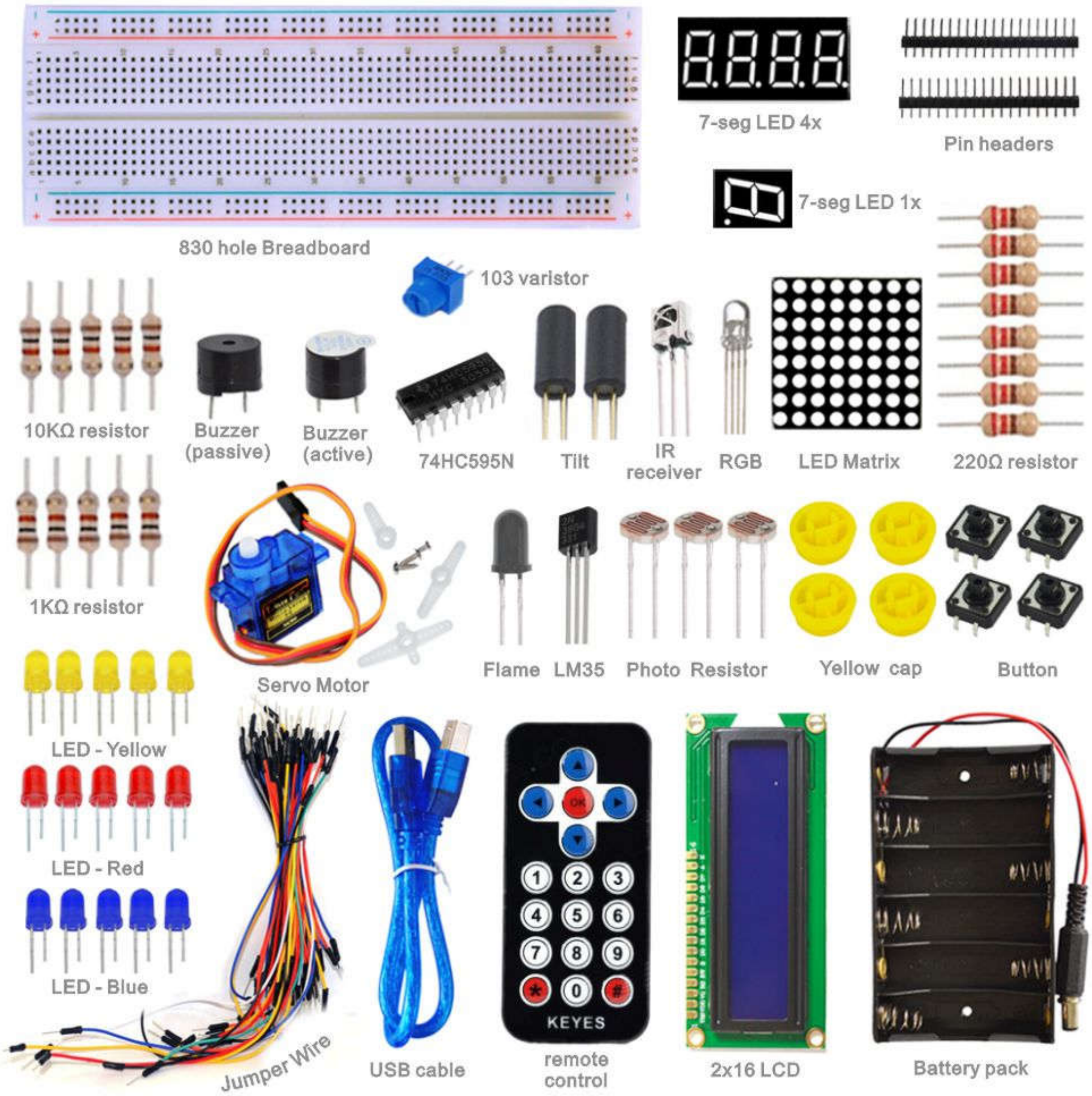
keyestudio

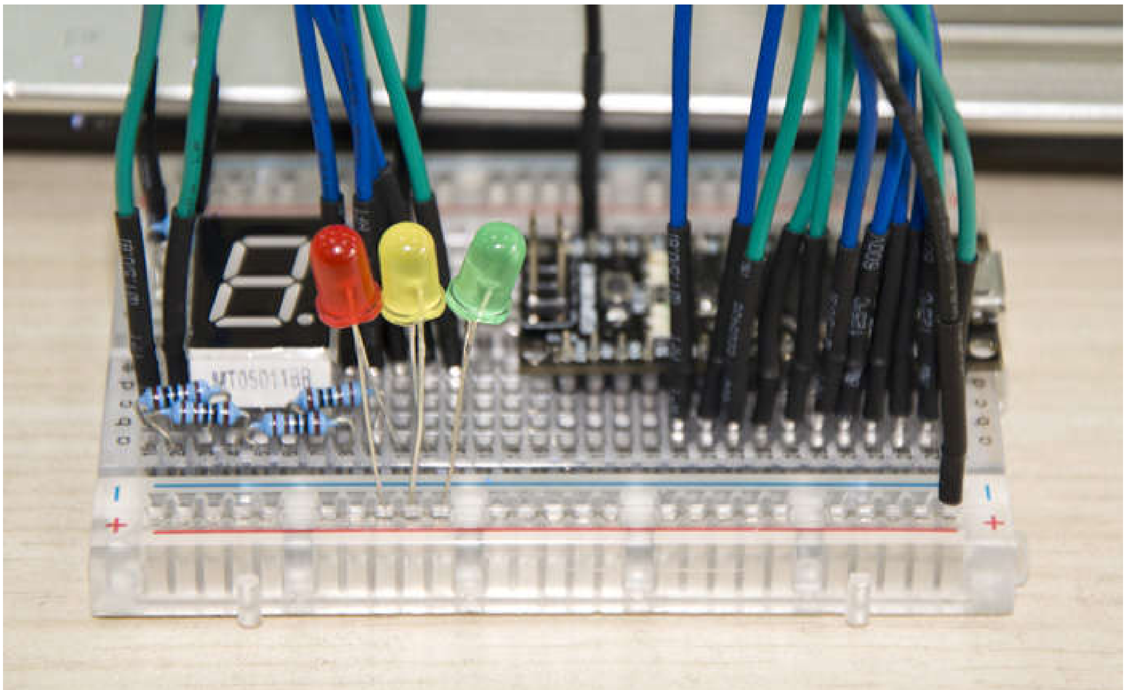
Keyestudio basic starter kit for UNO and Mega



Catalog

1. Kit introduction

This is the basic Starter Kit, developed specially for those beginners who are interested in Arduino. You will have a set of Arduino's most common and useful electronic components. What's more. We will offer you a detailed tutorials including project introduction and their source codes.You may learn about Arduino through using these basic projects. This kit will help you control the physical world with sensors.



2. Kit contents

Kit A for unoR3	Kit B for 2560 R3	Kit C Without board
UNO R3	Mega 2560	No controller board
5x LED - Blue	5x LED - Blue	5x LED - Blue
5x LED - Red	5x LED - Red	5x LED - Red
5x LED - Yellow	5x LED - Yellow	5x LED - Yellow
1x LED - RGB	1x LED - RGB	1x LED - RGB
5x 10K Ω resistor	5x 10K Ω resistor	5x 10K Ω resistor
5x 1K Ω resistor	5x 1K Ω resistor	5x 1K Ω resistor
8x 220 Ω resistor	8x 220 Ω resistor	8x 220 Ω resistor
1x 10K Ω Pot	1x 10K Ω Pot	1x 10K Ω Pot
1x 7-seg LED 1x module	1x 7-seg LED 1x module	1x 7-seg LED 1x module
1x 7-seg LED 4x module	1x 7-seg LED 4x module	1x 7-seg LED 4x module
1x 8x8 LED Matrix	1x 8x8 dot LED array	1x 8x8 dot LED array
1x Buzzer (active)	1x Buzzer (active)	1x Buzzer (active)
1x Buzzer (passive)	1x Buzzer (passive)	1x Buzzer (passive)
1x Flame sensor	1x Flame sensor	1x Flame sensor
1x IR receiver	1x IR receiver	1x IR receiver
1x IR remote control	1x IR remote control	1x IR remote control
1x LM35 Temp Sensor	1x LM35 Temp Sensor	1x LM35 Temp Sensor
2x Ball tilt sensor	2x Ball tilt sensor	2x Ball tilt sensor
3x Photo Resistor	3x Photo Resistor	3x Photo Resistor
4x Small button switch	4x Small button switch	4x Small button switch
1x IC 74HC595N 16-pin DIP	1x IC 74HC595N 16-pin DIP	1x IC 74HC595N 16-pin DIP
1x LCD1602	1X LCD1602	1X LCD1602
1x 9g servo	1X 9G sevro	1X 9G sevro
830-pin Breadboard	830-pin Breadboard	830-pin Breadboard
Dupont connector wires	Dupont connector wires	Dupont connector wires
1x 6-cell AA Battery pack	1x 6-cell AA Battery pack	1x 6-cell AA Battery pack
1x USB cable	1x USB cable	1x USB cable

3. Project list

1. Hello World
2. LED blinking
3. PWM
4. Traffic light
5. LED chase effect
6. Button-controlled LED
7. Active buzzer
8. Passive buzzer
9. RGB LED
10. Photo resistor
11. Flame sensor
12. LM35 temperature sensor
13. Tilt switch
14. IR remote control
15. Analog value reading
16. 74HC595
17. 1-digit LED segment display
18. 4-digit LED segment display
19. 8*8 LED matrix
20. 1602 LCD
21. 9g servo control

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

1. Arduino board x1
2. USB cable x1

Sample program

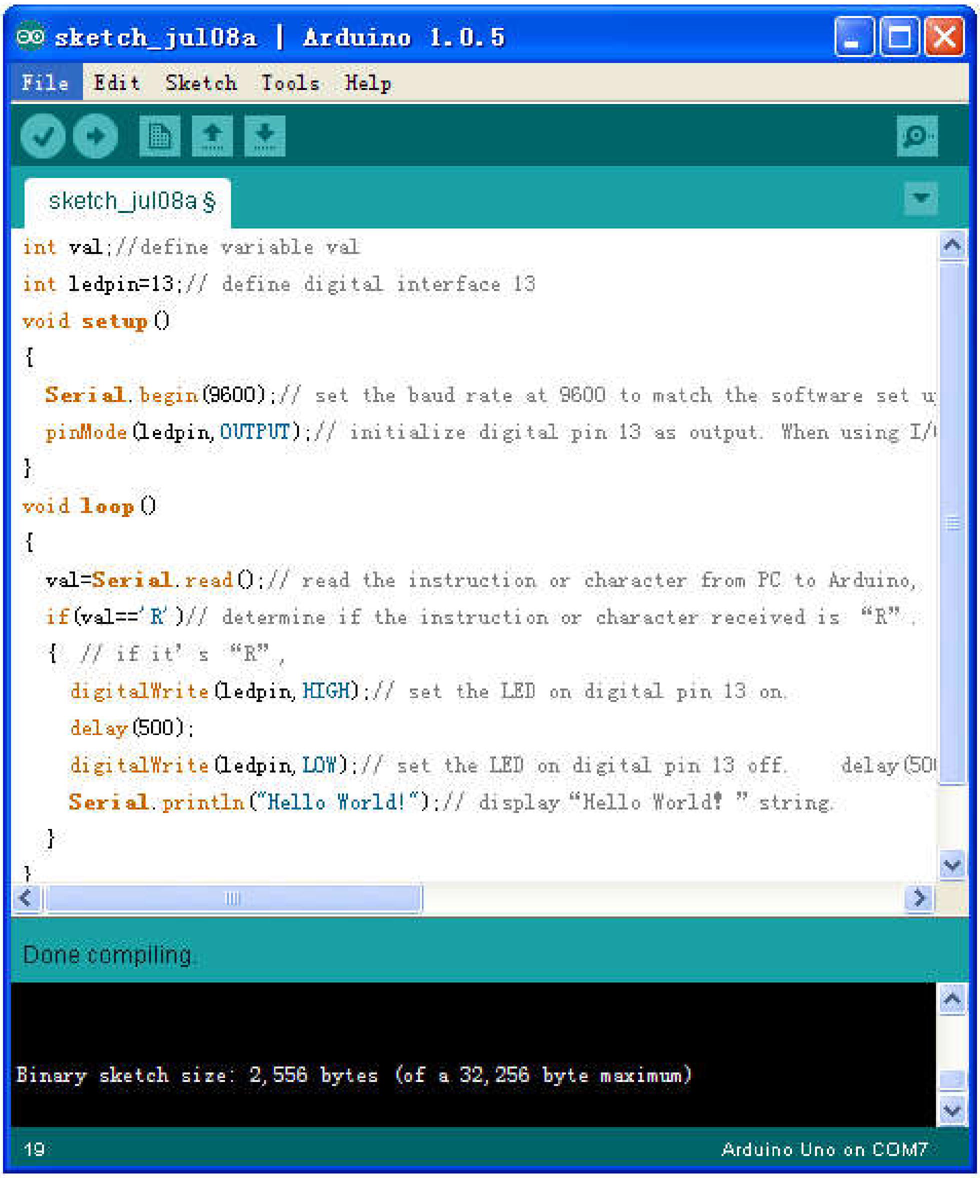
After installing driver for Arduino, let's open Arduino software and compile code that enables Arduino to print "Hello World!" under your instruction. Of course, you can compile code for Arduino to continuously echo "Hello World!" without instruction. A simple If () statement will do the instruction 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);
```

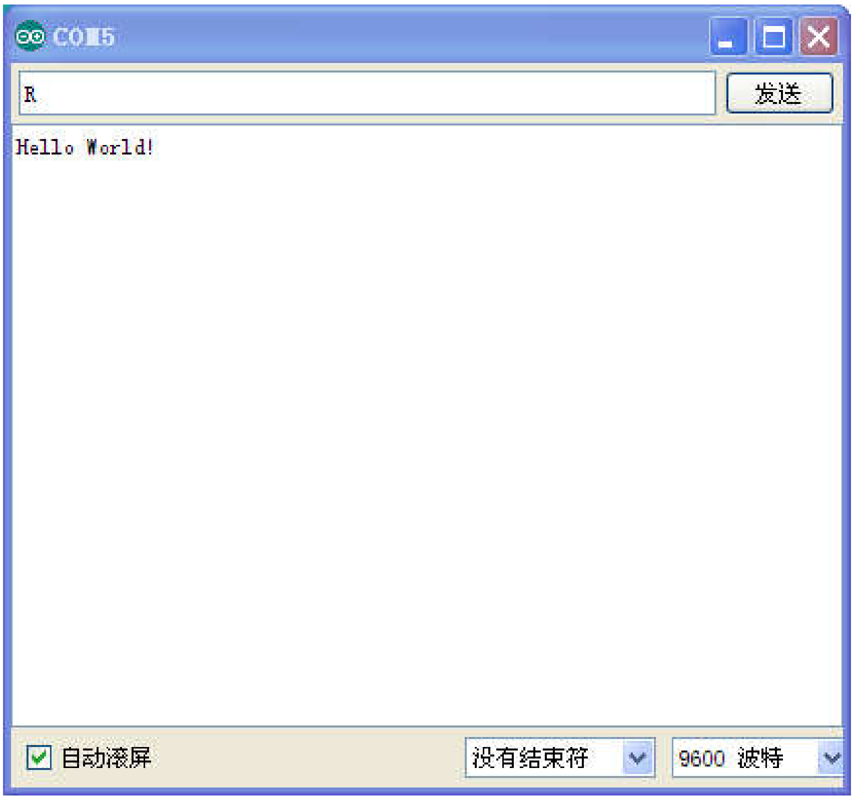
```
    digitalWrite(ledpin,LOW);// set the LED on digital pin 13 off.        delay(500);

    Serial.println("Hello World!");// display"Hello World！"string.
  }
}
////////////////////////////////////////////////////////////
```

Result

Screenshot



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



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

Project 2: LED blinking

Introduction

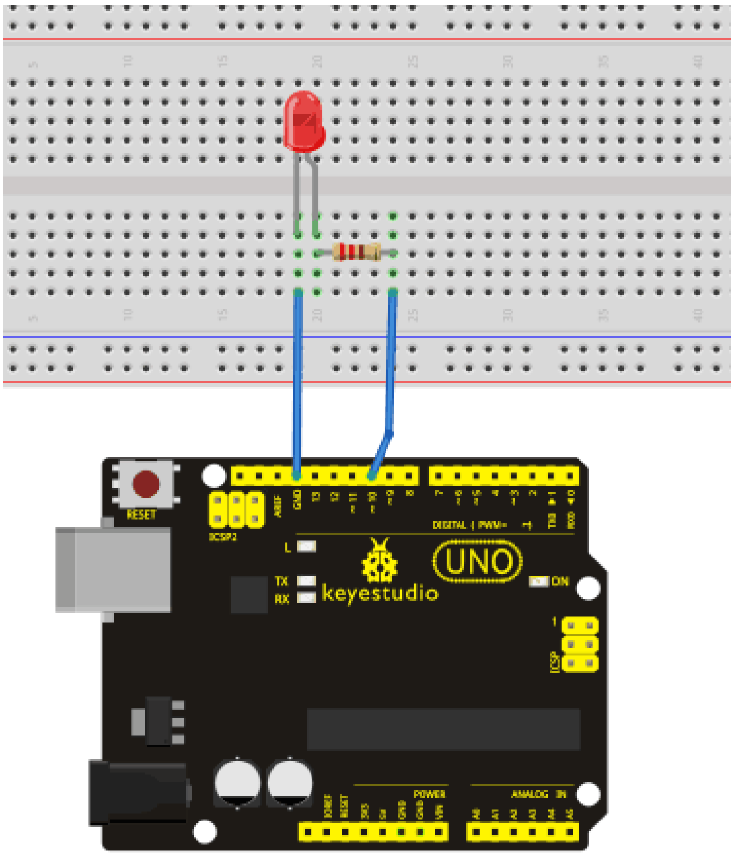
Blinking LED experiment is quite simple. In the "Hello World!" program, we have come across LED. This time, we are going to connect an LED to one of the digital pins rather than using LED13, which is soldered to the board. Except an Arduino and an USB cable, we will need extra parts as below:

Hardware required

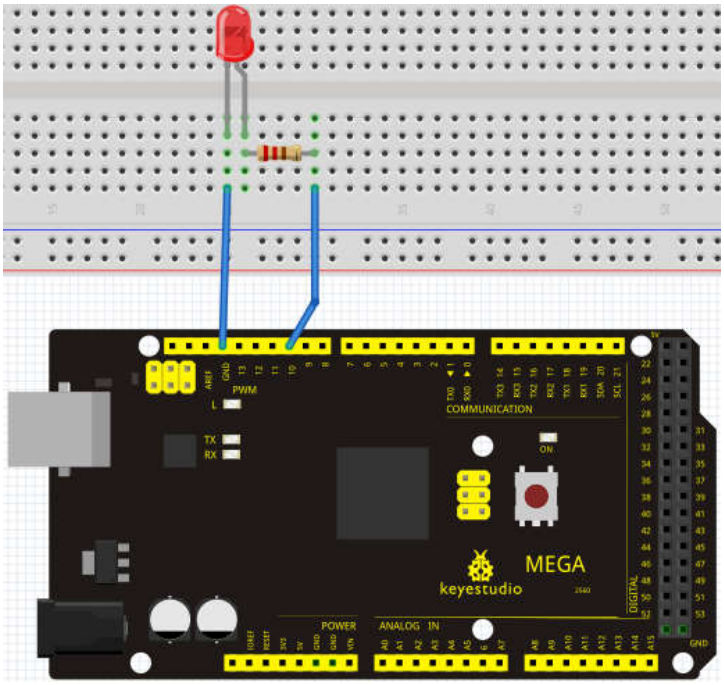
1. Red M5 LED*1
2. 220Ω resistor*1
3. Breadboard*1
4. Breadboard jumper wires* several

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:



Connection for 2560 R3:



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

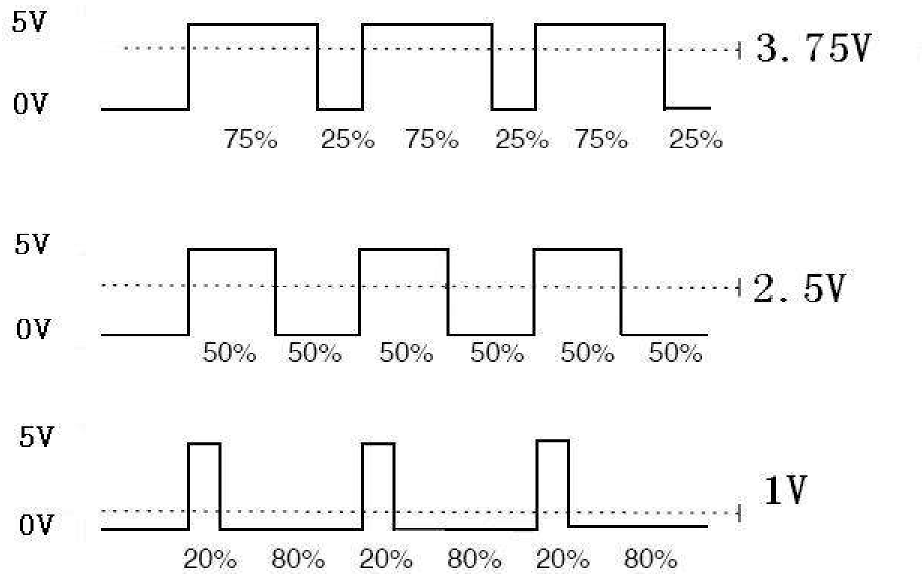
Result

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!

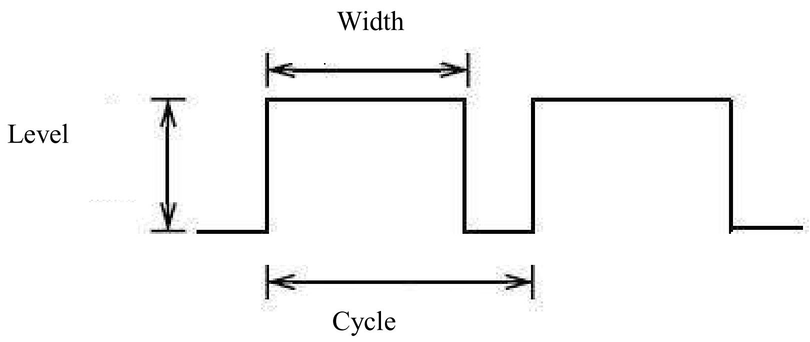
Project 3: PWM

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)
3. The voltage level（such as：0V-5V）

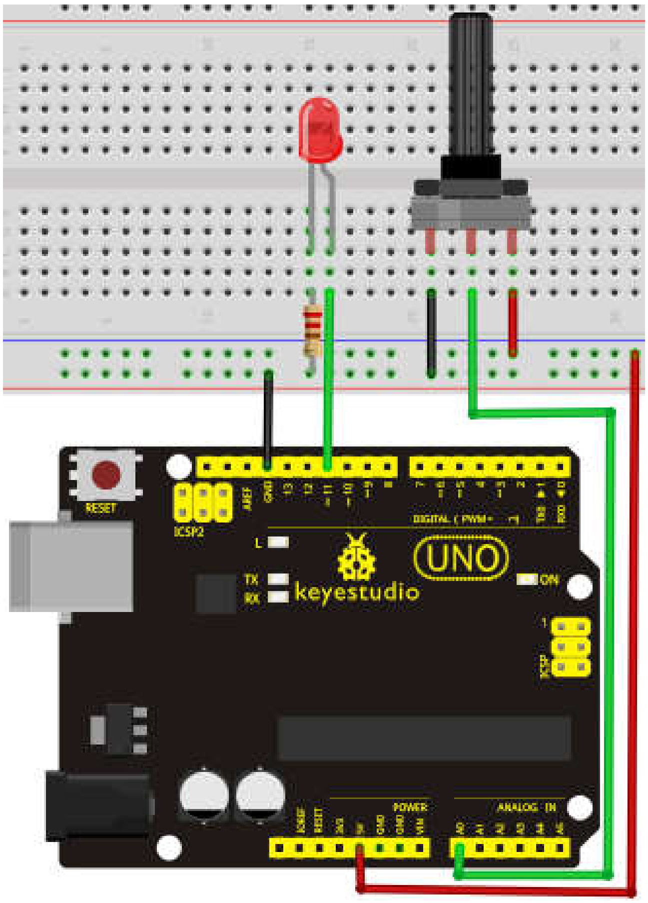
There are 6 PMW interfaces on Arduino, namely digital pin 3, 5, 6, 9, 10, and 11. In previous experiments, we have done "button-controlled LED", using digital signal to control digital pin, also one about potentiometer. This time, we will use a potentiometer to control the brightness of the LED.

Hardware required

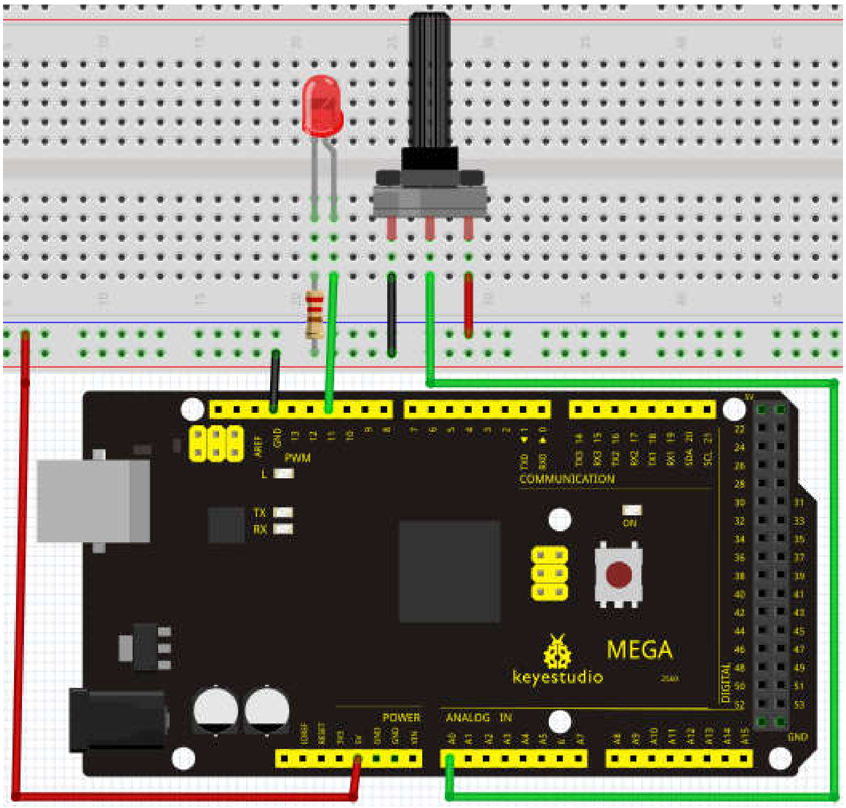
1. Potentiometer*1
2. Red M5 LED*1
3. 220Ω resistor
4. Breadboard*1
5. Breadboard jumper wires*several

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:



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
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.

Project 4: Traffic light

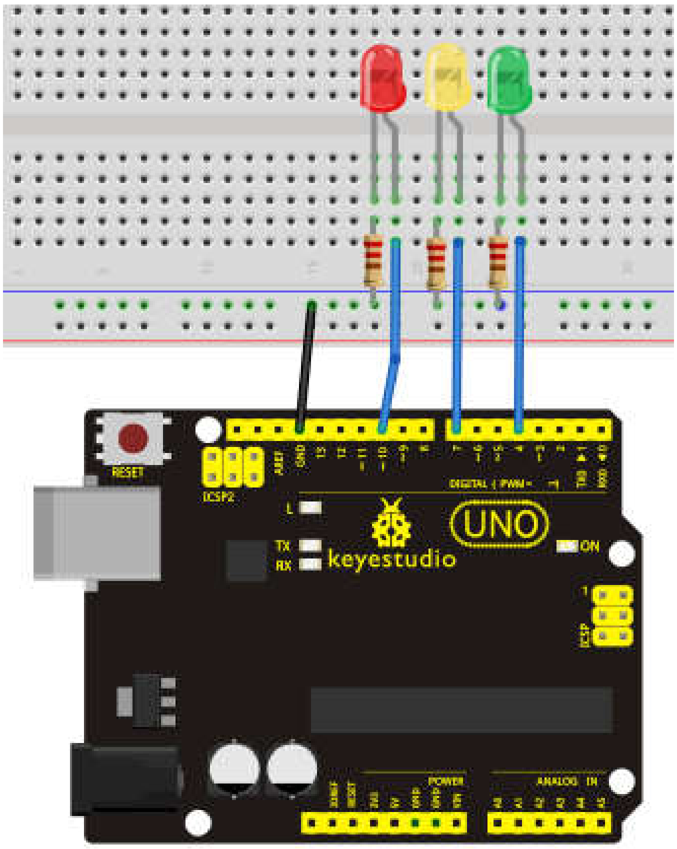
Introduction

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.

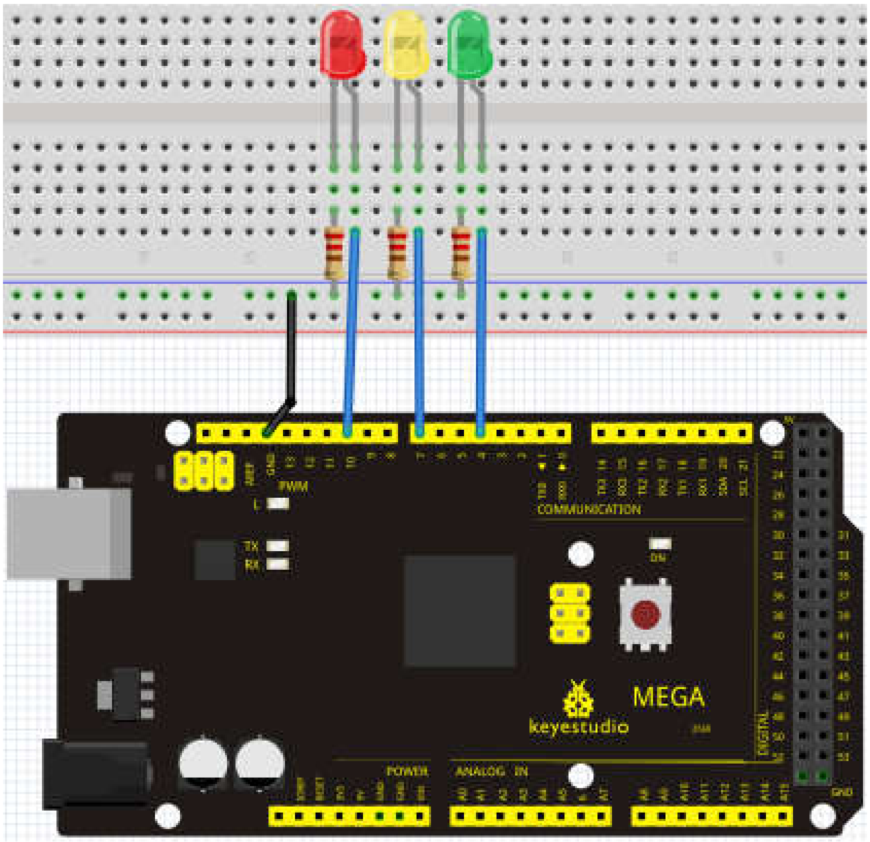
Hardware required

1. Arduino board *1
2. USB cable *1
3. Red M5 LED*1
4. Yellow M5 LED*1
5. Green M5 LED*1
6. 220Ω resistor *3
7. Breadboard*1
8. Breadboard jumper wires* several

Connection for UNO R3:



Connection for 2560 R3:



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
{
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.

Project 5: LED chasing effect

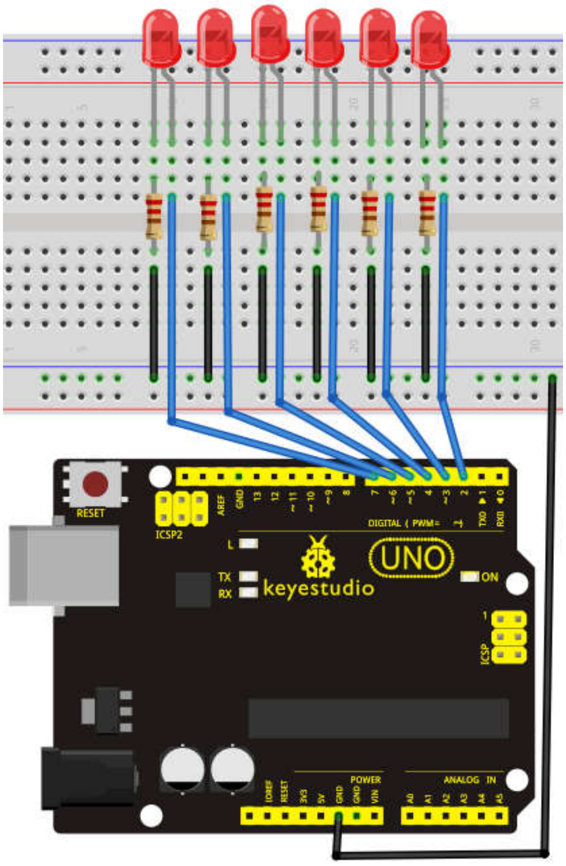
Introduction

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.

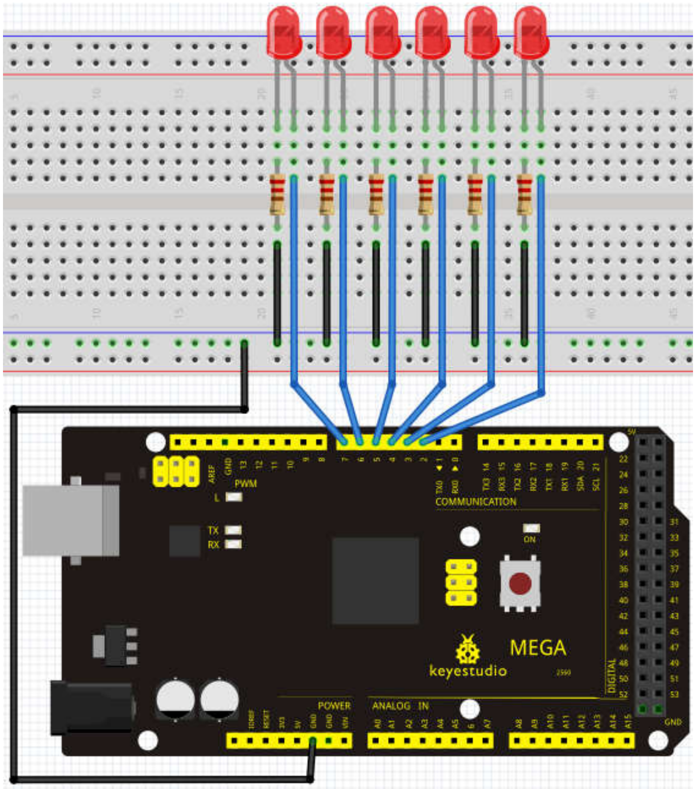
Hardware required

1. Led x6
2. 220Ω resistor x6
3. Colorful breadboard wires

Connection for UNO R3:



Connection for 2560 R3:



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 ++)
    {
      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

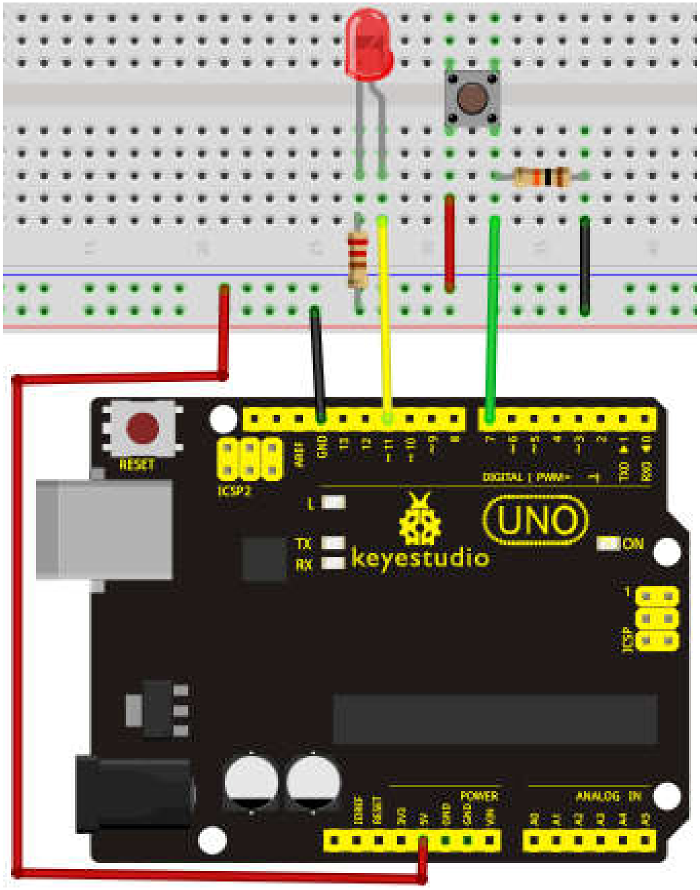
Introduction

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.

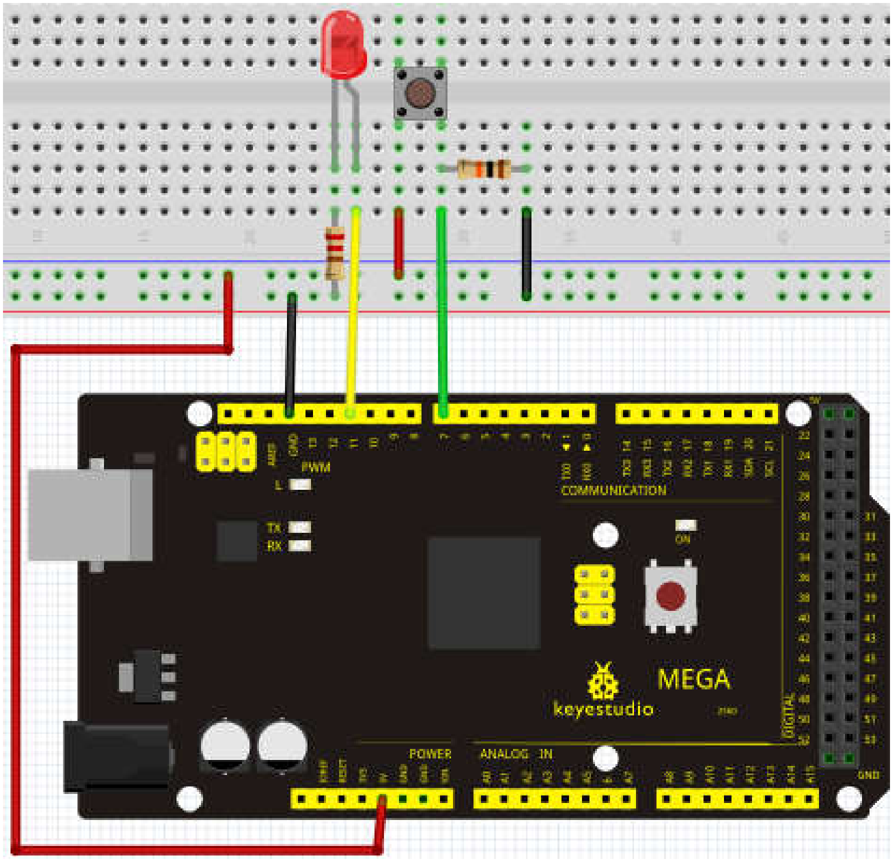
Hardware required

1. Button switch*1
2. Red M5 LED*1
3. 220Ω resistor*1
4. 10KΩ resistor*1
5. Breadboard*1
6. Breadboard jumper wires*several

Connection for UNO R3:



Connection for 2560 R3:



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()
{
val=digitalRead(inpin);// read the level value of pin 7 and assign if 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.

Project 7: Active buzzer

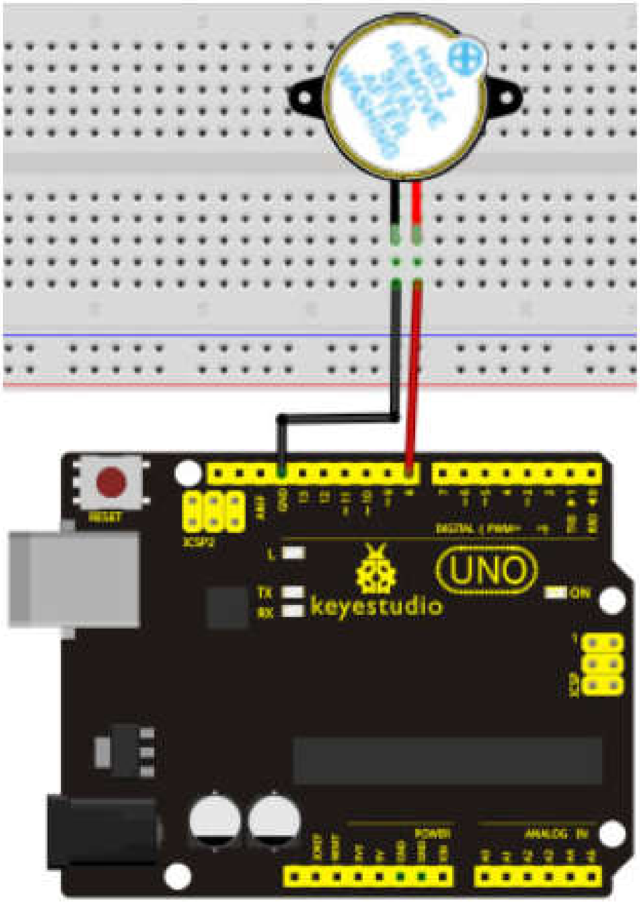
Introduction

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.

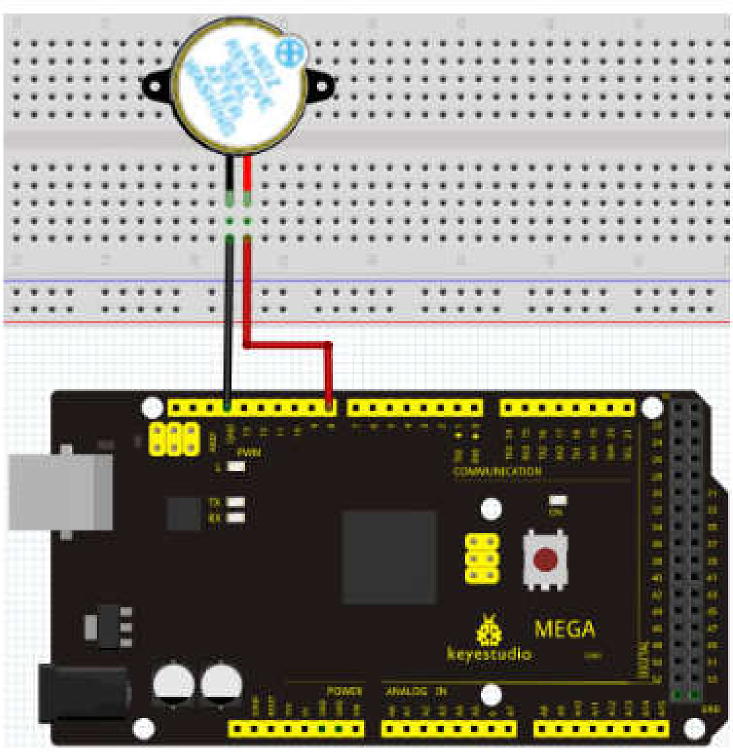
Hardware required

1. Buzzer*1
2. Key *1
3. Breadboard*1
4. Breadboard jumper wires*several

Connection for UNO R3:



Connection for 2560 R3:



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.

Project 8: Passive buzzer

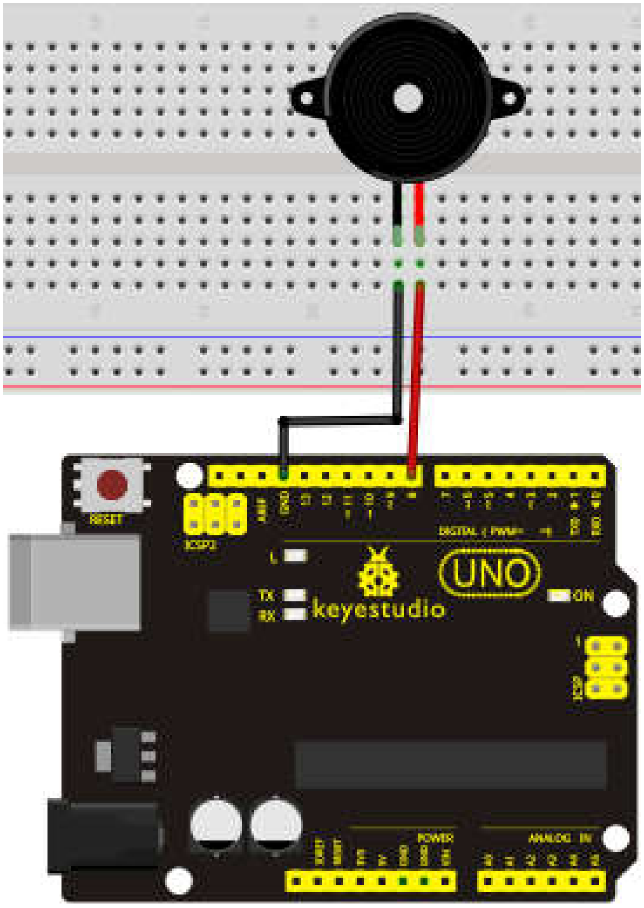
Introduction

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.

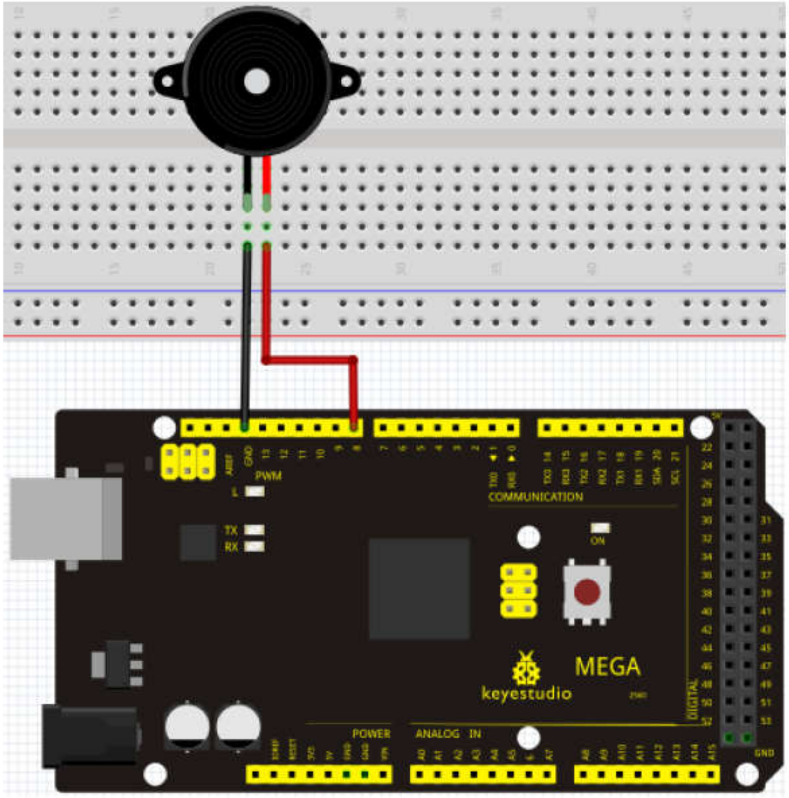
Hardware required

1. Passive buzzer*1
2. Key *1
3. Breadboard*1
4. Breadboard jumper wires* several

Connection for UNO R3:



Connection for 2560 R3:



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);//delay1ms
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
}
}
}
//////////////////////////////////////////////////////////
```

After downloading the program, buzzer experiment is finished.

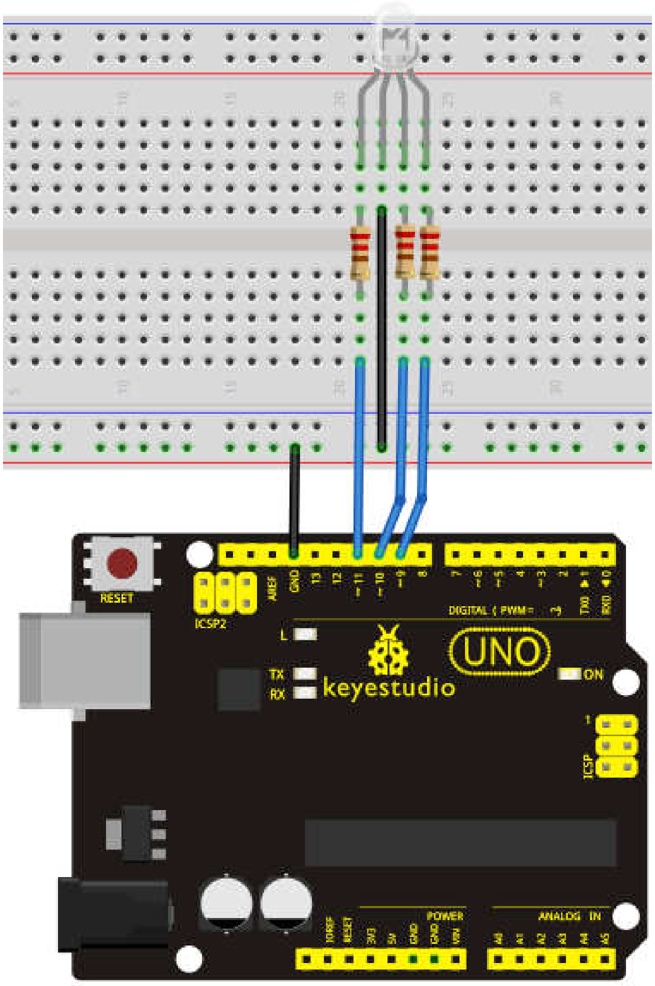
Project 9: RGB LED

Introduction

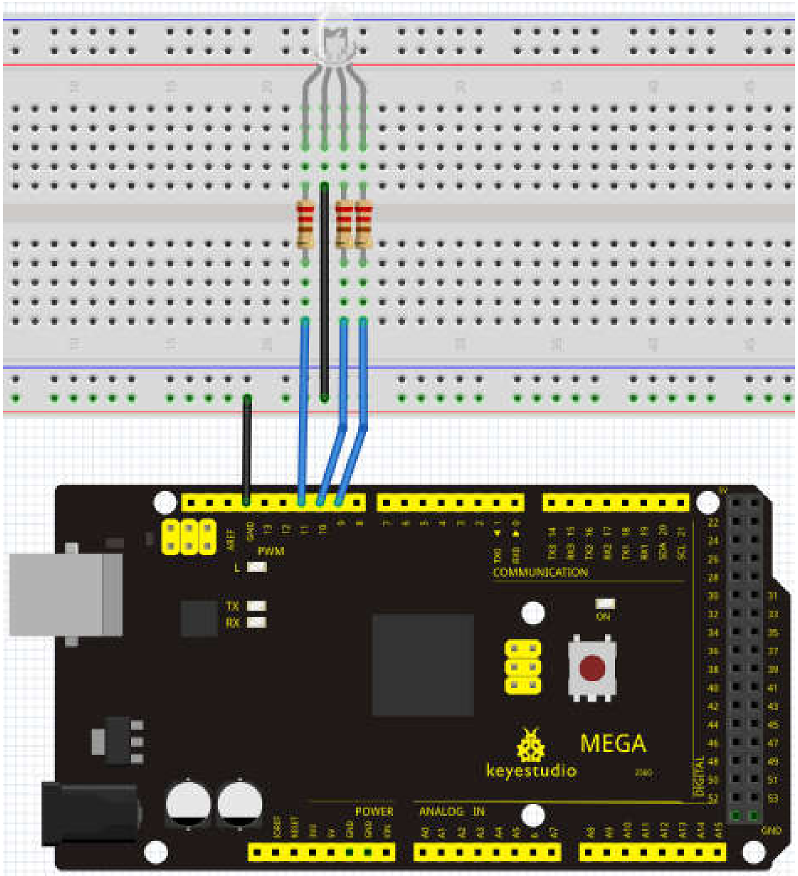
Tricolor principle to display various colors
PWM controlling ports to display full color
Can be driven directly by Arduino PWM interfaces

Hardware Required

Arduino controller × 1
USB cable × 1
Full-color LED module × 1
Connection for UNO R3:



Connection for 2560 R3:



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--)
   {
    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

Project 10: Photo resistor

Introduction

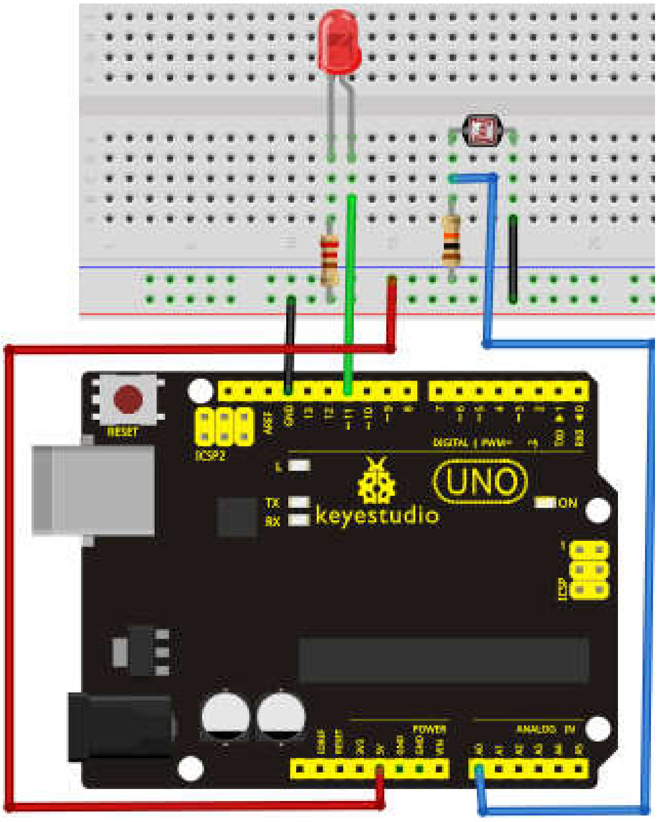
After completing all the previous experiments, we acquired some basic understanding and knowledge about Arduino application. We have learned digital input and output, analog input and PWM. Now, we can begin the learning of sensors applications. Photo resistor (Photovaristor) is a resistor whose resistance 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. Photovaristor 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.
We will start with a relatively simple experiment regarding photovaristor application. Photovaristor is an element that changes its resistance as light strenth changes. So we will need to read the analog values. We can refer to the PWM experiment, replacing the potentiometer with photovaristor. When there is change in light strength, there will be corresponding change on the LED.

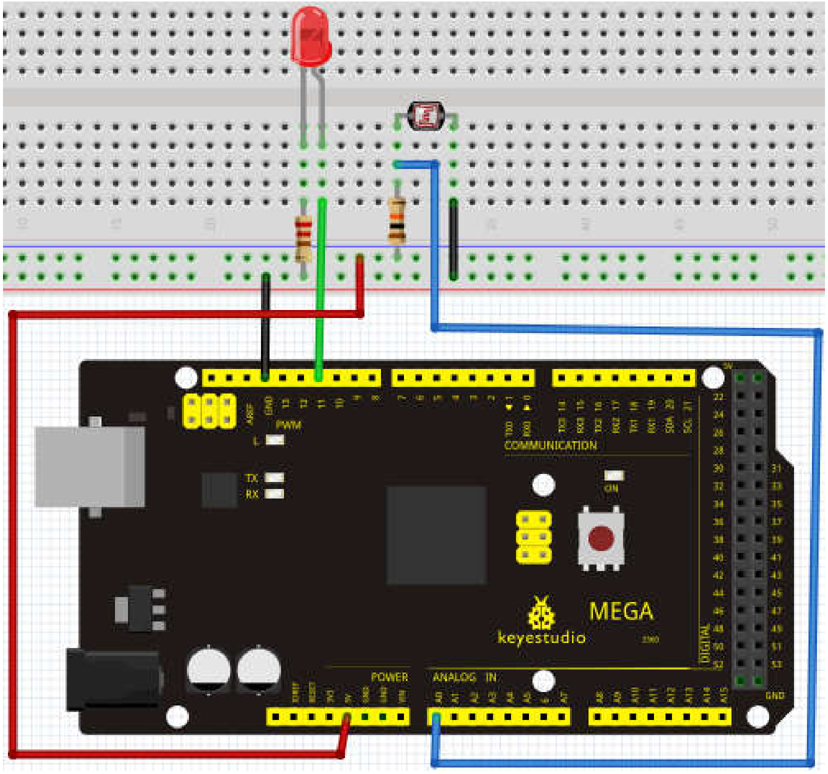
Hardware required

Photo resistor*1
Red M5 LED*1
10KΩresistor*1
220Ωresistor*1
Bread board*1
Bread board jumper wires*several

Connection for UNO R3:



Connection for 2560 R3:



Sample program

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

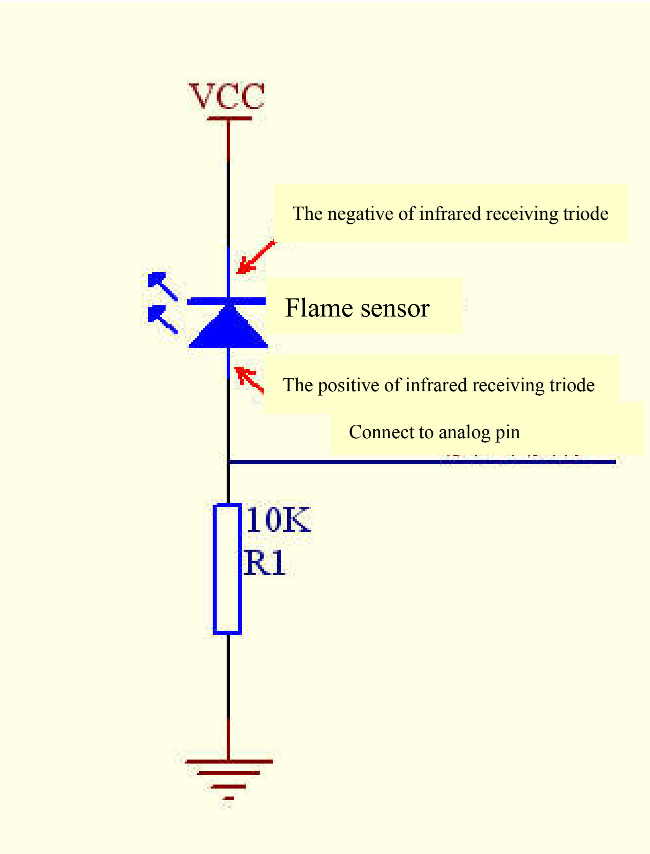
Introduction

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.

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:



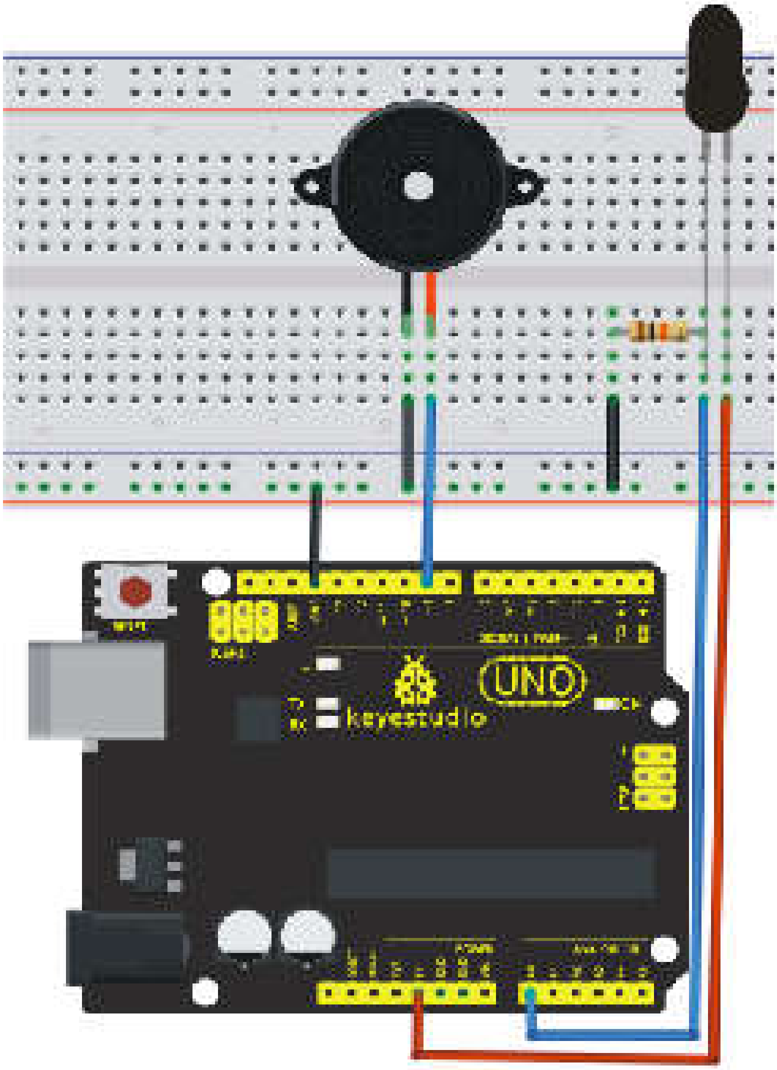
Hardware required

1. Flame sensor *1
2. Buzzer *1
3. 10K resistor x1
4. Breadboard jumper wires: several

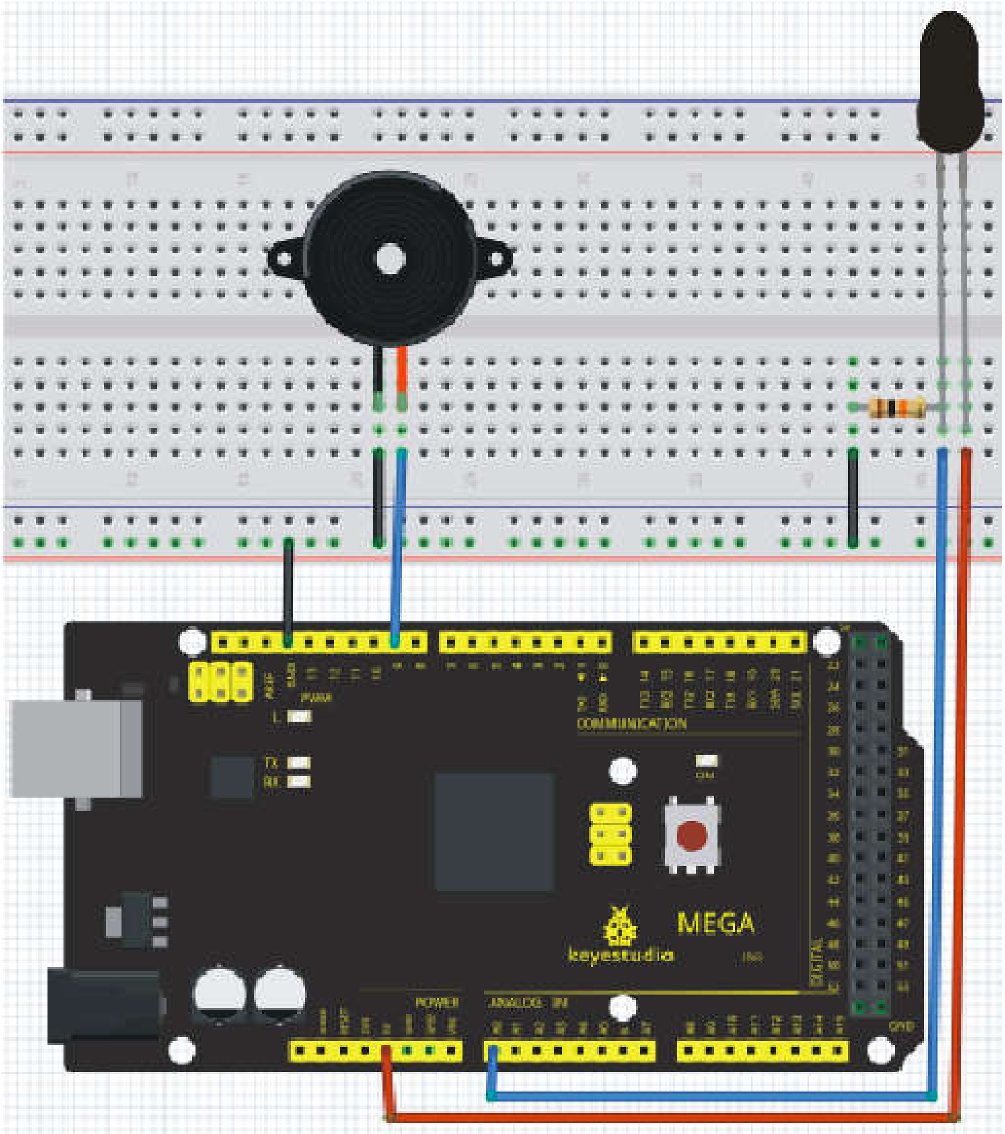
Experiment connection

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:



Connection for 2560 R3:



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, tthe 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"
 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

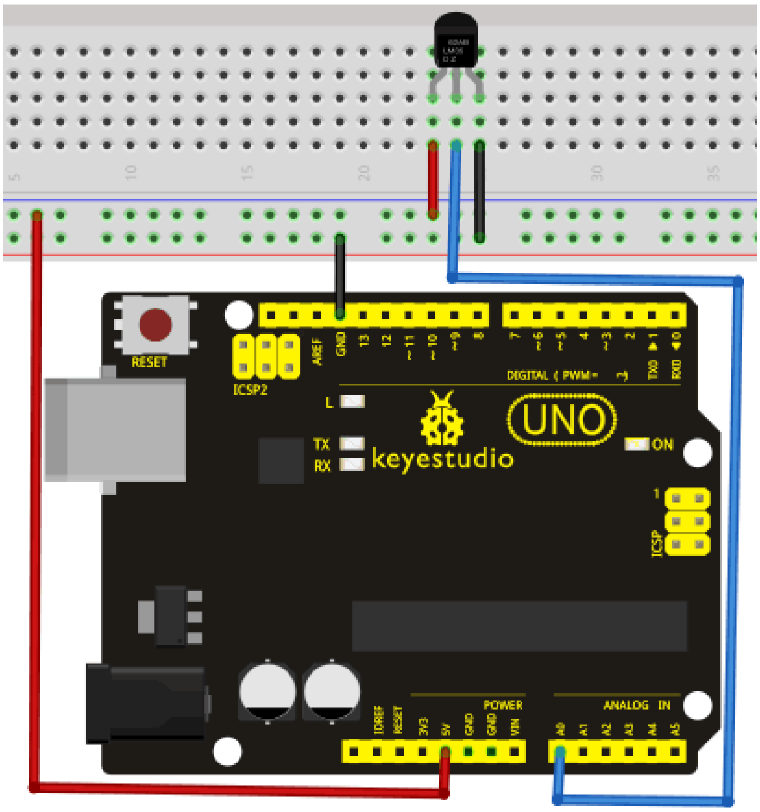
Introduction

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.

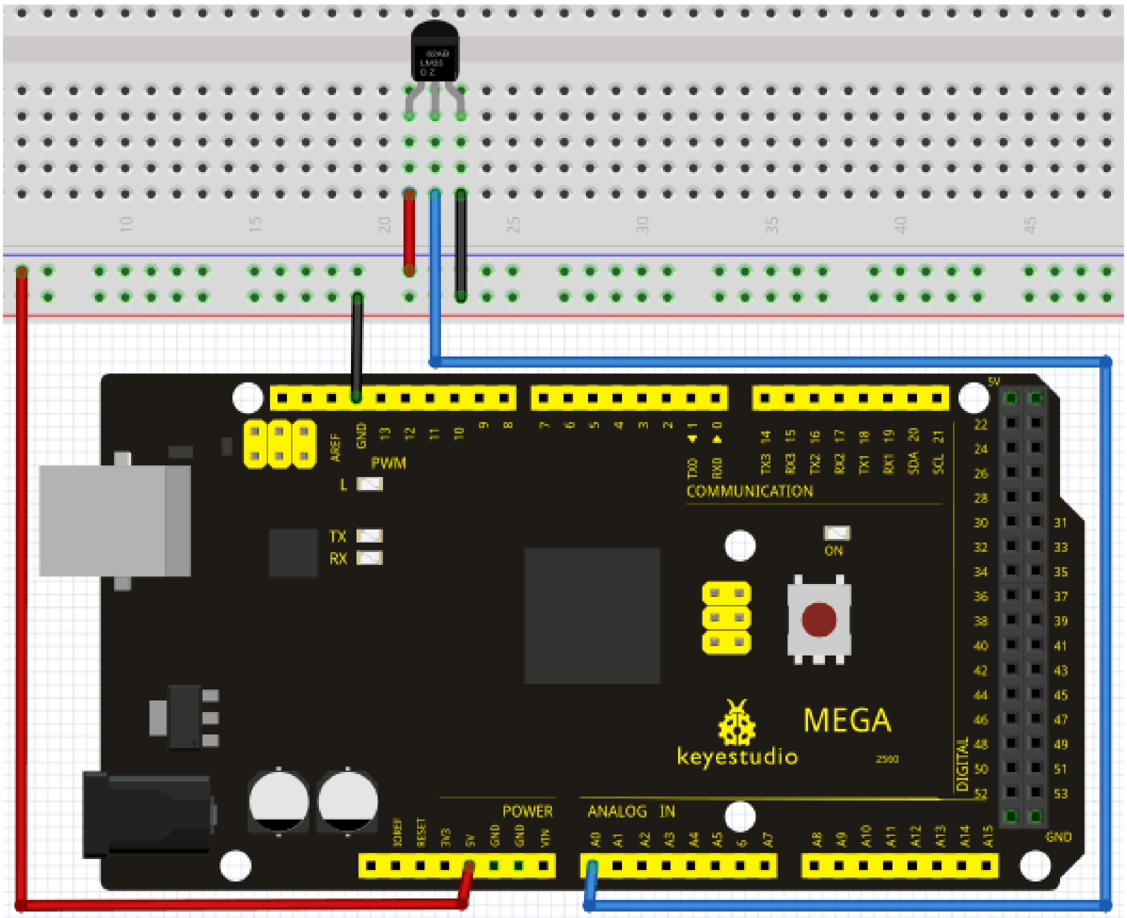
Hardware required

1. LM35*1
2. Breadboard*1
3. Breadboard jumper wires*several

Connection for UNO R3:



Connection for 2560 R3:



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

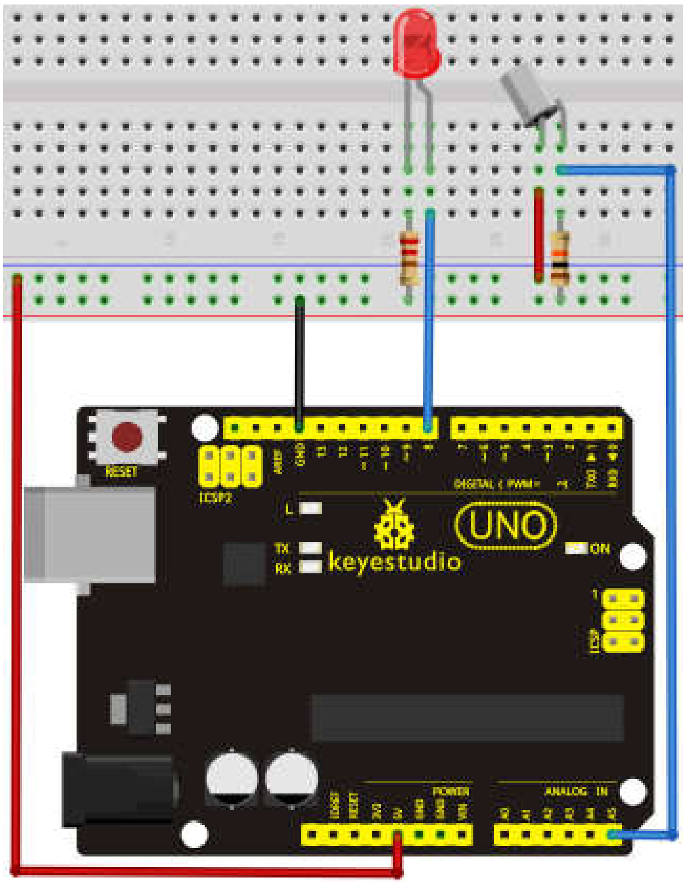
Introduction

Tilt switch controlling the ON and OFF of LED

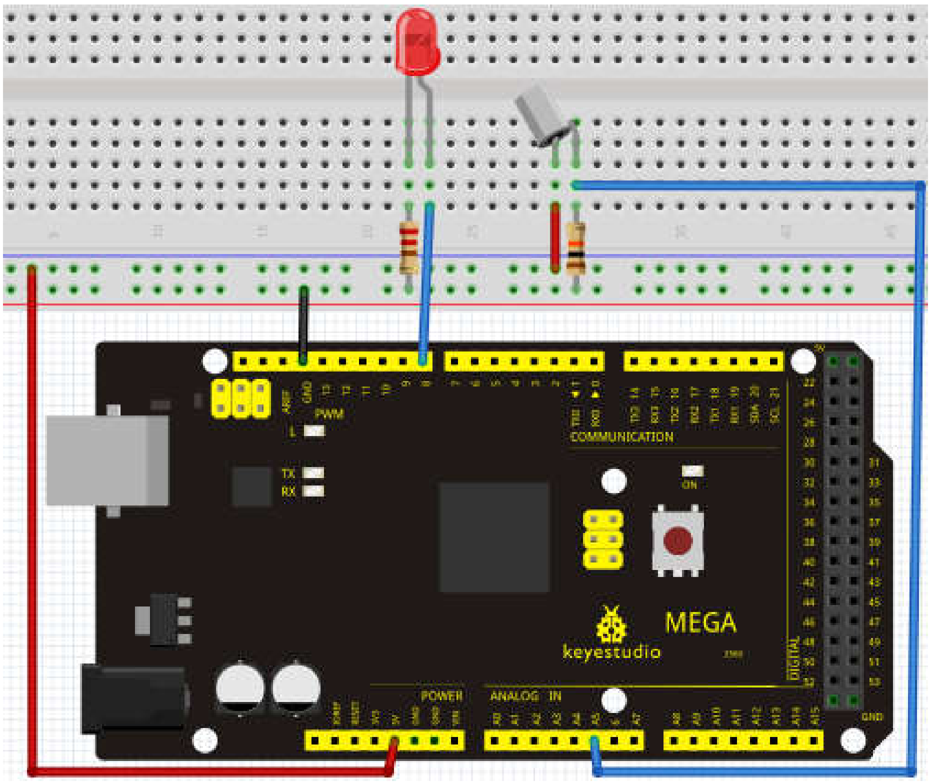
Hardware required

1. Ball switch*1
2. Led *1
3. 220Ω resistor*1
4. 10KΩ resistor*1
4. Breadboard jumper wires:several

Connection for UNO R3:



Connection for 2560 R3:



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)
{
  i=analogRead(5);// read the voltage value of analog pin 5
  if(i>512)// if larger that 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!

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

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

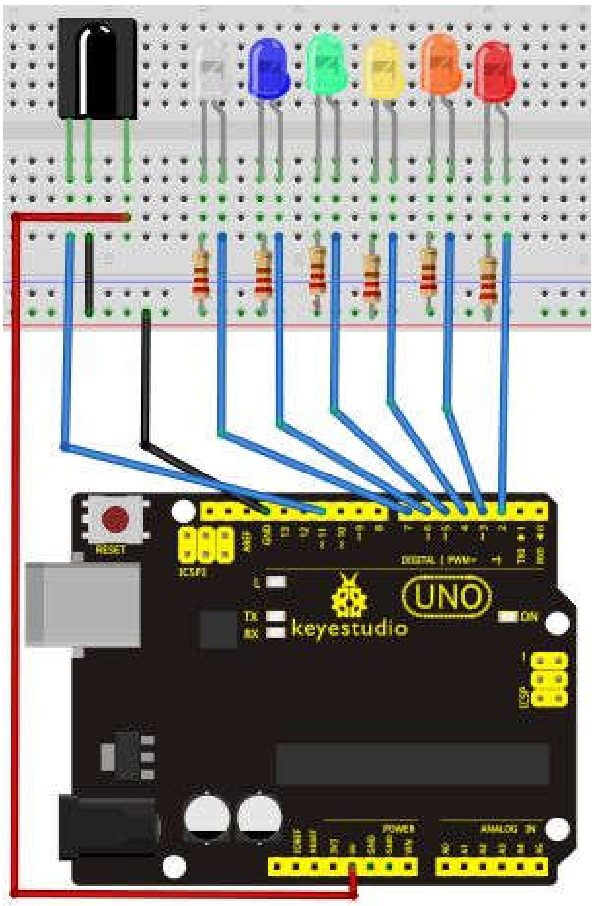
Infrared remote controller x1
Infrared receiver x1
LED x6
220Ω resistor x6

Multi-color breadboard wires x several

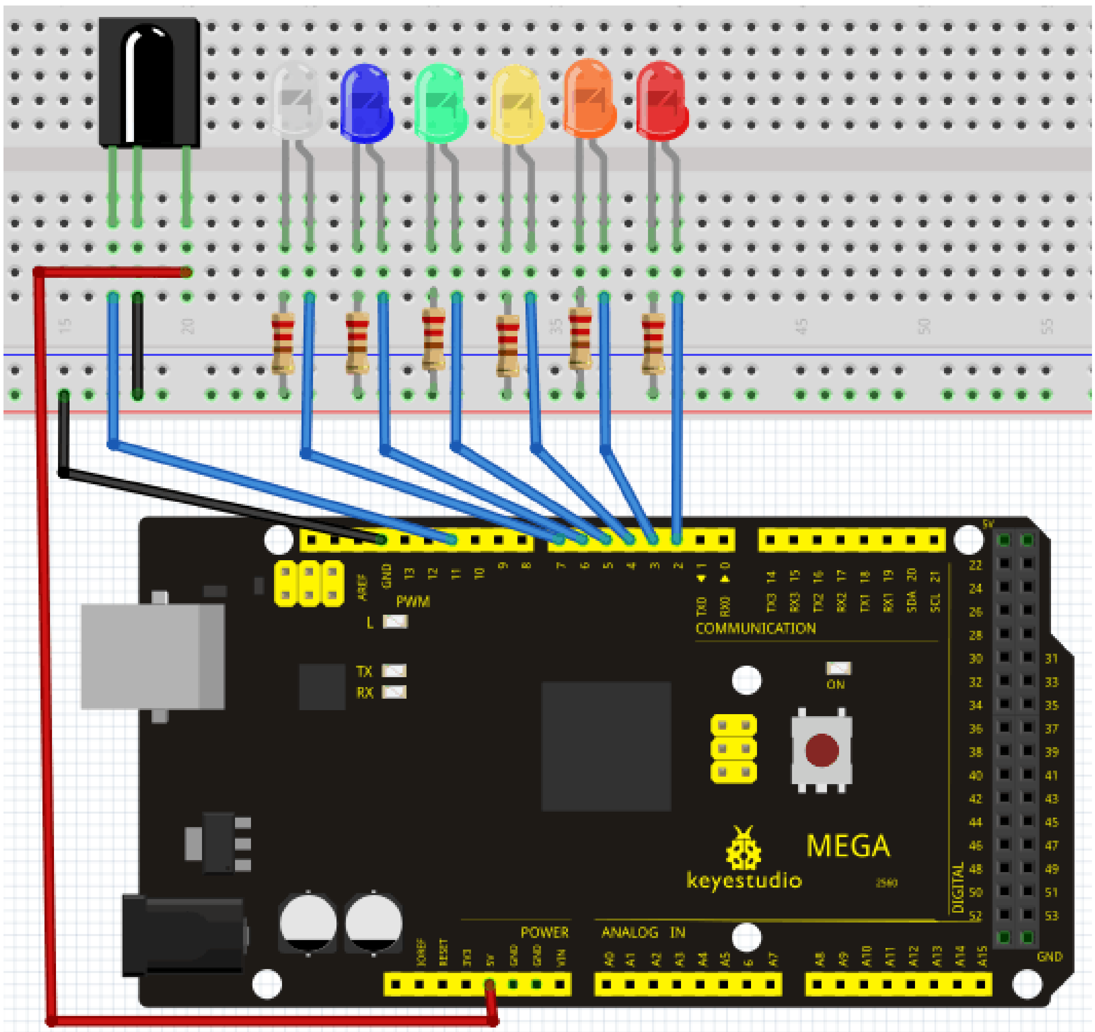
Connection

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 resisters to pin 2,3,4,5,6,7.

Connection for UNO R3:



Connection for 2560 R3:



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

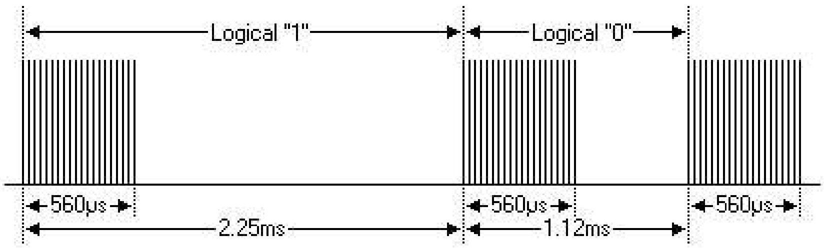
(3) pulse distance modulation

(4) carrier frequency of 38 KHZ

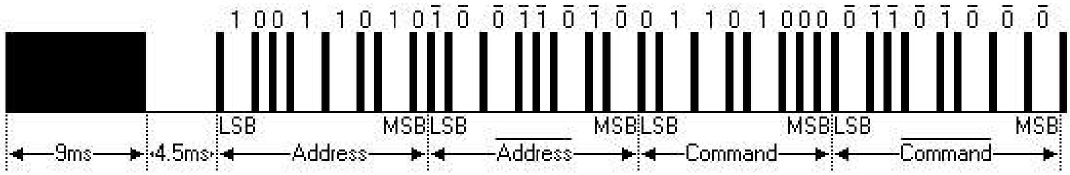
(5) bit time of 1.125ms or 2.25ms

Protocol is as below:

• Definition of logical 0 and 1 is as below

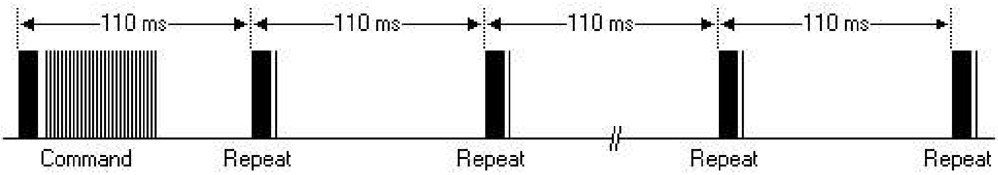


• Pulse transmitted when button is pressed and immediately released



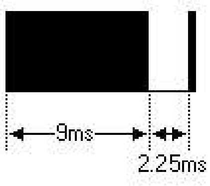
The picture above shows a typical pulse train of the NEC protocol. With this protocol the LSB is transmitted first. In this case Address $59 and Command $16 is transmitted. A message is started by a 9ms AGC burst, which was used to set the gain of the earlier IR receivers. This AGC burst is then followed 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 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)
          {
           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);
    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 )
     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

screen shot

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

For example： C:\Program Files\Arduino\libraries

Project 15: Analog value reading

Introduction

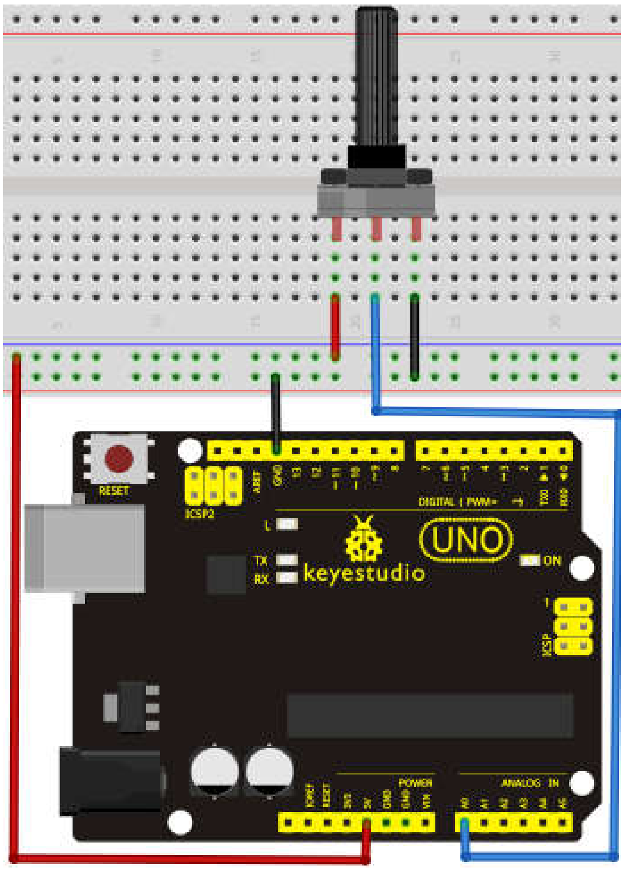
In this experiment, we will begin the learning of analog I/O interfaces. On an Arduino, there are 6 analog interfaces numbered from 0 to 5. These 6 interfaces can also be used as digital ones numbered as 14-19. After a brief introduction, let's begin our project. Potentiometer used here is a typical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

Hardware required

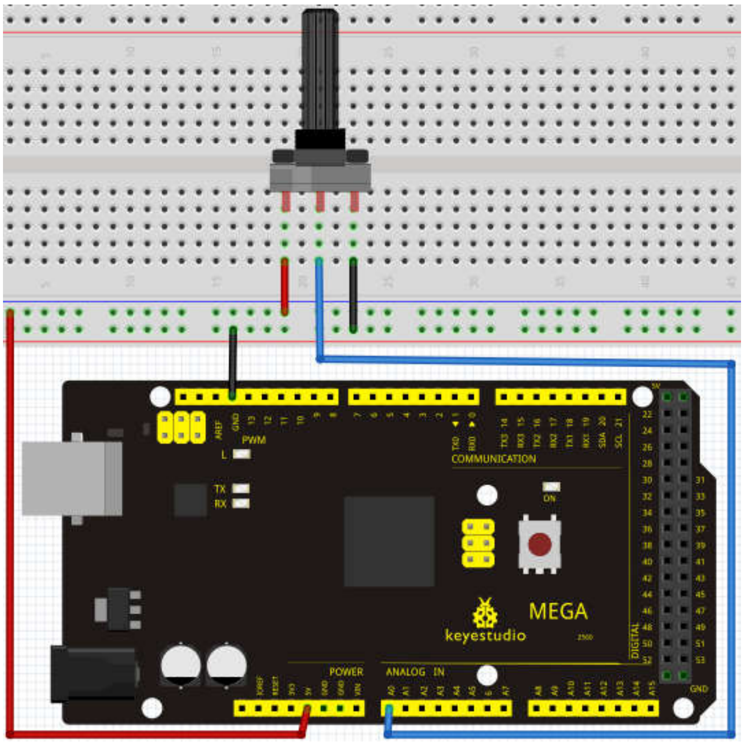
Potentiometer *1
Breadboard*1
Breadboard jumper wires * several

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:



Connection for 2560 R3:



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.

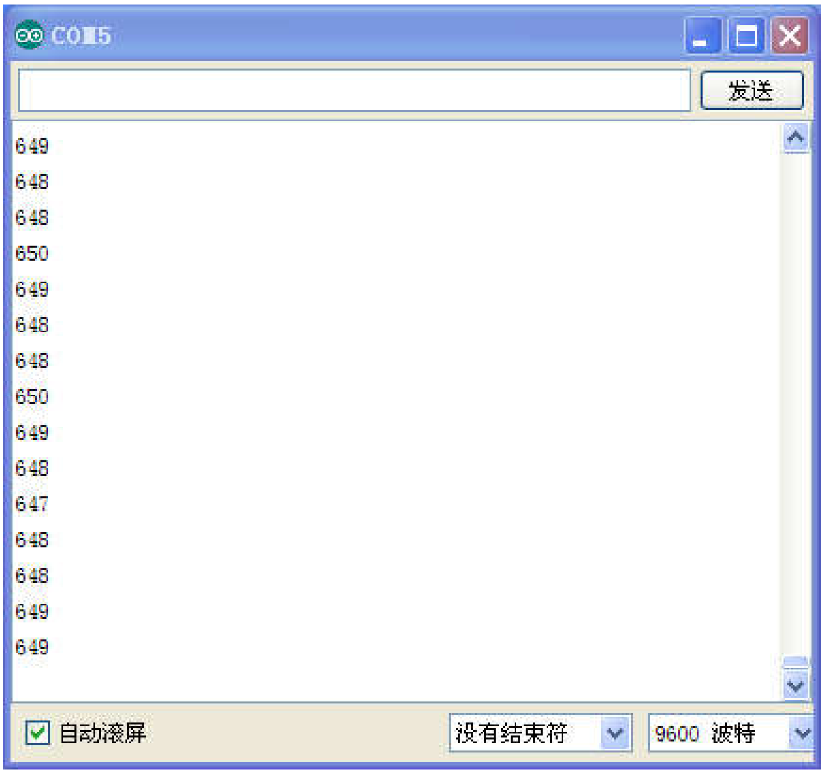
```
//////////////////////////////////////////////////////////
int potpin=0;// initialize analog pin 0
int ledpin=13;// initialize digital pin 13
int val=0;// define val, assign initial value 0
void setup()
{
pinMode(ledpin,OUTPUT);// set digital pin as "output"
```

```
Serial.begin(9600);// set baud rate at 9600

}
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.

Project 16: 74HC595

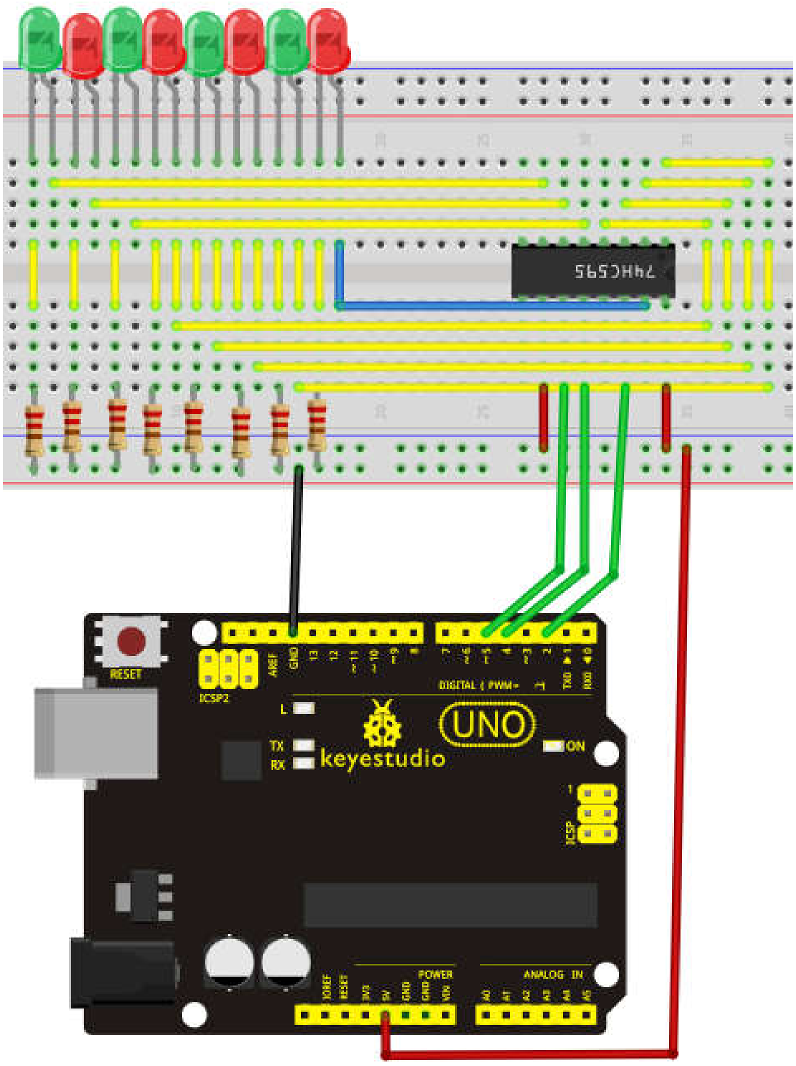
Introduction

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!

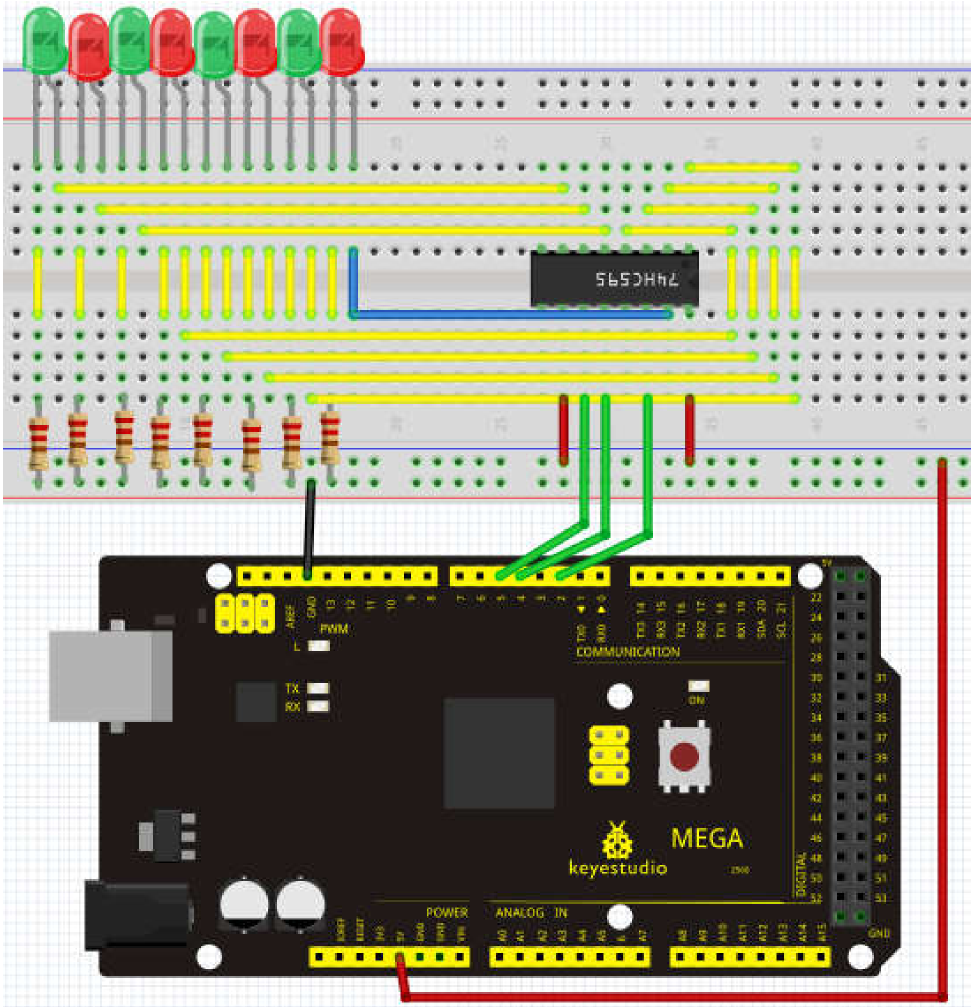
Hardware required

74HC595 chip*1
Red M5 LED*4
Green M5 LED*4
220Ω resistor*8
Breadboard*1
Breadboard jumper wires*several
Note: for pin 13 OE port of 74HC595, it needs to connect to GND

Connection for UNO R3:



Connection for 2560 R3:



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

Sample program

//

int data = 2;// set pin 14 of 74HC595as 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);
delay(500);
}
/////////////////////////////////////////////////////////////
```

Result

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

Project 17: 1-digit LED segment display

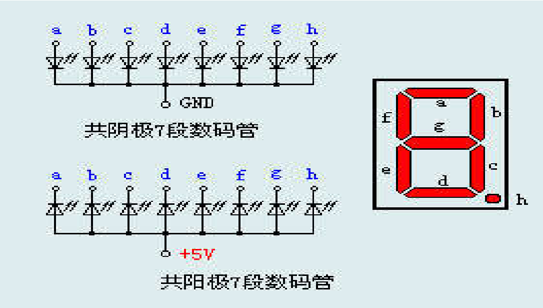
Introduction

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.

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

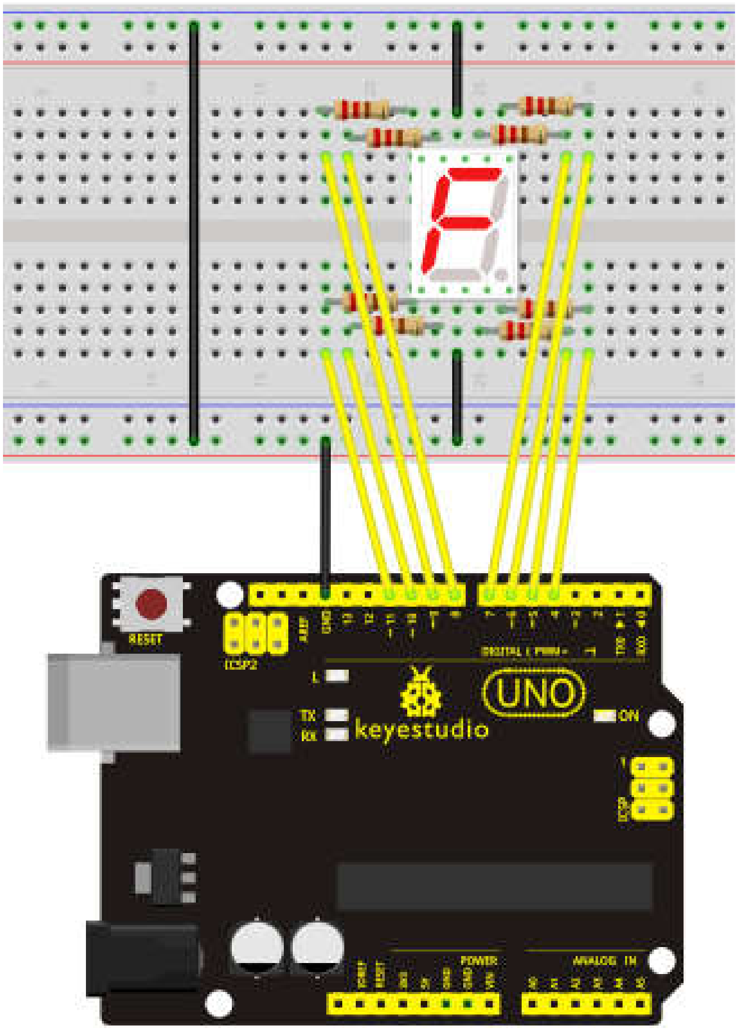
Eight-segment display*1
220Ω resistor*8

Breadboard*1
Breadboard jumper wires*several

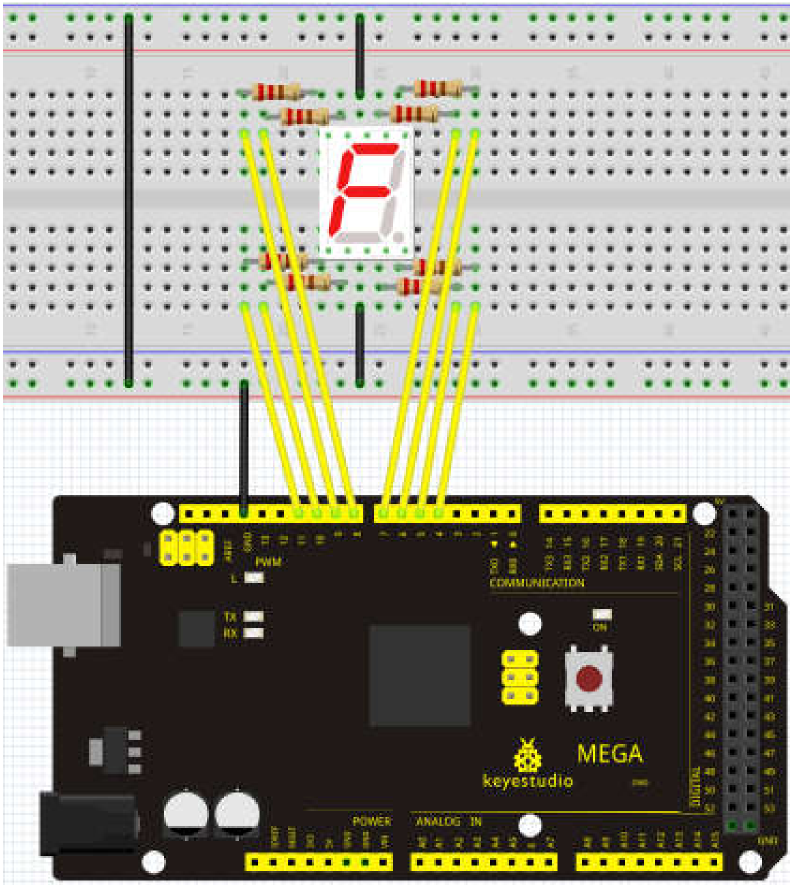
Connection

Refer to below connection diagram for circuit connection

Connection for UNO R3:



Connection for 2560 R3:



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);
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);
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);
}
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 4-11as "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
delay(1000); // wait for 1s
}
}
////////////////////////////////////////////////////////////
```

Result

LED segment display displays number 0 to 9

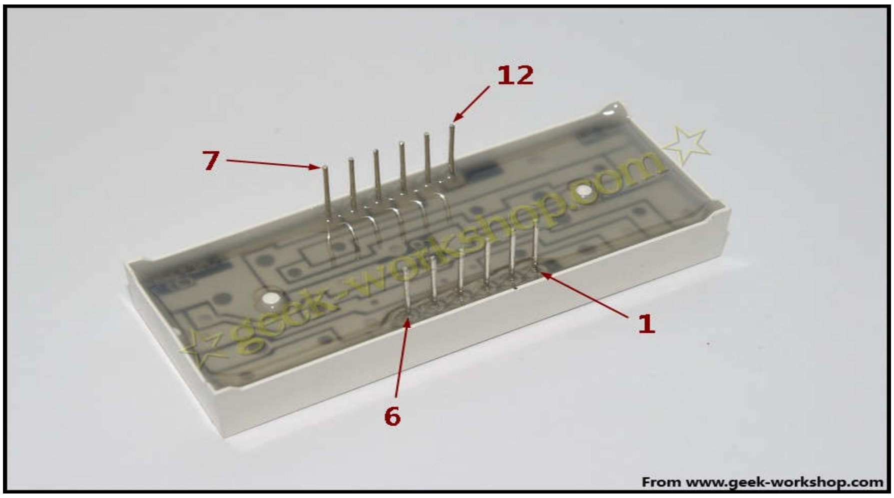
Project 18: 4-digit LED segment display

Introduction

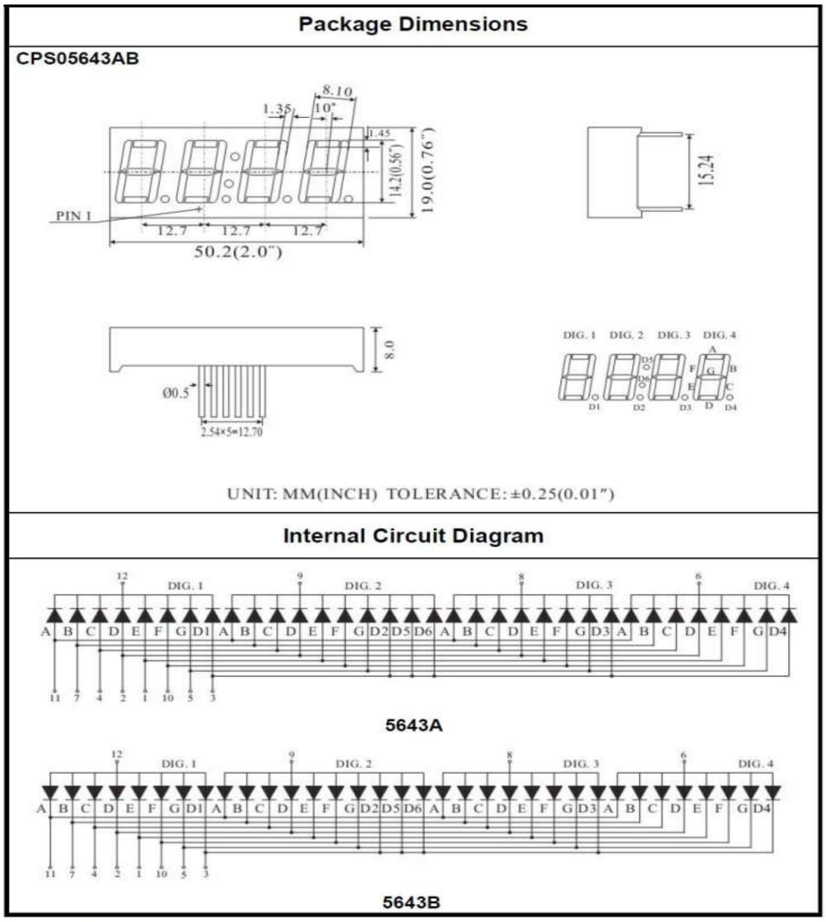
In this experiment, we use an Arduino to drive a common anode, 4-digit, 7-segment LED display. For LED display, current-limiting resistors are indispensable. There are two wiring method for Current-limiting resistor. One is to connect one resistor for each anode, 4 in totals for d1-d4 anode. An advantage 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).

Connection

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

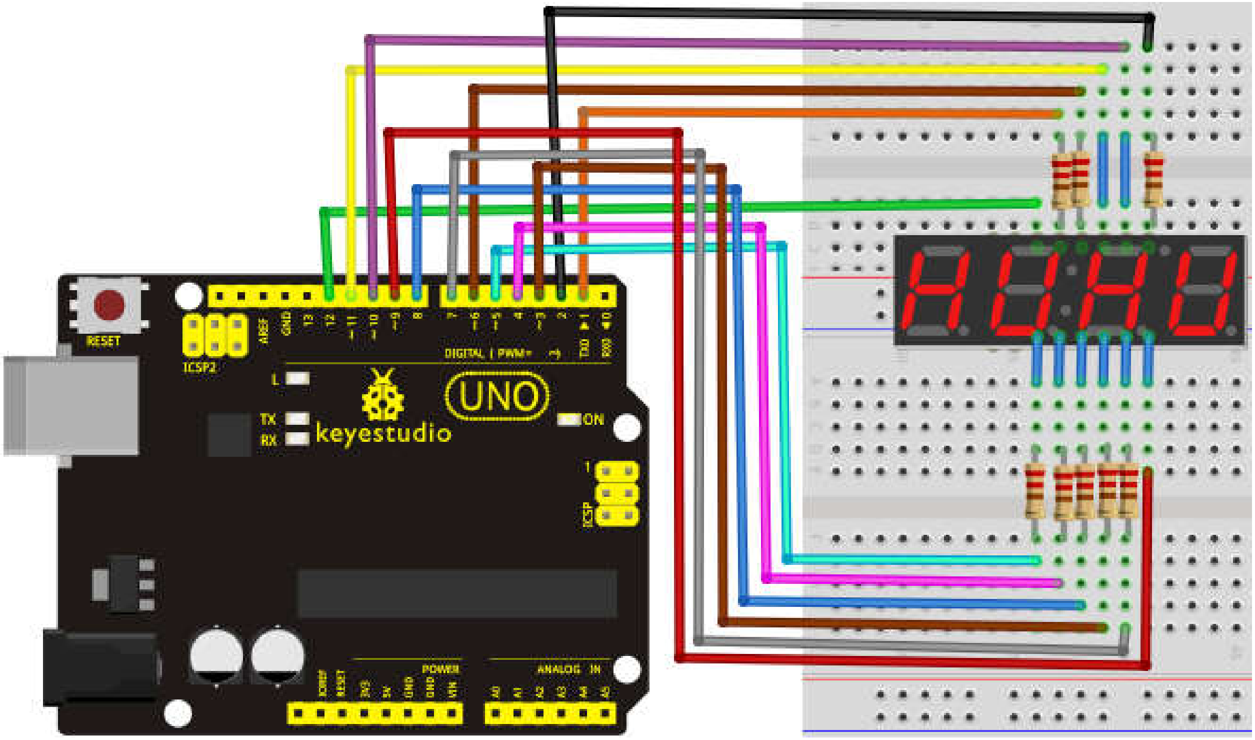


Manual for LED segment display

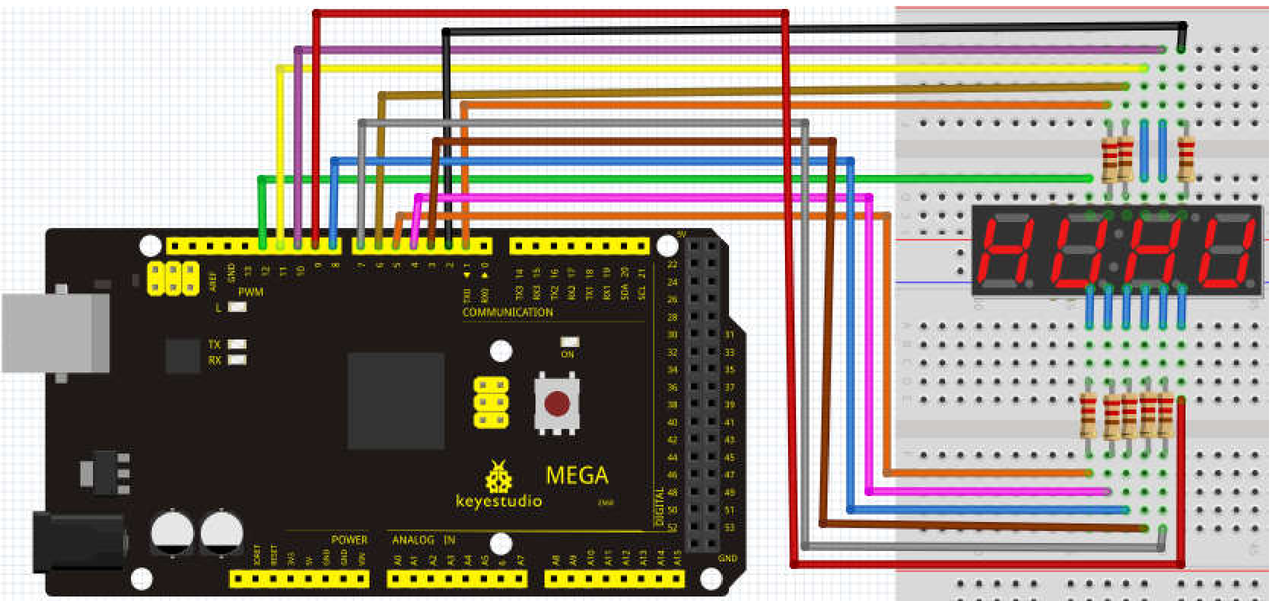


Four Digits Displays Series

Connection for UNO R3:



Connection for 2560 R3:



Sample Program

```
////////////////////////////////////////////////////////////
// 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);

}
///////////////////////////////////////////////////////////////
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);
   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()
{
   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);
}
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;
    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
{
```

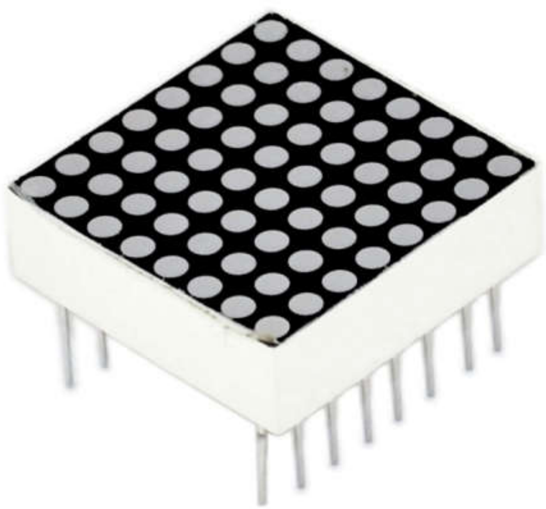
```
    WeiXuan(x);
    pickNumber(Number);
    delay(1);
    Clear() ; // clear the screen
}
```

//

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.

Project 19: 8*8 LED matrix



Introduction

Introduction

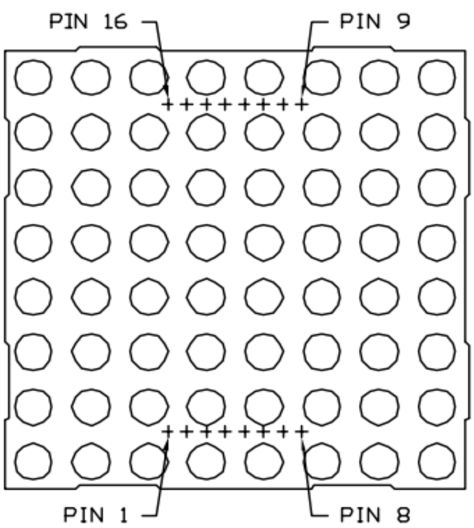
With low-voltage scanning, LED dot-matrix displays have advantages such as power saving, long service life, low cost, high brightness, wide angle of view, long visual range, waterproof, and numerous specifications. LED dot-matrix displays can meet the needs of different applications and thus have a broad 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 (220Ω)
1 * Breadboard
2 * 74HC595
1 * USB cable
Jumper wires

Circuit connection

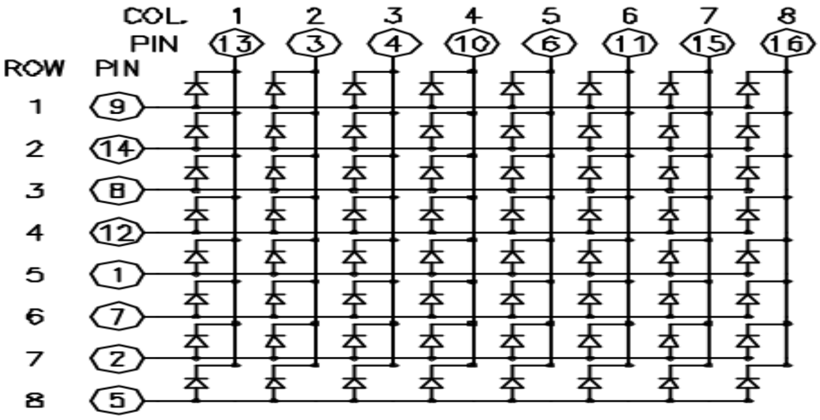
The external view of a dot-matrix is shown as follows:



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.

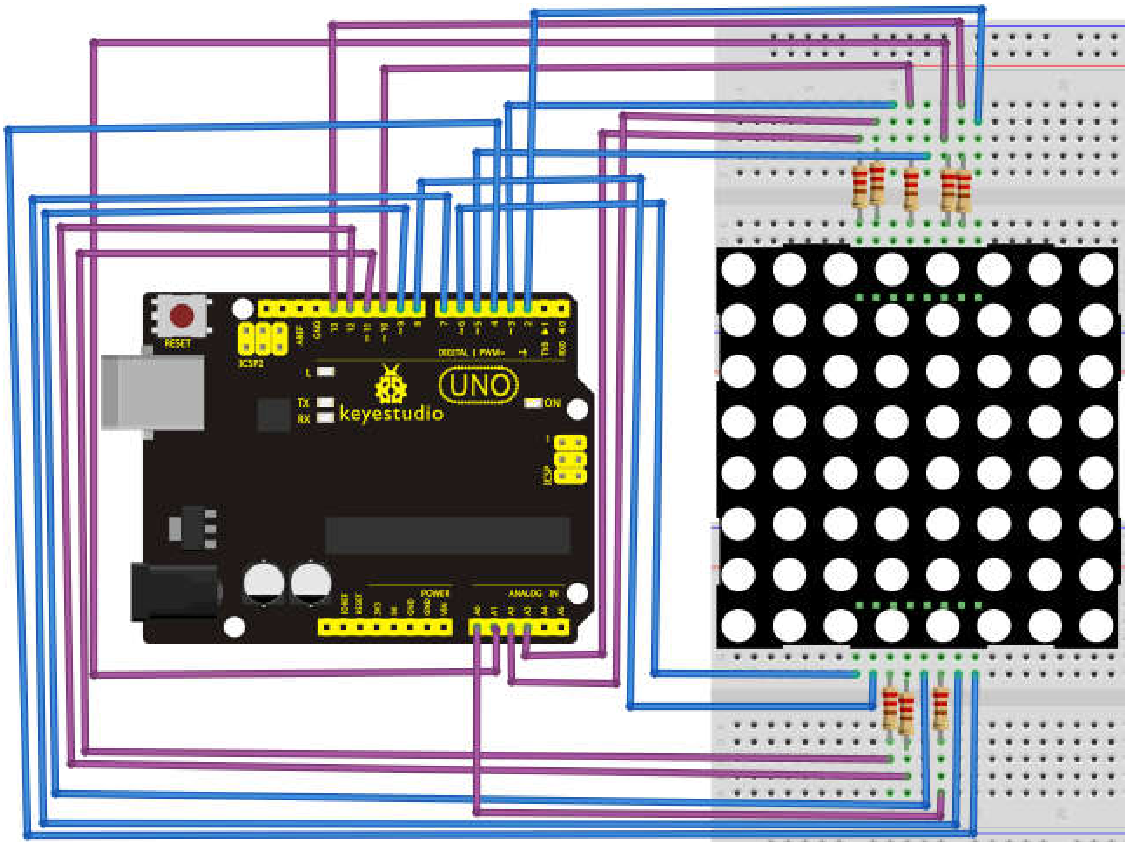
The internal view of a dot-matrix is shown as follows:



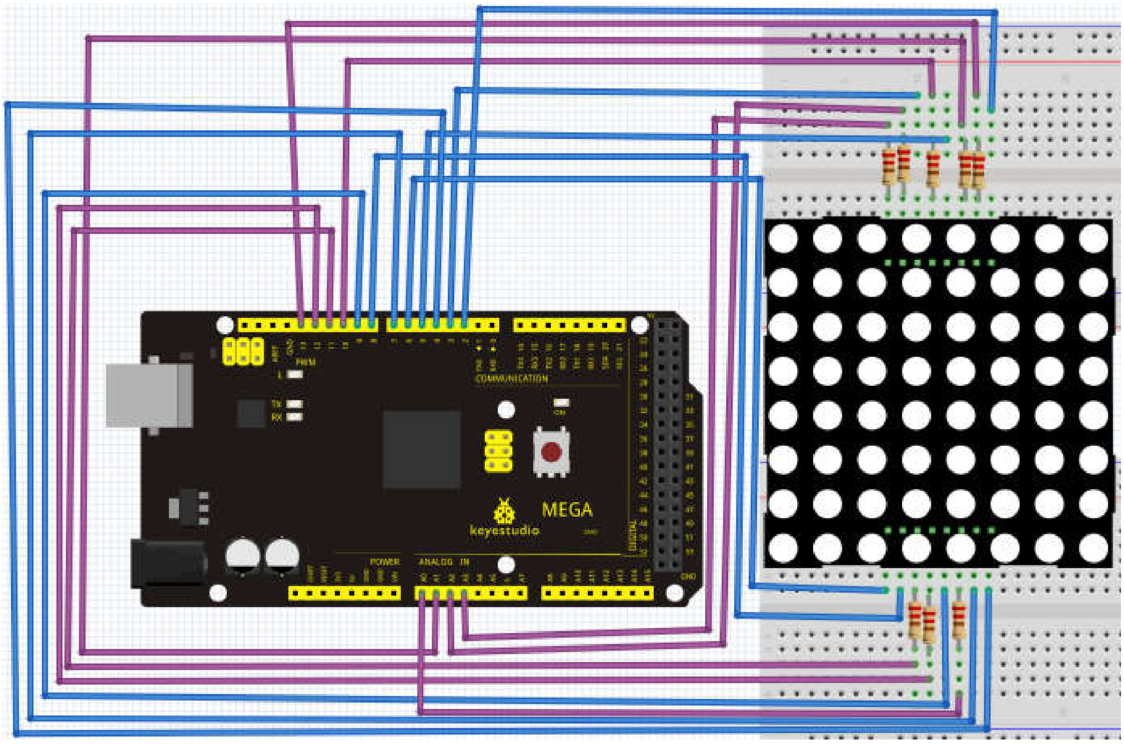
The principle of 74HC595 has been previously illustrated. One chip is used to control the rows of the dot-matrix while the other chip is used to control the columns.

Connect circuit as shown in the following diagram:

Connection for UNO R3:



Connection for 2560 R3:



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;

        }
    }
}
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.

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 5KΩ) in series for its adjustment. In this experiment, we use a 1KΩ 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.

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

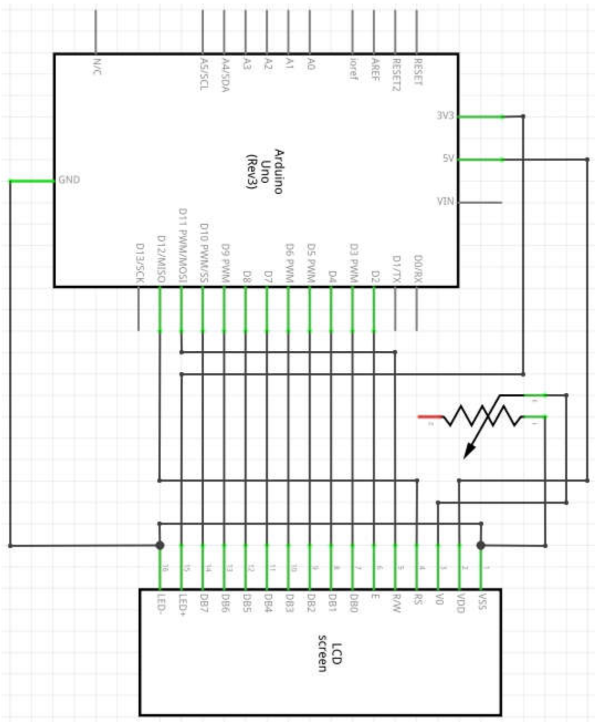
Hardware required

1 * Controller board
1 * 1602 LCD
1 * potentiometer
1 * Breadboard
1 * USB cable
Jumper wires

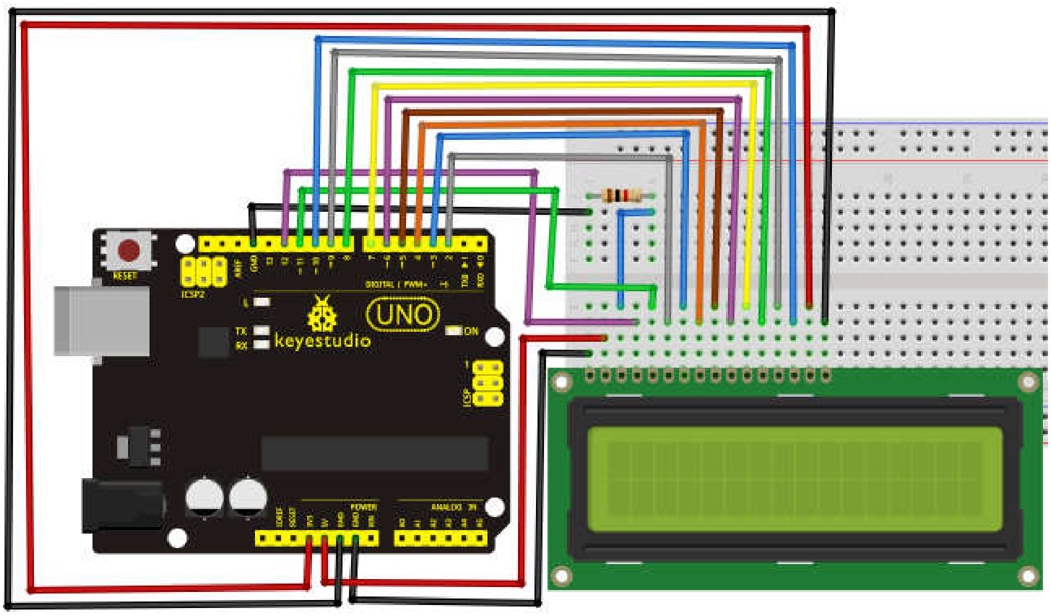
Connection & sample program

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

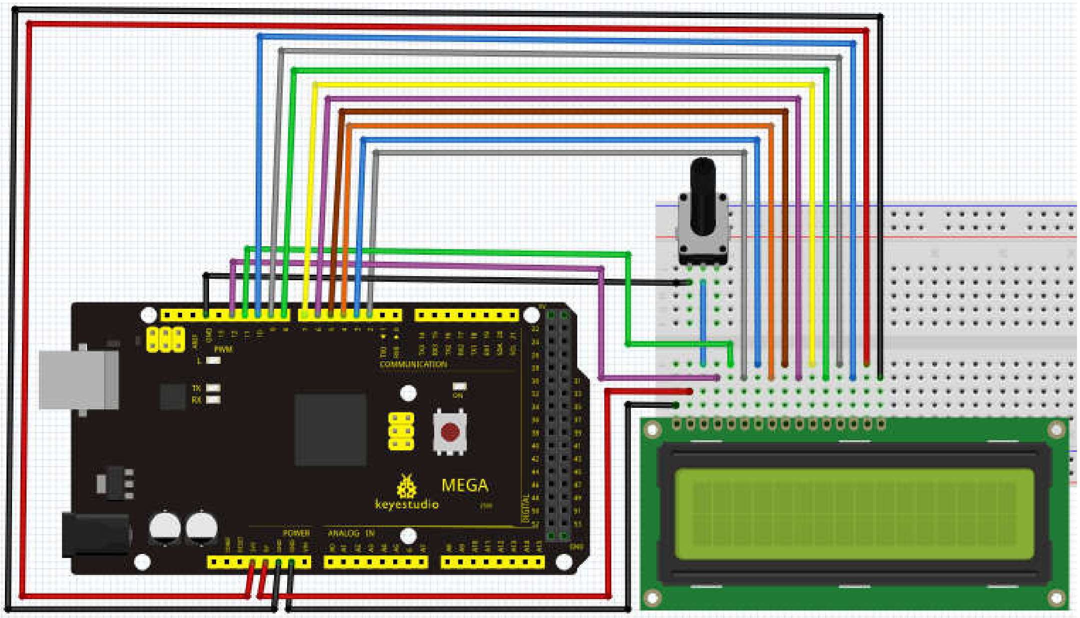
8-bit connection method:



Connection for UNO R3:



Connection for 2560 R3:



Sample code A:

```
////////////////////////////////////////////////////////
int DI = 12;
int RW = 11;
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);
}
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);
 LcdDataWrite('g');
 LcdDataWrite('e');
 LcdDataWrite('e');
 LcdDataWrite('k');
 LcdDataWrite('-');
 LcdDataWrite('w');
 LcdDataWrite('o');
 LcdDataWrite('r');
 LcdDataWrite('k');
```

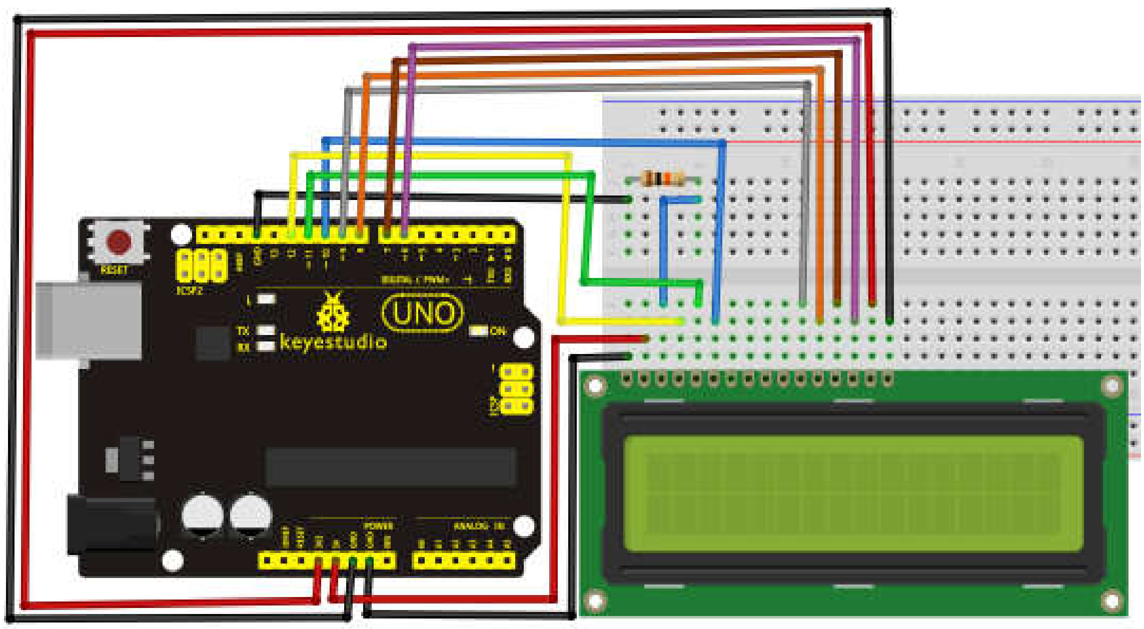
```
  LcdDataWrite('s');
  LcdDataWrite('h');
  LcdDataWrite('o');
  LcdDataWrite('p');
  delay(5000);
  LcdCommandWrite(0x01);  // clear the screen, cursor returns to 0
  delay(10);
  LcdDataWrite('I');
  LcdDataWrite(' ');
  LcdDataWrite('a');
  LcdDataWrite('m');
  LcdDataWrite(' ');
  LcdDataWrite('h');
  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');
  delay(5000);
}

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

4-bit connection method:

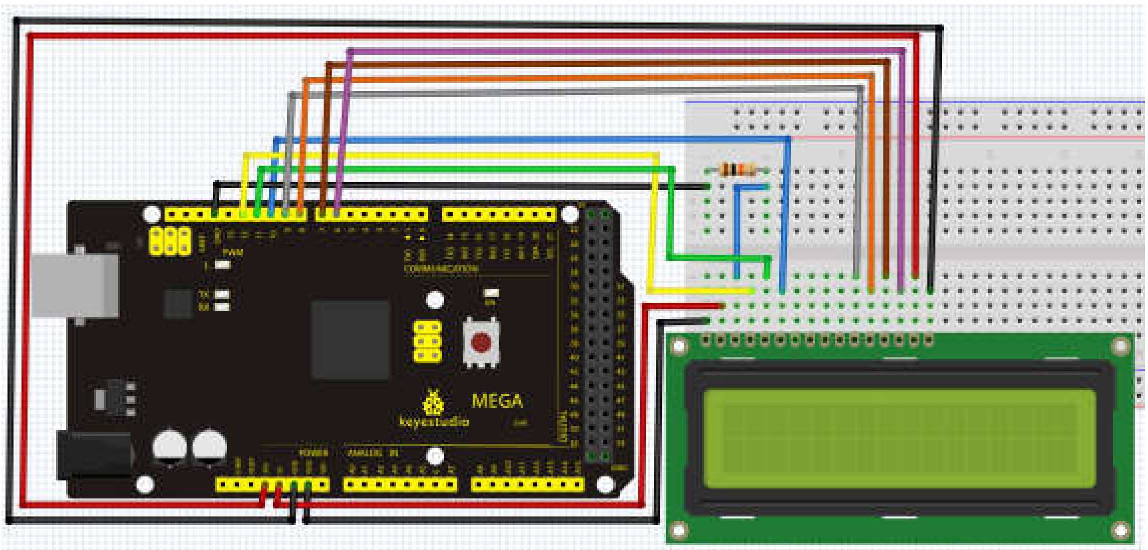
When using this module, 8-bit connection uses all the digital pins of the Arduino, leaving no pin for sensors. What then? We can use 4-bit connection.

Connection circuit:

Connection for UNO R3:



Connection for 2560 R3:



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);
}
```

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

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

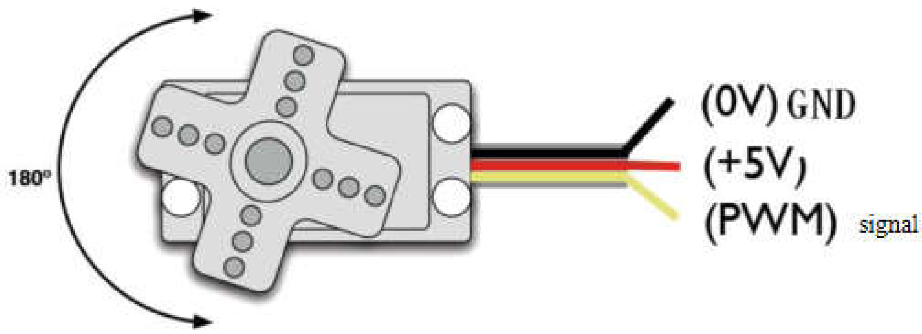
Project 21: 9g servo control

Introduction

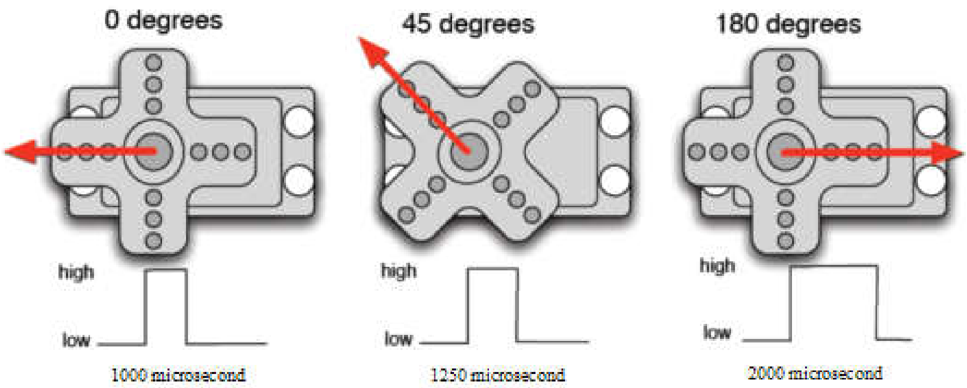
Servomotor is a position control rotary actuator. It mainly consists of housing, circuit board, core-less motor, gear and position sensor. The receiver or MCU outputs a signal to the servomotor. The motor has a built-in reference circuit that gives out reference signal, cycle of 20ms and width of 1.5ms.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

RB—412 servomotor*1
Breadboard jumper wire*several

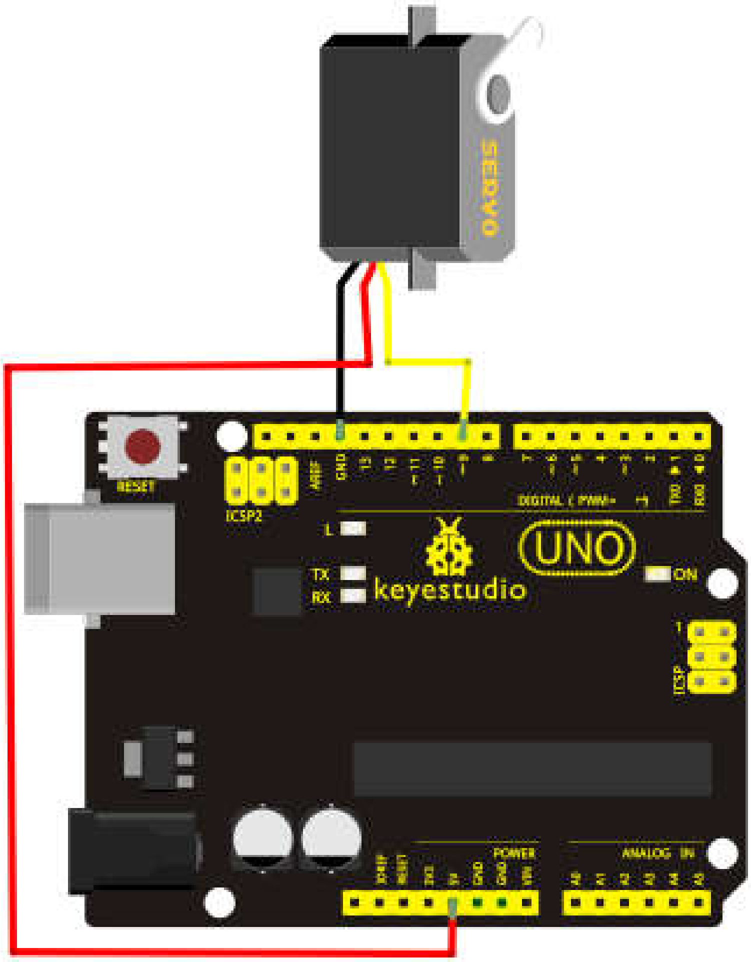
Connection & sample program

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 ang 10 can be used. The Arduino

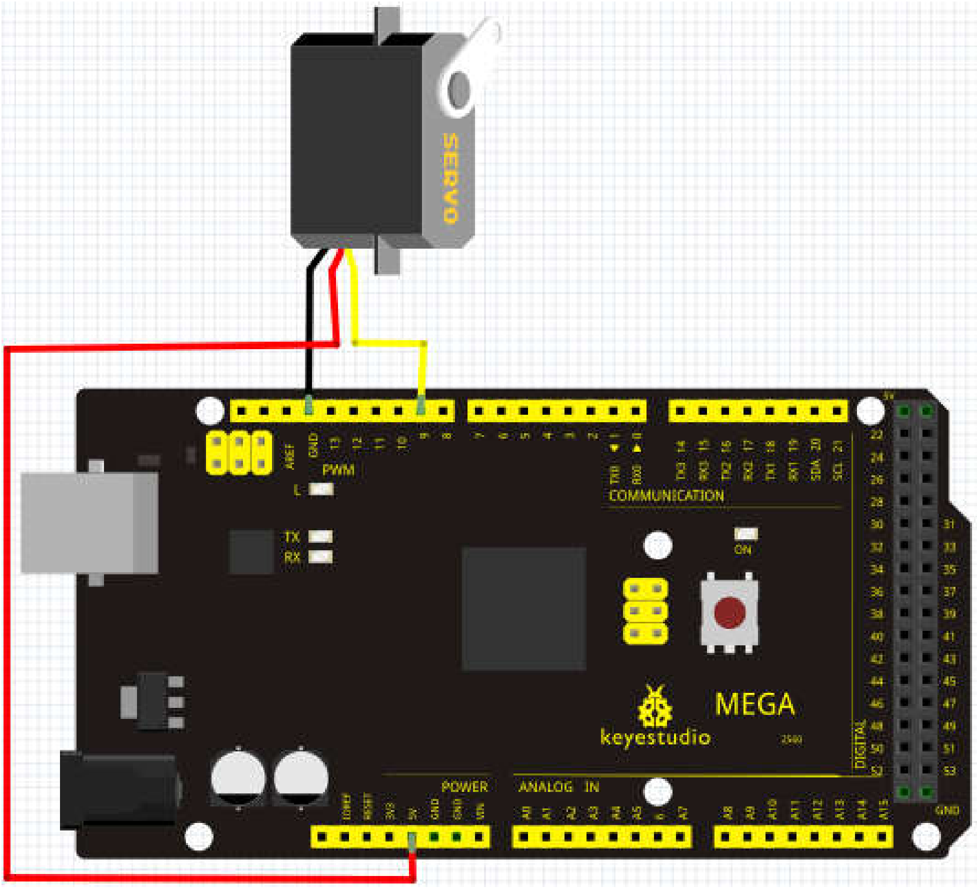
drive capacity is limited. So if you need to control more than one motor, you will need external power.

Method 1

Connection for UNO R3:



Connection for 2560 R3:



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()
{
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
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.