Preface

This super kit is suitable for SUNFOUNDER UNO, SUNFOUNDER MEGA 2560 ,SUNFOUNDER Duemilanove and SUNFOUNDER NANO. All the code in this user guide is also compatible with these boards.

Our SUNFOUNDER board is fully compatible with Arduino board.

This kit walks you through the basics of using the SUNFOUNDER in a hands-on way. You'll learn through building several creative projects. The kit includes a selection of the most common and useful electronic components. Starting the basics of electronics, to more complex projects, the kit will help you control the physical world with components.

Content

Lesson 1 Blinking LED

Introduction

In this lesson, we will start the journey to learn the SUNFOUNDER UNO board. Let's see the contents that will be realized in this routine first. We will light an LED and let it blink once per second.

Components

- SUNFOUNDER UNO control board *1
- USB download cable *1
- LED *1
- Resistor *1
- Several jumper wires

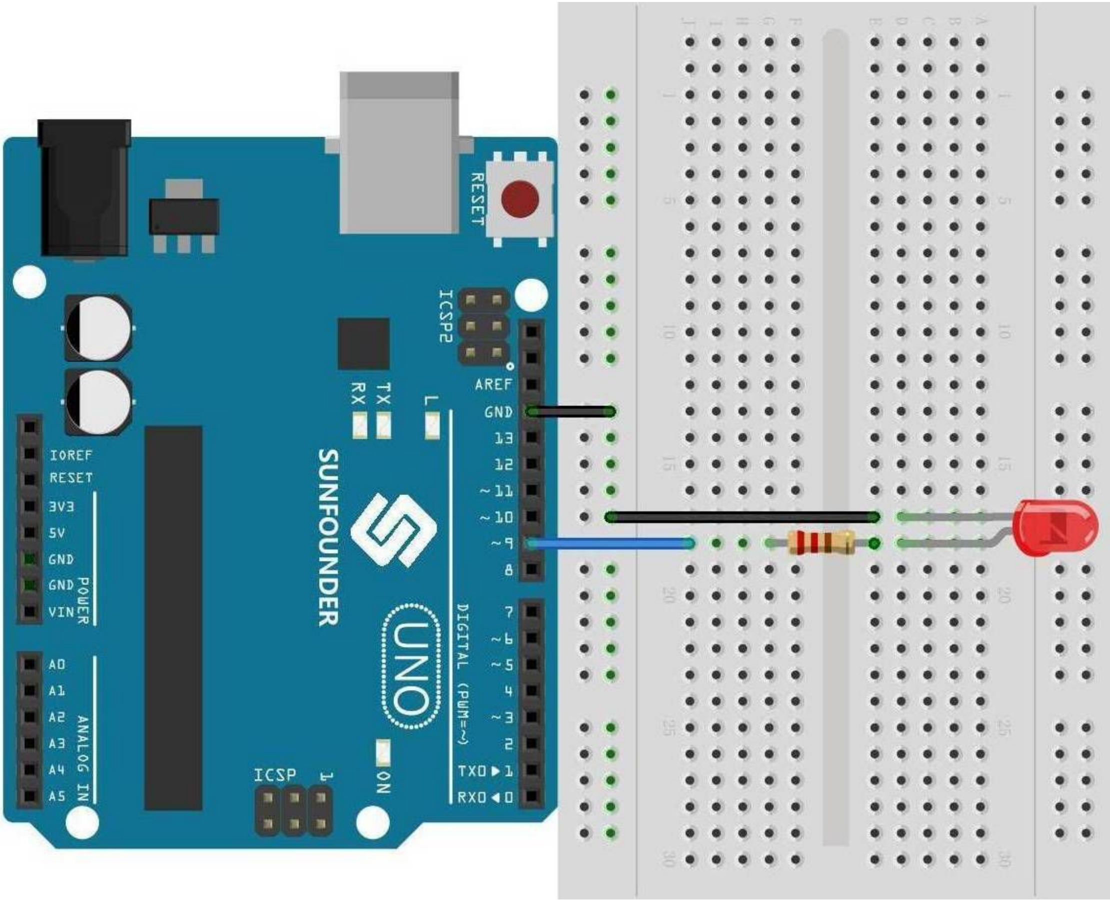
Principle

Semiconductor light-emitting diode is a type of component which can turn electric energy into light energy via PN junctions. According to its wavelength, semiconductor light-emitting diode can be categorized into laser diode, infrared light-emitting diode and visible light-emitting diode which, called light-emitting diode for short, is usually known as LED. LED is usually red, yellow, green, blue and color-changing. The color-changing LED can change its colors with different voltages.

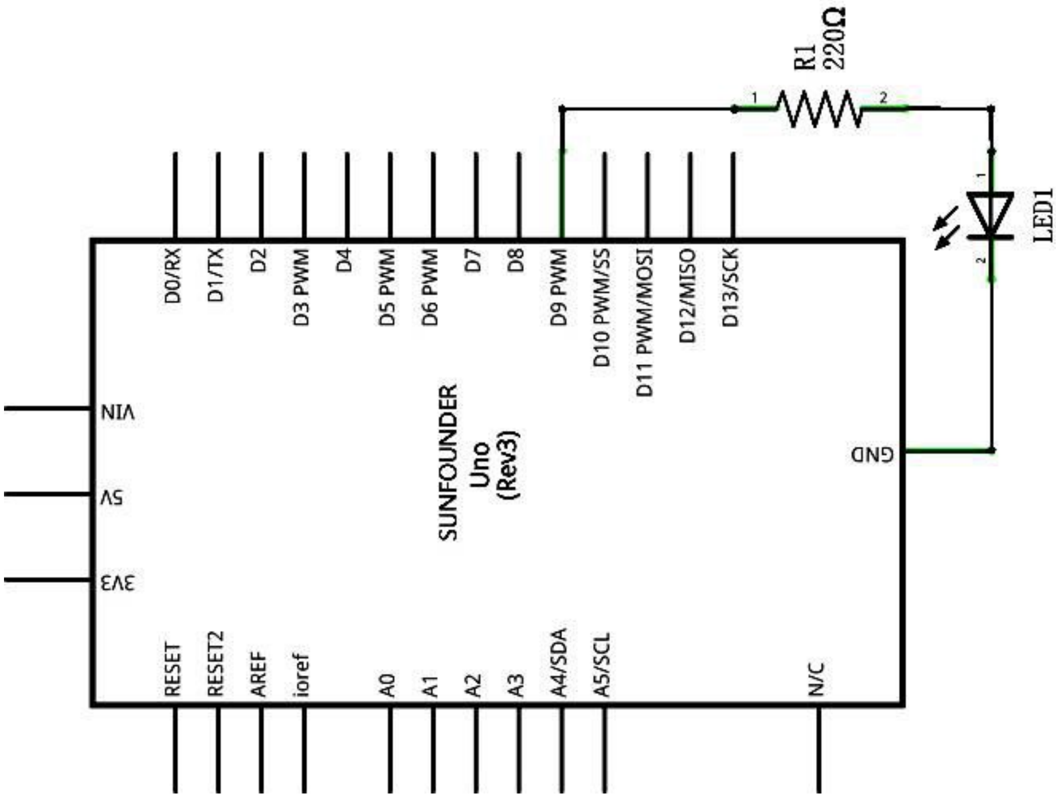
Before connecting any circuit, you must know about the parameters of components in the circuit, such as their operating voltage, operating circuit, etc. You must connect a current-limiting resistor when an LED is used, or the LED can be burned due to excessive current. In this experiment, the operating voltage of the LED we use is 1.5V -2.0V and the operating current is 10mA -20mA. The power supply voltage of SUNFOUNDER UNO control board is 5V, the operating voltage of the LED we choose is 1.7V, and its operating current is 15mA. So the current-limiting resistance = (total voltage - LED voltage)/current, that is, the current-limiting resistance = (5-1.7)/0.015=220ohm.

Experimental Procedures

Step 1: Connect the circuit as shown in the following diagram

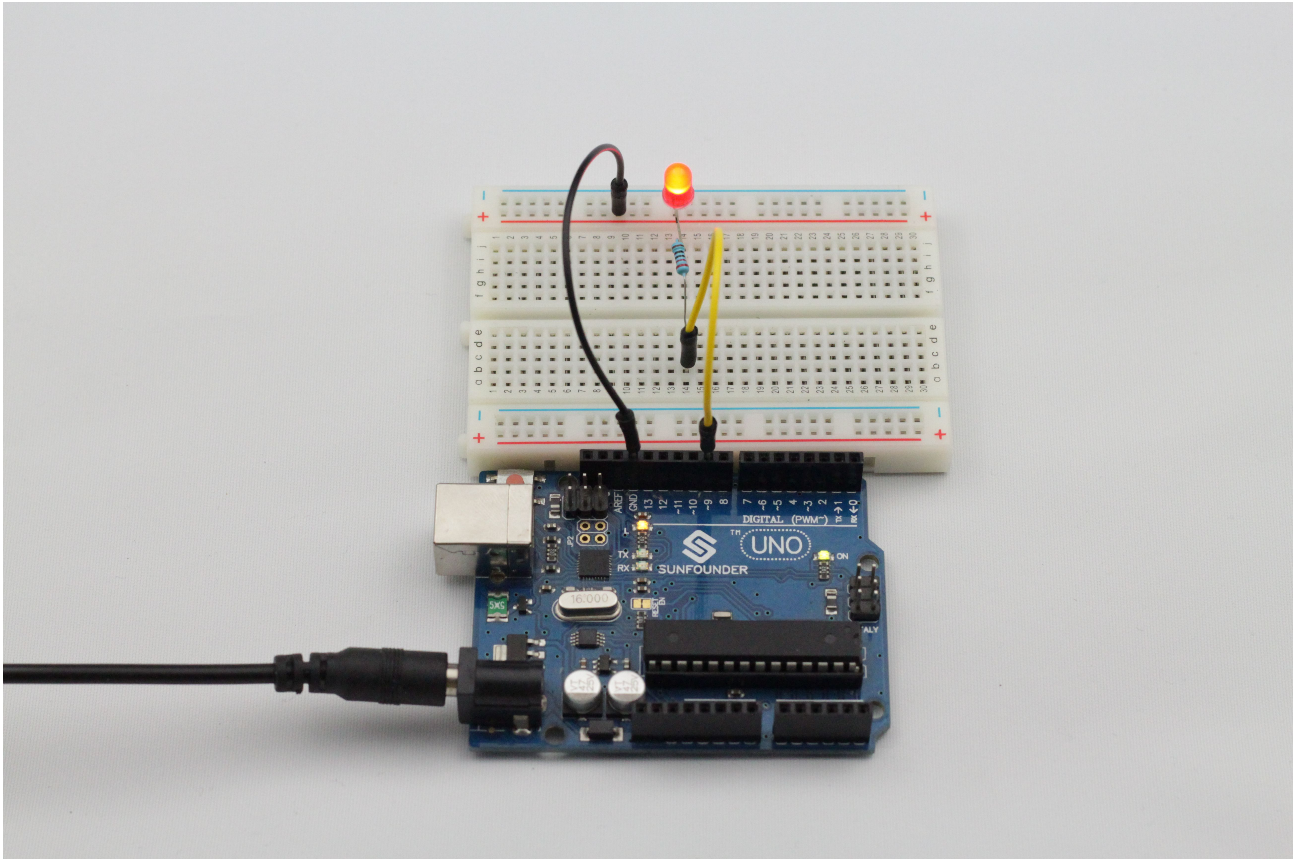


The corresponding schematic diagram is shown as follow



Step 2: Write a program
Step 3: Compile the program
Step 4: Burn the program into SUNFOUNDER UNO board

Now, you can see the LED light on the upper-left side of the board blinking.



Experimental Summary

Through this experiment, we have learnt how to drive an LED and how to change the blinking frequency of the LED by changing the **num** value in the delay function **delay (num)**. For example, if the delay function is changed into **delay (250)**, you will find that the LED blinks more quickly.

Lesson 2 Controlling LED by Button

Introduction

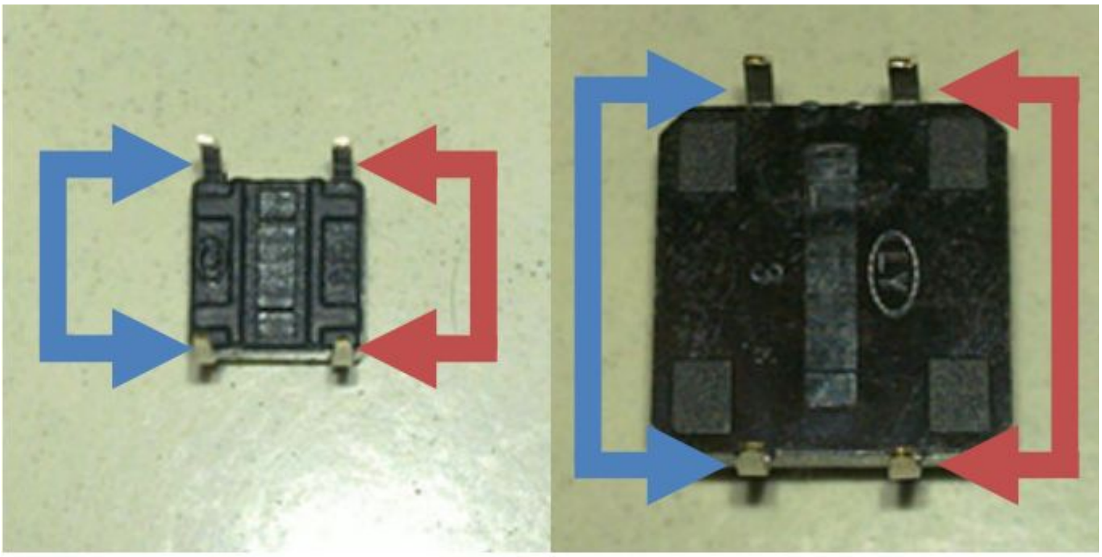
In this experiment, we will learn how to turn a single LED on or off with a button switch. I/O port refers to INPUT and OUTPUT port. We will use the input function of SUNFOUNDER UNO I/O port to read the output of the external device. And we will let you have a basic understanding about the I/O function through this experiment in which we will use a button and an LED to realize the combination of input and output. Since SUNFOUNDER UNO development board itself has an LED (connected to Pin 13), we will use the LED to accomplish the experiment for convenience.

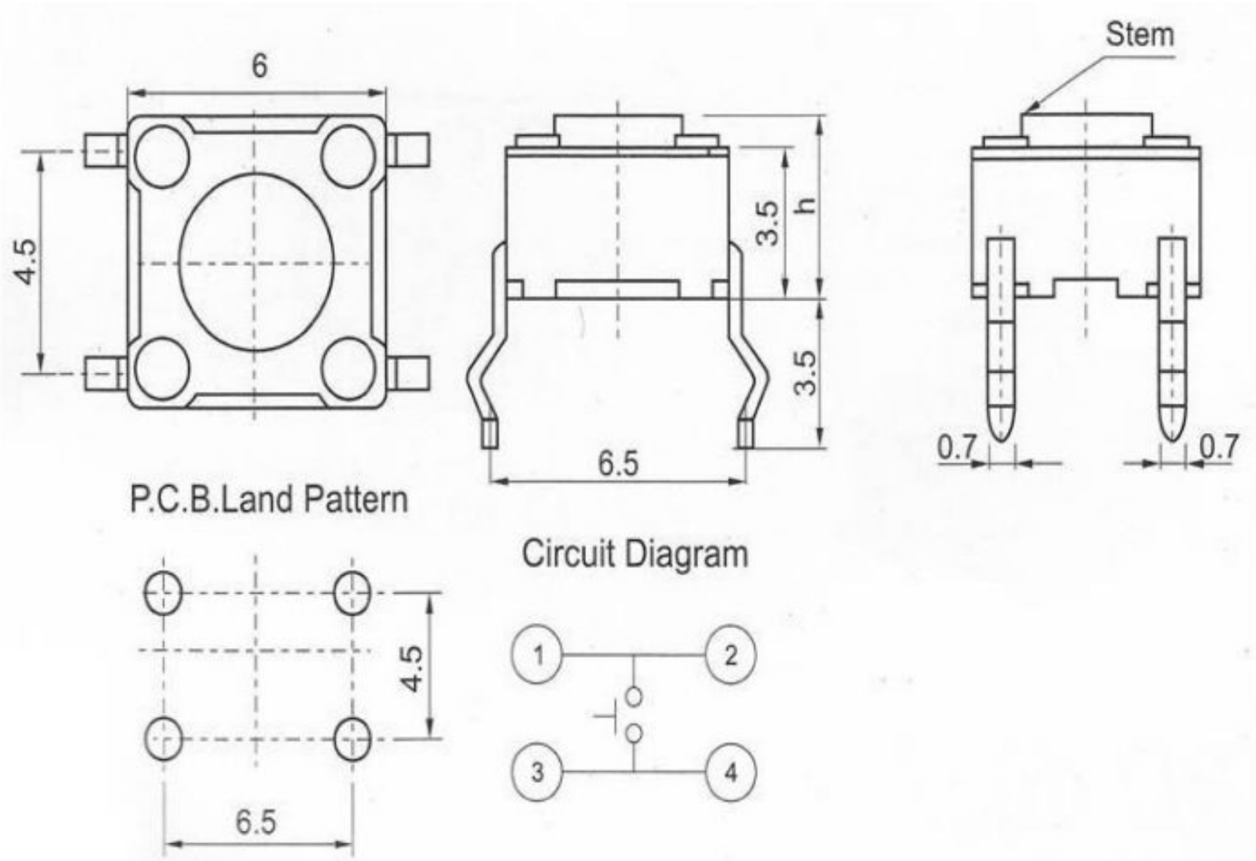
Components

- SUNFOUNDER UNO development board *1
- USB data cable *1
- Breadboard *1
- Button switch *1
- 10K Ohm resistor *1
- Several jumper wires

Principle

Buttons are a type of commonly used components to control electronic devices. Usually they are used as switches to connect or disconnect circuits to control the operation of electronic devices or other devices. Buttons have a variety of appearances, while the button used in this experiment is a 6mm mini-button as shown in the following pictures. The two pins pointed by the two arrows of same color are meant to be connected.





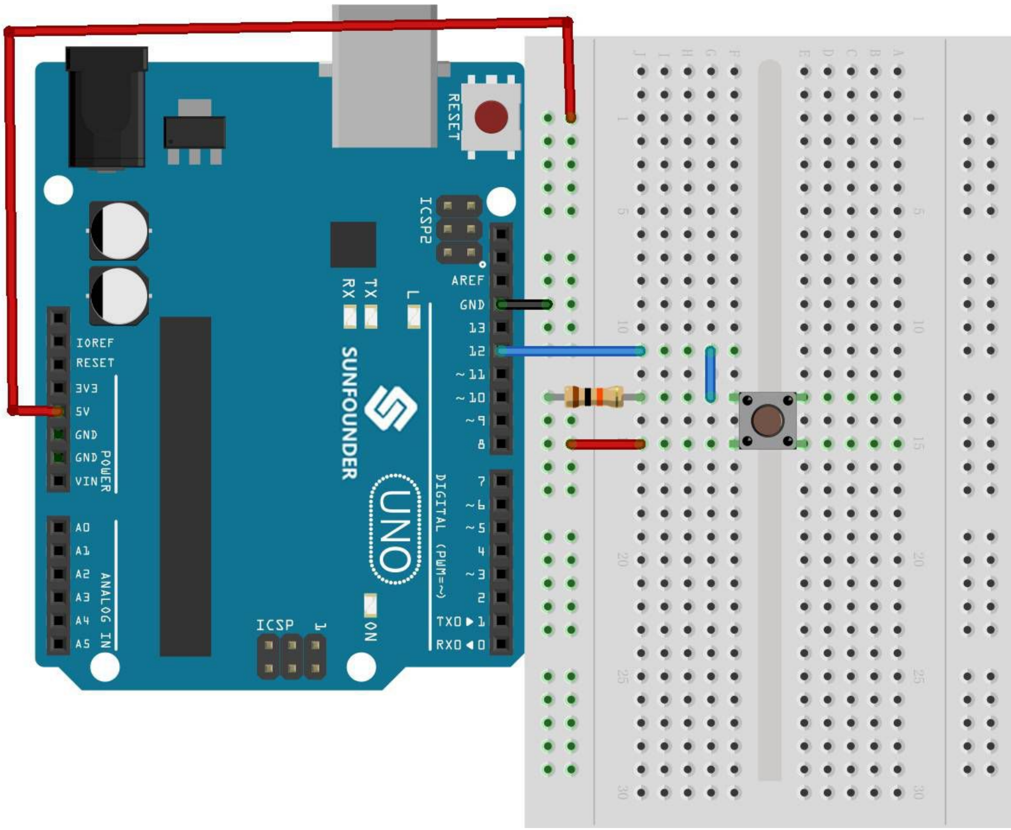
When you press the button, the pins pointed by the blue arrows will connect to the pins pointed by the red arrows.

Generally, we directly connect the button switch in series in an LED circuit to turn the LED on or off. This connection is relatively simple. However, sometimes the LED will light up automatically without pressing the button, which is caused by various interferences. In order to avoid these external interferences, we will connect a pull-down resistor, that is, connect a 1K–10K ohm resistor between the button port and GND. The function of the pull-down resistor is that when external interferences exist, they will be consumed during connecting to GND as long as the button switch is turned off.

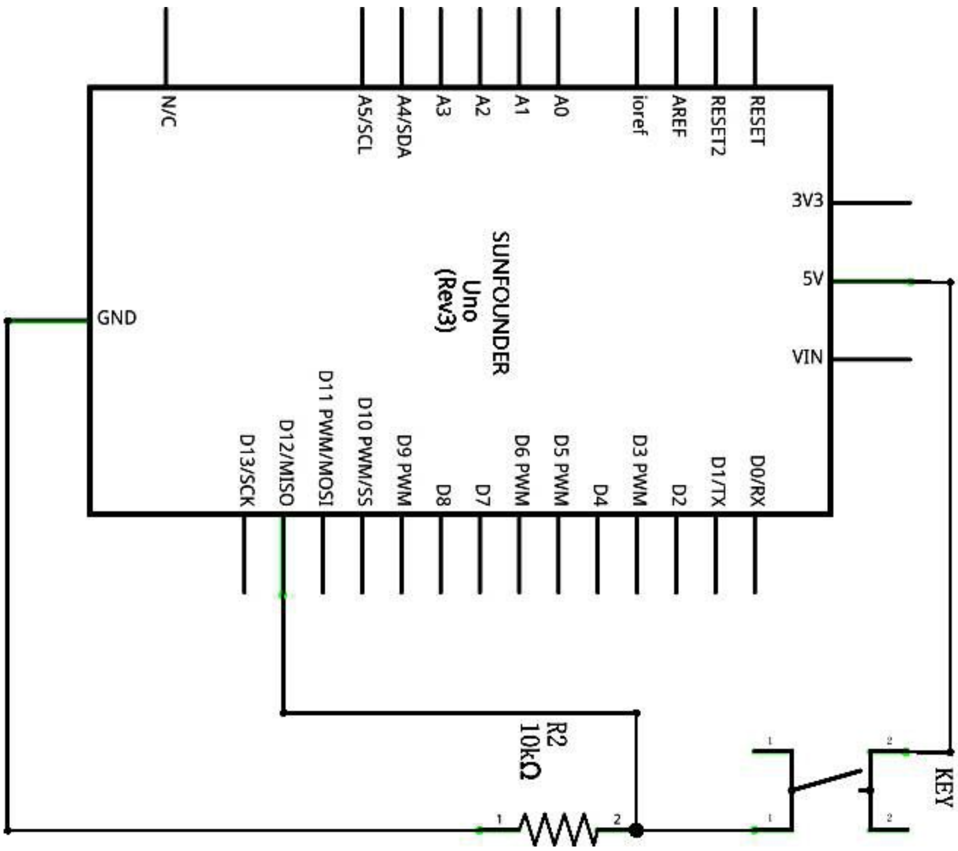
This circuit connection is widely used in numerous circuits and electronic devices. For example, when we press any button on our mobile phones, the backlight will light up.

Experimental Procedures

Step 1: Connect the circuit as shown in the following diagram

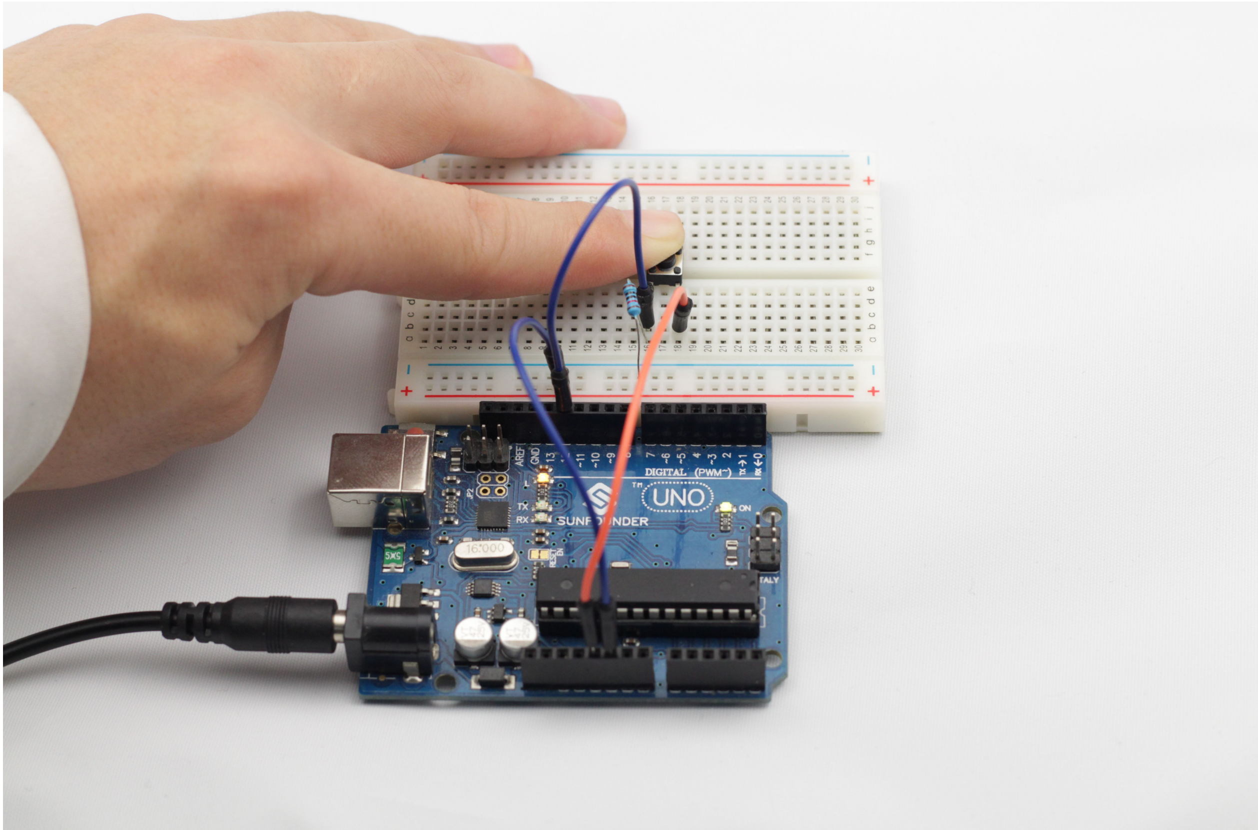


The corresponding circuit schematic diagram is shown as follow



Step 2: Write a program
Step 3: Compile and debug the program
Step 4: Burn the program into SUNFOUNDER UNO board

Now, if you press the button, the LED will light up.



Experimental Summary

Well, this experiment is done. Have you mastered the usage of buttons? Actually it is a very practical technology. By the way, are you becoming more and more interested in SUNFOUNDER UNO? What is coming will surely be more interesting and wonderful!

Lesson 3 Controlling LED by PWM

Introduction

Today let's play something easier. We will make gradual changes to the luminance of an LED through programming, which looks like breathing. So we give it a magical name - Breathing Light. This is what we called controlling the luminance of an LED by PWM (Pulse-width modulation). Can't wait to start? Now, let's check out the components we need.

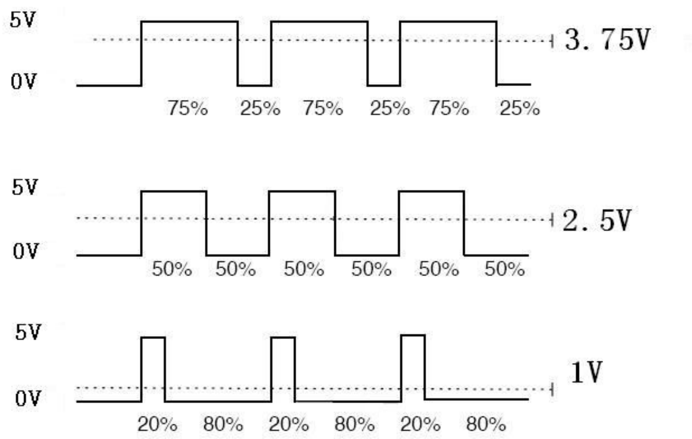
Components

- SUNFOUNDER UNO *1
- Breadboard *1
- Several connecting wires
- Red LED *1
- 220 Ohm Resistor *1

Principle

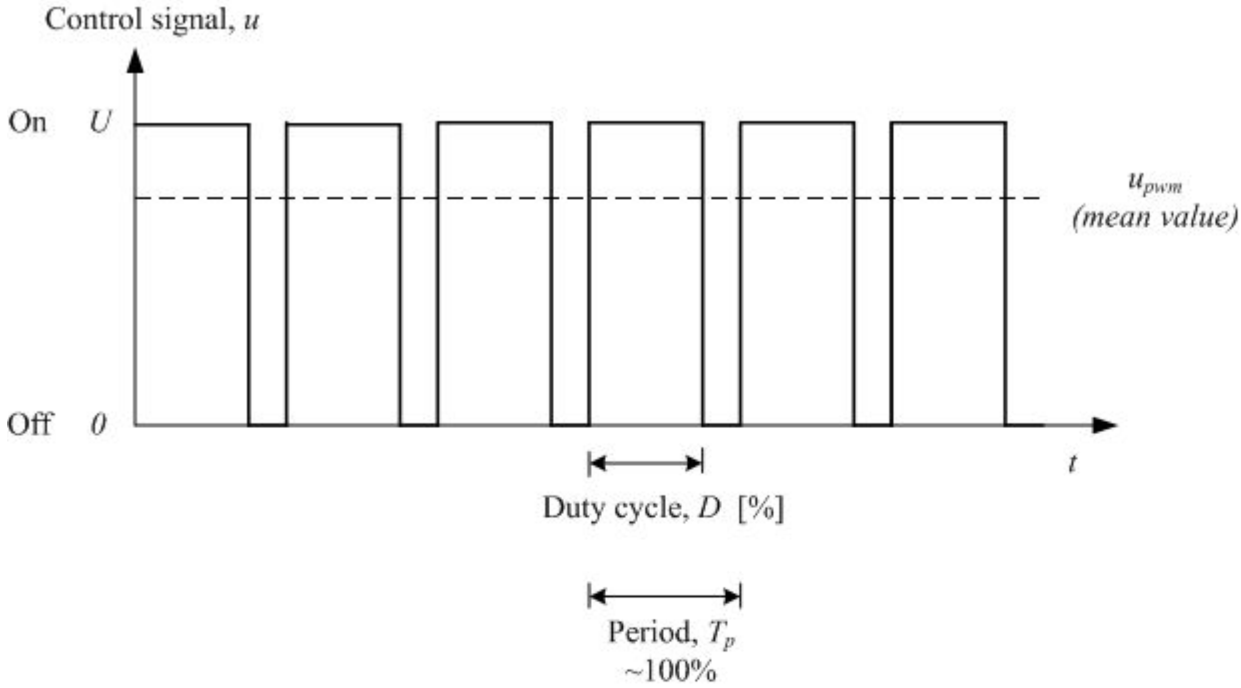
Before we talk about PWM, let's have a look at the applications of PWM first. PWM has been successfully applied in motor speed regulation, steering angle control, light intensity control and signal output. For example, when PWM is applied to a horn, it will make sounds. After we know about its special functions, let's find out what PWM really is.

Pulse Width Modulation commonly refers to PWM. Pulse Width Modulation (PWM) is a digital coding method for analog signal levels. Since a computer cannot output an analog voltage but digital voltage value 0V or 5V, we modulate the duty cycle of square waves to encode a specific level of analog signal by using a high-resolution counter. PWM signals are essentially digital signals, for the full amplitude DC power supply is either 5V (ON) or 0V (OFF) at any given time. Voltage or current source is applied to an analog load in the form of ON or OFF repetitive pulse sequence. When it is on, DC power supply will be applied to the load; when it is off, DC power supply will be disconnected. If only the bandwidth is wide enough, any analog value can be encoded by PWM. The output voltage value is calculated by the on and off time. $V_{out} = (T_{on}/ T)*V_{max}$.



We can see from the top oscillogram that the amplitude of DC voltage output is 5V. However, the actual voltage output is only 3.75V through PWM, for the high level only takes up 75% of the total voltage within a period.

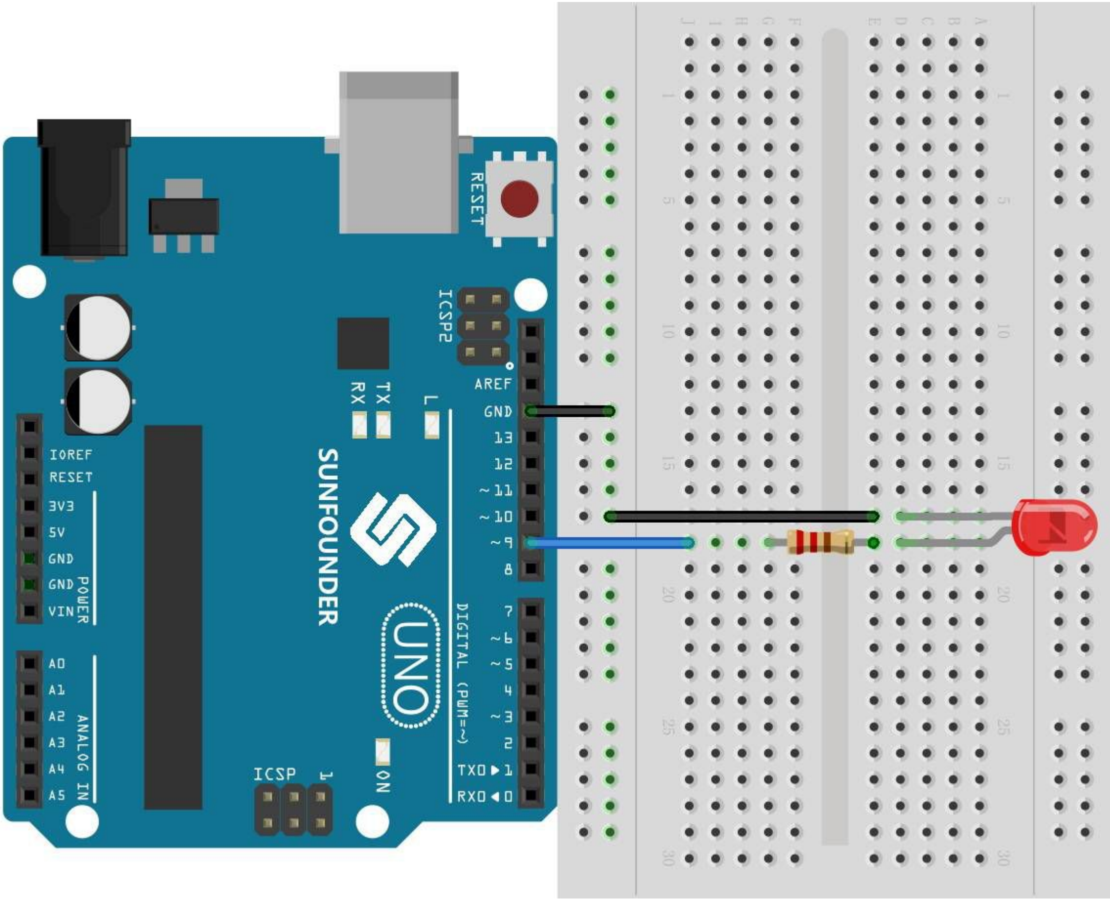
Here is the introduction to three basic parameters of PWM:



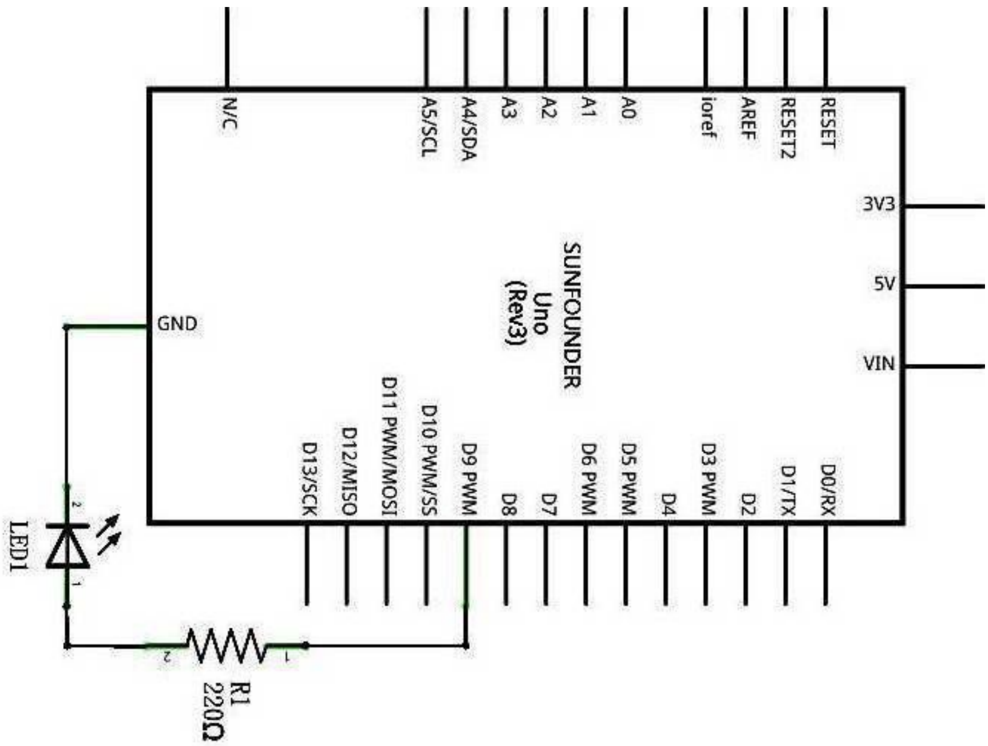
1. The term *duty cycle* describes the proportion of 'on' time to the regular interval or 'period' of time
2. The term *period* describes the reciprocal of pulses in one second
3. Voltage amplitude (e.g. 0V–5V)

Experimental Procedures

Step 1: Connect the circuit as shown in the following diagram

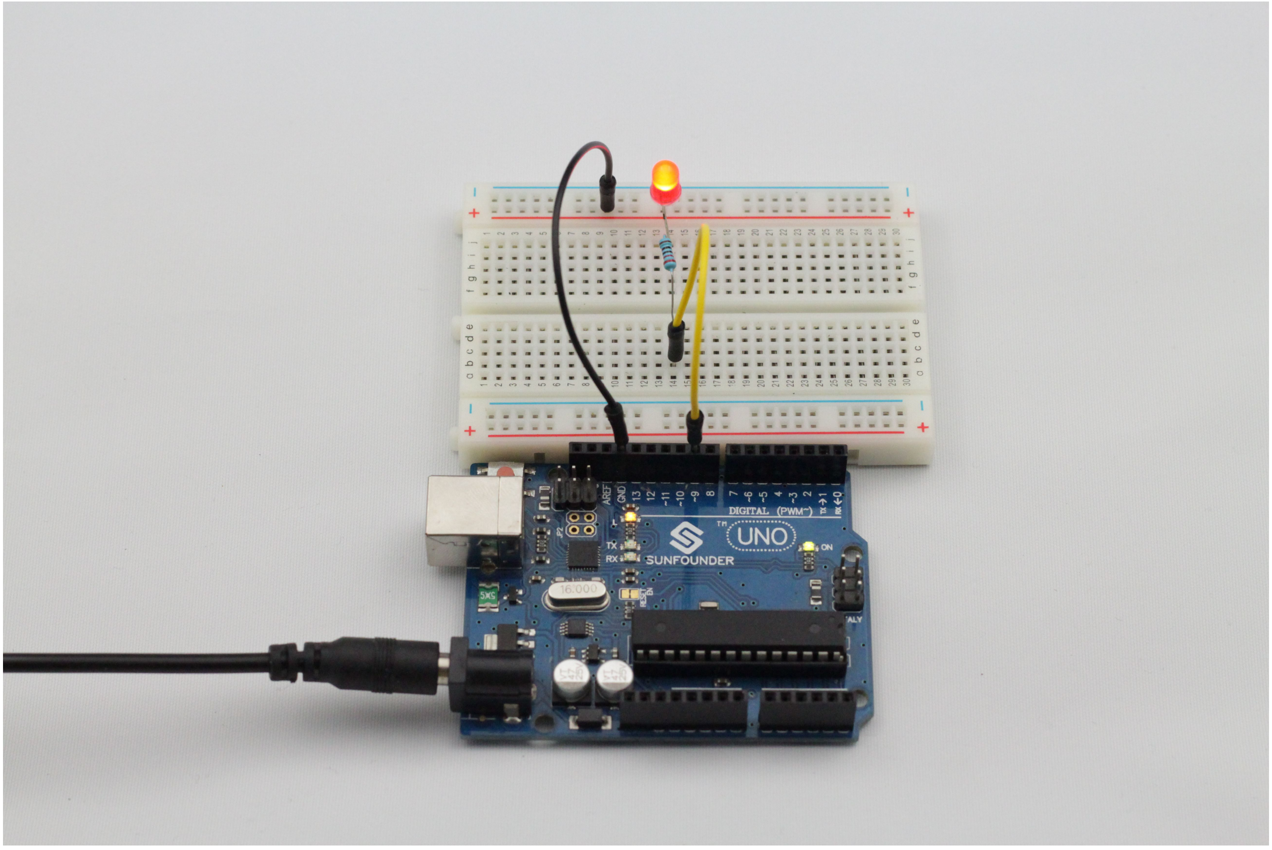


The corresponding schematic diagram is shown as follow



Step 2: Write a program
Step 3: Compile and debug the program
Step 4: Burn the program into SUNFOUNDER UNO board

Now, you will see the luminance of the LED regularly vary.



Experimental Summary

You should have succeeded doing this experiment. Do you have a great sense of accomplishment? I hope you can try harder. What is coming will be more interesting!

Lesson 4 Controlling LED by Potentiometer

Introduction

In last experiment, we have learnt how to control LED through PWM by only using software, which is interesting yet slightly abstract. Hence in this class let us feel PWM personally. We will control and change an LED luminance by rotating a potentiometer.

Components

-SUNFOUNDER UNO Control Board*1
- Breadboard *1
-Several Connecting wires
-220 Ohm Resistor *1
-Red LED *1
-Potentiometer *1
-USB Data Cable *1

Principle

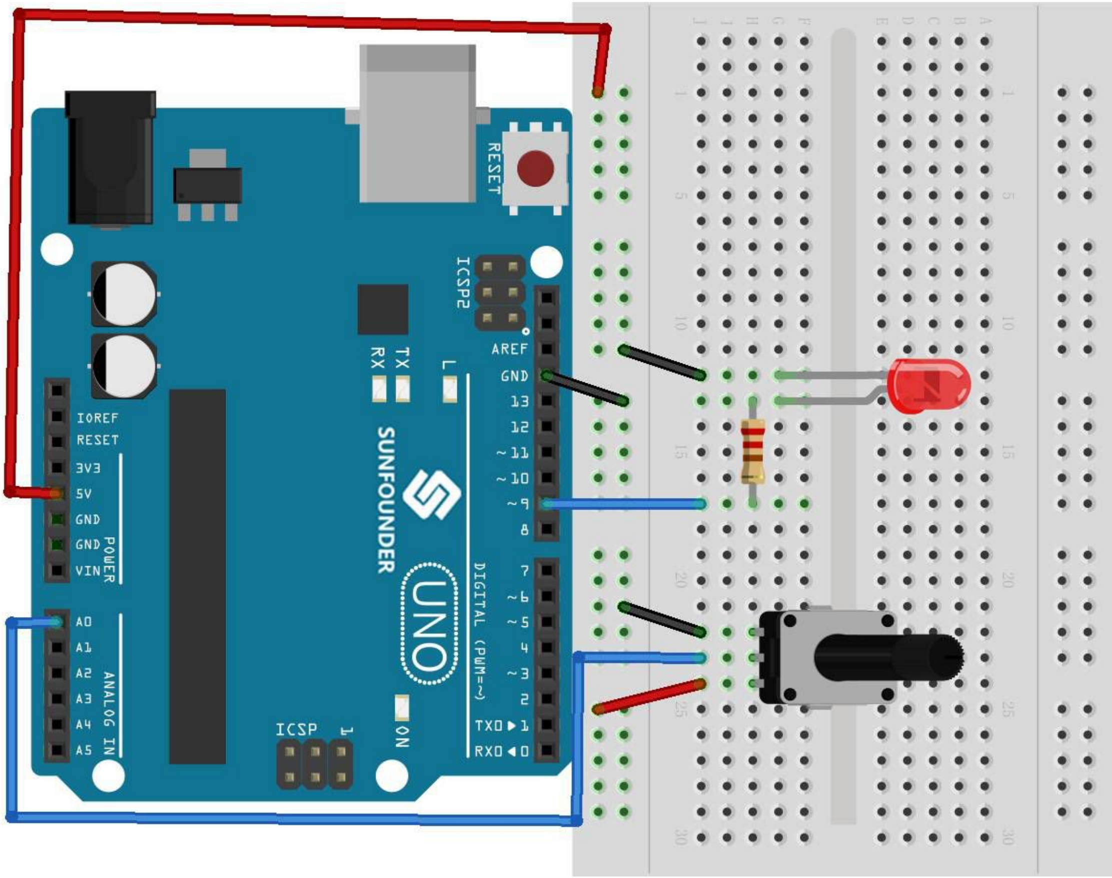
A linear potentiometer is an analog electronic component. What is the difference between the analog and the digital? Simply put, the digital refers to on/off, high/low level with just two states, i.e. either 0 or 1. Yet the data states of analog signals are linear, for example, from 1 to 1000. The signal value is changing over time instead of indicating an exact number. Analog signals include light intensity, humidity, temperatures and so on.

In this experiment we will use a potentiometer for an LED dimming so that the luminance of the LED will vary more uniformly unlike the stepwise change of luminance in the last button experiment.

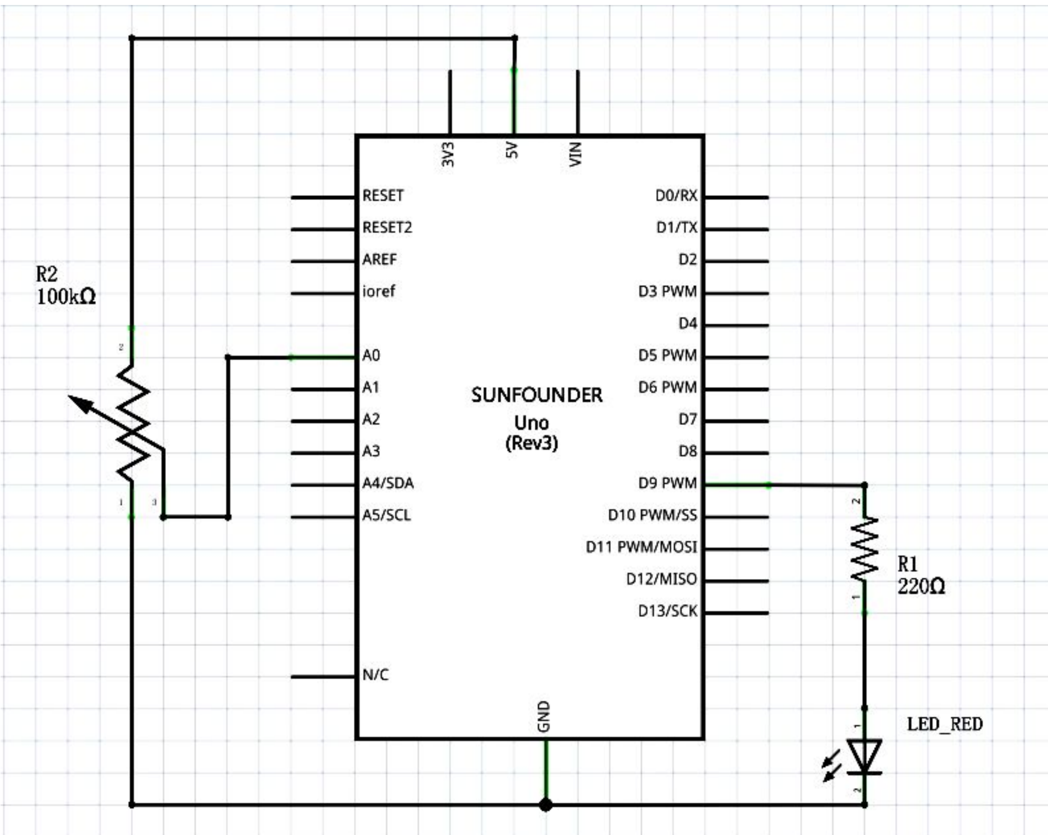
What we mean by PWM here is the digitalization of analog signals, which is a process of approaching analog signals. Since the potentiometer inputs analog signals, it should be connected to analog input ports, i.e. A0-A5, instead of digital ports.

Experimental Procedures

Step 1: Connect the circuit as shown in the following diagram



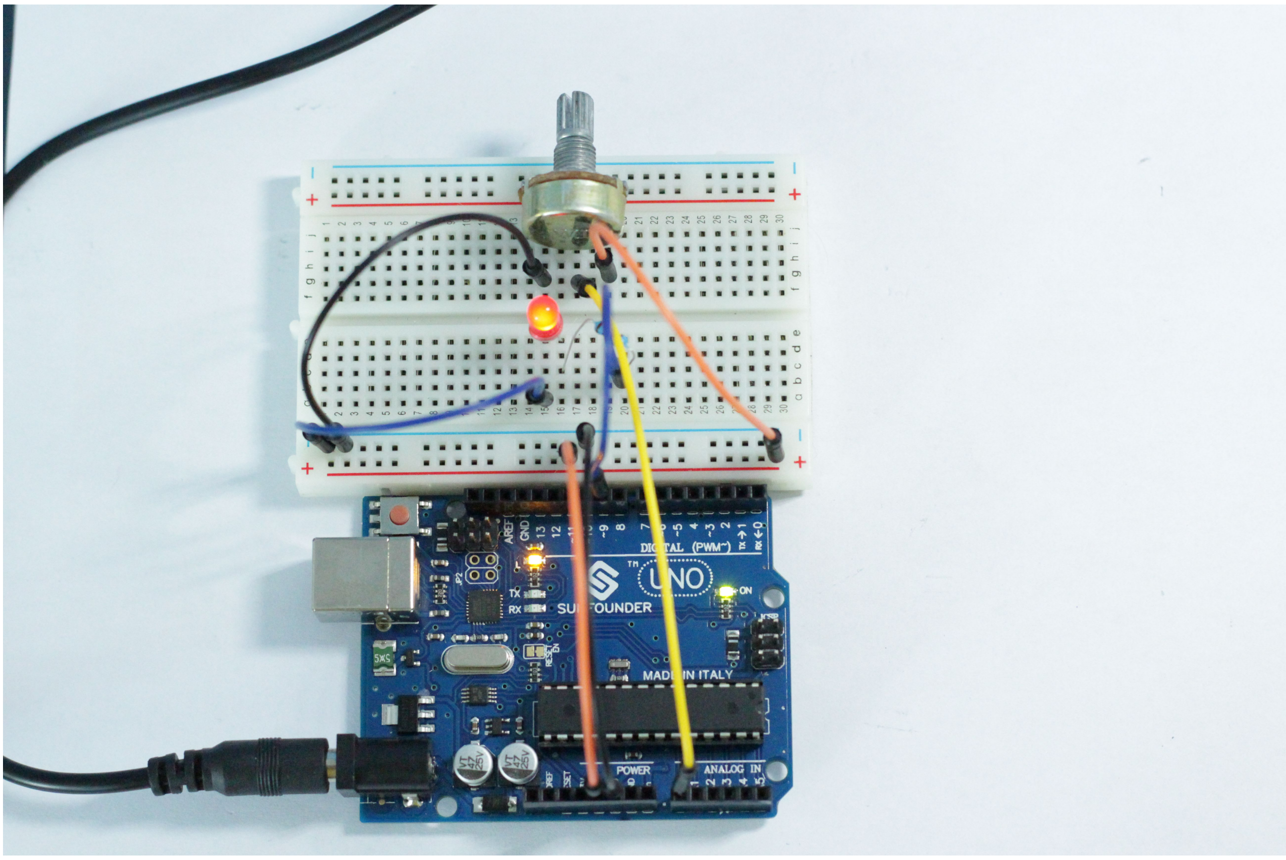
The corresponding schematic diagram is shown as follow



We can see that the potentiometer is connected to A0 analog detection port of SUNFOUNDER UNO, which can measure voltages from 0V to 5 V. The corresponding returned value is 0 to 1024. The measurement accuracy for voltage changes is relatively high.

Step 2: Write a program
Step 3: Debug the program
Step 4: Burn the program into SUNFOUNDER UNO board

Now, rotate the potentiometer, and you will see the luminance of the LED vary.



Experimental Summary

You have mastered the usage of potentiometer through this experiment. Next you can modify the routine we provided to achieve other functions.

Lesson 5 LED Flowing Lights

Introduction

In this lesson, we will conduct a simple but interesting experiment, that is, we will use eight LEDs to realize flowing lights. As the name implies, the flowing lights are made up of eight LEDs in a row which could successively light up and go off one after another like flowing water. In fact, we have learnt how to light an LED in the first lesson. I believe, clever as you are, you surely have known how to turn eight LEDs on.

Components

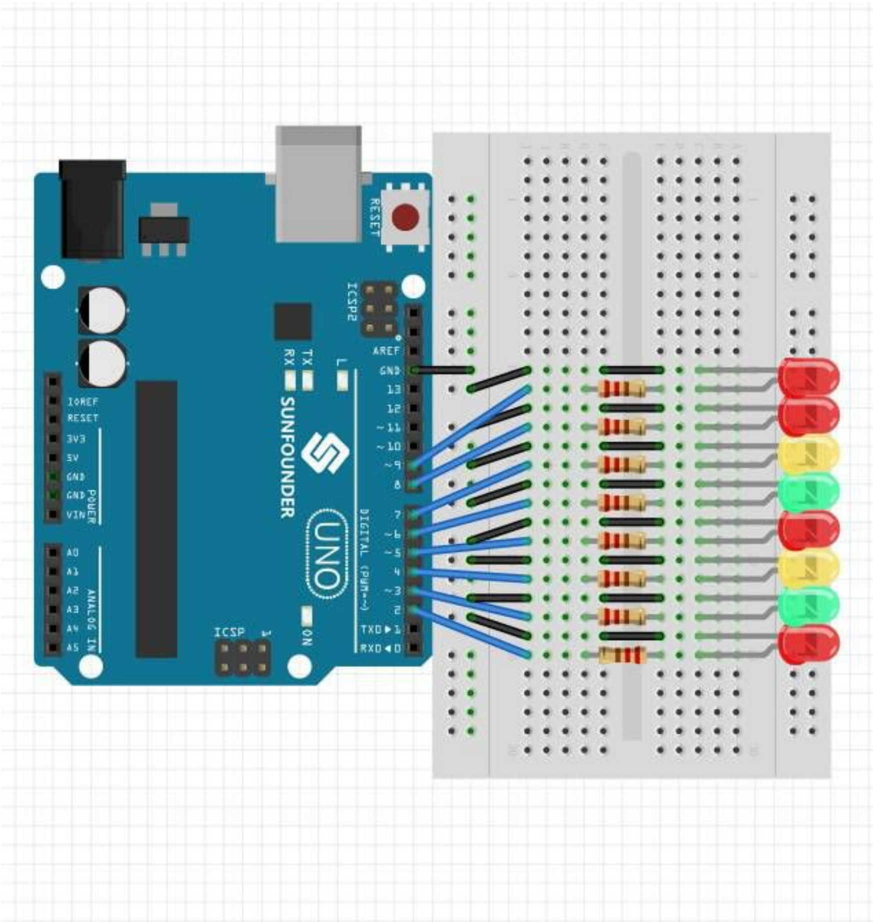
- SUNFOUNDER UNO *1
- Breadboard *1
- Several connecting wires
- LED light *8
- 220 Ohm resistor *8
- USB data cable *1

Principle

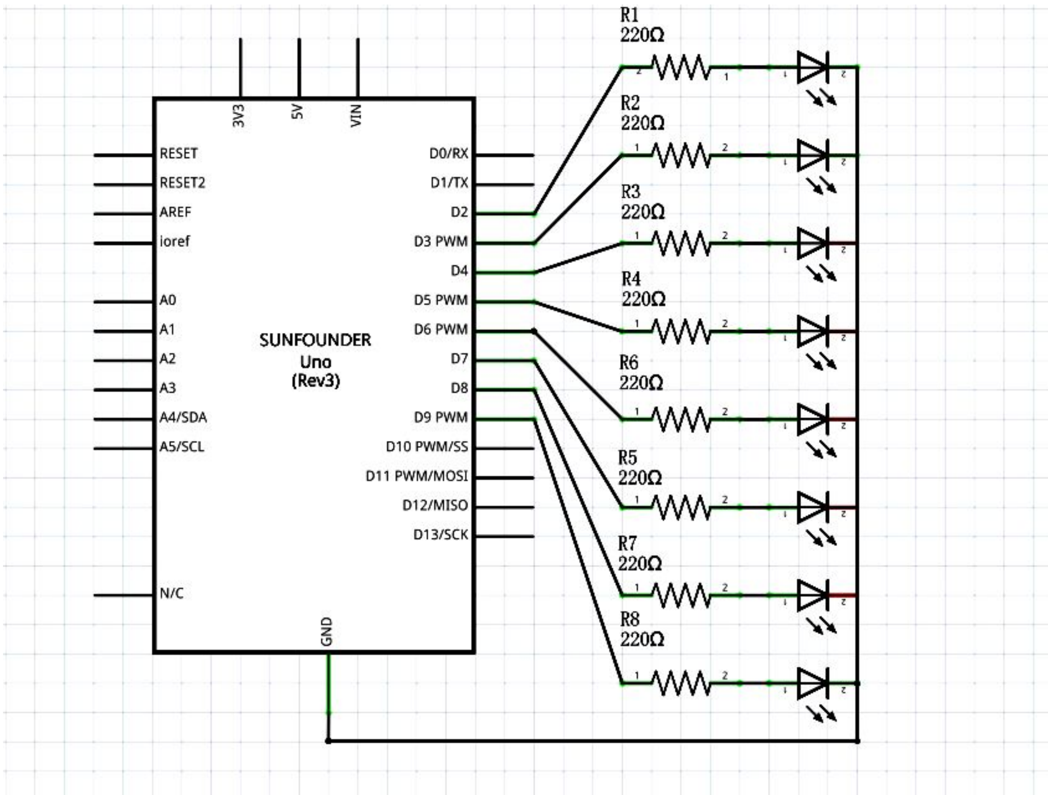
The principle of this experiment is quite simple, that is, turn eight LEDs on in certain turn. Now let's start to practice at once!

Experimental Procedures

Step 1: Connect the circuit as shown in the following diagram

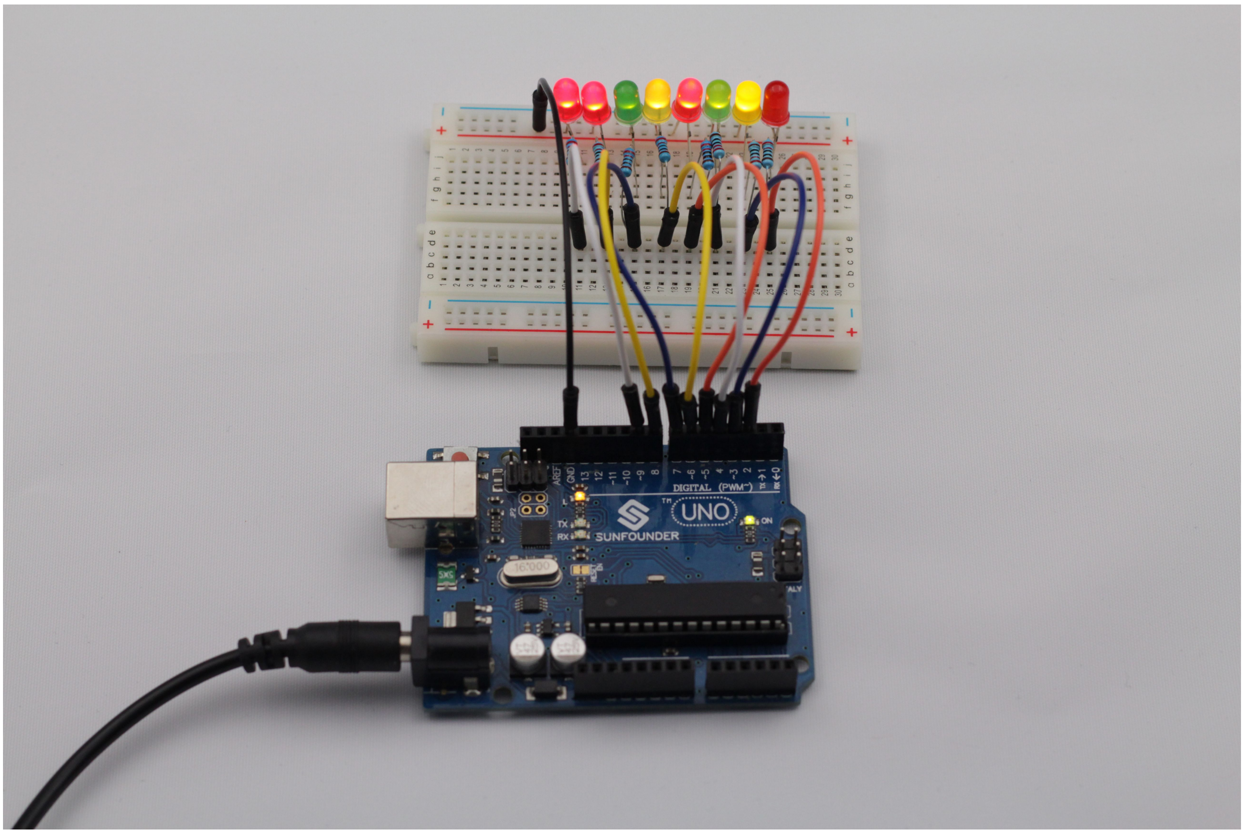


The corresponding schematic diagram is shown as follow



Step 2: Write a program
Step 3: Compile and debug the program
Step 4: Burn the program into SUNFOUNDER UNO board

Now, you will see eight LEDs light up one by one from left to right and then go out one by one from right to left; after that, the LEDs will light up one by one from right to left and then go out one by one from left to right. Such a process will be repeated again and again.



Experimental Summary

This simple but interesting experiment makes us more proficiently apply the LEDs. Besides, you can also modify the provided program to create all kinds of fantastic patterns with LEDs as you want.

Lesson 6 RGB LED

Introduction

In this routine, we will use PWM to control a RGB LED to display all kinds of different colors, and you will find it very interesting.

Components

-RGB LED *1
-220 Ohm resistor *3
-Breadboard *1
-SUNFOUNDER UNO controller *1
-Several connecting wires
-USB data cable *1

Principle

Color Principle of RGB

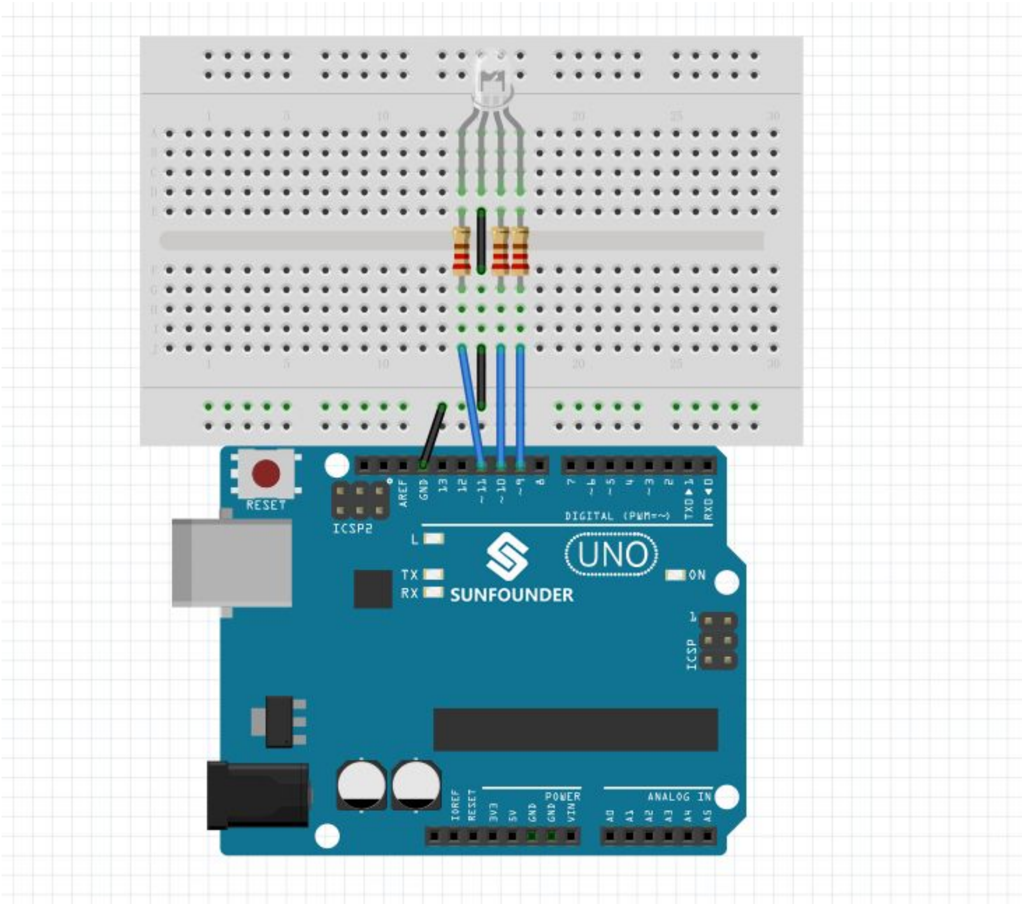
RGB, stands for three colors of red, green and blue channels, is an industry color standard. RGB obtains various new colors by changing the three color channels of red, green and blue and superimposing each other, which can compose 16777216 colors according to statistics. If you say the colors RGB displayed still cannot completely match some color in nature, then the color almost already cannot be differentiated with our naked eyes.

Each color of the three color channels of red, green and blue has 255 stages brightness. When the three primary colors are all 0, "LED light" is the darkest, that is, it turns off. When the three primary colors are all 255, "LED light" is the brightest. When superimposing the lights emitted by the three primary colors, the colors will be mixed. But the brightness is equal to the sum of both brightness, and the more you mixed, the brighter the LED is, that is, additive mixing.

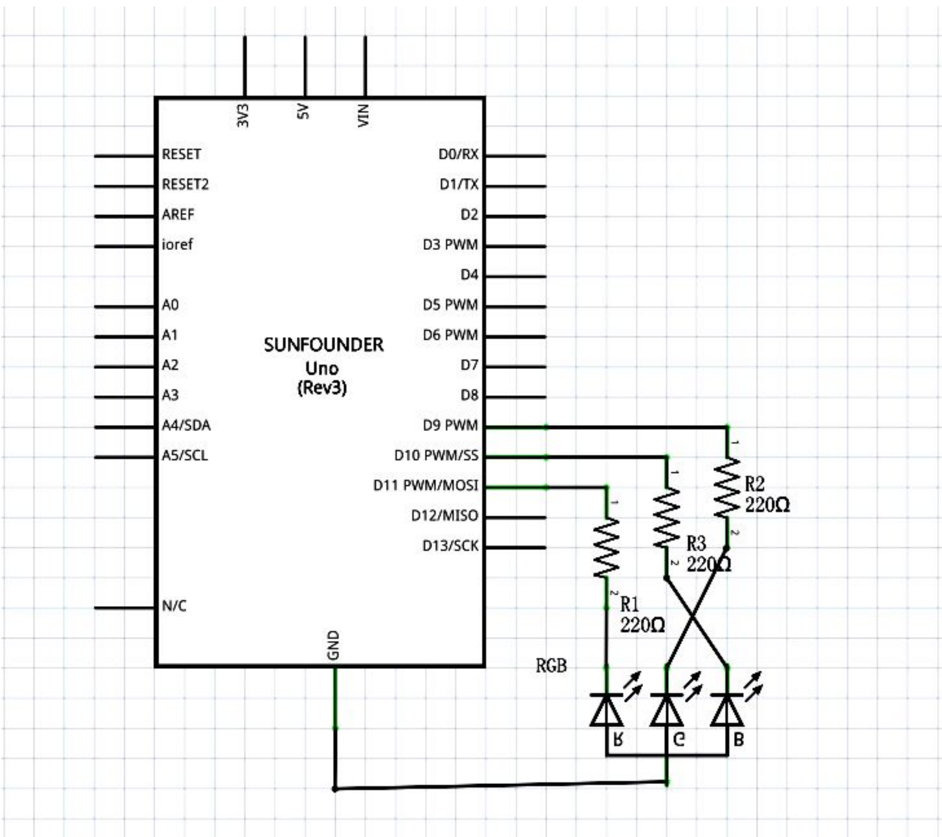
In this experiment, we will also use PWM which we have learnt previously. I believe you already have a basic understanding about PWM. Here we input any value between 0 and 255 to the three pins of RGB LED to make RGB LED display different colors.

Experimental Procedures

Step 1: Connect the circuit as shown in the following diagram

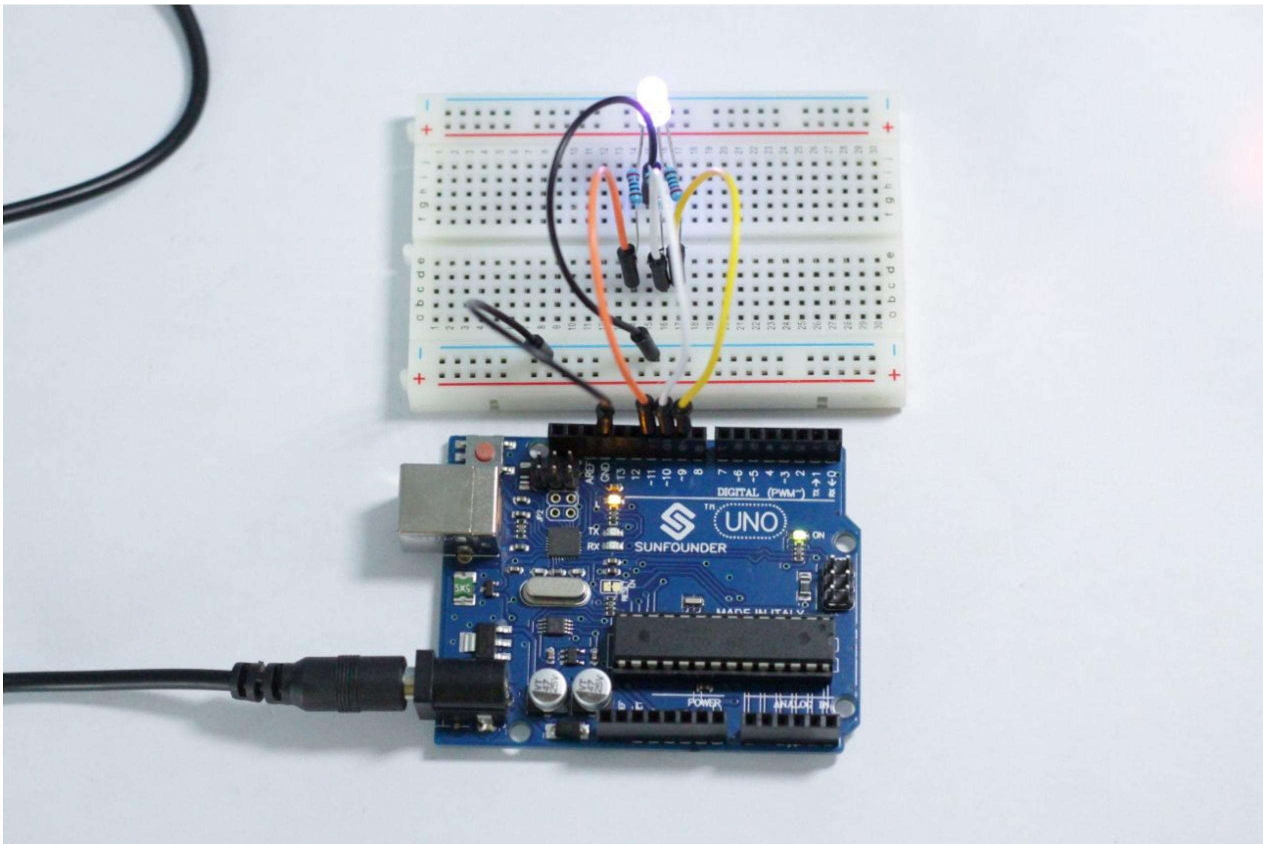


The corresponding schematic diagram is shown as follow



Step 2: Write a program
Step 3: Compile and debug the program
Step 4: Burn the program into SUNFOUNDER UNO controller

Now, you can see RGB LED appears red, green and blue first, and then appears red, orange, yellow, green, blue, indigo and purple.



Experimental Summary

You must have learnt the usage of RGB LED through this experiment. Based on the RGB LED and some components we have learnt previously, if you combine them properly, I am sure you can create more dazzling interactive works.

Lesson 7 DC Motor Control

Introduction

In this experiment, we will learn how to control the direction and speed of a small-sized direct current motor (DC motor) by using the driver chip L293D and SUNFOUNDER UNO.

In order to make it easier for beginners to learn, we will let the DC motor to rotate left and right, accelerate and decelerate automatically.

Components

- Small-sized DC motor *1
- L293D *1
- Optocoupler *2
- 220 Ohm Resistor *4
- Diode (1N4007) *4
- SUNFOUNDER UNO *1
- Breadboard *1
- Several jumper wires

Principle

Optocoupler

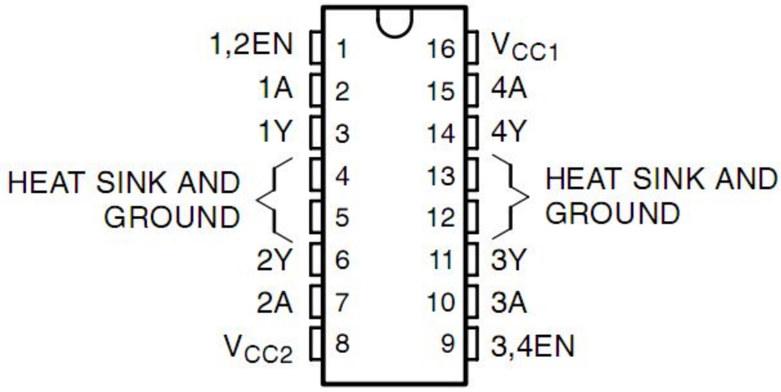
An optocoupler (OC for short), also called an optoisolator or a photocoupler, is a component that transfers electrical signals between two isolated circuits by using light.[It generally consists of three parts: the light emission, light reception, and light amplification. Optocouplers can isolate input and output electrical signals good. As a result, they have been widely used in various circuits. Electrical signals input drive light-emitted diode (LED) to emit lights with a certain wavelength. These light are then received by a light detector and generate photocurrents, and finally are output after further amplification.

Diode

A rectifier diode lets electrical current flow in only one direction and is mainly used for power supply operation. Rectifier diodes can handle higher current flow than regular diodes and are generally used in order to change alternating current into direct current. They are designed as discrete components or as integrated circuits and are usually fabricated from silicon and characterized by a fairly large P-N-junction surface. This results in high capacitance under reverse-bias conditions. In high-voltage supplies, two rectifier diodes or more may be connected in series in order to increase the peak-inverse-voltage (PIV) rating of the combination.

L293D

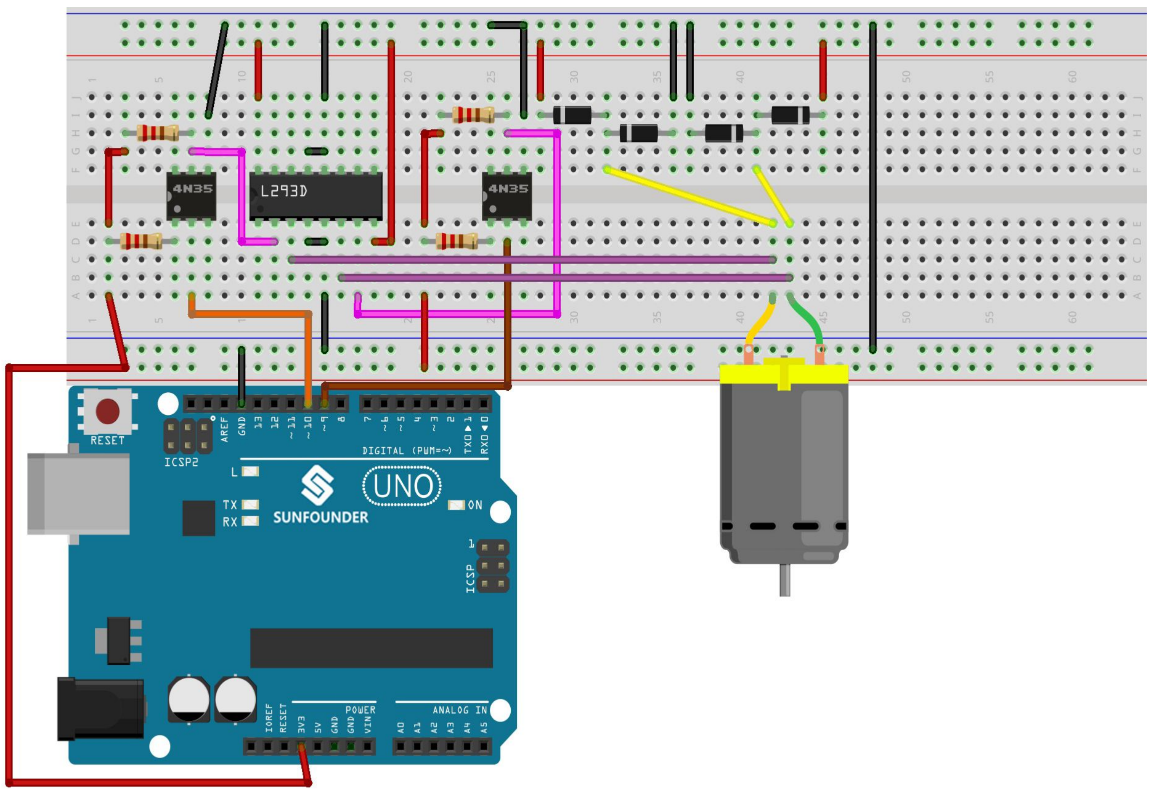
This is a very practical chip which can independently control two DC motors. In this experiment, we just use half of the chip. Since most pins on the right of the chip are used to control the second motor, we don't connect these pins.



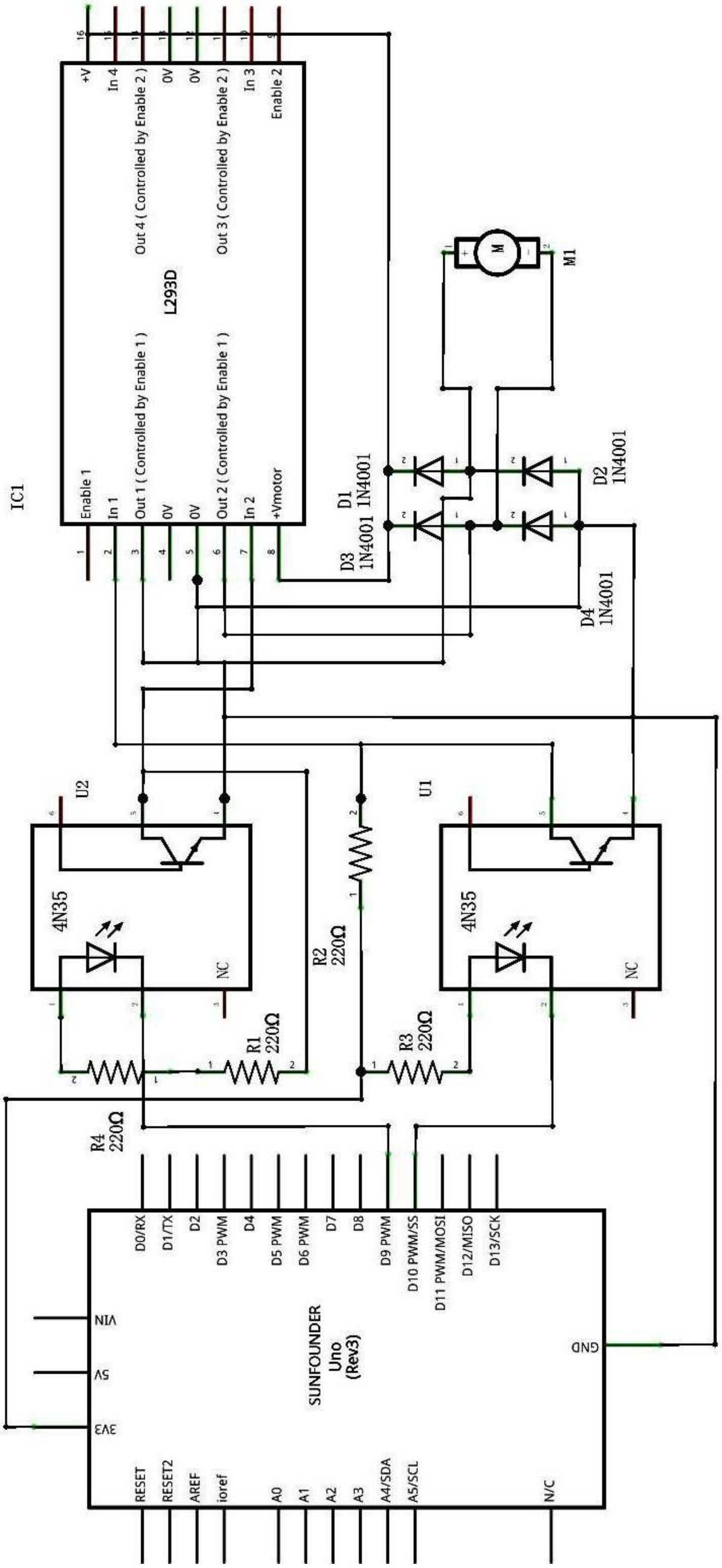
L293D has two pins (Vcc1 and Vcc2) for power supply. Thereinto, Vcc2 is used to supply power for the motor, while Vcc1 is used to supply power for the chip. Since we use a small-sized DC motor, we connect both the pins to +5v. If you use a motor with bigger power consumption, then you should connect Vcc2 to the external power supply. At the same time, the GND of L293D should be connected to the GND of SUNFOUNDER UNO.

Experimental Procedures

Step 1: Connect the circuit as shown in the following diagram

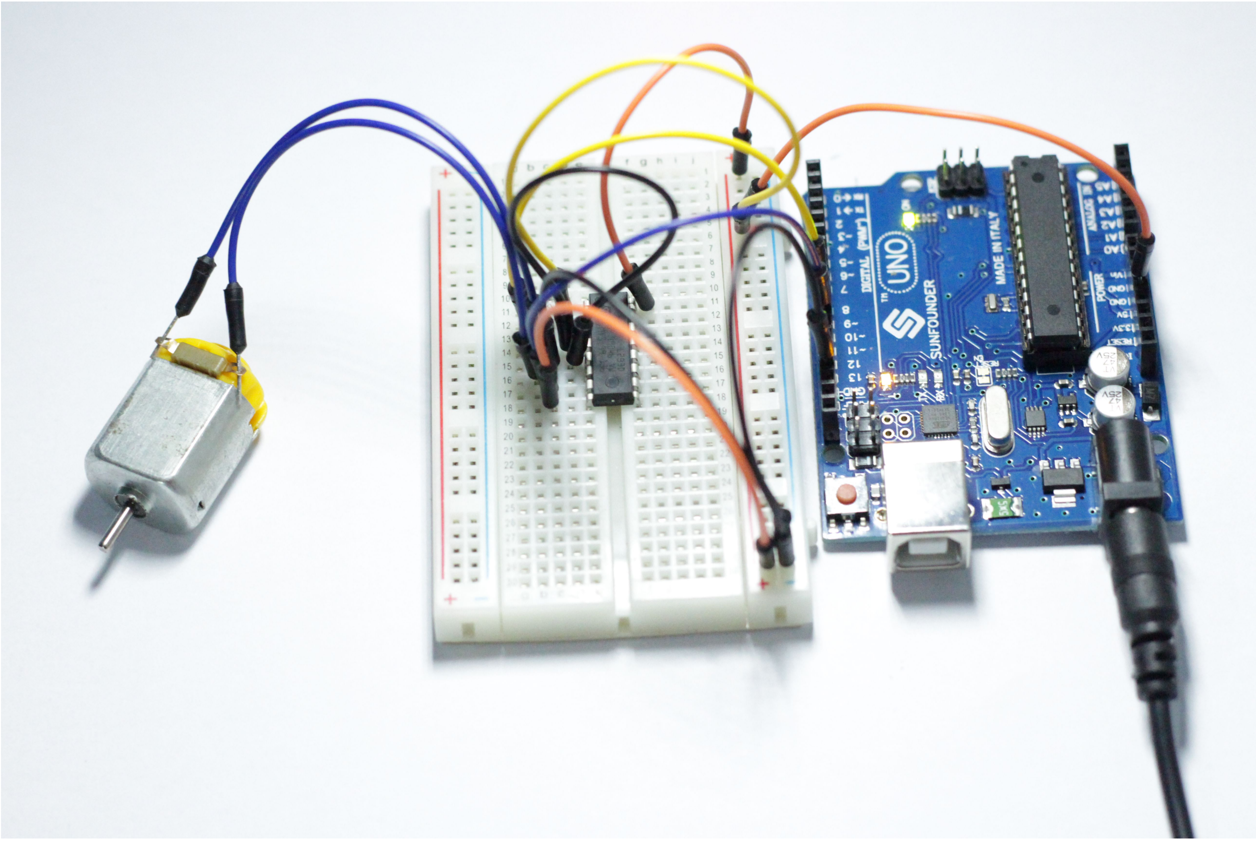


The corresponding schematic diagram is shown as follow



Step 2: Write a program
Step 3: Compile and debug the program
Step 4: Burn the compiled program into SUNFOUNDER UNO

Now you will see the DC motor rotate left and right, and its speed also varies accordingly.



Further Exploration

Please try to modify the code and add a potentiometer to adjust the speed of the motor. Of course you can also add a button to control the rotation direction of the motor.

Lesson 8 LCD1602

Introduction

In this experiment, we will use SUNFOUNDER UNO control board to directly drive liquid crystal display LCD1602 to display characters.

Components

- SUNFOUNDER UNO control board *1
- Breadboard*1
- Liquid crystal display LCD1602 *1
- 50K Ohm potentiometer *1
- Several connecting wires

Principle

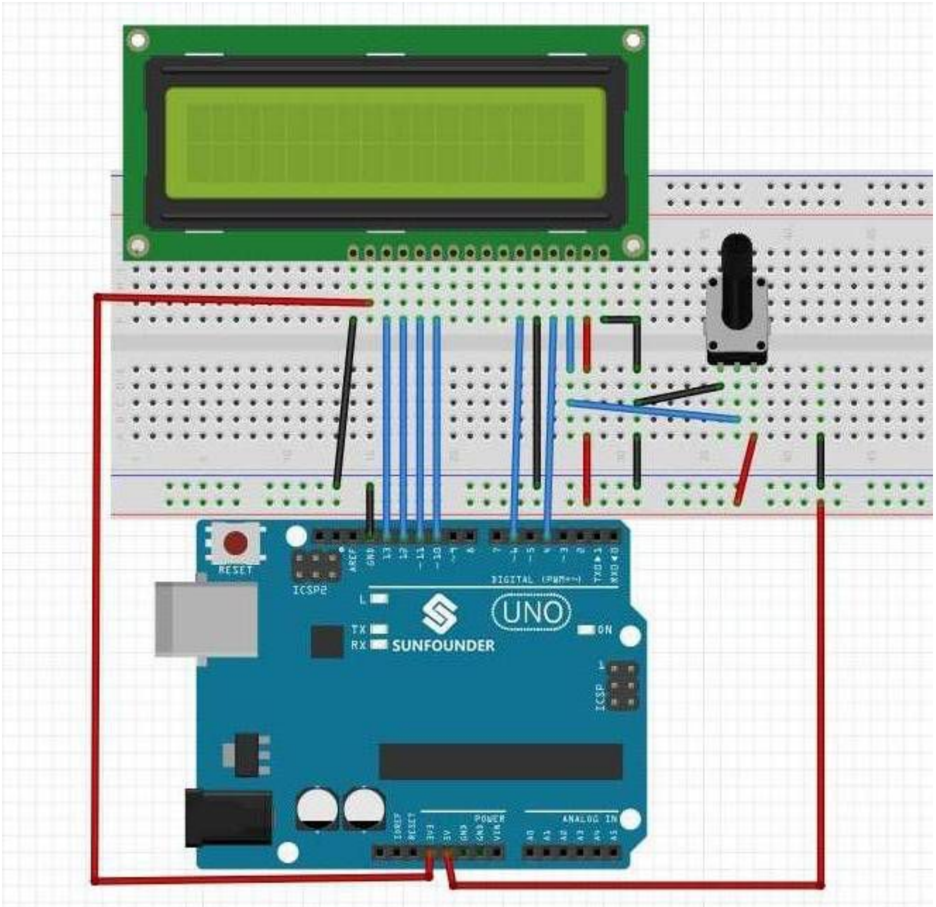
Generally speaking, LCD1602 has parallel ports, that is, it needs to control several pins at the same time. LCD1602 can be categorized into eight-port connection and four-port connection. If eight-port connection is used, then basically the digital ports of SUNFOUNDER UNO are occupied completely. If you want to connect some more sensors, there will be no ports available. Therefore, we will use four-port connection.

Introduction to the pins of LCD1602:
VSS: A pin that connects to ground
VDD: A pin that connects to +5V power supply
VO: A pin that adjust the contrast of LCD1602
RS: A register select pin that controls where in the LCD's memory you are writing data to. You can select either the data register, which holds what goes on the screen, or an instruction register, which is where the LCD's controller looks for instructions on what to do next.
R/W: A Read/Write pin that selects reading mode or writing mode
E: An enable pin, when being supplied low level, the LCD module will execute relevant instructions
D0-D7: Pins that read and write data
A and K: Pins that control the LED backlight

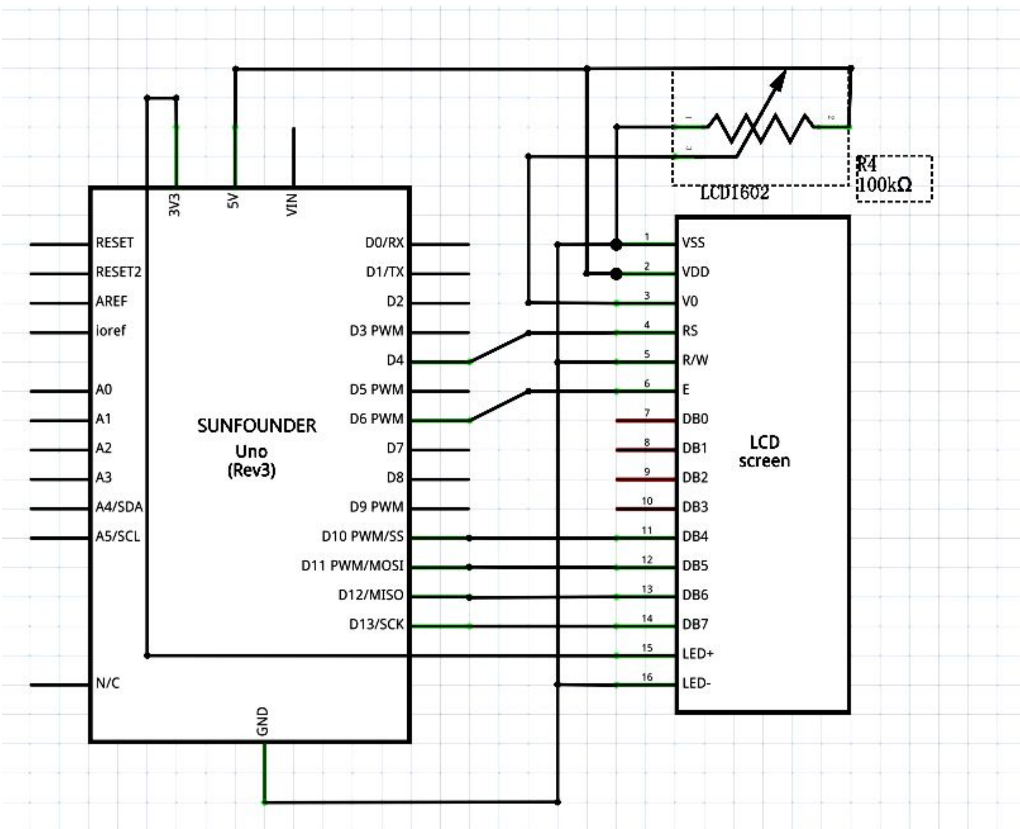
In this experiment we use a 50K Ohm potentiometer to adjust the contrast of LCD1602 to display characters or figures as you want. For programming, we will optimize it by calling function libraries.

Experimental Procedures

Step 1: Connect the circuit as shown in the following diagram (Note: please make sure the pins are connected correctly, or the characters will not display properly)



The corresponding schematic diagram is shown as follow

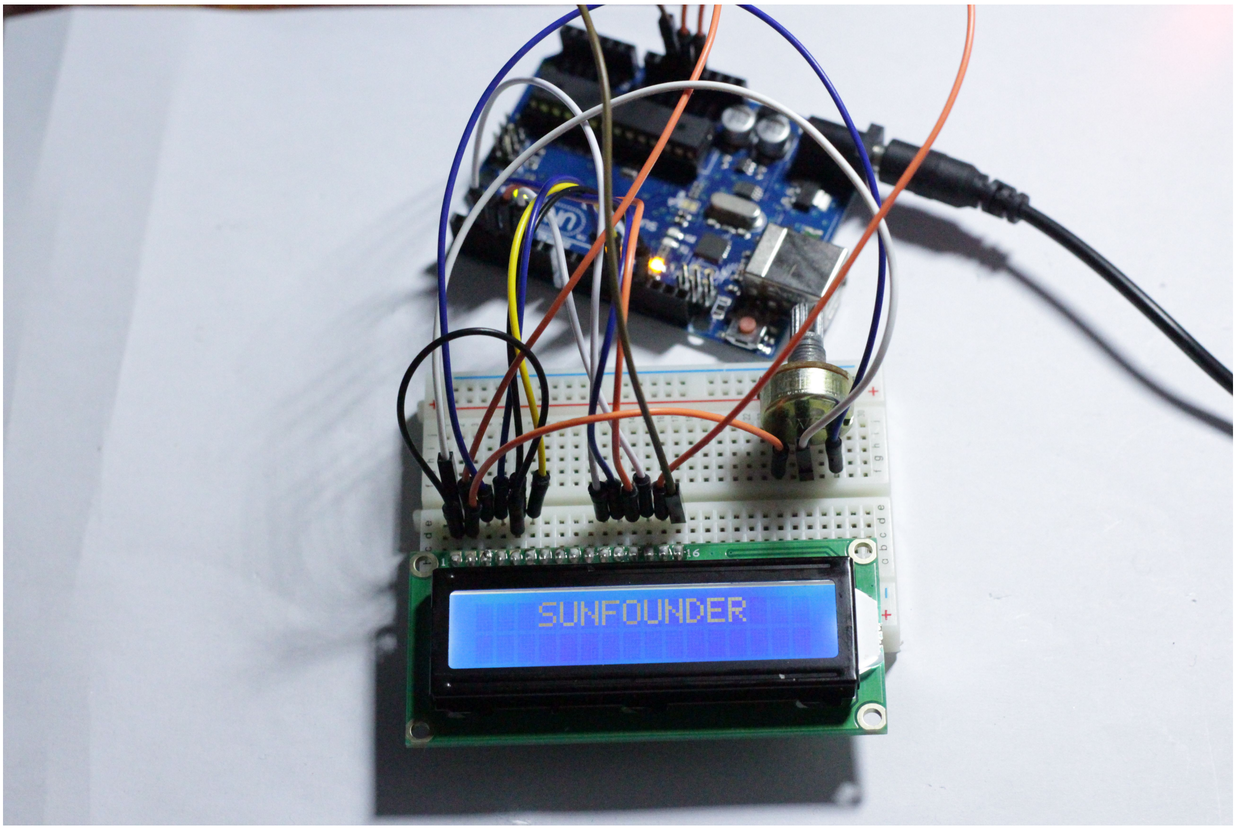


Step 2: Write a program

Step 3: Debug and compile the program

Step 4: Burn the compiled program into SUNFOUNDER UNO control board

Now, you can see your LCD1602 display the flowing characters "SUNFOUNDER" and "hello, world".



Experimental Summary

You should have learnt the way to drive LCD1602 through this experiment. You can also try to let your LCD1602 display some numbers.

Lesson 9 Serial Monitor

Introduction

In this experiment, we will learn how to turn LEDs on or off on a SUNFOUNDER UNO board through a computer and a SUNFOUNDER UNO serial monitor. The serial port is connected to the computer and the SUNFOUNDER UNO board. We can send and receive data via the serial port and can also control the SUNFOUNDER UNO board through the keyboard.

In this routine, you can input any color among red, green and blue into the serial monitor of the computer, and then the corresponding LED on the SUNFOUNDER UNO board will light up.

Components

– SUNFOUNDER UNO board *1

– Breadboard*1

– LED light *3

– 220 ohm resistor *3

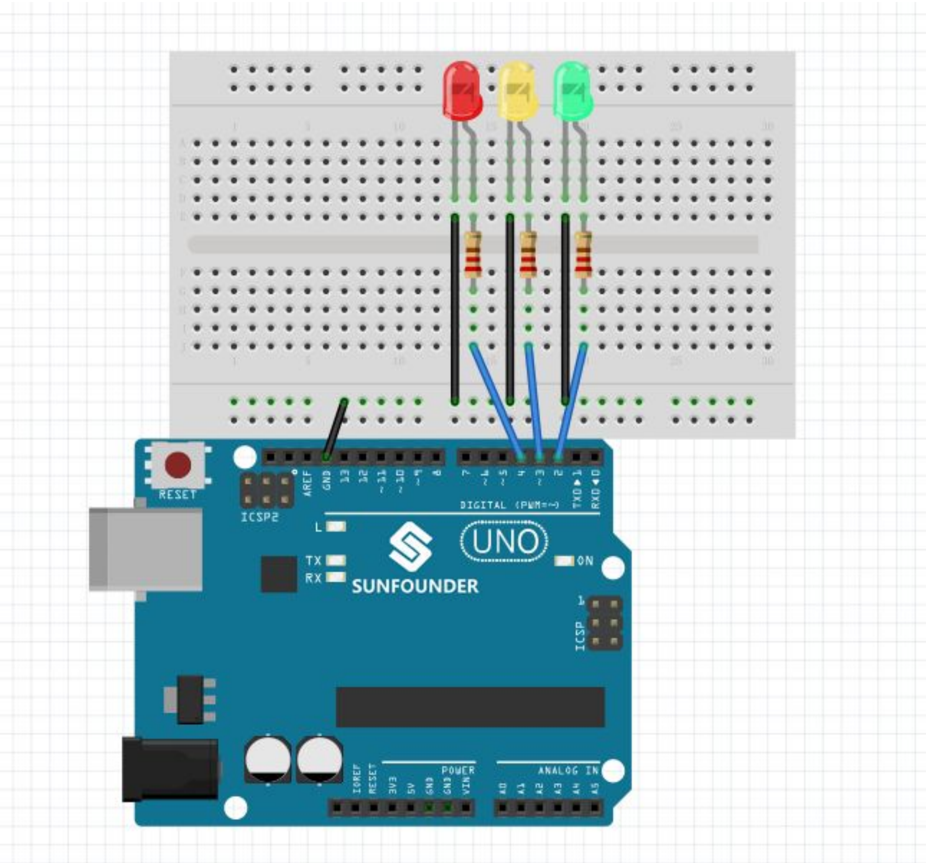
– Several connecting wires

Principle

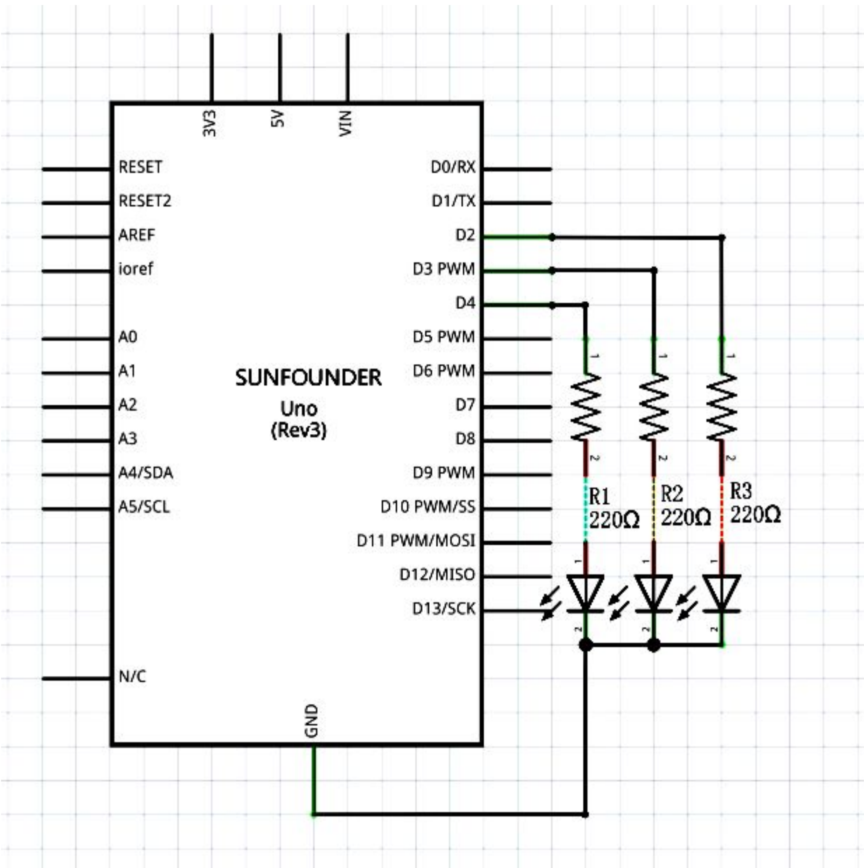
Here the serial port is a transfer station for communication between the computer and the SUNFOUNDER UNO board. The computer inputs data to the serial port, and then the SUNFOUNDER UNO board reads the data from the serial port via USB data cable. After that the SUNFOUNDER UNO board will perform related operations according to the contents having been read.

Experimental Procedures

Step 1: Connect the SUNFOUNDER UNO board to your computer via USB data cable. Open the serial monitor and then input red, green, blue or any other characters or character strings.

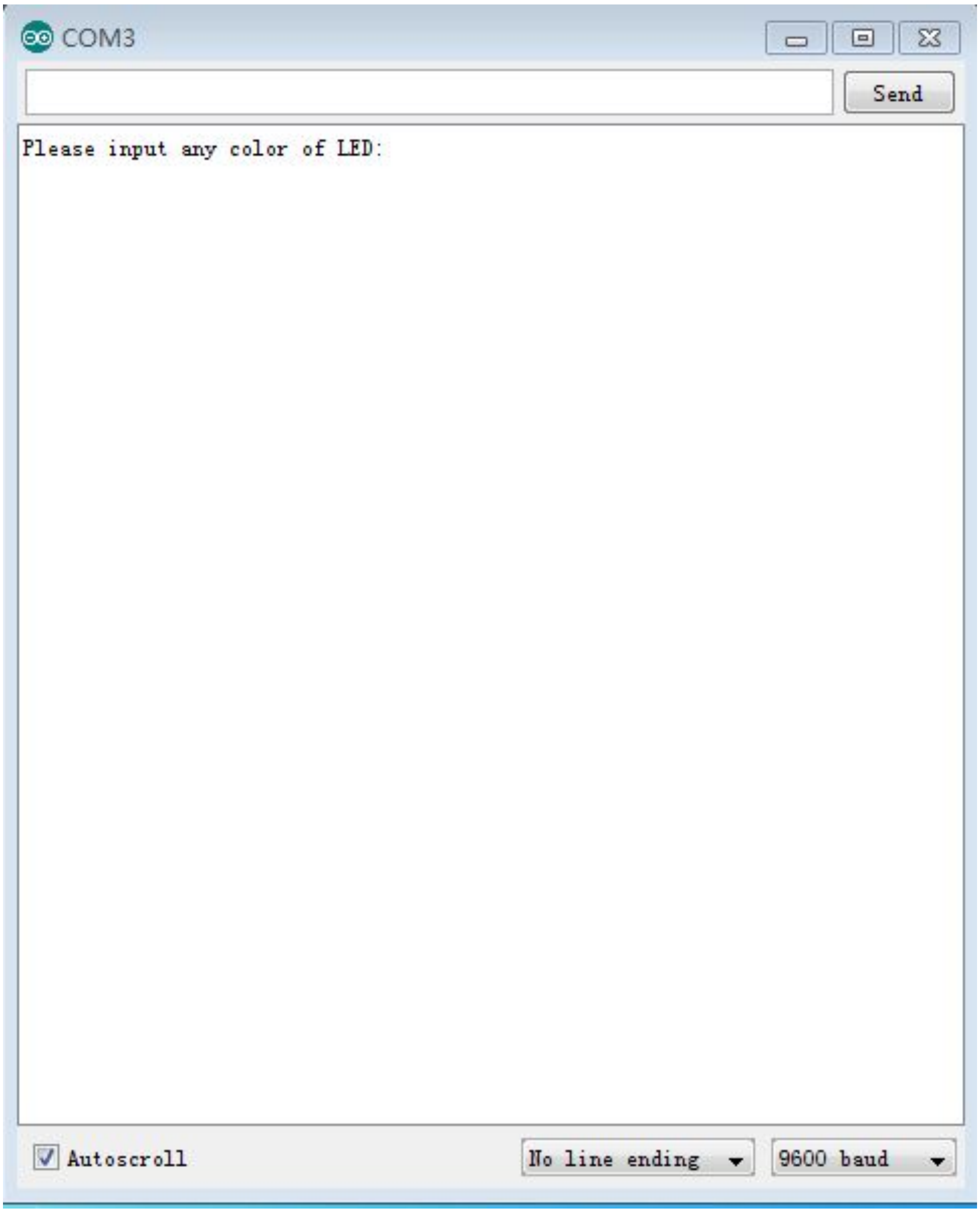


The corresponding schematic diagram is shown as follow



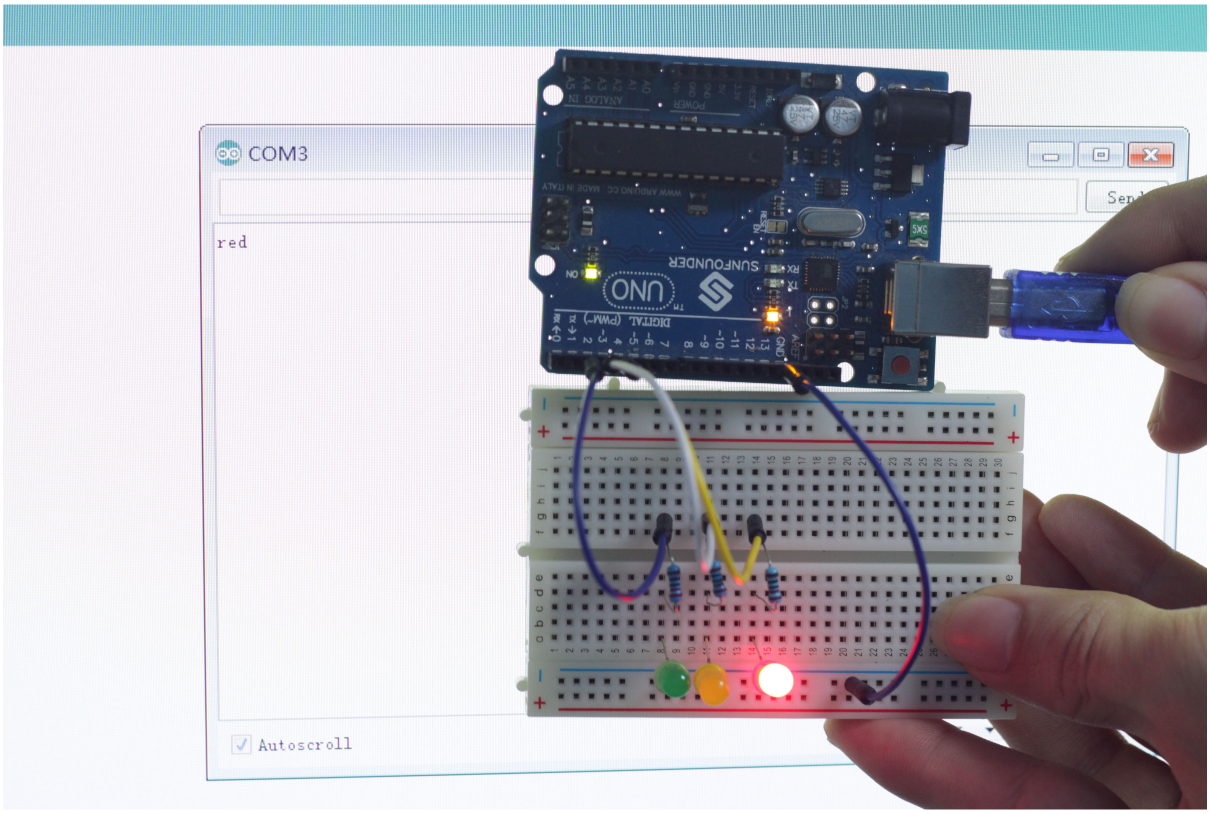
Step 2: Write a program
Step 3: Compile and debug the program
Step 4: Burn the compiled program into SUNFOUNDER UNO board

Now, if you click the icon on the upper-right corner of SUNFOUNDER UNO IDE, you will see the serial monitor window popup as shown in the following picture.



With this window, you can not only send information from your computer to the SUNFOUNDER UNO board via USB cable but also receive information from the board and display the information on the screen. When you open the serial monitor, it will display "**Please input any color of LED:**". You can input any color among red, green and blue, and then click **Send**. The corresponding LED light on the SUNFOUNDER UNO board will light up. But if you input any other colors except of these three colors, LED lights will be off.

For example, we input red, you will see the red LED light up.



Experimental Summary

Now you have realized communication between your computer and the SUNFOUNDER UNO board. You can also modify the source code we provided appropriately. For example, if you input a number into the serial monitor, the corresponding LED will light up.

Lesson 10 7-Segment Display

Introduction

Today let us play with a 7-segment display which is made up with an array of common cathode LEDs parallel connected together. A 7-segment display is a simple and common component for displaying numbers or characters. The code we use this time illumes only one light on the 7-segment display per unit time. The high refresh rate, higher than the resolution speed of our naked eyes, enables us to see the number 1, 2, 3, etc.. The 7-segment display has the advantage of high and uniform luminance.

Components

- SUNFOUNDER UNO board*1
- Single 7-segment display *1
- 220 Ohm resistor *8
- USB data cable *1
- Several connecting wires

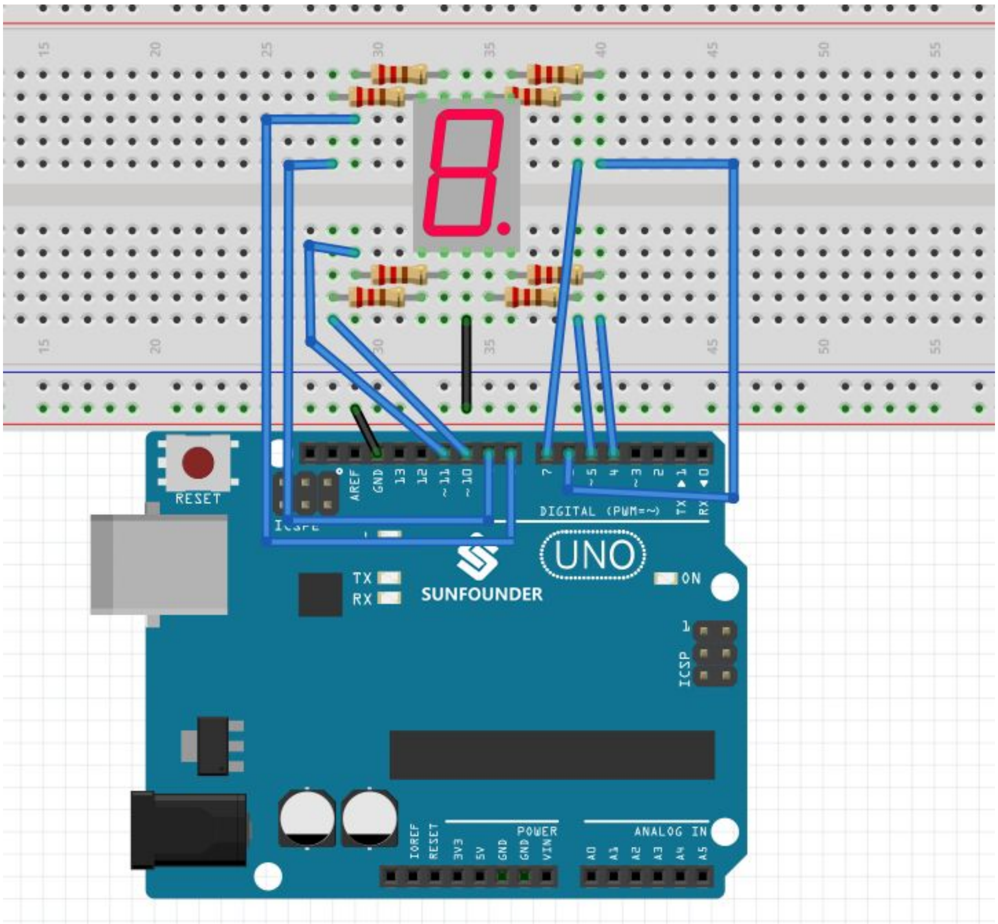
Principle

The 7-segment display, whose basic unit is the light-emitting diode, is a semiconductor light-emitting device. The 7-segment display can be categorized into seven-segment and eight-segment display by the number of segments, and the latter has one more light-emitting diode unit (or one more decimal point display) than the former one. The 7-segment display can be categorized into common anode and common cathode 7-segment display by the connection of light-emitting diodes. Common anode 7-segment display joins all the anodes of light-emitting diodes together to make a common anode (COM). When using common anode 7-segment display, you should connect the COM to +5V. When the cathode of light-emitting diode in a certain segment is low, this segment will be turned on. Whereas, when the cathode is high, the corresponding segment will be turned off. Common cathode 7-segment display joins all the cathodes of light-emitting diodes together to make a common cathode (COM). When using common cathode 7-segment display, you should connect the COM to GND. When the anode of light-emitting diode in a certain segment is high, this segment will be turned on. Whereas, when the anode is low, the corresponding segment will be turned off.

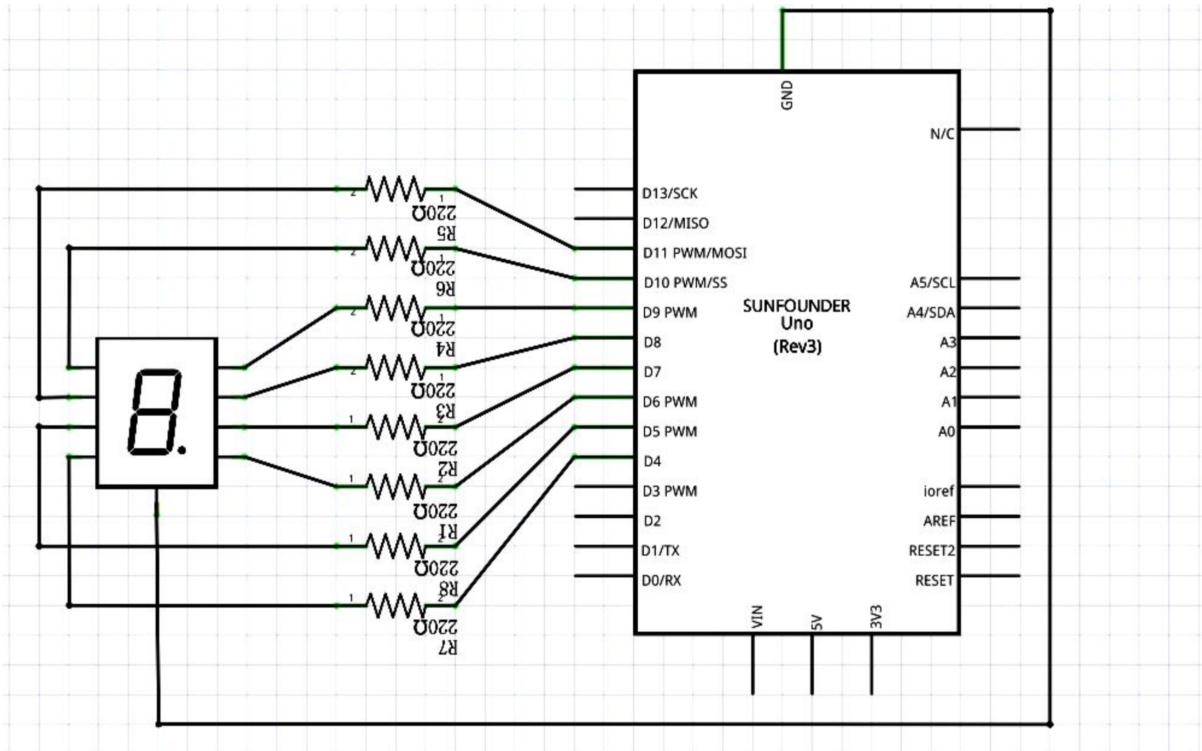
Every segment of the 7-segment display contains a light-emitting diode. As a result, when using a 7-segment display, you should connect a current-limiting resistor like using a light-emitting diode, or the light-emitting diode will be burned due to excessive current. In this experiment, we use common cathode 7-segment display. We should connect the COM to GND. When the anode of light-emitting diode in a certain segment is low, the corresponding segment will be turned off. Whereas, when the anode is high, the corresponding segment will be turned on. Having introduced the principle, let us start to practice.

Experimental Procedures

Step 1: Connect the circuit according to real connection diagram shown below



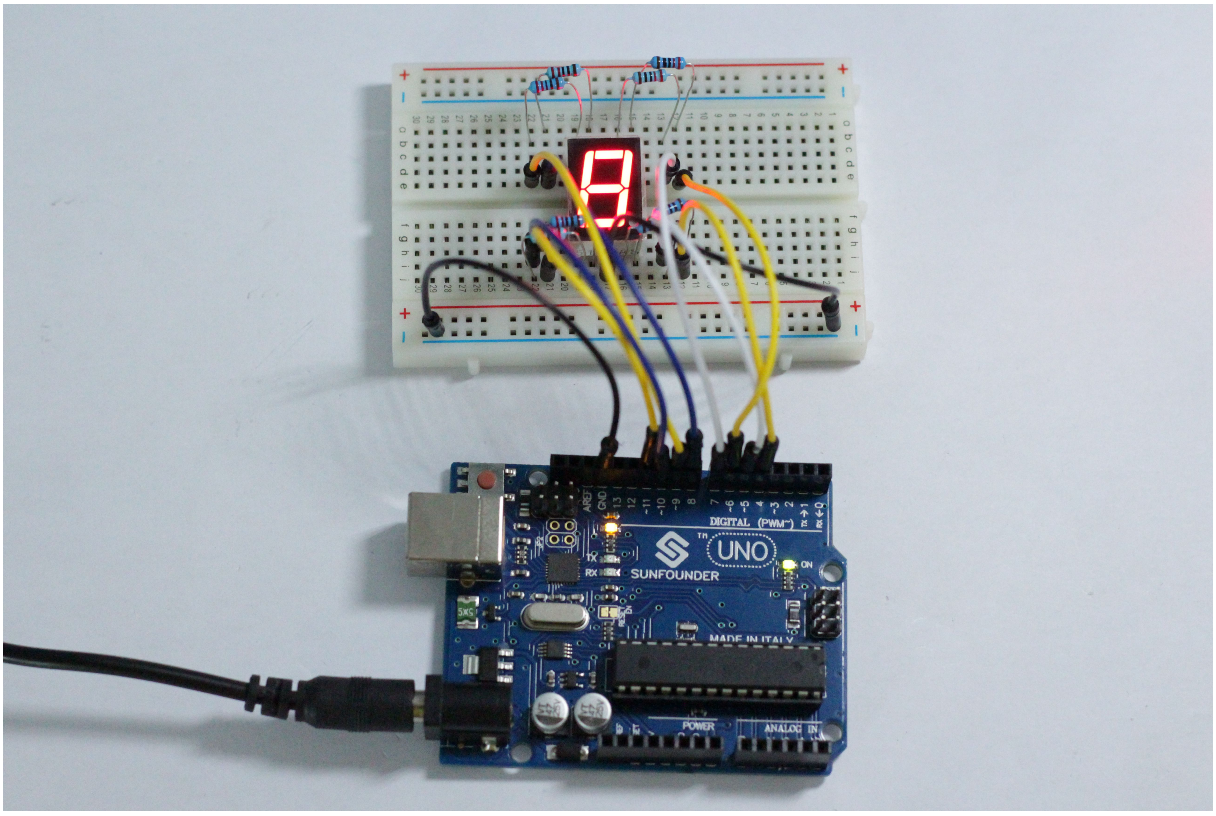
The corresponding schematic diagram is shown as follow



Step 2: Write a program

Step 3: Compile and debug the program
Step 4: Burn the program into SUNFOUNDER UNO board

Now, you can see the 7-segment display circularly display from 0 to F. So far the experiment is successfully done.



Experimental Summary

In this experiment, we have learnt how to directly drive a single 7-segment display via the SUNFOUNDER UNO board. You can also try to modify the code to make the 7-segment display displaying numbers, characters or even patterns as you want.

Lesson 11 74HC595

Introduction

In this experiment, we will learn how to use 74HC595 to drive a single 7-segment display to display numbers.

Generally speaking, there are two methods to drive single 7-segment display. One is to connect 8 pins directly to eight ports of the SUNFOUNDER UNO board, which we have learnt in previous experiment. And the other is to connect 74HC595 to three ports of the SUNFOUNDER UNO board and connect the 7-segment display to 74HC595. In this experiment, we will use the latter. The advantage of the latter method is that you can save five ports, which is very important for SUNFOUNDER UNO with limited ports.

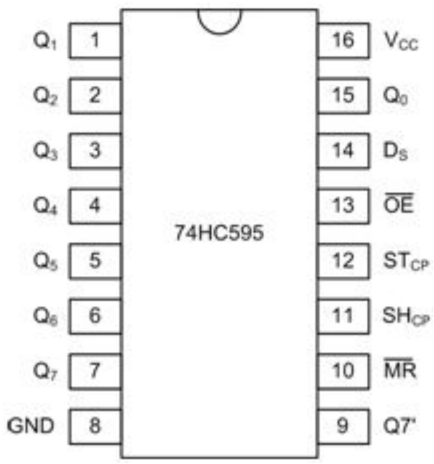
Components

- LED *8
- 220 Ohm resistor *8
- 74HC595 *1
- SUNFOUNDER UNO board*1
- Several connecting wires
- Breadboard *1

Principle

74HC595 Principle of Operation

74HC595 has an 8-bit shift register and a memory with three-state output function. Its main function is to transform serial data input into parallel data output so that we can save the IO port resource of MCU. 74HC595 is mainly used in multipath LEDs indication or multi-bit segment displays driving. At the same time, it supports three-state output. When the 13th pin is high, there will be no output in 74HC595. With data latching function, 74HC595 does not affect the instant output during shifting process; with data output function, 74HC595 enable us to cascade 74HC595 more conveniently.



Introduction to Pins of 74HC595

Ds: Serial data input pin

Q0-Q7: 8-bit parallel data output pins, able to control 8 LEDs or 8 pins of 7-segment display directly

Q7': series output pin connected to DS pin of the next 74HC595 to connect multiple 595s in series

OE: output enable pin, effective at low level, connected to the ground directly

MR: reset pin, effective at low level, directly connected to 5V high level in practical applications

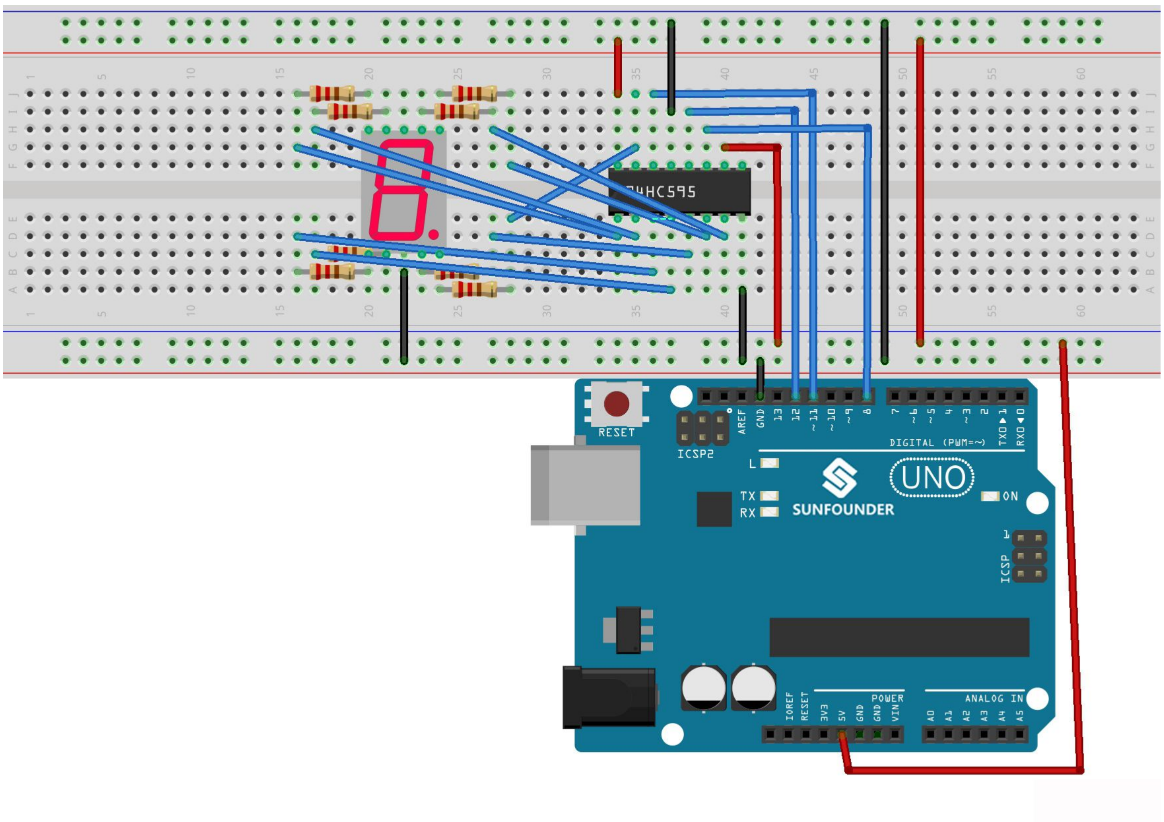
SH: time sequence input of shift register. On the rising edge, the data in shift register moves successively one bit, i.e. Data in Q1 moves to Q2, and so forth. While on the falling edge, the data in shift register remain unchanged

ST: time sequence input of memory register. On the rising edge, the data in shift register moves into memory register

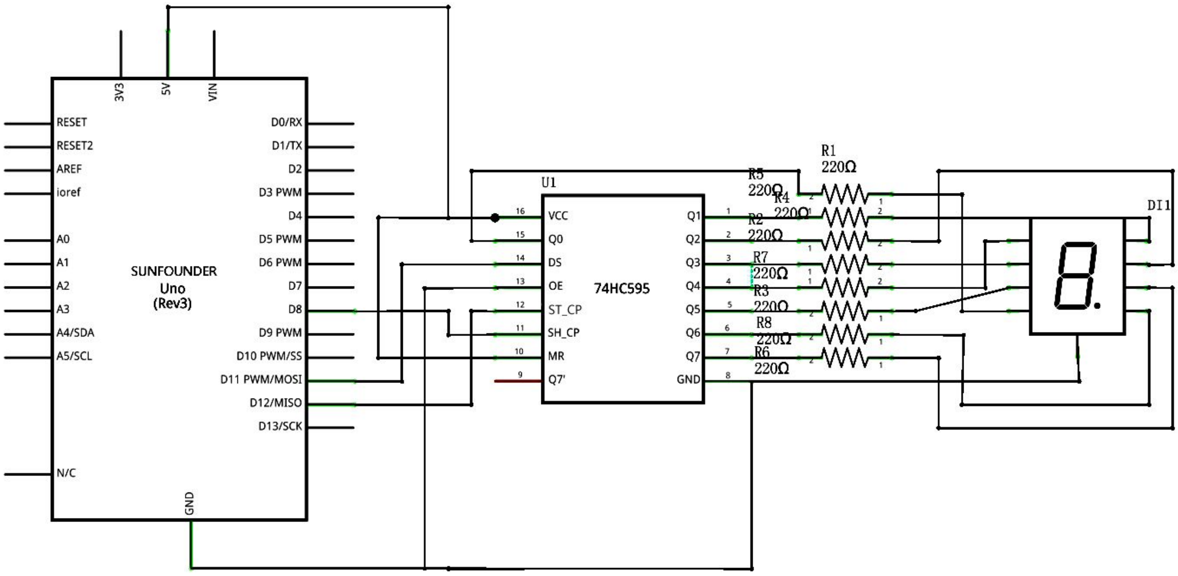
Here we have applied the **shiftout** function which comes with SUNFOUNDER IDE when programming. Just input a number from 0 to 255, memory register can transform it into 8-bit binary number and output it parallel so that you can easily control the 8 pins of the 7-segment display and let it display the patterns as you want.

Experimental Procedures

Step 1: Connect the circuit as shown in the following diagram

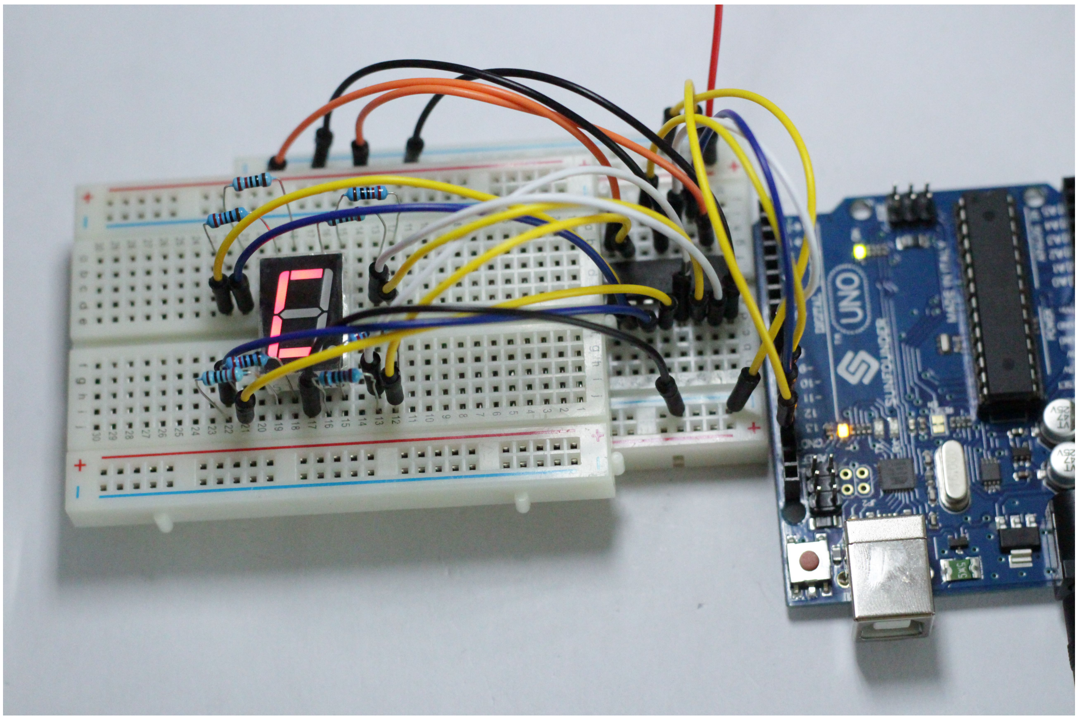


The corresponding schematic diagram is shown as follow



Step 2: Write a program
Step 3: Compile and debug the program
Step 4: Burn the compiled program into SUNFOUNDER UNO board

Now, you can see the 7-segment display circularly display from 0 to F.



Experimental Summary

In this experiment, we have learnt how to use 74HC595 to expand I/O ports, which is very practical. You should practice more.

Lesson 12 Dot-matrix Display

Introduction

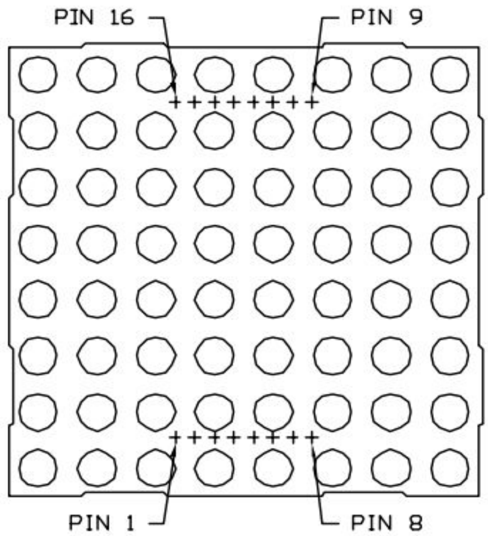
With low-voltage scanning, LED dot-matrix display has such advantages as power saving, long service life, low cost, high brightness, wide angle of view, long visual range, water proof and numerous specifications. LED dot-matrix display can meet the needs of different applications and therefore has a broad development prospect. This time we will conduct an LED dot-matrix experiment to experience the charm of LED dot-matrix by ourselves.

Components

- SUNFOUNDER UNO board*1
- 8*8 dot-matrix *1
- 220 ohm resistor *8
- Breadboard*1
- Several jumper wires

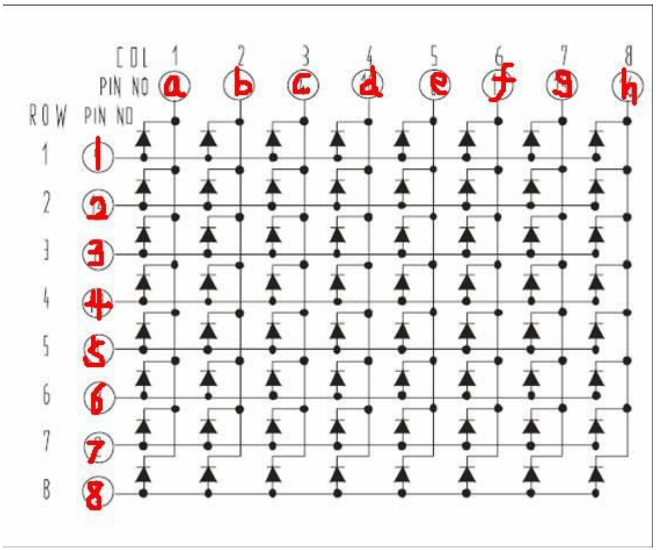
Principle

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



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

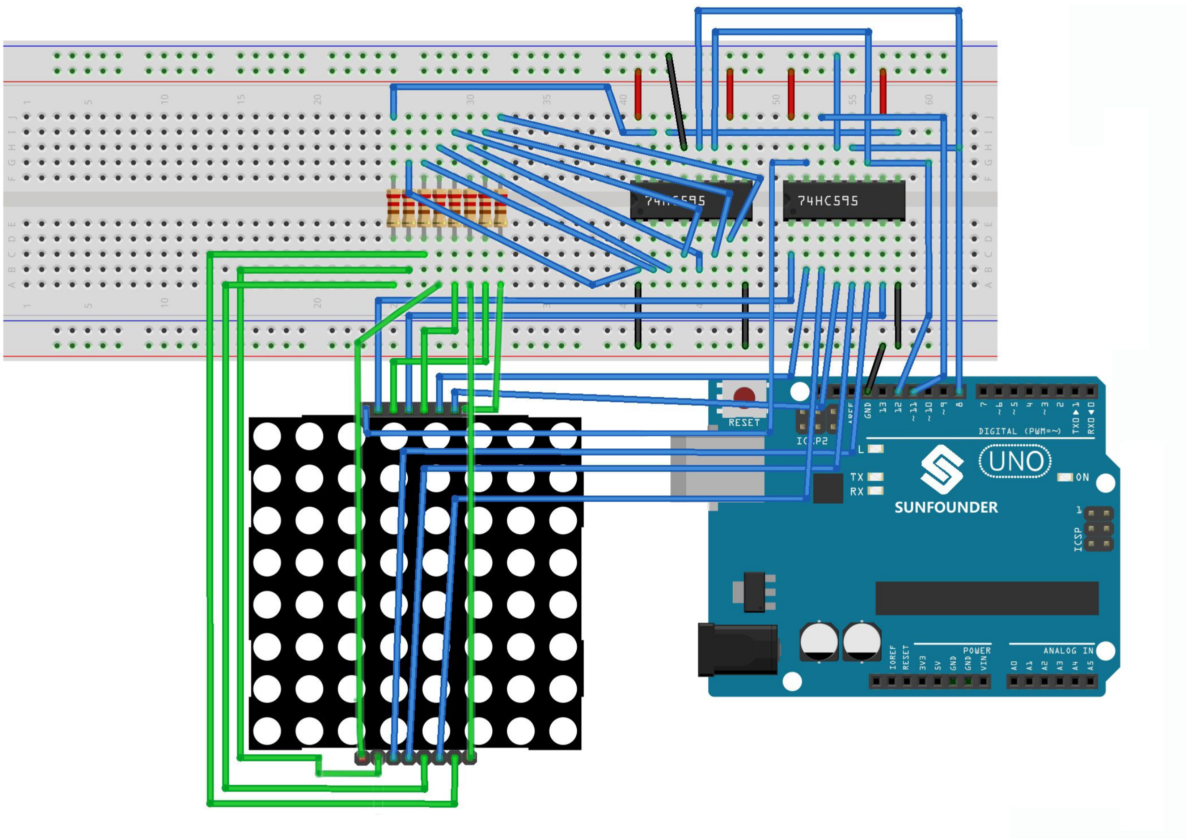
The 8*8 dot-matrix is made up of sixty-four LEDs and each LED is placed at the cross point of a row and a column. When the electrical level of a certain row is 1 and the electrical level of a certain column is 0, then the corresponding LED will light up; if you want to light the LED on the first dot, you should set PIN 1 to high level and PIN a to low level, then the LED on the first dot will light up; if you want to light the LEDs on the first row, you should set PIN 1 to high level and PIN (a, b, c, d, e, f, g, h) to low level, then all the LEDs on the first row will light up; if you want to light the LEDs on the first column, you should set PIN a to low level and PIN (1, 2, 3, 4, 5, 6, 7, 8) to high level, then all the LEDs on the first column will light up.



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

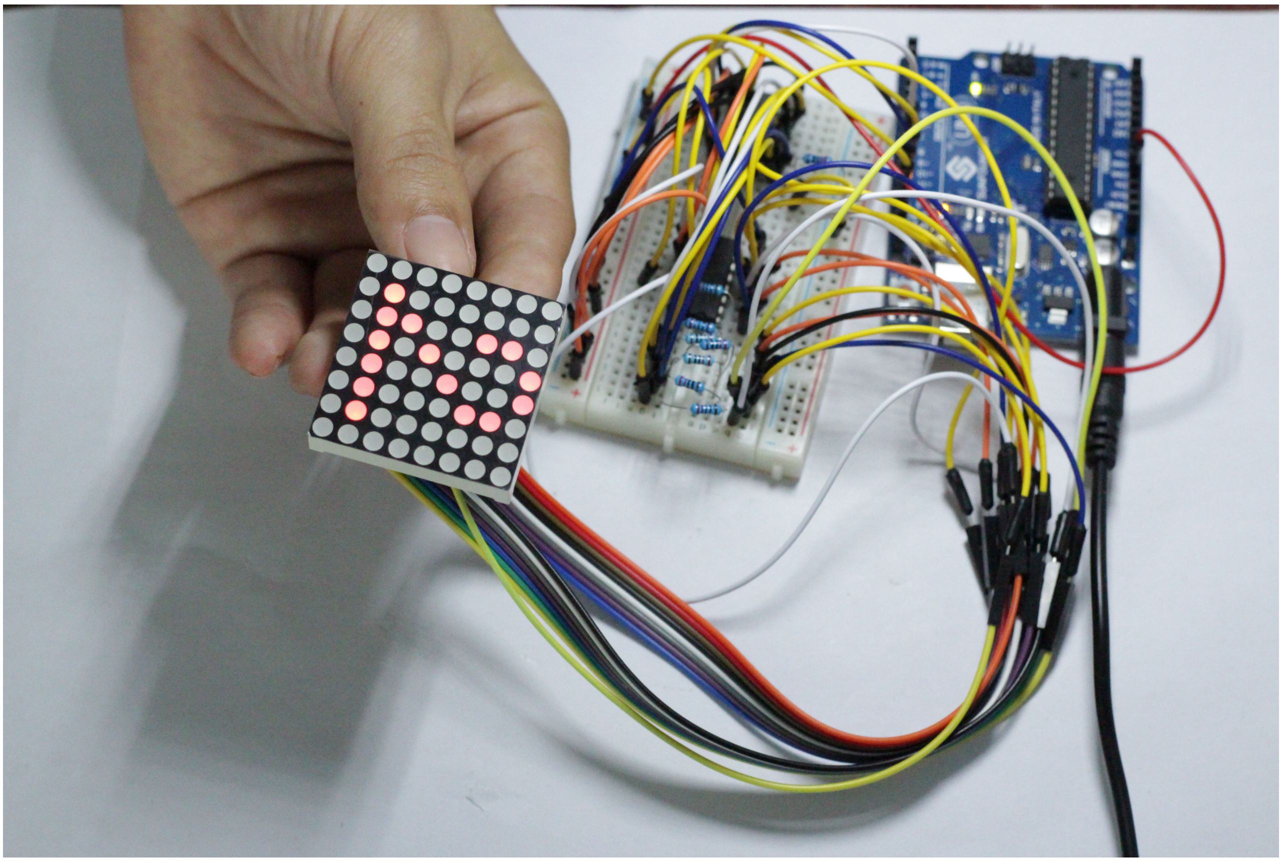
Experimental Procedures

Step 1: Connect the circuit as shown in the following diagram



Step 2: Write a program
Step 3: Debug and compile the program
Step 4: Burn the compiled program into SUNFOUNDER UNO control board

Now, you can see the dot-matrix display from 0 to F circularly.



Experimental Summary

You have learnt how to drive a dot-matrix through this experiment. Please try to modify the code to let your dot-matrix display the patterns as you want.

Lesson 13 NE555 Timer

Introduction

If you ask electronics fans to rank the most commonly and widely applied integrated circuit, the famous 555 time-base integrated circuit will absolutely come first on the list. The 555 time-base integrated circuit, a mixed circuit composed of analog and digital circuits, integrates analogue and logical functions into an independent integrated circuit, and hence tremendously expands the application range of analog integrated circuits. The 555 is widely used in various timers, pulse generators and oscillators. In this experiment, we will use a SUNFOUNDER UNO board to test the frequencies of square waves generated by the 555 oscillating circuit and show them on a serial monitor.

Components

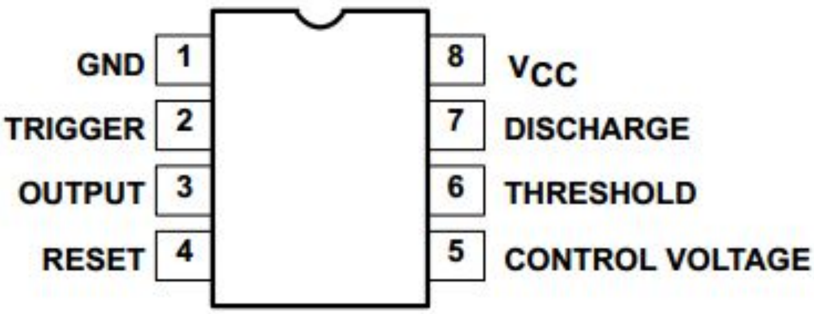
- SUNFOUNDER UNO control board*1
- Breadboard *1
- NE555 *1
- 104 ceramic capacitor *2
- 50k ohm potentiometer *1
- 10k ohm resistor *1

Principle

The 555 time-base circuit is mainly used in multivibrator circuit, monostable trigger circuit, and RS trigger circuit. How could it achieve all those functions?

The 555 integrated circuit is originally used as a timer, and that is why it is called 555 timer or 555 time-base circuit. It is widely used in various electronic products because of its reliability, convenience and low price. There are dozens of components in the 555 integrated circuit, such as divider, comparator, basic R-S trigger, discharge tube, buffer and so on. It is a complex circuit and a hybrid composed of analog and digital circuit.

Introduction to 555 chip pins



As shown in the picture, the 555 integrated circuit is dual in-line with 8 pins package. Thereinto:

Pin 6 is the **THRESHOLD** for the input of upper comparator;

Pin 2 is **TRIGGER** for the input of lower comparator;

Pin 3 is the **OUTPUT** having two states of 0 and 1 decided by the input electrical level;

Pin 7, the **DISCHARGE** which has two states of suspension and ground connection also decided by input, is the output of the internal discharge tube;

Pin 4 is the **RESET** that outputs low level when supplied low voltage level;

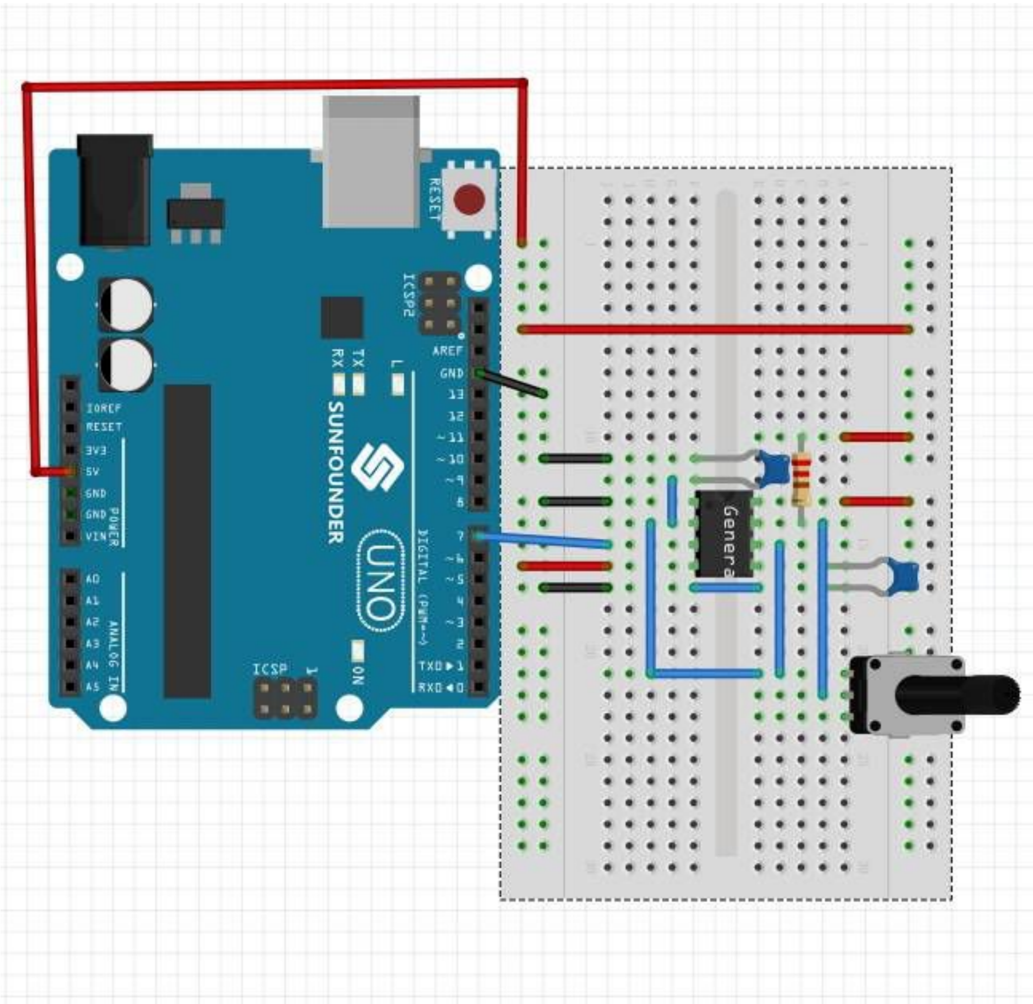
Pin 5 is the **CONTROL VOLTAGE** that can change the upper and lower level trigger value;

Pin 8 (**Vcc**) is the power supply;

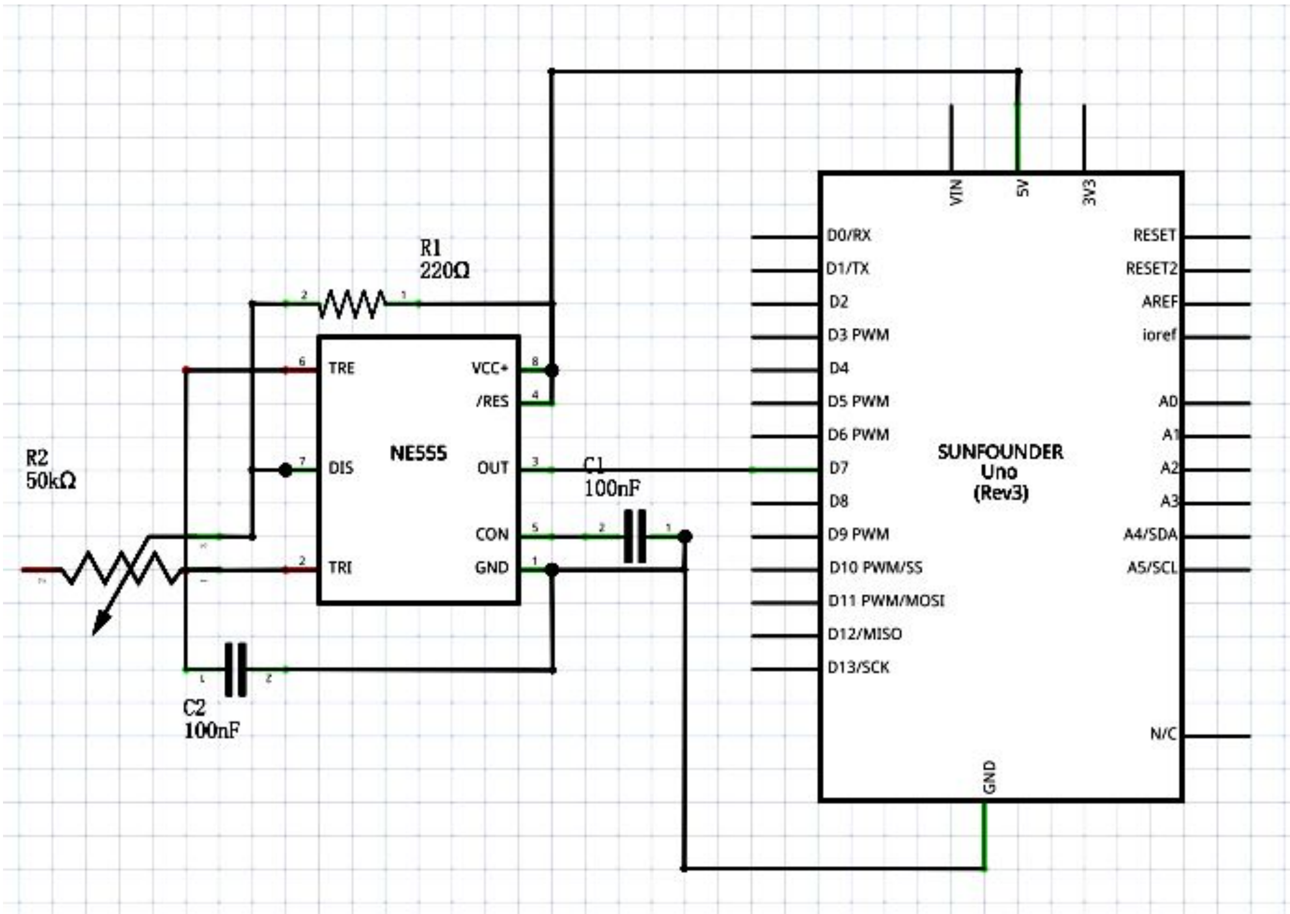
Pin 1(**GND**) is the ground.

Experimental Procedures

Step 1: Connect the circuit as shown in the following diagram

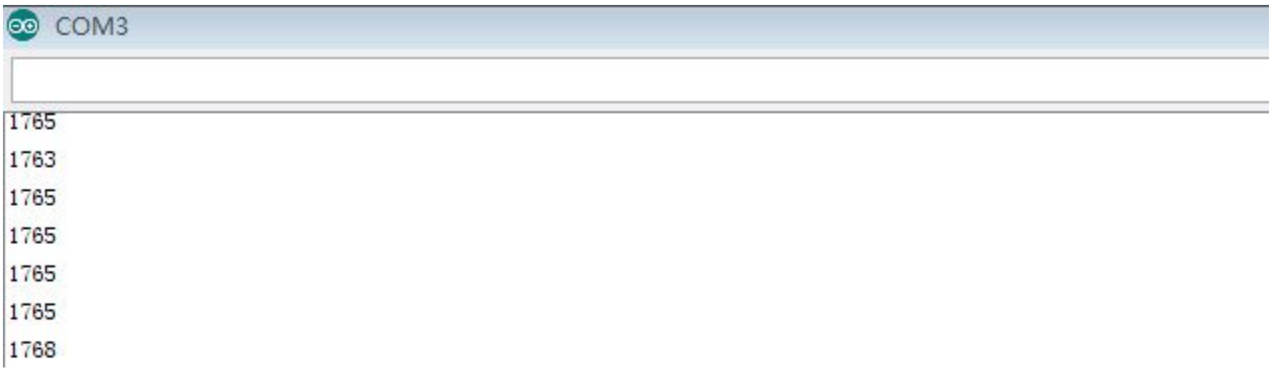


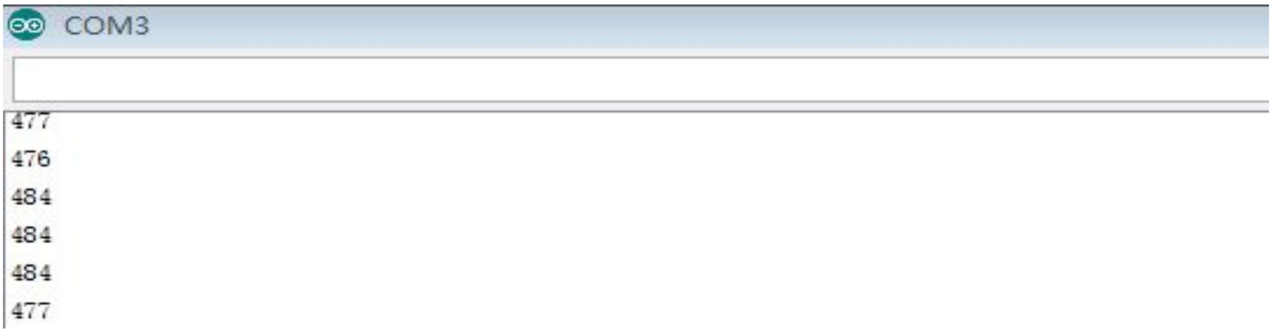
The corresponding schematic diagram is shown as follow

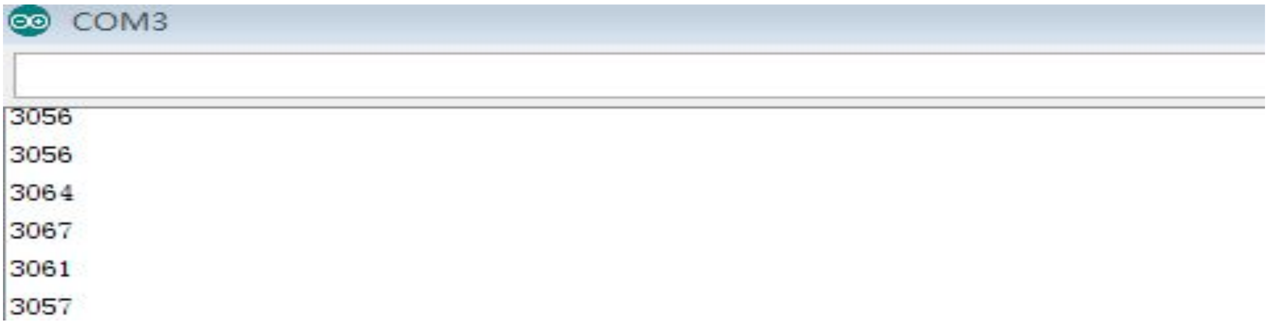


Step 2: Compile a program
Step 3: Debug and compile the program
Step 4: Burn the compiled program into SUNFOUNDER UNO control board

After burning the program, open the serial monitor and you will see the picture shown below. Rotate the potentiometer and the length of the pulse (in microseconds) displayed will change accordingly.







Experimental Summary

In this experiment, we have learnt the usage of NE555. Please try to modify the code and print the frequency values you have measured on your LCD1602.

Lesson 14 Rotary Encoder

Introduction

In this experiment, we will learn how to use rotary encoders. A rotary encoder is an electro-mechanical device that converts the angular position or motion of a shaft or axle to an analog or digital code. Rotary encoders are usually placed at the side which is perpendicular to the shaft. Rotary encoders act as sensors for detecting angle, speed, length, position and acceleration in automation field.

Components

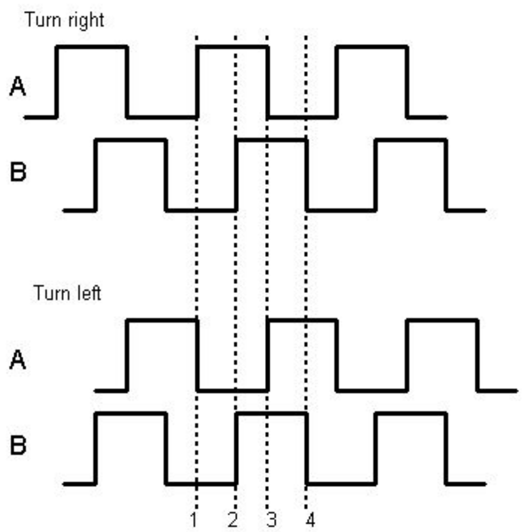
- SUNFOUNDER UNO board*1
- Breadboard *1
- Rotary encoder module*1
- Several connecting wires

Principle

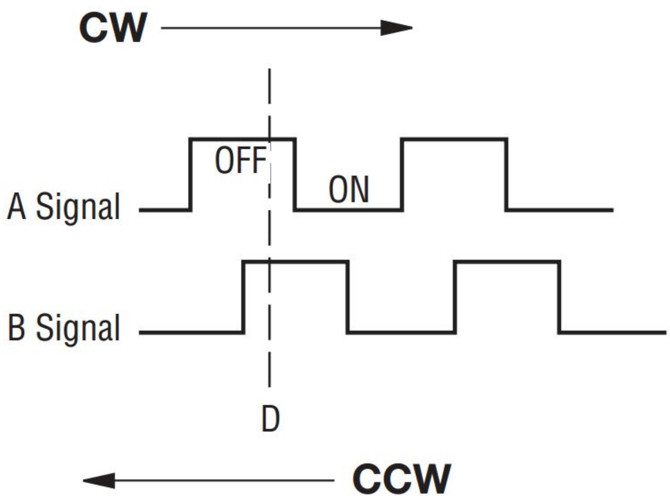
There are two main types of rotary encoder: absolute and incremental (relative). The output of absolute encoders indicates the current position of the shaft, making them angle transducers. The output of incremental encoders provides information about the motion of the shaft, which is typically further processed elsewhere into information such as speed, distance, and position.

In this experiment, we will use the latter.

An incremental encoder is a rotary sensor to turn rotational displacement into a series of digital pulse signals which are then used to control the angular displacement. It generates two-phase square waves whose phase difference is 90° . Usually the two-phase square waves are called channel A and channel B as shown below:



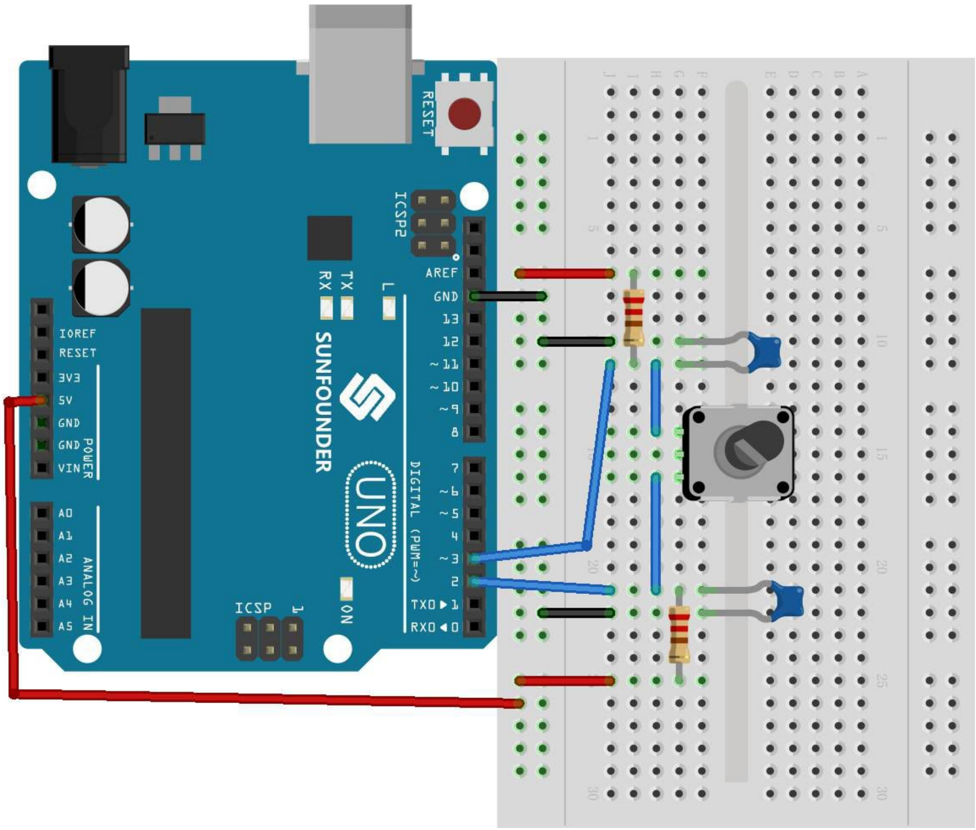
It is difficult to distinguish left turn and right turn during SCM programming. However, when using oscilloscope to observe left turn and right turn of a switch, you will find a phase difference exists between the signals of the two output pins. The phase difference is shown as follows:



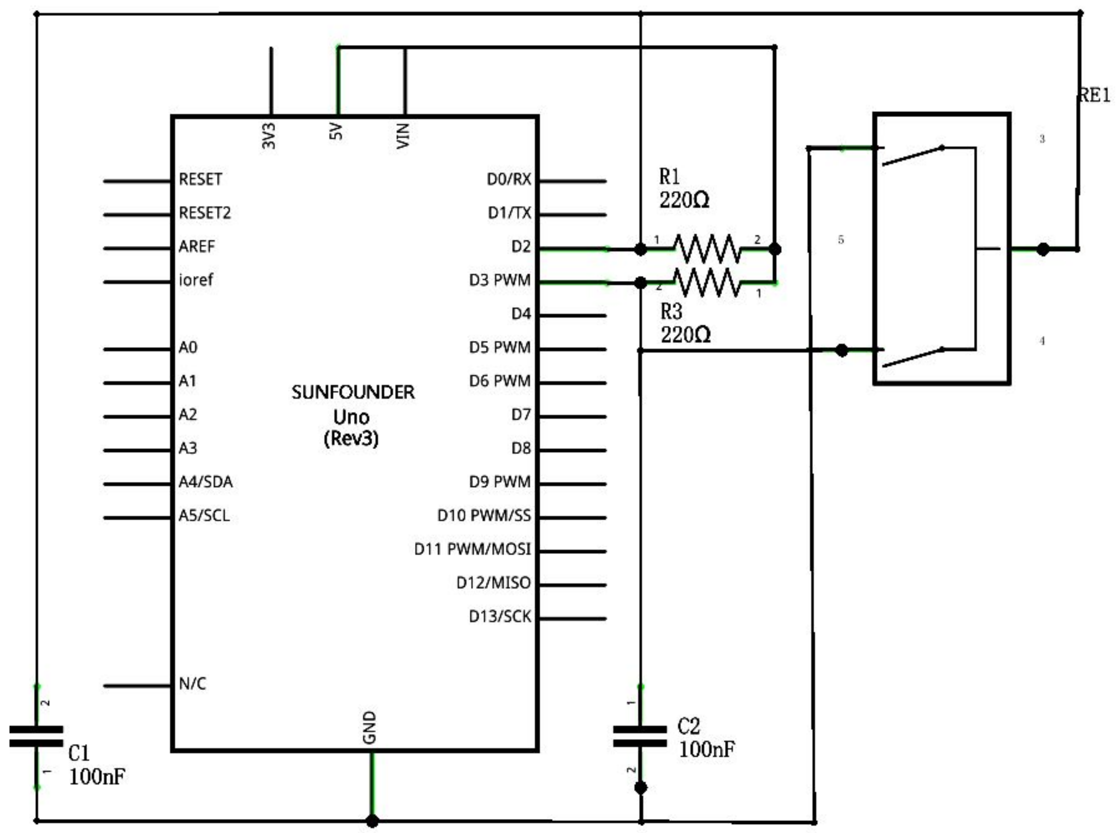
It shows that if output 1 is high and output 2 is high, then the switch rotates clockwise; if output 1 is high and output 2 is low, then the switch rotates counterclockwise. As a result, during SCM programming, if output 1 is high, then you can judge whether the rotary encoder turns left or right as long as you know the state of output 2.

Experimental Procedures

Step 1: Connect the circuit as shown in the following diagram (For convenience, we use a rotary encoder module to replace all independent components. Connect pins +5V and GND of the rotary encoder module to pins +5V and GND of SUNFOUND UNO board, pins clock and DT of the module to digital pins 2 and 3 of the board)

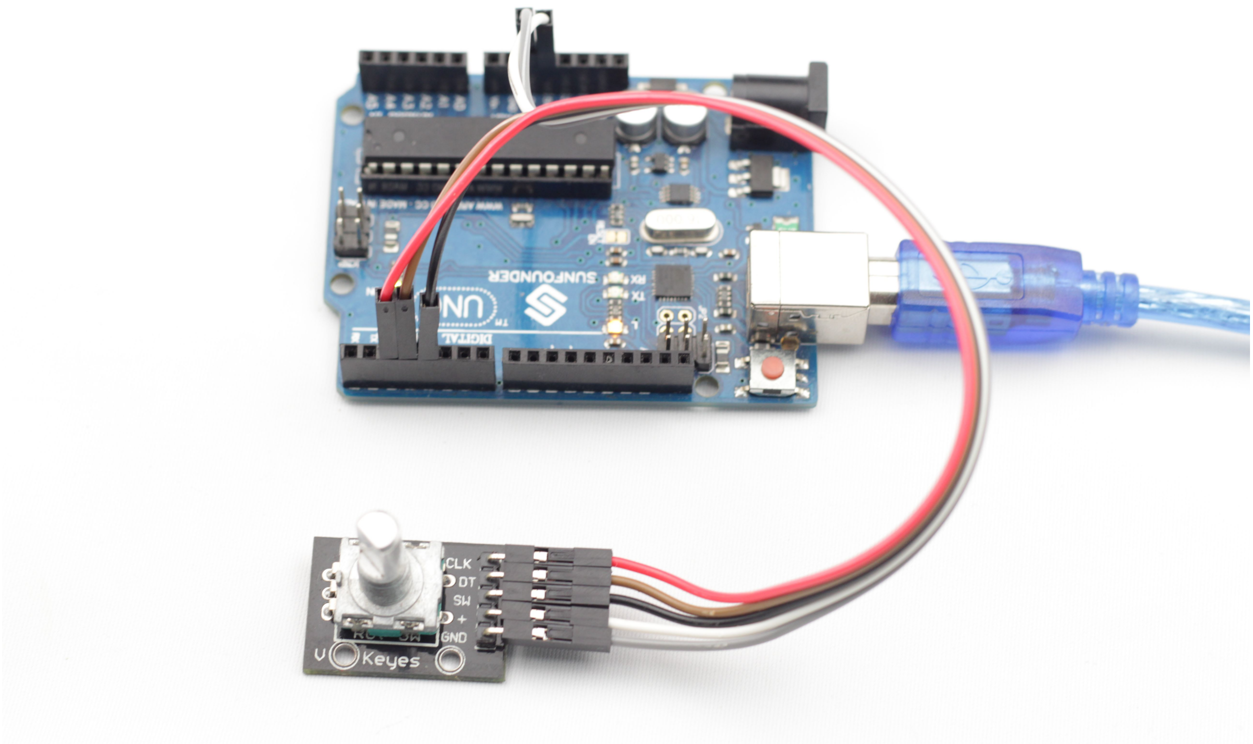


The corresponding schematic diagram is shown as follow



Step 2: Write a program
Step 3: Compile and debug the program
Step 4: Burn the compiled program into SUNFOUNDER UNO control board

Now, you will see the angular displacement of rotary encoder printed on the serial monitor of the computer. When the rotary encoder rotates clockwise, the angular displacement is increased; when counterclockwise, decreased; if you press the switch on the rotary encoder, related readings will return to zero.



Experimental Summary

We have learnt the basic usage of rotary encoders through this experiment. Please try to modify the routine we provided to print the displayed data on LCD1602.

Lesson 15 ADXL335

Introduction

In this experiment we will learn how to use the ADXL335. The ADXL335 is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. The product measures acceleration with a minimum full-scale range of ±3 *g*. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration.

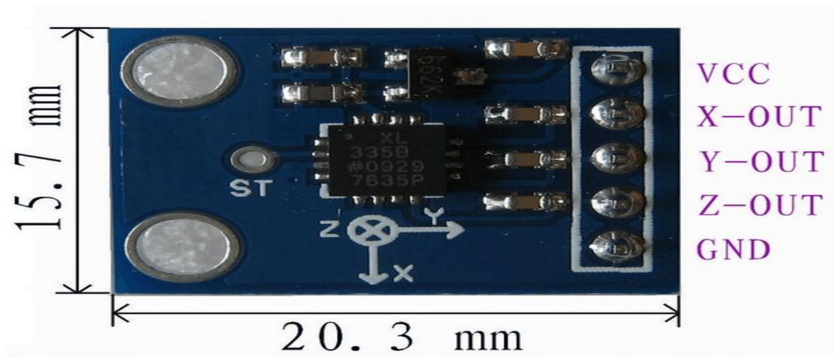
Components

- SUNFOUNDER UNO board*1
- Breadboard *1
- ADXL335 module *1
- USB Data cable*1

Principle

ADXL335

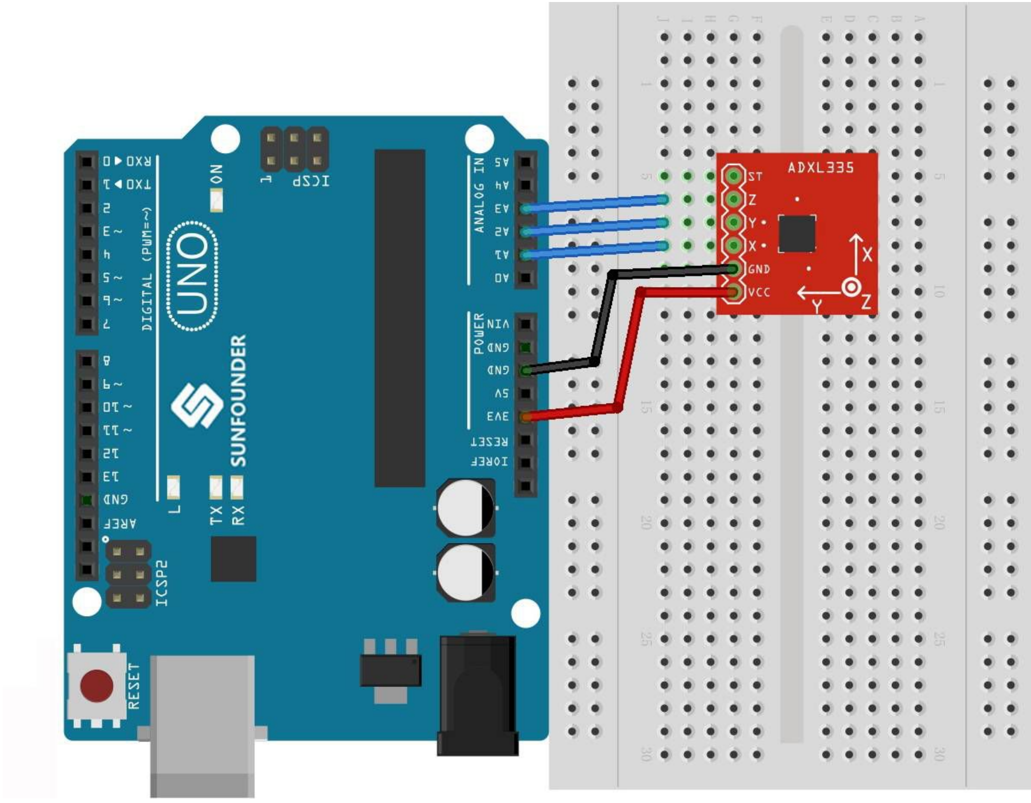
The operating voltage of ADXL335 ranges from 1.8V to 3.6V. The ADXL335 uses 5×5×2 mm LCC package when ambient temperature ranges from -55℃ to 125℃. This product features in lightness, and the size of PCB module is only 16mm×20mm, as shown in the following picture. It is quite convenient for embedding hardware of engineering projects. ADXL335 can obtain power from the analog port A0 and A4 of the SUNFOUNDER UNO board. But for convenience, we directly supply 3.3V voltage of the SUNFOUNDER UNO board to the ADXL335. Hereby we specially remind that do not use the 5V voltage of the SUNFOUNDER UNO board to supply power for the ADXL335.



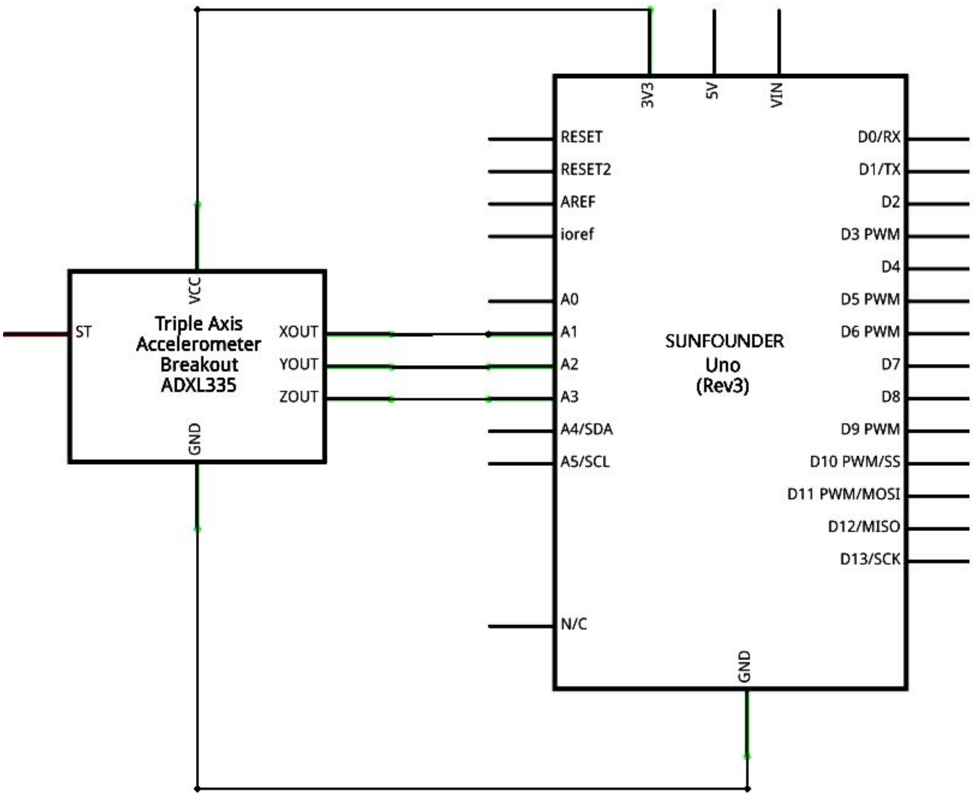
What the ADXL335 outputs are analog voltage values; therefore, what we need to do is collect output voltage values when programming. Of course you also need to perform some engineering projects. If you want to test accurate figures, you need to edit some more code according to relevant data manuals.

Experimental Procedures

Step 1: Connect the circuit as shown in the following diagram



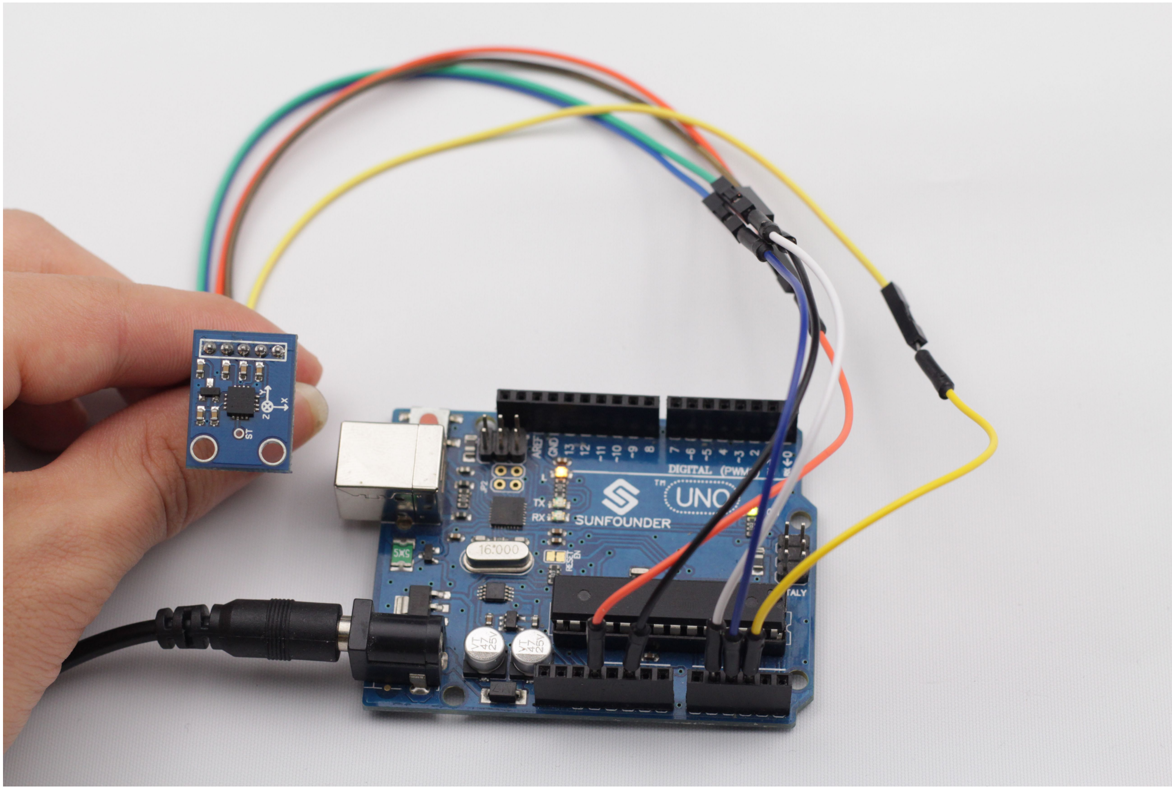
The corresponding schematic diagram is shown as follow



Step 2: Write a program

Step 3: Debug and compile the program
Step 4: Burn the compiled program into SUNFOUNDER UNO control board

After burning the program, open the serial monitor debugging window, then you can see the data we detected being displayed on the window. When the acceleration varies, the figure will vary accordingly.



Experimental Summary

We have learnt the basic usage of ADXL335 through this experiment. If you want your ADXL335 becoming more interesting, please try to modify the code.

Lesson 16 Simple Creation – Light Alarm

Introduction

We will conduct an interesting experiment this time – DIY photistor. This so-called DIY photistor use the principle of glow effect and photoelectric effect of LEDs. That is, LEDs will generate weak currents when being shined by light rays. We use a transistor to amplify the currents and trigger the SUNFOUNDER UNO board to detect them.

Components

- SUNFOUNDER UNO control board*1
- Breadboard *1
- USB data cable*1
- Several jumper wires
- Passive buzzer *1
- 10K Ohm resistor*1
- LED *1
- NPN Transistor S8050 *1

Principle

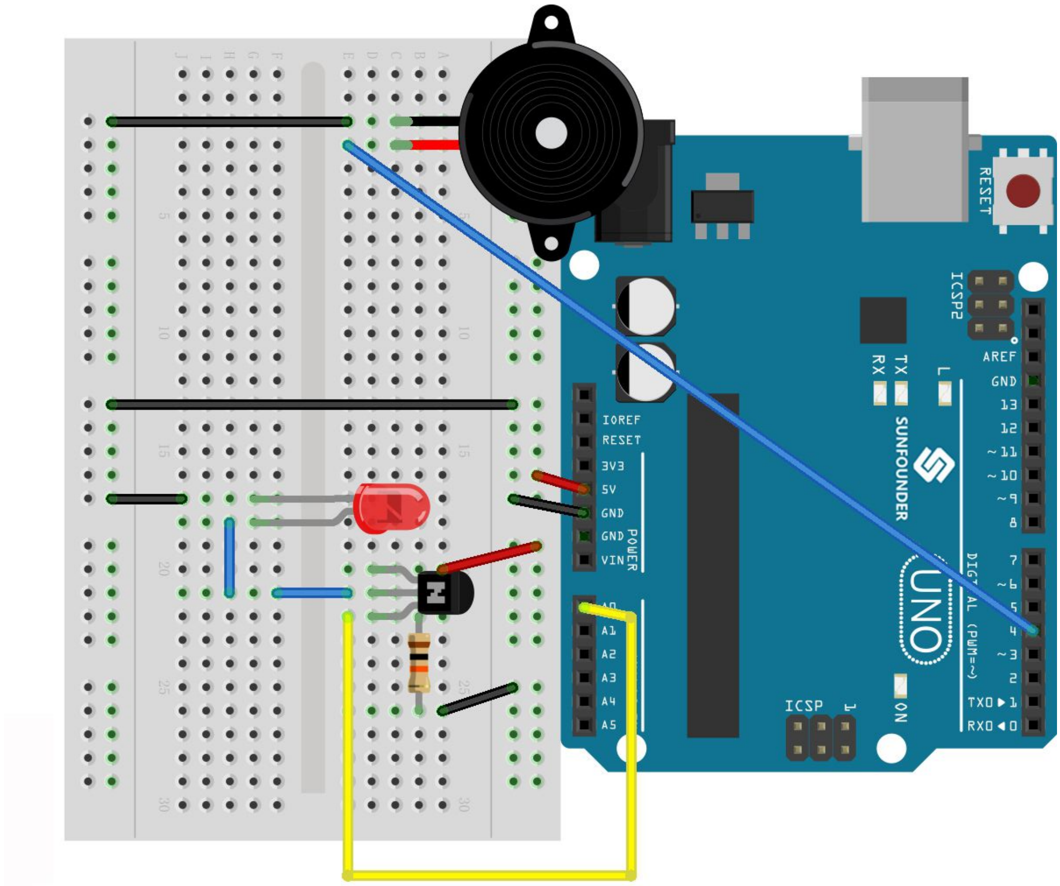
LEDs have not only glow effect but also photoelectric effect. They will generate weak currents when being shined by light rays.

Transistors (NPN type) are easy to use (the semicircle, flat side placed upwards, and the pins side placed downwards). The left pin is attached to power source, the middle pin is trigger electrode, and the right pin is output. This is a bit like a switch. If only the middle pin has weak trigger currents, they would flow from left to right of the LED like a switch being opened.

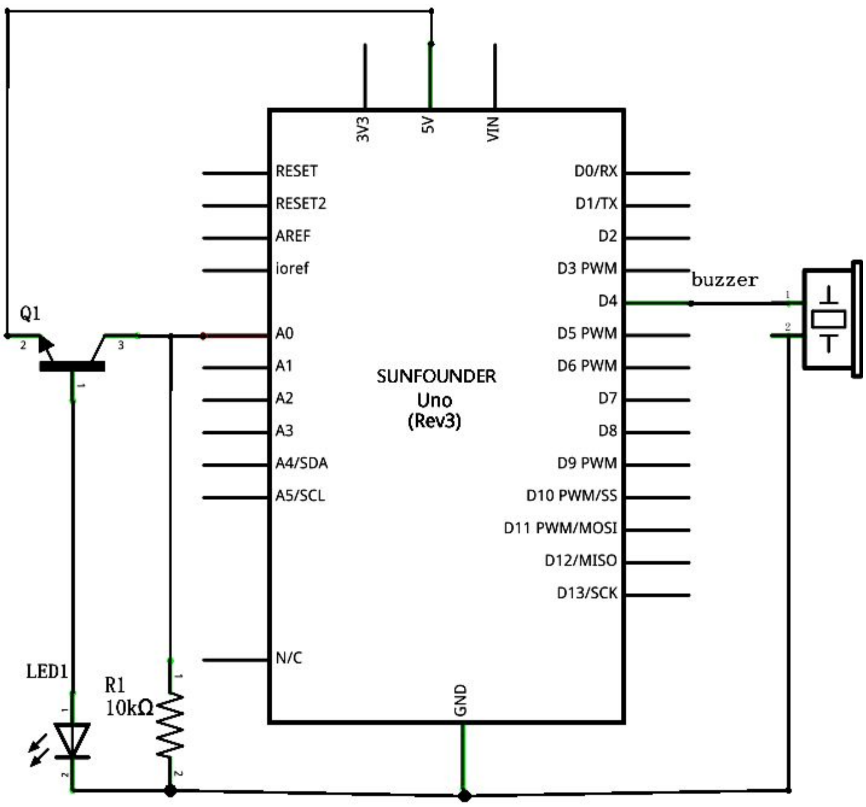
A 10K Ohm pull-down resistor is attached to the transistor output stage in order to avoid analog port suspending to interfere with signals and cause misjudgment.

Experimental Procedures

Step 1: Connect the circuit as shown in the following diagram

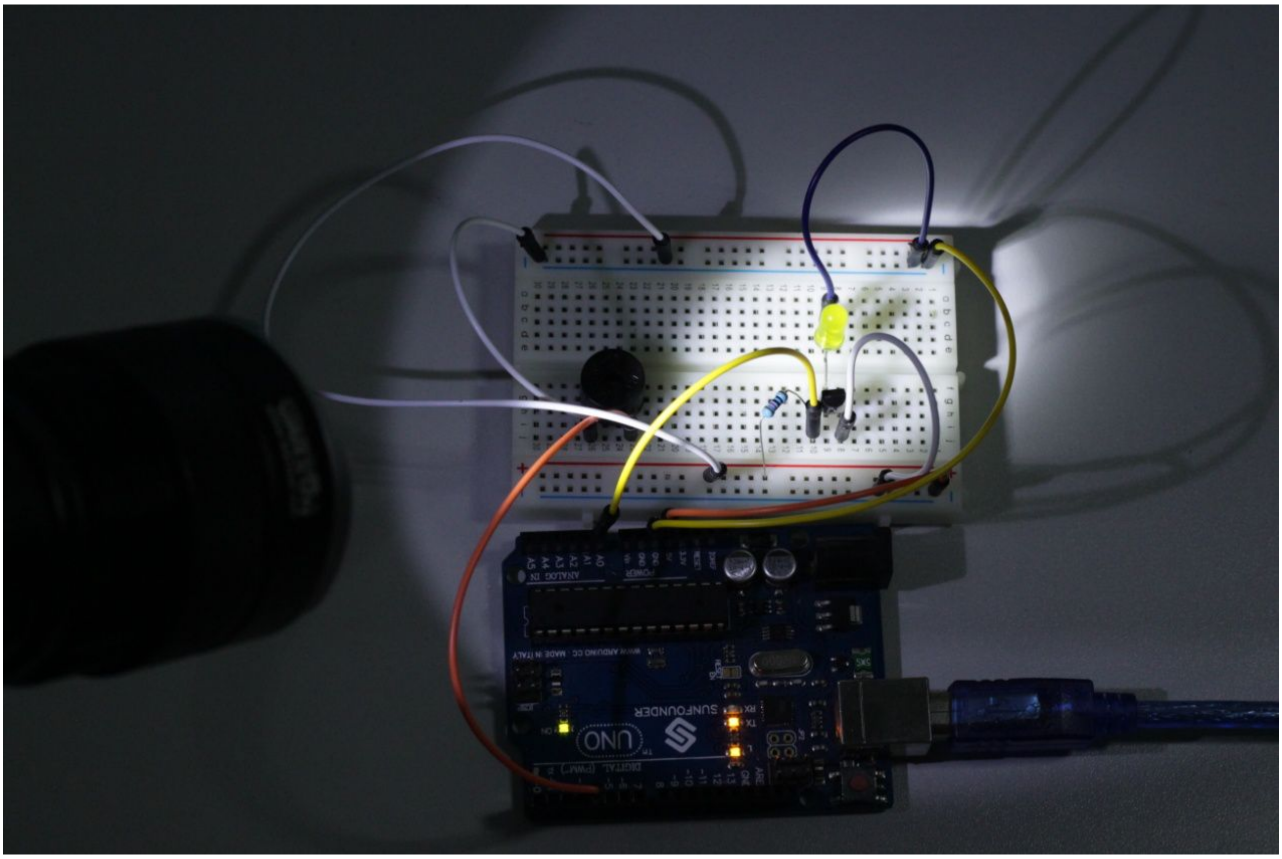


The corresponding schematic diagram is as follow



Step 2: Write a program
Step 3: Compile the program
Step 4: Burn the compiled program into SUNFOUNDER control board

Now, you can hear that the buzzer make sounds when the LED is shined.



Experimental Summary

Through this experiment, we have had a basic understanding about analog circuits. We can also create many interesting interactive works by combining analog circuit and a SUNFOUNDER UNO board together. Here is just a beginning.

Lesson 17 Simple Creation – Traffic Light

Introduction

We will conduct an experiment about traffic lights this time. The model of traffic lights here is ideal. But it has the same logic with real traffic lights controller. Rotating a rotary encoder will change the frequency of a traffic light being turned on sequentially.

Components

– SUNFOUNDER control board*1

– Breadboard*1

–USB data cable*1

– Several jumper wires

– Rotary Encoder*1

– 10K Ohm resistor*2

– LED*3

– 220 Ohm resistor*3

– 104 ceramic capacitor*2

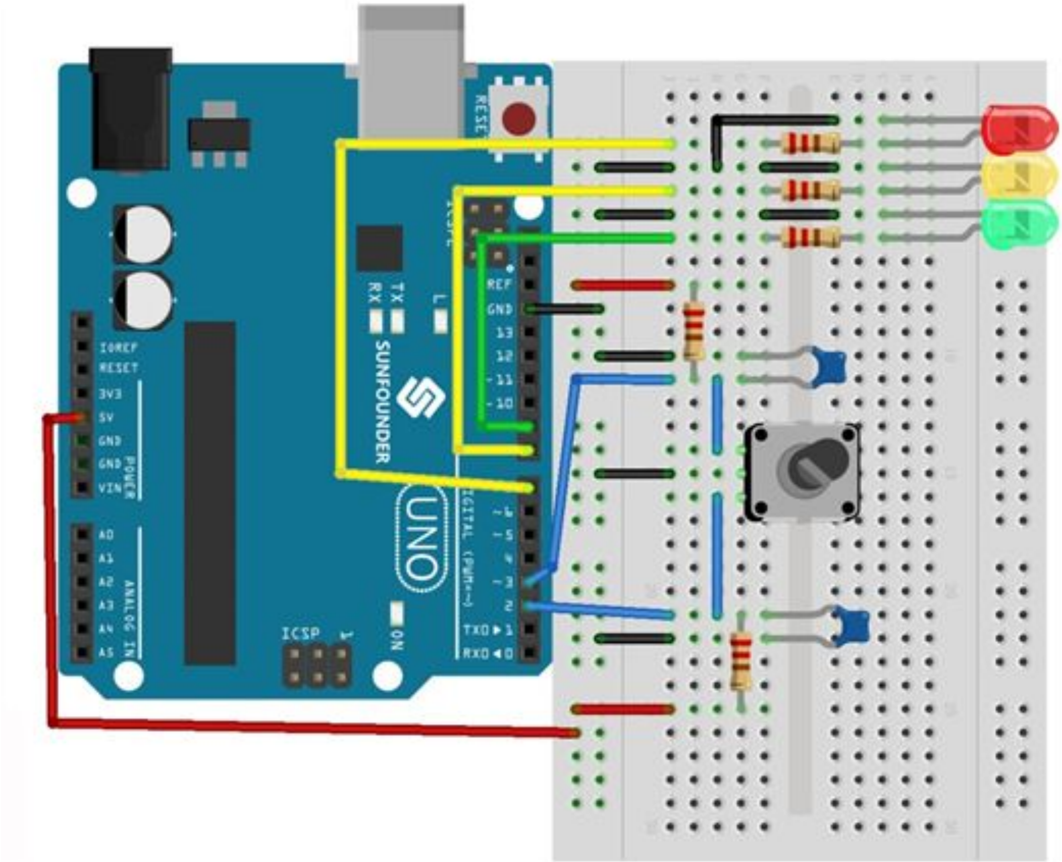
Principle

In real traffic, the time length for displaying red and green is much longer than the yellow for traffic lights. As a result, we define two cycles with a program: short cycle and long cycle. In a short cycle, a traffic light change its orders at a rate of roughly once per second. While the long cycle changed by a rotary encoder determines the time length of red light and green light.

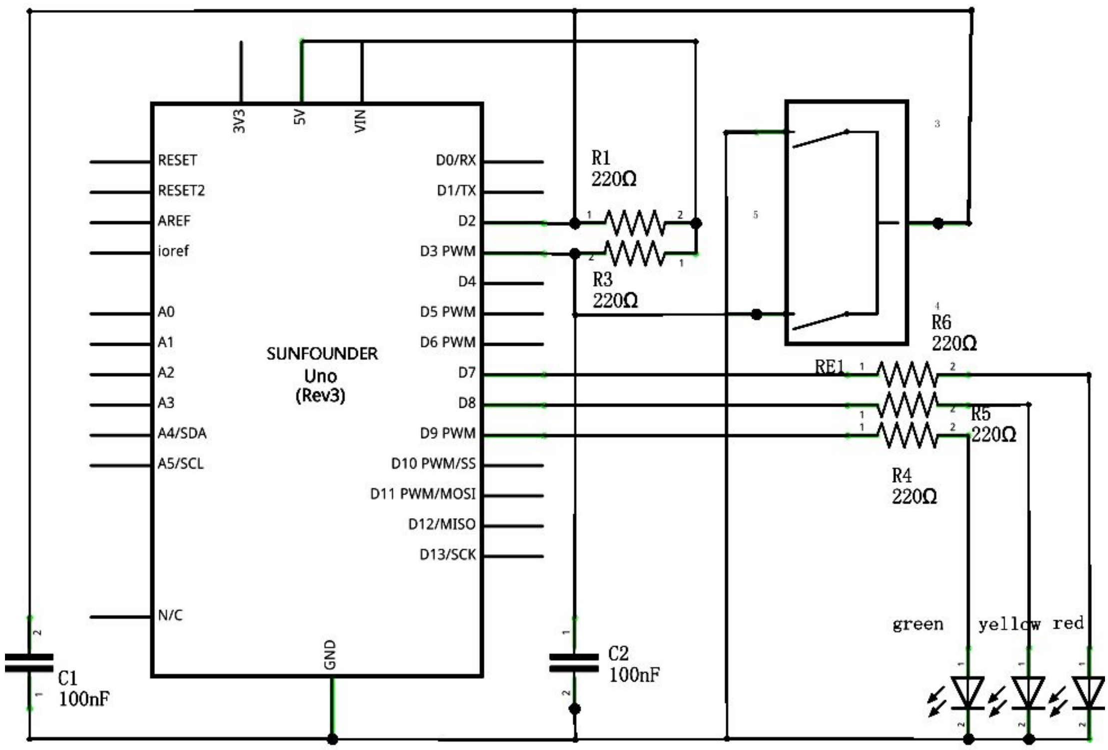
A pull-up resistor and a 104 ceramic capacitor must be connected to Pin A and pin B of the rotary encoder to avoid interferences.

Experimental Procedures

Step 1: Connect the circuit as shown in the following diagram

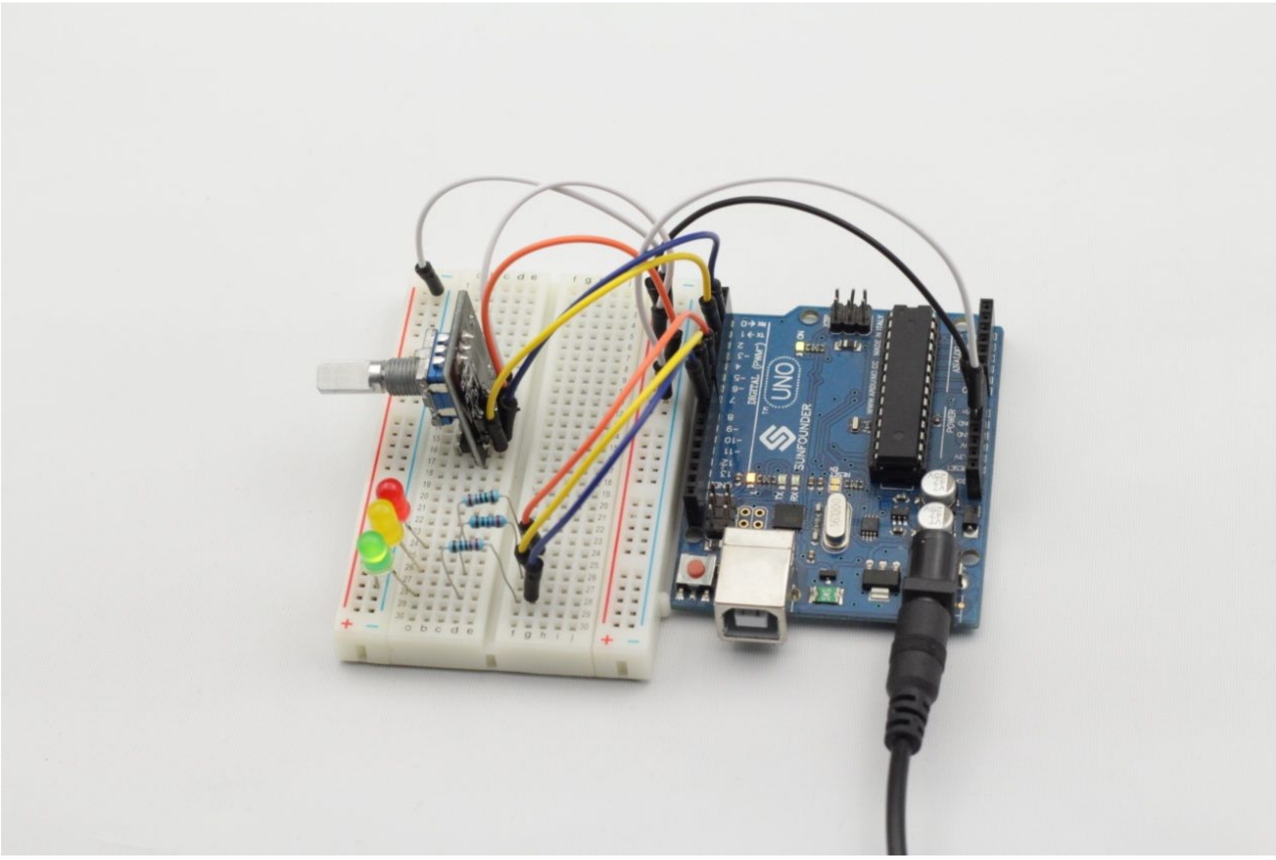


The corresponding schematic diagram is as follow



Step 2: Write a program
Step 3: Compile the program
Step 4: Burn the compiled program into SUNFOUNDER control board

Now, you can see the red LED light up first, then the red LED and yellow LED light up, then the green LED light up ,finally the yellow LED light up.



Experimental Summary

Through this experiment, we have learnt the combination usage of rotary encoder and LEDs. I believe you should have had a deeper understanding about rotary encoders.

Lesson 18 Simple Creation – Digital Dice

Introduction

In previous experiment, we have done experiments about single 7-segment display and controlling LED by button. Through these experiments, I believe you have learnt the basic usage of the two components. So this time we will combine a 7-segment display and a button together to create a simple digital dice.

Components

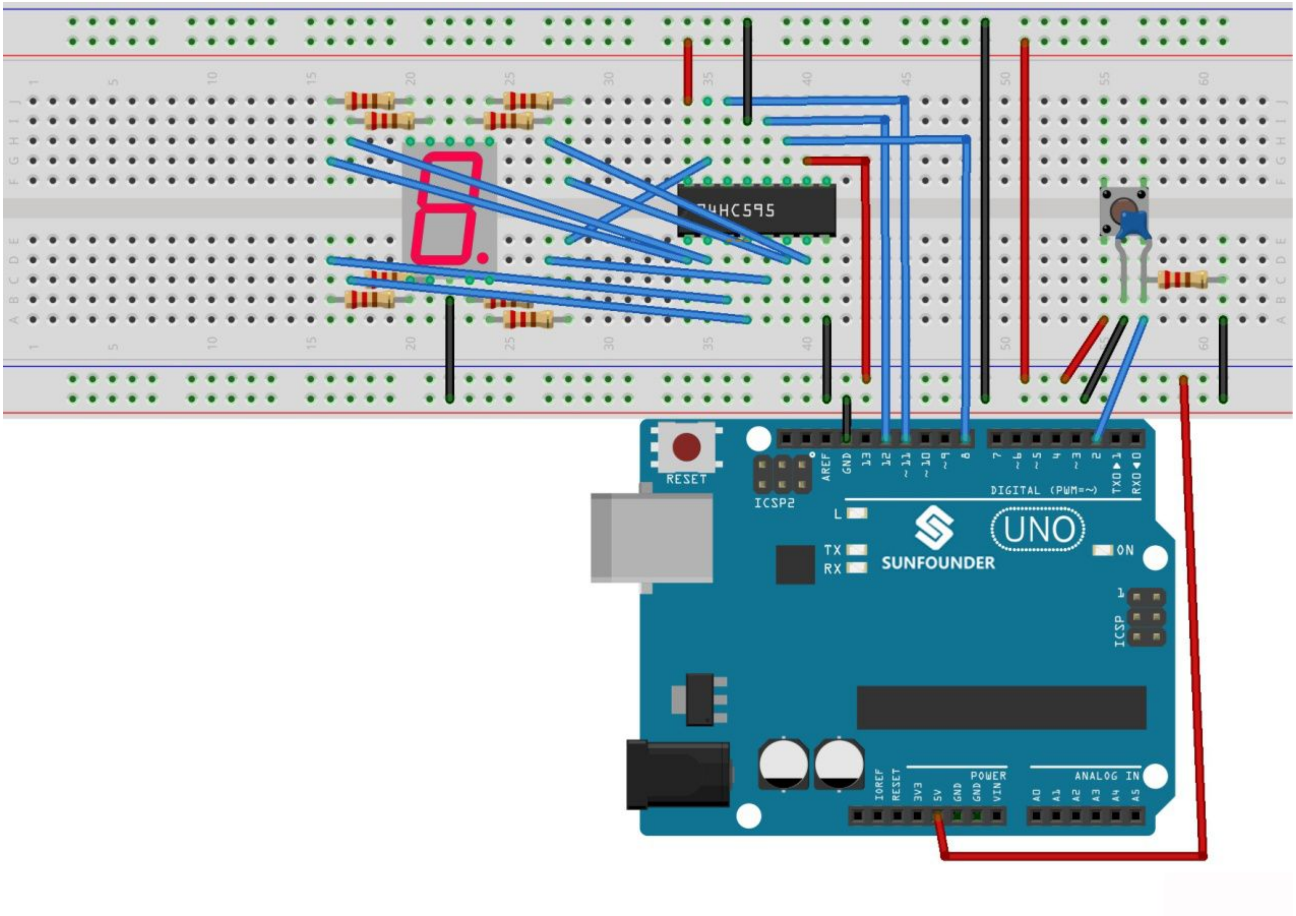
- SUNFOUNDER control board*1
- Breadboard *1
- USB data cable*1
- Several jumper wires
- Button*1
- 10K Ohm resistor*1
- 220 Ohm resistor*8
- Seven-segment display*1
- 104 ceramic capacitor*1

Principle

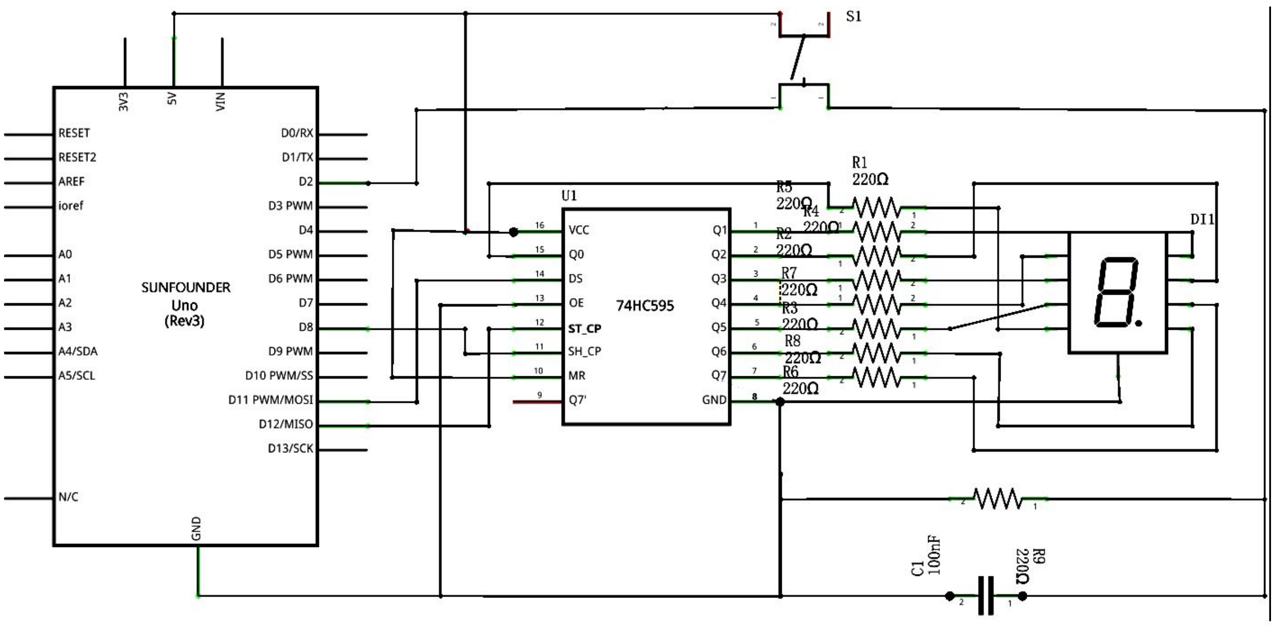
The principle of a digital dice is very simple. That is, a single 7-segment display circularly jumps from 1 to 6 quickly. When the button is pressed, the 7-segment display jumping will slow down and stop at a certain number three seconds later, no longer jumping. When the button is pressed again after stopping, the above process will be repeated again.

Experimental Procedures

Step 1: Connect the circuit as shown in the following diagram



The corresponding schematic diagram is shown as follow

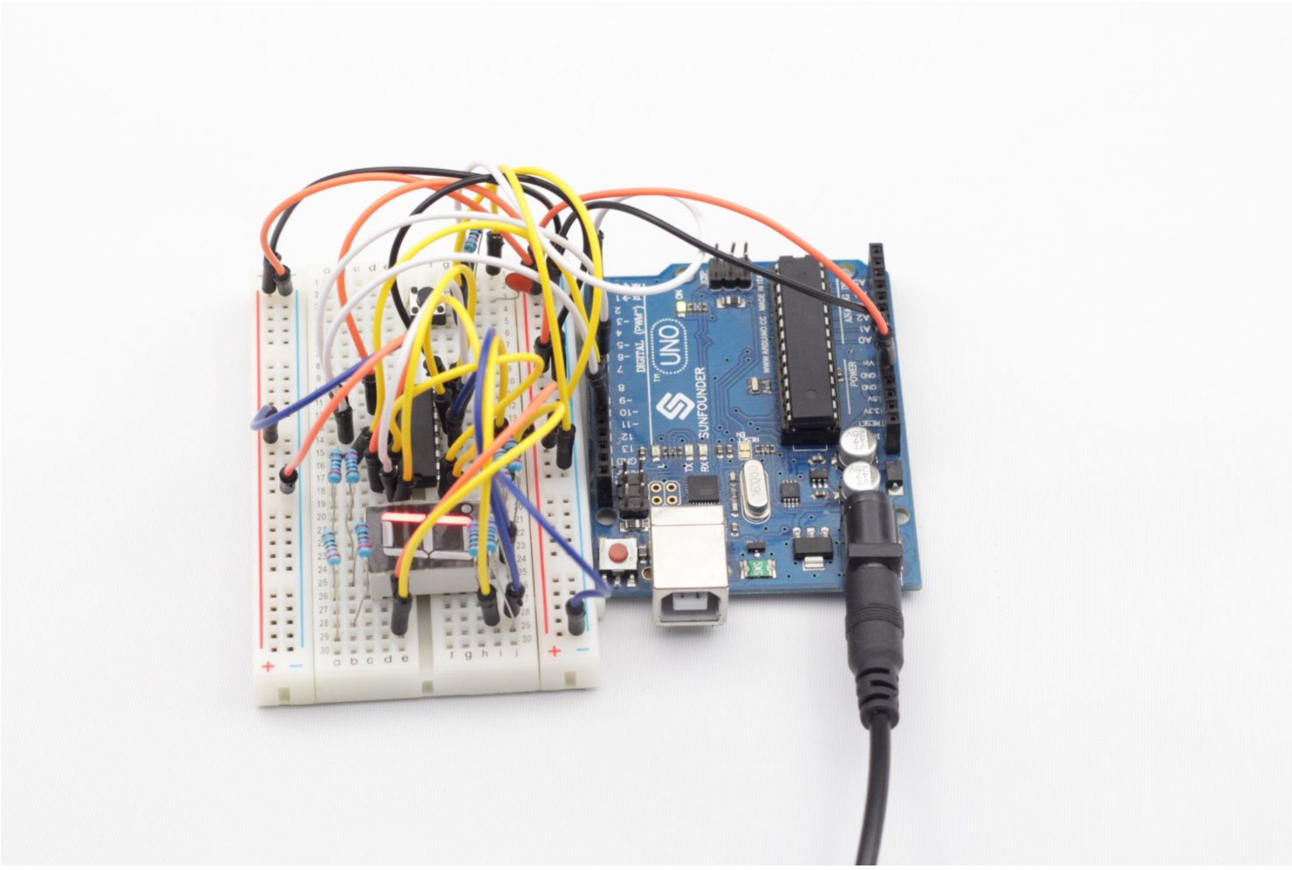


Step 2: Write a program

Step 3: Compile the program

Step 4: Burn the compiled program into SUNFOUNDER control board

Now, you can see the single 7-segment display circularly jumps from 1 to 6 quickly. When the button is pressed, the 7-segment display jumping will slow down and stop at a certain number three seconds later, no longer jumping. When the button is pressed again after stopping, the above process will be repeated again.



Experimental Summary

Through this experiment, we have learnt the combination usage of a 7-segment display and a button. Of course we can also create many funny things by using the button as an input device and the 7-segment display as a display device.

Lesson 19 Simple Creation – Small Fan

Introduction

In this experiment, we will combine a button and a motor to assemble a simple small fan. We can shift the rotational speed of the small fan by pressing the button. Let us just call it gear selection (3 gears available). The experiment is very practical.

Components

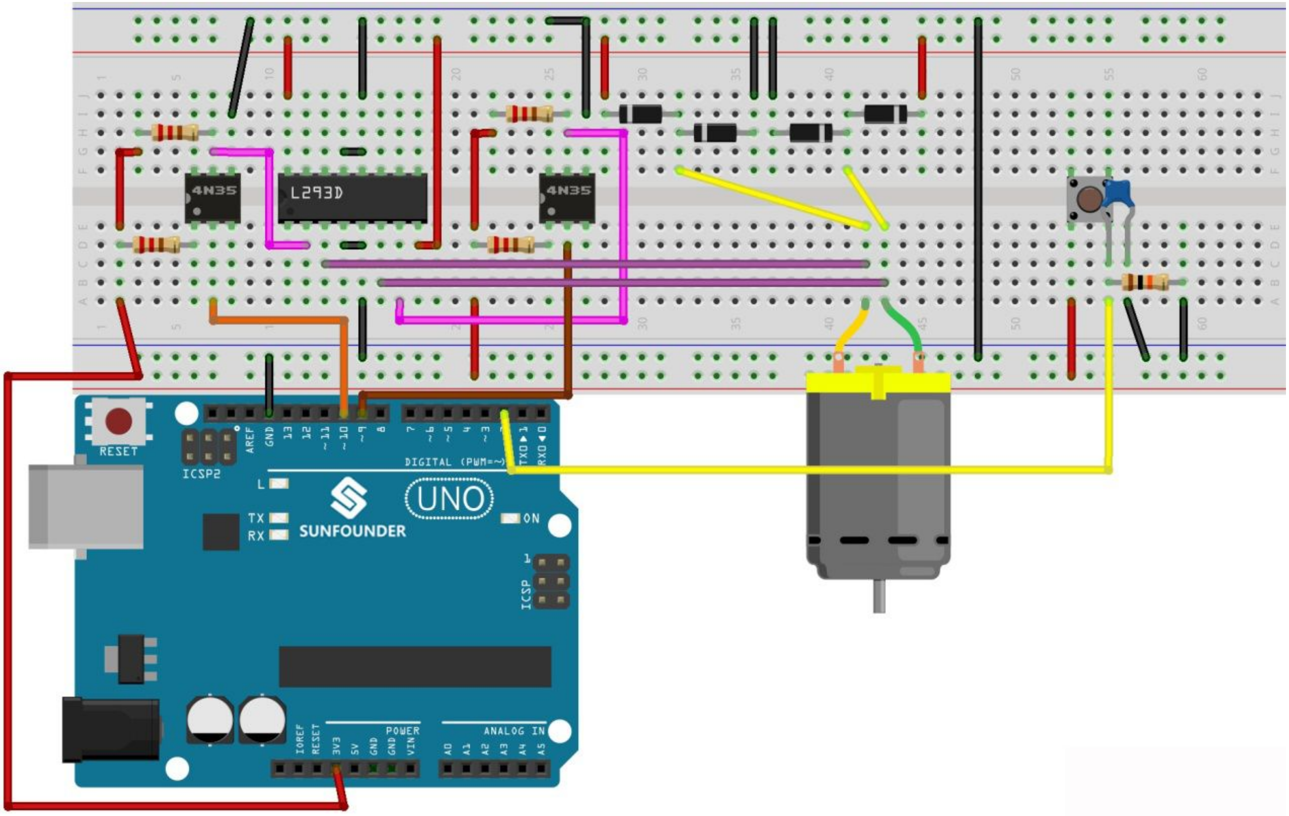
- SUNFOUNDER control board*1
- Breadboard *1
- USB data cable*1
- Several jumper wires
- DC Motor*1
- 10K Ohm resistor*1
- Button*1
- Motor diver chip L293D*1

Principle

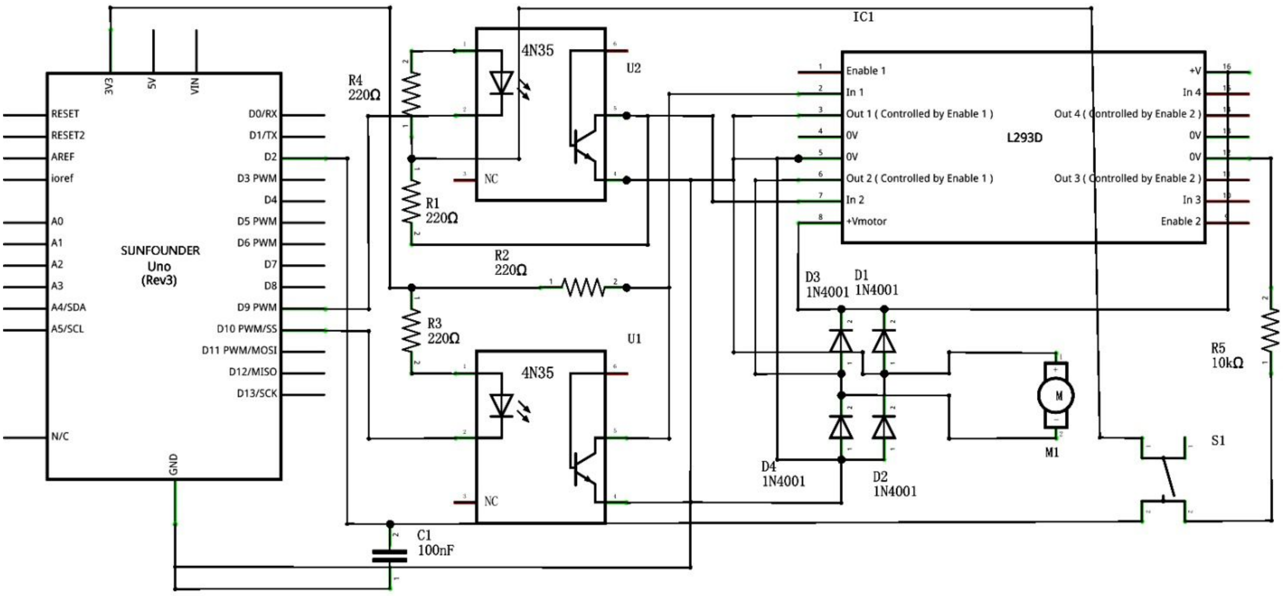
The principle of this experiment is very simple. In short, control the rotational speed of the motor by reading the times that the button is pressed. After startup, the default gear is 0, that is, the small fan will not rotate. If the button is pressed one time, the small fan will enter into gear 1 (low-speed) and rotate slowly; if the button is pressed twice, it will enter into gear 2 (medium-speed) and rotate at a medium-speed; if the button is pressed three times, it will enter into gear 3 (high-speed) and rotate rapidly. If the button is pressed four times, it will stop rotating and so forth.

Experimental Procedures

Step 1: Connect the circuit as shown in the following diagram



The corresponding schematic diagram is shown as follow

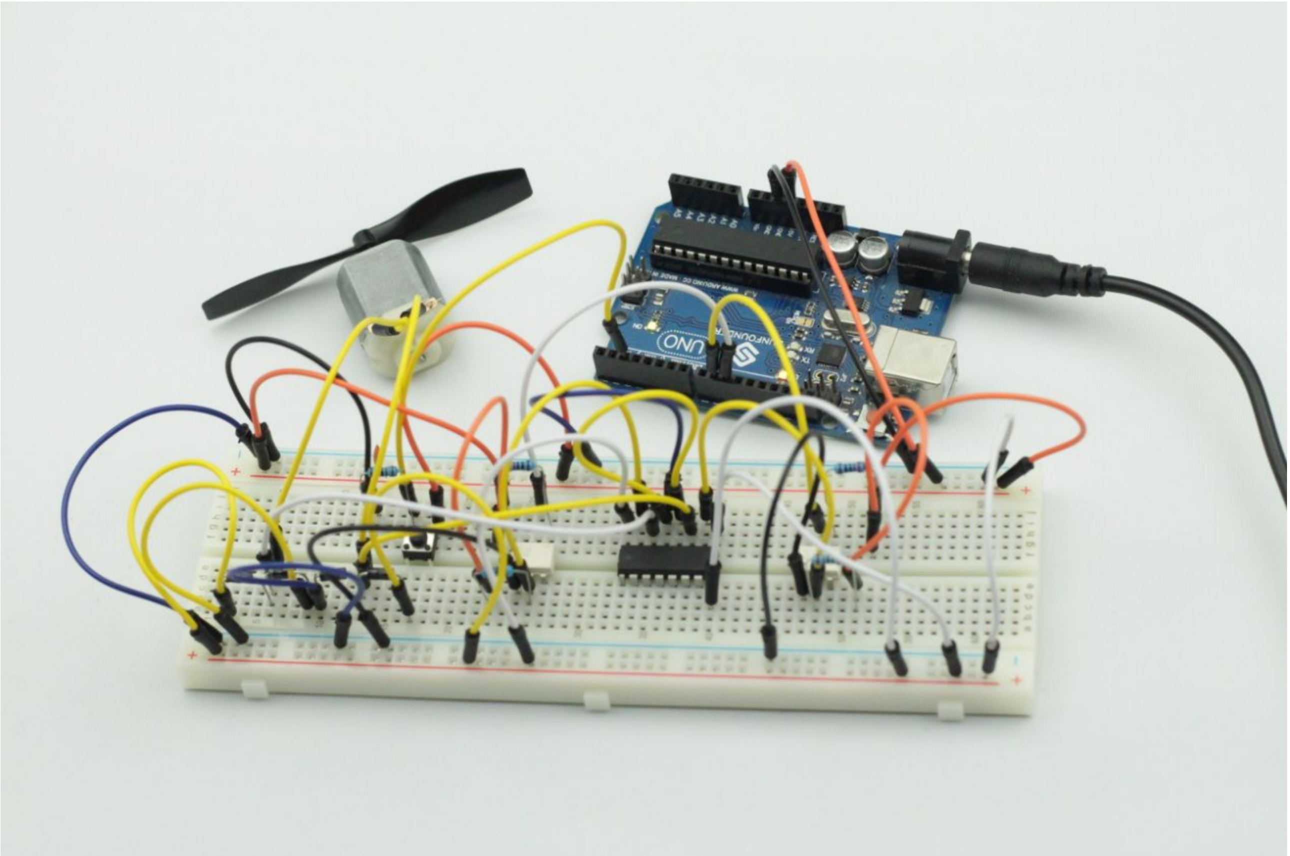


Step 2: Write a program

Step 3: Compile the program

Step 4: Burn the compiled program into SUNFOUNDER control board

Now, if you press the button one time, the small fan will rotate slowly; if you press the button twice, it will rotate at a medium-speed; if you press the button three times, it will rotate rapidly; if you press the button four times, it will stop rotating and so forth.



Experimental Summary

Through this experiment, we have learnt the usage of motors in depth. I hope you can create more funny interactive works by yourselves.