Preface

About SunFounder

SunFounder is a company focused on STEAM education with products like open source robots, development boards, STEAM kit, modules, tools and other smart devices distributed globally. In SunFounder, we strive to help elementary and middle school students as well as hobbyists, through STEAM education, strengthen their hands-on practices and problem-solving abilities. In this way, we hope to disseminate knowledge and provide skill training in a full-of-joy way, thus fostering your interest in programming and making, and exposing you to a fascinating world of science and engineering. To embrace the future of artificial intelligence, it is urgent and meaningful to learn abundant STEAM knowledge.

About Sensor Kit V2.0

This sensor kit is suitable for the Raspberry Pi model B+, 2 model B, 3 model B, 3 model B+ and 4 Model B. It includes dozens of different modules for you to learn and we provide corresponding lessons which are simple and useful for better understanding. Hope you can learn their applications quickly and use them in your own projects!

In this book, we will show you circuits with both realistic illustrations and schematic diagrams. You can go to our official website www.sunfounder.com to view the PDF user manual by clicking **Learn** -> **Raspberry Pi**.

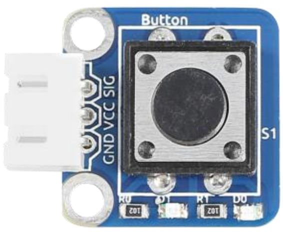
Free Support

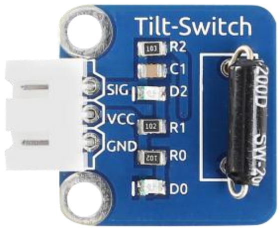
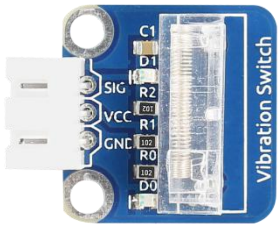
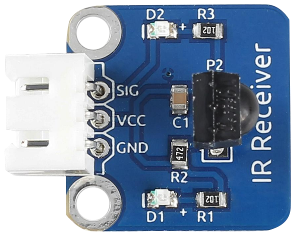
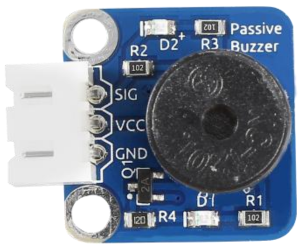
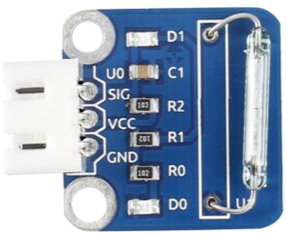
If you have any **TECHNICAL questions**, add a topic under **Community** -> **Forum** section on our website and we'll reply as soon as possible.

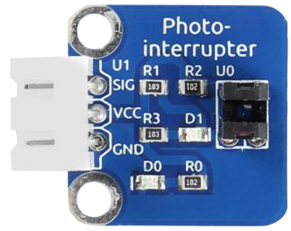
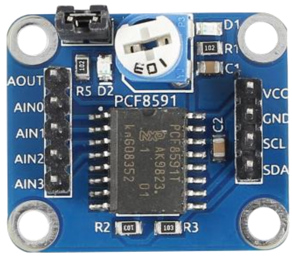
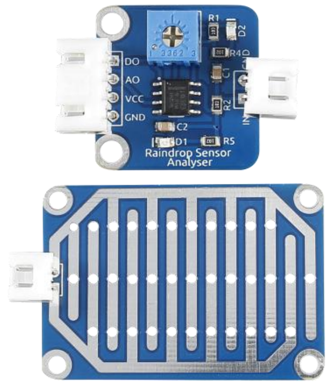
For **NON-TECH questions** like order and shipment issues, please **send an email to service@sunfounder.com**. You're also welcomed to share your projects on FORUM.

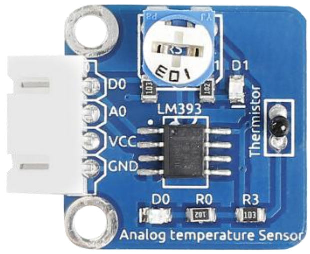
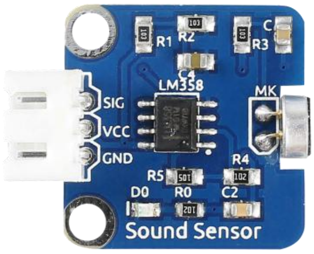
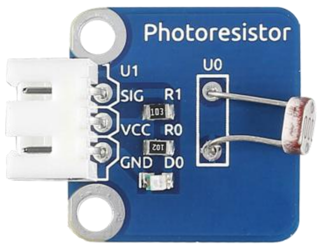
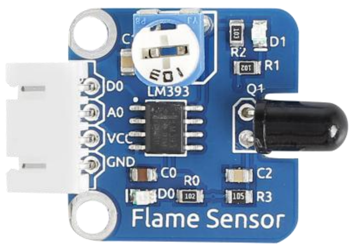
Contents

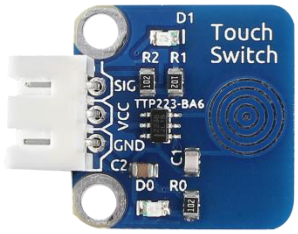
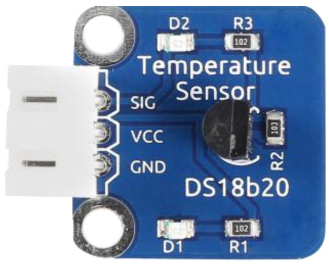
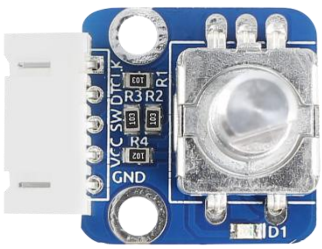
Component List

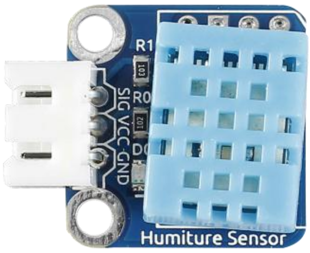
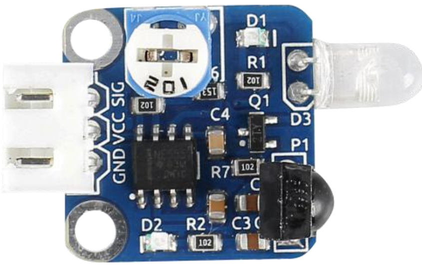
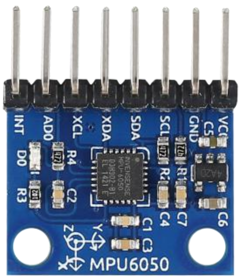
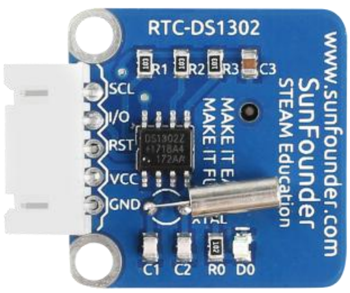
No.	Name	Qty	Component
1	Dual-Color LED	1	
2	RGB LED	1	
3	Auto Flash LED	1	
4	Relay Module	1	
5	Laser Emitter	1	
6	Button	1	

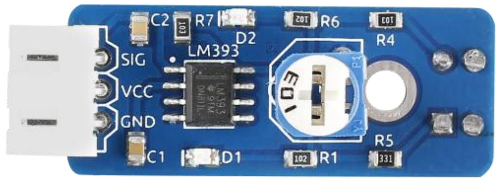
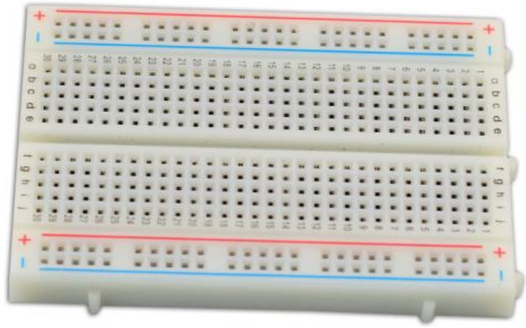
7	Tilt-Switch	1	
8	Vibration Switch	1	
9	IR Receiver	1	
10	Active Buzzer	1	
11	Passive Buzzer	1	
12	Reed Switch	1	

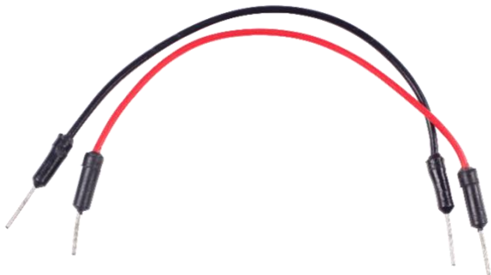
13	Photo-interrupter	1	
14	AD/DA Converter PCF8591	1	
15	Raindrop Sensor	1	
16	Joystick PS2	1	
17	Potentiometer	1	
18	Analog Hall Sensor	1	

19	Hall Switch Sensor	1	
20	Analog Temperature Sensor	1	
21	Thermistor	1	
22	Sound Sensor	1	
23	Photoresistor	1	
24	Flame Sensor	1	

25	Gas Sensor	1	
26	Remote Control	1	
27	Touch Switch	1	
28	Ultrasonic	1	
29	Temperature Sensor DS18B20	1	
30	Rotary Encoder	1	

31	Humiture Sensor	1	
32	IR Obstacle Module	1	
33	I2C LCD1602 Module	1	
34	Barometer-BMP180	1	
35	MPU6050 Module	1	
36	RTC-DS1302 Module	1	

37	Tracking Sensor	1	
38	Breadboard	1	
39	T-Cobbler	1	
40	40-pin Ribbon Cable for T-Cobbler	1	
41	2-Pin Anti-reverse Cable	2	

42	3-Pin Anti-reverse Cable	5	
43	4-Pin Anti-reverse Cable	5	
44	5-Pin Anti-reverse Cable	5	
45	Jumper wires (Male to Female)	20	
46	Jumper wires (Male to Male)	10	

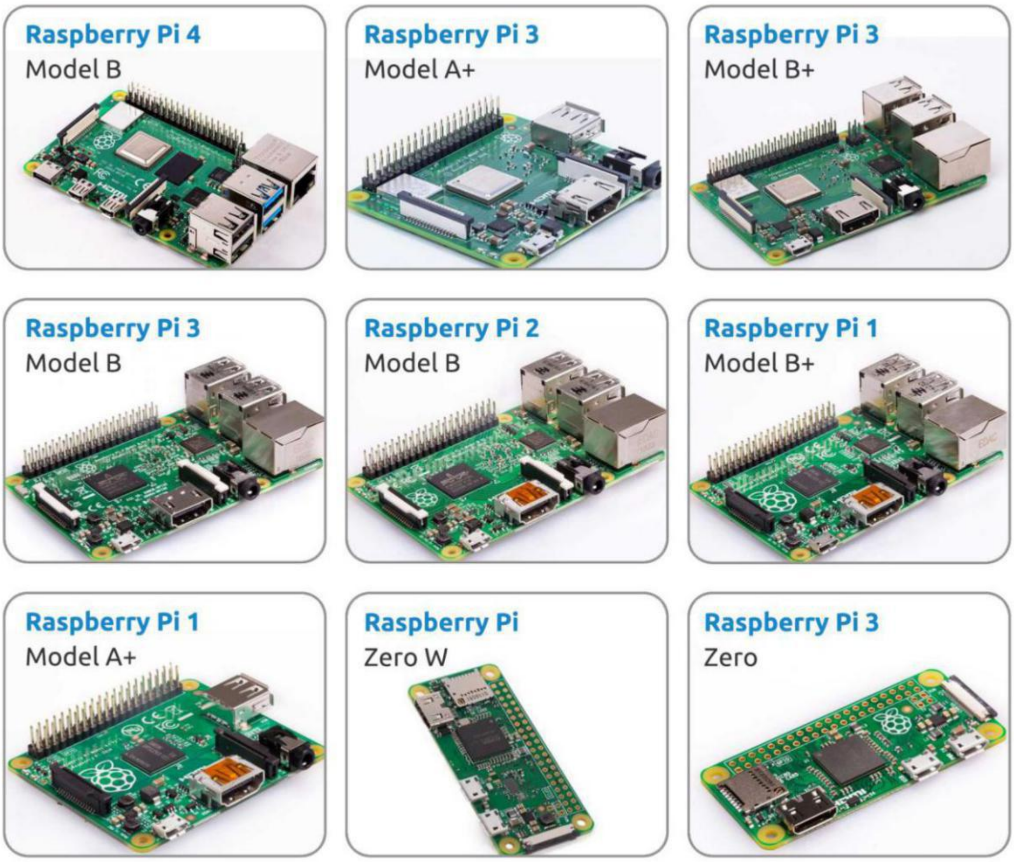
What We Need?

Required Components

Raspberry Pi

The Raspberry Pi is a low cost, credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It is a capable little device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python.

Our kit applies to the following versions of the product of Raspberry Pi :



Power Adapter

To connect to a power socket, the Raspberry Pi has a micro USB port (the same found on many mobile phones). You will need a power supply which provides at least 2.5 amps.

Micro SD Card

Your Raspberry Pi needs an SD card to store all its files and the Raspberry Pi OS. You will need a micro SD card with a capacity of at least 8 GB.

Optional Components

Screen

To view the desktop environment of Raspberry Pi, you need to use the screen that can be a TV screen or a computer monitor. If the screen has built-in speakers, the Pi plays sounds via them.

Mouse & Keyboard

When you use a screen , a USB keyboard and a USB mouse are also needed.

HDMI

The Raspberry Pi has a HDMI output port that is compatible with the HDMI ports of most modern TV and computer monitors. If your screen has only DVI or VGA ports, you will need to use the appropriate conversion line.

Case

You can put the Raspberry Pi in a case; by this means, you can protect your device.

Sound or Earphone

The Raspberry Pi is equipped with an audio port about 3.5 mm that can be used when your screen has no built-in speakers or when there is no screen operation.

Preparation

In this chapter, we firstly learn to start up Raspberry Pi.

Depending on the different devices you use, you can start up the Raspberry Pi in different methods. We have two situations: having a screen or no screen, and you can refer to relevant tutorials respectively. If your Raspberry Pi is set up, you can skip the chapter and go into the next chapter.

If You Have a Screen

If you have a screen, you can use the NOOBS (New Out Of Box System) to install the Raspberry Pi OS.

Required Components

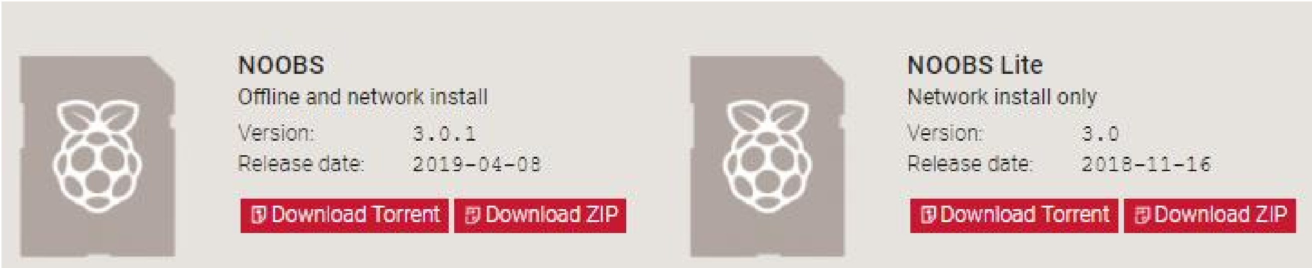
Any Raspberry Pi	1 * Power Adapter
1 * Monitor	1 * Monitor Power Adapter
1 * HDMI cable	1 * Mirco SD card
1 * Mouse	1 * Keyboard
1 * Personal Computer	

Procedures

Step 1

To download NOOBS from your PC, you can choose **NOOBS** or **NOOBS LITE -** the only difference is that there is a built-in offline Raspberry Pi OS installer in **NOOBS**, while the **NOOBS LITE** can only be operated online. Here, you are suggested to use the former.

Here is the download address of Noobs:
https://www.raspberrypi.org/downloads/noobs/



Step 2

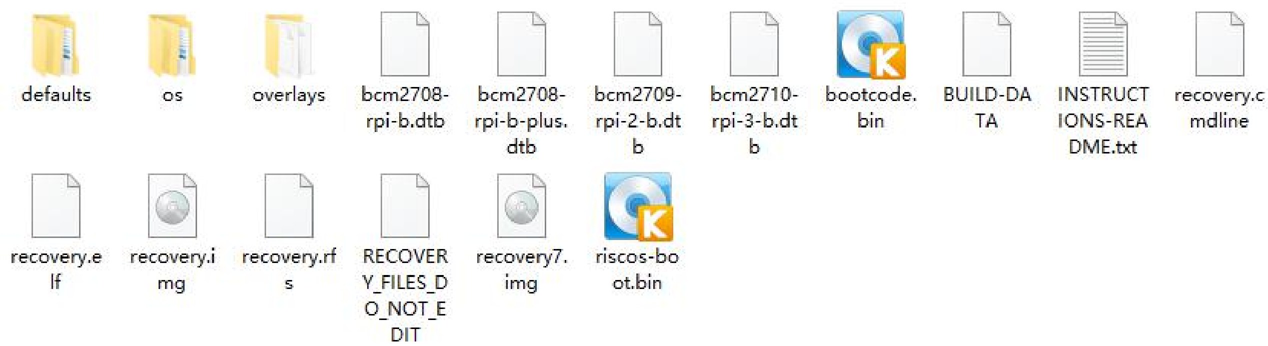
Plug in the Micro SD reader and format the Micro SD card with the SD Formatter (*https://www.sdcard.org/downloads/formatter/index.html*). If there are some important files in the Micro SD card, please backup them first.

Step 3

Next, you will need to extract the files from the NOOBS zip archive you downloaded from the Raspberry Pi website.

- Find the downloaded archive — by default, it should be in your Downloads folder.
- Double-click on it to extract the files, and keep the resulting Explorer/Finder window open.

Finally Select all the files in the NOOBS folder and copy them to the SD card.



Step 4

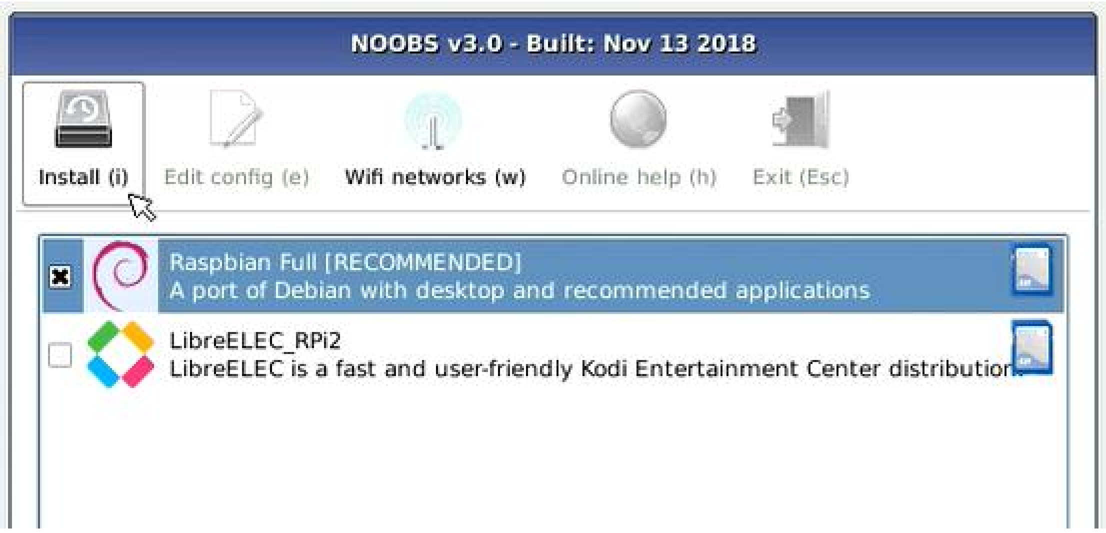
All the files transferred, the SD card pops up.

Step 5

Insert the SD card into the Raspberry Pi. In addition, connect the screen, and mouse to it. Finally power up the Raspberry Pi with a power adapter.

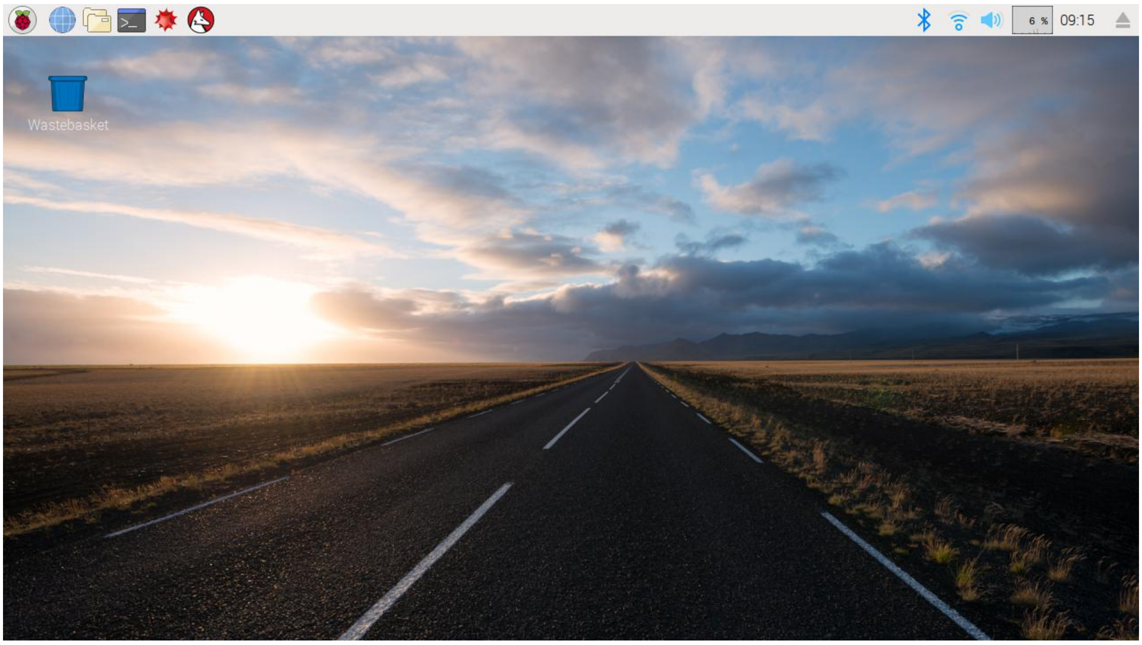
Step 6

It will go to the NOOBS interface after starting up. If you use NOOBS LITE, you need to select Wi-Fi networks (w) first. Tick the checkbox of the Raspbian and click Install in the top left corner. The NOOBS will help to conduct the installation automatically. This process will take a few minutes.



Step 7

When the installation is done, the system will restart automatically and the desktop of the system will appear.



Step 8

If you run Raspberry Pi for the first time, the application of “Welcome to Raspberry Pi” pops up and guides you to perform the initial setup.

Step 9

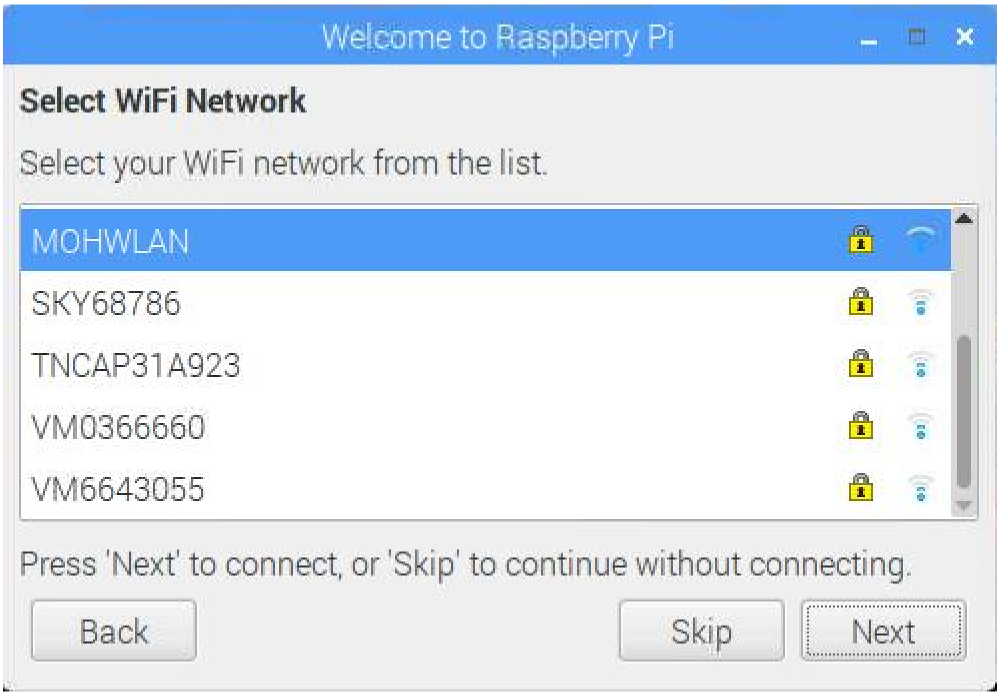
Set country/region, language and time zone, and then click “next” again.

Step 10

Input the new password of Raspberry Pi and click “Next”.

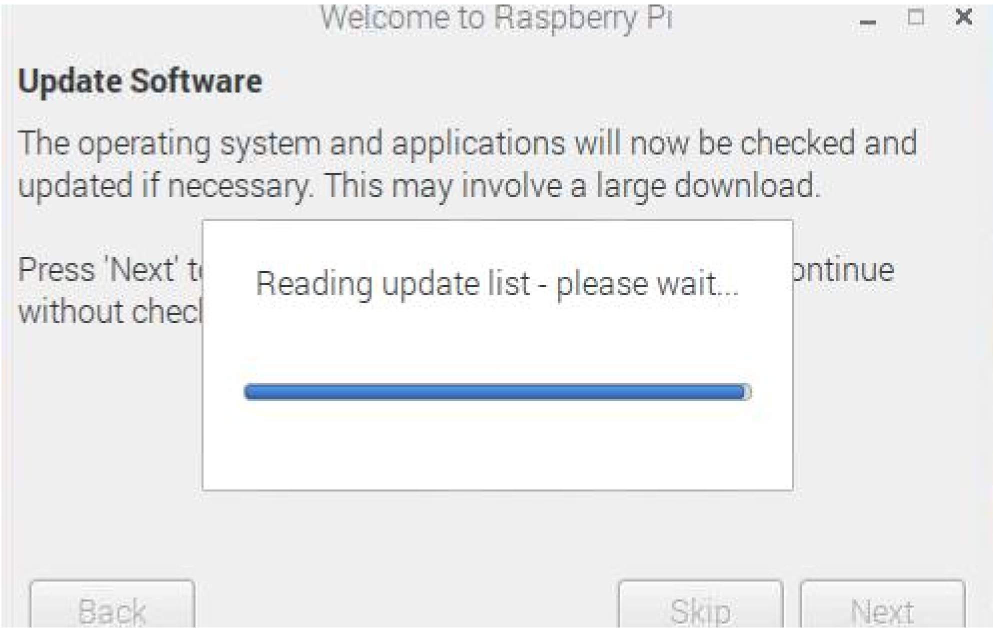
Step 11

Connect the Raspberry Pi to WIFI and click "Next".



Step 12

Retrieve update.

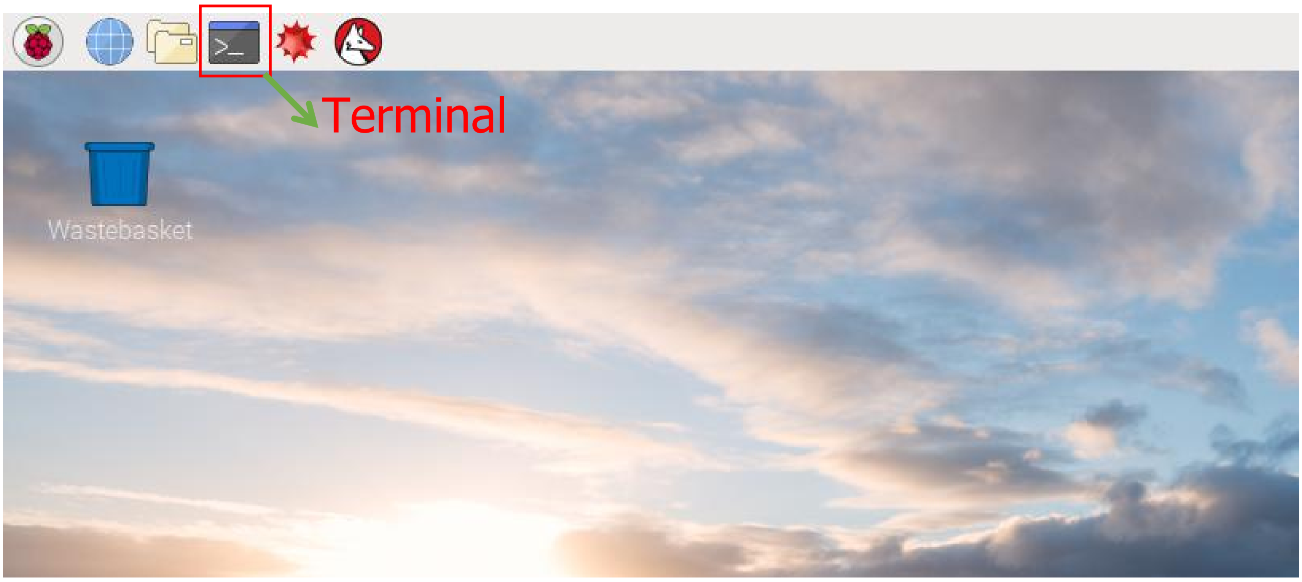


Step 13

Click "Done" to complete the Settings.

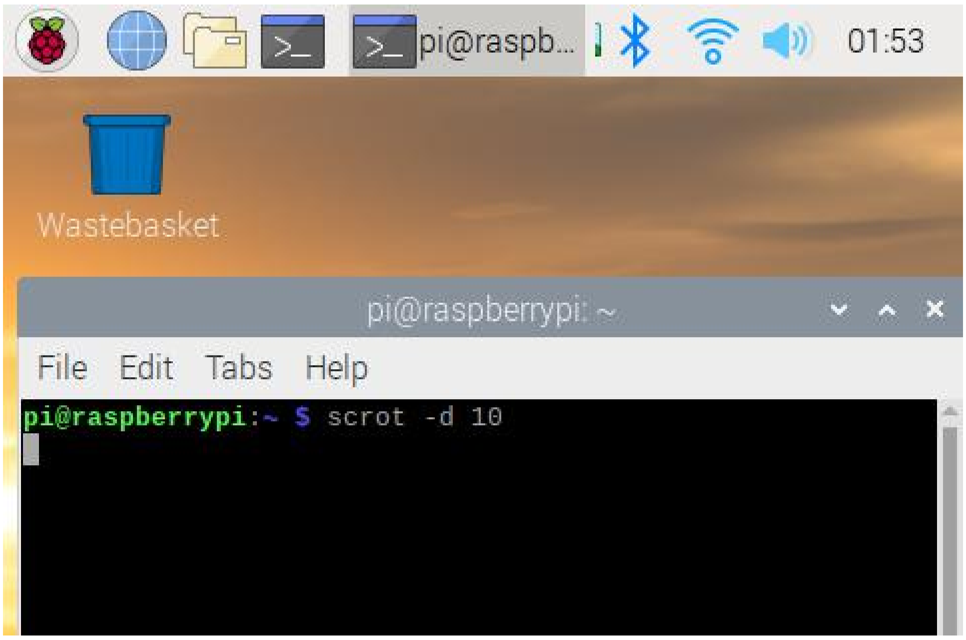
Step 14

Click the Terminal icon on the top left corner.



Step 15

Then you can input the commands on the Terminal.



Note: You can check the complete tutorial of NOOBS on the official website of the Raspberry Pi: *https://www.raspberrypi.org/help/noobs-setup/*.

If You Have No Screen

If we don't have a screen, we can directly write the Raspberry Pi OS system to the Micro SD card and we can control the Raspberry Pi on PC remotely by directly modifying the configuration file of the network settings in the Micro SD card.

Required Components

Any Raspberry Pi	1 * Power Adapter
1 * Micro SD card	1 * Personal computer

Installing System

There are 2 ways to install the system, **Using Raspberry Pi Imager** or **Using Raspberry Pi OS**. **Using Raspberry Pi Imager** is a kind of method recommended by Raspberry Pi official website for beginners with which you can directly write the Raspberry Pi OS into SD card after downloading Raspberry Pi Imager. However, each time the system is reinstalled, this method can take several hours.

In the later method, you need to download Raspberry Pi OS image at first, then use the tool to write it to your SD card, which can be confusing. But once you successfully finish the flashing at the first time, it only takes about 10 minutes to flash again.

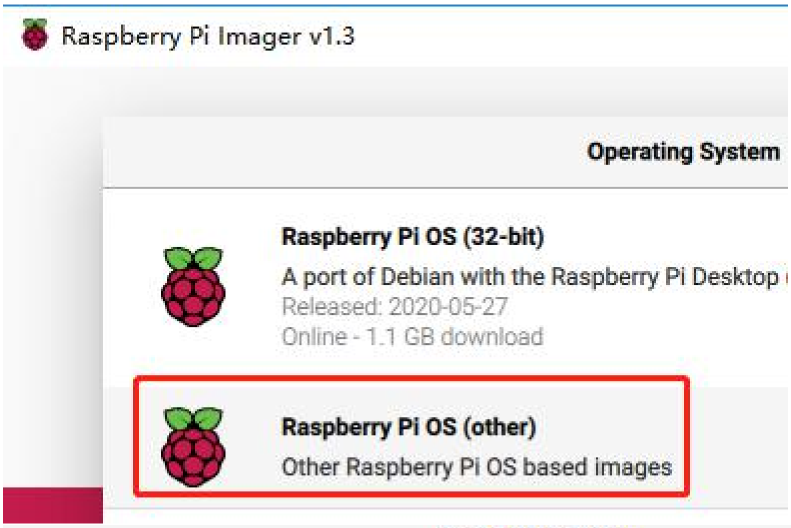
➢ Using Raspberry Pi Imager

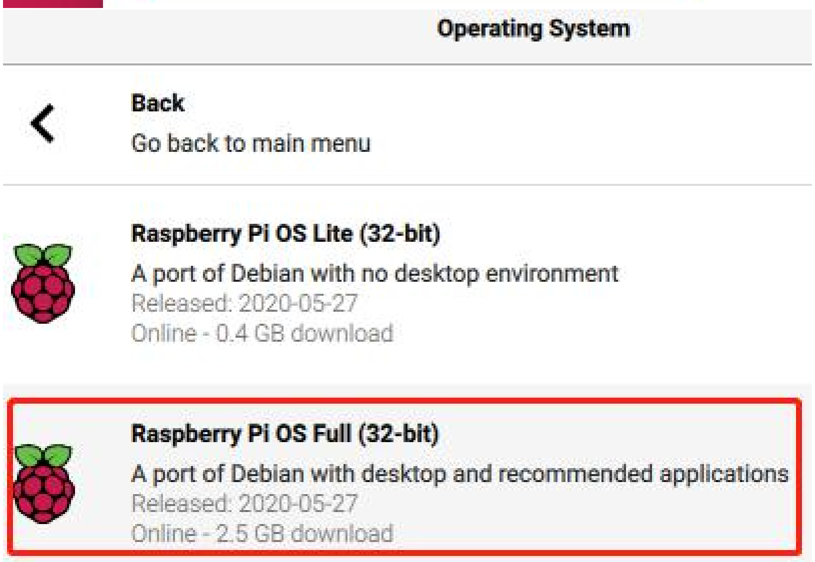
Raspberry Pi have developed a graphical SD card writing tool that works on Mac OS, Ubuntu 18.04 and Windows, and is the easiest option for most users as it will download the image and install it automatically to the SD card.

1) Download the latest version of **Raspberry Pi Imager**(*https://www.raspberrypi.org/downloads/*) and install it.

2) Connect an SD card reader with the SD card inside.

3) Open Raspberry Pi Imager and choose **Raspberry Pi OS (other) -> Raspberry Pi OS Full (32-bit)**.





4) Choose the SD card you wish to write your image to.

5) Review your selections and click 'WRITE' to begin writing data to the SD card.

> **Note:** If using the Raspberry Pi Imager on Windows 10 with Controlled Folder Access enabled, you will need to explicitly allow the Raspberry Pi Imager permission to write the SD card. If this is not done, Raspberry Pi Imager will fail with a "failed to write" error.

Using Raspberry Pi OS

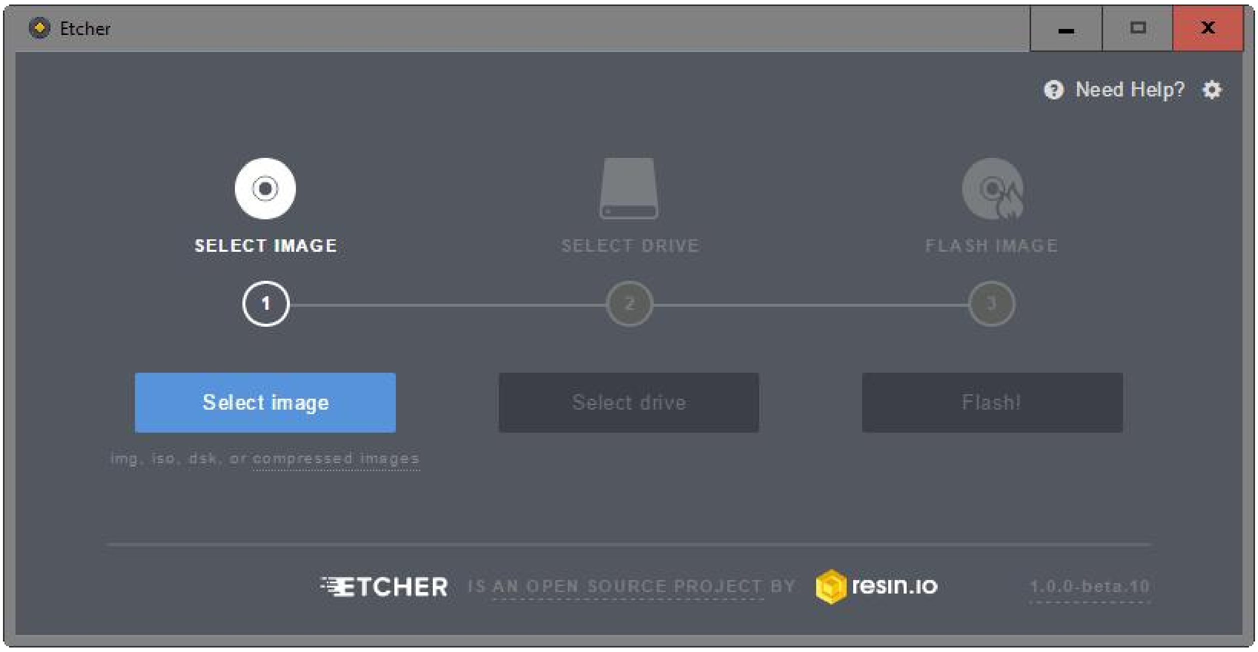
Step 1: Prepare the tool of image burning. Here we use the **balenaEtcher**. You can download the software from the link: https://www.balena.io/etcher/

Step 2: Download the complete image on the official website by clicking this link: https://www.raspberrypi.org/downloads/raspberry-pi-os/. There are three different kinds of Raspberry Pi OS system available, You are recommend to install the version: **Raspberry Pi OS with desktop and recommended software**.

Step 3: Unzip the package downloaded and you will see the *.img* file inside.

Note: The Raspberry Pi OS with desktop image contained in the ZIP archive is over 4GB in size and uses the ZIP64 format. To uncompress the archive, a unzip tool that supports ZIP64 is required. The following zip tools support ZIP64: 7-Zip (Windows), The Unarchiver (Mac) and Unzip (Linux).

Step 4: Plug the USB card reader into the computer, then you can burn the **.img** file with the Etcher.



At this point, Raspberry Pi OS is installed. **Keep the USB card reader plug in your computer**. If you want to apply it, next you need to complete the settings accordingly.

Connect the Raspberry Pi to the Internet

There are two methods to help get the Raspberry Pi connected to the network: the first one is using a network cable, the other way is using WIFI. We will talk in detail about how to connect via WIFI as below.

Since the 3B and above version of the product, Raspberry Pi has a built-in Wifi function. If what you use is the early version of Raspberry Pi, a USB WIFI Adapter is needed. Log in the website, https://elinux.org/RPi_USB_Wi-Fi_Adapters for more.

If you want to use the WIFI function, you need to modify a WIFI configuration file wpa_supplicant.conf in the SD card by your PC that is located in the directory /etc/wpa_supplicant/.

If your personal computer is working on a linux system, you can access the directory directly to modify the configuration file; however, if your PC use Windows system, then you can't access the directory and what you need next is to go to the directory, */boot/* to create a new file with the same name, **wpa_supplicant.conf**.

Input the following content in the file.

```
ctrl_interface=DIR=/var/run/wpa_supplicant GROUP=netdev
update_config=1
country=COUNTRY
network={
ssid="SSID"
psk="PASSWORD"
key_mgmt=WPA-PSK
priority=1
}
```

COUNTRY should be set the two-letter ISO/IEC alpha2 code for the country in which you are using your Raspberry Pi, please refer to the following link:

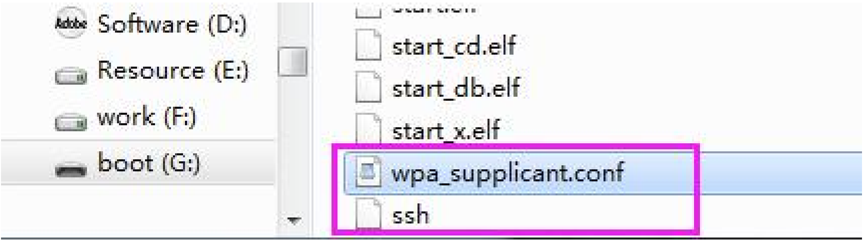
https://en.wikipedia.org/wiki/ISO_3166-1_alpha-2#Officially_assigned_code_elements

You need to replace "**SSID**" with your custom name of WiFi and "**PASSWORD**" with your password.

By doing these, the Raspberry Pi OS will move this file to the target directory automatically to overwrite the original WIFI configuration file when it runs next time.

Start SSH

To use the function of remote control of the Raspberry Pi, you need to start SSH firstly that is a more reliable protocol providing security for remote login sessions and other network services. Generally, SSH of Raspberry Pi is in a disabled state. Additionally, if you want to run it, you need to create a file named SSH under directory /boot/.



Now, the Raspberry Pi OS is configured. When the SD card is inserted into the Raspberry Pi, you can use it immediately.

Get the IP Address

After the Raspberry Pi is connected to WIFI, we need to get the IP address of it. There are many ways to know the IP address, and two of them are listed as follows.

1. Checking via the router

If you have permission to log in the router(such as a home network), you can check the addresses assigned to Raspberry Pi on the admin interface of router.

The default hostname of the Raspberry Pi OS is **raspberrypi**, and you need to find it. (If you are using ArchLinuxARM system, please find alarmpi.)

2. Network Segment Scanning

You can also use network scanning to look up the IP address of Raspberry Pi. You can apply the software, Advanced IP scanner and so on.

Scan the IP range set, and the name of all connected devices will be displayed. Similarly, the default hostname of the Raspberry Pi OS is **raspberrypi**, now you need to find the hostname.

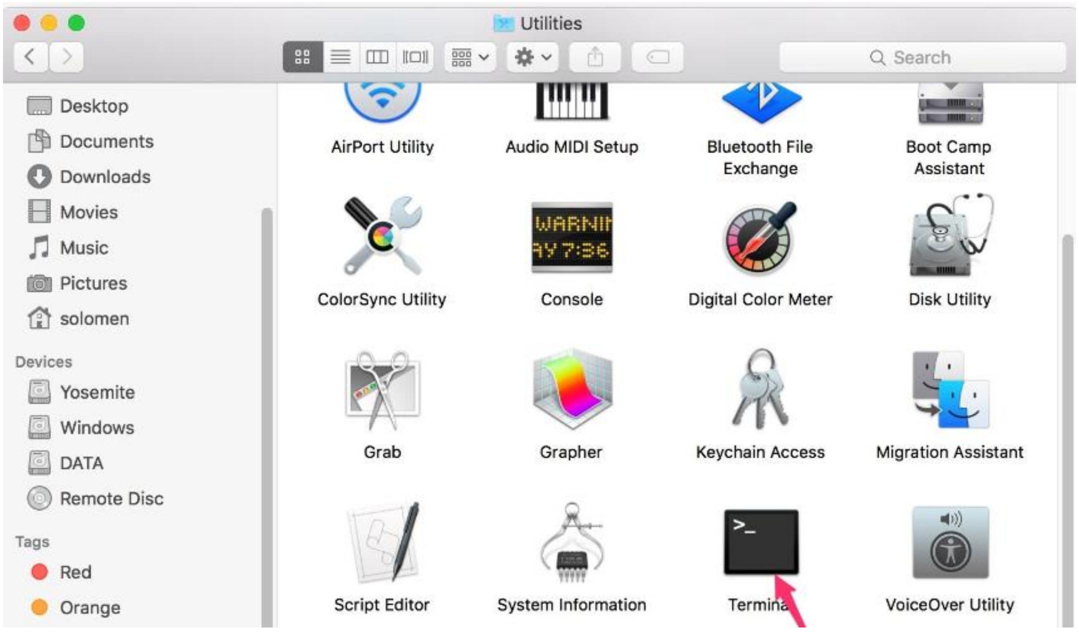
Use the SSH Remote Control

We can open the Bash Shell of Raspberry Pi by applying SSH. Bash is the standard default shell of Linux. The Shell itself is a program written in C that is the bridge linking the customers and Unix/Linux. Moreover, it can help to complete most of the work needed.

For Linux or/Mac OS X Users

Step 1

Go to **Applications**->**Utilities**, find the **Terminal**, and open it.



Step 2

Type in **ssh pi@ip_address** . "pi"is your username and "ip_address" is your IP address. For example:

```
ssh pi@192.168.18.197
```

Step 3

Input "yes".

```
1. ssh pi@192.168.18.197 (ssh)
Last login: Fri Apr 12 16:56:20 on ttys000

# hang_chen @ hang-chendeMacBook-Pro in ~ [17:09:55]
$ ssh pi@192.168.18.197
The authenticity of host '192.168.18.197 (192.168.18.197)' can't be established.
ECDSA key fingerprint is SHA256:6OtKKQtCCRvUCohWmvVcbp7tBHtQL0f8/0kusPjVsEU.
Are you sure you want to continue connecting (yes/no)?
```

Step 4

Input the passcode and the default password is **raspberry**.

```
1. ssh pi@192.168.18.197 (ssh)
Last login: Fri Apr 12 16:56:20 on ttys000

# hang_chen @ hang-chendeMacBook-Pro in ~ [17:09:55]
$ ssh pi@192.168.18.197
The authenticity of host '192.168.18.197 (192.168.18.197)' can't be established.
ECDSA key fingerprint is SHA256:6OtKKQtCCRvUCohWmvVcbp7tBHtQL0f8/0kusPjVsEU.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '192.168.18.197' (ECDSA) to the list of known hosts.
pi@192.168.18.197's password:
```

Step 5

We now get the Raspberry Pi connected and are ready to go to the next step.

```
1. pi@raspberrypi: ~ (ssh)
Last login: Fri Apr 12 16:56:20 on ttys000

# hang_chen @ hang-chendeMacBook-Pro in ~ [17:09:55]
$ ssh pi@192.168.18.197
The authenticity of host '192.168.18.197 (192.168.18.197)' can't be established.
ECDSA key fingerprint is SHA256:6OtKKQtCCRvUCohWmvVcbp7tBHtQL0f8/0kusPjVsEU.
Are you sure you want to continue connecting (yes/no)? yes
Warning: Permanently added '192.168.18.197' (ECDSA) to the list of known hosts.
pi@192.168.18.197's password:
Linux raspberrypi 4.9.80-v7+ #1098 SMP Fri Mar 9 19:11:42 GMT 2018 armv7l

The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.
Last login: Tue May 21 07:29:46 2019 from 192.168.18.126

SSH is enabled and the default password for the 'pi' user has not been changed.
This is a security risk - please login as the 'pi' user and type 'passwd' to set
 a new password.

pi@raspberrypi:~ $
```

Note: When you input the password, the characters do not display on window accordingly, which is normal. What you need is to input the correct passcode.

For Windows Users

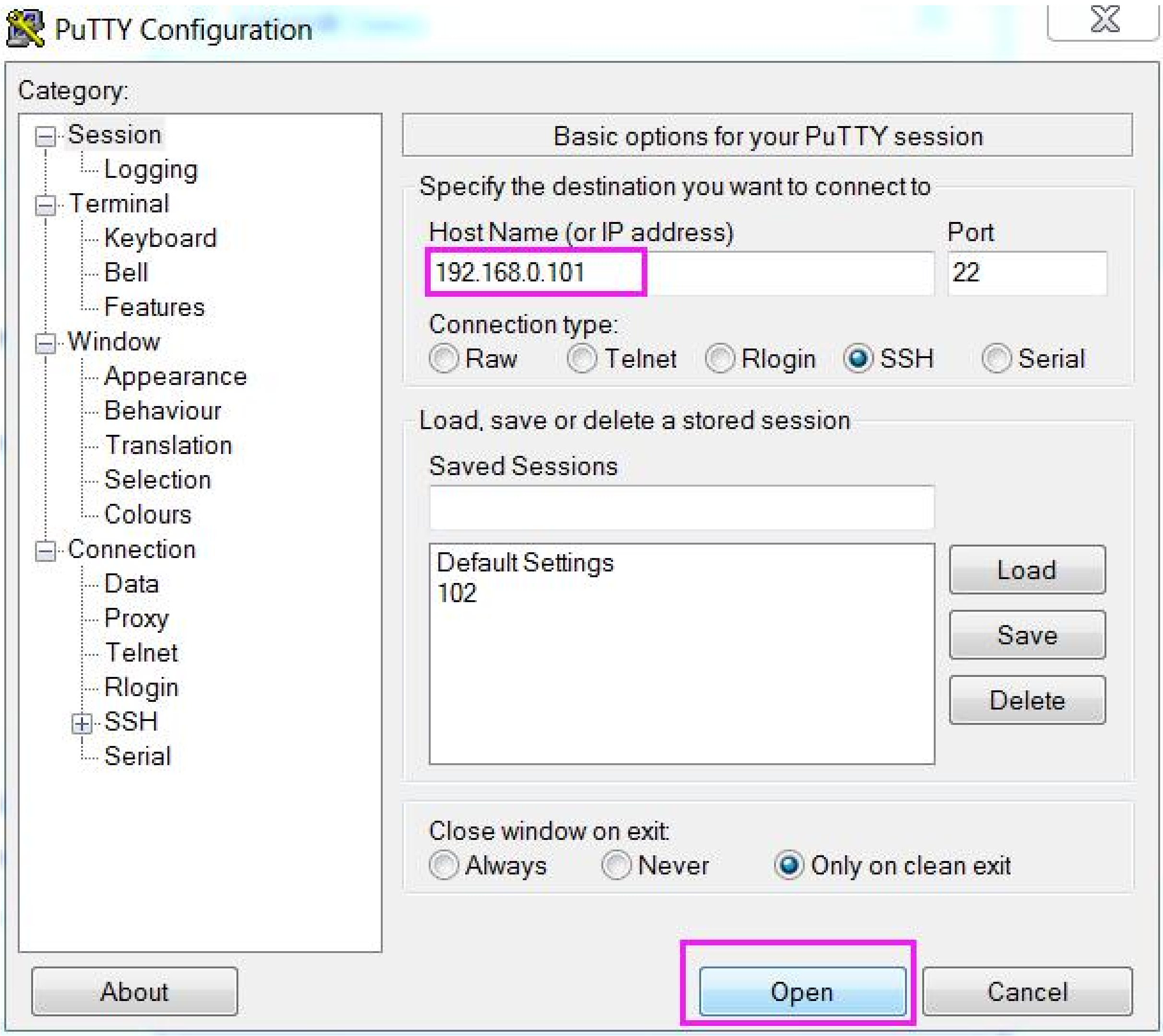
If you're a Windows user, you can use SSH with the application of some software. Here, we recommend PuTTY.

Step 1

Download PuTTY.

Step 2

Open PuTTY and click **Session** on the left tree-alike structure. Enter the IP address of the RPi in the text box under **Host Name (or IP address)** and 22 under **Port** (by default it is 22).

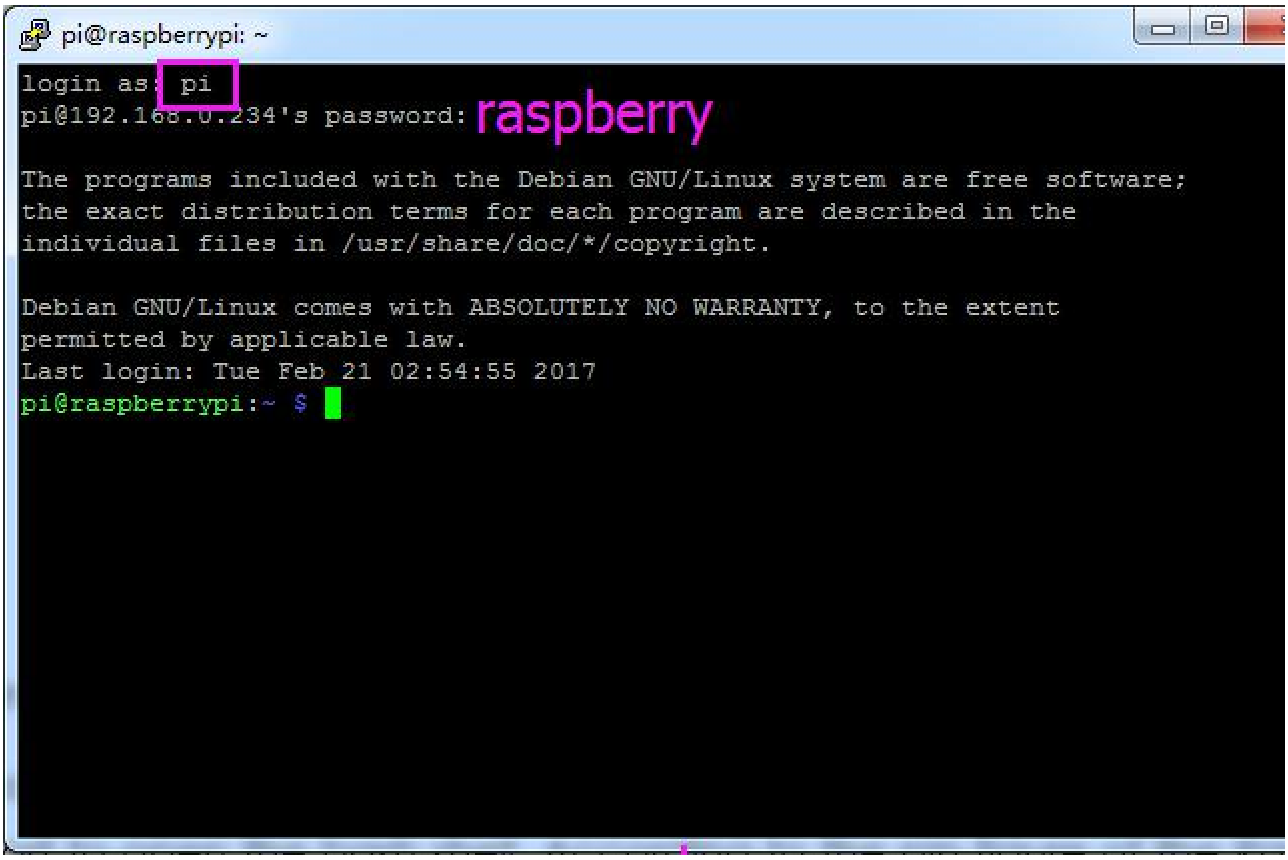


Step 3

Click **Open**. Note that when you first log in to the Raspberry Pi with the IP address, there prompts a security reminder. Just click **Yes**.

Step 4

When the PuTTY window prompts “**login as:”**, type in “**pi”**(the user name of the RPi), and **password:** **“**raspberry” (the default one, if you haven't changed it).



Step 5

Here, we get the Raspberry Pi connected and it is time to conduct the next steps.

Note: When you input the password, the characters do not display on window accordingly, which is normal. What you need is to input the correct passcode.

Remote Desktop

If you are not satisfied with using the command window to control the Raspberry Pi, you can also use the remote desktop function, which can help us manage the files in the Raspberry Pi easily. There are two ways to control the desktop of the Raspberry Pi remotely : **VNC** and **XRDP**.

VNC

You can use the function of remote desktop through VNC.

Enable VNC service

The VNC service has been installed in the system. By default, VNC is disabled. You need to enable it in config.

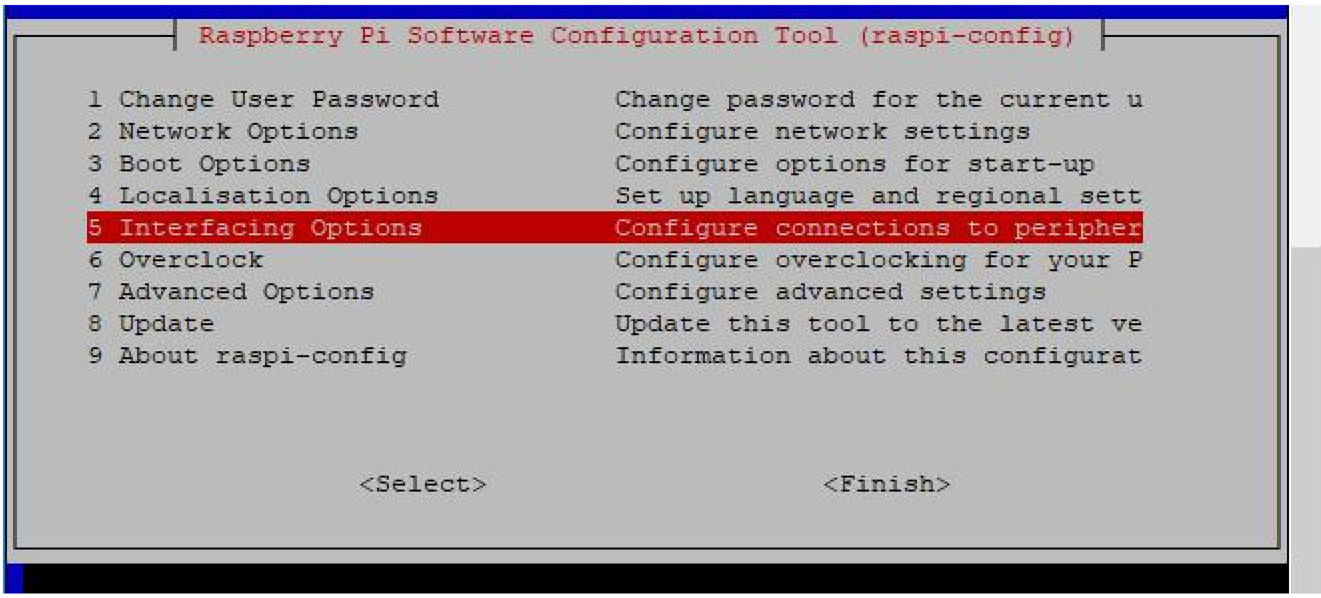
Step 1

Input the following command:

```
sudo raspi-config
```

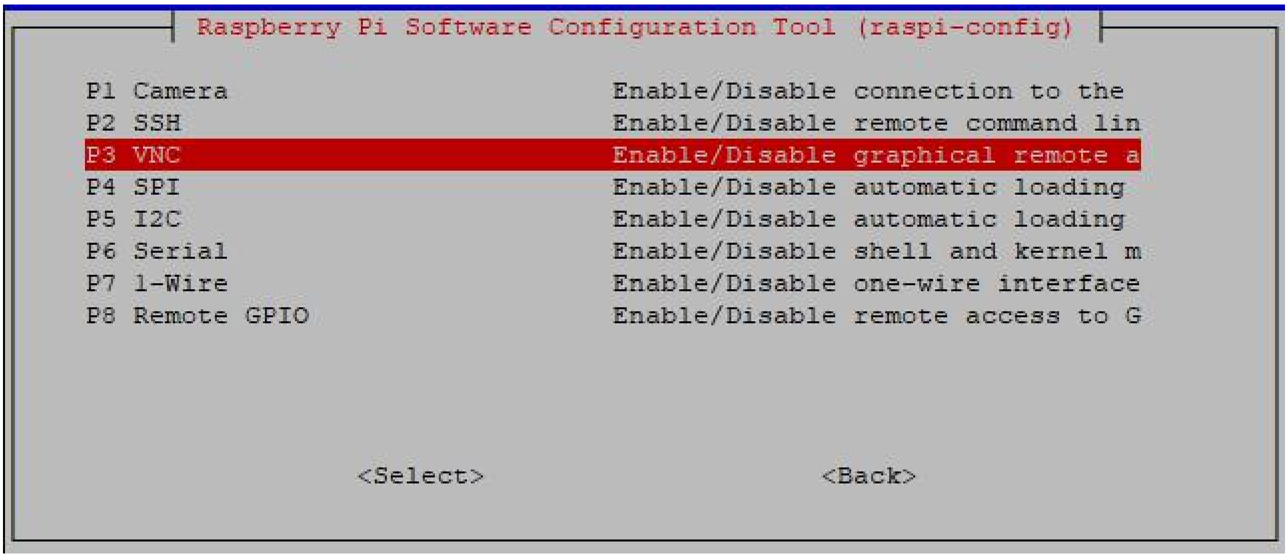
Step 2

On the config interface, select “**Interfacing Options**” by the forward and backward keys.



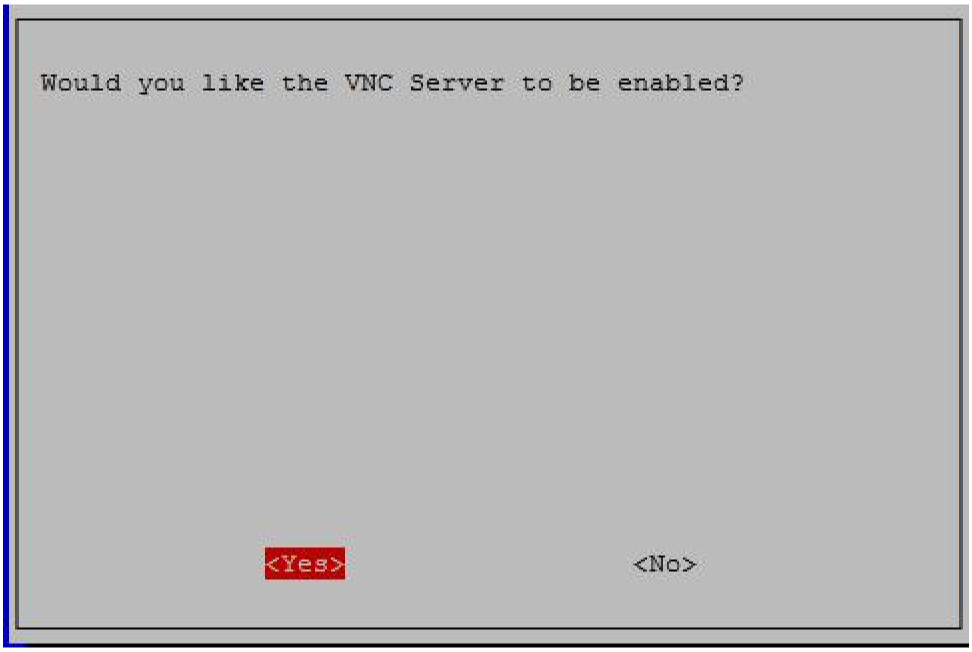
Step 3

Select **VNC**.



Step 4

Select **Yes -> OK -> Finish** to exit the configuration.



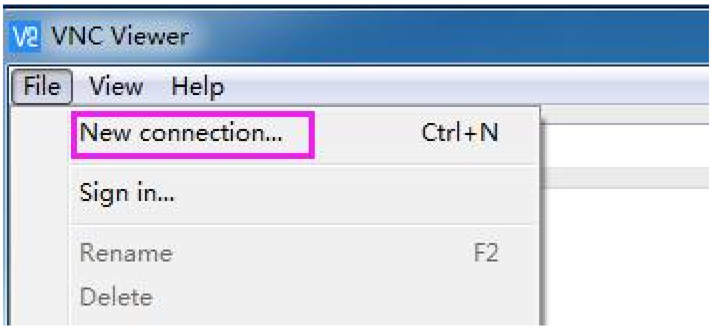
Login to VNC

Step 1

You need to install the VNC Viewer on personal computer. After the installation is done, open it.

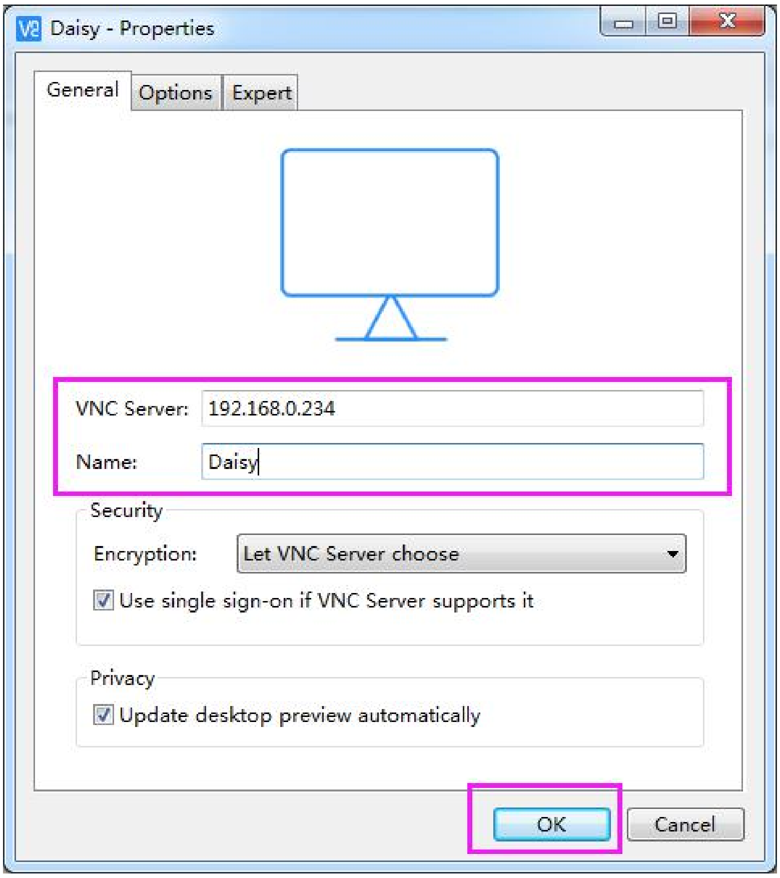
Step 2

Then select "**New connection**".



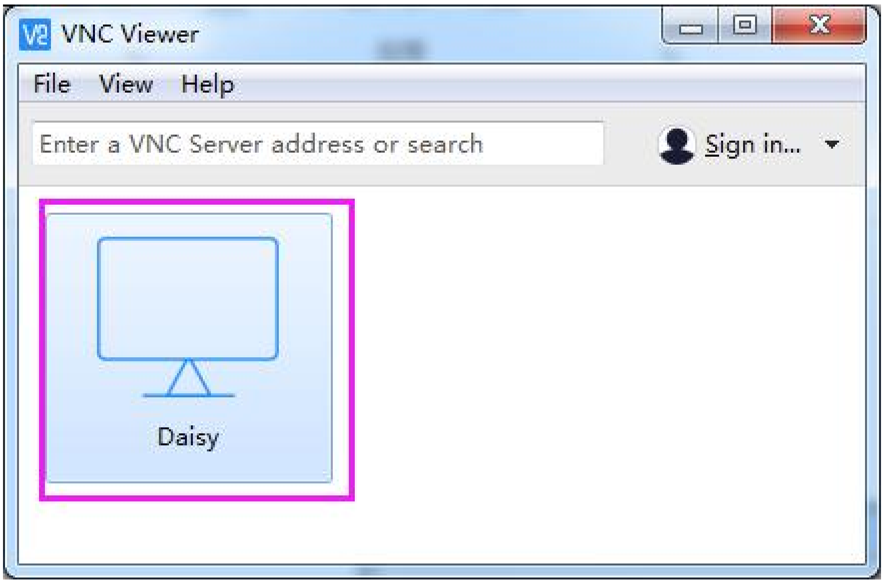
Step 3

Input IP address of Raspberry Pi and any **name**.



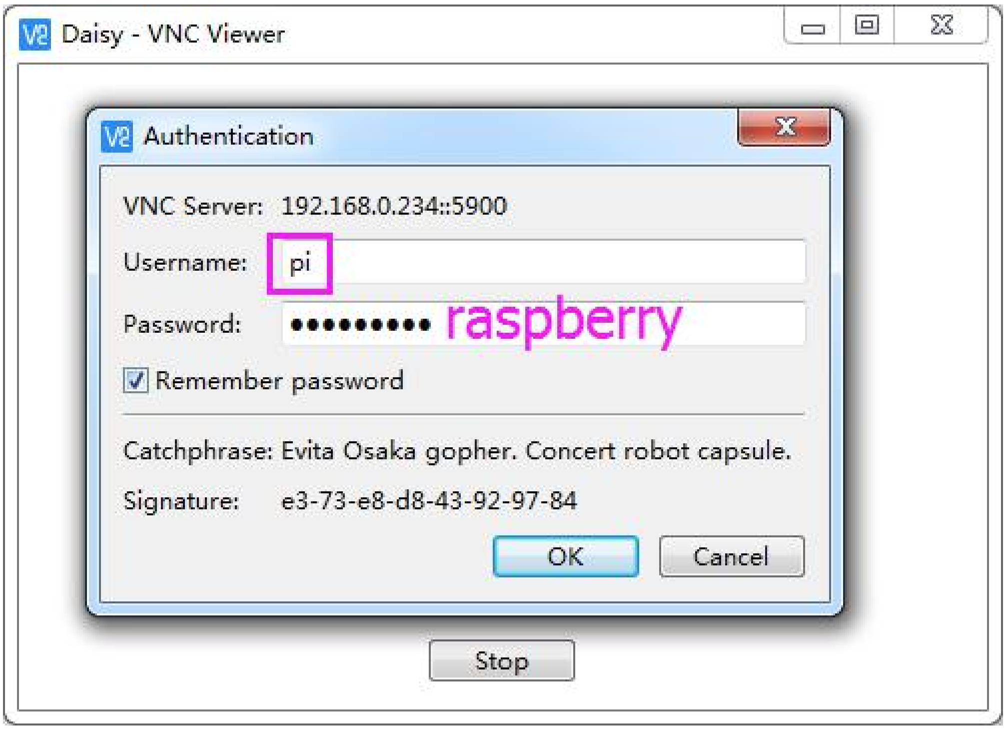
Step 4

Double click the **connection** just created:



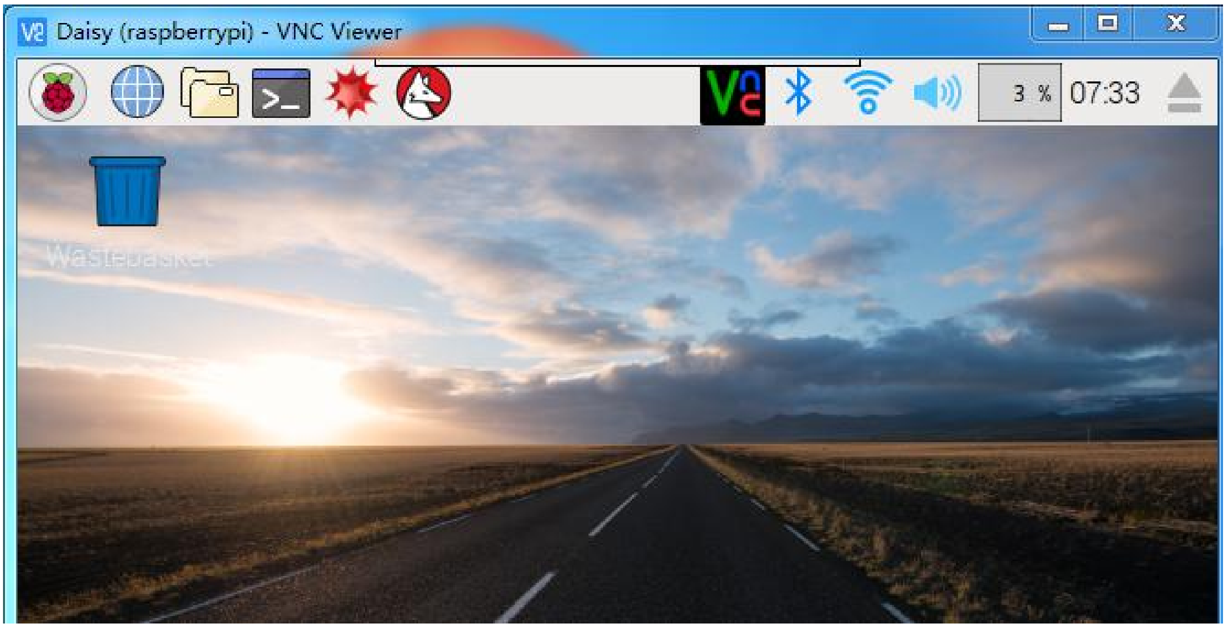
Step 5

Enter Username (**pi**) and Password (**raspberry** by default).



Step 6

Now you can see the desktop of the Raspberry Pi:



XRDP

xrdp provides a graphical login to remote machines using RDP (Microsoft Remote Desktop Protocol).

Install XRDP

Step 1

Login to Raspberry Pi by using SSH.

Step 2

Input the following instructions to install XRDP.

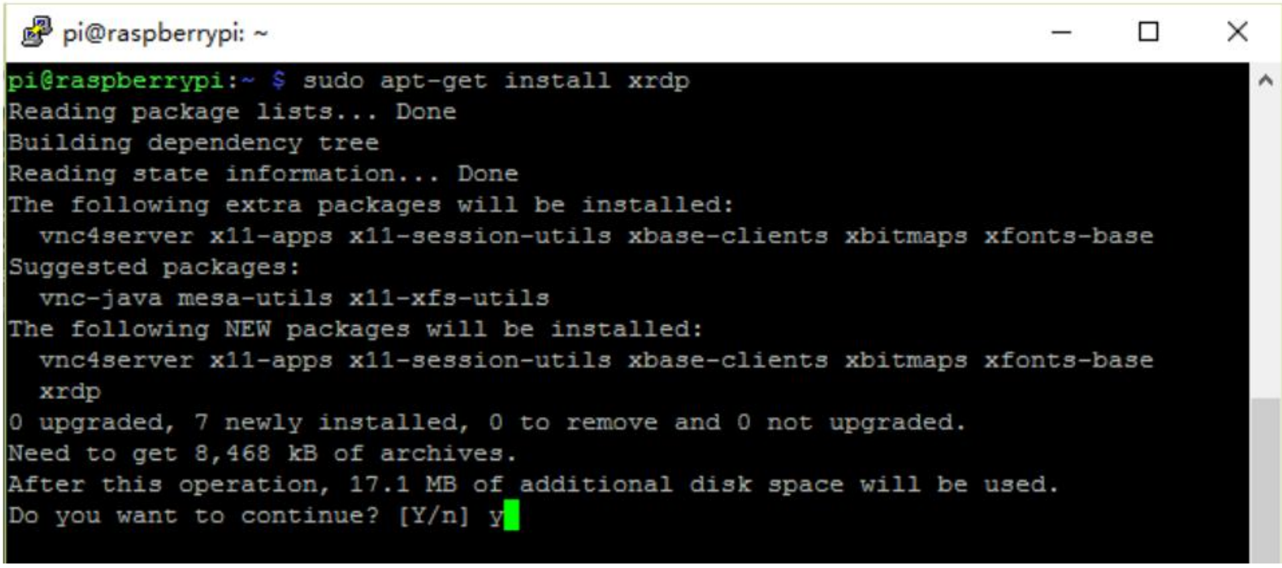
```
sudo apt-get update

sudo apt-get install xrdp
```

Step 3

Later, the installation starts.

Enter "Y", press key “Enter” to confirm.



Step 4

After the installation is completed, you can use Windows remote desktop applications to login to your RPi.

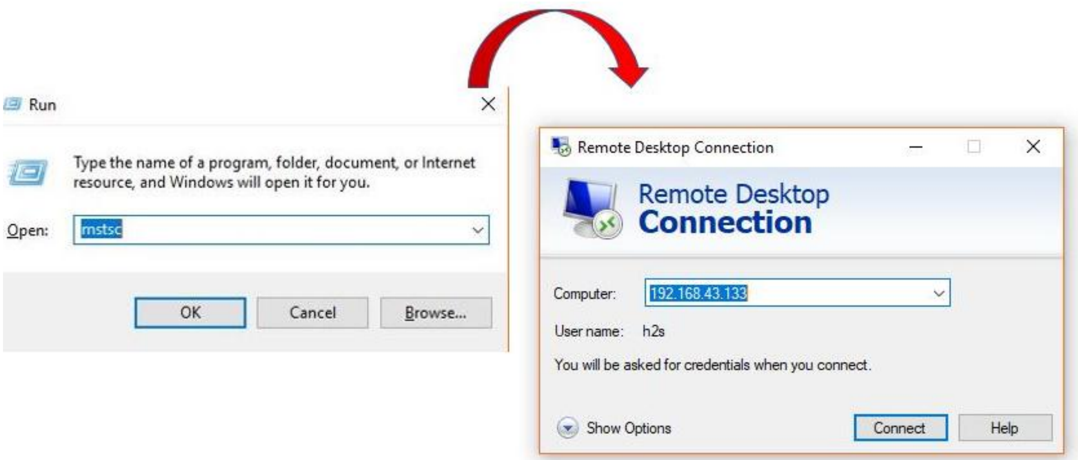
Login to XRDP

Step 1

If you are a Windows user, you can use the Remote Desktop feature that comes with Windows. If you are a Mac user, you can download and use Microsoft Remote Desktop from the APP Store, and there is not much difference between the two. The next example is Windows remote desktop.

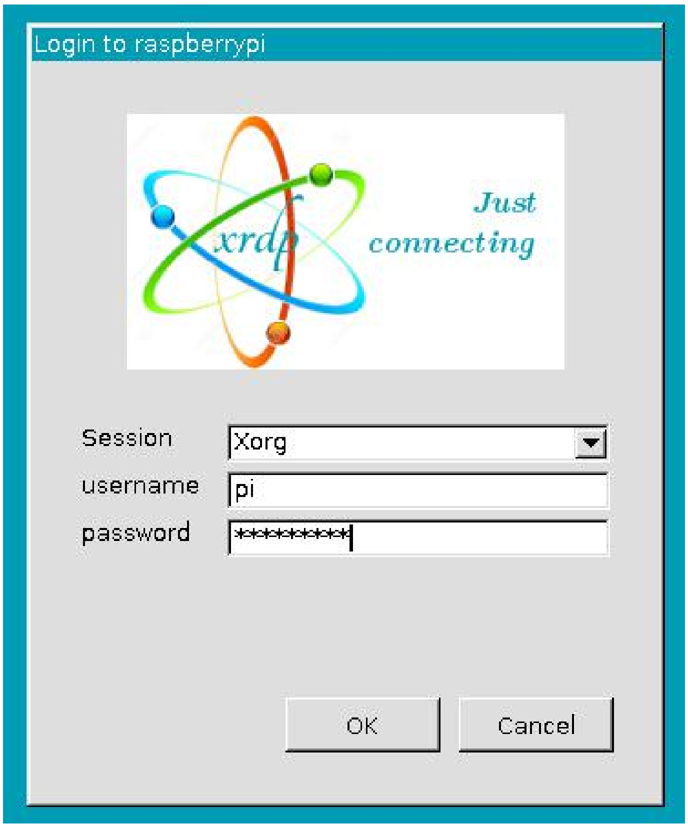
Step 2

Type in"mstsc" in Run (WIN+R) to open the Remote Desktop Connection, and input the IP address of Raspberry Pi, then click on "Connect".



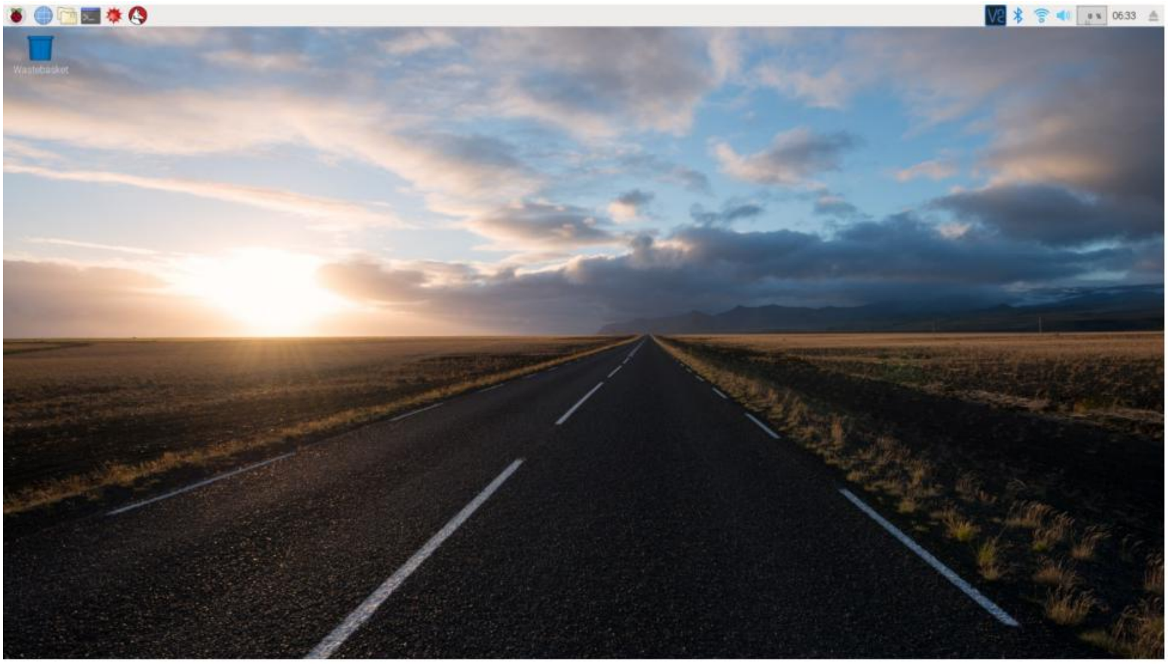
Step 3

There will be xrdp login screen. Enter the user name and password of RPi and click OK. By default, the user name of Raspberry Pi is **"pi"** and the password is **"raspberry"**.



Step 4

Here, you successfully login to RPi by using the remote desktop.

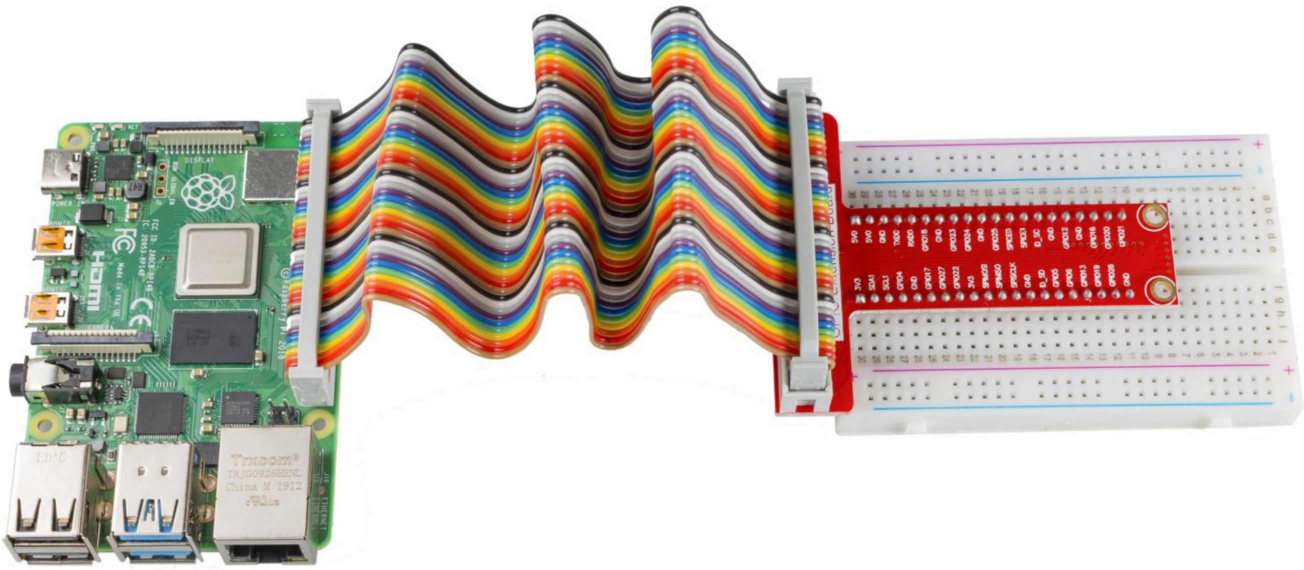


GPIO Extension Board

Connect to Raspberry Pi

Before starting to learn the commands, you first need to know more about the pins of the Raspberry Pi, which is key to the subsequent study.

We can easily lead out pins of the Raspberry Pi to breadboard by GPIO Extension Board to avoid GPIO damage caused by frequent plugging in or out. This is our 40-pin GPIO Extension Board and GPIO cable for Raspberry Pi model B+, 2 model B and 3, 4 model B.



Pin Number

The pins of Raspberry Pi have three kinds of ways to name and they are wiringPi, BCM and Board. Among these naming methods, 40-pin GPIO Extension board uses the naming method, BCM. But for some special pins, such as I2C port and SPI port, they use the Name that comes with themselves. The following table shows us the naming methods of WiringPi, Board and the intrinsic Name of each pin on GPIO Extension board. For example, for the GPIO17, the Board naming method of it is 11, the wiringPi naming method is 0, and the intrinsic naming method of it is GPIO0.

Note:

1) In C Language, what is used is the naming method WiringPi.

2) In Python Language, the applied naming methods are Board and BCM, and the function GPIO.setmode() is used to set them.

Name	WiringPi	Board	BCM		Board	WiringPi	Name
			GPIO Extention Board				
3.3V	3V3	1	3V3	5.0V	2	5.0V	5V
SDA	8	3	SDA	5.0V	4	5.0V	5V
SCL	9	5	SCL	GND	6	GND	0V
GPIO7	7	7	GPIO4	TXD	8	15	TXD
0V	GND	9	GND	RXD	10	16	RXD
GPIO0	0	11	GPIO17	GPIO18	12	1	GPIO1
GPIO2	2	13	GPIO27	GND	14	GND	0V
GPIO3	3	15	GPIO22	GPIO23	16	4	GPIO4
3.3V	3.3V	17	3.3V	GPIO24	18	5	GPIO5
MOSI	12	19	MOSI	GND	20	GND	0V
MISO	13	21	MISO	GPIO25	22	6	GPIO6
SCLK	14	23	SCLK	CE0	24	10	CEO
0V	GND	25	GND	CE1	26	11	CE1
IN_SDA	30	27	EED	EEC	28	31	ID_SCL
GPIO21	21	29	GPIO5	GND	30	GND	0V
GPIO22	22	31	GPIO6	GPIO12	32	26	GPIO26
GPIO23	23	33	GPIO13	GND	34	GND	0V
GPIO24	24	35	GPIO19	GPIO16	36	27	GPIO27
GPIO25	25	37	GPIO26	GPIO20	38	28	GPIO28
0V	GND	39	GND	GPIO21	40	29	GPIO29

Libraries

Two important libraries are used in programming with Raspberry Pi, and they are wiringPi and RPi.GPIO. The Raspberry Pi OS image of Raspberry Pi installs them by default, so you can use them directly.

RPi.GPIO

If you are a Python user, you can program GPIOs with API provided by RPi.GPIO.

RPi.GPIO is a module to control Raspberry Pi GPIO channels. This package provides a class to control the GPIO on a Raspberry Pi. For examples and documents, visit *http://sourceforge.net/p/raspberry-gpio-python/wiki/Home/*

Test whether RPi.GPIO is installed or not, type in python:

```
python
```

```
pi@raspberrypi:~ $ python
Python 2.7.9 (default, Mar  8 2015, 00:52:26)
[GCC 4.9.2] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>>
```

In Python CLI, input "import RPi.GPIO", If no error prompts, it means RPi.GPIO is installed.

```
import RPi.GPIO
```

```
pi@raspberrypi:~ $ python
Python 2.7.9 (default, Mar  8 2015, 00:52:26)
[GCC 4.9.2] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>> import RPi.GPIO
>>>
```

If you want to quit python CLI, type in:

```
exit()
```

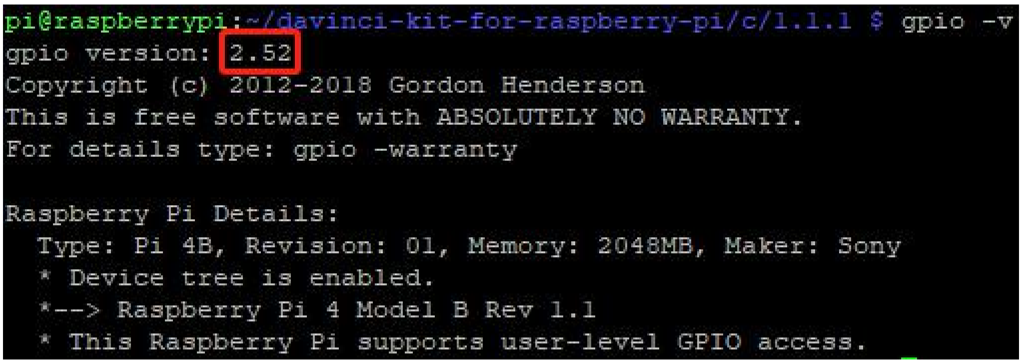
```
>>> exit()
pi@raspberrypi:~ $
```

WiringPi

wiringPi is a C language GPIO library applied to the Raspberry Pi platform. It complies with GUN Lv3. The functions in wiringPi are similar to those in the wiring system of Arduino. They enable the users familiar with Arduino to use wiringPi more easily.

wiringPi includes lots of GPIO commands which enable you to control all kinds of interfaces on Raspberry Pi. You can test whether the wiringPi library is installed successfully or not by the following instructions.

```
gpio -v
```



Note:

If you are using Raspberry Pi 4B, but the GPIO version is **2.50**, it will cause no response after the C language code is running, that is, GPIO pins do not work. At this time, you need to manually update to version **2.52**, the update steps are as follows :

```
cd /tmp
wget https://project-downloads.drogon.net/wiringpi-latest.deb
sudo dpkg -i wiringpi-latest.deb
```

Check with:

```
gpio -v
```

and make sure it’s version 2.52.

gpio readall

```
pi@raspberrypi:~ $ gpio readall
 +-----+-----+---------+------+---+---Pi 3---+---+------+---------+-----+-----+
 | BCM | wPi |   Name  | Mode | V | Physical | V | Mode | Name    | wPi | BCM |
 +-----+-----+---------+------+---+----++----+---+------+---------+-----+-----+
 |     |     |    3.3v |      |   |  1 || 2  |   |      | 5v      |     |     |
 |   2 |   8 |   SDA.1 | ALT0 | 1 |  3 || 4  |   |      | 5V      |     |     |
 |   3 |   9 |   SCL.1 | ALT0 | 1 |  5 || 6  |   |      | 0v      |     |     |
 |   4 |   7 | GPIO. 7 |   IN | 0 |  7 || 8  | 1 | IN   | TxD     | 15  | 14  |
 |     |     |      0v |      |   |  9 || 10 | 1 | IN   | RxD     | 16  | 15  |
 |  17 |   0 | GPIO. 0 |   IN | 0 | 11 || 12 | 0 | IN   | GPIO. 1 | 1   | 18  |
 |  27 |   2 | GPIO. 2 |   IN | 0 | 13 || 14 |   |      | 0v      |     |     |
 |  22 |   3 | GPIO. 3 |   IN | 0 | 15 || 16 | 0 | IN   | GPIO. 4 | 4   | 23  |
 |     |     |    3.3v |      |   | 17 || 18 | 0 | IN   | GPIO. 5 | 5   | 24  |
 |  10 |  12 |    MOSI | ALT0 | 1 | 19 || 20 |   |      | 0v      |     |     |
 |   9 |  13 |    MISO | ALT0 | 1 | 21 || 22 | 0 | IN   | GPIO. 6 | 6   | 25  |
 |  11 |  14 |    SCLK | ALT0 | 0 | 23 || 24 | 1 | OUT  | CE0     | 10  | 8   |
 |     |     |      0v |      |   | 25 || 26 | 1 | OUT  | CE1     | 11  | 7   |
 |   0 |  30 |   SDA.0 |   IN | 1 | 27 || 28 | 1 | OUT  | SCL.0   | 31  | 1   |
 |   5 |  21 | GPIO.21 |   IN | 0 | 29 || 30 |   |      | 0v      |     |     |
 |   6 |  22 | GPIO.22 |   IN | 0 | 31 || 32 | 0 | IN   | GPIO.26 | 26  | 12  |
 |  13 |  23 | GPIO.23 |   IN | 1 | 33 || 34 |   |      | 0v      |     |     |
 |  19 |  24 | GPIO.24 |   IN | 0 | 35 || 36 | 0 | IN   | GPIO.27 | 27  | 16  |
 |  26 |  25 | GPIO.25 |   IN | 0 | 37 || 38 | 0 | IN   | GPIO.28 | 28  | 20  |
 |     |     |      0v |      |   | 39 || 40 | 0 | IN   | GPIO.29 | 29  | 21  |
 +-----+-----+---------+------+---+----++----+---+------+---------+-----+-----+
 | BCM | wPi |   Name  | Mode | V | Physical | V | Mode | Name    | wPi | BCM |
 +-----+-----+---------+------+---+---Pi 3---+---+------+---------+-----+-----+
```

For more details about wiringPi, you can refer to: http://wiringpi.com/download-and-install/

Download the Code

Change directory to */home/pi*

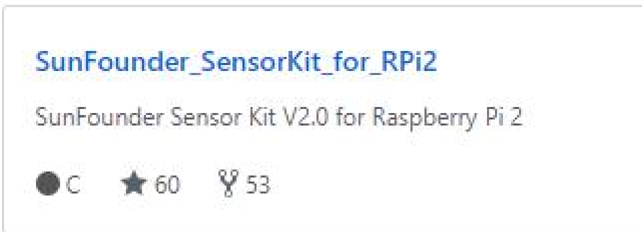
```
cd /home/pi/
```

Note: cd, short for change directory is to change to the intended directory from the current path. Informally, here is to go to the path */home/pi/.*

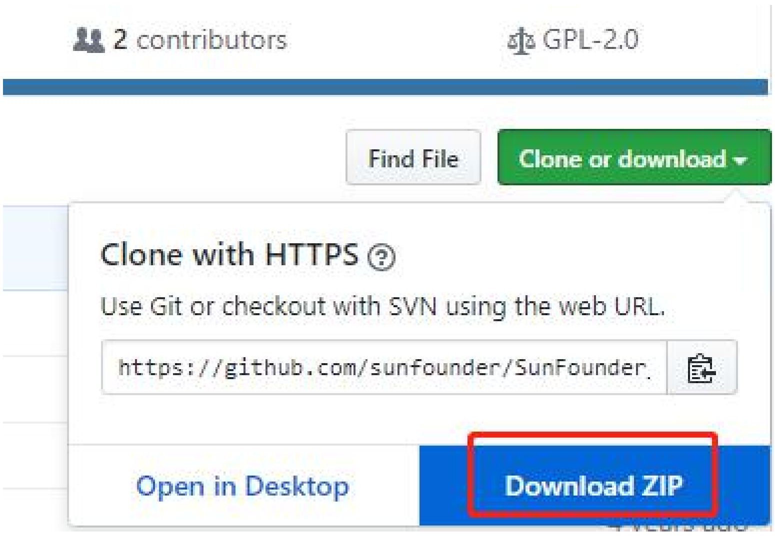
Clone the repository from github (C code and python code)

```
git clone https://github.com/sunfounder/SunFounder_SensorKit_for_RPi2
```

The advantage of this method is that, you can download the latest code any time you want, and then place the code under the path */home/pi/*. But in case of incorrect typing which is possible especially when you're strange to the commands, you can just enter github.com/sunfounder at the address bar of a web browser, and on the page directed find the code for Sensor Kit.



Click on the repository. On the page directed, click **Clone or download** on the right side.



After download, transfer the package to */home/pi/*.

Now you can start the experiments. Let's rock!

Lesson 1 Dual-Color LED

Introduction

A dual-color light emitting diode (LED) is capable of emitting two different colors of light, typically red and green, rather than only one color. It is housed in a 3mm or 5mm epoxy package. It has 3 leads; common cathode or common anode is available. A dual-color LED features two LED terminals, or pins, arranged in the circuit in anti-parallel and connected by a cathode/anode. Positive voltage can be directed towards one of the LED terminals, causing that terminal to emit light of the corresponding color; when the direction of the voltage is reversed, the light of the other color is emitted. In a dual-color LED, only one of the pins can receive voltage at a time. As a result, this type of LED frequently functions as indicator lights for a variety of devices, including televisions, digital cameras, and remote controls.

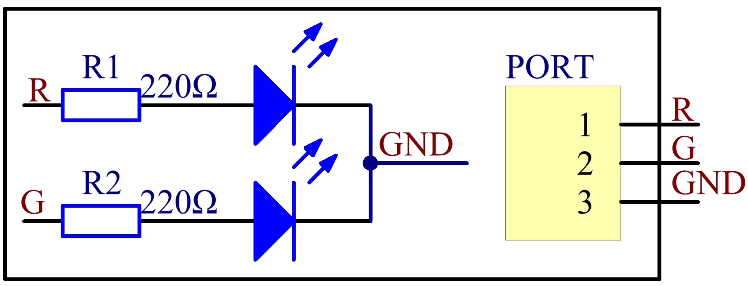
Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- Several Jumper wires
- 1 * Dual-color LED module
- 1 * 3-Pin anti-reverse cable

Experimental Principle

Connect pin R and G to GPIOs of Raspberry Pi, program the Raspberry Pi to change the color of the LED from red to green, and then use PWM to mix into other colors.

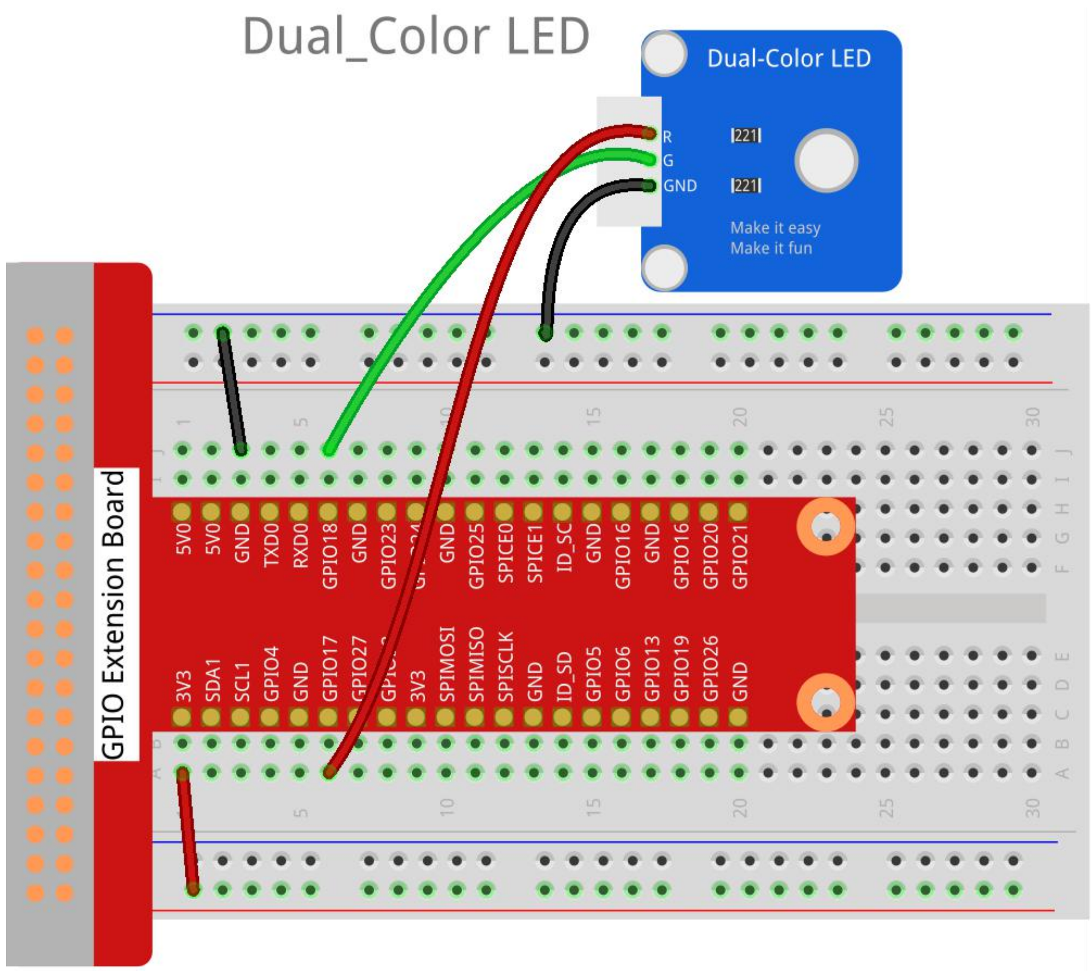
The schematic diagram of the module is as shown below:



Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	Dual-Color LED Module
GPIO0	GPIO17	R
GND	GND	GND
GPIO1	GPIO18	G



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/01_dule_color_led/
```

Step 3: Compile.

```
gcc dule_color_led.c -lwiringPi -lpthread
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

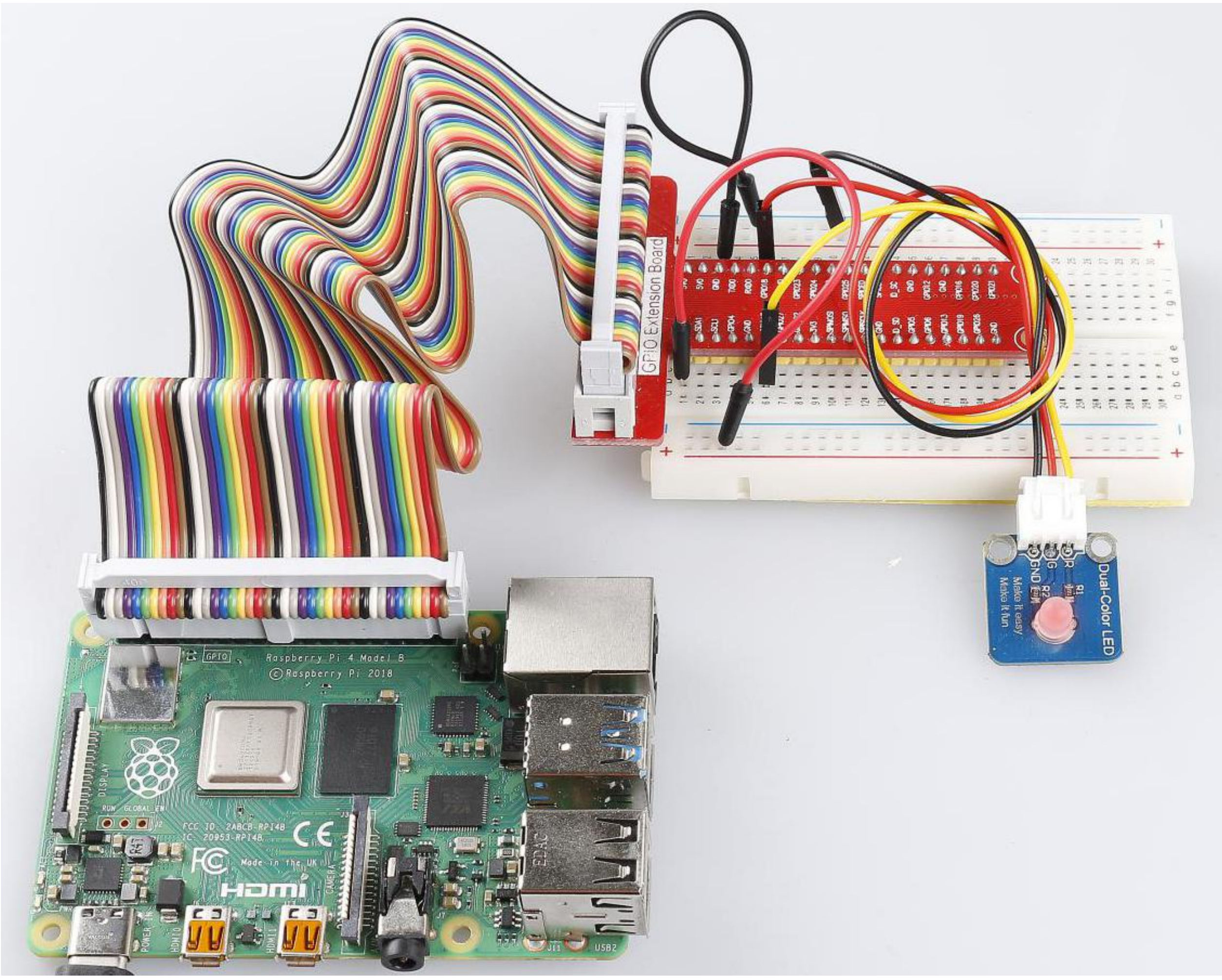
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 01_dule_color_led.py
```

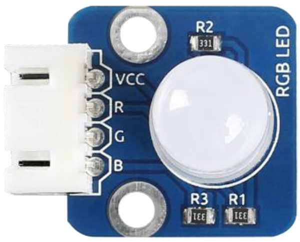
You can see the dual-color LED render green, red, and mixed colors.



Lesson 2 RGB LED Module

Introduction

RGB LED modules can emit various colors of light. Three LEDs of red, green, and blue are packaged into a transparent or semitransparent plastic shell with four pins led out. The three primary colors of red, green, and blue can be mixed and compose all kinds of colors by brightness, so you can make an RGB LED emit colorful light by controlling the circuit.



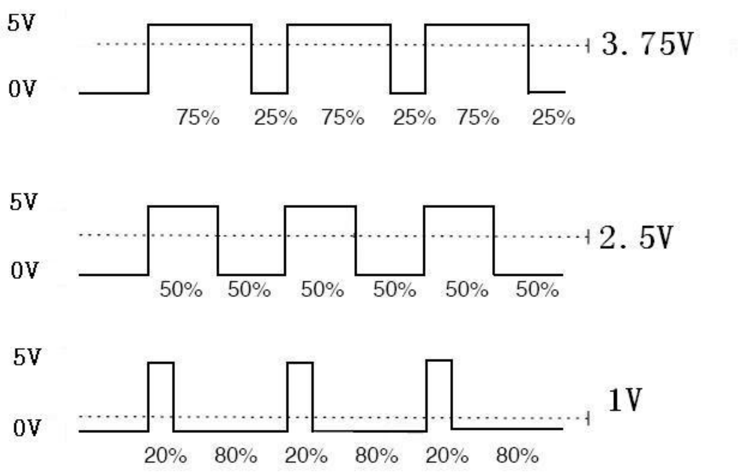
Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- Several Jumper wires
- 1 * RGB LED module
- 1 * 4-Pin anti-reverse cable

Experimental Principle

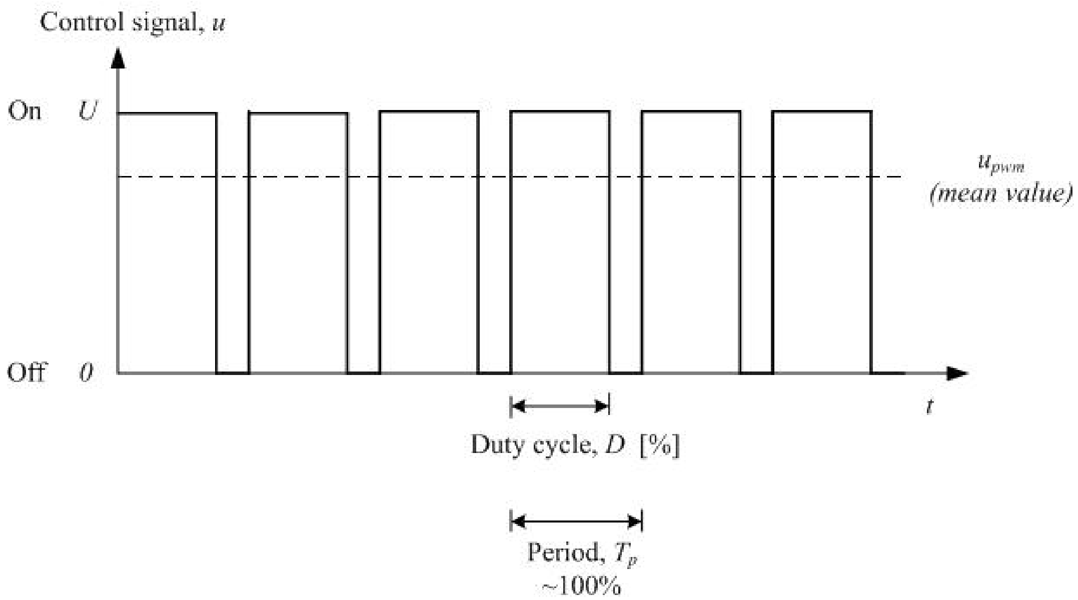
In this experiment, we will use PWM technology to control the brightness of RGB.

Pulse Width Modulation, or PWM, is a technique for getting analog results with digital means. Digital control is used to create a square wave, a signal switched between on and off. This on-off pattern can simulate voltages in between full on (5 Volts) and off (0 Volts) by changing the portion of the time the signal spends on versus the time that the signal spends off. The duration of "on time" is called the pulse width. To get varying analog values, you change, or modulate, that pulse width. If you repeat this on-off pattern fast enough with an LED for example, the result is as if the signal is a steady voltage between 0 and 5v controlling the brightness of the LED.



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 are the three basic parameters of PWM:



1. The term **duty cycle** describes the proportion of "on" time to the regular interval or "period" of time

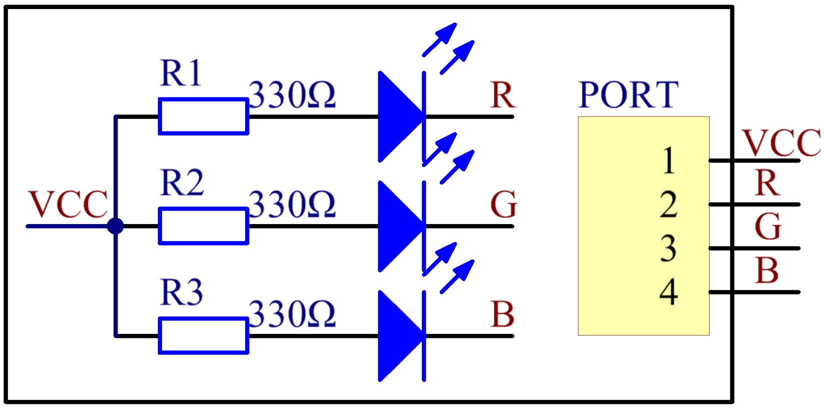
2. **Period** describes the reciprocal of pulses in one second.

3. The voltage amplitude here is 0V-5V.

Here we input any value between 0 and 255 to the three pins of the RGB LED to make it display different colors.

RGB LEDs can be categorized into common anode LED and common cathode LED. In this experiment, we use a common cathode RGB LED.

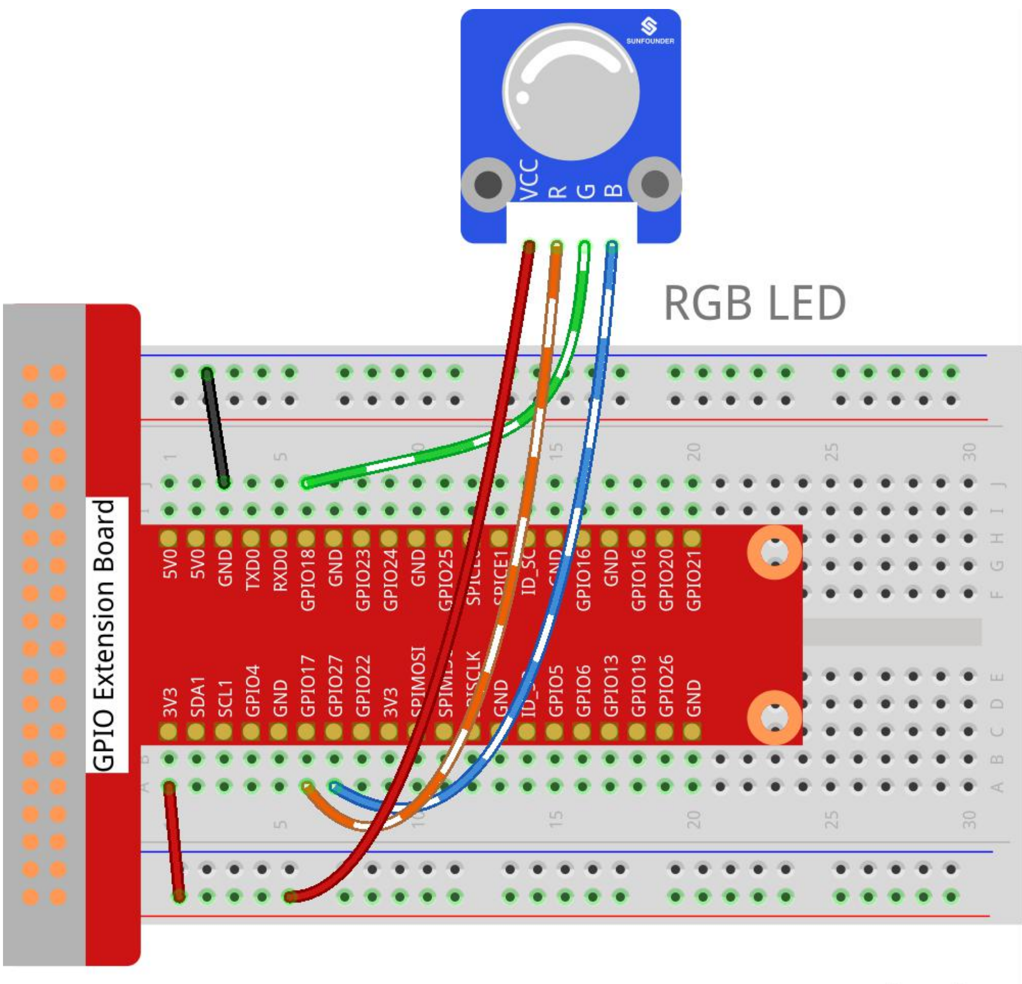
The schematic diagram of the module is as shown below:



Experimental Procedures

Step 1: Build the circuit according to the following method.

Raspberry Pi	GPIO Extension Board	RGB LED Module
3.3V	3V3	VCC
GPIO0	GPIO17	R
GPIO1	GPIO18	G
GPIO2	GPIO27	B



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/02_rgb_led/
```

Step 3: Compile.

```
gcc rgb_led.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

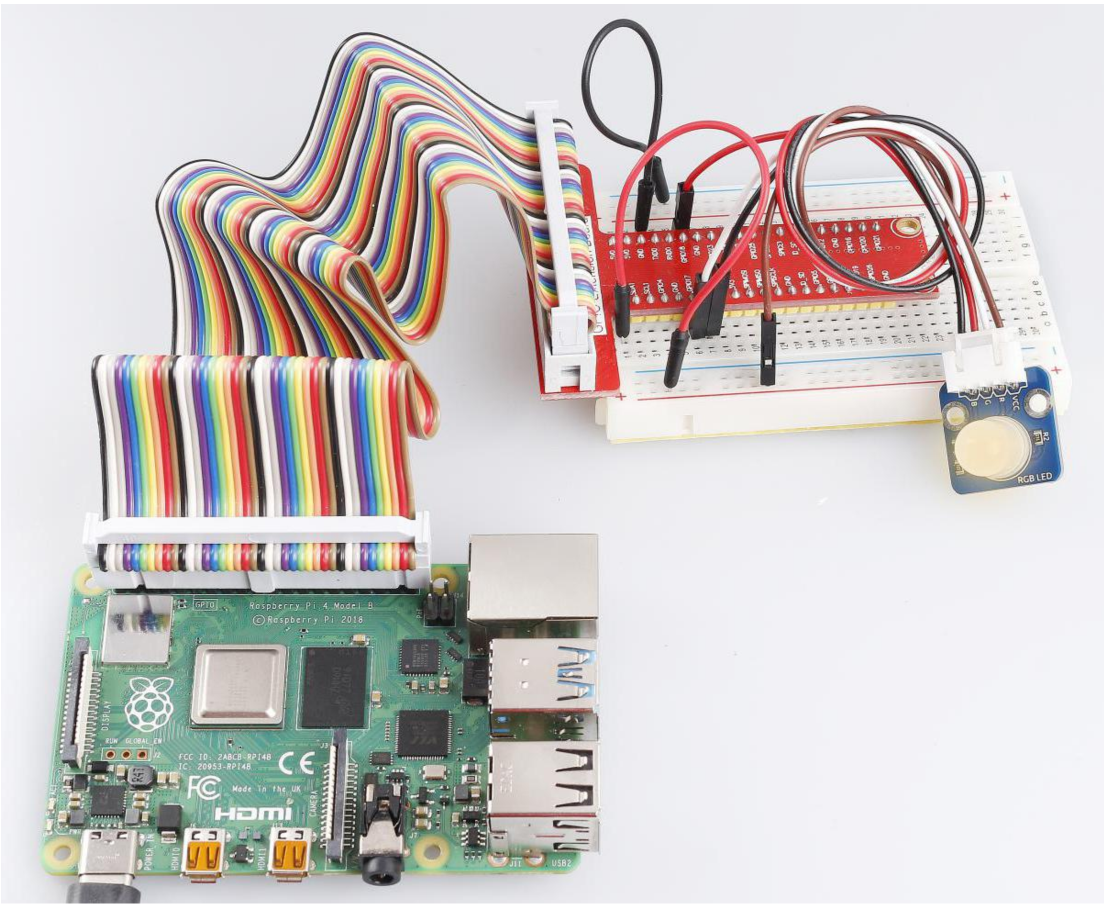
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 02_rgb_led.py
```

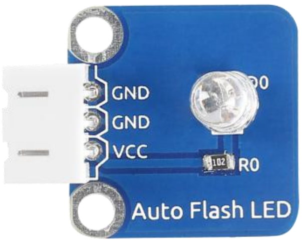
You will see the RGB LED light up, and display different colors in turn.



Lesson 3 7-Color Auto-flash LED

Introduction

On the 7-Color Auto-flash LED module, the LED can automatically flash built-in colors after power on. It can be used to make quite fascinating light effects.



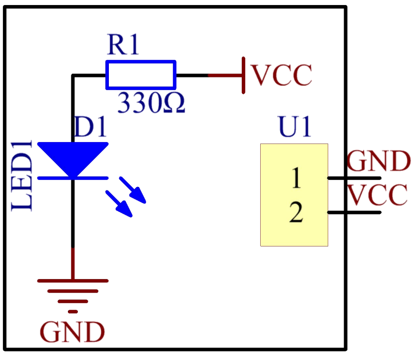
Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * 7-color auto-flash LED module
- 1 * 3-Pin anti-reverse cable

Experimental Principle

When it is power on, the 7-color auto-flash LED will flash built-in colors.

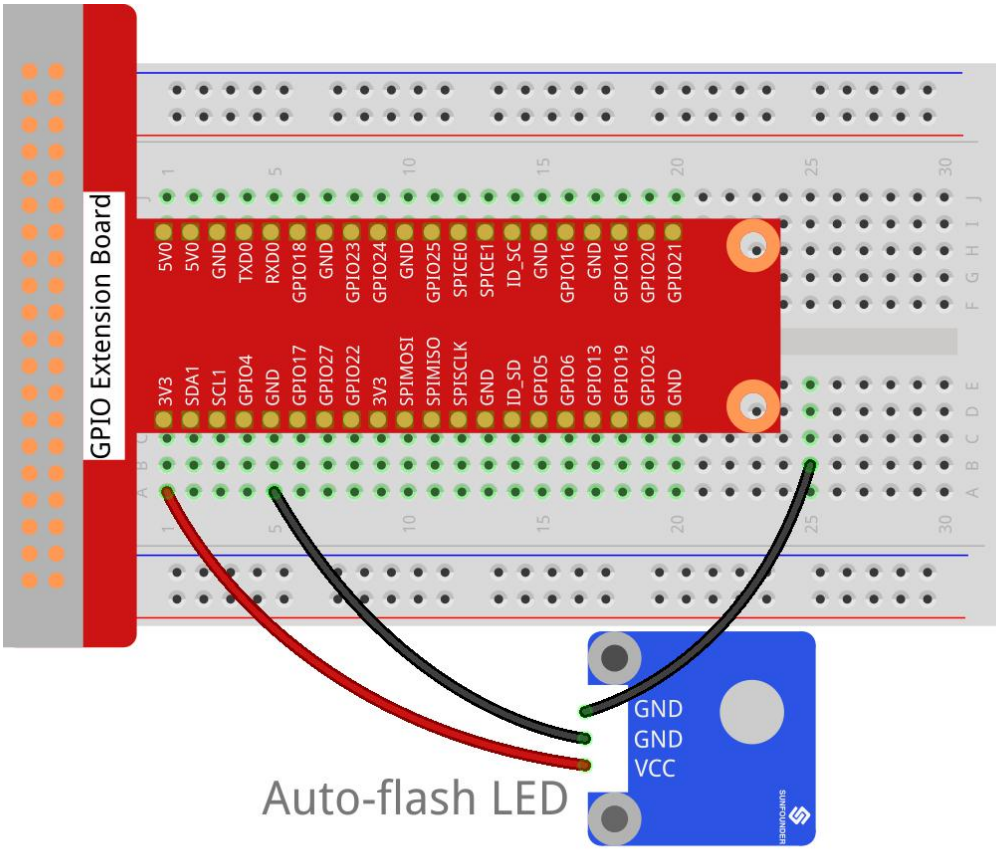
The schematic diagram of the module is as shown below:



Experimental Procedures

Build the circuit.

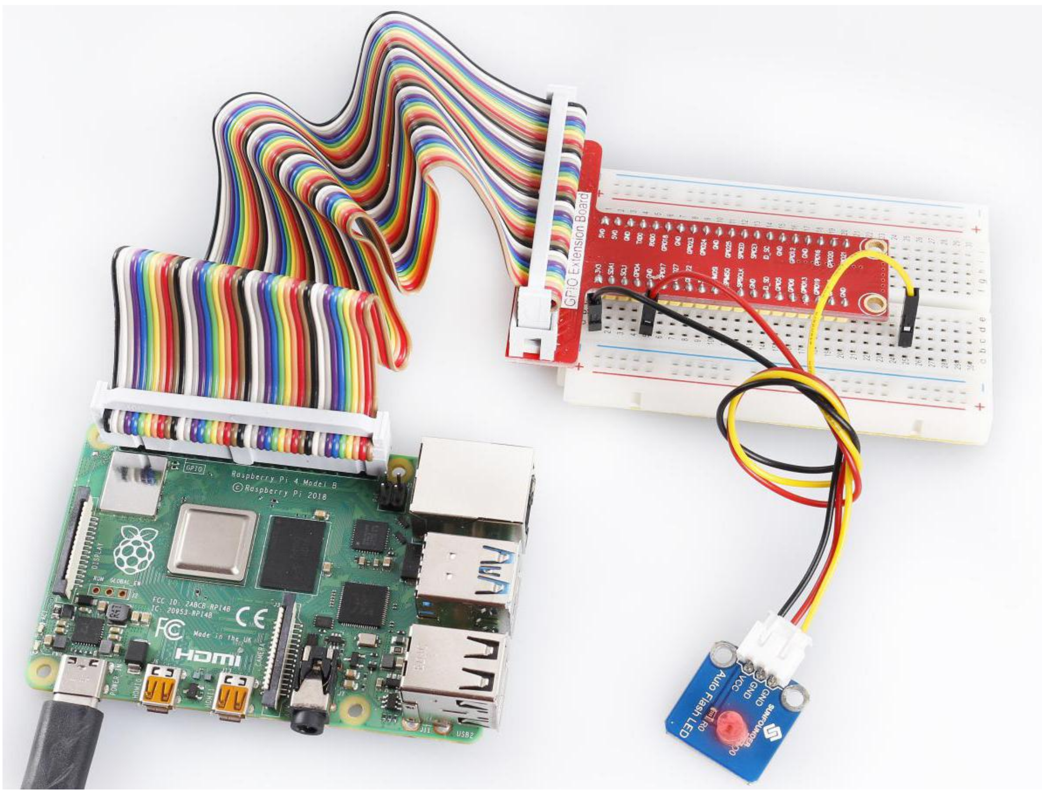
Raspberry Pi	GPIO Extension Board	Auto-flash LED Module
GND	GND	GND
3.3V	3V3	VCC



Note:

There are two "GND" pins on the module. You only need to connect one of them.

Now, you will see 7-color auto-flash LED flashing seven colors.



Lesson 4 Relay Module

Introduction

Relay is a device which is used to provide connection between two or more points or devices in response to the input signal applied. It is suitable for driving high power electric equipment, such as light bulbs, electric fans and air conditioning. You can use a relay to control high voltage with low voltage by connecting it to Raspberry Pi.

Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- Several Jumper wires
- 1 * Relay module
- 1 * Dual-color LED module
- 2 * 3-Pin anti-reverse cable

Experimental Principle

Relay

– There are 5 parts in every relay:

1. **Electromagnet** – It consists of an iron core wounded by coil of wires. When electricity is passed through, it becomes magnetic. Therefore, it is called electromagnet.

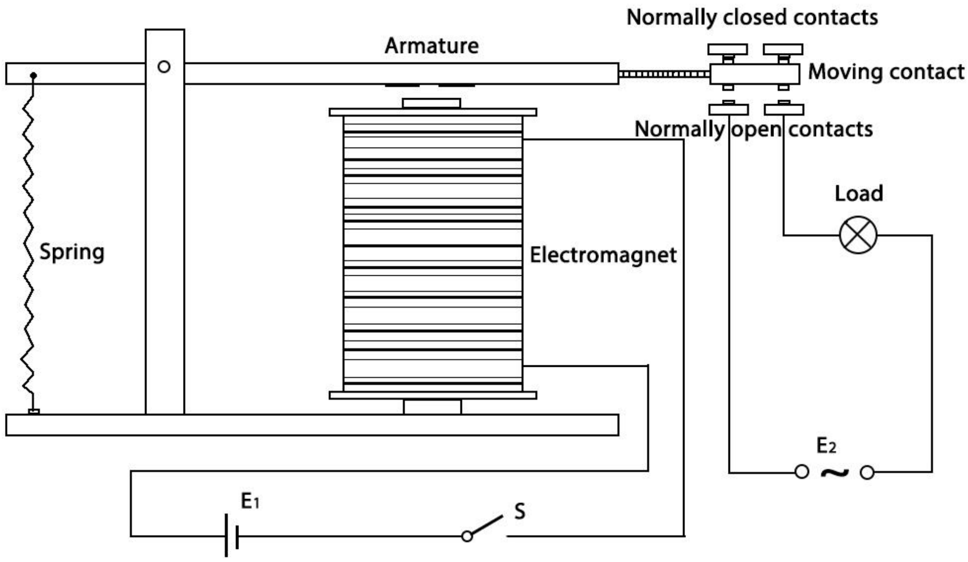
2. **Armature** – The movable magnetic strip is known as armature. When current flows through them, the coil is it energized thus producing a magnetic field which is used to make or break the normally open (N/O) or normally close (N/C) points. And the armature can be moved with direct current (DC) as well as alternating current (AC).

3. **Spring** – When no currents flow through the coil on the electromagnet, the spring pulls the armature away so the circuit cannot be completed.

4. Set of electrical **contacts** – There are two contact points:

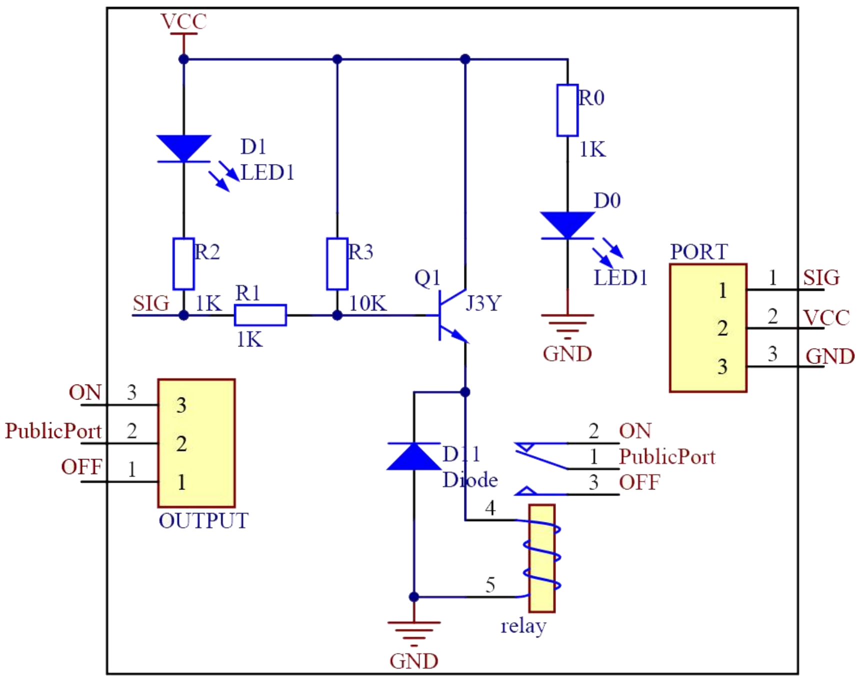
- Normally open - connected when the relay is activated, and disconnected when it is inactive.
- Normally close – not connected when the relay is activated, and connected when it is inactive.

5. Molded frame – Relays are covered with plastic for protection.



Connect the SIG pin of this module to GPIO pin. When we make GPIO pin output high level (3.3V) by programming, the transistor will conduct because of current saturation. The normally open contact of the relay will be closed, while the normally closed contact of the relay will be broken; when we make it output low level (0V), the transistor will be cut off, and the relay will recover to initial state.

The schematic diagram of the module is as shown below:

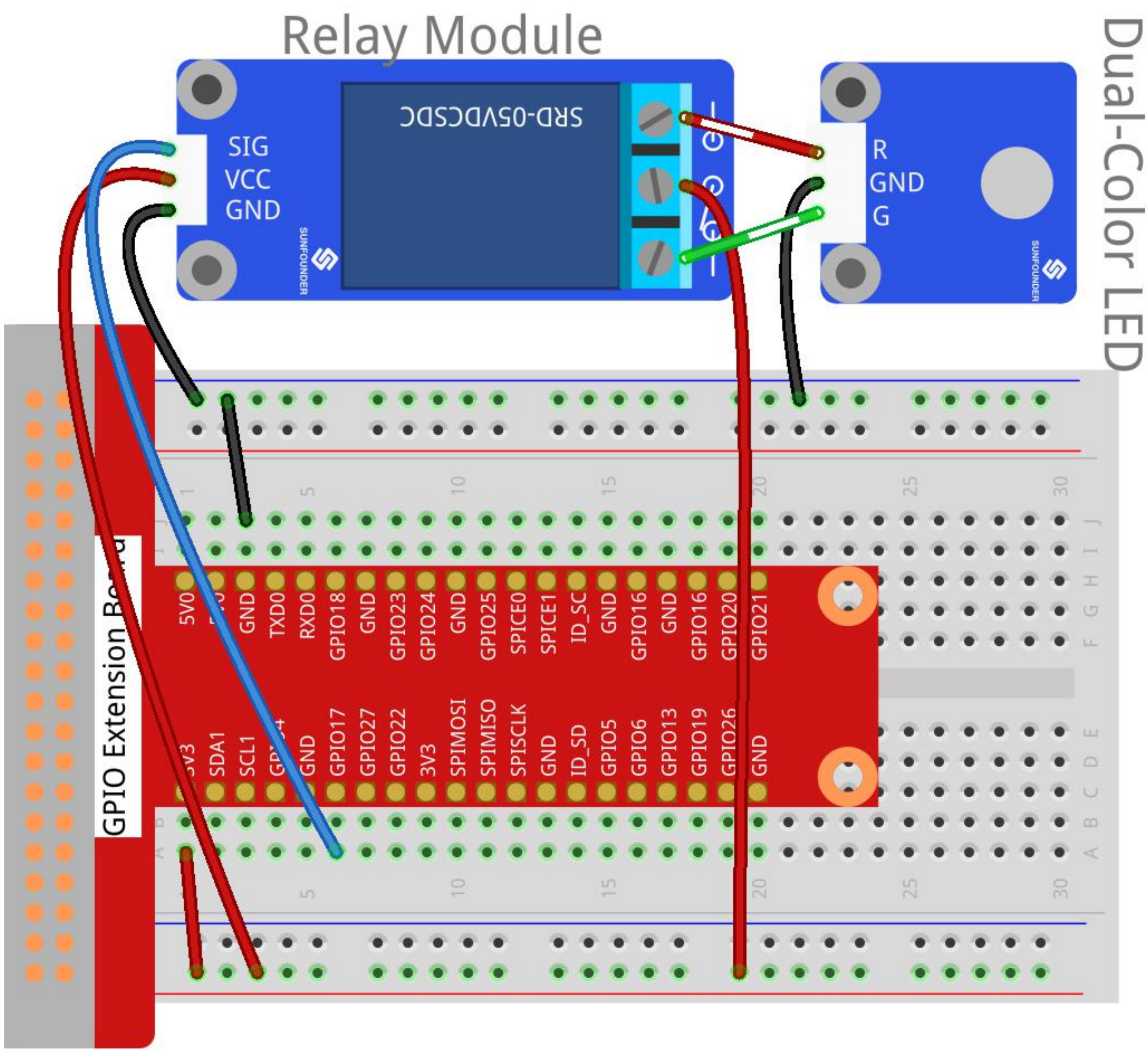


Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	Relay Module
GPIO0	GPIO17	SIG
3.3V	3V3	VCC
GND	GND	GND
3.3V	3V3	COM

Dual-color LED Module	GPIO Extension Board	Relay Module
R	*	Normal Open
GND	GND	*
G	*	Normal Close



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/04_relay/
```

Step 3: Compile.

```
gcc relay.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

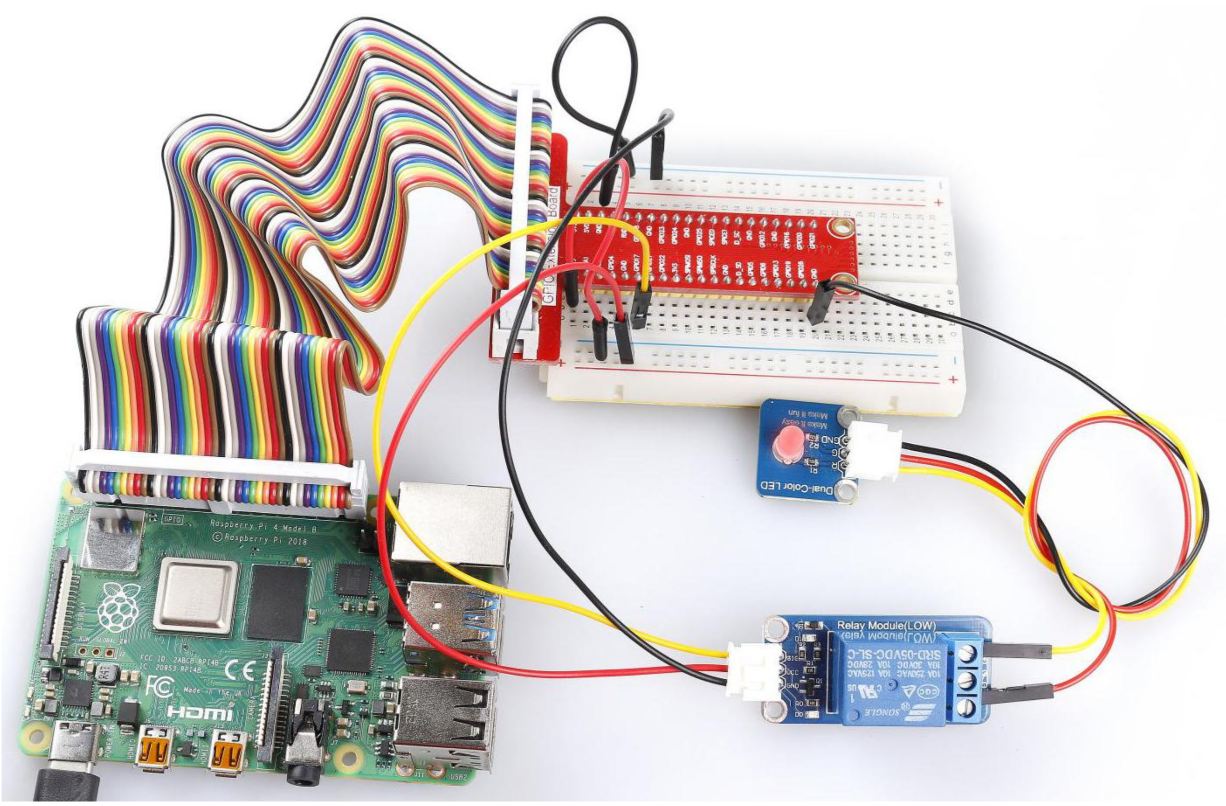
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 04_relay.py
```

Now, you may hear the ticktock. That's the normally closed contact opened and the normally open contact closed. You can attach a high voltage device you want to control, like a 220V bulb, to the output port of the relay. Then the relay will act as an automatic switch.



Lesson 5 Laser Emitter Module

Introduction

Laser is widely used in medical treatment, military, and other fields due to its good directivity and energy concentration.

Required Components

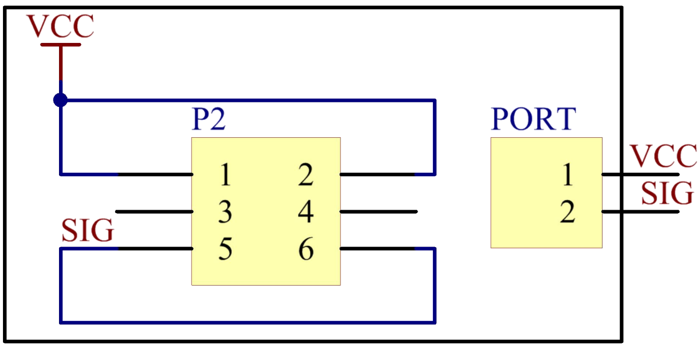
- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * Laser Emitter module
- 1 * 2-Pin anti-reverse cable

Experimental Principle

A laser is a device that emits light through a process of optical amplification based on the stimulated emission of electromagnetic radiation. Lasers differ from other sources of light because they emit light coherently.

Spatial coherence allows a laser to be focused to a tight spot, enabling applications like laser cutting and lithography, and a laser beam to stay narrow over long distances (collimation), enabling applications like laser pointers. Lasers can also have high temporal coherence which allows them to have a very narrow spectrum, i.e., they only emit light of a single color. And its temporal coherence can be used to produce pulses of light—as short as a femtosecond.

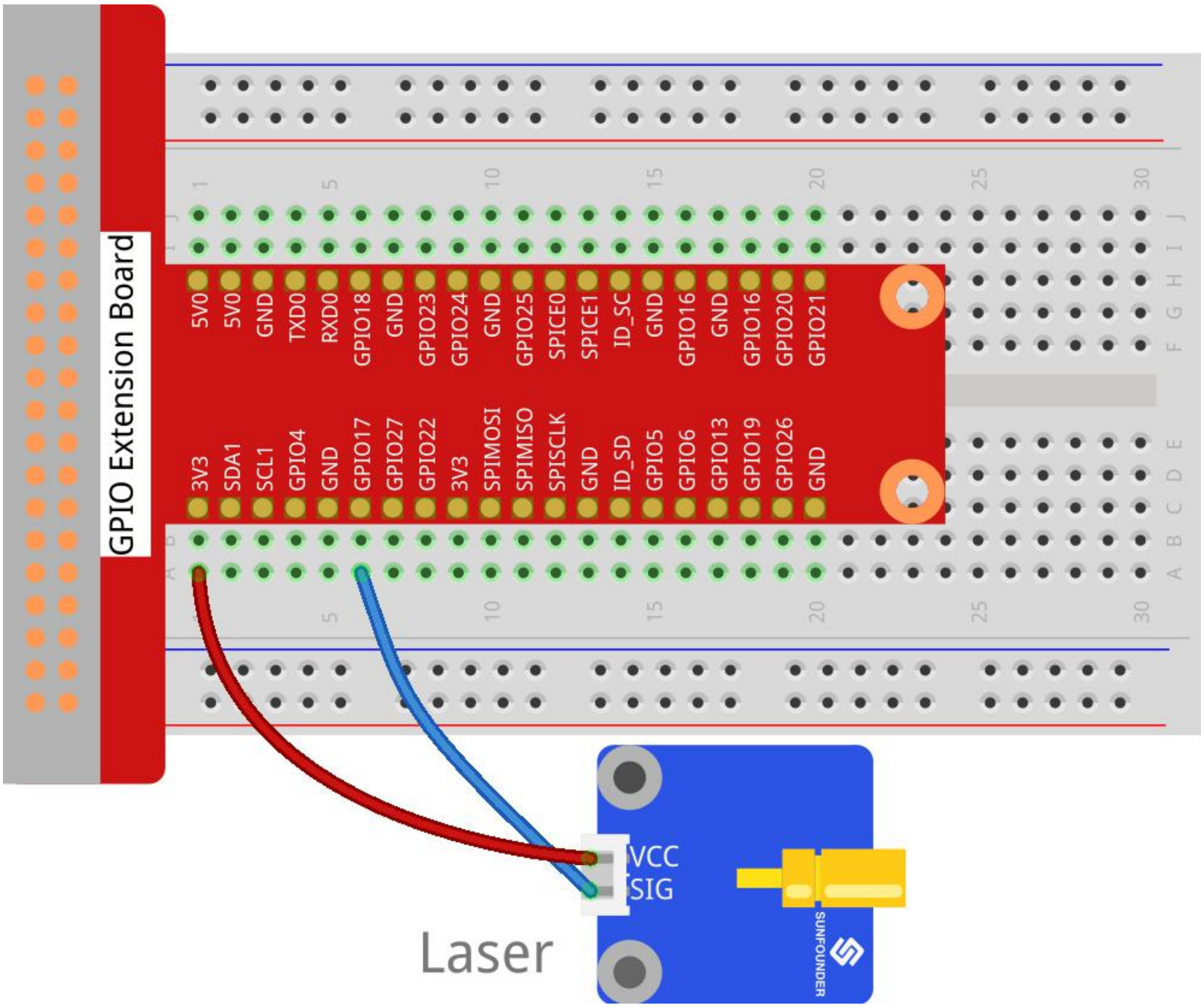
The schematic diagram of the module is as shown below:



Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	Laser Emitter Module
3.3V	3V3	VCC
GPIO0	GPIO17	SIG



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/05_laser/
```

Step 3: Compile.

```
gcc laser.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

Step 2: Change directory.

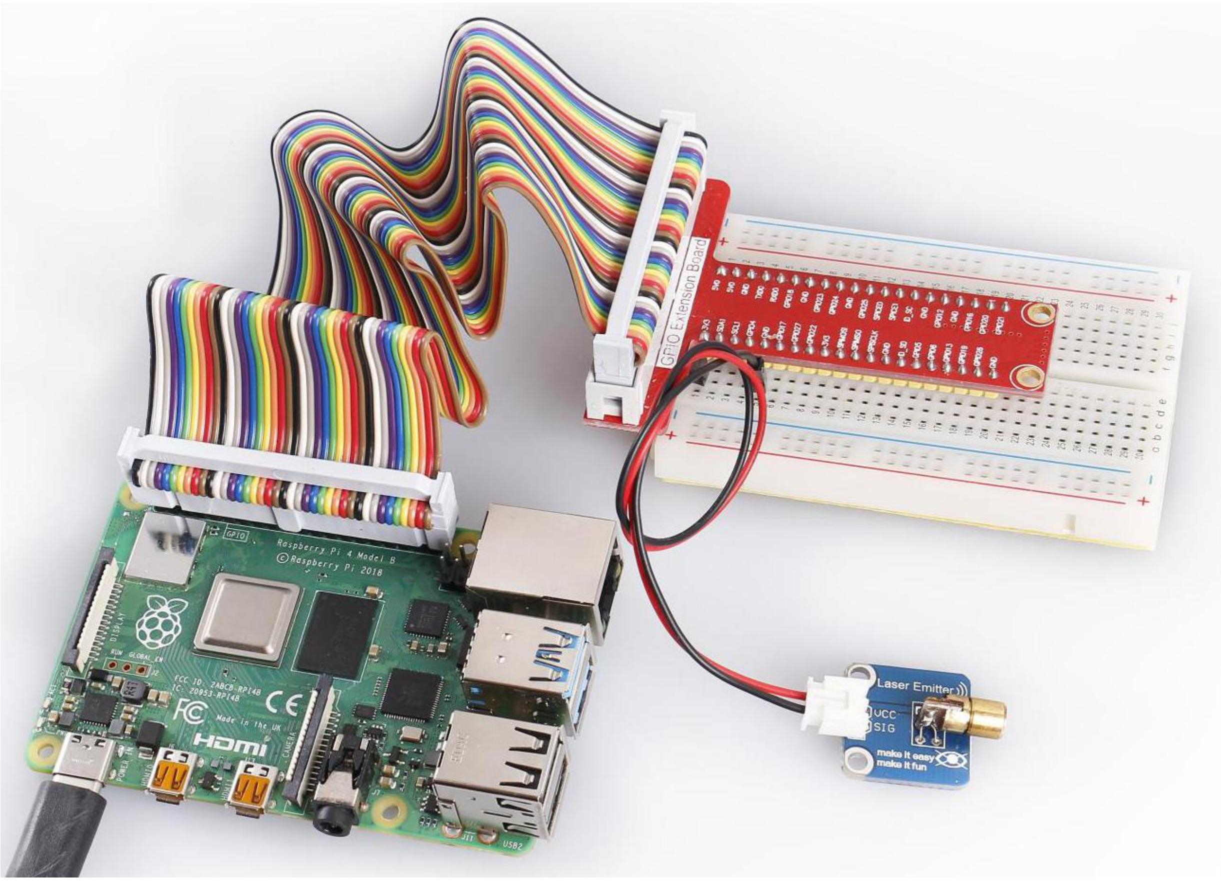
```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 05_laser.py
```

Now you can see the module send out Morse signals.

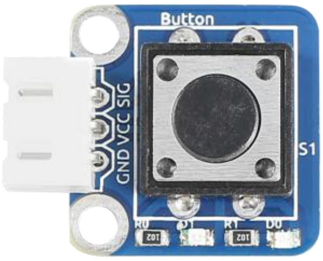
Note: DO NOT look directly at the laser head. It can cause great harm to your eyes. You can point the laser beam to the table and see the light spot flashing on the table.



Lesson 6 Button Module

Introduction

In this lesson, we will use button module to control a dual-color LED module.



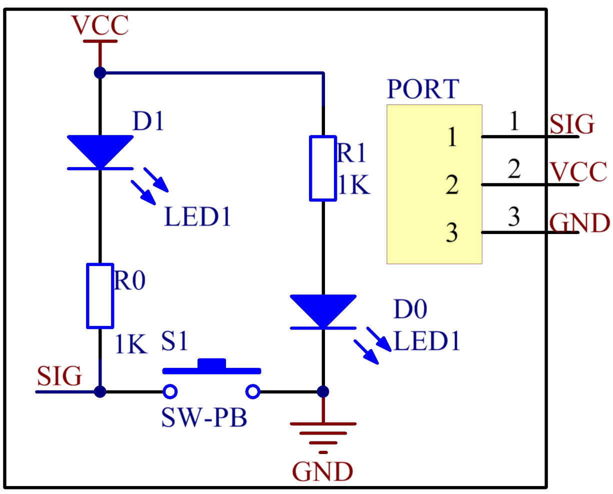
Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- Several Jumper wires
- 1 * Button module
- 1 * Dual-color LED module
- 2 * 3-Pin anti-reverse cable

Experimental Principle

Use a normally open button as an input device of Raspberry Pi. When the button is pressed, the General Purpose Input/Output (GPIO) connected to the button will change to low level (0V). You can detect the state of the GPIO through programming. That is, if the GPIO turns into low level, it means the button is pressed, so you can run the corresponding code. In this experiment, we will print a string on the screen and control an LED.

The schematic diagram of the module is as shown below:

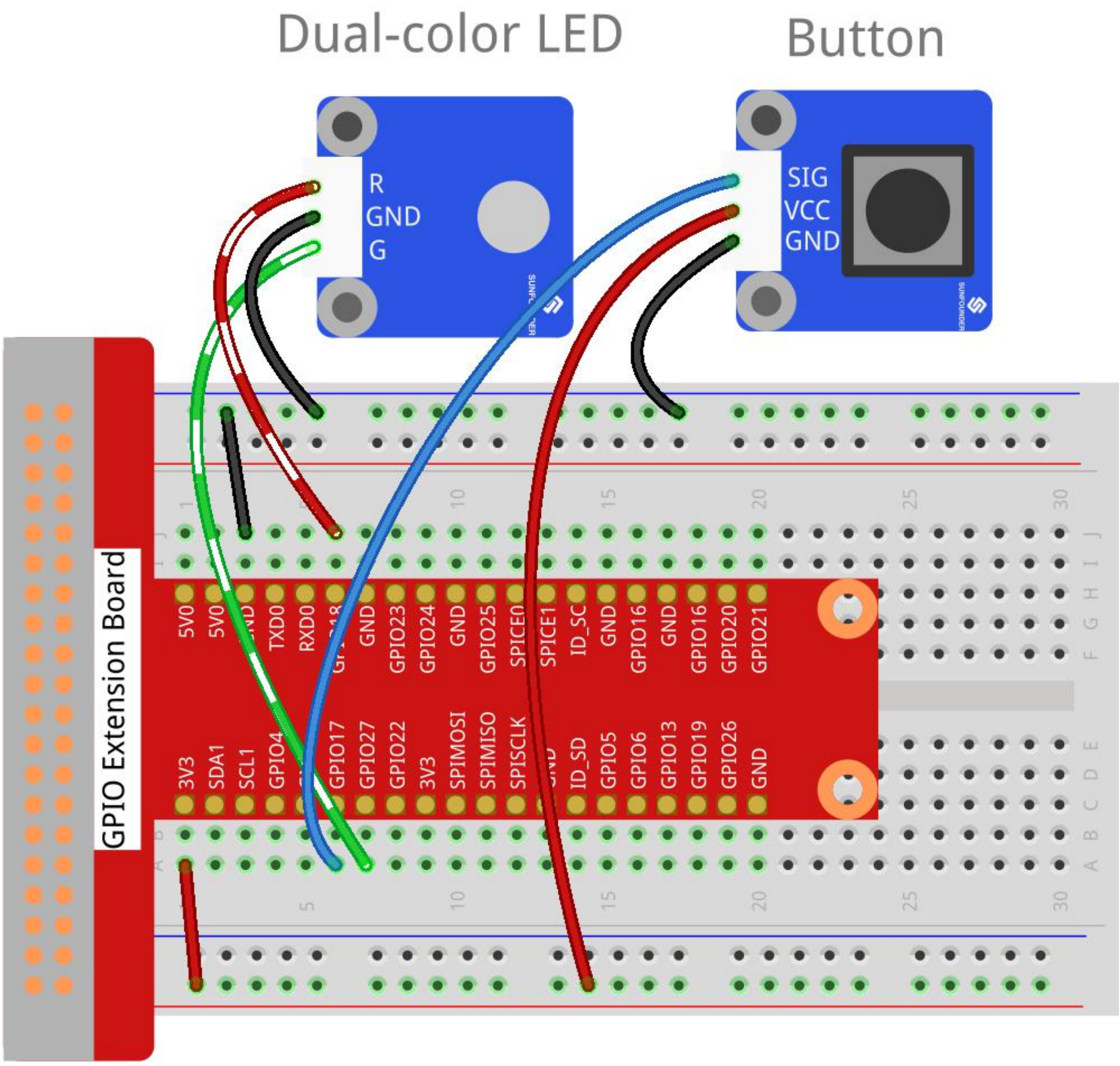


Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	Button Module
GPIO0	GPIO17	SIG
3.3V	3V3	VCC
GND	GND	GND

Raspberry Pi	GPIO Extension Board	Dual-Color LED Module
GPIO1	GPIO18	R
GND	GND	GND
GPIO2	GPIO27	G



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/06_button/
```

Step 3: Compile.

```
gcc button.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

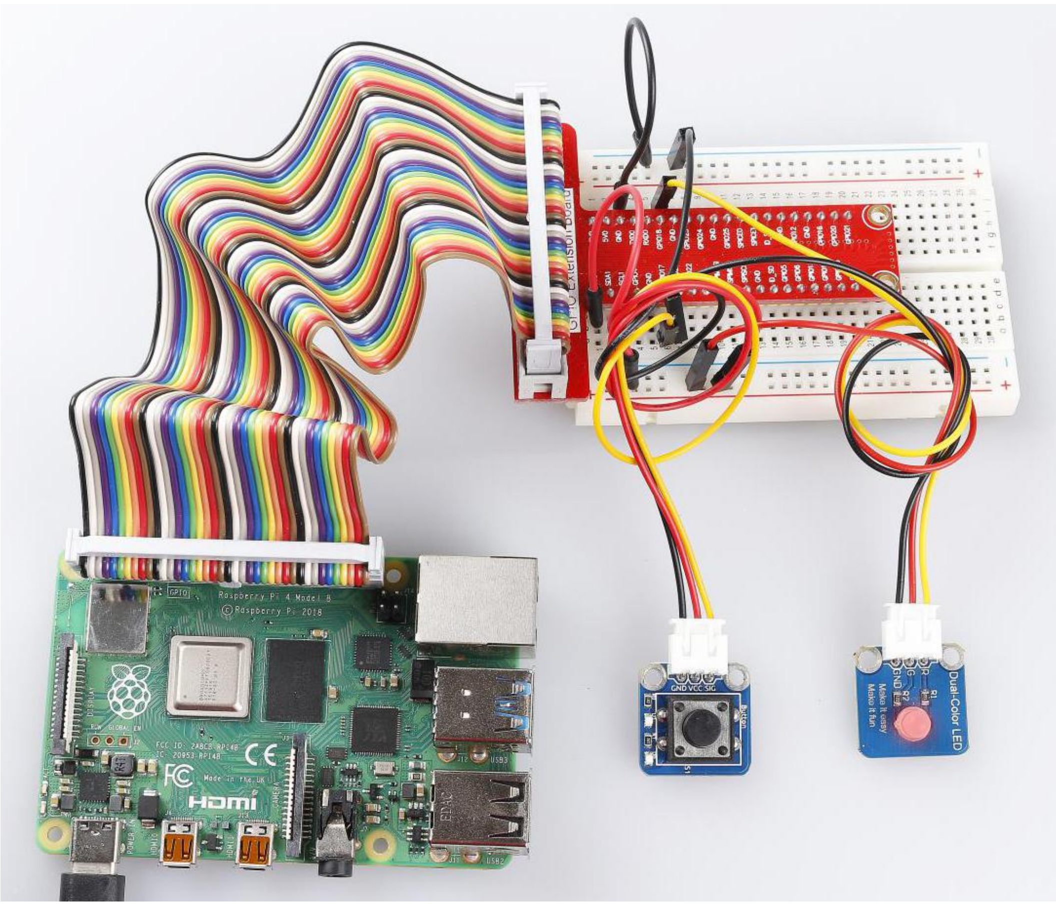
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 06_button.py
```

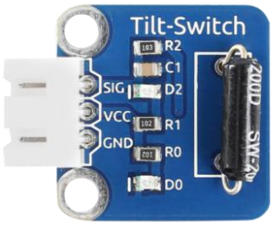
The LED on the module will emit green light. If you press the button, "Button pressed" will be printed on the screen and the LED will emit red light. If you release the button, "Button released" will be printed on the screen and the LED will flash green again.



Lesson 7 Tilt-Switch Module

Introduction

The tilt-switch module (as shown below) in this kit is a ball tilt-switch with a metal ball inside. It is used to detect inclinations of a small angle.



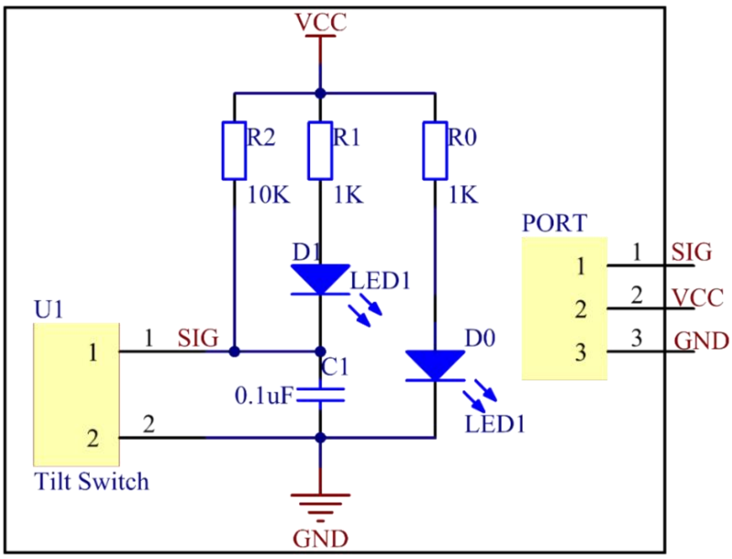
Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * Dual-color LED module
- 1 * Tilt-switch module
- 2 * 3-Pin anti-reverse cable

Experimental Principle

The principle is very simple. The ball in the tilt-switch changes with different angle of inclination to trigger the circuit. When the ball in tilt switch runs from one end to the other end due to shaking caused by external force, the tilt switch will conduct and the LED will emit red light, otherwise it will break and the LED will emit green light.

The schematic diagram of the module is as shown below:

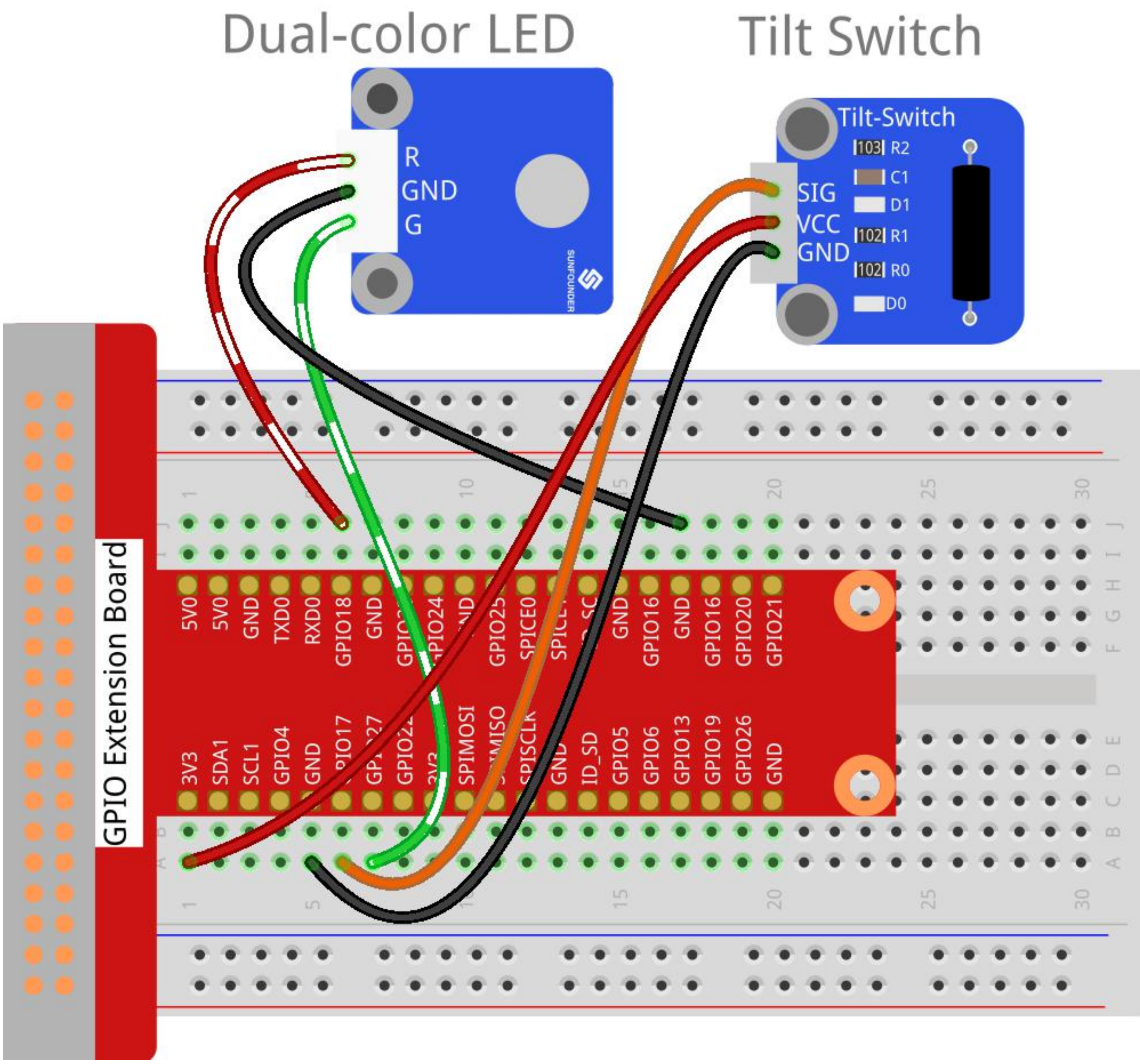


Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	Tilt Switch Module
GPIO0	GPIO17	SIG
3.3V	3V3	VCC
GND	GND	GND

Raspberry Pi	GPIO Extension Board	Dual-Color LED Module
GPIO1	GPIO18	R
GND	GND	GND
GPIO2	GPIO27	G



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/07_tilt_switch/
```

Step 3: Compile.

```
gcc tilt_switch.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

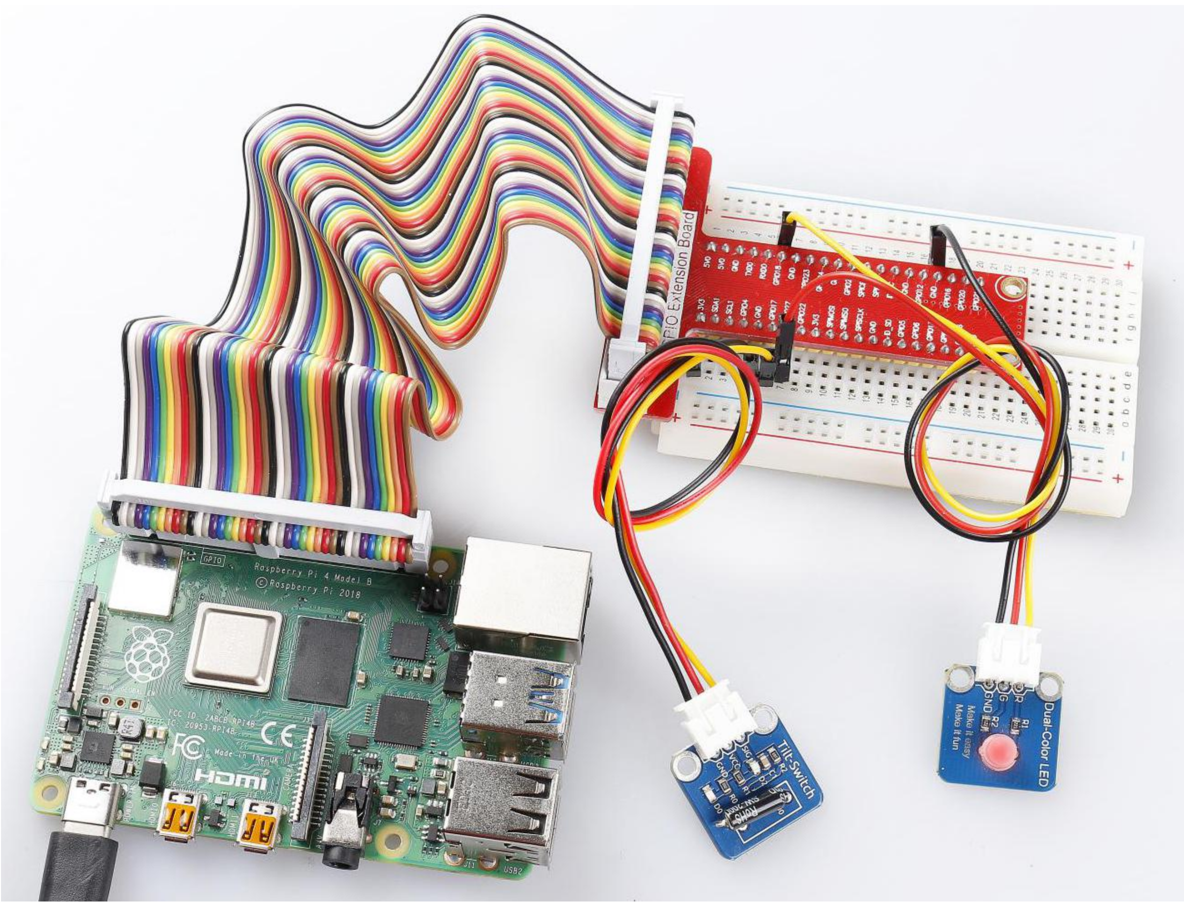
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

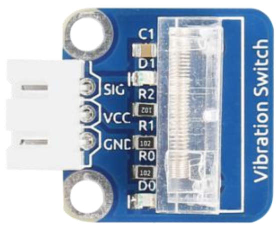
```
sudo python3 07_tilt_switch.py
```

Place the tilt switch module horizontally, and the LED will flash green. If you tilt it, "Tilt!" will be printed on the screen and the LED will change to red. Place it horizontally again, and the LED will flash green again.



Lesson 8 Vibration Switch

Introduction



A vibration switch, also called spring switch or shock sensor, is an electronic switch which induces shock force and transfers the result to a circuit device thus triggering it to work. It contains the following parts: conductive vibration spring, switch body, trigger pin, and packaging agent.

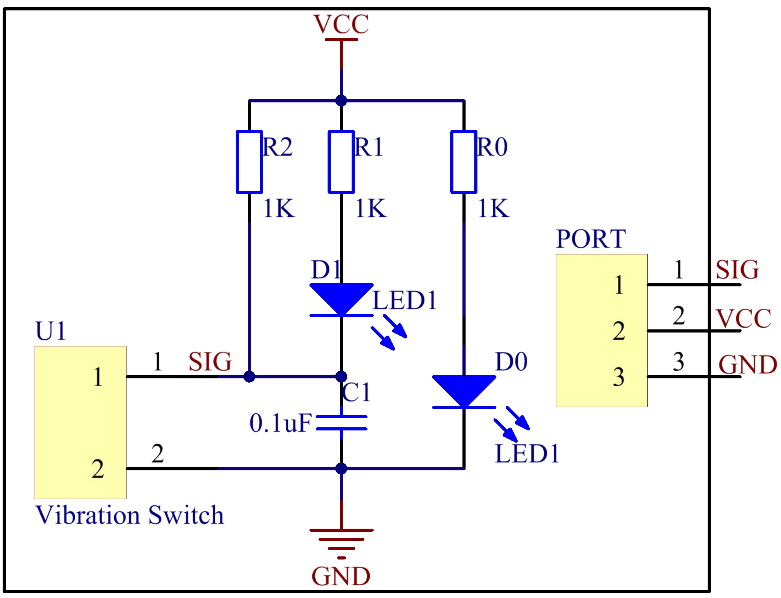
Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * Dual-color LED module
- 1 * Vibration switch module
- 2 * 3-Pin anti-reverse cable

Experimental Principle

In a vibration switch module, the conductive vibration spring and trigger pin are precisely placed in the switch and fixed by adhesive. Normally, the spring and the trigger pin are separated. Once the sensor detects shock, the spring will vibrate and contact with the trigger pin, thus conducting and generating trigger signals.

In this experiment, connect a dual-color LED module to the Raspberry Pi to indicate the changes. When you knock or tap the vibration sensor, it will get turned on and the dual-color LED will flash red. Tap it again and the LED will change to green – just between the two colors for each tap or knock. The schematic diagram:

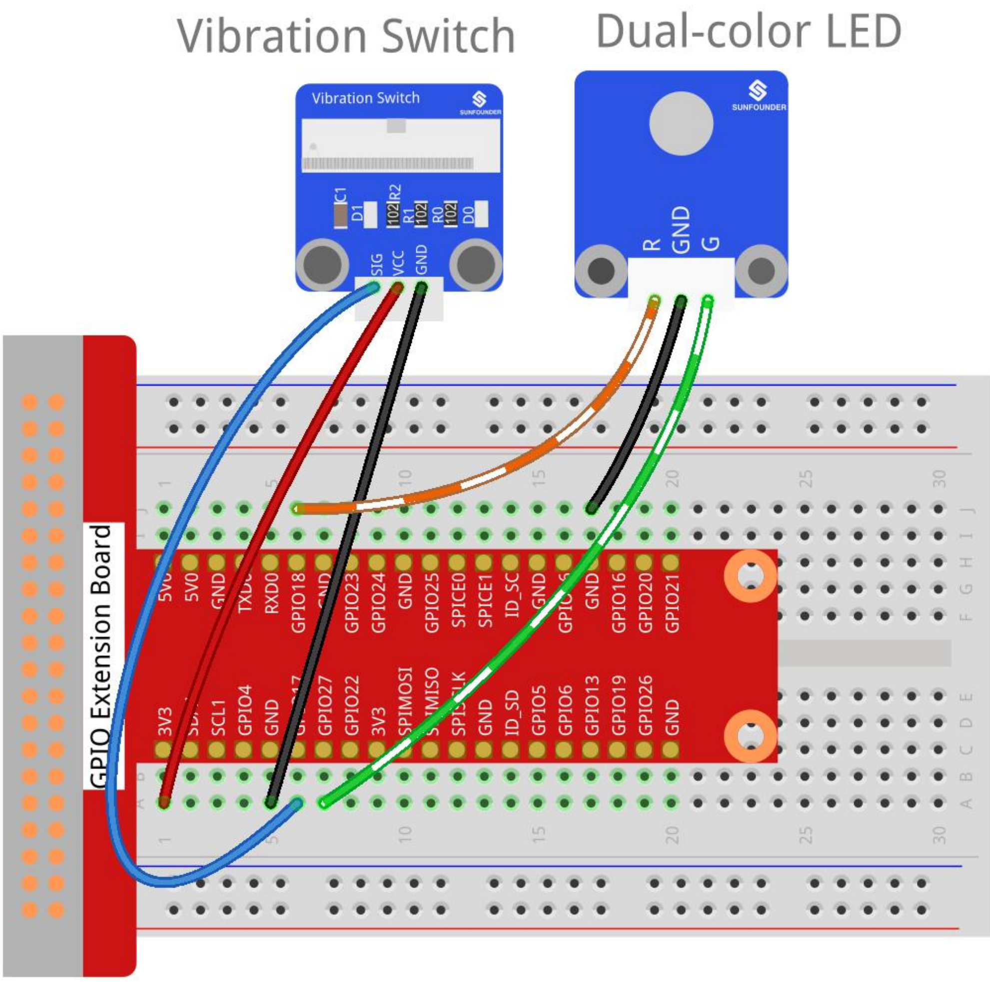


Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	Vibration Switch Module
GPIO0	GPIO17	SIG
3.3V	3V3	VCC
GND	GND	GND

Raspberry Pi	GPIO Extension Board	Dual-Color LED Module
GPIO1	GPIO18	R
GND	GND	GND
GPIO2	GPIO27	G



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/08_vibration_switch/
```

Step 3: Compile.

```
gcc vibration_switch.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

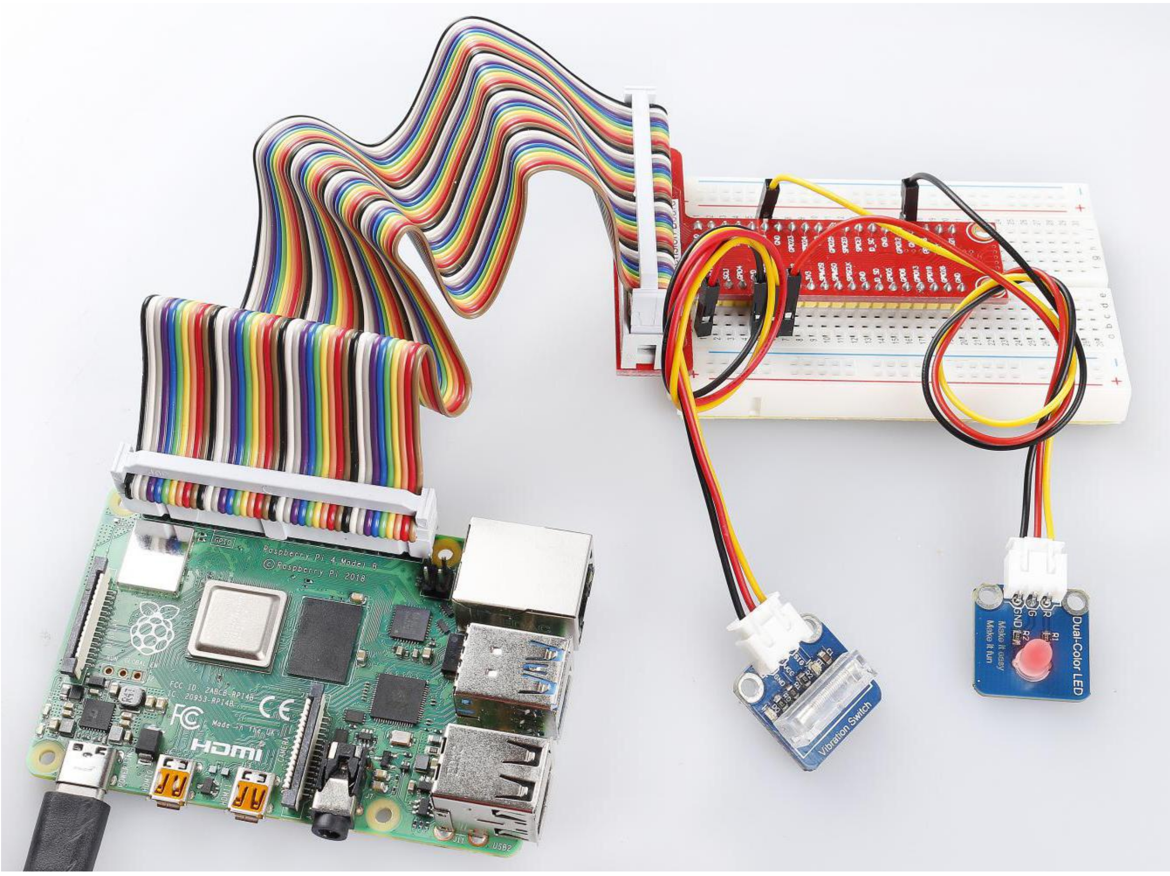
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 08_vibration_switch.py
```

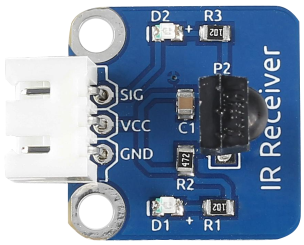
Now tap or knock the module and you can see the dual-color LED flash red. Tap the sensor again, and the LED will change to green. Each tap or knock would make it change between red and green.



Lesson 9 IR Receiver Module

Introduction

An infrared-receiver (as shown below) is a component which receives infrared signals and can independently receive infrared rays and output signals compatible with TTL level. It is similar with a normal plastic-packaged transistor in size and is suitable for all kinds of infrared remote control and infrared transmission.



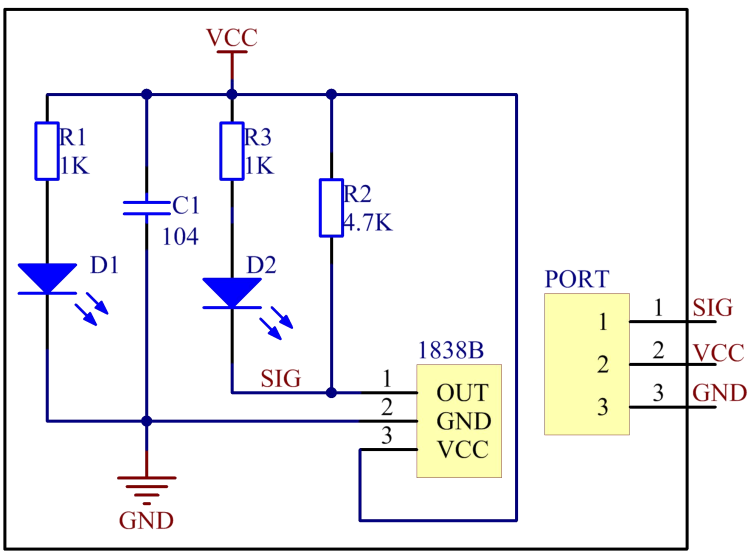
Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * IR receiver module
- 1 * IR Remote Controller
- 1 * 3-Pin anti-reverse cable

Experimental Principle

In this experiment, send signals to IR receiver by pressing buttons on the IR remote controller. The counter will add 1 every time it receives signals; in other words, the increased number indicates IR signals are received.

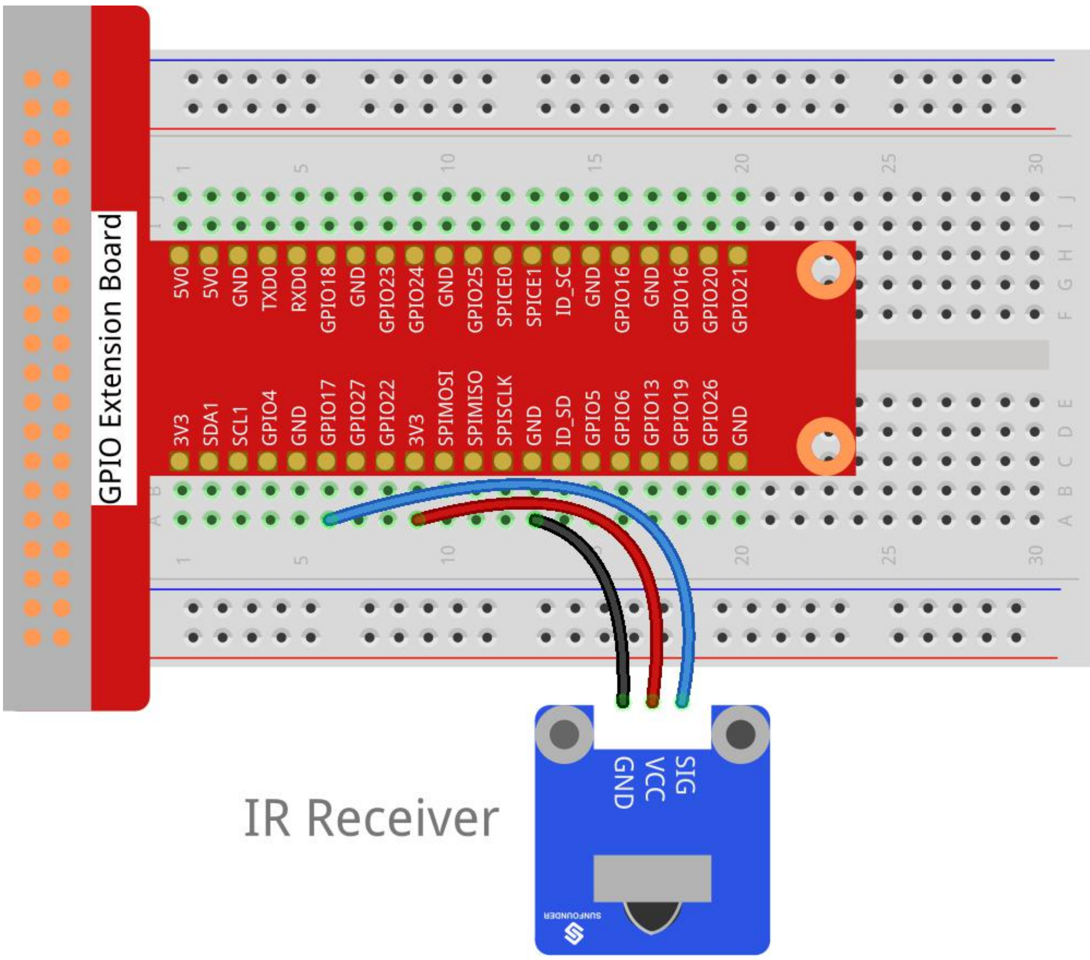
The schematic diagram of the module is as shown below:



Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	IR Receiver Module
GPIO0	GPIO17	SIG
3.3V	3V3	VCC
GND	GND	GND



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/09_ir_receiver/
```

Step 3: Compile.

```
gcc ir_receiver.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

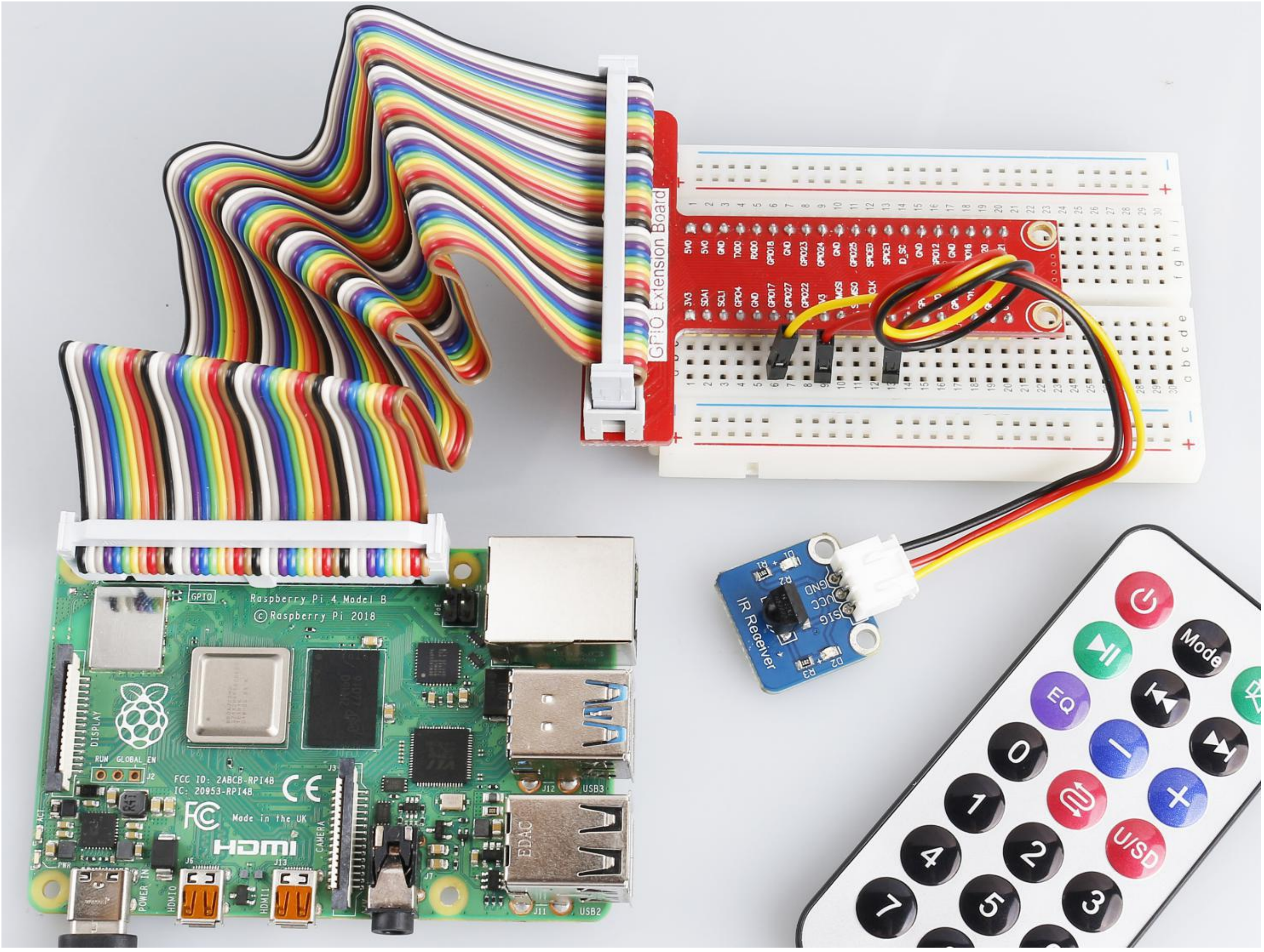
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 09_ir_receiver.py
```

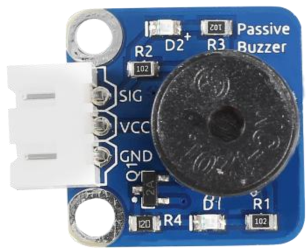
Press any key of the remote. Then you can see the LED on the module blinking, and "Received infrared. cnt = xxx" printed on the screen. ""xxx" means the time you pressed the key(s).



Lesson 10 Buzzer Module

Introduction

Buzzers can be categorized as active and passive ones (See the following picture).



Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * Passive buzzer module
- 1 * Active buzzer module
- 1 * 3-Pin anti-reverse cable

Experimental Principle

Place the pins of two buzzers face up and you can see the one with a green circuit board is a passive buzzer, while the other with a black tape, instead of a board, is an active buzzer.

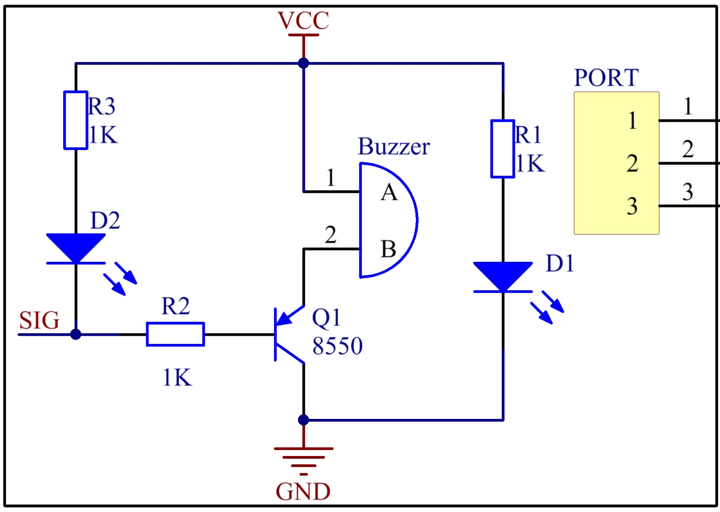
Active buzzer

Passive buzzer

The difference between an active buzzer and a passive buzzer is:

An active buzzer has a built-in oscillating source, so it will make sounds when electrified. But a passive buzzer does not have such source, so it will not beep if DC signals are used; instead, you need to use square waves whose frequency is between 2K and 5K to drive it. The active buzzer is often more expensive than the passive one because of multiple built-in oscillating circuits.

The schematic diagram of the module is as shown below:



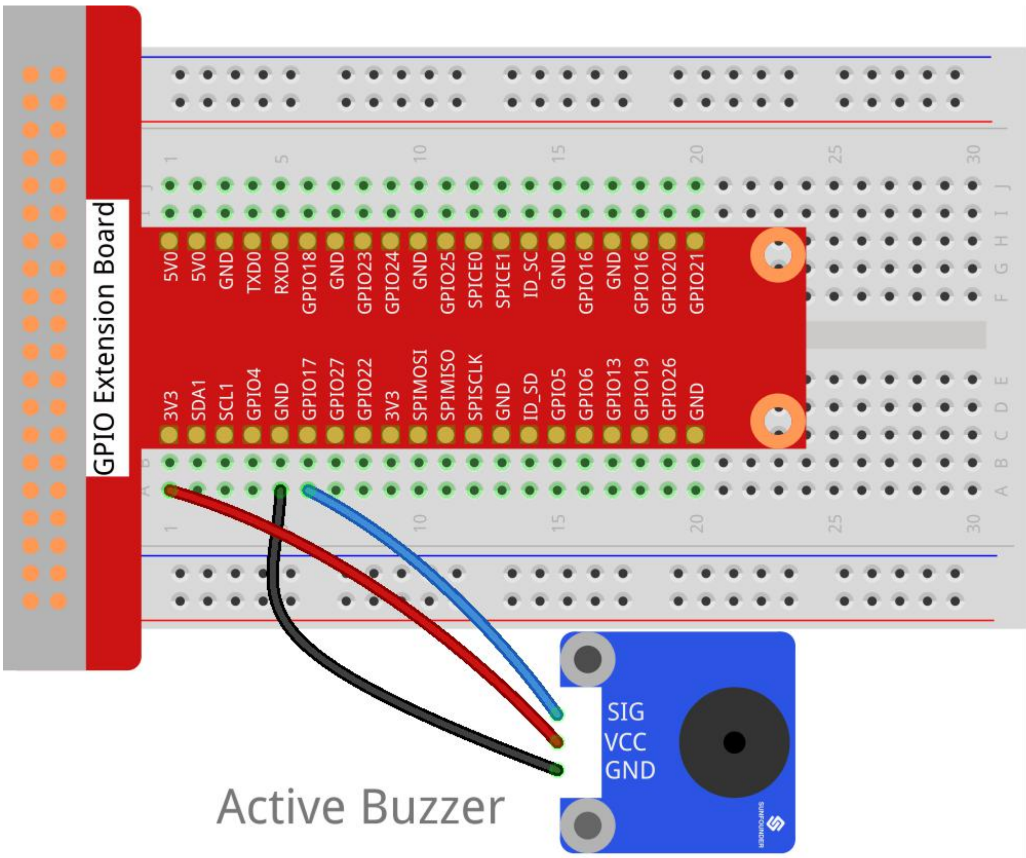
Experimental Procedures

Active Buzzer

Note:

The active buzzer has built-in oscillating source, so it will beep as long as it is wired up, but it can only beep with fixed frequency.

Step 1: Build the circuit.



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/10_active_buzzer/
```

Step 3: Compile.

```
gcc active_buzzer.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

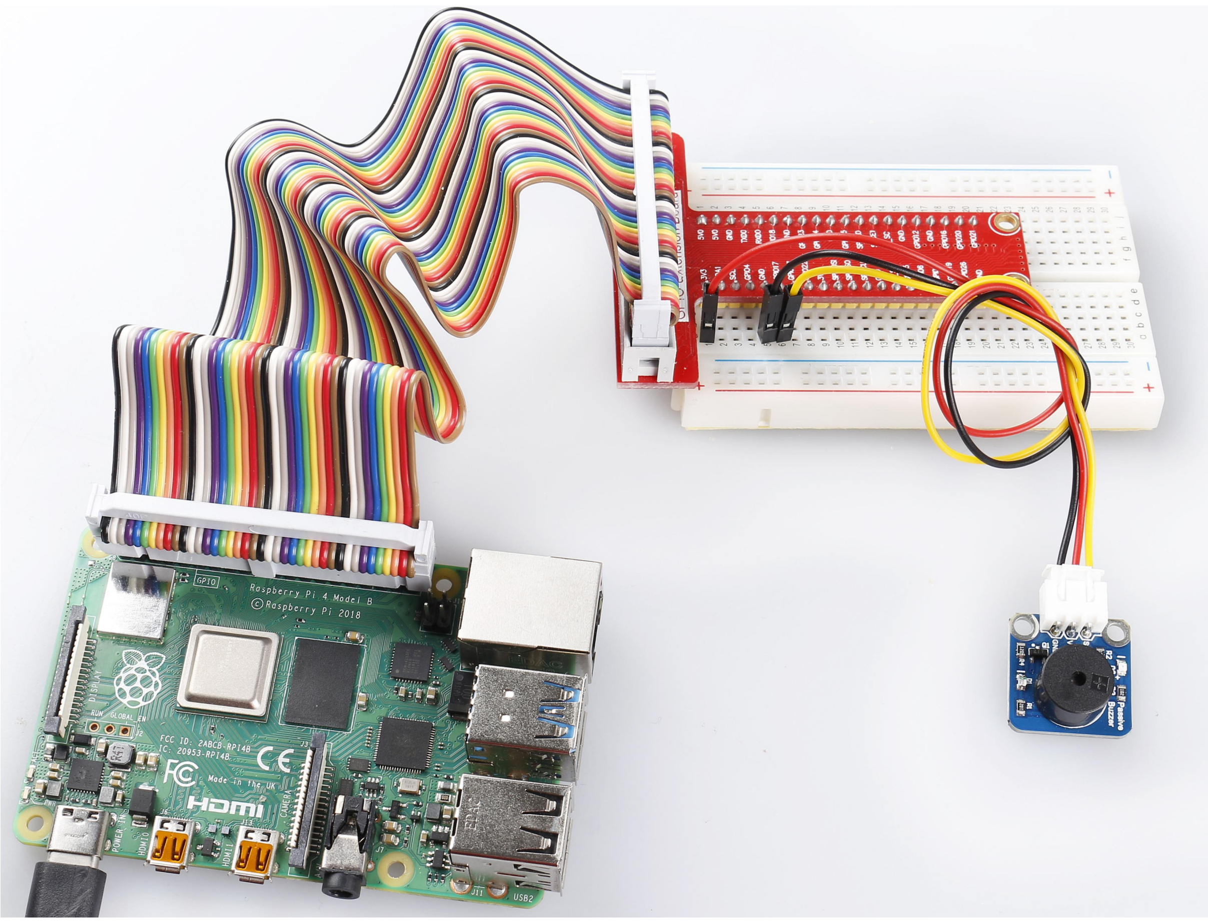
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 10_active_buzzer.py
```

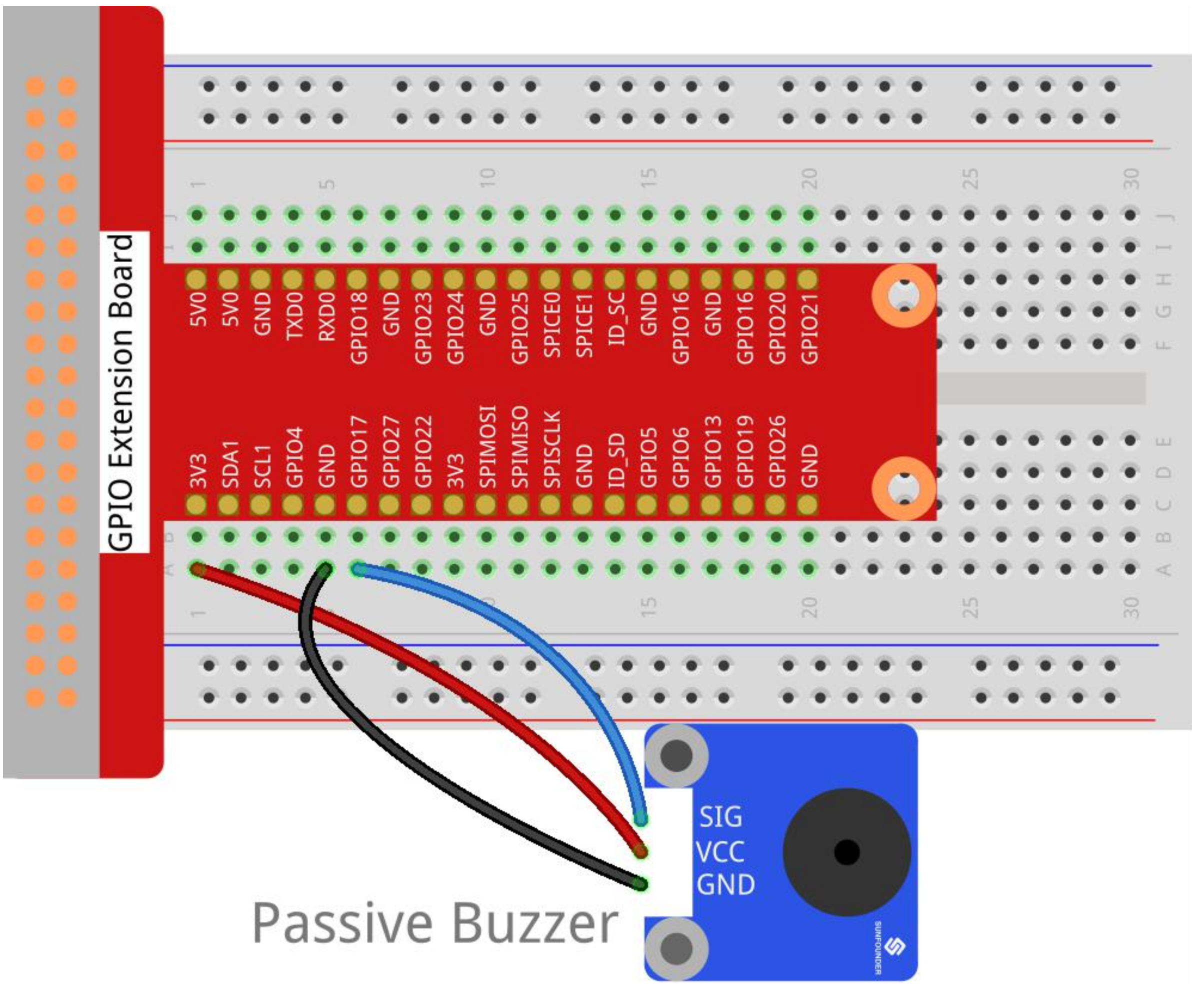
Now you can hear the active buzzer beeping.



Passive Buzzer

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	Passive Buzzer Module
GPIO0	GPIO17	SIG
3.3V	3V3	VCC
GND	GND	GND



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/10_passive_buzzer/
```

Step 3: Compile.

```
gcc passive_buzzer.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

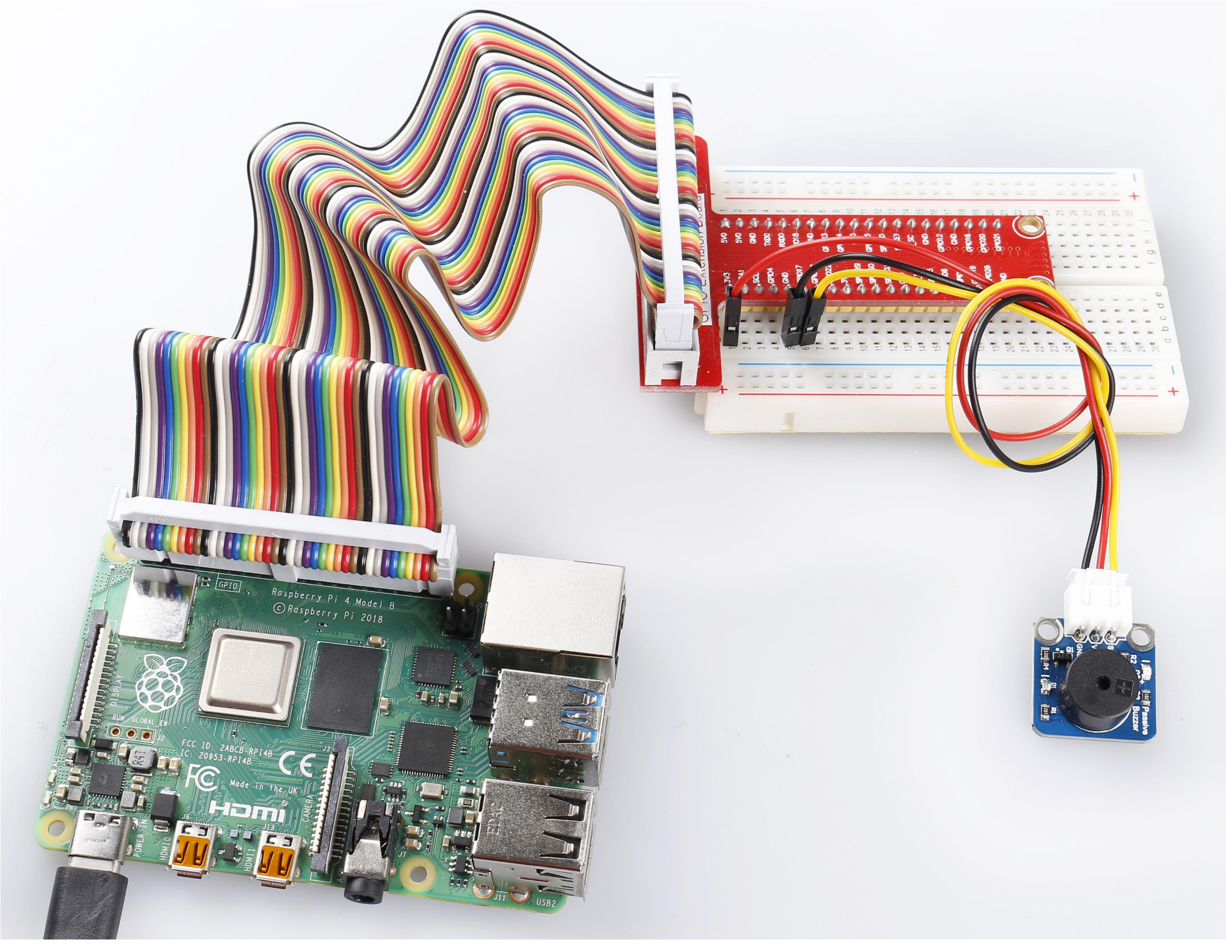
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 10_passive_buzzer.py
```

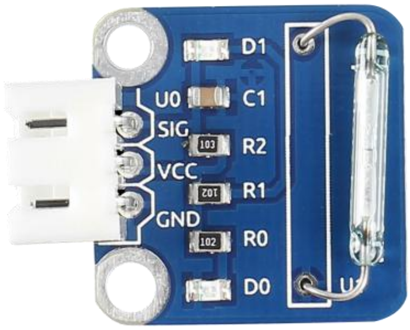
Now you can hear the passive buzzer playing music.



Lesson 11 Reed Switch

Introduction

A reed switch (as shown below) is used to detect the magnetic field. Hall sensors are generally used to measure the speed of intelligent vehicles and count in assembly lines, while reed switches are often used to detect the existence of a magnetic field.



Required Components

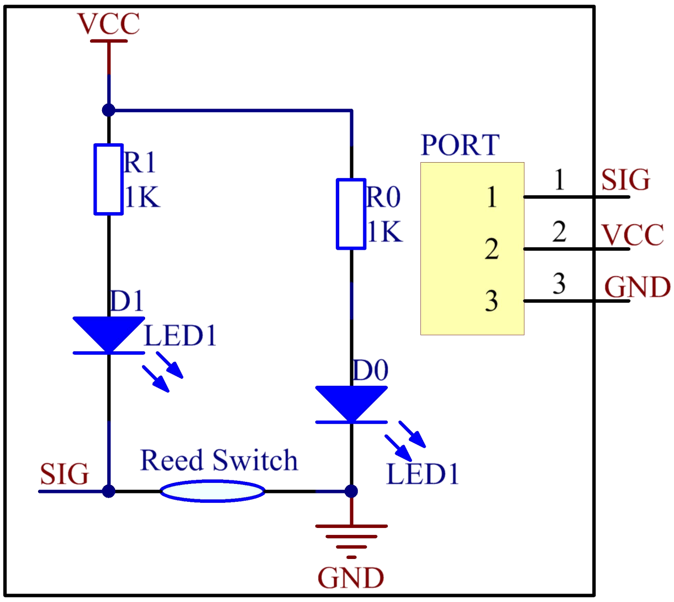
- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * Reed switch module
- 1 * Dual-color LED module
- 2 * 3-Pin anti-reverse cable
- 1 * Magnet (Self provided)

Experimental Principle

A reed switch is a type of line switch component that realizes control by magnetic signals. It induces by a magnet. The "switch" here means dry reed pipe, which is a kind of contact passive electronic switch component with the advantage of simple structure, small size, and convenient control. The shell of a reed switch is commonly a sealed glass pipe in which two iron elastic reed electroplates are equipped and inert gases are filled. Normally, the two reeds made of special materials in the glass tube are separated. However, when a magnetic substance approaches the glass tube, the two reeds in the glass tube are magnetized to attract each other and contact under the function of magnetic field lines. As a result, the two reeds will pull together to connect the circuit connected with the nodes.

After external magnetic force disappears, the two reeds will be separated with each other because they have the same magnetism, so the circuit is also disconnected. Therefore, as a line switch component controlling by magnetic signals, the dry reed pipe can be used as a sensor to count, limit positions and so on. At the same time, it is widely used in a variety of communication devices.

The schematic diagram of the module is as shown below:

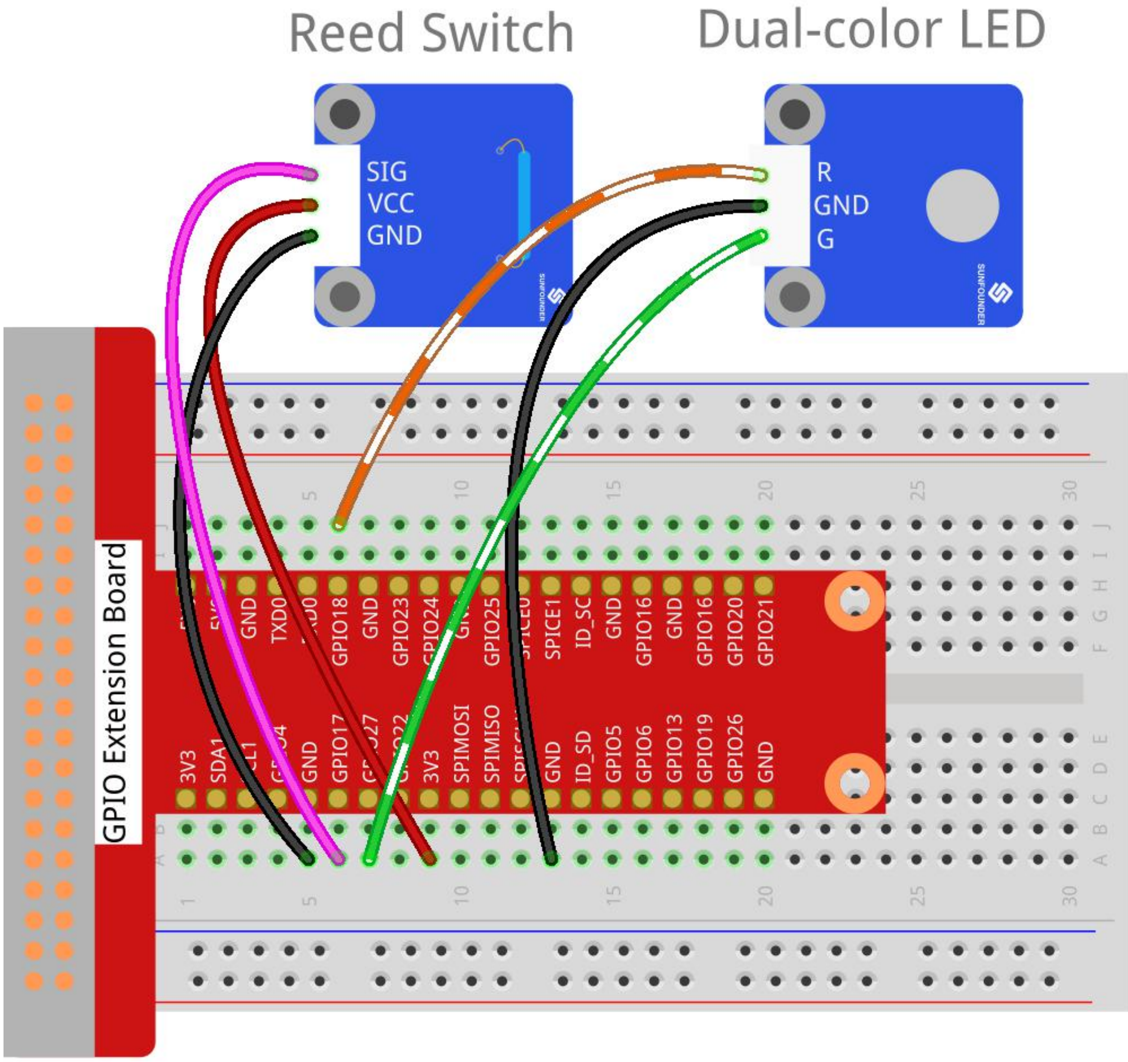


Experimental Procedures

Step 1: Build the circuit

Raspberry Pi	GPIO Extension Board	Reed Switch Module
GPIO0	GPIO17	SIG
3.3V	3V3	VCC
GND	GND	GND

Raspberry Pi	GPIO Extension Board	Dual-color LED Module
GPIO1	GPIO18	R
GND	GND	GND
GPIO2	GPIO27	G



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/11_reed_switch/
```

Step 3: Compile.

```
gcc reed_switch.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

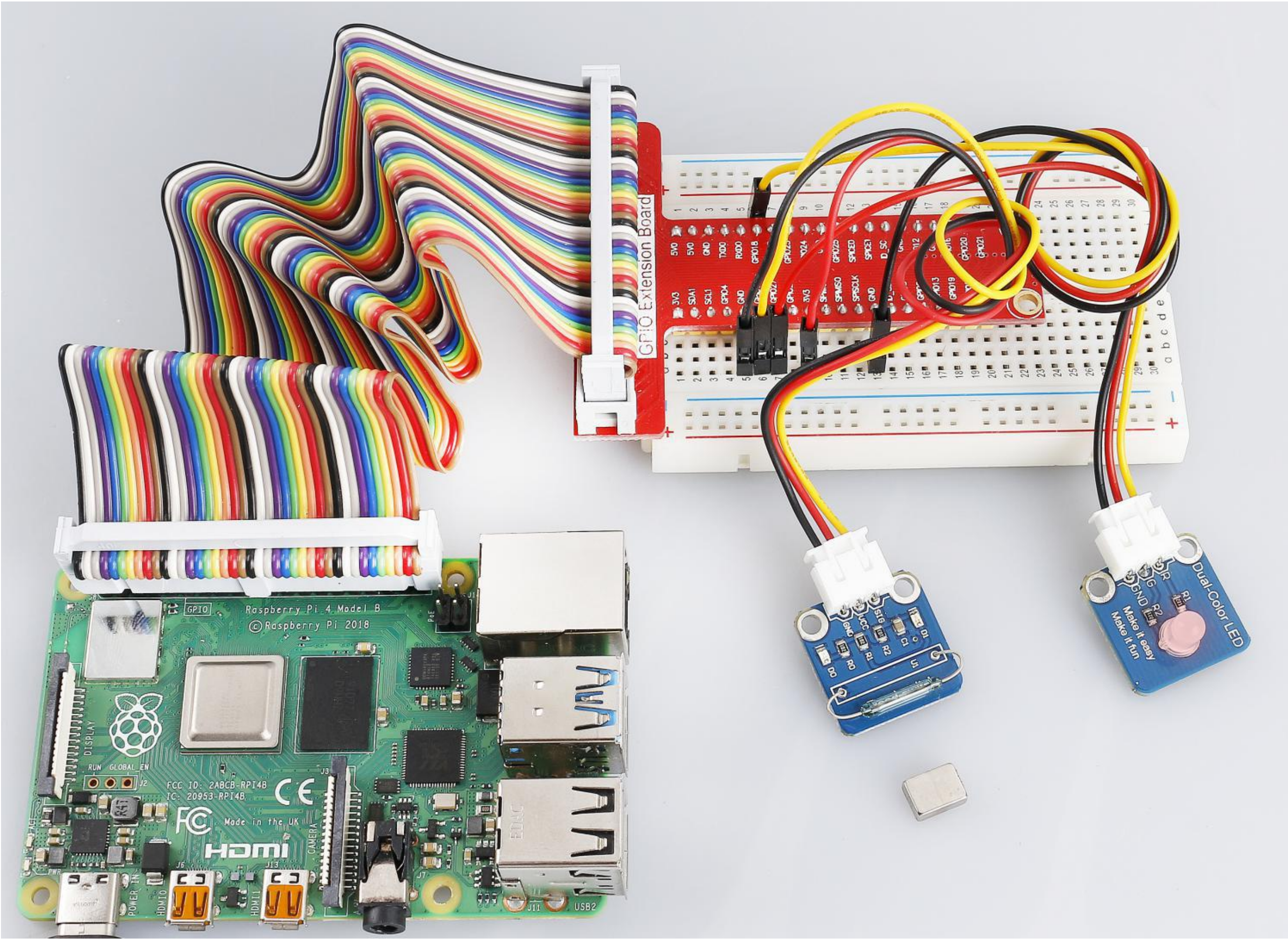
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

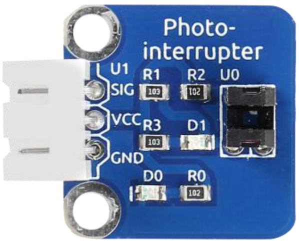
```
sudo python3 11_reed_switch.py
```

Then the LED will flash green. Place a magnet near the reed switch, "Detected Magnetic Material!" will be printed on the screen and the LED will change to red. Move away the magnet, the LED will turn green again.



Lesson 12 Photo-interrupter

Introduction



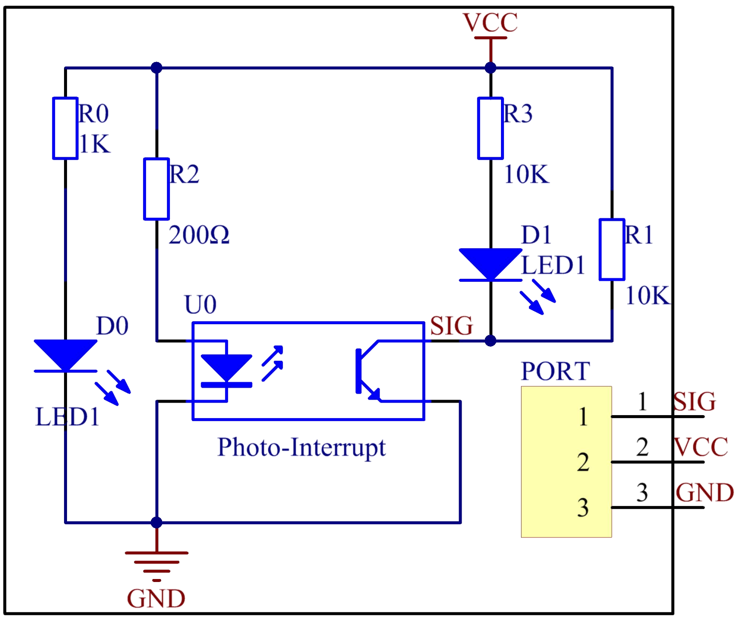
A photo-interrupter (as shown below) is a sensor with a light-emitting component and light-receiving component packaged and placed on face-to-face. It applies the principle that light is interrupted when an object passes through the sensor. Therefore, photo-interrupters are widely used in speed measurement.

Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * Dual-color LED module
- 1 * Photo-interrupter module
- 2 * 3-Pin anti-reverse cable

Experimental Principle

Basically a photo-interrupter consists of two parts: transmitter and receiver. The transmitter (e.g., an LED or a laser) emits light and then the light goes to the receiver. If that light beam between the transmitter and receiver is interrupted by an obstacle, the receiver will detect no incident light even for a moment and the output level will change. In this experiment, we will turn an LED on or off by using this change. The schematic diagram:

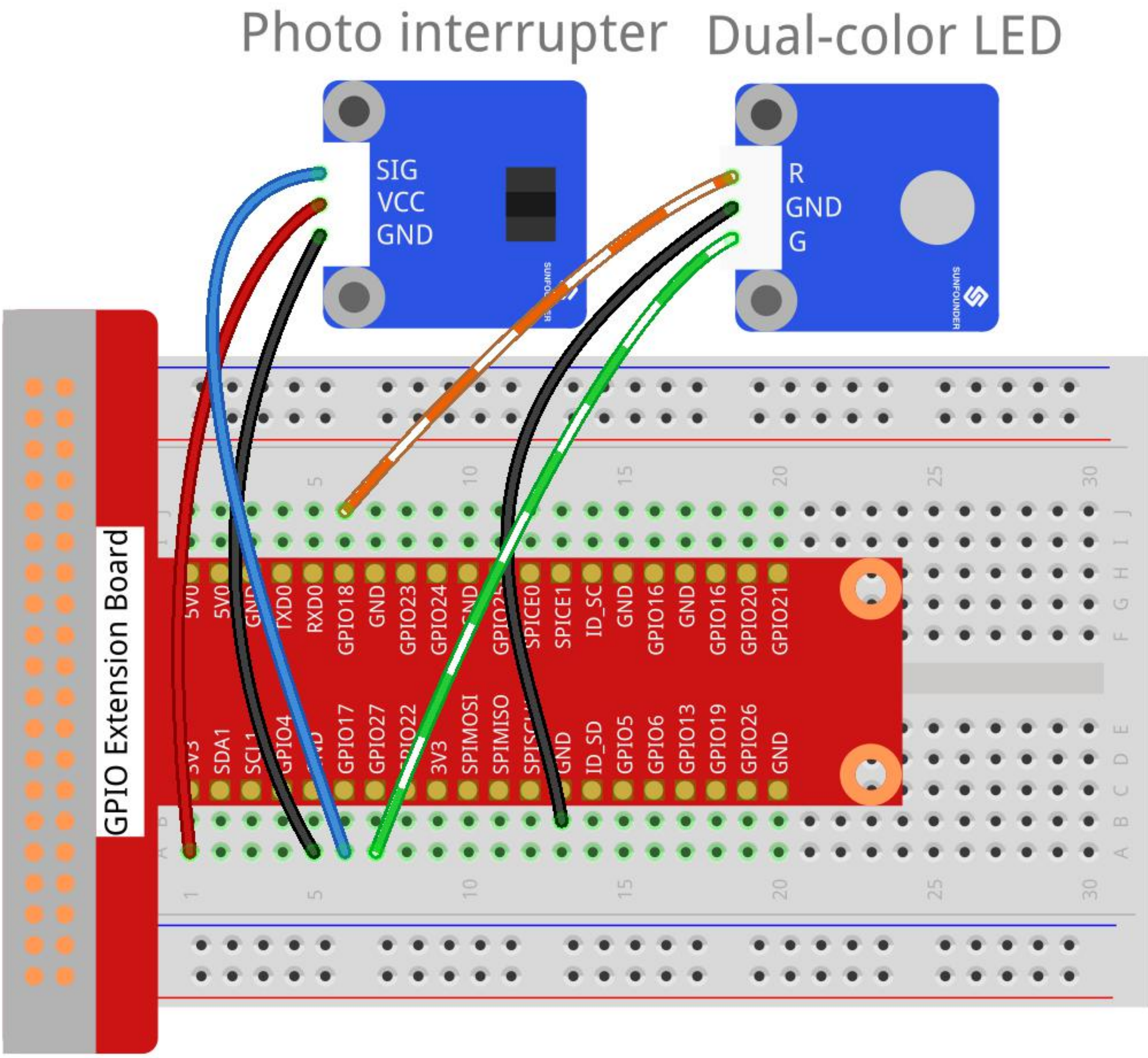


Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	Photo-interrupter Module
GPIO0	GPIO17	SIG
3.3V	3V3	VCC
GND	GND	GND

Raspberry Pi	GPIO Extension Board	Dual-color LED Module
GPIO1	GPIO18	R
GND	GND	GND
GPIO2	GPIO27	G



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/12_photo_interrupter/
```

Step 3: Compile.

```
gcc photo_interrupter.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

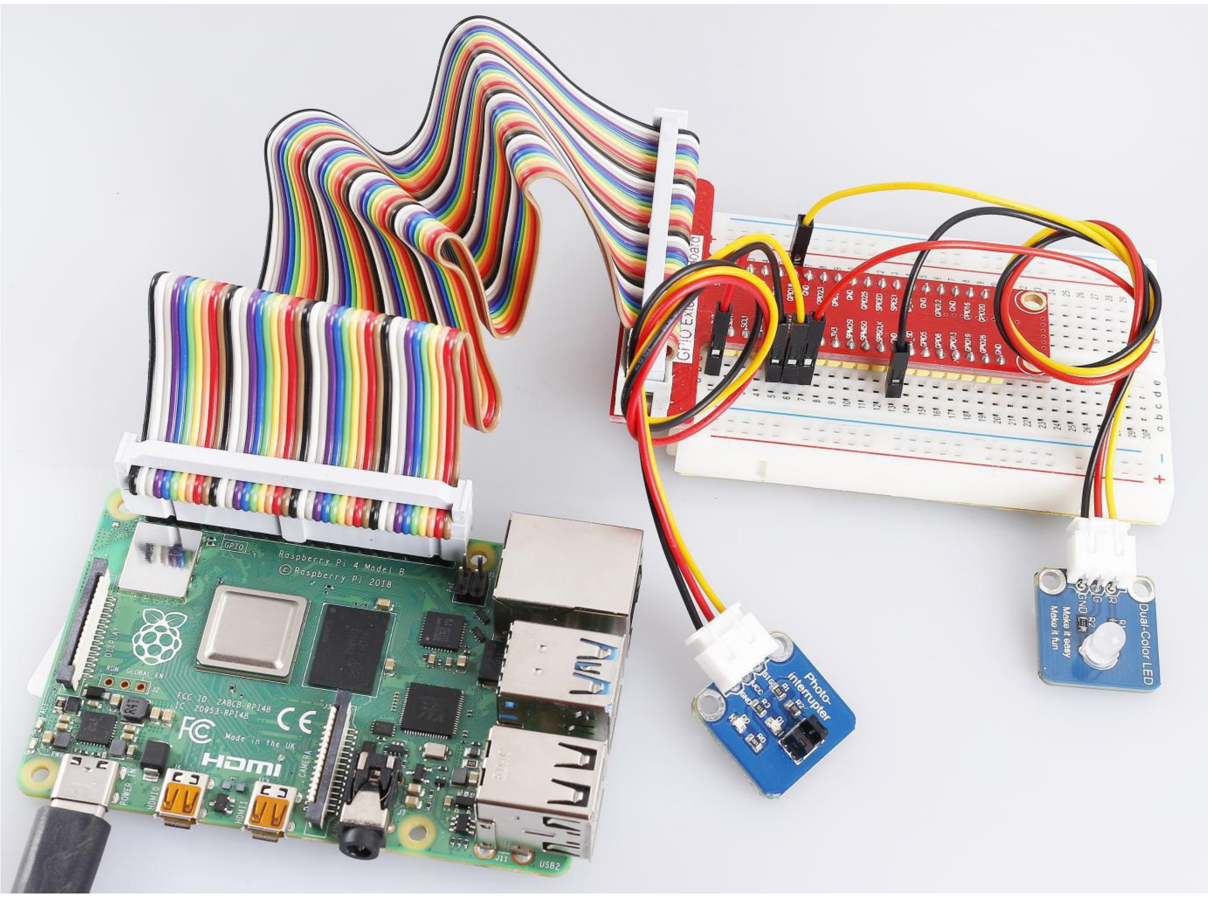
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 12_photo_interrupter.py
```

Now the LED will light up green. Stick a piece of paper in the gap of photo interrupter. Then "Light was blocked" will be printed on the screen and the LED will flash red. Remove the paper, and the LED will turn green again.

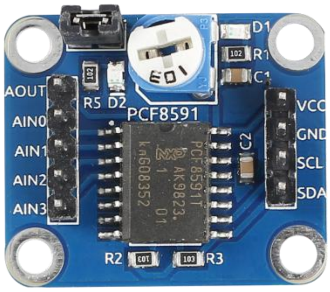


Lesson 13 PCF8591

Introduction

The PCF8591 is a single-chip, single-supply low-power 8-bit CMOS data acquisition device with four analog inputs, one analog output and a serial I2C-bus interface. Three address pins A0, A1 and A2 are used for programming the hardware address, allowing the use of up to eight devices connected to the I2C-bus without additional hardware. Address, control and data to and from the device are transferred serially via the two-line bidirectional I2C-bus.

The functions of the device include analog input multiplexing, on-chip track and hold function, 8-bit analog-to-digital conversion and an 8-bit digital-to-analog conversion. The maximum conversion rate is given by the maximum speed of the I2C-bus.



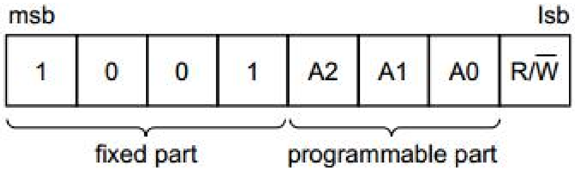
Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- Several Jumper wires
- 1 * PCF8591 module
- 1 * Dual-Color LED module
- 1 * 3-Pin anti-reverse cable

Experimental Principle

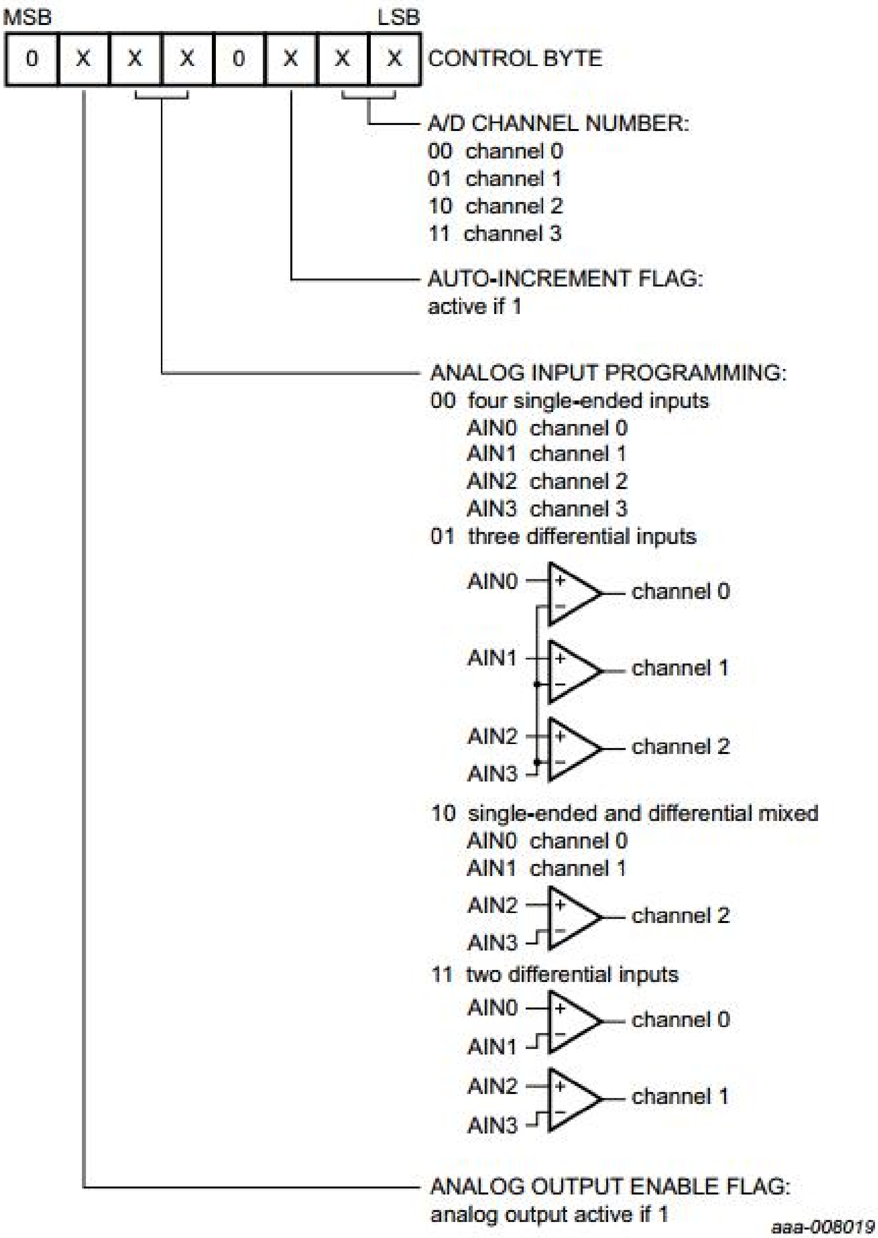
Addressing:

Each PCF8591 device in an I2C-bus system is activated by sending a valid address to the device. The address consists of a fixed part and a programmable part. The programmable part must be set according to the address pins A0, A1 and A2. The address always has to be sent as the first byte after the start condition in the I2C-bus protocol. The last bit of the address byte is the read/write-bit which sets the direction of the following data transfer (see as below).



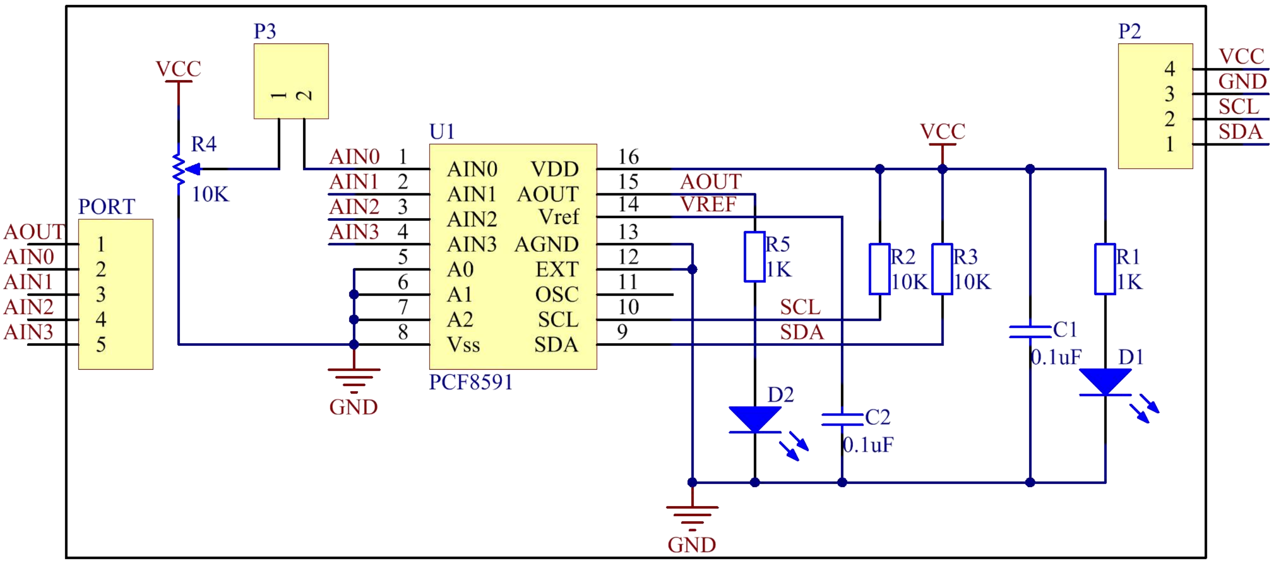
Control byte:

The second byte sent to a PCF8591 device will be stored in its control register and is required to control the device function. The upper nibble of the control register is used for enabling the analog output, and for programming the analog inputs as single-ended or differential inputs. The lower nibble selects one of the analog input channels defined by the upper nibble (see Fig.5). If the auto-increment flag is set, the channel number is incremented automatically after each A/D conversion. See the figure below.



In this experiment, the AIN0 (Analog Input 0) port is used to receive analog signals from the potentiometer module, and AOUT (Analog Output) is used to output analog signals to the dual-color LED module so as to change the luminance of the LED.

The schematic diagram:



Experimental Procedures

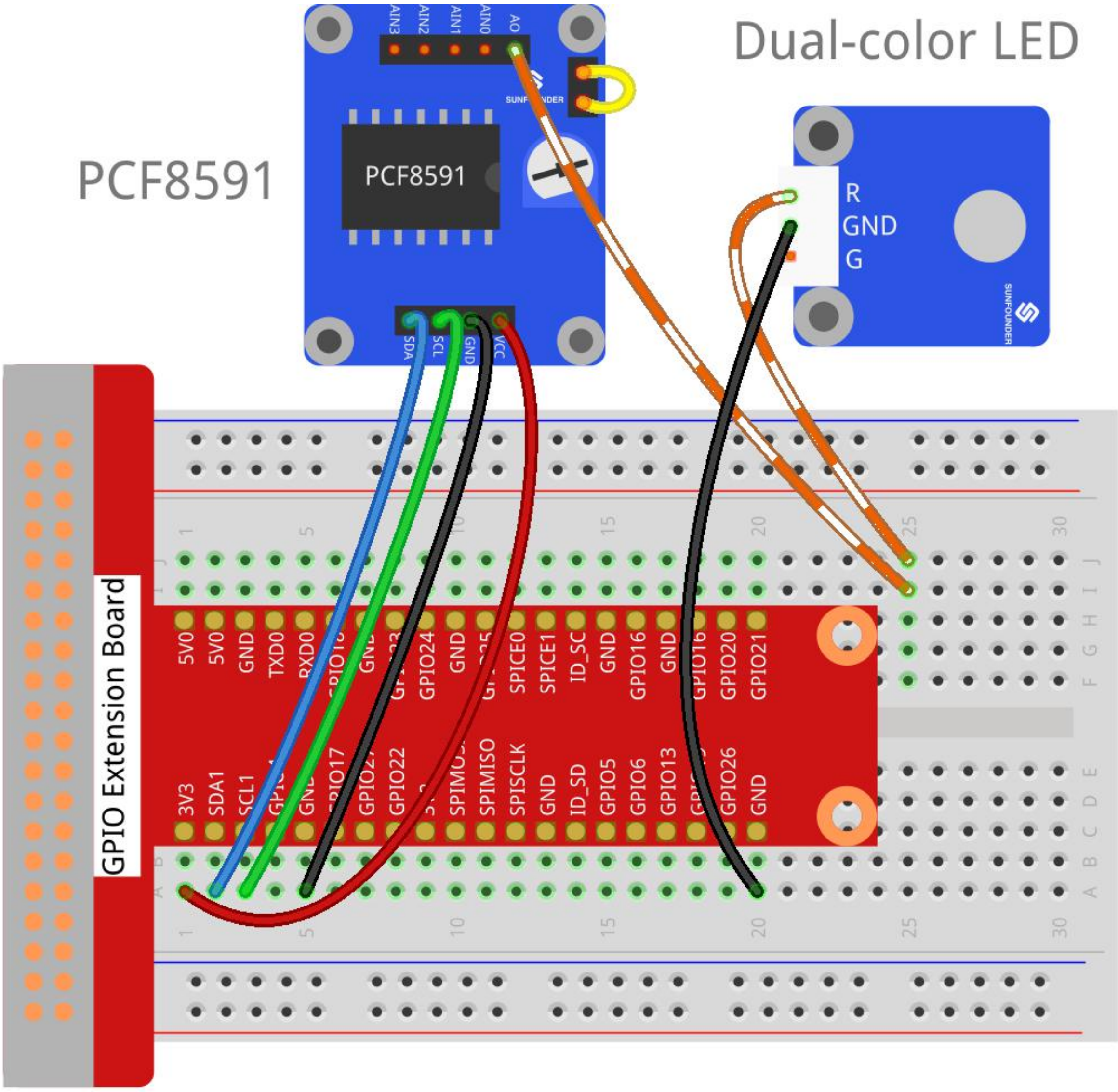
Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	PCF8591 Module
SDA	SDA1	SDA
SCL	SCL1	SCL
3.3V	3V3	VCC
GND	GND	GND

Dual-Color Module	GPIO Extension Board	PCF8591 Module
R	*	AOUT
GND	GND	GND
G	*	*

Note:

Connect the two pins next to the potentiometer of the PCF8591 module with the jumper cap attached.



Step 2: Setup I2C (see **Appendix**. If you have set I2C, skip this step.)

For C Users:

Step 3: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/13_pcf8591/
```

Step 4: Compile.

```
gcc pcf8591.c -lwiringPi
```

Step 5: Run.

```
sudo ./a.out
```

For Python Users:

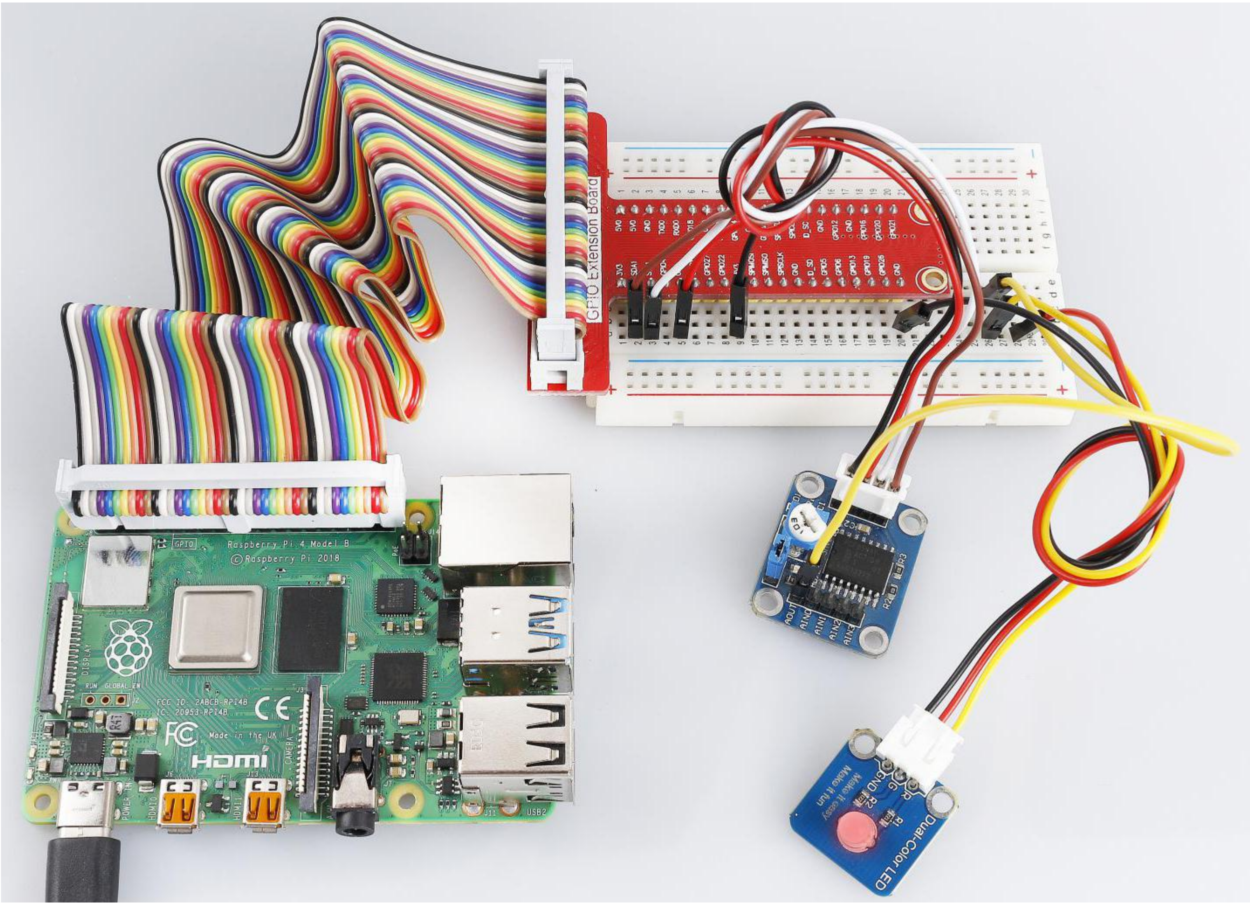
Step 3: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 4: Run.

```
sudo python3 13_pcf8591.py
```

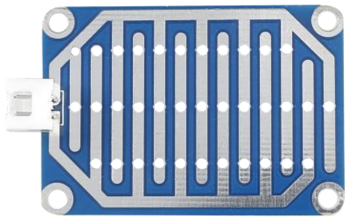
Now, turn the knob of the potentiometer on PCF8591, and you can see the luminance of the LED change and a value between 0 and 255 printed on the screen.



Lesson 14 Rain Detection Module

Introduction

The rain detection module detects rain on the board. Place the rain detection board in the open air. When it is raining, the rain detection module will sense the raindrops and send signals to the Raspberry Pi.

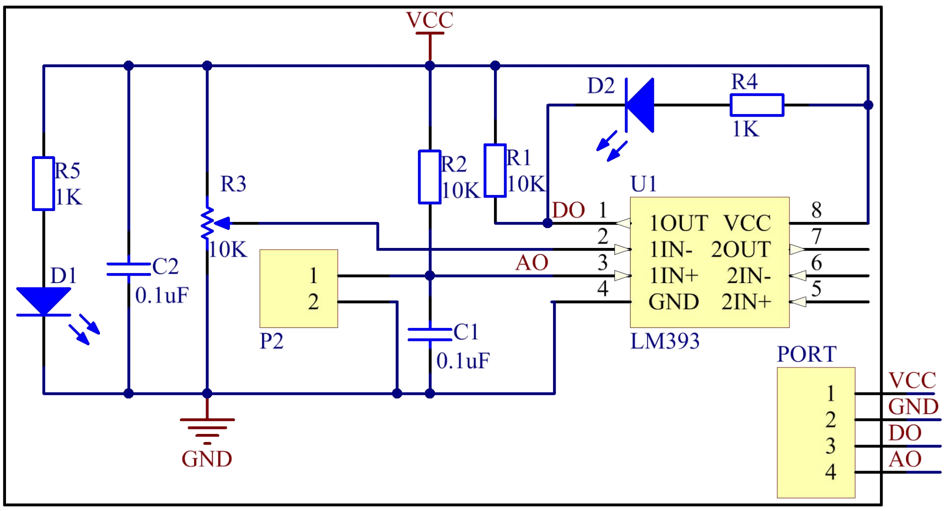


Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * Rain Detection module
- 1 * PCF8591
- 1 * LM393
- 1 * 2-Pin ribbon cable
- 1 * 4-Pin anti-reverse cable
- Several Jumper wires

Experimental Principle

There are two metal wires that are close to each other but do not cross on the rain detection board. When rain drops on the board, the two metal wires will conduct, thus there is a voltage between the two metal wires. The schematic diagram:



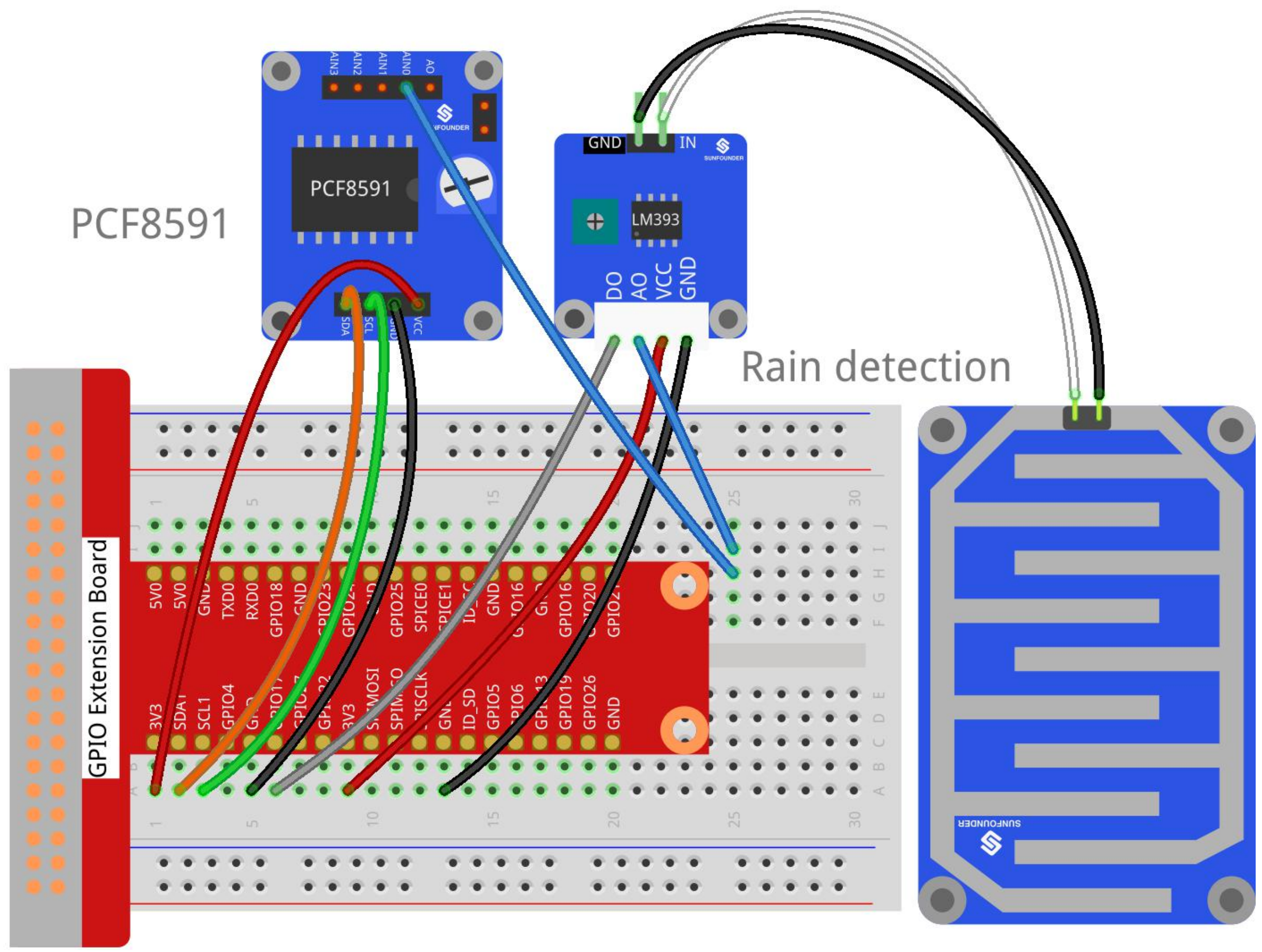
Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	PCF8591 Module
SDA	SDA1	SDA
SCL	SCL1	SCL
3.3V	3V3	VCC
GND	GND	GND

LM393	GPIO Extension Board	PCF8591 Module
DO	GPIO17	*
AO	*	AIN0
VCC	3V3	VCC
GND	GND	GND

Note: The two pins on the rain detection board are exactly the same. You can connect them to pin IN and GND on LM393.



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/14_rain_detector/
```

Step 3: Compile.

```
gcc rain_detector.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

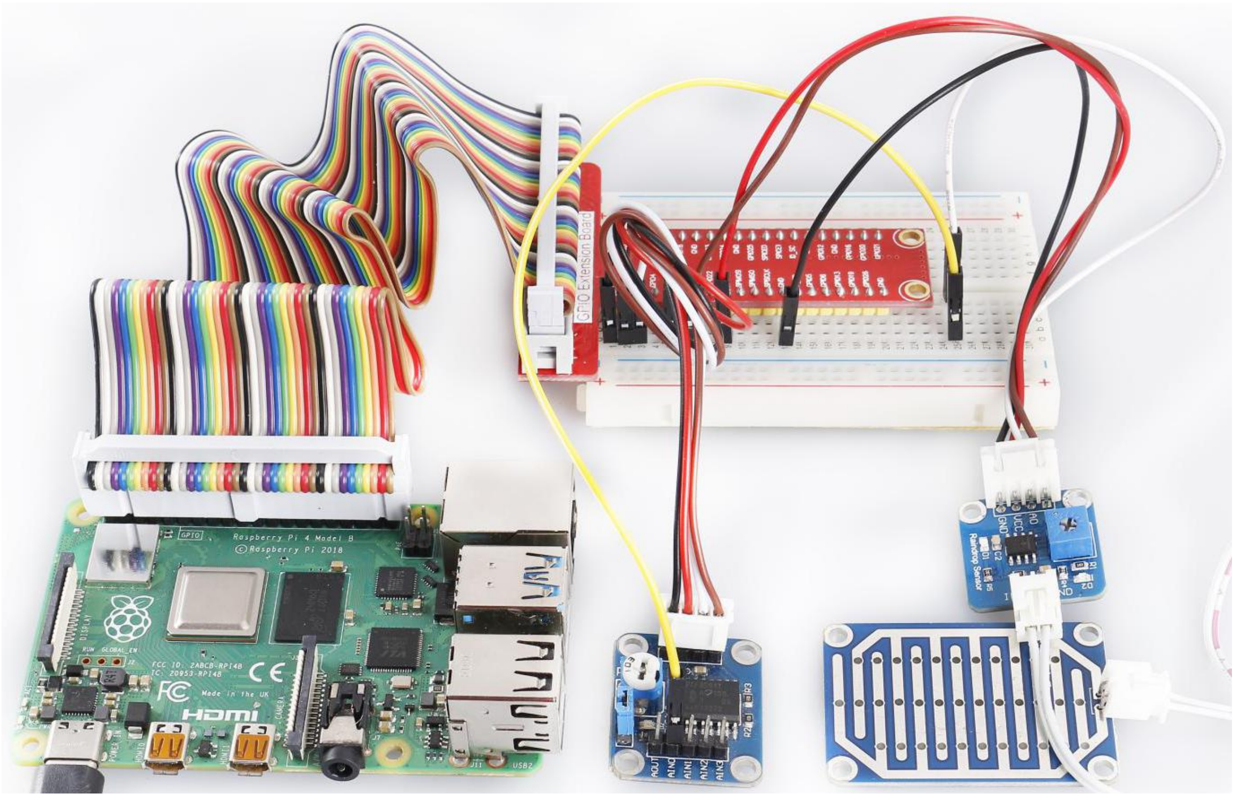
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 14_rain_detector.py
```

Now drop some water onto the rain detection board until "**raining**" displayed on the screen. You can adjust the potentiometer on LM393 to detect the threshold of rainfall.



Lesson 15 Joystick PS2

Introduction

There are five operation directions for joystick PS2: up, down, left, right and press-down.

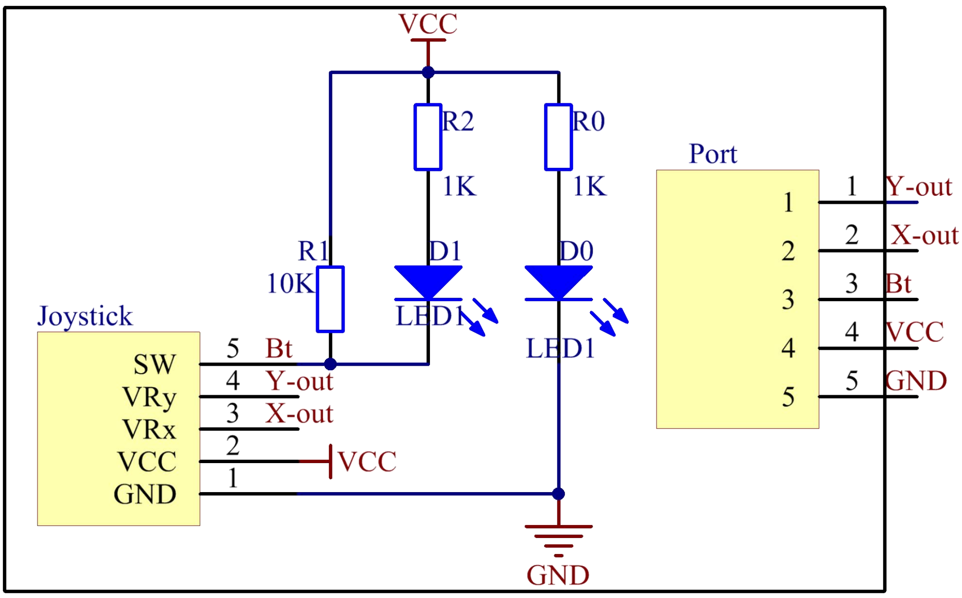
Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * PCF8591
- 1 * Joystick PS2 module
- 1 * 5-Pin anti-reverse cable
- Several Jumper wires

Experimental Principle

This module has two analog outputs (corresponding to X and Y coordinates) and one digital output representing whether it is pressed on Z axis.

In this experiment, we connect pin X and Y to the analog input ports of the A/D convertor so as to convert analog quantities into digital ones. Then program on Raspberry Pi to detect the moving direction of the Joystick. The schematic diagram:

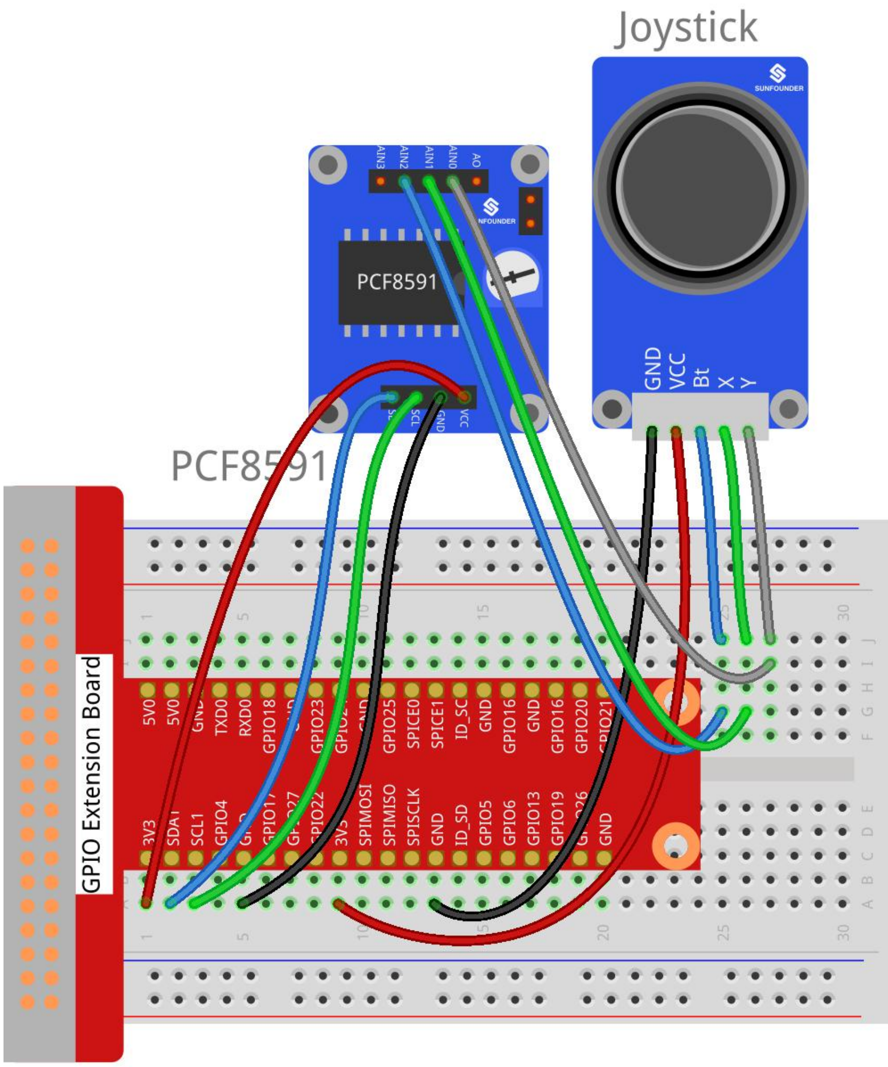


Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	PCF8591 Module
SDA	SDA1	SDA
SCL	SCL1	SCL
3.3V	3V3	VCC
GND	GND	GND

Joystick PS2	GPIO Extension Board	PCF8591 Module
Y	*	AIN0
X	*	AIN1
Bt	*	AIN2
VCC	3V3	VCC
GND	GND	GND



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/15_joystick_PS2/
```

Step 3: Compile.

```
gcc joystick_PS2.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

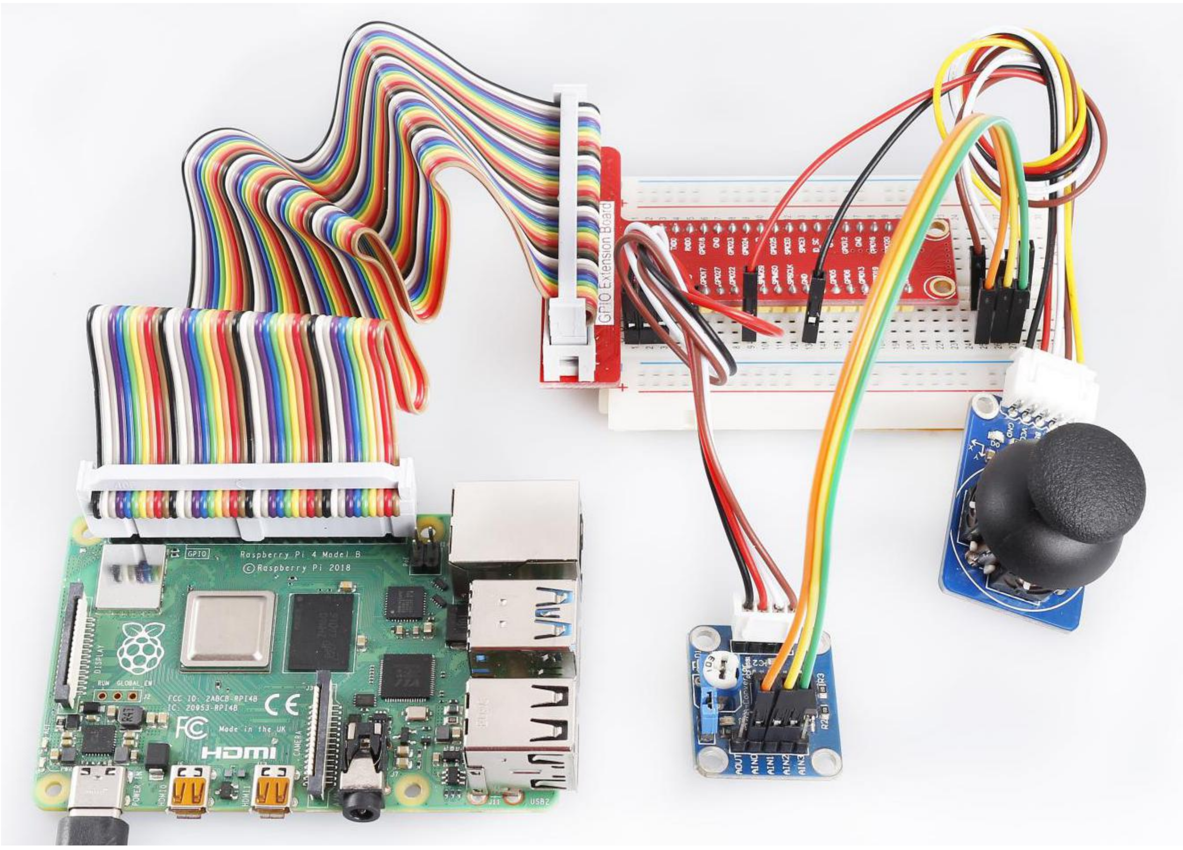
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 15_joystick_PS2.py
```

Now push the rocker upwards, and a string "**up**" will be printed on the screen; push it downwards, and "**down**" will be printed; if you push it left, "**Left**" will be printed on; If you push it right, and "**Right**" will be printed; If you press down the cap, "**Button Pressed**" will be printed on the screen.



Lesson 16 Potentiometer Module

Introduction

A potentiometer is a device which is used to vary the resistance in an electrical circuit without interrupting the circuit.

Required Components

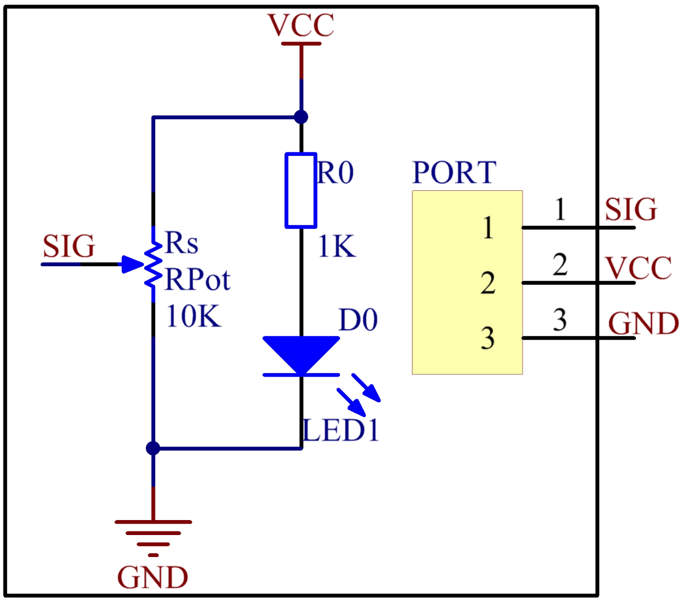
- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * Potentiometer module
- 1 * Dual-Color LED module
- 2 * 3-Pin anti-reverse cable
- Several Jumper wires

Experimental Principle

An analog potentiometer is an analog electronic component. What's the difference between an analog one and a digital one? Simply put, a digital potentiometer refers to just two states like on/off, high/low levels, i.e. either 0 or 1, while a digital one supports analog signals like a number from 1 to 1000. The signal value changes over time instead of keeping an exact number. Analog signals include light intensity, humidity, temperature, and so on.

In this experiment, PCF8591 is used to read the analog value of the potentiometer and output the value to LED. Connect pin SIG of the potentiometer to pin AIN0 of PCF8591. Connect pin R or Pin G of the Dual-Color LED to pin AOUT of PCF8591 to observe the change of LED.

The schematic diagram of the module is as shown below:



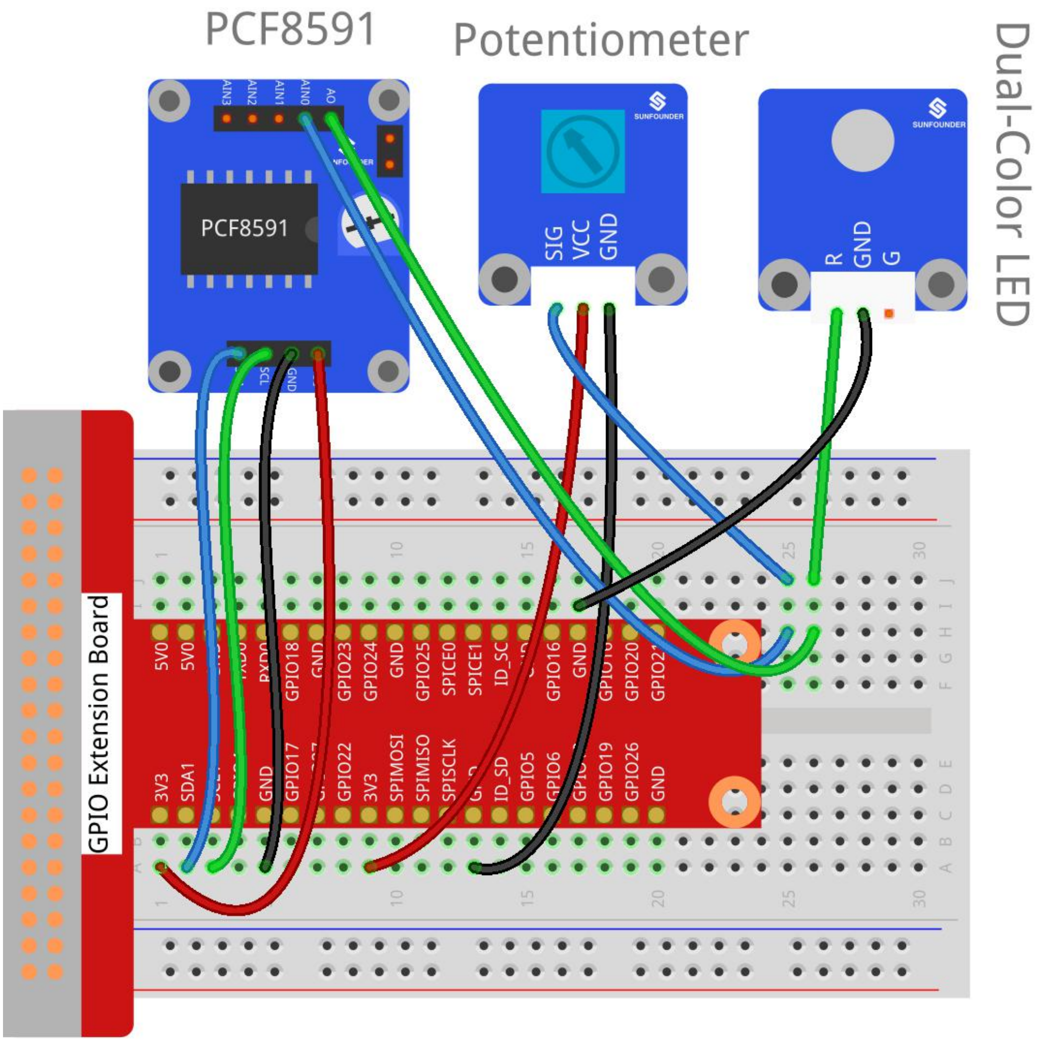
Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	PCF8591 Module
SDA	SDA1	SDA
SCL	SCL1	SCL
3.3V	3V3	VCC
GND	GND	GND

Potentiometer	GPIO Extension Board	PCF8591 Module
SIG	*	AIN0
VCC	3V3	VCC
GND	GND	GND

Dual-Color Module	GPIO Extension Board	PCF8591 Module
R	*	AOUT
GND	GND	GND
G	*	*



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/16_potentiometer/
```

Step 3: Compile.

```
gcc potentiometer.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

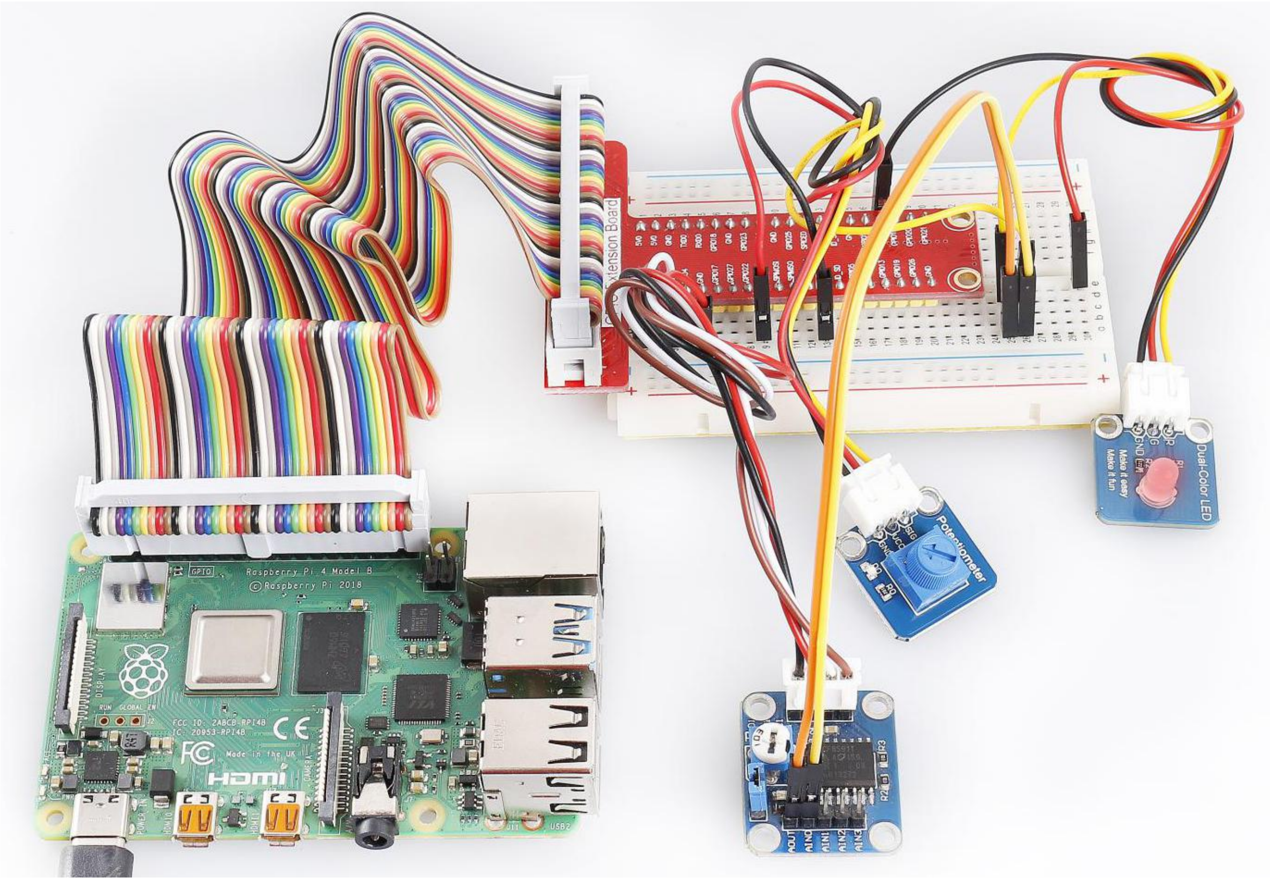
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 16_potentiometer.py
```

Turn the knob of the potentiometer, and you can see the value printed on the screen change from 0 (minimum) to 255 (maximum).

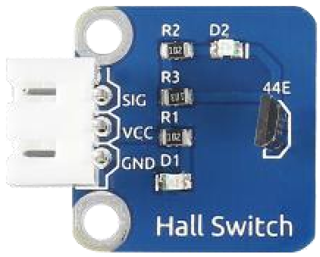


Lesson 17 Hall Sensor

Introduction

Based on Hall Effect, a Hall sensor is a one that varies its output voltage in response to a magnetic field. Hall sensors are used for proximity switching, positioning, speed detection, and current sensing applications.

Hall sensors can be categorized into linear (analog) Hall sensors and switch Hall sensors. A switch Hall sensor consists of voltage regulator, Hall element, differential amplifier, Schmitt trigger, and output terminal and it outputs digital values. A linear Hall sensor consists of Hall element, linear amplifier, and emitter follower and it outputs analog values. If you add a comparator to a linear (analog) Hall sensor it will be able to output both analog and digital signals.



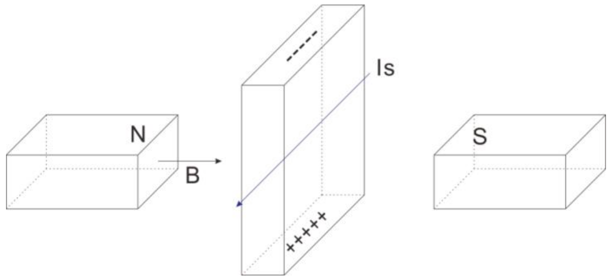
Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * Analog Hall Switch module
- 1 * Dual-color LED module
- 1 * Switch hall module
- 1 * PCF8591
- 2 * 3-Pin anti-reverse cable
- 1 * 4-Pin anti-reverse cable
- Several Jumper wires

Experimental Principles

Hall Effect

Hall Effect is a kind of electromagnetic effect. It was discovered by Edwin Hall in 1879 when he was researching conductive mechanism about metals. The effect is seen when a conductor is passed through a uniform magnetic field. The natural electron drift of the charge carriers causes the magnetic field to apply a Lorentz force (the force exerted on a charged particle in an electromagnetic field) to these charge carriers. The result is what is seen as a charge separation, with a buildup of either positive or negative charges on the bottom or on the top of the plate.

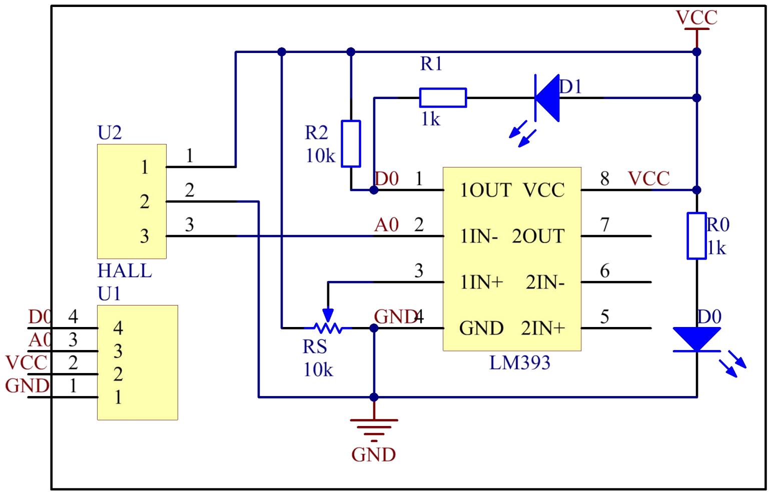


Hall sensor

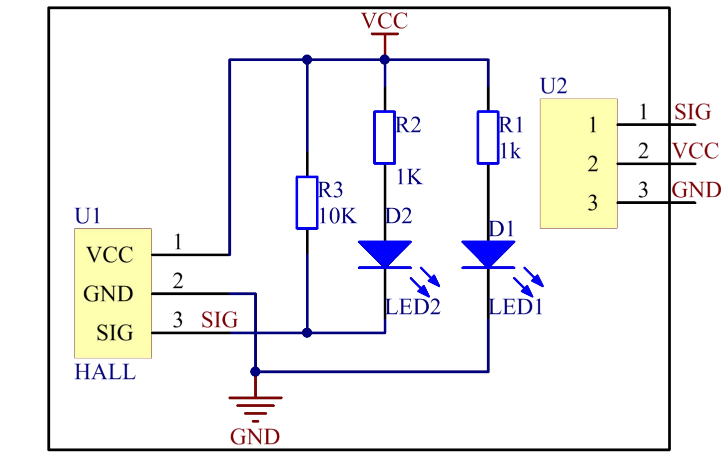
A Hall sensor is a kind of magnetic field sensor based on it.

Electricity carried through a conductor will produce a magnetic field that varies with current, and a Hall sensor can be used to measure the current without interrupting the circuit. Typically, the sensor is integrated with a wound core or permanent magnet that surrounds the conductor to be measured.

The schematic diagram of the analog Hall sensor module:



The schematic diagram of the Switch hall module:



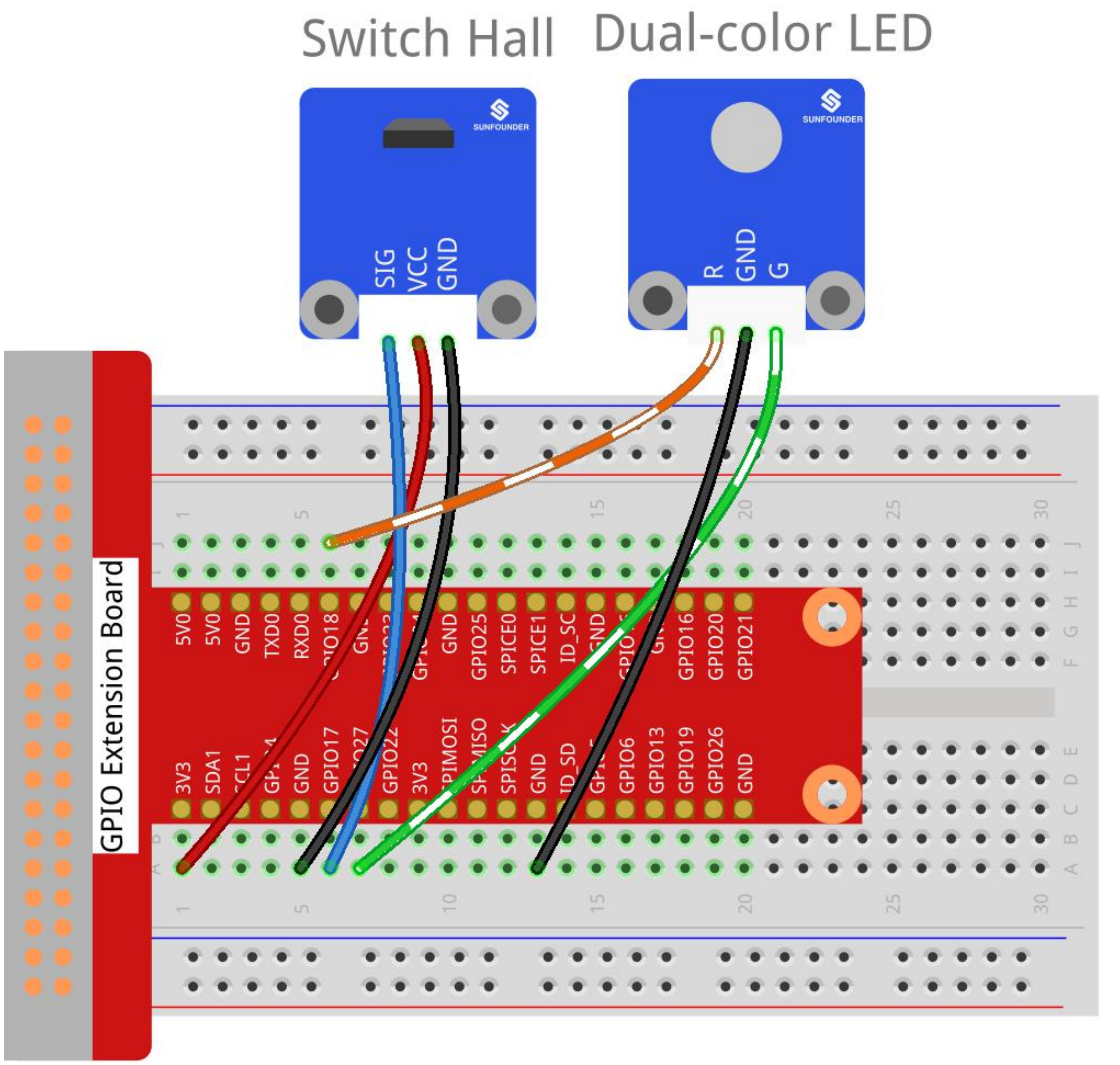
Experimental Procedures

For switch Hall sensor, take the following steps.

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	Switch Hall Module
GPIO0	GPIO17	SIG
3.3V	3V3	VCC
GND	GND	GND

Raspberry Pi	GPIO Extension Board	Dual-color LED Module
GPIO1	GPIO18	R
GND	GND	GND
GPIO2	GPIO27	G



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/17_switch_hall/
```

Step 3: Compile.

```
gcc switch_hall.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

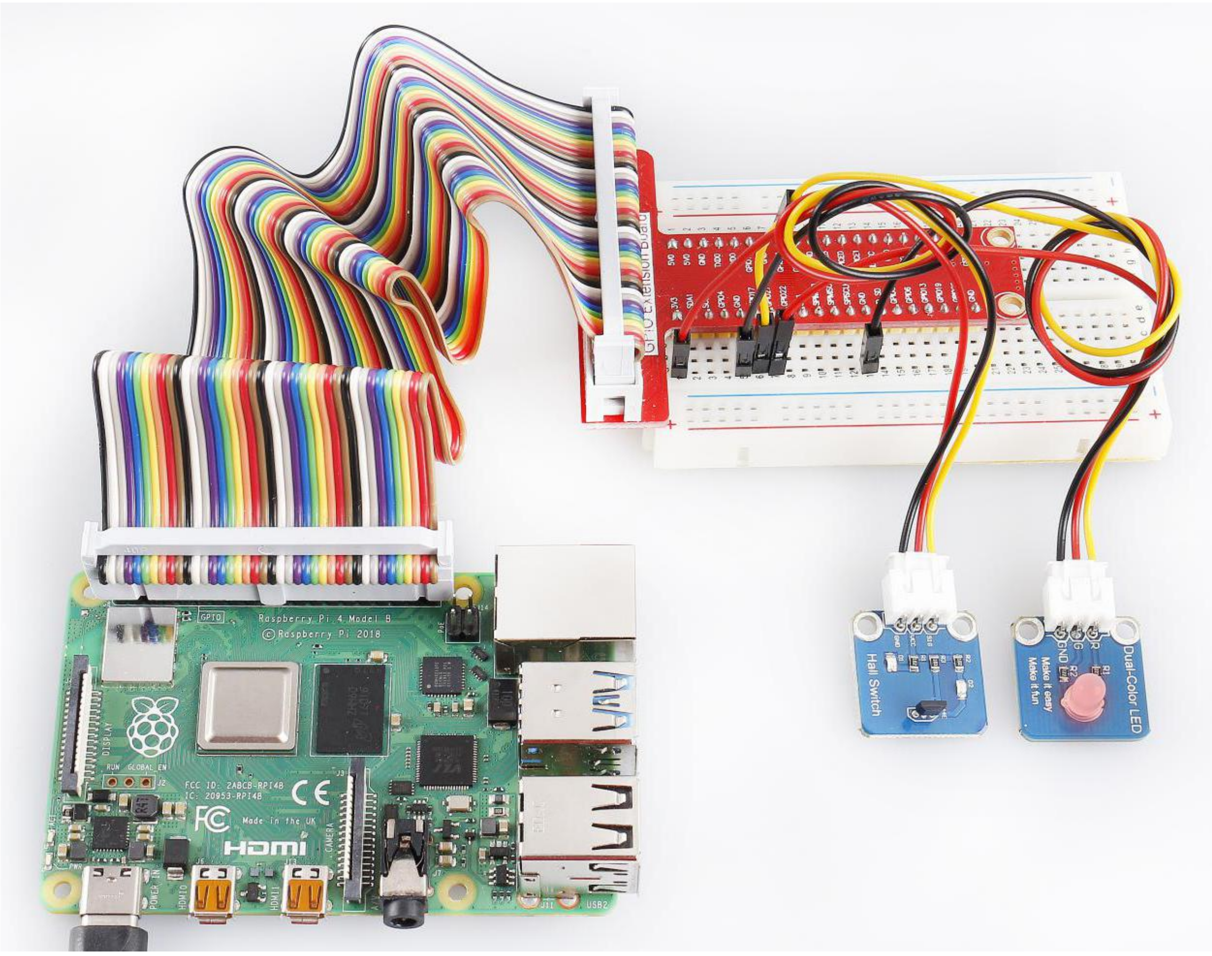
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 17_switch_hall.py
```

Put a magnet close to the Switch Hall sensor. Then a string “**Detected magnetic materials**” will be printed on the screen and the LED will light up.

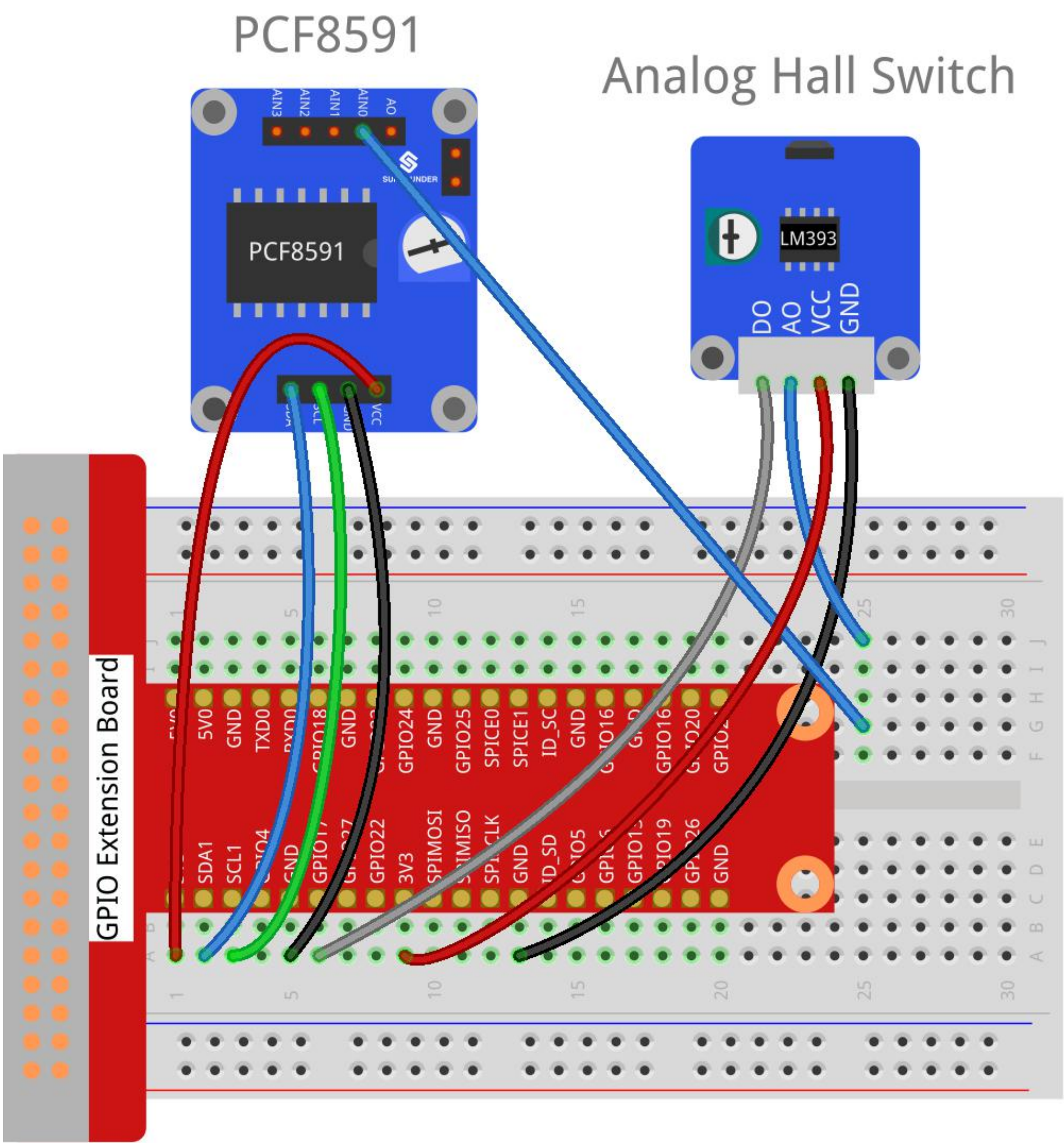


For **Analog Hall Switch**, take the following steps.

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	PCF8591 module
SDA	SDA1	SDA
SCL	SCL1	SCL
3.3V	3V3	VCC
GND	GND	GND

Analog Hall Switch	GPIO Extension Board	PCF8591 module
DO	GPIO17	*
AO	*	AIN0
VCC	3V3	VCC
GND	GND	GND



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/17_analog_hall_switch/
```

Step 3: Compile.

```
gcc analog_hall_switch.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

Step 2: Change directory.

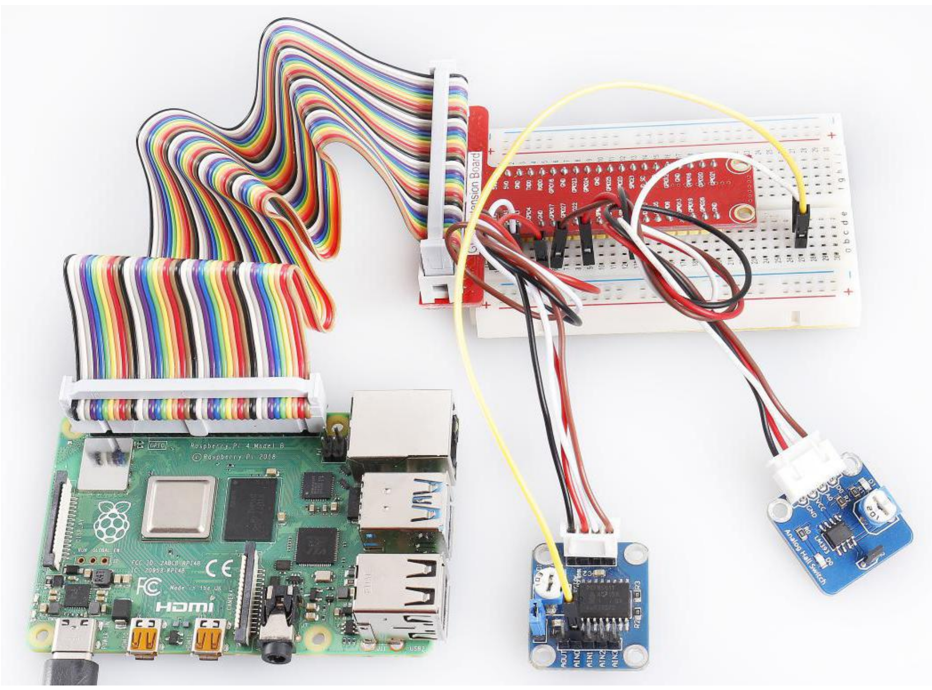
```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 17_analog_hall_switch.py
```

Now "Current intensity of magnetic field : xxx " will be displayed on the screen. Put the magnet close to the analog Hall sensor, with the north magnetic pole towards the sensor, and then " Magnet: North." will be displayed. Move the magnet away, and " Magnet: None." will be printed. If the magnet approaches the sensor with the south magnetic pole towards it, " Magnet: South." will be printed on the screen.

Note: Pin D0 of the Analog Hall Sensor will output "0" only when the south pole of the magnet approaches it, otherwise it will output "1".

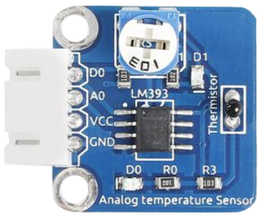


Lesson 18 Temperature Sensor

Introduction

A temperature sensor is a component that senses temperature and converts it into output signals. By material and component features, temperature sensors can be divided into two types: thermal resistor and thermocouple. Thermistor is one kind of the former type. It is made of semiconductor materials; most thermistors are negative temperature coefficient (NTC) ones, the resistance of which decreases with rising temperature. Since their resistance changes acutely with temperature changes, thermistors are the most sensitive temperature sensors.

There are two kinds of thermistor module in this kit (as shown below).



Analog temperature sensor

Thermistor

Required Components

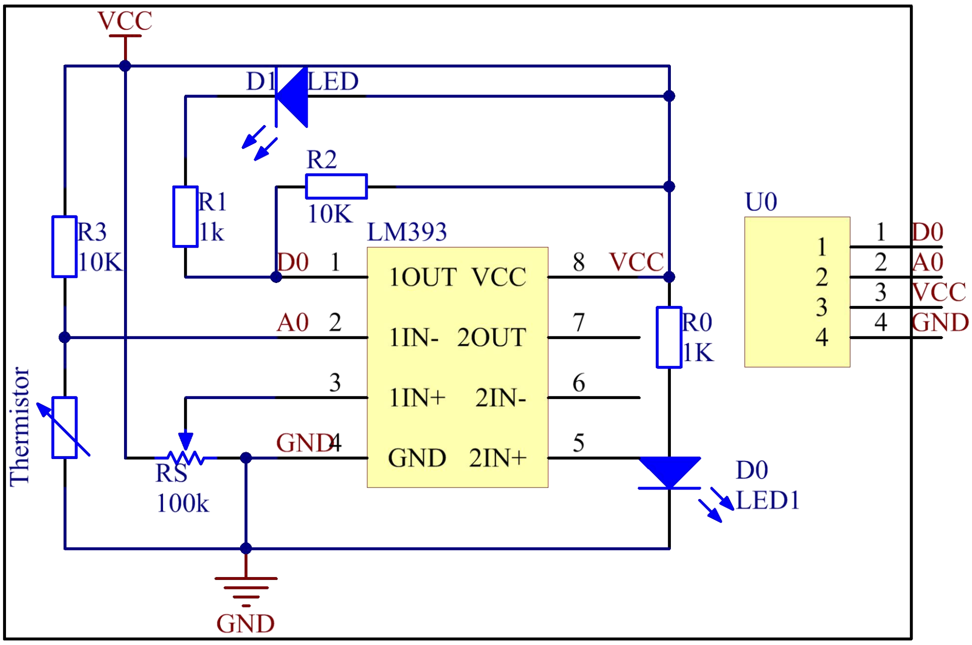
- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * Analog-temperature Sensor module
- 1 * Thermistor module
- 1 * PCF8591
- 1 * 3-Pin anti-reverse cable
- 1 * 4-Pin anti-reverse cable
- Several Jumper wires

Experimental Principle

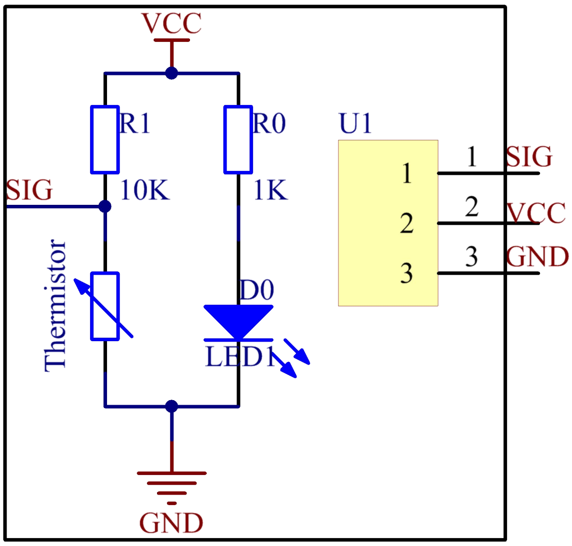
This module is based on the principle of the thermistor, whose resistance varies significantly with ambient temperature. When the ambient temperature increases, the resistance of the thermistor decreases; when decreases, it increases. It can detect surrounding temperature changes in a real-time manner.

In this experiment, we use an analog-digital converter PCF8591 to convert analog signals into digital ones.

The schematic diagram for analog temperature sensor:



The schematic diagram for the thermistor module:



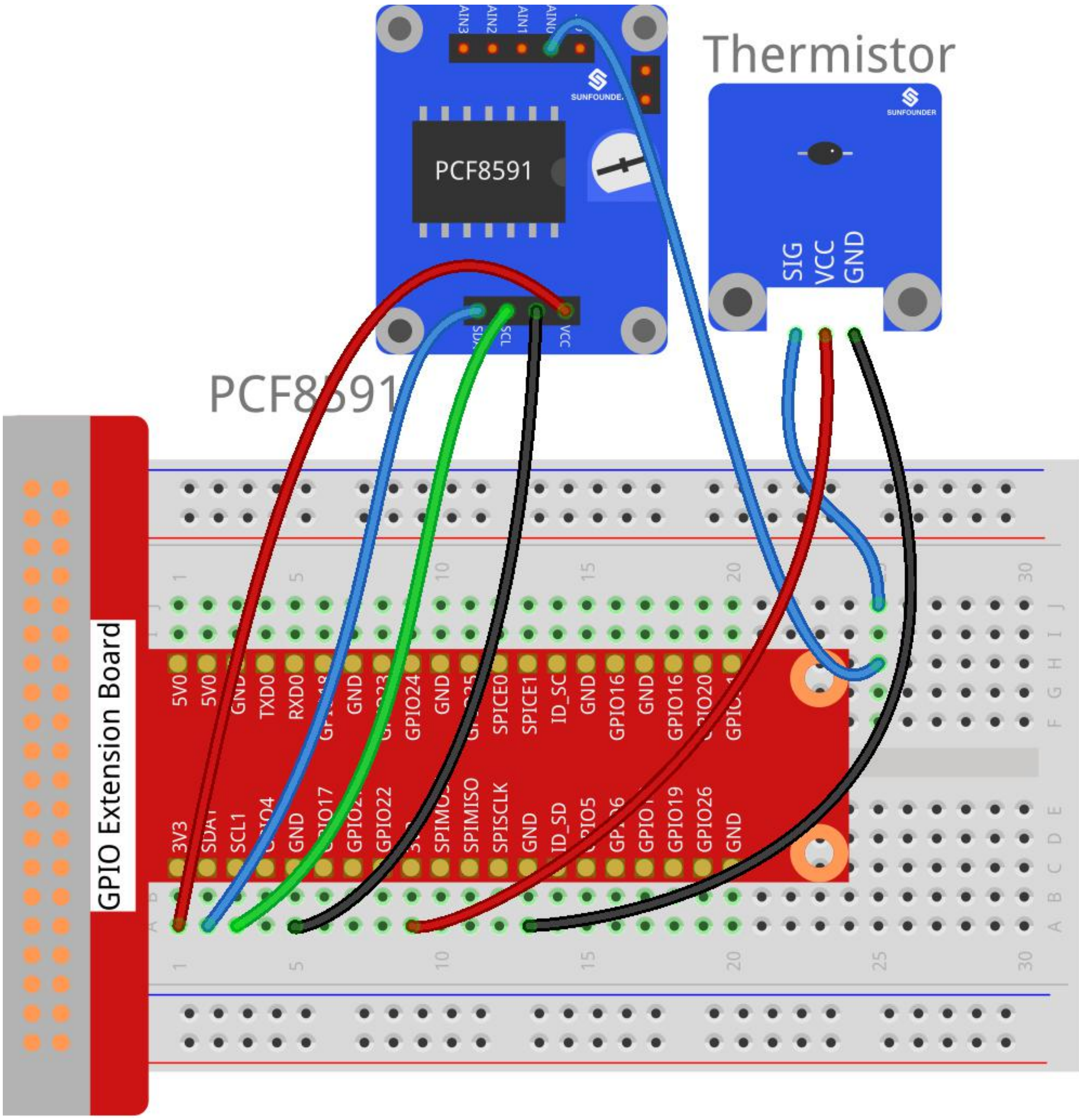
Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	PCF8591 Module
SDA	SDA1	SDA
SCL	SCL1	SCL
3.3V	3V3	VCC
GND	GND	GND

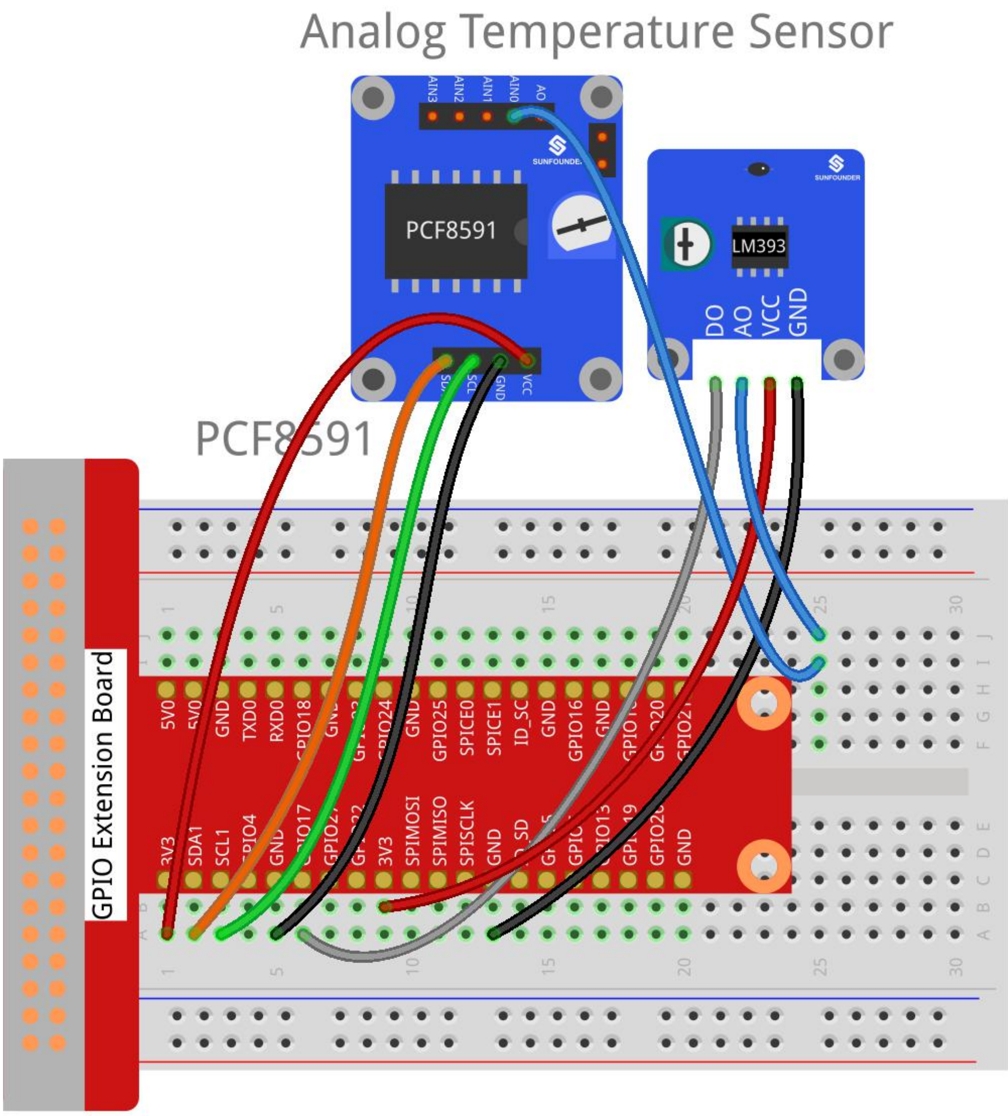
For thermistor module:

Thermistor Module	GPIO Extension Board	PCF8591 Module
SIG	*	AIN0
VCC	3V3	VCC
GND	GND	GND



For analog temperature sensor module:

Analog Temperature Module	GPIO Extension Board	PCF8591 Module
DO	GPIO17	*
AO	*	AIN0
VCC	3V3	VCC
GND	GND	GND



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/18_thermistor/
```

Step 3: Compile.

```
gcc thermistor.c -lwiringPi -lm
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 18_thermistor.py
```

Now touch the thermistor and you can see the value of current temperature printed on the screen change accordingly.

Temperature alarm setting:

If you use the **Analog Temperature Sensor** module, uncomment the line under **1**:

For C language:

```
// For a threshold, uncomment one of the code for
// which module you use. DONOT UNCOMMENT BOTH!
//---------------------------------------
// 1. For Analog Temperature module(with DO)
tmp = digitalRead(DO);

// 2. For Thermister module(with sig pin)
// if (temp > 33) tmp = 0;
// else if (temp < 31) tmp = 1;
```

For Python

```
####################################################
# 1. For Analog Temperature module(with DO)
tmp = GPIO.input(DO);

# 2. For Thermister module(with sig pin)
#if temp > 33:
#      tmp = 0;
#elif temp < 31:
#      tmp = 1;
####################################################
```

If you use the **Thermistor module**, uncomment the lIne under **2**:

For C language:

```
        // For a threshold, uncomment one of the code for
        // which module you use. DONOT UNCOMMENT BOTH!
        //-----------------------------------------
        // 1. For Analog Temperature module(with DO)
        // tmp = digitalRead(DO);

        // 2. For Thermister module(with sig pin)
        if (temp > 33) tmp = 0;
        else if (temp < 31) tmp = 1;
        //-----------------------------------------
```

For Python

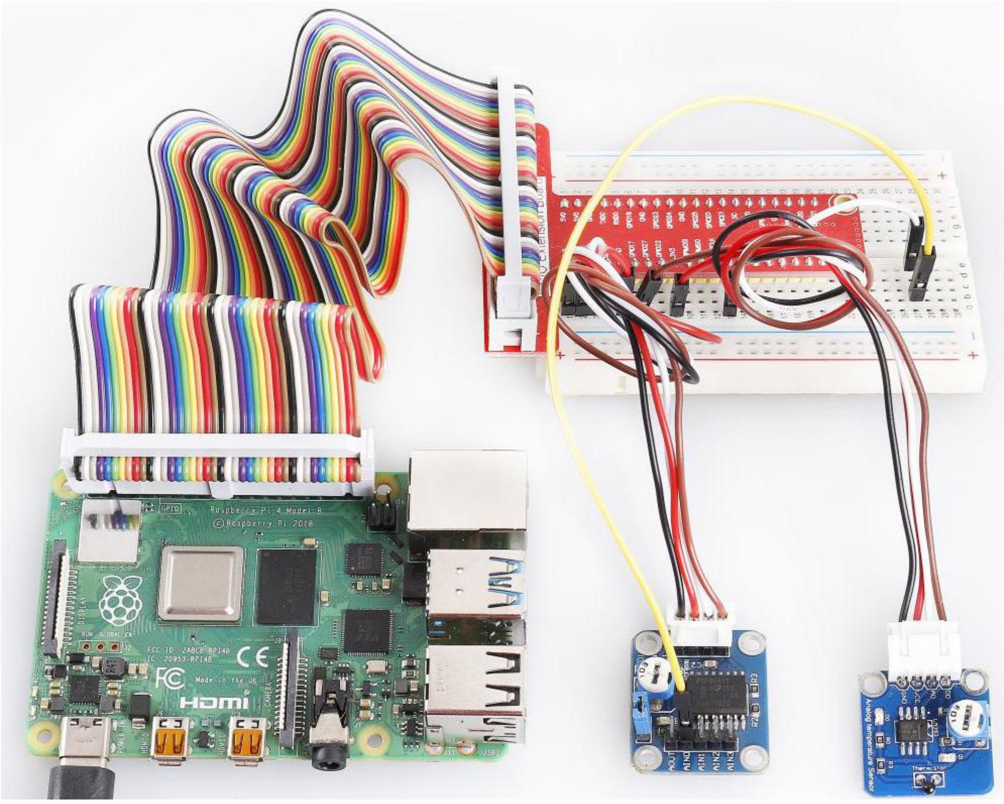
```
        ###################################################
        # 1. For Analog Temperature module(with DO)
        #tmp = GPIO.input(DO);
        #
        # 2. For Thermister module(with sig pin)
        if temp > 33:
            tmp = 0;
        elif temp < 31:
            tmp = 1;
        ###################################################
```

After editing the code, repeat step 2, 3, and 4 (or step 2, 3 for Python users).

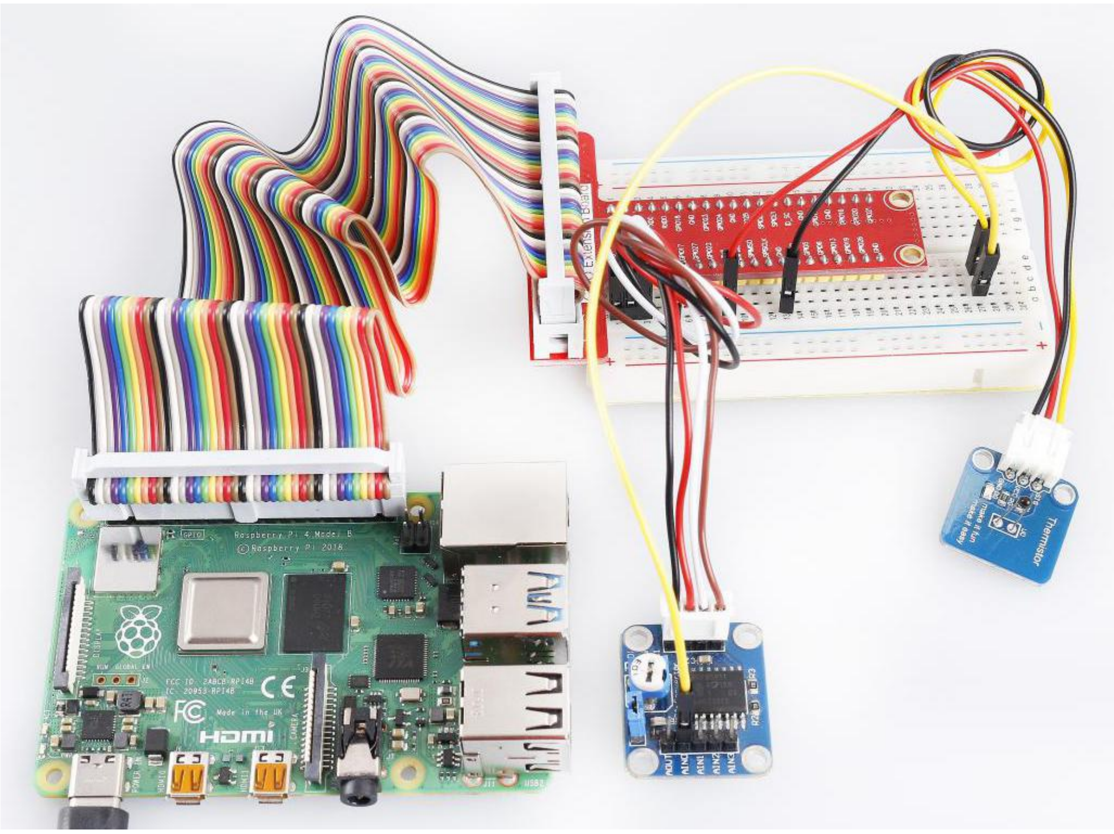
You can still see temperature value printed on the screen constantly. If you pinch the thermistor for a while, its temperature will rise slowly. "Too Hot!" will be printed on the screen. Release your fingers, and let it stay in the open air for a while, or blow on the module. When the temperature drops down slowly, "Better" will be printed.

Note: The analog temperature sensor adjusts alarm temperature by the potentiometer on the module. The thermistor changes the alarm temperature by program.

The physical picture for analog temperature sensor:



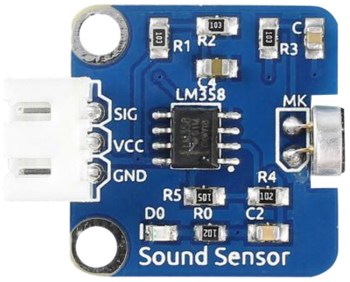
The physical picture for thermistor module:



Lesson 19 Sound Sensor

Introduction

Sound sensor is a component that receives sound waves and converts them into electrical signal. It detects the sound intensity in ambient environment like a microphone.



Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * PCF8591
- 1 * Sound sensor module
- 1 * 3-Pin anti-reverse cable
- Several Jumper wires

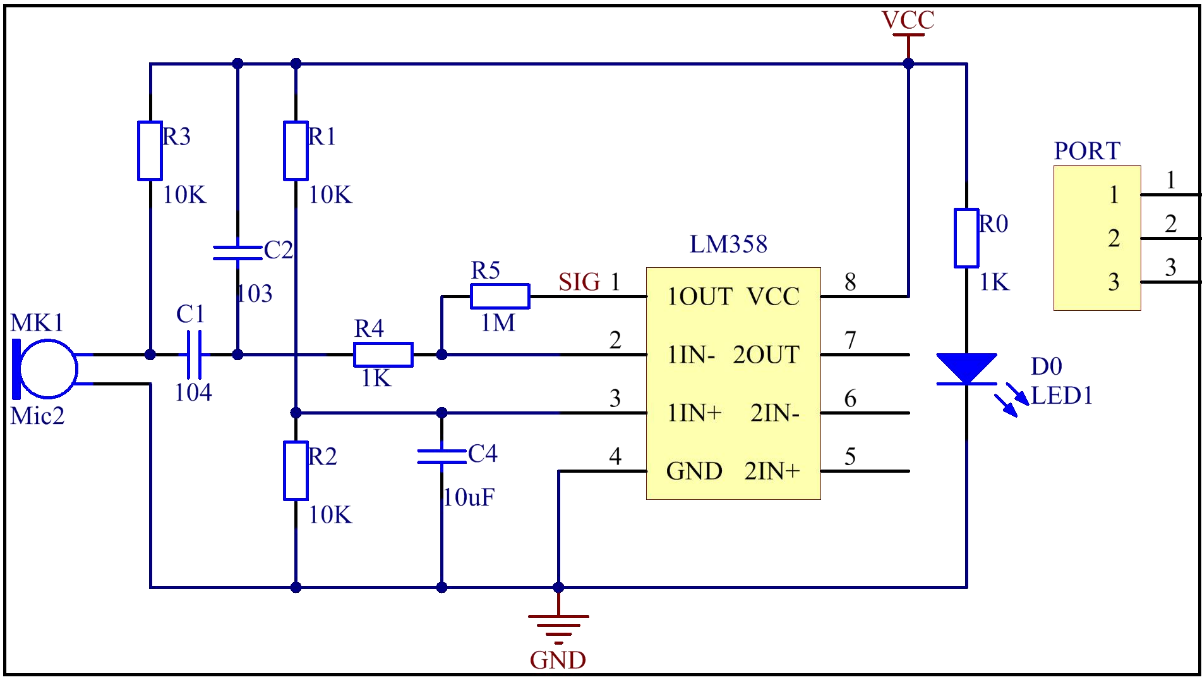
Experimental Principle

The microphone on the sensor module can convert audio signals into electrical signals (analog quantity), then convert analog quantity into digital quantity by PCF8591 and transfer them to MCU.

LM358 is a dual-channel operational amplifier. It contains two independent, high gain, and internally compensated amplifiers, but we will only use one of them in this experiment. The microphone transforms sound signals into electrical signals and then sends out the signals to pin 2 of LM358 and outputs them to pin 1 (that's, pin SIG of the module) via the external circuit. Then use PCF8591 to read analog values.

PCF8591 is an 8-bit resolution, 4-channel A/D, 1-channel D/A conversion chip. We connect the output terminal (SIG) to AIN0 of PCF8591 so as to detect the strength of voice signal in a real-time manner.

The schematic diagram of the module is as shown below:

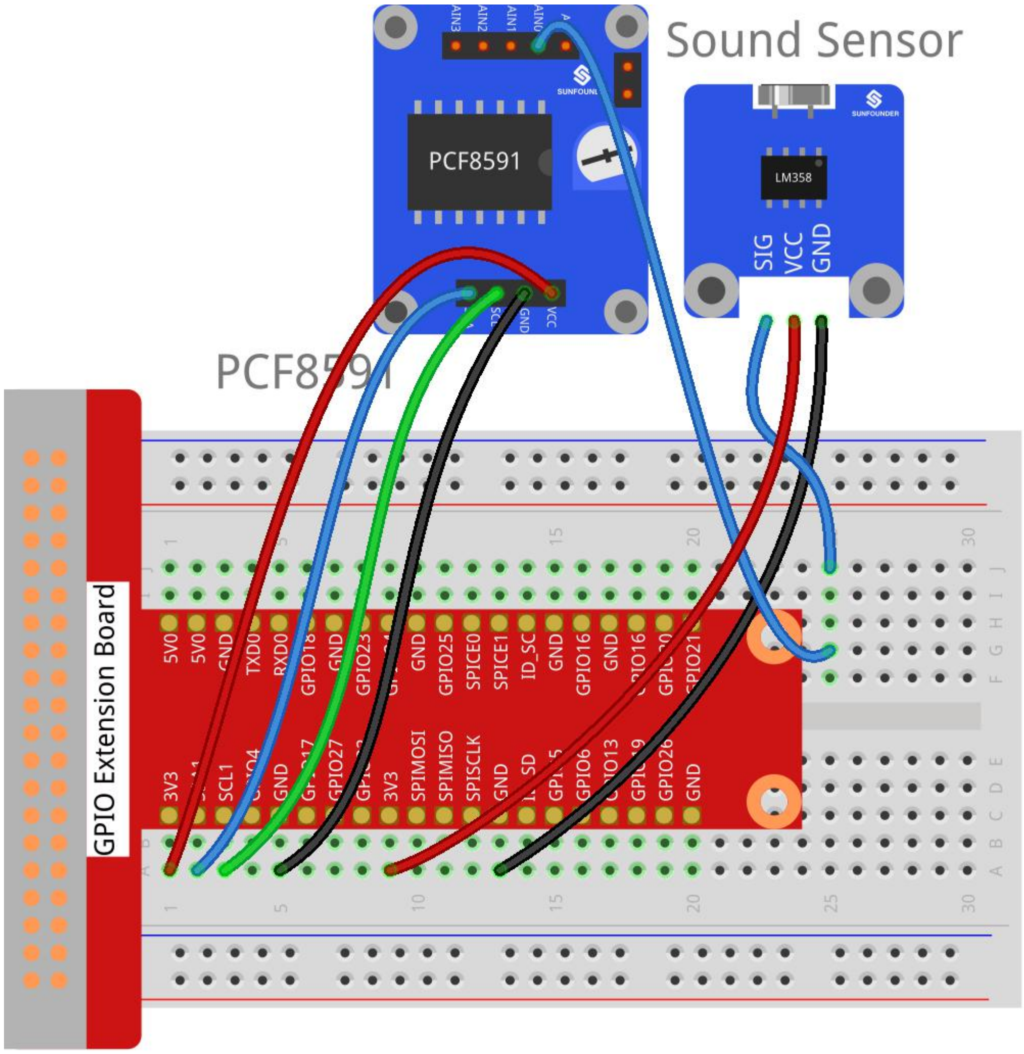


Experimental Procedures

Step 1: Build the circuit according to the following method.

Raspberry Pi	GPIO Extension Board	PCF8591 Module
SDA	SDA1	SDA
SCL	SCL1	SCL
3.3V	3V3	VCC
GND	GND	GND

Sound Sensor Module	GPIO Extension Board	PCF8591 Module
SIG	*	AIN0
VCC	3V3	VCC
GND	GND	GND



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/19_sound_sensor/
```

Step 3: Compile.

```
gcc sound_sensor.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

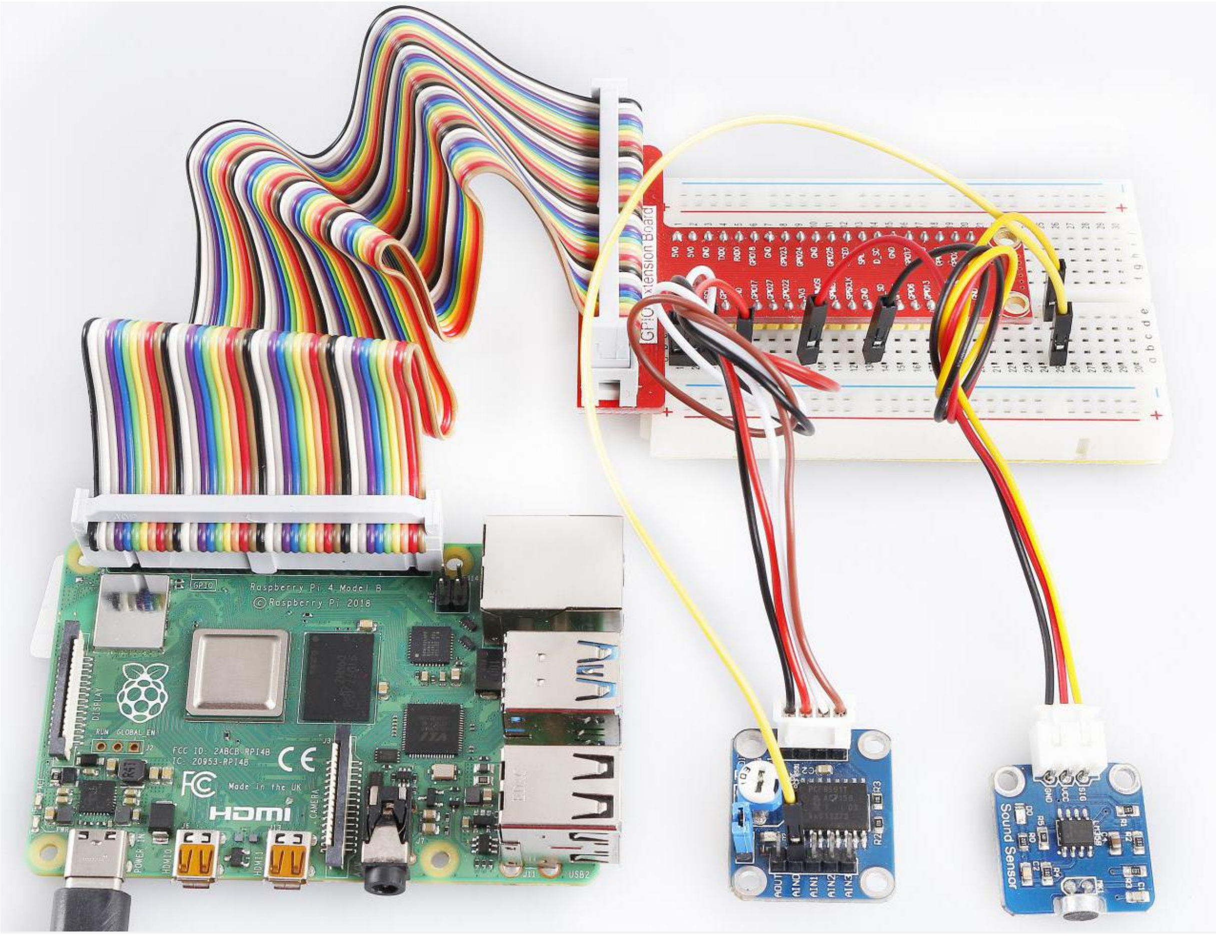
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 19_sound_sensor.py
```

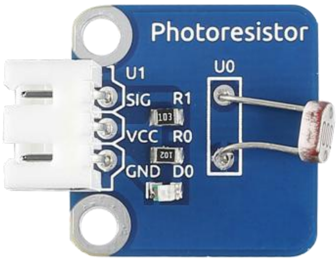
Now, speak close to or blow to the microphone, and you can see “Voice In!! ***” printed on the screen.



Lesson 20 Photoresistor Module

Introduction

A photoresistor is a light-controlled variable resistor. The resistance of a photoresistor decreases with increasing incident light intensity.

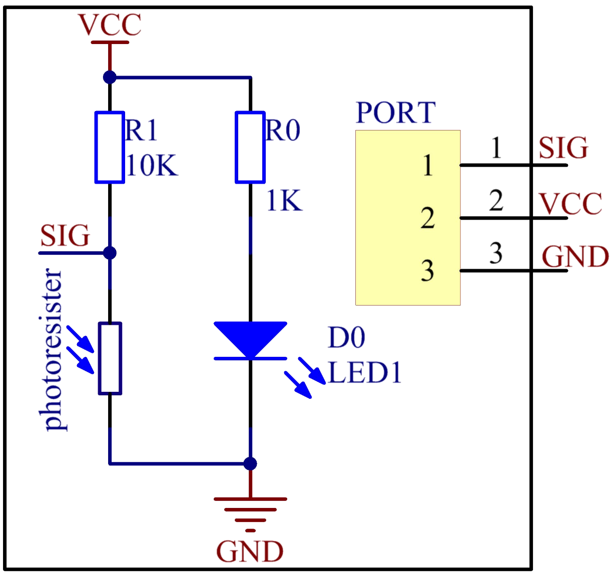


Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * PCF8591
- 1 * Photoresistor module
- 1 * 3-Pin anti-reverse cable
- Several Jumper wires

Experimental Principle

With light intensity increasing, the resistance of a photoresistor will decrease. Thus the output voltage changes. Analog signals collected by the photoresistor are converted to digital signals through PCF8591. Then these digital signals are transmitted to Raspberry Pi and printed on the screen. The schematic diagram:

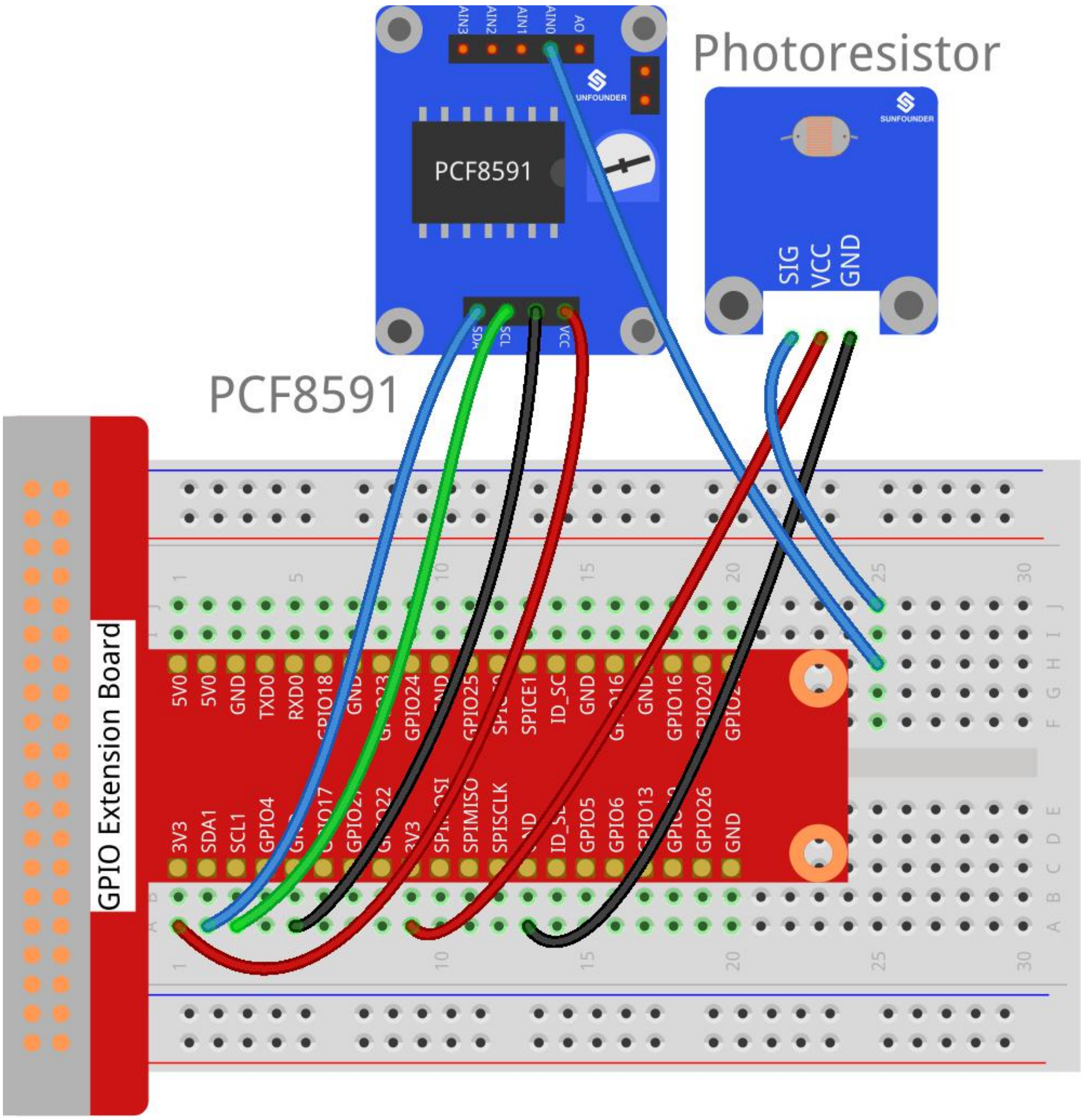


Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	PCF8591 Module
SDA	SDA1	SDA
SCL	SCL1	SCL
3.3V	3V3	VCC
GND	GND	GND

Photoresistor	GPIO Extension Board	PCF8591 Module
SIG	*	AIN0
VCC	3V3	VCC
GND	GND	GND



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/20_photoresistor/
```

Step 3: Compile.

```
gcc photoresistor.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

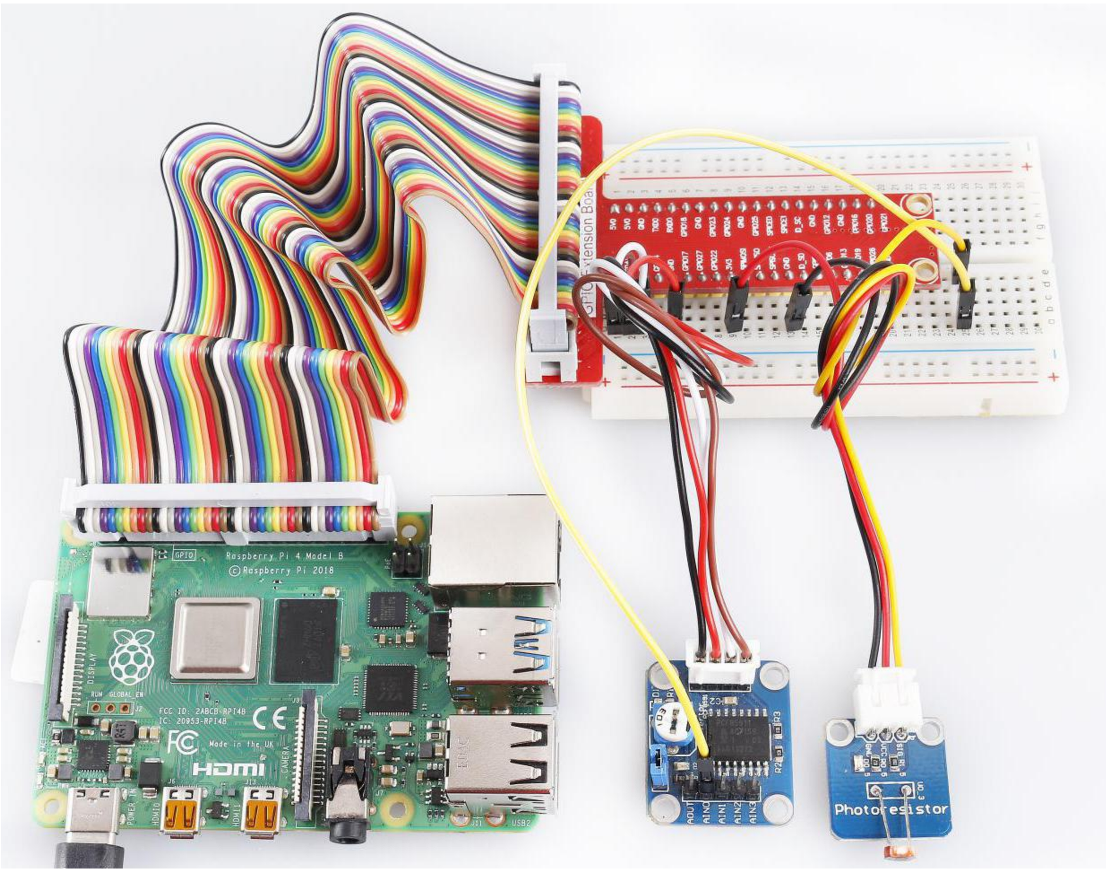
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 20_photoresistor.py
```

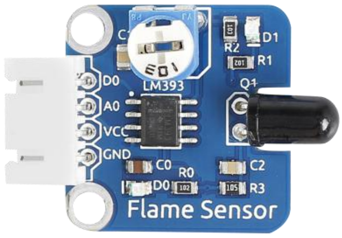
Now, change light intensity (e.g. cover the module with a pad), and the value printed on the screen will change accordingly.



Lesson 21 Flame Sensor

Introduction

A flame sensor (as shown below) performs detection by capturing infrared rays with specific wavelengths from flame. It can be used to detect and warn of flames.

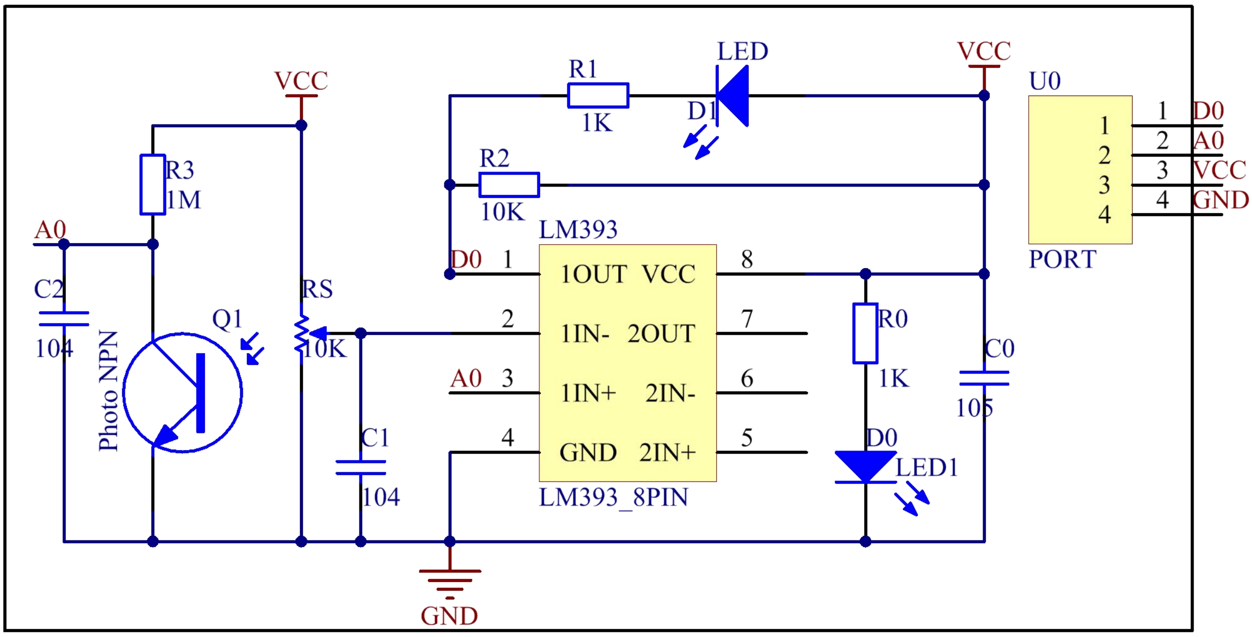


Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * Flame sensor module
- 1 * PCF8591
- 1 * 4-Pin anti-reverse cable
- Several Jumper wires

Experimental Principle

There are several types of flame sensors. In this experiment, we will use a far-infrared flame sensor. It can detect infrared rays with wavelength ranging from 700nm to 1000nm. A far-infrared flame probe converts the strength changes of external infrared light into current changes. And then it convert analog quantities into digital ones. In this experiment, connect pin D0 of the Flame Sensor module to a GPIO of Raspberry Pi to detect by programming whether any flame exists. The schematic diagram:

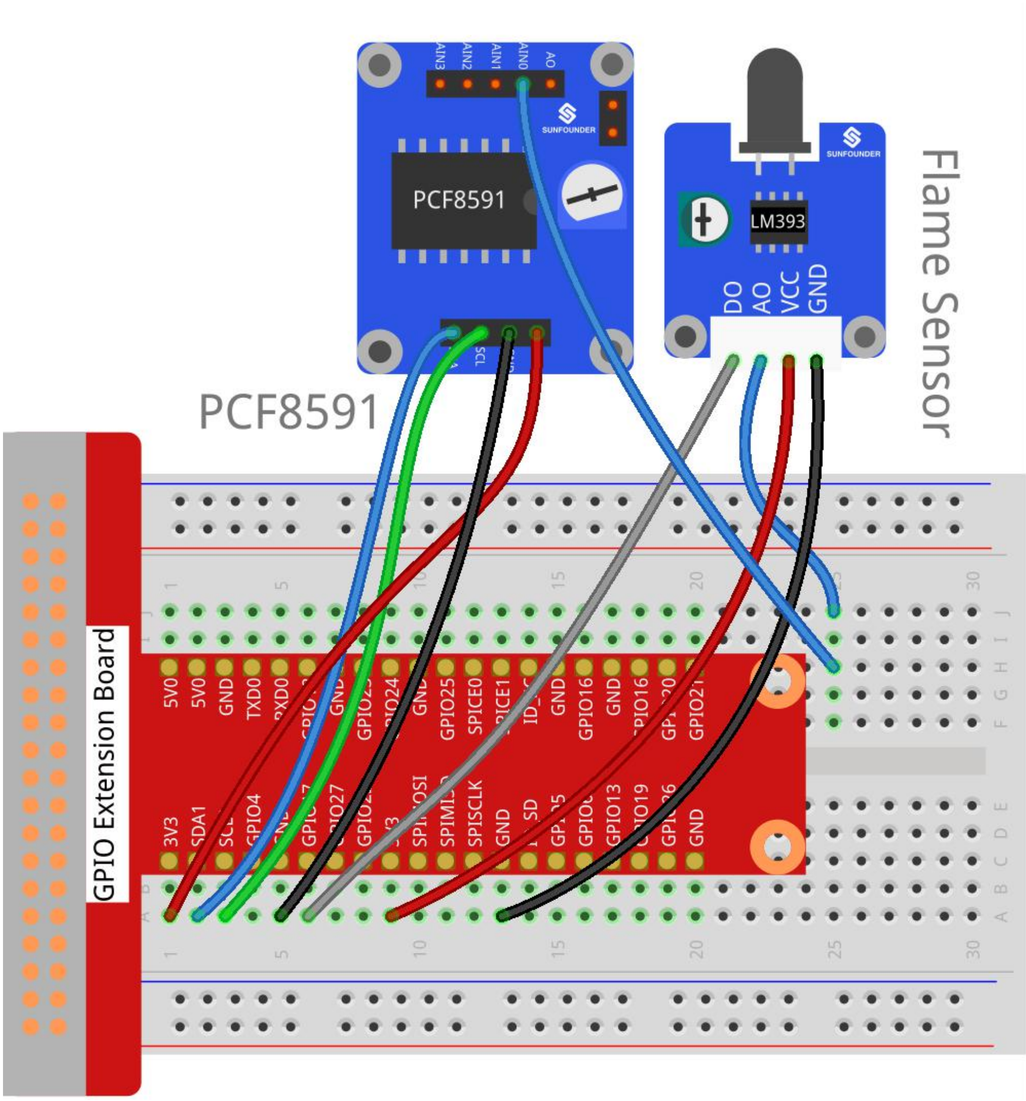


Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	PCF8591 Module
SDA	SDA1	SDA
SCL	SCL1	SCL
3.3V	3V3	VCC
GND	GND	GND

Flame Sensor	GPIO Extension Board	PCF8591 Module
DO	GPIO17	*
AO	*	AIN0
VCC	3V3	VCC
GND	GND	GND



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/21_flame_sensor/
```

Step 3: Compile.

```
gcc flame_sensor.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

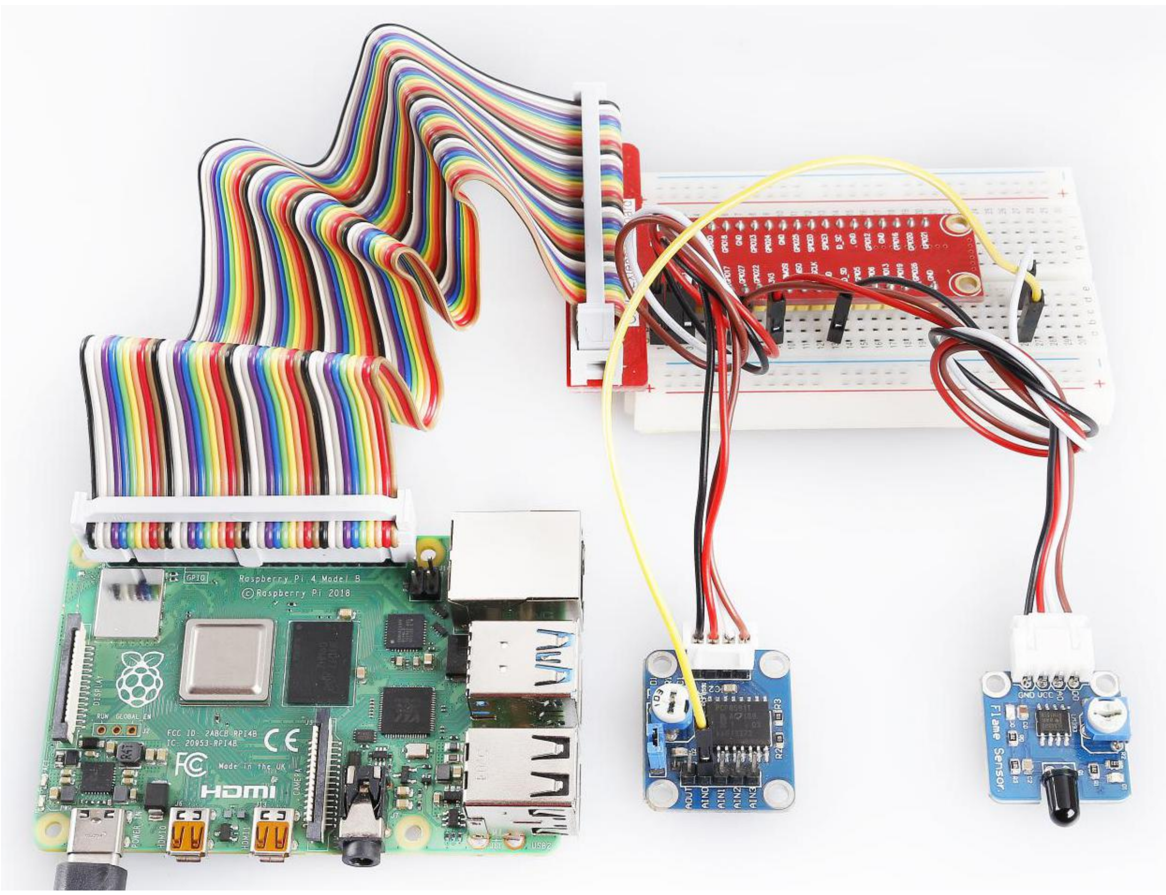
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 21_flame_sensor.py
```

Now, ignite a lighter near the sensor, within the range of 80cm, and "Fire!" will be displayed on the screen. If you put out the lighter or just move the flames away from the flame sensor, "Safe~" will be displayed then.



Lesson 22 Gas Sensor

Introduction

Gas Sensor MQ-2 is a sensor for flammable gas and smoke by detecting the concentration of combustible gas in the air. They are used in gas detecting equipment for smoke and flammable gasses in household, industry or automobile.

Required Components

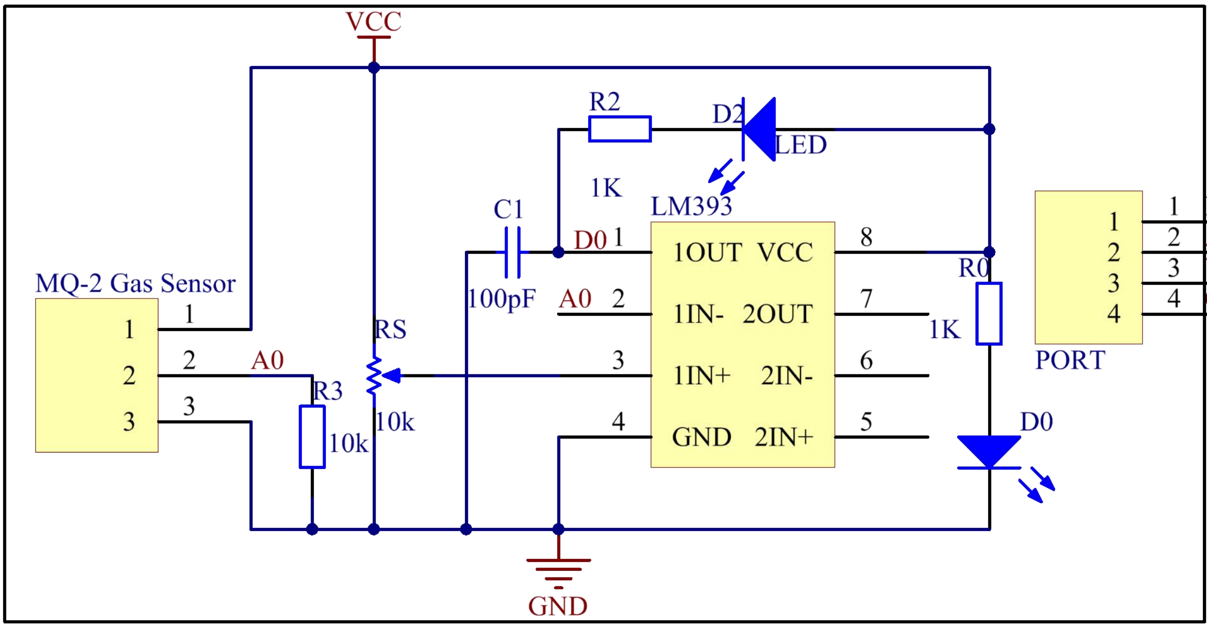
- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * Active Buzzer module
- 1 * PCF8591
- 1 * Gas sensor module
- 1 * 3-Pin anti-reverse cable
- 1 * 4-Pin anti-reverse cable
- Several Jumper wires

Experimental Principle

MQ-2 gas sensor is a kind of surface ion type and N-type semiconductors, which uses tin oxide semiconductor gas sensitive material. When ambient temperature is in 200 ~ 300℃, tin oxide will adsorb oxygen in the air and form oxygen anion adsorption to decrease electron density in semiconductor so as to increase its resistance. When in contact with the smoke, if grain boundary barrier is modulated by the smoke and changed, it could cause surface conductivity change. So you can gain the information of the smoke existence, The higher the smoke concentration is, the more conductive the material becomes, thus the lower the output resistance is.

In this experiment, if harmful gases reach a certain concentration, the buzzer will beep to warn.

The schematic diagram of the module is as shown below:



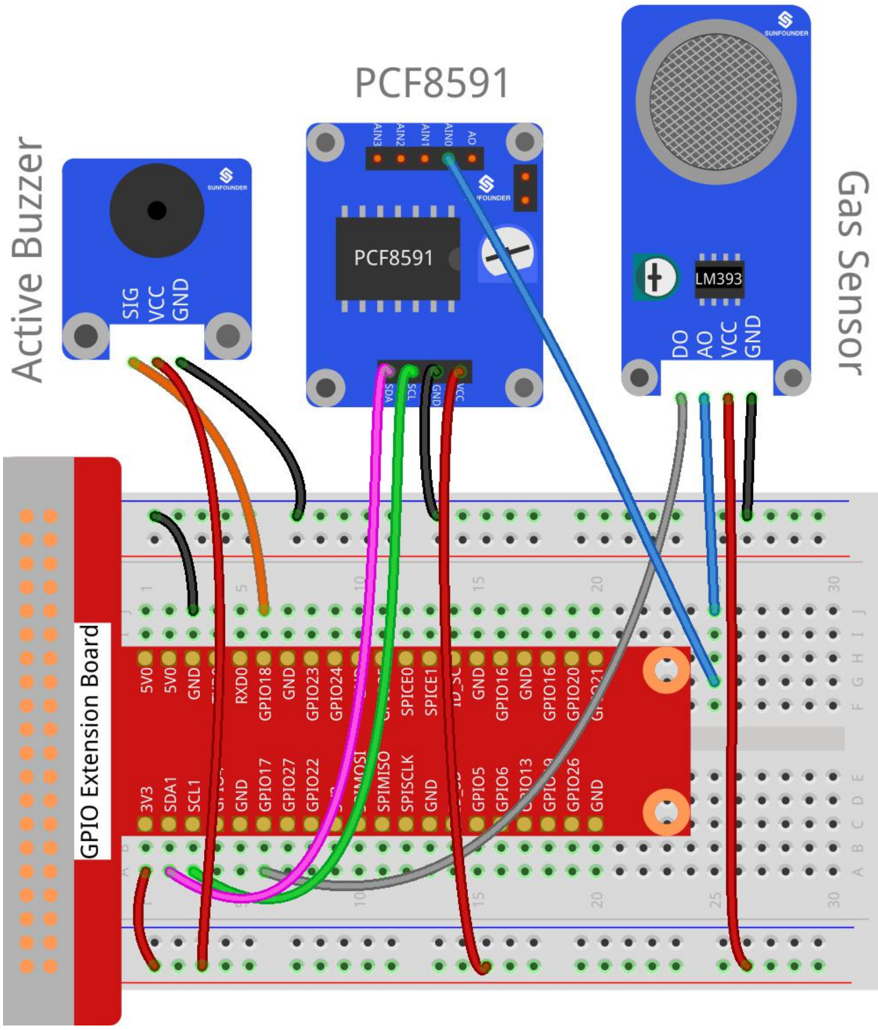
Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	PCF8591 Module
SDA	SDA1	SDA
SCL	SCL1	SCL
3.3V	3V3	VCC
GND	GND	GND

Gas Sensor Module	GPIO Extension Board	PCF8591 Module
DO	GPIO17	*
AO	*	AIN0
VCC	3V3	*
GND	GND	GND

Raspberry Pi	GPIO Extension Board	Active Buzzer Module
GPIO1	GPIO18	SIG
3.3V	3V3	VCC
GND	GND	GND



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/22_gas_sensor/
```

Step 3: Compile.

```
gcc gas_sensor.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

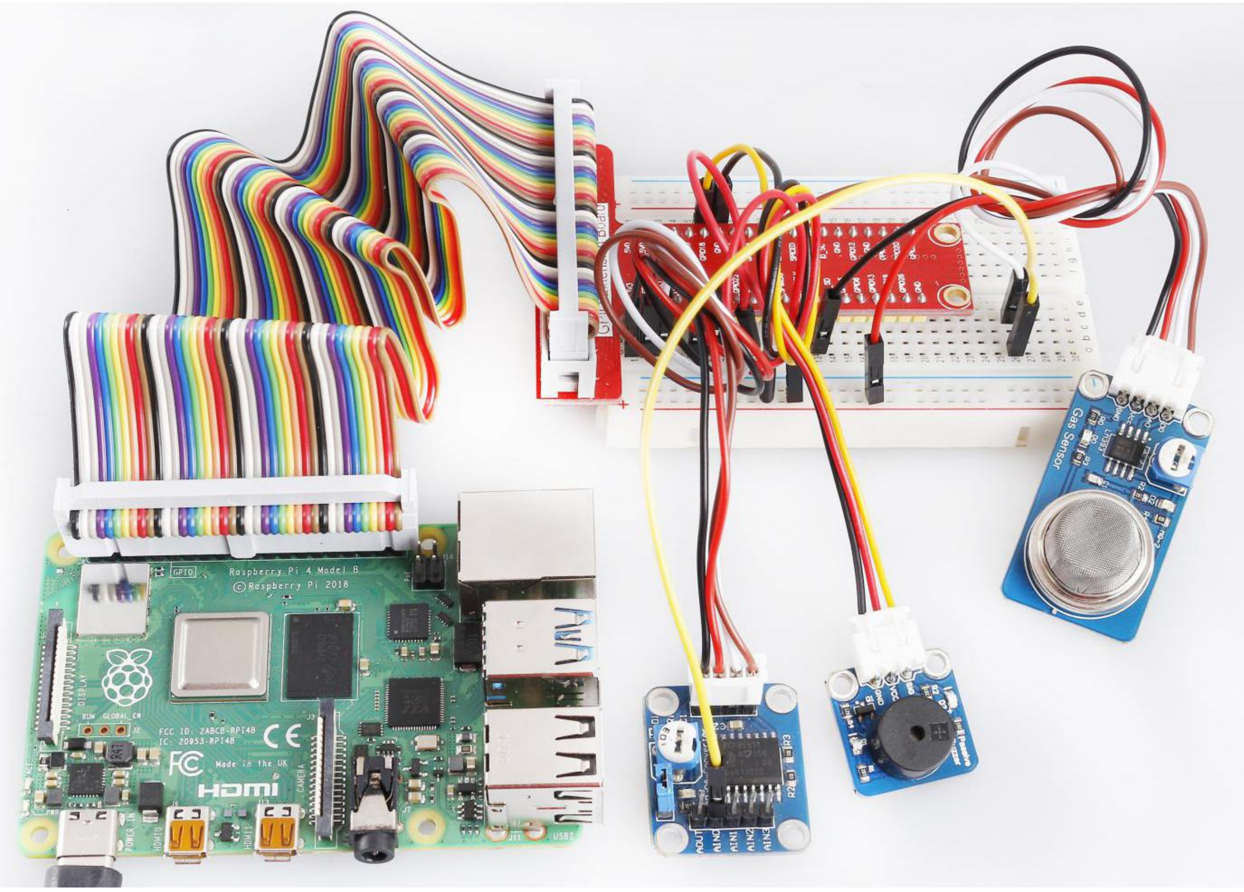
```
sudo python3 22_gas_sensor.py
```

Place a lighter close to the MQ-2 gas sensor, and press the switch to release gasses. A value between 0 and 255 will be displayed on the screen. If harmful gases reach a certain concentration, the buzzer will beep, and “Danger Gas!” will be printed on the screen.

You can also turn the shaft of the potentiometer on the module to raise or reduce the concentration threshold.

The MQ-2 gas sensor needs to be heated up for a while. Wait until the value printed on screen stays steady and the sensor gets warm, which means it can work normally and sensitively at that time.

Note: It is normal that the gas sensor generates heat. Actually, the higher the temperature is, the sensor is more sensitive.



Lesson 23 IR Remote Control

Introduction

Each button of an IR remote control (as shown below) has a string of specific encoding. When a button is pressed, the IR transmitter in the remote control will send out the corresponding IR encoding signals. On the other side, when the IR receiver receives certain encoding signals, it will decode them to identify which button is pressed.

Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * IR Receiver
- 1 * RGB LED module
- 1 * IR Remote Control
- 1 * 3-Pin anti-reverse cable
- 1 * 4-Pin anti-reverse cable

Experimental Principle

In this experiment, we use the lirc library to read infrared signals returned by buttons of the remote control and translate them to button values. Then use liblircclient-dev (C) and pylirc (Python) to simplify the process for reading values from the remote control. In this experiment use 9 buttons on the top of the remote to control the color of the RGB LED module. Each row represents one color, and each column represents the brightness.

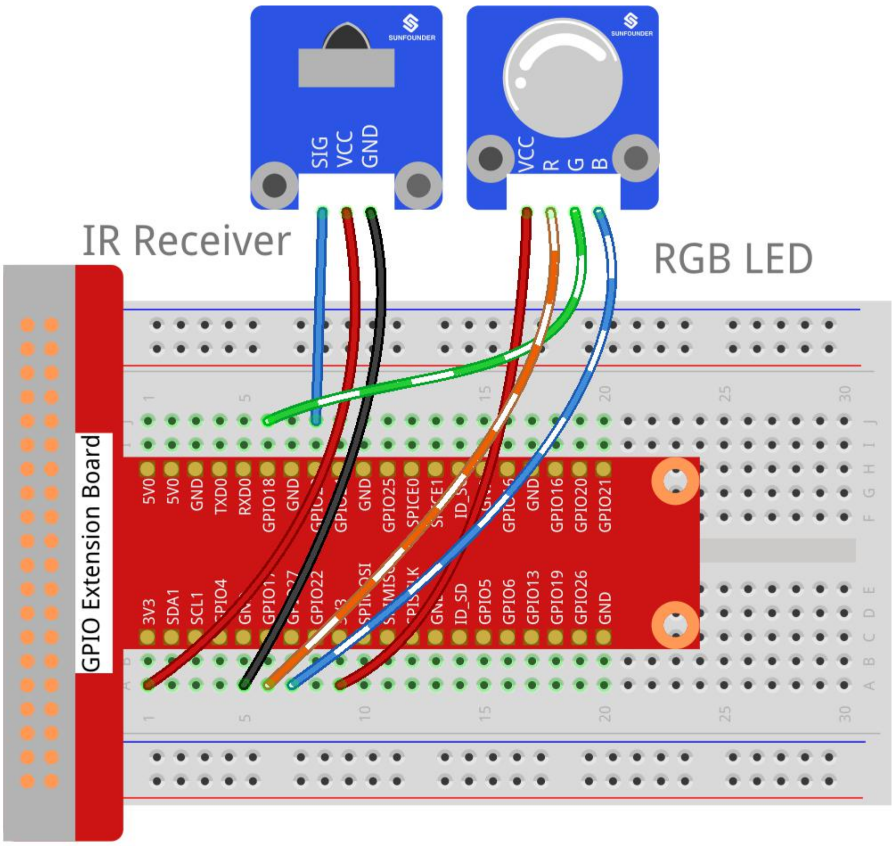
	OFF	Dark	Bright
Red			
Green			
Blue			

Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	IR Receiver Module
GPIO4	GPIO23	SIG
3.3V	3V3	VCC
GND	GND	GND

Raspberry Pi	GPIO Extension Board	RGB LED Module
3.3V	3V3	VCC
GPIO0	GPIO17	R
GPIO1	GPIO18	G
GPIO2	GPIO27	B



Step 2: Upgrade.

```
    sudo su -c "grep '^deb ' /etc/apt/sources.list | sed 's/^deb/deb-src/g' >
/etc/apt/sources.list.d/deb-src.list"
    sudo apt update
    sudo apt install devscripts
```

Step 3: Installing with a patch for gpio-ir in Raspbian Buster or higher version.

```
sudo apt install dh-exec doxygen expect libasound2-dev libftdi1-dev libsystemd-dev libudev-dev libusb-1.0-0-dev libusb-dev man2html-base portaudio19-dev socat xsltproc python3-yaml dh-python libx11-dev python3-dev python3-setuptools
mkdir build
cd build
apt source lirc
wget https://raw.githubusercontent.com/neuralassembly/raspi/master/lirc-gpio-ir-0.10.patch
patch -p0 -i lirc-gpio-ir-0.10.patch
cd lirc-0.10.1
debuild -uc -us -b
cd ..
sudo apt install ./liblirc0_0.10.1-5.2_armhf.deb ./liblircclient0_0.10.1-5.2_armhf.deb ./lirc_0.10.1-5.2_armhf.deb
```

Installing with a patch for gpio-ir in Raspbian Stretch:

```
sudo apt build-dep lirc
mkdir build
cd build
apt source lirc
wget https://raw.githubusercontent.com/neuralassembly/raspi/master/lirc-gpio-ir.patch
patch -p0 -i lirc-gpio-ir.patch
cd lirc-0.9.4c
debuild -uc -us -b
cd ..
sudo apt install ./liblirc0_0.9.4c-9_armhf.deb ./liblirc-client0_0.9.4c-9_armhf.deb ./lirc_0.9.4c-9_armhf.deb
```

If you encounter problems during the installation process, please try a few more times. The final install command will fail. Then please configure the files shown below first, i.e., /boot/config.txt and /etc/lirc/lirc_options.conf. After that, please try the final install command again. Then the install will success.

Step 4: Set up lirc.

Open your */boot/config.txt* file:

```
sudo nano /boot/config.txt
```

Add this to the file:

```
# Uncomment this to enable the lirc-rpi module
#dtoverlay=lirc-rpi
dtoverlay=gpio-ir,gpio_pin=23
dtoverlay=gpio-ir-tx,gpio_pin=22
```

Press Ctrl +O and Ctrl +X, save and exit .

Step 5: When you are using Raspbian Buster, first, please execute the following command.

```
sudo mv /etc/lirc/lirc_options.conf.dist /etc/lirc/lirc_options.conf
sudo mv /etc/lirc/lircd.conf.dist /etc/lirc/lircd.conf
```

Step 6: edit /etc/lirc/lirc_options.conf.

Open the /etc/lirc/lirc_options.conf

```
sudo nano /etc/lirc/lirc_options.conf
```

Modify the file as below:

```
driver = default
device = /dev/lirc1
```

Step 7: Run install command again.

```
sudo apt
install ./liblirc0_0.10.1-5.2_armhf.deb ./liblircclient0_0.10.1-5.2_armhf.deb ./lirc_0.10.1-5.2_armhf.deb
```

Step 8: Copy the configuration file to/home/pi and /etc/lirc:

```
cd /home/pi/SunFounder_SensorKit_for_RPi2
cp lircd.conf /home/pi
sudo cp lircd.conf /etc/lirc/
```

Step 9: Reboot the Raspberry Pi after the change.

```
sudo reboot
```

Step 10: Test the IR receiver.

Check if lirc module is loaded:

```
ls /dev/li*
```

You should see this:

```
/dev/lirc0        /dev/lirc1
```

Step 11: Run the command to start outputting raw data from the IR receiver:

```
irw
```

When you press a button on the remote, you can see the button name printed on the screen.

```
pi@raspberrypi:~ $ irw
0000000000000001 00 KEY_CHANNELDOWN ./lircd.conf
0000000000000003 00 KEY_CHANNELUP ./lircd.conf
0000000000000002 00 KEY_CHANNEL ./lircd.conf
0000000000000004 00 KEY_PREVIOUS ./lircd.conf
0000000000000005 00 KEY_NEXT ./lircd.conf
0000000000000006 00 KEY_PLAYPAUSE ./lircd.conf
0000000000000008 00 KEY_VOLUMEDOWN ./lircd.conf
0000000000000007 00 KEY_VOLUMEUP ./lircd.conf
0000000000000009 00 KEY_EQUAL ./lircd.conf
0000000000000015 00 BTN_1 ./lircd.conf
0000000000000014 00 BTN_0 ./lircd.conf
000000000000000a 00 KEY_NUMERIC_0 ./lircd.conf
000000000000000b 00 KEY_NUMERIC_1 ./lircd.conf
```

If it does not appear, somewhere may be incorrectly configured. Check again that you've connected everything and haven't crossed any wires.

For C Users:

Step 5: Download LIRC client library:

```
sudo apt-get install liblircclient-dev
```

Step 6: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/23_ircontrol/
```

Step 7: Copy the *lircrc* file to */etc/lirc/lirc/*:

```
sudo cp lircrc /etc/lirc/
```

Step 8: Compile.

```
gcc ircontrol.c -lwiringPi -llirc_client
```

Step 9: Run.

```
sudo ./a.out
```

For Python Users:

Step 5: Download and install pylirc:

Pylirc is LIRC Python wrapper and it's required to access LIRC from Python programs. To install Pylirc you should complete the following steps.

Install Pylirc dependencies:

```
sudo apt-get install python3-dev
sudo apt-get install liblircclient-dev
```

Install Pylirc:

```
wget
https://files.pythonhosted.org/packages/a9/e1/a19ed9cac5353ec07294be7b1aefc8f8
9985987b356e916e2c39b5b03d9a/pylirc2-0.1.tar.gz
tar xvf pylirc2-0.1.tar.gz
cd pylirc2-0.1
```

Step 6: Replace file pylircmodule.c:

```
rm pylircmodule.c
wget
https://raw.githubusercontent.com/project-owner/Peppy.doc/master/files/pylircmod
ule.c
```

Step 7: Install Pylirc (assuming that Python 3.7 is in use):

```
sudo python3 setup.py install
sudo mv
/usr/local/lib/python3.7/dist-packages/pylircmodule.cpython-37m-arm-linux-gnueab
ihf.so
/usr/local/lib/python3.7/dist-packages/pylirc.cpython-37m-arm-linux-gnueabihf.so
```

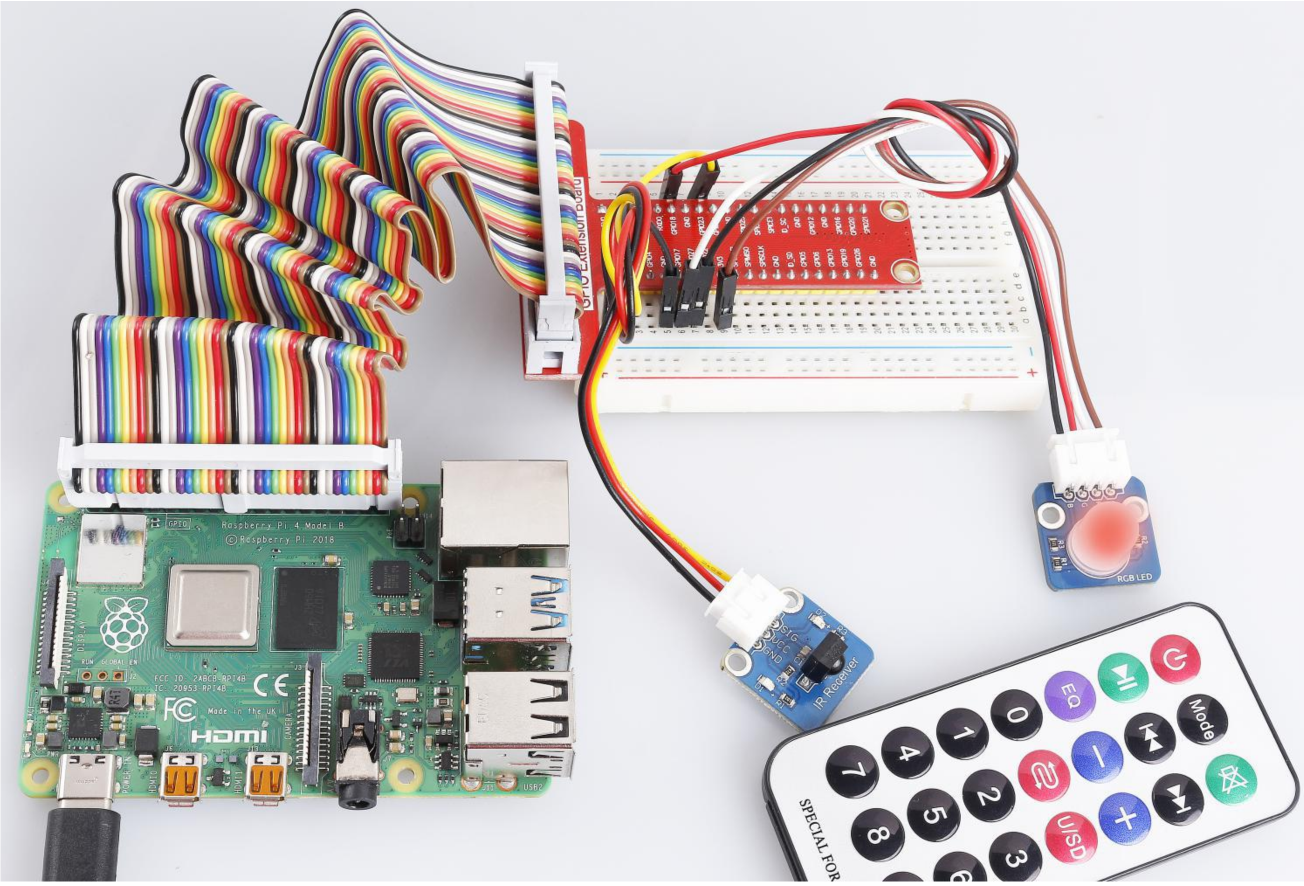
Step 8: Change directory:

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 9: Run.

```
sudo python3 23_ircontrol.py
```

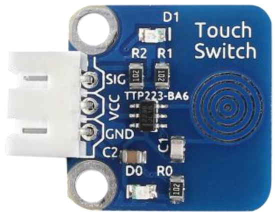
Each of the top three rows of buttons on the remote control represents a kind of color, i.e. red, green, and blue, top to bottom. Each column represents off, light, and dark. For example, press the second button (light) on the first row (red), and the LED will flash light red. You can use the remote to generate 27 colors in total (including all the LEDs off). Try to change the color of the RGB LED with the 9 buttons!



Lesson 24 Touch Switch

Introduction

A touch sensor operate with the conductivity of human body. When you touch the metal on the base electrode of the transistor, the level of pin SIG will turn over.

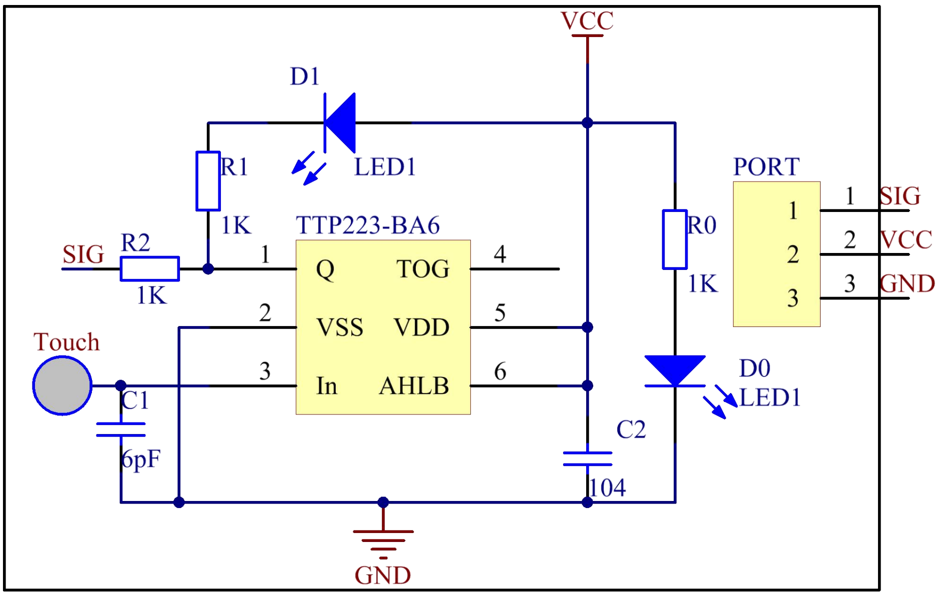


Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * Touch sensor module
- 1 * Dual-Color LED module
- 2 * 3-Pin anti-reverse cable

Experimental Principle

In this experiment, touch the base electrode of the transistor by fingers to make it conduct as human body itself is a kind of conductor and an antenna that can receive electromagnetic waves in the air. These electromagnetic wave signals collected from the human body are amplified by the transistor and processed by the comparator on the module to output steady signals. The schematic diagram:

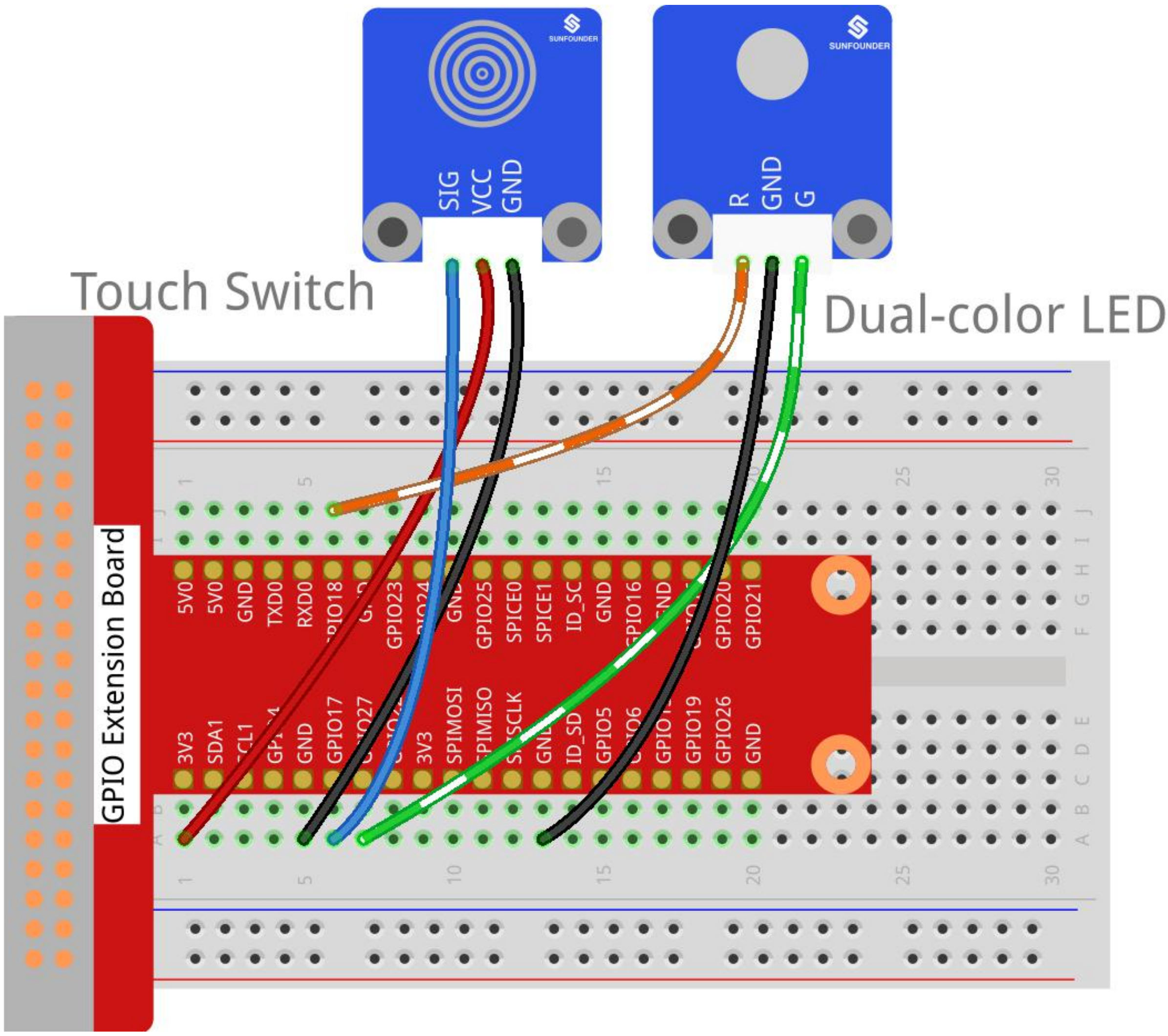


Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	Touch Sensor Module
GPIO0	GPIO17	SIG
3.3V	3V3	VCC
GND	GND	GND

Raspberry Pi	GPIO Extension Board	Dual-Color LED Module
GPIO1	GPIO18	R
GND	GND	GND
GPIO2	GPIO27	G



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/24_touch_switch/
```

Step 3: Compile.

```
gcc touch_switch.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

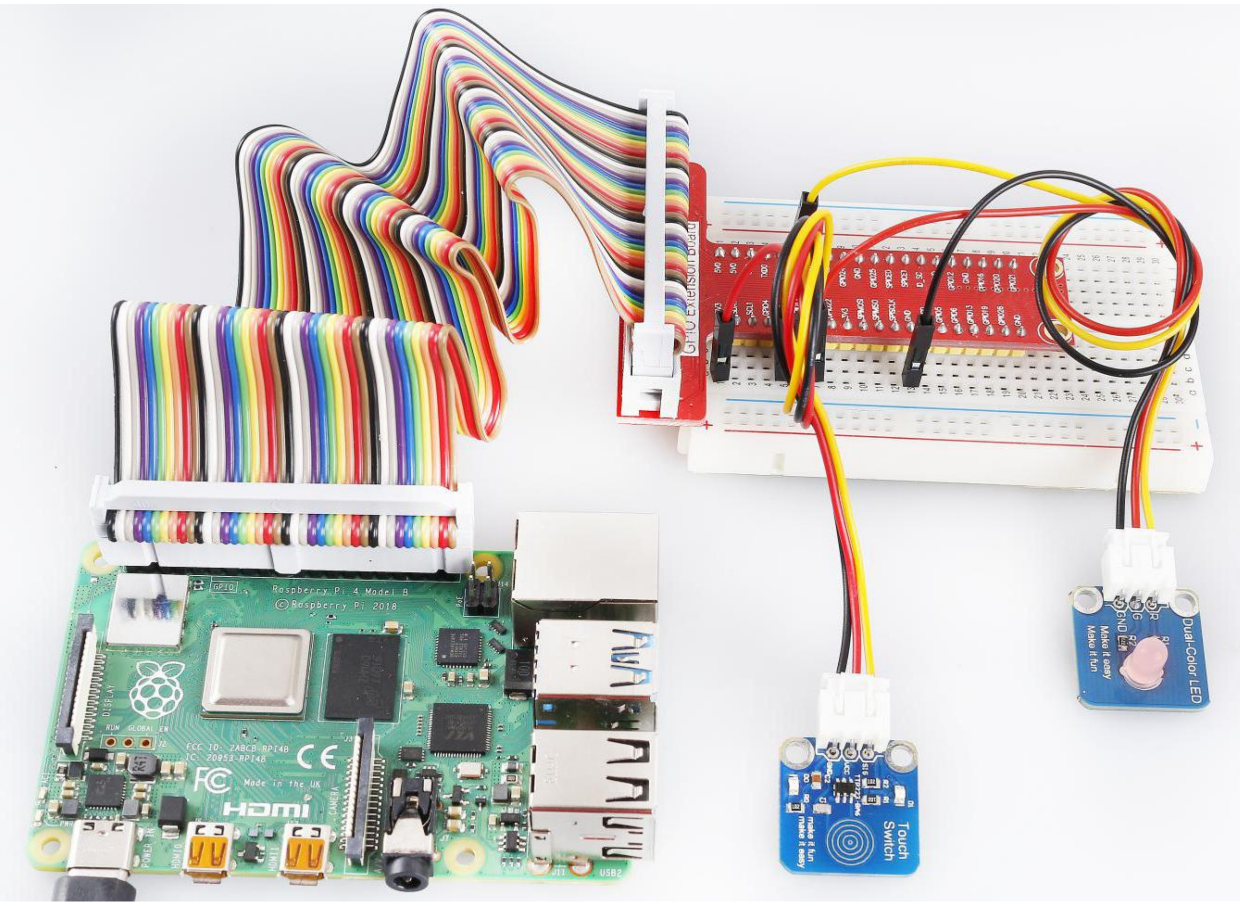
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 24_touch_switch.py
```

Now, touch the metal disk, you can see the LED change its colors and "ON" and "OFF" printed on the screen.



Lesson 25 Ultrasonic Ranging Module

Introduction

The ultrasonic sensor uses sound to accurately detect objects and measure distances. It sends out ultrasonic waves and converts them into electronic signals.

Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * Ultrasonic ranging module
- 1 * 4-Pin anti-reverse cable

Experimental Principle

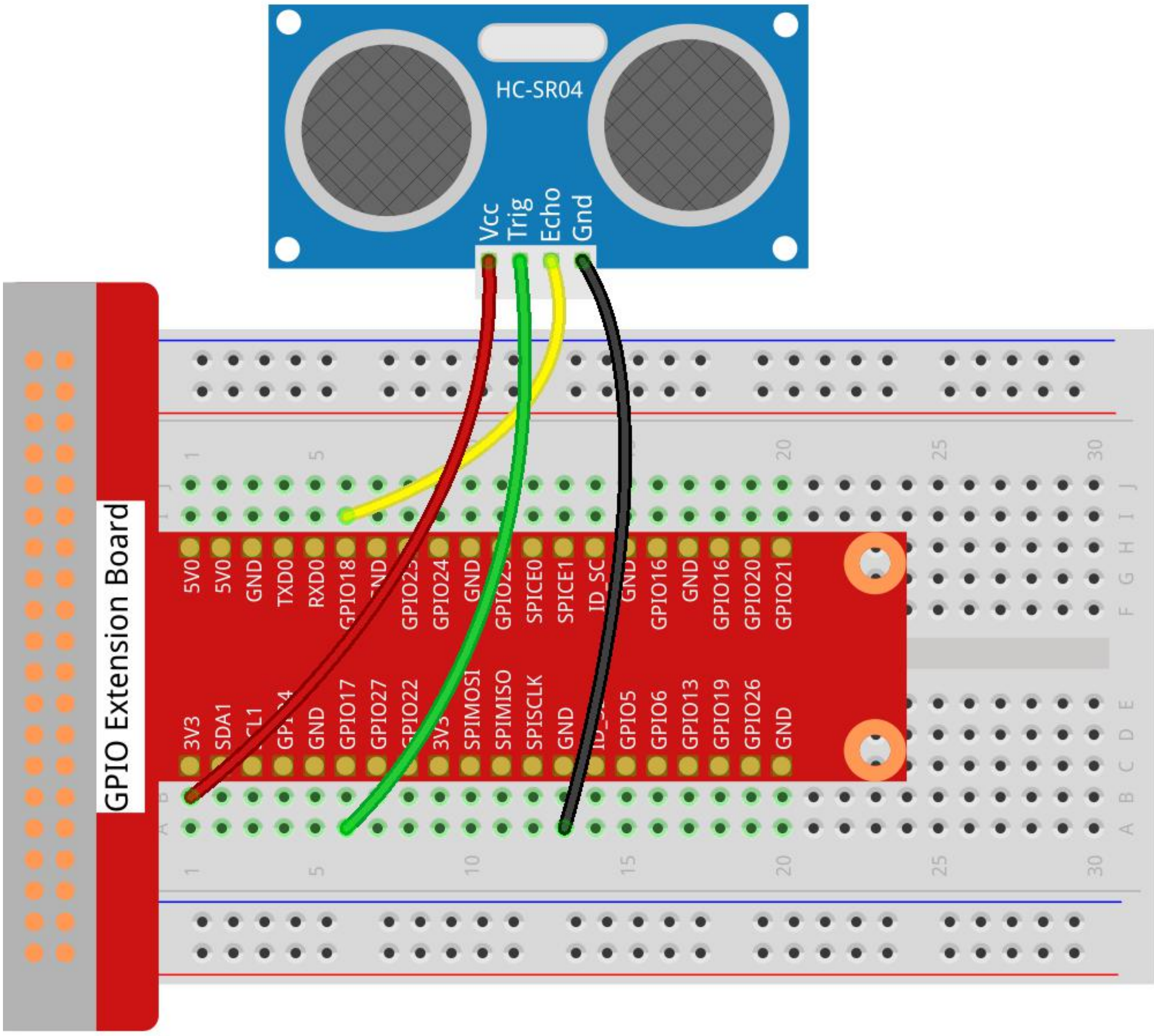
This sensor works by sending a sound wave out and calculating the time it takes for the sound wave to get back to the ultrasonic sensor. By doing this, it can tell us how far away objects are relative to the ultrasonic sensor.

Test distance = (high level time * velocity of sound (340M/S)) / 2 (in meters)

Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	Ultrasonic Ranging Module
3.3V	3V3	VCC
GPIO0	GPIO17	Trig
GPIO1	GPIO18	Echo
GND	GND	GND



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/25_ultrasonic_ranging/
```

Step 3: Compile.

```
gcc ultrasonic_ranging.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

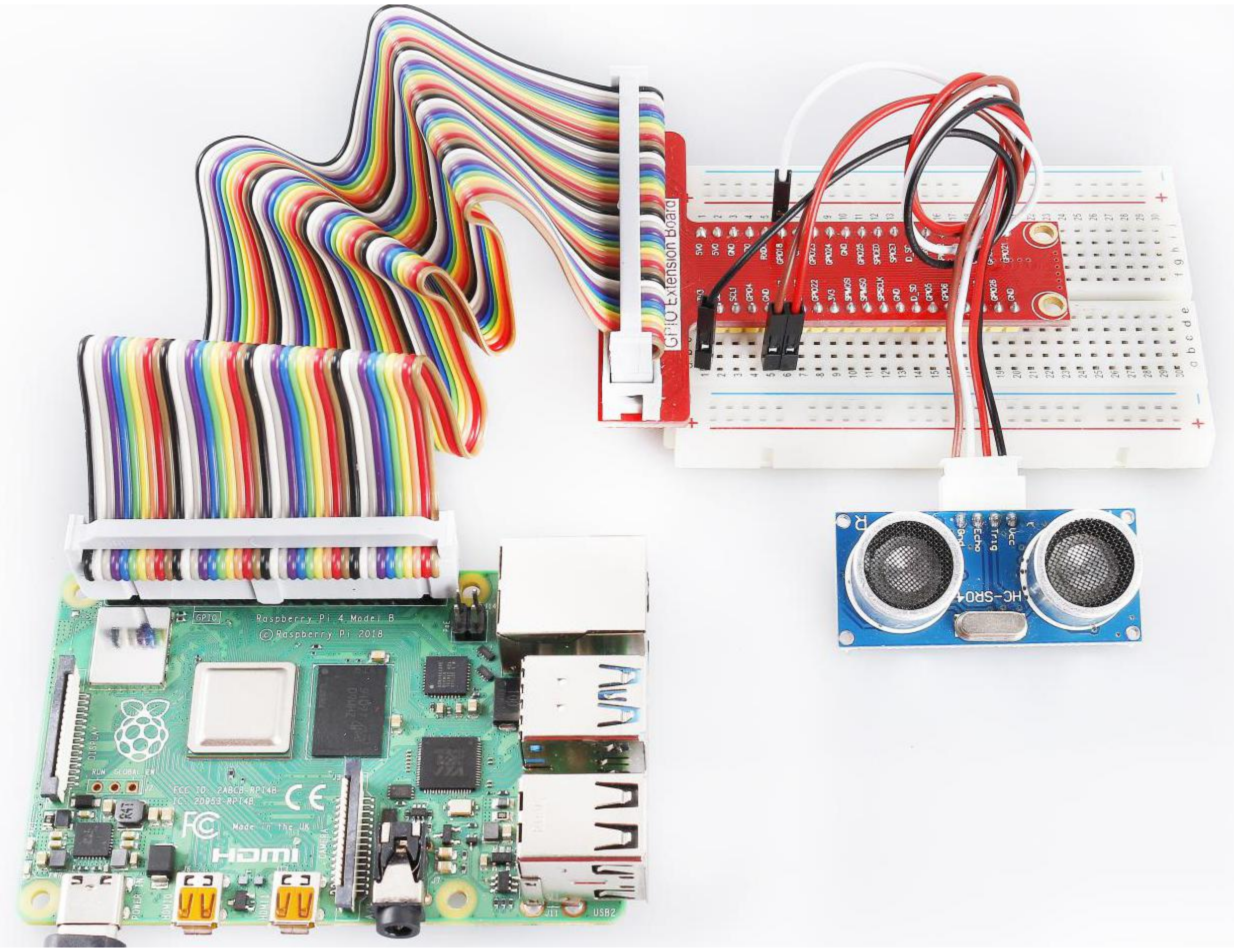
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

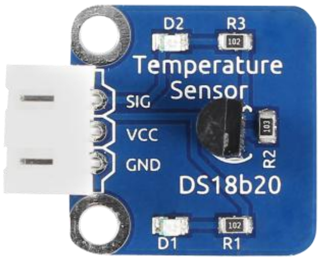
```
sudo python3 25_ultrasonic_ranging.py
```

Now you can see the distance between the ultrasonic ranging module and the obstacle (like your palm) in front on the screen. Sway your hand over the ultrasonic ranging module slowly and observe the distance printed on the screen.



Lesson 26 DS18B20 Temperature Sensor

Introduction



Temperature Sensor DS18B20 is a commonly used digital temperature sensor featured with small size, low-cost hardware, strong anti-interference capability and high precision. The digital temperature sensor is easy to wire and can be applied a various occasions after packaging. Different from conventional AD collection temperature sensors, it uses a 1-wire bus and can directly output temperature data.

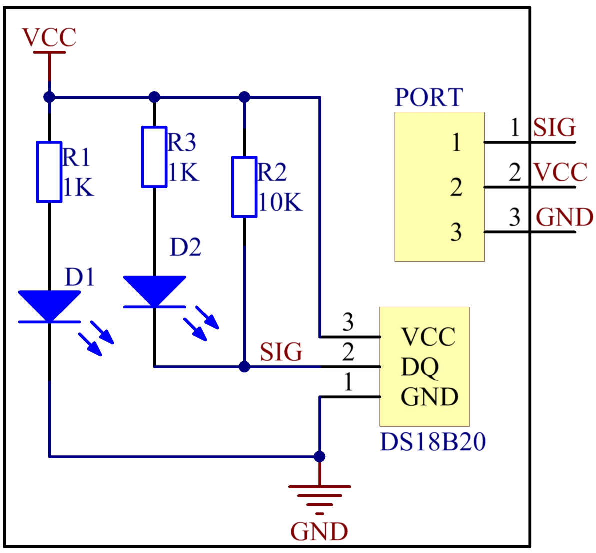
Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * DS18B20 Temperature Sensor module
- 1 * 3-Pin anti-reverse cable

Experimental Principle

With a unique single-wire interface, DS18B20 requires only one pin for a two-way communication with a microprocessor. It supports multi-point networking to measure multi-point temperatures. Eight sensors can be connected at most, because it will consume too much power supply and cause low voltage thus harming the stability of transmission.

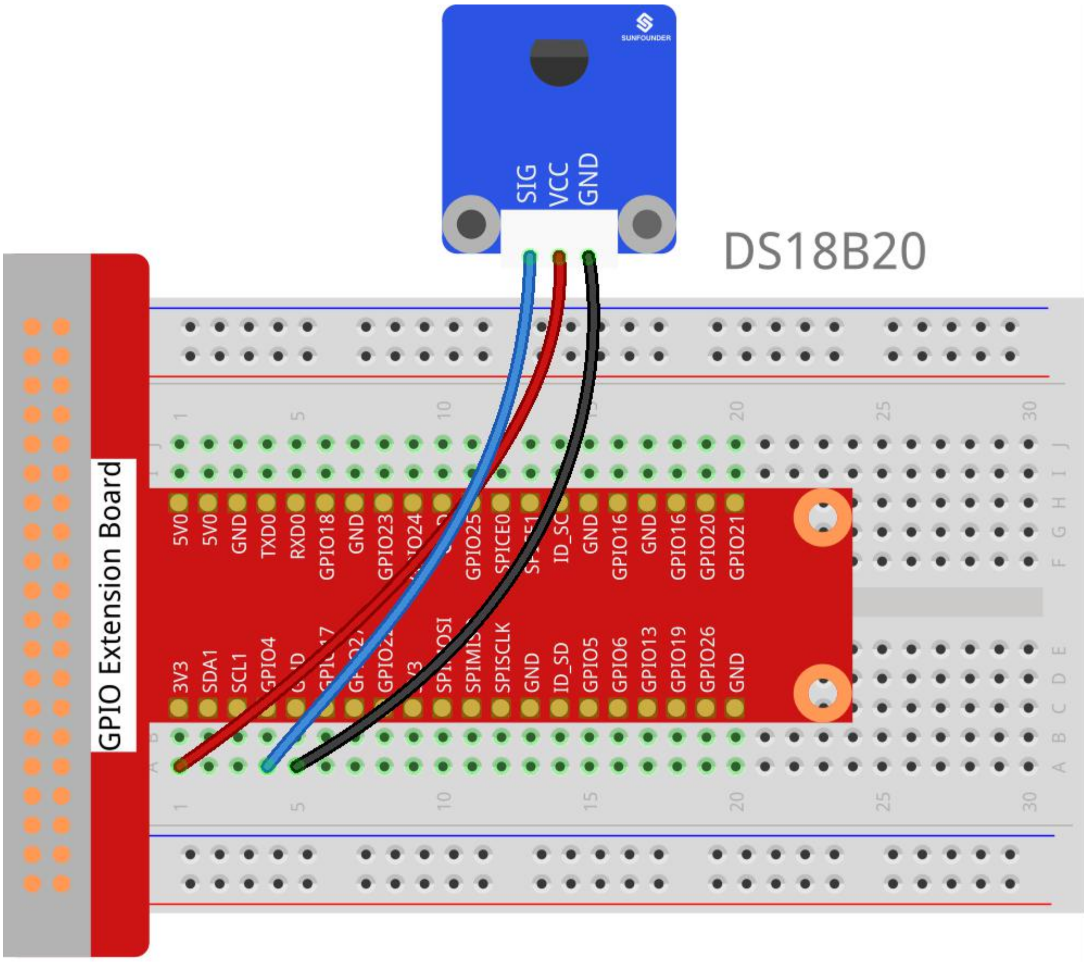
When using the DS18B20, you need to connect a 10KΩ resistor to the middle pin DQ to pull up the level. The schematic diagram of the module is as shown below:



Experimental Procedures

Step 1: Build the circuit according to the following method.

Raspberry Pi	GPIO Extension Board	DS18B20 Temperature Sensor
GPIO7	GPIO4	SIG
3.3V	3V3	VCC
GND	GND	GND



Step 2: Upgrade your kernel.

```
sudo apt-get update
sudo apt-get upgrade
```

Step 3: You can edit that file with nano.

```
sudo nano /boot/config.txt
```

Then scroll to the bottom and type.

```
dtoverlay=w1-gpio
```

Then reboot with

```
sudo reboot
```

Mount the device drivers and confirm whether the device is effective or not.

```
sudo modprobe w1-gpio
sudo modprobe w1-therm
cd /sys/bus/w1/devices/
ls
```

The result is as follows:

```
root@rasberrypi:/sys/bus/w1/devices# ls
28-00000495db35 w1_bus_master1
```

28-00000495db35 is an external temperature sensor device, but it may vary with every client. This is the serial number of your ds18b20.

Step 4: Check the current temperature.

```
cd 28-00000495db35
ls
```

The result is as follows:

```
root@rasberrypi:/sys/bus/w1/devices/28-00000495db35# ls
driver  id  name    power   subsystem   uevent  w1_slave
cat w1_slave
```

The result is as follows:

```
root@raspberrypi:/sys/bus/w1_slave/28-00000495db35# cat w1_slave
a3 01 4b 46 7f ff 0d 10 ce : crc=ce YES
a3 01 4b 46 7f ff 0d 10 ce t=26187
```

The second line t=26187 is current temperature value. If you want to convert it to degree Celsius, you can divide by 1000, that is, the current temperature is 26187/1000=26.187 ℃.

For C Users:

Step 2: Change directory and edit.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/26_ds18b20/
nano ds18b20.c
```

Find the following line, replace "28-00000495db35" with your sensor address. Save and exit.

```
char* addr = "/sys/bus/w1/devices/28-00000495db35/w1_slave";
```

Step 6: Compile.

```
gcc ds18b20.c -lwiringPi
```

Step 7: Run.

```
sudo ./a.out
```

For Python Users:

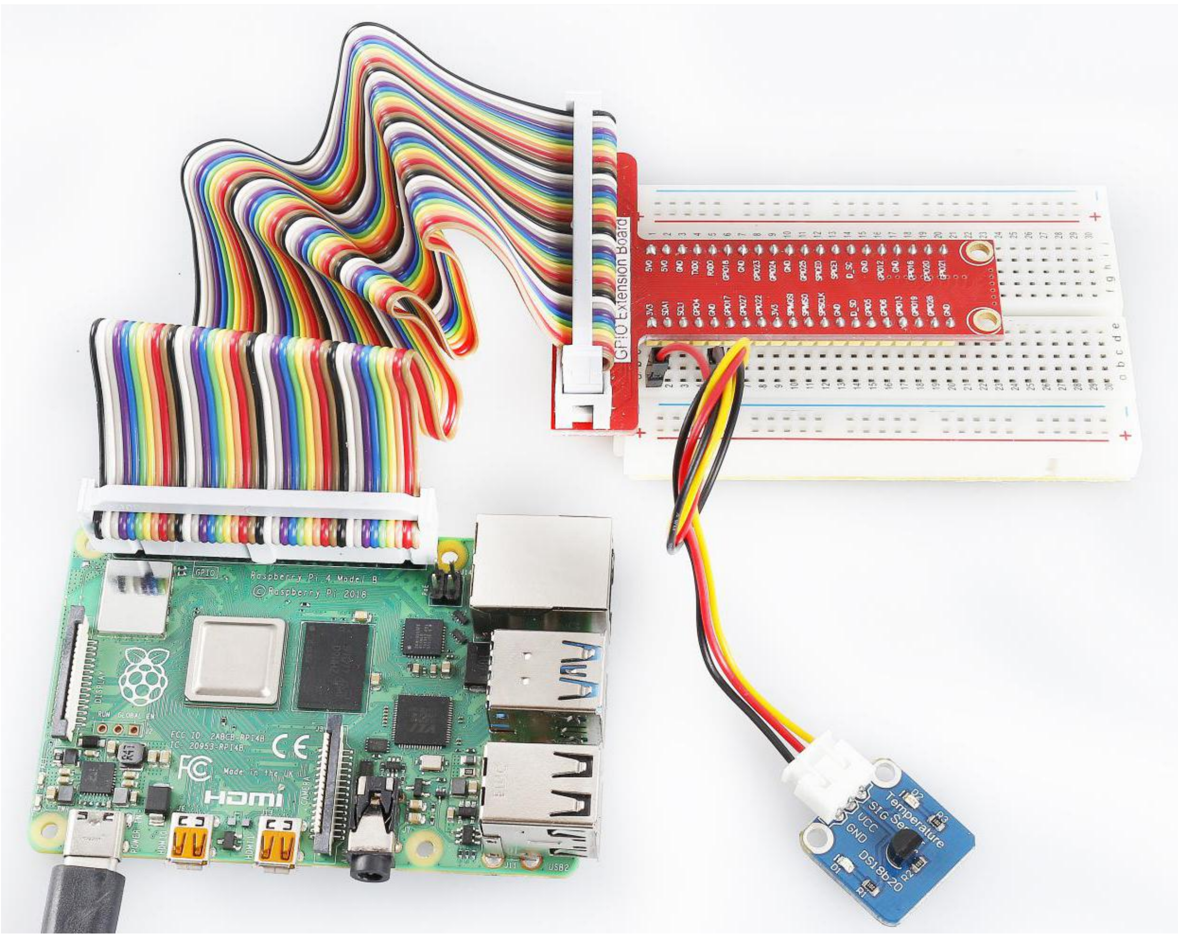
Step 5: Change directory and edit.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
nano 26_ds18b20.py
```

Step 6: Run.

```
sudo python3 26_ds18b20.py
```

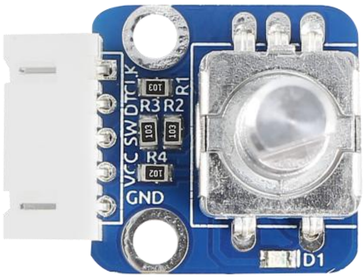
Now, you can see the current temperature value displayed on the screen.



Lesson 27 Rotary Encoder Module

Introduction

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



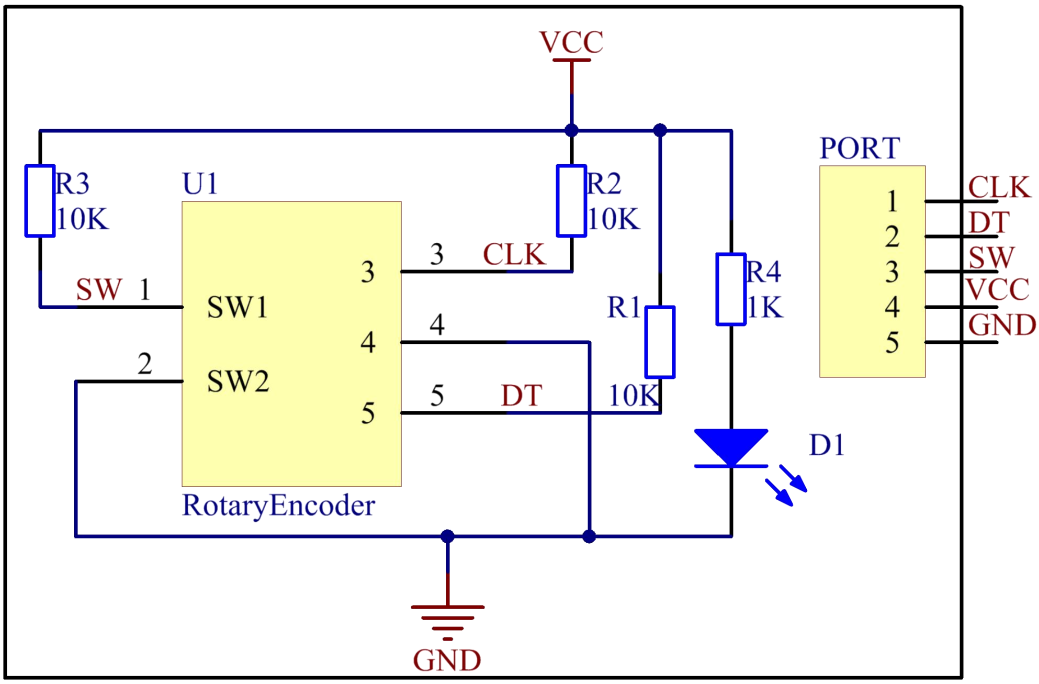
Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * Rotary Encoder module
- 1 * 5-Pin anti-reverse cable

Experimental Principle

Most rotary encoders have 5 pins with three functions of turning left & right and pressing down. Pin 1 and pin 2 are switch wiring terminals used to press. They are similar to buttons previously mentioned, so we will no longer discuss them in this experiment. Pin 4 is generally connected to ground. Pin 3 and pin 5 are first connected to pull-up resistor and then to the microprocessor. In this experiment, they are connected to GPIO0 and GPIO1 of Raspberry Pi. When it is rotated left and right, there will be pulse inputs in pin 1 and pin 3.

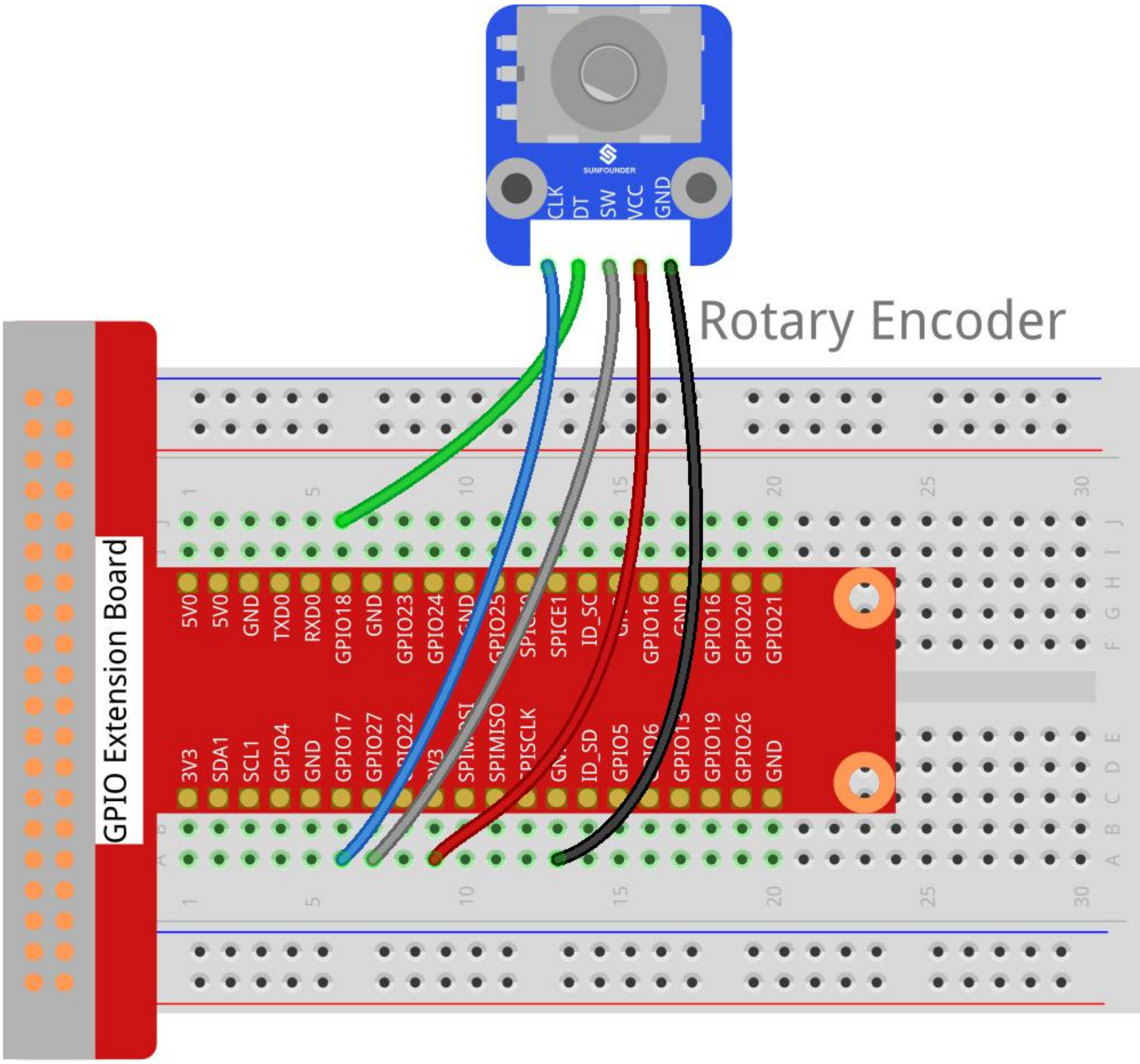
It shows that if output 1 is high and output 2 is high, then the switch rotates clockwise; if output 1 is high and output 2 is low, then the switch rotates counterclockwise. As a result, during SCM programming, if output 1 is high, then you can tell whether the rotary encoder rotates left or right as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



Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	Rotary Encoder Module
GPIO0	GPIO17	CLK
GPIO1	GPIO18	DT
GPIO2	GPIO27	SW
3.3V	3V3	VCC
GND	GND	GND



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/27_rotary_encoder/
```

Step 3: Compile.

```
gcc rotary_encoder.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

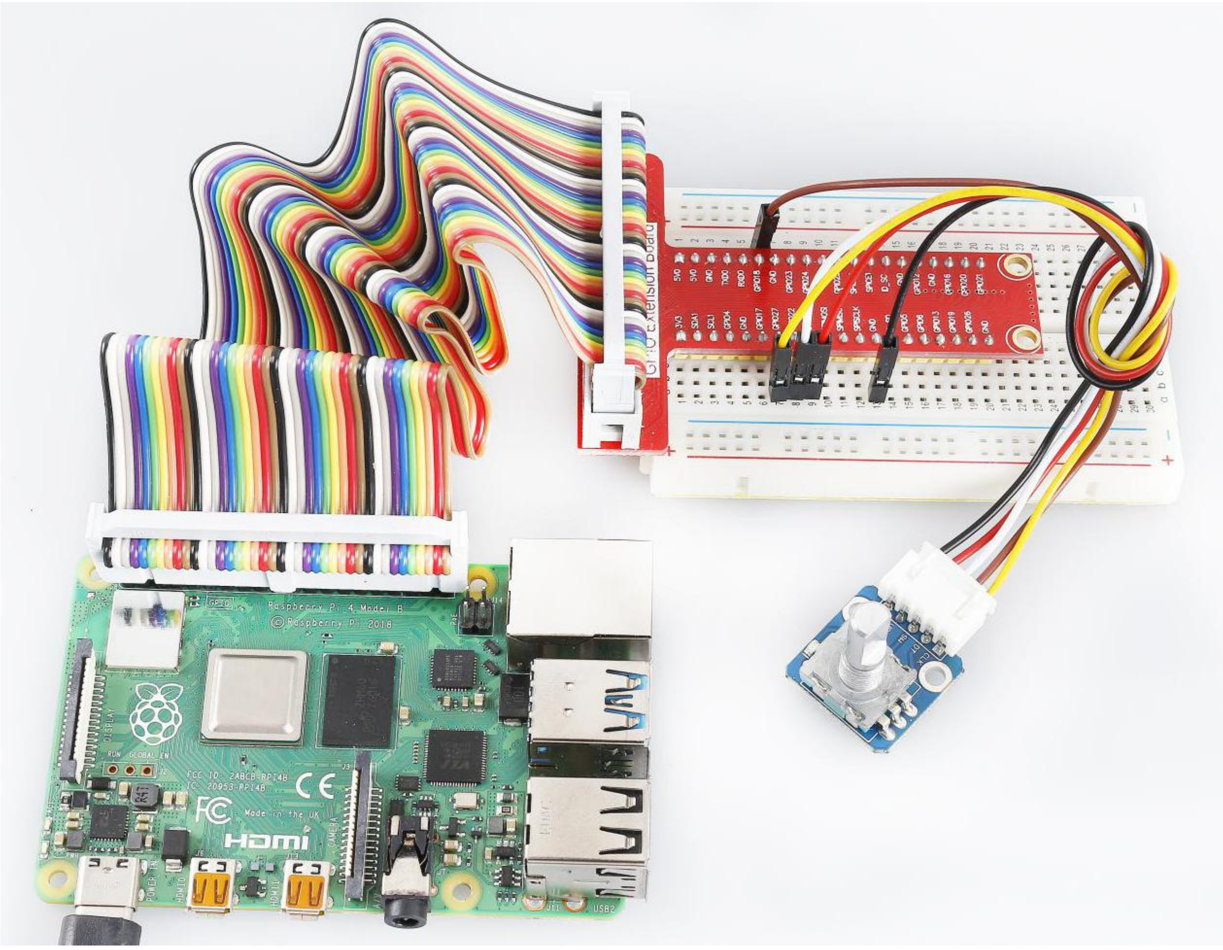
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 27_rotary_encoder.py
```

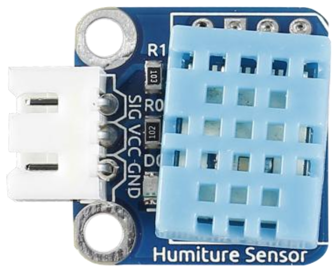
Now rotate the shaft of the rotary encoder, and the value printed on the screen will change. Rotate the rotary encoder clockwise, the value will increase; Rotate it counterclockwise, the value will decrease; Press the rotary encoder, the value will be reset to 0.



Lesson 28 Humiture Sensor

Introduction

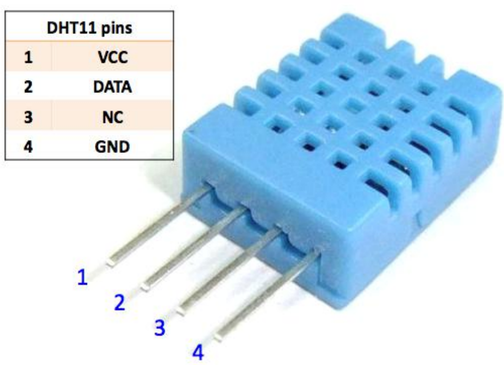
The digital temperature and humidity sensor DHT11 is a composite sensor that contains a calibrated digital signal output of temperature and humidity. The technology of a dedicated digital modules collection and the temperature and humidity sensing technology are applied to ensure that the product has high reliability and excellent long-term stability.



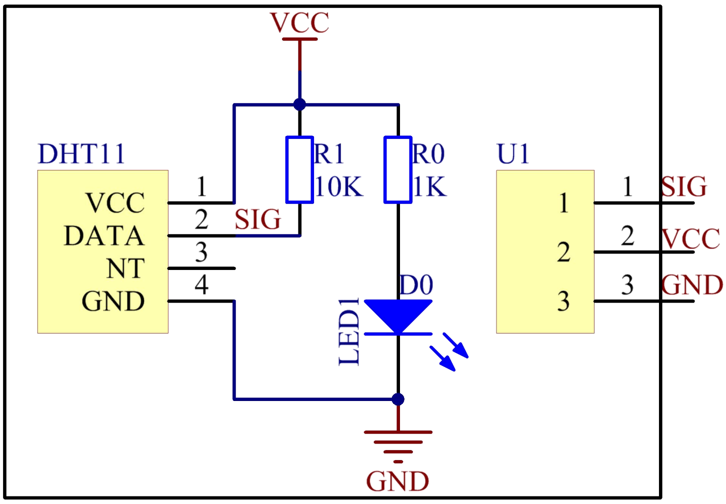
Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * Humiture module
- 1 * 3-Pin anti-reverse cable

Experimental Principle



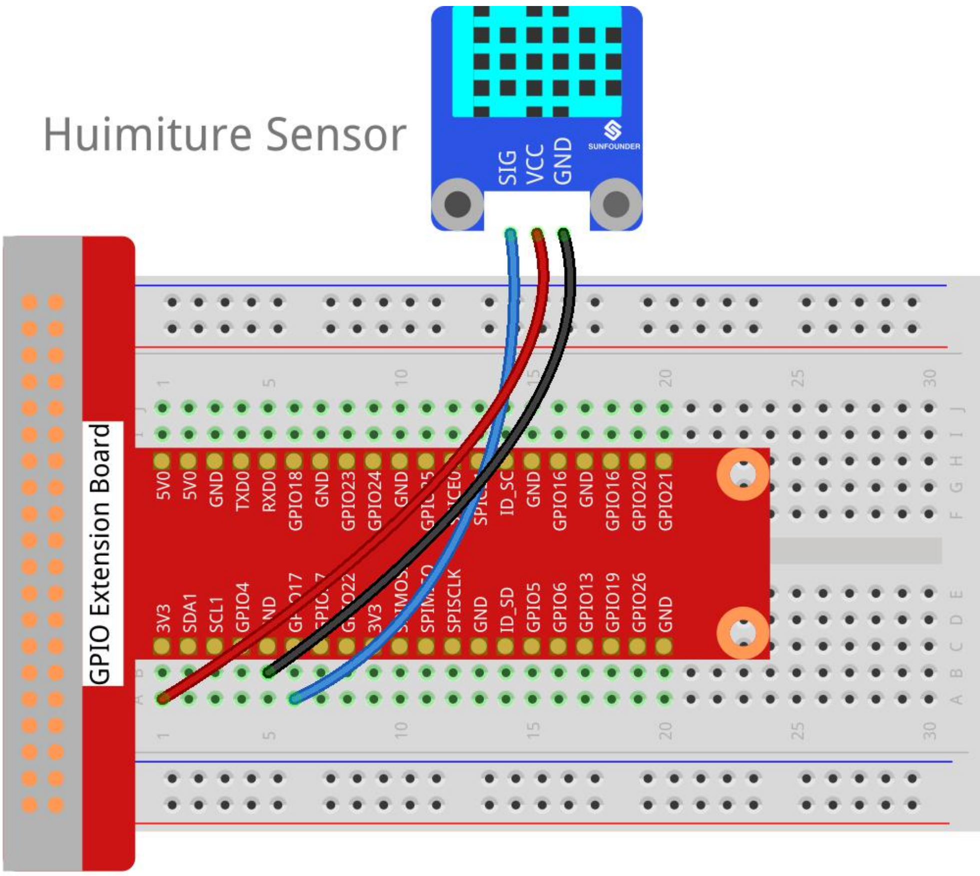
Only three pins are available for use: VCC, GND, and DATA. The communication process begins with the DATA line sending start signal to DHT11, and DHT11 receives the signal and returns an answer signal, then the host receives the answer signal and begins to receive 40-bit humiture data (8-bit humidity integer + 8-bit humidity decimal + 8-bit temperature integer + 8-bit temperature decimal + 8-bit checksum). For more information, please refer to the datasheet of DHT11.



Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	Humiture Module
GPIO0	GPIO17	SIG
3.3V	3V3	VCC
GND	GND	GND



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/28_humiture/
```

Step 3: Compile.

```
gcc humiture.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

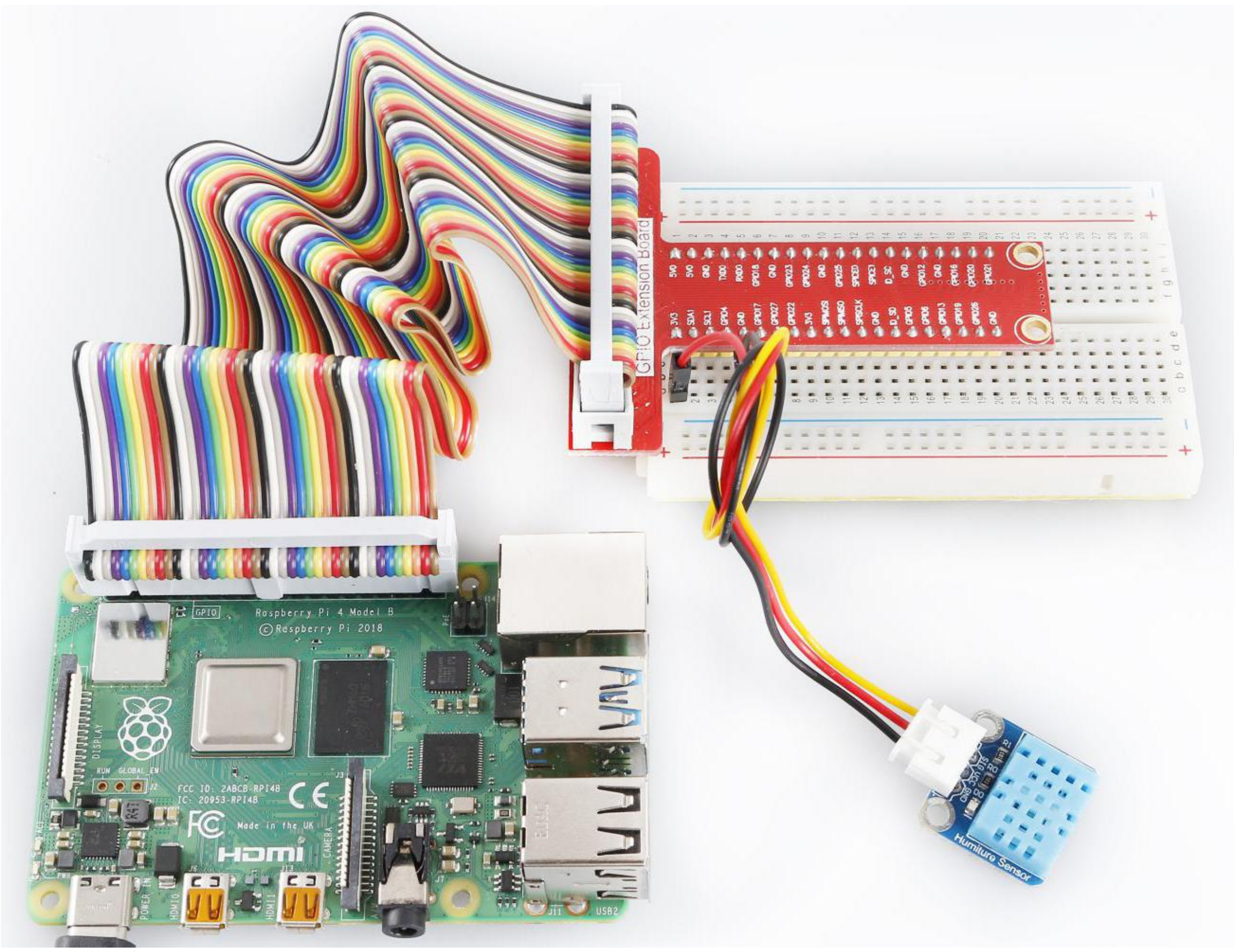
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 28_humiture.py
```

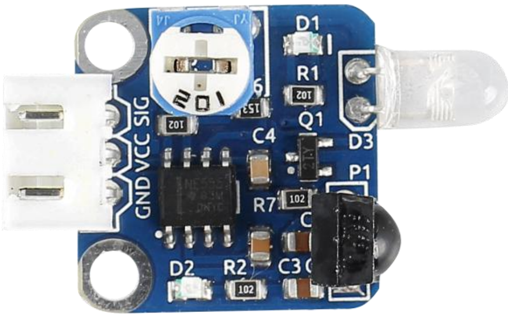
Now, you can see humidity and temperature value printed on the screen.



Lesson 29 IR Obstacle Avoidance Module

Introduction

An IR obstacle avoidance module (as shown below) is used in this Lesson.



Required Components

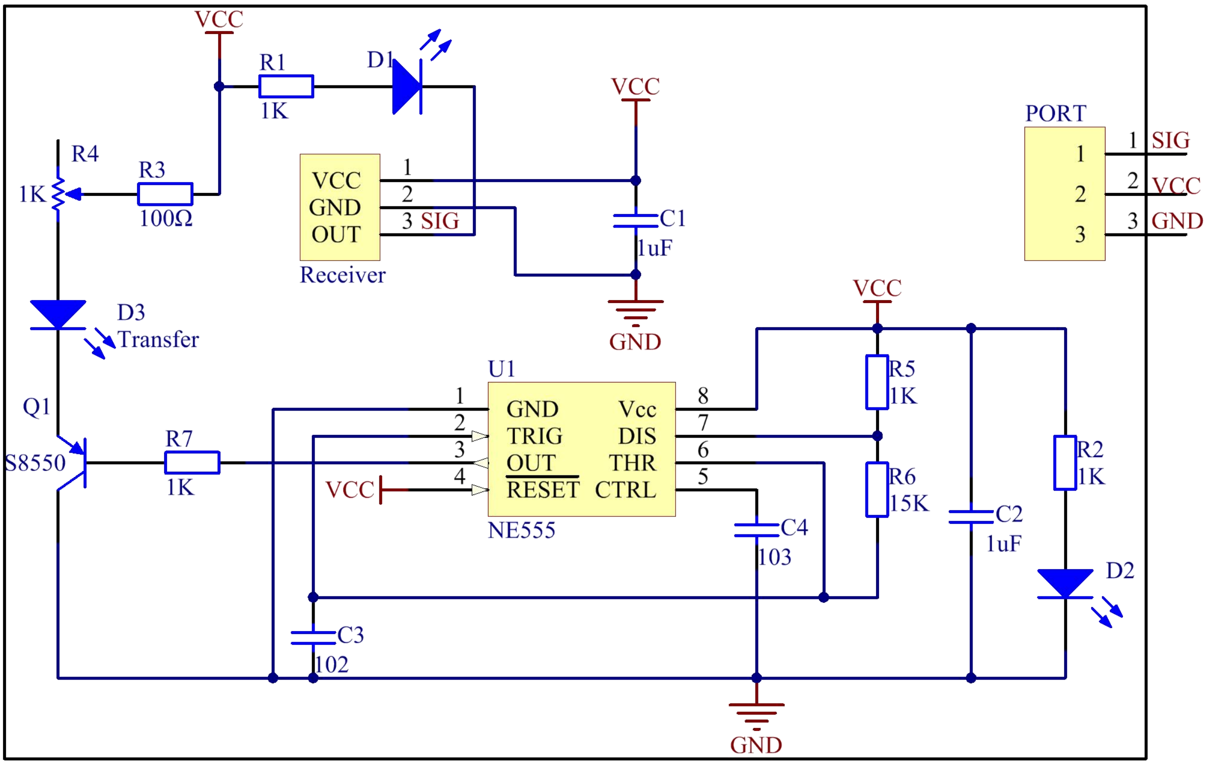
- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * IR Obstacle module
- 1 * 3-Pin anti-reverse cable

Experimental Principle

An obstacle avoidance sensor mainly consists of an infrared-transmitter, an infrared-receiver and a potentiometer. According to the reflecting feature of an object, if there is no obstacle, emitted infrared ray will weaken with the propagation distance and finally disappear. If there is an obstacle, when infrared ray encounters an obstacle, it will be reflected back to the infrared-receiver. Then the infrared-receiver detects this signal and confirms an obstacle exists ahead.

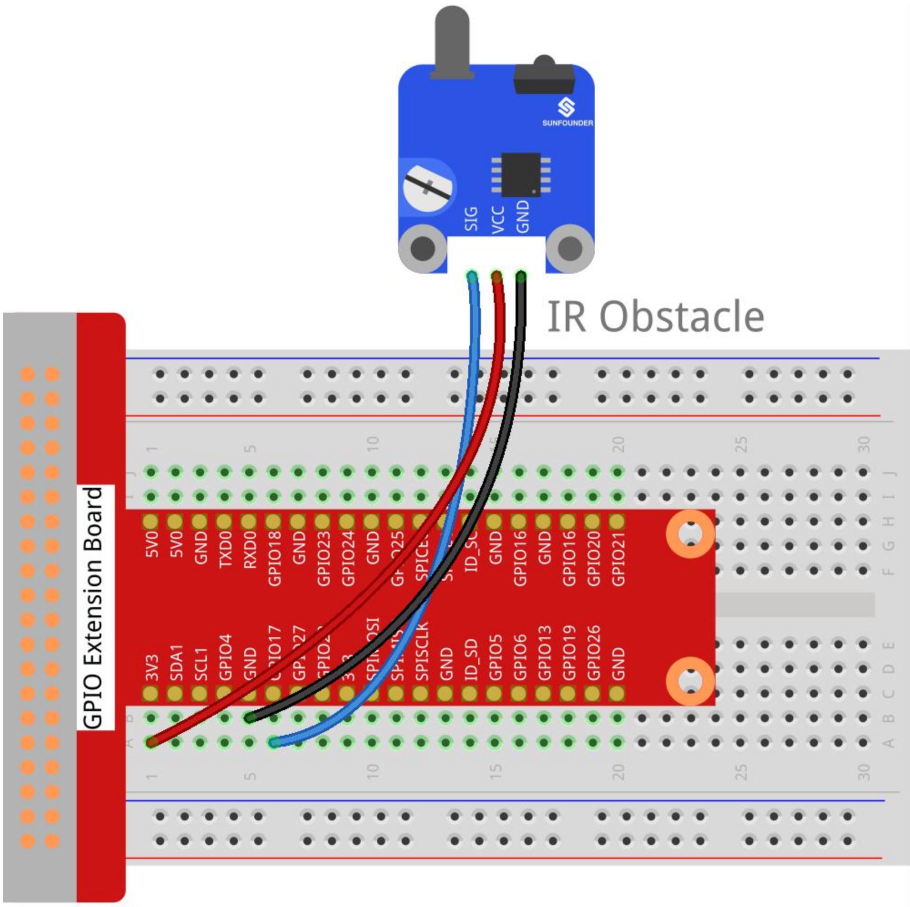
Note: The detection distance of the infrared sensor is adjustable - you may adjust it by the potentiometer.

The schematic diagram of the module is as shown below:



Experimental Procedures

Step 1: Build the circuit.



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/30_ir_obstacle/
```

Step 3: Compile.

```
gcc ir_obstacle.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

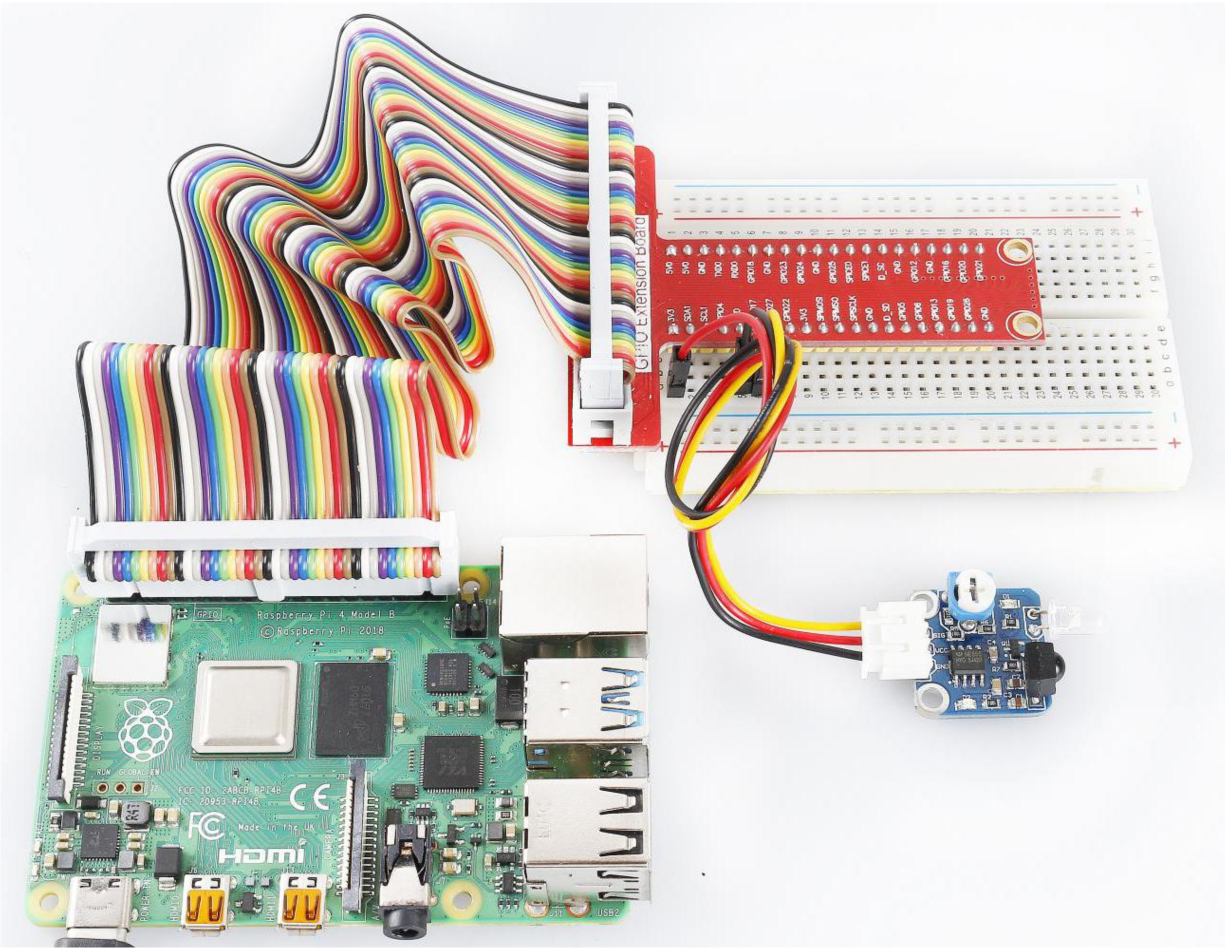
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 30_ir_obstacle.py
```

Now, if there is an obstacle ahead, a string “Detected Barrier!” will be printed on the screen.



Lesson 30 I2C LCD1602

Introduction

LCD1602 is a character type liquid crystal display, which can display 32 (16*2) characters at the same time. It has 16 pins, of which at least 7 would be used each time. You can use a PCF8574 I2C chip to expand I/O ports so only two GPIO ports would be occupied.

Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * I2C LCD1602
- Several jumper wires

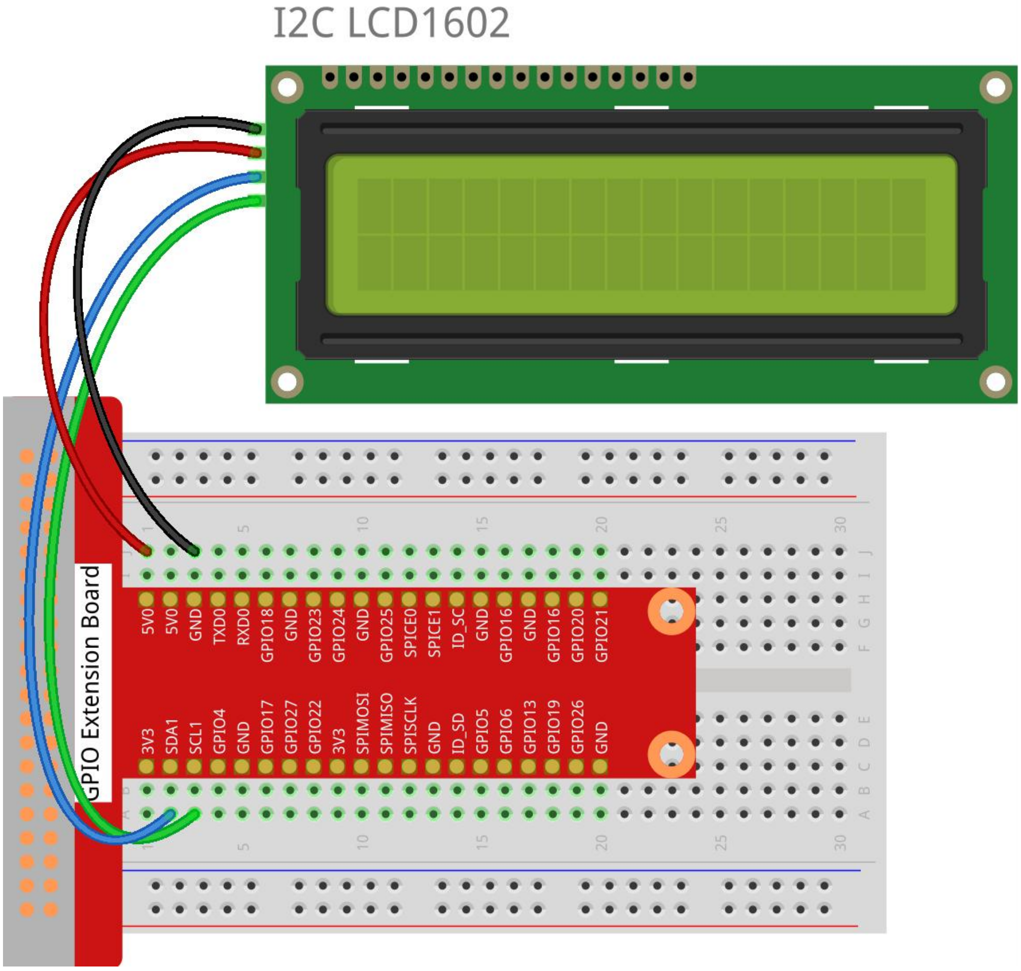
Experimental Principle

In this experiment, I2C is used to configure LCD so that you can control the LCD1602 to display characters. The I2C slave address of I2C LCD1602 here is 0x27.

Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	I2C LCD1602 Module
SCL	SCL1	SCL
SDA	SDA1	SDA
5V	5V0	VCC
GND	GND	GND



Step 2: Setup I2C (see Appendix. If you have set I2C, skip this step.)

For C Users:

Step 3: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/30_i2c_lcd1602/
```

Step 4: Compile.

```
gcc i2c_lcd1602.c -lwiringPi
```

Step 5: Run.

```
sudo ./a.out
```

For Python Users:

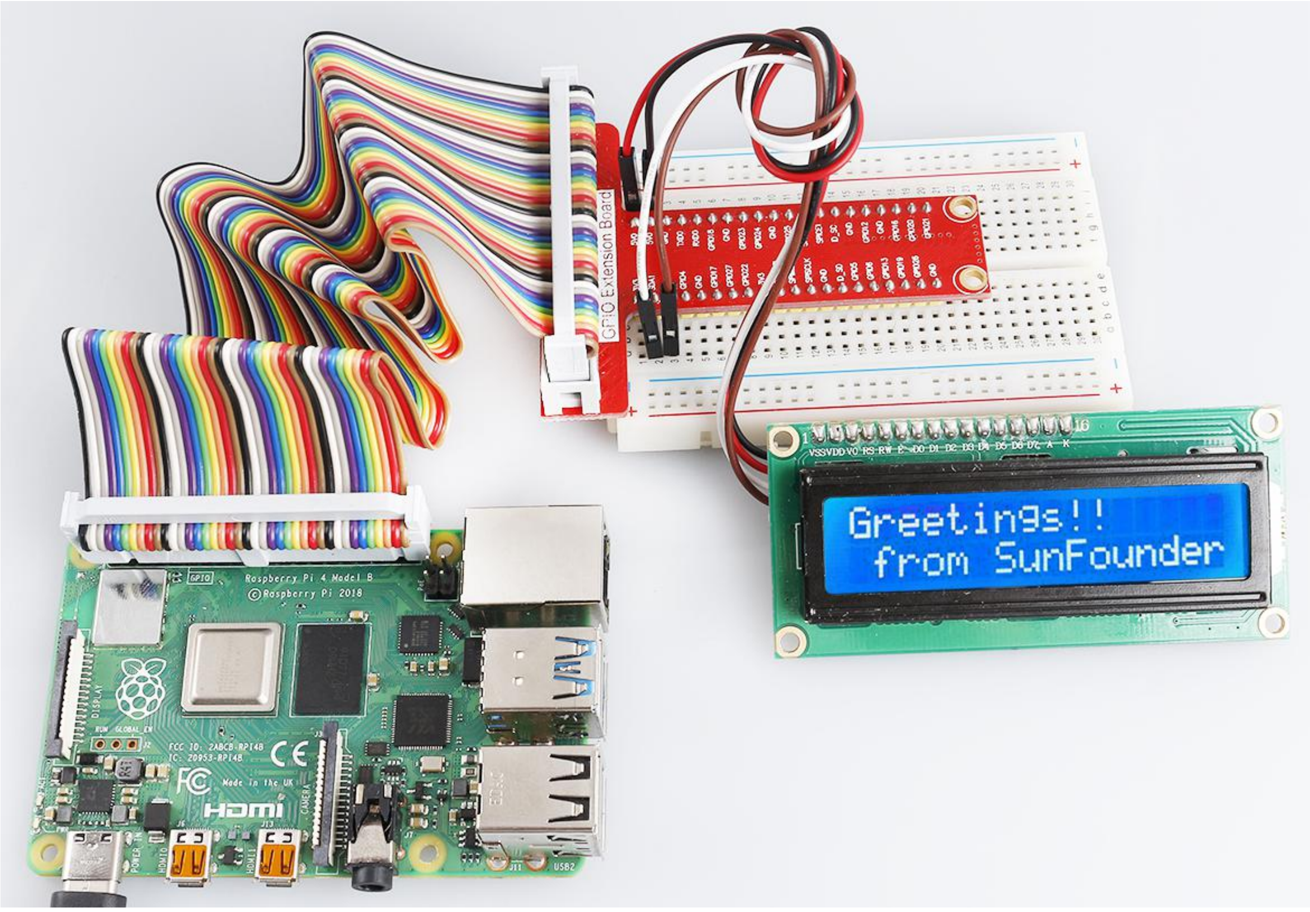
Step 3: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 4: Run.

```
sudo python3 30_i2c_lcd1602.py
```

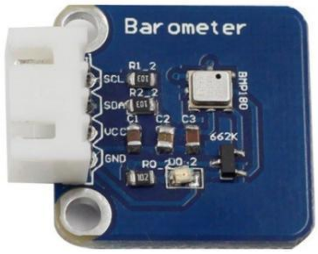
Now you can see “Greetings! From SunFounder” displayed on the LCD.



Lesson 31 Barometer-BMP180 Module

Introduction

The BMP180 barometer is the new digital barometric pressure sensor, with a very high performance, which enables applications in advanced mobile devices, such as smart phones, tablets and sports devices. It complies with the BMP085 but boasts many improvements, like a smaller size and more digital interfaces.

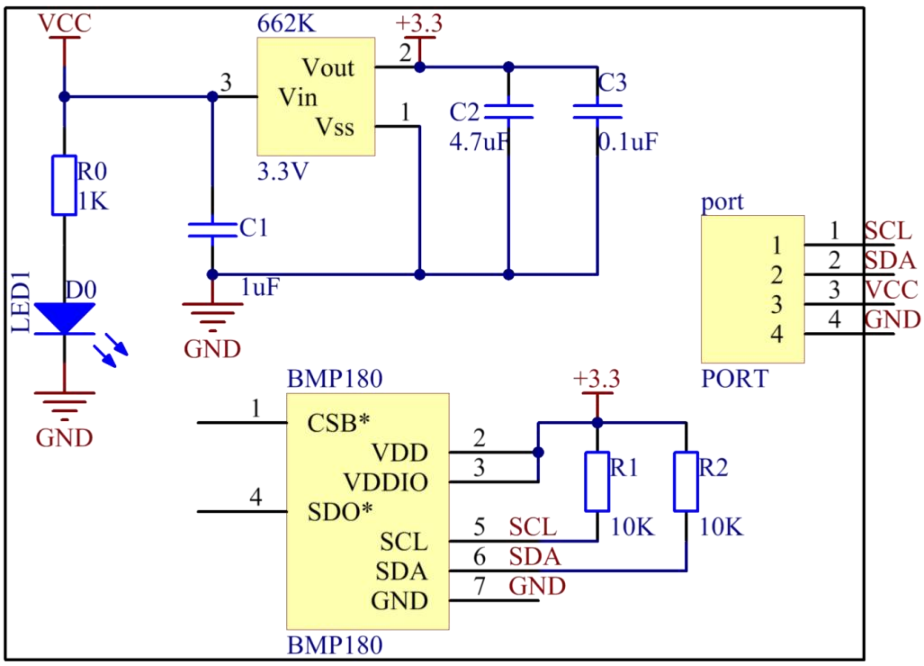


Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * Barometer module
- 1 * 4-Pin anti-reverse cable

Experimental Principle

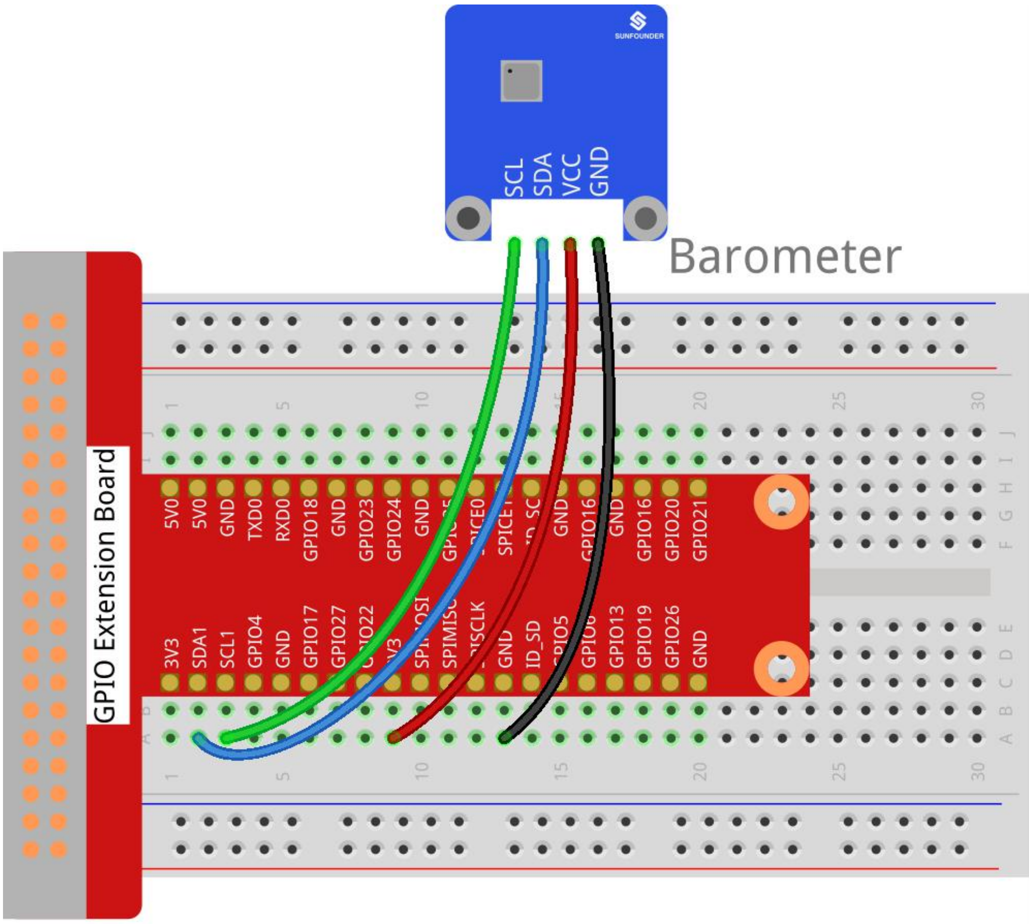
Use a barometer to measure air pressure and temperature. The schematic diagram of the module is as follows:



Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	Barometer
SCL	SCL1	SCL
SDA	SDA1	SDA
3.3V	3V3	VCC
GND	GND	GND



Step 2: Setup I2C (see Appendix . If you have set I2C, skip this step.)

For C Users:

Step 3: Download libi2c-dev.

```
sudo apt-get install libi2c-dev
```

Step 4: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/31_barometer/
```

Step 5: Compile.

```
gcc barometer.c bmp180.c -lm -lwiringPi -lwiringPiDev
```

Step 6: Run.

```
sudo ./a.out
```

For Python Users:

Step 3: Install smbus for I2C.

```
sudo apt-get install python3-smbus i2c-tools
```

Step 4: We'll need to install some utilities for the Raspberry Pi to communicate over I2C.

```
git clone https://github.com/adafruit/Adafruit_Python_BMP.git
cd Adafruit_Python_BMP
sudo python3 setup.py install
```

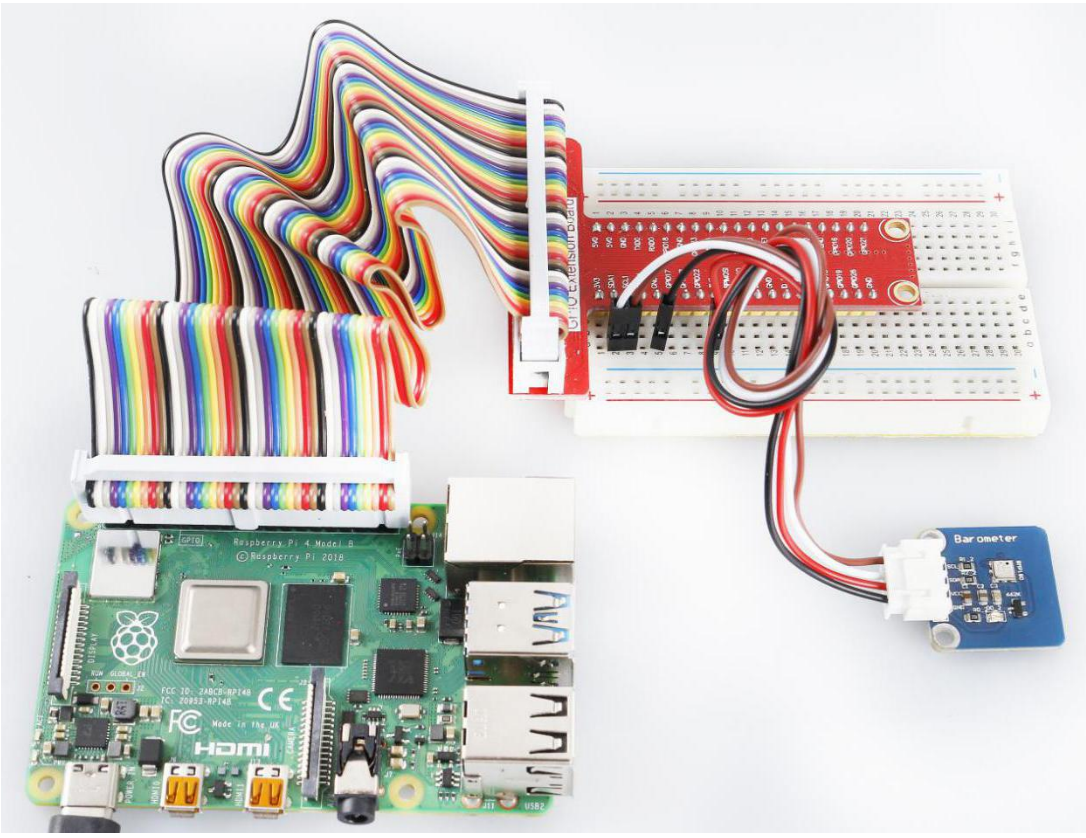
Step 5: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 6: Run.

```
sudo python3 31_barometer.py
```

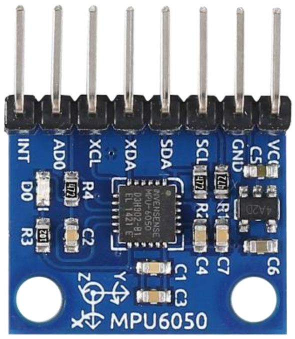
Now you can see the temperature and pressure value displayed on the screen.



Lesson 32 MPU6050 Gyro Acceleration Sensor

Introduction

The MPU-6050 is the world's first and only 6-axis motion tracking devices designed for the low power, low cost, and high performance requirements of smartphones, tablets and wearable sensors.



Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * MPU-6050 module
- Several Jumper wires

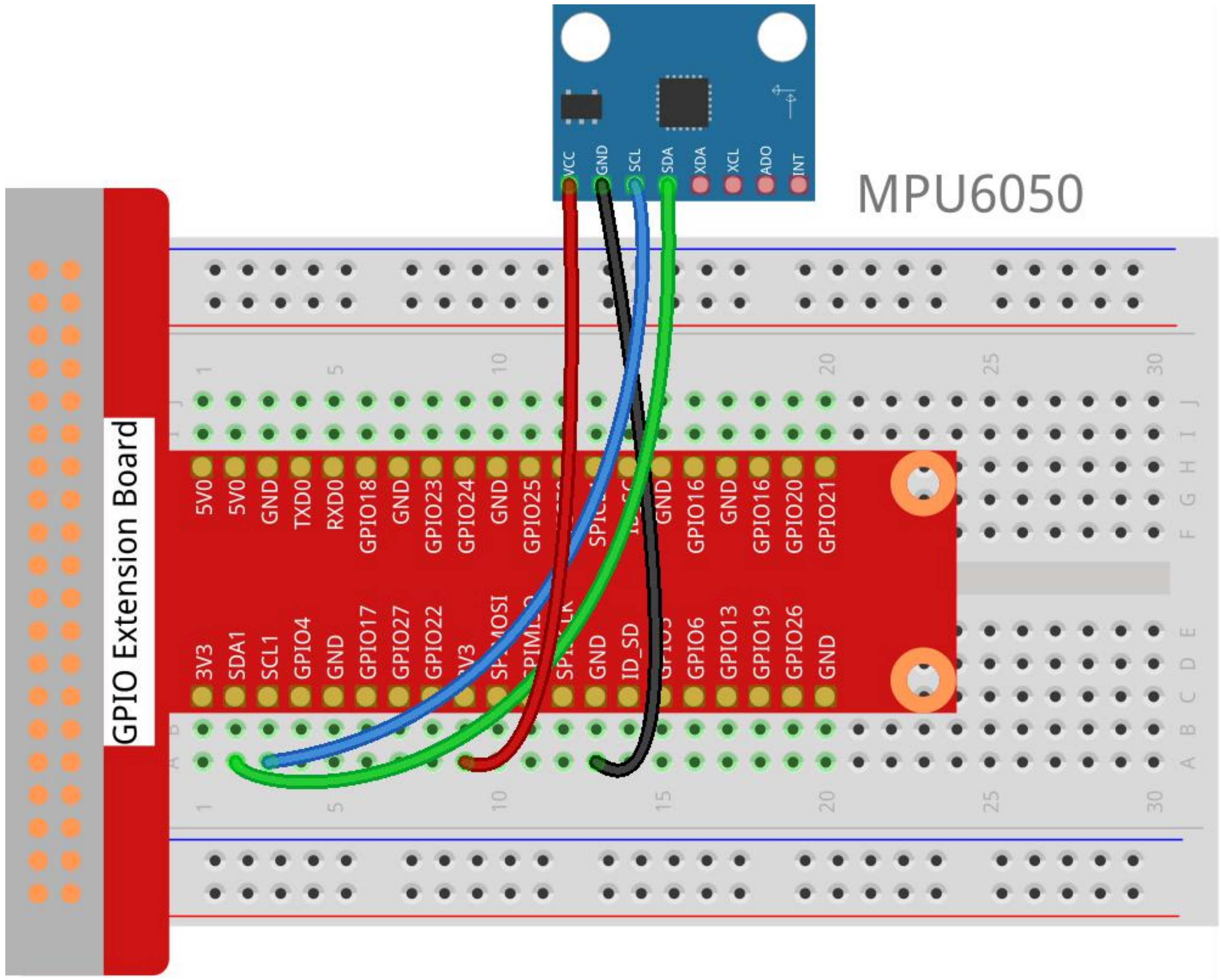
Experimental Principle

In this experiment, use I2C to obtain the values of the three-axis acceleration sensor and three-axis gyroscope for MPU6050 and display them on the screen.

Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	MPU-6050 Module
SCL	SCL1	SCL
SDA	SDA1	SDA
3.3V	3V3	VCC
GND	GND	GND



Step 2: Setup I2C (see Appendix. If you have set I2C, skip this step.)

For C Users:

Step 3: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/32_mpu6050/
```

Step 4: Compile.

```
gcc 32_mpu6050.c -lwiringPi -lm
```

Step 5: Run.

```
sudo ./a.out
```

For Python Users:

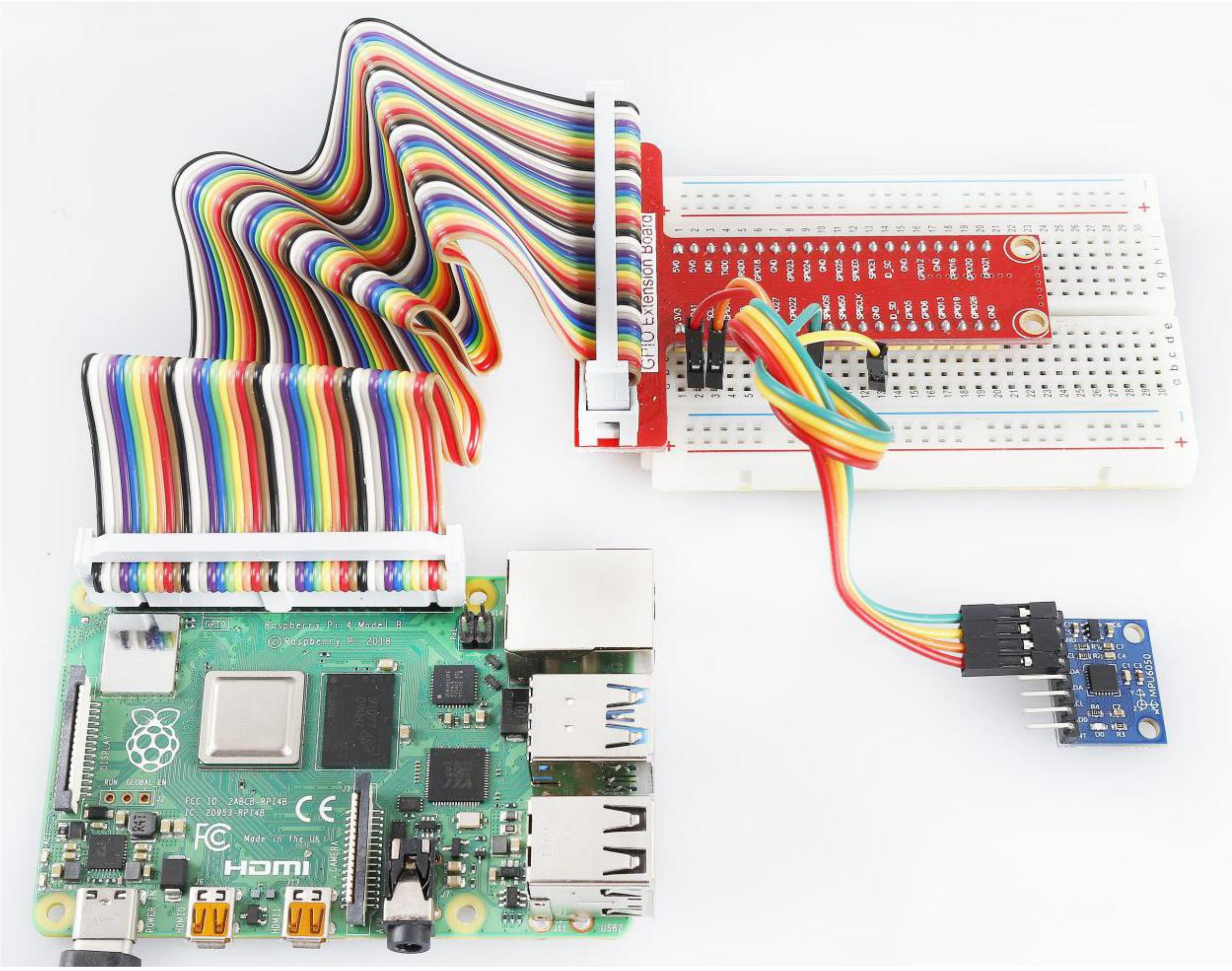
Step 3: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 4: Run.

```
sudo python3 32_mpu6050.py
```

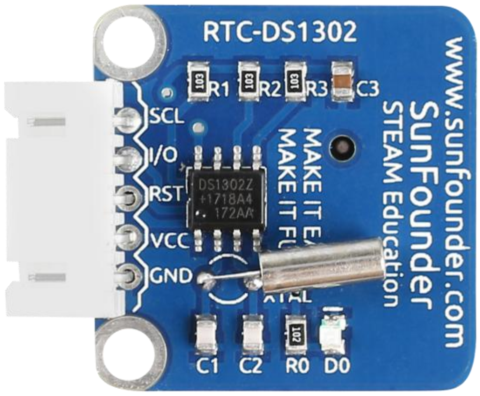
Now you can see the values of the acceleration sensor, gyroscope, and XY-axis rotation read by MPU6050 printed on the screen constantly.



Lesson 33 RTC DS1302

Introduction

DS1302 is a trickle charging clock chip, launched by DALLAS in America. With a built-in real-time clock/calendar and a 31-byte static RAM, it can communicate with MCU through simple serial interfaces. The real-time clock/calendar circuit provides information about second, minute, hour, day, week, month, and year. DS1302 can automatically adjust the number of days per month and days in leap year. You can determine to use a 24-hour or 12-hour system by AM/PM selection.



Required Components

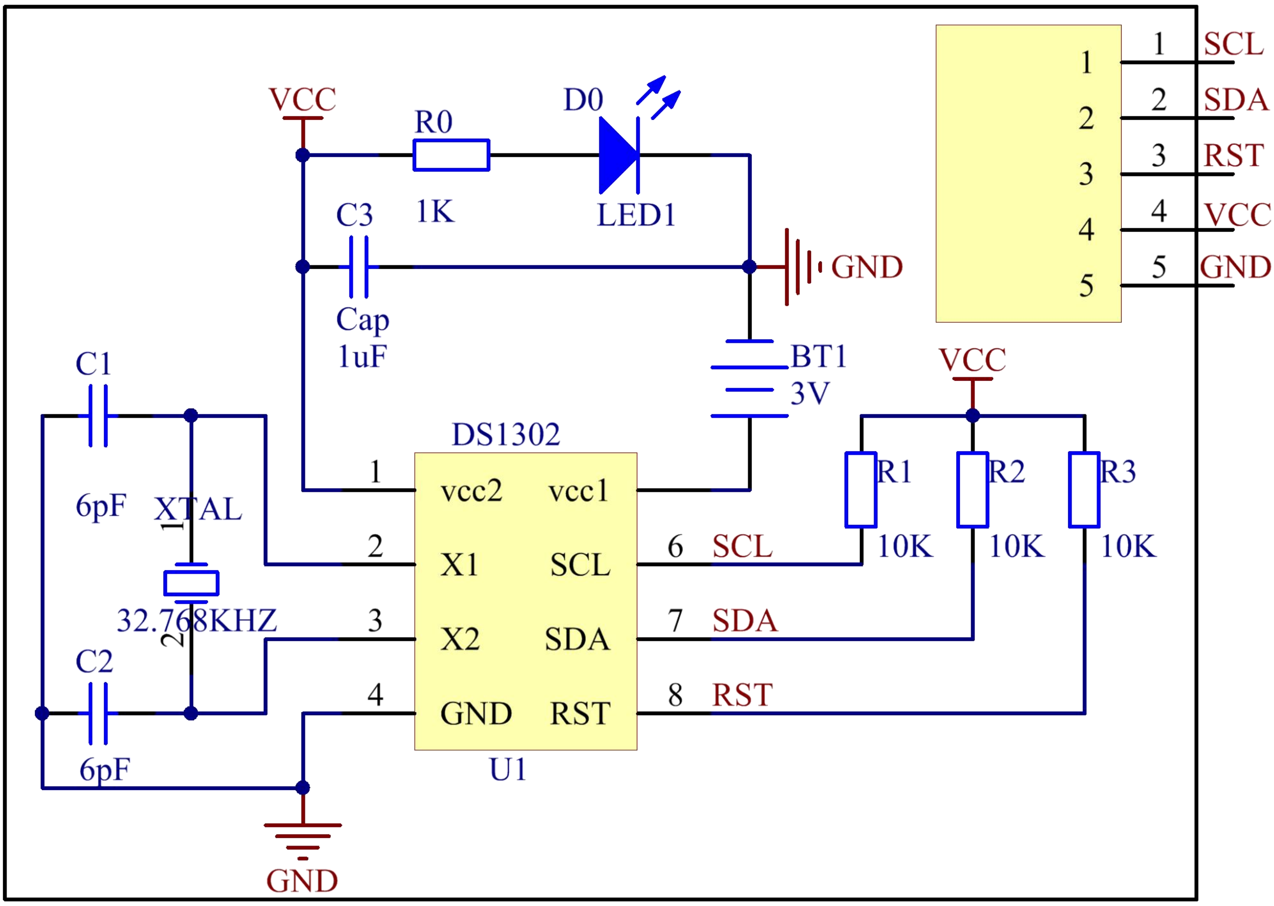
- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * DS1302 RTC module
- 1 * 5-Pin anti-reverse cable

Experimental Principle

Interfacing the DS1302 with a microprocessor is simplified by using synchronous serial communication. Only three wires are required to communicate with the clock/RAM: RST, serial data (SDA) and serial clock (SCL). SDA can be transferred to and from the clock/RAM one byte at a time or in a burst of up to 31 bytes.

After the time of the DS1302 is set manually, the MCU starts to read the accurate time and date returned by DS1302.

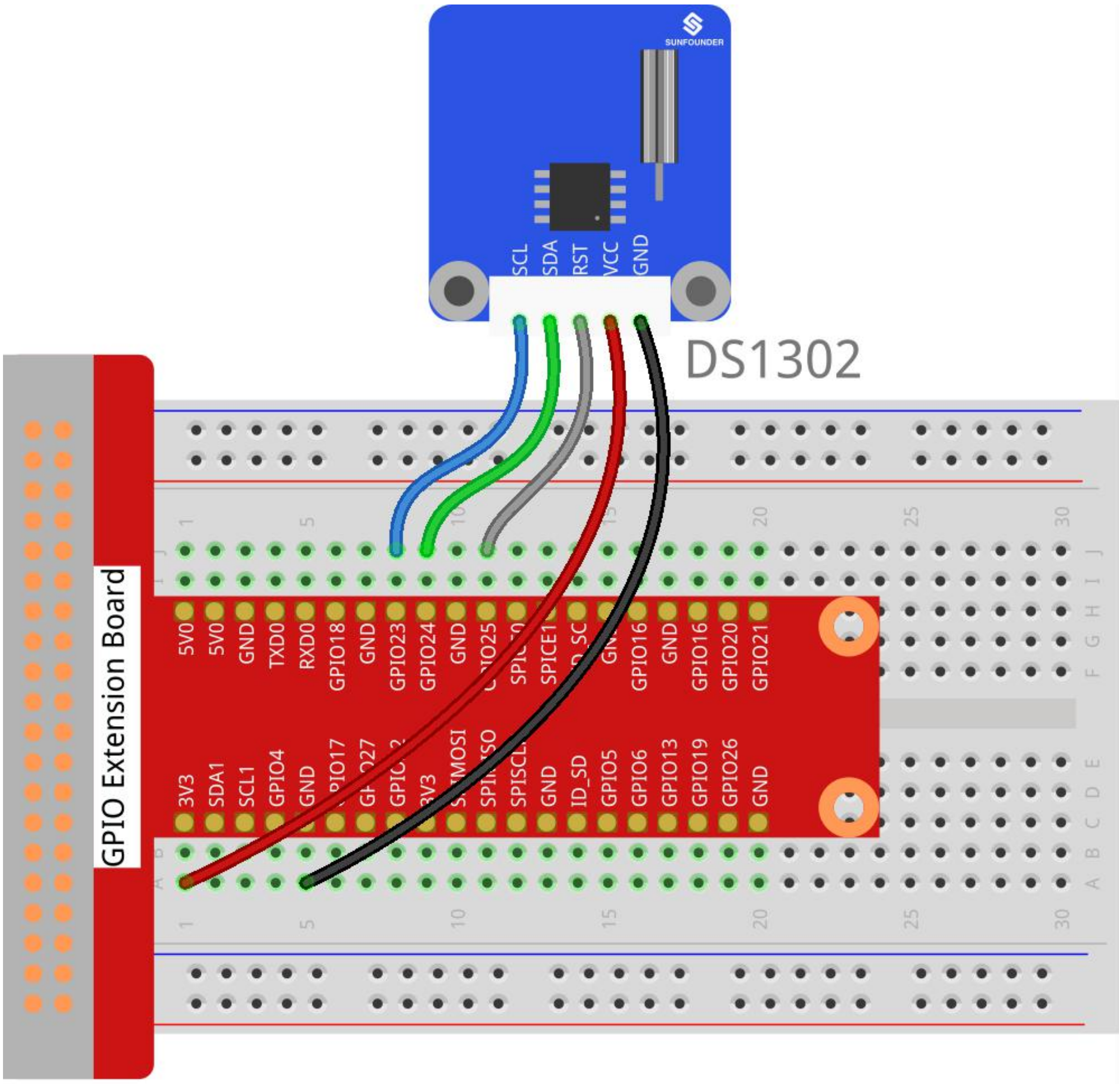
The schematic diagram of the module is as shown below:



Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	RTC DS1302 Module
GPIO4	GPIO23	SCL
GPIO5	GPIO24	I/O or SDA
GPIO6	GPIO25	RST
3.3V	3V3	VCC
GND	GND	GND



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/33_ds1302/
```

Step 3: Compile:

```
gcc rtc_ds1302.c -lwiringPi -lwiringPiDev
```

Step 4: Set up time by:

```
sudo ./a.out -sdsc
```

Set year, month, date as YYYYMMDD

Set hour, minute, second as HHMMSS(24-hour clock)

Set weekday (0 as Sunday)

Step 5: Run:

```
sudo ./a.out
```

For Python Users:

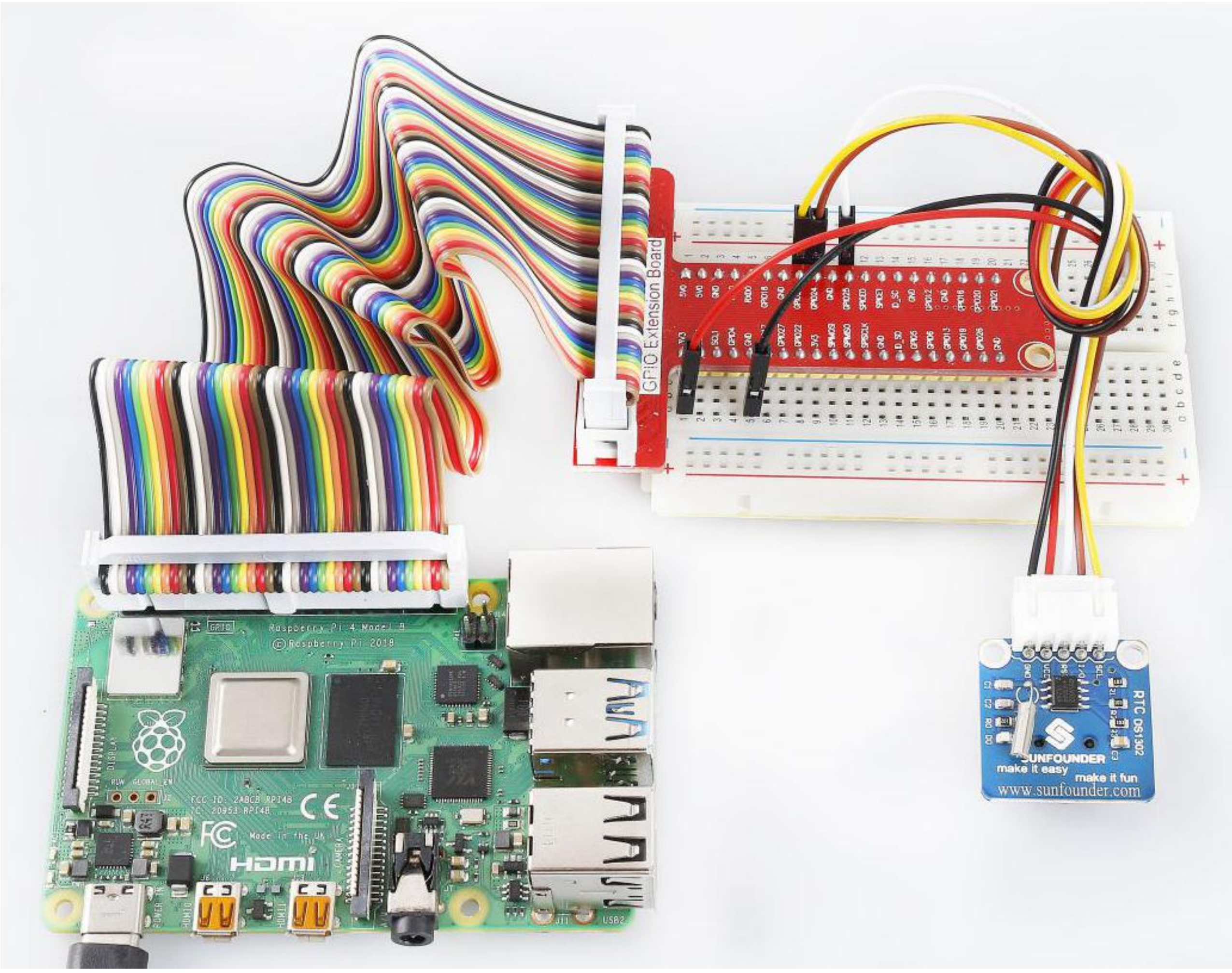
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 33_ds1302.py
```

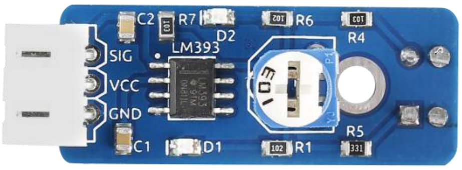
Now you can see the time on the screen.



Lesson 34 Tracking Sensor

Introduction

The infrared tracking sensor uses a TRT5000 sensor. The blue LED of TRT5000 is the emission tube and after electrified it emits infrared light invisible to human eye. The black part of the sensor is for receiving; the resistance of the resistor inside changes with the infrared light received.

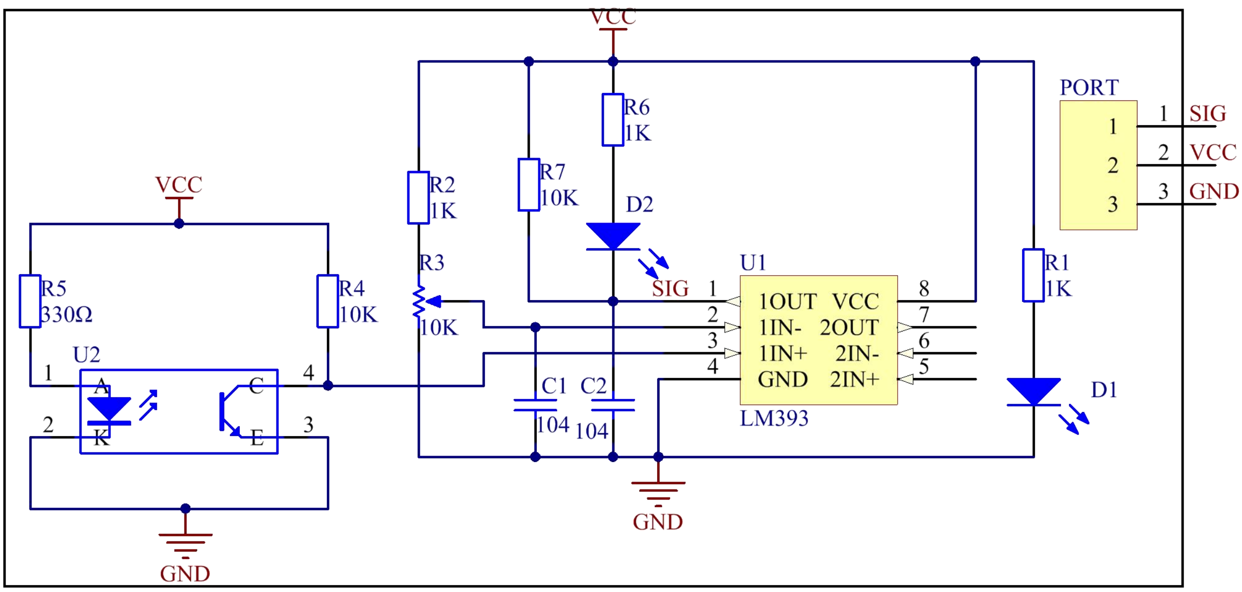


Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * Tracking sensor module
- 1 * 3-Pin anti-reverse cable

Experimental Principle

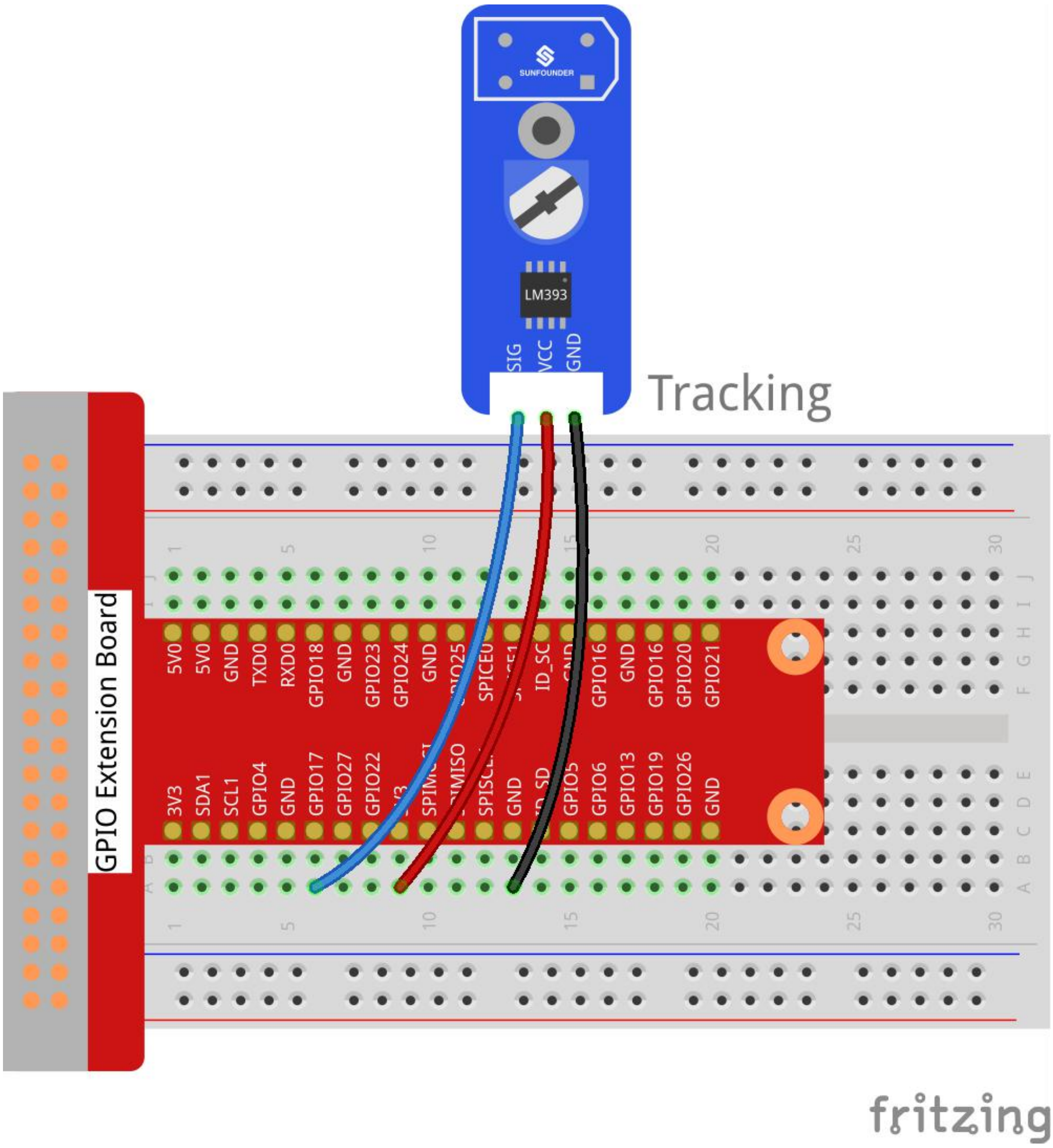
When the infrared transmitter emits rays to a piece of paper, if the rays shine on a white surface, they will be reflected and received by the receiver, and pin SIG will output low level; If the rays encounter black lines, they will be absorbed, thus the receiver gets nothing, and pin SIG will output high level. The schematic diagram of the module is as shown below:



Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	Tracking Sensor Module
GPIO0	GPIO17	SIG
3.3V	3V3	VCC
GND	GND	GND



For C Users:

Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/34_tracking/
```

Step 3: Compile.

```
gcc tracking.c -lwiringPi
```

Step 4: Run.

```
sudo ./a.out
```

For Python Users:

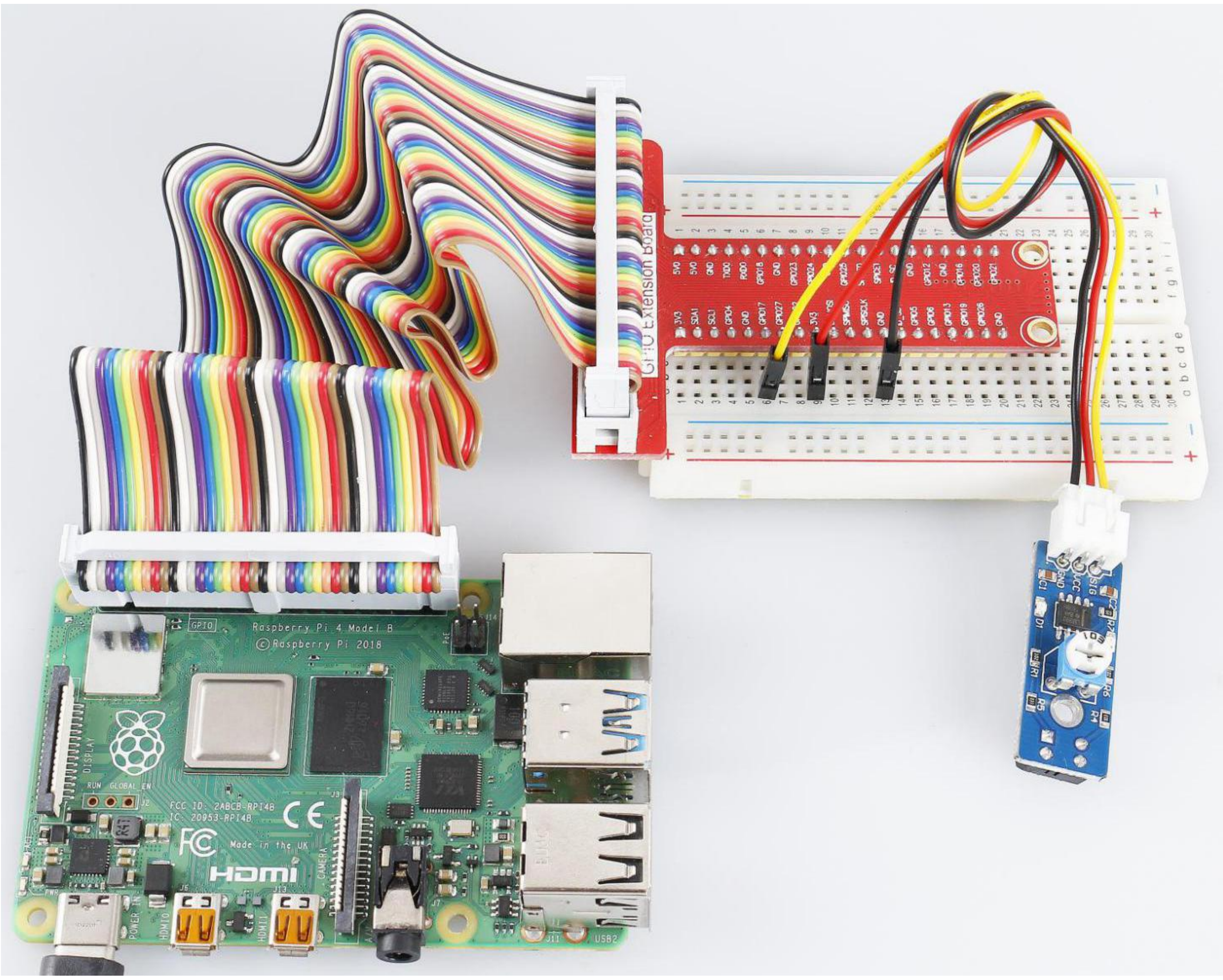
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 3: Run.

```
sudo python3 34_tracking.py
```

When the tracking sensor encounters black lines, a string "Black Line is detected" will be printed on the screen.



Lesson 35 Intelligent Temperature Measurement System

Introduction

In this experiment, we will use some modules together to build an intelligent temperature measurement system.

Required Components

- 1 * Raspberry Pi
- 1 * Breadboard
- 1 * Active Buzzer
- 1 * RGB LED Module
- 1 * DS18B20 Temperature Sensor
- 1 * PCF8591
- 1 * Joystick PS2
- Several Jumper wires

Experimental Principle

It is similar with lesson 26. The only difference is that we can adjust the lower limit and upper limit value by joystick PS2 when programming.

As mentioned previously, joystick PS2 has five operation directions: up, down, left, right and press-down. Well, in this experiment, we will use the left and right directions to control the upper limit value and up/down direction to control the lower limit. If you press down the joystick, the system will log out.

Experimental Procedures

Step 1: Build the circuit.

Raspberry Pi	GPIO Extension Board	DS18B20 Module
GPIO7	GPIO4	SIG
3.3V	3V3	VCC
GND	GND	GND

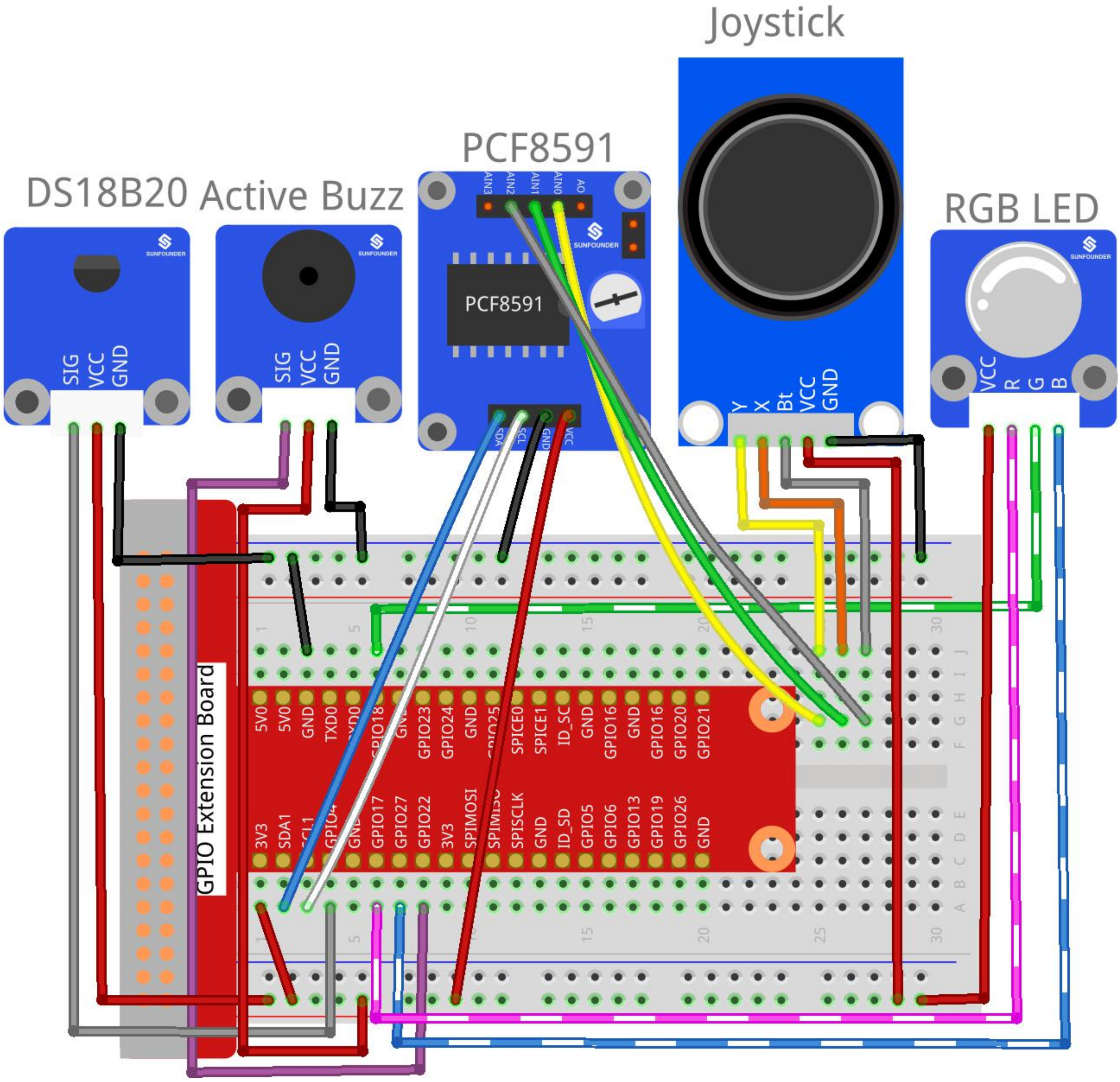
Raspberry Pi	GPIO Extension Board	PCF8591 Module

SDA	SDA1	SDA
SCL	SCL1	SCL
3.3V	3V3	VCC
GND	GND	GND

Joystick PS2	GPIO Extension Board	PCF8591 Module
Y	*	AIN0
X	*	AIN1
Bt	*	AIN2
VCC	3V3	*
GND	GND	*

Raspberry Pi	GPIO Extension Board	RGB LED Module
GPIO0	GPIO17	R
GPIO1	GPIO18	G
GPIO2	GPIO27	B
3.3V	3V3	VCC

Raspberry Pi	GPIO Extension Board	Active Buzzer Module
GPIO3	GPIO22	SIG
3.3V	3V3	VCC
GND	GND	GND



For C Users:

Step 2: Check the address of your sensor.

```
ls /sys/bus/w1/devices/
```

It may be like this:

```
28-031467805fff    w1_bus_master1
```

Copy or write down 28-XXXXXXX. It is the address of your sensor.

Step 2: Change directory and edit.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/C/35_expand02/
nano temp_monitor.c
```

Find the function *float tempRead(void)*, and the line "fd = open(XXXXXX)". Replace "28-031467805ff" with your sensor address.

```
float tempRead(void)
{
float temp;
int i, j;
int fd;
int ret;

char buf[BUFSIZE];
char tempBuf[5];

fd = open("/sys/bus/w1/devices/28-031467805fff/w1_slave", O_RDONLY);

if(-1 == fd){
perror("open device file error");
return 1;
}
```

Save and exit.

Step 4: Compile.

```
gcc temp_monitor.c -lwiringPi
```

Step 5: Run.

```
sudo ./a.out
```

For Python Users:

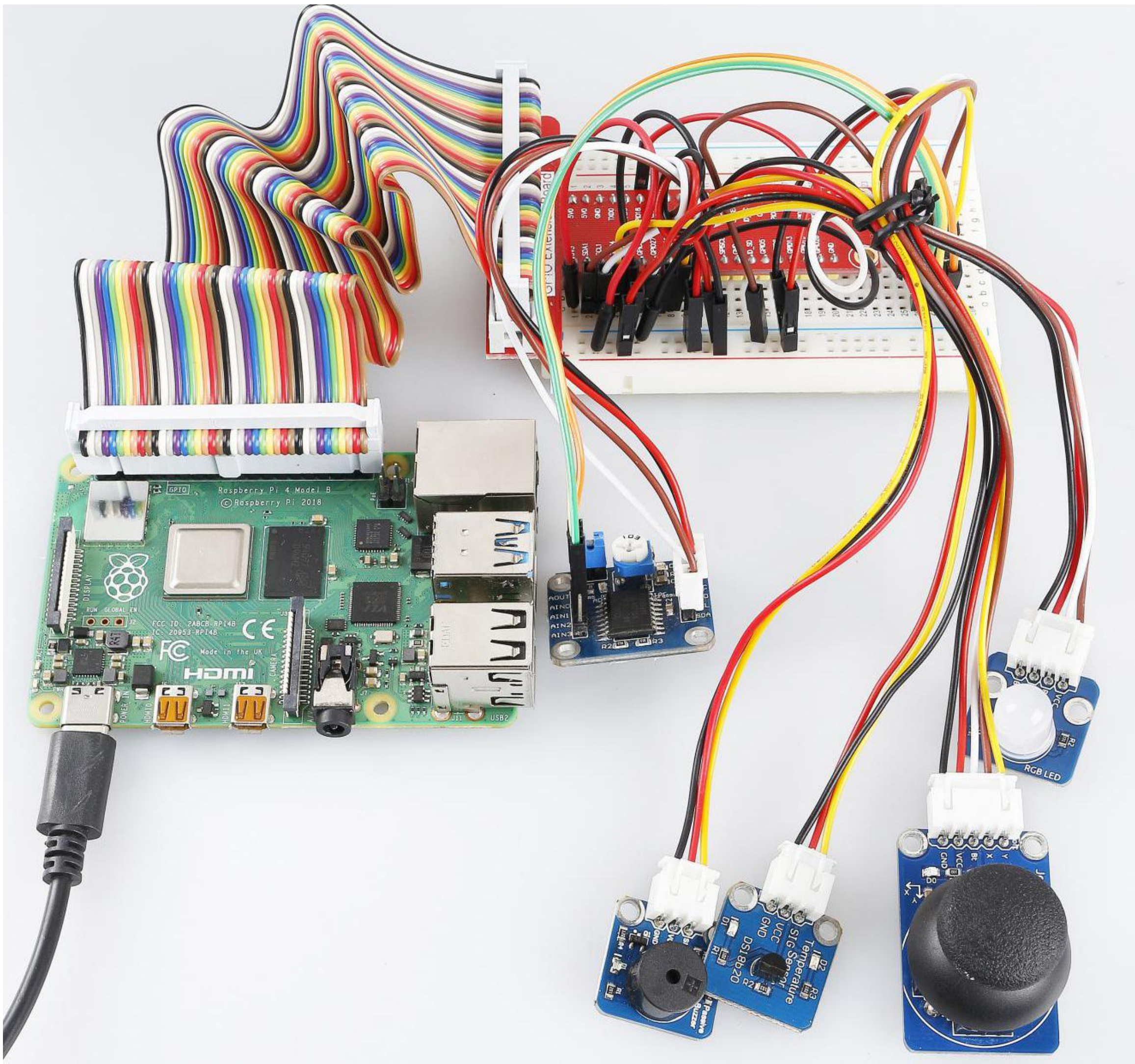
Step 2: Change directory.

```
cd /home/pi/SunFounder_SensorKit_for_RPi2/Python/
```

Step 4: Run.

```
sudo python3 35_temp_monitor.py
```

Now, you can pull the shaft of the joystick left and right to set the upper limit value, and up and down to set the lower limit value. Then, if the ambient temperature reaches the upper limit value or lower limit value, the buzzer will beep in a different frequency to warn.

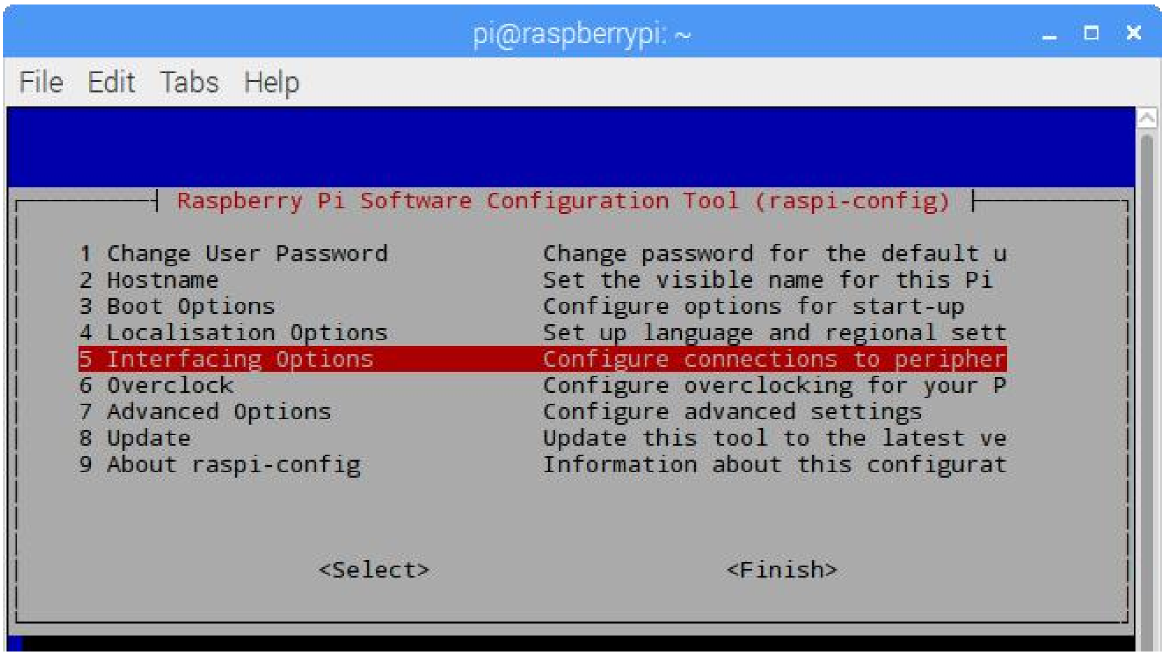

Raspberry Pi 4 Model B
© Raspberry Pi 2018
HDMI
RGB LED

Appendix: I2C Configuration

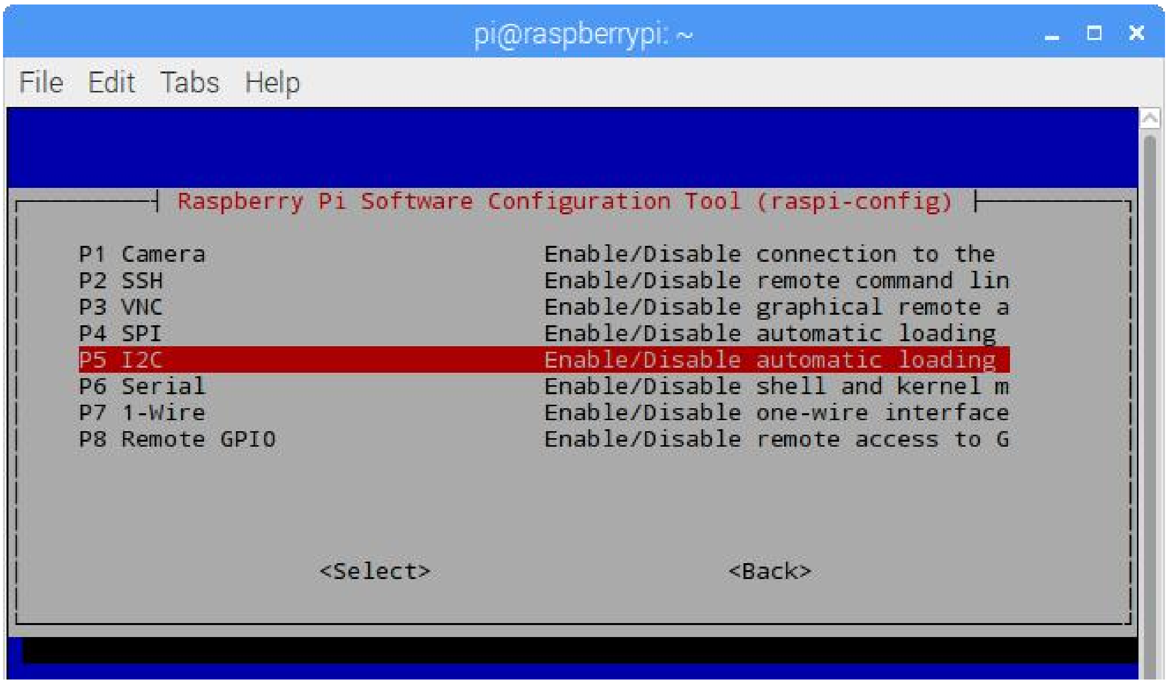
Step 1: Enable the I2C port of your Raspberry Pi (If you have enabled it, skip this; if you do not know whether you have done that or not, please continue):

```
sudo raspi-config
```

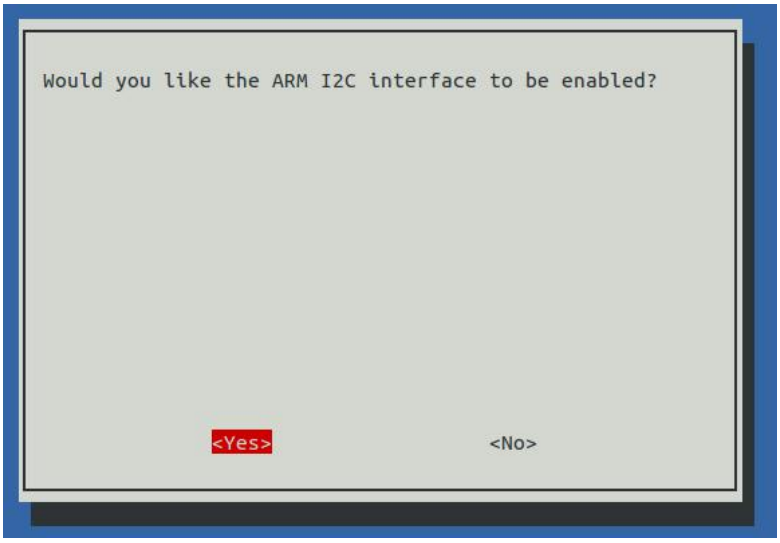
5 Interfacing options



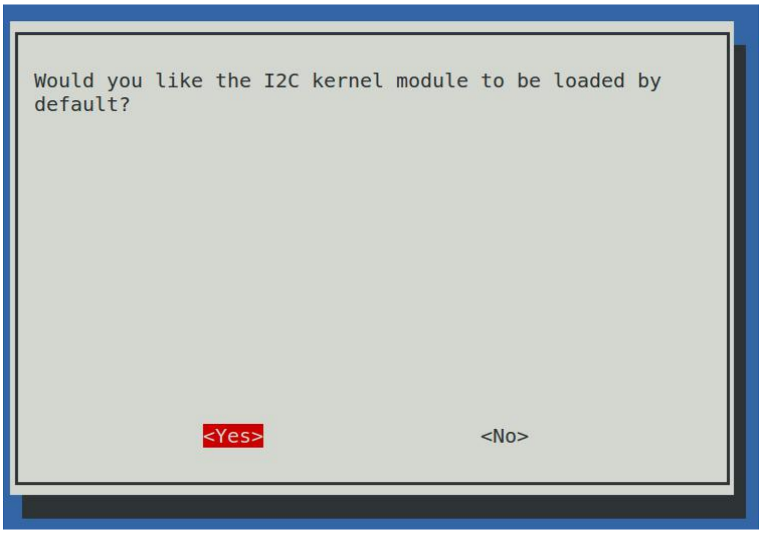
P5 I2C



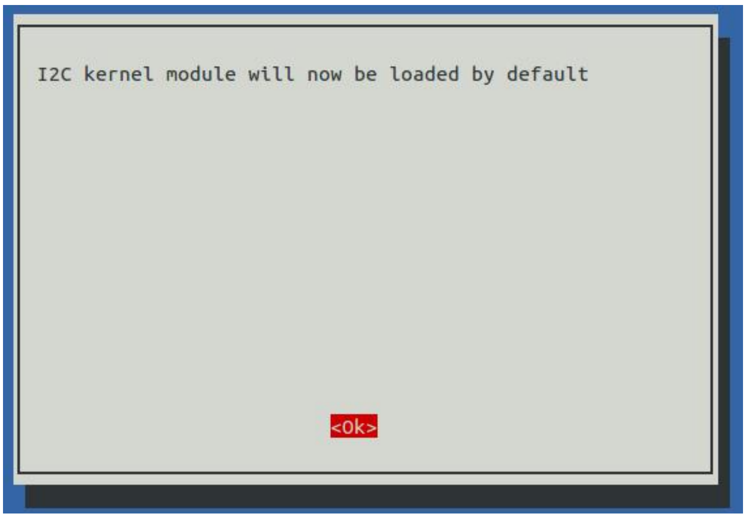
<Yes>


Would you like the ARM I2C interface to be enabled?
<Yes>
<No>

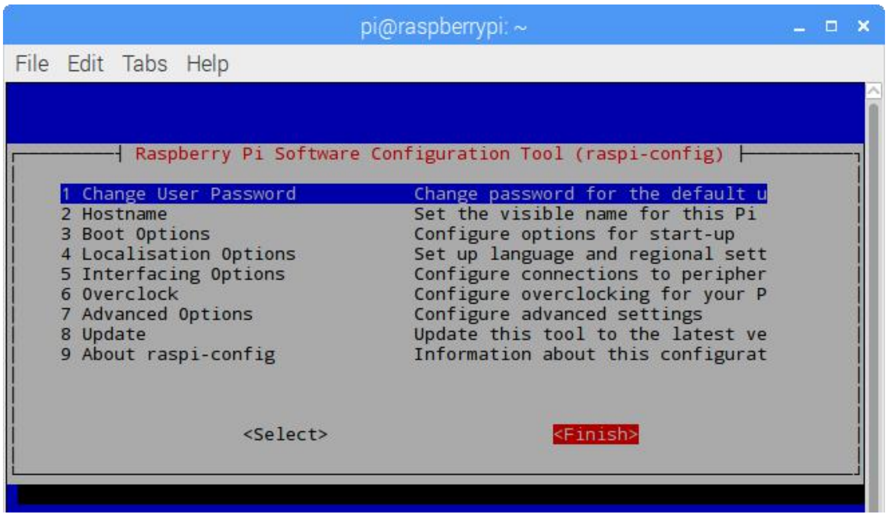
<Yes>


Would you like the I2C kernel module to be loaded by default?
<Yes>
<No>

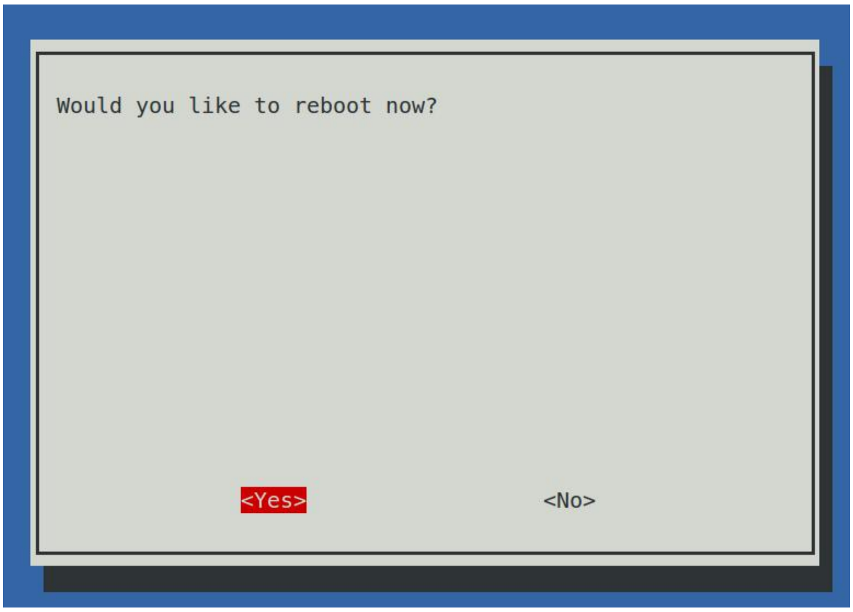
<Ok>


I2C kernel module will now be loaded by default
<Ok>

<Finish>



<Yes> (If you do not see this page, continue to the next step)



Step 2: Check that the i2c modules are loaded and active:

```
lsmod | grep i2c
```

Then the following code will appear (the number may be different).

```
i2c_dev                    6276     0
i2c_bcm2708                 4121     0
```

Step 3: Install i2c-tools.

```
sudo apt-get install i2c-tools
```

Step 4: Check the address of the I2C device:

```
i2cdetect -y 1      # For Raspberry Pi 2 and higher version
i2cdetect -y 0      # For Raspberry Pi 1
```

```
pi@raspberrypi ~ $ i2cdetect -y 1
     0  1  2  3   4  5  6  7  8  9   a  b  c  d  e  f
00:          -- -- -- -- -- -- -- -- -- -- -- -- --
10: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
20: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
30: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
40: -- -- -- -- -- -- -- -- 48 -- -- -- -- -- -- --
50: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
60: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
70: -- -- -- -- -- -- -- --
```

If there's an I2C device connected, the results will be similar as shown above – since the address of the device is 0x48, 48 is printed.

Step 5:

For C language users: Install libi2c-dev.

```
sudo apt-get install libi2c-dev
```

For Python users: Install smbus for I2C.

```
sudo apt-get install python3-smbus
```

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