HIGH);
digitalWrite( LCD1602_RW,LOW);
digitalWrite( LCD1602_EN,LOW);

temp=dat & 0xf0;
for (i=DB[0]; i <= 9; i++)
{
    digitalWrite(i,temp & 0x80);
    temp <<= 1;
}

digitalWrite( LCD1602_EN,HIGH);
delayMicroseconds(1);
digitalWrite( LCD1602_EN,LOW);

temp=(dat & 0x0f)<<4;
for (i=DB[0]; i <= 10; i++)
{
    digitalWrite(i,temp & 0x80);
    temp <<= 1;
}

digitalWrite( LCD1602_EN,HIGH);
delayMicroseconds(1);
digitalWrite( LCD1602_EN,LOW);
}

void LCD_SET_XY( int x, int y )
{
int address;
if (y ==0)    address = 0x80 + x;
else         address = 0xC0 + x;
LCD_Command_Write(address);
}

void LCD_Write_Char( int x,int y,int dat)
{
LCD_SET_XY( x, y );
```

# keystudio

---

```
LCD_Data_Write(dat);
}

void LCD_Write_String(int X,int Y,char *s)
{
    LCD_SET_XY( X, Y );    // address setup
    while (*s)            // write character string
    {
        LCD_Data_Write(*s);
        s ++;
    }
}

void setup (void)
{
    int i = 0;
    for (i=6; i <= 12; i++)
    {
        pinMode(i,OUTPUT);
    }
    delay(100);
    LCD_Command_Write(0x28);// 4 wires, 2 lines 5x7
    delay(50);
    LCD_Command_Write(0x06);
    delay(50);
    LCD_Command_Write(0x0c);
    delay(50);
    LCD_Command_Write(0x80);
    delay(50);
    LCD_Command_Write(0x01);
    delay(50);
}

void loop (void)
{
    LCD_Command_Write(0x01);
    delay(50);
    LCD_Write_String(3,0,str1);// line 1, start at the fourth address
    delay(50);
    LCD_Write_String(1,1,str2);// line 2, start at the second address
    delay(5000);
}
```

# keystudio

---

```
LCD_Command_Write(0x01);
delay(50);
LCD_Write_String(0,0,str3);
delay(50);
LCD_Write_String(0,1,str4);
delay(5000);

}
/////////////////////////////////////////////////////////////////
*****
```

## Project 21: 9g servo control



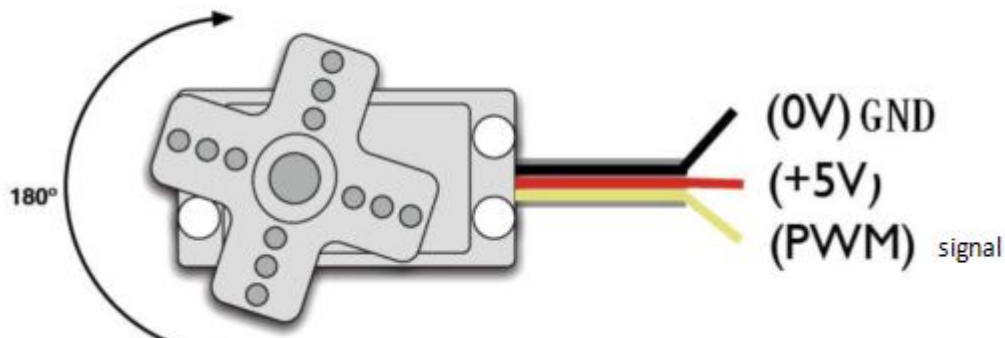
### Introduction

Servomotor is a position control rotary actuator. It mainly consists of housing, circuit board, core-less motor, gear and position sensor. The receiver or MCU outputs a signal to the servomotor. The motor has a built-in reference circuit that gives out reference signal, cycle of 20ms and width of 1.5ms. The motor compares the acquired DC bias voltage to the voltage of the potentiometer

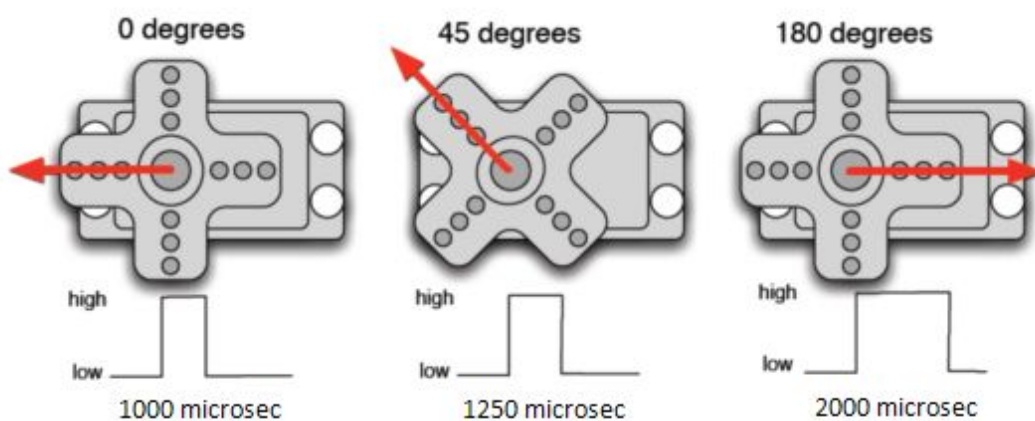
# keyestudio

and outputs a voltage difference. The IC on the circuit board will decide the rotate direction accordingly and drive the core-less motor. The gear then pass the force to the shaft. The sensor will determine if it has reached the commanded position according to the feedback signal. Servomotors are used in control systems that requires to have and maintain different angles. When the motor speed is definite, the gear will cause the potentiometer to rotate. When the voltage difference reduces to zero, the motor stops. Normally, the rotation angle range is among 0-180 degrees.

Servomotor comes with many specifications. But all of them have three connection wires, distinguished by brown, red, orange colors(different brand may have different color). Brown one is for GND, red one for power positive, orange one for signal line.



The rotate angle of the servo motor is controlled by regulating the duty cycle of the PWM(Pulse-Width Modulation) signal. The standard cycle of the PWM signal is 20ms (50Hz). Theoretically, the width is distributed between 1ms-2ms, but in fact, it's between 0.5ms-2.5ms. The width corresponds the rotate angle from 0° to 180°. But note that for different brand motor, the same signal may have different rotate angle.



After some basic knowledge, let's learn how to control a servomotor. For this experiment, you only need a servomotor and several jumper wires.

## Hardware required

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9G servo motor\*1

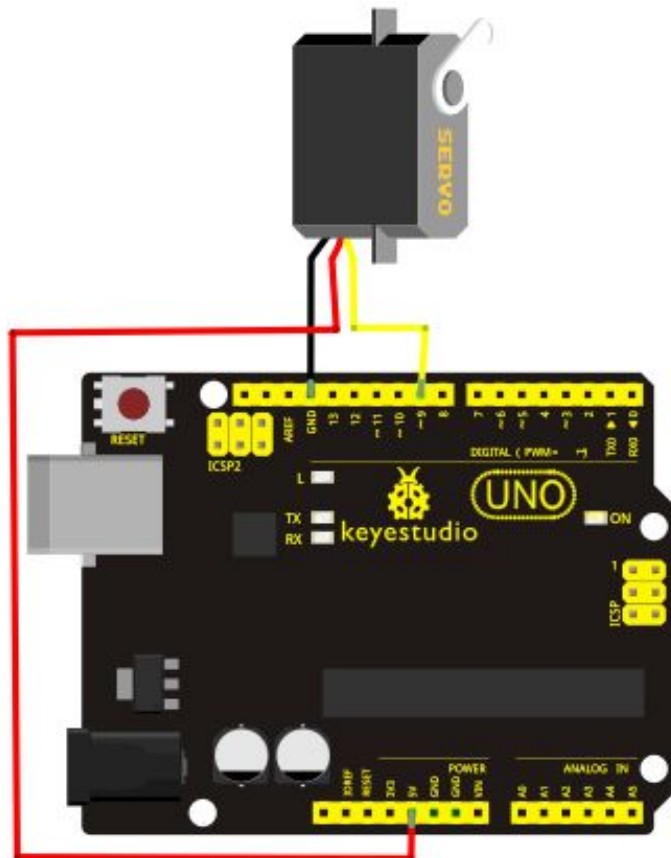
Breadboard jumper wire\*several

## Connection & sample program

There are two ways to control a servomotor with Arduino. One is to use a common digital sensor port of Arduino to produce square wave with different duty cycle to simulate PWM signal and use that signal to control the positioning of the motor. Another way is to directly use the Servo function of the Arduino to control the motor. In this way, the program will be easier but it can only control two-contact motor because for the servo function, only digital pin 9 and 10 can be used. The Arduino drive capacity is limited. So if you need to control more than one motor, you will need external power.

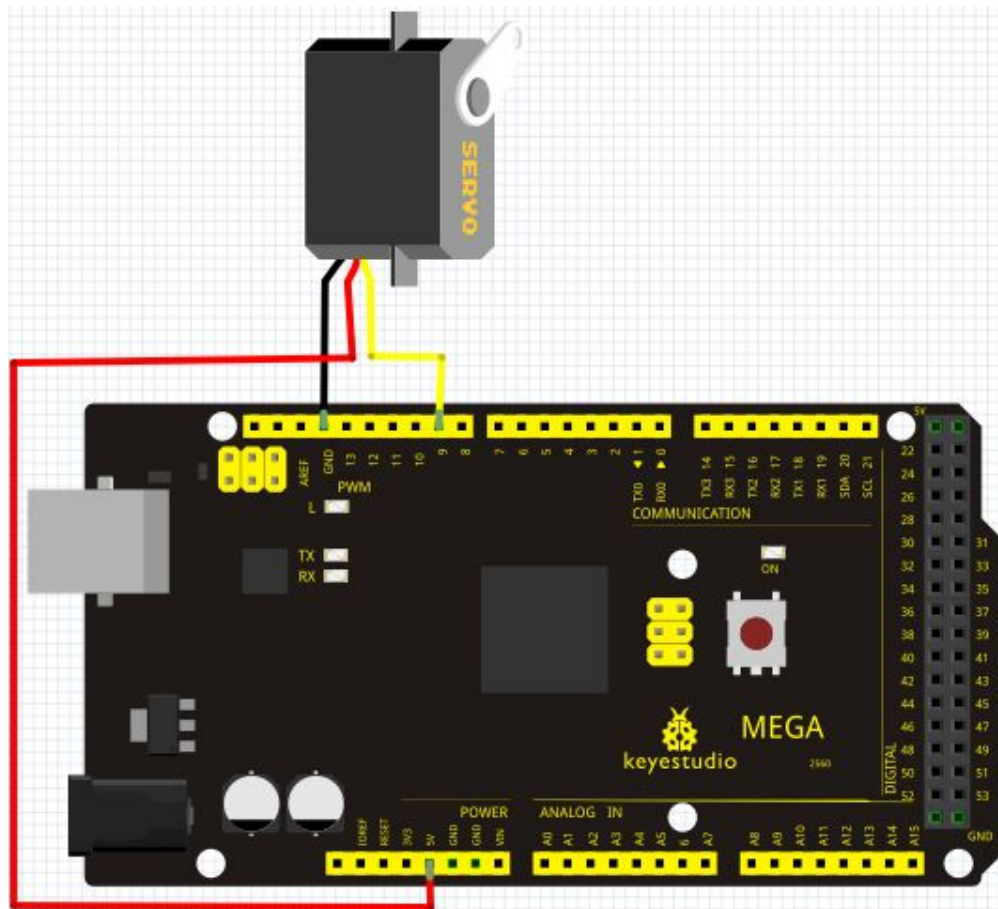
### Method 1

Connection for UNO R3:



Connection for 2560 R3:

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Connect the motor to digital pin 9.

Compile a program to control the motor to rotate to the commanded angle input by the user and display the angle on the screen.

### Sample program A

```
////////////////////////////////////  
int servopin=9;// select digital pin 9 for servomotor signal line  
int myangle;// initialize angle variable  
int pulsewidth;// initialize width variable  
int val;  
void servopulse(int servopin,int myangle)// define a servo pulse function  
{  
pulsewidth=(myangle*11)+500;// convert angle to 500-2480 pulse width  
digitalWrite(servopin,HIGH);// set the level of servo pin as "high"  
delayMicroseconds(pulsewidth);// delay microsecond of pulse width  
digitalWrite(servopin,LOW);// set the level of servo pin as "low"  
delay(20-pulsewidth/1000);  
}  
void setup()  
{
```

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---

```
pinMode(servopin,OUTPUT);// set servo pin as "output"
Serial.begin(9600);// connect to serial port, set baud rate at "9600"
Serial.println("servo=o_seral_simple ready" );
}
void loop();// convert number 0 to 9 to corresponding 0-180 degree angle, LED blinks
corresponding number of time
{
val=Serial.read();// read serial port value
if(val>'0'&&val<='9')
{
val=val-'0';// convert characteristic quantity to numerical variable
val=val*(180/9);// convert number to angle
Serial.print("moving servo to ");
Serial.print(val,DEC);
Serial.println();
for(int i=0;i<=50;i++) // giving the servo time to rotate to commanded position
{
servopulse(servopin,val);// use the pulse function
}
}
}
}
////////////////////////////////////
```

## Method 2:

Let's first take a look at the Arduino built-in servo function and some of its common statements.

1. attach ( interface ) ——select pin for servo, can only use pin 9 or 10.
2. write ( angle ) ——used to control the rotate angle of the servo, can set the angle among 0 degree to 180 degree.
3. read ( ) ——used to read the angle of the servo, consider it a function to read the value in the write() function.
4. attached ( ) ——determine whether the parameter of the servo is sent to the servo pin.
5. detach ( ) —— disconnect the servo and the pin, and the pin(digital pin 9 or 10) can be used for PWM port.

Note: Note: the written form of the above statements are " servo variable name. specific statement ()", e.g. myservo. Attach (9).

Still, connect the servo to pin 9.

## Sample program B:

```
////////////////////////////////////
#include <Servo.h>// define a header file. Special attention here, you can call the servo function
directly from Arduino's software menu
bar Sketch>Importlibrary>Servo, or input #include <Servo.h>. Make sure there is a space
```



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between #include and <Servo.h>. Otherwise, it will cause compile error.

```
Servo myservo;// define servo variable name
void setup()
{
myservo.attach(9);// select servo pin(9 or 10)
}
void loop()
{
myservo.write(90);// set rotate angle of the motor
}
////////////////////////////////////
```

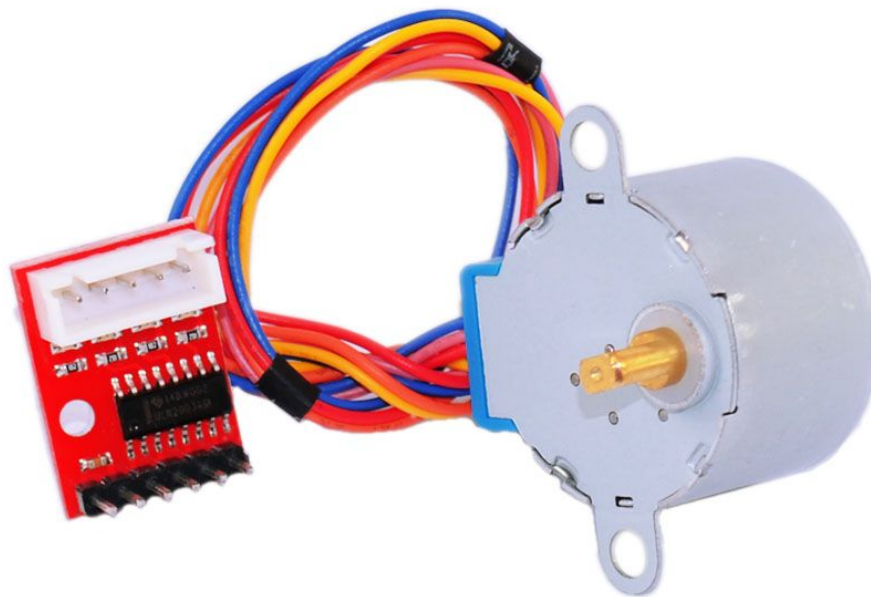
Above are the two methods to control the servo. You can choose either one according to your liking or actual need.

\*\*\*\*\*

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## Project 22: 5V Stepper Motor



### Introduction

A stepper motor is an electromechanical device which converts electrical pulses into discrete mechanical movements. The shaft or spindle of a stepper motor rotates in discrete step increments when electrical command pulses are applied to it in the proper sequence. The motor's rotation has several direct relationships to these applied input pulses. The sequence of the applied pulses is directly related to the direction of motor shafts rotation. The speed of the motor shafts rotation is directly related to the frequency of the input pulses and the length of rotation is directly related to the number of input pulses applied. One of the most significant advantages of a stepper motor is its ability to be accurately controlled in an open loop system. Open loop control means no feedback information about position is needed. This type of control eliminates the need for expensive sensing and feedback devices such as optical encoders. Your position is known simply by keeping

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---

track of the input step pulses.

## Features

The rotation angle of the motor is proportional to the input pulse.

The motor has full torque at standstill(if the windings are energized)

Precise positioning and repeatability of movement since good stepper motors have an accuracy of – 5% of a step and this error is non cumulative from one step to the next.

Excellent response to starting/stopping/reversing.

Very reliable since there are no contact brushes in the motor. Therefore the life of the motor is simply dependant on the life of the bearing.

The motors response to digital input pulses provides open-loop control, making the motor simpler and less costly to control.

It is possible to achieve very low speed synchronous rotation with a load that is directly coupled to the shaft.

A wide range of rotational speeds can be realized as the speed is proportional to the frequency of the input pulses.

Stepper motor 28BYJ-48 Parameters

Model: 28BYJ-48

Rated voltage: 5VDC

Number of Phase: 4

Speed Variation Ratio: 1/64

Stride Angle: 5.625° /64

Frequency : 100Hz

DC resistance: 50Ω±7%(25°C)

Idle In-traction Frequency : > 600Hz

Idle Out-traction Frequency : > 1000Hz

In-traction Torque >34.3mN.m(120Hz)

Self-positioning Torque >34.3mN.m

Friction torque : 600-1200 gf.cm

Pull in torque : 300 gf.cm

Insulated resistance >10MΩ(500V)

Insulated electricity power: 600VAC/1mA/1s

Insulation grade: A

Rise in Temperature <40K(120Hz)

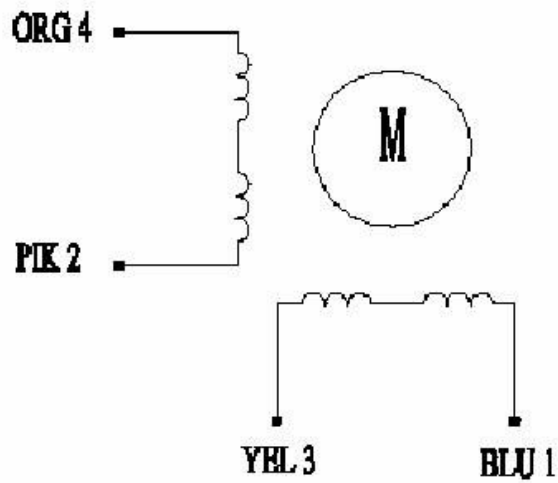
Noise <35dB(120Hz,No load,10cm)

## Circuit connection

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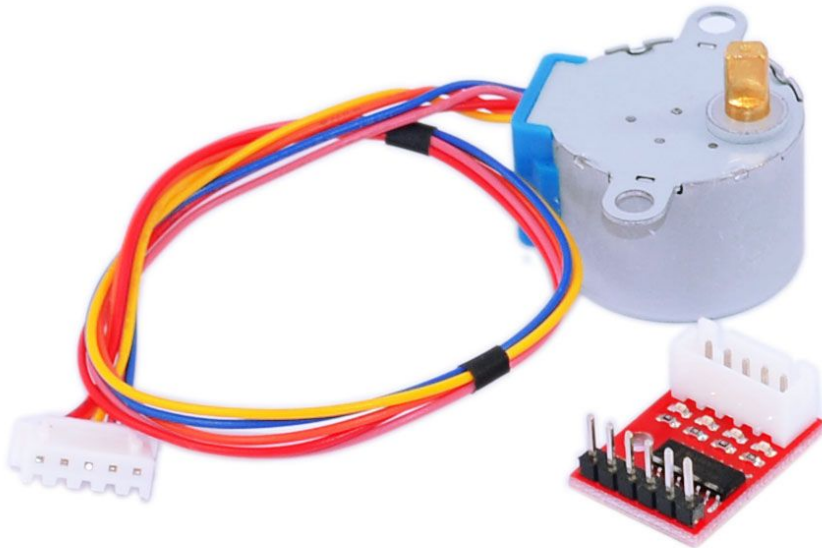
## WIRING DIAGRAM



The bipolar stepper motor usually has four wires coming out of it. Unlike unipolar steppers, bipolar steppers have no common center connection. They have two independent sets of coils instead. You can distinguish them from unipolar steppers by measuring the resistance between the wires. You should find two pairs of wires with equal resistance. If you've got the leads of your meter connected to two wires that are not connected (i.e. not attached to the same coil), you should see infinite resistance (or no continuity).

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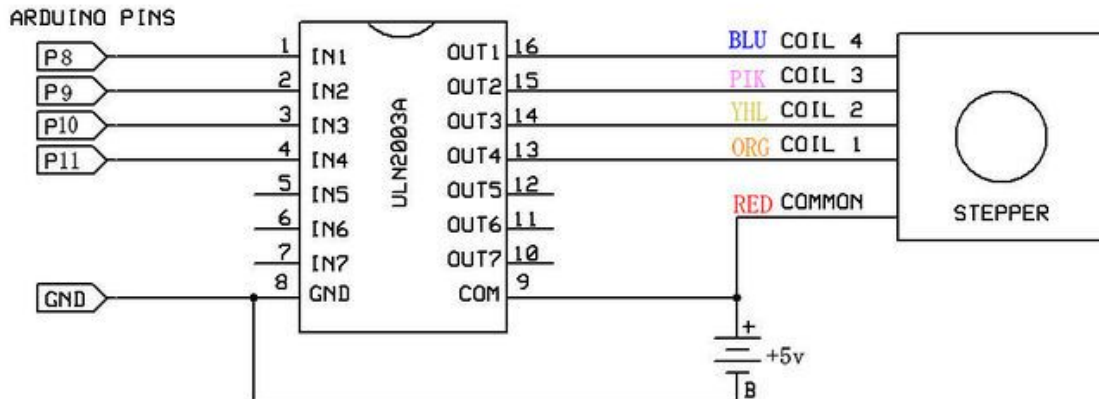
The simplest way of interfacing a unipolar stepper to Arduino is to use a breakout for ULN2003A transistor array chip. The ULN2003A contains seven darlington transistor drivers and is somewhat like having seven TIP120 transistors all in one package. The ULN2003A can pass up to 500 mA per channel and has an internal voltage drop of about 1V when on. It also contains internal clamp diodes to dissipate voltage spikes when driving inductive loads. To control the stepper, apply voltage to each of the coils in a specific sequence.

The sequence would go like this:

Lead Wire Color	---> CW Direction (1-2 Phase)							
	1	2	3	4	5	6	7	8
4 ORG	-	-						-
3 YEL		-	-	-				
2 PIK				-	-	-		
1 BLU						-	-	-

Here are schematics showing how to interface a unipolar stepper motor to four controller pins using a ULN2003A, and showing how to interface using four TIP120's.

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## Sample code

```
int Pin0 = 8;
int Pin1 = 9;
int Pin2 = 10;
int Pin3 = 11;
int _step = 0;
boolean dir = true; // gre
void setup()
{
  pinMode(Pin0, OUTPUT);
  pinMode(Pin1, OUTPUT);
  pinMode(Pin2, OUTPUT);
  pinMode(Pin3, OUTPUT);
}
void loop()
{
  switch(_step){
    case 0:
      digitalWrite(Pin0, LOW);
      digitalWrite(Pin1, LOW);
      digitalWrite(Pin2, LOW);
      digitalWrite(Pin3, HIGH);
      break;
    case 1:
      digitalWrite(Pin0, LOW);
      digitalWrite(Pin1, LOW);
      digitalWrite(Pin2, HIGH);
      digitalWrite(Pin3, HIGH);
```

# keystudio

---

```
break;
case 2:
    digitalWrite(Pin0, LOW);
    digitalWrite(Pin1, LOW);
    digitalWrite(Pin2, HIGH);
    digitalWrite(Pin3, LOW);
break;
case 3:
    digitalWrite(Pin0, LOW);
    digitalWrite(Pin1, HIGH);
    digitalWrite(Pin2, HIGH);
    digitalWrite(Pin3, LOW);
break;
case 4:
    digitalWrite(Pin0, LOW);
    digitalWrite(Pin1, HIGH);
    digitalWrite(Pin2, LOW);
    digitalWrite(Pin3, LOW);
break;
case 5:
    digitalWrite(Pin0, HIGH);
    digitalWrite(Pin1, HIGH);
    digitalWrite(Pin2, LOW);
    digitalWrite(Pin3, LOW);
break;
case 6:
    digitalWrite(Pin0, HIGH);
    digitalWrite(Pin1, LOW);
    digitalWrite(Pin2, LOW);
    digitalWrite(Pin3, LOW);
break;
case 7:
    digitalWrite(Pin0, HIGH);
    digitalWrite(Pin1, LOW);
    digitalWrite(Pin2, LOW);
    digitalWrite(Pin3, HIGH);
break;
default:
    digitalWrite(Pin0, LOW);
    digitalWrite(Pin1, LOW);
    digitalWrite(Pin2, LOW);
    digitalWrite(Pin3, LOW);
```

# keystudio

---

```
break;
}
if(dir){
  _step++;
}else{
  _step--;
}
if(_step>7){
  _step=0;
}
if(_step<0){
  _step=7;
}
delay(1);
}
*****
```

## Project 23: PIR Motion Sensor



### Introduction



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Pyroelectric infrared motion sensor can detect infrared signals from a moving person or moving animal, and output switching signals. It can be applied to a variety of occasions to detect the movement of human body. Conventional pyroelectric infrared sensors require body pyroelectric infrared detector, professional chip, complex peripheral circuit, so the size is bigger, with complex circuit, and lower reliability. Now we launch this new pyroelectric infrared motion sensor, specially designed for Arduino. It uses an integrated digital body pyroelectric infrared sensor, has smaller size, higher reliability, lower power consumption and simpler peripheral circuit.

Specification:

Input Voltage: 3.3 ~ 5V, 6V Maximum

Working Current: 15uA

Working Temperature: -20 ~ 85 °C

Output Voltage: High 3V, low 0V

Output Delay Time (High Level): About 2.3 to 3 Seconds

Detection angle: 100 °

Detection distance: 7 meters

Output Indicator LED (When output HIGH, it will be ON)

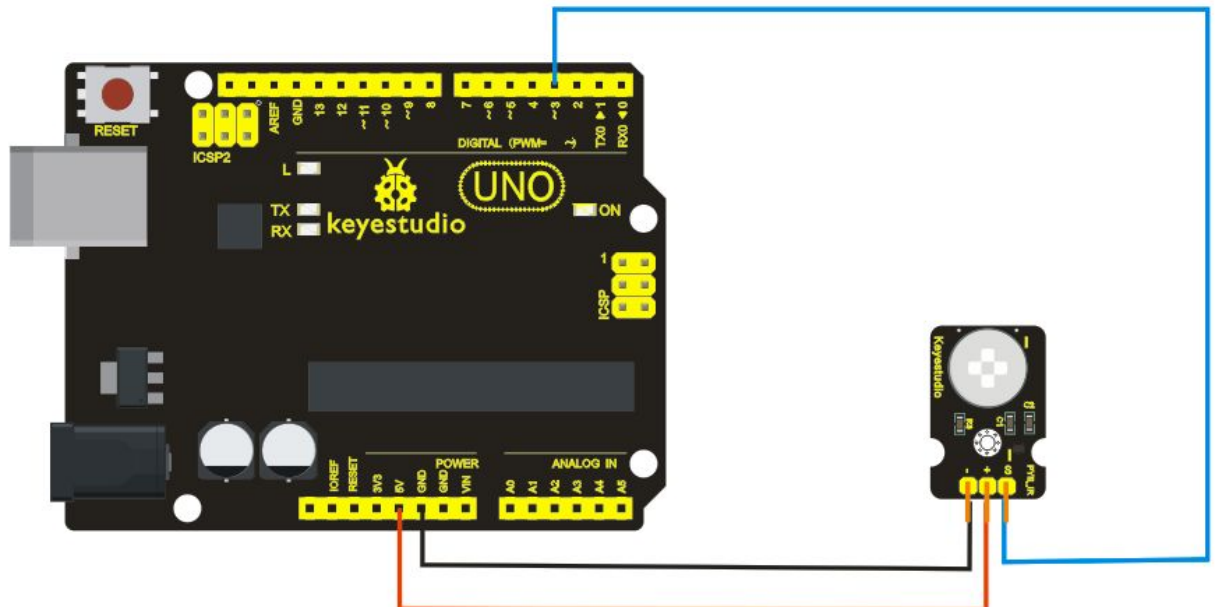
Pin limit current: 100mA

Size: 30\*20mm

Weight: 4g

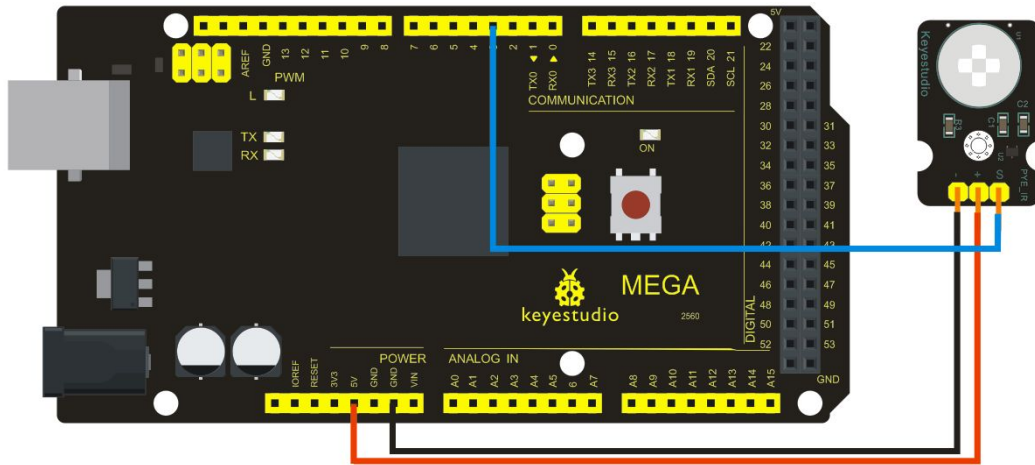
## Circuit connection

Connection for UNO R3:



Connection for MEGA 2560 R3:

# keystudio

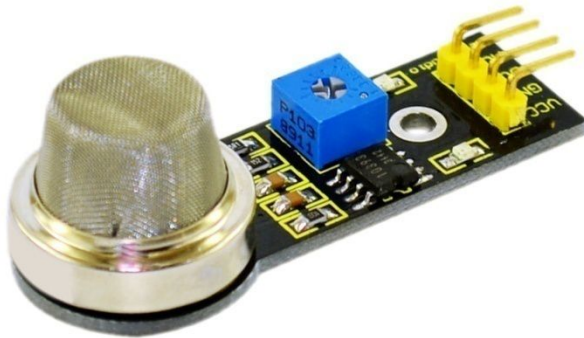


## Sample Code

```
byte sensorPin = 3;
byte indicator = 13;
void setup()
{
  pinMode(sensorPin,INPUT);
  pinMode(indicator,OUTPUT);
  Serial.begin(9600);
}

void loop()
{
  byte state = digitalRead(sensorPin);
  digitalWrite(indicator,state);
  if(state == 1)Serial.println("Somebody is in this area!");
  else if(state == 0)Serial.println("No one!");
  delay(500);
}
*****
```

## Project 24: Analog Gas Sensor



### Introduction

This analog gas sensor - MQ2 is used in gas leakage detecting equipment in consumer electronics and industrial markets. This sensor is suitable for detecting LPG, I-butane, propane, methane, alcohol, Hydrogen and smoke. It has high sensitivity and quick response. In addition, the sensitivity can be adjusted by the potentiometer.

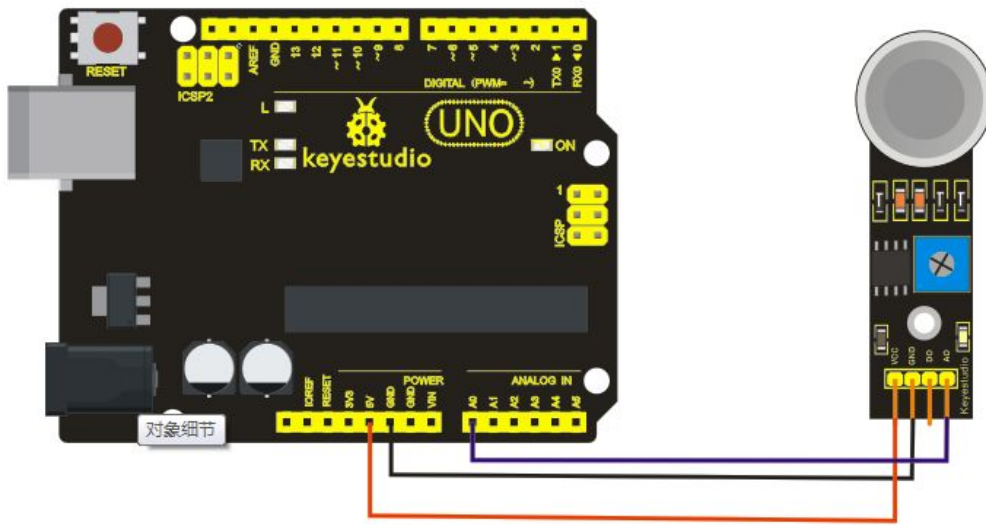
### Specification

Power supply: 5V  
Interface type: Analog  
Wide detecting scope  
Quick response and High sensitivity  
Simple drive circuit  
Stable and long lifespan  
Size: 49.7\*20mm  
Weight: 8g

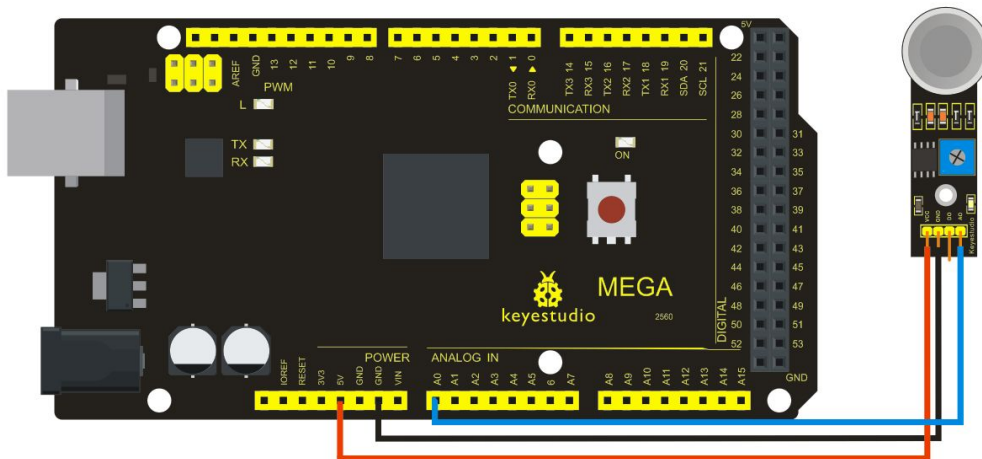
### Circuit connection

Connection for unoR3:

# keyestudio



Connection for MEGA 2560 R3:



## Sample Code

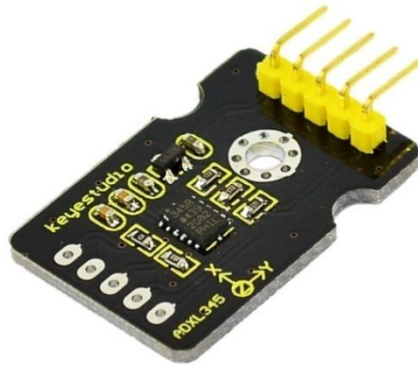
```
void setup()
{
  Serial.begin(9600); //Set serial baud rate to 9600 bps
}
void loop()
{int val;
val=analogRead(0);//Read Gas value from analog 0
Serial.println(val,DEC);//Print the value to serial port
delay(100);
}
```

\*\*\*\*\*

# keystudio

---

## Project 25: ADXL345 Three Axis Acceleration Module



### Introduction

The ADXL345 is a small, thin, low power, 3-axis MEMS accelerometer with high resolution (13-bit) measurement at up to  $\pm 16$  g. Digital output data is formatted as 16-bit twos complement and is accessible through either a SPI (3- or 4-wire) or I2C digital interface.

The ADXL345 is well suited to measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion or shock. Its high resolution (4 mg/LSB) enables measurement of inclination changes less than 1.0 degrees;.

Specification:

2.0-3.6VDC Supply Voltage

Ultra Low Power: 40uA in measurement mode, 0.1uA in standby@ 2.5V

Tap/Double Tap Detection

Free-Fall Detection

SPI and I2C interfaces

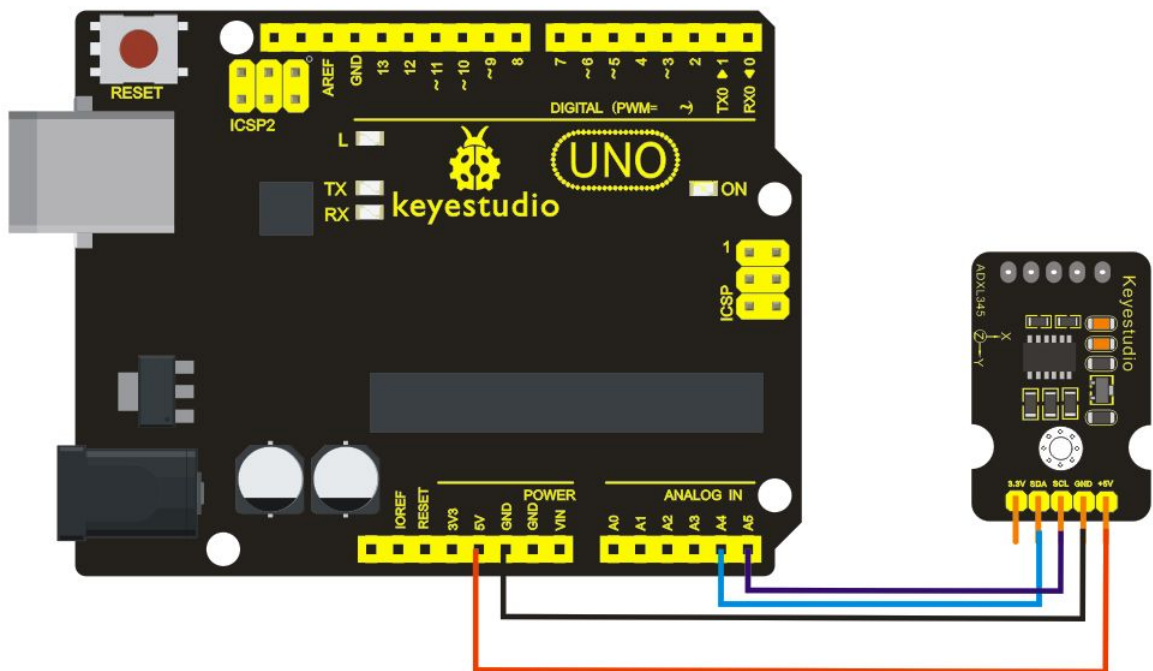
Size: 30\*20mm

Weight: 3g

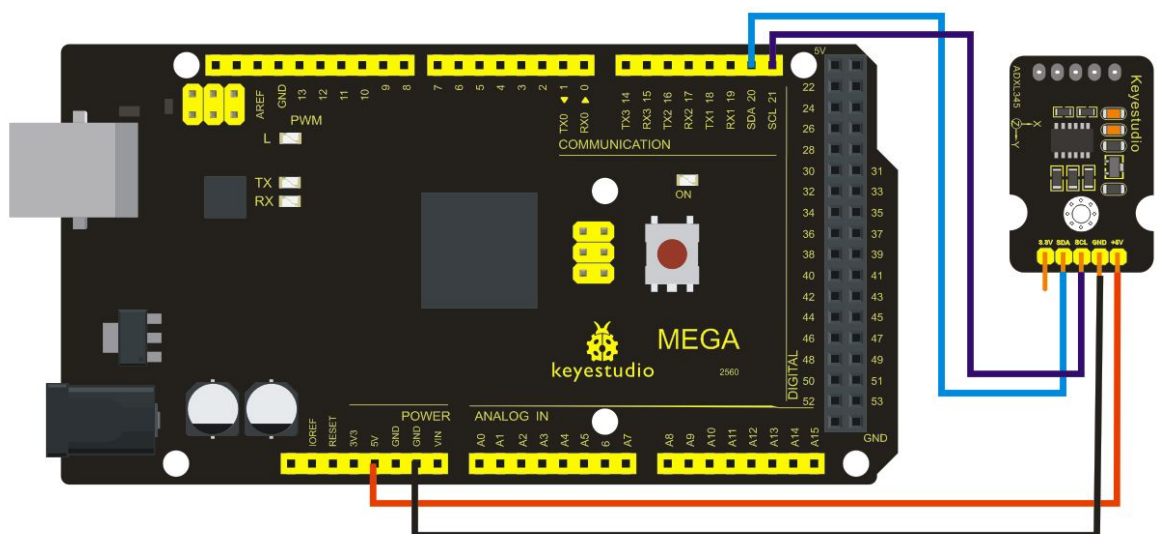
### Circuit connection

Connection for UNO R3:

# keystudio



Connection for MEGA 2560 R3:



## Sample Code

/\*

The circuit:

VCC: 5V

GND: ground

SCL: UNO SCL

SDA: UNO SDA

# keystudio

---

This example code is in the public domain.

```
*/
#include <Wire.h>
// Registers for ADXL345
#define ADXL345_ADDRESS (0xA6 >> 1) // address for device is 8 bit but shift to the
// right by 1 bit to make it 7 bit because the
// wire library only takes in 7 bit addresses
#define ADXL345_REGISTER_XLSB (0x32)

int accelerometer_data[3];
// void because this only tells the cip to send data to its output register
// writes data to the slave's buffer
void i2c_write(int address, byte reg, byte data) {
    // Send output register address
    Wire.beginTransmission(address);
    // Connect to device
    Wire.write(reg);
    // Send data
    Wire.write(data); //low byte
    Wire.endTransmission();
}

// void because using pointers
// microcontroller reads data from the sensor's input register
void i2c_read(int address, byte reg, int count, byte* data) {
    // Used to read the number of data received
    int i = 0;
    // Send input register address
    Wire.beginTransmission(address);
    // Connect to device
    Wire.write(reg);
    Wire.endTransmission();

    // Connect to device
    Wire.beginTransmission(address);
    // Request data from slave
    // Count stands for number of bytes to request
    Wire.requestFrom(address, count);
    while(Wire.available()) // slave may send less than requested
    {
        char c = Wire.read(); // receive a byte as character
    }
}
```

# keyestudio

---

```
    data[i] = c;
    i++;
}
Wire.endTransmission();
}

void init_adxl345() {
    byte data = 0;

    i2c_write(ADXL345_ADDRESS, 0x31, 0x0B); // 13-bit mode  +_ 16g
    i2c_write(ADXL345_ADDRESS, 0x2D, 0x08); // Power register

    i2c_write(ADXL345_ADDRESS, 0x1E, 0x00); // X
    i2c_write(ADXL345_ADDRESS, 0x1F, 0x00); // Y
    i2c_write(ADXL345_ADDRESS, 0x20, 0x05); // Z

    // Check to see if it worked!
    i2c_read(ADXL345_ADDRESS, 0x00, 1, &data);
    if(data==0xE5)
        Serial.println("it work Success");
    else
        Serial.println("it work Fail");
}

void read_adxl345() {
    byte bytes[6];
    memset(bytes,0,6);

    // Read 6 bytes from the ADXL345
    i2c_read(ADXL345_ADDRESS, ADXL345_REGISTER_XLSB, 6, bytes);
    // Unpack data
    for (int i=0;i<3;++i) {
        accelerometer_data[i] = (int)bytes[2*i] + (((int)bytes[2*i + 1]) << 8);
    }
}

// initialise and start everything
void setup() {
    Wire.begin();
    Serial.begin(9600);
    for(int i=0; i<3; ++i) {
        accelerometer_data[i] = 0;
    }
}
```



# keystudio

---

```
init_adxl345();
}

void loop() {
  read_adxl345();
  Serial.print("ACCEL: ");
  Serial.print(float(accelerometer_data[0])*3.9/1000); //3.9mg/LSB scale factor in 13-bit mode
  Serial.print("\t");
  Serial.print(float(accelerometer_data[1])*3.9/1000);
  Serial.print("\t");
  Serial.print(float(accelerometer_data[2])*3.9/1000);
  Serial.print("\n");
  delay(100);
}
*****
```

## Project 26: HC-SR04 Ultrasonic Sensor



# keystudio

---

## **Introduction**

The HC-SR04 Ultrasonic Sensor is a very affordable proximity/distance sensor that has been used mainly for object avoidance in various robotics projects. It essentially gives your Arduino eyes / spacial awareness and can prevent your robot from crashing or falling off a table. It has also been used in turret applications, water level sensing, and even as a parking sensor. This simple project will use the HC-SR04 sensor with an Arduino and a Processing sketch to provide a neat little interactive display on your computer screen.

## **Specification**

Working Voltage: DC 5V

Working Current: 15mA

Working Frequency: 40Hz

Max Range: 4m

Min Range: 2cm

Measuring Angle: 15 degree

Trigger Input Signal: 10 $\mu$ S TTL pulse

Echo Output Signal Input TTL lever signal and the range in proportion

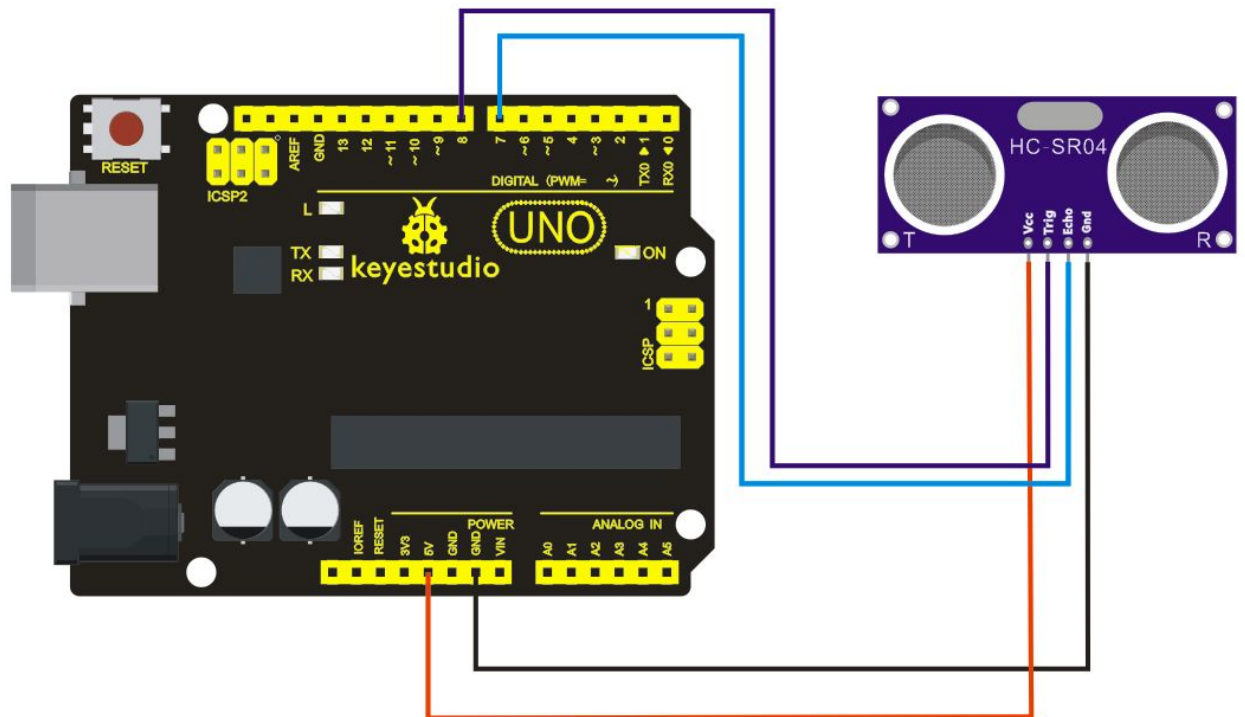
Size: 46\*20.4mm

Weight: 9g

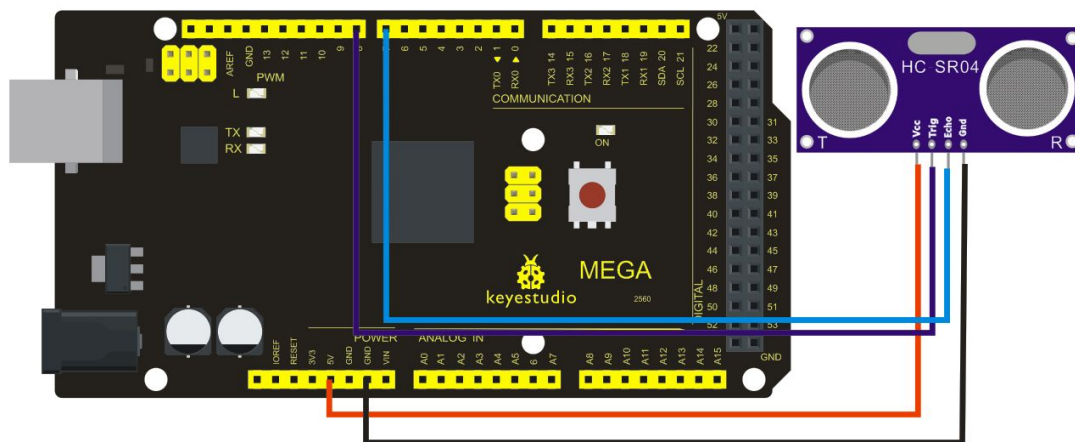
## **Circuit connection**

Connection for UNO R3:

# keyestudio



Connection for MEGA 2560 R3:



## Sample Code

VCC to arduino 5v  
GND to arduino GND  
Echo to Arduino pin 7  
Trig to Arduino pin 8

```
#define echoPin 7 // Echo Pin  
#define trigPin 8 // Trigger Pin  
#define LEDPin 13 // Onboard LED
```

# keystudio

---

```
int maximumRange = 200; // Maximum range needed
int minimumRange = 0; // Minimum range needed
long duration, distance; // Duration used to calculate distance

void setup() {
  Serial.begin (9600);
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);
  pinMode(LEDPin, OUTPUT); // Use LED indicator (if required)
}

void loop() {
  /* The following trigPin/echoPin cycle is used to determine the
  distance of the nearest object by bouncing soundwaves off of it. */
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);

  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);

  digitalWrite(trigPin, LOW);
  duration = pulseIn(echoPin, HIGH);

  //Calculate the distance (in cm) based on the speed of sound.
  distance = duration/58.2;

  if (distance >= maximumRange || distance <= minimumRange){
    /* Send a negative number to computer and Turn LED ON
    to indicate "out of range" */
    Serial.println("-1");
    digitalWrite(LEDPin, HIGH);
  }
  else {
    /* Send the distance to the computer using Serial protocol, and
    turn LED OFF to indicate successful reading. */
    Serial.println(distance);
    digitalWrite(LEDPin, LOW);
  }

  //Delay 50ms before next reading.
  delay(50);
}
```

}

\*\*\*\*\*

## Project 27: Joystick Module



### Introduction

Lots of robot projects need joystick. This module provides an affordable solution. By simply connecting to two analog inputs, the robot is at your commands with X, Y control. It also has a switch that is connected to a digital pin. This joystick module can be easily connected to Arduino by IO Shield. This module is for Arduino(V5) with cables supplied.

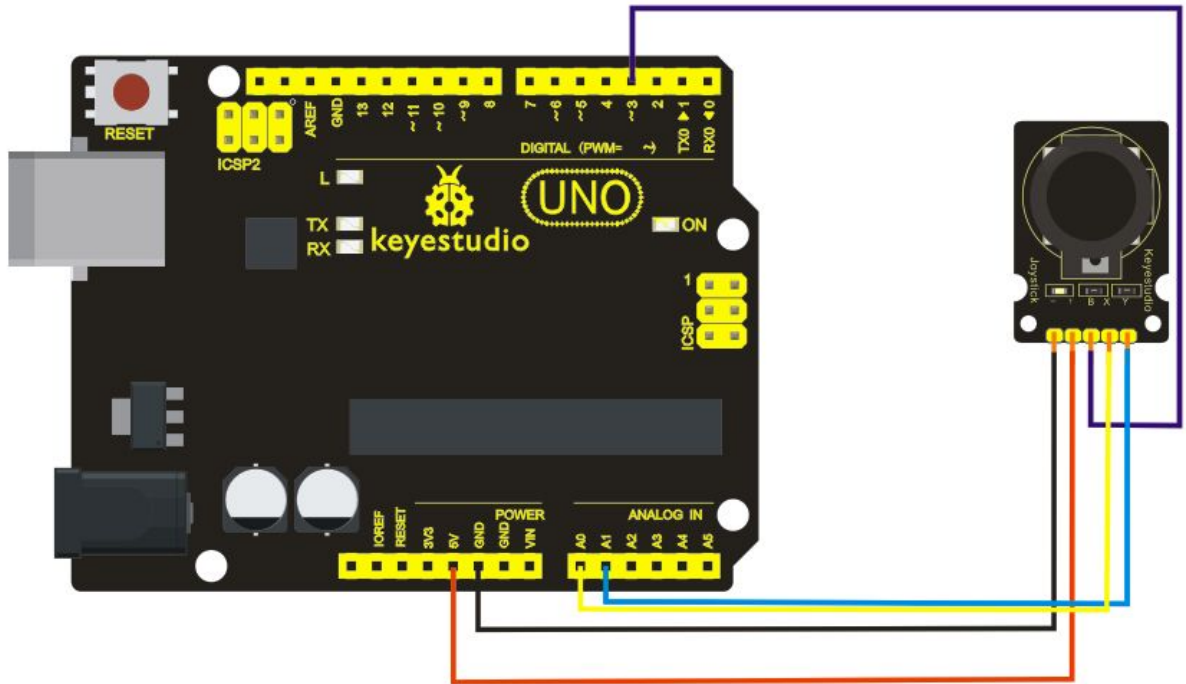
### Specification

Supply Voltage: 3.3V to 5V  
Interface: Analog x2, Digital x1  
Size: 40\*28mm  
Weight: 12g

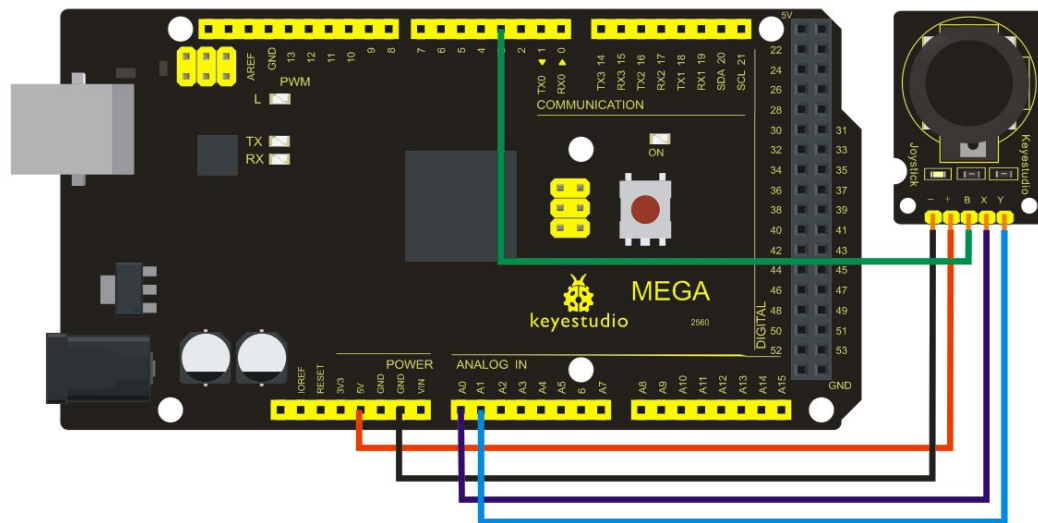
### Circuit connection

Connection for UNO R3:

# keystudio



Connection for MEGA 2560 R3:



## Sample Code

```
int JoyStick_X = 0; //x
int JoyStick_Y = 1; //y
int JoyStick_Z = 3; //key
void setup()
{
  pinMode(JoyStick_Z, INPUT);
  Serial.begin(9600); // 9600 bps
}
```

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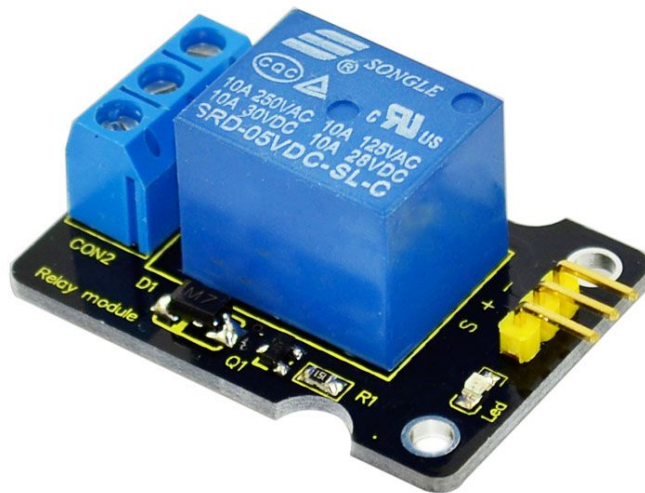
---

```
}  
void loop()  
{  
  int x,y,z;  
  x=analogRead(JoyStick_X);  
  y=analogRead(JoyStick_Y);  
  z=digitalRead(JoyStick_Z);  
  Serial.print(x,DEC);  
  Serial.print(",");  
  Serial.print(y,DEC);  
  Serial.print(",");  
  Serial.println(z,DEC);  
  delay(100);  
}  
*****
```

# keystudio

---

## Project 28: 5V Relay Module



### Introduction

This single relay module can be used in interactive projects. This module uses SONGLE 5v high-quality relay. It can also be used to control lighting, electrical and other equipment. The modular design makes it easy to expand with the Arduino board (not included). The Relay output is by a light-emitting diode. It can be controlled through digital IO port, such as solenoid valves, lamps, motors and other high current or high voltage devices.

### Specification

Type: Digital

Rated current: 10A (NO) 5A (NC)

Maximum switching voltage: 150VAC 24VDC

Digital interface

Control signal: TTL level

Rated load: 8A 150VAC (NO) 10A 24VDC (NO), 5A 250VAC (NO/NC) 5A 24VDC (NO/NC)

Maximum switching power: AC1200VA DC240W (NO) AC625VA DC120W (NC)



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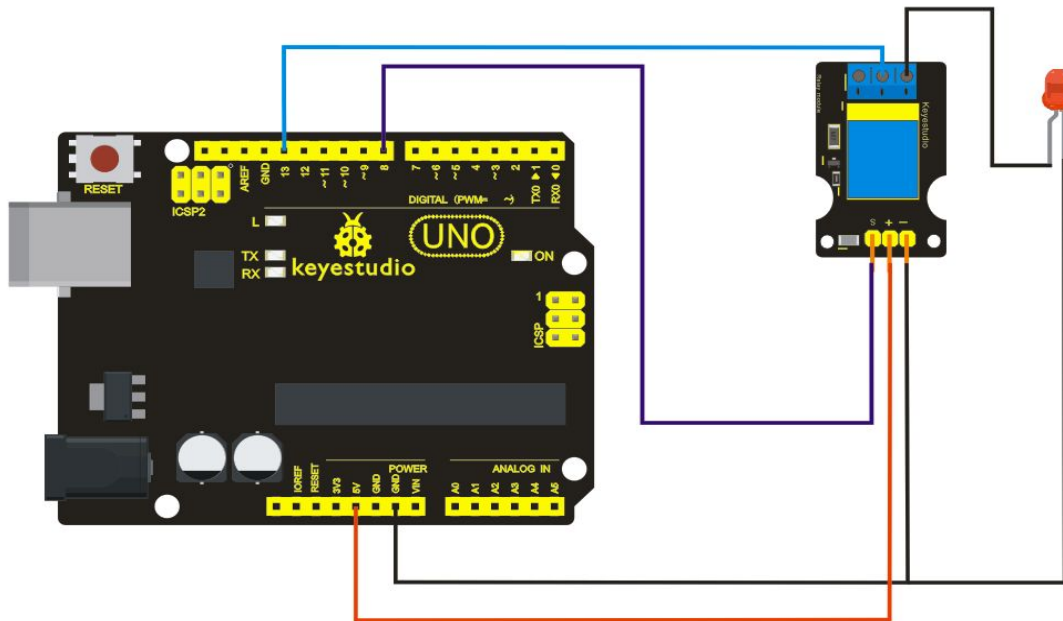
Contact action time: 10ms

Size: 40\*28mm

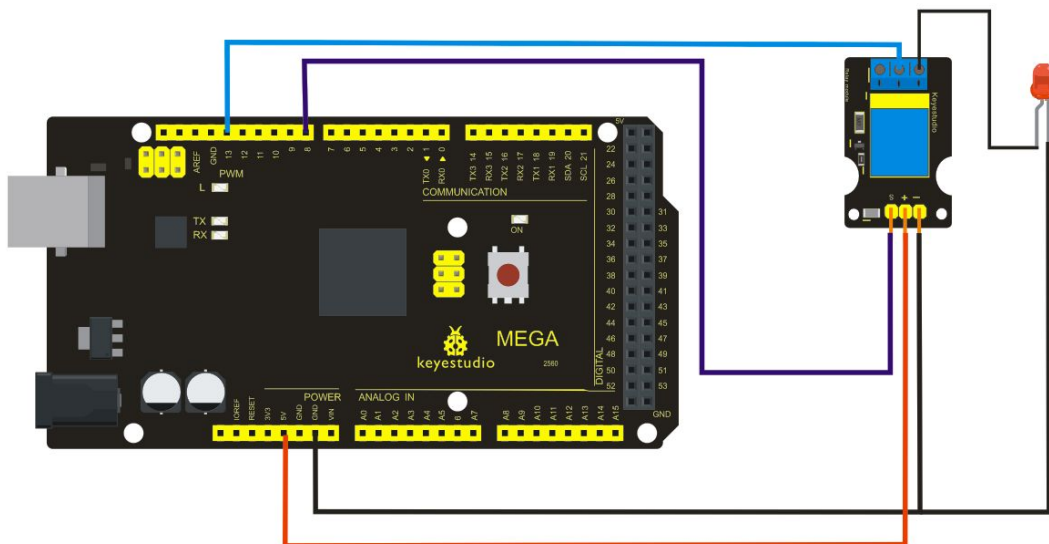
Weight: 15g

## Circuit connection

Connection for UNO R3:



Connection for MEGA 2560 R3:



## Sample Code

```
int Relay = 8;  
void setup()  
{
```

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---

```
pinMode(13, OUTPUT);    //Set Pin13 as output
digitalWrite(13, HIGH); //Set Pin13 High
pinMode(Relay, OUTPUT); //Set Pin3 as output
}
void loop()
{
    digitalWrite(Relay, HIGH); //Turn off relay
    delay(2000);
    digitalWrite(Relay, LOW);  //Turn on relay
    delay(2000);
}
*****
```

# keystudio

---

## Project 29: DS3231 Clock Module



### Introduction

DS3231 is equipped with integrated TCXO and crystal, which makes it a cost-effective I2C real time clock with high precision. The device carries a battery input, so if you disconnect the main power supply, it can still maintain accurate timing. The integrated oscillator ensures the long-term accuracy of the device and reduces the number of components. DS3231 provides both commercial and industrial temperature range and supports 16 pins small-outline package (300mil). The module itself can adapt to the system of 3.3V and 5V without level switch, which is quite convenient!

### Specification

Temperature range: -40 to +85; Timing accuracy :  $\pm 5\text{ppm}$  ( $\pm 0.432$  seconds / day)

Provide battery backup for continuous timing

Low power consumption

Device package and function compatible with DS3231

Complete clock calendar function contains seconds and minutes, hour, week, date, month, and year timing and provides leap year compensation until 2100.

Two calendar clock

Output: 1Hz and 32.768kHz

# keyestudio

Reset output and Input Debounce of Pushbutton

High speed (400kHz), I2C serial bus

Supply voltage: +3.3V to +5.5V

Digital temperature sensor with a precision of  $\pm 3^{\circ}\text{C}$

Working temperature:  $-40 \sim \text{C}$  to  $+85 \sim \text{C}$

16 pins Small Outline Package (300mil)

Certified by American Association of Underwriters Laboratories (UL)

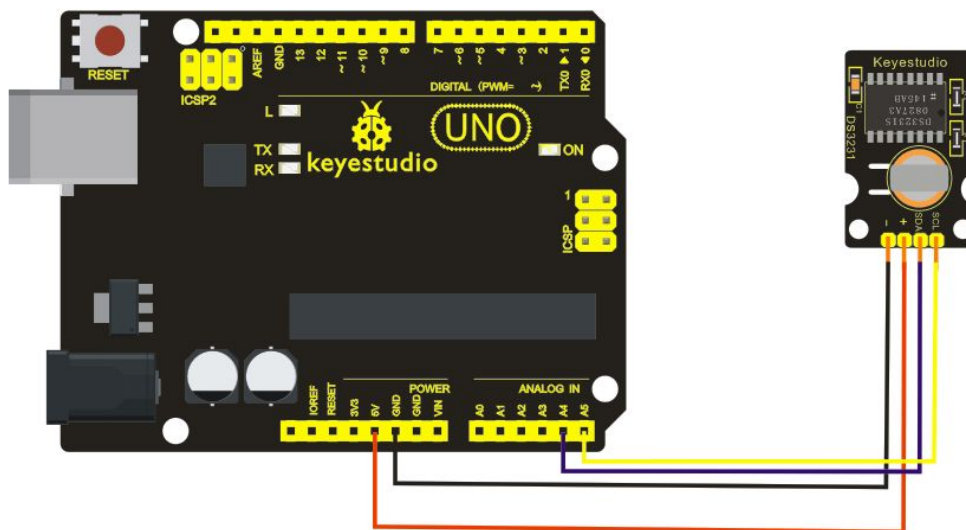
Size: 30\*20mm

Weight: 4g

## Circuit connection

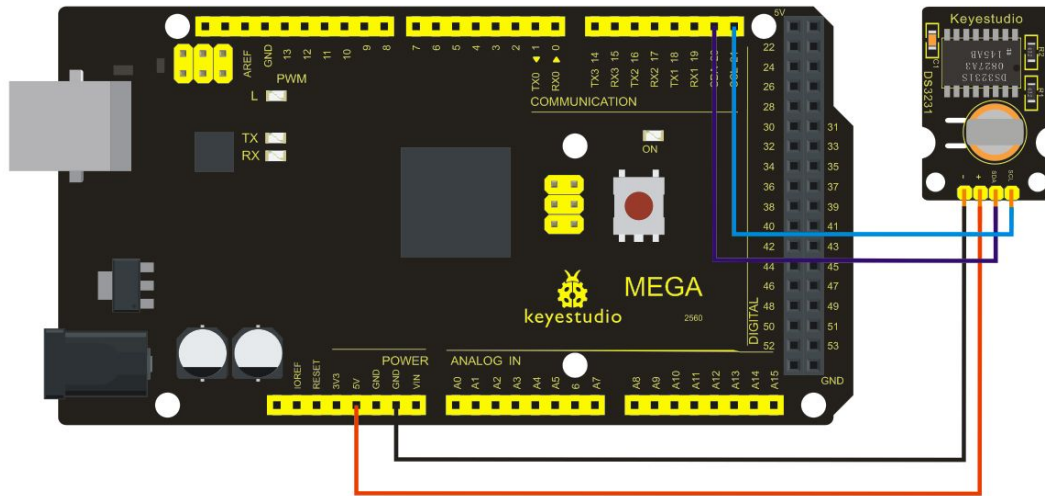
This module adopts the IIC test method, so we only need to connect 'SDA' to Arduino A4, 'SCL' to A5, '+' to VCC and '-' to GND as follows:

Connection for UNO R3:



Connection for MEGA 2560 R3:

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## Sample Code

```
#include <Wire.h>
#include "DS3231.h"
DS3231 RTC; //Create the DS3231 object
char weekDay[][4] = {"Sun", "Mon", "Tue", "Wed", "Thu", "Fri", "Sat" };
//year, month, date, hour, min, sec and week-day(starts from 0 and goes to 6)
//writing any non-existent time-data may interfere with normal operation of the RTC.
//Take care of week-day also.
DateTime dt(2011, 11, 10, 15, 18, 0, 5); //open the series port and you can check time here or make
a change to the time as needed.
void setup ()
{
  Serial.begin(57600); //set baud rate to 57600
  Wire.begin();
  RTC.begin();
  RTC.adjust(dt); //Adjust date-time as defined 'dt' above
}
void loop ()
{
  DateTime now = RTC.now(); //get the current date-time
  Serial.print(now.year(), DEC);
  Serial.print('/');
  Serial.print(now.month(), DEC);
  Serial.print('/');
  Serial.print(now.date(), DEC);
  Serial.print(' ');
  Serial.print(now.hour(), DEC);
  Serial.print(':');
```

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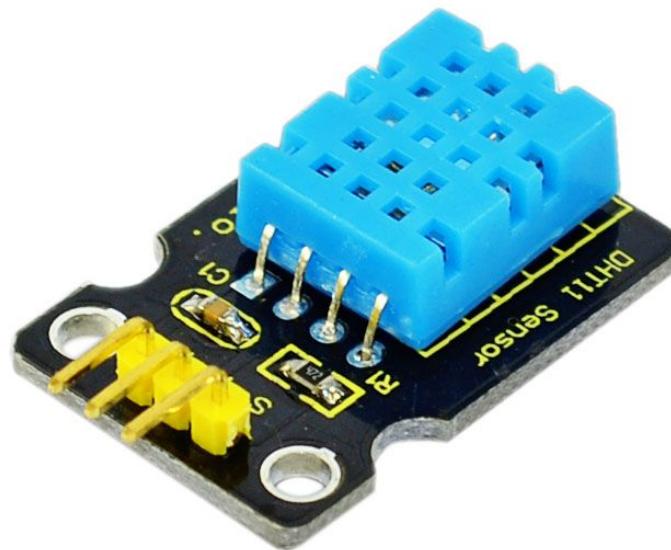
```
Serial.print(now.minute(), DEC);  
Serial.print(':');  
Serial.print(now.second(), DEC);  
Serial.println();  
Serial.print(weekday[now.dayOfWeek()]);  
Serial.println();  
delay(1000);  
}
```

Before compiling the code, you'd better put [DS3231 library](#) under file into Arduino catalogue,. When the above steps are done, you can upload the code to arduino and open the series monitor and get following results:



\*\*\*\*\*

## Project 30: DHT11 Temperature and Humidity Sensor



### Introduction

This DHT11 Temperature and Humidity Sensor features calibrated digital signal output with the temperature and humidity sensor complex. Its technology ensures high reliability and excellent long-term stability. A high-performance 8-bit microcontroller is connected. This sensor includes a resistive element and a sense of wet NTC temperature measuring devices. It has excellent quality, fast response, anti-interference ability and high cost performance advantages.

Each DHT11 sensor features extremely accurate calibration data of humidity calibration chamber. The calibration coefficients stored in the OTP program memory, internal sensors detect signals in the process, and we should call these calibration coefficients. The single-wire serial interface system is integrated to make it quick and easy. Qualities of small size, low power, and 20-meter signal transmission distance make it a wide applied application and even the most

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demanding one. Convenient connection, special packages can be provided according to users need.

## Specification

Supply Voltage: +5 V

Temperature range: 0-50 °C error of  $\pm 2$  °C

Humidity: 20-90% RH  $\pm 5\%$  RH error

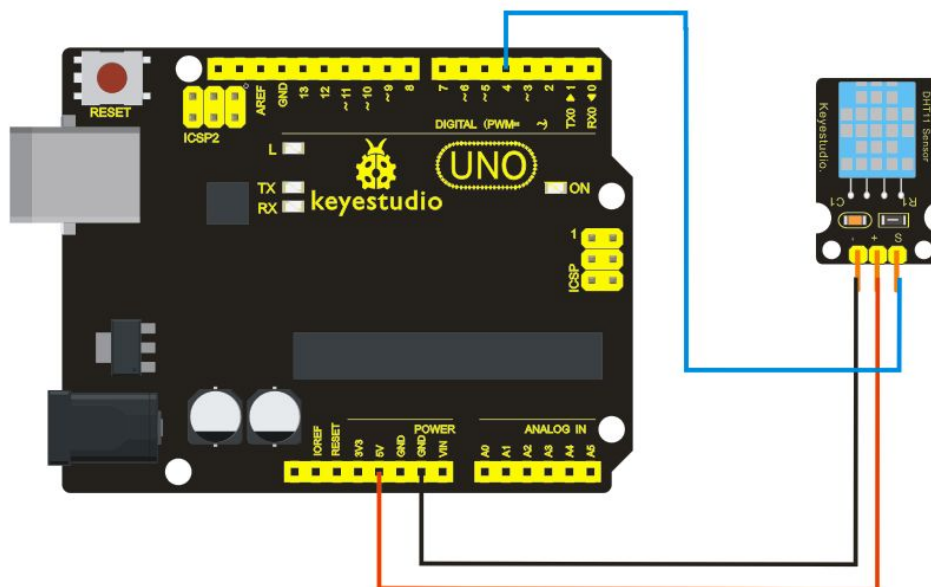
Interface: Digital

Size: 30\*20mm

Weight: 4g

## Circuit connection

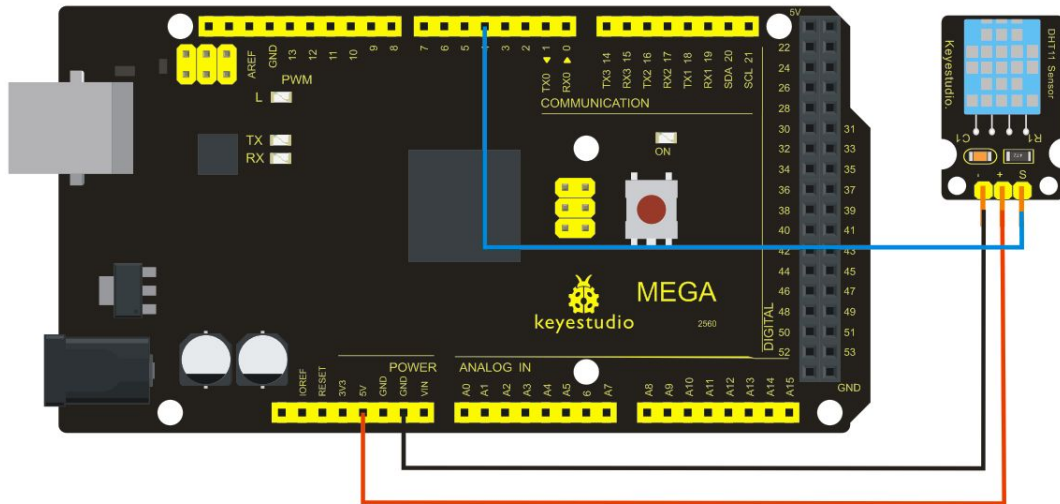
Connection for UNO R3:



Connection for MEGA 2560 R3:



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## Sample Code

Please download the [DHT11Lib](#) firstly.Or,[see the website](#)

```
#include <dht11.h>
```

```
dht11 DHT;
```

```
#define DHT11_PIN 4
```

```
void setup(){
```

```
  Serial.begin(9600);
```

```
  Serial.println("DHT TEST PROGRAM ");
```

```
  Serial.print("LIBRARY VERSION: ");
```

```
  Serial.println(DHT11LIB_VERSION);
```

```
  Serial.println();
```

```
  Serial.println("Type,\tstatus,\tHumidity (%),\tTemperature (C)");
```

```
}
```

```
void loop(){
```

```
  int chk;
```

```
  Serial.print("DHT11, \t");
```

```
  chk = DHT.read(DHT11_PIN);  // READ DATA
```

```
  switch (chk){
```

```
    case DHTLIB_OK:
```

```
      Serial.print("OK,\t");
```

```
      break;
```

```
    case DHTLIB_ERROR_CHECKSUM:
```

```
      Serial.print("Checksum error,\t");
```

```
      break;
```

```
    case DHTLIB_ERROR_TIMEOUT:
```

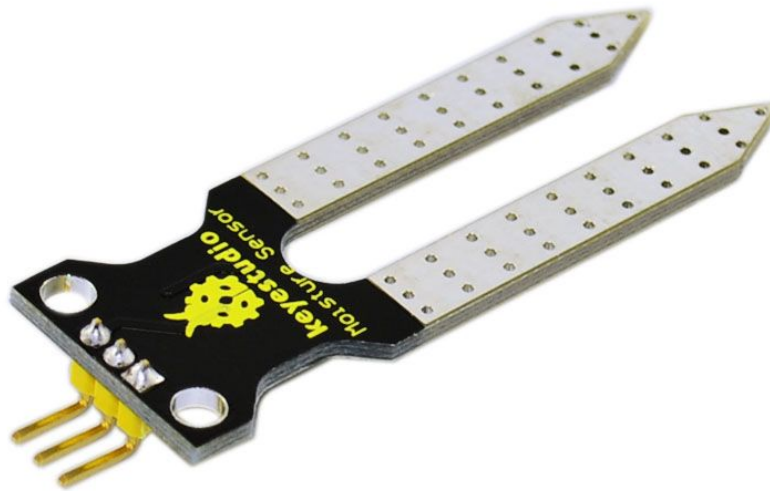
# keystudio

---

```
        Serial.print("Time out error,\t");
        break;
    default:
        Serial.print("Unknown error,\t");
        break;
    }
// DISPLAT DATA
Serial.print(DHT.humidity,1);
Serial.print(",\t");
Serial.println(DHT.temperature,1);

    delay(1000);
}
*****
```

## Project 31: Soil Humidity Sensor



### Introduction

This is a simple soil humidity sensor aims to detect the soil humidity. If the soil is in lack of water, the analog value output by the sensor will decrease, otherwise, it will increase. If you use this sensor to make an automatic watering device, it can detect whether your botany is thirsty to prevent it from withering when you go out. Using the sensor with Arduino controller makes your plant more comfortable and your garden smarter.

The soil humidity sensor module is not as complicated as you might think, and if you need to detect the soil in your project , it will be your best choice.

The sensor is set with two probes inserted into the soil, then with the current go through the soil,

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---

the sensor will get resistance value by reading the current changes between the two probes and convert such resistance value into moisture content. The higher moisture (less resistance), the higher conductivity the soil has.

The surface of the sensor have undergone metallization process to prolong its service life. Insert it into the soil and then use the AD converter to read it. With the help of this sensor, the plant can remind you: I need water.



## Specification

Power Supply Voltage: 3.3V or 5V

Working Current:  $\leq 20\text{mA}$

Output Voltage: 0-2.3V (When the sensor is totally immersed in water, the voltage will be 2.3V) 5V power supply, the higher humidity, the higher the output voltage

Packaging : Electrostatic bag sealing

Sensor type: Analog output

Interface definition: Pin1- signal, pin2- GND, pin3 - VCC

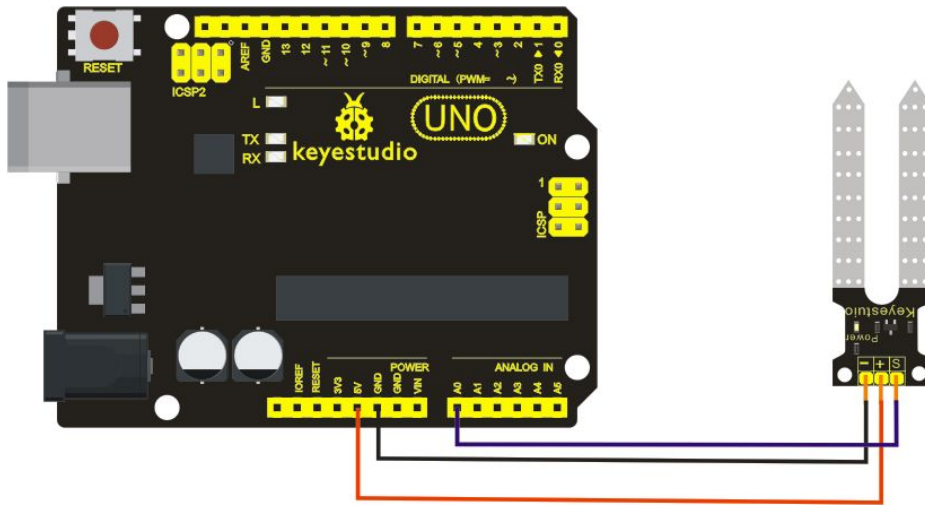
Service life: About one year (gold-plated surface for enhancing conductivity and corrosion resistance )

Module size: 20X60mm

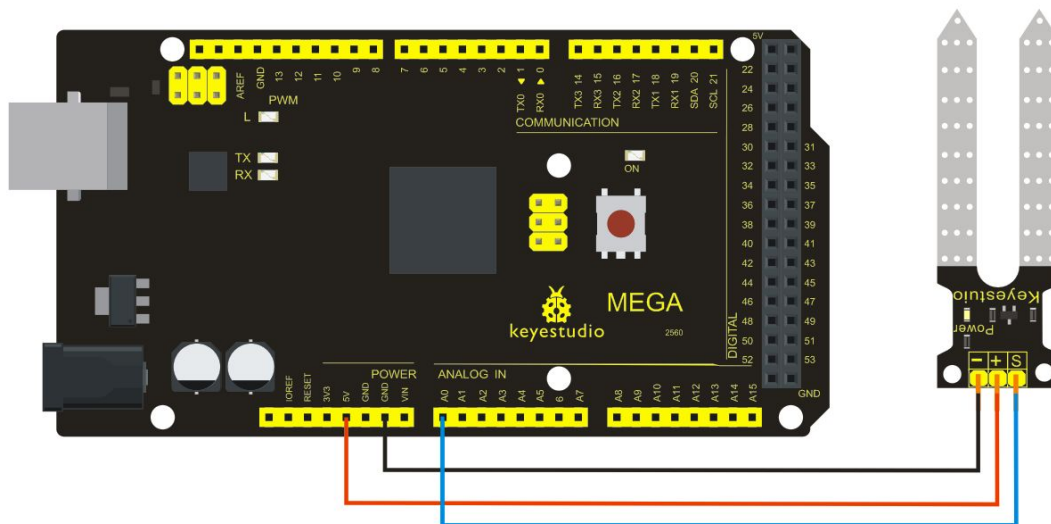
## Circuit connection

Connection for UNO R3:

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Connection for MEGA 2560 R3:



## Sample code

```
# 0 ~300    dry soil
# 300~700   humid soil
# 700~950   in water
*/
void setup(){
  Serial.begin(57600);
}

void loop(){

  Serial.print("Moisture Sensor Value:");
```

# keystudio

---

```
Serial.println(analogRead(0));  
delay(100);}  
*****
```

## Project 32: RC522 RFID module



### Introduction

MF522-AN module adopts Philips MFRC522 original reader circuit chip design, easy to use, low cost, suitable for equipment development, development of advanced applications such reader users, the need for RF card terminal design / production of the user. This module can be loaded directly into a variety of readers molds. Module uses voltage of 3.3V, through the SPI interface simple few lines can be directly connected to the user any CPU board communication module can guarantee stable and reliable work, reader distance;

# keystudio

---

## Electrical parameters

Current :13-26mA / DC 3.3V

Idle Current :10-13mA / DC 3.3V

Sleep current: <80uA

Peak current: <30mA

Operating Frequency: 13.56MHz

Supported card types: mifare1 S50, mifare1 S70, mifare UltraLight, mifare Pro, mifare Desfire

\*60mm mce\_style="BACKGROUND-COLOR: #fff">Product Physical Characteristics:



Dimensions: 40mm \* 60mm

Environmental Operating temperature: -20-80 degrees Celsius

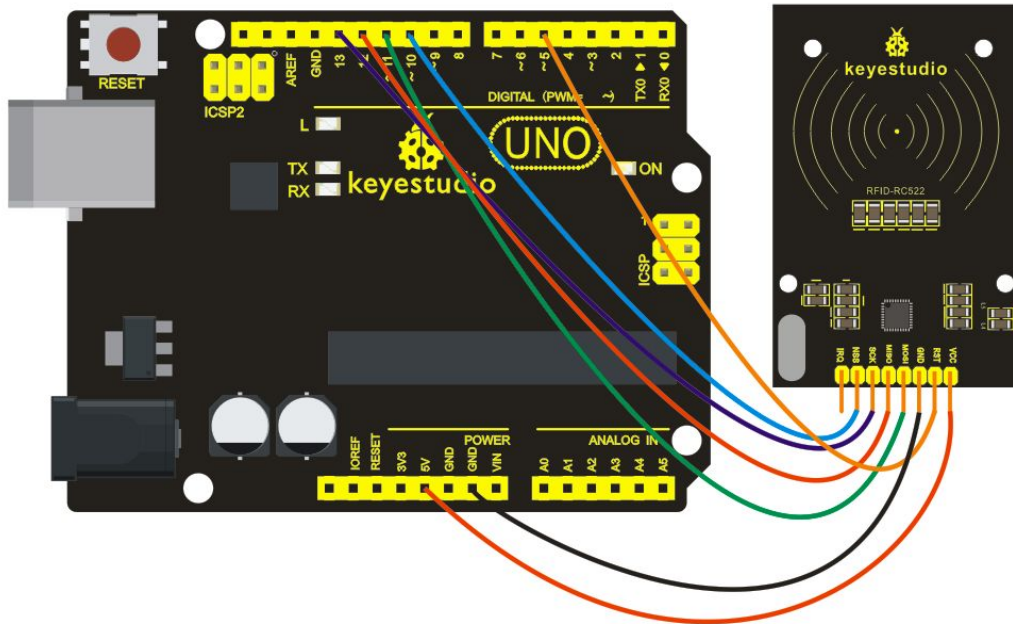
Environment Storage temperature: -40-85 degrees Celsius

Relative Humidity: 5% -95%

## Circuit connection

RFID	Arduino UNO	Arduino MEGA 2560
GND	GND	GND
VIN	5V	5V
SS	10	53
SCK	13	52
MOSI	11	51
MISO	12	50
3V3		
RST	5	5

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## Sample Code

```
////////////////////////////////////  
#include <SPI.h>  
#define uchar unsigned char  
#define uint unsigned int  
#define MAX_LEN 16  
const int chipSelectPin = 10;//if the controller is UNO,328,168  
const int NRSTPD = 5;  
  
//MF522command word  
#define PCD_IDLE 0x00 //NO action;concel current command  
#define PCD_AUTHENT 0x0E //verify key  
#define PCD_RECEIVE 0x08 //receive data  
#define PCD_TRANSMIT 0x04 //send data  
#define PCD_TRANSCEIVE 0x0C //receive and send data  
#define PCD_RESETPHASE 0x0F //reset  
#define PCD_CALCCRC 0x03 //CRC calculation  
  
//Mifare_One Card command word  
#define PICC_REQIDL 0x26 // line-tracking area is dormant  
#define PICC_REQALL 0x52 //line-tracking area is  
interfered  
#define PICC_ANTICOLL 0x93 //Anti collision  
#define PICC_SEIECTTAG 0x93 //choose cards  
#define PICC_AUTHENT1A 0x60 //Verify A key
```



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```
#define PICC_AUTHENT1B      0x61          //Verify B key
#define PICC_READ           0x30          // Reader Module
#define PICC_WRITE          0xA0          // letter block
#define PICC_DECREMENT      0xC0
#define PICC_INCREMENT      0xC1
#define PICC_RESTORE        0xC2          //Transfer data to buffer
#define PICC_TRANSFER       0xB0          //Save buffer data
#define PICC_HALT           0x50          //Dormancy

//MF522 Error code returned when communication
#define MI_OK                0
#define MI_NOTAGERR          1
#define MI_ERR               2

//-----MFRC522 Register-----
//Page 0:Command and Status
#define Reserved00           0x00
#define CommandReg          0x01
#define CommIEnReg          0x02
#define DivIEnReg           0x03
#define CommIrqReg          0x04
#define DivIrqReg           0x05
#define ErrorReg            0x06
#define Status1Reg          0x07
#define Status2Reg          0x08
#define FIFODataReg         0x09
#define FIFOLevelReg        0x0A
#define WaterLevelReg       0x0B
#define ControlReg          0x0C
#define BitFramingReg       0x0D
#define CollReg             0x0E
#define Reserved01          0x0F
//Page 1:Command
#define Reserved10           0x10
#define ModeReg              0x11
#define TxModeReg           0x12
#define RxModeReg           0x13
#define TxControlReg        0x14
#define TxAutoReg           0x15
#define TxSelReg            0x16
```

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```
#define RxSelReg          0x17
#define RxThresholdReg    0x18
#define DemodReg          0x19
#define Reserved11        0x1A
#define Reserved12        0x1B
#define MifareReg         0x1C
#define Reserved13        0x1D
#define Reserved14        0x1E
#define SerialSpeedReg    0x1F
//Page 2:CFG
#define Reserved20        0x20
#define CRCResultRegM     0x21
#define CRCResultRegL     0x22
#define Reserved21        0x23
#define ModWidthReg       0x24
#define Reserved22        0x25
#define RFCfgReg          0x26
#define GsNReg            0x27
#define CWGsPReg          0x28
#define ModGsPReg         0x29
#define TModeReg          0x2A
#define TPrescalerReg     0x2B
#define TReloadRegH       0x2C
#define TReloadRegL       0x2D
#define TCounterValueRegH 0x2E
#define TCounterValueRegL 0x2F
//Page 3:TestRegister
#define Reserved30        0x30
#define TestSel1Reg       0x31
#define TestSel2Reg       0x32
#define TestPinEnReg      0x33
#define TestPinValueReg   0x34
#define TestBusReg        0x35
#define AutoTestReg       0x36
#define VersionReg        0x37
#define AnalogTestReg     0x38
#define TestDAC1Reg       0x39
#define TestDAC2Reg       0x3A
#define TestADCReg        0x3B
#define Reserved31        0x3C
#define Reserved32        0x3D
#define Reserved33        0x3E
```

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```
#define Reserved34 0x3F
uchar serNum[5];
uchar writeDate[16]={'T','e','n','g',' ','B','o',0,0,0,0,0,0,0,0};
uchar sectorKeyA[16][16] = {{0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF},
                             {0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF},
                             {0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF},
                             };
uchar sectorNewKeyA[16][16] = {{0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF},
                               {0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF,
0xff,0x07,0x80,0x69, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF},
                               {0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF,
0xff,0x07,0x80,0x69, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF, 0xFF},
                               };

void setup() {
    Serial.begin(9600); // RFID reader SOUT pin connected to Serial
RX pin at 2400bps
    // start the SPI library:
    SPI.begin();

    pinMode(chipSelectPin,OUTPUT); // Set digital pin 10 as OUTPUT to connect
it to the RFID /ENABLE pin
    digitalWrite(chipSelectPin, LOW); // Activate the RFID reader
    pinMode(NRSTPD,OUTPUT); // Set digital pin 10 , Not Reset and
Power-down
    digitalWrite(NRSTPD, HIGH);

    MFRC522_Init();
}

void loop()
{
    uchar i,tmp;
    uchar status;
    uchar str[MAX_LEN];
    uchar RC_size;
    uchar blockAddr; //Select the address of the operation 0~63

    // searching card, return card type
    status = MFRC522_Request(PICC_REQIDL, str);
    if (status == MI_OK)
```

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```
{
}

status = MFRC522_Anticoll(str);
memcpy(serNum, str, 5);
if (status == MI_OK)
{
    Serial.println("The card's number is  :");
    Serial.print(serNum[0],BIN);
    Serial.print(serNum[1],BIN);
    Serial.print(serNum[2],BIN);
    Serial.print(serNum[3],BIN);
    Serial.print(serNum[4],BIN);
    Serial.println(" ");
}

// select card, return card capacity
RC_size = MFRC522_SelectTag(serNum);
if (RC_size != 0)
{}

// write data card
blockAddr = 7;          // data block 7
status = MFRC522_Auth(PICC_AUTHENT1A, blockAddr, sectorKeyA[blockAddr/4],
serNum); // authentication
if (status == MI_OK)
{
    // write data
    status = MFRC522_Write(blockAddr, sectorNewKeyA[blockAddr/4]);
    Serial.print("set the new card password, and can modify the data of
the Sector: ");

    Serial.print(blockAddr/4,DEC);

    // write data
    blockAddr = blockAddr - 3 ;
    status = MFRC522_Write(blockAddr, writeDate);
    if(status == MI_OK)
    {
        Serial.println("OK!");
    }
}
}
```

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```
// read card
blockAddr = 7;          // data block 7
status      = MFRC522_Auth(PICC_AUTHENT1A, blockAddr,
sectorNewKeyA[blockAddr/4], serNum); // authentication
if (status == MI_OK)
{
    // read data
    blockAddr = blockAddr - 3 ;
    status = MFRC522_Read(blockAddr, str);
    if (status == MI_OK)
    {
        Serial.println("Read from the card ,the data is : ");
        for (i=0; i<16; i++)
        {
            Serial.print(str[i]);
        }
        Serial.println(" ");
    }
}
Serial.println(" ");
MFRC522_Halt();        // command card to enter standby mode
}

void Write_MFRC522(uchar addr, uchar val)
{
    digitalWrite(chipSelectPin, LOW);

    SPI.transfer((addr<<1)&0x7E);
    SPI.transfer(val);

    digitalWrite(chipSelectPin, HIGH);
}

uchar Read_MFRC522(uchar addr)
{
    uchar val;

    digitalWrite(chipSelectPin, LOW);
```

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```
// address format: 1XXXXXX0
SPI.transfer(((addr<<1)&0x7E) | 0x80);
val =SPI.transfer(0x00);

digitalWrite(chipSelectPin, HIGH);

return val;
}

void SetBitMask(uchar reg, uchar mask)
{
    uchar tmp;
    tmp = Read_MFRC522(reg);
    Write_MFRC522(reg, tmp | mask); // set bit mask
}

void ClearBitMask(uchar reg, uchar mask)
{
    uchar tmp;
    tmp = Read_MFRC522(reg);
    Write_MFRC522(reg, tmp & (~mask)); // clear bit mask
}

void AntennaOn(void)
{
    uchar temp;

    temp = Read_MFRC522(TxControlReg);
    if (!(temp & 0x03))
    {
        SetBitMask(TxControlReg, 0x03);
    }
}

void AntennaOff(void)
{
    ClearBitMask(TxControlReg, 0x03);
}
```

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```
}

void MFRC522_Reset(void)
{
    Write_MFRC522(CommandReg, PCD_RESETPHASE);
}

void MFRC522_Init(void)
{
    digitalWrite(NRSTPD,HIGH);

    MFRC522_Reset();

    //Timer: TPrescaler*TreloadVal/6.78MHz = 24ms
    Write_MFRC522(TModeReg, 0x8D);      //Tauto=1; f(Timer) = 6.78MHz/TPreScaler
    Write_MFRC522(TPrescalerReg, 0x3E); //TModeReg[3..0] + TPrescalerReg
    Write_MFRC522(TReloadRegL, 30);
    Write_MFRC522(TReloadRegH, 0);

    Write_MFRC522(TxAutoReg, 0x40);     //100%ASK
    Write_MFRC522(ModeReg, 0x3D);      //CRC initial value

0x6363   ???

    AntennaOn();    // open antenna
}
uchar MFRC522_Request(uchar reqMode, uchar *TagType)
{
    uchar status;
    uint backBits;          // received data bits

    Write_MFRC522(BitFramingReg, 0x07); //TxLastBists = BitFramingReg[2..0]   ???

    TagType[0] = reqMode;
    status = MFRC522_ToCard(PCD_TRANSCEIVE, TagType, 1, TagType, &backBits);

    if ((status != MI_OK) || (backBits != 0x10))
    {
        status = MI_ERR;
    }

    return status;
}
```

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```
}

uchar MFRC522_ToCard(uchar command, uchar *sendData, uchar sendLen, uchar *backData,
uint *backLen)
{
    uchar status = MI_ERR;
    uchar irqEn = 0x00;
    uchar waitIRq = 0x00;
    uchar lastBits;
    uchar n;
    uint i;

    switch (command)
    {
        case PCD_AUTHENT:      // card key authentication
        {
            irqEn = 0x12;
            waitIRq = 0x10;
            break;
        }
        case PCD_TRANSCEIVE:  // send data in FIFO
        {
            irqEn = 0x77;
            waitIRq = 0x30;
            break;
        }
        default:
            break;
    }

    Write_MFRC522(CommIEncReg, irqEn|0x80); // Allow interrupt request
    ClearBitMask(CommIrqReg, 0x80);        // clear bits of all interrupt request
    SetBitMask(FIFOLevelReg, 0x80);        //FlushBuffer=1, FIFO initialization

    Write_MFRC522(CommandReg, PCD_IDLE); //NO action; cancel current command   ???

    // write data into FIFO
    for (i=0; i<sendLen; i++)
    {
        Write_MFRC522(FIFODataReg, sendData[i]);
    }
}
```



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```
// execute command
Write_MFRC522(CommandReg, command);
if (command == PCD_TRANSCEIVE)
{
    SetBitMask(BitFramingReg, 0x80);          //StartSend=1,transmission of data starts
}

// wait for the completion of data receiving
i = 2000; // adjust i according to clock frequency, maximum waiting time of operating M1 is
25ms    ???
do
{
    //CommIrqReg[7..0]
    //Set1 TxIRq RxIRq IdleIRq HiAlerIRq LoAlertIRq ErrIRq TimerIRq
    n = Read_MFRC522(CommIrqReg);
    i--;
}
while ((i!=0) && !(n&0x01) && !(n&waitIRq));

ClearBitMask(BitFramingReg, 0x80);          //StartSend=0

if (i != 0)
{
    if(!(Read_MFRC522(ErrorReg) & 0x1B)) //BufferOvfl Collerr CRCErr ProtecolErr
    {
        status = MI_OK;
        if (n & irqEn & 0x01)
        {
            status = MI_NOTAGERR;          //??
        }

        if (command == PCD_TRANSCEIVE)
        {
            n = Read_MFRC522(FIFOLevelReg);
            lastBits = Read_MFRC522(ControlReg) & 0x07;
            if (lastBits)
            {
                *backLen = (n-1)*8 + lastBits;
            }
            else
            {

```

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```
        *backLen = n*8;
    }

    if (n == 0)
    {
        n = 1;
    }
    if (n > MAX_LEN)
    {
        n = MAX_LEN;
    }

    // read data which FIFO received
    for (i=0; i<n; i++)
    {
        backData[i] = Read_MFRC522(FIFODataReg);
    }
}
else
{
    status = MI_ERR;
}

}

//SetBitMask(ControlReg,0x80);           //timer stops
//Write_MFRC522(CommandReg, PCD_IDLE);

return status;
}

uchar MFRC522_Anticoll(uchar *serNum)
{
    uchar status;
    uchar i;
    uchar serNumCheck=0;
    uint unLen;

    Write_MFRC522(BitFramingReg, 0x00);    //TxLastBists = BitFramingReg[2..0]

    serNum[0] = PICC_ANTICOLL;
```

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```
serNum[1] = 0x20;
status = MFRC522_ToCard(PCD_TRANSCEIVE, serNum, 2, serNum, &unLen);

if (status == MI_OK)
{
    // verify card sequence number
    for (i=0; i<4; i++)
    {
        serNumCheck ^= serNum[i];
    }
    if (serNumCheck != serNum[i])
    {
        status = MI_ERR;
    }
}

//SetBitMask(CollReg, 0x80);          //ValuesAfterColl=1

return status;
}

void CalulateCRC(uchar *pIndata, uchar len, uchar *pOutData)
{
    uchar i, n;

    ClearBitMask(DivIrqReg, 0x04);      //CRCIrq = 0
    SetBitMask(FIFOLevelReg, 0x80);     // clear FIFO pointer
    //Write_MFRC522(CommandReg, PCD_IDLE);

    // write data into FIFO
    for (i=0; i<len; i++)
    {
        Write_MFRC522(FIFODataReg, *(pIndata+i));
    }
    Write_MFRC522(CommandReg, PCD_CALCCRC);

    // wait for the completion of CRC calculation
    i = 0xFF;
    do
    {
        n = Read_MFRC522(DivIrqReg);
        i--;
    }
```

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```
    }
    while ((i!=0) && !(n&0x04));           //CRCIrq = 1

    // read CRC calculation result
    pOutData[0] = Read_MFRC522(CRCResultRegL);
    pOutData[1] = Read_MFRC522(CRCResultRegM);
}

uchar MFRC522_SelectTag(uchar *serNum)
{
    uchar i;
    uchar status;
    uchar size;
    uint recvBits;
    uchar buffer[9];

    //ClearBitMask(Status2Reg, 0x08);           //MFCrypto1On=0

    buffer[0] = PICC_SELECTTAG;
    buffer[1] = 0x70;
    for (i=0; i<5; i++)
    {
        buffer[i+2] = *(serNum+i);
    }
    CalculateCRC(buffer, 7, &buffer[7]);       //??
    status = MFRC522_ToCard(PCD_TRANSCEIVE, buffer, 9, buffer, &recvBits);

    if ((status == MI_OK) && (recvBits == 0x18))
    {
        size = buffer[0];
    }
    else
    {
        size = 0;
    }

    return size;
}

uchar MFRC522_Auth(uchar authMode, uchar BlockAddr, uchar *Sectorkey, uchar *serNum)
{
    uchar status;
```

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```
uint recvBits;
uchar i;
uchar buff[12];

// Verification commands + block address + sector password + card sequence number
buff[0] = authMode;
buff[1] = BlockAddr;
for (i=0; i<6; i++)
{
    buff[i+2] = *(Sectorkey+i);
}
for (i=0; i<4; i++)
{
    buff[i+8] = *(serNum+i);
}
status = MFRC522_ToCard(PCD_AUTHENT, buff, 12, buff, &recvBits);

if ((status != MI_OK) || (!(Read_MFRC522(Status2Reg) & 0x08)))
{
    status = MI_ERR;
}

return status;
}

uchar MFRC522_Read(uchar blockAddr, uchar *recvData)
{
    uchar status;
    uint unLen;

    recvData[0] = PICC_READ;
    recvData[1] = blockAddr;
    CalculateCRC(recvData,2, &recvData[2]);
    status = MFRC522_ToCard(PCD_TRANSCEIVE, recvData, 4, recvData, &unLen);

    if ((status != MI_OK) || (unLen != 0x90))
    {
        status = MI_ERR;
    }

    return status;
}
```

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```
uchar MFRC522_Write(uchar blockAddr, uchar *writeData)
{
    uchar status;
    uint recvBits;
    uchar i;
    uchar buff[18];

    buff[0] = PICC_WRITE;
    buff[1] = blockAddr;
    CalculateCRC(buff, 2, &buff[2]);
    status = MFRC522_ToCard(PCD_TRANSCEIVE, buff, 4, buff, &recvBits);

    if ((status != MI_OK) || (recvBits != 4) || ((buff[0] & 0x0F) != 0x0A))
    {
        status = MI_ERR;
    }

    if (status == MI_OK)
    {
        for (i=0; i<16; i++)    // write 16Byte data into FIFO
        {
            buff[i] = *(writeData+i);
        }
        CalculateCRC(buff, 16, &buff[16]);
        status = MFRC522_ToCard(PCD_TRANSCEIVE, buff, 18, buff, &recvBits);

        if ((status != MI_OK) || (recvBits != 4) || ((buff[0] & 0x0F) != 0x0A))
        {
            status = MI_ERR;
        }
    }

    return status;
}

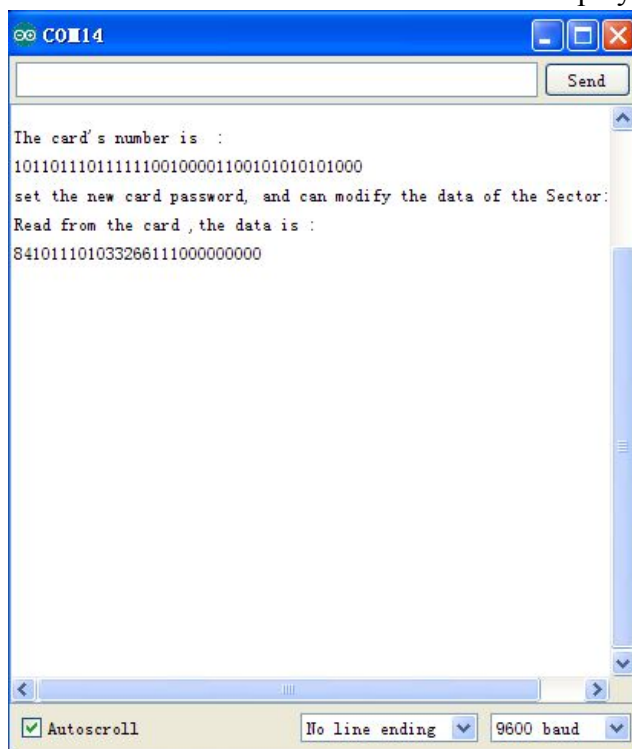
void MFRC522_Halt(void)
{
    uchar status;
    uint unLen;
    uchar buff[4];
```

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```
buff[0] = PICC_HALT;  
buff[1] = 0;  
CalculateCRC(buff, 2, &buff[2]);  
  
status = MFRC522_ToCard(PCD_TRANSCEIVE, buff, 4, buff,&unLen);  
}  
////////////////////////////////////
```

## Result

In this experiment, when the IC card approaches, RFID module will write data to the IC card and read the card's data and then display data on the monitor window.



\*\*\*\*\*