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Warning

When you purchase or use Freenove Basic Starter Kit for Raspberry Pi, please note the following:

- This product contains small parts. Swallowing or improper operation can cause serious infections and death. Seek immediate medical attention when the accident happened.
- Do not allow children under 3 years old to play with or near this product. Please place this product in where children under 3 years of age cannot reach.
- Do not allow children lack of ability of safe to use this product alone without parental care.
- Never use this product and its parts near any AC electrical outlet or other circuits to avoid the potential risk of electric shock.
- Never use this product near any liquid and fire.
- Keep conductive materials away from this product.
- Never store or use this product in any extreme environments such as extreme hot or cold, high humidity and etc.
- Remember to turn off circuits when not in use this product or when left.
- Do not touch any moving and rotating parts of this product while they are operating.
- Some parts of this product may become warm to touch when used in certain circuit designs. This is normal. Improper operation may cause excessively overheating.
- Using this product not in accordance with the specification may cause damage to the product.

About

Freenove is an open-source electronics platform. Freenove is committed to helping customer quickly realize the creative idea and product prototypes, making it easy to get started for enthusiasts of programing and electronics and launching innovative open source products. Our services include:

- Electronic components and modules
- Learning kits for Arduino
- Learning kits for Raspberry Pi
- Learning kits for Technology
- Product customization service
- Robot kits
- Auxiliary tools for creations

Our code and circuit are open source. You can obtain the details and the latest information through visiting the following web sites:

http://www.freenove.com

https://github.com/freenove

Your comments and suggestions are warmly welcomed, and please send them to the following email address:

support@freenove.com

If you have any business matters, please feel free to contact us:

sale@freenove.com

References

You can download the sketches and references used in this product in the following websites:
http://www.freenove.com
https://github.com/freenove
If you have any difficulties, you can send email to technical support for help.

The references for this product is named Freenove Basic Starter Kit for Raspberry Pi, which includes the following folders and files:

- Datasheet Datasheet of electronic components and modules
- Code Code for project
- Readme.txt Instructions
- Processing Help you learning how creat virtual tools and games. It is based on Java.

Support

Freenove provides free and quick technical support, including but not limited to:

- Quality problems of products
- Problems in using products
- Questions for learning and technology
- Opinions and suggestions
- Ideas and thoughts

Please send email to:
support@freenove.com
On working day, we usually reply to you within 24 hours.

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Contents

Preface

If you want to become a maker, you may have heard of Raspberry Pi or Arduino before. If not, it doesn't matter. Through referencing this tutorial, you can be relaxed in using Raspberry Pi to create dozens of electronical interesting projects, and gradually realize the fun of using Raspberry Pi to complete creative works.

Raspberry Pi and Arduino have a lot of fans in the world. They are keen to exploration, innovation and DIY and they contributed a great number of high-quality open source code, circuit and rich knowledge base. So we can realize our own creativity more efficiently by using these free resource. Of course, you can also contribute your own strength to the resource.

Raspberry Pi, different from Arduino, is more like a control center with a complete operating system, which can deal with more tasks at the same time. Of course, you can also combine the advantages of them to make something creative.

Usually, a Raspberry Pi project consists of code and circuit. If you are familiar with computer language and very interested in the electronic module. Then this tutorial is very suitable for you. It will, from easy to difficult, explain the Raspberry Pi programming knowledge, the use of various types of electronic components and sensor modules and their operation principle. And we assign scene applications for most of the module.

We provide code of both C and Python language versions for each project, so, whether you are a C language user or a Python language user, you are able to easily grasp the code in this tutorial. The supporting kit, contains all the electronic components and modules needed to complete these projects. After completing all projects in this tutorial, you can also use these components and modules to achieve your own creativity, like smart home, smart car and robot.

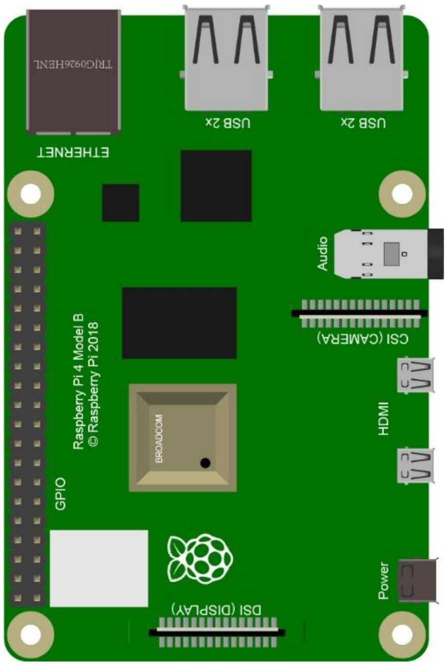
Additionally, if you have any difficulties or questions about this tutorial and the kit, you can always ask us for quick and free technical support.

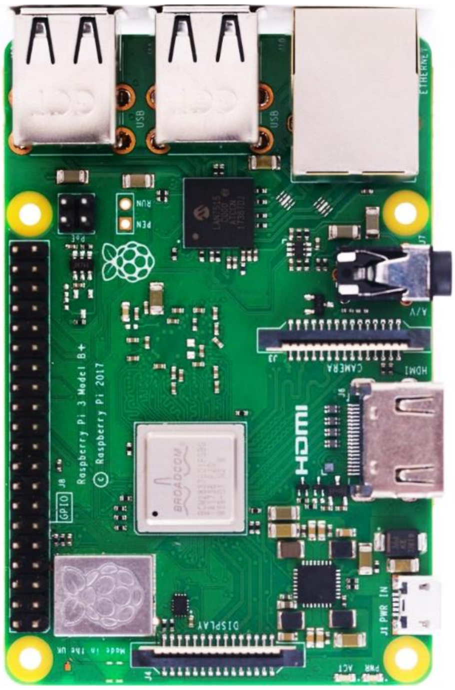
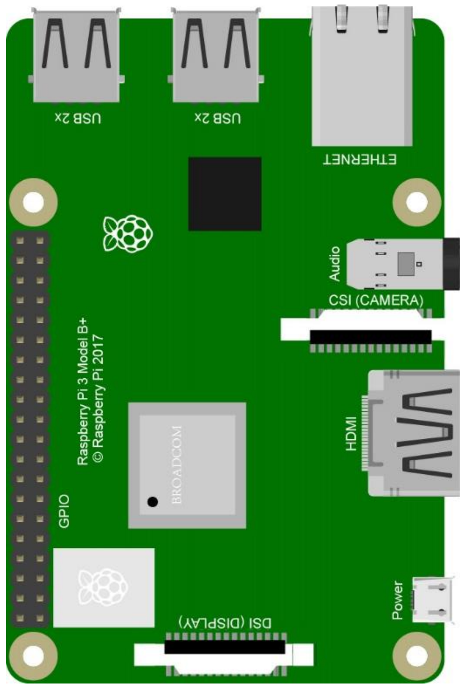
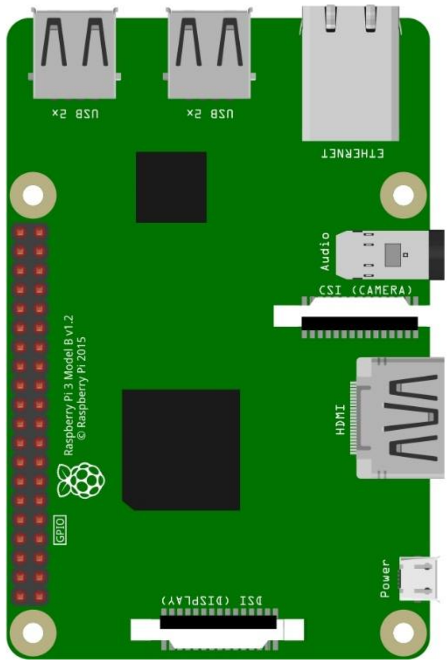
Raspberry Pi

Raspberry Pi (called RPi, RPI, RasPi, the text these words will be used alternately later), a micro-computer with size of a card, quickly swept the world since its debut. It is widely used in desktop workstation, media center, smart home, robots, and even the servers, etc. It can do almost anything, which continues to attract fans to explore it. Raspberry Pi used to be running in Linux system and along with the release of windows 10 IoT. We can also run it in Windows. Raspberry Pi (with interfaces USB, network, HDMI, camera, audio, display and GPIO), as a microcomputer, can be running in command line mode and desktop system mode. Additionally, it is easy to operate just like Arduino, and you can even directly operate the GPIO of CPU.

So far, Raspberry Pi has developed to the fourth generation. Changes in versions are accompanied by increase and upgrades in hardware. A type and B type, the first generation of products, have been stopped due to various reasons. Other versions are popular and active and the most important is that they are consistent in the order and number of pins, which makes the compatibility of peripheral devices greatly enhanced between different versions.

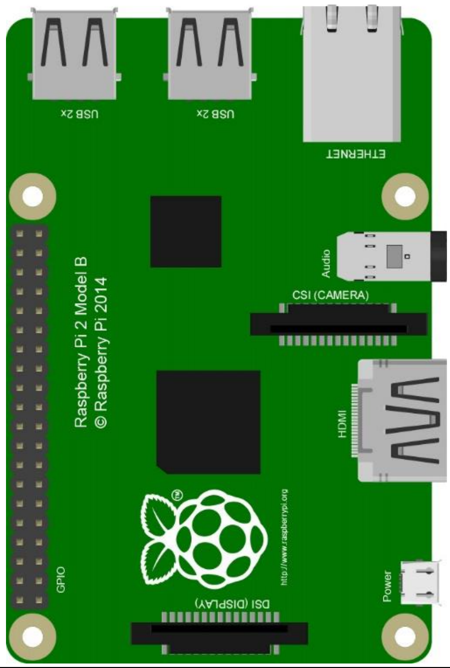
Below are the raspberry pi pictures and model pictures supported by this product.

Practicality picture of Raspberry Pi 4 Model B:	Model diagram of Raspberry Pi 4 Model B:
	

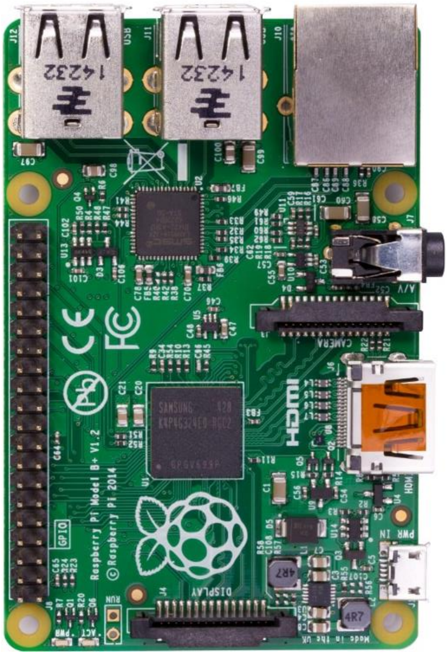
Practicality picture of Raspberry Pi 3 Model B+: 	Model diagram of Raspberry Pi 3 Model B+: 
Practicality picture of Raspberry Pi 3 Model B: 	Model diagram of Raspberry Pi 3 Model B: 

Practicality picture of Raspberry Pi 2 Model B:

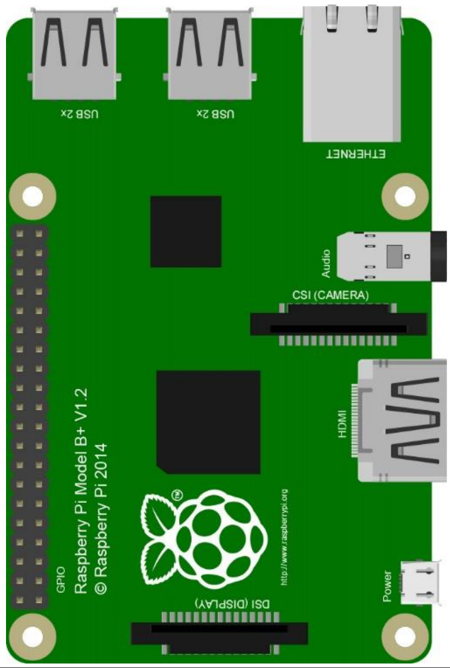
Model diagram of Raspberry Pi 2 Model B:

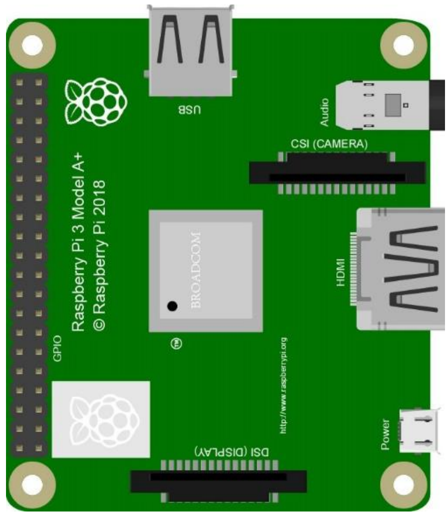
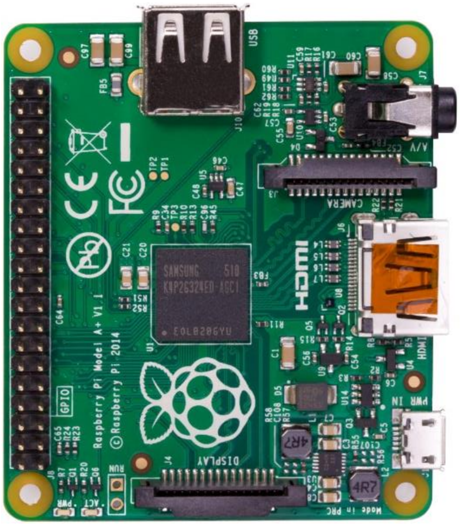
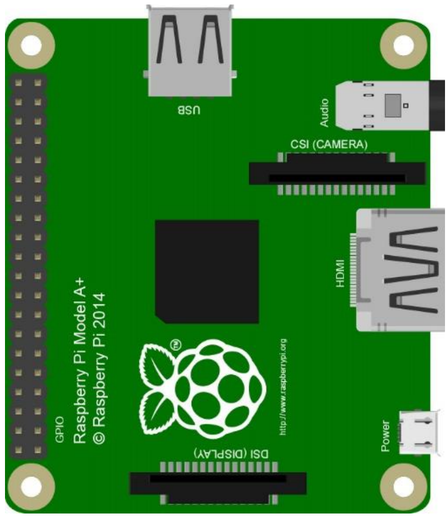


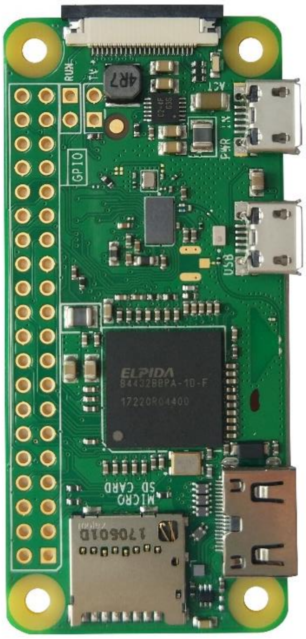
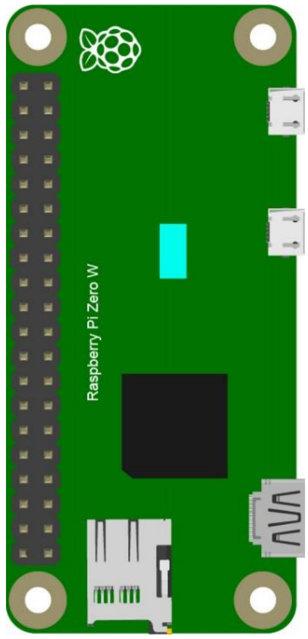
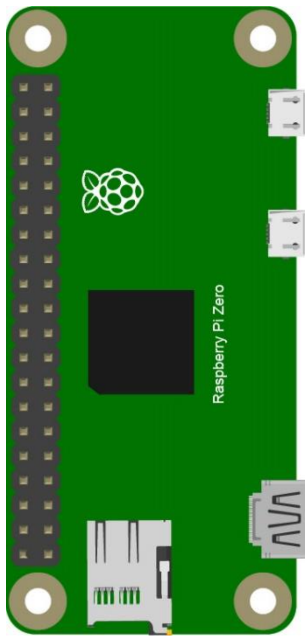
Practicality picture of Raspberry Pi 1 Model B+:



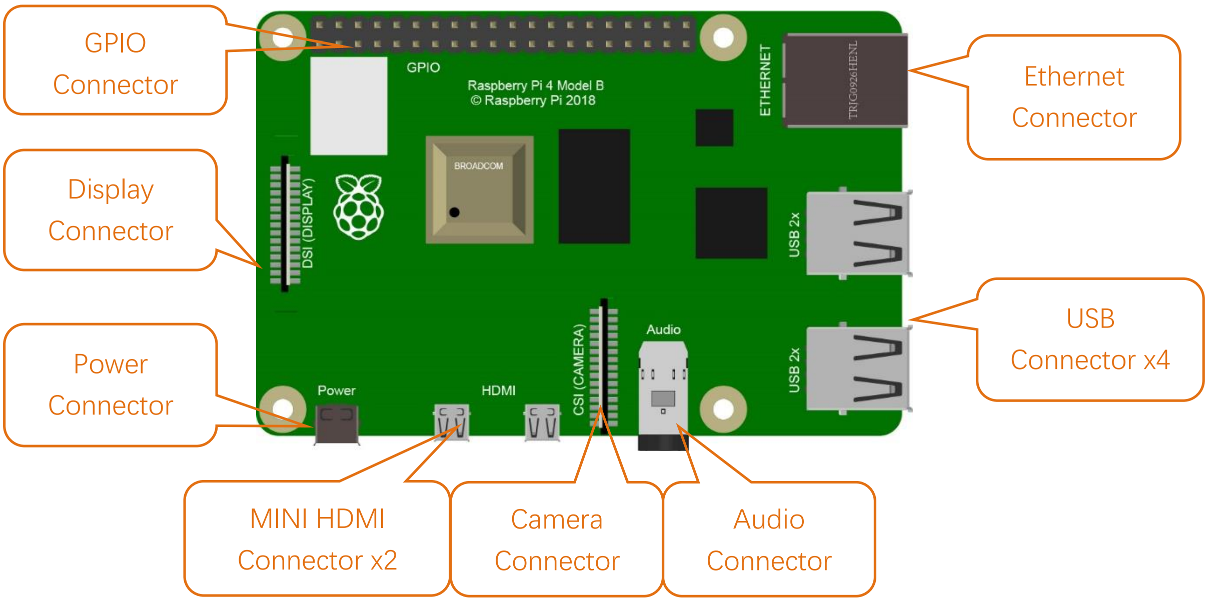
Model diagram of Raspberry Pi 1 Model B+:



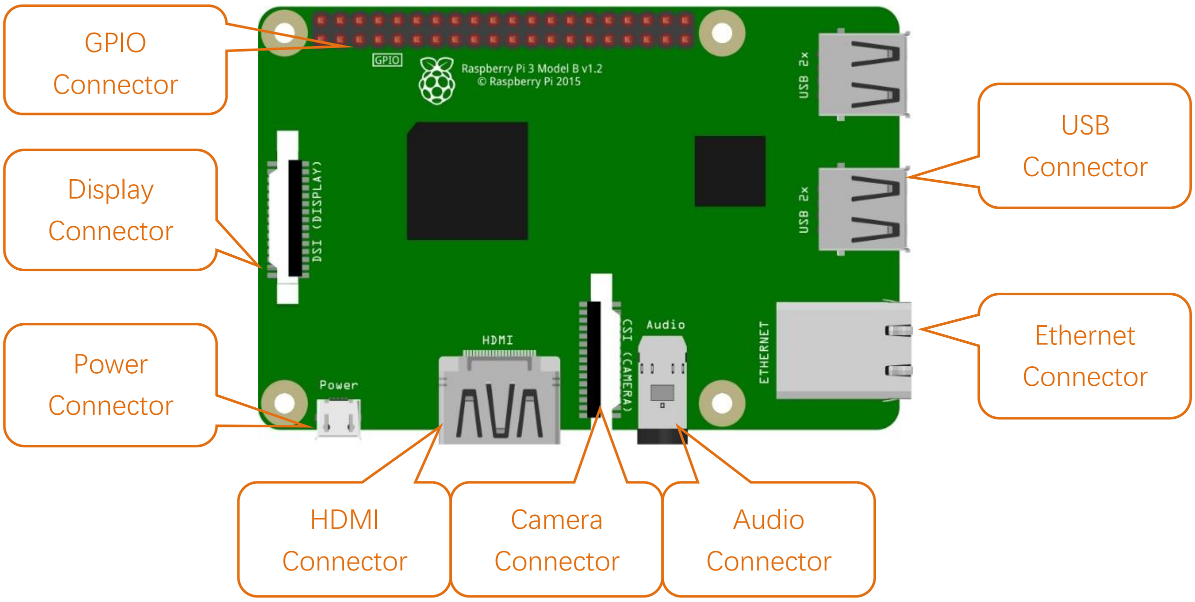
Practicality picture of Raspberry Pi 3 Model A+: 	Model diagram of Raspberry Pi 3 Model A+: 
Practicality picture of Raspberry Pi 1 Model A+: 	Model diagram of Raspberry Pi 1 Model A+: 

Practicality picture of Raspberry Pi Zero W:	Model diagram of Raspberry Pi Zero W:
	
Practicality picture of Raspberry Pi Zero:	Model diagram of Raspberry Pi Zero:
	

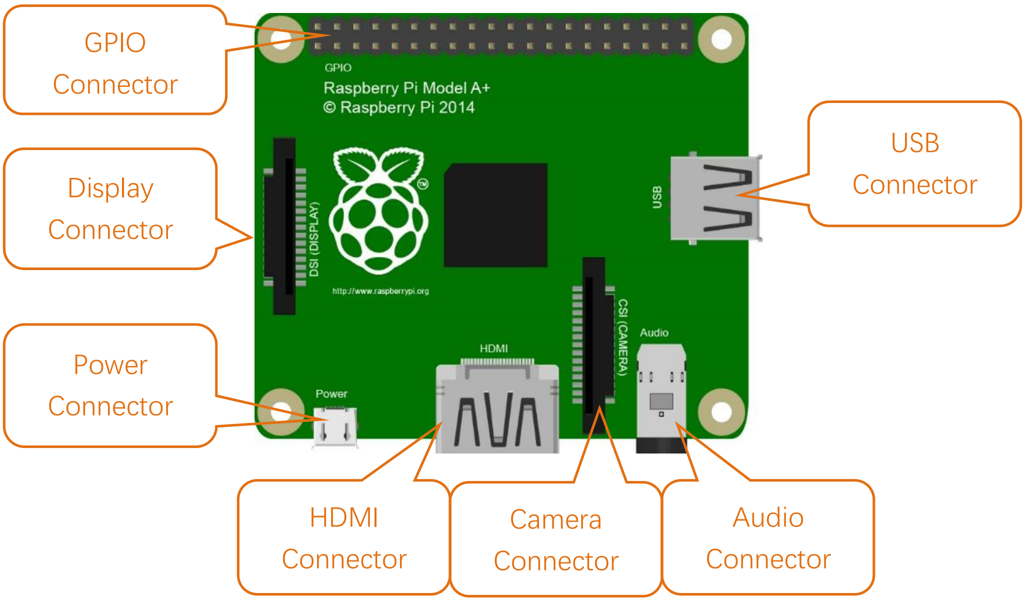
Hardware interface diagram of RPi 4B is shown below:



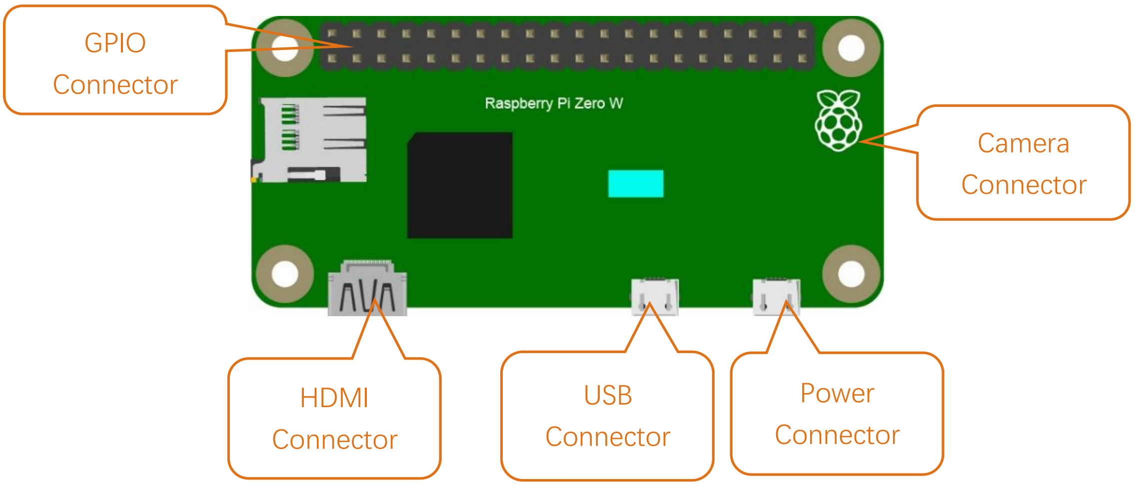
Hardware interface diagram of RPi 3B+/3B/2B/1B+ are shown below:



Hardware interface diagram of RPi 3A+/A+ is shown below:



Hardware interface diagram of RPi Zero/Zero W is shown below:

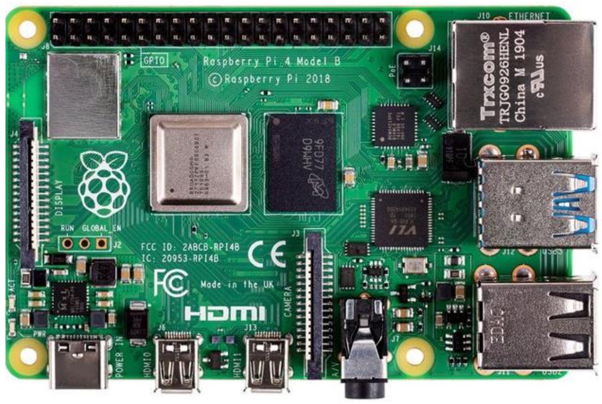
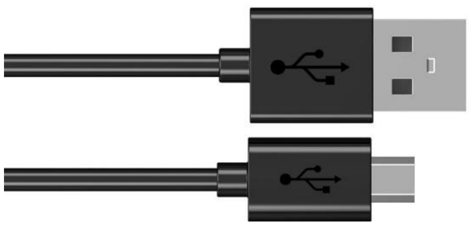


Install the System

Firstly, install a system for your RPi.

Component List

Required Components

Any Raspberry Pi 	5V/3A Power Adapter. Different versions of Raspberry Pi have different power requirements. 
Micro or Type-C USB Cable x1 	Micro SD Card(TF Card)x1, Card Reader x1 

Power requirement of different versions of Raspberry Pi is shown in following table:

Product	Recommended PSU current capacity	Maximum total USB peripheral current draw	Typical bare-board active current consumption
Raspberry Pi Model A	700mA	500mA	200mA
Raspberry Pi Model B	1.2A	500mA	500mA
Raspberry Pi Model A+	700mA	500mA	180mA
Raspberry Pi Model B+	1.8A	600mA/1.2A (switchable)	330mA
Raspberry Pi 2 Model B	1.8A	600mA/1.2A (switchable)	350mA
Raspberry Pi 3 Model B	2.5A	1.2A	400mA
Raspberry Pi 3 Model A+	2.5A	Limited by PSU, board, and connector ratings only.	350mA
Raspberry Pi 3 Model B+	2.5A	1.2A	500mA
Raspberry Pi 4 Model B	3.0A	1.2A	600mA
Raspberry Pi Zero W	1.2A	Limited by PSU, board, and connector ratings only.	150mA
Raspberry Pi Zero	1.2A	Limited by PSU, board, and connector ratings only	100mA

For more details, please refer to https://www.raspberrypi.org/help/faqs/#powerReqs

In addition, RPi also needs a network cable used to connect it to wide area network.

All of these components are necessary. Among them, the power supply is required at least 5V/2.5A, because lack of power supply will lead to many abnormal problems, even damage to your RPi. So power supply with 5V/2.5A is highly recommend. SD Card Micro (recommended capacity 16GB or more) is a hard drive for RPi, which is used to store the system and personal files. In later projects, the components list with a RPi will contains these required components, using only RPi as a representative rather than presenting details.

Optional Components

Under normal circumstances, there are two ways to login to Raspberry Pi: using independent monitor, or remote desktop to share a monitor with your PC.

Required Accessories for Monitor

If you want to use independent monitor, mouse and keyboard, you also need the following accessories.
1.Display with HDMI interface
2.Mouse and Keyboard with USB interface

As to Pi Zero and Pi Zero W, you also need the following accessories.

1. Mini-HDMI to HDMI converter&wire.
2. Micro-USB to USB-A Receptacles converter&wire (Micro USB OTG wire).
3. USB HUB.
4. USB transferring to Ethernet interface or USB Wi-Fi receiver.

For different Raspberry Pi, the optional items are slightly different. But all of their aims are to convert the special interface to standard interface of standard Raspberry Pi.

<table>
<tr><th></th><th>Pi Zero</th><th>Pi A+</th><th>Pi Zero W</th><th>Pi 3A+</th><th>Pi B+/2B</th><th>Pi 3B/3B+</th><th>Pi 4B</th></tr>
<tr><td>Monitor</td><td colspan="7">Yes</td></tr>
<tr><td>Mouse</td><td colspan="7">Yes</td></tr>
<tr><td>Keyboard</td><td colspan="7">Yes</td></tr>
<tr><td>Mini-HDMI to HDMI converter or wire</td><td>Yes</td><td>No</td><td>Yes</td><td>No</td><td>No</td><td>No</td><td>No</td></tr>
<tr><td>Micro-HDMI to HDMI converter & wire</td><td colspan="6">No</td><td>Yes</td></tr>
<tr><td>Micro-USB to USB-A Receptacles converter & wire (Micro USB OTG wire)</td><td>Yes</td><td>No</td><td>Yes</td><td colspan="4">No</td></tr>
<tr><td>USB HUB</td><td>Yes</td><td>Yes</td><td>Yes</td><td>Yes</td><td>No</td><td>No</td><td></td></tr>
<tr><td>USB transferring to Ethernet interface</td><td colspan="2" rowspan="2">select one from two or select two from two</td><td colspan="2">optional</td><td>Internal Integration</td><td colspan="2" rowspan="2">Internal Integration</td></tr>
<tr><td>USB Wi-Fi receiver</td><td colspan="2">Internal Integration</td><td>optional</td></tr>
</table>

Required Accessories for Remote Desktop

If you don't have an independent monitor, or you want to use a remote desktop, first you need to login to Raspberry Pi through SSH, then open the VNC or RDP service. So you need the following accessories.

<table>
<tr><th></th><th>Pi Zero</th><th>Pi Zero W</th><th>Pi A+</th><th>Pi 3A+</th><th>Pi B+/2B</th><th>Pi 3B/3B+/4B</th></tr>
<tr><td>Micro-USB to USB-A Receptacles converter&wire (Micro USB OTG wire)</td><td>Yes</td><td>Yes</td><td>No</td><td colspan="3" rowspan="2">NO</td></tr>
<tr><td>USB transferring to Ethernet interface</td><td>Yes</td><td>Yes</td><td>Yes</td></tr>
</table>

Raspbian System

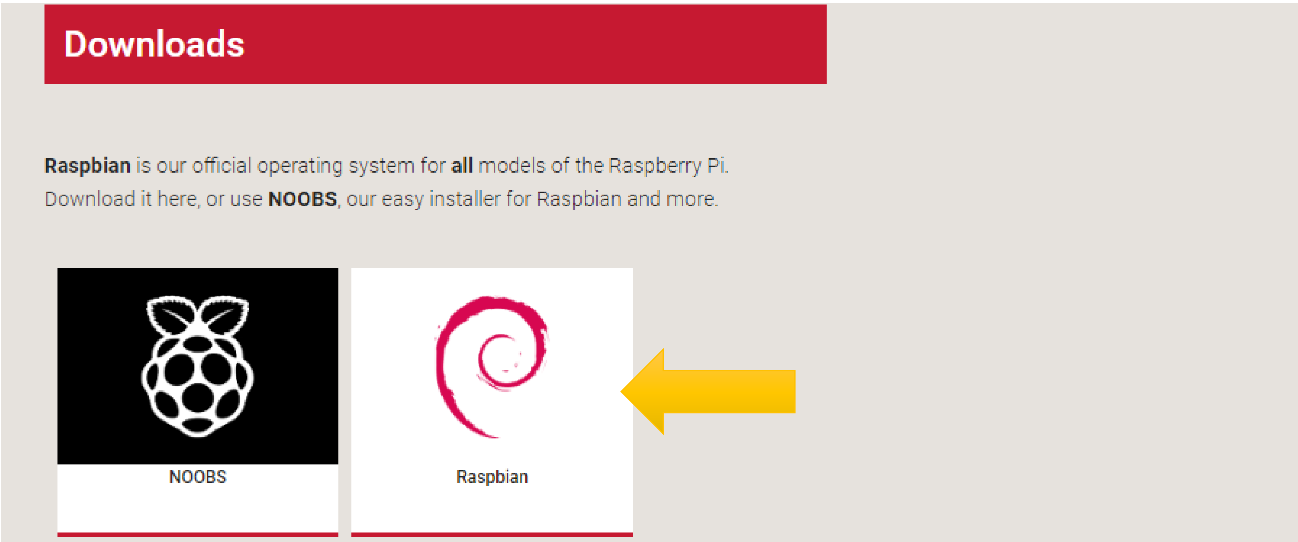
Tool and System image

Software Tool

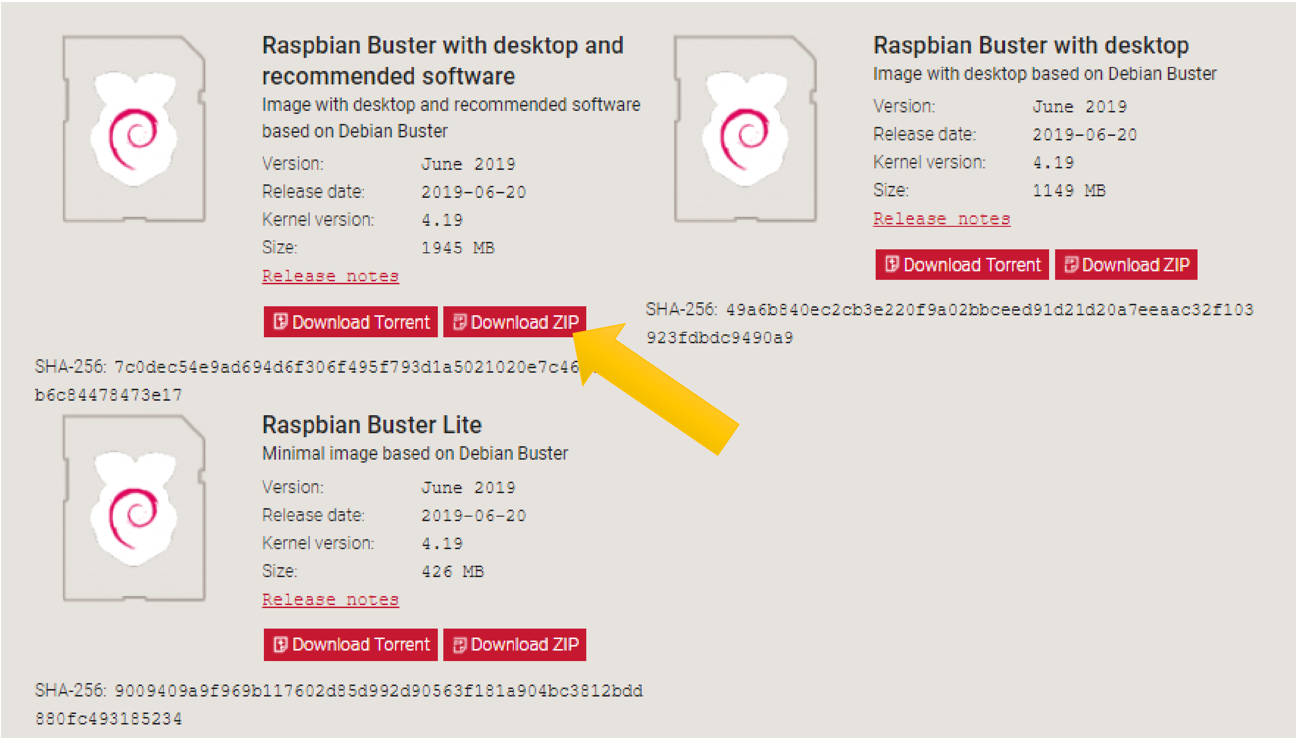
A tool Disk Imager Win32 is required to write system. You can download and install it through visiting the web site: https://sourceforge.net/projects/win32diskimager/

Selecting System

Visit RPi official website (https://www.RaspberryPi.org/), click "Downloads" and choose to download "RASPBIAN". RASPBIAN supported by RPI is an operating system based on Linux, which contains a number of contents required for RPi. We recommended RASPBIAN system to beginners. All projects in this tutorial are operated under the RASPBIAN system.



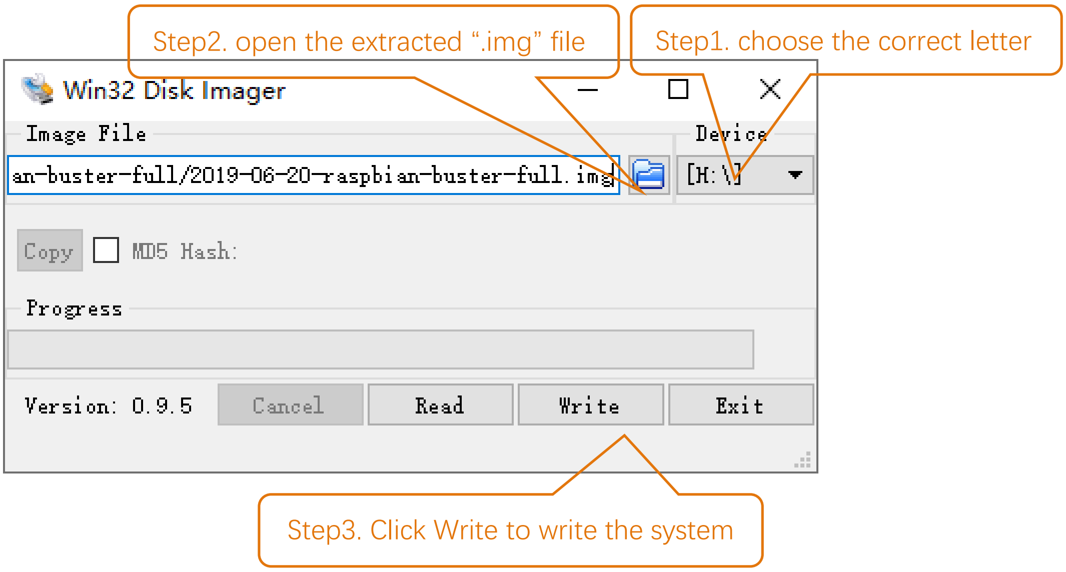
https://www.raspberrypi.org/downloads/raspbian/



After download, extract file with suffix (.img). Preparation is ready to start making the system.

Write System to Micro SD Card

First, put your Micro SD card into card reader and connect it to USB port of PC. Then open Win32 disk imager, choose the correct letter of your Micro SD Card (here is “H”), open the extracted “.img” file and then click the "Write".



Start Raspberry Pi

If you don't have a spare monitor, please jumper to next section. If you have a spare monitor, please follow steps in this section.

After the system is written successfully, take out Micro SD Card and put it into the card slot of RPi. Then connect RPi to screen through the HDMI, to mouse and keyboard through the USB port, to network cable through the network card interface and to the power supply. Then your RPi starts initially. Later, you need to enter the user name and password to login. The default user name: pi; password: raspberry. Enter and login. After login, you can enter the following interface.

Now, you have successfully installed the RASPBIAN operating system for your RPi.

Remote desktop & VNC

If you don't have a spare display, mouse and keyboard for your RPi, you can use a remote desktop to share a display, keyboard, and mouse with your PC. Below is how to use remote desktop to control RPi under the Windows operating system.

Under windows, Raspberry Pi can be generally accessed remotely through two applications. The first one is the windows built-in application remote desktop, which corresponds to the Raspberry Pi xrdp service. The second one is the free application VNC Viewer, which corresponds to the VNC interface of Raspberry Pi. Each way has its own advantages. You can choose either one or two.

Windows	Raspberry Pi
Remote Desktop Connection	Xrdp
VNC Viewer	VNC

VNC Viewer can not only run under Windows, but also under system MAC, Linux, IOS, Android and so on.

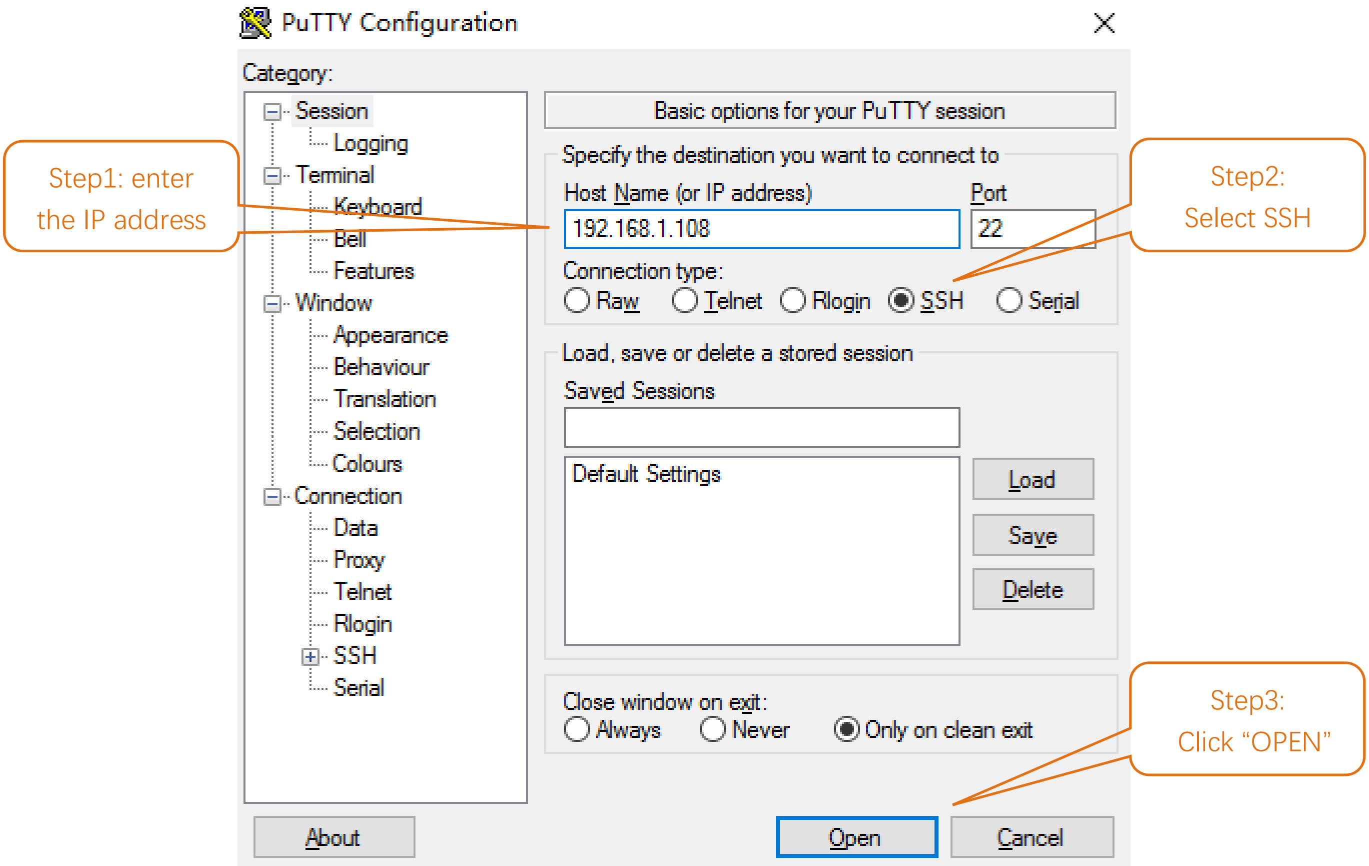
SSH

Under previous Raspbian system, SSH is opened by default. Under the latest version of Raspbian system, it is closed by default. So you need to open it first.

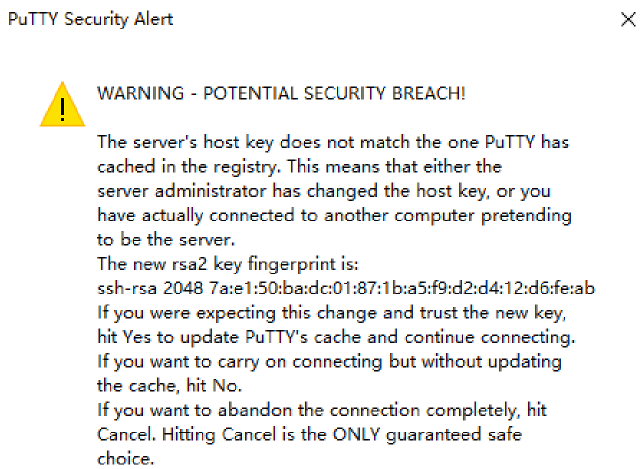
Method: after the system is written. Create a folder named "ssh" under generated boot disk, then the SSH connection will be opened.

And then, download the tool software Putty. Its official address: http://www.putty.org/
Or download it here: http://www.chiark.greenend.org.uk/~sgtatham/putty/download.html

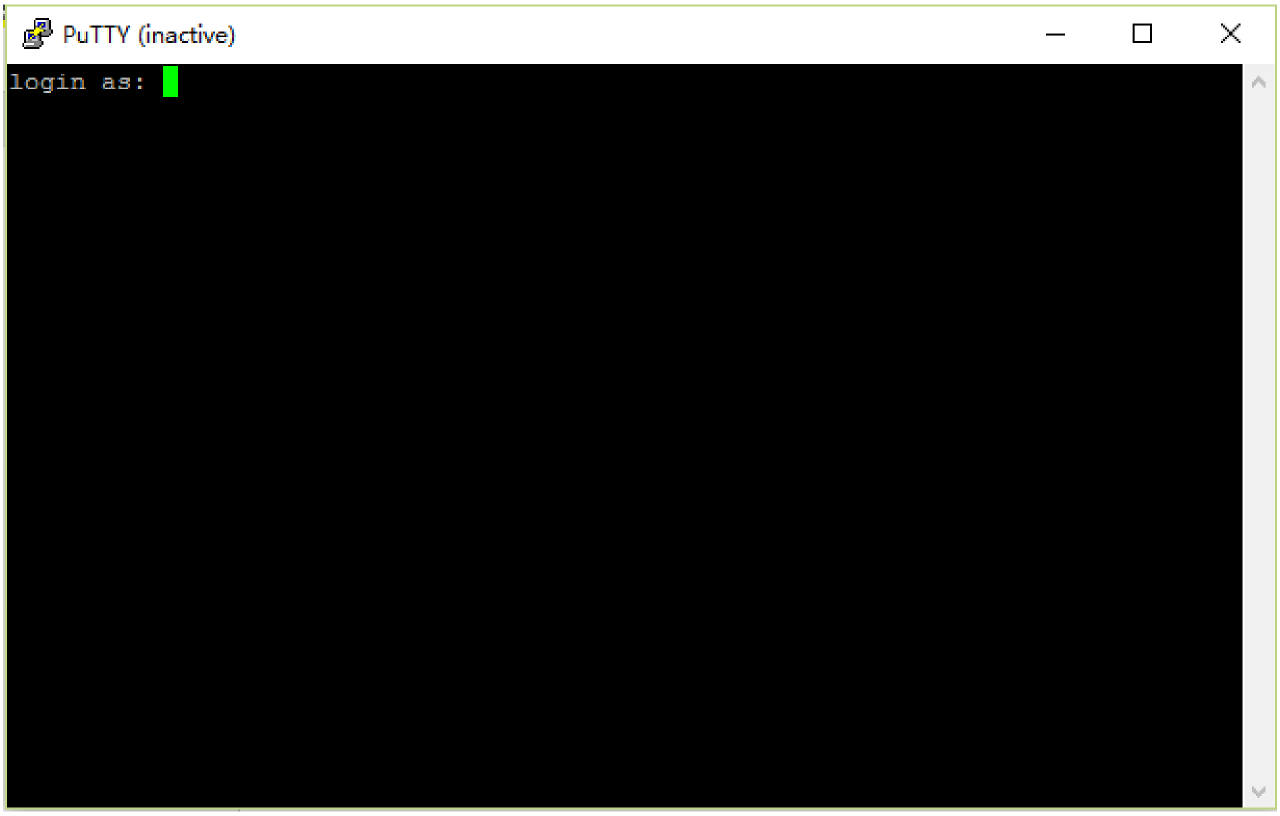
Then use cable to connect your RPi to the routers of your PC LAN, to ensure your PC and your RPi in the same LAN. Then put the system Micro SD Card prepared before into the slot of the RPi and turn on the power supply waiting for starting RPi. Later, enter control terminal of the router to inquiry IP address named “raspberry pi”. For example, I have inquired to my RPi IP address, and it is “192.168.1.108". Then open Putty, enter the address, select SSH, and then click "OPEN", as shown below:



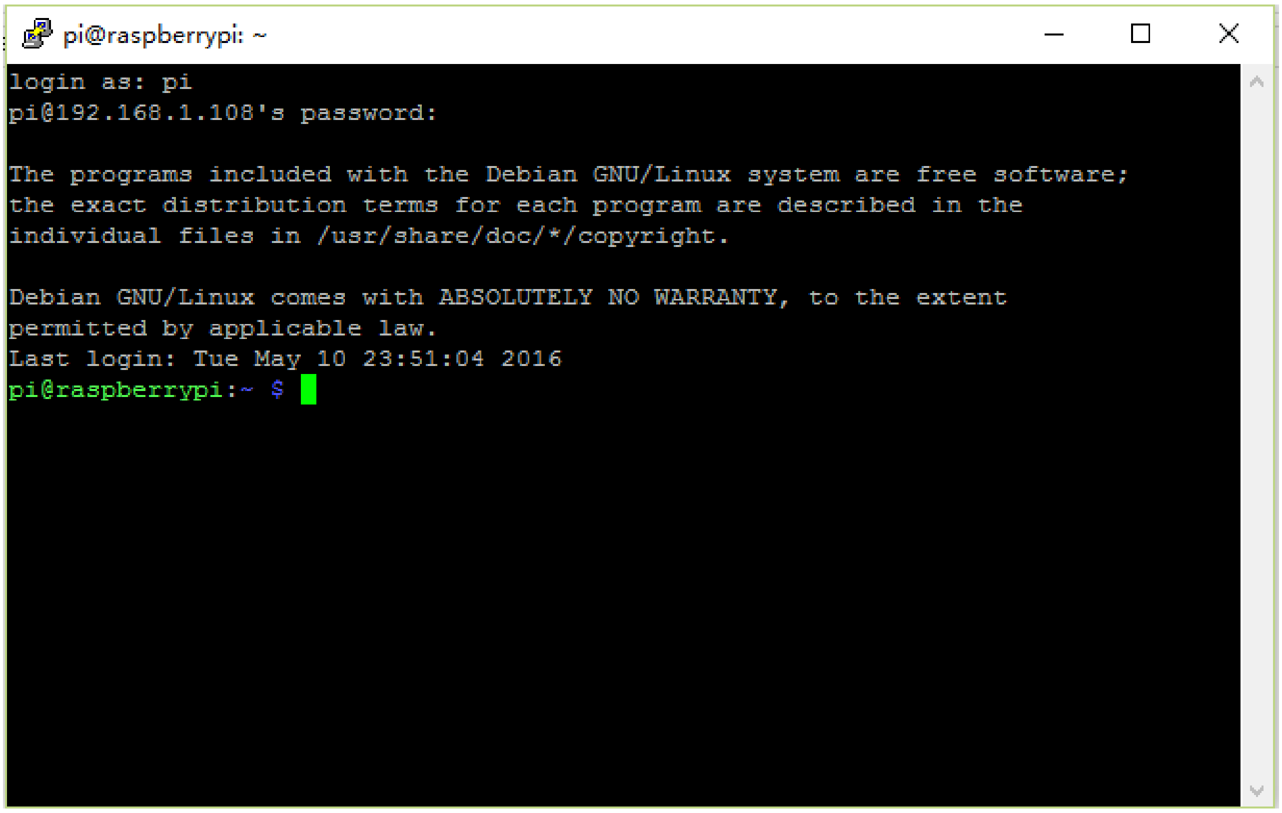
There will appear a security warning at first login. Just click “YES”.



Then there will be a login interface (RPi default user name: pi; the password: raspberry). When you enter the password, there will be no display on the screen. This is normal. After the correct output, press "Enter" to confirm.



Then enter the command line of RPi, which means that you have successfully login to RPi command line mode.



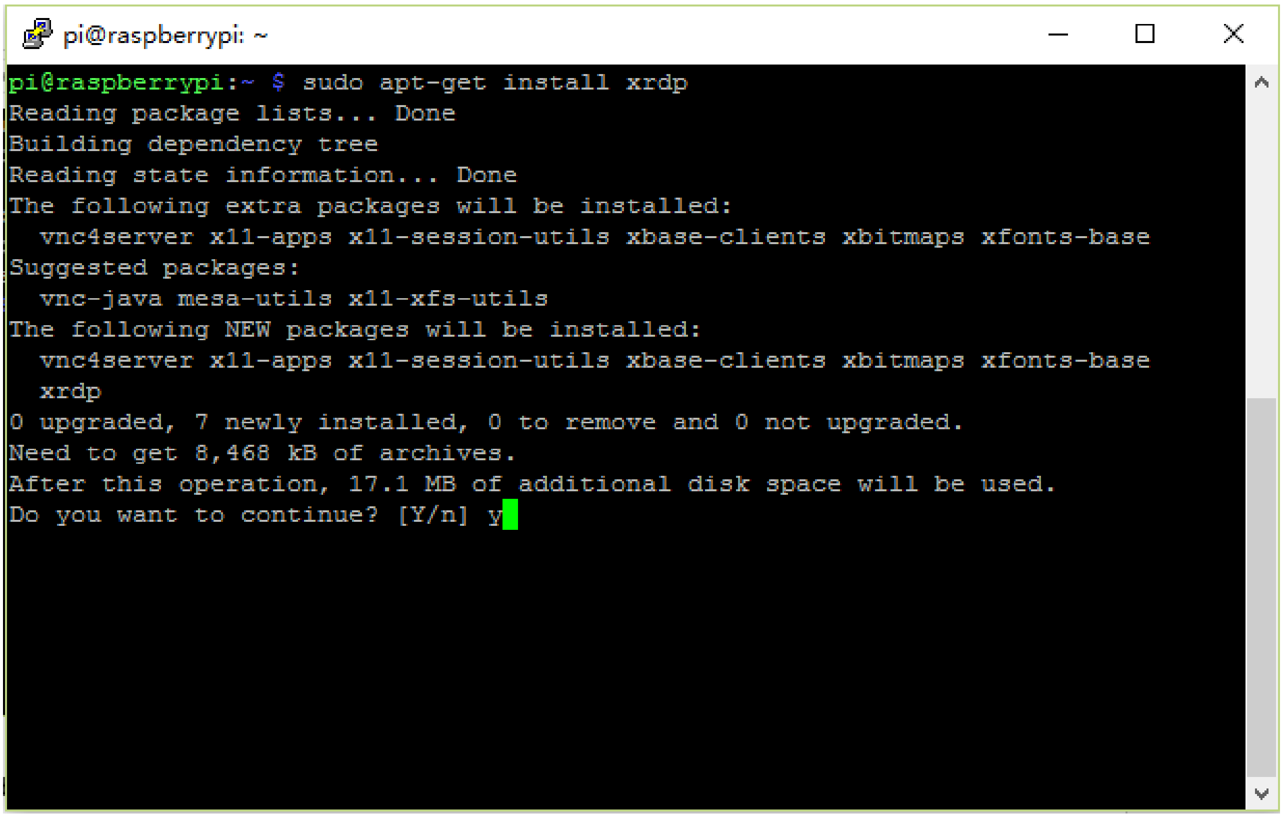
Remote Desktop Connection & xrdp

If you want to use built-in Remote Desktop Connection under Windows, you need install xrdp service on Raspberry Pi.

Next, install a xrdp service, an open source remote desktop protocol(rdp) server, for RPi. Type the following command, then press enter to confirm:

```
sudo apt-get install xrdp
```

Later, the installation starts.

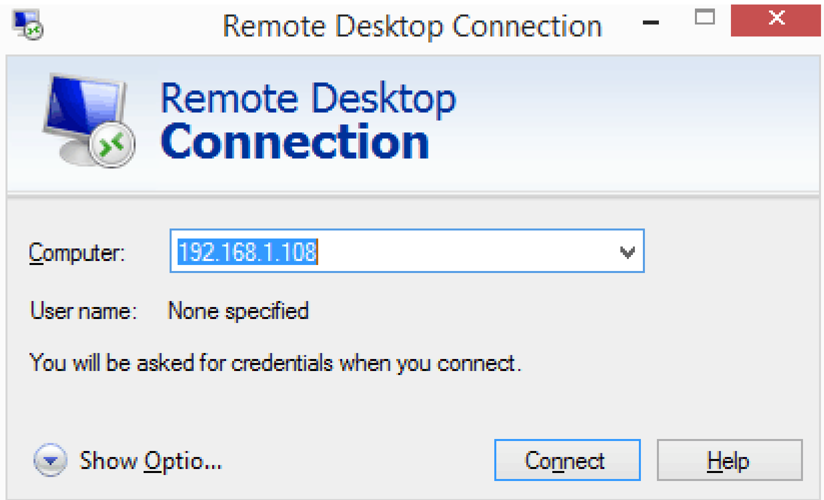


```
pi@raspberrypi: ~
pi@raspberrypi:~ $ sudo apt-get install xrdp
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following extra packages will be installed:
  vnc4server x11-apps x11-session-utils xbase-clients xbitmaps xfonts-base
Suggested packages:
  vnc-java mesa-utils x11-xfs-utils
The following NEW packages will be installed:
  vnc4server x11-apps x11-session-utils xbase-clients xbitmaps xfonts-base
  xrdp
0 upgraded, 7 newly installed, 0 to remove and 0 not upgraded.
Need to get 8,468 kB of archives.
After this operation, 17.1 MB of additional disk space will be used.
Do you want to continue? [Y/n] y
```

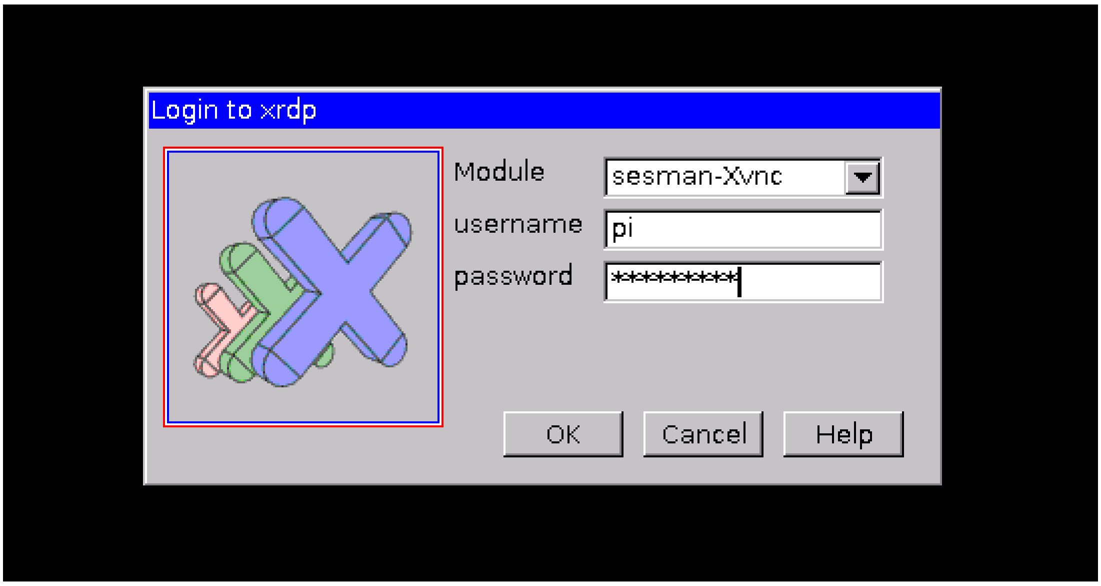
Enter "Y", press key “Enter” to confirm.
After the installation is completed, you can use Windows remote desktop applications to login to your RPi.

Login to Windows remote desktop

Use "WIN+R" or search function, open the remote desktop application "mstsc.exe" under Windows, enter the IP address of RPi and then click “Connect”.



Later, there will be xrdp login screen. Enter the user name and password of RPi (RPi default user name: pi; password: raspberry) and click “OK”.



Later, you can enter the RPi desktop system.

Here, you have successfully used the remote desktop login to RPi.

VNC Viewer & VNC

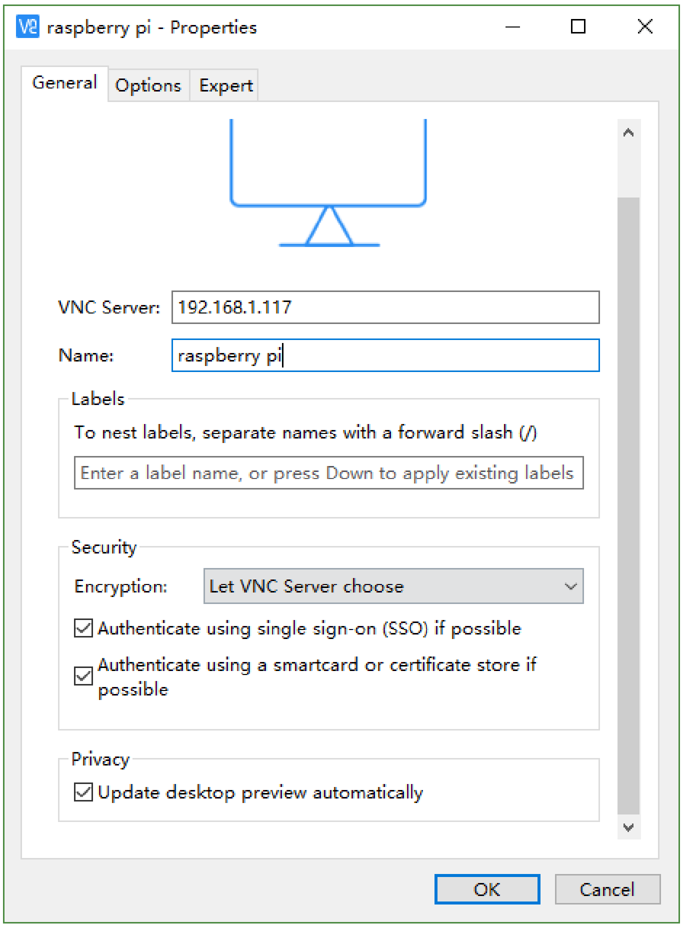
Type the following command. And select 5 Interfacing Options→P3 VNC →Yes→OK→Finish. Here Raspberry Pi may need be restarted, and choose ok. Then open VNC interface.

```
sudo raspi-config
```

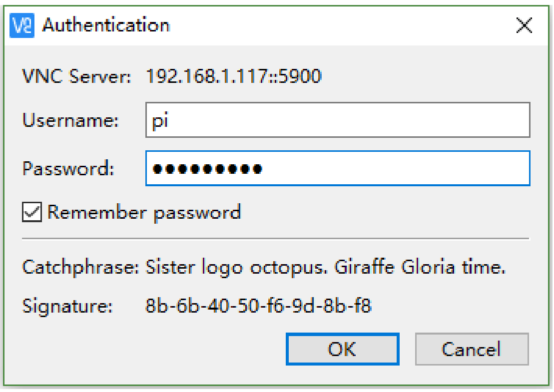
```
Raspberry Pi Software Configuration Tool (raspi-config)

1 Change User Password          Change password for the current u
2 Network Options               Configure network settings
3 Boot Options                  Configure options for start-up
4 Localisation Options          Set up language and regional sett
5 Interfacing Options           Configure connections to peripher
6 Overclock                     Configure overclocking for your P
7 Advanced Options              Configure advanced settings
8 Update                        Update this tool to the latest ve
9 About raspi-config            Information about this configurat

              <Select>                      <Finish>
```

```
Raspberry Pi Software Configuration Tool (raspi-config)

P1 Camera                       Enable/Disable connection to the
P2 SSH                          Enable/Disable remote command lin
P3 VNC                          Enable/Disable graphical remote a
P4 SPI                          Enable/Disable automatic loading
P5 I2C                          Enable/Disable automatic loading
P6 Serial                       Enable/Disable shell and kernel m
P7 1-Wire                       Enable/Disable one-wire interface
P8 Remote GPIO                  Enable/Disable remote access to G

              <Select>                      <Back>
```

Then download and install VNC Viewer by click following link:
https://www.realvnc.com/en/connect/download/viewer/windows/
After installation is completed, open VNC Viewer. And click File → New Connection. Then the interface is shown below.



Enter ip address of your Raspberry Pi and fill in a Name. And click OK.
Then on the VNC Viewer panel, double-click new connection you just created, and the following dialog box pops up.



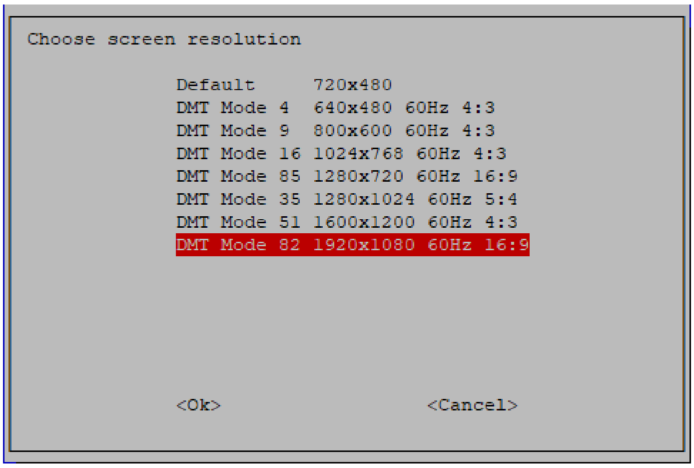
Enter username: pi and Password: raspberry. And click OK.

Here, you have logged in to Raspberry Pi successfully by using VNC Viewer

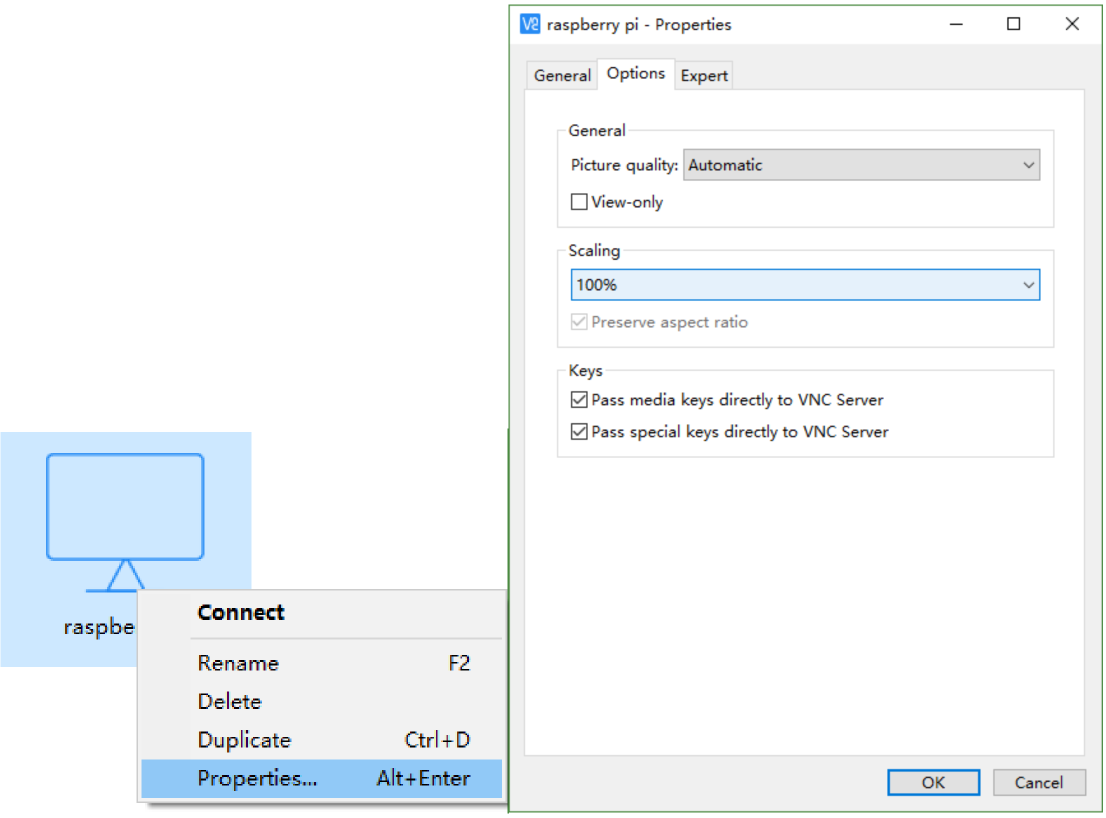
If you think resolution ratio is not OK, you can set a proper resolution ratio on set interface of Raspberry Pi.

```
sudo raspi-config
```

Select 7 Advanced Options→A5 Resolution→proper resolution ratio(set by yourself)→OK. If it needs restart, just restart.



In addition, your VNC Viewer window may zoom your Raspberry Pi desktop. You can change it. On your VNC View control panel, click right key. And select Properties->Options label->Scaling. Then set proper scaling.



Here, you have logged in to Raspberry Pi successfully by using VNC Viewer and operated proper setting. Then continue to do some preparation work: install a GPIO library wiringPi for your RPi.

Wi-Fi

Raspberry Pi 3B+/3B integrates a Wi-Fi adaptor. You can use it to connect to your Wi-Fi. Then you can use the wireless remote desktop to control your RPi. This will be helpful for the following work. Raspberry Pi of other models can use wireless remote desktop through accessing an external USB wireless card.

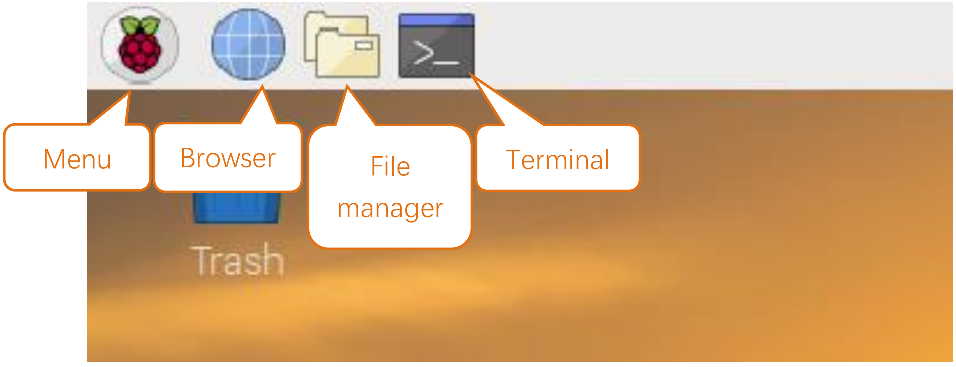
Chapter 0 Preparation

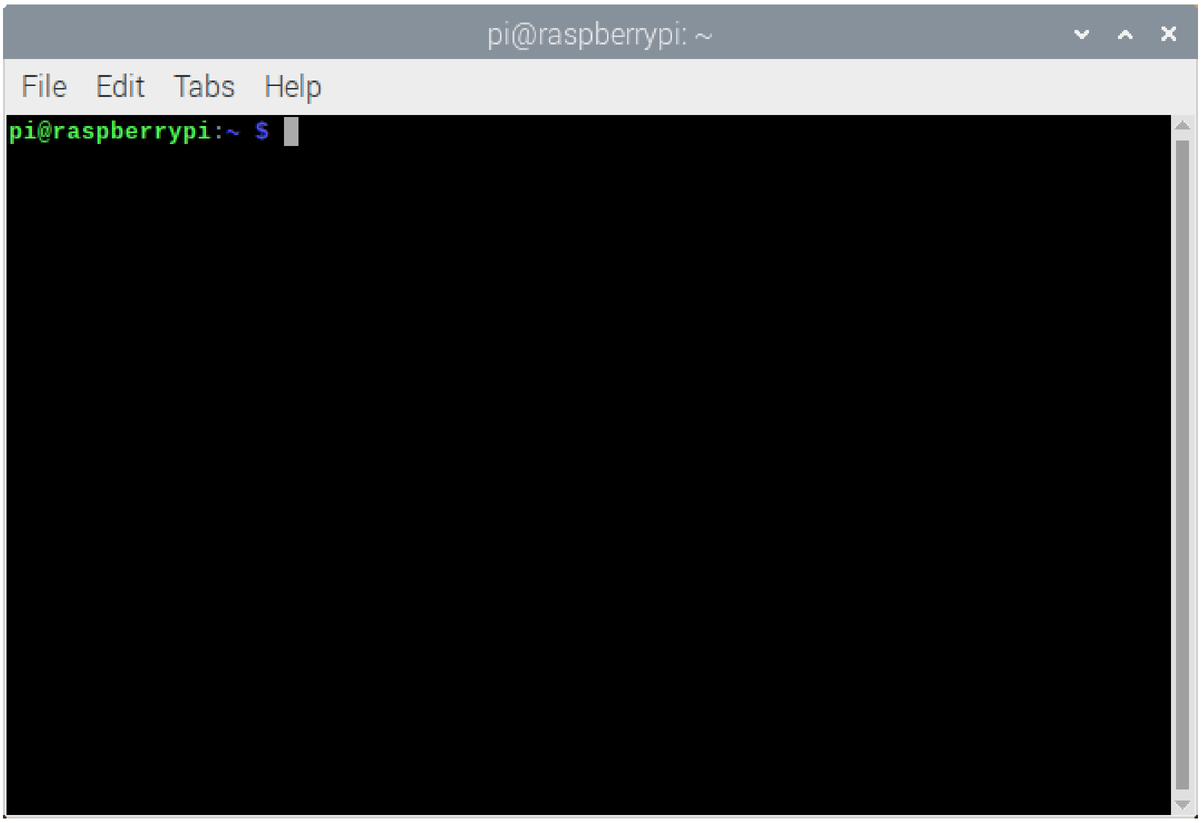
Why is “Chapter 0”? Because in the program code, all the counts are starting from 0. We choose to follow this rule (just a joke). In this chapter, we will do some necessary preparation work: start your Pi Raspberry and install some necessary libraries. If your Raspberry Pi can be started normally and used normally, you can skip this chapter.

Linux Command

Raspbian is based on Linux operation system. Now we will introduct some frequently-used Linux commands and useage methods.

First, opent terminal. All commands are executed in terminal.





And the terminal is case sensitive.

Then type “ls” in terminal and press “Enter” key. The result is shown below:

```
pi@raspberrypi: ~
File  Edit  Tabs  Help
pi@raspberrypi:~ $ ls
Desktop                                            Music
Documents                                          Pictures
Downloads                                          Public
Freenove_Three-wheeled_Smart_Car_Kit_for_Raspberry_Pi  Templates
Freenove_Ultimate_Starter_Kit_for_Raspberry_Pi     thinclient_drives
MagPi                                              Videos
mu_code
```

”ls”, List information about the FILEs (the current directory by default). Sort entries alphabetically.

Content between “$” and ”pi@raspberrypi:” is the current working path. “~” presents user directory. It is equal to “/home/pi” here. “pwd” can be used to view current working path.

```
pi@raspberrypi:~ $ pwd
/home/pi
```

“cd” is used to change directory. “/” presents root directory.

```
pi@raspberrypi:~ $ cd /usr
pi@raspberrypi:/usr $ ls
bin  games  include  lib  local  man  sbin  share  src
pi@raspberrypi:/usr $ cd ~
pi@raspberrypi:~ $
```

In later content, we will often change working path. Typing commands under wrong working path will cause error messages. And the commands can not continue to be executed.

There are some frequently used commands and instructions in following table.

Command	instruction
ls	List information about the FILEs (the current directory by default). Sort entries alphabetically.
cd	Change directory
sudo + cmd	Excute cmd under root authority
./	Under current directory
gcc	GNU Compiler Collection
git clone URL	Use git tool to clone the contents of specified repository, and URL is the repository address.

There are many commands later. For more details about command. You can refer to:
http://www.linux-commands-examples.com

Shortcut Key

Now, we will introduce several shortcuts that are very useful and commonly used in terminal.

1. **up and down arrow keys**. History commands can be quickly brought back by using up and down arrow keys, which are very useful when you need to reuse certain commands.
When you need to type command, pressing "↑" will bring back the previous command, and pressing "↓" will bring back the latter command.

2. **Tab key**. The Tab key can automatically complete the command/path you want to type. When there are multiple commands/paths conforming to the already typed letter, pressing Tab key once won't have any result. And pressing Tab key again will list all the eligible options. This command/path will be directly completed when there is only one eligible option.

As shown below, under the'~'directory, enter the Documents directory with the "cd" command. After typing "cd D", press Tab key, then there is no response. Press Tab key again, then all the files/folders that begin with "D" is listed. Continue to type the character "oc", then press the Tab key, and then "Documents" is completed automatically.

```
pi@raspberrypi:~ $ cd D
Desktop/   Documents/ Downloads/
pi@raspberrypi:~ $ cd Doc
```

```
pi@raspberrypi:~ $ cd D
Desktop/   Documents/ Downloads/
pi@raspberrypi:~ $ cd Documents/
```

Install WiringPi

WiringPi is a GPIO access library written in C for the BCM2835/BMC2836/ BMC2837 used in the Raspberry Pi. It's released under the GNU LGPLv3 license and is usable from C, C++ and many other languages with suitable wrappers (See below) It's designed to be familiar to people who have used the Arduino "wiring" system. (for more details, please refer to http://wiringpi.com/)

WiringPi Installation Steps

New Raspbian system has integrated this library. So it may prompt that you have installed it.
open the terminal. Follow these steps and commands to complete the installation.
For command with many lines, execute them line by line.
Enter the following command in the terminal to install WiringPi:

```
sudo apt-get update
sudo apt-get upgrade
sudo apt-get install wiringpi
```

As shown below, the installation will be completed soon.

```
pi@raspberrypi:~ $ sudo apt-get install wiringpi
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following packages were automatically installed and are no longer required:
  freetype2-doc rpi.gpio-common
Use 'sudo apt autoremove' to remove them.
The following NEW packages will be installed:
  wiringpi
0 upgraded, 1 newly installed, 0 to remove and 0 not upgraded.
Need to get 0 B/52.9 kB of archives.
After this operation, 0 B of additional disk space will be used.
Selecting previously unselected package wiringpi.
(Reading database ... 159071 files and directories currently installed.)
Preparing to unpack .../wiringpi_2.50_armhf.deb ...
Unpacking wiringpi (2.50) ...
Setting up wiringpi (2.50) ...
Processing triggers for man-db (2.8.5-2) ...
```

Run the gpio command to check the installation:

```
gpio -v
```

That should give you some confidence that it's working well.

```
pi@raspberrypi:~ $ gpio -v
gpio version: 2.50
Copyright (c) 2012-2018 Gordon Henderson
This is free software with ABSOLUTELY NO WARRANTY.
For details type: gpio -warranty

Raspberry Pi Details:
  Type: Unknown17, Revision: 01, Memory: 1024MB, Maker: Sony
  * Device tree is enabled.
  *--> Raspberry Pi 4 Model B Rev 1.1
  * This Raspberry Pi supports user-level GPIO access.
```

Obtain the Project Code

After the above work is done, you can visit our official website (http://www.freenove.com) or our github (https://github.com/freenove) to download the latest project code. We provide both **C** language and **Python** language code for each project in order to apply to user skilled in different languages.

Method for obtaining the code:
In the pi directory of the RPi terminal, enter the following command.

```
cd ~
git clone https://github.com/freenove/Freenove_Basic_Starter_Kit_for_Raspberry_Pi
```

(There is no need for password. If you get some errors, please check if your commands is correct.)

After the download is completed, a new folder "Freenove_Basic_Starter_Kit_for_Raspberry_Pi" is generated, which contains all the tutorials and code.

If you think the folder name is too long. You can rename it by following command.

```
mv Freenove_Basic_Starter_Kit_for_Raspberry_Pi xxx
```

Among them, "xxx" represents the new folder name. If you rename the folder, you must change **every** "Freenove_Basic_Starter_Kit_for_Raspberry_Pi" to new folder name in later commands which contain folder name.

If you never learned any things of python, it is recommended to refer to follow website for basic knowledge.
https://python.swaroopch.com/basics.html

Python2 & Python3

If you only use C/C++, you can skip this section.

Now Python code of our kits can run on Python2 and Python3. **Python3 is recommend**. If you want to use python2, please make sure your Python version is above 2.7. Python2 and Python3 is not fully compatible. However, Python2.6 and Python2.7 are transition versions to python3. So you can also use Python2.6 and 2.7 to execute some Python3 code.

You can type python2 and python3 respectively to check if python has been installed. Press Ctrl-Z to exit.

```
pi@raspberrypi:~ $ python2
Python 2.7.13 (default, Nov 24 2017, 17:33:09)
[GCC 6.3.0 20170516] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>>
[2]+  Stopped                 python2
pi@raspberrypi:~ $ python3
Python 3.5.3 (default, Jan 19 2017, 14:11:04)
[GCC 6.3.0 20170124] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>>
```

Type python, and the terminal shows that it links to python2.

```
pi@raspberrypi:~ $ python
Python 2.7.13 (default, Nov 24 2017, 17:33:09)
[GCC 6.3.0 20170516] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>>
```

If you want to set Python3 as default Python actuators. please follow the steps below.

1. Enter directory /usr/bin

```
cd /usr/bin
```

2. Delete the old python link.

```
sudo rm python
```

3. Creat new python links to python3.

```
sudo ln -s python3 python
```

4. Execute python to check whether the link succeeds.

```
python
```

```
pi@raspberrypi:/usr/bin $ sudo rm python
pi@raspberrypi:/usr/bin $ sudo ln -s python3 python
pi@raspberrypi:/usr/bin $ python
Python 3.5.3 (default, Jan 19 2017, 14:11:04)
[GCC 6.3.0 20170124] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>>
```

If you want to set python2 as default python actuators, repeat above steps and just change the third command to the following.

```
sudo ln -s python2 python
```

```
pi@raspberrypi:/usr/bin $ sudo rm python
pi@raspberrypi:/usr/bin $ sudo ln -s python2 python
pi@raspberrypi:/usr/bin $ python
Python 2.7.13 (default, Nov 24 2017, 17:33:09)
[GCC 6.3.0 20170516] on linux2
Type "help", "copyright", "credits" or "license" for more information.
>>>
```

We will execute a same python file Hello.py with Python2 and Python3.

First, use Python2 to execute the code.

1. Use cd command to enter 00.0.0_Hello directory of Python code.

```
cd ~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/Python_Code/00.0.0_Hello
```

2. Use python2 command to execute python code Hello.py.

```
python2 Hello.py
```

```
pi@raspberrypi:~ $ cd ~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/Python_Code/00.0.0_Hello
pi@raspberrypi:~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/Python_Code/00.0.0_Hello $ python2 Hello.py
Hello World!
```

Use Python3 to execute the code under same directory.

3. Use python3 command to execute python code Hello.py.

```
python3 Hello.py
```

As you can see, we get same results.

```
pi@raspberrypi:~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/Python_Code/00.0.0_Hello $ python3 Hello.py
Hello World!
```

Because the code for our kit supports Python2 and Python3. We just say python later, not specific Python2 or Python3. You can shoose python version according to your situation.

Code Editor

vi, nano, Geany

Here we will introduce three kinds of code editor: vi, nano and Geany. Among them, nano and vi are used to edit files directly in the terminal. And Geany is an independent editing software, which is recommended for begainer. We will use the three editors to open an example code "Hello.c" respectively. First we will show how use vi and nano editor:

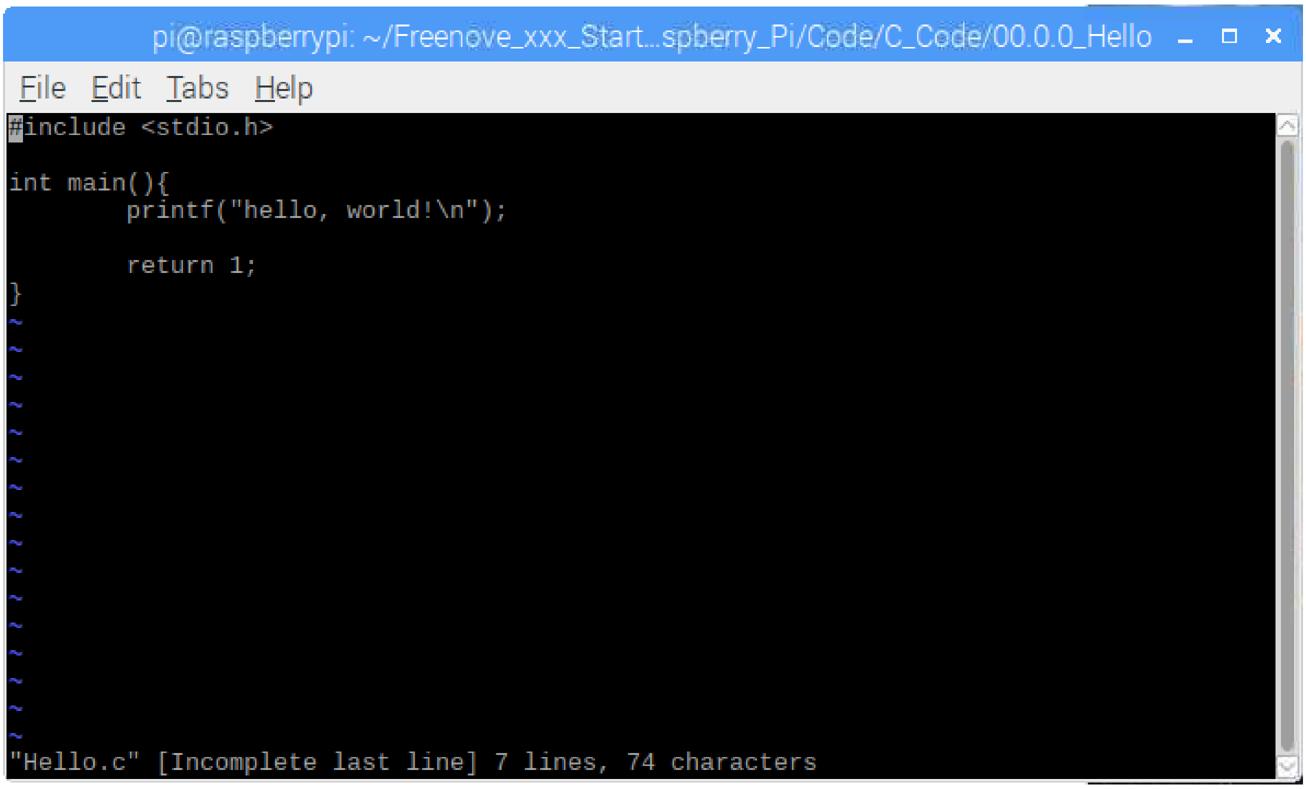
First, use cd command to enter the sample code folder.

```
cd ~
cd ~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/C_Code/00.0.0_Hello
```

Use the vi editor to open the file "Hello.c", then press ": q" and “Enter” to exit.

```
vi Hello.c
```

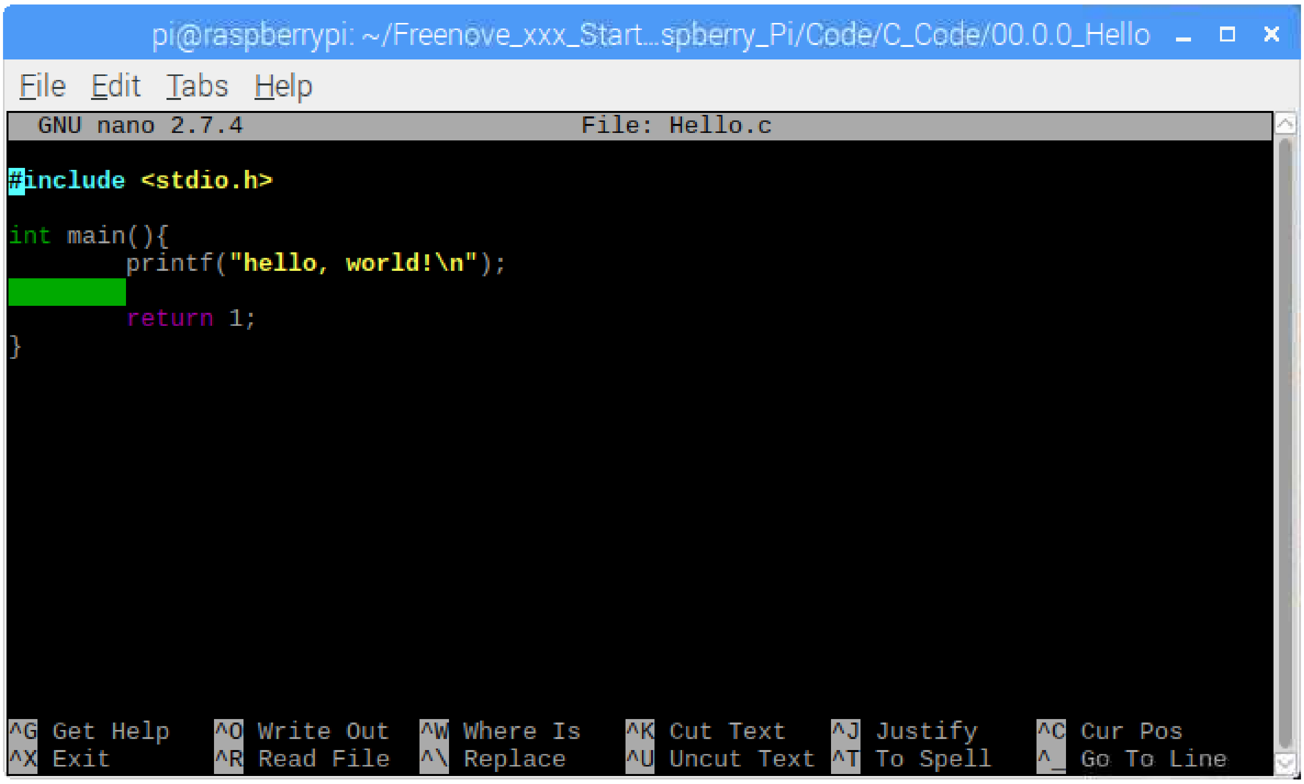
As is shown below:



Use the nano editor to open the file "Hello.c", then press " Ctrl+X " to exit.

```
nano Hello.c
```

As is shown below:



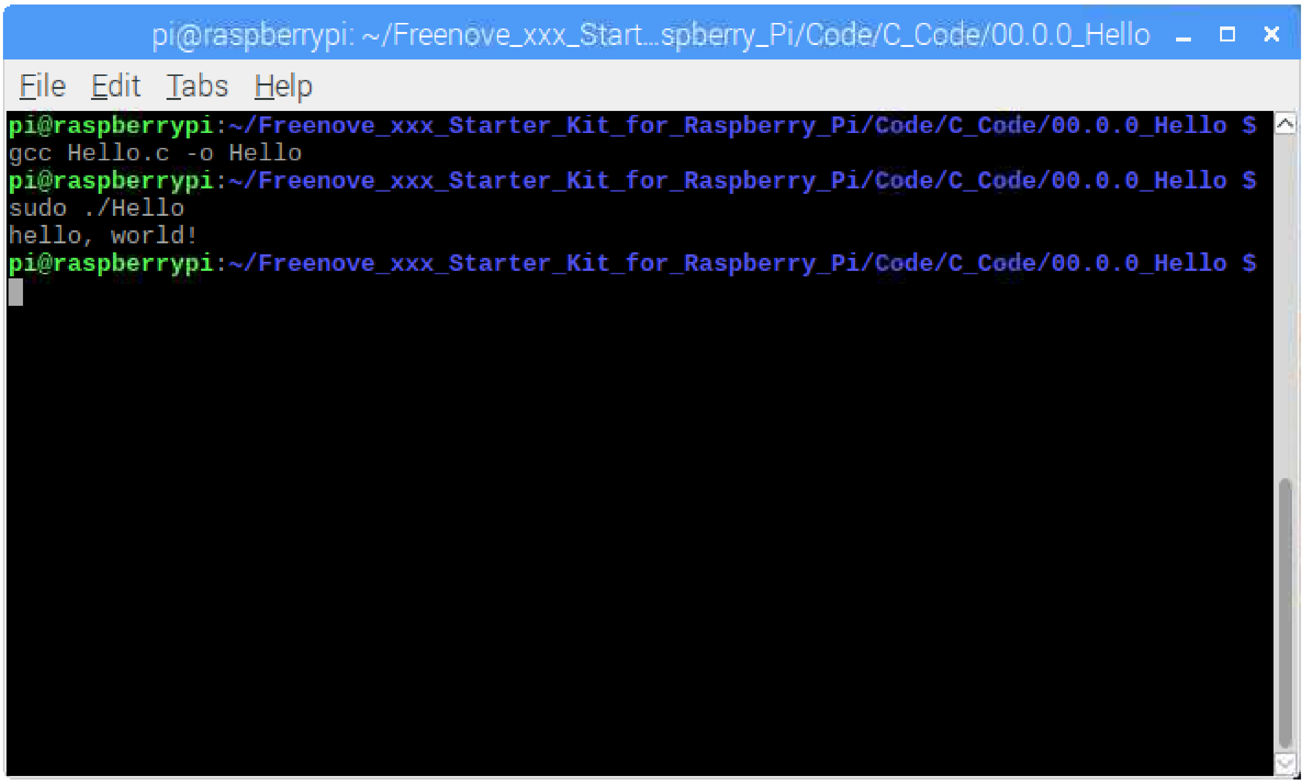
Use the following command to compile the code to generate the executable file “Hello”.

```
gcc Hello.c    -o Hello
```

Use the following command to run the executable file “Hello”.

```
sudo ./Hello
```

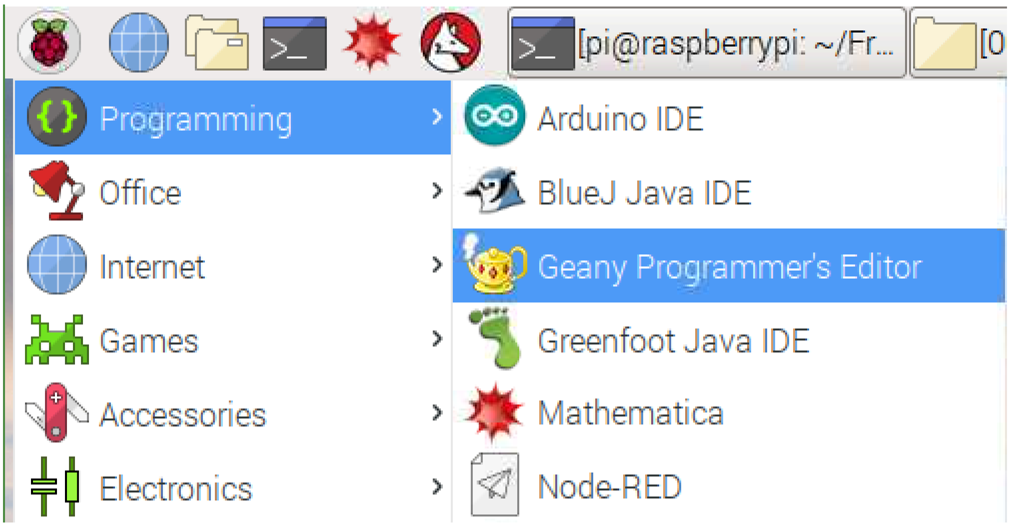
After the execution, "Hello, World!" is printed out in terminal.

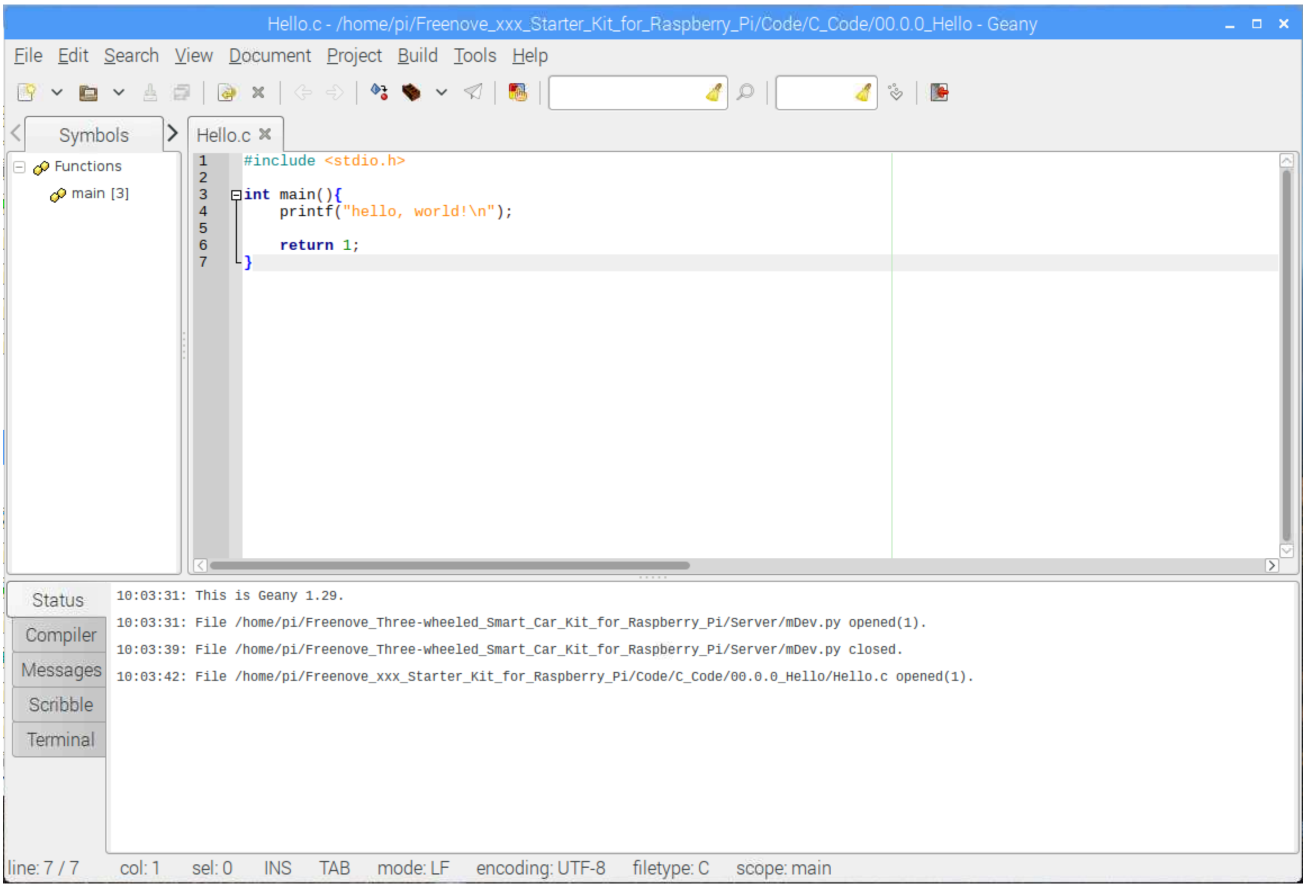


Next, learn to use the Geany editor. Use the following command to open the Geany in the sample file "Hello.c" file directory path.

```
geany Hello.c
```

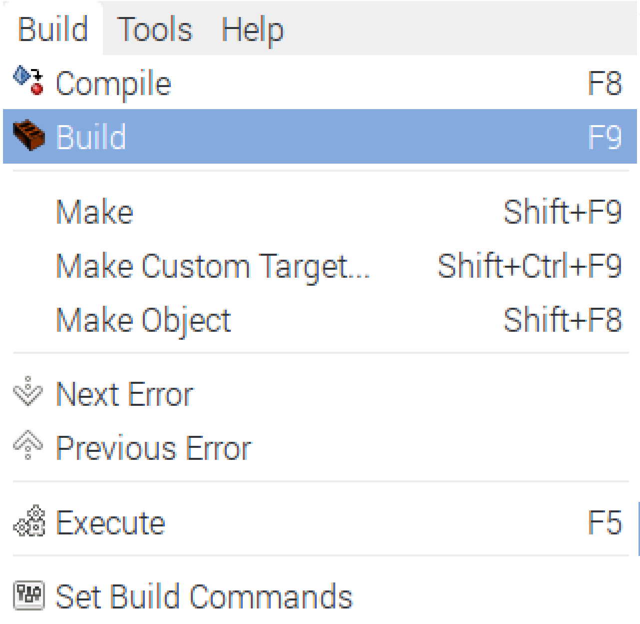
Or find and open Geany directly in the desktop main menu, and then click **File→Open** to open the "Hello.c", Or drag "Hello.c" to Geany directly.

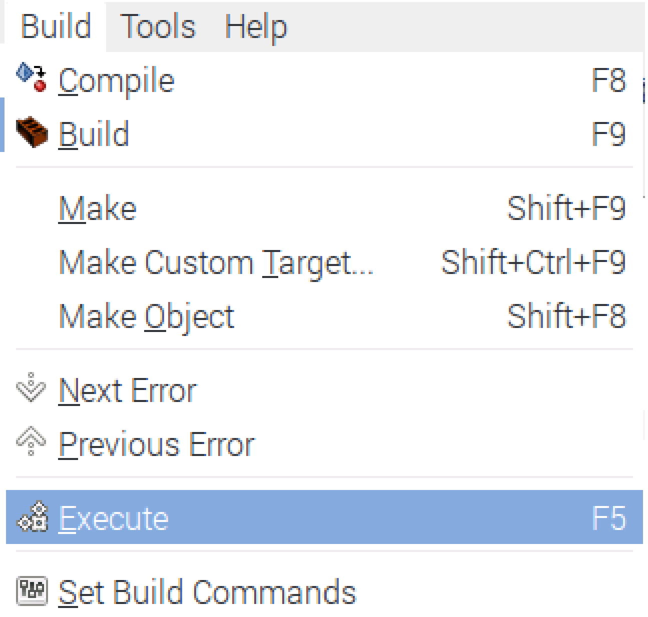




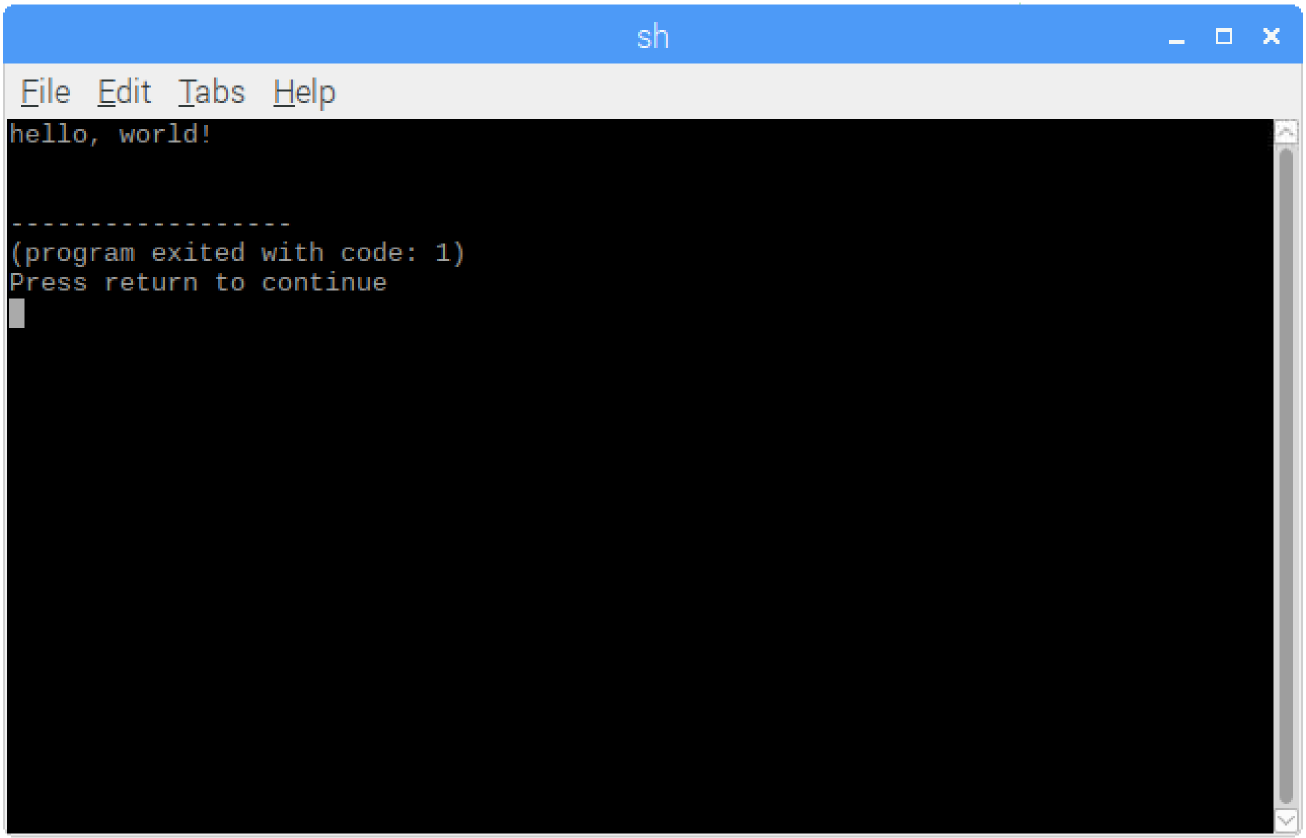
If you want creat a new code, click File→New→File→Save as (name.c or name.py). Then write the code.

Generates an executable file by clicking menu bar Build->Build, then execute the generated file by clicking menu bar Build->Execute.

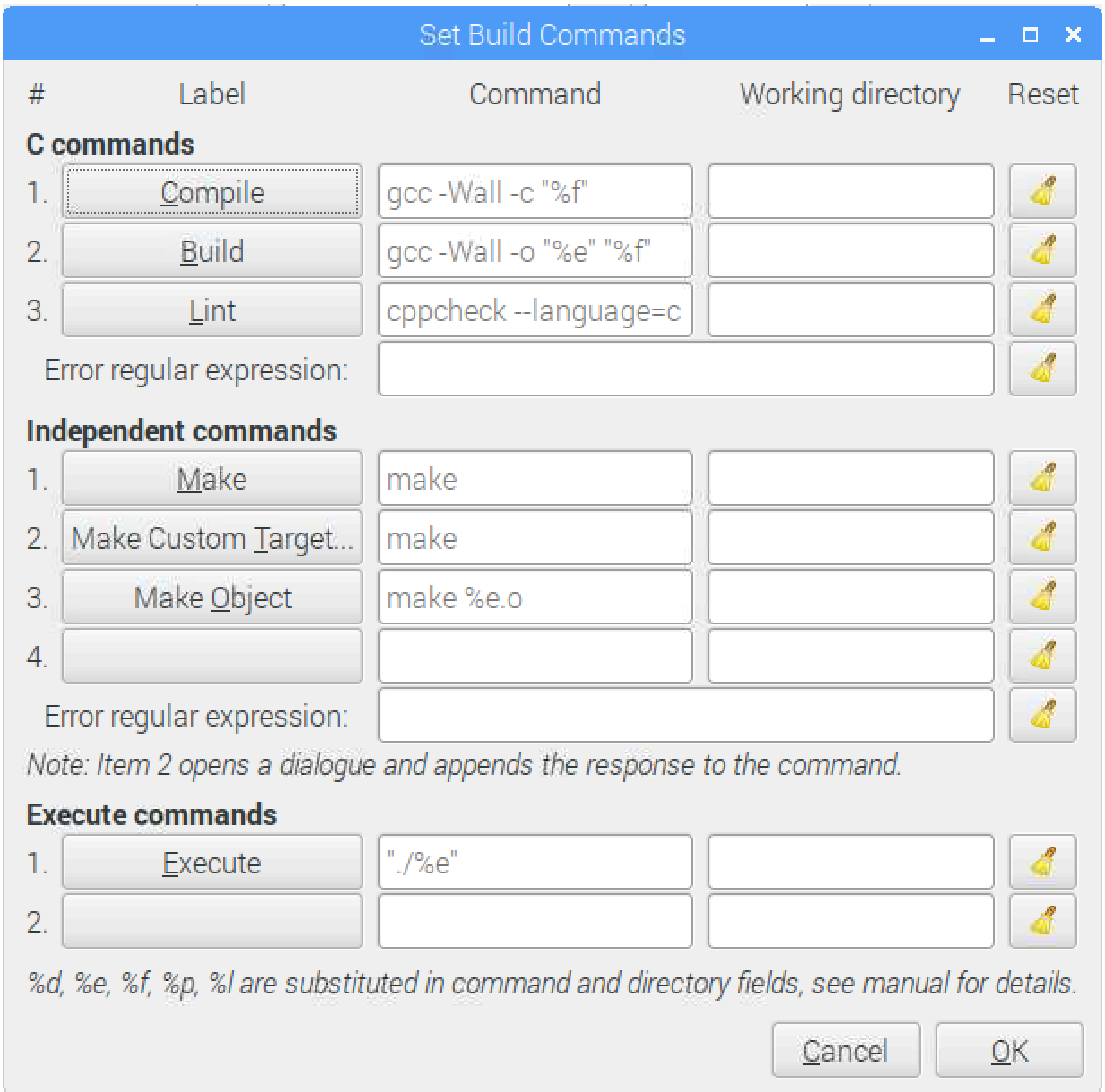




After the execution, there will be a terminal printing out the characters “Hello, World!”, as shown below:



You can click Build->Set Build Commands to set compiler commands. In later projects, we will use various compiler command options. If you choose to use Geany, you will need change the compiler command here. As is shown below:



Summary

Here we have introduced three code editors. There also many other good code editors, and you can choose any one you like. In later projects, about the entry path and the compiler execute commands, we will operate the contents in the terminal as examples. We won't emphasize the code editing process, but will explain the contents of the code in details.

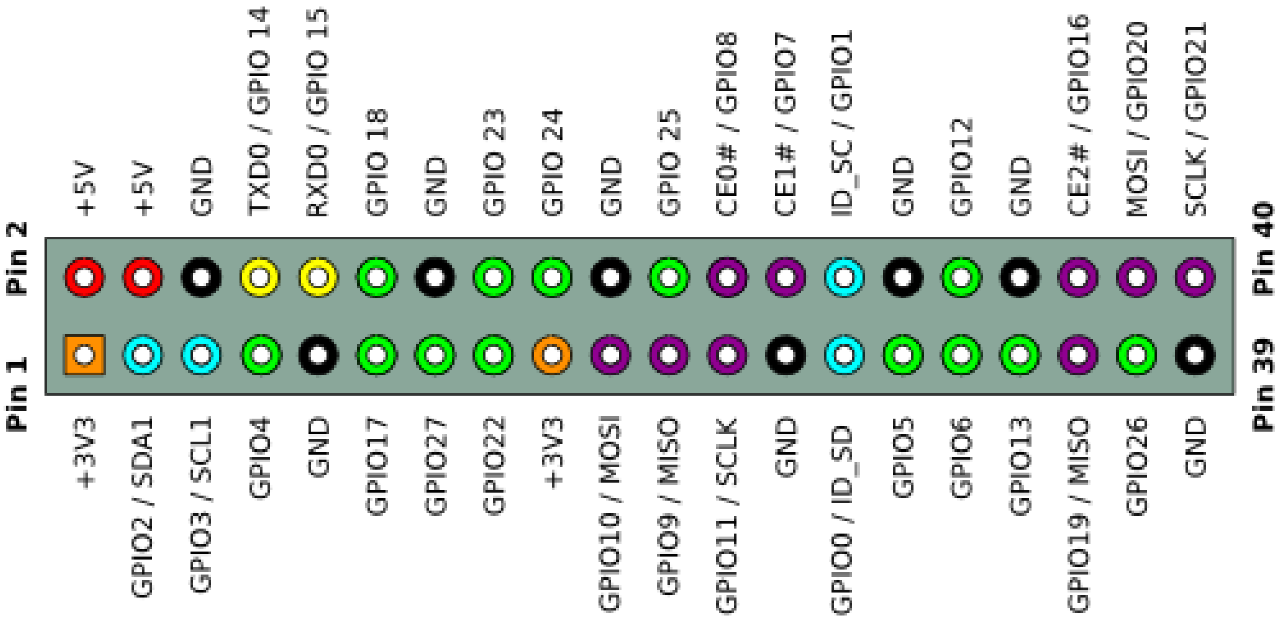
GPIO

GPIO: General purpose input/output. We will introduce the specific feature of the pins on the Raspberry Pi and what you can do with them. You can use them for all sorts of purposes. Most of them can be used as either inputs or outputs, depending on your program.
When programming the GPIO pins there are 3 different ways to refer to them: GPIO numbering, physical numbering, WiringPi GPIO Numbering.

BCM GPIO Numbering

Raspberry Pi CPU use BCM2835/BCM2836/BCM2837of Broadcom. GPIO pin number is set by chip manufacturer. These are the GPIO pins as that computer recognizes. The numbers don't make any sense to humans. They jump all over the place, so there is no easy way to remember them. You will need a printed reference or a reference board that fits over the pins.

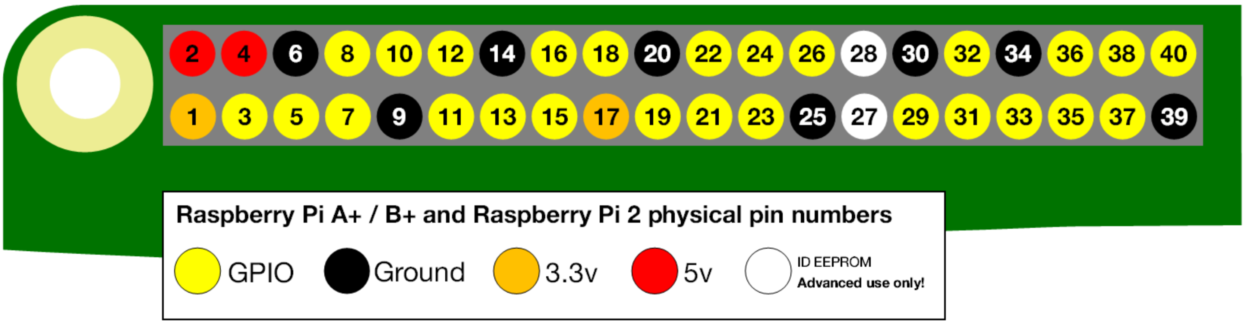
Each pin is defined as below:



For more details about pin definition of GPIO, please refer to http://pinout.xyz/

PHYSICAL Numbering

Another way to refer to the pins is by simply counting across and down from pin 1 at the top left (nearest to the SD card). This is 'physical numbering', as shown below:



WiringPi GPIO Numbering

Different from the previous mentioned two kinds of GPIO serial numbers, RPi GPIO serial number of the WiringPi was renumbered. Here we have three kinds of GPIO number mode: based on the number of BCM chip, based on the physical sequence number and based on wiringPi. The correspondence between these three GPIO numbers is shown below:

wiringPi Pin	BCM GPIO	Name	Header	Name	BCM GPIO	wiringPi Pin
—	—	3.3v	1 | 2	5v	—	—
8	R1:0/R2:2	SDA	3 | 4	5v	—	—
9	R1:1/R2:3	SCL	5 | 6	0v	—	—
7	4	GPIO7	7 | 8	TxD	14	15
—	—	0v	9 | 10	RxD	15	16
0	17	GPIO0	11 | 12	GPIO1	18	1
2	R1:21/R2:27	GPIO2	13 | 14	0v	—	—
3	22	GPIO3	15 | 16	GPIO4	23	4
—	—	3.3v	17 | 18	GPIO5	24	5
12	10	MOSI	19 | 20	0v	—	—
13	9	MISO	21 | 22	GPIO6	25	6
14	11	SCLK	23 | 24	CE0	8	10
—	—	0v	25 | 26	CE1	7	11
30	0	SDA.0	27 | 28	SCL.0	1	31
21	5	GPIO.21	29 | 30	0V		
22	6	GPIO.22	31 | 32	GPIO.26	12	26
23	13	GPIO.23	33 | 34	0V		
24	19	GPIO.24	35 | 36	GPIO.27	16	27
25	26	GPIO.25	37 | 38	GPIO.28	20	28
		0V	39 | 40	GPIO.29	21	29
wiringPi Pin	BCM GPIO	Name	Header	Name	BCM GPIO	wiringPi Pin

For Pi B

For A+, B+, 2B, 3B, 3B+, 4B, Zero

(For more details, please refer to https://projects.drogon.net/raspberry-pi/wiringpi/pins/)

You can also use the following command to view their correspondence.

```
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 | 1 |  7 || 8  | 1 | ALT5 | TxD     | 15  | 14  |
 |     |     |      0v |      |   |  9 || 10 | 1 | ALT5 | 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 | 0 | 19 || 20 |   |      | 0v      |     |     |
 |   9 |  13 |    MISO | ALT0 | 0 | 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 | IN   | SCL.0   | 31  | 1   |
 |   5 |  21 | GPIO.21 |   IN | 1 | 29 || 30 |   |      | 0v      |     |     |
 |   6 |  22 | GPIO.22 |   IN | 1 | 31 || 32 | 0 | IN   | GPIO.26 | 26  | 12  |
 |  13 |  23 | GPIO.23 |   IN | 0 | 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---+---+------+---------+-----+-----+
```

If you are using Raspberry Pi 4B, there will be errors when executing command “gpio readall”. As is below:

```
pi@raspberrypi:~ $ gpio readall
Oops - unable to determine board type... model: 17
```

This is because the official version of the library supporting 4B has not yet been released, resulting in some commands can not be used properly. But it won't affect the next project. For this problem, you can solve it by installing a patch. Just execute the commands below in the terminal.

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

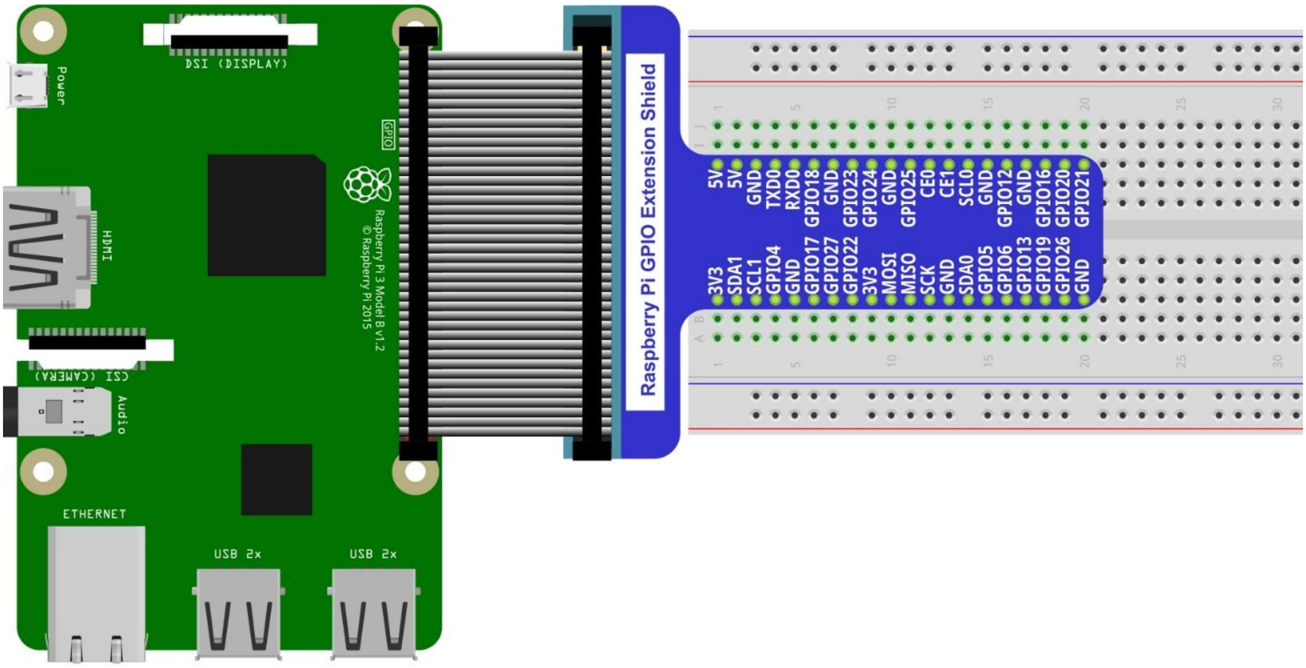
After the installation is completed, Execute "gpio-v" and “gpio readall" commands again.

```
pi@raspberrypi:~ $ gpio -v
gpio version: 2.52
Copyright (c) 2012-2018 Gordon Henderson
This is free software with ABSOLUTELY NO WARRANTY.
For details type: gpio -warranty

Raspberry Pi Details:
  Type: Pi 4B, Revision: 01, Memory: 1024MB, Maker: Sony
   * Device tree is enabled.
   *--> Raspberry Pi 4 Model B Rev 1.1
   * This Raspberry Pi supports user-level GPIO access.
pi@raspberrypi:~ $ gpio readall
 +-----+-----+---------+------+---+---Pi 4B--+---+------+---------+-----+-----+
 | 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 | 1 |  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 |   IN | 0 | 19 || 20 |   |      | 0v      |     |     |
 |   9 |  13 |    MISO |   IN | 0 | 21 || 22 | 0 | IN   | GPIO. 6 | 6   | 25  |
 |  11 |  14 |    SCLK |   IN | 0 | 23 || 24 | 1 | IN   | CE0     | 10  | 8   |
 |     |     |      0v |      |   | 25 || 26 | 1 | IN   | CE1     | 11  | 7   |
 |   0 |  30 |   SDA.0 |   IN | 1 | 27 || 28 | 1 | IN   | SCL.0   | 31  | 1   |
 |   5 |  21 | GPIO.21 |   IN | 1 | 29 || 30 |   |      | 0v      |     |     |
 |   6 |  22 | GPIO.22 |   IN | 1 | 31 || 32 | 0 | IN   | GPIO.26 | 26  | 12  |
 |  13 |  23 | GPIO.23 |   IN | 0 | 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 4B--+---+------+---------+-----+-----+
```

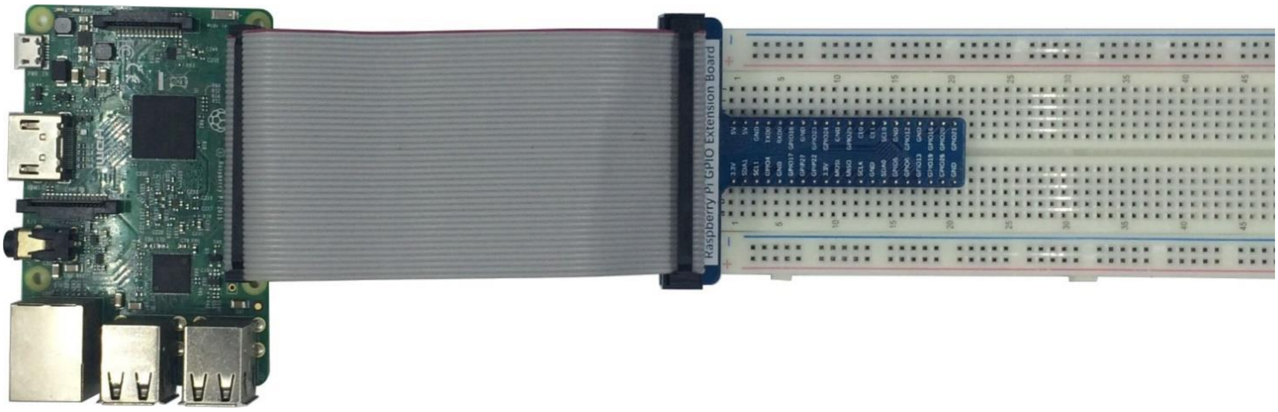
For more details about wiringPi, please refer to http://wiringpi.com/ .

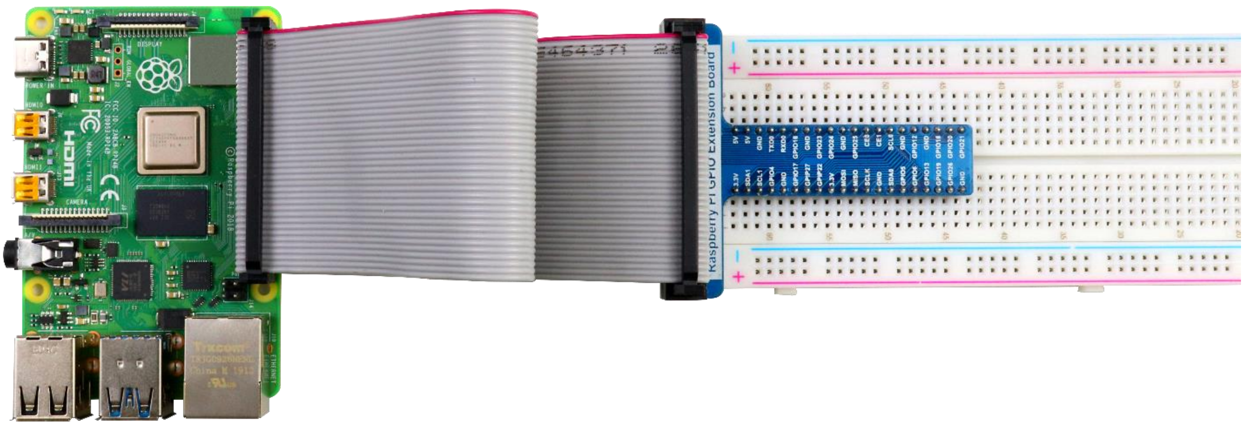
GPIO Extension Board

When we use RPi to do the project, we had better use GPIO, which is more convenient to extend all IO ports of RPi to the bread board directly. The GPIO sequence on Extension Board is identical to the GPIO sequence of RPi. Since the GPIO of different versions of RPi is different, the corresponding extensions board are also different. For example, a GPIO extensions board with 40 pins is connected to RPi as follows:

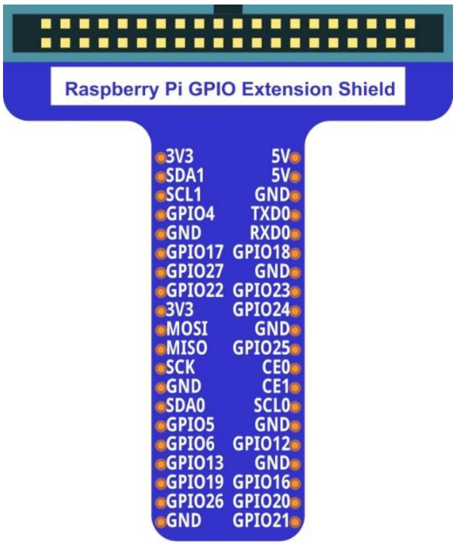
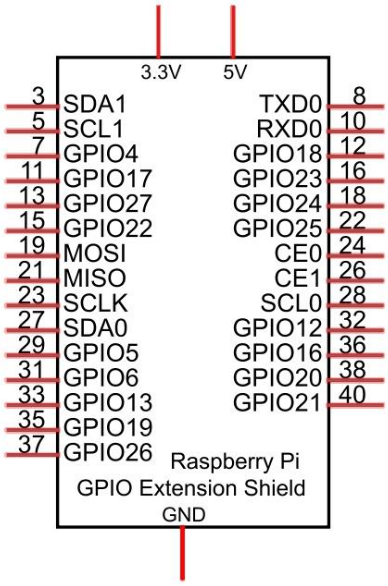


Practicality picture of connection:



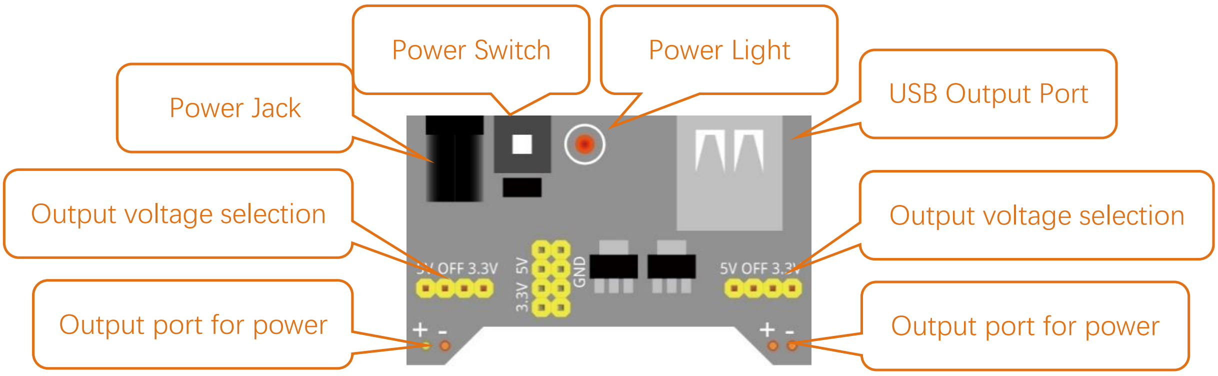


GPIO Extension Board and its schematic are shown below:

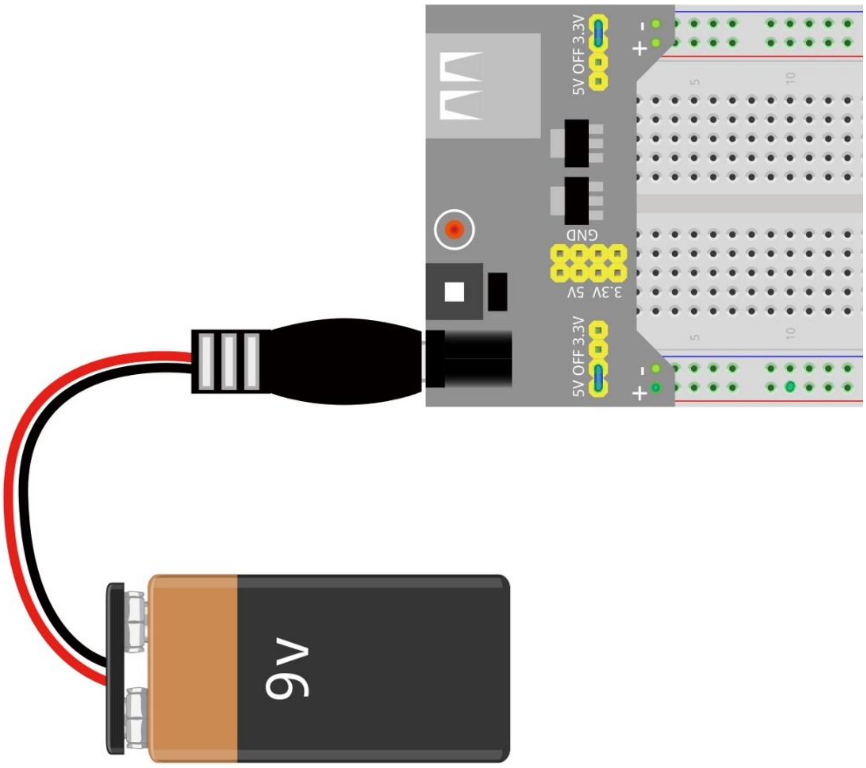
GPIO Extension Board	Definition of pins
	

Breadboard Power Module

Breadboard Power Module is an independent board, which can provide independent 5V or 3.3V power for bread board when used to build the circuit, and it can avoid excessive load power damaging RPi power. The schematic diagram of the Breadboard Power Module is shown below:



The connection between Breadboard Power Module and Breadboard is shown below:



Next

Here, all preliminary preparations have been completed. Next, we will combine the RPi and electronic components to do a series of projects from easy to difficult and focus on explaining the relevant knowledge of electronic circuit.

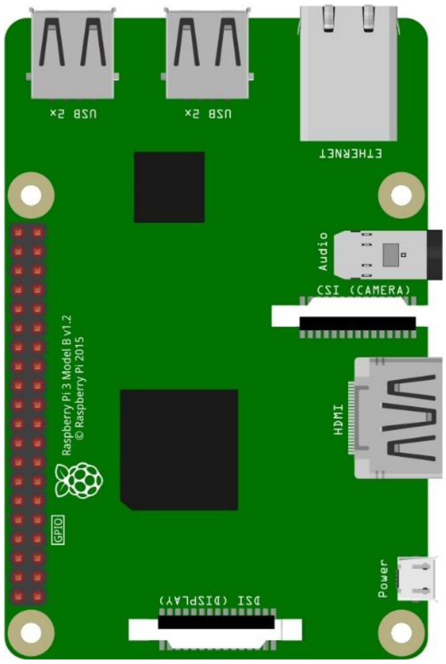
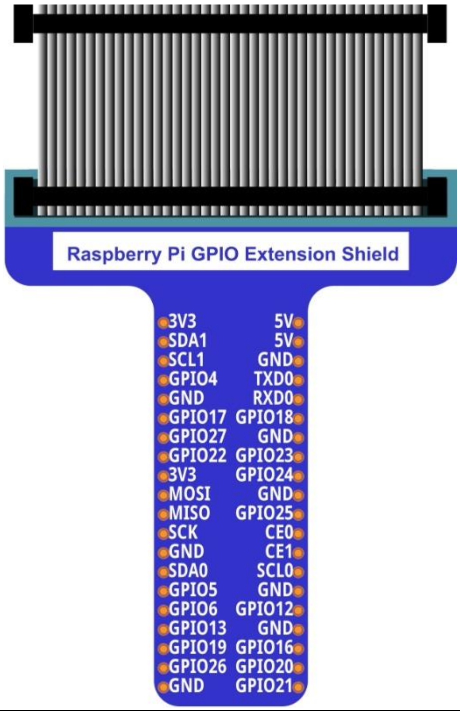
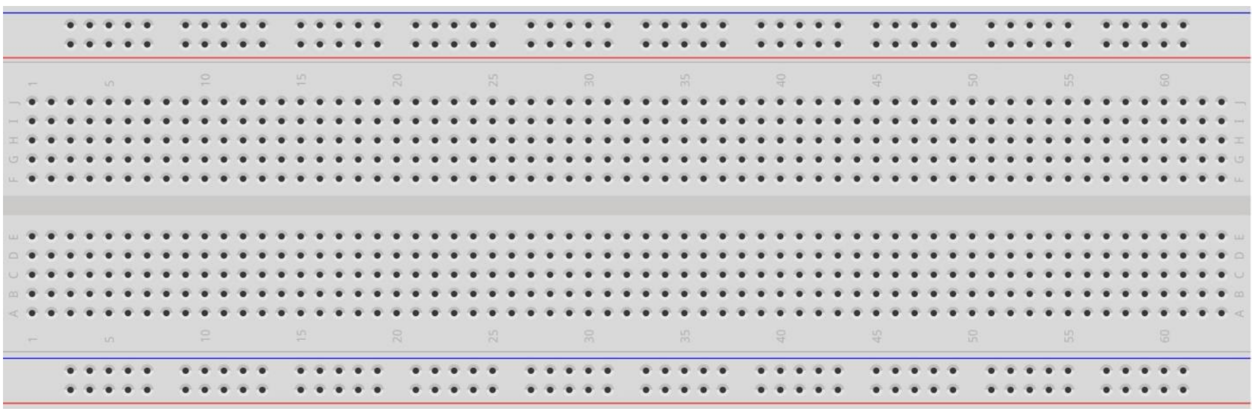
Chapter 1 LED

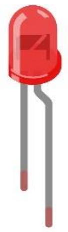
This chapter is the starting point of the journey to explore RPi electronic projects. Let's start with simple "Blink".

Project 1.1 Blink

In this project, let's try to use RPi to control LED blinking.

Component List

<table>
<tr>
<td>Raspberry Pi 3B x1

</td>
<td>GPIO Extension Board & Wire x1

</td>
</tr>
<tr>
<td colspan="2">BreadBoard x1
</td>
</tr>
</table>

LED x1	Resistor 220Ω x1	Jumper
		

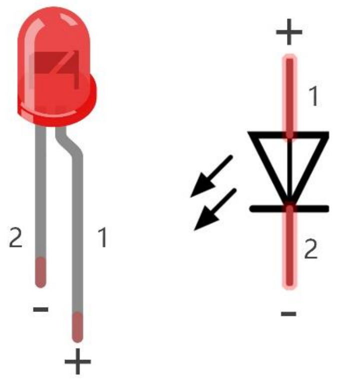
In the components list, 3B GPIO, Extension Shield Raspberry and Breadboard are necessary for each project. They will be listed only in text form later.

Component knowledge

LED

LED is a kind of diode. LED will shine only if the long pin of LED is connected to the positive electrode and the short pin is connected to negative electrode.

This is also the features of the common diode. Diode works only if the voltage of its positive electrode is higher than its negative electrode.



LED	Voltage	Maximum current	Recommended current
Red	1.9-2.2V	20mA	10mA
Green	2.9-3.4V	10mA	5mA
Blue	2.9-3.4V	10mA	5mA
Volt ampere characteristics conform to diode			

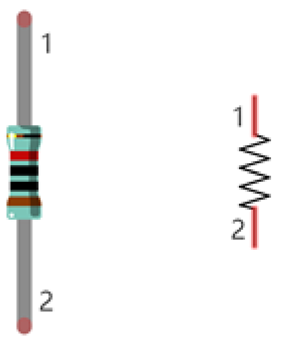
The LED can not be directly connected to power supply, which can damage component. A resistor with certain resistance must be connected in series in the circuit of LED.

Resistor

The unit of resistance(R) is ohm(Ω). 1MΩ=1000kΩ, 1kΩ=1000Ω.

Resistor is an electrical component that limits or regulates the flow of current in an electronic circuit.

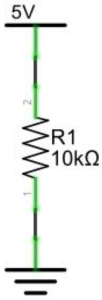
The left is the appearance of resistor, and the right is the symbol of resistor represented in circuit.



Color rings attached to the resistor is used to indicate its resistance. For more details of resistor color code, please refer to the appendix of this tutorial.

With the same voltage there will be less current with more resistance. And the links among current, voltage and resistance can be expressed by the formula below: I=U/R.

In the following diagram, the current through R1 is: I=U/R=5V/10kΩ=0.0005A=0.5mA.



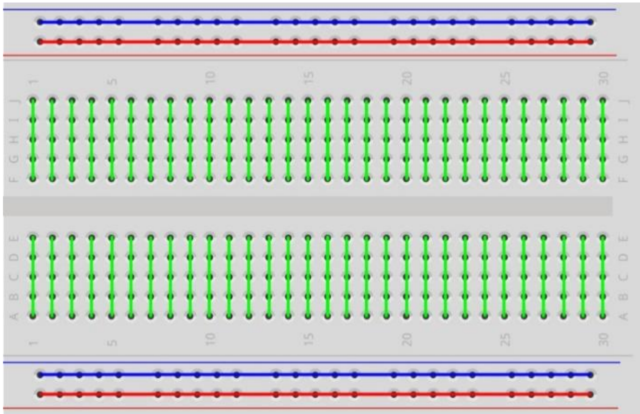
Do not connect the two poles of power supply with low resistance, which will make the current too high to damage electronic components.

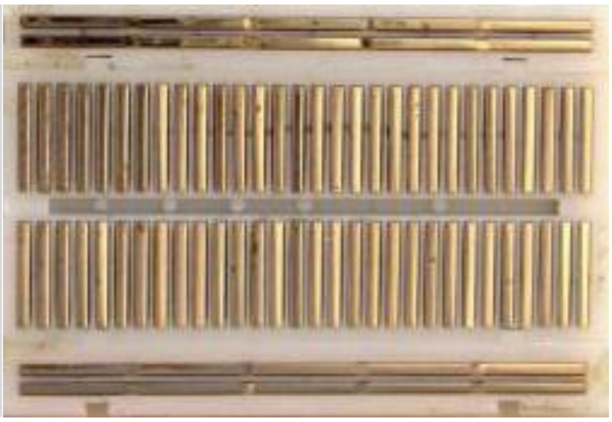
And resistor has no poles.

Breadboard

Take a short breadboard as an example to introduce its feature, as below.

The left picture shows the way of connection of pins. The right picture shows the pratical internal structure.

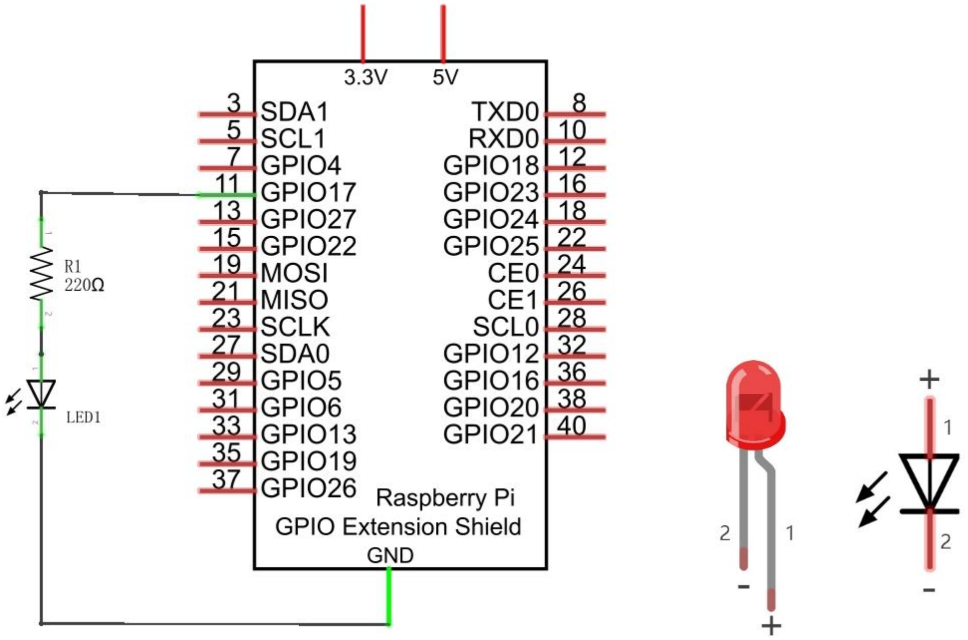




Circuit

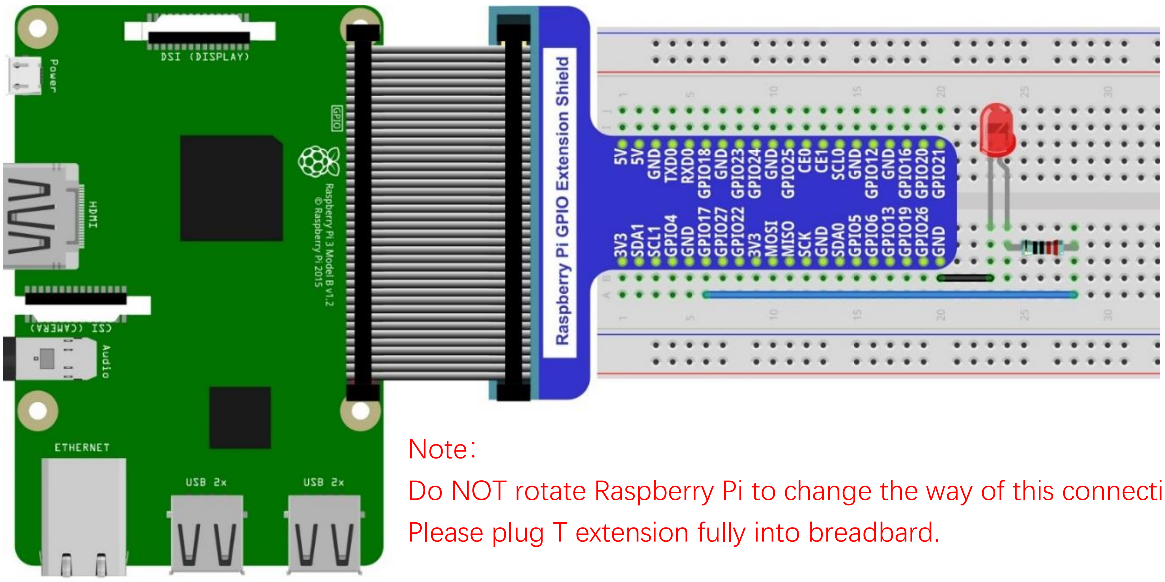
Disconnect RPi from GPIO Extension Shield first. Then build the circuit according to the circuit diagram and the hardware connection diagram. After the circuit is built and confirmed, connect RPi to GPIO Extension Shield. In addition, short circuit (especially 5V and GND, 3.3V and GND) should be avoid, because short circuit may cause abnormal circuit work, or even damage to RPi.

Schematic diagram



Hardware connection.

If you need any support, please contact us via: support@freenove.com



Note:
Do NOT rotate Raspberry Pi to change the way of this connection.
Please plug T extension fully into breadboard.

Because Numbering of GPIO Extension Shield is the same as RPi GPIO, later Hardware connection diagram will only show the part of breadboard and GPIO Extension Shield.

Code

According to the circuit, when the GPIO17 of RPi output high level, LED is turned on. Conversely, when the GPIO17 RPi output low level, LED is turned off. Therefore, we can let GPIO17 output high and low level in cycle to make LED blink. We will use both C code and Python code to achieve the target.

C Code 1.1.1 Blink

First, execute command into the terminal one by one. Then observe the project result, and analyze the code. If you want to execute it with editor, please refer to section Code Editor to configure.

If you have any concerns, please contact us via: support@freenove.com

It is recommended to execute code as below.

1. Use cd command to enter 01.1.1_Blink directory of C code.

```
cd ~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/C_Code/01.1.1_Blink
```

2. Use the following command to compile the code "Blink.c" and generate executable file "Blink".

"l" of "lwiringPi" is low case of "L".

```
gcc Blink.c -o Blink -lwiringPi
```

3. Then run the generated file "blink".

```
sudo ./Blink
```

Now, LED start blink.

```
pi@raspberrypi:~ $ cd ~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/C_Code/01.1.1_Blink
pi@raspberrypi:~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/C_Code/01.1.1_Blink $ gcc Blink.c -o Blink -lwiringPi
pi@raspberrypi:~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/C_Code/01.1.1_Blink $ sudo ./Blink
wiringPi initialize successfully, GPIO 0(wiringPi pin)
led on...
...led off
led on...
```

You can press "Ctrl+C" to end the program. The following is the program code:

```c
#include <wiringPi.h>
#include <stdio.h>

#define  ledPin    0   //define the led pin number

void main(void)
{
    printf("Program is starting ... \n");

    wiringPiSetup();  //Initialize wiringPi.

    pinMode(ledPin, OUTPUT);//Set the pin mode
    printf("Using pin%d\n",%ledPin);    //Output information on terminal
    while(1){
        digitalWrite(ledPin, HIGH);  //Make GPIO output HIGH level
        printf("led turned on >>>\n");      //Output information on terminal
        delay(1000);                        //Wait for 1 second
        digitalWrite(ledPin, LOW);  //Make GPIO output LOW level
        printf("led turned off <<<\n");         //Output information on terminal
        delay(1000);                        //Wait for 1 second
```

```
    }
}
```

GPIO connected to ledPin in the circuit is GPIO17. And GPIO17 is defined as 0 in the wiringPi numbering. So ledPin should be defined as 0 pin. You can refer to the corresponding table in Chapter 0.

```
#define  ledPin    0 //define the led pin number
```

In the main function main(), initialize wiringPi first.

```
    wiringPiSetup();  //Initialize wiringPi.
```

After the wiringPi is initialized successfully, set the ledPin to output mode. And then enter the while cycle, which is an endless loop. That is, the program will always be executed in this cycle, unless it is ended outside. In this cycle, use digitalWrite (ledPin, HIGH) to make ledPin output high level, then LED is turned on. After a period of time delay, use digitalWrite(ledPin, LOW) to make ledPin output low level, then LED is turned off, which is followed by a delay. Repeat the cycle, then LED will start blinking.

```
    pinMode(ledPin, OUTPUT);//Set the pin mode
    printf("Using pin%d\n",%ledPin);   //Output information on terminal
    while(1){
        digitalWrite(ledPin, HIGH);  //Make GPIO output HIGH level
        printf("led turned on >>>\n");      //Output information on terminal
        delay(1000);                        //Wait for 1 second
        digitalWrite(ledPin, LOW);  //Make GPIO output LOW level
        printf("led turned off <<<\n");         //Output information on terminal
        delay(1000);                        //Wait for 1 second
    }
```

Among them, the configuration function for GPIO is shown below as:

void pinMode(int pin, int mode);

This sets the mode of a pin to either INPUT, OUTPUT, PWM_OUTPUT or GPIO_CLOCK. Note that only wiringPi pin 1 (BCM_GPIO 18) supports PWM output and only wiringPi pin 7 (BCM_GPIO 4) supports CLOCK output modes.
This function has no effect when in Sys mode. If you need to change the pin mode, then you can do it with the gpio program in a script before you start your program

void digitalWrite (int pin, int value);

Writes the value HIGH or LOW (1 or 0) to the given pin which must have been previously set as an output.

For more related functions, please refer to http://wiringpi.com/reference/

Python Code 1.1.1 Blink

Net, we will use Python language to make LED blink.

First, observe the project result, and then analyze the code.

If you have any concerns, please contact us via: support@freenove.com

1. Use cd command to enter 01.1.1_Blink directory of Python code.

```
cd ~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/Python_Code/01.1.1_Blink
```

2. Use python command to execute python code blink.py.

```
python Blink.py
```

Now, LED start blinking.

```
pi@raspberrypi:~ $ cd ~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/Python_Code/01.1.1_Blink
pi@raspberrypi:~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/Python_Code/01.1.1_Blink $ python Blink.py
using pin11
...led on
led off...
```

You can press “Ctrl+C” to end the program. The following is the program code:

```python
import RPi.GPIO as GPIO
import time

ledPin = 11    # define ledPin

def setup():
    GPIO.setmode(GPIO.BOARD)       # use PHYSICAL GPIO Numbering
    GPIO.setup(ledPin, GPIO.OUT)   # set the ledPin to OUTPUT mode
    GPIO.output(ledPin, GPIO.LOW)  # make ledPin output LOW level
    print (’using pin%d’%ledPin)

def loop():
    while True:
        GPIO.output(ledPin, GPIO.HIGH)  # make ledPin output HIGH level to turn on led
        print (’led turned on >>>’)        # print information on terminal
        time.sleep(1)                   # Wait for 1 second
        GPIO.output(ledPin, GPIO.LOW)   # make ledPin output LOW level to turn off led
        print (’led turned off <<<’)
        time.sleep(1)                   # Wait for 1 second

def destroy():
    GPIO.cleanup()                      # Release all GPIO

if __name__ == ’__main__’:     # Program entrance
    print (’Program is starting ... \n’)
    setup()
    try:
        loop()
    except KeyboardInterrupt:   # Press ctrl-c to end the program.
        destroy()
```

In subfunction setup(), GPIO.setmode (GPIO.BOARD) is used to set the serial number for GPIO based on physical location of the pin. GPIO17 use pin 11 of the board, so define ledPin as 11 and set ledPin to output mode (output low level).

```
ledPin = 11     # define ledPin

def setup():
    GPIO.setmode(GPIO.BOARD)        # use PHYSICAL GPIO Numbering
    GPIO.setup(ledPin, GPIO.OUT)    # set the ledPin to OUTPUT mode
    GPIO.output(ledPin, GPIO.LOW)   # make ledPin output LOW level
    print ('using pin%d'%ledPin)
```

In loop(), there is a while cycle, which is an endless loop. That is, the program will always be executed in this cycle, unless it is ended outside. In this cycle, set ledPin output high level, then LED is turned on. After a period of time delay, set ledPin output low level, then LED is turned off, which is followed by a delay. Repeat the cycle, then LED will start blinking.

```
def loop():
    while True:
        GPIO.output(ledPin, GPIO.HIGH)  # make ledPin output HIGH level to turn on led
        print ('led turned on >>>')         # print information on terminal
        time.sleep(1)                   # Wait for 1 second
        GPIO.output(ledPin, GPIO.LOW)   # make ledPin output LOW level to turn off led
        print ('led turned off <<<')
        time.sleep(1)                   # Wait for 1 second
```

Finally, when the program is terminated, subfunction will be executed, the LED will be turned off and then the IO port will be released. If close the program terminal directly, the program will be terminated too, but destroy() function will not be executed. So, GPIO resources won't be released, in the warning message may appear next time you use GPIO. So, it is not a good habit to close the program terminal directly.

```
def destroy():
    GPIO.cleanup()                      # Release all GPIO
```

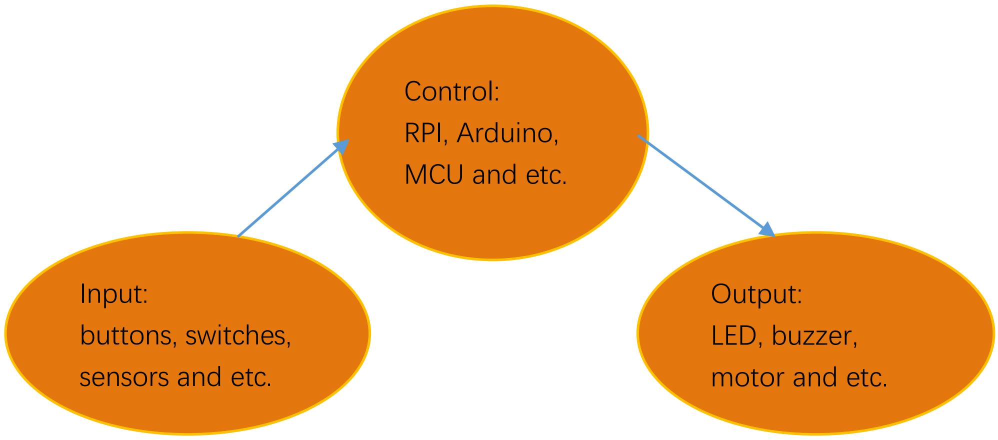
About RPi.GPIO:

RPi.GPIO
This is a Python module to control the GPIO on a Raspberry Pi. It includes basic output function and input function of GPIO, and function used to generate PWM.
GPIO.setmode(mode)
Set the mode for pin serial number of GPIO. mode=GPIO.BOARD, which represents the GPIO pin serial number is based on physical location of RPi. mode=GPIO.BCM, which represents the pin serial number is based on CPU of BCM chip.
GPIO.setup(pin,mode)
Set pin to input mode or output mode. "pin" for the GPIO pin, "mode" for INPUT or OUTPUT.
GPIO.output(pin,mode)
Set pin to output mode. "pin" for the GPIO pin, "mode" for HIGH (high level) or LOW (low level).

For more functions related to RPi.GPIO, please refer to:
https://sourceforge.net/p/raspberry-gpio-python/wiki/Examples/
"import time" time is a module of python.
https://docs.python.org/2/library/time.html?highlight=time%20time#module-time

Chapter 2 Button & LED

Usually, there are three essential parts in a complete automatic control device: INPUT, OUTPUT, and CONTROL. In last section, the LED module is the output part and RPI is the control part. In practical applications, we not only just let the LED lights flash, but make the device sense the surrounding environment, receive instructions and then make the appropriate action such as lights the LED, make a buzzer beep and so on.

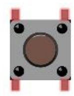


Next, we will build a simple control system to control LED through a button.

Project 2.1 Button & LED

In the project, we will control the LED state through a button. When the button is pressed, LED will be turn on, and when it is released, LED will be turn off.

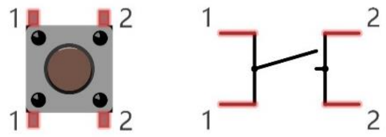
Component List

<table>
<tr><td>Raspberry Pi 3B x1
GPIO Extension Board & Wire x1
BreadBoard x1</td><td rowspan="2">LED x1
</td><td rowspan="2">Resistor 220Ω x1
</td><td rowspan="2">Resistor 10kΩ x2
</td><td rowspan="2">Push button x1
</td></tr>
<tr><td>Jumper
</td></tr>
</table>

Component knowledge

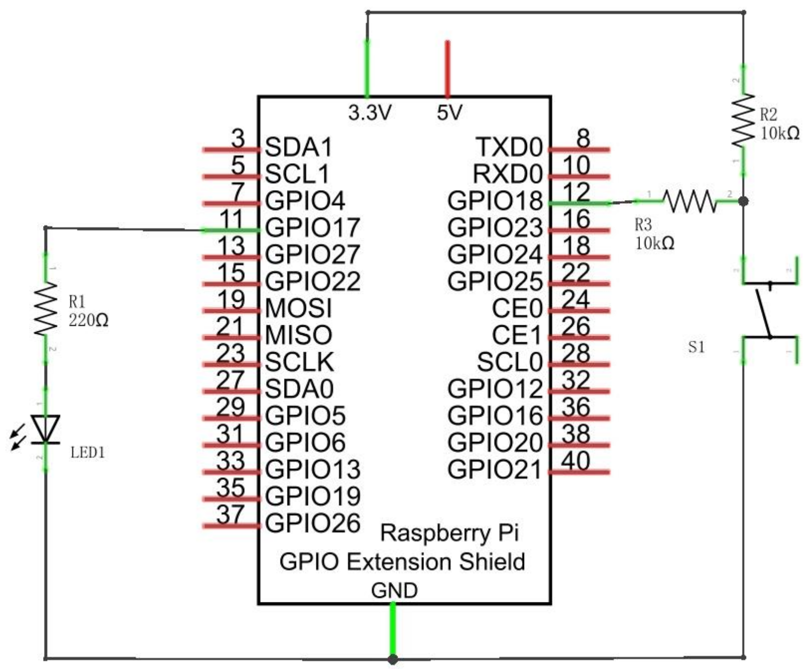
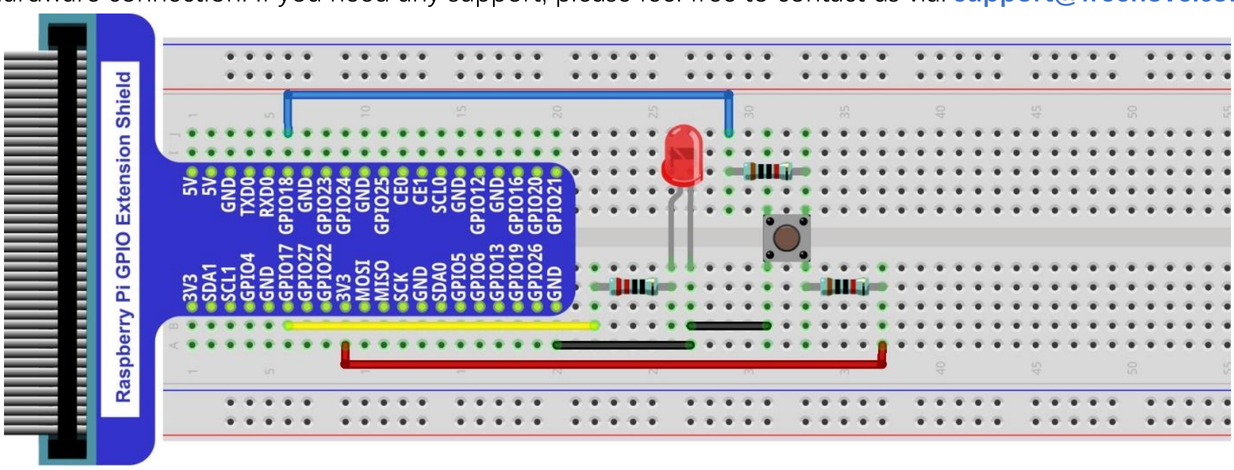
Push button

Push button has 4 pins. Two pins on the left is connected, and the right is similar as the left, which is shown in the below:



When the push button is pressed, the circuit is turned on.

Circuit

Schematic diagram

Hardware connection. If you need any support, please feel free to contact us via: **support@freenove.com**


Code

This project is designed for learning how to use button to control LED. We first need to read the state of button, and then determine whether turn on LED according to the state of the button.

C Code 2.1.1 ButtonLED

First, observe the project result, then analyze the code.

If you have any concerns, please contact us via: support@freenove.com

1. Use cd command to enter 02.1.1_ButtonLED directory of C code.

```
cd ~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/C_Code/02.1.1_ButtonLED
```

2. Use the following command to compile the code “ButtonLED.c” and generate executable file “ButtonLED”

```
gcc ButtonLED.c -o ButtonLED -lwiringPi
```

3. Then run the generated file “ButtonLED”.

```
sudo ./ButtonLED
```

Later, the terminal window continues to print out the characters “led off…”. Press the button, then LED is turned on and then terminal window prints out the "led on…". Release the button, then LED is turned off and then terminal window prints out the "led off…". You can press "Ctrl+C" to terminate the program.

The following is the program code:

```
#include <wiringPi.h>
#include <stdio.h>

#define ledPin    0   //define the ledPin
#define buttonPin 1       //define the buttonPin

void  main(void)
{
    printf("Program is starting ... \n");

    wiringPiSetup();  //Initialize wiringPi.

    pinMode(ledPin, OUTPUT); //Set ledPin to output
    pinMode(buttonPin, INPUT);//Set buttonPin to input

    pullUpDnControl(buttonPin, PUD_UP);  //pull up to HIGH level
    while(1){
        if(digitalRead(buttonPin) == LOW){ //button is pressed
            digitalWrite(ledPin, HIGH);  //Make GPIO output HIGH level
            printf("Button is pressed, led turned on >>>\n");        //Output information on
terminal
        }
        else {                              //button is released
            digitalWrite(ledPin, LOW);  //Make GPIO output LOW level
            printf("Button is released, led turned off <<<\n");      //Output information on
terminal
```

```
        }
    }
}
```

In the circuit connection, LED and Button are connected with GPIO17 and GPIO18 respectively, which correspond to 0 and 1 respectively in wiringPI. So define ledPin and buttonPin as 0 and 1 respectively.

```
#define ledPin    0     //define the ledPin
#define buttonPin 1     //define the buttonPin
```

In the while cycle of main function, use digitalRead(buttonPin) to determine the state of Button. When the button is pressed, the function returns low level, the result of "if" is true, and then turn on LED. Or, turn off LED.

```
if(digitalRead(buttonPin) == LOW){ //button has pressed down
            digitalWrite(ledPin, HIGH);   //led on
            printf("led on...\n");
        }
        else {              //button has released
            digitalWrite(ledPin, LOW);   //led off
            printf("...led off\n");
        }
```

Reference:

```
int digitalRead (int pin);
```

This function returns the value read at the given pin. It will be "**HIGH**" or "**LOW**"(1 or 0) depending on the logic level at the pin.

Python Code 2.1.1 ButtonLED

First, observe the project result, then analyze the code.

If you have any concerns, please contact us via: support@freenove.com

1. Use cd command to enter 01.1.1_btnLED directory of Python code.

```
cd ~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/Python_Code/02.1.1_ButtonLED
```

2. Use Python command to execute btnLED.py.

```
python ButtonLED.py
```

Later, the terminal window continue to print out the characters “led off…”, press the button, then LED is turned on and then terminal window print out the "led on…". Release the button, then LED is turned off and then terminal window print out the "led off…". You can press "Ctrl+C" to terminate the program.

The following is the program code:

```
import RPi.GPIO as GPIO

ledPin = 11    # define ledPin
buttonPin = 12    # define buttonPin

def setup():

    GPIO.setmode(GPIO.BOARD)      # use PHYSICAL GPIO Numbering
    GPIO.setup(ledPin, GPIO.OUT)   # set ledPin to OUTPUT mode
    GPIO.setup(buttonPin, GPIO.IN, pull_up_down=GPIO.PUD_UP)    # set buttonPin to PULL UP
INPUT mode

def loop():
    while True:
        if GPIO.input(buttonPin)==GPIO.LOW: # if button is pressed
            GPIO.output(ledPin,GPIO.HIGH)   # turn on led
            print ('led turned on >>>')     # print information on terminal
        else : # if button is relessed
            GPIO.output(ledPin,GPIO.LOW) # turn off led
            print ('led turned off <<<')

def destroy():
    GPIO.cleanup()                     # Release GPIO resource

if __name__ == '__main__':     # Program entrance
    print ('Program is starting...')
    setup()
    try:
        loop()
    except KeyboardInterrupt:  # Press ctrl-c to end the program.
        destroy()
```

In subfunction setup (), GPIO.setmode (GPIO.BOARD) is used to set the serial number of the GPIO, which is based on physical location of the pin. So, GPIO17 and GPIO18 correspond to pin11 and pin12 respectively in the circuit. Then set ledPin to output mode, buttonPin to input mode with a pull resistor.

```
ledPin = 11     # define ledPin
buttonPin = 12    # define buttonPin

def setup():

    GPIO.setmode(GPIO.BOARD)      # use PHYSICAL GPIO Numbering
    GPIO.setup(ledPin, GPIO.OUT)   # set ledPin to OUTPUT mode
    GPIO.setup(buttonPin, GPIO.IN, pull_up_down=GPIO.PUD_UP)    # set buttonPin to PULL UP
INPUT mode
```

In the loop function while dead circulation, continue to judge whether the key is pressed. When the button is pressed, the GPIO.input(buttonPin) will return low level, then the result of "if" is true, ledPin outputs high level, LED is turned on. Or, LED will be turned off.

```
def loop():
    while True:
        if GPIO.input(buttonPin)==GPIO.LOW: # if button is pressed
            GPIO.output(ledPin,GPIO.HIGH)   # turn on led
            print ('led turned on >>>')     # print information on terminal
        else : # if button is relessed
            GPIO.output(ledPin,GPIO.LOW) # turn off led
            print ('led turned off <<<')
```

Execute the function destroy (), close the program and release the resource.

About function GPIO.input ():

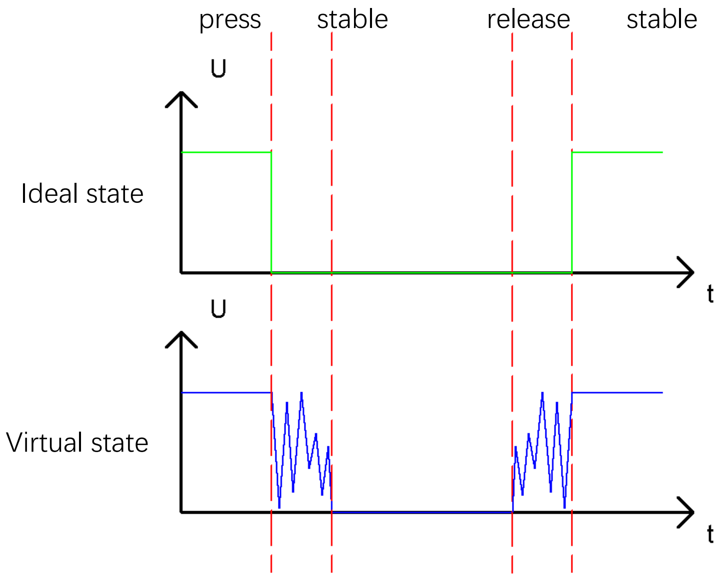
GPIO.input()
This function returns the value read at the given pin. It will be "**HIGH**" or "**LOW**"(1 or 0) depending on the logic level at the pin.

Project 2.2 MINI table lamp

We will also use a button, LED and RPi to make a MINI table lamp. But the function is different: Press the button, the LED will be turned on, and press the button again, the LED goes out.
First, let us learn some knowledge about the button.

Debounce for Push Button

When a Push Button is pressed, it will not change from one state to another state immediately. Due to mechanical vibration, there will be a continuous buffeting before it becomes another state. And the releasing-situation is similar with that process.



Therefore, if we directly detect the state of Push Button, there may be multiple pressing and releasing action in one pressing process. The buffeting will mislead the high-speed operation of the microcontroller to cause a lot of false judgments. So we need to eliminate the impact of buffeting. Our solution is: to judge the state of the button several times. Only when the button state is stable after a period of time, can it indicate that the button is pressed down.
This project needs the same components and circuits with the last section.

Code

In the project, we still detect the state of Button to control LED. Here we need to define a variable to save the state of LED. And when the button is pressed once, the state of LED will be changed once. This has achieved the function of the table lamp.

C Code 2.2.1 Tablelamp

First observe the project result, and then analyze the code.

If you have any concerns, please contact us via: support@freenove.com

1. Use cd command to enter 02.2.1_Tablelamp directory of C code.

```
cd ~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/C_Code/02.1.1_Tablelamp
```

2. Use following command to compile "Tablelamp.c" and generate executable file "Tablelamp".

```
gcc Tablelamp.c -o Tablelamp -lwiringPi
```

3. Tablelamp. Then run the generated file "Tablelamp".

```
sudo ./Tablelamp
```

When the program is executed, press the Button once, then LED is turned on. Press the Button another time, then LED is turned off.

```
#include <wiringPi.h>
#include <stdio.h>

#define ledPin    0   //define the ledPin
#define buttonPin 1       //define the buttonPin
int ledState=LOW;     //store the State of led
int buttonState=HIGH; //store the State of button
int lastbuttonState=HIGH;//store the lastState of button
long lastChangeTime;  //store the change time of button state
long captureTime=50;  //set the stable time for button state
int reading;
int main(void)
{
    printf("Program is starting...\n");

    wiringPiSetup(); //Initialize wiringPi.

    pinMode(ledPin, OUTPUT);   Set ledPin to output
    pinMode(buttonPin, INPUT); Set buttonPin to input

    pullUpDnControl(buttonPin, PUD_UP);  //pull up to high level
    while(1){
        reading = digitalRead(buttonPin); //read the current state of button
        if( reading != lastbuttonState){  //if the button state has changed, record the time
point
            lastChangeTime = millis();
        }
```

```
        //if changing-state of the button last beyond the time we set, we consider that
        //the current button state is an effective change rather than a buffeting
        if(millis() - lastChangeTime > captureTime){
            //if button state is changed, update the data.
            if(reading != buttonState){
                buttonState = reading;
                //if the state is low, it means the action is pressing
                if(buttonState == LOW){
                    printf("Button is pressed!\n");
                    ledState = !ledState; //Reverse the LED state
                    if(ledState){
                        printf("turn on LED ...\n");
                    }
                    else {
                        printf("turn off LED ...\n");
                    }
                }
                //if the state is high, it means the action is releasing
                else {
                    printf("Button is released!\n");
                }
            }
        }
        digitalWrite(ledPin,ledState);
        lastbuttonState = reading;
    }

    return 0;
}
```

This code focuses on eliminating the buffeting of button. We define several variables to save the state of LED and button. Then read the button state in while () constantly, and determine whether the state has changed. If it is, record this time point.

```
reading = digitalRead(buttonPin); //read the current state of button
        if( reading != lastbuttonState){
            lastChangeTime = millis();
        }
```

millis()

This returns a number representing the number of milliseconds since your program called one of the wiringPiSetup functions. It returns an unsigned 32-bit number which wraps after 49 days.

Then according to just recorded time point, judge the duration of the button state change. If the duration exceeds captureTime (buffeting time) we set, it indicates that the state of the button has changed. During that time, the while () is still detecting the state of the button, so if there is a change, the time point of change will be updated. Then duration will be judged again until the duration of there is a stable state exceeds the time we set.

```
        if(millis() - lastChangeTime > captureTime){
            //if button state is changed ,update the data.
            if(reading != buttonState){
                buttonState = reading;
```

Finally, judge the state of Button. And if it is low level, the changing state indicates that the button is pressed, if the state is high level, then the button is released. Here, we change the status of the LED variable, and then update the state of LED.

```
                if(buttonState == LOW){
                    printf("Button is pressed!\n");
                    ledState = !ledState; //Reverse the LED state
                    if(ledState){
                        printf("turn on LED ...\n");
                    }
                    else {
                        printf("turn off LED ...\n");
                    }
                }
                //if the state is high, it means the action is releasing
                else {
                    printf("Button is released!\n");
                }
```

Python Code 2.2.1 Tablelamp

First observe the project result, and then analyze the code.

If you have any concerns, please contact us via: support@freenove.com

1. Use cd command to enter 02.2.1_Tablelamp directory of Python code

```
cd ~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/Python_Code/02.2.1_Tablelamp
```

2. Use python command to execute python code “Tablelamp.py”.

```
python Tablelamp.py
```

When the program is executed, press the Button once, then LED is turned on. Press the Button another time, then LED is turned off.

```
import RPi.GPIO as GPIO

ledPin = 11       # define ledPin
buttonPin = 12    # define buttonPin
ledState = False

def setup():
    GPIO.setmode(GPIO.BOARD)        # use PHYSICAL GPIO Numbering
    GPIO.setup(ledPin, GPIO.OUT)    # set ledPin to OUTPUT mode
    GPIO.setup(buttonPin, GPIO.IN, pull_up_down=GPIO.PUD_UP)    # set buttonPin to PULL UP
INPUT mode

def buttonEvent(channel): # When button is pressed, this function will be executed
    global ledState
    print ('buttonEvent GPIO%d' %channel)
    ledState = not ledState
    if ledState :
        print ('Led turned on >>>')
    else :
        print ('Led turned off <<<')
    GPIO.output(ledPin,ledState)

def loop():
    #Button detect
    GPIO.add_event_detect(buttonPin,GPIO.FALLING,callback = buttonEvent,bouncetime=300)
    while True:
        pass

def destroy():
    GPIO.cleanup()                     # Release GPIO resource

if __name__ == '__main__':     # Program entrance
    print ('Program is starting...')
    setup()
    try:
```

```
        loop()
    except KeyboardInterrupt:  # Press ctrl-c to end the program.
        destroy()
```

RPi.GPIO provides us with a simple and effective function to eliminate the jitter, that is GPIO.add_event_detect(). It uses callback function. Once it detect that the buttonPin has a specified action FALLING, execute the specified function buttonEvent(). In the function buttonEvent, each time the ledState is reversed, the state of the LED will be updated.

```
def buttonEvent(channel): # When button is pressed, this function will be executed
    global ledState
    print ('buttonEvent GPIO%d' %channel)
    ledState = not ledState
    if ledState :
        print ('Led turned on >>>')
    else :
        print ('Led turned off <<<')
    GPIO.output(ledPin,ledState)

def loop():
    #Button detect
    GPIO.add_event_detect(buttonPin,GPIO.FALLING,callback = buttonEvent,bouncetime=300)
    while True:
        pass
```

Of course, you can also use the same programming idea of C code above to achieve this target.

GPIO.add_event_detect(channel, GPIO.RISING, callback=my_callback, bouncetime=200)
This is an event detection function. The first parameter specifies the IO port to be detected. The second parameter specifies the action to be detected. The third parameter specified a function name, the function will be executed when the specified action is detected. And the fourth parameter is used to set the jitter time.

Chapter 3 LEDBar Graph

We have learned how to control a LED blinking, and next we will learn how to control a number of LED.

Project 3.1 Flowing Water Light

In this project, we use a number of LED to make a flowing water light.

Component List

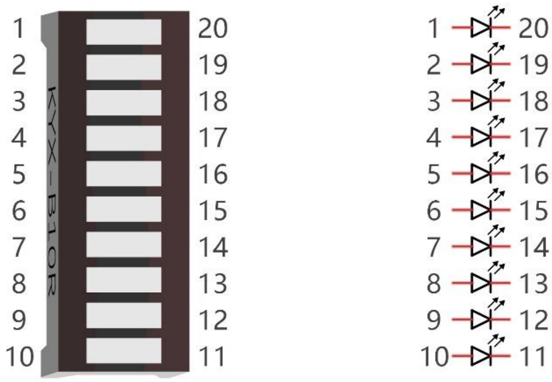
Raspberry Pi 3B x1 GPIO Extension Board & Wire x1 BreadBoard x1	LED bar graph x1 	Resistor 220Ω x10 
Jumper 		

Component knowledge

Let us learn about the basic features of components to use them better.

LED bar graph

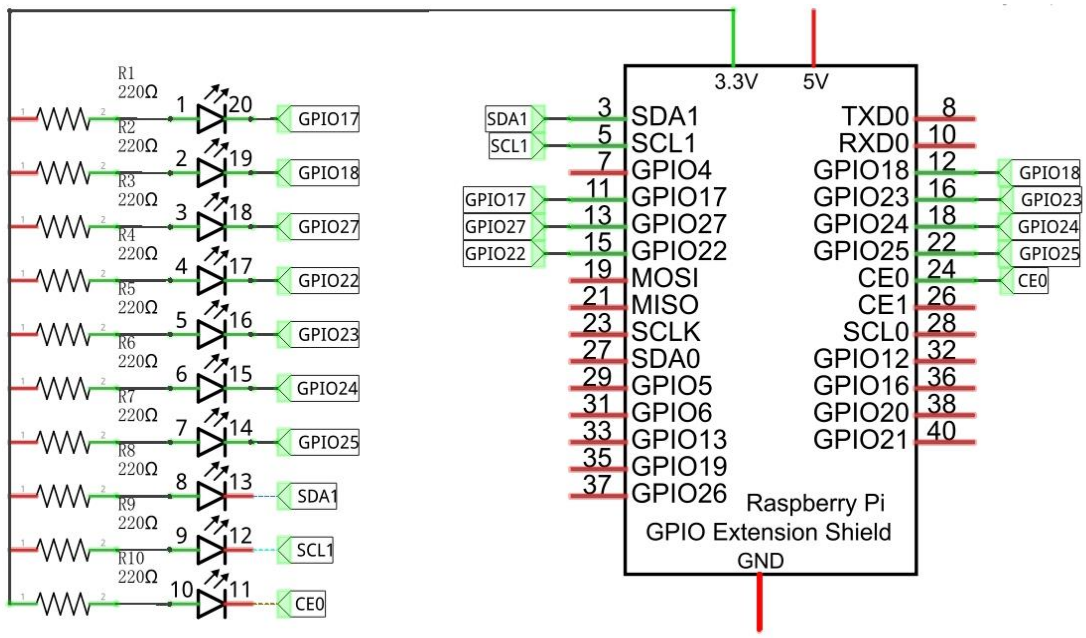
LED bar graph is a component Integration consist of 10 LEDs. There are two rows of pins at its bottom.



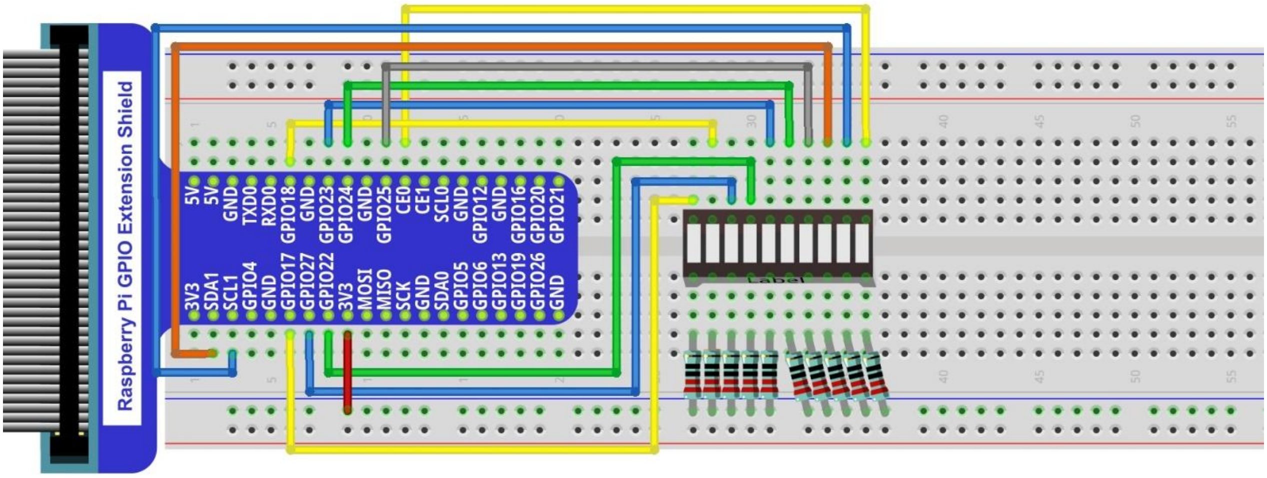
Circuit

The network label is used in the circuit diagram below, and the pins with the same network label are connected together.

Schematic diagram



Hardware connection. If you need any support, please feel free to contact us via: **support@freenove.com**



If LEDbar doesn't work, rotate LEDbar 180° to try. The label is random.

In this circuit, the cathode of LED is connected to GPIO, which is the different from the front circuit. So, LED will be turned on when GPIO output low level in the program.

Code

This project is designed to make a water lamp. First turn on the first LED, then turn off it. Then turn on the second LED, and then turn off it...... Until the last LED is turned on, then is turned off. And repeats the process to achieve the effect of flowing water light.

C Code 3.1.1 LightWater

First observe the project result, and then analyze the code.

If you have any concerns, please contact us via: support@freenove.com

1. Use cd command to enter 03.1.1_LightWater directory of C code.

```
cd ~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/C_Code/03.1.1_LightWater
```

2. Use following command to compile “LightWater.c” and generate executable file “LightWater”.

```
gcc LightWater.c -o LightWater -lwiringPi
```

3. Then run the generated file “LightWater”.

```
sudo ./LightWater
```

After the program is executed, you will see that LEDBar Graph starts with the flowing water way to be turned on from left to right, and then from right to left.

The following is the program code:

```
#include <wiringPi.h>
#include <stdio.h>

#define ledCounts 10
int pins[ledCounts] = {0,1,2,3,4,5,6,8,9,10};

void main(void)
{
    int i;
    printf("Program is starting ... \n");

    wiringPiSetup(); //Initialize wiringPi.

    for(i=0;i<ledCounts;i++){       //Set pinMode for all led pins to output
        pinMode(pins[i], OUTPUT);
    }
    while(1){
        for(i=0;i<ledCounts;i++){   // move led(on) from left to right
            digitalWrite(pins[i],LOW);
            delay(100);
            digitalWrite(pins[i],HIGH);
        }
        for(i=ledCounts-1;i>-1;i--){   // move led(on) from right to left
            digitalWrite(pins[i],LOW);
            delay(100);
            digitalWrite(pins[i],HIGH);
```

```
            }
        }
}
```

In the program, configure the GPIO0-GPIO9 to output mode. Then, in the endless "while" cycle of main function, use two "for" cycle to realize flowing water light from left to right and from right to left.

```
    while(1){
        for(i=0;i<ledCounts;i++){   // move led(on) from left to right
            digitalWrite(pins[i],LOW);
            delay(100);
            digitalWrite(pins[i],HIGH);
        }
        for(i=ledCounts-1;i>-1;i--){   // move led(on) from right to left
            digitalWrite(pins[i],LOW);
            delay(100);
            digitalWrite(pins[i],HIGH);
        }
    }
}
```

Python Code 3.1.1 LightWater

First observe the project result, and then analyze the code.

If you have any concerns, please contact us via: support@freenove.com

1. Use cd command to enter 03.1.1_LightWater directory of Python code.

```
cd ~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/Python_Code/03.1.1_LightWater
```

2. Use Python command to execute Python code "LightWater.py".

```
python LightWater.py
```

After the program is executed, you will see that LEDBar Graph starts with the flowing water way to be turned on from left to right, and then from right to left.

The following is the program code:

```
import RPi.GPIO as GPIO
import time

ledPins = [11, 12, 13, 15, 16, 18, 22, 3, 5, 24]

def setup():
    GPIO.setmode(GPIO.BOARD)        # use PHYSICAL GPIO Numbering
    GPIO.setup(ledPins, GPIO.OUT)   # set all ledPins to OUTPUT mode
    GPIO.output(ledPins, GPIO.HIGH) # make all ledPins output HIGH level, turn off all led

def loop():
    while True:
        for pin in ledPins:        # make led(on) move from left to right
            GPIO.output(pin, GPIO.LOW)
```

```
            time.sleep(0.1)
            GPIO.output(pin, GPIO.HIGH)
        for pin in ledPins[::-1]:      # make led(on) move from right to left
            GPIO.output(pin, GPIO.LOW)
            time.sleep(0.1)
            GPIO.output(pin, GPIO.HIGH)

def destroy():
    GPIO.cleanup()                        # Release all GPIO

if __name__ == '__main__':     # Program entrance
    print ('Program is starting...')
    setup()
    try:
        loop()
    except KeyboardInterrupt:  # Press ctrl-c to end the program.
        destroy()
```

In the program, first define 10 pins connected to LED, and set them to output mode in subfunction setup(). Then in the loop() function, use two "for" cycles to realize flowing water light from right to left and from left to right. Among them, ledPins[::-1] is used to traverse elements of ledPins in reverse order.

```
def loop():
    while True:
        for pin in ledPins:     #make led on from left to right
            GPIO.output(pin, GPIO.LOW)
            time.sleep(0.1)
            GPIO.output(pin, GPIO.HIGH)
        for pin in ledPins[::-1]:       #make led on from right to left
            GPIO.output(pin, GPIO.LOW)
            time.sleep(0.1)
            GPIO.output(pin, GPIO.HIGH)
```

Chapter 4 Analog & PWM

In previous study, we have known that one button has two states: pressed and released, and LED has light-on/off state, then how to enter a middle state? How to output an intermediate state to let LED "semi bright"? That's what we're going to learn.

First, let's learn how to control the brightness of a LED.

Project 4.1 Breathing LED

Breathing light, that is, LED is turned from off to on gradually, gradually from on to off, just like "breathing". So, how to control the brightness of a LED? We will use PWM to achieve this target.

Component List

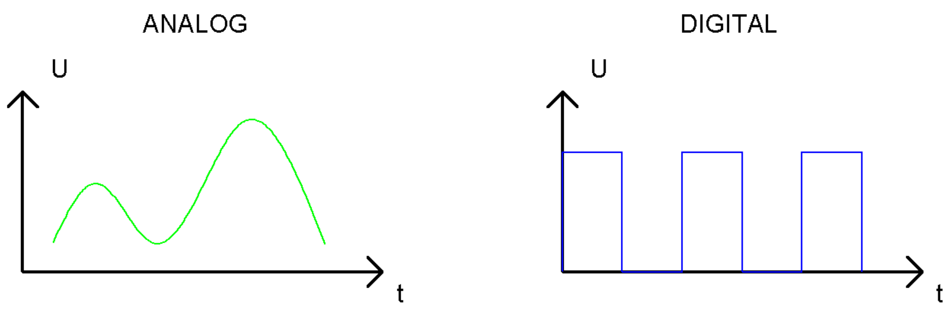
Raspberry Pi 3B x1 GPIO Extension Board & Wire x1 BreadBoard x1	LED x1 	Resistor 220Ω x1 
Jumper 		

Circuit knowledge

Analog & Digital

The analog signal is a continuous signal in time and value. On the contrary, digital signal is a discrete signal in time and value. Most signals in life are analog signals, for example, the temperature in one day is continuously changing, and will not appear a sudden change directly from 0℃ to 10℃, while the digital signal is a jump change, which can be directly from 1 to 0.

Their difference can be illustrated by the following figure.



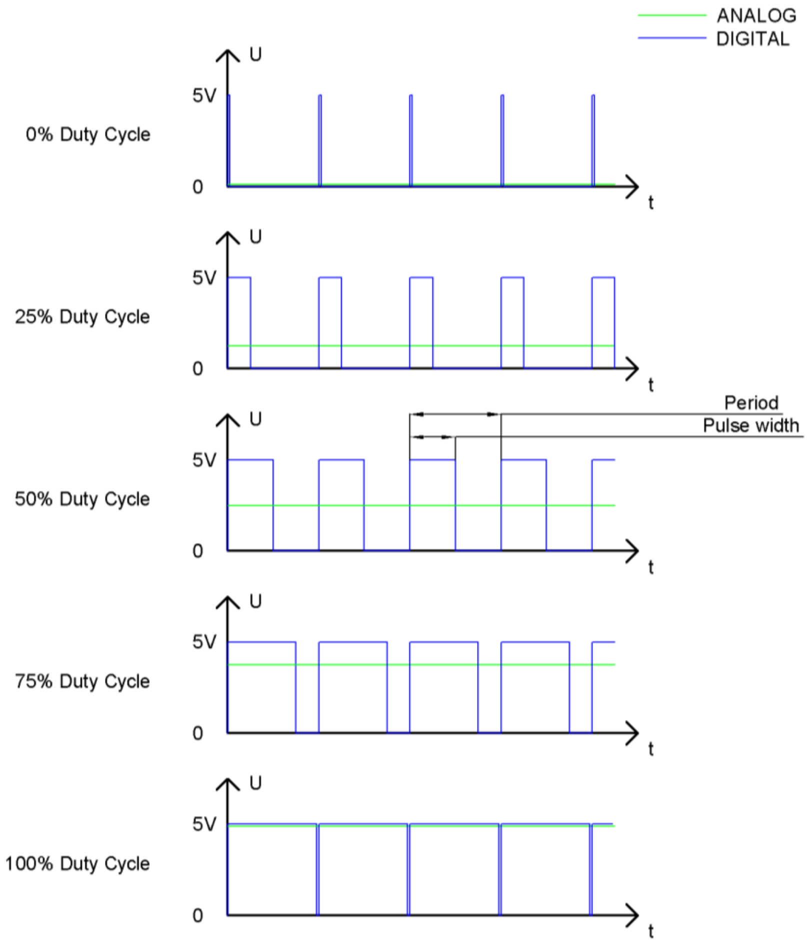
In practical application, we often use binary signal as digital signal, that is 0 and 1. The binary signal only has two forms (0 or 1), so it has strong stability. And digital signal and analog signal can be converted to each other.

PWM

PWM, namely Pulse-Width Modulation, is a very effective technique for using digital signals to control analog circuits. The common processors can not directly output analog signals. PWM technology make it very convenient to achieve this purpose.

PWM technology uses digital pins to send certain frequency of square waves, that is, the output of high level and low level that last for a while alternately. The total time for each set of high level and low level is generally fixed, which is called period (the reciprocal of the period is frequency). The time of high level outputting is generally called pulse width, and the percentage of pulse width is called duty cycle.

The longer the output of high level last, the larger the duty cycle and the larger the corresponding voltage in analog signal will be. The following figures show how the analog signals voltage vary between 0V-5V (high level is 5V) corresponding to the pulse width 0%-100%:



The larger PWM duty cycle is, the lager the output power will be. So we can use PWM to control the brightness of LED, the speed of DC motor and so on.

It is evident from the above that PWM is not real analog, and the effective value of the voltage is equivalent to the corresponding analog. so, we can control the output power of the LED and other output modules to achieve different effects.

In RPi, only GPIO18 has the ability to output hardware PWM with a 10-bit accuracy, that is, 100% of the pulse width can be divided into 2^{10}=1024 equal parts.

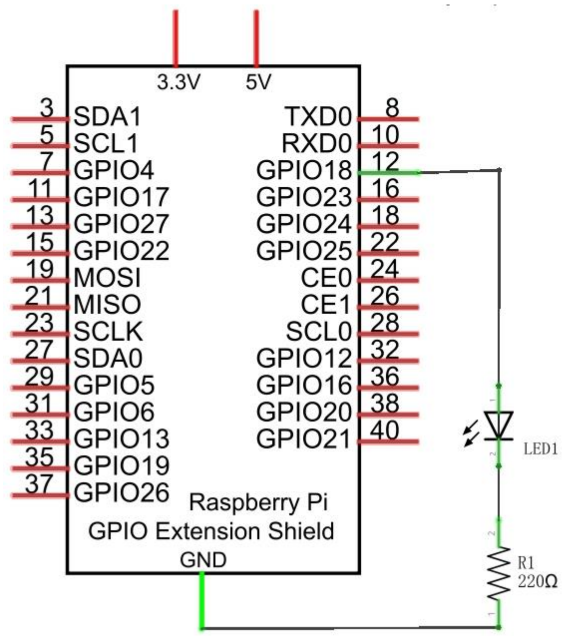
The wiringPi library of C provides a hardware PWM method and a software PWM method, while wiringPi library of Python doesn't provide hardware PWM method. There is only software PWM for Python.

The hardware PWM only needs to be configured, does not occupy CPU resources, and is more precise in time control. The software PWM requires the CPU to work all the time, using the code to output high level and low level. This part of the code is carried out in multi-thread, and the time precision is relatively not high enough.

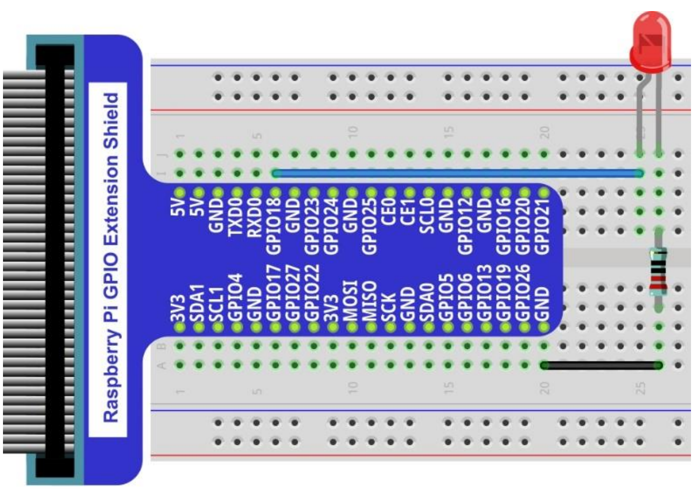
In order to keep the running results consistent, we adopt the way of software PWM.

Circuit

Schematic diagram



Hardware connection. If you need any support, please feel free to contact us via: **support@freenove.com**



Code

This project is designed to make PWM output GPIO18 with pulse width increasing from 0% to 100%, and then reducing from 100% to 0% gradually.

C Code 4.1.1 BreathingLED

First observe the project result, and then analyze the code.

If you have any concerns, please contact us via: support@freenove.com

1. Use cd command to enter 04.1.1_BreathingLED directory of C code.

```
cd ~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/C_Code/04.1.1_BreathingLED
```

2. Use following command to compile "BreathingLED.c" and generate executable file "BreathingLED".

```
gcc BreathingLED.c -o BreathingLED -lwiringPi
```

3. Then run the generated file "BreathingLED"

```
sudo ./BreathingLED
```

After the program is executed, you'll see that LED is turned from on to off and then from off to on gradually like breathing.

The following is the program code:

```
#include <wiringPi.h>
#include <stdio.h>
#include <softPwm.h>

#define ledPin    1

void main(void)
{
    int i;

    printf("Program is starting ... \n");

    wiringPiSetup();  //Initialize wiringPi.

    softPwmCreate(ledPin,  0, 100);//Creat SoftPWM pin

    while(1){
        for(i=0;i<100;i++){  //make the led brighter
            softPwmWrite(ledPin, i);
            delay(20);
        }
        delay(300);
        for(i=100;i>=0;i--){  //make the led darker
            softPwmWrite(ledPin, i);
            delay(20);
        }
        delay(300);
    }
}
```

First, create a software PWM pin.

```
softPwmCreate(ledPin,  0, 100);//Creat SoftPWM pin
```

There are two "for" cycles in the next endless "while" cycle. The first makes the ledPin output PWM from 0% to 100% and the second makes the ledPin output PWM from 100% to 0%.

```
    while(1){
        for(i=0;i<100;i++){
            softPwmWrite(ledPin, i);
            delay(20);
        }
        delay(300);
        for(i=100;i>=0;i--){
            softPwmWrite(ledPin, i);
            delay(20);
```

```
        }
        delay(300);
    }
```

You can also adjust the rate of the state change of LED by changing the parameters of the delay() function in the "for" cycle.

int softPwmCreate (int pin, int initialValue, int pwmRange) ;
This creates a software controlled PWM pin.
void softPwmWrite (int pin, int value) ;
This updates the PWM value on the given pin.

For more details, please refer http://wiringpi.com/reference/software-pwm-library/

Python Code 4.1.1 BreathingLED

First observe the project result, and then analyze the code.

If you have any concerns, please contact us via: support@freenove.com

1. Use cd command to enter 04.1.1_BreathingLED directory of Python code.

```
cd ~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/Python_Code/04.1.1_BreathingLED
```

2. Use python command to execute python code "BreathingLED.py".

```
python BreathingLED.py
```

After the program is executed, you'll see that LED is turned from on to off and then from off to on gradually like breathing.

The following is the program code:

```python
import RPi.GPIO as GPIO
import time

LedPin = 12       # define the LedPin

def setup():
    global p
    GPIO.setmode(GPIO.BOARD)       # use PHYSICAL GPIO Numbering
    GPIO.setup(LedPin, GPIO.OUT)   # set LedPin to OUTPUT mode
    GPIO.output(LedPin, GPIO.LOW)  # make ledPin output LOW level to turn off LED

    p = GPIO.PWM(LedPin, 500)      # set PWM Frequence to 500Hz
    p.start(0)                     # set initial Duty Cycle to 0

def loop():
    while True:
        for dc in range(0, 101, 1):   # make the led brighter
            p.ChangeDutyCycle(dc)     # set dc value as the duty cycle
            time.sleep(0.01)
        time.sleep(1)
        for dc in range(100, -1, -1): # make the led darker
            p.ChangeDutyCycle(dc)     # set dc value as the duty cycle
            time.sleep(0.01)
```

```
        time.sleep(1)

def destroy():
    p.stop() # stop PWM
    GPIO.cleanup() # Release all GPIO

if __name__ == '__main__':     # Program entrance
    print ('Program is starting ... ')
    setup()
    try:
        loop()
    except KeyboardInterrupt:  # Press ctrl-c to end the program.
        destroy()
```

LED is connected to the IO port called GPIO18. And LedPin is defined as 12 and set to output mode according to the corresponding chart for pins. Then create a PWM instance and set the PWM frequency to 1000HZ, the initial duty cycle to 0%.

```
LedPin = 12      # define the LedPin

def setup():
    global p
    GPIO.setmode(GPIO.BOARD)       # use PHYSICAL GPIO Numbering
    GPIO.setup(LedPin, GPIO.OUT)   # set LedPin to OUTPUT mode
    GPIO.output(LedPin, GPIO.LOW)  # make ledPin output LOW level to turn off LED

    p = GPIO.PWM(LedPin, 500)      # set PWM Frequence to 500Hz
    p.start(0)                     # set initial Duty Cycle to 0
```

There are two "for" cycles used to realize breathing LED in the next endless "while" cycle. The first makes the ledPin output PWM from 0% to 100% and the second makes the ledPin output PWM from 100% to 0%.

```
def loop():
    while True:
        for dc in range(0, 101, 1):   # make the led brighter
            p.ChangeDutyCycle(dc)     # set dc value as the duty cycle
            time.sleep(0.01)
        time.sleep(1)
        for dc in range(100, -1, -1): # make the led darker
            p.ChangeDutyCycle(dc)     # set dc value as the duty cycle
            time.sleep(0.01)
        time.sleep(1)
```

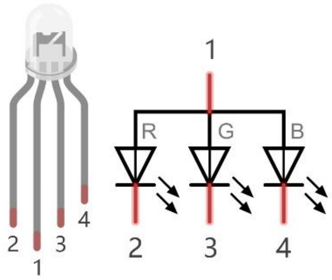
The related functions of PWM are described as follows:

p = GPIO.PWM(channel, frequency)
To create a PWM instance:
p.start(dc)
To start PWM:， where dc is the duty cycle (0.0 <= dc <= 100.0)
p.ChangeFrequency(freq)
To change the frequency， where freq is the new frequency in Hz
p.ChangeDutyCycle(dc)
To change the duty cycle， where 0.0 <= dc <= 100.0
p.stop()
To stop PWM.

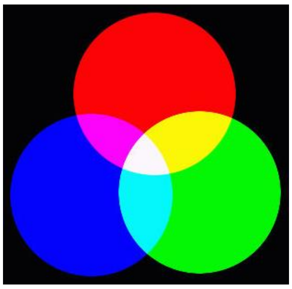
For more details about usage method for PWM of RPi.GPIO, please refer to:
https://sourceforge.net/p/raspberry-gpio-python/wiki/PWM/

Chapter 5 RGBLED

In this chapter, we will learn how to control a RGBLED.
RGB LED has integrated 3 LEDs that can respectively emit red, green and blue light. And it has 4 pins. The long pin (1) is the common port, that is, 3 LED 's positive or negative port. The RGB LED with common positive port and its symbol are shown below. We can make RGB LED emit various colors of light by controlling these 3 LEDs to emit light with different brightness,



Red, green, and blue light are called 3 primary colors. When you combine these three primary-color light with different brightness, it can produce almost all kinds of visible lights. Computer screens, single pixel of cell phone screen, neon, and etc. are working under this principle.



RGB

If we use three 8 bit PWM to control the RGBLED, in theory, we can create $2^8*2^8*2^8$=16777216 (16 million) color through different combinations.
Next, we will use RGBLED to make a colorful LED.

Project 5.1 Colorful LED

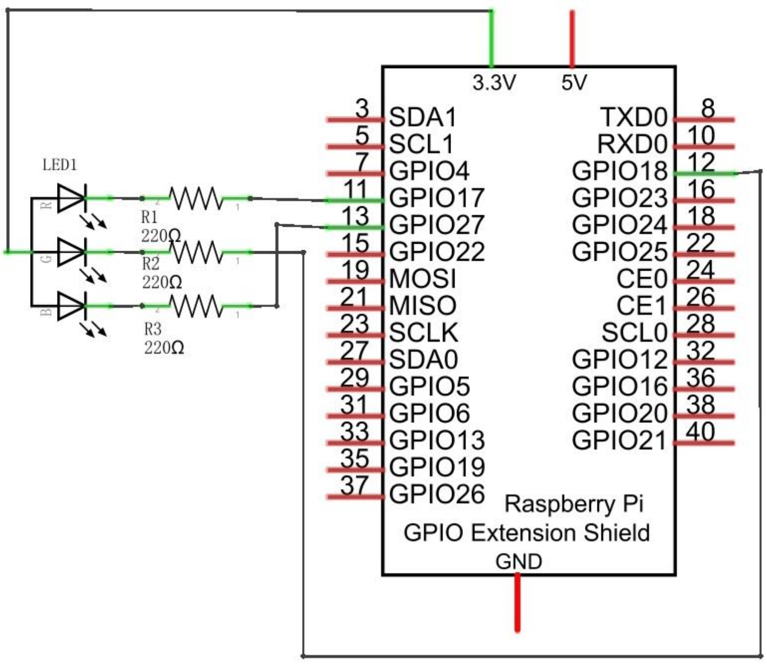
In this project, we will make a colorful LED. And we can control RGBLED to switch different colors automatically.

Component List

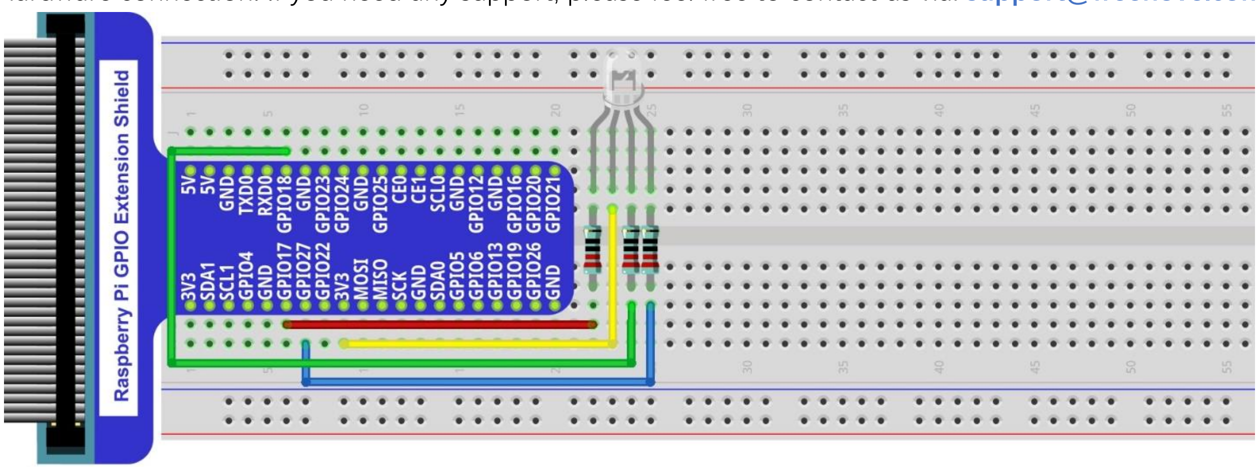
Raspberry Pi 3B x1 GPIO Extension Board & Wire x1 BreadBoard x1	RGBLED x1 	Resistor 220Ω x3 
Jumper 		

Circuit

Schematic diagram



Hardware connection. If you need any support, please feel free to contact us via: **support@freenove.com**



Code

Since this project requires 3 PWM, but in RPi, only one GPIO has the hardware capability to output PWM, we need to use the software to make the ordinary GPIO output PWM.

C Code 5.1.1 ColorfulLED

First observe the project result, and then analyze the code.

If you have any concerns, please contact us via: support@freenove.com

1. Use cd command to enter 05.1.1_ColorfulLED directory of C code.

```
cd ~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/C_Code/05.1.1_ColorfulLED
```

2. Use following command to compile "ColorfulLED.c" and generate executable file "ColorfulLED". Note: in this project, the software PWM uses a multi-threading mechanism. So "-lpthread" option need to be add the compiler.

```
gcc ColorfulLED.c -o ColorfulLED -lwiringPi -lpthread
```

3. And then run the generated by "ColorfulLED".

```
sudo ./ColorfulLED
```

After the program is executed, you will see that the RGBLED shows light of different color randomly.

The following is the program code:

```c
#include <wiringPi.h>
#include <softPwm.h>
#include <stdio.h>
#include <stdlib.h>

#define ledPinRed    0
#define ledPinGreen  1
#define ledPinBlue   2

void setupLedPin(void)
{
    softPwmCreate(ledPinRed,  0, 100); //Creat SoftPWM pin for red
    softPwmCreate(ledPinGreen,0, 100);  //Creat SoftPWM pin for green
    softPwmCreate(ledPinBlue, 0, 100);  //Creat SoftPWM pin for blue
}

void setLedColor(int r, int g, int b)
{
    softPwmWrite(ledPinRed,   r);  //Set the duty cycle
    softPwmWrite(ledPinGreen, g);   //Set the duty cycle
    softPwmWrite(ledPinBlue,  b);   //Set the duty cycle
}

int main(void)
{
    int r,g,b;
```

```

    printf("Program is starting ...\n");

    wiringPiSetup();  //Initialize wiringPi.

    setupLedPin();
    while(1){
        r=random()%100;  //get a random in (0,100)
        g=random()%100;  //get a random in (0,100)
        b=random()%100;  //get a random in (0,100)
        setLedColor(r,g,b);//set random as the duty cycle value
        printf("r=%d,  g=%d,  b=%d \n",r,g,b);
        delay(300);
    }
    return 0;
}
```

First, in subfunction of ledInit(), create the software PWM control pins used to control the R, G, B pin respectively.

```
void setupLedPin(void)
{
    softPwmCreate(ledPinRed,  0,  100);  //Creat SoftPWM pin for red
    softPwmCreate(ledPinGreen,0,  100);  //Creat SoftPWM pin for green
    softPwmCreate(ledPinBlue, 0,  100);  //Creat SoftPWM pin for blue
}
```

Then create subfunction, and set the PWM of three pins.

```
void setLedColor(int r, int g, int b)
{
    softPwmWrite(ledPinRed,   r);  //Set the duty cycle
    softPwmWrite(ledPinGreen, g);   //Set the duty cycle
    softPwmWrite(ledPinBlue,  b);   //Set the duty cycle
}
```

Finally, in the “while” cycle of main function, get three random numbers and specify them as the PWM duty cycle, which will be assigned to the corresponding pins. So RGBLED can switch the color randomly all the time.

```
    while(1){
        r=random()%100;  //get a random in (0,100)
        g=random()%100;  //get a random in (0,100)
        b=random()%100;  //get a random in (0,100)
        setLedColor(r,g,b);//set random as the duty cycle value
        printf("r=%d,  g=%d,  b=%d \n",r,g,b);
        delay(300);
    }
```

The related function of Software PWM can be described as follws:

long random();
This function will return a random number.

For more details about Software PWM, please refer to: http://wiringpi.com/reference/software-pwm-library/

Python Code 5.1.1 ColorfulLED

First observe the project result, and then analyze the code.

If you have any concerns, please contact us via: support@freenove.com

1. Use cd command to enter 05.1.1_ColorfulLED directory of Python code.

```
cd ~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/Python_Code/05.1.1_ColorfulLED
```

2. Use python command to execute python code "ColorfulLED.py".

```
python ColorfulLED.py
```

After the program is executed, you will see that the RGBLED shows light of different color randomly.

The following is the program code:

```python
import RPi.GPIO as GPIO
import time
import random

pins = {'pinRed':11, 'pinGreen':12, 'pinBlue':13}  # define the pins for RGBLED

def setup():
    global pwmRed,pwmGreen,pwmBlue
    GPIO.setmode(GPIO.BOARD)       # use PHYSICAL GPIO Numbering
    GPIO.setup(pins, GPIO.OUT)     # set RGBLED pins to OUTPUT mode
    GPIO.output(pins, GPIO.HIGH)   # make RGBLED pins output HIGH level
    pwmRed = GPIO.PWM(pins['pinRed'], 2000)      # set PWM Frequence to 2kHz
    pwmGreen = GPIO.PWM(pins['pinGreen'], 2000)  # set PWM Frequence to 2kHz
    pwmBlue = GPIO.PWM(pins['pinBlue'], 2000)    # set PWM Frequence to 2kHz
    pwmRed.start(0)      # set initial Duty Cycle to 0
    pwmGreen.start(0)
    pwmBlue.start(0)

def setColor(r_val,g_val,b_val):      # change duty cycle for three pins to r_val,g_val,b_val
    pwmRed.ChangeDutyCycle(r_val)     # change pwmRed duty cycle to r_val
    pwmGreen.ChangeDutyCycle(g_val)
    pwmBlue.ChangeDutyCycle(b_val)

def loop():
    while True :
        r=random.randint(0,100)  #get a random in (0,100)
        g=random.randint(0,100)
        b=random.randint(0,100)
        setColor(r,g,b)          #set random as a duty cycle value
```

```
        print ('r=%d, g=%d, b=%d ' %(r ,g, b))
        time.sleep(0.3)

def destroy():
    pwmRed.stop()
    pwmGreen.stop()
    pwmBlue.stop()
    GPIO.cleanup()

if __name__ == '__main__':     # Program entrance
    print ('Program is starting ... ')
    setup()
    try:
        loop()
    except KeyboardInterrupt:  # Press ctrl-c to end the program.
        destroy()
```

In last chapter, we have learned how to use python language to make a pin output PWM. In this project, we let three pins output PWM, and the usage is exactly the same as last chapter. In the “while” cycle of “loop” function, we first obtain three random numbers, and then specify these three random numbers as the PWM value of the three pins.o that the RGBLED switching of different colors randomly.

```
def loop():
    while True :
        r=random.randint(0,100)  #get a random in (0,100)
        g=random.randint(0,100)
        b=random.randint(0,100)
        setColor(r,g,b)          #set random as a duty cycle value
        print ('r=%d, g=%d, b=%d ' %(r ,g, b))
        time.sleep(0.3)
```

About function randint():

random.randint(a, b)
The function can returns a random integer within the specified range (a, b).

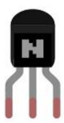
Chapter 6 Buzzer

In this chapter, we will learn a component that can sound, buzzer.

Project 6.1 Doorbell

We will make this kind of doorbell: when the button is pressed, the buzzer sounds; and when the button is released, the buzzer stops sounding.

Component List

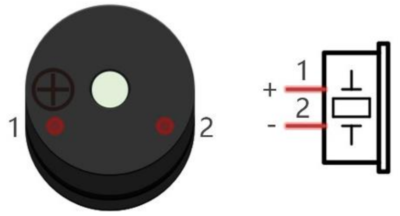
<table>
<tr><td colspan="2">Raspberry Pi 3B x1
GPIO Extension Board & Wire x1
BreadBoard x1</td><td colspan="3">Jumper
</td></tr>
<tr><td>NPN transistorx1
(S8050)
</td><td>Active buzzer x1
</td><td>Push button x1
</td><td>Resistor 1kΩ x1
</td><td>Resistor 10kΩ x2
</td></tr>
</table>

Component knowledge

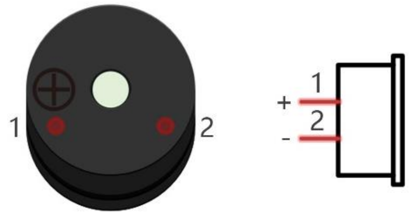
Buzzer

Buzzer is a sounding component, which is widely used in electronic devices such as calculator, electronic warning clock, alarm. Buzzer has active and passive type. Active buzzer has oscillator inside, and it will sound as long as it is supplied with power. Passive buzzer requires external oscillator signal (generally use PWM with different frequency) to make a sound.

Active buzzer



Passive buzzer



Active buzzer is easy to use. Generally, it can only make a specific frequency of sound. Passive buzzer requires an external circuit to make a sound, but it can be controlled to make a sound with different frequency. The resonant frequency of the passive buzzer is 2kHz, which means the passive buzzer is loudest when its resonant frequency is 2kHz.

Next, we will use an active buzzer to make a doorbell and a passive buzzer to make an alarm.

How to identify active and passive buzzer?

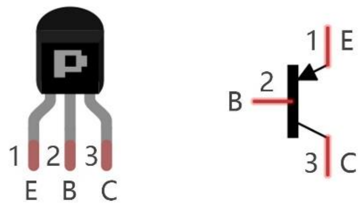
1. Usually, there is a label on the surface of active buzzer covering the vocal hole, but this is not an absolute judgment method.
2. Active buzzer is more complex than passive buzzer in manufacture. There are a lot of circuits and crystal oscillator elements inside active buzzer, which are covered with a waterproof coating, around its pins. Passive buzzer doesn't have these coatings. From the pins of passive buzzer, you can even see the circuit board, coils, and permanent magnets directly.

Transistor

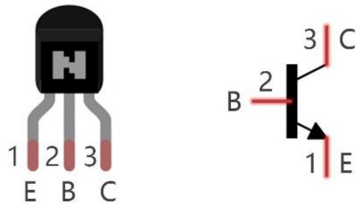
Due to the current operating of buzzer is so large that GPIO of RPi output capability can not meet the requirement. A transistor of NPN type is needed here to amplify the current.

Transistor, the full name: semiconductor transistor, is a semiconductor device that controls current. Transistor can be used to amplify weak signal, or works as a switch. It has three electrodes(PINs): base (b), collector (c) and emitter (e). When there is current passing between "be", "ce" will allow several-fold current (transistor magnification) pass, at this point, transistor works in the amplifying area. When current between "be" exceeds a certain value, "ce" will not allow current to increase any longer, at this point, transistor works in the saturation area. Transistor has two types shown below: PNP and NPN,

PNP transistor



NPN transistor

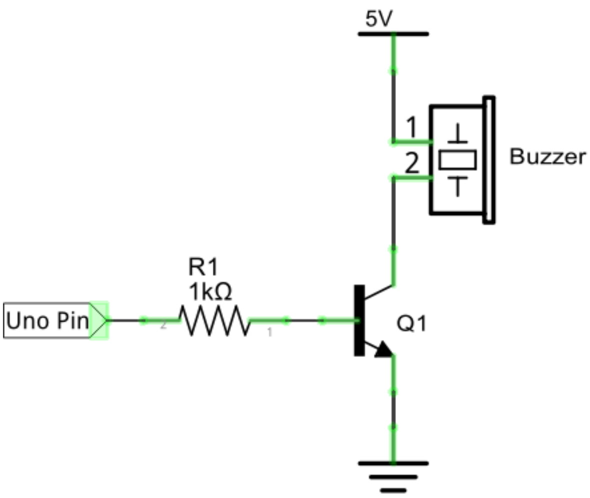
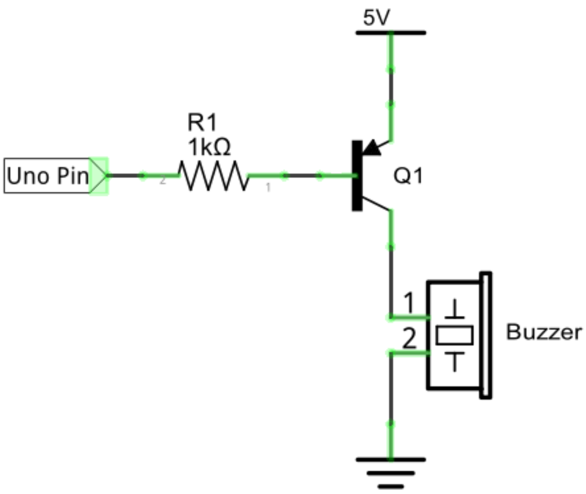


In our kit, the PNP transistor is marked with 8550, and the NPN transistor is marked with 8050.

According to the transistor's characteristics, it is often used as a switch in digital circuits. For micro-controller's capacity of output current is very weak, we will use transistor to amplify current and drive large-current components.

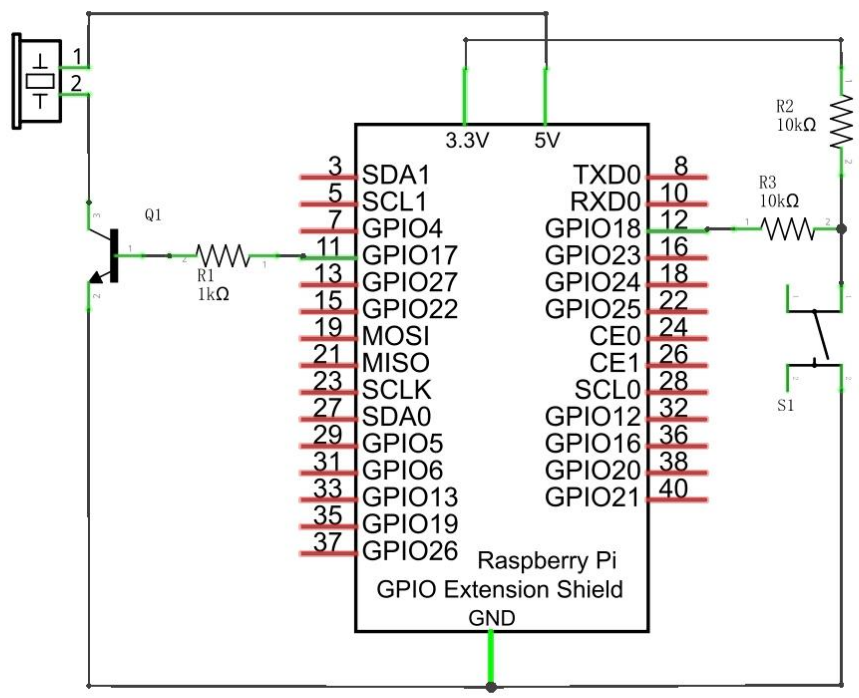
When use NPN transistor to drive buzzer, we often adopt the following method. If GPIO outputs high level, current will flow through R1, the transistor gets conducted, and the buzzer make a sound. If GPIO outputs low level, no current flows through R1, the transistor will not be conducted, and buzzer will not sound.

When use PNP transistor to drive buzzer, we often adopt the following method. If GPIO outputs low level, current will flow through R1, the transistor gets conducted, buzzer make a sound. If GPIO outputs high level, no current flows through R1, the transistor will not be conducted, and buzzer will not sound.

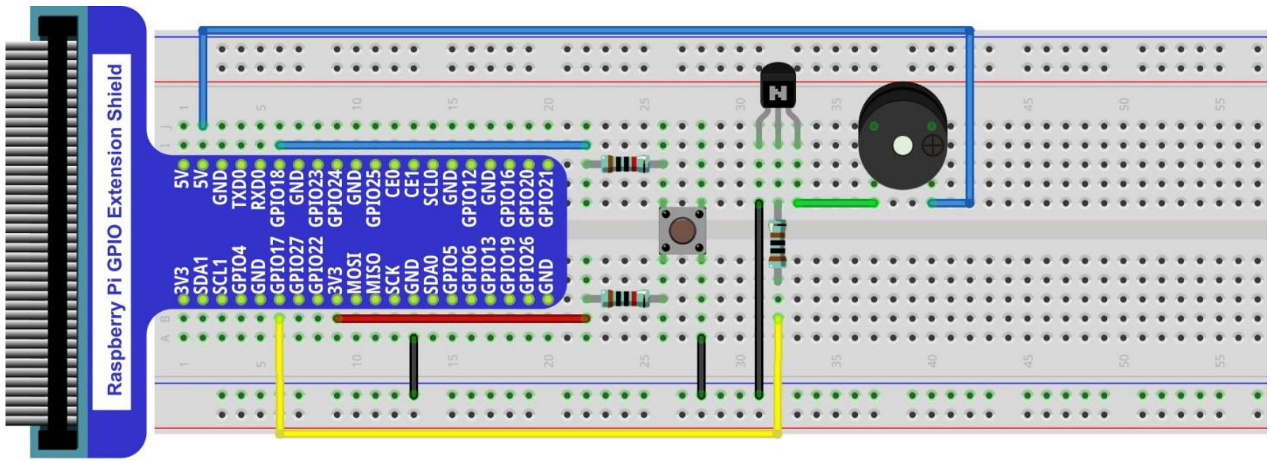
NPN transistor to drive buzzer	PNP transistor to drive buzzer
	

Circuit

Schematic diagram



Hardware connection. If you need any support, please feel free to contact us via: **support@freenove.com**



Note: in this circuit, the power supply for buzzer is 5V, and pull-up resistor of the button connected to the power 3.3V. The buzzer can work when connected to power 3.3V, but it will reduce the loudness.

Code

In this project, buzzer is controlled by the button. When the button is pressed, the buzzer sounds. And when the button is released, the buzzer stops sounding. In the logic, it is the same to using button to control LED.

C Code 6.1.1 Doorbell

First observe the project result, and then analyze the code.

If you have any concerns, please contact us via: support@freenove.com

1. Use cd command to enter 06.1.1_Doorbell directory of C code.

```
cd ~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/C_Code/06.1.1_Doorbell
```

2. Use following command to compile “Doorbell.c” and generate executable file “Doorbell.c”.

```
gcc Doorbell.c -o Doorbell -lwiringPi
```

3. Then run the generated file “Doorbell”.

```
sudo ./Doorbell
```

After the program is executed, press the button, then buzzer sounds. And when the button is release, the buzzer will stop sounding.

The following is the program code:

```
#include <wiringPi.h>
#include <stdio.h>

#define buzzerPin 0   //define the buzzerPin
#define buttonPin 1       //define the buttonPin

void main(void)
{
    printf("Program is starting ... \n");

    wiringPiSetup();

    pinMode(buzzerPin, OUTPUT);
    pinMode(buttonPin, INPUT);

    pullUpDnControl(buttonPin, PUD_UP);  //pull up to HIGH level
    while(1){

        if(digitalRead(buttonPin) == LOW){ //button is pressed
            digitalWrite(buzzerPin, HIGH);   //Turn on buzzer
            printf("buzzer turned on >>> \n");
        }
        else {                  //button is released
            digitalWrite(buzzerPin, LOW);   //Turn off buzzer
            printf("buzzer turned off <<< \n");
        }
```

```
    }
}
```

The code is exactly the same to using button to control LED logically. You can try to use the PNP transistor to achieve the function of his circuit once again.

Python Code 6.1.1 Doorbell

First observe the project result, then analyze the code.

If you have any concerns, please contact us via: support@freenove.com

1. Use cd command to enter 06.1.1_Doorbell directory of Python code.

```
cd ~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/Python_Code/06.1.1_Doorbell
```

2. Use python command to execute python code “Doorbell.py”.

```
python Doorbell.py
```

After the program is executed, press the button, then buzzer sounds. And when the button is released, the buzzer will stop sounding.

The following is the program code:

```
import RPi.GPIO as GPIO

buzzerPin = 11    # define buzzerPin
buttonPin = 12    # define buttonPin

def setup():
    GPIO.setmode(GPIO.BOARD)        # use PHYSICAL GPIO Numbering
    GPIO.setup(buzzerPin, GPIO.OUT)   # set buzzerPin to OUTPUT mode
    GPIO.setup(buttonPin, GPIO.IN, pull_up_down=GPIO.PUD_UP)    # set buttonPin to PULL UP INPUT mode

def loop():
    while True:
        if GPIO.input(buttonPin)==GPIO.LOW: # if button is pressed
            GPIO.output(buzzerPin,GPIO.HIGH) # turn on buzzer
            print ('buzzer turned on >>>')
        else : # if button is relessed
            GPIO.output(buzzerPin,GPIO.LOW) # turn off buzzer
            print ('buzzer turned off <<<')

def destroy():
    GPIO.cleanup()                     # Release all GPIO

if __name__ == '__main__':     # Program entrance
    print ('Program is starting...')
    setup()
    try:
```

```
        loop()
    except KeyboardInterrupt:  # Press ctrl-c to end the program.
        destroy()
```

The code is exactly the same to using button to control LED logically. You can try to use the PNP transistor to achieve the function of his circuit once again.

Project 6.2 Alertor

Next, we will use a passive buzzer to make an alarm.

Component list and the circuit part is the similar to last section. In the Doorbell circuit only the active buzzer needs to be replaced with a passive buzzer.

Code

In this project, the buzzer alarm is controlled by the button. Press the button, then buzzer sounds. If you release the button, the buzzer will stop sounding. In the logic, it is the same to using button to control LED. In the control method, passive buzzer requires PWM of certain frequency to sound.

C Code 6.2.1 Alertor

First observe the project result, and then analyze the code.

If you have any concerns, please contact us via: support@freenove.com

1. Use cd command to enter 06.2.1_Alertor directory of C code.

```
cd ~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/C_Code/06.2.1_Alertor
```

2. Use following command to compile “Alertor.c” and generate executable file “Alertor”. “-lm” and “-lpthread” compiler options are needed to add here.

```
gcc Alertor.c -o Alertor -lwiringPi -lm -lpthread
```

3. Then run the generated file “Alertor”.

```
sudo ./Alertor
```

After the program is executed, press the button, then buzzer sounds. And when the button is release, the buzzer will stop sounding.

The following is the program code:

```
#include <wiringPi.h>
#include <stdio.h>
#include <softTone.h>
#include <math.h>

#define buzzerPin    0    //define the buzzerPin
#define buttonPin      1      //define the buttonPin

void alertor(int pin){
    int x;
    double sinVal, toneVal;
```

```
    for(x=0;x<360;x++){ // frequency of the alertor is consistent with the sine wave
        sinVal = sin(x * (M_PI / 180));         //Calculate the sine value
        toneVal = 2000 + sinVal * 500;      //Add the resonant frequency and weighted sine
value
        softToneWrite(pin,toneVal);             //output corresponding PWM
        delay(1);
    }
}
void stopAlertor(int pin){
    softToneWrite(pin,0);
}
int main(void)
{
    printf("Program is starting ... \n");

    wiringPiSetup();

    pinMode(buzzerPin, OUTPUT);
    pinMode(buttonPin, INPUT);
    softToneCreate(buzzerPin); //set buzzerPin
    pullUpDnControl(buttonPin, PUD_UP);  //pull up to HIGH level
    while(1){
        if(digitalRead(buttonPin) == LOW){ //button is pressed
            alertor(buzzerPin);   // turn on buzzer
            printf("alertor turned on >>> \n");
        }
        else {                //button is released
            stopAlertor(buzzerPin);   // turn off buzzer
            printf("alertor turned off <<< \n");
        }
    }
    return 0;
}
```

The code is the same to the active buzzer logically, but the way to control the buzzer is different. Passive buzzer requires PWM of certain frequency to control, so you need to create a software PWM pin though softToneCreate (buzzeRPin). Here softTone is dedicated to generate square wave with variable frequency and duty cycle fixed to 50%, which is a better choice for controlling the buzzer.

```
softToneCreate(buzzeRPin);
```

In the while cycle of main function, when the button is pressed, subfunction alertor() will be called and the alertor will issue a warning sound. The frequency curve of the alarm is based on the sine curve. We need to calculate the sine value from 0 to 360 degree and multiply a certain value (here is 500) and plus the resonant frequency of buzzer. We can set the PWM frequency through softToneWrite (pin, toneVal).

```
void alertor(int pin){
    int x;
    double sinVal, toneVal;
    for(x=0;x<360;x++){ //The frequency is based on the sine curve.
        sinVal = sin(x * (M_PI / 180));
        toneVal = 2000 + sinVal * 500;
        softToneWrite(pin,toneVal);
        delay(1);
    }
}
```

If you want to close the buzzer, just set PWM frequency of the buzzer pin to 0.

```
void stopAlertor(int pin){
    softToneWrite(pin,0);
}
```

The related functions of softTone is described as follows:

int softToneCreate (int pin) ;
This creates a software controlled tone pin.
void softToneWrite (int pin, int freq) ;
This updates the tone frequency value on the given pin.

For more details about softTone, please refer to :http://wiringpi.com/reference/software-tone-library/

Python Code 6.2.1 Alertor

First observe the project result, and then analyze the code.

If you have any concerns, please contact us via: support@freenove.com

1. Use cd command to enter 06.2.1_Alertor directory of Python code.

```
cd ~/Freenove_Basic_Starter_Kit_for_Raspberry_Pi/Code/Python_Code/06.2.1_Alertor
```

2. Use the python command to execute the Python code “Alertor.py”.

```
python Alertor.py
```

After the program is executed, press the button, then the buzzer sounds. When the button is released, the buzzer will stop sounding.

The following is the program code:

```
import RPi.GPIO as GPIO
import time
import math

buzzerPin = 11    # define the buzzerPin
buttonPin = 12    # define the buttonPin
```

```

def setup():
    global p
    GPIO.setmode(GPIO.BOARD)         # Use PHYSICAL GPIO Numbering
    GPIO.setup(buzzerPin, GPIO.OUT)   # set RGBLED pins to OUTPUT mode
    GPIO.setup(buttonPin, GPIO.IN, pull_up_down=GPIO.PUD_UP)    # Set buttonPin to INPUT
mode, and pull up to HIGH level, 3.3V
    p = GPIO.PWM(buzzerPin, 1)
    p.start(0);

def loop():
    while True:
        if GPIO.input(buttonPin)==GPIO.LOW:
            alertor()
            print ('alertor turned on >>> ')
        else :
            stopAlertor()
            print ('alertor turned off <<<')
def alertor():
    p.start(50)
    for x in range(0,361):     # Make frequency of the alertor consistent with the sine wave
        sinVal = math.sin(x * (math.pi / 180.0))        # calculate the sine value
        toneVal = 2000 + sinVal * 500  # Add to the resonant frequency with a Weighted
        p.ChangeFrequency(toneVal)     # Change Frequency of PWM to toneVal
        time.sleep(0.001)

def stopAlertor():
    p.stop()

def destroy():
    GPIO.output(buzzerPin, GPIO.LOW)     # Turn off buzzer
    GPIO.cleanup()                       # Release GPIO resource

if __name__ == '__main__':     # Program entrance
    print ('Program is starting...')
    setup()
    try:
        loop()
    except KeyboardInterrupt:  # Press ctrl-c to end the program.
        destroy()
```

The code is the same to the active buzzer logically, but the way to control the buzzer is different. Passive buzzer requires PWM of certain frequency to control, so you need to create a software PWM pin through softToneCreate (buzzeRPin). The way to create PWM is also introduced before in the sections about BreathingLED and RGBLED.

```
def setup():
    global p
    GPIO.setmode(GPIO.BOARD)        # Use PHYSICAL GPIO Numbering
    GPIO.setup(buzzerPin, GPIO.OUT)   # set RGBLED pins to OUTPUT mode
    GPIO.setup(buttonPin, GPIO.IN, pull_up_down=GPIO.PUD_UP)    # Set buttonPin to INPUT
mode, and pull up to HIGH level, 3.3V
    p = GPIO.PWM(buzzerPin, 1)
    p.start(0);
```

In the while cycle of main function, when the button is pressed, subfunction alertor() will be called and the alertor will issue a warning sound. The frequency curve of the alarm is based on the sine curve. We need to calculate the sine value from 0 to 360 degree and multiply a certain value (here is 500) and plus the resonant frequency of buzzer. We can set the PWM frequency through p.ChangeFrequency(toneVal).

```
def alertor():
    p.start(50)
    for x in range(0,361):
        sinVal = math.sin(x * (math.pi / 180.0))
        toneVal = 2000 + sinVal * 500
        p.ChangeFrequency(toneVal)
        time.sleep(0.001)
```

When the button is released, the buzzer will be closed.

```
def stopAlertor():
    p.stop()
```

Chapter 7 WebIOPi & IOT

In this chapter, we will learn how to use GPIO to control RPi through remote network and how to build a WebIOPi service on the RPi.

“IOT” is Internet of Things. The development of IOT will greatly change our habits and make our lives more convenient and efficient.

“WebIOPi” is the Raspberry Pi Internet of Things Framework.After configuration for WebIOPi on your RPi is completed, you can use web browser on mobile phones, computers and other equipments to control, debug and use RPi GPIO conveniently. It also supports many commonly used communication protocol, such as serial, I2C, SPI, etc., and a lot of equipments, like AD/DA converter pcf8591 used before and so on. Then on this basis, through adding some peripheral circuits, you can create your own smart home.

For more details about WebIOPi, please refer to: http://webiopi.trouch.com/

Project 07.1 Remote LED

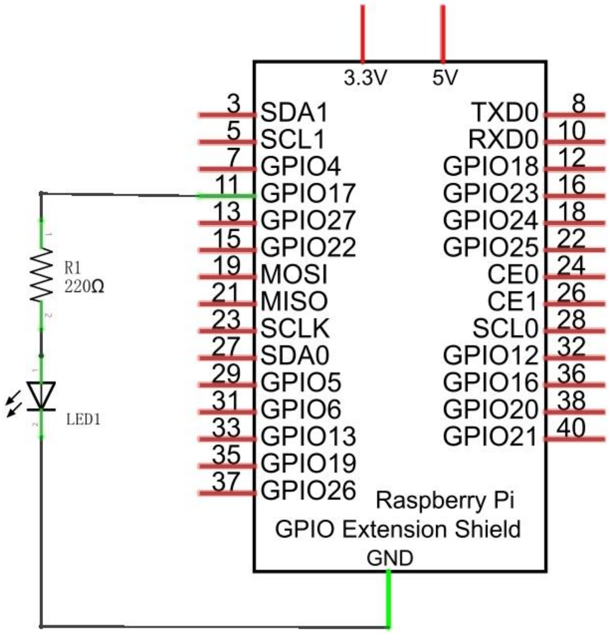
In this experiment, we need build a WebIOPi service, and then control the RPi GPIO to control a LED through Web browser of phone or PC.

Component List

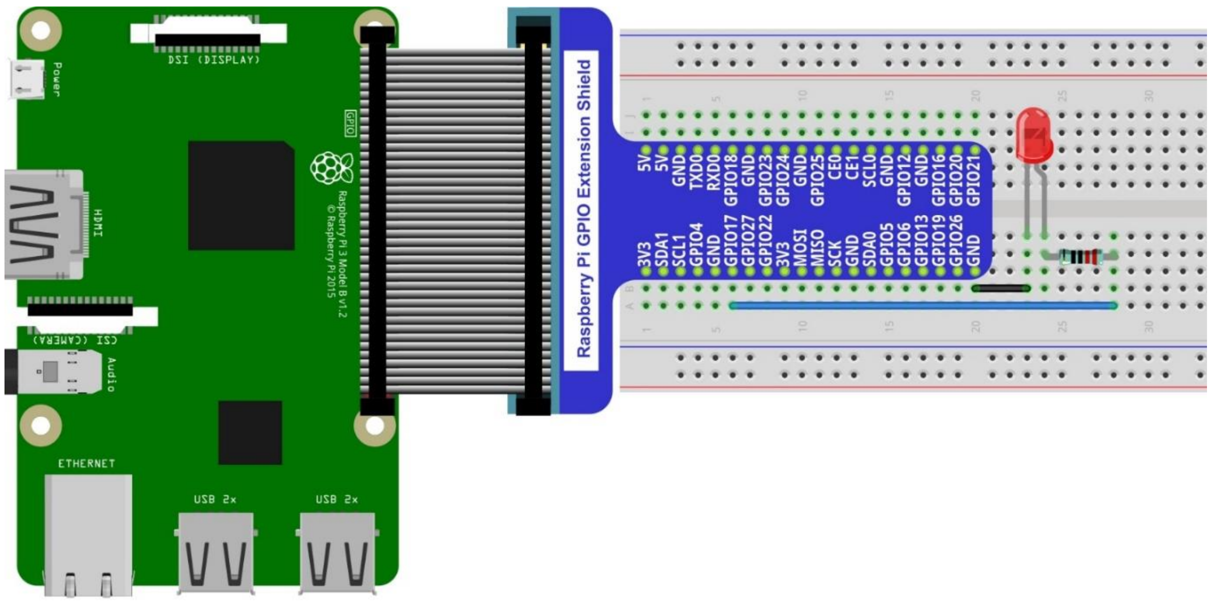
Raspberry Pi 3B x1 GPIO Extension Board & Wire x1 BreadBoard x1	LED x1 	Resistor 220Ω x1 
Jumper M/M x2 		

Circuit

Schematic diagram



Hardware connection. If you need any support, please feel free to contact us via: **support@freenove.com**



Build WebIOPi Service Framework

The following is the key part of this chapter. The installation steps refer to WebIOPi official. And you also can directly refer to the official installation steps. The latest version (until 2016-6-27) WebIOPi is 0.7.1. So, you may have some problems in use. We will explain these problems and provide the solution in the following installation steps.

Here are the steps to build WebIOPi:

Installation

1. Get the installation package. You can use the following command to obtain.

```
wget https://github.com/Freenove/WebIOPi/archive/master.zip -O WebIOPi.zip
```

2. Extract the package and generate a folder named "WebIOPi-master". Then enter the folder.

```
unzip WebIOPi.zip
cd WebIOPi-master/WebIOPi-0.7.1
```

3. Patch for Raspberry Pi B+, 2B, 3B, 3B+.

```
patch -p1 -i webiopi-pi2bplus.patch
```

4. Run setup.sh to start the installation, and the process need a period of time to wait.

```
sudo ./setup.sh
```

5. If setup.sh does not have permission to execute, execute the following command

```
sudo sh ./setup.sh
```

Run

After the installation is completed, you can use the webiopi command to start running.

```
$ sudo webiopi [-h] [-c config] [-l log] [-s script] [-d] [port]

    Options:
      -h, --help              Display this help
      -c, --config  file      Load config from file
      -l, --log     file      Log to file
      -s, --script  file      Load script from file
      -d, --debug             Enable DEBUG

    Arguments:
      port                    Port to bind the HTTP Server
```

For instance, to start with verbose output and the default config file :

```
sudo webiopi -d -c /etc/webiopi/config
```

The Port is 8000 in default.

Until now, WebIOPi has been launched, and you can press "Ctrl+C" to terminate service.

Access WebIOPi over local network

Under the same network, use mobile phone or PC browser to open your RPi IP address, and add port number like 8000. For example, my raspberry pi IP address is 192.168.1.109. Then, in the browser, should input: http://192.168.1.109:8000/

Default user is "webiopi" and password is "raspberry"。

Then, enter the main control interface:

WebIOPi Main Menu

GPIO Header

Control and Debug the Raspberry Pi GPIO with a display which looks like the physical header.

GPIO List

Control and Debug the Raspberry Pi GPIO ordered in a single column.

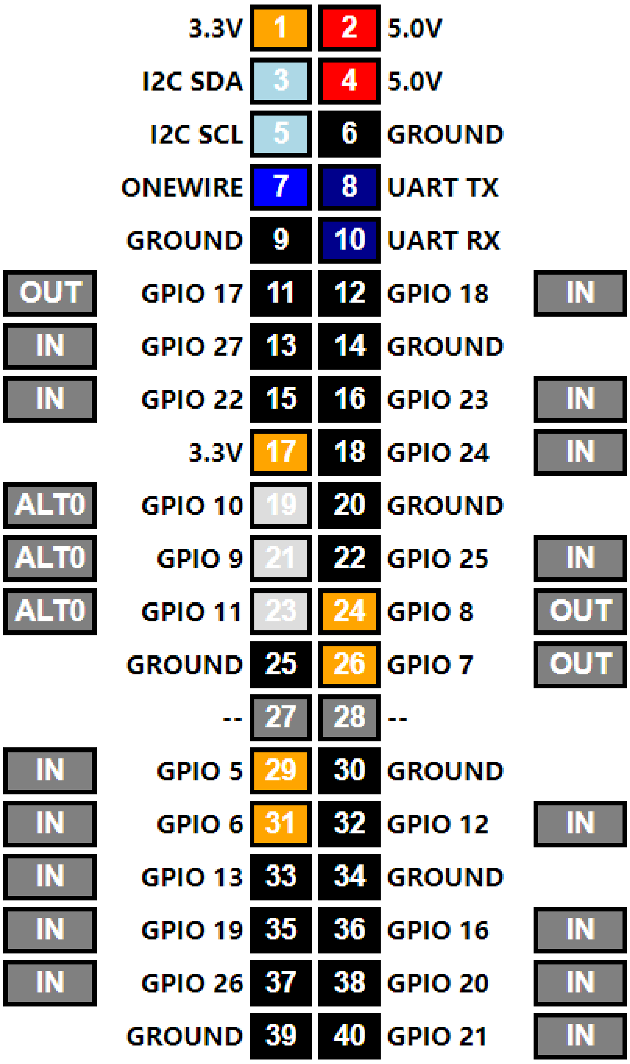
Serial Monitor

Use the browser to play with Serial interfaces configured in WebIOPi.

Devices Monitor

Control and Debug devices and circuits wired to your Pi and configured in WebIOPi.

Click on GPIO Header to enter the GPIO control interface.



Control methods:

- Click/Tap the OUT/IN button to change GPIO direction.
- Click/Tap pins to change the GPIO output state.

Completed

According to the circuit we build, set GPIO17 to OUT, then click Header11 to control the LED.

About WebIOPi

(If you are using raspberry pie 4B, you may have some trouble. We will also finish the WebIOPi adaptation to raspberry 4B as soon as possible, and update it at the first time.)

The reason for changing file in the configuration process is that the model of new generation of RPi CPU is different form old one, which result in some of the issues during using.

WebIOPi has not provide corresponding installation package for latest RPi timely. Therefore, there are two changes in the configuration, and some BUG may exist to cause some problems to WebIOPi function. We look forward to that the author of WebIOPi to provide a complete set of the latest version of installation package to fit with RPi. WebIOPi can achieve far more than this, so we also look forward to learning and exploring with the funs.

What's next?

Thanks for your reading.

This tutorial is all over here. If you find any mistakes, omissions or you have other ideas and questions about contents of this tutorial or the kit and etc, please feel free to contact us, and we will check and correct it as soon as possible.

If you are interesting in processing, you can learn the Processing.pdf in the unzipped folder.

If you want to learn more about Arduino, Raspberry Pi, smart cars, robots and other interesting products in science and technology, please continue to focus on our website. We will continue to launch cost-effective, innovative and exciting products.
http://www.freenove.com/

Thank you again for choosing Freenove products.