

Important Information

Thank you for choosing Freenove products!

Getting Started

First, please read the **Read Me First.pdf** document in the unzipped folder you created.

If you have not yet downloaded the zip file, associated with this kit, please do so now and unzip it.

Get Support and Offer Input

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

- Product quality issues
- Product use and build issues
- Questions regarding the technology employed in our products for learning and education
- Your input and opinions are always welcome
- We also encourage your ideas and suggestions for new products and product improvements

For any of the above, you may send us an email to:

support@freenove.com

Safety and Precautions

Please follow the following safety precautions when using or storing this product:

- Keep this product out of the reach of children under 6 years old.
- This product should be **used only when there is adult supervision present** as young children lack necessary judgment regarding safety and the consequences of product misuse.
- This product contains small parts and parts, which are sharp. This product contains electrically conductive parts. **Use caution with electrically conductive parts near or around power supplies, batteries and powered (live) circuits.**
- When the product is turned ON, activated or tested, some parts will move or rotate. **To avoid injuries to hands and fingers keep them away from any moving parts!**
- It is possible that an improperly connected or shorted circuit may cause overheating. **Should this happen, immediately disconnect the power supply or remove the batteries and do not touch anything until it cools down!** When everything is safe and cool, review the product tutorial to identify the cause.
- Only operate the product in accordance with the instructions and guidelines of this tutorial, otherwise parts may be damaged or you could be injured.
- Store the product in a cool dry place and avoid exposing the product to direct sunlight.
- After use, always turn the power OFF and remove or unplug the batteries before storing.

Any concerns?  support@freenove.com



About Freenove

Freenove provides open source electronic products and services worldwide.

Freenove is committed to assist customers in their education of robotics, programming and electronic circuits so that they may transform their creative ideas into prototypes and new and innovative products. To this end, our services include but are not limited to:

- Educational and Entertaining Project Kits for Robots, Smart Cars and Drones
- Educational Kits to Learn Robotic Software Systems for Arduino, Raspberry Pi and micro:bit
- Electronic Component Assortments, Electronic Modules and Specialized Tools
- **Product Development and Customization Services**

You can find more about Freenove and get our latest news and updates through our website:

<http://www.freenove.com>

sale@freenove.com

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Preface

ESP32-S3 is a micro control unit with integrated Wi-Fi launched by Espressif, which features strong properties and integrates rich peripherals. It can be designed and studied as an ordinary Single Chip Microcontroller(SCM) chip, or connected to the Internet and used as an Internet of Things device.

ESP32-S3 can be developed using the Arduino platform, which will definitely make it easier for people who have learned Arduino to master. Moreover, the code of ESP32-S3 is completely open-source, so beginners can quickly learn how to develop and design IOT smart household products including smart curtains, fans, lamps and clocks.

Generally, ESP32-S3 projects consist of code and circuits. Don't worry even if you've never learned code and circuits, because we will gradually introduce the basic knowledge of C programming language and electronic circuits, from easy to difficult. Our products contain all the electronic components and modules needed to complete these projects. It's especially suitable for beginners.

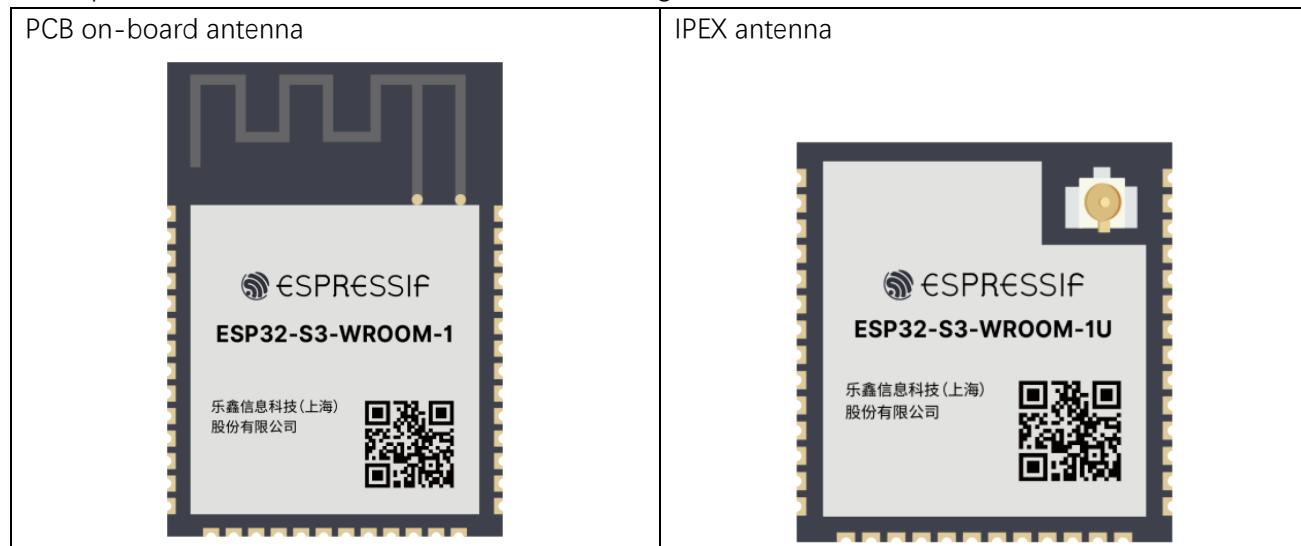
We divide each project into four parts, namely Component List, Component Knowledge, Circuit and Code. Component List helps you to prepare material for the experiment more quickly. Component Knowledge allows you to quickly understand new electronic modules or components, while Circuit helps you understand the operating principle of the circuit. And Code allows you to easily master the use of SEP32 and accessory kit. After finishing all the projects in this tutorial, you can also use these components and modules to make products such as smart household, smart cars and robots to transform your creative ideas into prototypes and new and innovative products.

In addition, if you have any difficulties or questions with this tutorial or toolkit, feel free to ask for our quick and free technical support through support@freenove.com

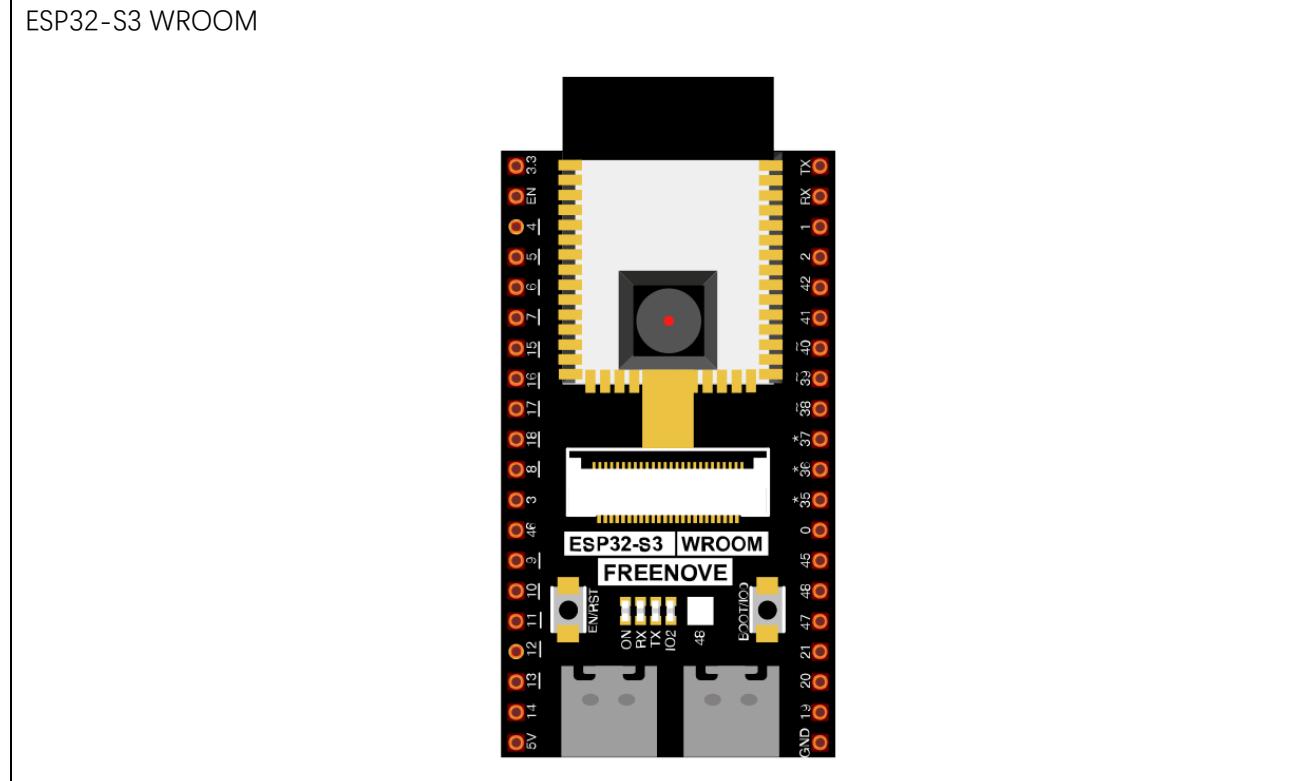
Any concerns?  support@freenove.com

ESP32-S3 WROOM

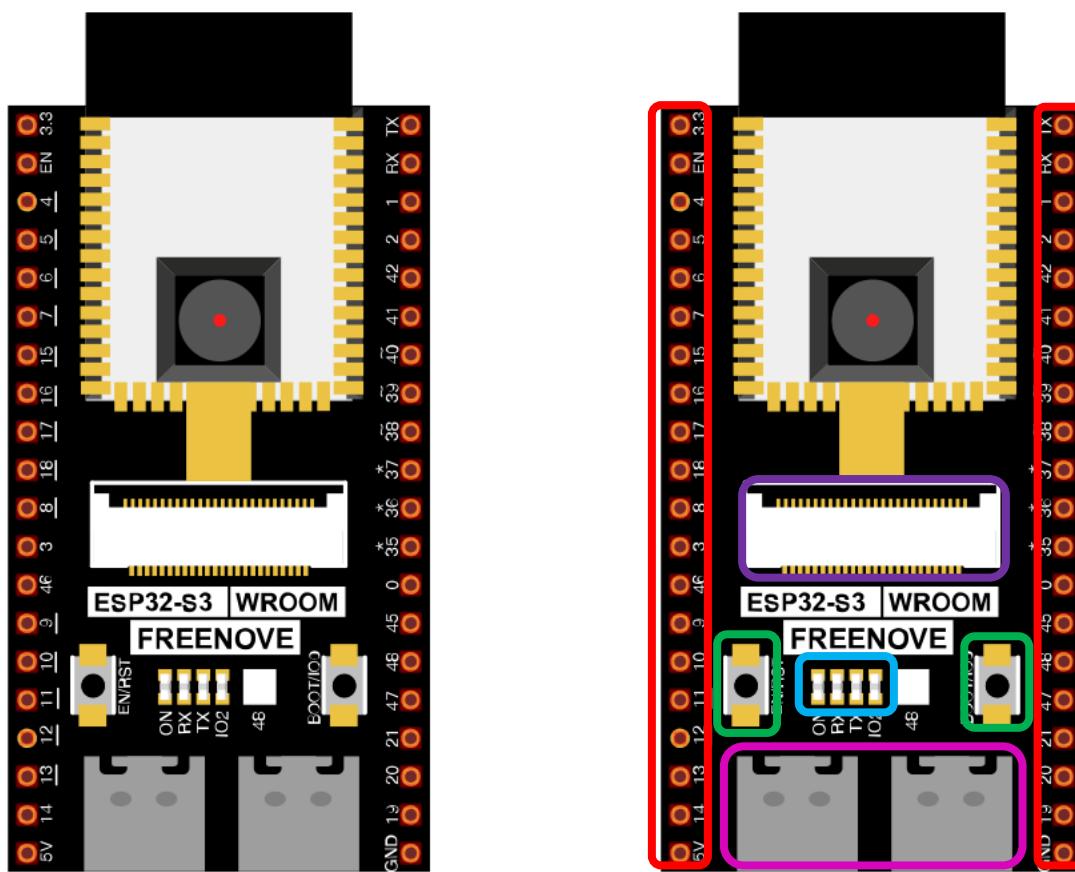
ESP32-S3-WROOM-1 has launched a total of two antenna packages, PCB on-board antenna and IPEX antenna respectively. The PCB on-board antenna is an integrated antenna in the chip module itself, so it is convenient to carry and design. The IPEX antenna is a metal antenna derived from the integrated antenna of the chip module itself, which is used to enhance the signal of the module.



In this tutorial, the ESP32-S3 WROOM is designed based on the PCB on-board antenna-packaged ESP32-S3-WROOM-1 module.



The hardware interfaces of ESP32-S3 WROOM are distributed as follows:



Compare the left and right images. We've boxed off the resources on the ESP32-S3 WROOM in different colors to facilitate your understanding of the ESP32-S3 WROOM.

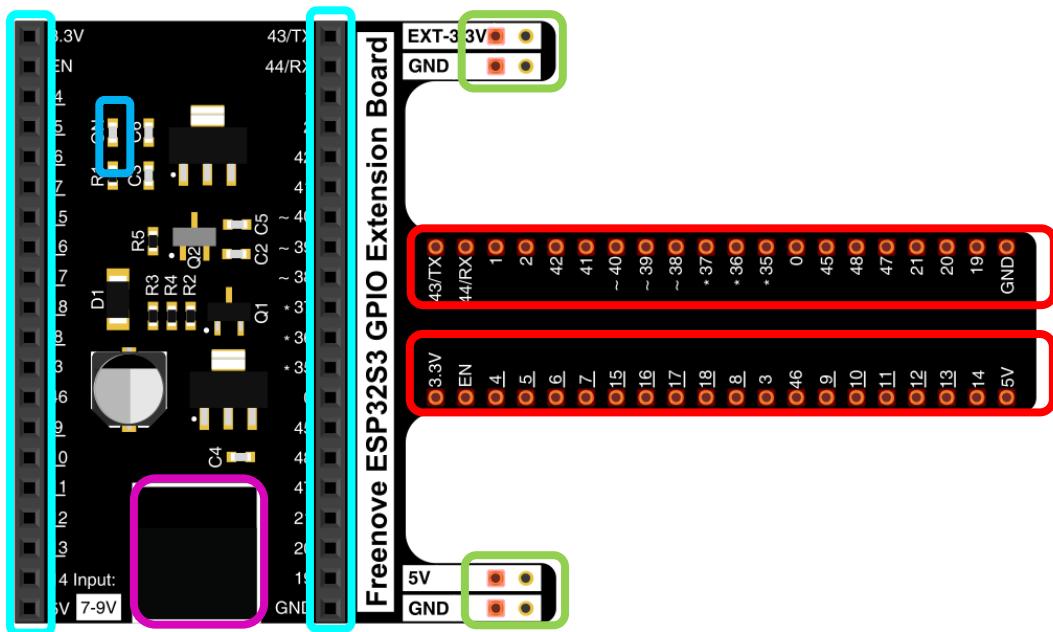
Box color	Corresponding resources introduction
Red	GPIO pin
Cyan	LED indicator
Purple	Camera interface
Green	Reset button, Boot mode selection button
Magenta	USB port

For more information, please visit: https://www.espressif.com.cn/sites/default/files/documentation/esp32-s3-wroom-1_wroom-1u_datasheet_en.pdf.

Extension board of the ESP32-S3 WROOM

And we also design an extension board, so that you can use the ESP32-S3 more easily in accordance with the circuit diagram provided. The followings are their photos.

The hardware interfaces of ESP32-S3 WROOM are distributed as follows:



We've boxed off the resources on the ESP32-S3 WROOM in different colors to facilitate your understanding of the ESP32-S3 WROOM.

Box color	Corresponding resources introduction
Red	GPIO pin
Blue	LED indicator
Green	GPIO interface of development board
Magenta	power supplied by the extension board
	External power supply

In ESP32S3, GPIO is an interface to control peripheral circuit.

In the following projects, we only use USB cable to power ESP32-S3 WROOM by default.

In the whole tutorial, we don't use T extension to power ESP32-S3 WROOM. So 5V and 3.3V (including EXT 3.3V) on the extension board are provided by ESP32-S3 WROOM.

We can also use DC jack of extension board to power ESP32-S3 WROOM. In this way, 5v and EXT 3.3V on extension board are provided by external power resource.

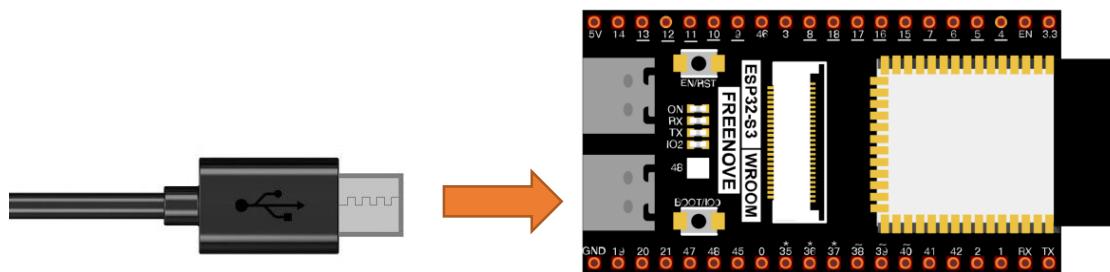
CH343 (Importance)

ESP32-S3 WROOM uses CH343 to download codes. So before using it, we need to install CH343 driver in our computers.

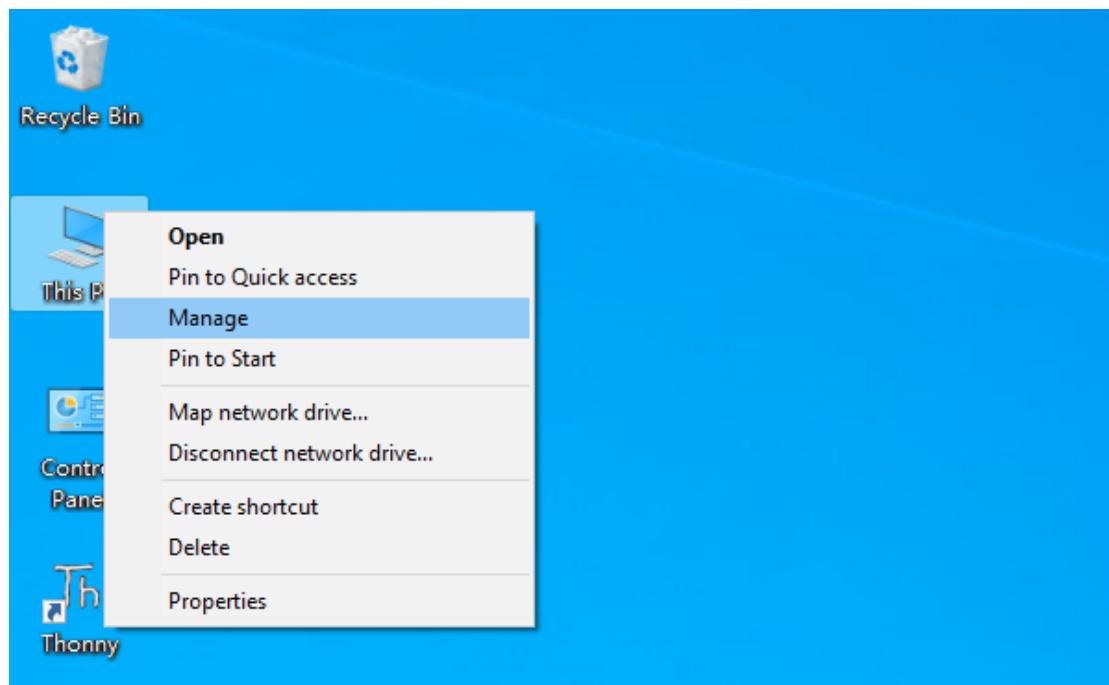
Windows

Check whether CH343 has been installed

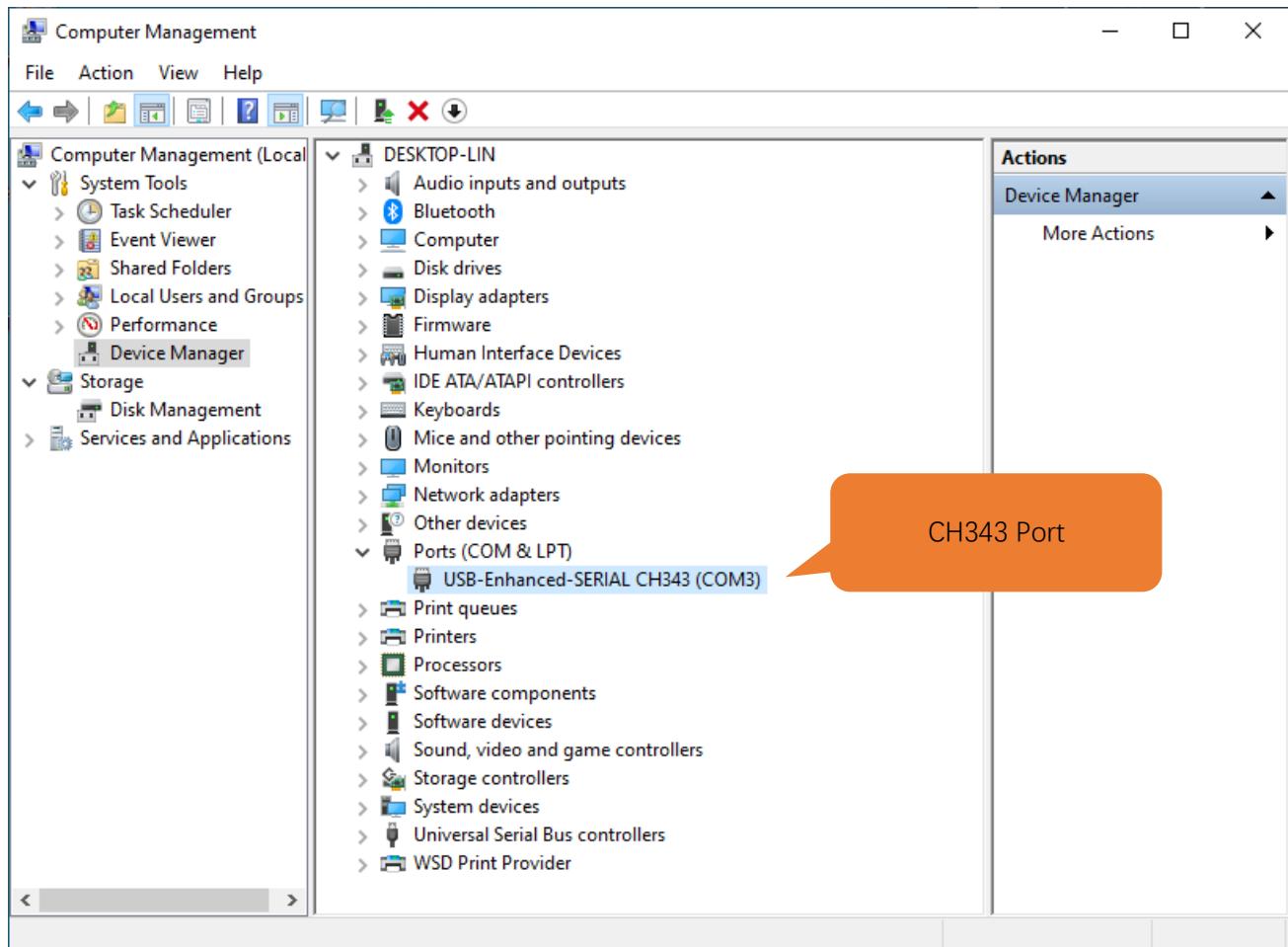
1. Connect your computer and ESP32-S3 WROOM with a USB cable.



2. Turn to the main interface of your computer, select "This PC" and right-click to select "Manage".



3. Click "Device Manager". If your computer has installed CH343, you can see "USB-Enhanced-SERIAL CH343 (COMx)". And you can click [here](#) to move to the next step.



Installing CH343

1. First, download CH343 driver, click <http://www.wch-ic.com/search?t=all&q=ch343> to download the appropriate one based on your operating system.

keyword ch343

Downloads(8)

file category	file content	version	upload time
DataSheet			
CH343DS1.PDF	CH343 datasheet, USB to single serial port, supports up to 6M baud rate, serial port signals support 5V/3.3V/2.5V/1.8V, built-in crystal oscillator. CH343 supports built-in CDC driver in operating system or multi-functional high-speed VCP manufacture driver.	1.5	2021-11-18
Driver&Tools			
CH343SER.ZIP	For CH342/CH343/CH344/CH347/CH9101/CH9102/CH9103/CH9143, USB to high-speed serial port VCP vendor driver, supports Windows 11/10/8.1/8/7/VISTA/XP/2000	1.61	2022-05-13
CH343CDC.ZIP	For CH342/CH343/CH344/CH347/CH910X/CH9143/CH9340, USB to CDC serial port driver, supports Windows 11/10/8.1/8/7/VISTA/XP/2000	1.4	2022-05-13
CH343SER.EXE	For CH342/CH343/CH344/CH347/CH9101/CH9102/CH9103/CH9143, USB to high-speed serial port VCP vendor driver, supports Windows 11/10/8.1/8/7/VISTA/XP/2000	1.61	2022-05-13
CH34XSER_MAC.ZIP	For MAC, CH342/CH343/CH344/CH347/CH9101/CH9102/CH9103/CH9143, USB to serial port VCP vendor driver of macOS	1.7	2022-05-13
CH343CDC.EXE	For CH342/CH343/CH344/CH347/CH910X/CH9143/CH9340, USB to CDC serial port driver, supports Windows 11/10/8.1/8/7/VISTA/XP/2000	1.4	2022-05-13
Application			
CH34xSerCfg.ZIP	USB configuration tool of Windows for CH340/CH342/CH343/CH344/CH347/CH348/CH9101/CH9102/CH9103. Via this tool, the chip's Vendor ID, product ID, maximum current value, BCD version	1.2	2022-05-24

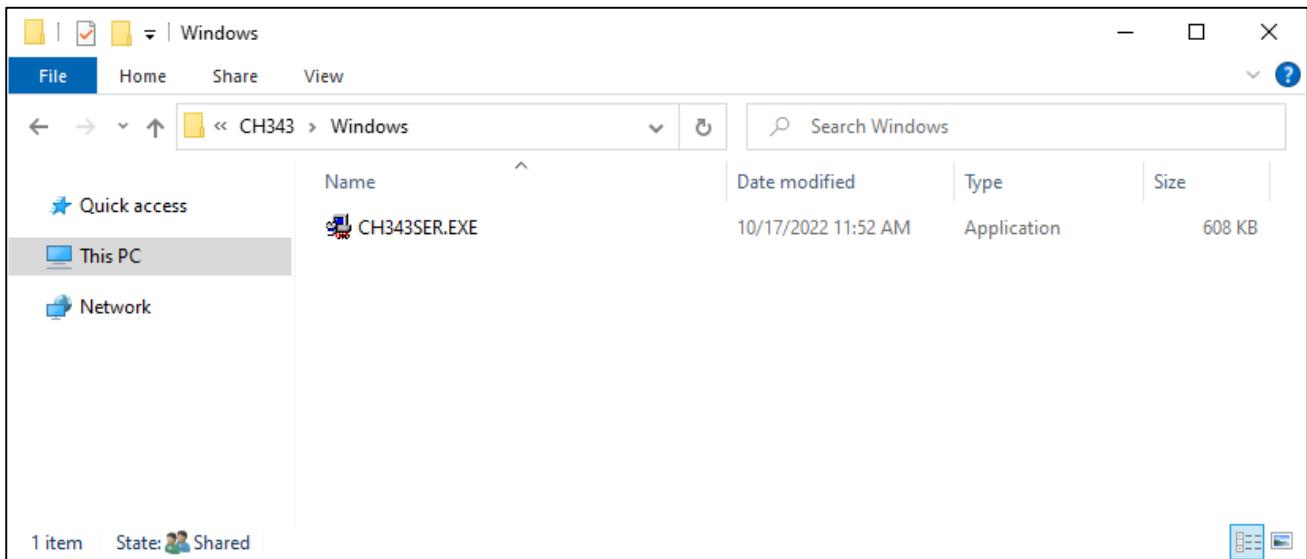
If you would not like to download the installation package, you can open

["Freenove_Basic_Starter_Kit_for_ESP32_S3/CH343"](#), we have prepared the installation package.

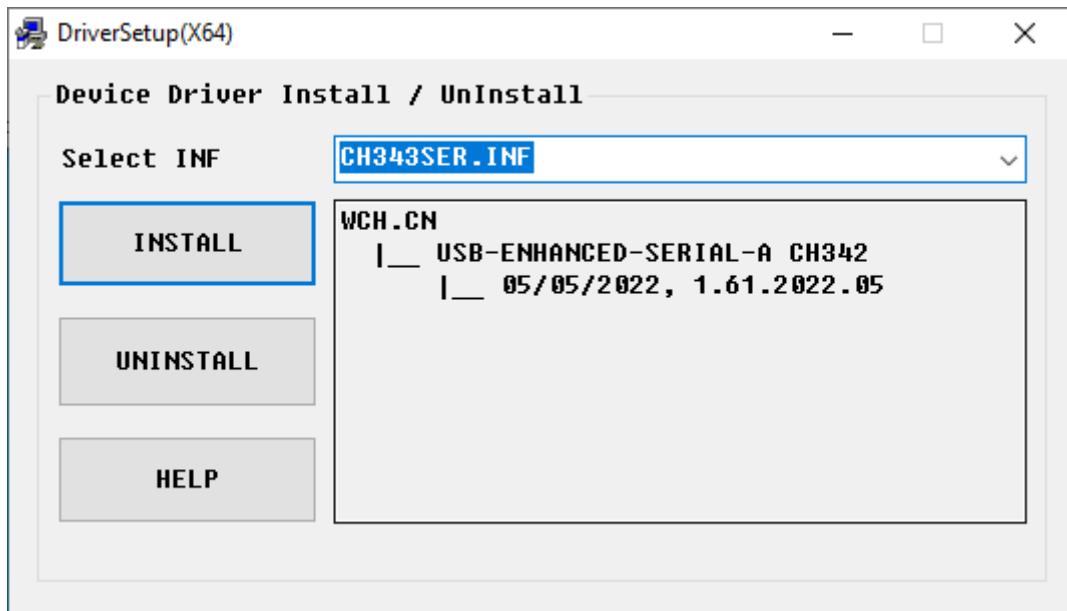
 Linux	10/17/2022 1:30 PM	File folder
 MAC	10/17/2022 1:30 PM	File folder
 Windows	10/17/2022 1:30 PM	File folder



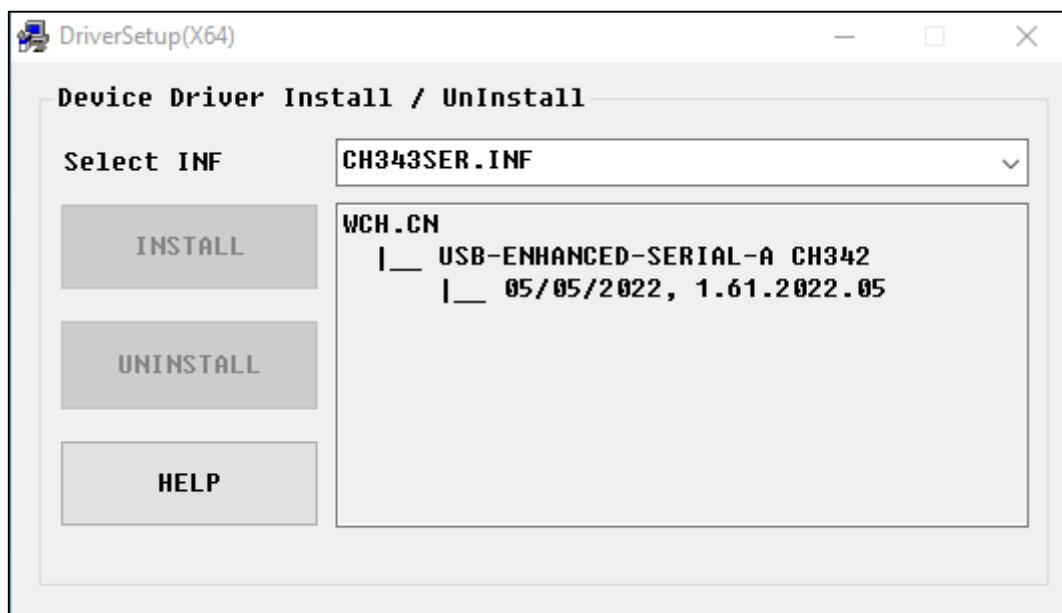
2. Open the folder “Freenove_Basic_Starter_Kit_for_ESP32_S3/CH343/Windows/”



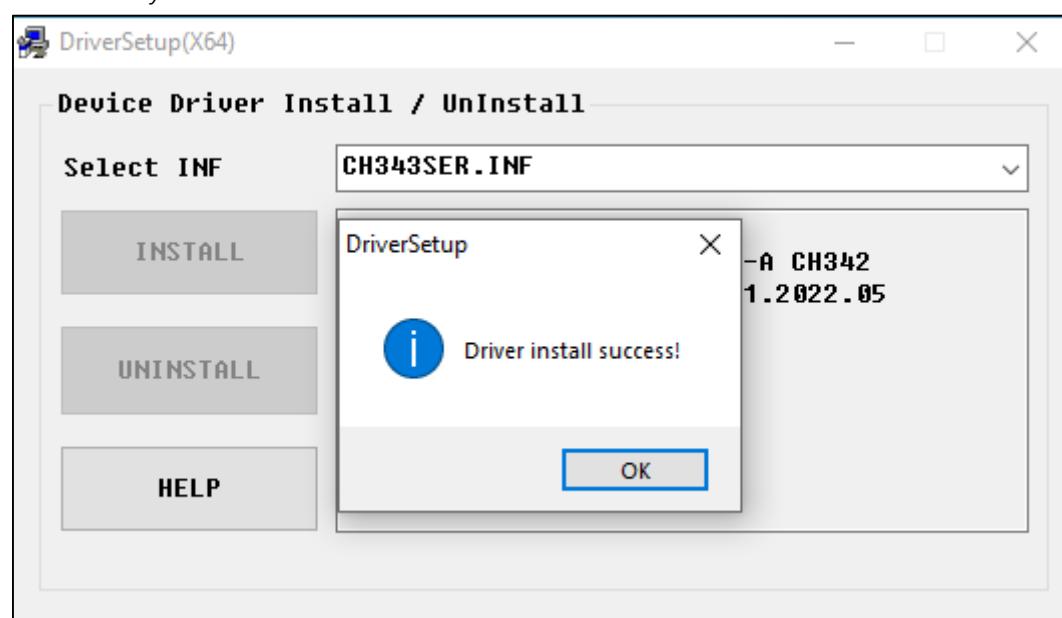
3. Double click “CH343SER.EXE”.



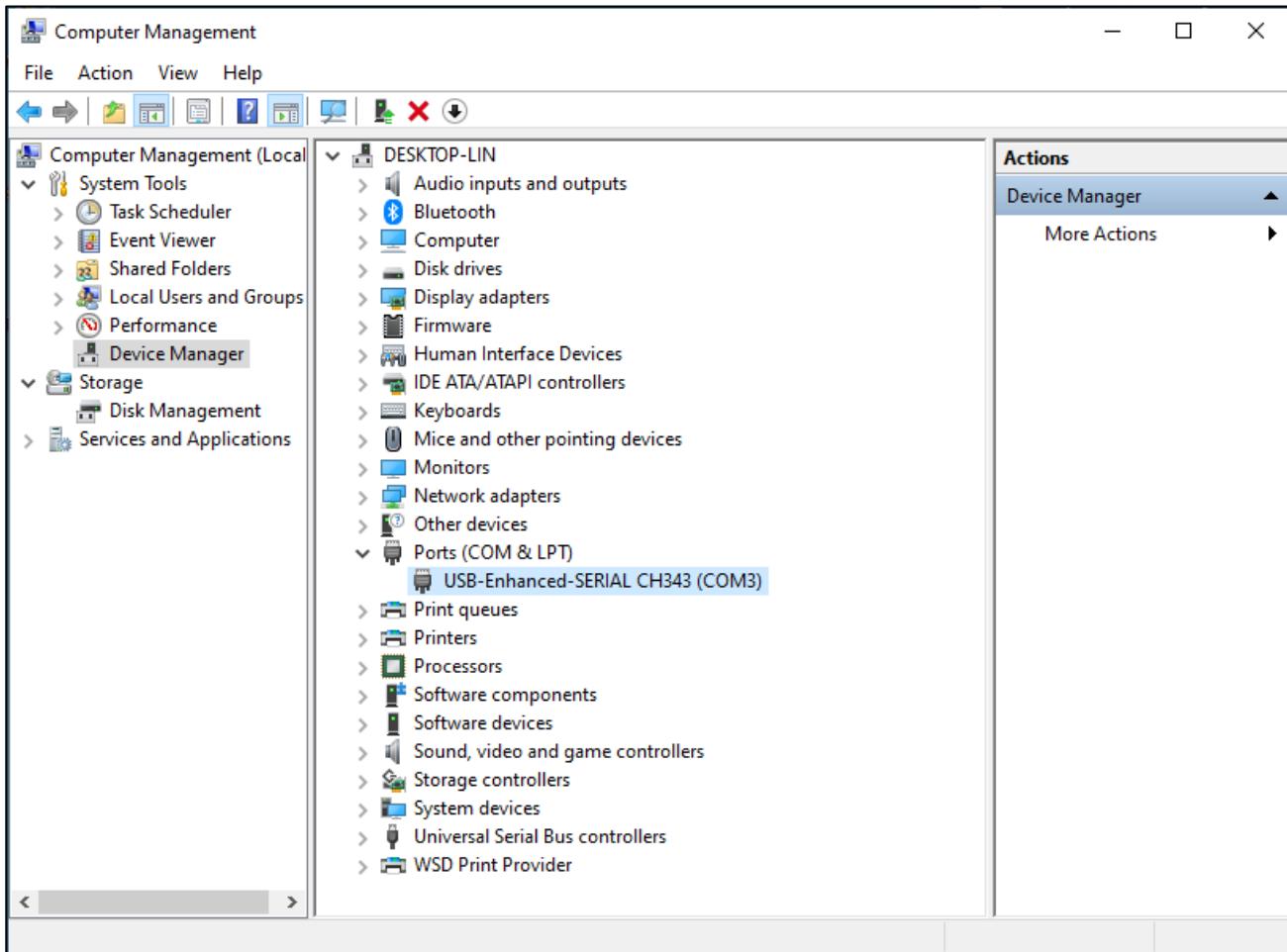
4. Click “INSTALL” and wait for the installation to complete.



5. Install successfully. Close all interfaces.



6. When ESP32-S3 WROOM is connected to computer, select “This PC”, right-click to select “Manage” and click “Device Manager” in the newly pop-up dialog box, and you can see the following interface.



7. So far, CH343 has been installed successfully. Close all dialog boxes.

MAC

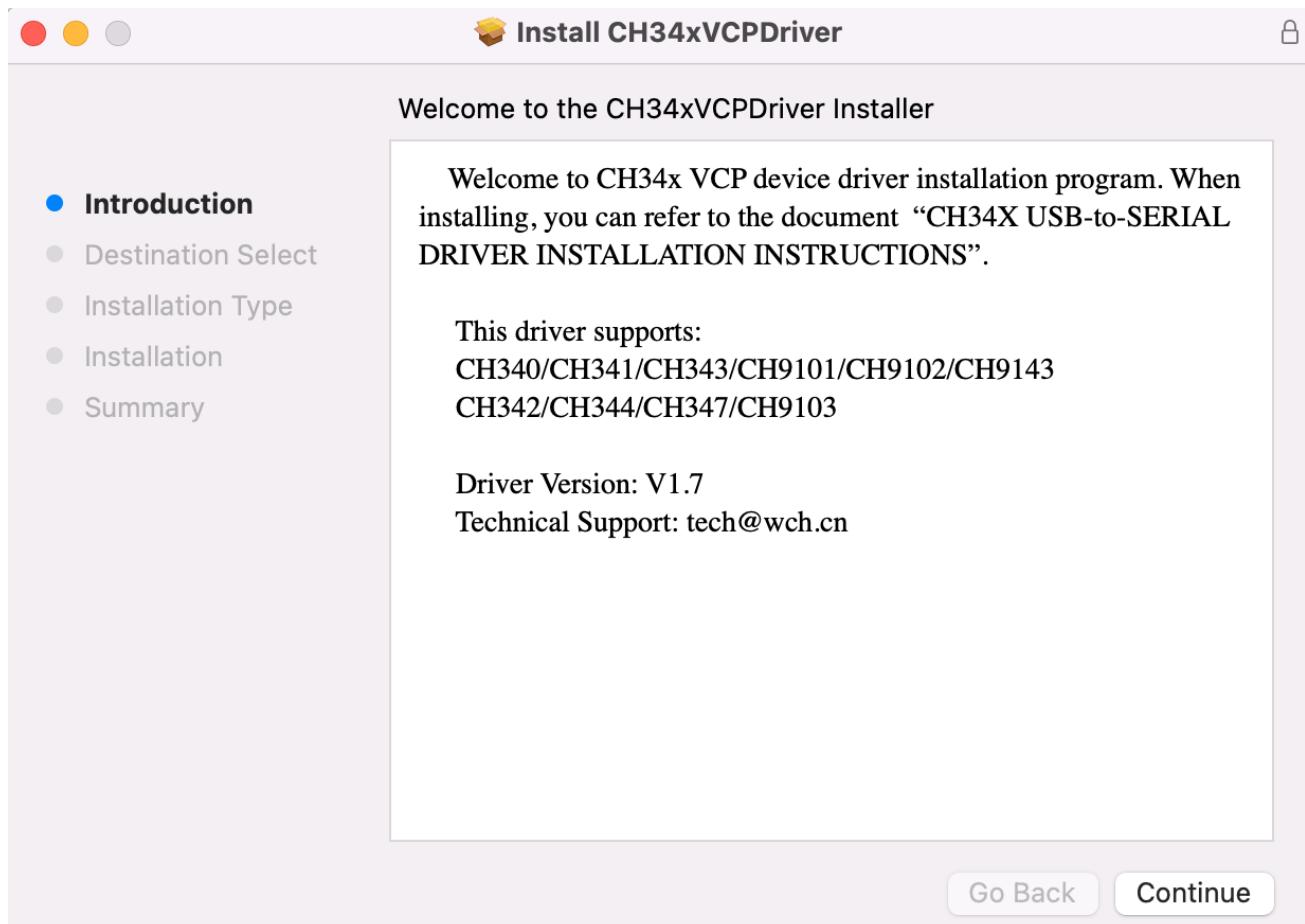
First, download CH343 driver, click <http://www.wch-ic.com/search?t=all&q=ch343> to download the appropriate one based on your operating system.

keyword ch343				
Downloads(8)				
file category	file content	version	upload time	
DataSheet				
CH343DS1.PDF	CH343 datasheet, USB to single serial port, supports up to 6M baud rate, serial port signals support 5V/3.3V/2.5V/1.8V, built-in crystal oscillator. CH343 supports built-in CDC driver in operating system or multi-functional high-speed VCP manufacture driver.	1.5	2021-11-18	
Driver&Tools				
CH343SER.ZIP	For CH342/CH343/CH344/CH347/CH9101/CH9102/CH9103/CH9143, USB to high-speed serial port VCP vendor driver, supports Windows 11/10/8.1/8/7/VISTA/XP/2000	1.61	2022-05-13	
CH343CDC.ZIP	For CH342/CH343/CH344/CH347/CH910X/CH9143/CH9340, USB to CDC serial port driver, supports Windows 11/10/8.1/8/7/VISTA/XP/2000	1.4	2022-05-13	
CH343SER.EXE	For CH342/CH343/CH344/CH347/CH9101/CH9102/CH9103/CH9143, USB to high-speed serial port VCP vendor driver, supports Windows 11/10/8.1/8/7/VISTA/XP/2000	1.61	2022-05-13	
CH34XSER_MAC.ZI...	For MAC, CH342/CH343/CH344/CH347/CH9101/CH9102/CH9103/CH9143, USB to serial port VCP vendor driver of macOS	1.7	2022-05-13	
CH343CDC.EXE	For CH342/CH343/CH344/CH347/CH910X/CH9143/CH9340, USB to CDC serial port driver, supports Windows 11/10/8.1/8/7/VISTA/XP/2000	1.4	2022-05-13	
Application				
CH34xSerCfg.ZIP	USB configuration tool of Windows for CH340/CH342/CH343/CH344/CH347/CH348/CH9101/CH9102/CH9103. Via this tool, the chip's Vendor ID, product ID, maximum current value, BCD version	1.2	2022-05-24	

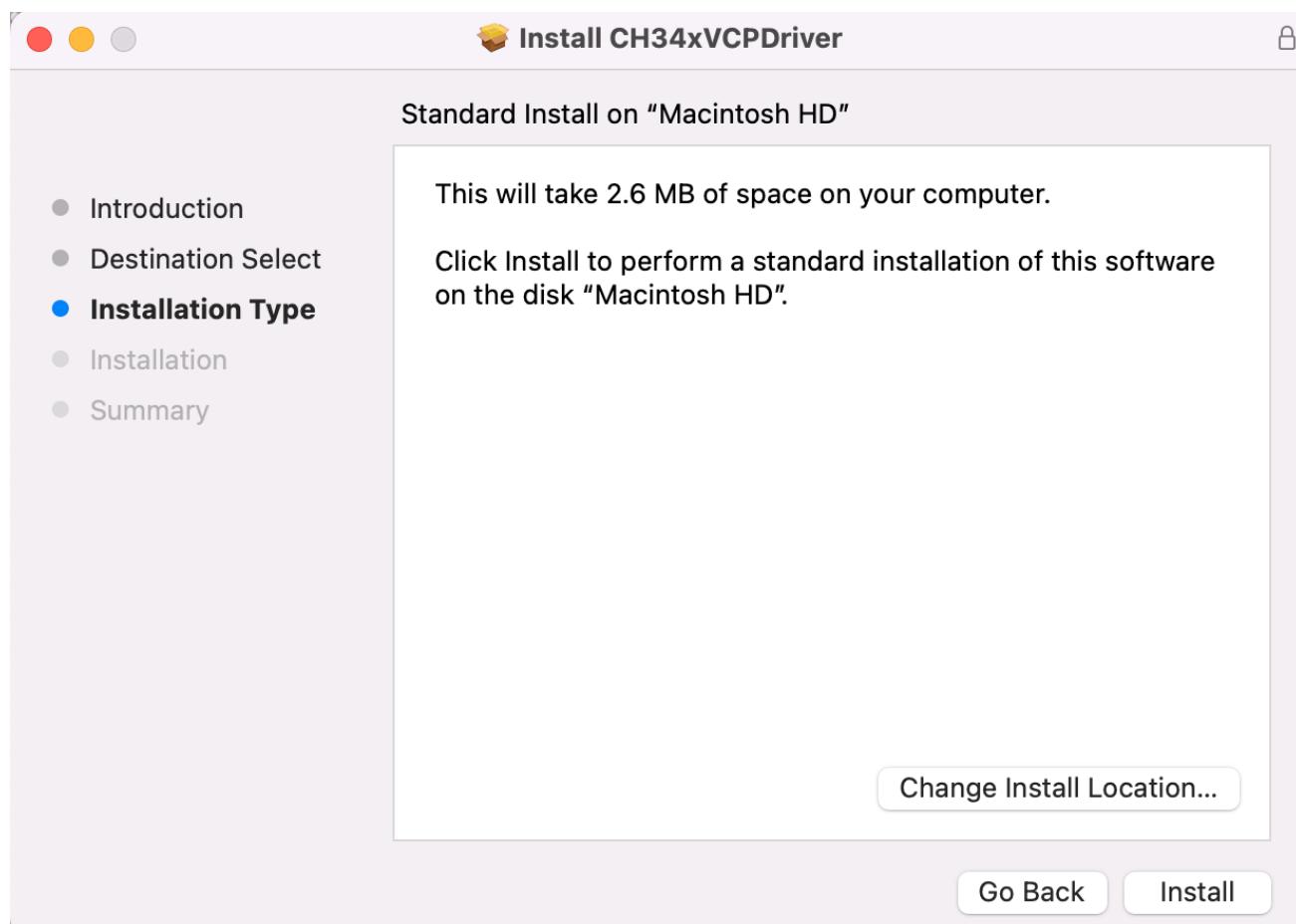
If you would not like to download the installation package, you can open “**Freenove_Basic_Starter_Kit_for_ESP32_S3/CH343**”, we have prepared the installation package. Second, open the folder “**Freenove_Basic_Starter_Kit_for_ESP32_S3/CH343/MAC/**”



Third, click Continue.

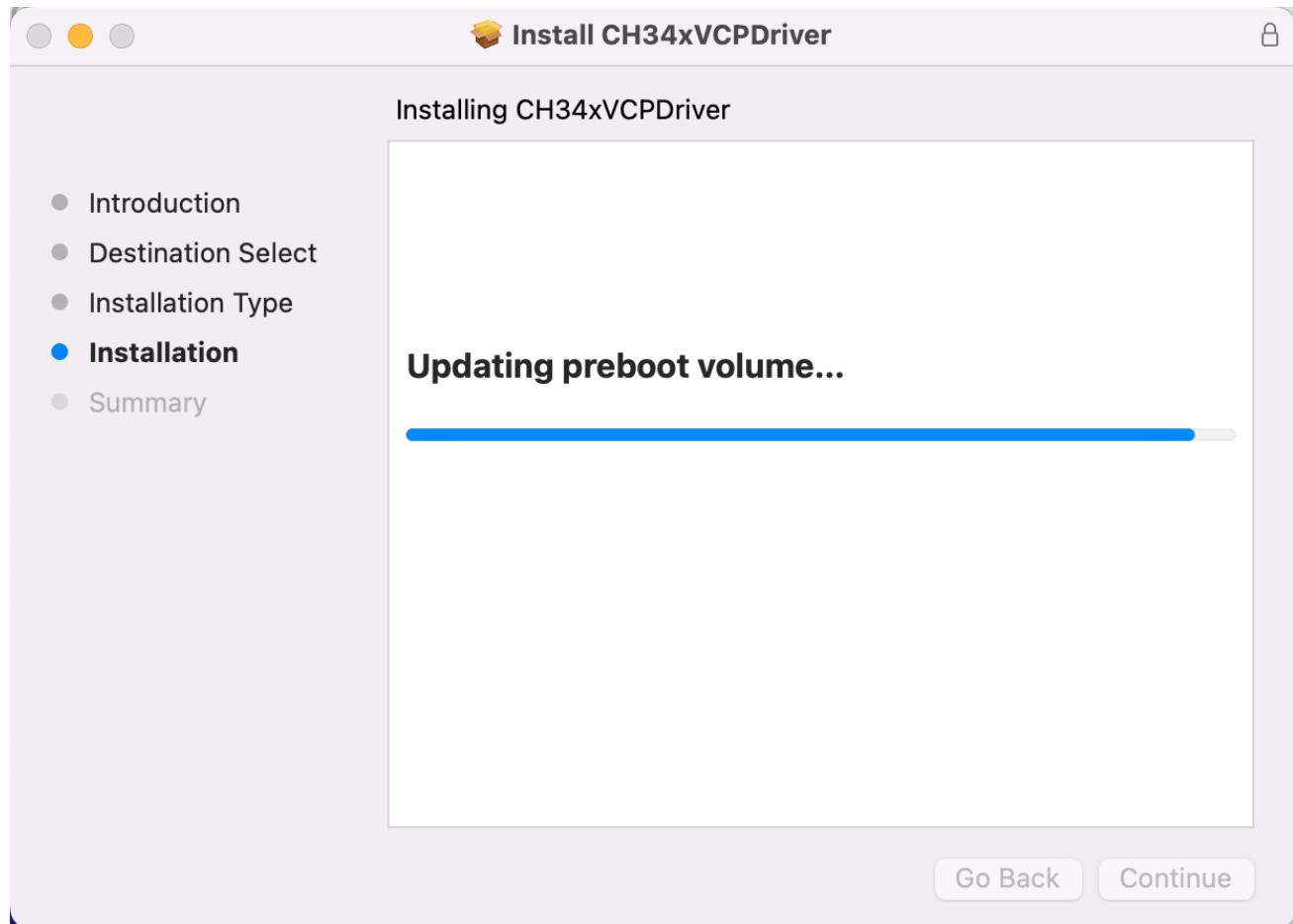


Fourth, click Install.

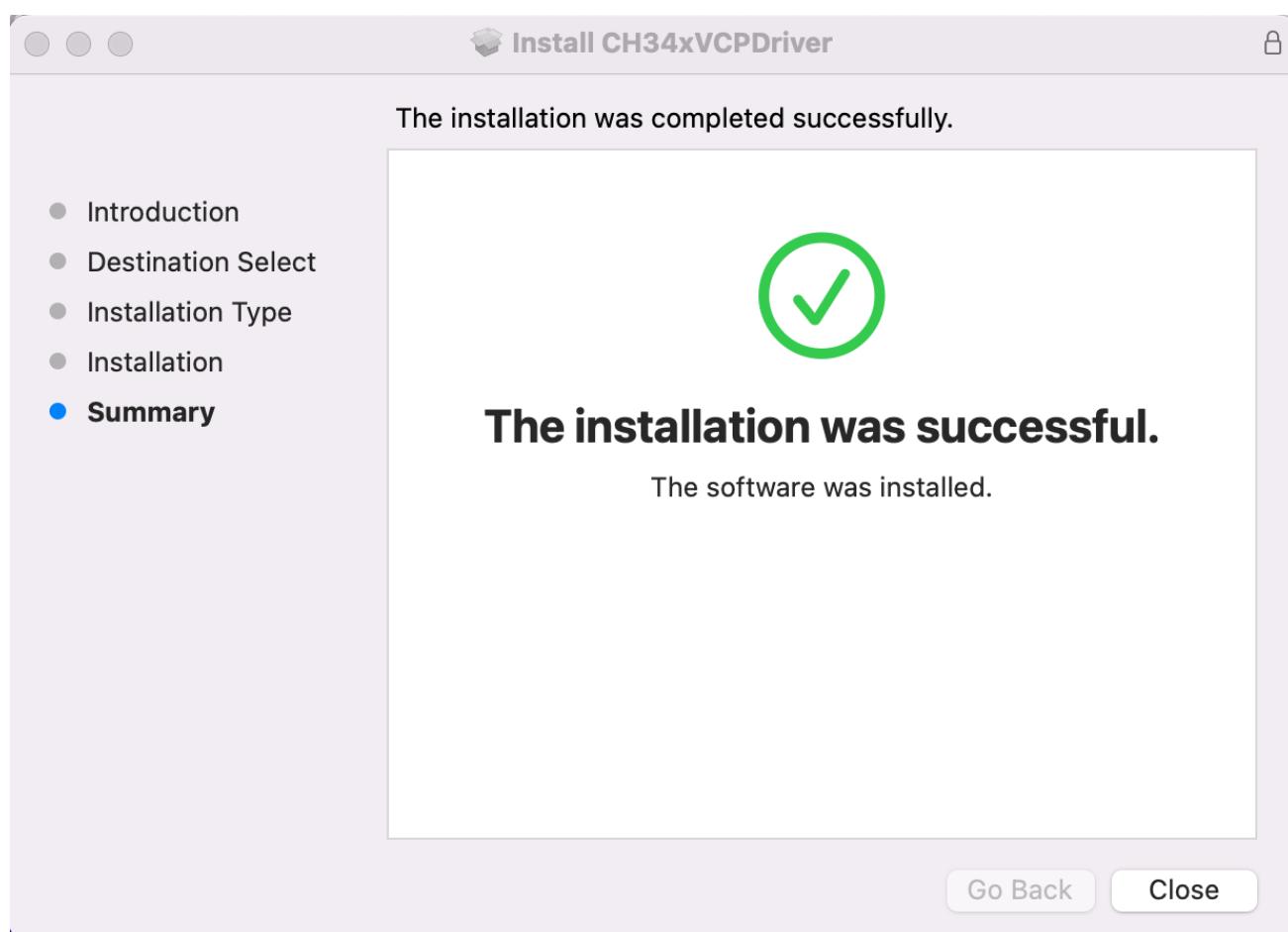




Then, waiting Finsh.

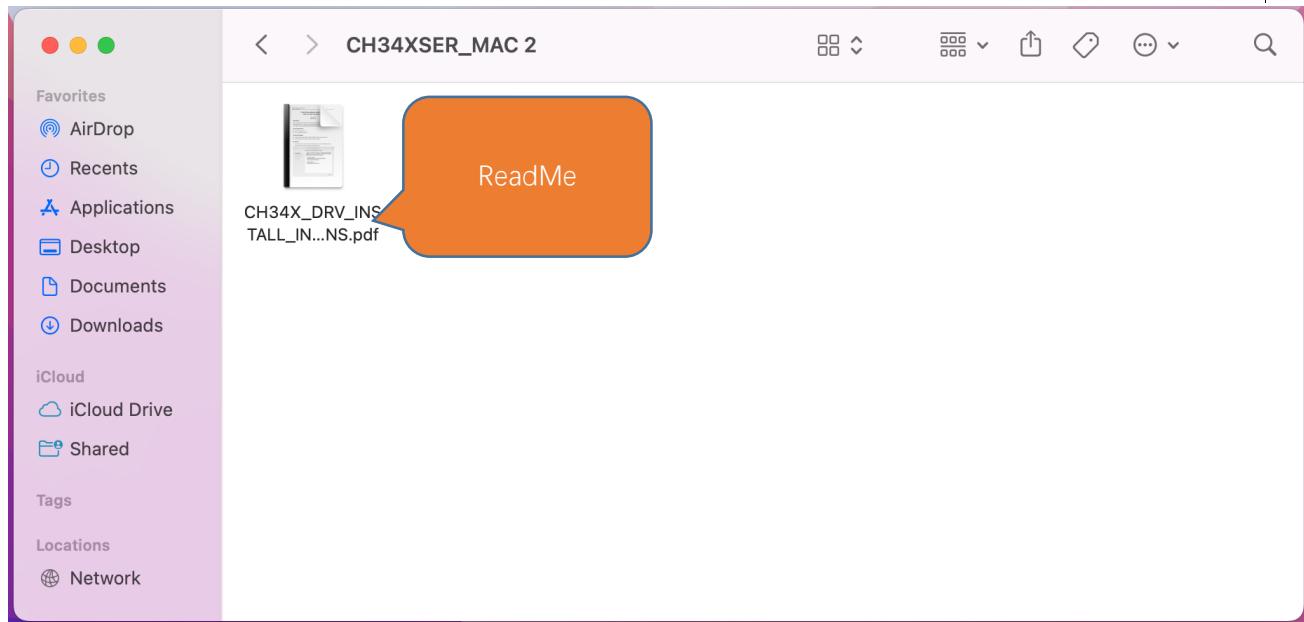


Finally, restart your PC.





If you still haven't installed the CH340 by following the steps above, you can view `readme.pdf` to install it.



Programming Software

Thonny is a free, open-source software platform with compact size, simple interface, simple operation and rich functions, making it a Python IDE for beginners. In this tutorial, we use this IDE to develop ESP32-S3 during the whole process.

Thonny supports various operating system, including Windows、Mac OS、Linux.

Downloading Thonny

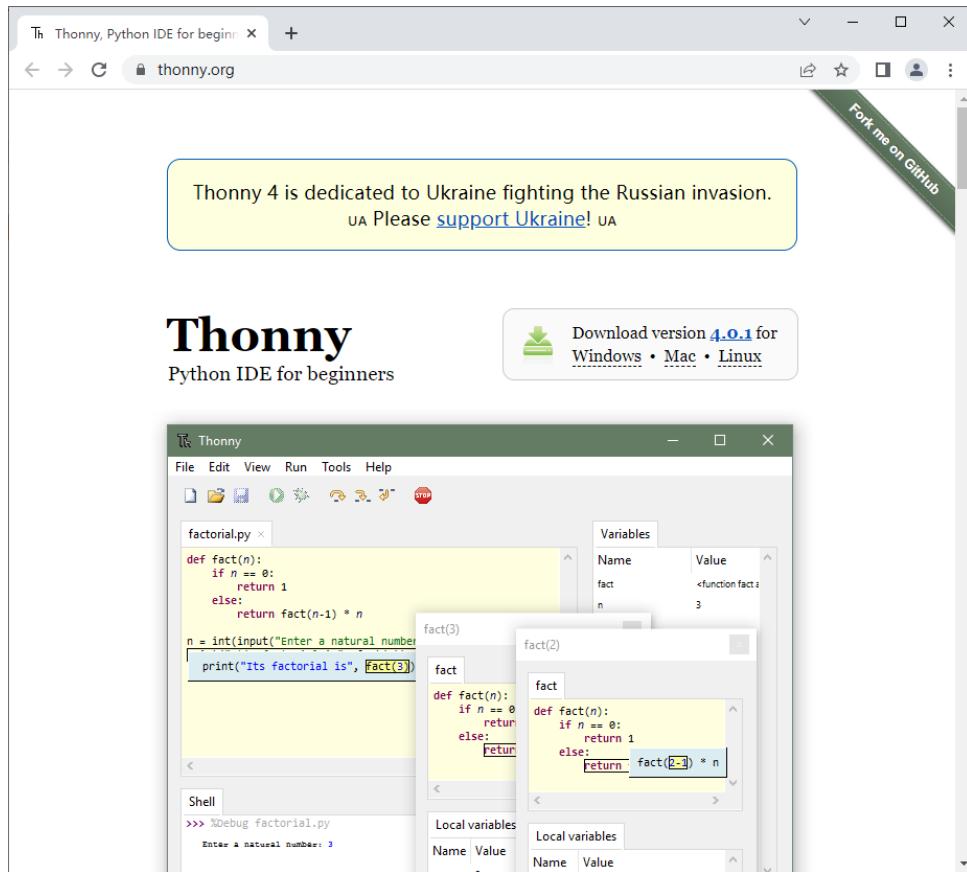
Official website of Thonny: <https://thonny.org>

Open-source code repositories of Thonny: <https://github.com/thonny/thonny>

Follow the instruction of official website to install Thonny or click the links below to download and install.
(Select the appropriate one based on your operating system.)

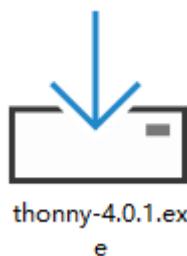
Operating System	Download links/methods
Windows	https://github.com/thonny/thonny/releases/download/v4.0.1/thonny-4.0.1.exe
Mac OS	https://github.com/thonny/thonny/releases/download/v4.0.1/thonny-4.0.1.pkg
Linux	Official downloads for Linux Installer (installs private Python 3.10 on x86_64, uses existing python3 elsewhere) bash <(wget -O - https://thonny.org/installer-for-linux) Re-using an existing Python installation (for advanced users) pip3 install thonny 3rd party distributions (may have older version) Flatpak flatpak install org.thonny.Thonny Debian, Raspbian, Ubuntu, Mint and others sudo apt install thonny Fedor sudo dnf install thonny

You can also open “**Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Software**”, we have prepared it in advance.



Installing on Windows

The icon of Thonny after downloading is as below. Double click "thonny-4.0.1.exe".

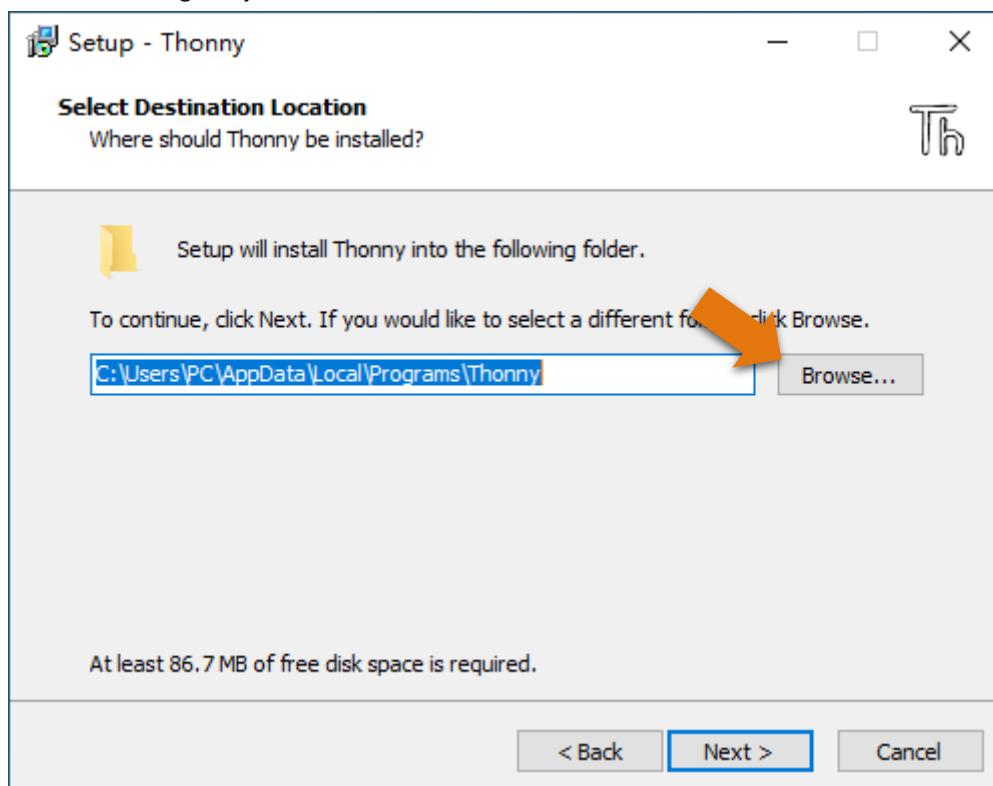


If you're not familiar with computer software installation, you can simply keep clicking "Next" until the installation completes.



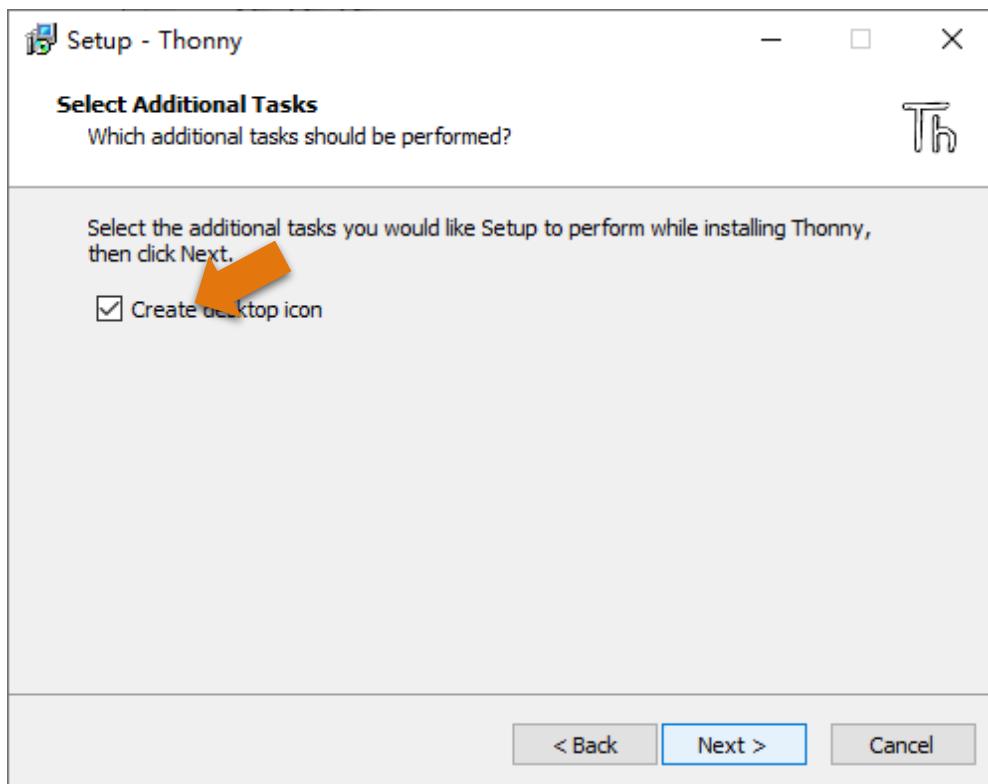
If you want to change Thonny's installation path, you can click "Browse" to modify it. After selecting installation path, click "OK".

If you do not want to change it, just click "Next".

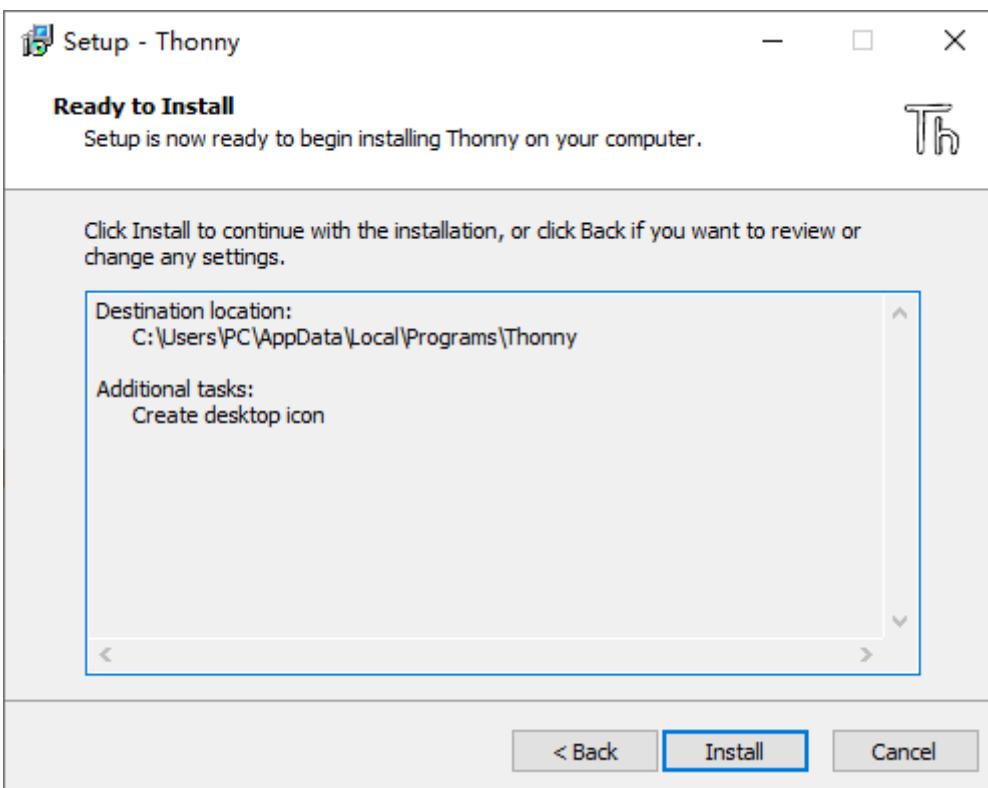




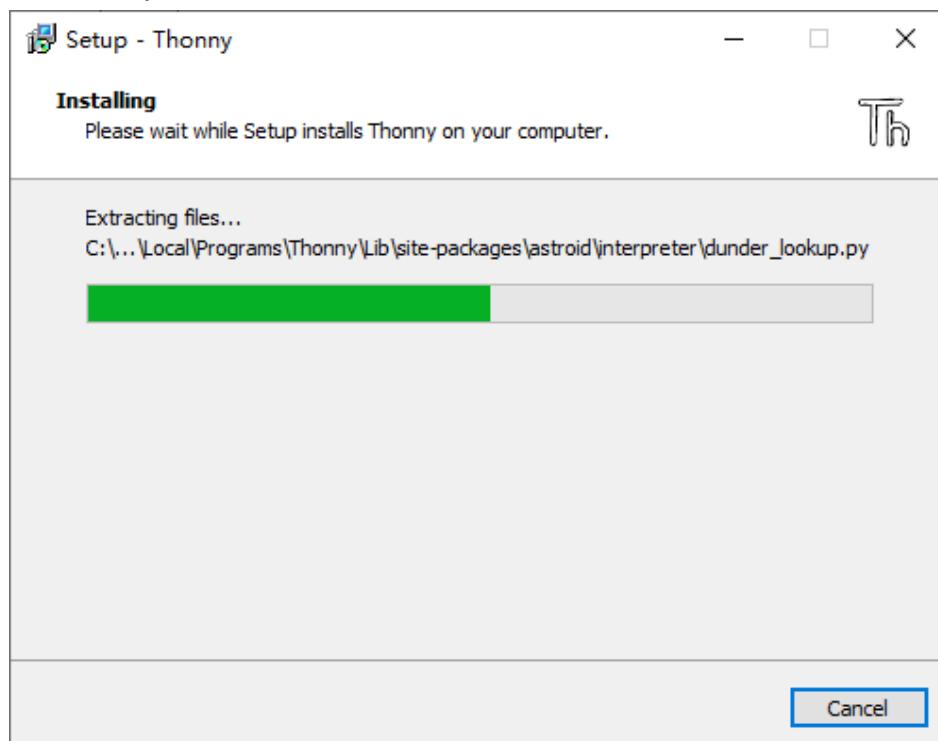
Check “Create desktop icon” and then it will generate a shortcut on your desktop to facilitate you to open Thonny later.



Click “install” to install the software.



During the installation process, you only need to wait for the installation to complete, and you must not click "Cancel", otherwise Thonny will fail to be installed.



Once you see the interface as below, Thonny has been installed successfully.



If you've checked "Create desktop icon" during the installation process, you can see the below icon on your desktop.

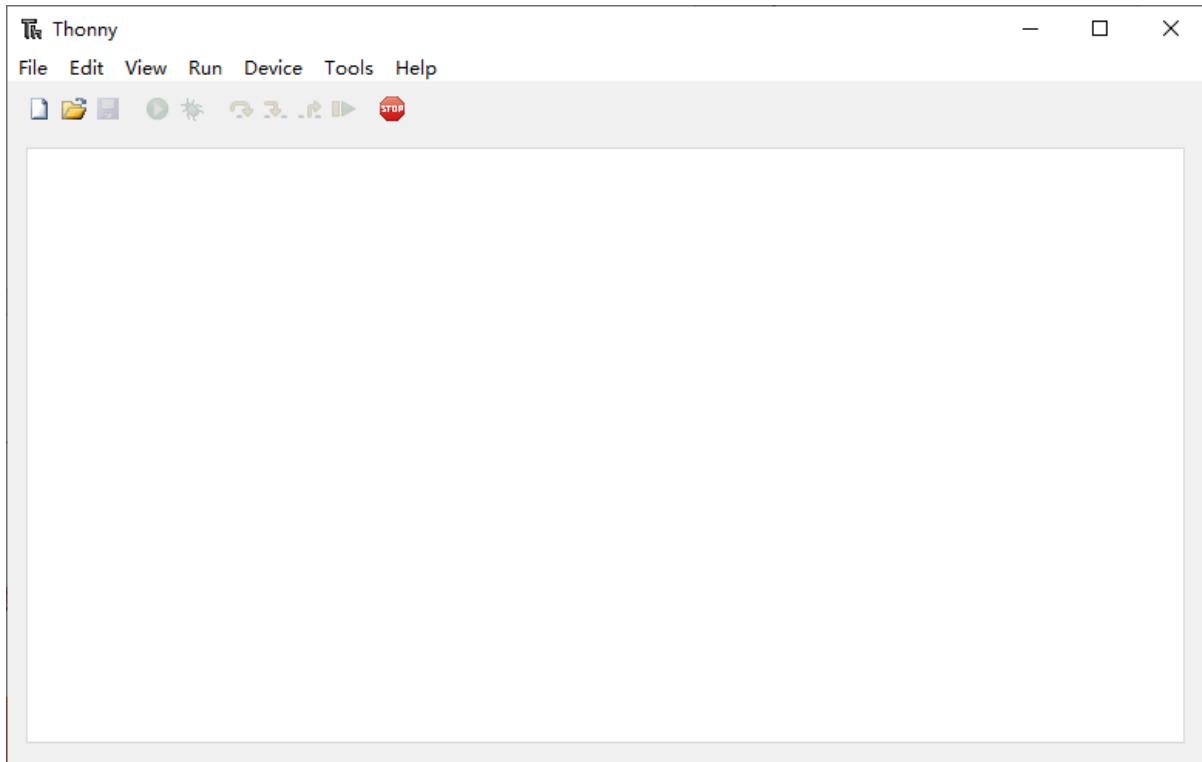


Any concerns? [✉ support@freenove.com](mailto:support@freenove.com)

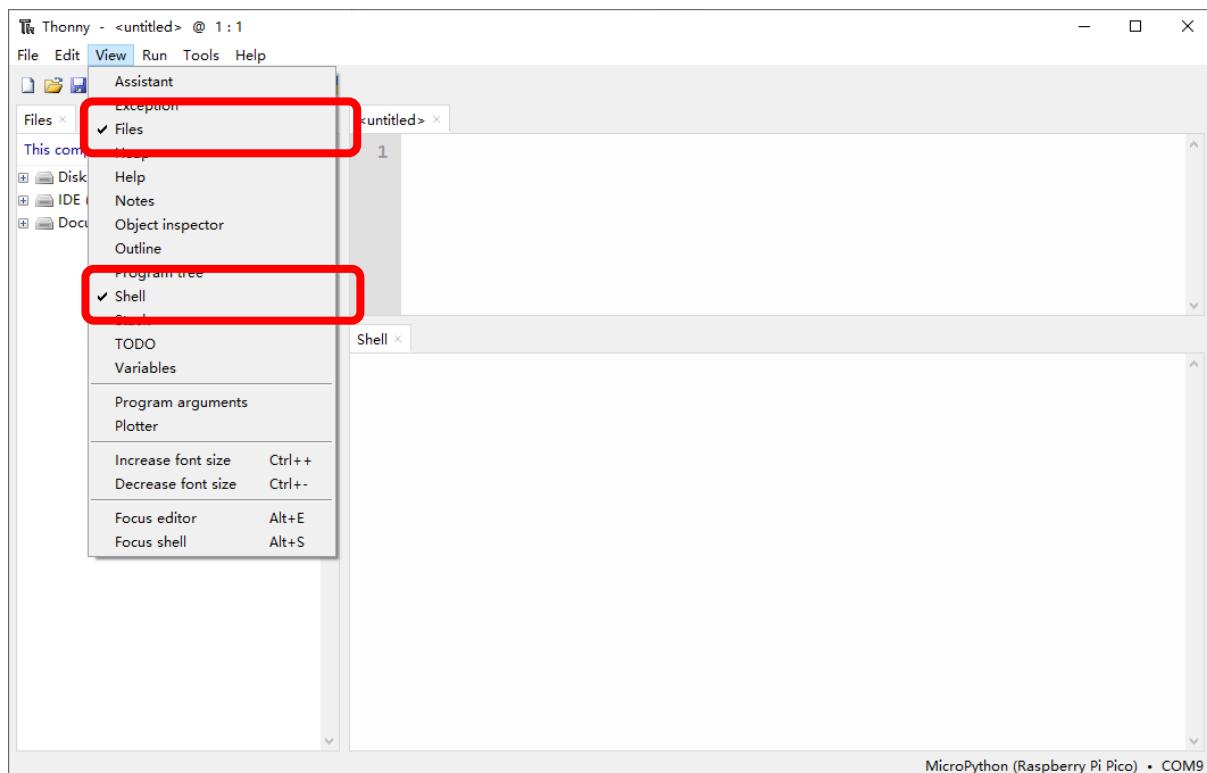


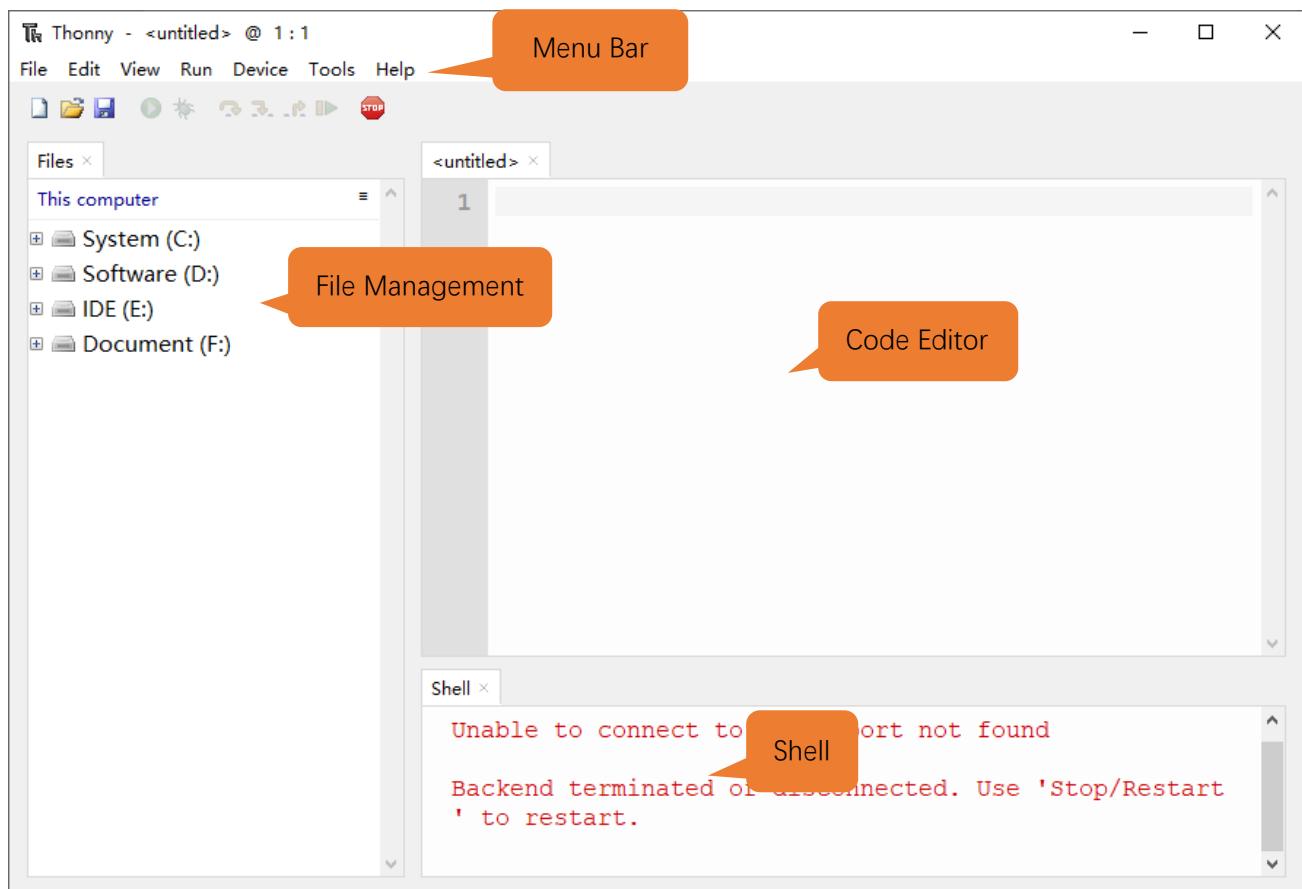
Basic Configuration of Thonny

Click the desktop icon of Thonny and you can see the interface of it as follows:



Select "View" → "Files" and "Shell".







Burning Micropython Firmware (Important)

To run Python programs on ESP32S3, we need to burn a firmware to ESP32-S3 first.

Downloading Micropython Firmware

Official website of microPython: <http://micropython.org/>

Webpage listing firmware of microPython for ESP32S3: https://micropython.org/download/GENERIC_S3/

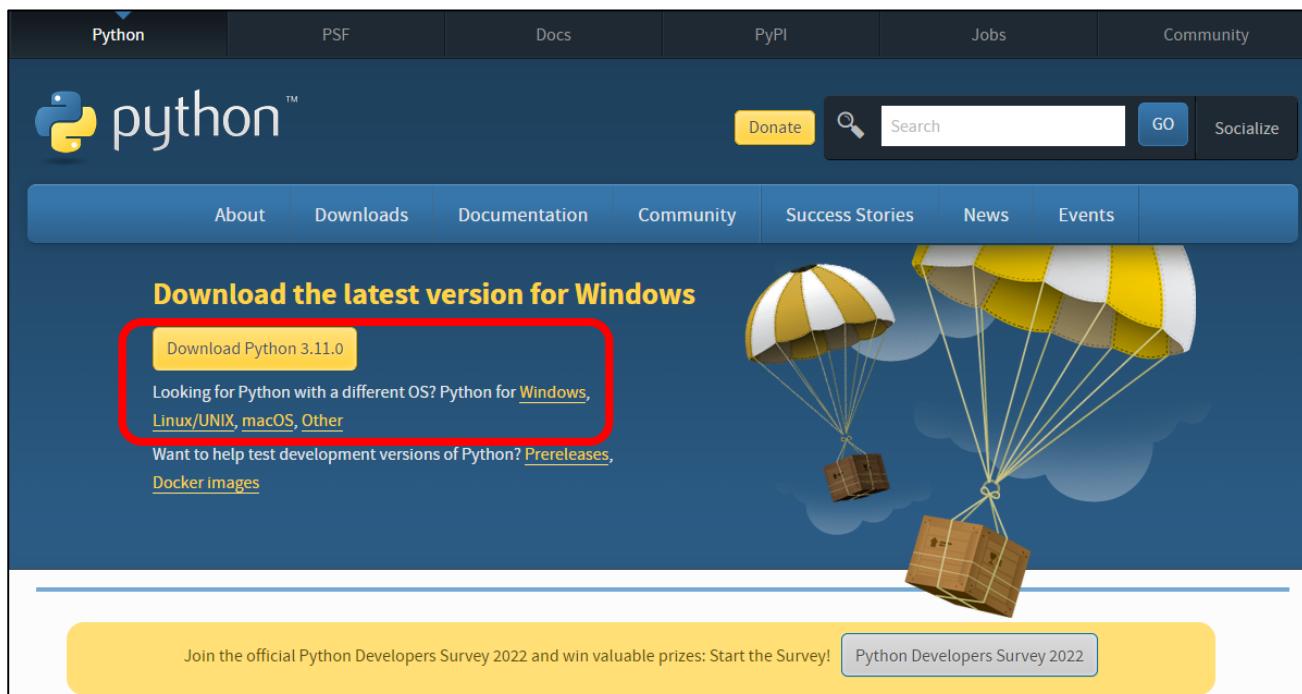
The screenshot shows the "Firmware" section of the MicroPython website. Under the "Releases" heading, the link "v1.19.1 (2022-06-18) .uf2 [.bin] [.elf] [.map] [Release notes] (latest)" is highlighted with an orange border. Below this, under the "Nightly builds" heading, several other build links are listed in red text: v1.19.1-608-gb52fe52d3 (2022-11-02) .uf2 [.bin] [.elf] [.map], v1.19.1-607-g46bb52adf (2022-11-01) .uf2 [.bin] [.elf] [.map], v1.19.1-604-g3ed017677 (2022-10-31) .uf2 [.bin] [.elf] [.map], and v1.19.1-601-g5b2929a0e (2022-10-31) .uf2 [.bin] [.elf] [.map].

Firmware used in this tutorial is **GENERIC_S3-20220618-v1.19.1.bin**

This file is also provided in our data folder "**Freenove_Basic_Starter_Kit_for_ESP32_S3 /Python/Python_Firmware**".。

Install python3

Before burning the firmware to ESP32S3, we need to ensure that Python 3 has been installed on the computer. If you have not already installed it, please install it first. Python Official download address is: <https://www.python.org/downloads/>

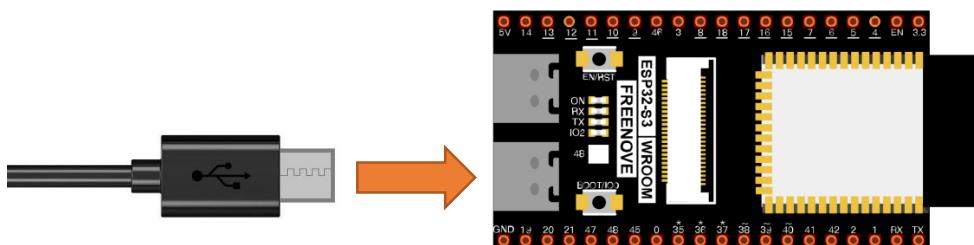


Please follow the official instructions to download and install.

Burning a Micropython Firmware

Window

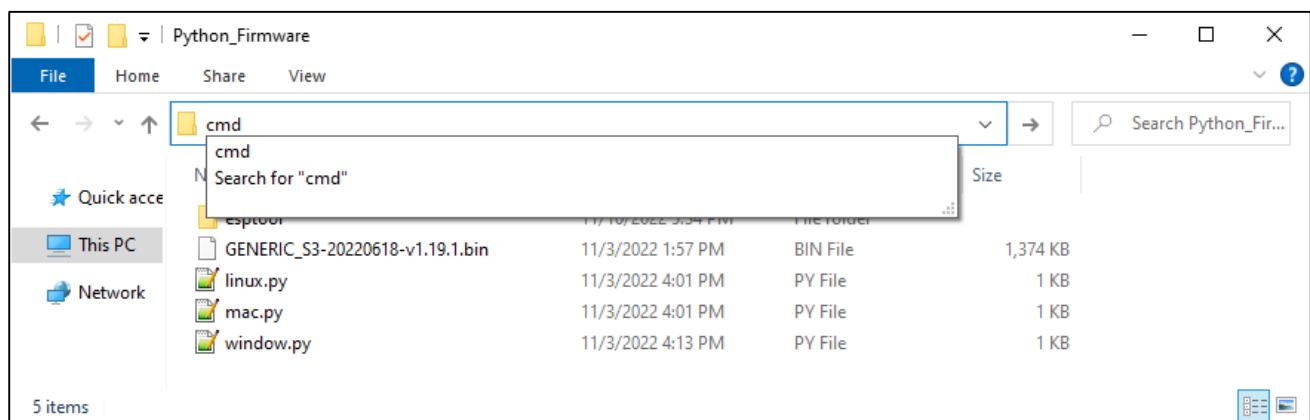
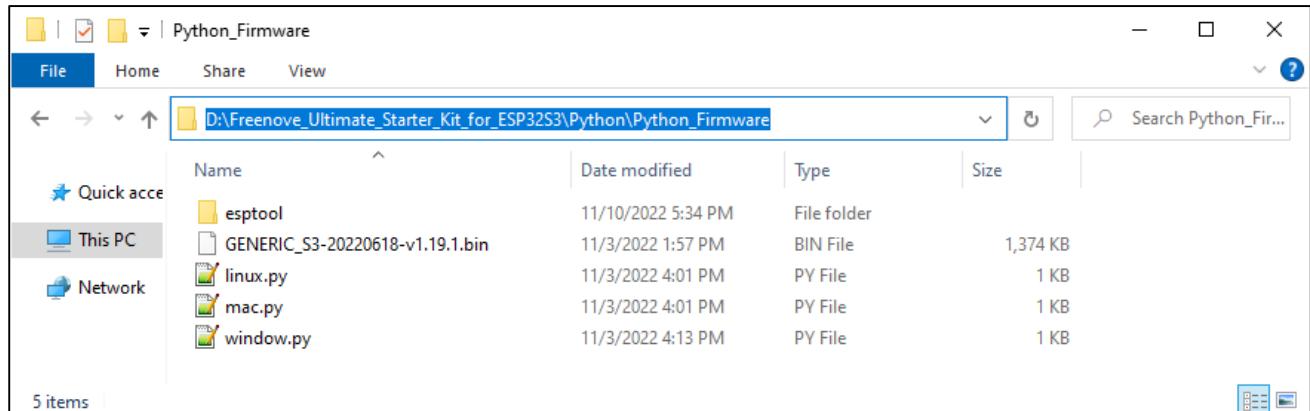
Connect your computer and ESP32-S3 with a USB cable.



Any concerns? ✉ support@freenove.com

Open Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Firmware

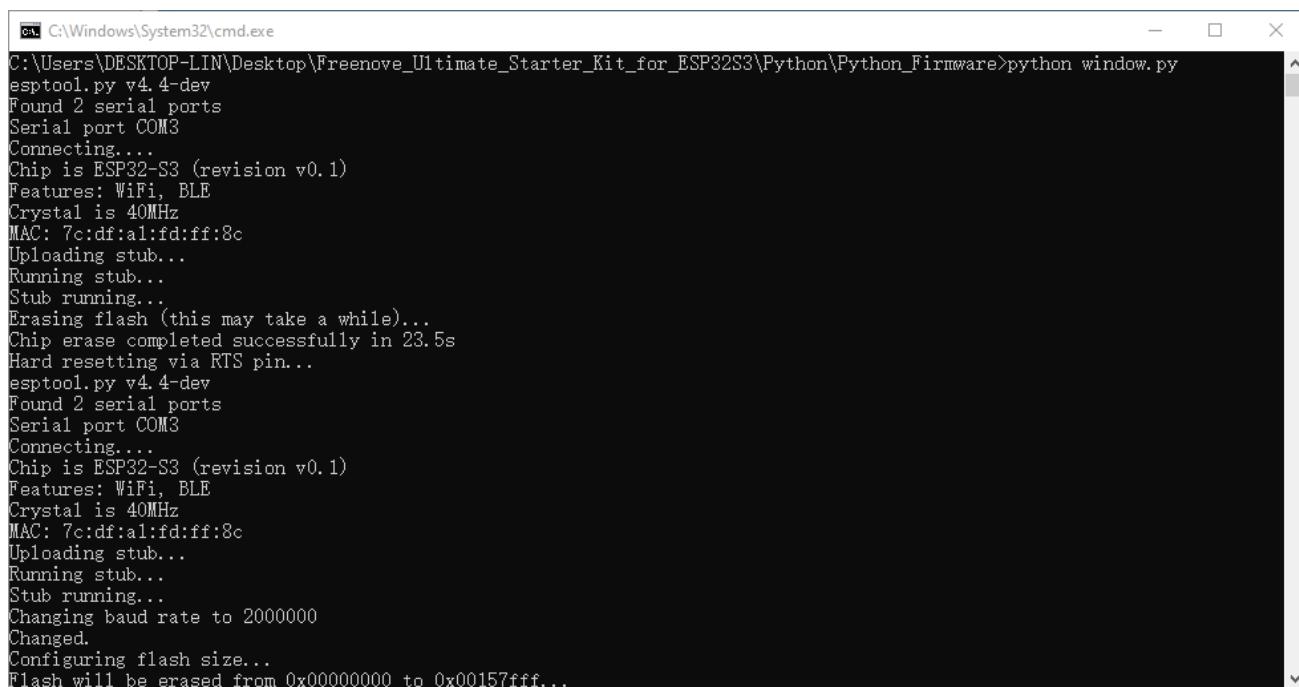
Enter cmd on path bar then press Enter.



Here my python3 version is 3.8.1.

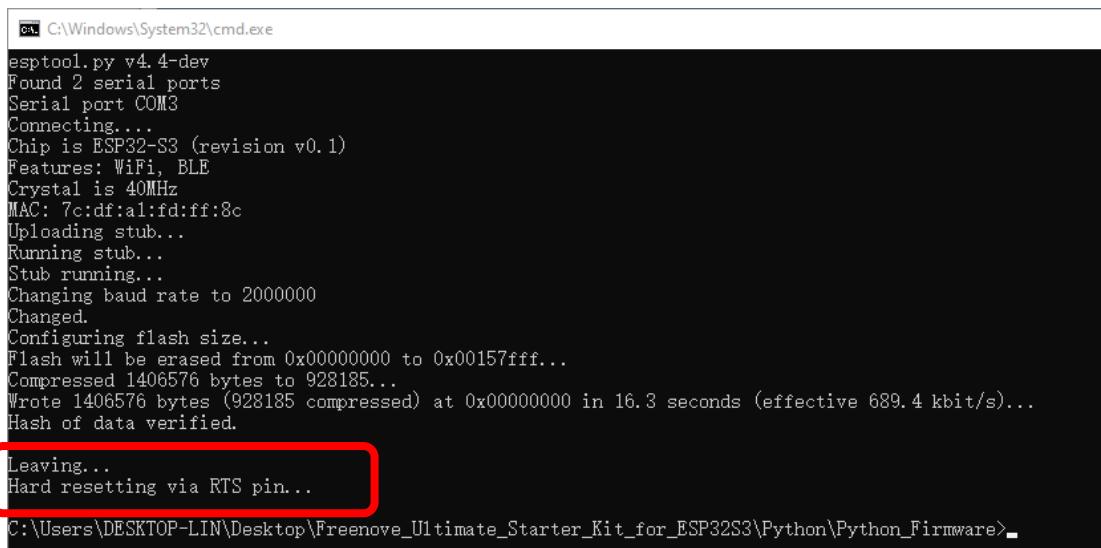


Enter "python window.py". Micropython firmware will be automatically burned to ESP32S3.



```
C:\Users\DESKTOP-LIN\Desktop\Freenove_Ultimate_Starter_Kit_for_ESP32S3\Python\Python_Firmware>python window.py
esptool.py v4.4-dev
Found 2 serial ports
Serial port COM3
Connecting....
Chip is ESP32-S3 (revision v0.1)
Features: WiFi, BLE
Crystal is 40MHz
MAC: 7c:df:al:fd:ff:8c
Uploading stub...
Running stub...
Stub running...
Erasing flash (this may take a while)...
Chip erase completed successfully in 23.5s
Hard resetting via RTS pin...
esptool.py v4.4-dev
Found 2 serial ports
Serial port COM3
Connecting....
Chip is ESP32-S3 (revision v0.1)
Features: WiFi, BLE
Crystal is 40MHz
MAC: 7c:df:al:fd:ff:8c
Uploading stub...
Running stub...
Stub running...
Changing baud rate to 2000000
Changed.
Configuring flash size...
Flash will be erased from 0x00000000 to 0x00157fff...
```

As shown in the figure below after completion.



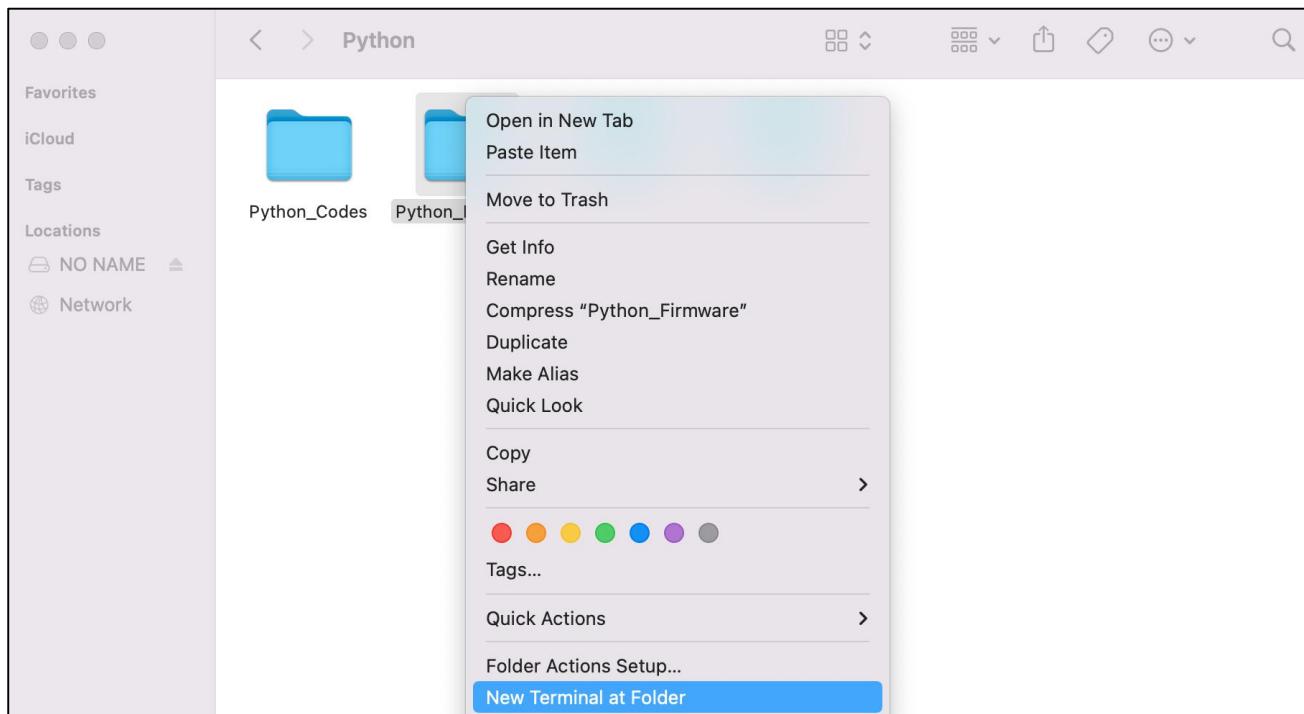
```
C:\Windows\System32\cmd.exe
esptool.py v4.4-dev
Found 2 serial ports
Serial port COM3
Connecting...
Chip is ESP32-S3 (revision v0.1)
Features: WiFi, BLE
Crystal is 40MHz
MAC: 7c:df:a1:fd:ff:8c
Uploading stub...
Running stub...
Stub running...
Changing baud rate to 2000000
Changed.
Configuring flash size...
Flash will be erased from 0x00000000 to 0x00157fff...
Compressed 1406576 bytes to 928185...
Wrote 1406576 bytes (928185 compressed) at 0x00000000 in 16.3 seconds (effective 689.4 kbit/s)...
Hash of data verified.

Leaving...
Hard resetting via RTS pin...

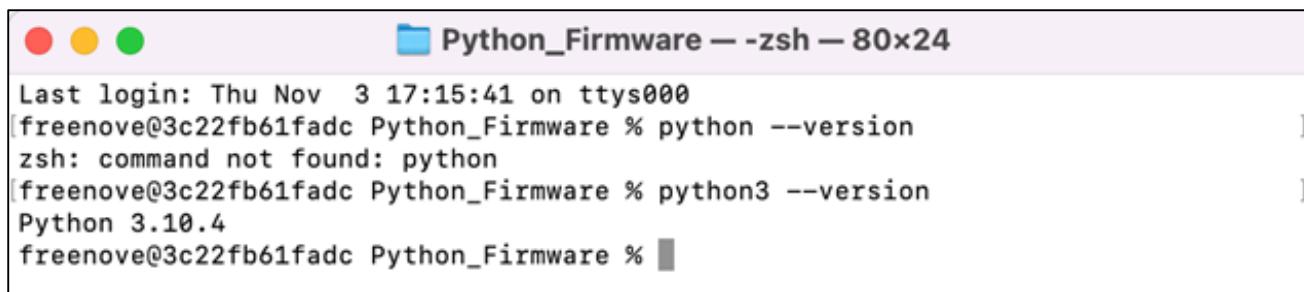
C:\Users\DESKTOP-LIN\Desktop\Freenove_Ultimate_Starter_Kit_for_ESP32S3\Python\Python_Firmware>
```

Mac

Open **Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Firmware**. Right-click and select New Terminal at Folder.



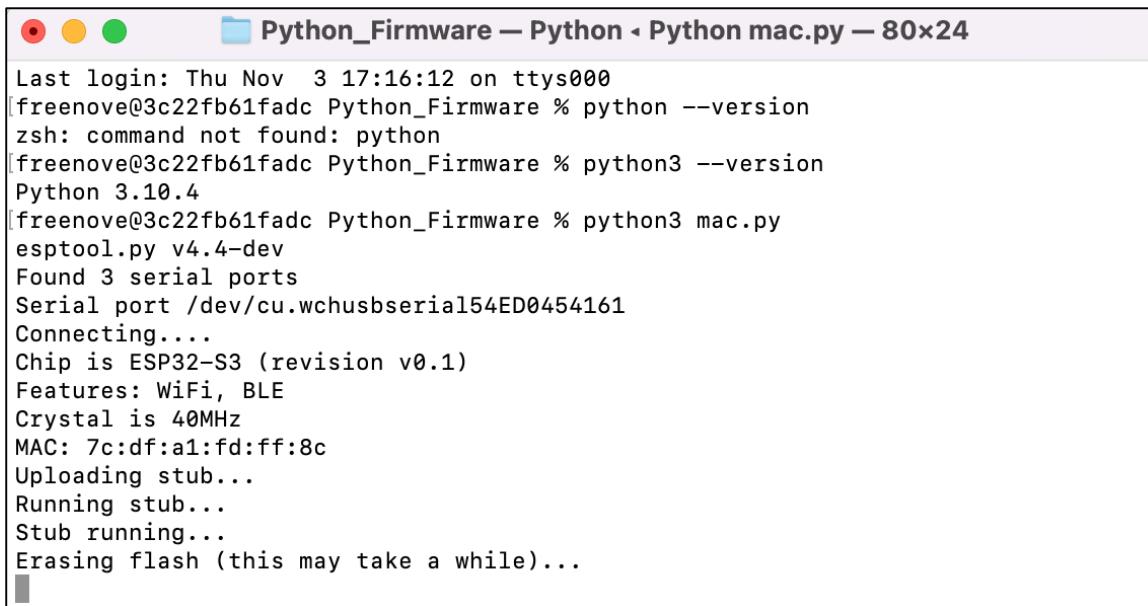
Here, my python3 version is 3.10.4



```
Last login: Thu Nov  3 17:15:41 on ttys000
[freenove@3c22fb61fad Python_Firmware % python --version
zsh: command not found: python
[freenove@3c22fb61fad Python_Firmware % python3 --version
Python 3.10.4
freenove@3c22fb61fad Python_Firmware % ]
```

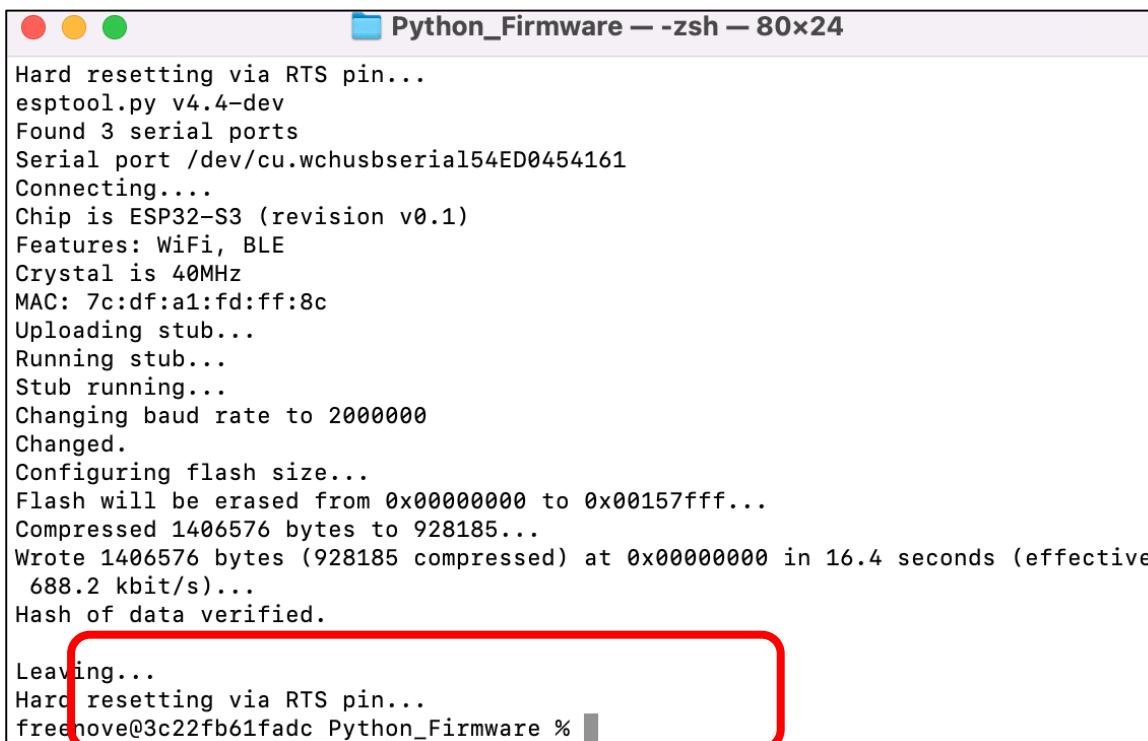
Any concerns? [✉ support@freenove.com](mailto:support@freenove.com)

Enter "python3 mac.py" in the terminal, press Enter, and wait for the code to automatically burn the microython firmware into ESP32S3.



```
Last login: Thu Nov  3 17:16:12 on ttys000
[freenove@3c22fb61fad Python_Firmware % python --version
zsh: command not found: python
[freenove@3c22fb61fad Python_Firmware % python3 --version
Python 3.10.4
[freenove@3c22fb61fad Python_Firmware % python3 mac.py
esptool.py v4.4-dev
Found 3 serial ports
Serial port /dev/cu.wchusbserial54ED0454161
Connecting....
Chip is ESP32-S3 (revision v0.1)
Features: WiFi, BLE
Crystal is 40MHz
MAC: 7c:df:a1:fd:ff:8c
Uploading stub...
Running stub...
Stub running...
Erasing flash (this may take a while)...
```

After completion, it is shown below.



```
Hard resetting via RTS pin...
esptool.py v4.4-dev
Found 3 serial ports
Serial port /dev/cu.wchusbserial54ED0454161
Connecting....
Chip is ESP32-S3 (revision v0.1)
Features: WiFi, BLE
Crystal is 40MHz
MAC: 7c:df:a1:fd:ff:8c
Uploading stub...
Running stub...
Stub running...
Changing baud rate to 2000000
Changed.
Configuring flash size...
Flash will be erased from 0x00000000 to 0x00157fff...
Compressed 1406576 bytes to 928185...
Wrote 1406576 bytes (928185 compressed) at 0x00000000 in 16.4 seconds (effective
688.2 kbit/s)...
Hash of data verified.

Leaving...
Hard resetting via RTS pin...
freenove@3c22fb61fad Python_Firmware %
```

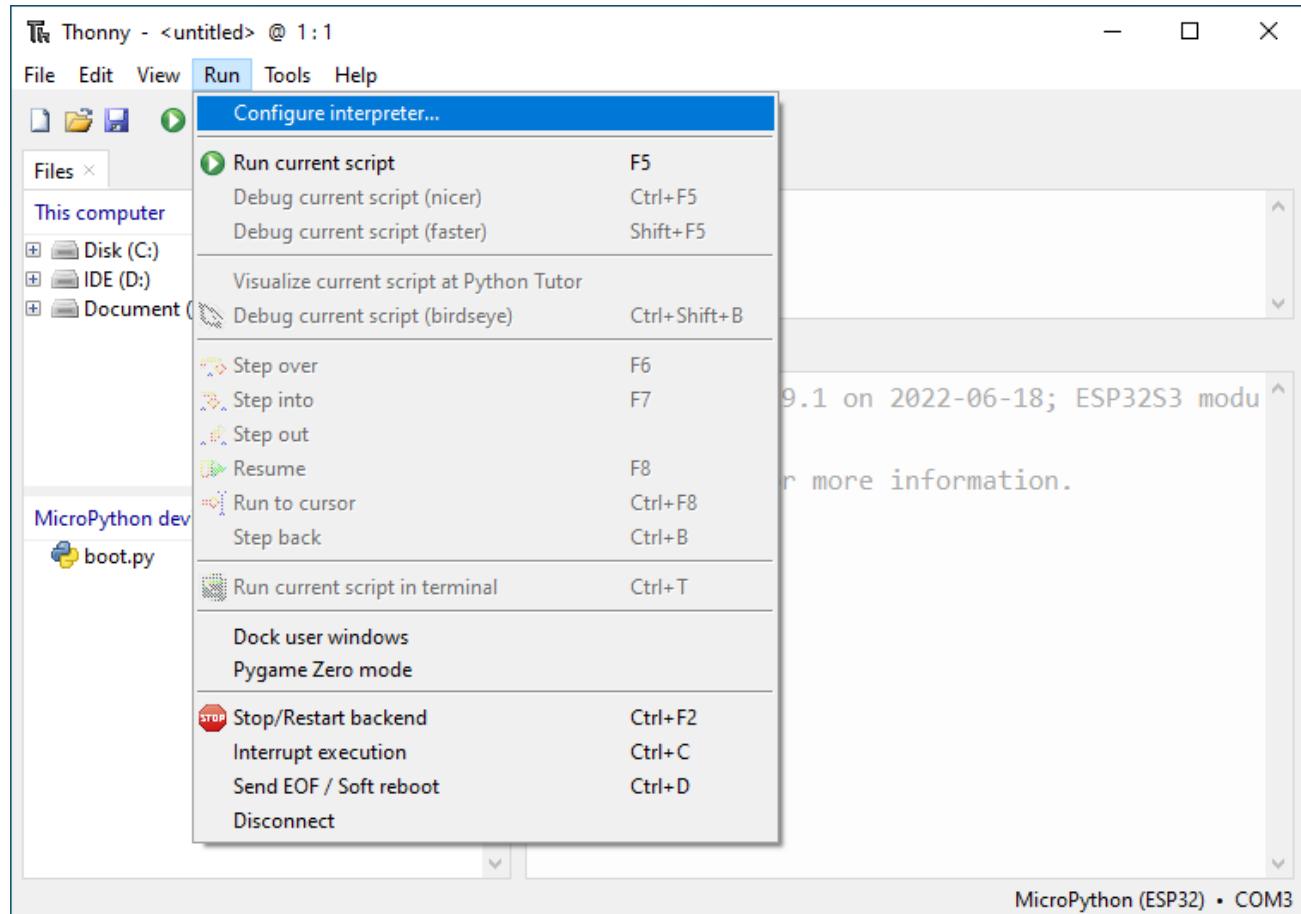
Note: The operation of the Linux system is similar to that of the Mac system. Please refer to the Mac system.



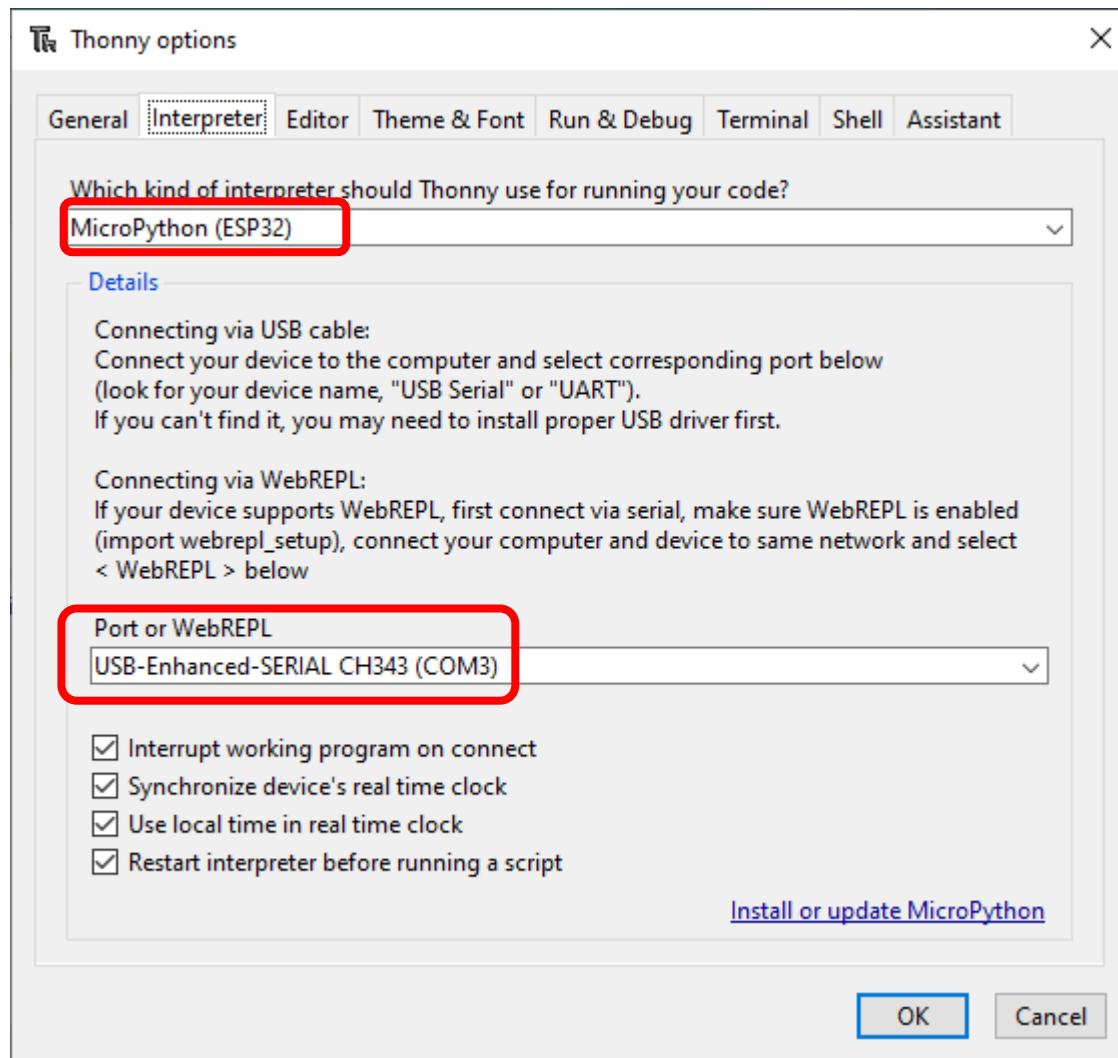
Testing codes (Important)

Testing Shell Command

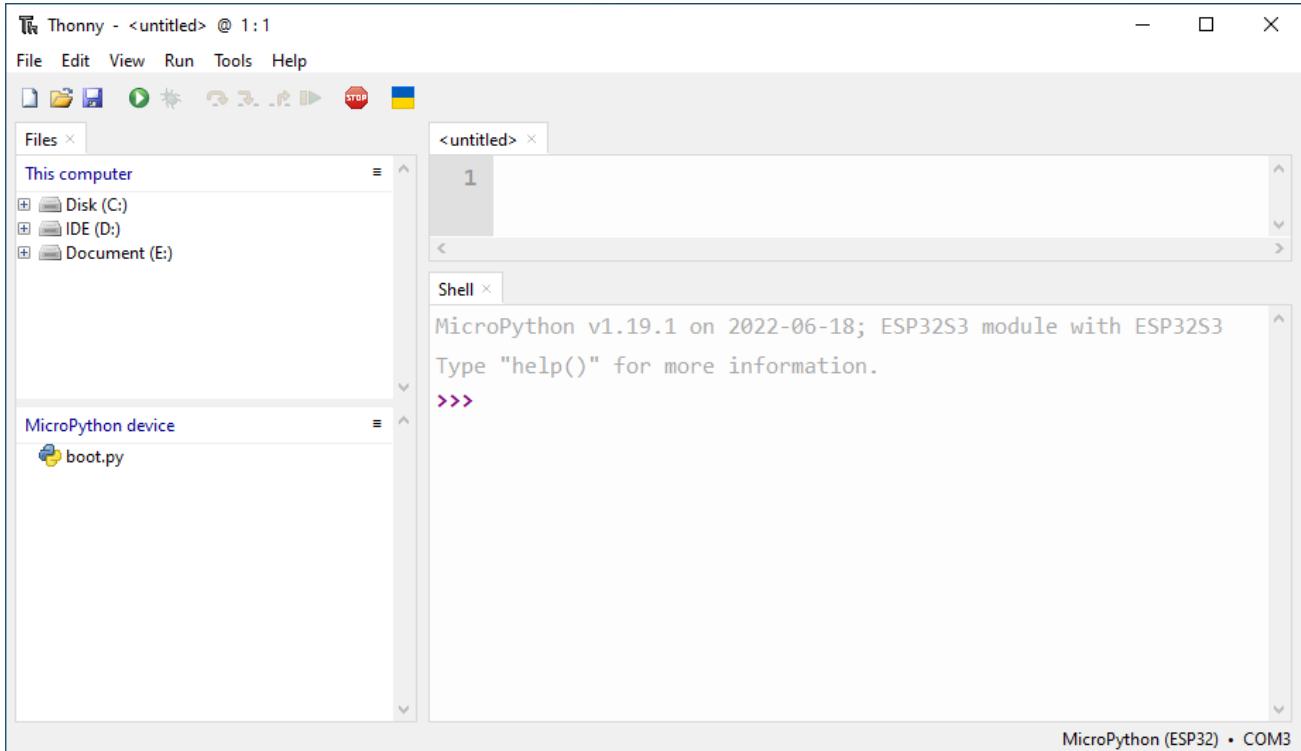
Make sure that the ESP 32S3 has burned the firmware and is connected to the computer through the data cable. Run Thonny. Click Run and select Configure interpreter.



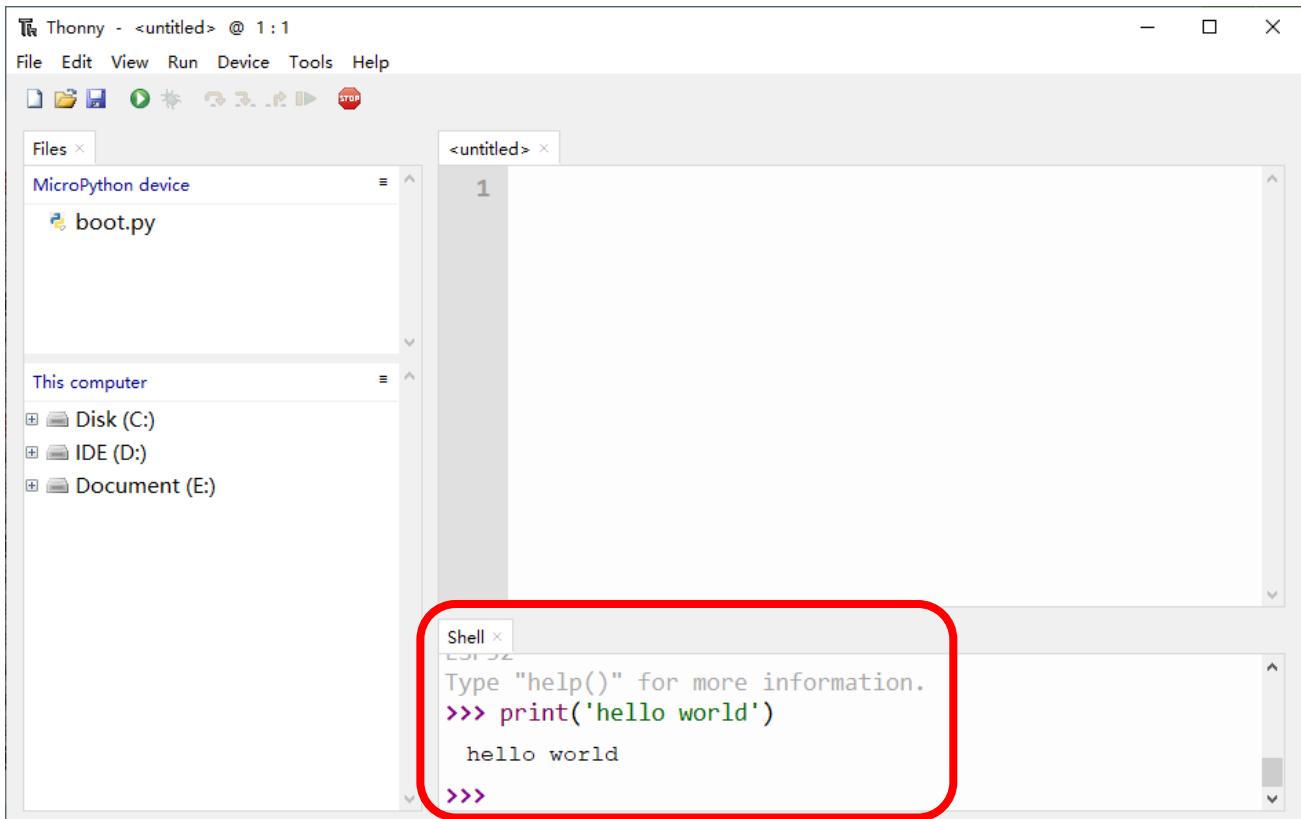
Please configure according to the following figure. Note that the port numbers of USB Enhanced SERIAL may be different for different systems. Please select according to the actual situation. After configuration, click OK.



After configuration, every time you open Thonny, it will communicate with ESP32S3. The interface is shown below.



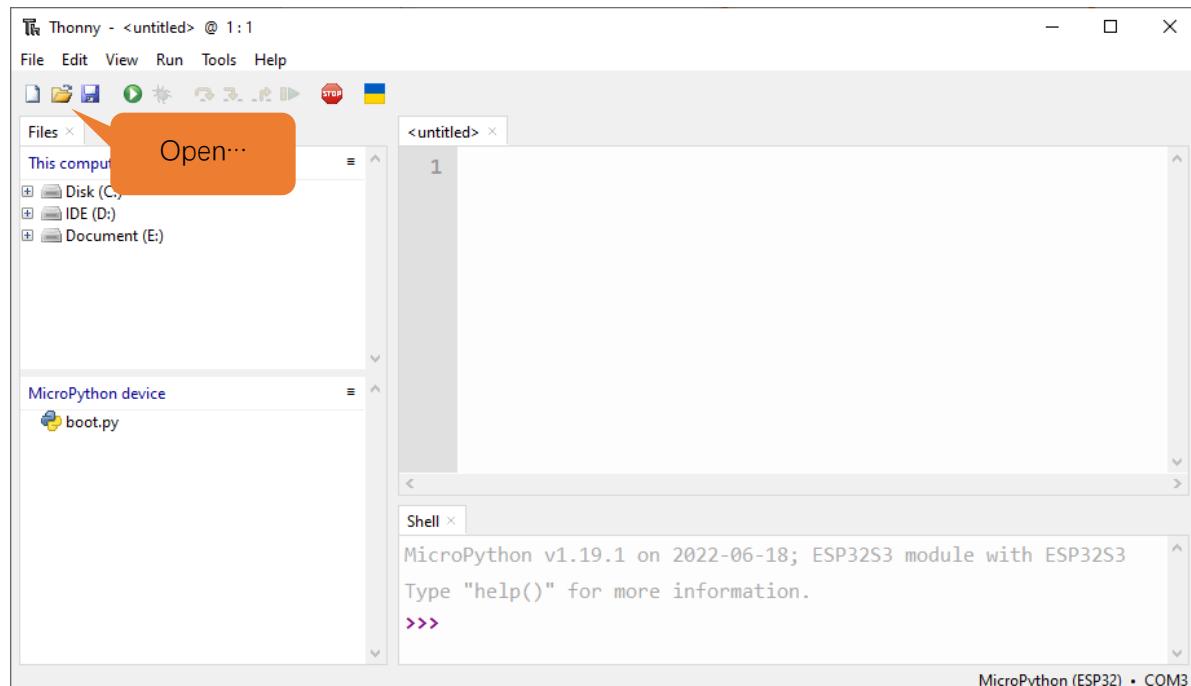
Enter "print('hello world')" in "Shell" and press Enter.



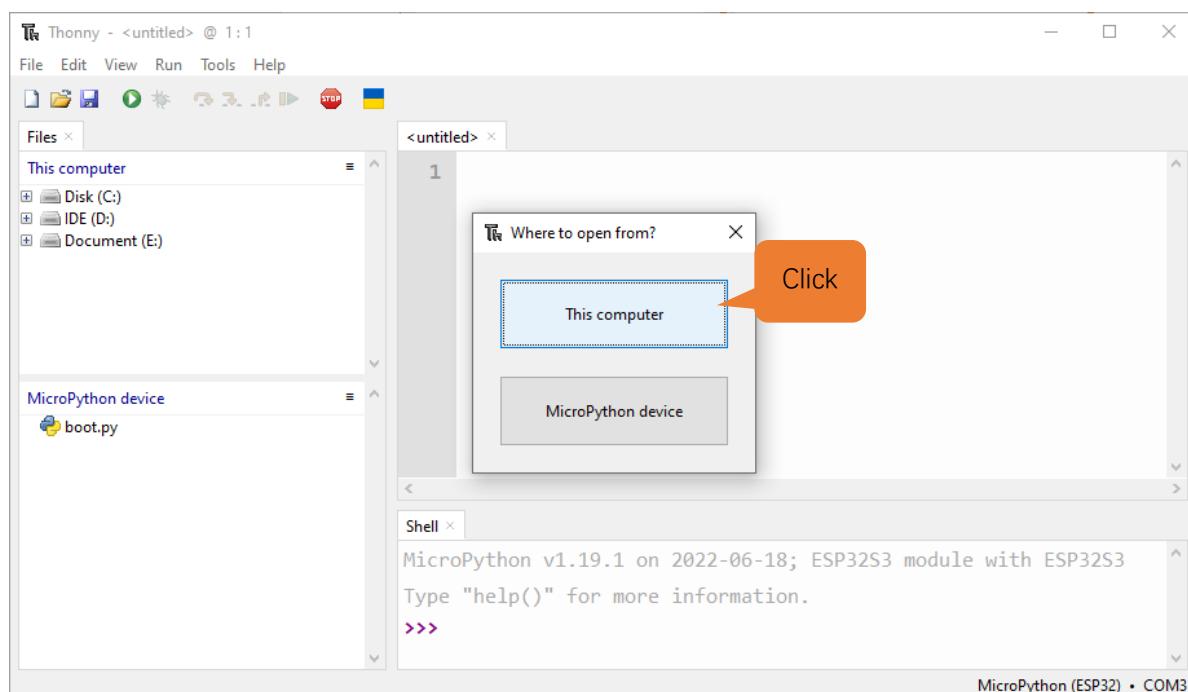
Running Online

ESP32-S3 needs to be connected to a computer when it is run online. Users can use Thonny to write and debug programs.

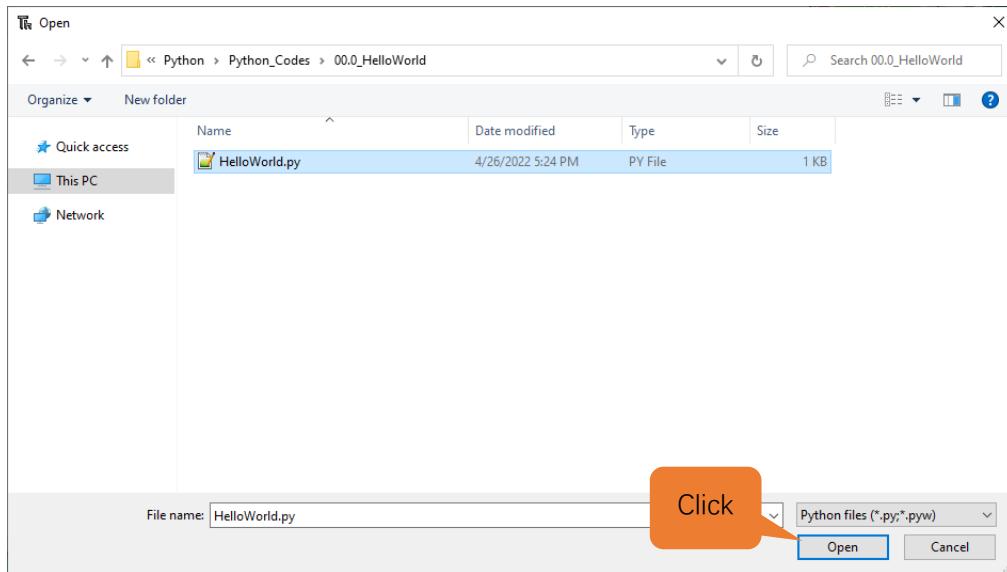
1. Open Thonny and click “Open…”.



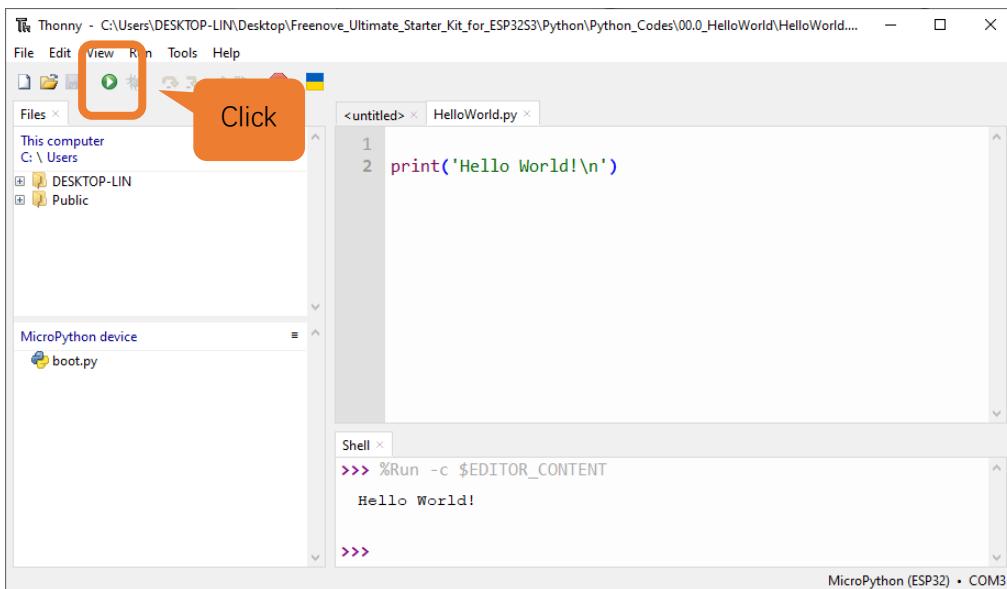
2. On the newly pop-up window, click “This computer”.



In the new dialog box, select “**HelloWorld.py**” in “**Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Codes/00.0_HelloWorld**” folder.



Click “Run current script” to execute the program and “Hello World” will be printed in “Shell”.

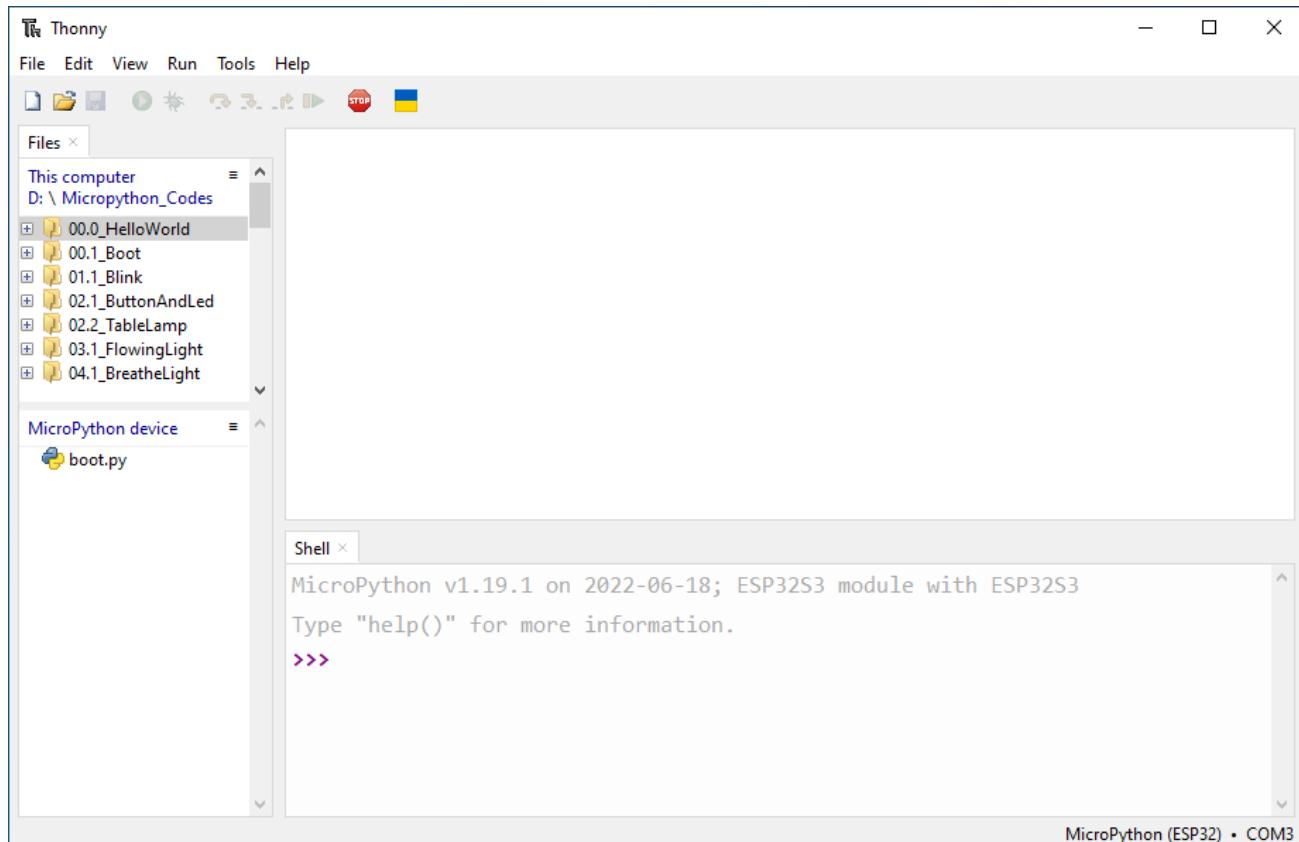


Note: When running online, if you press the reset key of ESP32S3, user's code will not be executed again. If you wish to run the code automatically after resetting the code, please refer to the following [Running Offline](#).

Running Offline (Importance)

After ESP32-S3 is reset, it runs the file boot.py in root directory first and then runs file main.py, and finally, it enters "Shell". Therefore, to make ESP32-S3 execute user's programs after resetting, we need to add a guiding program in boot.py to execute user's code.

Move the program folder "**Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Codes**" to disk(D) in advance with the path of "**D:/Micropython_Codes**". Open "Thonny".



Expand "00.1_Boot" in the "Micropython_Codes" in the directory of disk(D), and double-click boot.py, which is provided by us to enable programs in "MicroPython device" to run offline.

The screenshot shows the Thonny IDE interface. The top menu bar includes File, Edit, View, Run, Tools, and Help. The left sidebar shows a file tree under 'This computer' and a device list under 'MicroPython device'. The main area displays the 'boot.py' code:

```

1 #!/opt/bin/lv_micropython
2 import uos as os
3 import uerrno as errno
4 iter = os.ilistdir()
5 IS_DIR = 0x4000
6 IS_REGULAR = 0x8000

7
8 while True:
9     try:
10         entry = next(iter)
11         filename = entry[0]
12         file_type = entry[1]
13         if filename == 'boot.py':
14             continue
15         else:
16             print("====")
17             print(filename,end="")
18             if file_type == IS_DIR:
19                 print(" , File is a directory")
20                 print("====")

```

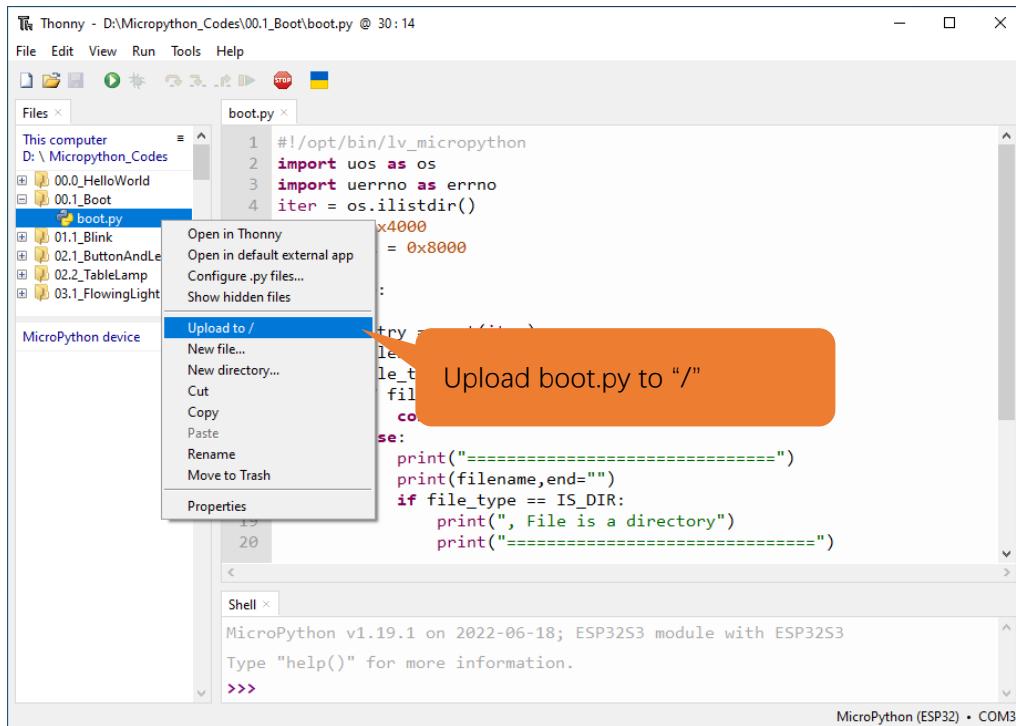
The bottom pane shows the MicroPython shell output:

```

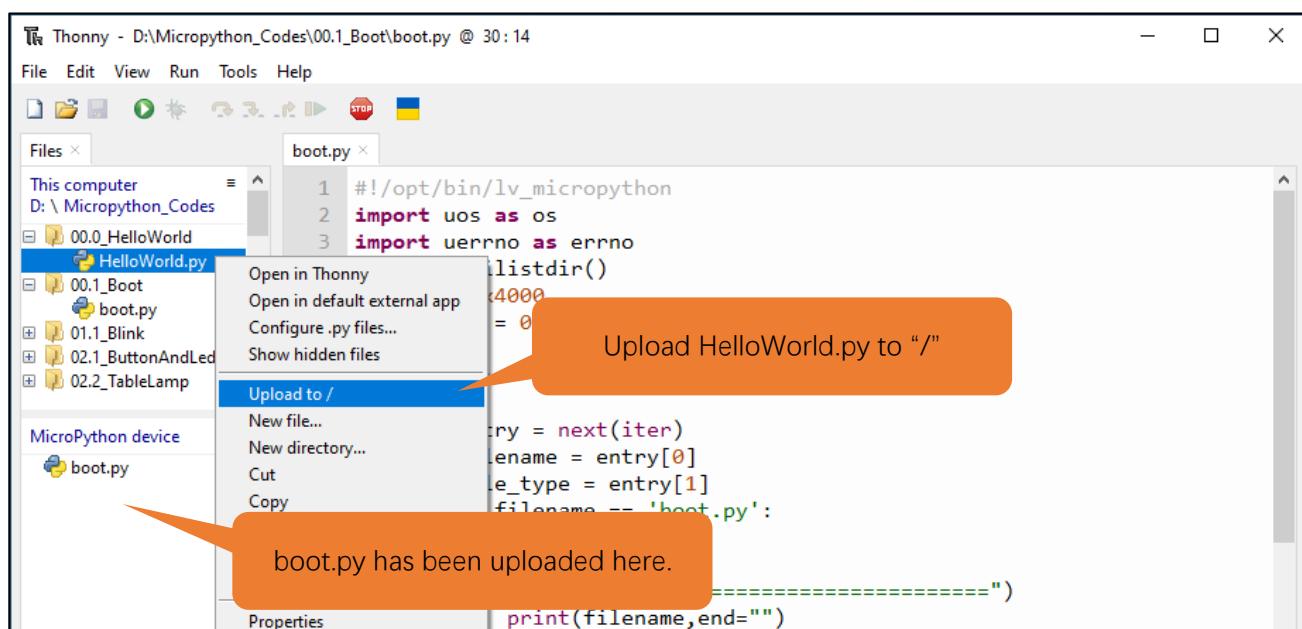
MicroPython v1.19.1 on 2022-06-18; ESP32S3 module with ESP32S3
Type "help()" for more information.
>>>

```

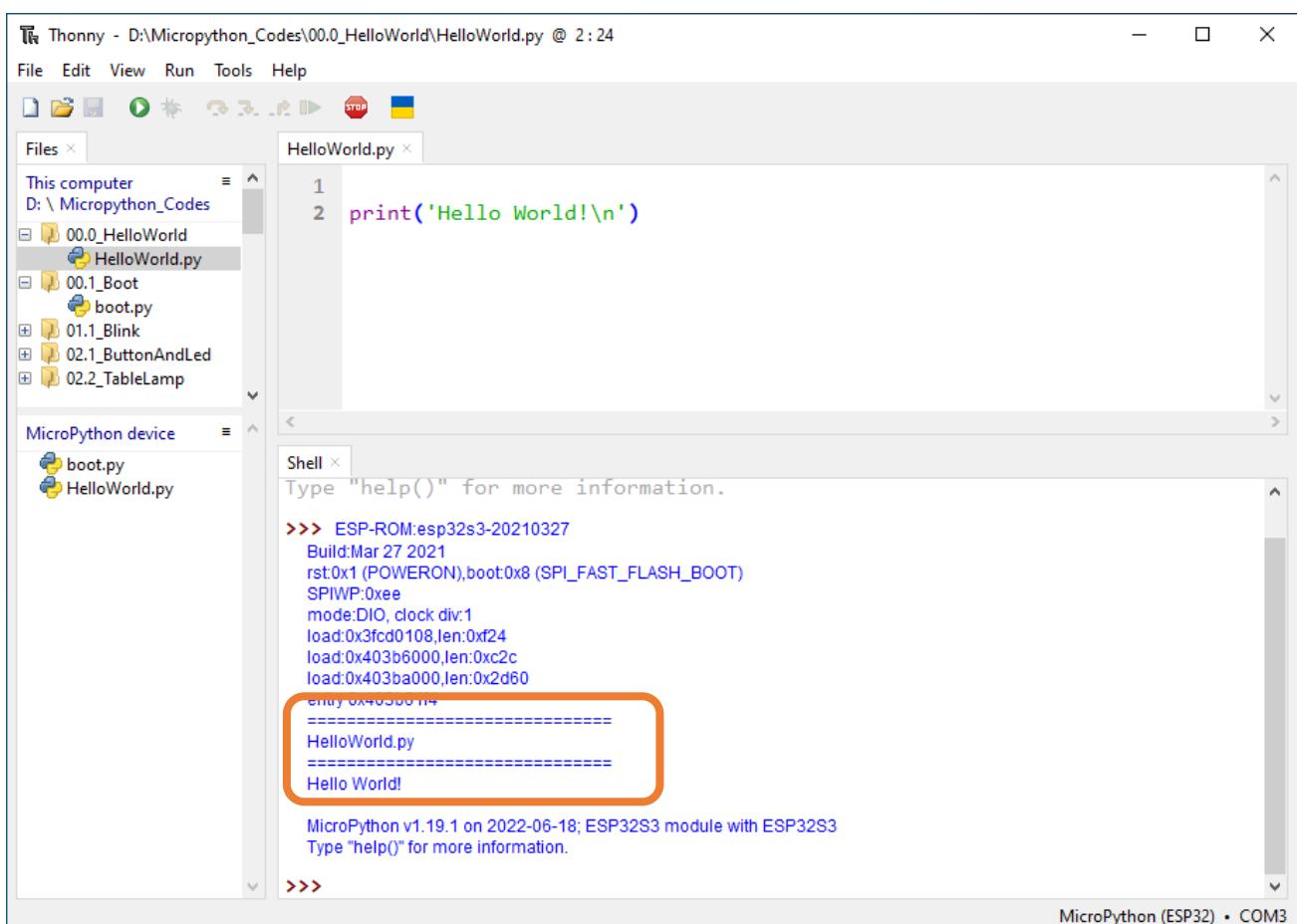
If you want your written programs to run offline, you need to upload boot.py we provided and all your codes to “MicroPython device” and press ESP32S3’s reset key. Here we use programs 00.0 and 00.1 as examples. Select “boot.py”, right-click to select “Upload to /”.



Similarly, upload “HelloWorld.py” to “MicroPython device”.



Press the reset key and in the box of the illustration below, you can see the code is executed.



Thonny Common Operation

Uploading Code to ESP32S3

Each time when ESP32-S3 restarts, if there is a “boot.py” in the root directory, it will execute this code first.

The screenshot shows the Thonny IDE interface. In the top menu bar, "File", "Edit", "View", "Run", "Tools", and "Help" are visible. Below the menu is a toolbar with icons for file operations like Open, Save, and Run. The main window has two panes: "Files" on the left and "Shell" on the right. The "Files" pane shows a file tree under "This computer" (D:\Micropython_Codes) and a "MicroPython device" section. A "boot.py" file is selected in the device section, highlighted with an orange box. The "boot.py" code in the editor pane is as follows:

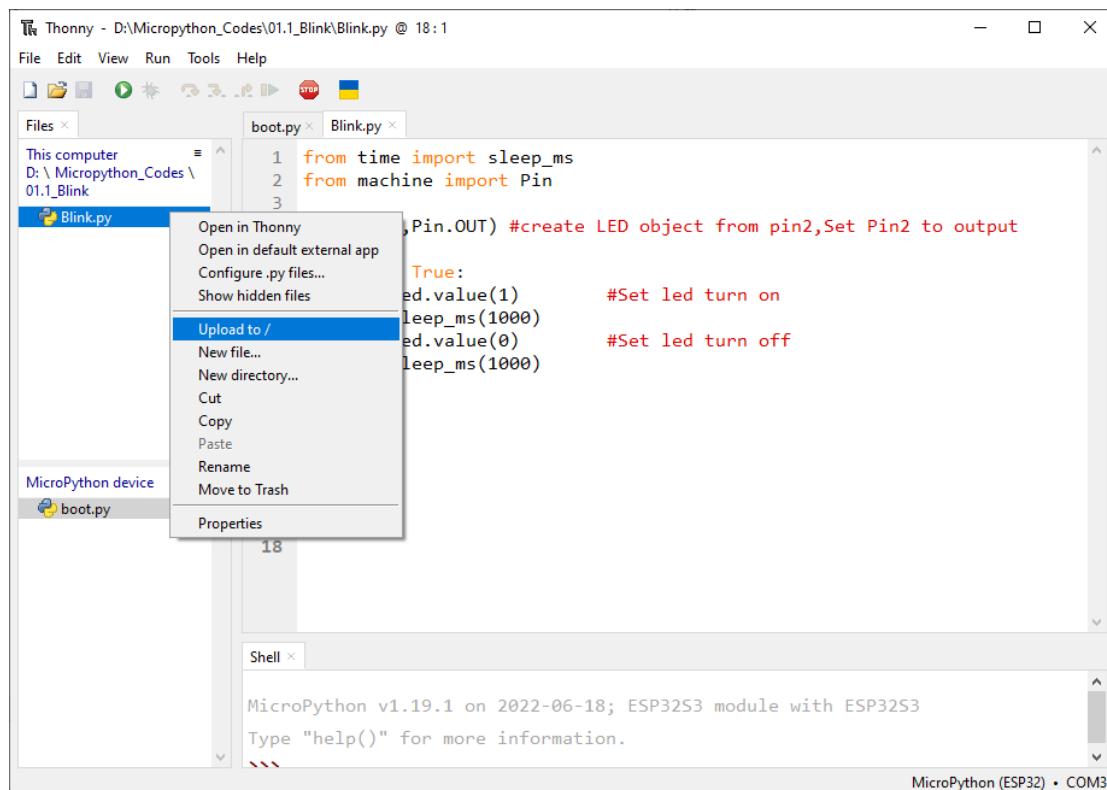
```
1 #!/opt/bin/lv_micropython
2 import uos as os
3 import uerrno as errno
4 iter = os.ilistdir()
5 IS_DIR = 0x4000
6 IS_REGULAR = 0x8000
7
8 while True:
9     try:
10         entry = next(iter)
11         filename = entry[0]
12         file_type = entry[1]
13         if filename == 'boot.py':
14             continue
15         else:
16             print("====")
17             print(filename,end="")
18             if file_type == IS_DIR:
19                 print(", File is a directory")
20                 print("====")
21             else:
```

The "Shell" pane at the bottom shows the MicroPython environment:

```
MicroPython v1.19.1 on 2022-06-18; ESP32S3 module with ESP32S3
Type "help()" for more information.
>>>
```

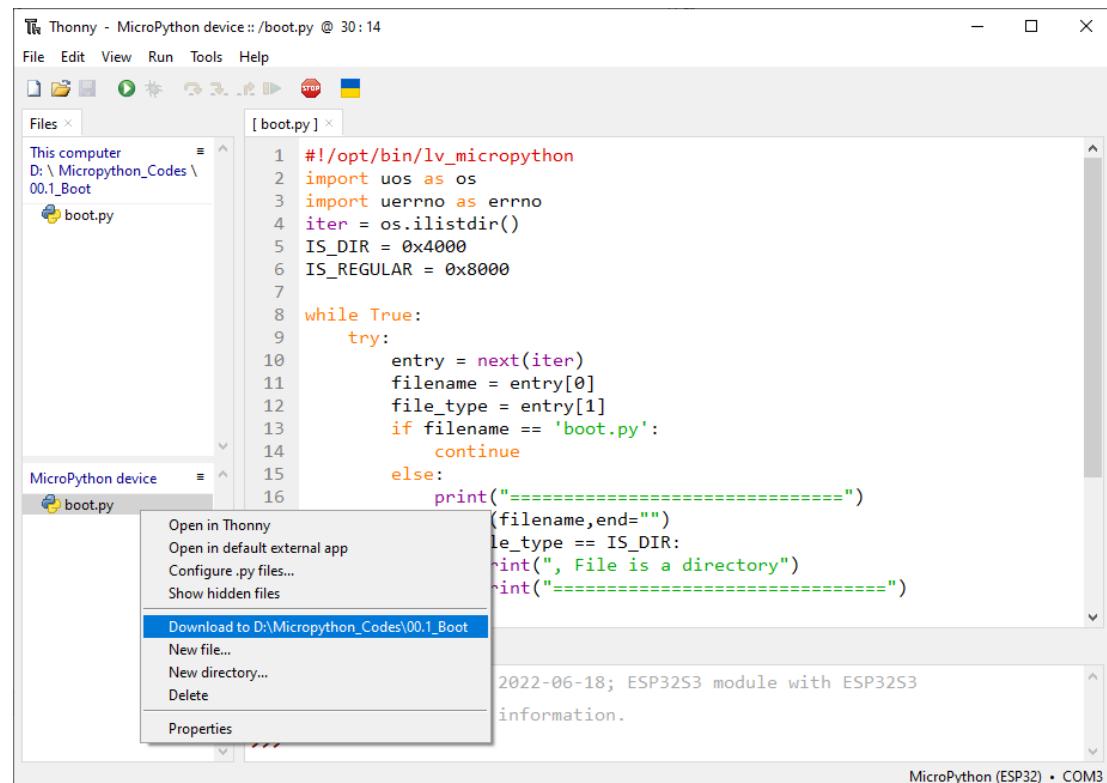
An orange callout bubble points from the "boot.py" file in the file tree to the code in the editor, containing the text: "Codes in ESP32S3's root directory will be executed automatically."

Select “Blink.py” in “01.1_Blink”, right-click your mouse and select “Upload to /” to upload code to ESP32S3’s root directory.



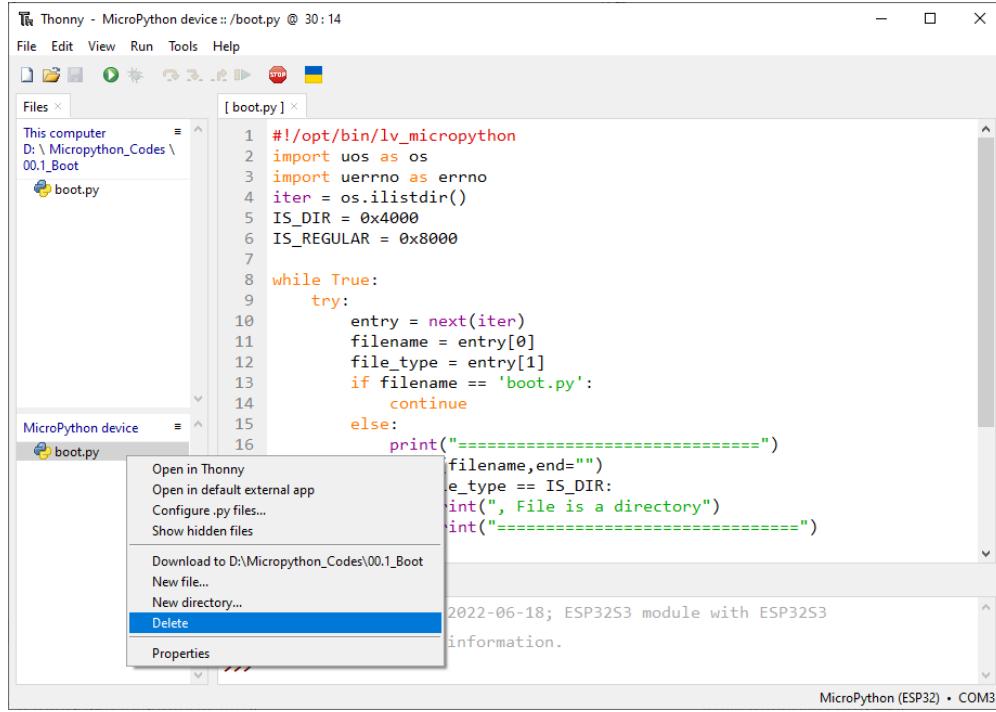
Downloading Code to Computer

Select “boot.py” in “MicroPython device”, right-click to select “Download to ...” to download the code to your computer.



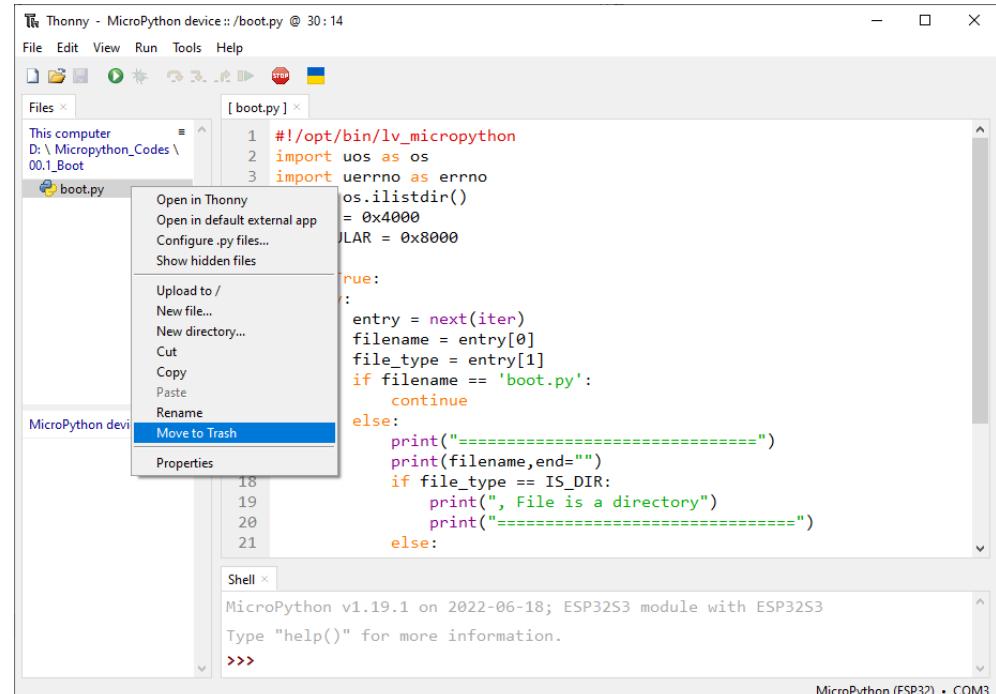
Deleting Files from ESP32S3's Root Directory

Select “boot.py” in “MicroPython device”, right-click it and select “Delete” to delete “boot.py” from ESP32S3’s root directory.



Deleting Files from your Computer Directory

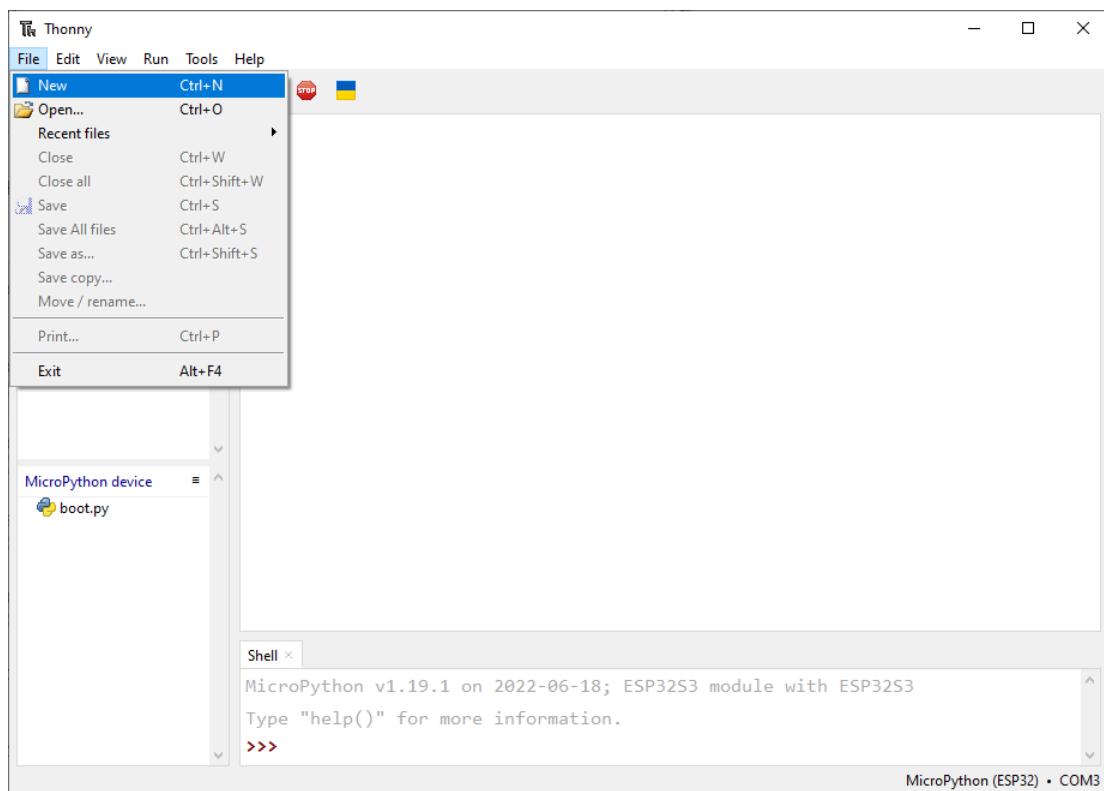
Select "boot.py" in "00.1_Boot", right-click it and select "Move to Recycle Bin" to delete it from "00.1_Boot".



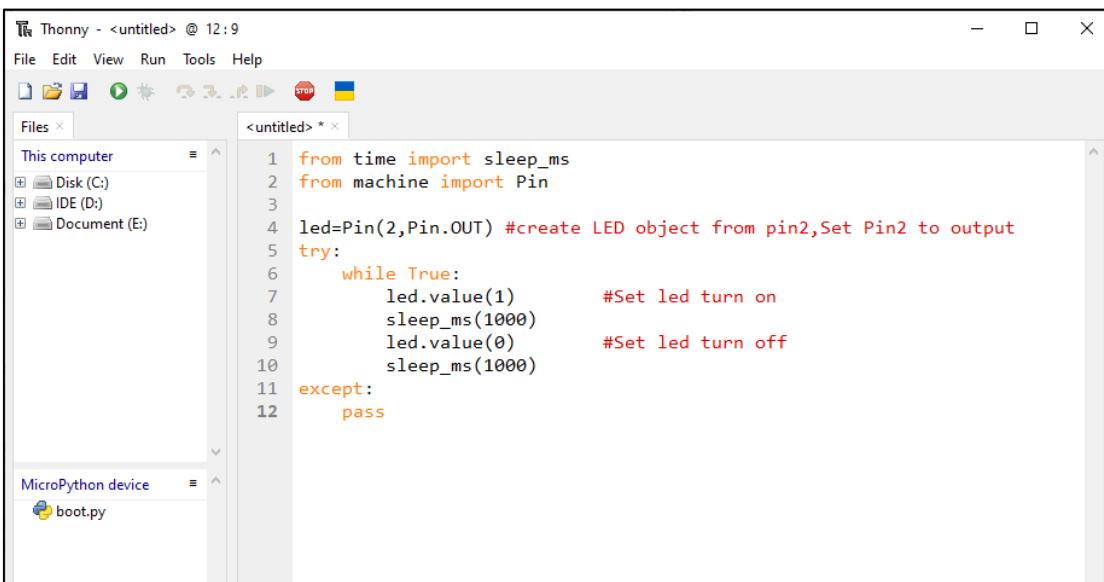
Any concerns? support@freenove.com

Creating and Saving the code

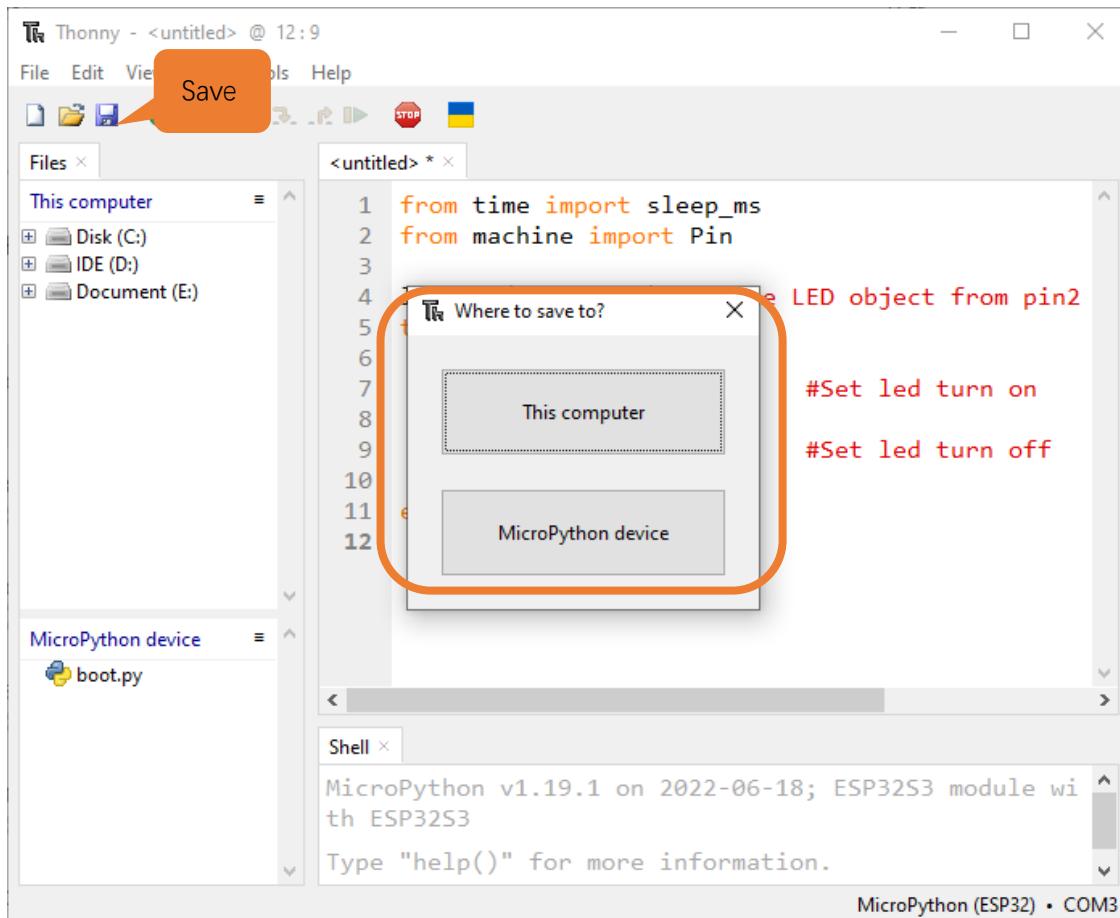
Click “File”→“New” to create and write codes.



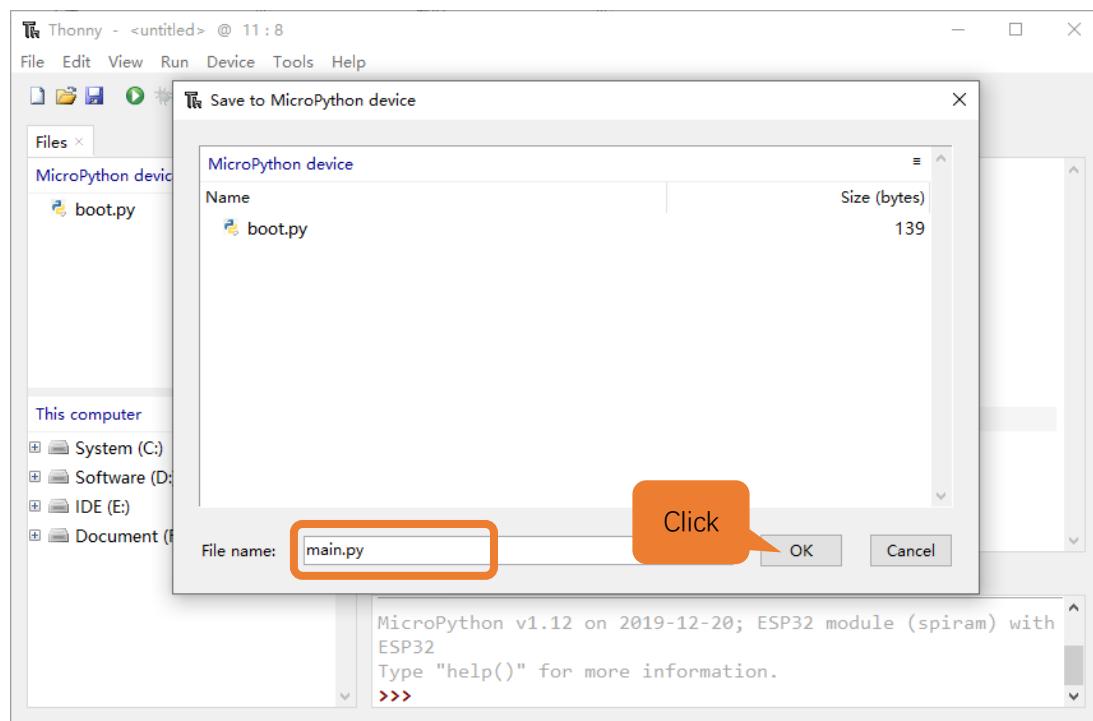
Enter codes in the newly opened file. Here we use codes of “01.1_Blink.py” as an example.



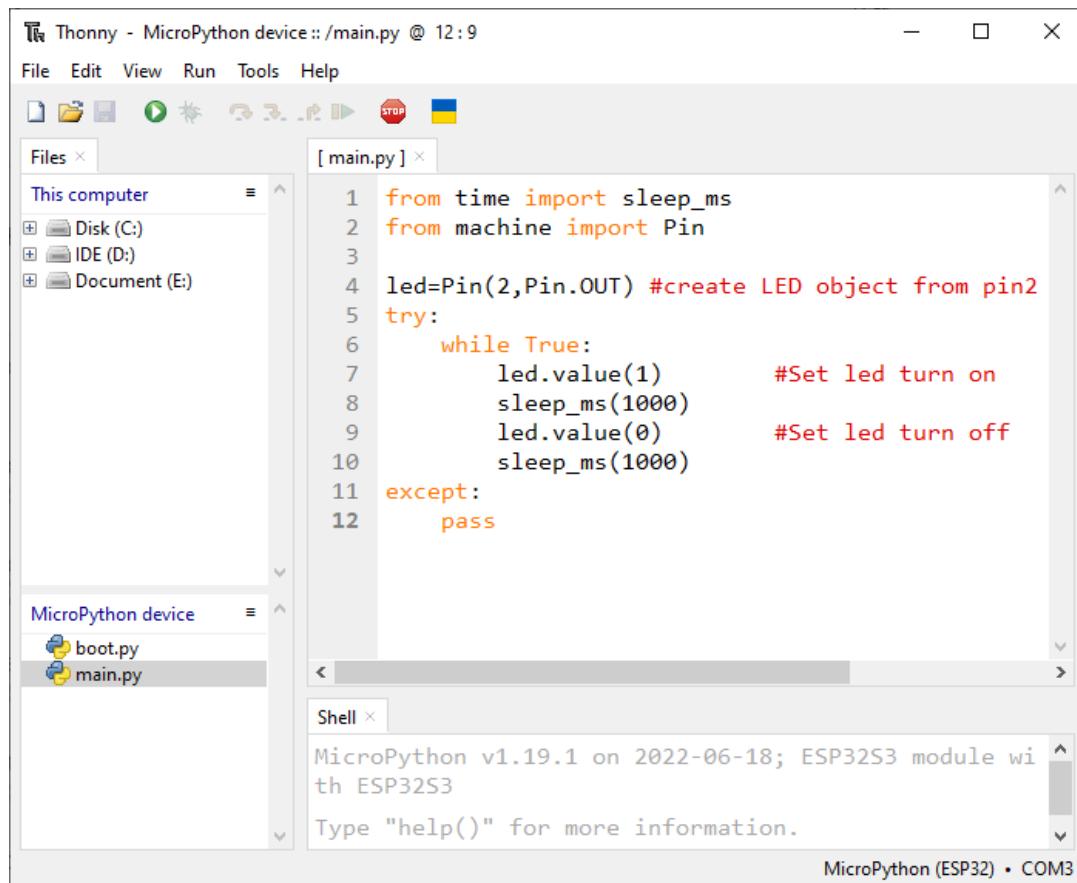
Click “Save” on the menu bar. You can save the codes either to your computer or to ESP32S3.



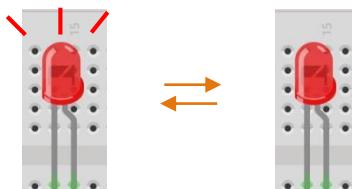
Select “MicroPython device”, enter “main.py” in the newly pop-up window and click “OK”.



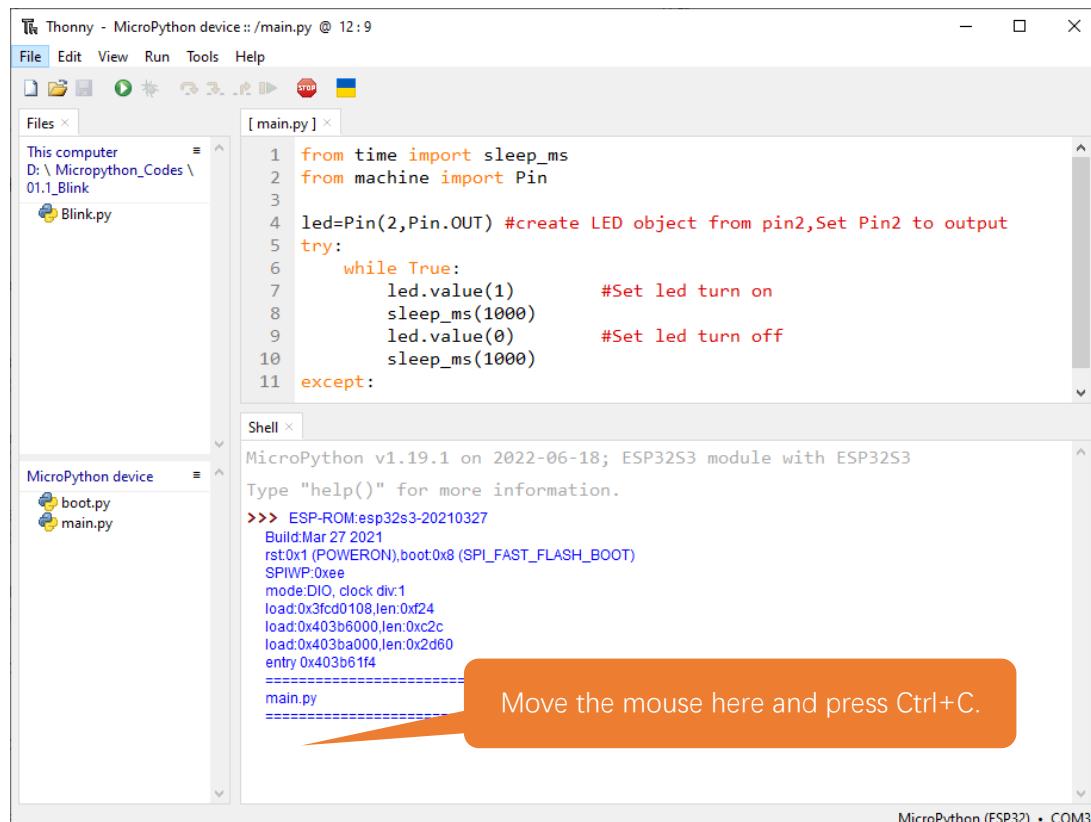
You can see that codes have been uploaded to ESP32S3.



Disconnect and reconnect USB cable, and you can see that LED is ON for one second and then OFF for one second, which repeats in an endless loop.



If you want to exit the offline operation mode, you can press **Ctrl+C** at the same time in the shell to let the ESP32-S3 exit the offline operation mode.



If there is no response after pressing, it is recommended to press again until exiting.

Notes for GPIO

Strapping Pin

There are four Strapping pins for ESP32S3: GPIO0、GPIO45、GPIO46、GPIO3。

With the release of the chip's system reset (power-on reset, RTC watchdog reset, undervoltage reset), the strapping pins sample the level and store it in the latch as "0" or "1", and keep it until the chip is powered off or turned off.

Each Strapping pin is connecting to internal pull-up/pull-down. Connecting to high-impedance external circuit or without an external connection, a strapping pin's default value of input level will be determined by internal weak pull-up/pull-down. To change the value of the Strapping, users can apply an external pull-down/pull-up resistor, or use the GPIO of the host MCU to control the level of the strapping pin when the ESP32-S3's power on reset is released.

When releasing the reset, the strapping pin has the same function as a normal pin.

The followings are default configurations of these four strapping pins at power-on and their functions under the corresponding configuration.

VDD_SPI Voltage			
Pin	Default	3.3 V	1.8 V
GPIO45	Pull-down	0	1
Booting Mode ¹			
Pin	Default	SPI Boot	Download Boot
GPIO0	Pull-up	1	0
GPIO46	Pull-down	Don't care	0
Enabling/Disabling ROM Messages Print During Booting ²			
Pin	Default	Enabled	Disabled
GPIO46	Pull-down	See the 2nd note	See the 2nd note
JTAG Signal Selection			
Pin	Default	EFUSE_DIS_USB_JTAG = 0, EFUSE_DIS_PAD_JTAG = 0, EFUSE_STRAP_JTAG_SEL=1	
GPIO3	N/A	0: JTAG signal from on-chip JTAG pins 1: JTAG signal from USB Serial/JTAG controller	

Note:

1. The strapping combination of GPIO46 = 1 and GPIO0 = 0 is invalid and will trigger unexpected behavior.
2. By default, the ROM boot messages are printed over UART0 (UOTXD pin) and USB Serial/JTAG controller together. The ROM code printing can be disabled through configuration register and eFuse. For detailed information, please refer to Chapter [Chip Boot Control](#) in *ESP32-S3 Technical Reference Manual*.

If you have any difficulties or questions with this tutorial or toolkit, feel free to ask for our quick and free technical support through support@freenove.com at any time.

or check: https://www.espressif.com/sites/default/files/documentation/esp32-s3-wroom-1_wroom-1u_datasheet_en.pdf

Any concerns? ✉ support@freenove.com



PSRAM Pin

The modules on the ESP32-S3 WROOM board use the ESP32-S3R8 chip with 8MB external Flash. When using OPI PSRAM, please note that GPIO35-GPIO37 on the ESP32-S3 WROOM board cannot be used for other purposes. When OPI PSRAM is not used, GPIO35-GPIO37 on the board can be used as a common GPIO.

ESP32-S3R8 / ESP32-S3R8V	In-package PSRAM (8 MB, Octal SPI)
SPICLK	CLK
SPICS1	CE#
SPIID	DQ0
SPIQ	DQ1
SPIWP	DQ2
SPIHD	DQ3
GPIO33	DQ4
GPIO34	DQ5
GPIO35	DQ6
GPIO36	DQ7
GPIO37	DQS/DM

SDcard Pin

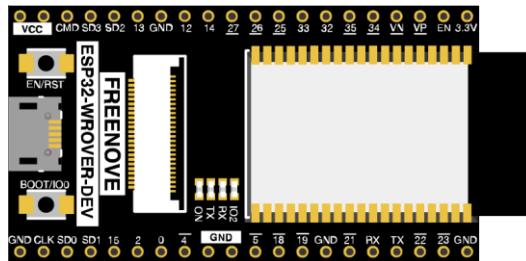
An SD card slot is integrated on the back of the ESP32-S3 WROOM board. We can use GPIO38-GPIO40 of ESP32-S3 WROOM to drive the SD card.

USB Pin

In Micropython, GPIO19 and GPIO20 are used for the USB function of ESP32S3, so they cannot be used as other functions!

Cam Pin

When using the camera of our ESP32-S3 WROOM, please check the pins of it. Pins with underlined numbers are used by the camera function, if you want to use other functions besides it, please avoid using them.



CAM_Pin	GPIO_pin
SIOD	GPIO4
SIOC	GPIO5
CSI_VSYNC	GPIO6
CSI_HREF	GPIO7
CSI_Y9	GPIO16
XCLK	GPIO15
CSI_Y8	GPIO17
CSI_Y7	GPIO18
CSI_PCLK	GPIO13
CSI_Y6	GPIO12
CSI_Y2	GPIO11
CSI_Y5	GPIO10
CSI_Y3	GPIO9
CSI_Y4	GPIO8

If you have any questions about the information of GPIO, you can click [here](#) to go back to ESP32-S3 WROOM to view specific information about GPIO.

or check: https://www.espressif.com/sites/default/files/documentation/esp32-s3_datasheet_en.pdf.



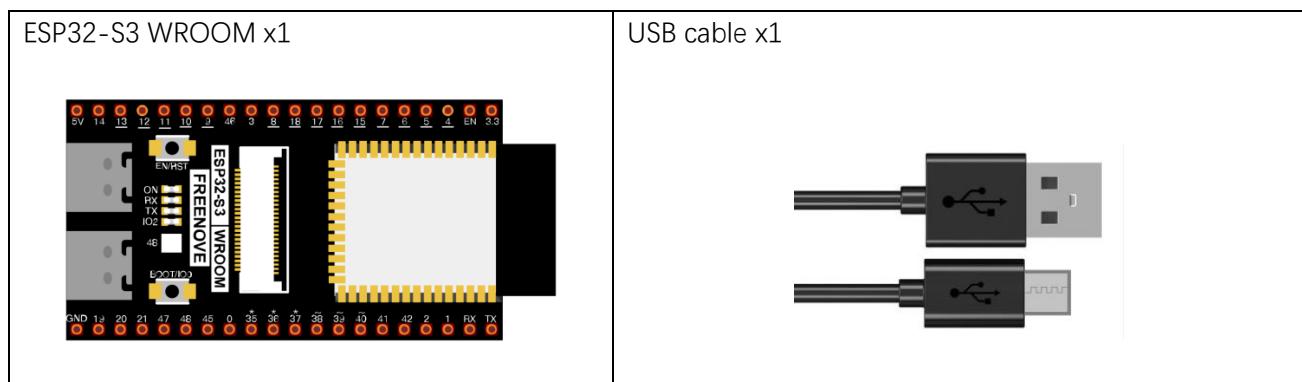
Chapter 1 LED (Important)

This chapter is the Start Point in the journey to build and explore ESP32-S3 WROOM electronic projects. We will start with simple “Blink” project.

Project 1.1 Blink

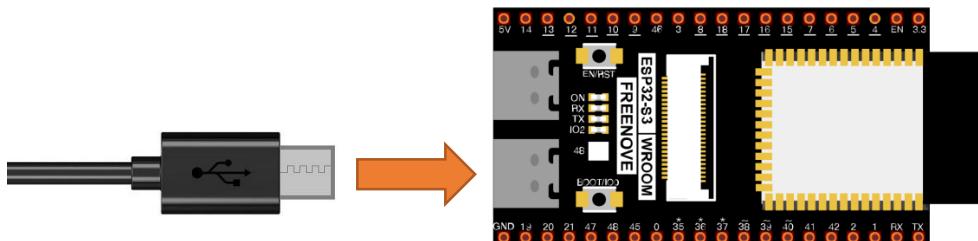
In this project, we will use ESP32-S3 WROOM to control blinking a common LED.

Component List



Power

ESP32-S3 WROOM needs 5v power supply. In this tutorial, we need connect ESP32-S3 WROOM to computer via USB cable to power it and program it. We can also use other 5v power source to power it.



In the following projects, we only use USB cable to power ESP32-S3 WROOM by default.

In the whole tutorial, we don't use T extension to power ESP32-S3 WROOM. So 5V and 3.3V (including EXT 3.3V) on the extension board are provided by ESP32-S3 WROOM.

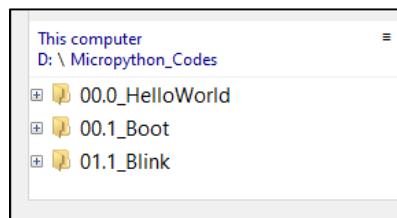
We can also use DC jack of extension board to power ESP32-S3 WROOM. In this way, 5v and EXT 3.3v on extension board are provided by external power resource.

Code

Codes used in this tutorial are saved in “**Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Codes**”. You can move the codes to any location. For example, we save the codes in Disk(D) with the path of “**D:/Micropython_Codes**”.

01.1_Blink

Open “Thonny”, click “This computer”→“D:”→“Micropython_Codes”.



Expand folder “01.1_Blink” and double click “Blink.py” to open it. As shown in the illustration below.



Make sure ESP32-S3 has been connected with the computer with ESP32-S3 correctly. Click “Stop/Rotate backend” or press the reset button, and then wait to see what interface will show up.

```

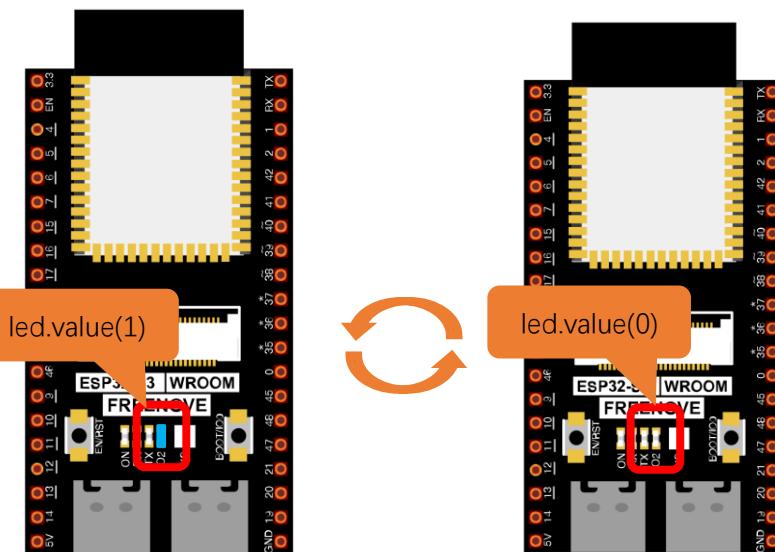
from time import sleep_ms
led = Pin(2, Pin.OUT)

while True:
    led.value(1)          #Set led turn on
    sleep_ms(1000)
    led.value(0)          #Set led turn off
    sleep_ms(1000)

except:
    pass

```

Click “Run current script” shown in the box above, the code starts to be executed and the LED in the circuit starts to blink.



Note:

This is the code [running online](#). If you disconnect USB cable and repower ESP32-S3 or press its reset key, LED stops blinking and the following messages will be displayed in Thonny.

The screenshot shows the Thonny IDE interface. The top menu bar includes File, Edit, View, Run, Device, Tools, and Help. Below the menu is a toolbar with icons for file operations like Open, Save, and Run. The left sidebar has a 'Files' tab showing 'This computer' and a file named 'Blink.py' which is selected. The main workspace contains a code editor with the following Python script:

```

1 from time import sleep_ms
2 from machine import Pin
3
4 led=Pin(2,Pin.OUT) #create LED object from pin2,Set Pin2 to output
5 try:
6     while True:
7         led.value(1)      #Set led turn on
8         sleep_ms(1000)
9         led.value(0)      #Set led turn off
10        sleep_ms(1000)
11 except:
12     pass

```

Below the code editor is a 'Shell' tab displaying MicroPython v1.18 output:

```

MicroPython v1.18 on 2022-01-17; ESP32 module (spiram) with ESP32
Type "help()" for more information.

>>>
Connection lost (GetOverlappedResult failed (PermissionError(13, 'Access is denied.', None, 5)))

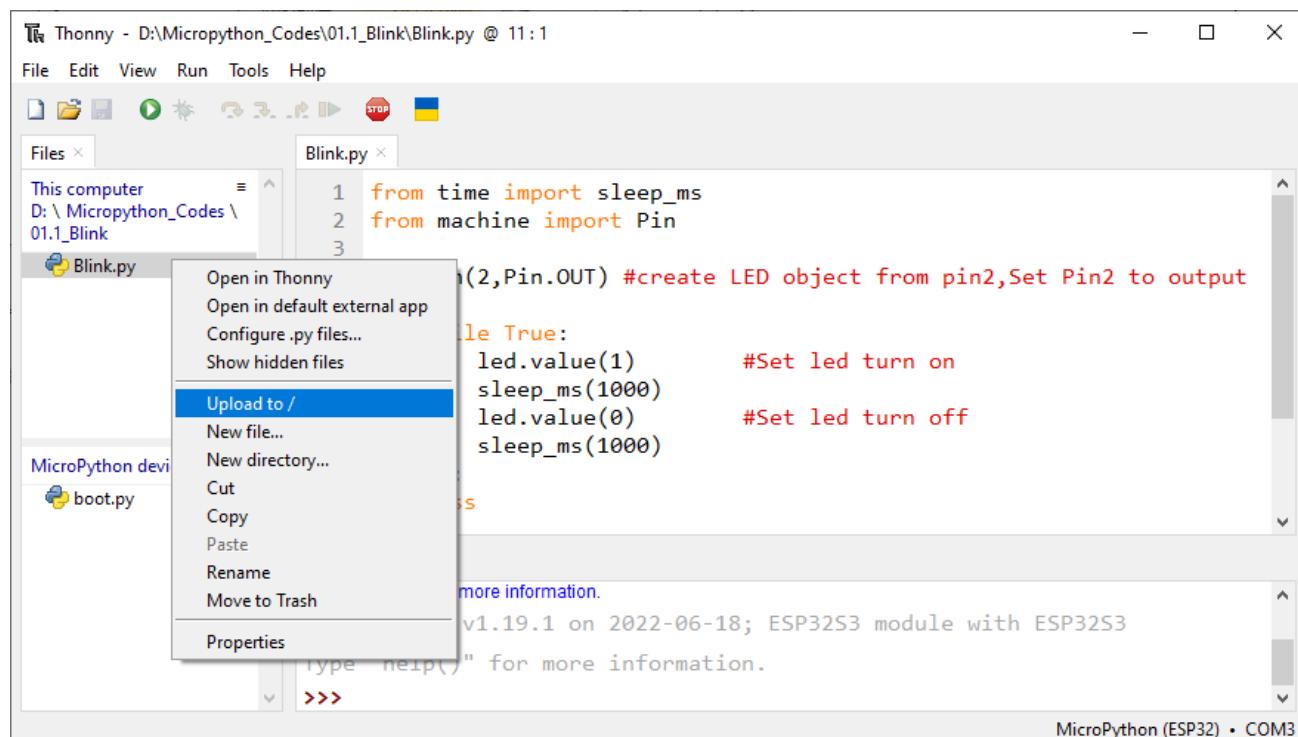
Use Stop/Restart to reconnect.

```

A red box highlights the error message in the shell.

Uploading code to ESP32S3

As shown in the following illustration, right-click the file Blink.py and select “Upload to /” to upload code to ESP32S3.



Upload boot.py in the same way.



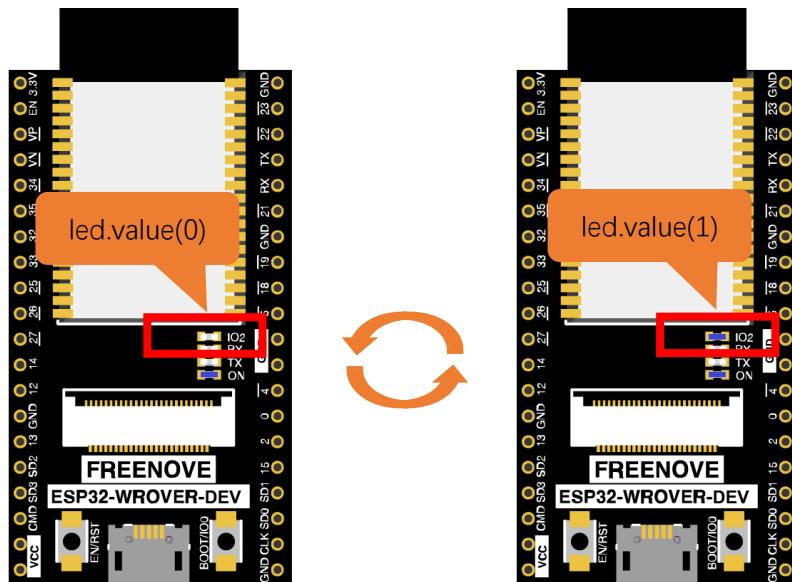
```

Thonny - D:\Micropython_Codes\01.1_Blink\Blink.py @ 11:1
File Edit View Run Tools Help
Blink.py x
This computer
D:\Micropython_Codes\01.1_Blink
Blink.py
MicroPython device
Blink.py
boot.py
from time import sleep_ms
from machine import Pin
led=Pin(2,Pin.OUT) #create LED object from pin2,Set Pin2 to output
try:
    while True:
        led.value(1)           #Set led turn on
        sleep_ms(1000)
        led.value(0)           #Set led turn off
        sleep_ms(1000)

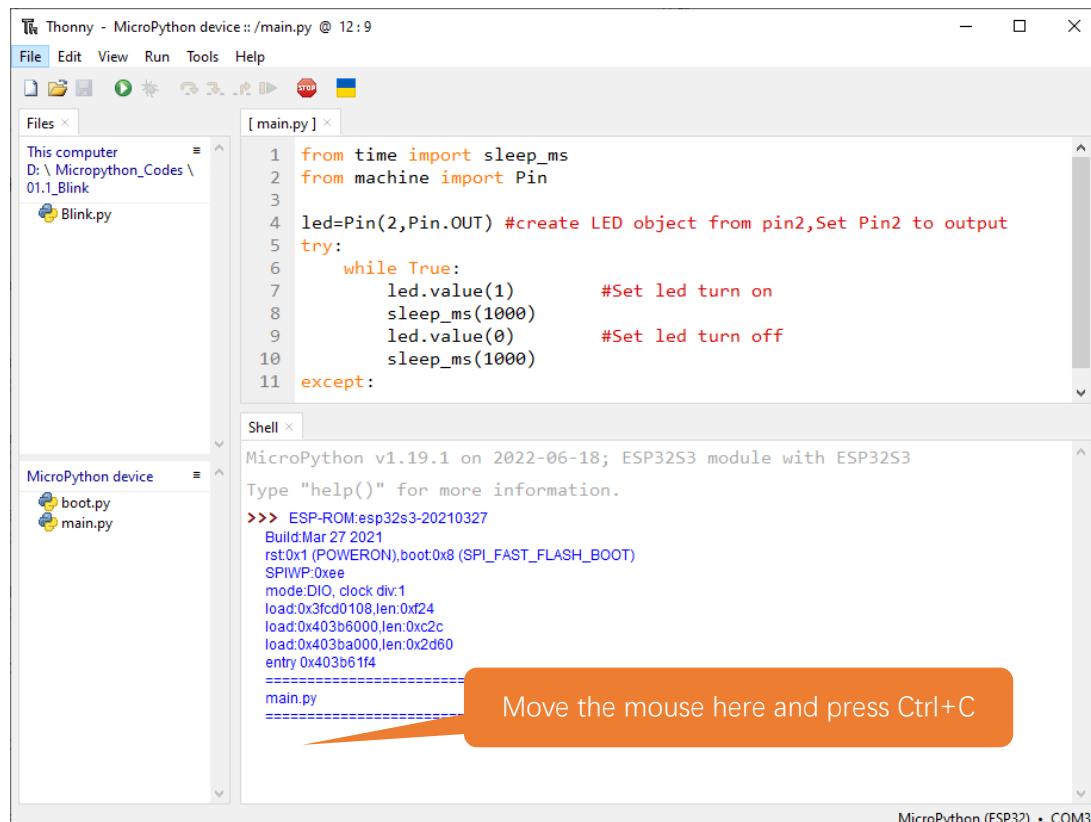
```

Make sure you have uploaded Blink.py and boot.py here,

Press the reset key of ESP32-S3 and you can see LED is ON for one second and then OFF for one second, which repeats in an endless loop.



If you want to exit the offline operation mode, you can press Ctrl+C at the same time in the shell to let the ESP32-S3 exit the offline operation mode.



If there is no response after pressing, it is recommended to press again until exiting.

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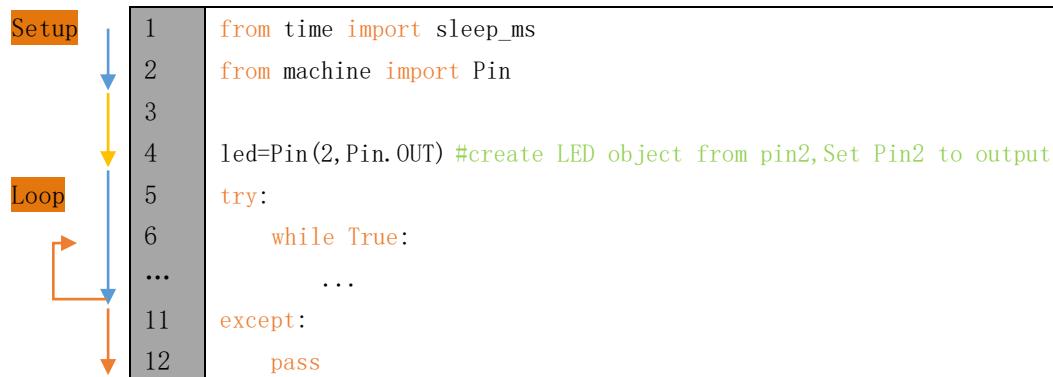
The following is the program code:

```

1  from time import sleep_ms
2  from machine import Pin
3
4  led=Pin(2,Pin.OUT) #create LED object from pin2, Set Pin2 to output
5  try:
6      while True:
7          led.value(1) #Set led turn on
8          sleep_ms(1000)
9          led.value(0) #Set led turn off
10         sleep_ms(1000)
11     except:
12         pass

```

Each time a new file is opened, the program will be executed from top to bottom. When encountering a loop construction, it will execute the loop statement according to the loop condition.



`Print()` function is used to print data to Terminal. It can be executed in Terminal directly or be written in a Python file and executed by running the file.

```
print("Hello world!")
```

Each time when using the functions of ESP32S3, you need to import modules corresponding to those functions: Import `sleep_ms` module of `time` module and `Pin` module of `machine` module.

```

1  from time import sleep_ms
2  from machine import Pin

```

Configure GPIO2 of ESP32-S3 to output mode and assign it to an object named "led".

```
4  led=Pin(2,Pin.OUT) #create LED object from pin2, Set Pin2 to output
```

It means that from now on, LED represents GPIO2 that is in output mode.

Set the value of LED to 1 and GPIO2 will output high level.

```
7  led.value(1) #Set led turn on
```

Set the value of LED to 0 and GPIO2 will output low level.

```
9  led.value(0) #Set led turn on
```

Execute codes in a while loop.

```

6  while True:
...

```

Put statements that may cause an error in “try” block and the executing statements when an error occurs in “except” block. In general, when the program executes statements, it will execute those in “try” block.

However, when an error occurs to ESP32-S3 due to some interference or other reasons, it will execute statements in “except” block.

“Pass” is an empty statement. When it is executed, nothing happens. It is useful as a placeholder to make the structure of a program look better.

```
5   try:  
...  
11  ...  
12  except:  
    pass
```

The single-line comment of Micropython starts with a “#” and continues to the end of the line. Comments help us to understand code. When programs are running, Thonny will ignore comments.

```
9 #Set led turn on
```

MicroPython uses indentations to distinguish different blocks of code instead of braces. The number of indentations is changeable, but it must be consistent throughout one block. If the indentation of the same code block is inconsistent, it will cause errors when the program runs.

```
6 while True:  
7     led.value(1) #Set led turn on  
8     sleep_ms(1000)  
9     led.value(0) #Set led turn off  
10    sleep_ms(1000)
```

How to import python files

Whether to import the built-in python module or to import that written by users, the command “import” is needed.

If you import the module directly you should indicate the module to which the function or attribute belongs when using the function or attribute (constant, variable) in the module. The format should be: <module name>.<function or attribute>, otherwise an error will occur.

```
import random  
  
num = random.randint(1, 100)  
print(num)
```

If you only want to import a certain function or attribute in the module, use the from...import statement. The format is as follows

```
from random import randint  
num = randint(1, 100)  
print(num)
```

When using “from...import” statement to import function, to avoid conflicts and for easy understanding, you can use “as” statement to rename the imported function, as follows

```
from random import randint as rand  
num = rand(1, 100)  
print(num)
```

Reference

Class machine

Before each use of the **machine** module, please add the statement “**import machine**” to the top of python file.

machine.freq(freq_val): When freq_val is not specified, it is to return to the current CPU frequency; Otherwise, it is to set the current CPU frequency.

freq_val: 80000000(80MHz)、160000000(160MHz)、240000000(240MHz)

machine.reset(): A reset function. When it is called, the program will be reset.

machine.unique_id(): Obtains MAC address of the device.

machine.idle(): Turns off any temporarily unused functions on the chip and its clock, which is useful to reduce power consumption at any time during short or long periods.

machine.disable_irq(): Disables interrupt requests and return the previous IRQ state. The disable_irq () function and enable_irq () function need to be used together; Otherwise the machine will crash and restart.

machine.enable_irq(state): To re-enable interrupt requests. The parameter **state** should be the value that was returned from the most recent call to the disable_irq() function

machine.time_pulse_us(pin, pulse_level, timeout_us=1000000):

Tests the duration of the external pulse level on the given pin and returns the duration of the external pulse level in microseconds. When pulse level = 1, it tests the high level duration; When pulse level = 0, it tests the low level duration.

If the setting level is not consistent with the current pulse level, it will wait until they are consistent, and then start timing. If the set level is consistent with the current pulse level, it will start timing immediately.

When the pin level is opposite to the set level, it will wait for timeout and return “-2”. When the pin level and the set level is the same, it will also wait timeout but return “-1”. **timeout_us** is the duration of timeout.

Class Pin(id[, mode, pull, value])

Before each use of the **Pin** module, please add the statement “**from machine import Pin**” to the top of python file.

id: Arbitrary pin number

mode: Mode of pins

Pin.IN: Input Mode

Pin.OUT: Output Mode

Pin.OPEN_DRAIN: Open-drain Mode

Pull: Whether to enable the internal pull up and down mode

None: No pull up or pull down resistors

Pin.PULL_UP: Pull-up Mode, outputting high level by default

Pin.PULL_DOWN: Pull-down Mode, outputting low level by default

Value: State of the pin level, 0/1

Pin.init(mode, pull): Initialize pins

Pin.value([value]): Obtain or set state of the pin level, return 0 or 1 according to the logic level of pins.

Without parameter, it reads input level. With parameter given, it is to set output level.

value: It can be either True/False or 1/0.

Pin.irq(trigger, handler): Configures an interrupt handler to be called when the pin level meets a condition.

trigger:

Pin.IRQ_FALLING: interrupt on falling edge

Pin.IRQ_RISING: interrupt on rising edge

3: interrupt on both edges

Handler: callback function

Class time

Before each use of the **time** module, please add the statement “**import time**” to the top of python file

time.sleep(sec): Sleeps for the given number of seconds

sec: This argument should be either an int or a float.

time.sleep_ms(ms): Sleeps for the given number of milliseconds, ms should be an int.

time.sleep_us(us): Sleeps for the given number of microseconds, us should be an int.

time.time(): Obtains the timestamp of CPU, with second as its unit.

time.ticks_ms(): Returns the incrementing millisecond counter value, which recounts after some values.

time.ticks_us(): Returns microsecond

time.ticks_cpu(): Similar to ticks_ms() and ticks_us(), but it is more accurate(return clock of CPU).

time.ticks_add(ticks, delta): Gets the timestamp after the offset.

ticks: ticks_ms()、ticks_us()、ticks_cpu()

delta: Delta can be an arbitrary integer number or numeric expression

time.ticks_diff(old_t, new_t): Calculates the interval between two timestamps, such as ticks_ms(), ticks_us() or ticks_cpu().

old_t: Starting time

new_t: Ending time



Project 1.2 Blink

In this project, we will use ESP32-S3 WROOM to control blinking a common LED.

Component List

ESP32-S3 WROOM x1	GPIO Extension Board x1	
A small black rectangular module with a yellow header and several pins at the bottom. It has a white label in the center that reads "ESP32-S3 WROOM" and "FREENOVE".	A breadboard-compatible board with a yellow header. It has various pins labeled with numbers (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48) and some component pads. A label on the board says "Freenove ESP32S3 GPIO Extension Board".	
Breadboard x1		
A standard breadboard with two rows of 40 pins each, designed for prototyping with jumper wires.		
LED x1	Resistor 220Ω x1	Jumper M/M x2
A red light-emitting diode (LED) with two leads.	A cylindrical resistor with a grey band indicating a value of 220Ω.	A long green jumper wire with black caps at both ends.

Component knowledge

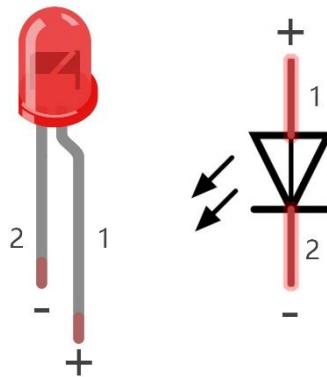
LED

A LED is a type of diode. All diodes only work if current is flowing in the correct direction and have two poles. A LED will only work (light up) if the longer pin (+) of LED is connected to the positive output from a power source and the shorter pin is connected to the negative (-). Negative output is also referred to as Ground (GND). This type of component is known as “diodes” (think One-Way Street).

All common 2 lead diodes are the same in this respect. Diodes work only if the voltage of its positive electrode

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is higher than its negative electrode and there is a narrow range of operating voltage for most all common diodes of 1.9 and 3.4V. If you use much more than 3.3V the LED will be damaged and burn out.



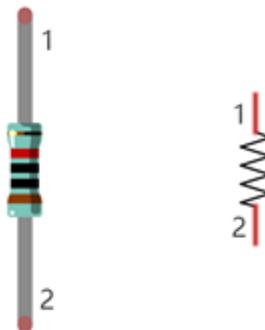
LED	Voltage	Maximum current	Recommended current
Red	1.9-2.2V	20mA	10mA
Green	2.9-3.4V	10mA	5mA
Blue	2.9-3.4V	10mA	5mA
Volt ampere characteristics conform to diode			

Note: LEDs cannot be directly connected to a power supply, which usually ends in a damaged component. A resistor with a specified resistance value must be connected in series to the LED you plan to use.

Resistor

Resistors use Ohms (Ω) as the unit of measurement of their resistance (R). $1M\Omega=1000k\Omega$, $1k\Omega=1000\Omega$.

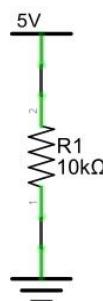
A resistor is a passive electrical component that limits or regulates the flow of current in an electronic circuit. On the left, we see a physical representation of a resistor, and the right is the symbol used to represent the presence of a resistor in a circuit diagram or schematic.



The bands of color on a resistor is a shorthand code used to identify its resistance value. For more details of resistor color codes, please refer to the appendix of this tutorial.

With a fixed voltage, there will be less current output with greater resistance added to the circuit. The relationship between Current, Voltage and Resistance can be expressed by this formula: $I=V/R$ known as Ohm's Law where I = Current, V = Voltage and R = Resistance. Knowing the values of any two of these allows you to solve the value of the third.

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

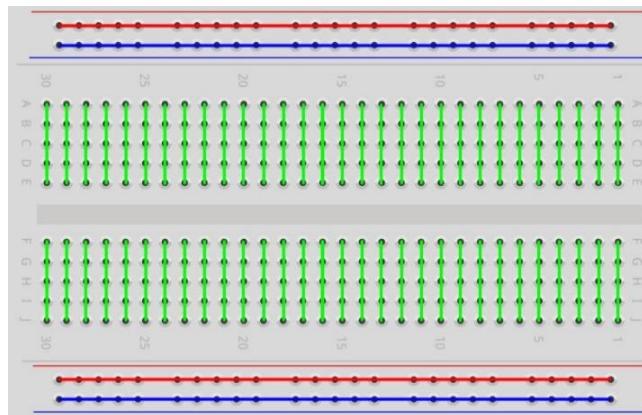


WARNING: Never connect the two poles of a power supply with anything of low resistance value (i.e. a metal object or bare wire) this is a Short and results in high current that may damage the power supply and electronic components.

Note: Unlike LEDs and diodes, resistors have no poles and are non-polar (it does not matter which direction you insert them into a circuit, it will work the same)

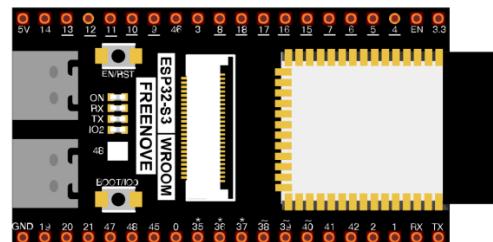
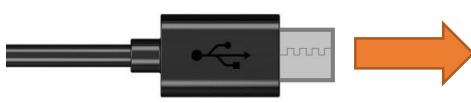
Breadboard

Here we have a small breadboard as an example of how the rows of holes (sockets) are electrically attached. The left picture shows the way to connect pins. The right picture shows the practical internal structure.



Power

ESP32-S3 WROOM needs 5v power supply. In this tutorial, we need connect ESP32-S3 WROOM to computer via USB cable to power it and program it. We can also use other 5v power source to power it.



In the following projects, we only use USB cable to power ESP32-S3 WROOM by default.

In the whole tutorial, we don't use T extension to power ESP32-S3 WROOM. So 5V and 3.3V (including EXT 3.3V) on the extension board are provided by ESP32-S3 WROOM.

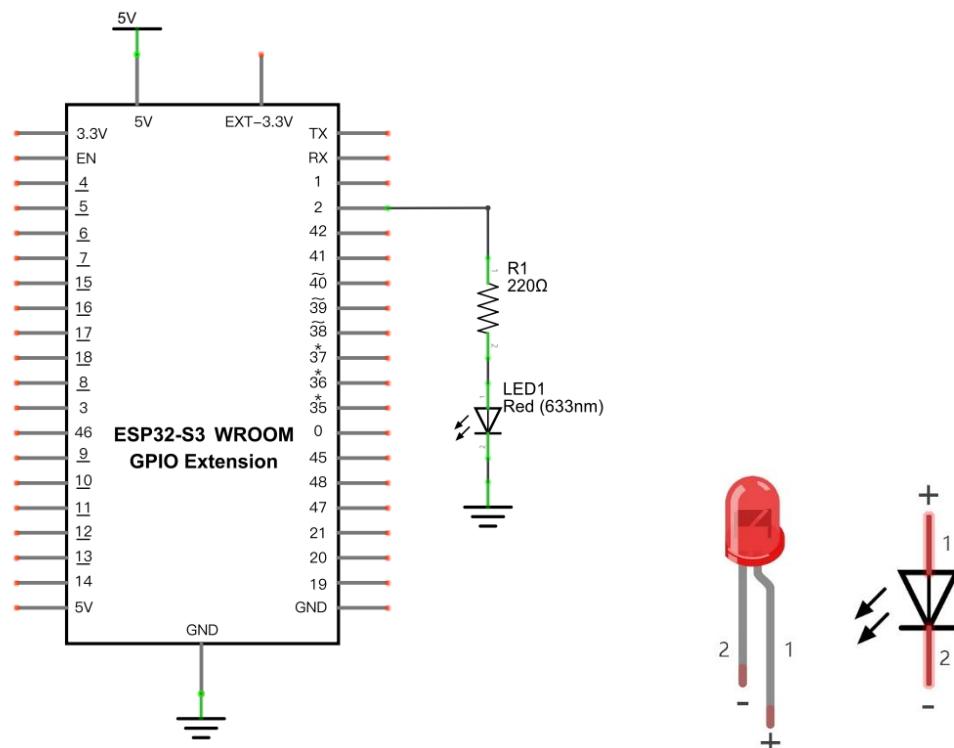
We can also use DC jack of extension board to power ESP32-S3 WROOM. In this way, 5v and EXT 3.3v on extension board are provided by external power resource.

Circuit

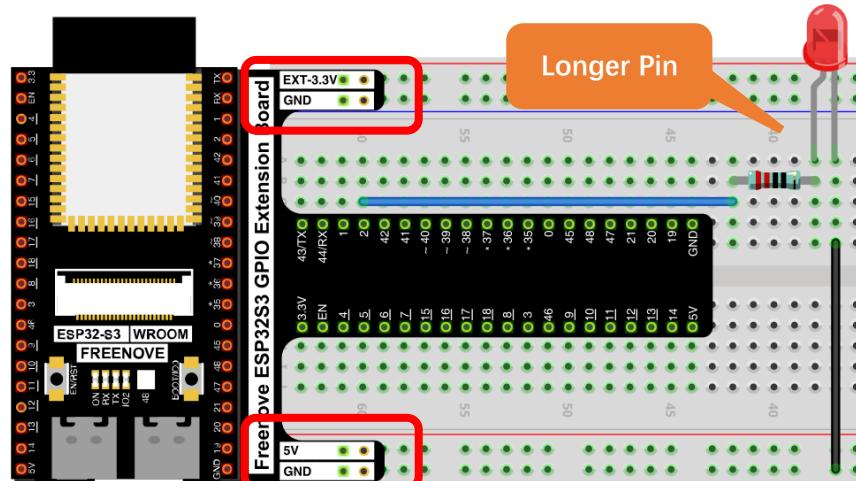
First, disconnect all power from the ESP32-S3 WROOM. Then build the circuit according to the circuit and hardware diagrams. After the circuit is built and verified correct, connect the PC to ESP32-S3 WROOM.

CAUTION: Avoid any possible short circuits (especially connecting 5V or GND, 3.3V and GND)! **WARNING:** A short circuit can cause high current in your circuit, generate excessive component heat and cause permanent damage to your hardware!

Schematic diagram



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



Don't rotate ESP32-S3 WROOM 180° for connection.

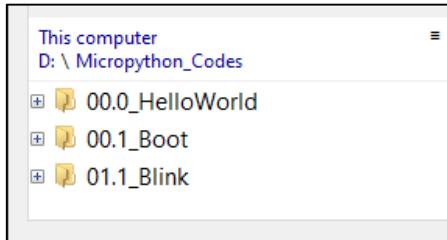
Any concerns? ✉ support@freenove.com

Code

Codes used in this tutorial are saved in “**Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Codes**”. You can move the codes to any location. For example, we save the codes in Disk(D) with the path of “**D:/Micropython_Codes**”.

01.1_Blink

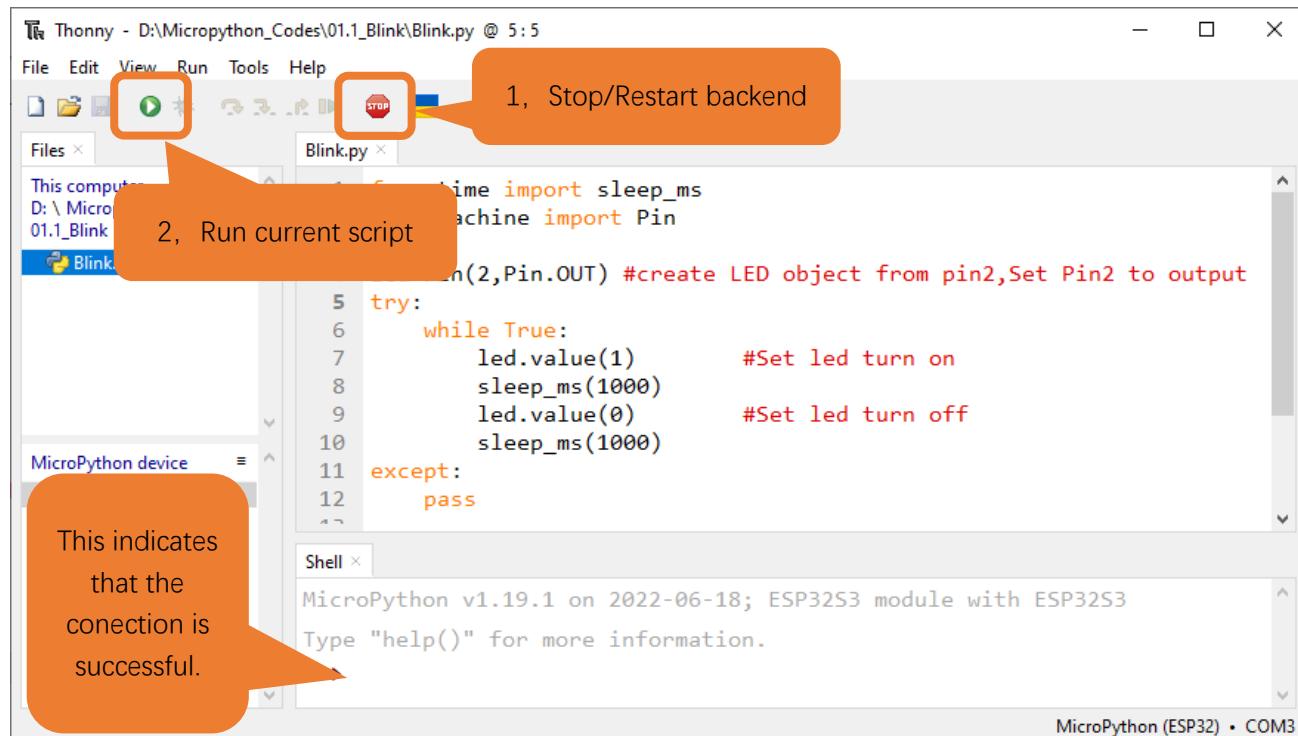
Open “Thonny”, click “This computer”→“D:”→“Micropython_Codes”.



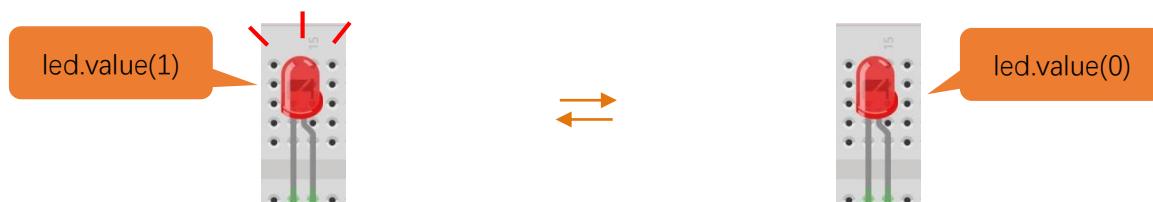
Expand folder “01.1_Blink” and double click “Blink.py” to open it. As shown in the illustration below.



Make sure ESP32-S3 has been connected with the computer with ESP32-S3 correctly. Click “Stop/Rotate backend” or press the reset button, and then wait to see what interface will show up.



Click “Run current script” shown in the box above, the code starts to be executed and the LED in the circuit starts to blink.



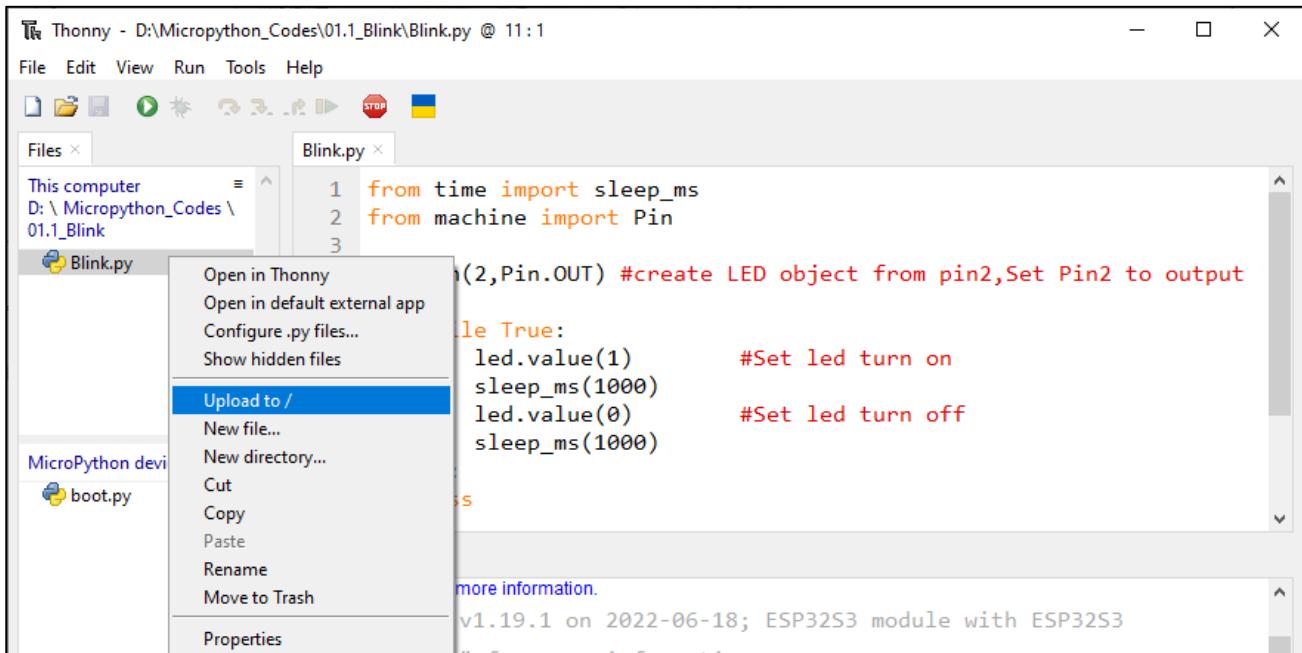
Note:

This is the code [running online](#). If you disconnect USB cable and repower ESP32-S3 or press its reset key, LED stops blinking and the following messages will be displayed in Thonny.

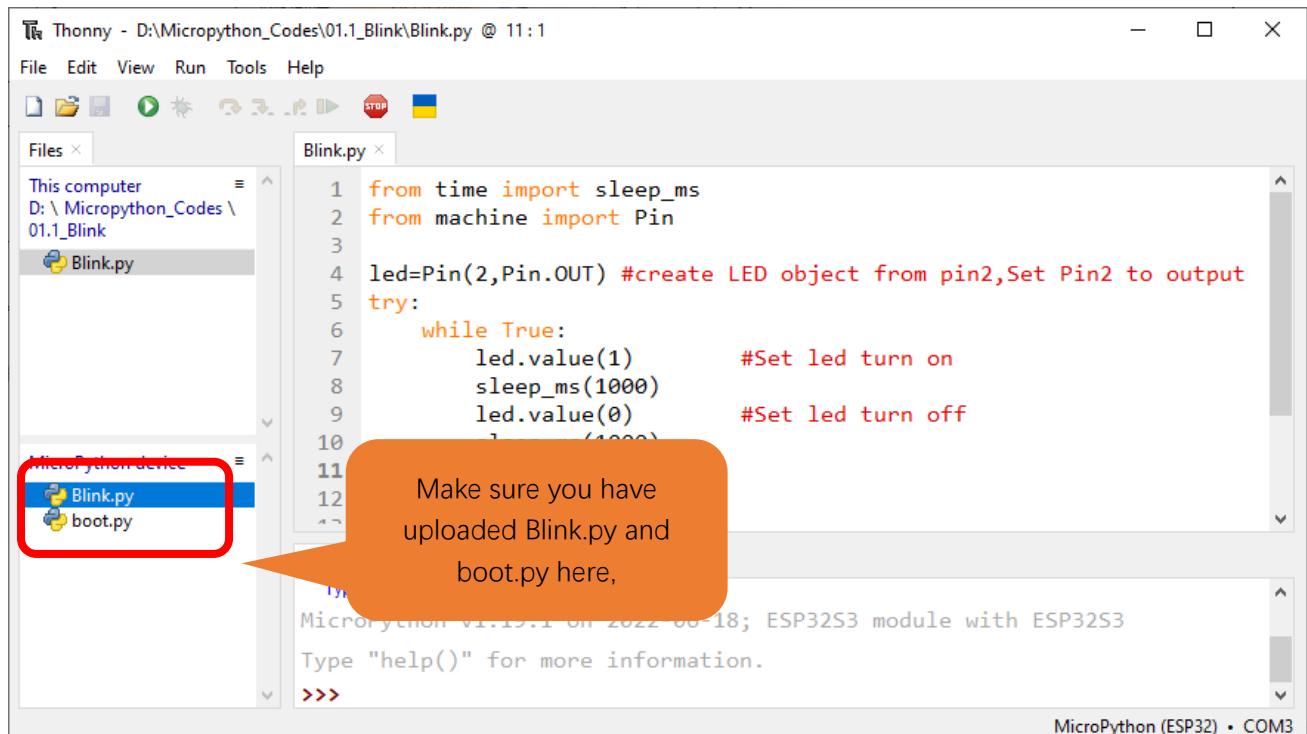


Uploading code to ESP32S3

As shown in the following illustration, right-click the file Blink.py and select “Upload to /” to upload code to ESP32S3.

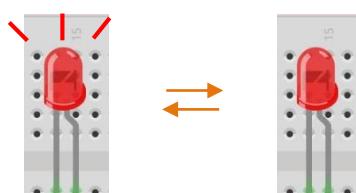


Upload boot.py in the same way.



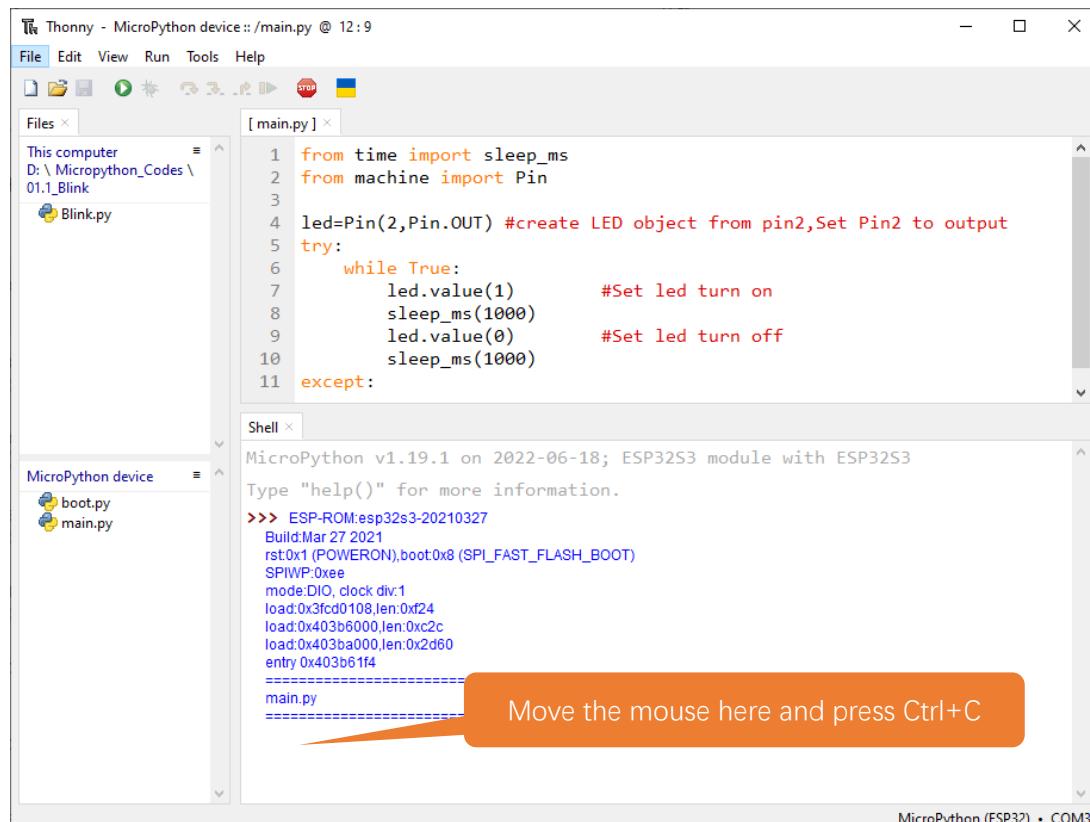
Press the reset key of ESP32-S3 and you can see LED is ON for one second and then OFF for one second, which repeats in an endless loop.

Press the reset key of ESP32-S3 and you can see LED is ON for one second and then OFF for one second, which repeats in an endless loop.



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If you want to exit the offline operation mode, you can press Ctrl+C at the same time in the shell to let the ESP32-S3 exit the offline operation mode.



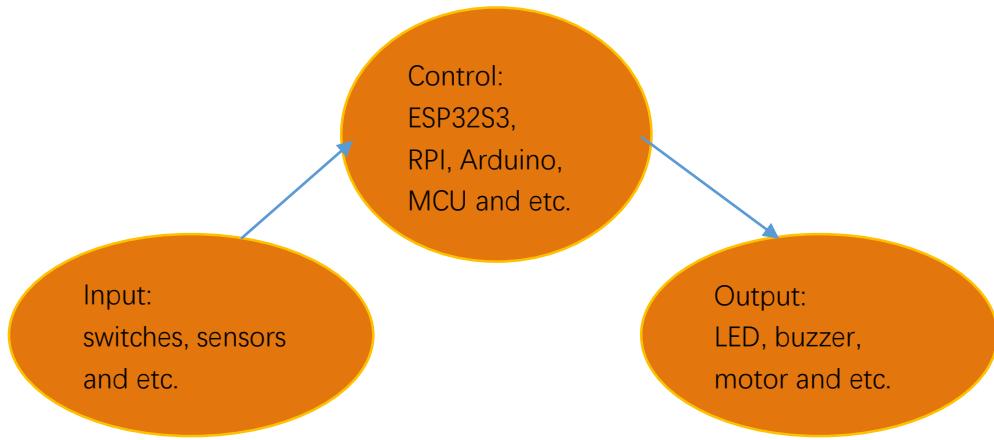
If there is no response after pressing, it is recommended to press again until exiting.

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

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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 was the output part and ESP32-S3 was the control part. In practical applications, we not only make LEDs flash, but also make a device sense the surrounding environment, receive instructions and then take the appropriate action such as LEDs light up, make a buzzer turn ON and so on.

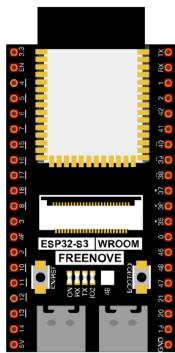
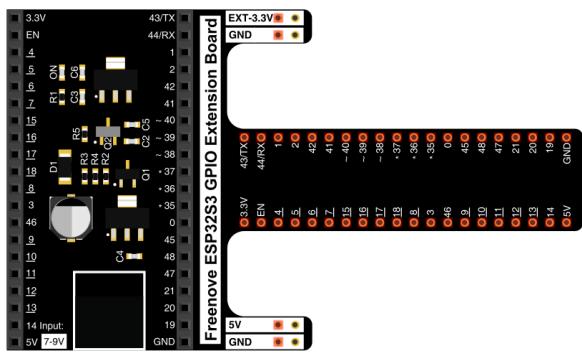
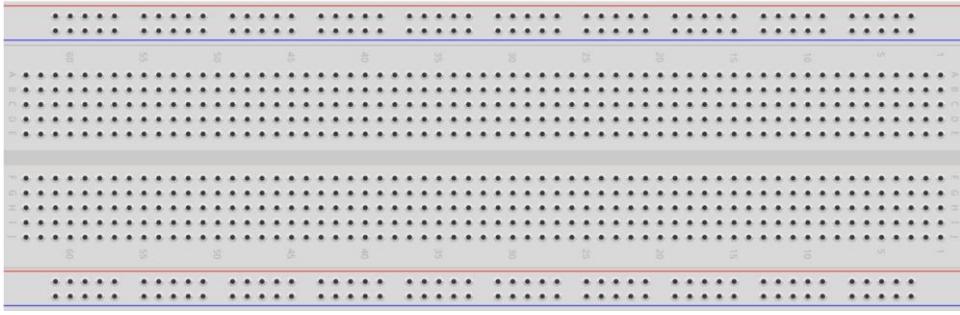


Next, we will build a simple control system to control a LED through a push button switch.

Project 2.1 Button & LED

In the project, we will control the LED state through a Push Button Switch. When the button is pressed, our LED will turn ON, and when it is released, the LED will turn OFF.

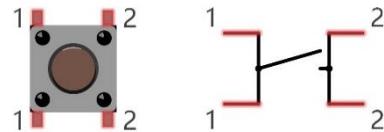
Component List

ESP32-S3 WROOM x1	GPIO Extension Board x1			
 				
Breadboard x1				
Jumper M/M x4	LED x1	Resistor 220Ω x1	Resistor 10kΩ x2	Push button x1
				

Component knowledge

Push button

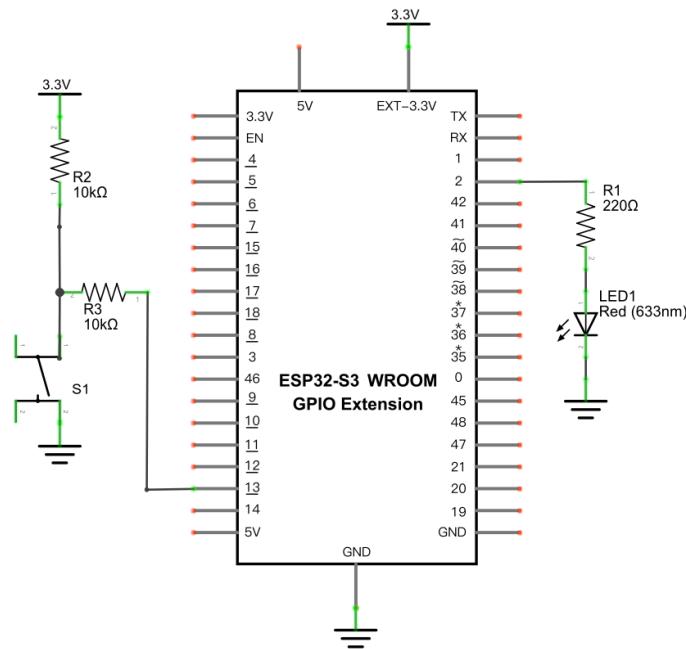
This type of push button switch has 4 pins (2 Pole Switch). Two pins on the left are connected, and both left and right sides are the same per the illustration:



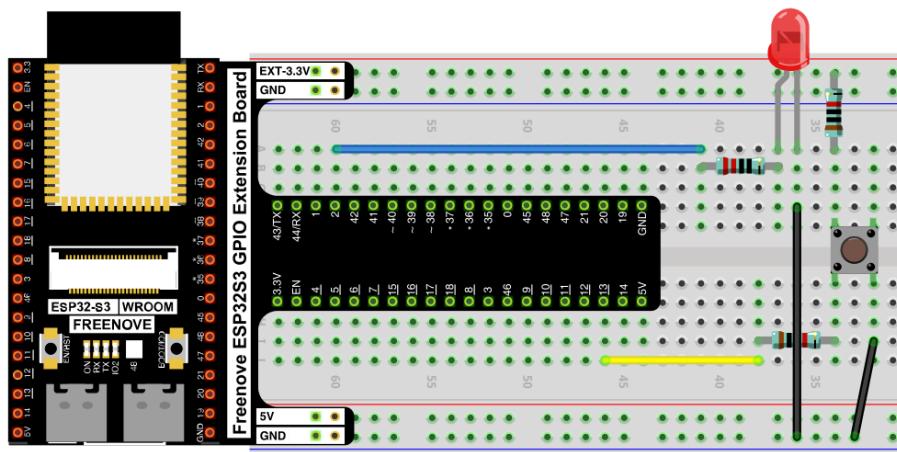
When the button on the switch is pressed, the circuit is completed (your project is powered ON).

Circuit

Schematic diagram



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



Any concerns? [✉ support@freenove.com](mailto:support@freenove.com)

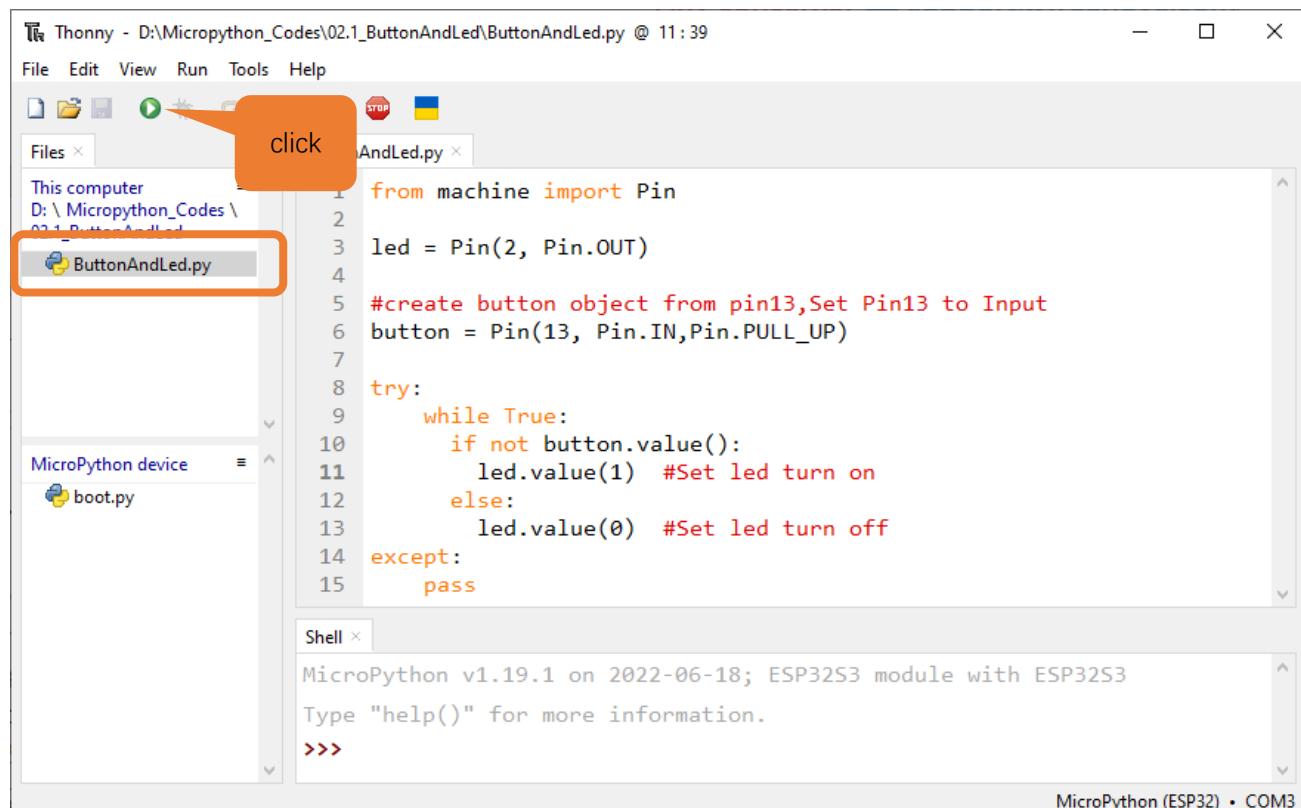
Code

This project is designed to learn to control an LED with a push button switch. First, we need to read the state of the switch and then decide whether the LED is turned on or not based on it.

Move the program folder “**Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Codes**” to disk(D) in advance with the path of “**D:/Micropython_Codes**”.

Open “Thonny”, click “This computer” → “D:” → “Micropython_Codes” → “02.1_ButtonAndLed” and double click “ButtonAndLed.py”.

02.1_ButtonAndLed

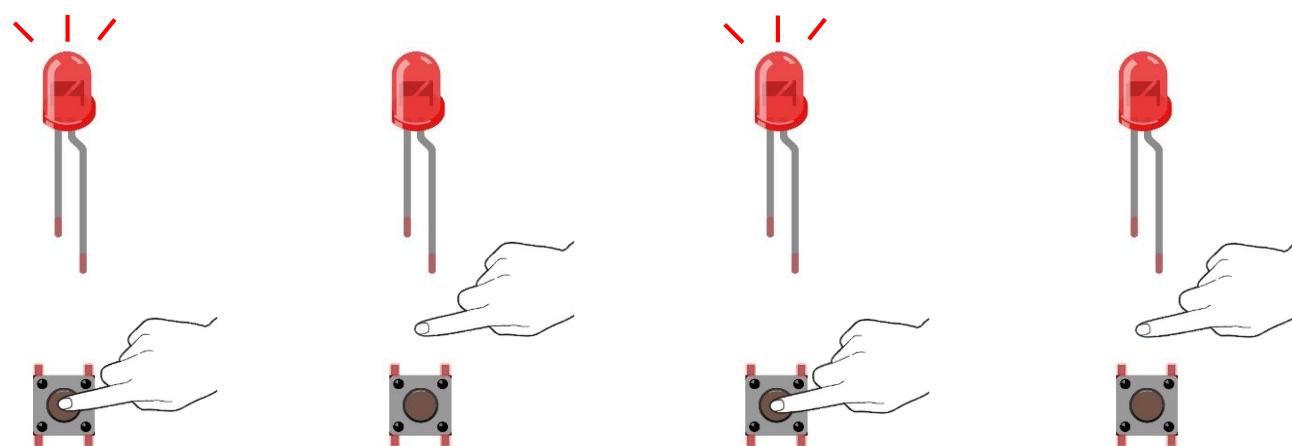


```

Thonny - D:\Micropython_Codes\02.1_ButtonAndLed\ButtonAndLed.py @ 11:39
File Edit View Run Tools Help
File Folders Run STOP
AndLed.py x
This computer
D:\Micropython_Codes\02.1_ButtonAndLed
ButtonAndLed.py x
from machine import Pin
led = Pin(2, Pin.OUT)
#create button object from pin13,Set Pin13 to Input
button = Pin(13, Pin.IN,Pin.PULL_UP)
try:
    while True:
        if not button.value():
            led.value(1) #Set led turn on
        else:
            led.value(0) #Set led turn off
except:
    pass
Shell x
MicroPython v1.19.1 on 2022-06-18; ESP32S3 module with ESP32S3
Type "help()" for more information.
>>>

```

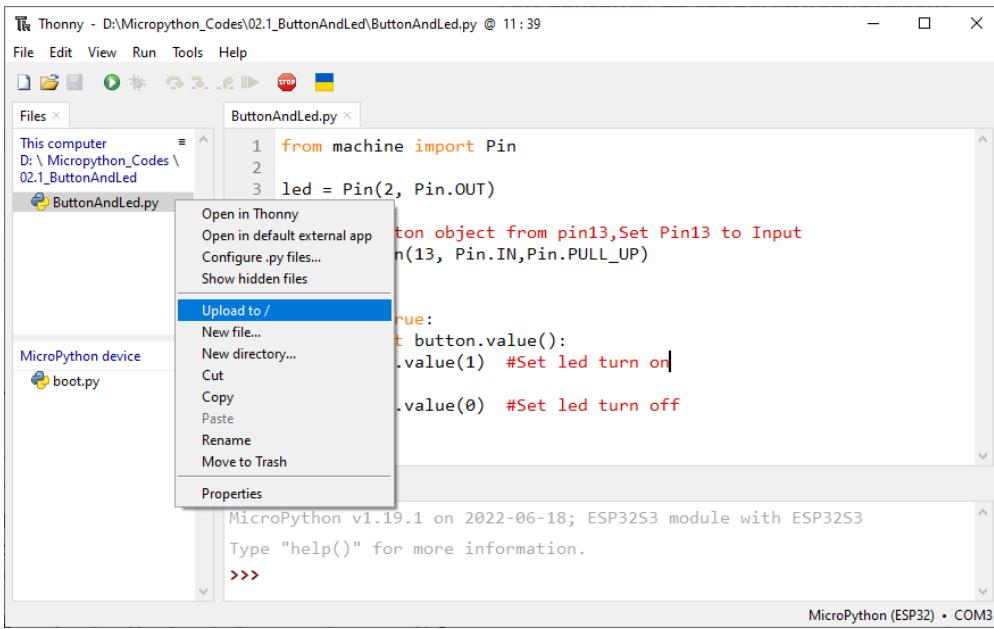
Click “Run current script” shown in the box of the above illustration, press the push button switch, LED turns ON; release the switch, LED turns OFF.



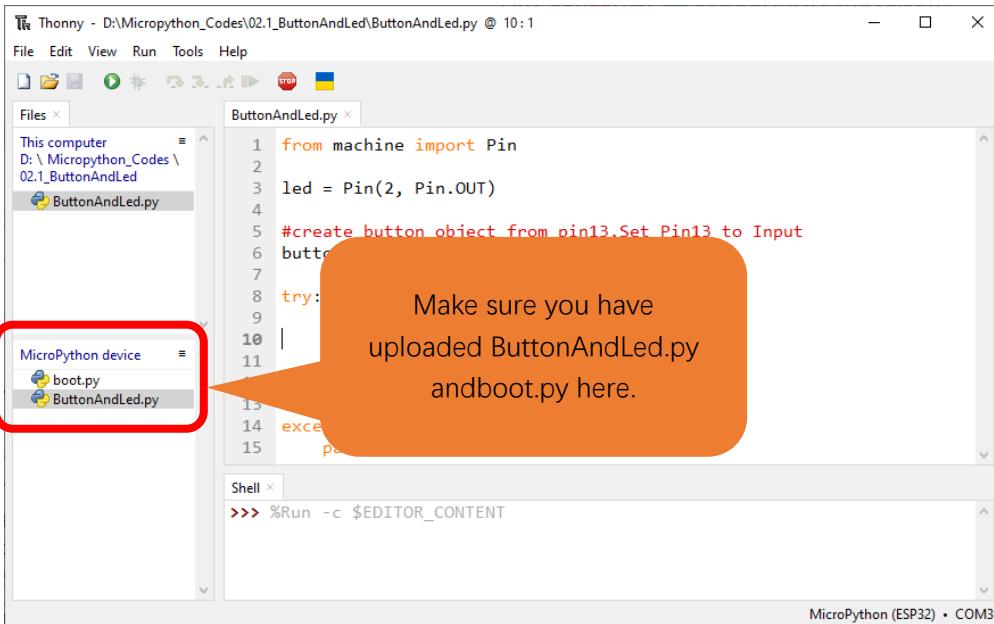


Upload Code to ESP32S3

As shown in the following illustration, right-click file 02.1_ButtonAndLed and select “Upload to /” to upload code to ESP32S3.



Upload boot.py in the same way.



The following is the program code:

```

1  from machine import Pin
2
3  led = Pin(2, Pin.OUT)
4
5  #create button object from pin13, Set Pin13 to Input
6  button = Pin(13, Pin.IN, Pin.PULL_UP)
7
8  try:
9      while True:
10         if not button.value():
11             led.value(1) #Set led turn on
12         else:
13             led.value(0) #Set led turn off
14     except:
15         pass

```

In this project, we use the Pin module of the machine, so before initializing the Pin, we need to import this module first.

```
1  from machine import Pin
```

In the circuit connection, LED and Button are connected with GPIO2 and GPIO13 respectively, so define led and button as 2 and 13 respectively.

```

3  led = Pin(2, Pin.OUT)
4
5  #create button object from pin13, Set Pin13 to Input
6  button = Pin(13, Pin.IN, Pin.PULL_UP)

```

Read the pin state of button with value() function. Press the button switch, the function returns low level and the result of "if" is true, and then LED will be turned ON; Otherwise, LED is turned OFF.

```

9  while True:
10     if not button.value():
11         led.value(1) #Set led turn on
12     else:
13         led.value(0) #Set led turn off

```

If statement is used to execute the next statement when a certain condition is proved to be true (or non0). It is often used together with "else" statement, which judges other statements except the if statement. If you need to judge if the result of a condition is 0, you can use if not statement.

```

10    if not button.value():
11        ...
12    else:
13        ...

```



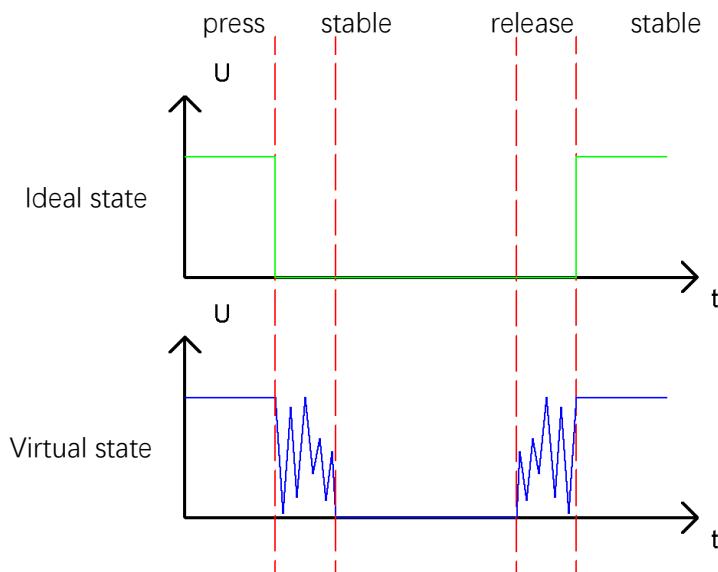
Project 2.2 MINI table lamp

We will also use a push button switch, LED and ESP32-S3 to make a MINI table lamp but this will function differently: Press the button, the LED will turn ON, and pressing the button again, the LED turns OFF. The ON switch action is no longer momentary (like a door bell) but remains ON without needing to continually press on the Button Switch.

First, let us learn something about the push button switch.

Debounce for Push Button

The moment when a push button switch is pressed, it will not change from one state to another state immediately. Due to tiny mechanical vibrations, there will be a short period of continuous buffeting before it completely reaches another state too fast for humans to detect but not for computer microcontrollers. The same is true when the push button switch is released. This unwanted phenomenon is known as “bounce”.



Therefore, if we can directly detect the state of the push button switch, there are multiple pressing and releasing actions in one pressing cycle. This buffeting will mislead the high-speed operation of the microcontroller to cause many false decisions. Therefore, we need to eliminate the impact of buffeting. Our solution: to judge the state of the button multiple times. Only when the button state is stable (consistent) over a period of time, can it indicate that the button is actually in the ON state (being pressed).

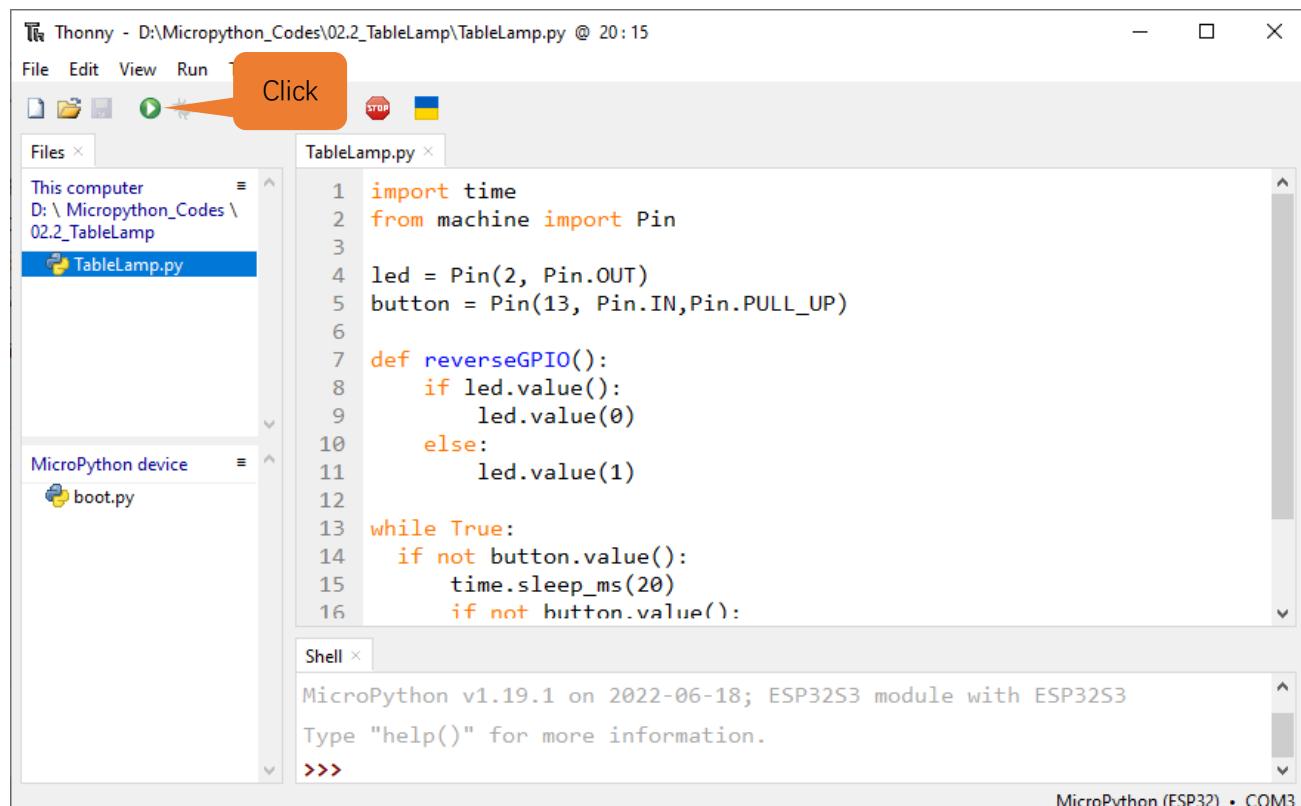
This project needs the same components and circuits as we used in the previous section.

Code

02.2_Tablelamp

Move the program folder “Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Codes” to disk(D) in advance with the path of “D:/Micropython_Codes”.

Open “Thonny”, click “This computer” → “D:” → “Micropython_Codes” → “02.2_TableLamp” and double click “TableLamp.py”.



```

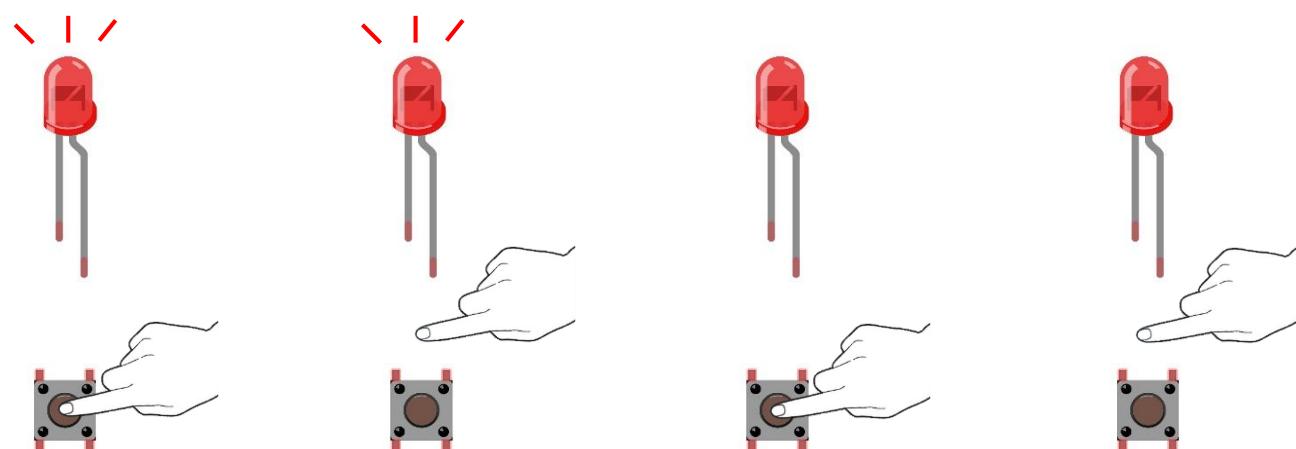
Thonny - D:\Micropython_Codes\02.2_TableLamp\TableLamp.py @ 20:15
File Edit View Run
File Files TableLamp.py
This computer D:\Micropython_Codes\02.2_TableLamp
TableLamp.py
MicroPython device boot.py
TableLamp.py
1 import time
2 from machine import Pin
3
4 led = Pin(2, Pin.OUT)
5 button = Pin(13, Pin.IN,Pin.PULL_UP)
6
7 def reverseGPIO():
8     if led.value():
9         led.value(0)
10    else:
11        led.value(1)
12
13 while True:
14     if not button.value():
15         time.sleep_ms(20)
16         if not button.value():
17             led.value(1)
18         else:
19             led.value(0)
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
39>>>

```

MicroPython v1.19.1 on 2022-06-18; ESP32S3 module with ESP32S3
Type "help()" for more information.
>>>

MicroPython (ESP32) • COM3

Click “Run current script” shown in the box of the above illustration, press the push button switch, LED turns ON; press it again, LED turns OFF.

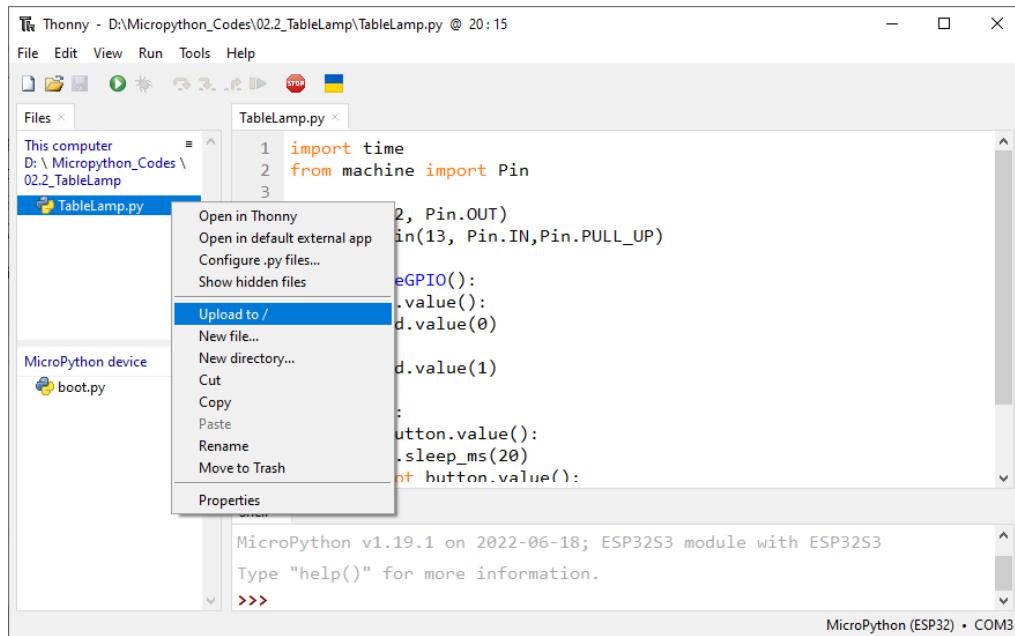


If you have any concerns, please contact us via: support@freenove.com

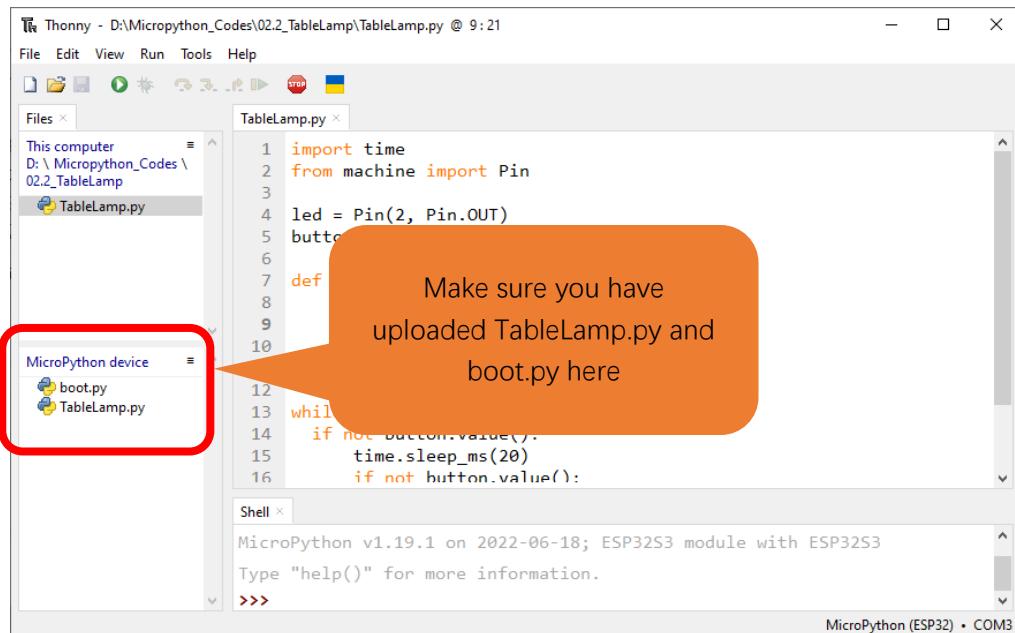
Any concerns? ✉ support@freenove.com

Upload code to ESP32S3

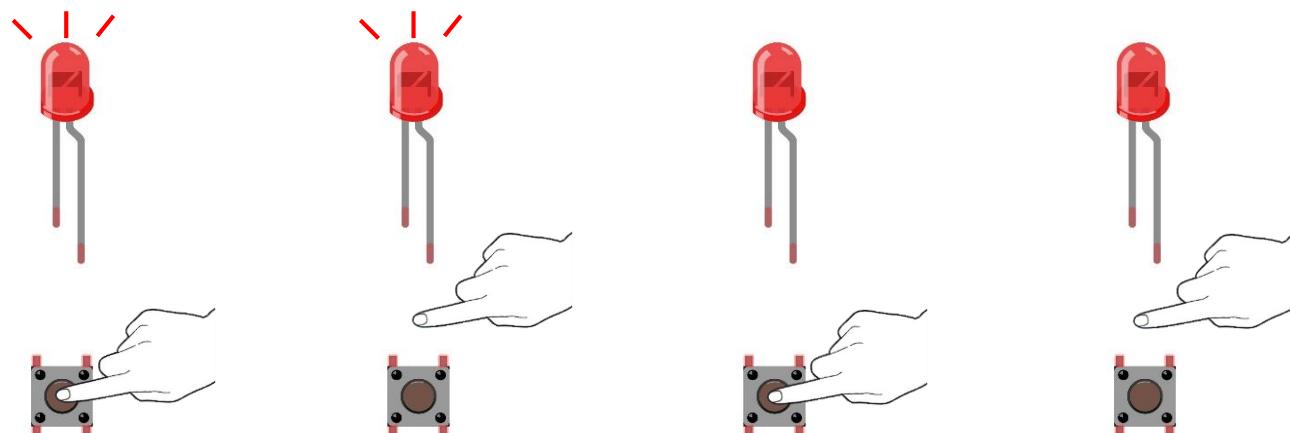
As shown in the following illustration, right-click file 02.2_TableLamp and select “Upload to /” to upload code to ESP32S3.



Upload boot.py in the same way.



Press ESP32S3's reset key, and then push the button switch, LED turns ON; Push the button again, LED turns OFF.



The following is the program code:

```

1 import time
2 from machine import Pin
3
4 led = Pin(2, Pin.OUT)
5 button = Pin(13, Pin.IN, Pin.PULL_UP)
6
7 def reverseGPIO():
8     if led.value():
9         led.value(0)
10    else:
11        led.value(1)
12
13 while True:
14     if not button.value():
15         time.sleep_ms(20)
16         if not button.value():
17             reverseGPIO()
18             while not button.value():
19                 time.sleep_ms(20)

```

When the button is detected to be pressed, delay 20ms to avoid the effect of bounce, and then check whether the button has been pressed again. If so, the conditional statement will be executed, otherwise it will not be executed.

```

13 while True:
14     if not button.value():
15         time.sleep_ms(20)
16         if not button.value():
17             reverseGPIO()
18             while not button.value():
19                 time.sleep_ms(20)

```



Customize a function and name it reverseGPIO(), which reverses the output level of the LED.

```
7  def reverseGPIO():
8      if led.value():
9          led.value(0)
10     else:
11         led.value(1)
```

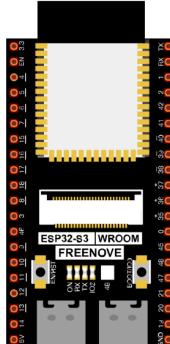
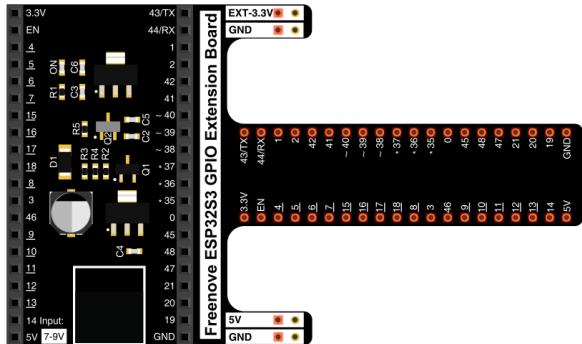
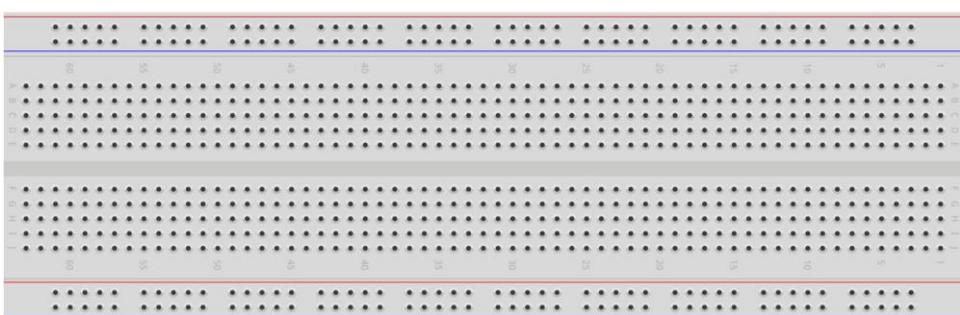
Chapter 3 LED Bar

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

Project 3.1 Flowing Light

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

Component List

ESP32-S3 WROOM x1	GPIO Extension Board x1	Breadboard x1
		

Jumper M/M x10	LED bar graph x1	Resistor 220Ω x10
		

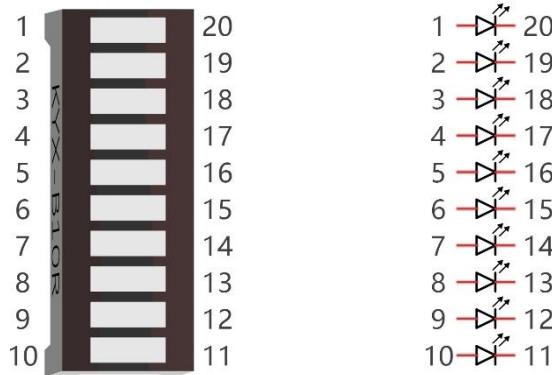


Component knowledge

Let's learn about the basic features of these components to use and understand them better.

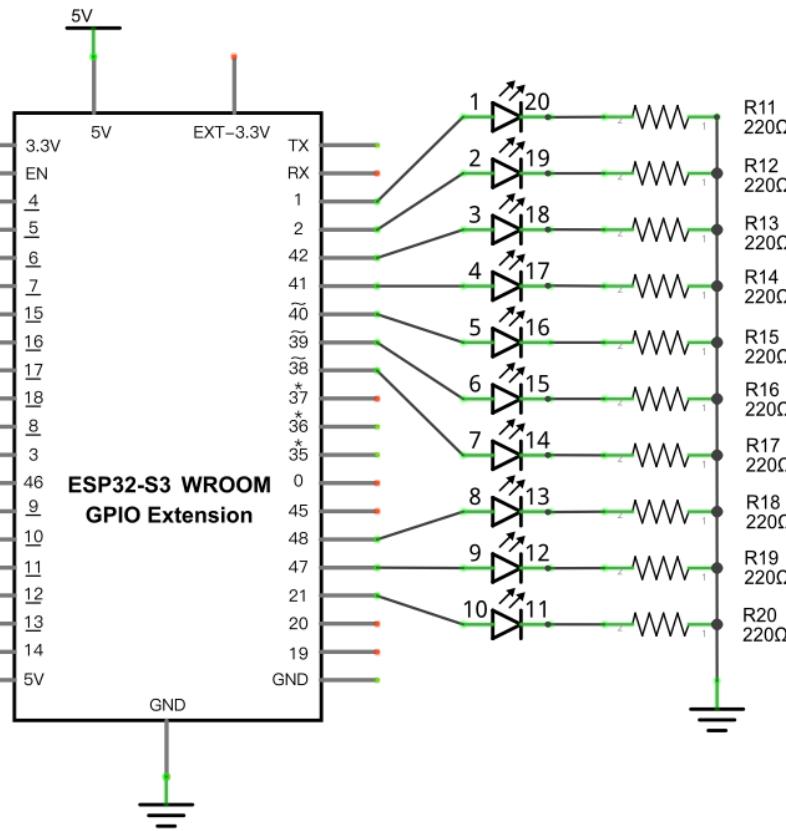
LED bar

A LED bar graph has 10 LEDs integrated into one compact component. The two rows of pins at its bottom are paired to identify each LED like the single LED used earlier.

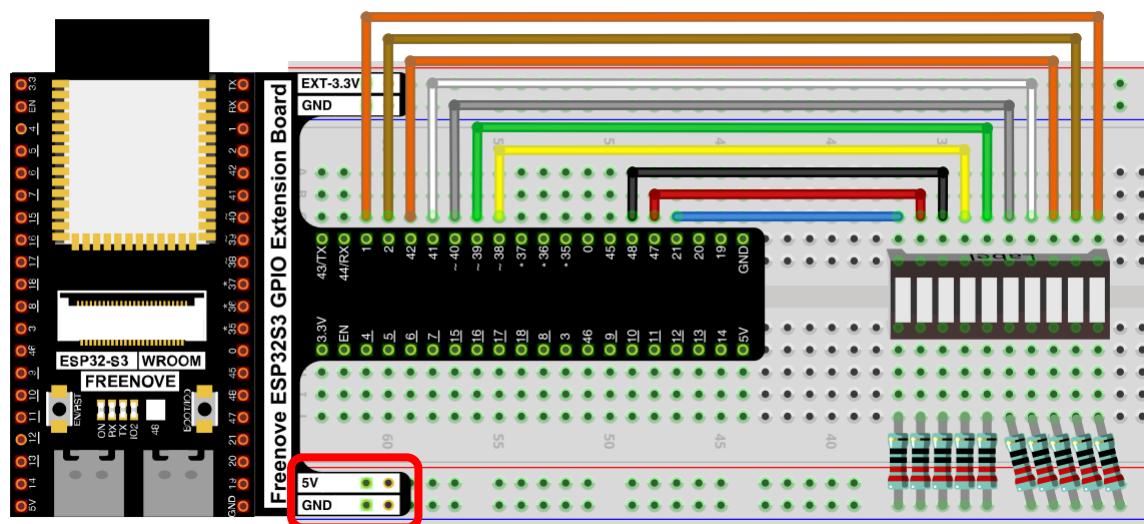


Circuit

Schematic diagram



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



If LED bar does not work, try to rotate it for 180°. The label is random.

Any concerns? ✉ support@freenove.com

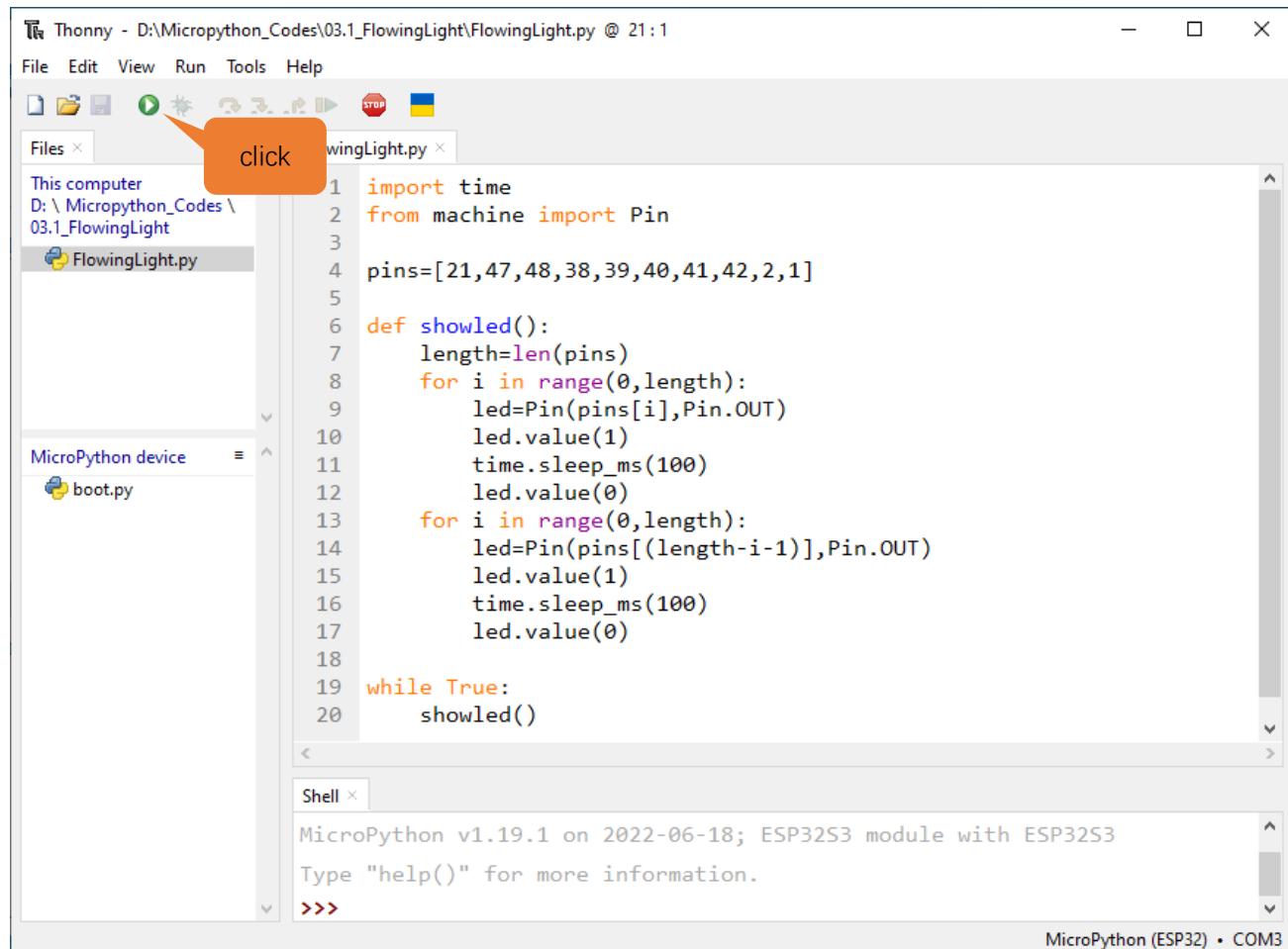
Code

This project is designed to make a flowing water lamp. Which are these actions: First turn LED #1 ON, then turn it OFF. Then turn LED #2 ON, and then turn it OFF... and repeat the same to all 10 LEDs until the last LED is turns OFF. This process is repeated to achieve the “movements” of flowing water.

03.1_FlowingLight

Move the program folder “Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Codes” to disk(D) in advance with the path of “D:/Micropython_Codes”.

Open “Thonny”, click “This computer” → “D:” → “Micropython_Codes” → “03.1_FlowingLight” and double click “FlowingLight.py”.



```

Thonny - D:\Micropython_Codes\03.1_FlowingLight\FlowingLight.py @ 21:1
File Edit View Run Tools Help
Files x FlowingLight.py x
This computer
D:\Micropython_Codes\03.1_FlowingLight
FlowingLight.py
MicroPython device
boot.py
1 import time
2 from machine import Pin
3
4 pins=[21,47,48,38,39,40,41,42,2,1]
5
6 def showled():
7     length=len(pins)
8     for i in range(0,length):
9         led=Pin(pins[i],Pin.OUT)
10        led.value(1)
11        time.sleep_ms(100)
12        led.value(0)
13     for i in range(0,length):
14         led=Pin(pins[(length-i-1)],Pin.OUT)
15         led.value(1)
16         time.sleep_ms(100)
17         led.value(0)
18
19 while True:
20     showled()

```

Shell x

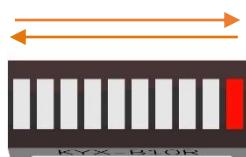
```

MicroPython v1.19.1 on 2022-06-18; ESP32S3 module with ESP32S3
Type "help()" for more information.
>>>

```

MicroPython (ESP32) • COM3

Click “Run current script” shown in the box above, LED Bar Graph will light up from left to right and then back from right to left.



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

Any concerns? ✉ support@freenove.com

The following is the program code:

```
1 import time
2 from machine import Pin
3
4 pins=[21, 47, 48, 38, 39, 40, 41, 42, 2, 1]
5
6 def showled():
7     length=len(pins)
8     for i in range(0, length):
9         led=Pin(pins[i], Pin.OUT)
10        led.value(1)
11        time.sleep_ms(100)
12        led.value(0)
13     for i in range(0, length):
14         led=Pin(pins[(length-i-1)], Pin.OUT)
15         led.value(1)
16         time.sleep_ms(100)
17         led.value(0)
18
19 while True:
20     showled()
```

Use an array to define 10 GPIO ports connected to LED Bar Graph for easier operation.

```
4 pins=[21, 47, 48, 38, 39, 40, 41, 42, 2, 1]
```

Use len() function to obtain the amount of elements in the list and use a for loop to configure pins as output mode.

```
7 length=len(pins)
8 for i in range(0, length):
9     led=Pin(pins[i], Pin.OUT)
```

Use two for loops to turn on LEDs separately from left to right and then back from right to left.

```
8 for i in range(0, length):
9     led=Pin(pins[i], Pin.OUT)
10    led.value(1)
11    time.sleep_ms(100)
12    led.value(0)
13 for i in range(0, length):
14     led=Pin(pins[(length-i-1)], Pin.OUT)
15     led.value(1)
16     time.sleep_ms(100)
17     led.value(0)
```



Reference

for i in range(start,end,num: int=1)

For loop is used to execute a program endlessly and iterate in the order of items (a list or a string) in the sequence

start: The initial value, the for loop starts with it

end: The ending value, the for loop end with it

num: Num is automatically added each time to the data. The default value is 1

Chapter 4 Analog & PWM

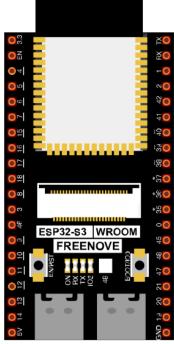
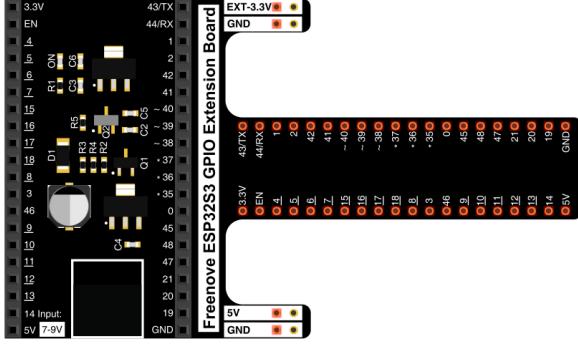
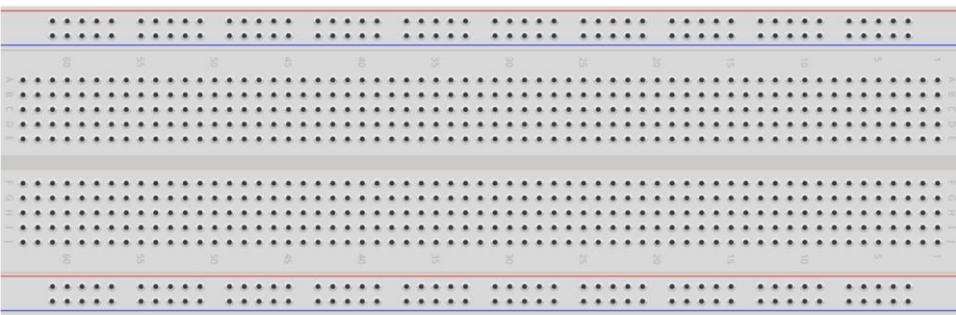
In previous study, we have known that one button has two states: pressed and released, and LED has light-on/off state, then how to enter a middle state? How to output an intermediate state to let LED "semi bright"? That's what we're going to learn.

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, and 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.

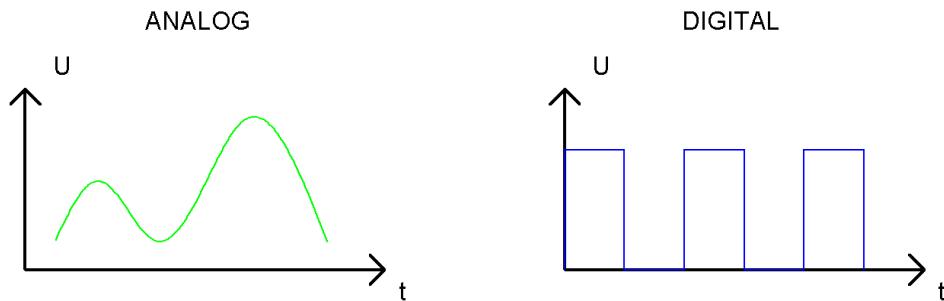
Component List

ESP32-S3 WROOM x1	GPIO Extension Board x1	
		
		
Breadboard x1		
		
LED x1	Resistor 220Ω x1	Jumper M/M x2
		

Related knowledge

Analog & Digital

An analog signal is a continuous signal in both time and value. On the contrary, a digital signal or discrete-time signal is a time series consisting of a sequence of quantities. Most signals in life are analog signals. A familiar example of an analog signal would be how the temperature throughout the day is continuously changing and could not suddenly change instantaneously from 0°C to 10°C. However, digital signals can instantaneously change in value. This change is expressed in numbers as 1 and 0 (the basis of binary code). Their differences can more easily be seen when compared when graphed as below.



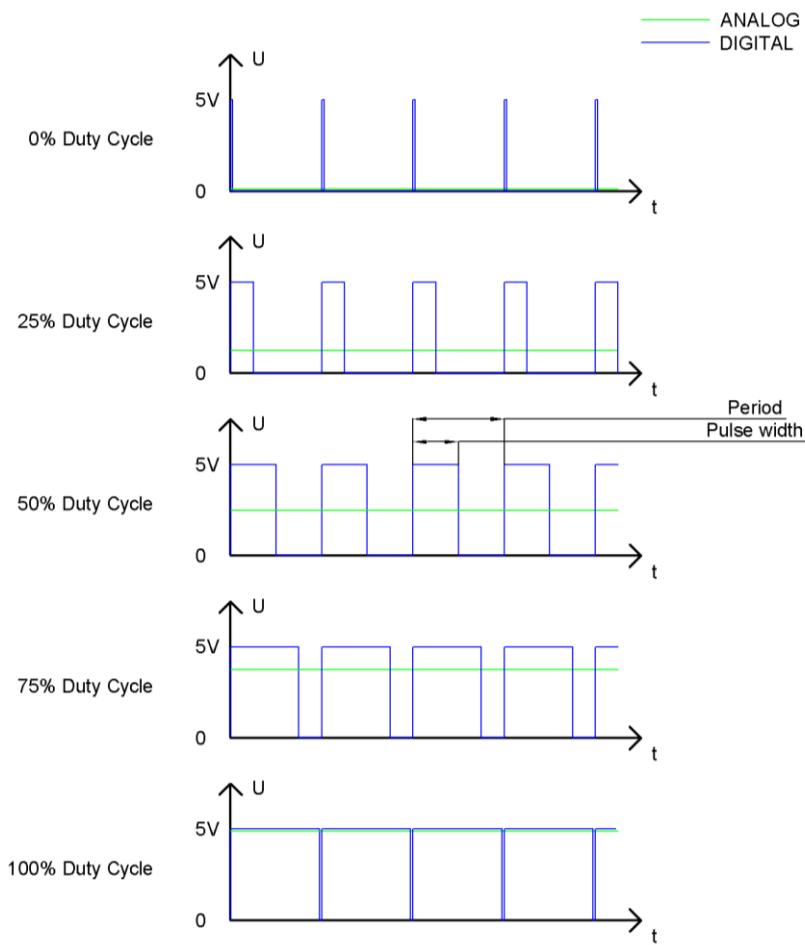
In practical application, we often use binary as the digital signal, that is a series of 0's and 1's. Since a binary signal only has two values (0 or 1), it has great stability and reliability. Lastly, both analog and digital signals can be converted into the other.

PWM

PWM, Pulse-Width Modulation, is a very effective method for using digital signals to control analog circuits. Common processors cannot directly output analog signals. PWM technology makes it very convenient to achieve this conversion (translation of digital to analog signals).

PWM technology uses digital pins to send certain frequencies of square waves, that is, the output of high levels and low levels, which alternately last for a while. The total time for each set of high levels and low levels is generally fixed, which is called the period (Note: the reciprocal of the period is frequency). The time of high level outputs are generally called "pulse width", and the duty cycle is the percentage of the ratio of pulse duration, or pulse width (PW) to the total period (T) of the waveform.

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



The longer the PWM duty cycle is, the higher the output power will be. Now that we understand this relationship, we can use PWM to control the brightness of a LED or 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. Therefore, we can control the output power of the LED and other output modules to achieve different effects.

ESP32-S3 and PWM

On ESP32S3, the LEDC(PWM) controller has 8 separate channels, each of which can independently control frequency, duty cycle, and even accuracy. Unlike traditional PWM pins, the PWM output pins of ESP32-S3 are configurable, with one or more PWM output pins per channel. The relationship between the maximum frequency and bit precision is shown in the following formula, where the maximum value of bit is 31.

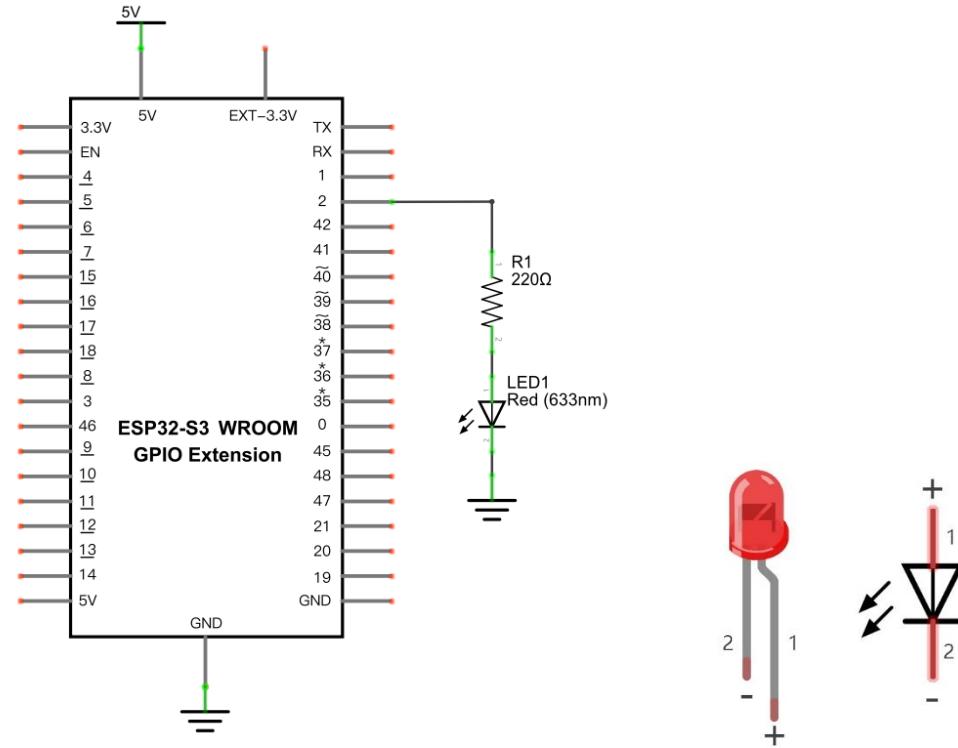
$$\text{Freq}_{\max} = \frac{80,000,000}{1 \ll \text{bit}}$$

For example, generate a PWM with an 8-bit precision ($2^8=256$. Values range from 0 to 255) with a maximum frequency of $80,000,000/256 = 312,500\text{Hz}$.

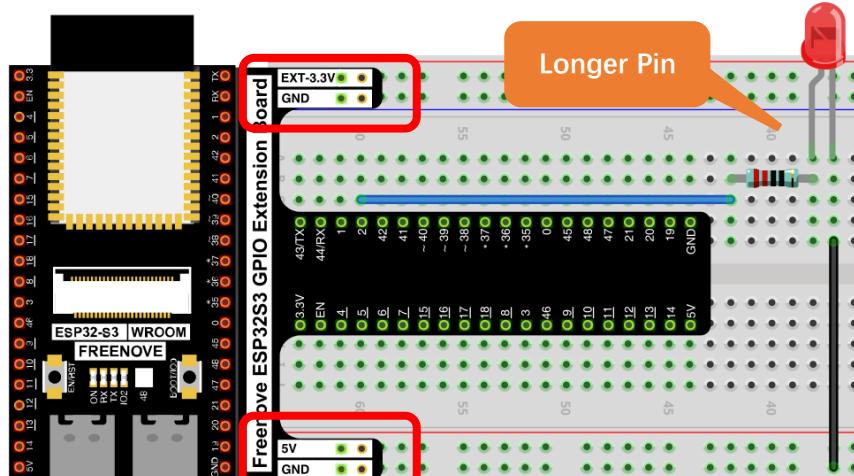
Circuit

This circuit is the same as the one in engineering Blink.

Schematic diagram



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



Don't rotate ESP32-S3 WROOM 180° for connection.

Code

This project is designed to make PWM output GPIO2 with pulse width increasing from 0% to 100%, and then reducing from 100% to 0% gradually.

Move the program folder “**Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Codes**” to disk(D) in advance with the path of “**D:/Micropython_Codes**”.

Open “Thonny”, click“This computer” → “D:” → “Micropython_Codes” → “04.1_BreatheLight” and double click “BreatheLight.py”.

04.1_BreatheLight

```

from machine import Pin,PWM
import time

pwm =PWM(Pin(2),10000)
try:
    while True:
        for i in range(0,1023):
            pwm.duty(i)
            time.sleep_ms(1)

        for i in range(1023,0,-1):
            pwm.duty(i)
            time.sleep_ms(1)
except:
    pwm.deinit()

```

Click “Run current script”, and you'll see that LED is turned from ON to OFF and then back from OFF to ON gradually like breathing.





The following is the program code:

```
1  from machine import Pin, PWM
2  import time
3
4  pwm = PWM(Pin(2, Pin.OUT), 10000)
5  try:
6      while True:
7          for i in range(0, 1023):
8              pwm.duty(i)
9              time.sleep_ms(1)
10
11         for i in range(0, 1023):
12             pwm.duty(1023-i)
13             time.sleep_ms(1)
14 except:
15     pwm.deinit()
```

The way that the ESP32-S3 PWM pins output is different from traditionally controllers. It can change frequency and duty cycle by configuring PWM's parameters at the initialization stage. Define GPIO2's output frequency as 10000Hz, and assign them to PWM.

```
4  pwm =PWM(Pin(2, Pin.OUT), 10000)
```

The range of duty cycle is 0-1023, so we use the first for loop to control PWM to change the duty cycle value, making PWM output 0% -100%; Use the second for loop to make PWM output 100%-0%.

```
7  for i in range(0, 1023):
8      pwm.duty(i)
9      time.sleep_ms(1)
10
11     for i in range(0, 1023):
12         pwm.duty(1023-i)
13         time.sleep_ms(1)
```

Each time PWM is used, the hardware Timer will be turned ON to cooperate it. Therefore, after each use of PWM, deinit() needs to be called to turned OFF the timer. Otherwise, the PWM may fail to work next time.

```
15  pwm.deinit()
```

Reference

Class `PWM(pin, freq)`

Before each use of PWM module, please add the statement “**from machine import PWM**” to the top of the python file.

pin: Any pin supports PWM output, except GPIO19,20

freq: Output frequency, with the range of 0-78125 Hz

duty: Duty cycle, with the range of 0-1023.

PWM.init(freq, duty): Initialize PWM, parameters are the same as above.

PWM.freq([freq_val]): When there is no parameter, the function obtains and returns PWM frequency; When parameters are set, the function is used to set PWM frequency and returns nothing.

PWM.duty([duty_val]): When there is no parameter, the function obtains and returns PWM duty cycle; When parameters are set, the function is used to set PWM duty cycle.

PWM.deinit(): Turn OFF PWM.



Project 4.2 Meteor Flowing Light

After learning about PWM, we can use it to control LED bar graph and realize a cooler flowing light. The component list, circuit, and hardware are exactly consistent with the project Flowing Light.

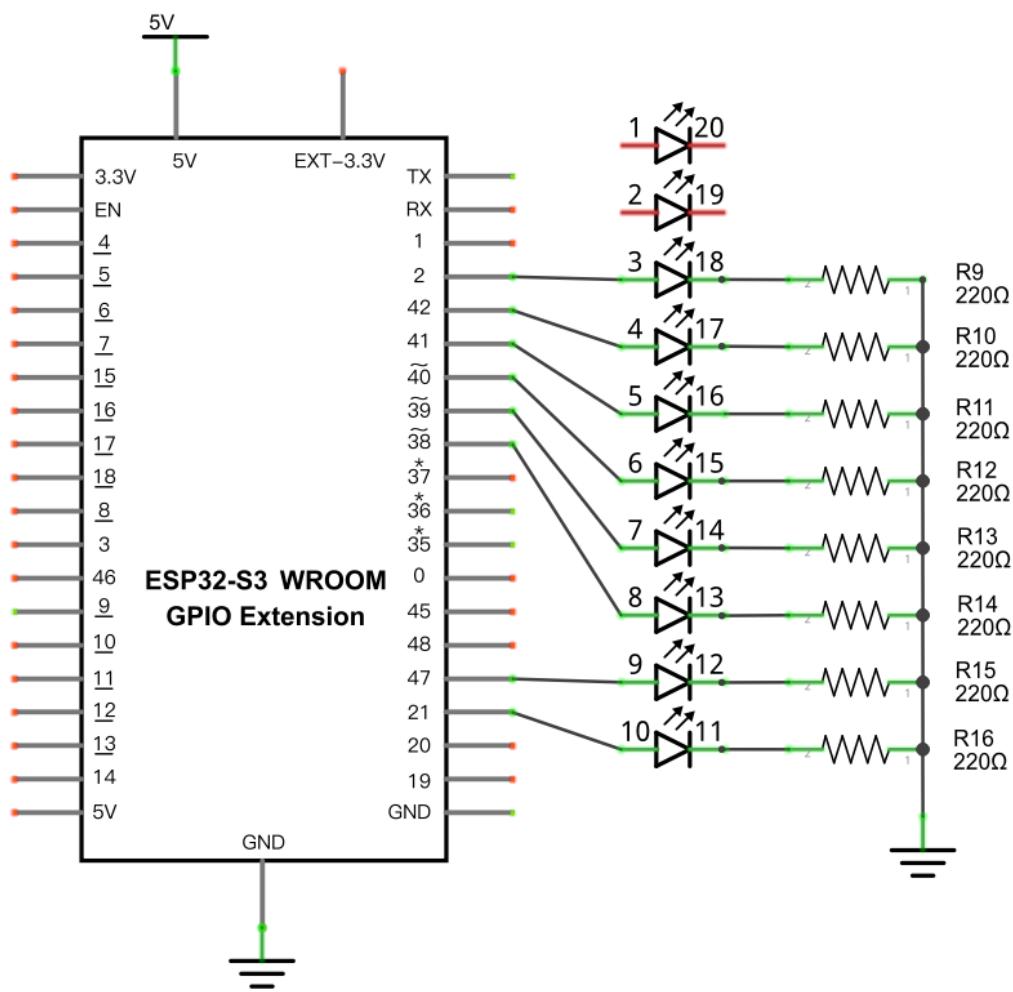
Component List

ESP32-S3 WROOM x1	GPIO Extension Board x1	Breadboard x1

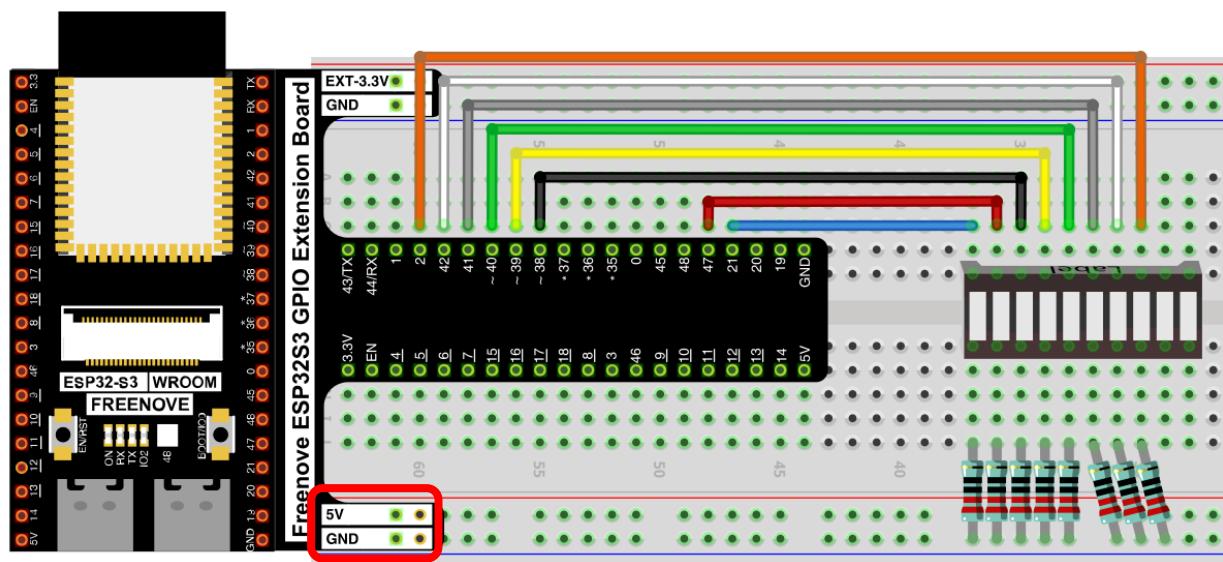
Jumper M/M x8	LED bar graph x1	Resistor 220Ω x8

Circuit

Schematic diagram



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



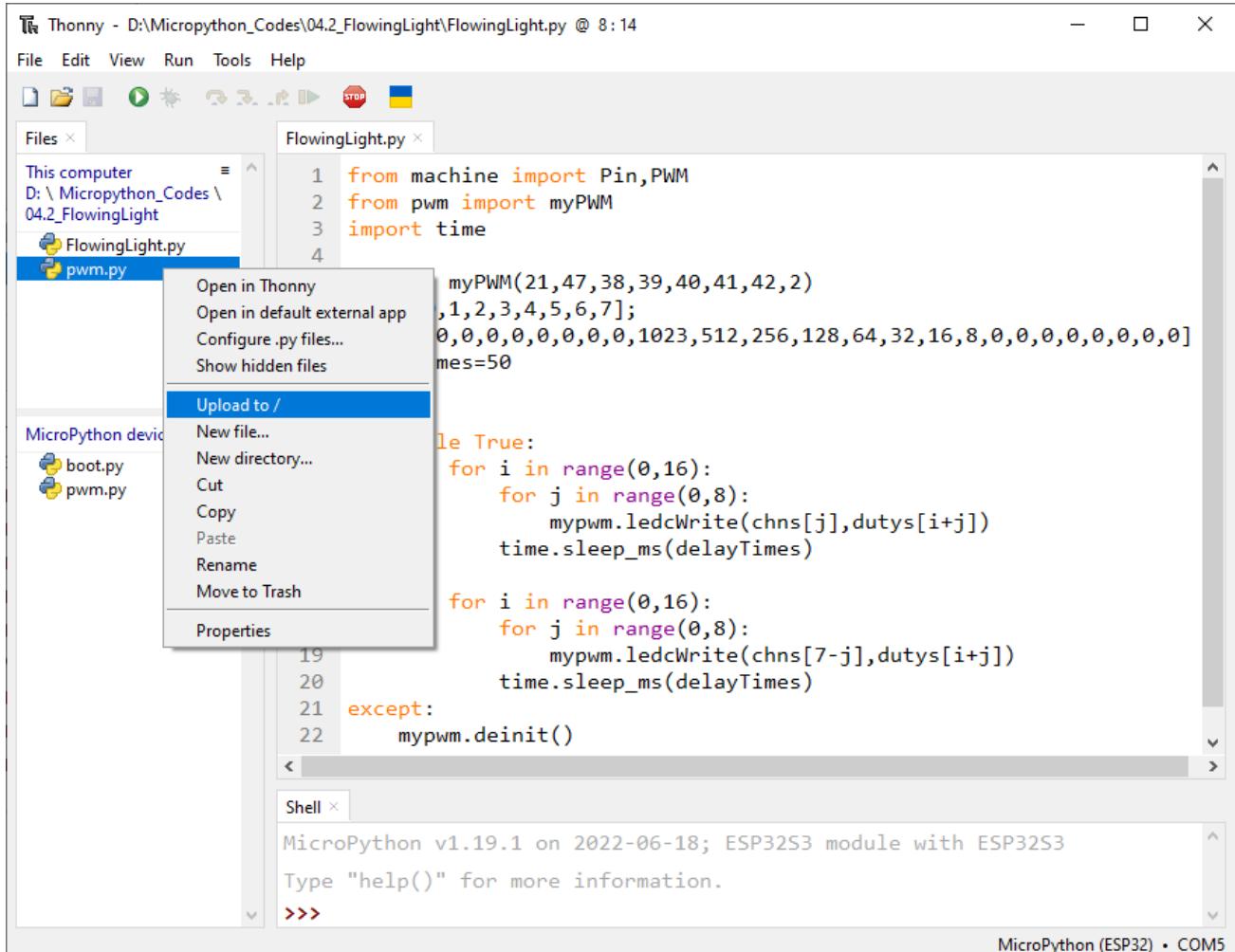
Any concerns? ✉ support@freenove.com

Code

Flowing Light with tail was implemented with PWM.

Open “Thonny”, click “This computer” → “D:” → “Micropython_Codes” → “04.2_FlowingLight”. Select “pwm.py”, right click to select “Upload to /”, wait for “pwm.py” to be uploaded to ESP32-S3 and then double click “FlowingLight.py”.

04.2_FlowingLight



Click “Run current script”, and LED Bar Graph will gradually light up and out from left to right, then light up and out from right to left.

The following is the program code:

```

1  from machine import Pin, PWM
2  from pwm import myPWM
3  import time
4
5  mypwm = myPWM(21, 47, 38, 39, 40, 41, 42, 2)
6  chns=[0, 1, 2, 3, 4, 5, 6, 7];
7  dutys=[0, 0, 0, 0, 0, 0, 0, 0, 1023, 512, 256, 128, 64, 32, 16, 8, 0, 0, 0, 0, 0, 0, 0, 0];
8  delayTimes=50
9
10 try:
11     while True:
12         for i in range(0,16):
13             for j in range(0,8):
14                 mypwm.ledcWrite(chns[j], dutys[i+j])
15                 time.sleep_ms(delayTimes)
16
17         for i in range(0,16):
18             for j in range(0,8):
19                 mypwm.ledcWrite(chns[7-j], dutys[i+j])
20                 time.sleep_ms(delayTimes)
21 except:
22     mypwm.deinit()

```

Import the object myPWM from pwm.py and set corresponding pins for PWM channel.

```

2  from pwm import myPWM
...
5  mypwm = myPWM(21, 47, 38, 39, 40, 41, 42, 2)

```

First we defined 8 GPIO, 8 PWM channels, and 24 pulse width values.

```

5  mypwm = myPWM(21, 47, 38, 39, 40, 41, 42, 2)
6  chns=[0, 1, 2, 3, 4, 5, 6, 7];
7  dutys=[0, 0, 0, 0, 0, 0, 0, 0, 1023, 512, 256, 128, 64, 32, 16, 8, 0, 0, 0, 0, 0, 0, 0];

```

Call ledcWrite()to set duty cycle dutys[i+j] for the chns[j] channel of PWM.

```
14  mypwm.ledcWrite(chns[j], dutys[i+j])
```

Close the PWM of the object myPWM.

```
14  mypwm.deinit()
```



In the code, a nesting of two for loops are used to achieve this effect.

```

12     for i in range(0, 16):
13         for j in range(0, 8):
14             mypwm.ledcWrite(chns[j], dutys[i+j])
15             time.sleep_ms(delayTimes)
16
17     for i in range(0, 16):
18         for j in range(0, 8):
19             mypwm.ledcWrite(chns[7-j], dutys[i+j])
20             time.sleep_ms(delayTimes)

```

In the main function, a nested for loop is used to control the pulse width of the PWM. Every time *i* in the first for loop increases by 1, the LED Bar Graph will move one grid, and gradually change according to the value in the array *dutys*. As shown in the following table, the value in the second row is the value of the array *dutys*, and the 8 green grids in each row below represent the 8 LEDs on the LED Bar Graph. Each time *i* increases by 1, the value of the LED Bar Graph will move to the right by one grid, and when it reaches the end, it will move from the end to the starting point, achieving the desired effect.

0	1	2	3	4	5	6	7	8	9	1	1	1	1	1	1	1	1	2	2	2	2	2
d	0	0	0	0	0	0	0		1	5	2	1	6	3	1	8	0	0	0	0	0	0
i									0	1	5	2	4	2	6							
0																						
1																						
...																						
14																						
15																						
16																						

How to import a custom python module

Each Python file, as long as it's stored on the file system of ESP32S3, is a module. To import a custom module, the module file needs to be located in the MicroPython environment variable path or in the same path as the currently running program.

First, customize a python module "custom.py". Create a new py file and name it "custom.py". Write code to it and save it to ESP32S3.



Second, import custom module "custom" to main.py

The screenshot shows a code editor interface with two tabs: 'main.py' and 'custom.py'. The 'main.py' tab is active, displaying the following code:

```
1 import custom
2 import time
3 while True:
4     custom.rand()
5     time.sleep(1)
```

Annotations with orange callout boxes point to specific parts of the code:

- An arrow points to the first line 'import custom' with the text 'Import custom module'.
- An arrow points to the line 'custom.rand()' with the text 'Call function rand() of custom module'.

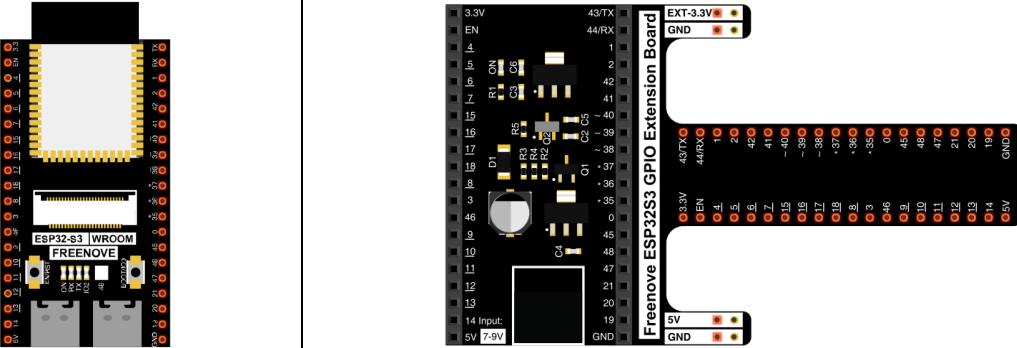
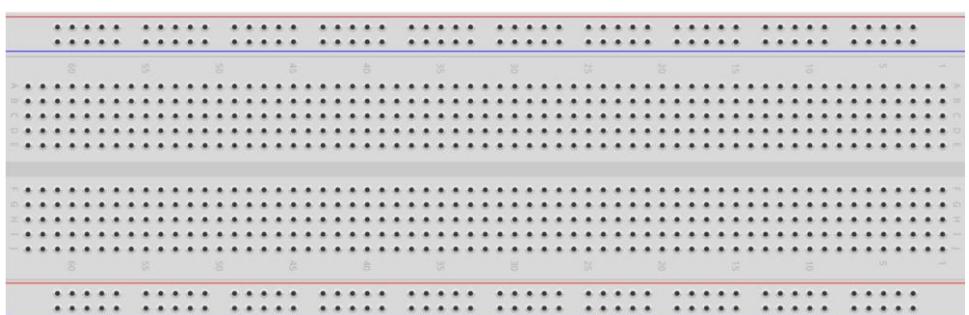
Chapter 5 RGB LED

In this chapter, we will learn how to control a RGB LED. It can emit different colors of light. Next, we will use RGB LED to make a multicolored light.

Project 5.1 Random Color Light

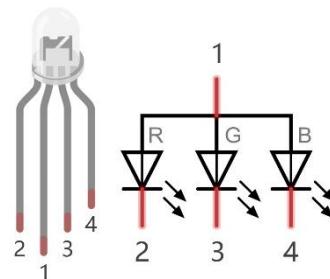
In this project, we will make a multicolored LED. And we can control RGB LED to switch different colors automatically.

Component List

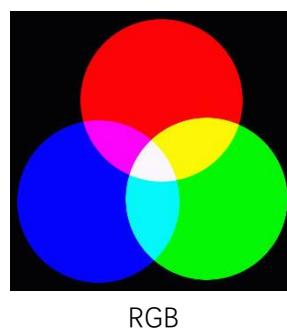
ESP32-S3 WROOM x1	GPIO Extension Board x1
	
Breadboard x1	
RGBLED x1	Resistor 220Ω x3
	
	Jumper M/M x4
	

Related knowledge

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 is 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 are known as three primary colors. When you combine these three primary-color lights 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.

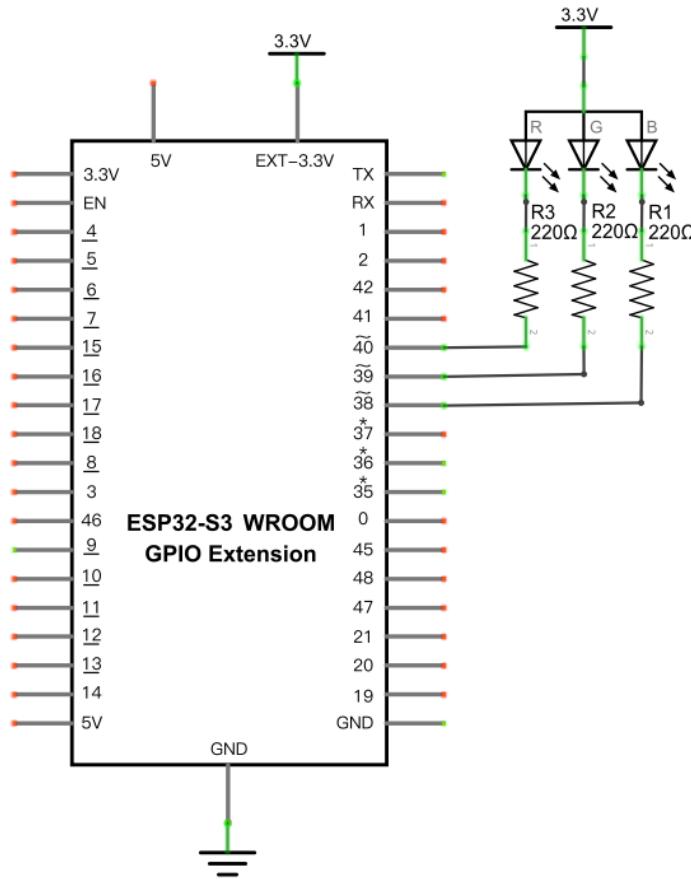


If we use three 8-bit PWMs to control the RGB LED, in theory, we can create $2^8 \times 2^8 \times 2^8 = 16777216$ (16 million) colors through different combinations.

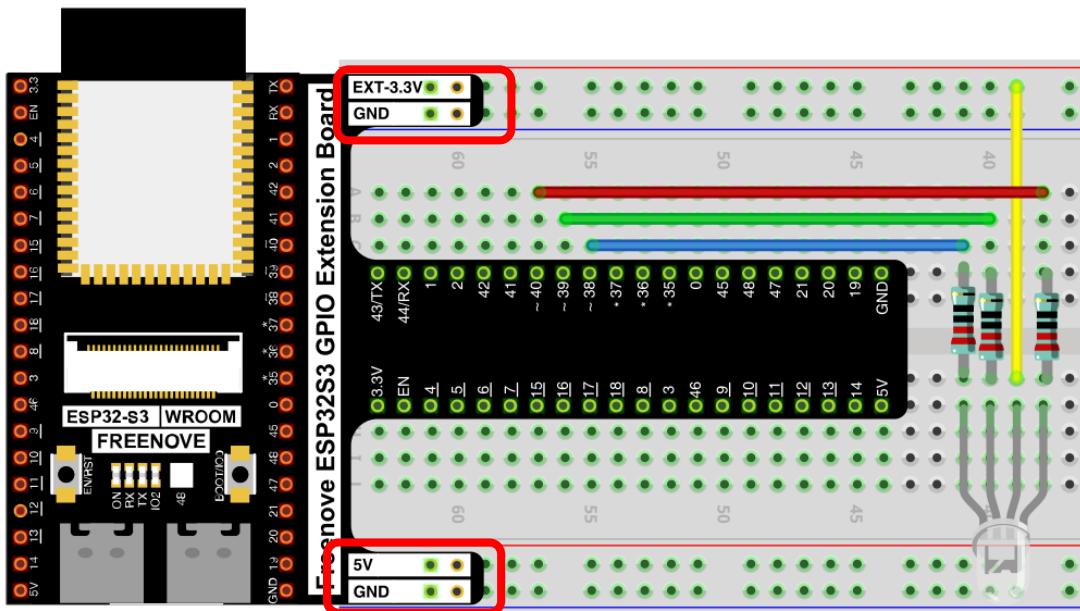


Circuit

Schematic diagram



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



Any concerns? ✉ support@freenove.com

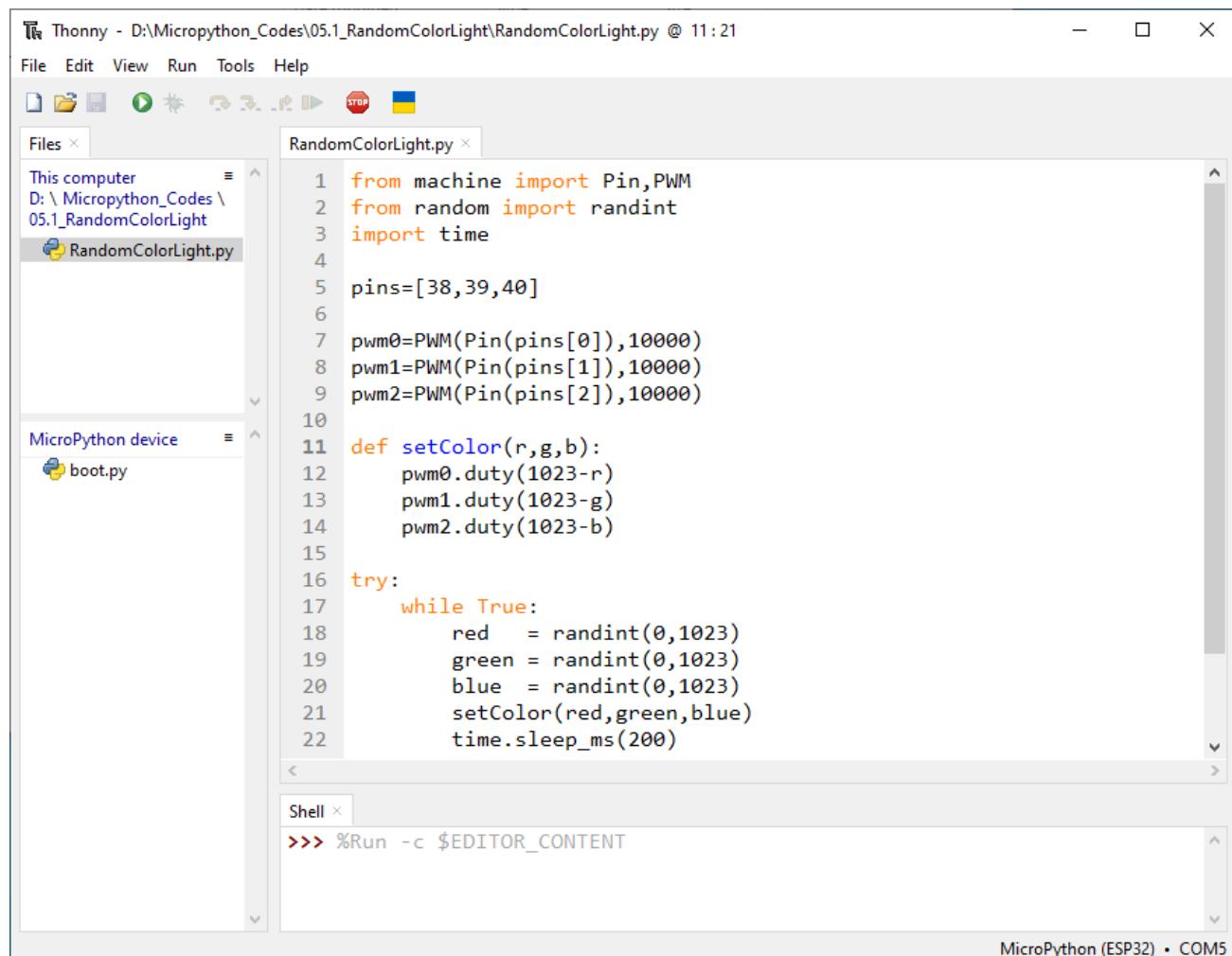
Code

We need to create three PWM channels and use random duty cycle to make random RGBLED color.

Move the program folder “**Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Codes**” to disk(D) in advance with the path of “**D:/Micropython_Codes**”.

Open “Thonny”, click “This computer” → “D:” → “Micropython_Codes” → “05.1_RandomColorLight” and double click “RandomColorLight.py”.

05.1_RandomColorLight



The screenshot shows the Thonny IDE interface. The title bar says "Thonny - D:\Micropython_Codes\05.1_RandomColorLight\RandomColorLight.py @ 11:21". The menu bar includes File, Edit, View, Run, Tools, Help. The toolbar has icons for file operations and a stop button. The left sidebar shows a "Files" tree with "This computer", "D:\ Micropython_Codes\ 05.1_RandomColorLight", and "RandomColorLight.py" selected. Below it is a "MicroPython device" section with "boot.py". The main editor area contains the Python code for RandomColorLight.py:

```
1 from machine import Pin,PWM
2 from random import randint
3 import time
4
5 pins=[38,39,40]
6
7 pwm0=PWM(Pin(pins[0]),10000)
8 pwm1=PWM(Pin(pins[1]),10000)
9 pwm2=PWM(Pin(pins[2]),10000)
10
11 def setColor(r,g,b):
12     pwm0.duty(1023-r)
13     pwm1.duty(1023-g)
14     pwm2.duty(1023-b)
15
16 try:
17     while True:
18         red = randint(0,1023)
19         green = randint(0,1023)
20         blue = randint(0,1023)
21         setColor(red,green,blue)
22         time.sleep_ms(200)
```

Below the editor is a "Shell" window with the command ">>> %Run -c \$EDITOR_CONTENT". The status bar at the bottom right says "MicroPython (ESP32) • COM5".

Click “Run current script”, RGBLED begins to display random colors.

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



The following is the program code:

```

1  from machine import Pin, PWM
2  from random import randint
3  import time
4
5  pins=[40, 39, 38]
6
7  pwm0=PWM(Pin(pins[0]), 10000)
8  pwm1=PWM(Pin(pins[1]), 10000)
9  pwm2=PWM(Pin(pins[2]), 10000)
10
11 def setColor(r, g, b):
12     pwm0.duty(1023-r)
13     pwm1.duty(1023-g)
14     pwm2.duty(1023-b)
15
16 try:
17     while True:
18         red    = randint(0, 1023)
19         green  = randint(0, 1023)
20         blue   = randint(0, 1023)
21         setColor(red, green, blue)
22         time.sleep_ms(200)
23 except:
24     pwm0.deinit()
25     pwm1.deinit()
26     pwm2.deinit()
```

Import Pin, PWM and Randon Function modules.

```

12  from machine import Pin, PWM
13  from random import randint
14  import time
```

Configure ouput mode of GPIO38, GPIO39 and GPIO40 as PWM output and PWM frequency as 10000Hz

```

5  pins=[40, 39, 38]
6
7  pwm0=PWM(Pin(pins[0]), 10000)
8  pwm1=PWM(Pin(pins[1]), 10000)
9  pwm2=PWM(Pin(pins[2]), 10000)
```

Define a function to set the color of RGBLED.

```

11 def setColor(r, g, b):
12     pwm0.duty(1023-r)
13     pwm1.duty(1023-g)
14     pwm2.duty(1023-b)
```

Call random function randint()to generate a random number in the range of 0-1023 and assign the value to red.

```
18     red    = randint(0, 1023)
```

Obtain 3 random number every 200 milliseconds and call function setColor to make RGBLED display dazzling colors.

```
17     while True:  
18         red    = randint(0, 1023)  
19         green  = randint(0, 1023)  
20         blue   = randint(0, 1023)  
21         setColor(red, green, blue)  
22         time.sleep_ms(200)
```

Reference

Class random

Before each use of the module **random**, please add the statement “**import random**” to the top of Python file.

randint(start, end): Randomly generates an integer between the value of start and end.

start: Starting value in the specified range, which would be included in the range.

end: Ending value in the specified range, which would be included in the range.

random(): Randomly generates a floating point number between 0 and 1.

random.uniform(start, end): Randomly generates a floating point number between the value of start and end

start: Starting value in the specified range, which would be included in the range.

end: Ending value in the specified range, which would be included in the range.

random.getrandbits(size): Generates an integer with **size** random bits

For example:

size = 4, it generates an integer in the range of 0 to 0b1111

size = 8, it generates an integer in the range of 0 to 0b11111111

random.randrange(start, end, step): Randomly generates a positive integer in the range from start to end and increment to step.

start: Starting value in the specified range, which would be included in the range

end: Ending value in the specified range, which would be included in the range.

step: An integer specifying the incrementation.

random.seed(sed): Specifies a random seed, usually being applied in conjunction with other random number generators

sed: Random seed, a starting point in generating random numbers.

random.choice(obj): Randomly generates an element from the object obj.

obj: list of elements

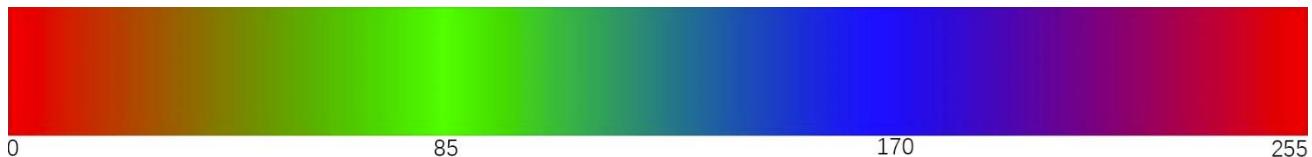


Project 5.2 Gradient Color Light

In the previous project, we have mastered the usage of RGB LED, but the random display of colors is rather stiff. This project will realize a fashionable light with soft color changes.

Component list and the circuit are exactly the same as the random color light.

Using a color model, the color changes from 0 to 255 as shown below.



In this code, the color model will be implemented and RGBLED will change colors along the model.

Open “Thonny”, click “This computer” → “D:” → “Micropython_Codes” → “05.2_GradientColorLight” and double click “GradientColorLight.py”.

05.2_GradientColorLight

The following is the program code:

```

1  from machine import Pin, PWM
2  import time
3
4  pins=[40, 39, 38];
5
6  pwm0=PWM(Pin(pins[0]), 1000)
7  pwm1=PWM(Pin(pins[1]), 1000)
8  pwm2=PWM(Pin(pins[2]), 1000)
9
10 red=0          #red
11 green=0        #green
12 blue=0         #blue
13
14 def setColor():
15     pwm0.duty(red)
16     pwm1.duty(green)
17     pwm2.duty(blue)
18
19 def wheel(pos):
20     global red, green, blue
21     WheelPos=pos%1023
22     print(WheelPos)
23     if WheelPos<341:
24         red=1023-WheelPos*3
25         green=WheelPos*3

```

```
26     blue=0
27
28     elif WheelPos>=341 and WheelPos<682:
29         WheelPos -= 341;
30         red=0
31         green=1023-WheelPos*3
32         blue=WheelPos*3
33     else :
34         WheelPos -= 682;
35         red=WheelPos*3
36         green=0
37         blue=1023-WheelPos*3
38
39     try:
40         while True:
41             for i in range(0, 1023):
42                 wheel(i)
43                 setColor()
44                 time.sleep_ms(15)
45     except:
46         pwm0.deinit()
47         pwm1.deinit()
48         pwm2.deinit()
```

The function `wheel()` is a color selection method of the color model introduced earlier. The value range of the parameter `pos` is 0-1023. The function will return a data containing the duty cycle values of 3 pins.

```
19     def wheel(pos):
20         global red, green, blue
21         WheelPos=pos%1023
22         print(WheelPos)
23         if WheelPos<341:
24             red=1023-WheelPos*3
25             green=WheelPos*3
26             blue=0
27
28         elif WheelPos>=341 and WheelPos<682:
29             WheelPos -= 341;
30             red=0
31             green=1023-WheelPos*3
32             blue=WheelPos*3
33         else :
34             WheelPos -= 682;
35             red=WheelPos*3
36             green=0
37             blue=1023-WheelPos*3
```



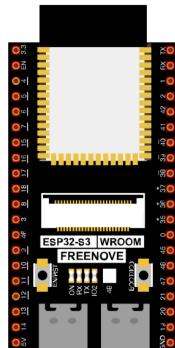
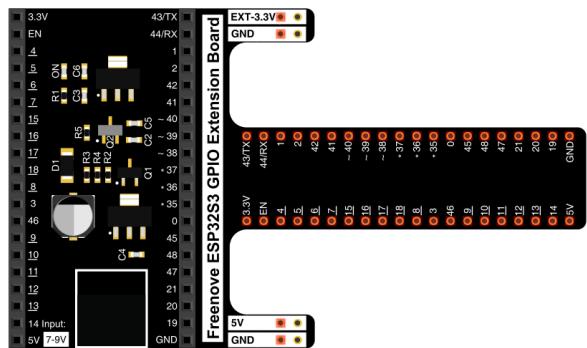
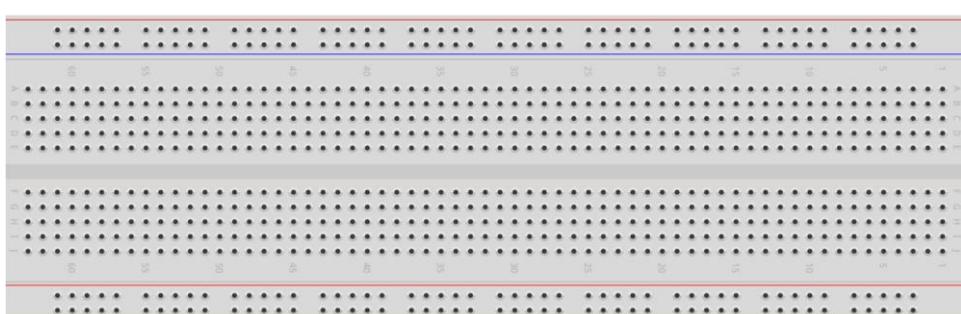
Chapter 6 Buzzer

In this chapter, we will learn about buzzers that can make sounds.

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

ESP32-S3 WROOM x1		GPIO Extension Board x1 		
Breadboard x1				
				
Jumper M/M x6				
NPN transistor x1 (S8050) 	Active buzzer x1 	Push button x1 	Resistor 1kΩ x1 	Resistor 10kΩ x2 

Any concerns?  support@freenove.com

Component knowledge

Buzzer

Buzzer is a sounding component, which is widely used in electronic devices such as calculator, electronic warning clock and alarm. Buzzer has two types: active and passive. Active buzzer has oscillator inside, which 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 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 buzzers are more complex than passive buzzers in their manufacture. There are many circuits and crystal oscillator elements inside active buzzers; all of this is usually protected with a waterproof coating (and a housing) exposing only its pins from the underside. On the other hand, passive buzzers do not have protective coatings on their underside. From the pin holes viewing of a passive buzzer, you can see the circuit board, coils, and a permanent magnet (all or any combination of these components depending on the model).

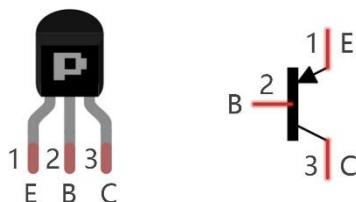


Transistor

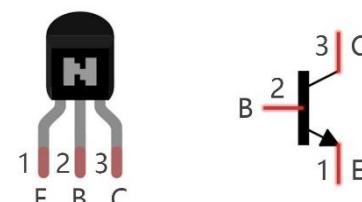
Because the buzzer requires such large current that GPIO of ESP32-S3 output capability cannot meet the requirement, a transistor of NPN type is needed here to amplify the current.

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 as shown below: PNP and NPN.

PNP transistor



NPN transistor

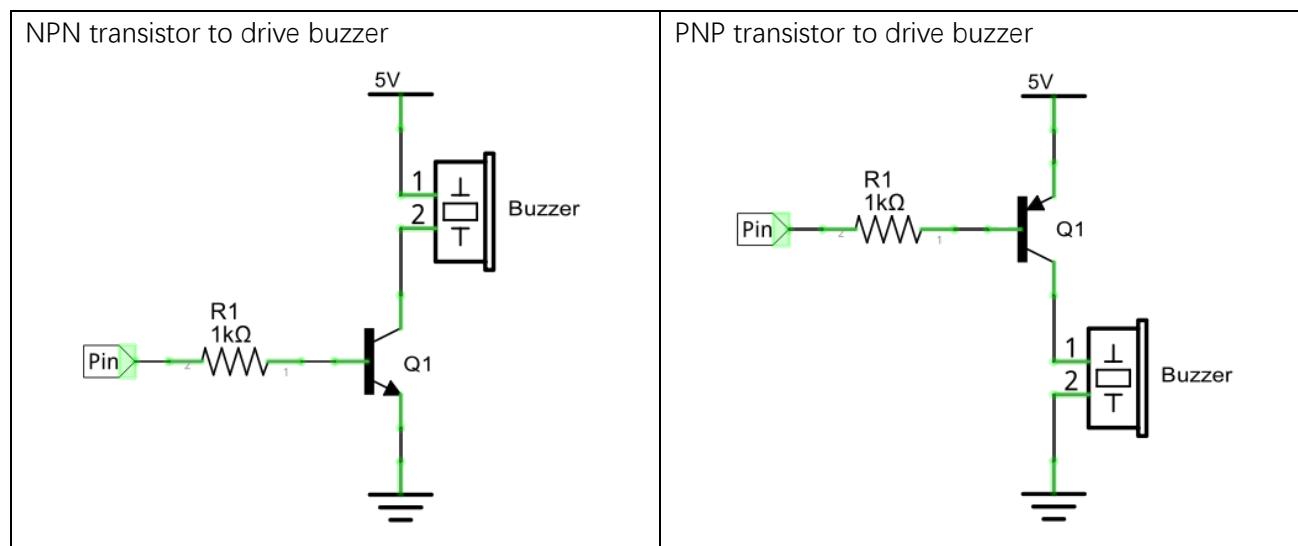


In our kit, the PNP transistor is marked with 8550, and the NPN transistor is marked with 8050.

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

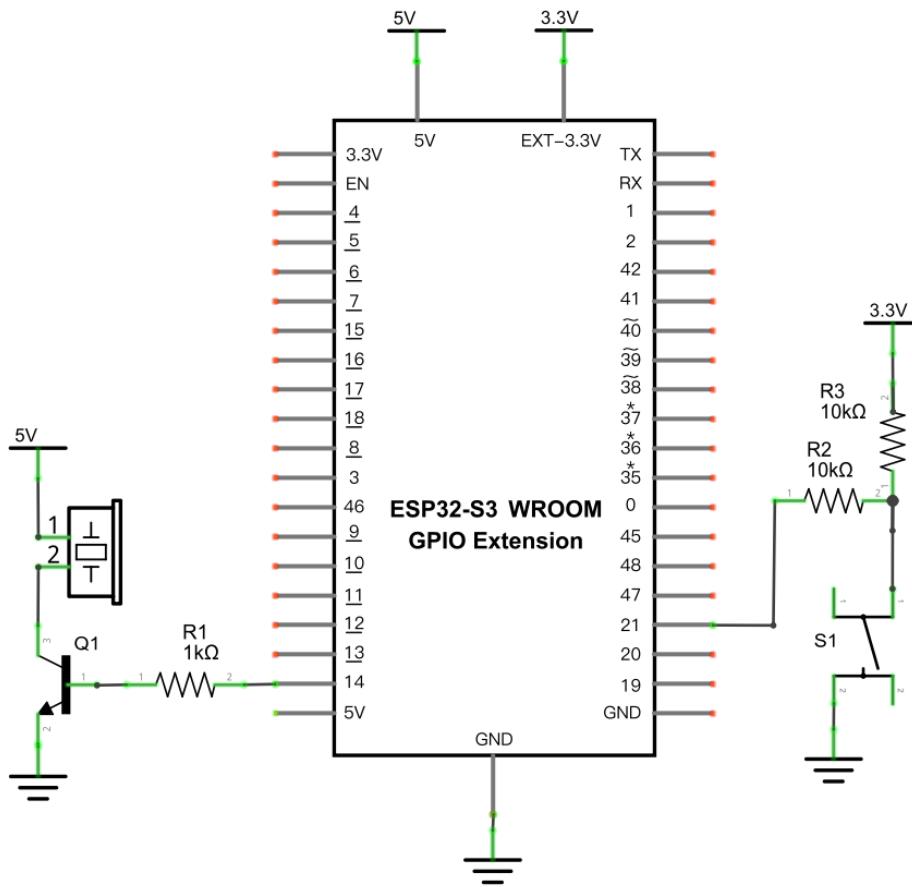
When use NPN transistor to drive buzzer, we often adopt the following method. If GPIO outputs high level, current will flow through R1, the transistor will get conducted, and the buzzer will sound. If GPIO outputs low level, no current flows through R1, the transistor will not be conducted, and buzzer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

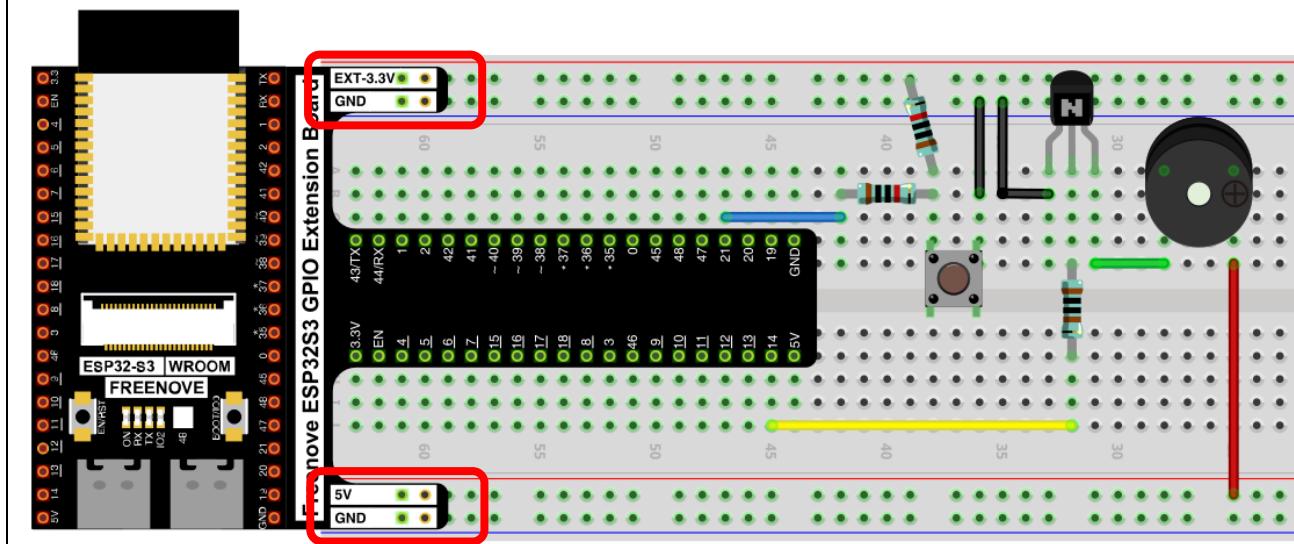


Circuit

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.

Any concerns? support@freenove.com

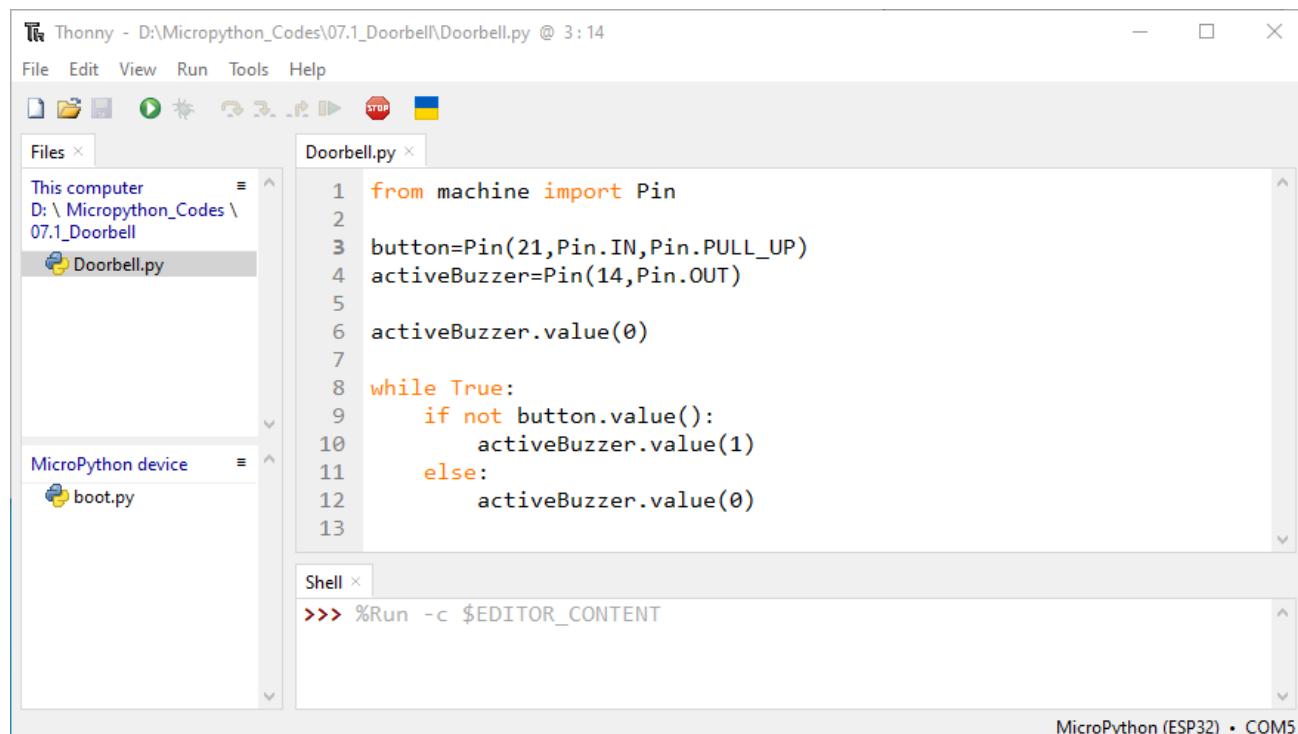
Code

In this project, a buzzer will be controlled by a push button switch. When the button switch is pressed, the buzzer sounds and when the button is released, the buzzer stops. It is analogous to our earlier project that controlled an LED ON and OFF.

Move the program folder “**Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Codes**” to disk(D) in advance with the path of “**D:/Micropython_Codes**”.

Open “Thonny”, click “This computer” → “D:” → “Micropython_Codes” → “06.1_Doorbell” and double click “Doorbell.py”.

06.1_Doorbell



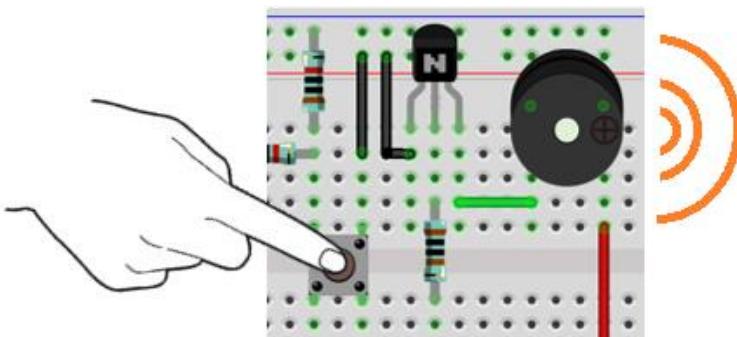
The screenshot shows the Thonny IDE interface. The title bar says "Thonny - D:\Micropython_Codes\07.1_Doorbell\Doorbell.py @ 3:14". The menu bar includes File, Edit, View, Run, Tools, Help. The toolbar has icons for file operations and a stop button. The left sidebar has "Files" and "MicroPython device" sections. The "Files" section shows "Doorbell.py" selected. The main editor window displays the following Python code:

```
1 from machine import Pin
2
3 button=Pin(21,Pin.IN,Pin.PULL_UP)
4 activeBuzzer=Pin(14,Pin.OUT)
5
6 activeBuzzer.value(0)
7
8 while True:
9     if not button.value():
10         activeBuzzer.value(1)
11     else:
12         activeBuzzer.value(0)
```

The bottom shell window shows the command: `>>> %Run -c $EDITOR_CONTENT`. The status bar at the bottom right says "MicroPython (ESP32) • COM5".



Click “Run current script”, press the push button switch and the buzzer will sound. Release the push button switch and the buzzer will stop.



The following is the program code:

```
1 from machine import Pin  
2  
3 button=Pin(21,Pin.IN,Pin.PULL_UP)  
4 activeBuzzer=Pin(14,Pin.OUT)  
5  
6 activeBuzzer.value(0)  
7  
8 while True:  
9     if not button.value():  
10         activeBuzzer.value(1)  
11     else:  
12         activeBuzzer.value(0)
```

The code is logically the same as using button to control LED.

Project 6.2 Alertor

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

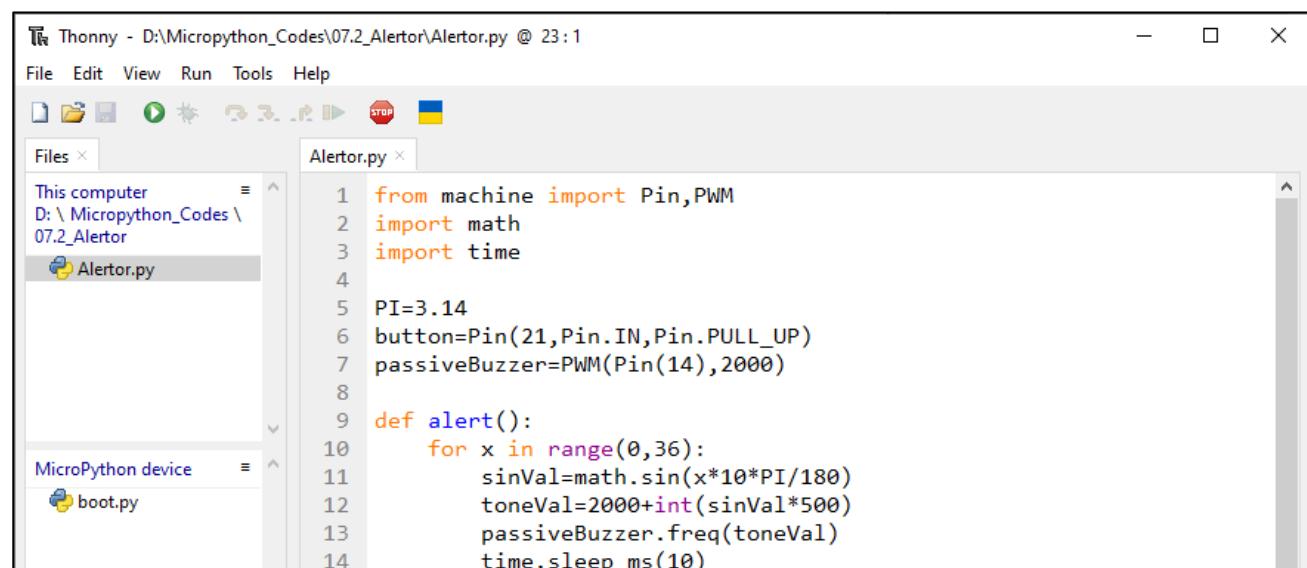
Component list and the circuit is similar to the last section. In the Doorbell circuit only the **active buzzer** needs to be **replaced** with a **passive buzzer**.

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 as using button to control LED. In the control method, passive buzzer requires PWM of certain frequency to sound.

Open “Thonny”, click “This computer” → “D:” → “Micropython_Codes” → “06.2_Alertor”, and double click “Alertor.py”.

06.2_Alertor

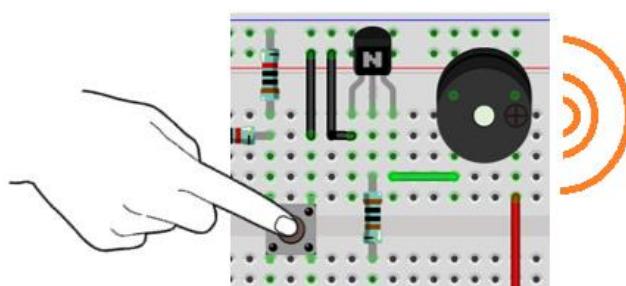


```

1  from machine import Pin,PWM
2  import math
3  import time
4
5  PI=3.14
6  button=Pin(21,Pin.IN,Pin.PULL_UP)
7  passiveBuzzer=PWM(Pin(14),2000)
8
9  def alert():
10     for x in range(0,36):
11         sinVal=math.sin(x*10*PI/180)
12         toneVal=2000+int(sinVal*500)
13         passiveBuzzer.freq(toneVal)
14         time.sleep_ms(10)

```

Click “Run current script”, press the button, then alarm sounds. And when the button is release, the alarm will stop sounding.



The following is the program code:

1	from machine import Pin,PWM
2	import math
3	import time
4	
5	PI=3.14

Any concerns? ✉ support@freenove.com

```

6   button=Pin(21, Pin.IN, Pin.PULL_UP)
7   passiveBuzzer=PWM(Pin(14), 2000)
8
9   def alert():
10    for x in range(0, 36):
11        sinVal=math.sin(x*10*PI/180)
12        toneVal=2000+int(sinVal*500)
13        passiveBuzzer.freq(toneVal)
14        time.sleep_ms(10)
15    try:
16        while True:
17            if not button.value():
18                passiveBuzzer.init()
19                alert()
20            else:
21                passiveBuzzer.deinit()
22    except:
23        passiveBuzzer.deinit()

```

Import PWM, Pin, math and time modules.

```

1   from machine import Pin, PWM
2   import math
3   import time

```

Define the pins of the button and passive buzzer.

```

5   PI=3.14
6   button=Pin(21, Pin.IN, Pin.PULL_UP)
7   passiveBuzzer=PWM(Pin(14), 2000, 512)

```

Call sin function of math module to generate the frequency data of the passive buzzer.

```

9   def alert():
10    for x in range(0, 36):
11        sinVal=math.sin(x*10*PI/180)
12        toneVal=2000+int(sinVal*500)
13        passiveBuzzer.freq(toneVal)
14        time.sleep_ms(10)

```

When not using PWM, please turn it OFF in time.

```

22  passiveBuzzer.deinit()

```

Reference

```
double ledcWriteTone(uint8_t channel, double freq);
```

This updates the tone frequency value on the given channel.

This function has some bugs in the current version (V1.0.4): when the call interval is less than 20ms, the resulting PWM will have an exception. We will get in touch with the authorities to solve this problem and give solutions in the following two projects.

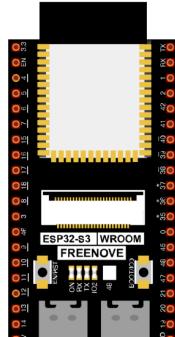
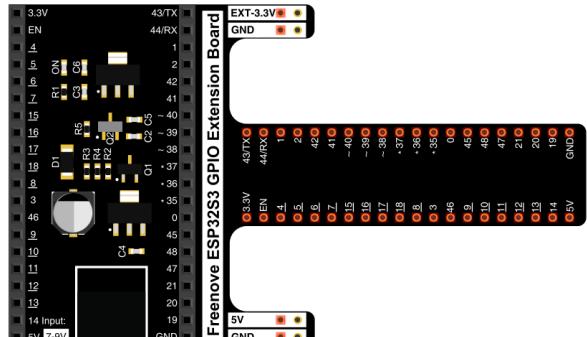
Chapter 7 Serial Communication

Serial Communication is a means of communication between different devices/devices. This section describes ESP32-S3's Serial Communication.

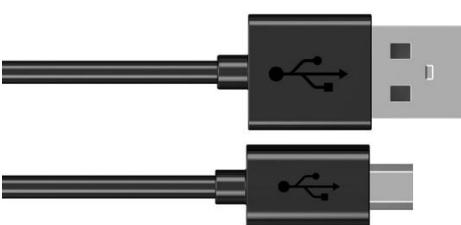
Project 7.1 Serial Print

This project uses ESP32-S3's serial communicator to send data to the computer and print it on the serial monitor.

Component List

ESP32-S3 WROOM x1	GPIO Extension Board x1
	

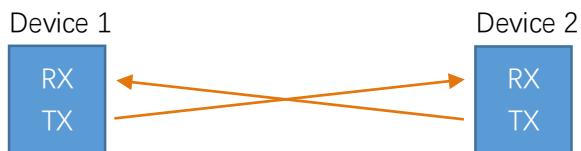
Micro USB Wire x1



Related knowledge

Serial communication

Serial communication generally refers to the Universal Asynchronous Receiver/Transmitter (UART), which is commonly used in electronic circuit communication. It has two communication lines, one is responsible for sending data (TX line) and the other for receiving data (RX line). The serial communication connections two devices use is as follows:



Before serial communication starts, the baud rate of both sides must be the same. Communication between devices can work only if the same baud rate is used. The baud rates commonly used is 9600 and 115200.

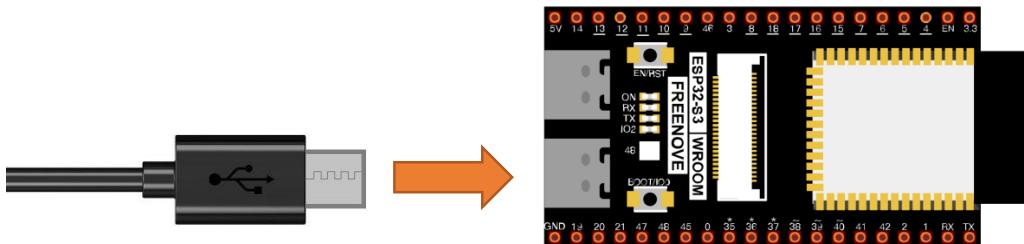
Serial port on ESP32S3

Freenove ESP32-S3 has integrated USB to serial transfer, so it could communicate with computer connecting to USB cable.



Circuit

Connect Freenove ESP32-S3 to the computer with USB cable.

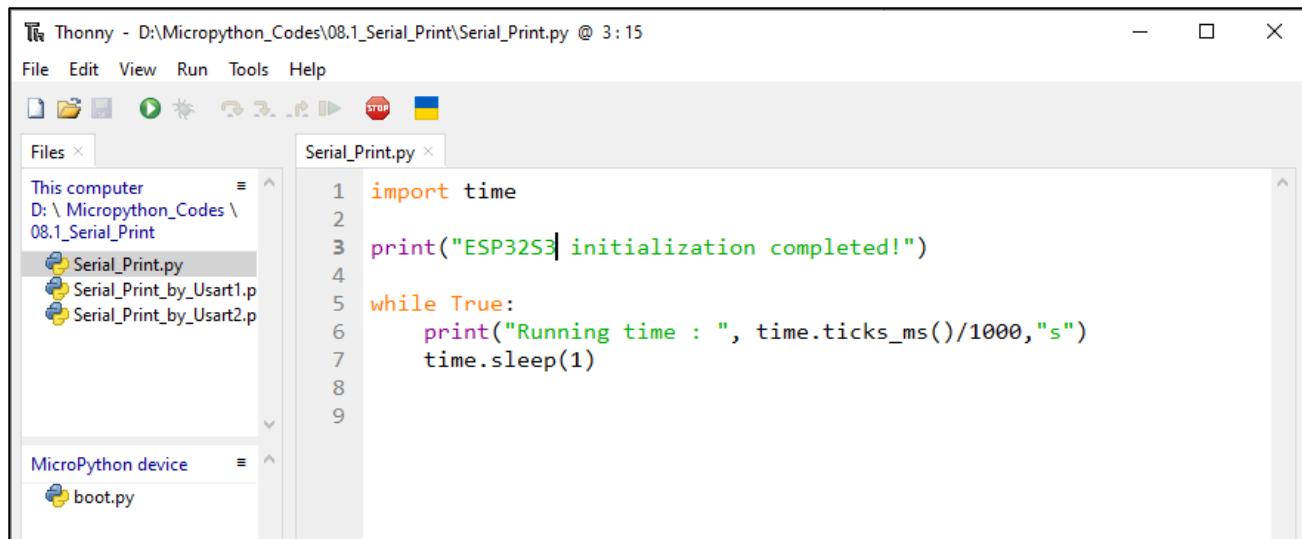


Code

Move the program folder “**Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Codes**” to disk(D) in advance with the path of “**D:/Micropython_Codes**”.

Open “Thonny”, click “This computer” → “D:” → “Micropython_Codes” → “07.1_Serial_Print” and double “Serial_Print.py”.

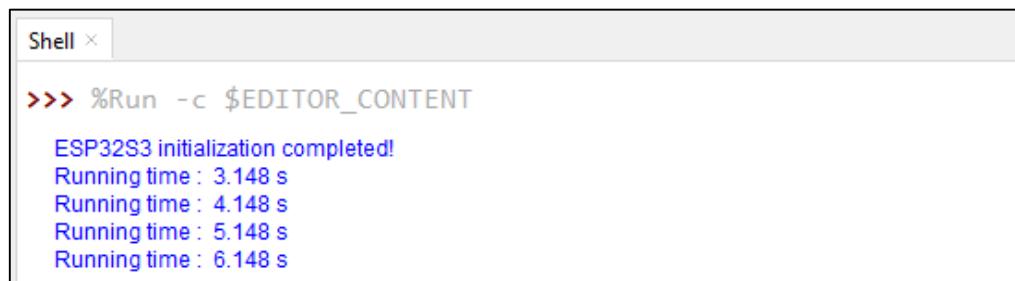
07.1_Serial_Print



The screenshot shows the Thonny IDE interface. The title bar says "Thonny - D:\Micropython_Codes\08.1_Serial_Print\Serial_Print.py @ 3:15". The menu bar includes File, Edit, View, Run, Tools, Help. Below the menu is a toolbar with icons for file operations and a stop button. The left sidebar has sections for "Files" (containing "This computer", "D:\Micropython_Codes\08.1_Serial_Print", "Serial_Print.py" which is selected, "Serial_Print_by_Uart1.p", "Serial_Print_by_Uart2.p"), "MicroPython device" (containing "boot.py"), and a status bar showing "MicroPython device". The main editor window titled "Serial_Print.py" contains the following code:

```
1 import time
2
3 print("ESP32S3 initialization completed!")
4
5 while True:
6     print("Running time : ", time.ticks_ms()/1000, "s")
7     time.sleep(1)
```

Click “Run current script” and observe the changes of “Shell”, which will display the time when ESP32-S3 is powered on once per second.



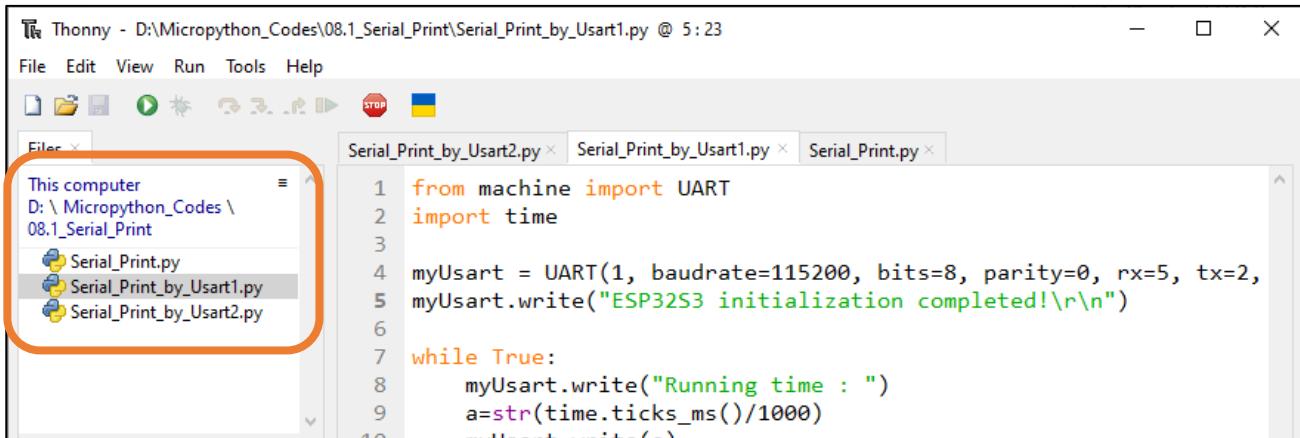
The screenshot shows the "Shell" window with the following output:

```
>>> %Run -c $EDITOR_CONTENT
ESP32S3 initialization completed!
Running time: 3.148 s
Running time: 4.148 s
Running time: 5.148 s
Running time: 6.148 s
```

The following is the program code:

```
1 import time
2
3 print("ESP32-S3 initialization completed!")
4
5 while True:
6     print("Running time : ", time.ticks_ms()/1000, "s")
7     time.sleep(1)
```

ESP32-S3 has 3 serial ports, one of which is used as REPL, that is, Pin(43) and Pin(44) are occupied, and generally it is not recommended to be used as tx, rx. The other two serial ports can be configured simply by calling the UART module.



```

from machine import UART
import time

myUsart = UART(1, baudrate=115200, bits=8, parity=0, rx=5, tx=2,
myUsart.write("ESP32S3 initialization completed!\r\n")

while True:
    myUsart.write("Running time : ")
    a=str(time.ticks_ms()/1000)
    myUsart.write(a)
    time.sleep(1)

```

Reference

Class UART

Before each use of **UART** module, please add the statement “**from machine import UART**” to the top of python file.

UART(id, baudrate, bits, parity, rx, tx, stop, timeout): Define serial ports and configure parameters for them.

id: Serial Number. The available serial port number is 1 or 2

baudrate: Baud rate

bits: The number of each character.

parity: Check even or odd, with 0 for even checking and 1 for odd checking.

rx, tx: UAPT's reading and writing pins

Note: Pin(1) and Pin(3) are occupied and not recommend to be used as tx,rx.

stop: The number of stop bits, and the stop bit is 1 or 2.

timeout: timeout period (Unit: millisecond)

$0 < \text{timeout} \leq 0x7FFF\ FFFF$ (decimal: $0 < \text{timeout} \leq 2147483647$)

UART.init(baudrate, bits, parity, stop, tx, rx, rts, cts): Initialize serial ports

tx: writing pins of uart

rx: reading pins of uart

rts: rts pins of uart

cts: cts pins of uart

UART.read(nbytes): Read nbytes bytes

UART.read(): Read data

UART.write(buf): Write byte buffer to UART bus

UART.readline(): Read a line of data, ending with a newline character.

UART.readinto(buf): Read and write data into buffer.

UART.readinto(buf, nbytes): Read and write data into buffer.

UART.any(): Determine whether there is data in serial ports. If yes, return the number of bytes; Otherwise, return 0.

Project 7.2 Serial Read and Write

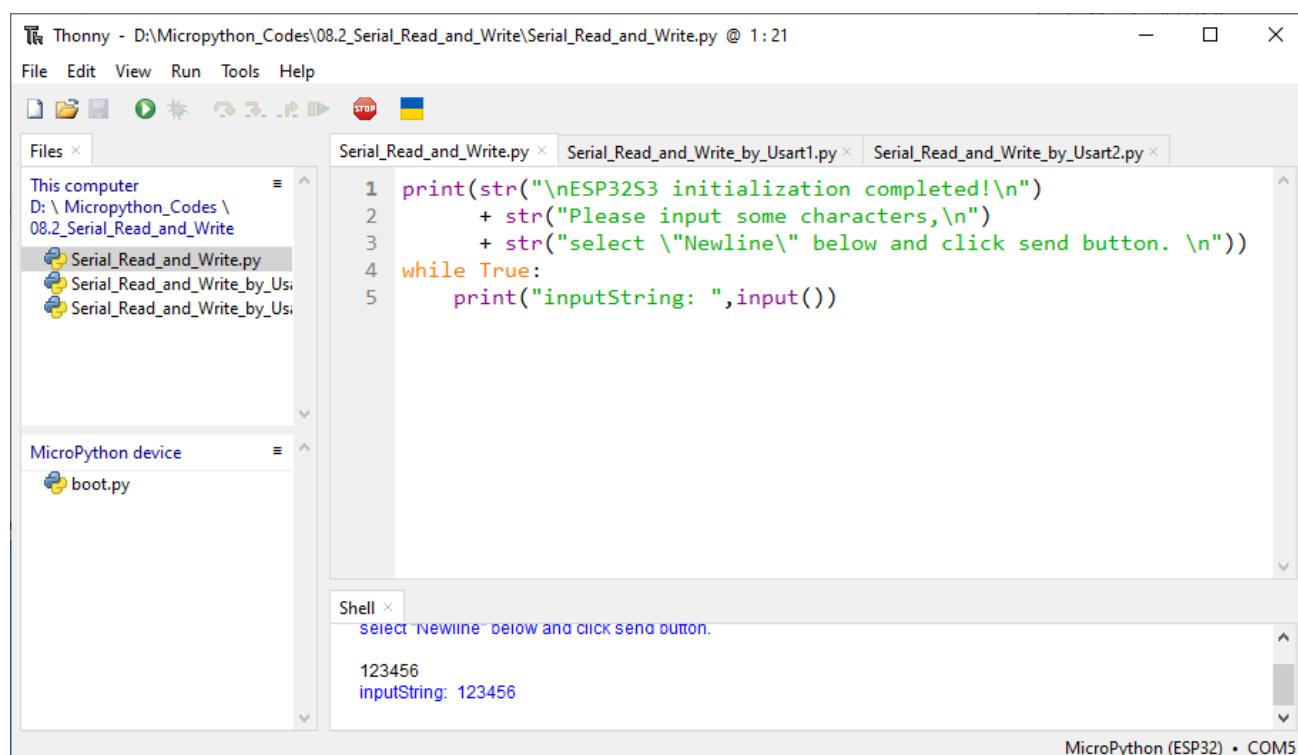
From last section, we use serial port on Freenove ESP32-S3 to send data to a computer, now we will use that to receive data from computer.

Component and circuit are the same as in the previous project.

Code

Open “Thonny”, click “This computer” → “D:” → “Micropython_Codes” → “07.2_Serial_Read_and_Write” and double click “Serial_Read_and_Write.py”.

07.2_Serial_Read_and_Write



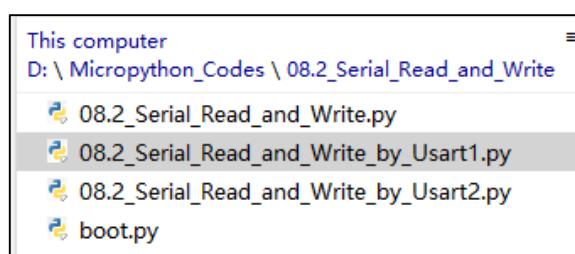
```

Thonny - D:\Micropython_Codes\08.2_Serial_Read_and_Write\Serial_Read_and_Write.py @ 1:21
File Edit View Run Tools Help
File Explorer Device Manager Shell
Files x Serial_Read_and_Write.py x Serial_Read_and_Write_by_Usart1.py x Serial_Read_and_Write_by_Usart2.py
This computer
D:\ Micropython_Codes \
08.2_Serial_Read_and_Write
Serial_Read_and_Write.py
Serial_Read_and_Write_by_Usart1.py
Serial_Read_and_Write_by_Usart2.py
MicroPython device
boot.py

1 print(str("\nESP32S3 initialization completed!\n"))
2     + str("Please input some characters,\n")
3     + str("select \"Newline\" below and click send button. \n"))
4 while True:
5     print("inputString: ",input())
Shell x
select "Newline" below and click send button.
123456
inputString: 123456

```

Click “Run current script” and ESP32-S3 will print out data at “Shell” and wait for users to enter any messages. Press Enter to end the input, and “Shell” will print out data that the user entered. If you want to use other serial ports, you can use other python files in the same directory.





Chapter 8 AD Converter

Signals in life are divided into digital signals and analog signals. In this chapter, we will learn how to use ESP32-S3 to read analog signals.

Project 8.1 Read the Voltage of Potentiometer

In this project, we will use the ADC function of ESP32-S3 to read the voltage value of the potentiometer and print it through the serial port monitor.

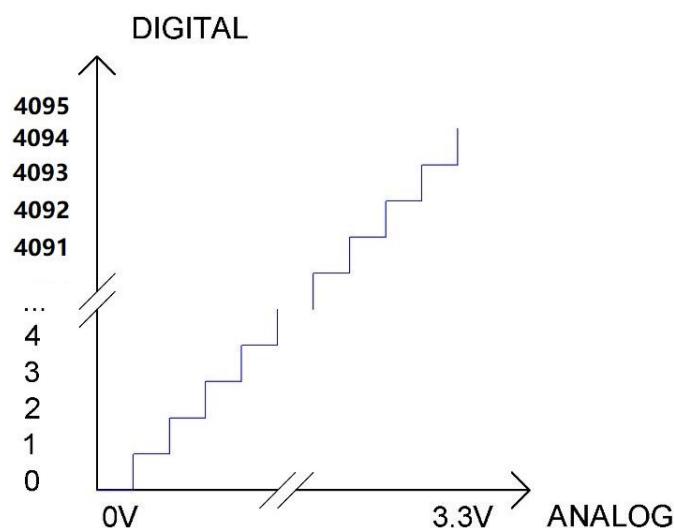
Component List

ESP32-S3 WROOM x1	GPIO Extension Board x1
Breadboard x1	
Rotary potentiometer x1	Jumper M/M x3

Related knowledge

ADC

An ADC is an electronic integrated circuit used to convert analog signals such as voltages to digital or binary form consisting of 1s and 0s. The range of our ADC on ESP32-S3 is 12 bits, that means the resolution is $2^{12}=4096$, and it represents a range (at 3.3V) will be divided equally to 4096 parts. The range of analog values corresponds to ADC values. So the more bits the ADC has, the denser the partition of analog will be and the greater the precision of the resulting conversion.



Subsection 1: the analog in rang of 0V---3.3/4095 V corresponds to digital 0;

Subsection 2: the analog in rang of 3.3/4095 V---2*3.3 /4095V corresponds to digital 1;

...

The following analog will be divided accordingly.

The conversion formula is as follows:

$$ADC\ Value = \frac{\text{Analog Voltage}}{3.3} * 4095$$



ADC on ESP32S3

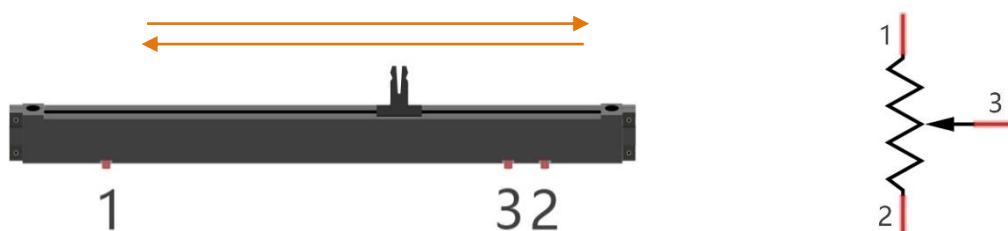
ESP32-S3 has two digital analog converters with successive approximations of 12-bit accuracy, and a total of 18 pins can be used to measure analog signals. GPIO pin sequence number and analog pin definition are shown in the following table.

GPIO number	ADC channel
GPIO 1	ADC1_CH0
GPIO 2	ADC1_CH1
GPIO 3	ADC1_CH2
GPIO 4	ADC1_CH3
GPIO 5	ADC1_CH4
GPIO 6	ADC1_CH5
GPIO 7	ADC1_CH6
GPIO 8	ADC1_CH7
GPIO 9	ADC1_CH8
GPIO 10	ADC1_CH9
GPIO 11	ADC2_CH0
GPIO 12	ADC2_CH1
GPIO 13	ADC2_CH2
GPIO 14	ADC2_CH3
GPIO 15	ADC2_CH4
GPIO 16	ADC2_CH5
GPIO 17	ADC2_CH6
GPIO 18	ADC2_CH7

Component knowledge

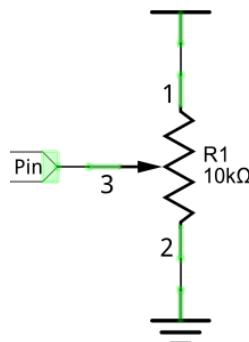
Potentiometer

A potentiometer is a three-terminal resistor. Unlike the resistors that we have used thus far in our project which have a fixed resistance value, the resistance value of a potentiometer can be adjusted. A potentiometer is often made up by a resistive substance (a wire or carbon element) and movable contact brush. When the brush moves along the resistor element, there will be a change in the resistance of the potentiometer's output side (3) (or change in the voltage of the circuit that is a part). The illustration below represents a linear sliding potentiometer and its electronic symbol on the right.



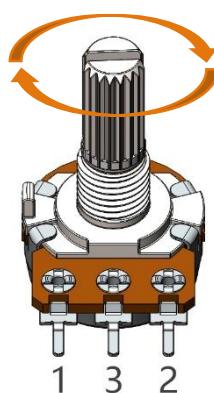
What between potentiometer pin 1 and pin 2 is the resistor body, and pins 3 is connected to brush. When brush moves from pin 1 to pin 2, the resistance between pin 1 and pin 3 will increase up to body resistance linearly, and the resistance between pin 2 and pin 3 will decrease down to 0 linearly.

In the circuit. The both sides of resistance body are often connected to the positive and negative electrode of the power. When you slide the brush pin 3, you can get a certain voltage in the range of the power supply.



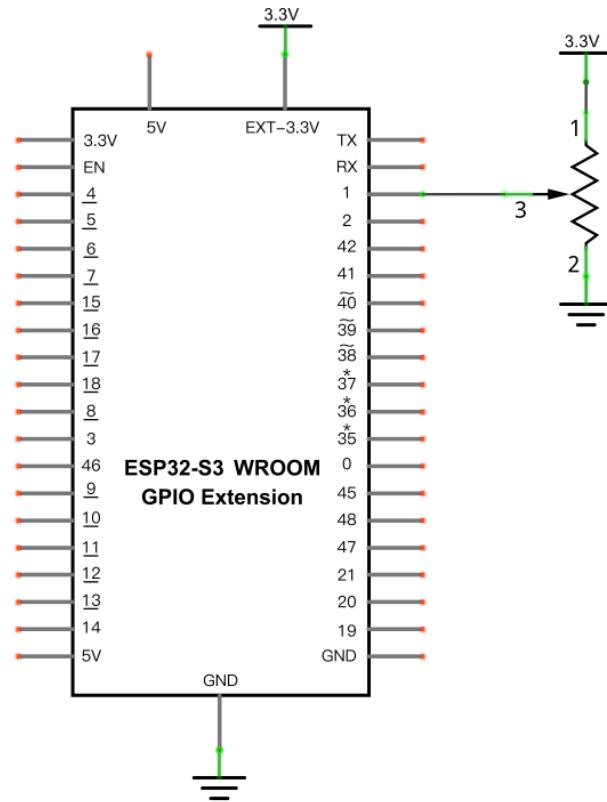
Rotary potentiometer

Rotary potentiometer and linear potentiometer have similar function; their only difference is: the resistance is adjusted by rotating the potentiometer.

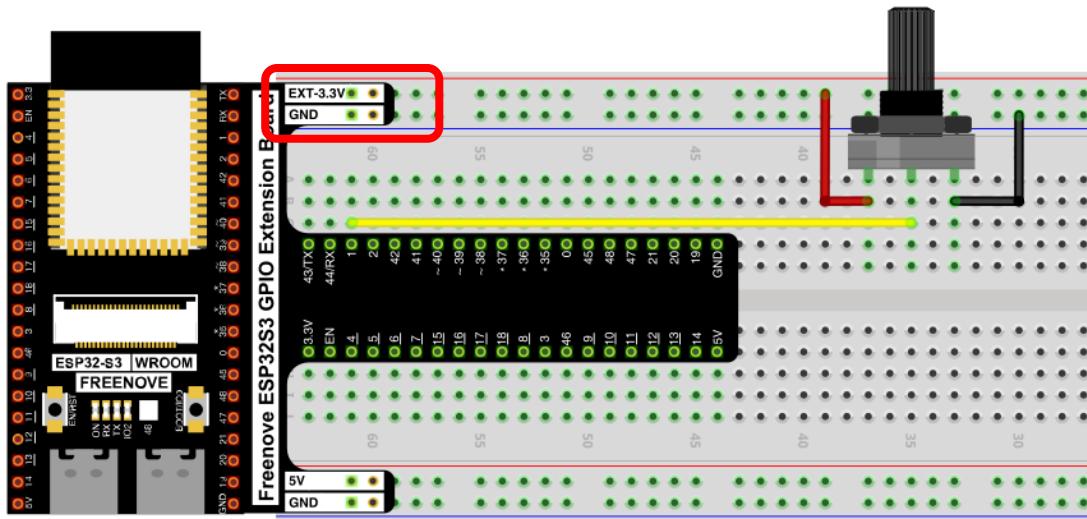


Circuit

Schematic diagram



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



Code

Move the program folder “Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Codes” to disk(D) in advance with the path of “D:/Micropython_Codes”.

Open “Thonny”, click “This computer” → “D:” → “Micropython_Codes” → “08.1_AnalogRead and then click “AnalogRead.py”.

08.1_AnalogRead

The screenshot shows the Thonny IDE interface. The title bar reads "Thonny - D:\Micropython_Codes\09.1_AnalogRead\AnalogRead.py @ 4:14". The menu bar includes File, Edit, View, Run, Tools, and Help. The toolbar features icons for file operations and a stop button. The left sidebar has a "Files" tab showing "This computer", "D:\Micropython_Codes\09.1_AnalogRead", and "AnalogRead.py" (which is selected). Below it is a "MicroPython device" tab with "boot.py". The main editor window displays the following Python code:

```
from machine import ADC,Pin
import time

adc=ADC(Pin(1))
adc.atten(ADC.ATTN_11DB)
adc.width(ADC.WIDTH_12BIT)

try:
    while True:
        adcVal=adc.read()
        voltage = adcVal / 4095.0 * 3.3
        print("ADC Val:",adcVal,"Voltage:",voltage,"V")
        time.sleep_ms(100)
except:
    pass
```

Click “Run current script” and observe the message printed in “Shell”.

ADC Val: 2915 Voltage: 2.349084 V
ADC Val: 2911 Voltage: 2.345861 V
ADC Val: 2909 Voltage: 2.344249 V
ADC Val: 2915 Voltage: 2.349084 V
ADC Val: 2915 Voltage: 2.349084 V
ADC Val: 2910 Voltage: 2.345055 V
ADC Val: 2915 Voltage: 2.349084 V
ADC Val: 2911 Voltage: 2.345861 V
ADC Val: 2910 Voltage: 2.345055 V
ADC Val: 2914 Voltage: 2.348279 V
ADC Val: 2915 Voltage: 2.349084 V
ADC Val: 2911 Voltage: 2.345861 V
ADC Val: 2915 Voltage: 2.349084 V
ADC Val: 2911 Voltage: 2.345861 V
ADC Val: 2910 Voltage: 2.345055 V
ADC Val: 2915 Voltage: 2.349084 V
ADC Val: 2911 Voltage: 2.345861 V
ADC Val: 2910 Voltage: 2.345055 V
ADC Val: 2914 Voltage: 2.348279 V

The following is the code:

```
1 from machine import ADC, Pin  
2 import time  
3  
4 adc=ADC(Pin(1))  
5 adc.atten(ADC.ATTN_11DB)  
6 adc.width(ADC.WIDTH_12BIT)
```

Any concerns?  support@freenove.com

```

7
8     try:
9         while True:
10            adcVal=adc.read()
11            voltage = adcVal / 4095.0 * 3.3
12            print("ADC Val:",adcVal,"Voltage:",voltage,"V")
13            time.sleep_ms(100)
14     except:
15         pass

```

Import Pin, ADC modules.

```

1 from machine import ADC,Pin
2 import time

```

Turn on and configure the ADC with the range of 0-3.3V and the data width of 12-bit data width.

```

4 adc=ADC(Pin(1))
5 adc.atten(ADC.ATTN_11DB)
6 adc.width(ADC.WIDTH_12BIT)

```

Read ADC value once every 100 millisecods, convert ADC value and print these data to "Shell".

```

9     while True:
10        adcVal=adc.read()
11        voltage = adcVal / 4095.0 * 3.3
12        print("ADC Val:",adcVal,"Voltage:",voltage,"V")
13        time.sleep_ms(100)

```

Reference

Class ADC

Before each use of ACD module, please add the statement “**from machine import ADC**” to the top of the python file.

machine.ADC(pin): Create an ADC object associated with the given pin.

pin: Available pins are: Pin(1-18).

ADC.read(): Read ADC and return the value.

ADC.attenu(db): Set attenuation ration (that is, the full range voltage, such as the voltage of 11db full range is 3.3V)

db: attenuation ratio

ADC.ATTIN_0DB —full range of 1.2V

ADC.ATTN_2_5_DB —full range of 1.5V

ADC.ATTN_6DB —full range of 2.0 V

ADC.ATTN_11DB —full range of 3.3V

ADC.width(bit): Set data width.

bit: data bit

ADC.WIDTH_9BIT —9 data width

ADC.WIDTH_10BIT — 10 data width

ADC.WIDTH_11BIT — 11 data width

ADC.WIDTH_12BIT — 12 data width

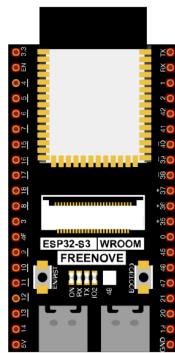
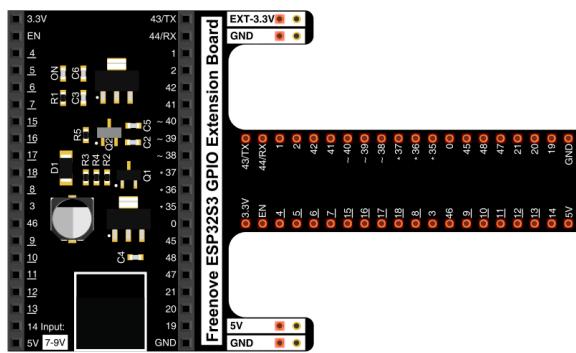
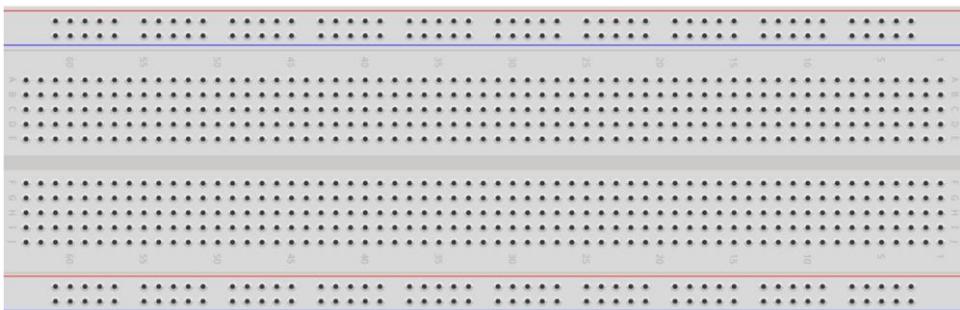
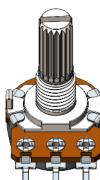
Chapter 9 Potentiometer & LED

We have already learned about the use of ADC and PWM. In this chapter, we will learn how to use a potentiometer to control the brightness of LED.

Project 9.1 Soft Light

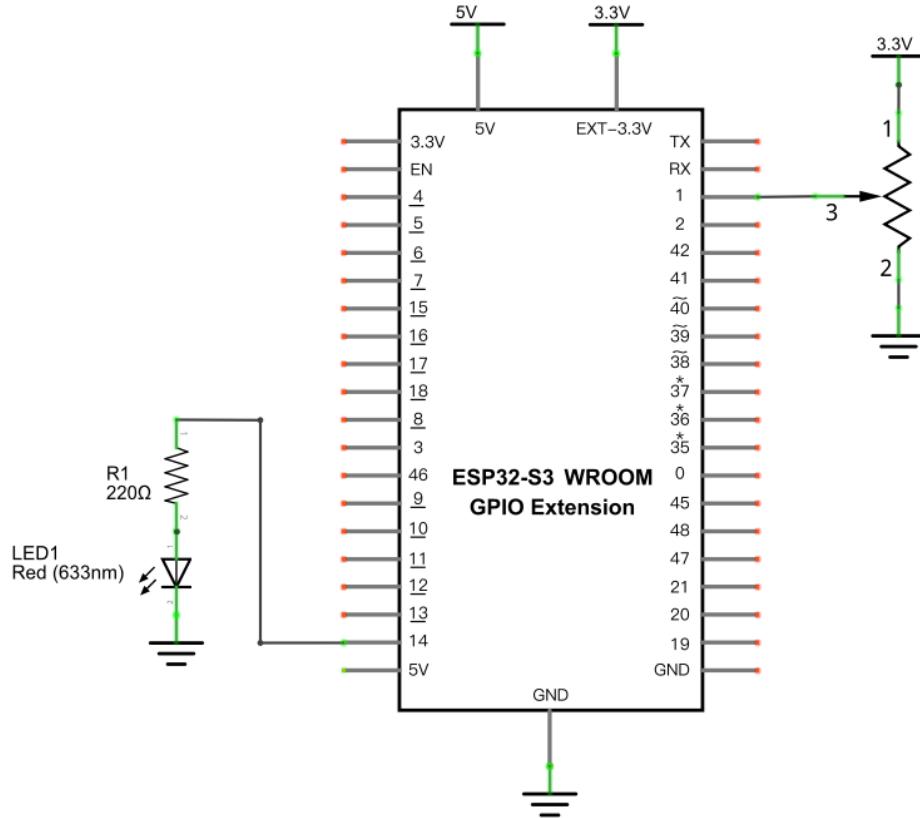
In this project, we will make a soft light. We will use an ADC Module to read ADC values of a potentiometer and map it to duty cycle of the PWM used to control the brightness of a LED. Then you can change the brightness of a LED by adjusting the potentiometer.

Component List

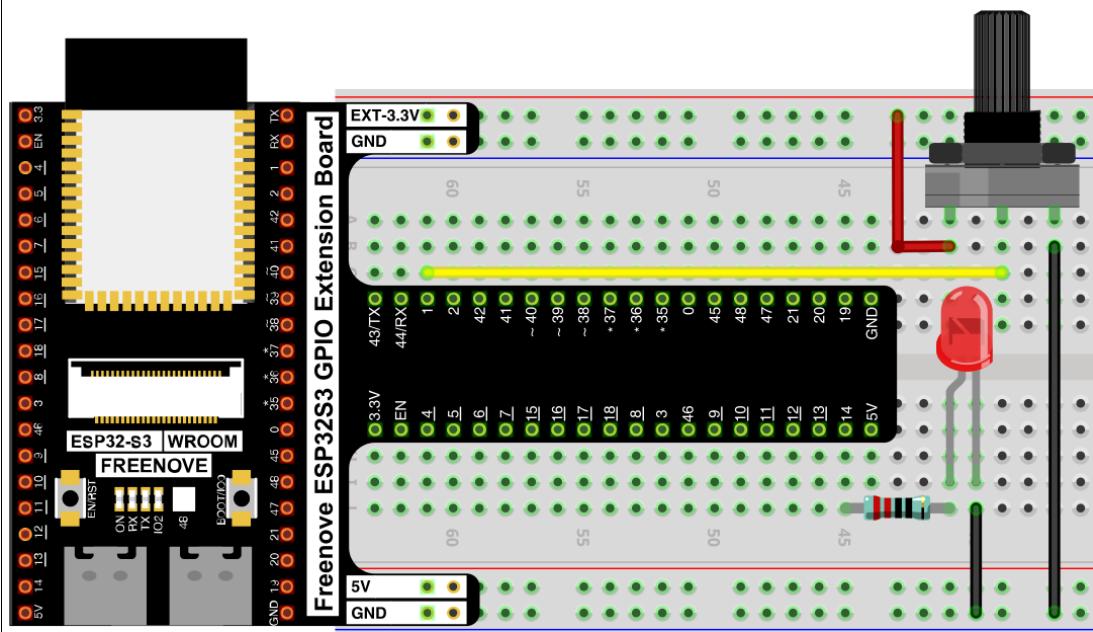
ESP32-S3 WROOM x1	GPIO Extension Board x1		
			
Breadboard x1			
			
Rotary potentiometer x1	Resistor 220Ω x1	LED x1	Jumper M/M x5
			

Circuit

Schematic diagram



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

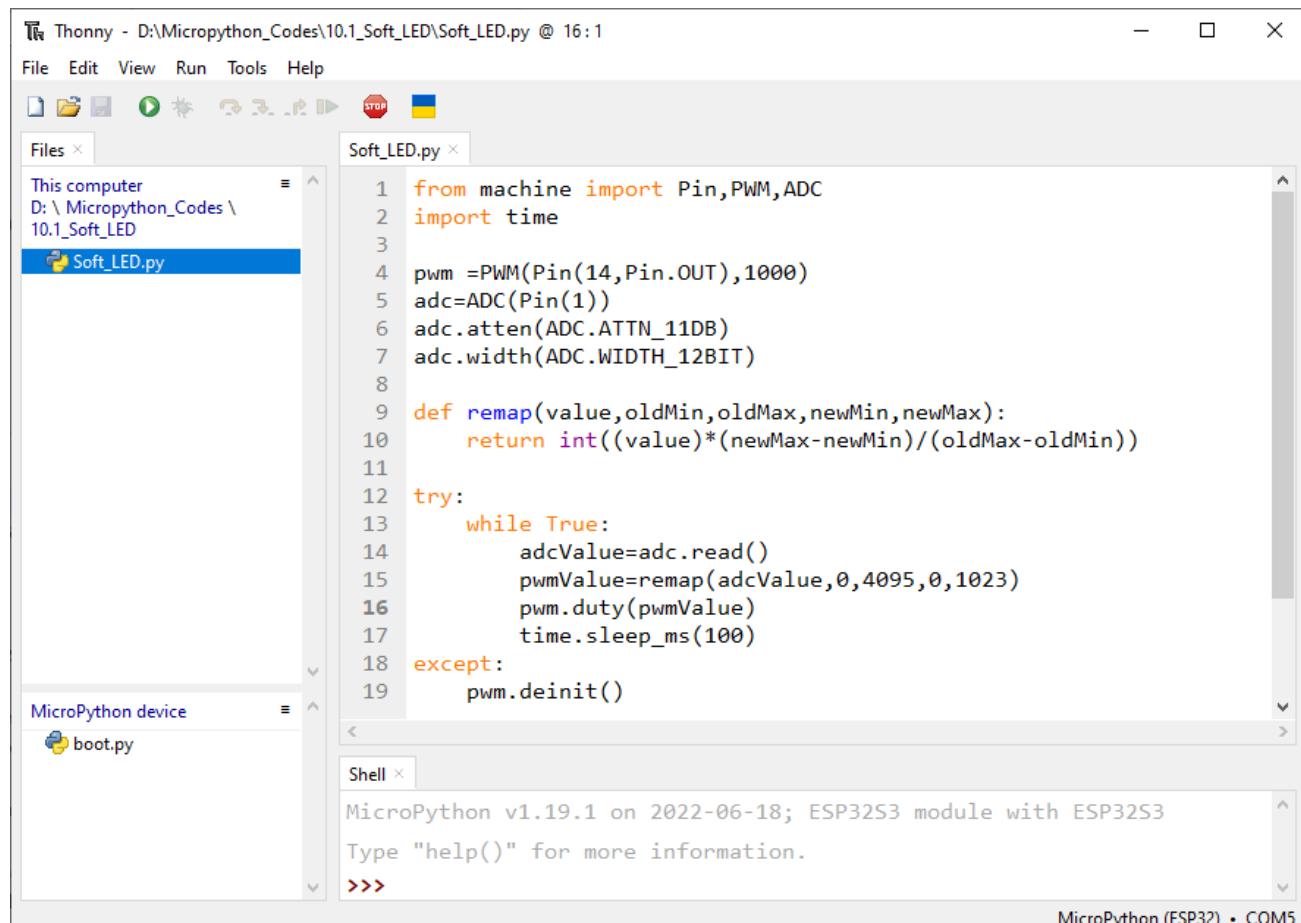


Code

Move the program folder “**Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Codes**” to disk(D) in advance with the path of “**D:/Micropython_Codes**”.

Open “Thonny”, click “This computer” → “D:” → “Micropython_Codes” → “09.1_Soft_LED” and double click “Soft_LED.py”.

09.1_Soft_LED



Click “Run current script”. Rotate the handle of potentiometer and the brightness of LED will change correspondingly.

The following is the code:

```

1 from machine import Pin,PWM,ADC
2 import time
3
4 pwm =PWM(Pin(14,Pin.OUT),1000)
5 adc=ADC(Pin(1))
6 adc.atten(ADC.ATTN_11DB)
7 adc.width(ADC.WIDTH_12BIT)
8
9 def remap(value,oldMin,oldMax,newMin,newMax):
10     return int((value)*(newMax-newMin)/(oldMax-oldMin))

```

```
11
12     try:
13         while True:
14             adcValue=adc.read()
15             pwmValue=remap(adcValue, 0, 4095, 0, 1023)
16             pwm.duty(pwmValue)
17             print(adcValue, pwmValue)
18             time.sleep_ms(100)
19     except:
20         pwm.deinit()
```

In the code, read the ADC value of the potentiometer. The ADC value range is 0-4095. However, the default input range of the duty() function is 0-1023. Therefore, we need to write a remap() function to map the read ADC value to a value that conforms to the input range of the duty() function.

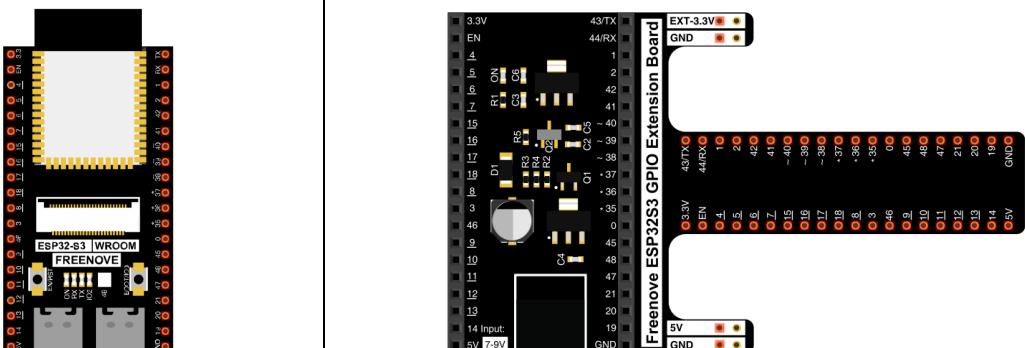
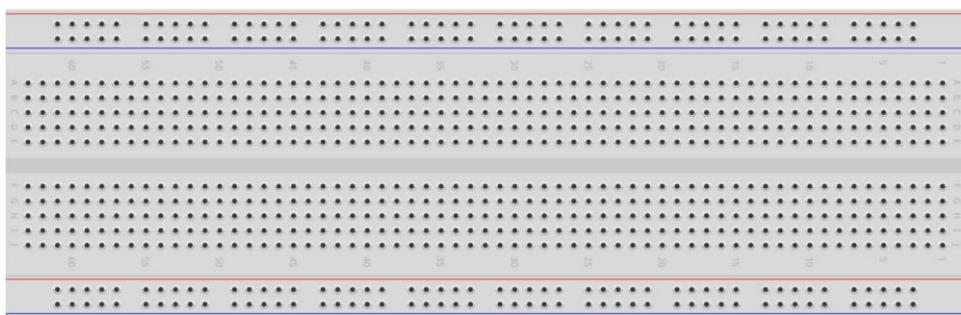
Chapter 10 Photoresistor & LED

In this chapter, we will learn how to use a photoresistor.

Project 10.1 NightLamp

A photoresistor is very sensitive to the amount of light present. We can take advantage of the characteristic to make a nightlight with the following function: when the ambient light is less (darker environment) the LED will automatically become brighter to compensate and when the ambient light is greater (brighter environment) the LED will automatically dim to compensate.

Component List

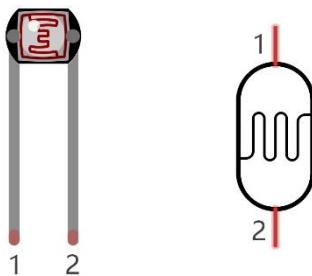
ESP32-S3 WROOM x1	GPIO Extension Board x1
	
Breadboard x1	
	
Photoresistor x1	Resistor
	220Ω x1 10KΩ x1
	LED x1
	Jumper M/M x4

Any concerns? [✉ support@freenove.com](mailto:support@freenove.com)

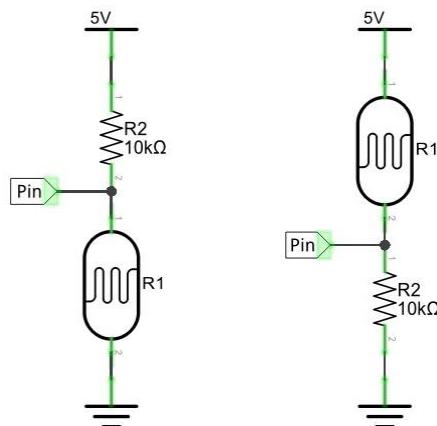
Component knowledge

Photoresistor

A photoresistor is simply a light sensitive resistor. It is an active component that decreases resistance with respect to receiving luminosity (light) on the component's light sensitive surface. A photoresistor's resistance value will change in proportion to the ambient light detected. With this characteristic, we can use a photoresistor to detect light intensity. The photoresistor and its electronic symbol are as follows.



The circuit below is used to detect the change of a photoresistor's resistance value:

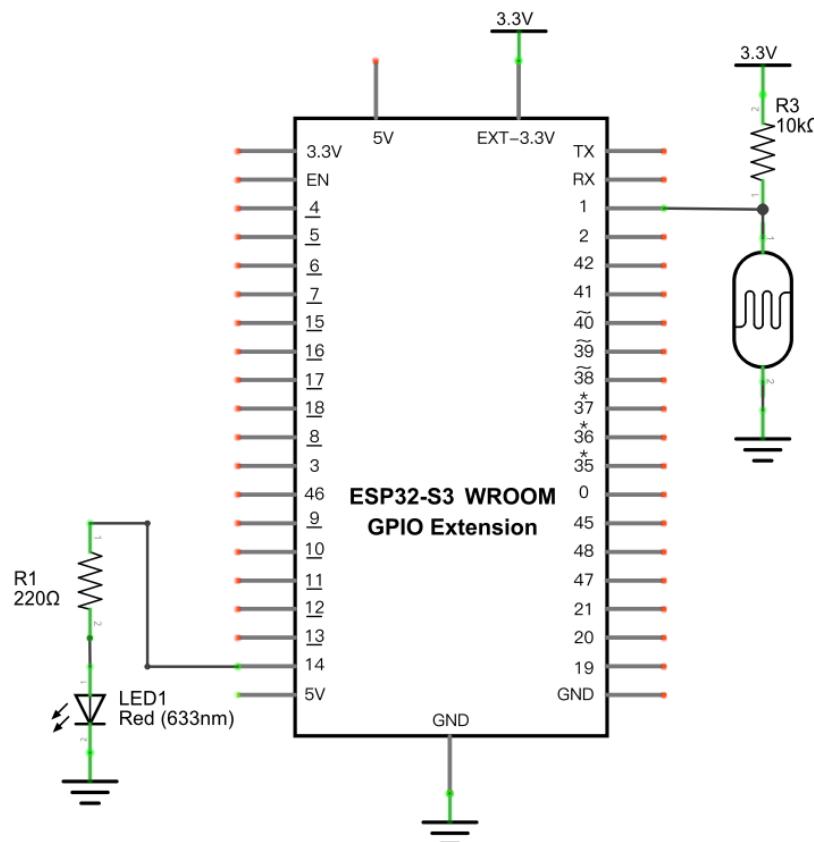


In the above circuit, when a photoresistor's resistance value changes due to a change in light intensity, the voltage between the photoresistor and resistor R1 will also change. Therefore, the intensity of the light can be obtained by measuring this voltage.

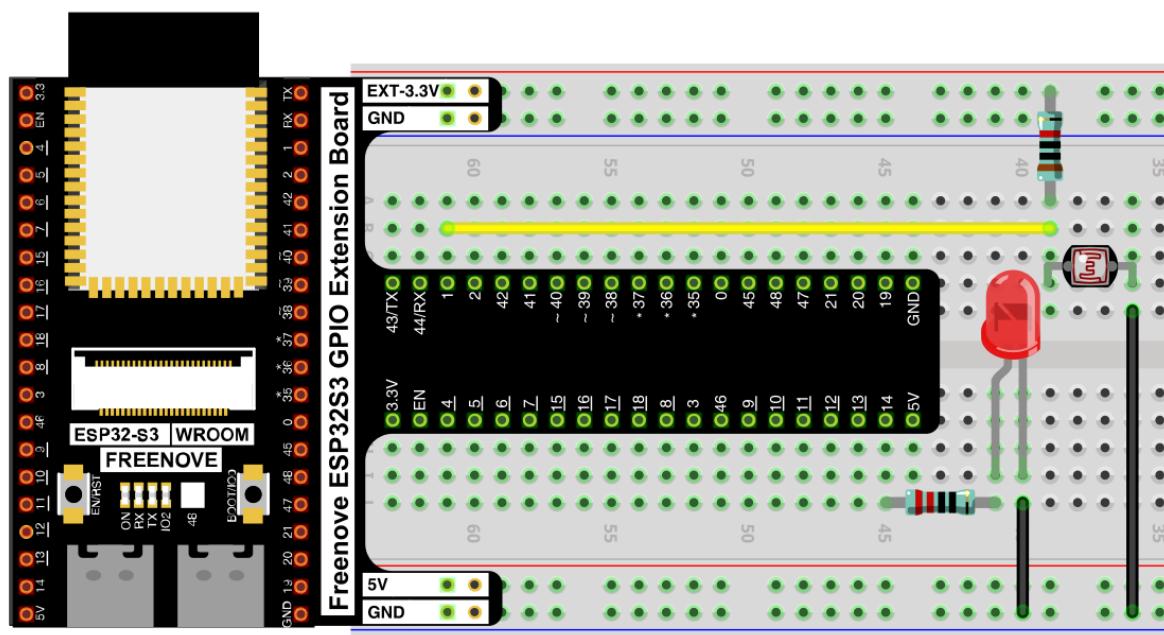
Circuit

The circuit of this project is similar to project Soft Light. The only difference is that the input signal is changed from a potentiometer to a combination of a photoresistor and a resistor.

Schematic diagram



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



Any concerns? ✉ support@freenove.com

Code

Move the program folder “**Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Codes**” to disk(D) in advance with the path of “**D:/Micropython_Codes**”.

Codes of this project is logically the same as the project [Soft Light](#).

10.1_Nightlamp

```

from machine import Pin, PWM, ADC
import time

pwm = PWM(Pin(14, Pin.OUT), 1000)
adc=ADC(Pin(1))
adc.atten(ADC.ATTN_11DB)
adc.width(ADC.WIDTH_12BIT)

def remap(value,oldMin,oldMax,newMin,newMax):
    return int((value)*(newMax-newMin)/(oldMax-oldMin))

try:
    while True:
        adcValue=adc.read()
        pwmValue=remap(adcValue,0,4095,0,1023)
        pwm.duty(pwmValue)
        print(adcValue,pwmValue)
        time.sleep_ms(100)
except:
    pwm.deinit()

```

MicroPython v1.19.1 on 2022-06-18; ESP32S3 module with ESP32S3
Type "help()" for more information.
>>>

Click “Run current script”. Cover the photoresistor with your hands or illuminate it with lights, the brightness of LEDs will change.

The following is the program code:

```

from machine import Pin, PWM, ADC
import time

pwm = PWM(Pin(14, Pin.OUT), 1000)
adc=ADC(Pin(1))
adc.atten(ADC.ATTN_11DB)
adc.width(ADC.WIDTH_12BIT)

def remap(value, oldMin, oldMax, newMin, newMax):
    return int((value)*(newMax-newMin)/(oldMax-oldMin))

```

```
11 try:  
12     while True:  
13         adcValue=adc.read()  
14         pwmValue=remap(adcValue, 0, 4095, 0, 1023)  
15         pwm.duty(pwmValue)  
16         print(adcValue, pwmValue)  
17         time.sleep_ms(100)  
18     except:  
19         pwm.deinit()
```

In this code, we use ADC to read the ADC value of the photoresist and map it to the PWM of the control LED, so that the brightness of the LED can change accordingly with the change of the ambient light intensity.

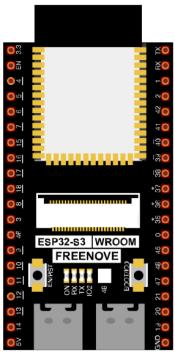
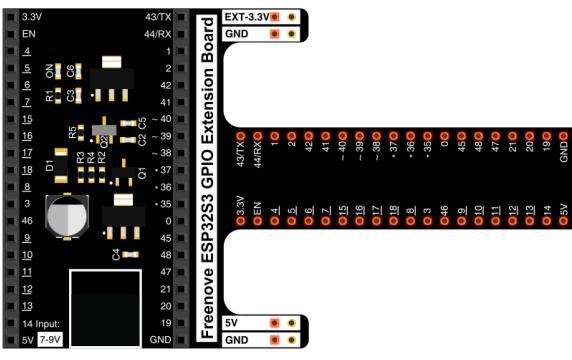
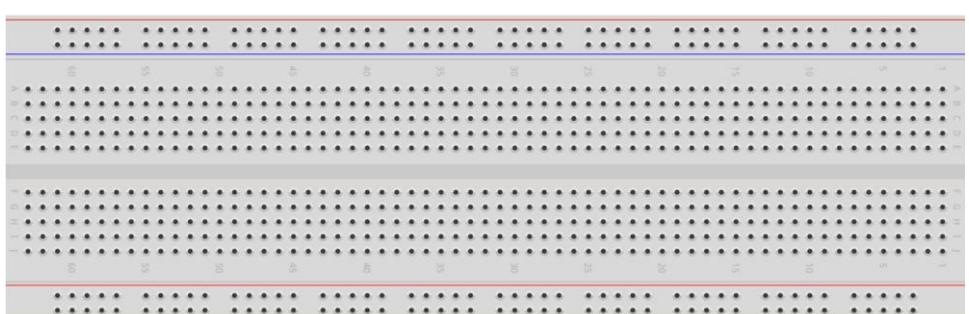
Chapter 11 Thermistor

In this chapter, we will learn about thermistors which are another kind of resistor

Project 11.1 Thermometer

A thermistor is a type of resistor whose resistance value is dependent on temperature and changes in temperature. Therefore, we can take advantage of this characteristic to make a thermometer.

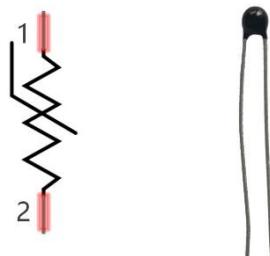
Component List

ESP32-S3 WROOM x1	GPIO Extension Board x1	
		
		
Breadboard x1		
		
Thermistor x1	Resistor 10kΩ x1	Jumper M/M x3
		

Component knowledge

Thermistor

A thermistor is a temperature sensitive resistor. When it senses a change in temperature, the resistance of the thermistor will change. We can take advantage of this characteristic by using a thermistor to detect temperature intensity. A thermistor and its electronic symbol are shown below.



The relationship between resistance value and temperature of a thermistor is:

$$R_t = R * \text{EXP} \left[B * \left(\frac{1}{T_2} - \frac{1}{T_1} \right) \right]$$

Where:

R_t is the thermistor resistance under T_2 temperature;

R is the nominal resistance of thermistor under T_1 temperature;

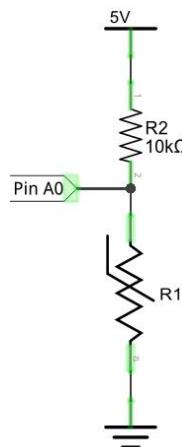
$\text{EXP}[n]$ is nth power of E;

B is for thermal index;

T_1, T_2 is Kelvin temperature (absolute temperature). Kelvin temperature=273.15 + Celsius temperature.

For the parameters of the thermistor, we use: $B=3950$, $R=10k$, $T_1=25$.

The circuit connection method of the thermistor is similar to photoresistor, as the following:



We can use the value measured by the ADC converter to obtain the resistance value of thermistor, and then we can use the formula to obtain the temperature value.

Therefore, the temperature formula can be derived as:

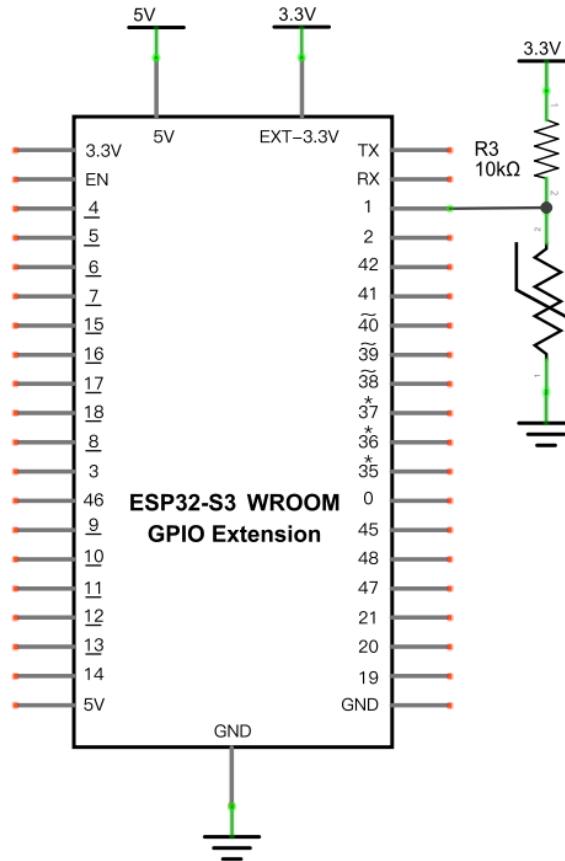
$$T_2 = 1 / \left(\frac{1}{T_1} + \ln \left(\frac{R_t}{R} \right) / B \right)$$



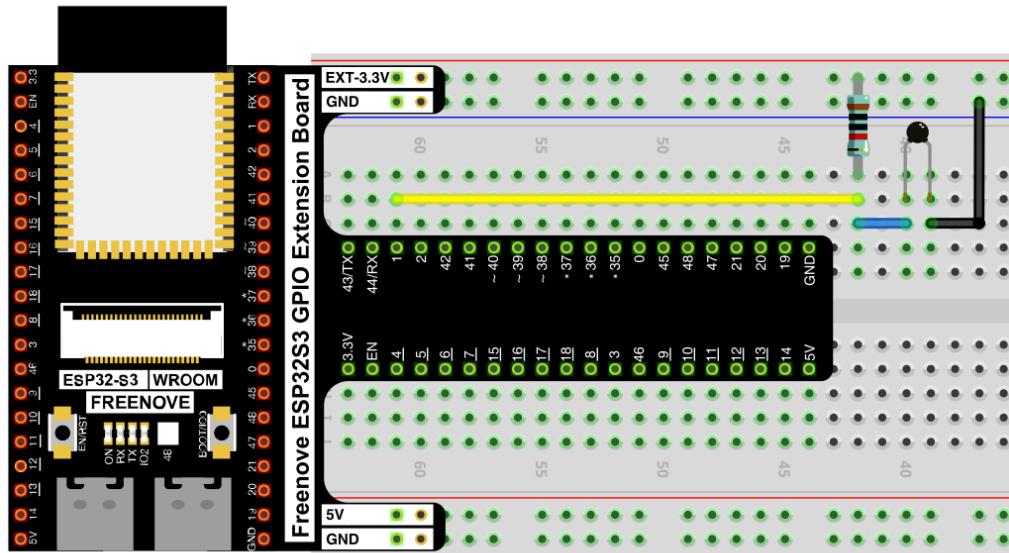
Circuit

The circuit of this project is similar to the one in the last chapter. The only difference is that the photoresistor is replaced by the thermistor.

Schematic diagram



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



Any concerns? ✉ support@freenove.com

Code

Move the program folder “**Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Codes**” to disk(D) in advance with the path of “**D:/Micropython_Codes**”.

Open “Thonny”, click “This computer” → “D:” → “Micropython_Codes” → “11.1_Thermometer” and double click “Thermometer.py”.

11.1 Thermometer

The screenshot shows the Thonny IDE interface. The title bar says "Thonny - D:\Micropython_Codes\12.1_Thermometer\Thermometer.py @ 19:1". The menu bar includes File, Edit, View, Run, Tools, Help. The toolbar has icons for file operations and a stop button. The left sidebar shows "Files" with "Thermometer.py" selected, "This computer" with "D:\Micropython_Codes\12.1_Thermometer", and "MicroPython device" with "boot.py". The main code editor window displays the following Python script:

```

1 from machine import Pin,ADC
2 import time
3 import math
4
5 adc=ADC(Pin(1))
6 adc.atten(ADC.ATTN_11DB)
7 adc.width(ADC.WIDTH_12BIT)
8 try:
9     while True:
10         adcValue=adc.read()
11         voltage=adcValue/4095*3.3
12         Rt=10*voltage/(3.3-voltage)
13         tempK=(1/(1/(273.15+25)+(math.log(Rt/10))/3950))
14         tempC=tempK-273.15
15         print("ADC value:",adcValue,"Voltage : ",voltage,"Temperature : ",tempC)
16         time.sleep_ms(1000)
17     except:
18         pass

```

The "Shell" window at the bottom shows the output of the script:

```

ADC value: 1771  Voltage : 1.427179  Temperature : 31.24362
ADC value: 1780  Voltage : 1.434432  Temperature : 31.03384
ADC value: 1785  Voltage : 1.438462  Temperature : 30.91751
ADC value: 1797  Voltage : 1.448132  Temperature : 30.63904

```

At the bottom right, it says "MicroPython (ESP32) • COM24".

Click “Run current script” and “Shell” will constantly display the current ADC value, voltage value and temperature value. Try to “pinch” the thermistor (without touching the leads) with your index finger and thumb for a brief time, you should see that the temperature value increases.

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

```
Shell x
MicroPython v1.12 on 2019-12-20, Lolin32 module (spirally-wire Lolin32)
Type "help()" for more information.
>>> %Run -c $EDITOR_CONTENT

ADC value: 2175      Voltage : 1.752747      Temperature : 22.21976
ADC value: 2176      Voltage : 1.753553      Temperature : 22.19809
ADC value: 2141      Voltage : 1.725348      Temperature : 22.95731
ADC value: 1989      Voltage : 1.602857      Temperature : 26.2919
ADC value: 1943      Voltage : 1.565788      Temperature : 27.31705
ADC value: 1943      Voltage : 1.565788      Temperature : 27.31705
ADC value: 1943      Voltage : 1.565788      Temperature : 27.31705
ADC value: 1942      Voltage : 1.564982      Temperature : 27.33945
ADC value: 1942      Voltage : 1.564982      Temperature : 27.33945
ADC value: 1943      Voltage : 1.565788      Temperature : 27.31705
ADC value: 2097      Voltage : 1.68989       Temperature : 23.91562
ADC value: 2218      Voltage : 1.787399      Temperature : 21.29001
```

pinching the
thermistor

The following is the code:

```
1  from machine import Pin, ADC
2  import time
3  import math
4
5  adc=ADC(Pin(1))
6  adc.atten(ADC.ATTN_11DB)
7  adc.width(ADC.WIDTH_12BIT)
8
9  try:
10     while True:
11         adcValue=adc.read()
12         voltage=adcValue/4095*3.3
13         Rt=10*voltage/(3.3-voltage)
14         tempK=(1/(1/(273.15+25)+(math.log(Rt/10))/3950))
15         tempC=tempK-273.15
16         print("ADC value:",adcValue,"Voltage : ",voltage,"Temperature : ",tempC);
17         time.sleep_ms(1000)
18     except:
19         pass
```

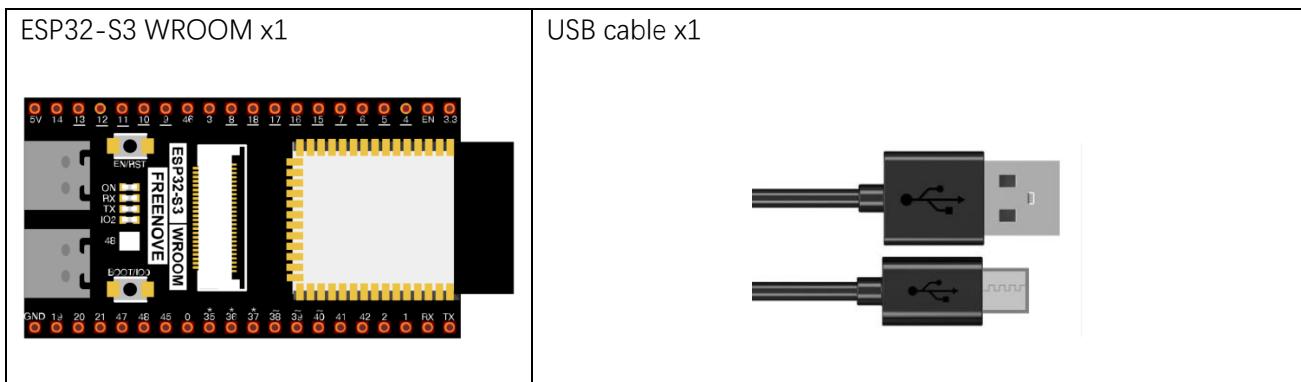
In the code, the ADC value of ADC module A0 port is read, and then it calculates the voltage and the resistance of Thermistor according to Ohms Law. Finally, it calculates the temperature sensed by the Thermistor, according to the formula.

Chapter 12 Bluetooth

This chapter mainly introduces how to make simple data transmission through Bluetooth of ESP32-S3 WROOM and mobile phones.

Project 12.1 Bluetooth Low Energy Data Passthrough

Component List



Component knowledge

ESP32S3's integrated Bluetooth function Bluetooth is a short-distance communication system, which can be divided into two types, namely Bluetooth Low Energy(BLE) and Classic Bluetooth. There are two modes for simple data transmission: master mode and slave mode.

Master mode

In this mode, works are done in the master device and it can connect with a slave device. And we can search and select slave devices nearby to connect with. When a device initiates connection request in master mode, it requires information of the other Bluetooth devices including their address and pairing passkey. After finishing pairing, it can connect with them directly.

Slave mode

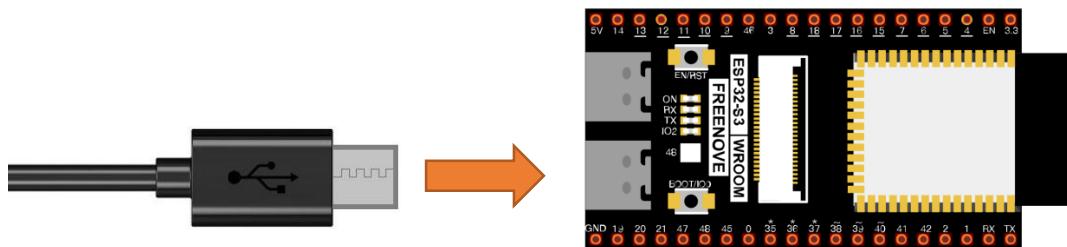
The Bluetooth module in slave mode can only accept connection request from a host computer, but cannot initiate a connection request. After connecting with a host device, it can send data to or receive from the host device.

Bluetooth devices can make data interaction with each other, as one is in master mode and the other in slave mode. When they are making data interaction, the Bluetooth device in master mode searches and selects devices nearby to connect to. When establishing connection, they can exchange data. When mobile phones exchange data with ESP32S3, they are usually in master mode and ESP32-S3 in slave mode.



Circuit

Connect Freenove ESP32-S3 to the computer using the USB cable.



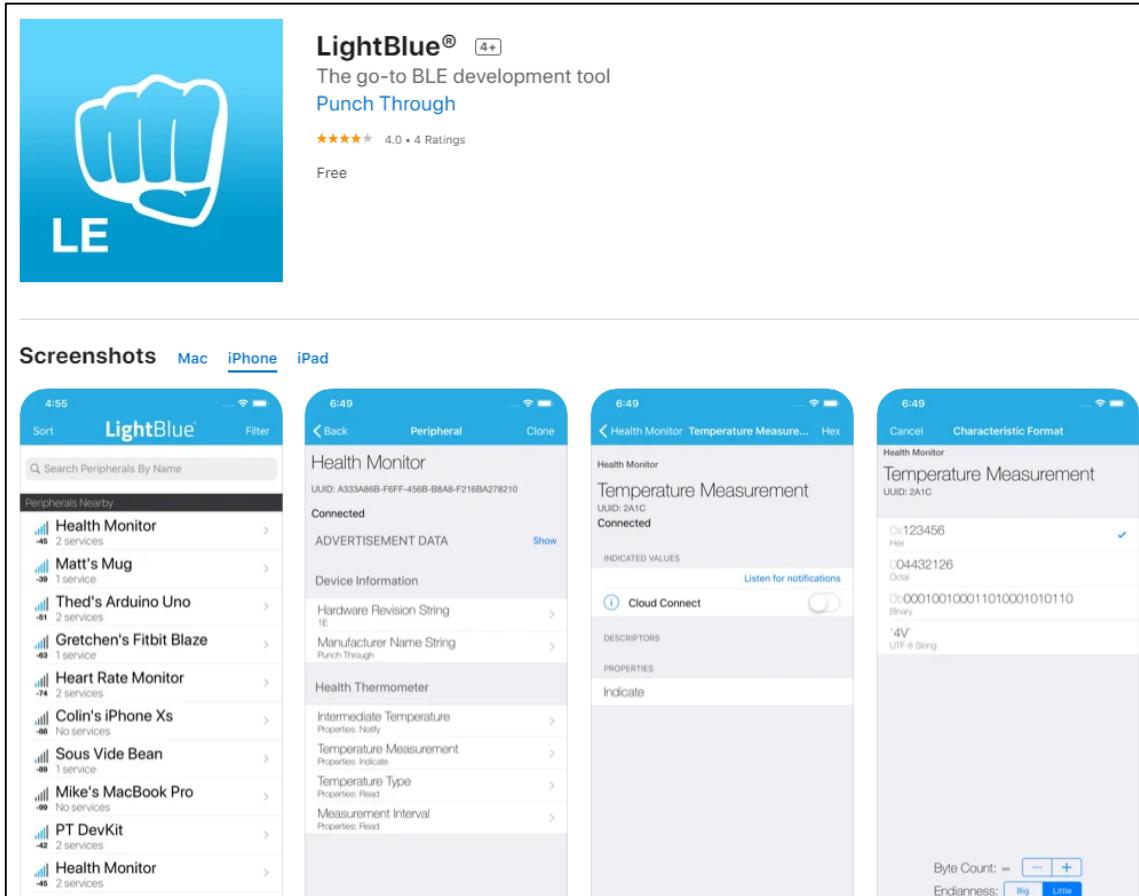
Any concerns? support@freenove.com



Lightblue

If you can't install Serial Bluetooth on your phone, try LightBlue. If you do not have this software installed on your phone, you can refer to this link:

<https://apps.apple.com/us/app/lightblue/id557428110#?platform=iphone.>

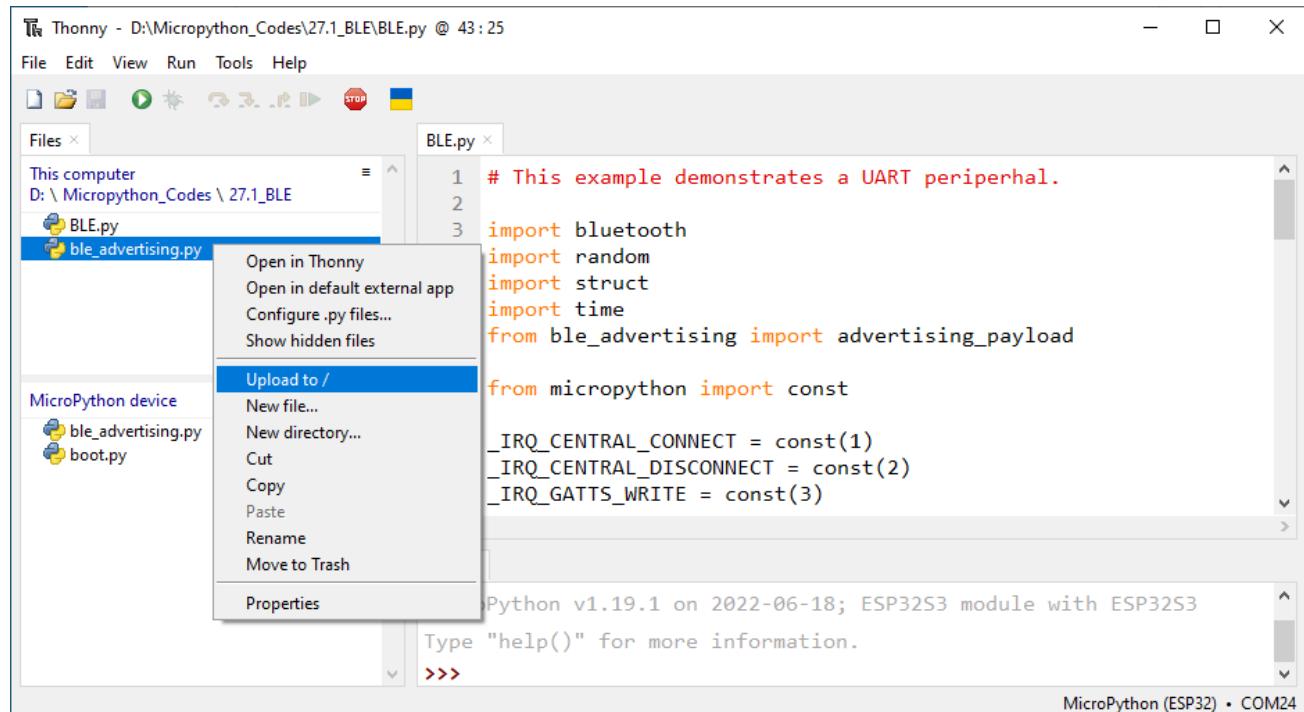


Code

Move the program folder “**Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Codes**” to disk(D) in advance with the path of “**D:/Micropython_Codes**”.

Open “Thonny”, click “This computer” → “D:” → “Micropython_Codes” → “12.1_BLE”. Select “ble_advertising.py”, right click your mouse to select “Upload to /”, wait for “ble_advertising.py” to be uploaded to ESP32-S3 and then double click “BLE.py”.

12.1_BLE





Click run for BLE.py.

The screenshot shows the Thonny IDE interface. In the top bar, it says "Thonny - D:\Micropython_Codes\27.1_BLE\BLE.py @ 43:25". The menu bar includes File, Edit, View, Run, Tools, Help. Below the menu is a toolbar with icons for file operations and a stop button. The left sidebar has two sections: "Files" showing "This computer" with "D:\Micropython_Codes\27.1_BLE\BLE.py" selected, and "MicroPython device" showing "ble_advertising.py" and "boot.py". The main area has a tab for "BLE.py" containing Python code:

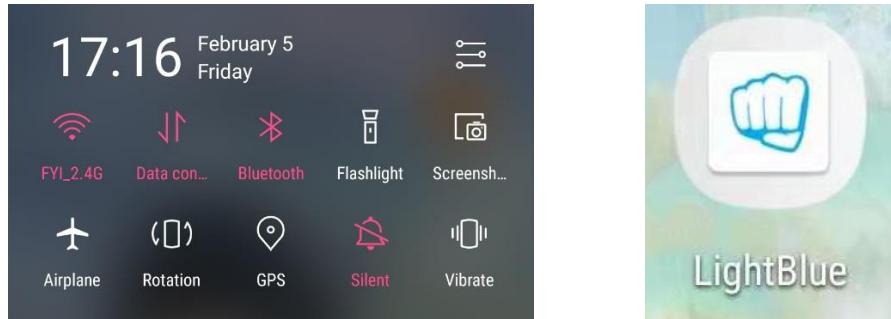
```

1 # This example demonstrates a UART peripheral.
2
3 import bluetooth
4 import random
5 import struct
6 import time
7 from ble_advertising import advertising_payload

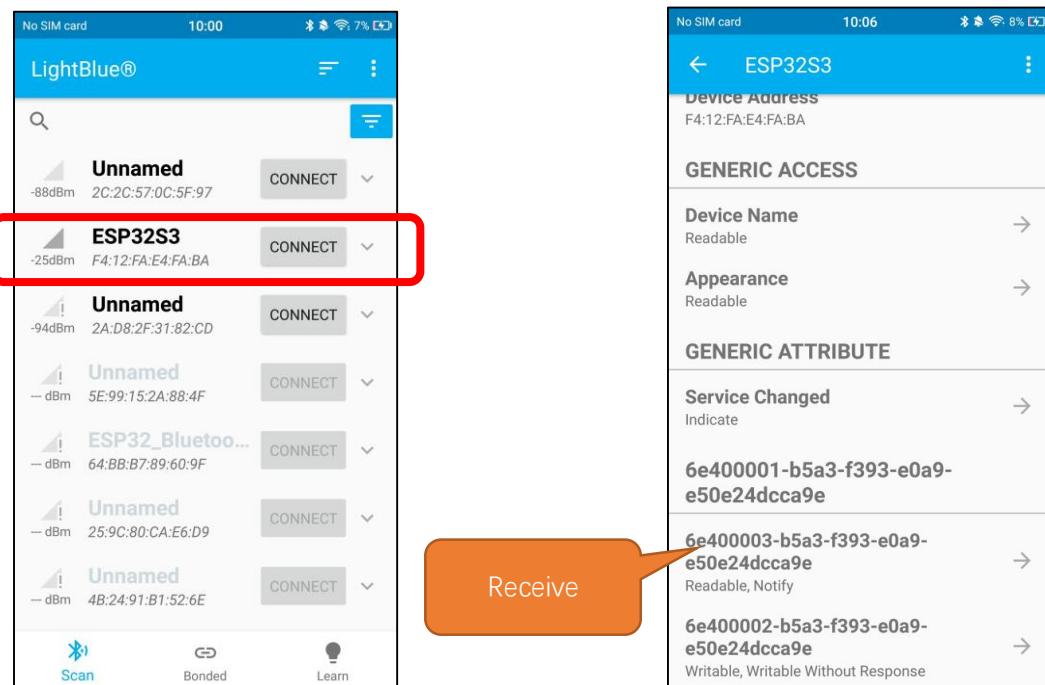
```

Below the code is a "Shell" tab with the command ">>> %Run -c \$EDITOR_CONTENT" and the output "Starting advertising Please use LightBlue to connect to ESP32S3." At the bottom right, it says "MicroPython (ESP32) • COM24".

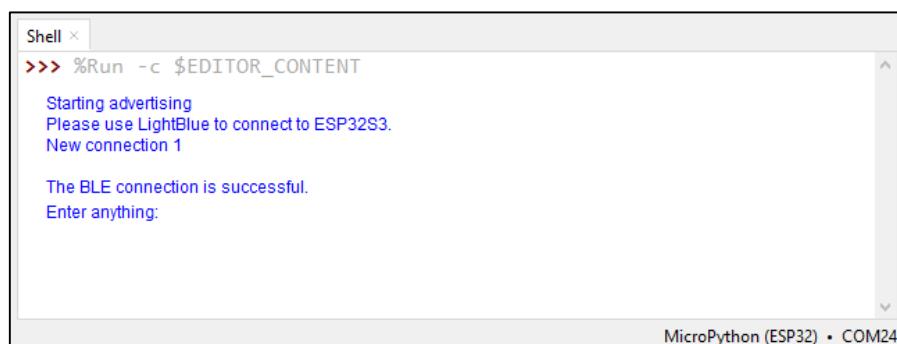
Turn ON Bluetooth on your phone, and open the Lightblue APP.



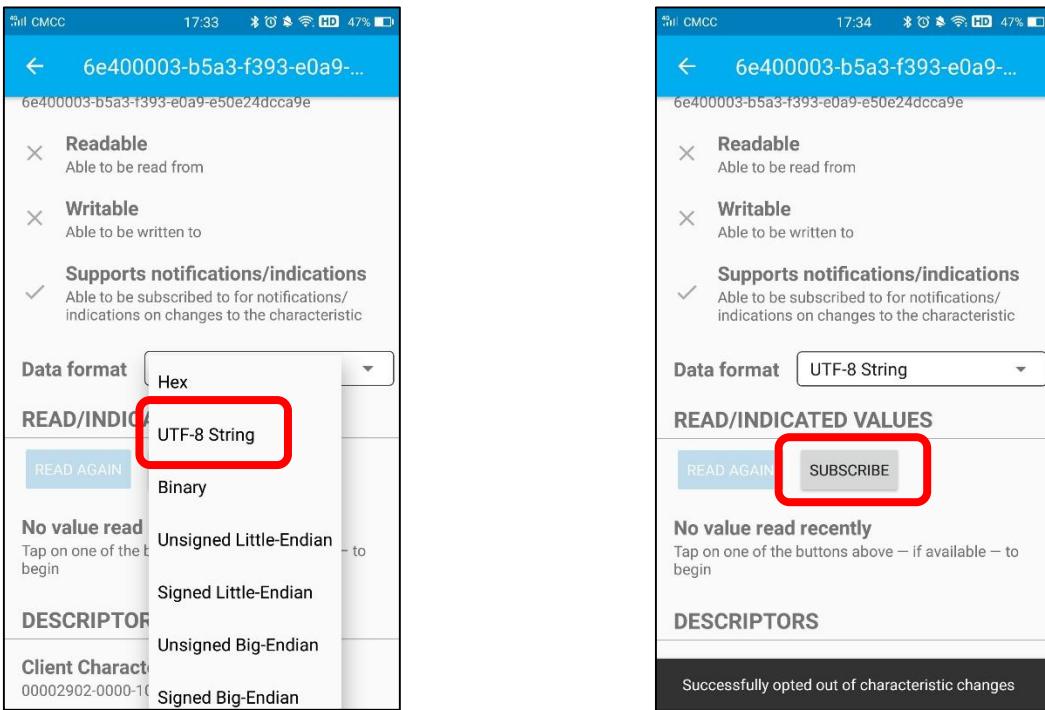
In the Scan page, swipe down to refresh the name of Bluetooth that the phone searches for. Click ESP32S3.



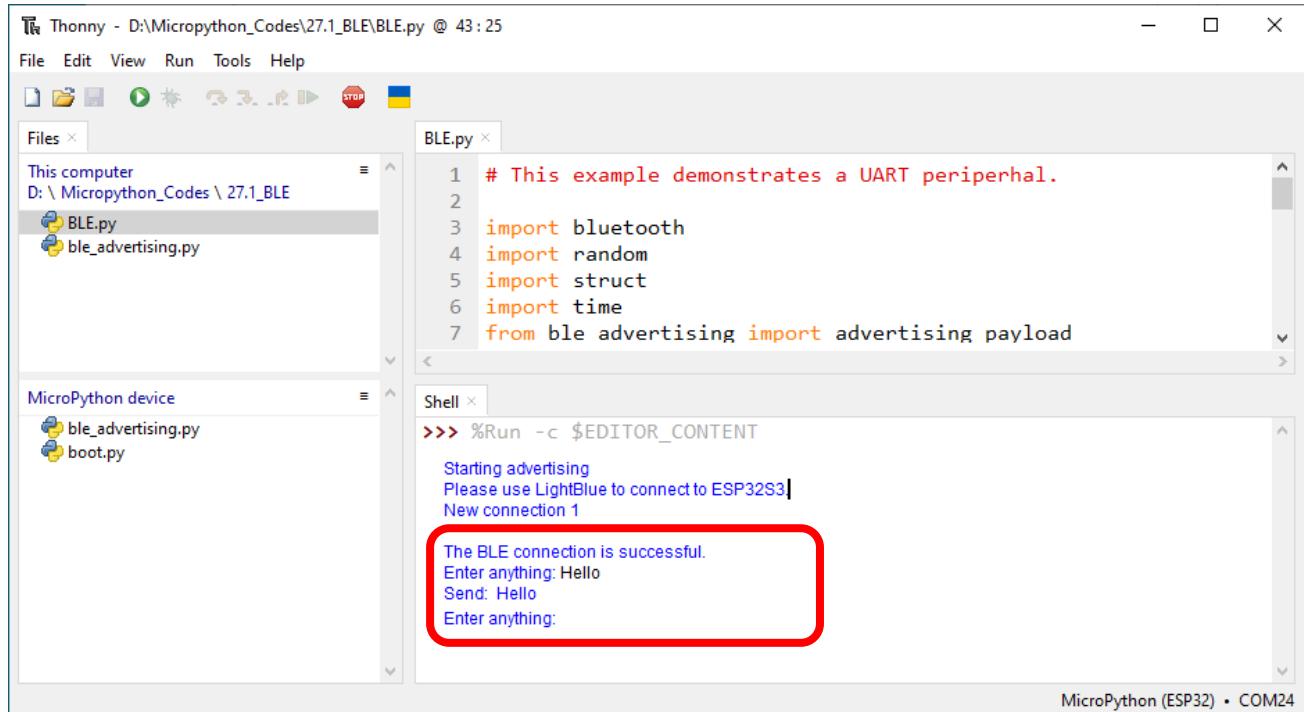
After Bluetooth is connect successfully, Shell will printer the information.



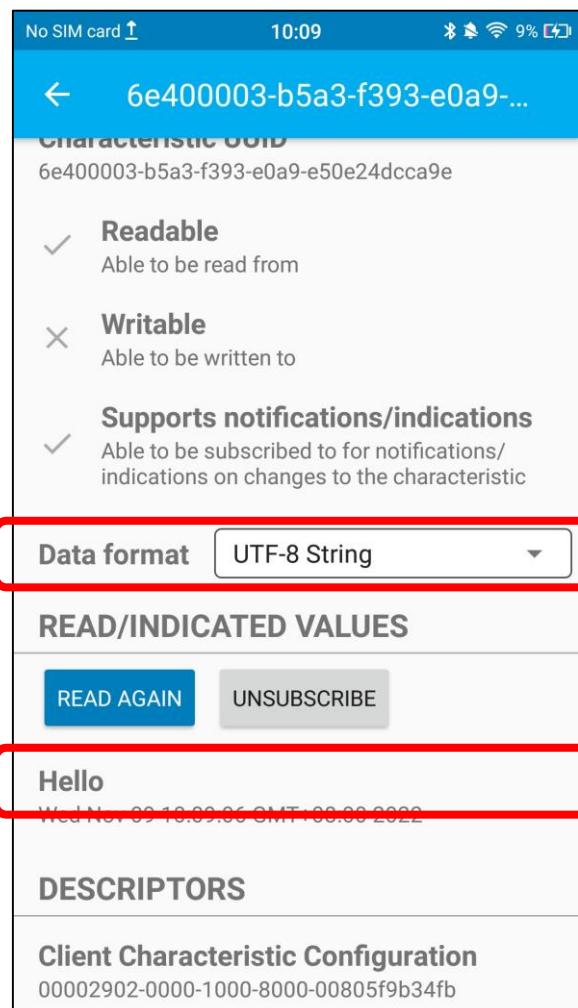
Click "Receive". Select the appropriate Data format in the box to the right of Data Format. For example, HEX for hexadecimal, utf-string for character, Binary for Binary, etc. Then click SUBSCRIBE.



You can type “Hello” in Shell and press “Enter” to send.

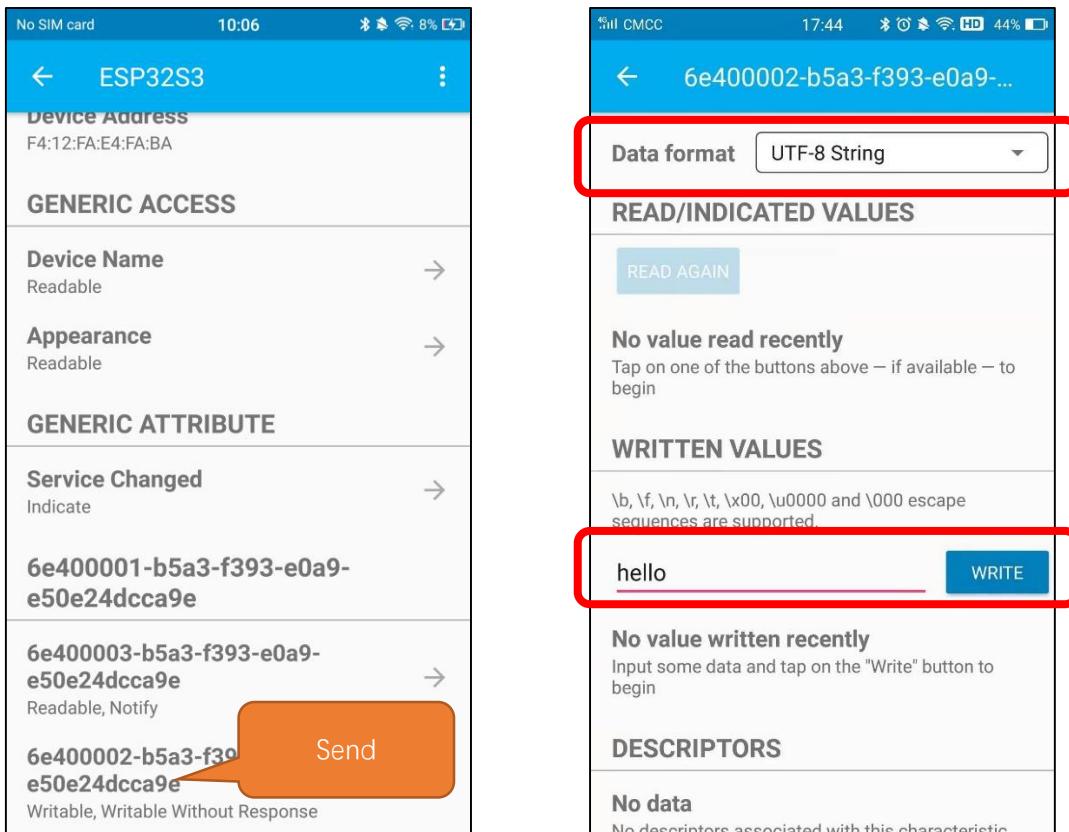


And then you can see the mobile Bluetooth has received the message.

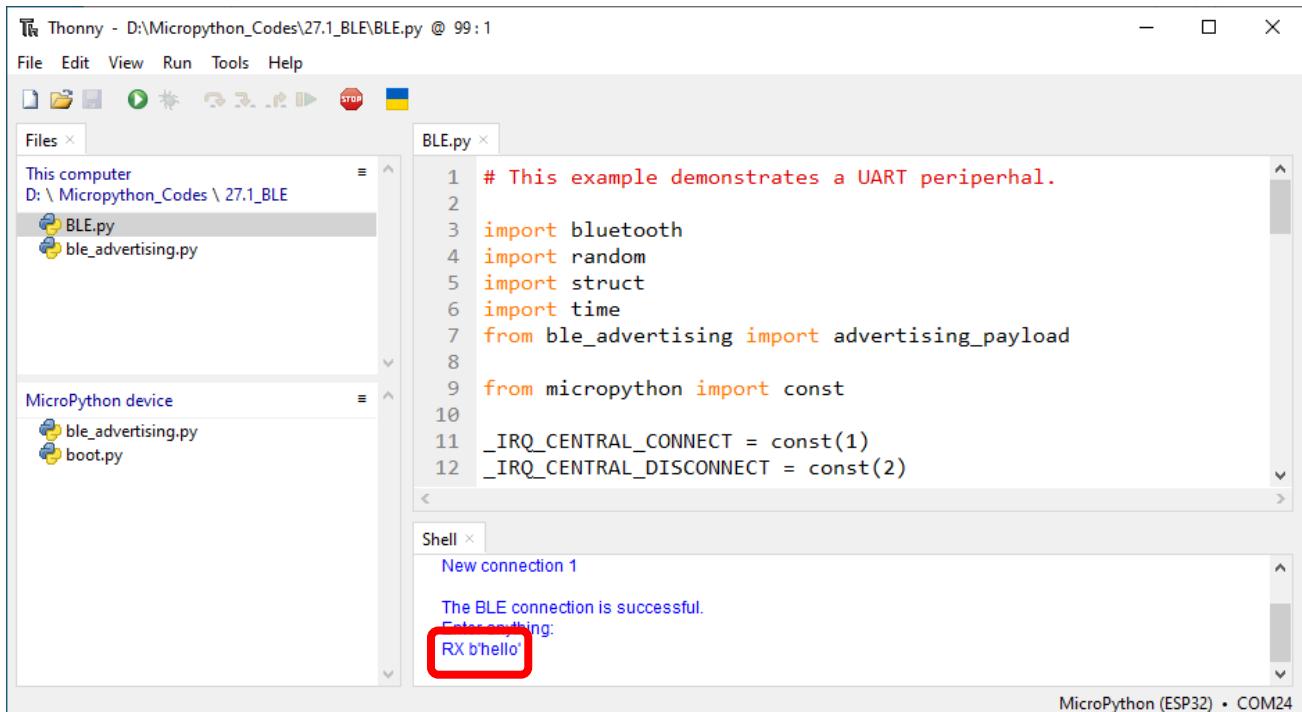




Similarly, you can select “Send” on your phone. Set Data format, and then enter anything in the sending box and click Write to send.



You can check the message from Bluetooth in “Shell”.



And now data can be transferred between your mobile phone and computer via ESP32S3.

The following is the program code:

```
1 import bluetooth
2 import random
3 import struct
4 import time
5 from ble_advertising import advertising_payload
6 from micropython import const
7
8 _IRQ_CENTRAL_CONNECT = const(1)
9 _IRQ_CENTRAL_DISCONNECT = const(2)
10 _IRQ_GATTS_WRITE = const(3)
11 _FLAG_READ = const(0x0002)
12 _FLAG_WRITE_NO_RESPONSE = const(0x0004)
13 _FLAG_WRITE = const(0x0008)
14 _FLAG_NOTIFY = const(0x0010)
15
16 _UART_UUID = bluetooth.UUID("6E400001-B5A3-F393-E0A9-E50E24DCCA9E")
17 _UART_TX = (
18     bluetooth.UUID("6E400003-B5A3-F393-E0A9-E50E24DCCA9E"),
19     _FLAG_READ | _FLAG_NOTIFY,
20 )
21 _UART_RX = (
22     bluetooth.UUID("6E400002-B5A3-F393-E0A9-E50E24DCCA9E"),
23     _FLAG_WRITE | _FLAG_WRITE_NO_RESPONSE,
24 )
25 _UART_SERVICE = (
26     _UART_UUID,
27     (_UART_TX, _UART_RX),
28 )
29 class BLESimplePeripheral:
30     def __init__(self, ble, name="ESP32S3"):
31         self._ble = ble
32         self._ble.active(True)
33         self._ble.irq(self._irq)
34         ((self._handle_tx, self._handle_rx),) =
35         self._ble.gatts_register_services((_UART_SERVICE,))
36         self._connections = set()
37         self._write_callback = None
38         self._payload = advertising_payload(name=name, services=[_UART_UUID])
39         self._advertise()
40     def _irq(self, event, data):
41         # Track connections so we can send notifications.
42         if event == _IRQ_CENTRAL_CONNECT:
```

```

43         conn_handle, _, _ = data
44         print("New connection", conn_handle)
45         print("\nThe BLE connection is successful.")
46         self._connections.add(conn_handle)
47     elif event == _IRQ_CENTRAL_DISCONNECT:
48         conn_handle, _, _ = data
49         print("Disconnected", conn_handle)
50         self._connections.remove(conn_handle)
51         # Start advertising again to allow a new connection.
52         self._advertise()
53     elif event == _IRQ_GATTS_WRITE:
54         conn_handle, value_handle = data
55         value = self._ble.gatts_read(value_handle)
56         if value_handle == self._handle_rx and self._write_callback:
57             self._write_callback(value)
58     def send(self, data):
59         for conn_handle in self._connections:
60             self._ble.gatts_notify(conn_handle, self._handle_tx, data)
61     def is_connected(self):
62         return len(self._connections) > 0
63     def _advertise(self, interval_us=500000):
64         print("Starting advertising")
65         self._ble.gap_advertise(interval_us, adv_data=self._payload)
66     def on_write(self, callback):
67         self._write_callback = callback
68     def demo():
69         ble = bluetooth.BLE()
70         p = BLESimplePeripheral(ble)
71         def on_rx(rx_data):
72             print("RX", rx_data)
73         p.on_write(on_rx)
74         print("Please use LightBlue to connect to ESP32S3.")
75         while True:
76             if p.is_connected():
77                 # Short burst of queued notifications.
78                 tx_data = input("Enter anything: ")
79                 print("Send: ", tx_data)
80                 p.send(tx_data)
81             if __name__ == "__main__":
82                 demo()

```

Define the specified UUID number for BLE vendor.

```

18     _UART_UUID = bluetooth.UUID("6E400001-B5A3-F393-E0A9-E50E24DCCA9E")
19     _UART_TX = (
20         bluetooth.UUID("6E400003-B5A3-F393-E0A9-E50E24DCCA9E"),

```

```

21     _FLAG_READ | _FLAG_NOTIFY,
22 )
23 _UART_RX = (
24     bluetooth.UUID("6E400002-B5A3-F393-E0A9-E50E24DCCA9E"),
25     _FLAG_WRITE | _FLAG_WRITE_NO_RESPONSE,
26 )

```

Write an _irq function to manage BLE interrupt events.

```

42     def _irq(self, event, data):
43         # Track connections so we can send notifications.
44         if event == _IRQ_CENTRAL_CONNECT:
45             conn_handle, _, _ = data
46             print("New connection", conn_handle)
47             print("\nThe BLE connection is successful.")
48             self._connections.add(conn_handle)
49         elif event == _IRQ_CENTRAL_DISCONNECT:
50             conn_handle, _, _ = data
51             print("Disconnected", conn_handle)
52             self._connections.remove(conn_handle)
53             # Start advertising again to allow a new connection.
54             self._advertise()
55         elif event == _IRQ_GATTS_WRITE:
56             conn_handle, value_handle = data
57             value = self._ble.gatts_read(value_handle)
58             if value_handle == self._handle_rx and self._write_callback:
59                 self._write_callback(value)

```

Initialize the BLE function and name it.

```

33     def __init__(self, ble, name="ESP32S3"):

```

When the mobile phone send data to ESP32-S3 via BLE Bluetooth, it will print them out with serial port;

When the serial port of ESP32-S3 receive data, it will send them to mobile via BLE Bluetooth.

```

70     def demo():
71         ble = bluetooth.BLE()
72         p = BLESimplePeripheral(ble)
73         def on_rx(rx_data):
74             print("RX", rx_data)
75             p.on_write(on_rx)
76         print("Please use LightBlue to connect to ESP32S3.")
77         while True:
78             if p.is_connected():
79                 # Short burst of queued notifications.
80                 tx_data = input("Enter anything: ")
81                 print("Send: ", tx_data)
82                 p.send(tx_data)
83             lastMsg = now;
84     }

```

Project 12.2 Bluetooth Control LED

In this section, we will control the LED with Bluetooth.

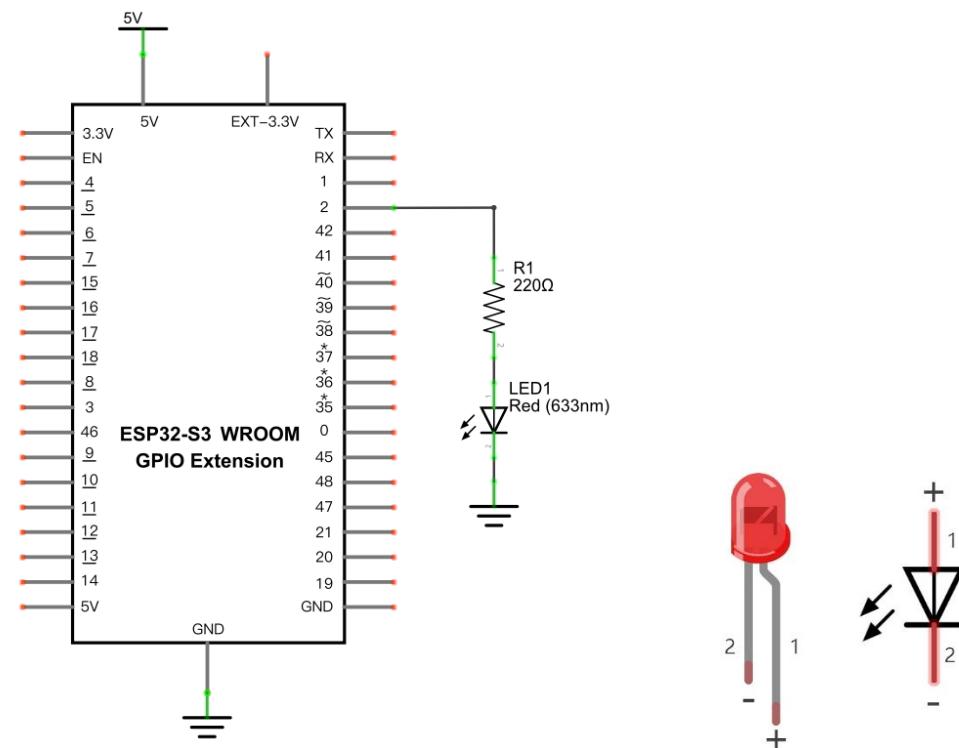
Component List

ESP32-S3 WROOM x1	GPIO Extension Board x1		
Micro USB Wire x1	LED x1	Resistor 220Ω x1	Jumper M/M x2
Breadboard x1			

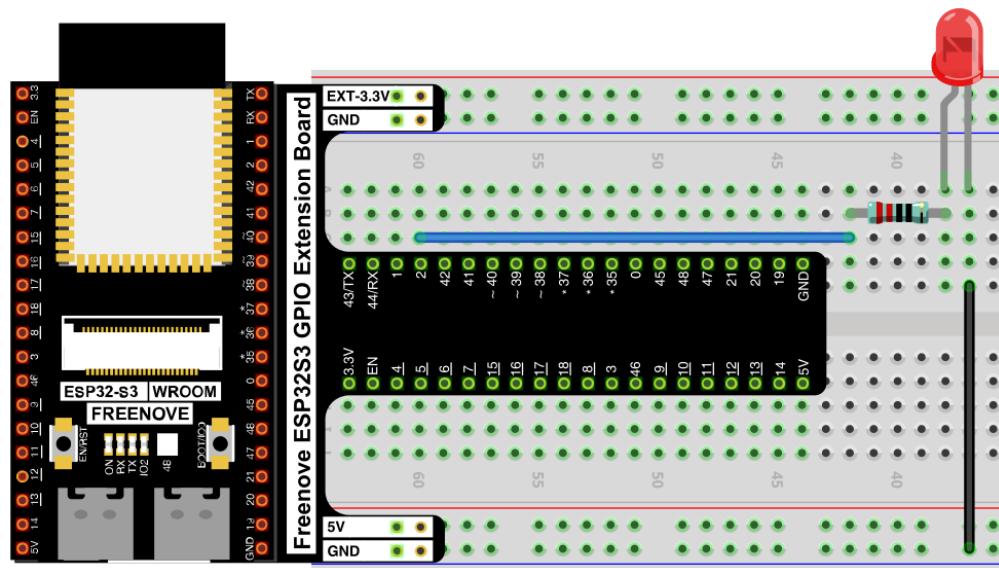
Circuit

Connect Freenove ESP32-S3 to the computer using a USB cable.

Schematic diagram



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



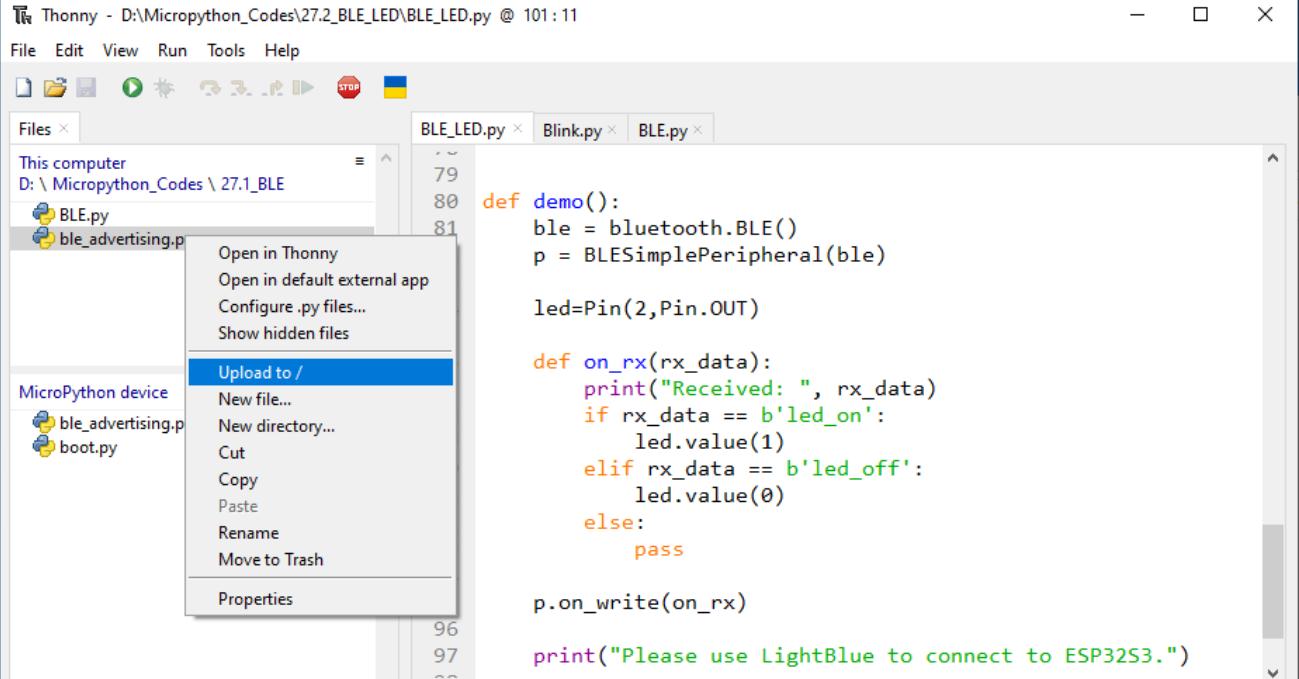
Any concerns? support@freenove.com

Code

Move the program folder “**Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Codes**” to disk(D) in advance with the path of “**D:/Micropython_Codes**”.

Open “Thonny”, click “This computer” → “D:” → “Micropython_Codes” → “12.2_BLE_LED”. Select “ble_advertising.py”, right click your mouse to select “Upload to /”, wait for “ble_advertising.py” to be uploaded to ESP32-S3 and then double click “BLE_LED.py”.

12.2_BLE_LED



```

def demo():
    ble = bluetooth.BLE()
    p = BLESimplePeripheral(ble)

    led=Pin(2,Pin.OUT)

    def on_rx(rx_data):
        print("Received: ", rx_data)
        if rx_data == b'led_on':
            led.value(1)
        elif rx_data == b'led_off':
            led.value(0)
        else:
            pass

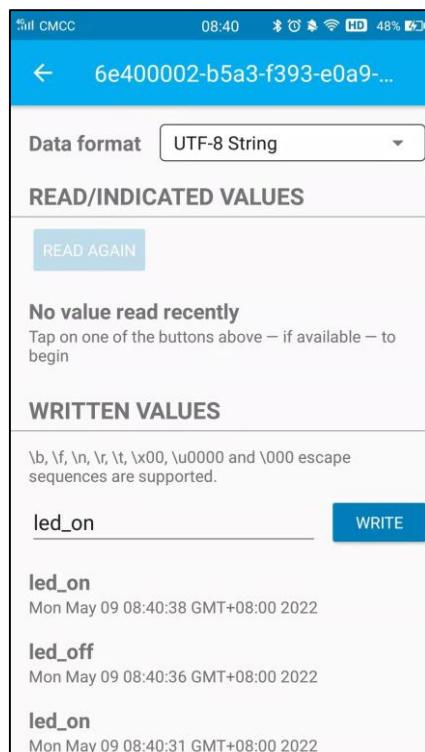
    p.on_write(on_rx)

    print("Please use LightBlue to connect to ESP32S3.")

```

Compile and upload code to ESP32S3. The operation of the APP is the same as 12.1, you only need to change the sending content to "led_on" and "led_off" to operate LEDs on the ESP32S3.

Data sent from mobile APP:



You can check the message sent by Bluetooth in "Shell".

```

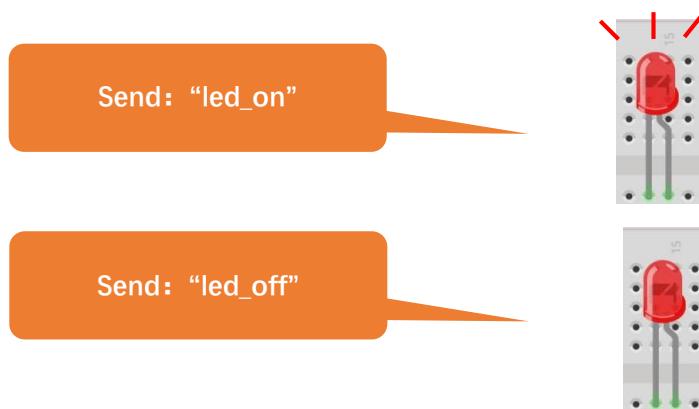
Shell >>> %Run -c $EDITOR_CONTENT
Starting advertising
Please use LightBlue to connect to ESP32S3.

>>> New connection 1
The BLE connection is successful.
Received: b'led_on'
Received: b'led_off'
Received: b'led_on'
Received: b'led_off'
Received: b'led_on'

```

MicroPython (ESP32) • COM24

The phenomenon of LED



Attention: If the sending content isn't "led_on" or "led_off", then the state of LED will not change. If the LED is on, when receiving irrelevant content, it keeps on; Correspondingly, if the LED is off, when receiving irrelevant content, it keeps off.



The following is the program code:

```
1 import bluetooth
2 import random
3 import struct
4 import time
5 from ble_advertising import advertising_payload
6 from machine import Pin
7 from micropython import const
8
9 _IRQ_CENTRAL_CONNECT = const(1)
10 _IRQ_CENTRAL_DISCONNECT = const(2)
11 _IRQ_GATTS_WRITE = const(3)
12
13 _FLAG_READ = const(0x0002)
14 _FLAG_WRITE_NO_RESPONSE = const(0x0004)
15 _FLAG_WRITE = const(0x0008)
16 _FLAG_NOTIFY = const(0x0010)
17
18 _UART_UUID = bluetooth.UUID("6E400001-B5A3-F393-E0A9-E50E24DCCA9E")
19 _UART_TX = (
20     bluetooth.UUID("6E400003-B5A3-F393-E0A9-E50E24DCCA9E"),
21     _FLAG_READ | _FLAG_NOTIFY,
22 )
23 _UART_RX = (
24     bluetooth.UUID("6E400002-B5A3-F393-E0A9-E50E24DCCA9E"),
25     _FLAG_WRITE | _FLAG_WRITE_NO_RESPONSE,
26 )
27 _UART_SERVICE = (
28     _UART_UUID,
29     (_UART_TX, _UART_RX),
30 )
31 class BLESimplePeripheral:
32     def __init__(self, ble, name="ESP32S3"):
33         self._ble = ble
34         self._ble.active(True)
35         self._ble.irq(self._irq)
36         ((self._handle_tx, self._handle_rx),) =
37         self._ble.gatts_register_services((_UART_SERVICE,))
38         self._connections = set()
39         self._write_callback = None
40         self._payload = advertising_payload(name=name, services=[_UART_UUID])
41         self._advertise()
42     def _irq(self, event, data):
```

```
43     # Track connections so we can send notifications.
44     if event == _IRQ_CENTRAL_CONNECT:
45         conn_handle, _, _ = data
46         print("New connection", conn_handle)
47         print("\nThe BLE connection is successful.")
48         self._connections.add(conn_handle)
49     elif event == _IRQ_CENTRAL_DISCONNECT:
50         conn_handle, _, _ = data
51         print("Disconnected", conn_handle)
52         self._connections.remove(conn_handle)
53         # Start advertising again to allow a new connection.
54         self._advertise()
55     elif event == _IRQ_GATTS_WRITE:
56         conn_handle, value_handle = data
57         value = self._ble.gatts_read(value_handle)
58         if value_handle == self._handle_rx and self._write_callback:
59             self._write_callback(value)
60     def send(self, data):
61         for conn_handle in self._connections:
62             self._ble.gatts_notify(conn_handle, self._handle_tx, data)
63     def is_connected(self):
64         return len(self._connections) > 0
65     def _advertise(self, interval_us=500000):
66         print("Starting advertising")
67         self._ble.gap_advertise(interval_us, adv_data=self._payload)
68     def on_write(self, callback):
69         self._write_callback = callback
70     def demo():
71         ble = bluetooth.BLE()
72         p = BLESimplePeripheral(ble)
73         led=Pin(2, Pin.OUT)
74         def on_rx(rx_data):
75             print("Received: ", rx_data)
76             if rx_data == b'led_on':
77                 led.value(1)
78             elif rx_data == b'led_off':
79                 led.value(0)
80             else:
81                 pass
82         p.on_write(on_rx)
83         print("Please use LightBlue to connect to ESP32S3.")
84     if __name__ == "__main__":
85         demo()
```



Compare received message with "led_on" and "led_off" and take action accordingly.

```
76     if rx_data == b'led_on':  
77         led.value(1)  
78     elif rx_data == b'led_off':  
79         led.value(0)
```

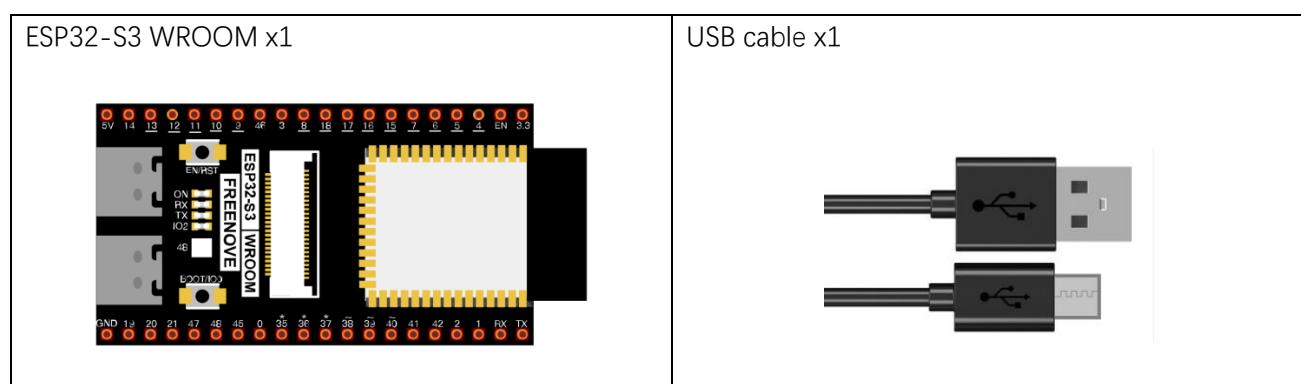
Chapter 13 WiFi Working Modes

In this chapter, we'll focus on the WiFi infrastructure for ESP32-S3 WROOM.

ESP32-S3 WROOM has 3 different WiFi operating modes: station mode, AP mode and AP+station mode. All WiFi programming projects must be configured with WiFi operating mode before using WiFi, otherwise WiFi cannot be used.

Project 13.1 Station mode

Component List



Component knowledge

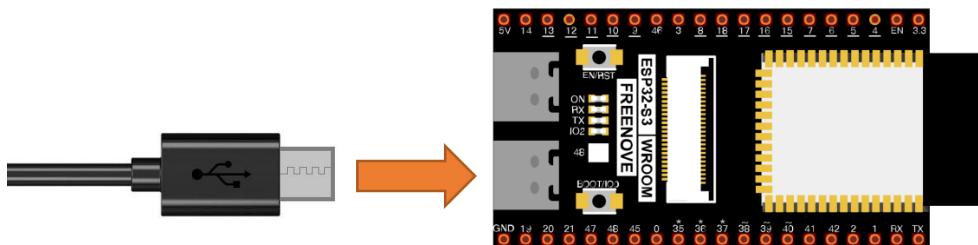
Station mode

When ESP32-S3 selects Station mode, it acts as a WiFi client. It can connect to the router network and communicate with other devices on the router via WiFi connection. As shown below, the PC is connected to the router, and if ESP32-S3 wants to communicate with the PC, it needs to be connected to the router.



Circuit

Connect Freenove ESP32-S3 to the computer using the USB cable.



Code

Move the program folder “**Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Codes**” to disk(D) in advance with the path of “**D:/Micropython_Codes**”.

Open “Thonny”, click “This computer” → “D:” → “Micropython_Codes” → “13.1_Station_mode” and double click “Station_mode.py”.

13.1_Station_mode

```
Thonny - D:\Micropython_Codes\28.1_Station_mode\Station_mode.py @ 5:27
File Edit View Run Tools Help
This computer D:\ Micropython_Codes \ 28.1_Station_mode
Station_mode.py
1.py x Station_mode.py * x
1 import time
2 import network
3
4 ssidRouter      = '*****' #Enter the router name
5 passwordRouter = '*****' #Enter the router password
6
7 def STA_Setup(ssidRouter,passwordRouter):
8     print("Setup start")
9     sta_if = network.WLAN(network.STA_IF)
10    if not sta_if.isconnected():
11        print('connecting to',ssidRouter)
12        sta_if.active(True)
13        sta_if.connect(ssidRouter,passwordRouter)
14        while not sta_if.isconnected():
15            pass
16        print('Connected, IP address:', sta_if.ifconfig())
17        print("Setup End")
18
19 try:
20     STA_Setup(ssidRouter,passwordRouter)
21 except:
22     sta_if.disconnect()
Shell x
>>> %Run -c $EDITOR_CONTENT
Setup start
connecting to FYI_2.4G
Connected, IP address: ('192.168.1.129', '255.255.255.0', '192.168.1.1', '192.168.1.1')
Setup End
>>>
MicroPython (ESP32) • COM24
```

Enter the correct Router name and password.

Because the names and passwords of routers in various places are different, before the Code runs, users need to enter the correct router's name and password in the box as shown in the illustration above.

After making sure the router name and password are entered correctly, compile and upload codes to ESP32S3, wait for ESP32-S3 to connect to your router and print the IP address assigned by the router to ESP32-S3 in "Shell".

```
>>> %Run -c $EDITOR_CONTENT
Setup start
connecting to FYI_2.4G
Connected, IP address: ('192.168.1.129', '255.255.255.0', '192.168.1.1', '192.168.1.1')
Setup End
```

The following is the program code:

```
1 import time
2 import network
3
4 ssidRouter      = '*****' #Enter the router name
5 passwordRouter = '*****' #Enter the router password
6
7 def STA_Setup(ssidRouter,passwordRouter):
8     print("Setup start")
9     sta_if = network.WLAN(network.STA_IF)
10    if not sta_if.isconnected():
11        print(' connecting to',ssidRouter)
12        sta_if.active(True)
13        sta_if.connect(ssidRouter,passwordRouter)
14        while not sta_if.isconnected():
15            pass
16        print(' Connected, IP address:', sta_if.ifconfig())
17        print("Setup End")
18
19 try:
20     STA_Setup(ssidRouter,passwordRouter)
21 except:
22     sta_if.disconnect()
```

Import network module.

```
2 import network
```

Enter correct router name and password.

```
3 const char *ssid_Router      = "*****"; //Enter the router name
4 const char *password_Router = "*****"; //Enter the router password
```

Set ESP32-S3 in Station mode.

```
9 sta_if = network.WLAN(network.STA_IF)
```

Activate ESP32-S3's Station mode, initiate a connection request to the router and enter the password to connect.

```
12 sta_if.active(True)
13 sta_if.connect(ssidRouter,passwordRouter)
```

Wait for ESP32-S3 to connect to router until they connect to each other successfully.

```
14     while not sta_if.isconnected():
15         pass
```

Print the IP address assigned to ESP32-S3 in “Shell”.

```
16     print('Connected, IP address:', sta_if.ifconfig())
```

Reference

Class network

Before each use of **network**, please add the statement “**import network**” to the top of the python file.

WLAN(interface_id): Set to WiFi mode.

network.STA_IF: Client, connecting to other WiFi access points.

network.AP_IF: Access points, allowing other WiFi clients to connect.

active(is_active): With parameters, it is to check whether to activate the network interface; Without parameters, it is to query the current state of the network interface.

scan(ssid, bssid, channel, RSSI, authmode, hidden): Scan for wireless networks available nearby (only scan on STA interface), return a tuple list of information about the WiFi access point.

bssid: The hardware address of the access point, returned in binary form as a byte object. You can use `ubinascii.hexlify()` to convert it to ASCII format.

authmode: Access type

```
AUTH_OPEN = 0
AUTH_WEP = 1
AUTH_WPA_PSK = 2
AUTH_WPA2_PSK = 3
AUTH_WPA_WPA2_PSK = 4
AUTH_MAX = 6
```

Hidden: Whether to scan for hidden access points

False: Only scanning for visible access points

True: Scanning for all access points including the hidden ones.

isconnected(): Check whether ESP32-S3 is connected to AP in Station mode. In STA mode, it returns True if it is connected to a WiFi access point and has a valid IP address; Otherwise it returns False.

connect(ssid, password): Connecting to wireless network.

ssid: WiFi name

password: WiFi password

disconnect(): Disconnect from the currently connected wireless network.



Project 13.2 AP mode

Component List & Circuit

Component List & Circuit are the same as in Project 13.1.

Component knowledge

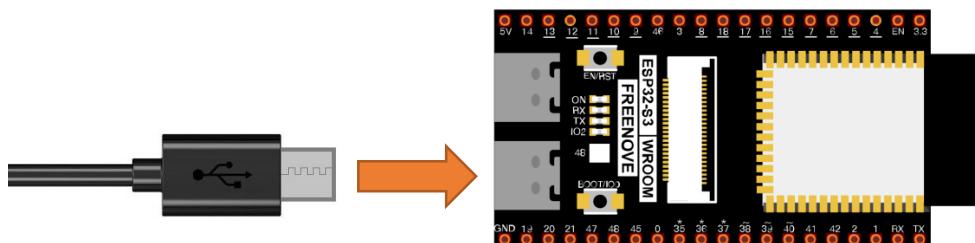
AP mode

When ESP32-S3 selects AP mode, it creates a hotspot network that is separate from the Internet and waits for other WiFi devices to connect. As shown in the figure below, ESP32-S3 is used as a hotspot. If a mobile phone or PC wants to communicate with ESP32S3, it must be connected to the hotspot of ESP32S3. Only after a connection is established with ESP32-S3 can they communicate.



Circuit

Connect Freenove ESP32-S3 to the computer using the USB cable.



Any concerns? [✉ support@freenove.com](mailto:support@freenove.com)

Code

Move the program folder “**Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Codes**” to disk(D) in advance with the path of “**D:/Micropython_Codes**”.

Open “Thonny”, click “This computer” → “D:” → “Micropython_Codes” → “13.2_AP_mode”. and double click “AP_mode.py”.

13.2_AP_mode

```

Thonny - D:\Micropython_Codes\28.2_AP_mode\AP_mode.py @ 35:5
File Edit View Run Tools Help
AP_mode.py x
1 import network
2
3 ssidAP      = 'WiFi_Name' #Enter the router name
4 passwordAP   = '12345678' #Enter the router password
5
6 local_IP     = '192.168.1.10'
7 gateway      = '192.168.1.1'
8 subnet       = '255.255.255.0'
9 dns          = '8.8.8.8'
10
11 ap_if = network.WLAN(network.AP_IF)
12
13 def AP_Setup(ssidAP,passwordAP):
14     ap_if.ifconfig([local_IP,gateway,subnet,dns])
15     print("Setting soft-AP ... ")
16     ap_if.config(essid=ssidAP,authmode=network.AUTH_WPA_WPA2_PSK)
17     ap_if.active(True)
18     print('Success, IP address:', ap_if.ifconfig())
19     print("Setup End\n")
20
21 try:
22     AP_Setup(ssidAP,passwordAP)
    
```

Set a name and a password for ESP32S3 AP.

Shell x

```

>>> %Run -c $EDITOR_CONTENT
Setting soft-AP ...
Success, IP address: ('192.168.1.10', '192.168.1.1', '255.255.255.0', '8.8.8.8')
Setup End
    
```

MicroPython (ESP32) • COM24

Before the Code runs, you can make any changes to the AP name and password for ESP32-S3 in the box as shown in the illustration above. Of course, you can leave it alone by default.

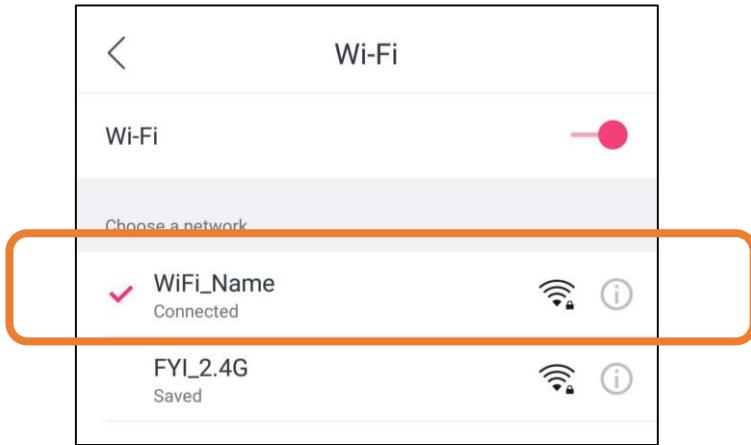
Click “Run current script”, open the AP function of ESP32-S3 and print the access point information.

```

Shell x
>>> %Run -c $EDITOR_CONTENT
Setting soft-AP ...
Success, IP address: ('192.168.1.10', '192.168.1.1', '255.255.255.0', '8.8.8.8')
Setup End
    
```

MicroPython (ESP32) • COM24

Turn on the WiFi scanning function of your phone, and you can see the ssid_AP on ESP32S3, which is called "WiFi_Name" in this Code. You can enter the password "12345678" to connect it or change its AP name and password by modifying Code.



The following is the program code:

```

1 import network
2
3 ssidAP      = 'WiFi_Name' #Enter the router name
4 passwordAP  = '12345678' #Enter the router password
5
6 local_IP    = '192.168.1.10'
7 gateway     = '192.168.1.1'
8 subnet      = '255.255.255.0'
9 dns         = '8.8.8.8'
10
11 ap_if = network.WLAN(network.AP_IF)
12
13 def AP_Setup(ssidAP, passwordAP):
14     ap_if.ifconfig([local_IP, gateway, subnet, dns])
15     print("Setting soft-AP ... ")
16     ap_if.config(essid=ssidAP, authmode=network.AUTH_WPA_WPA2_PSK, password=passwordAP)
17     ap_if.active(True)
18     print(' Success, IP address:', ap_if.ifconfig())
19     print("Setup End\n")
20
21 try:
22     AP_Setup(ssidAP, passwordAP)
23 except:
24     ap_if.disconnect()

```

Import network module.

1	import network
---	----------------

Enter correct AP name and password.

```
3 ssidAP      = 'WiFi_Name' #Enter the router name
4 passwordAP = '12345678' #Enter the router password
```

Set ESP32-S3 in AP mode.

```
11 ap_if = network.WLAN(network.AP_IF)
```

Configure IP address, gateway and subnet mask for ESP32S3.

```
14 ap_if.ifconfig([local_IP, gateway, subnet, dns])
```

Turn on an AP in ESP32S3, whose name is set by ssid_AP and password is set by password_AP.

```
16 ap_if.config(essid=ssidAP, authmode=network.AUTH_WPA_WPA2_PSK, password=passwordAP)
17 ap_if.active(True)
```

If the program is running abnormally, the AP disconnection function will be called.

```
14 ap_if.disconnect()
```

Reference

Class network

Before each use of **network**, please add the statement “**import network**” to the top of the python file.

WLAN(interface_id): Set to WiFi mode.

network.STA_IF: Client, connecting to other WiFi access points

network.AP_IF: Access points, allowing other WiFi clients to connect

active(is_active): With parameters, it is to check whether to activate the network interface; Without parameters, it is to query the current state of the network interface

isconnected(): In AP mode, it returns True if it is connected to the station; otherwise it returns False.

connect(ssid, password): Connecting to wireless network

ssid: WiFi name

password: WiFi password

config(essid, channel): To obtain the MAC address of the access point or to set the WiFi channel and the name of the WiFi access point.

ssid: WiFi account name

channel: WiFi channel

ifconfig([(ip, subnet, gateway, dns)]): Without parameters, it returns a 4-tuple (ip, subnet_mask, gateway, DNS_server); With parameters, it configures static IP.

ip: IP address

subnet_mask: subnet mask

gateway: gateway

DNS_server: DNS server

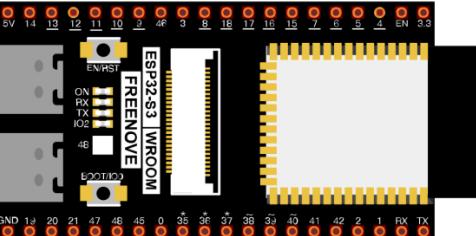
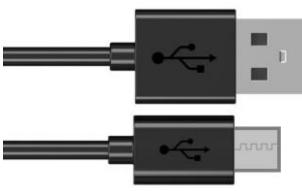
disconnect(): Disconnect from the currently connected wireless network

status(): Return the current status of the wireless connection



Project 13.3 AP+Station mode

Component List

ESP32-S3 WROOM x1	USB cable x1
 A detailed pinout diagram of the ESP32-S3 WROOM module. It shows a 40-pin DIP package with various pins labeled: 5V, 14, 13, 12, 11, 10, 9, 4F, 3, 8, 16, 17, 16, 15, 15, 7, 6, 5, 4, EN, 3.3. On the left side, there are several pins grouped together: GND, 1d, 20, 21, 47, 48, 45, 0, 35, 36, 37, 38, 3d, 40, 41, 42, 2, 1, RX, TX, IO2, 4B, and CHG/INT. A yellow ribbon cable is attached to the right side of the module.	 A diagram showing two USB cables. One is a standard A-to-A cable, and the other is a shorter cable with an A connector on one end and a smaller micro-B or similar connector on the other.

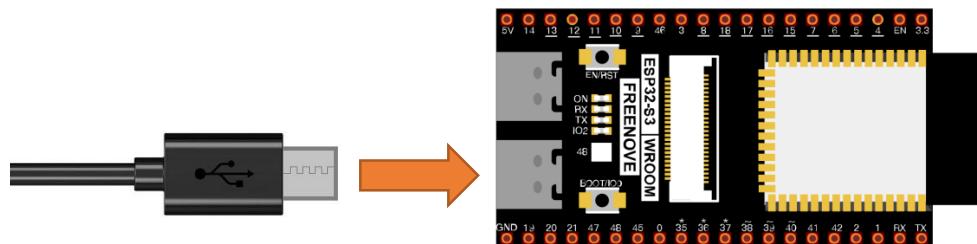
Component knowledge

AP+Station mode

In addition to AP mode and station mode, ESP32-S3 can also use AP mode and station mode at the same time. This mode contains the functions of the previous two modes. Turn on ESP32S3's station mode, connect it to the router network, and it can communicate with the Internet via the router. At the same time, turn on its AP mode to create a hotspot network. Other WiFi devices can choose to connect to the router network or the hotspot network to communicate with ESP32S3.

Circuit

Connect Freenove ESP32-S3 to the computer using the USB cable.



Code

Move the program folder “**Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Codes**” to disk(D) in advance with the path of “**D:/Micropython_Codes**”.

Open “Thonny”, click “This computer” → “D:” → “Micropython_Codes” → “13.3_AP+STA_mode” and double click “AP+STA_mode.py”.

13.3_AP+STA_mode

```

1 import network
2
3 ssidRouter      = '*****' #Enter the router name
4 passwordRouter = '*****' #Enter the router password
5
6 ssidAP          = 'WiFi_Name'#Enter the AP name
7 passwordAP      = '12345678' #Enter the AP password
8
9 local_IP        = '192.168.4.150'
10 gateway         = '192.168.4.1'
11 subnet          = '255.255.255.0'
12 dns             = '8.8.8.8'
13
14 sta_if = network.WLAN(network.STA_IF)
15 ap_if = network.WLAN(network.AP_IF)
16
17 def STA_Setup(ssidRouter,passwordRouter):
18     print("Setting soft-STA ... ")
19     if not sta_if.isconnected():
20         print('connecting to',ssidRouter)
21         sta_if.active(True)
22         sta_if.connect(ssidRouter,passwordRouter)

```

It is analogous to Project 13.1 and Project 13.2. Before running the Code, you need to modify ssidRouter, passwordRouter, ssidAP and passwordAP shown in the box of the illustration above.

After making sure that the code is modified correctly, click “Run current script” and the “Shell” will display as follows:

Any concerns? ✉ support@freenove.com



```

Shell x
>>> %Run -c $EDITOR_CONTENT
Setting soft-AP ...
Success, IP address: ('192.168.4.150', '192.168.4.1', '255.255.255.0', '8.8.8.8')
Setup End

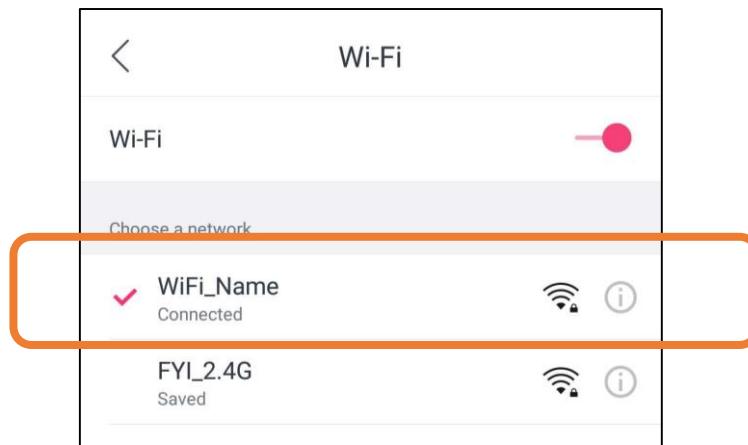
Setting soft-STA ...
connecting to FYI_2.4G
Connected, IP address: ('192.168.1.129', '255.255.255.0', '192.168.1.1', '192.168.1.1')
Setup End

>>>

```

MicroPython (ESP32) • COM24

Turn on the WiFi scanning function of your phone, and you can see the ssidAP on ESP32-S3.



The following is the program code:

```

1 import network
2
3 ssidRouter      = '*****' #Enter the router name
4 passwordRouter = '*****' #Enter the router password
5
6 ssidAP          = 'WiFi_Name'#Enter the AP name
7 passwordAP      = '12345678' #Enter the AP password
8
9 local_IP        = '192.168.4.150'
10 gateway         = '192.168.4.1'
11 subnet          = '255.255.255.0'
12 dns             = '8.8.8.8'
13
14 sta_if = network.WLAN(network.STA_IF)
15 ap_if = network.WLAN(network.AP_IF)
16
17 def STA_Setup(ssidRouter, passwordRouter):
18     print("Setting soft-STA ... ")

```

```
19     if not sta_if.isconnected():
20         print('connecting to',ssidRouter)
21         sta_if.active(True)
22         sta_if.connect(ssidRouter, passwordRouter)
23         while not sta_if.isconnected():
24             pass
25         print('Connected, IP address:', sta_if.ifconfig())
26         print("Setup End")
27
28 def AP_Setup(ssidAP, passwordAP):
29     ap_if.ifconfig([local_IP, gateway, subnet, dns])
30     print("Setting soft-AP ... ")
31     ap_if.config(essid=ssidAP, authmode=network.AUTH_WPA_WPA2_PSK, password=passwordAP)
32     ap_if.active(True)
33     print(' Success, IP address:', ap_if.ifconfig())
34     print("Setup End\n")
35
36 try:
37     AP_Setup(ssidAP, passwordAP)
38     STA_Setup(ssidRouter, passwordRouter)
39 except:
40     sta_if.disconnect()
41     ap_if.disconnect()
```

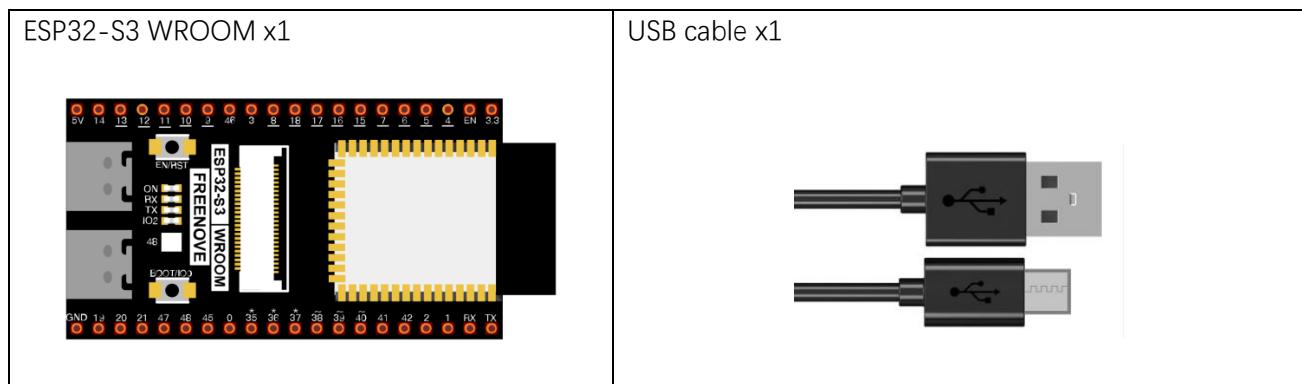
Chapter 14 TCP/IP

In this chapter, we will introduce how ESP32-S3 implements network communications based on TCP/IP protocol. There are two roles in TCP/IP communication, namely Server and Client, which will be implemented respectively with two projects in this chapter.

Project 14.1 As Client

In this section, ESP32-S3 is used as Client to connect Server on the same LAN and communicate with it.

Component List



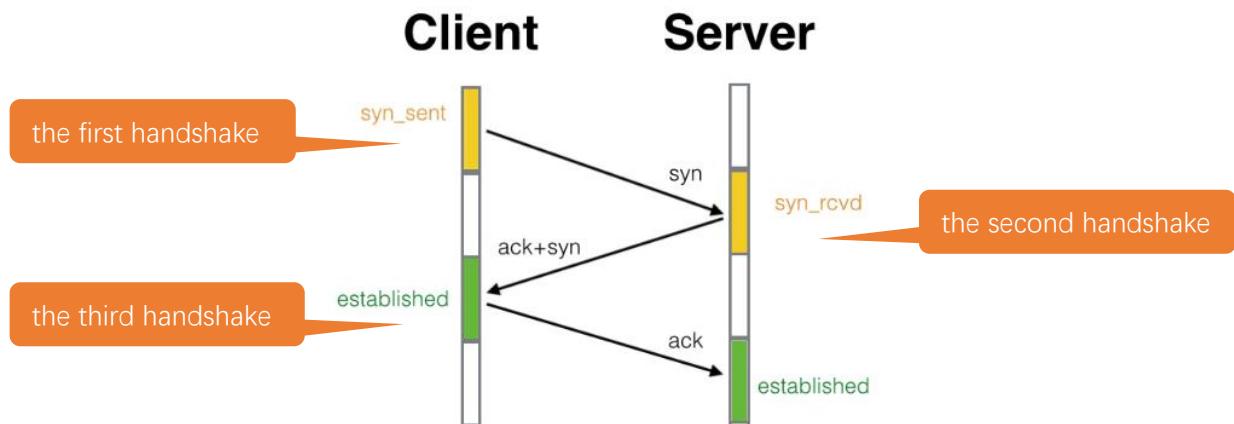
Component knowledge

TCP connection

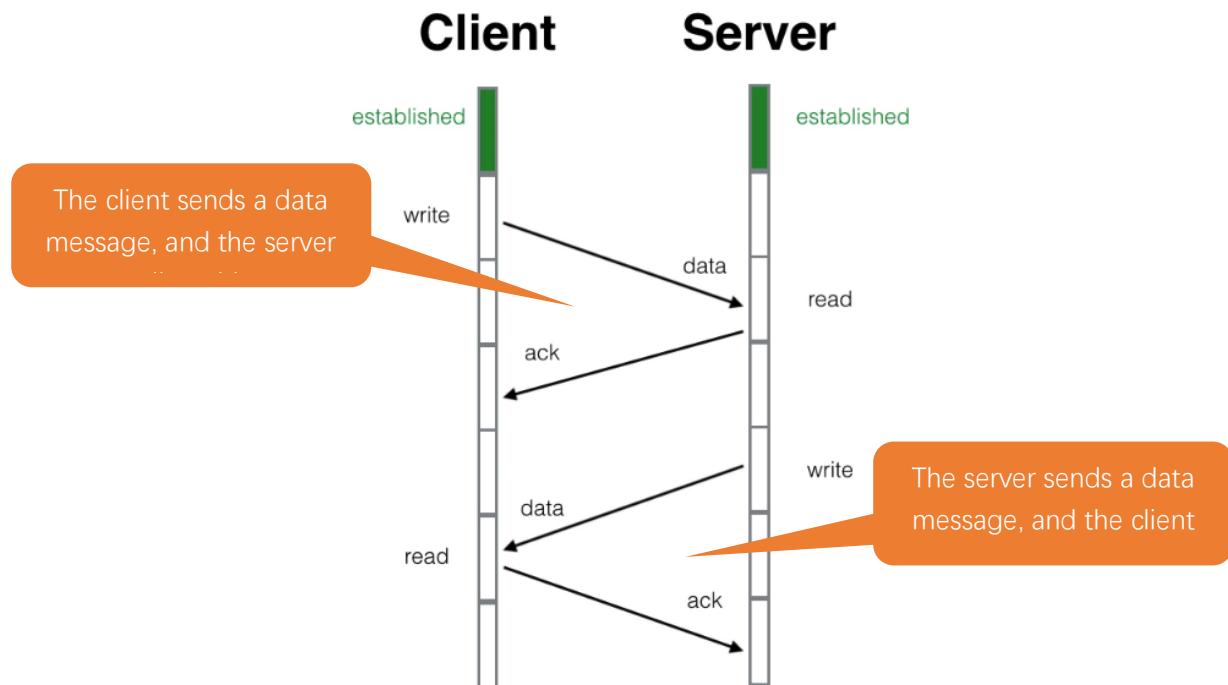
Before transmitting data, TCP needs to establish a logical connection between the sending end and the receiving end. It provides reliable and error-free data transmission between the two computers. In the TCP connection, the client and the server must be clarified. The client sends a connection request to the server, and each time such a request is proposed, a "three-times handshake" is required.

Three-times handshake: In the TCP protocol, during the preparation phase of sending data, the client and the server interact three times to ensure the reliability of the connection, which is called "three-times handshake". The first handshake, the client sends a connection request to the server and waits for the server to confirm. The second handshake, the server sends a response back to the client informing that it has received the connection request.

The third handshake, the client sends a confirmation message to the server again to confirm the connection.



TCP is a connection-oriented, low-level transmission control protocol. After TCP establishes a connection, the client and server can send and receive messages to each other, and the connection will always exist as long as the client or server does not initiate disconnection. Each time one party sends a message, the other party will reply with an ack signal.





Install Processing

In this tutorial, we use Processing to build a simple TCP/IP communication platform.

If you've not installed Processing, you can download it by clicking <https://processing.org/download/>. You can choose an appropriate version to download according to your PC system.

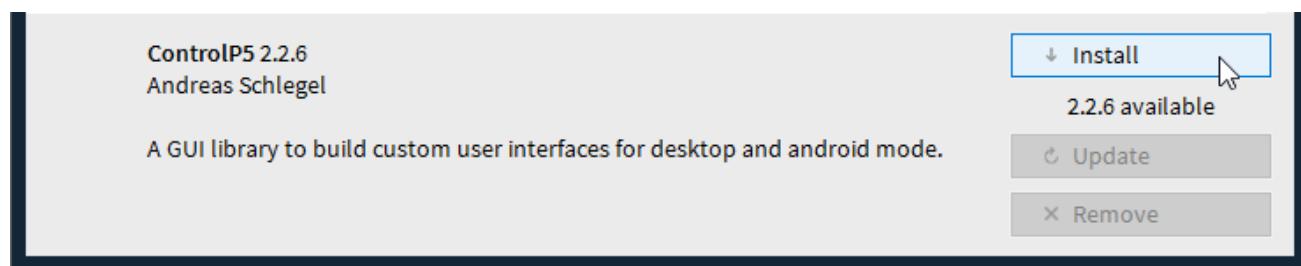
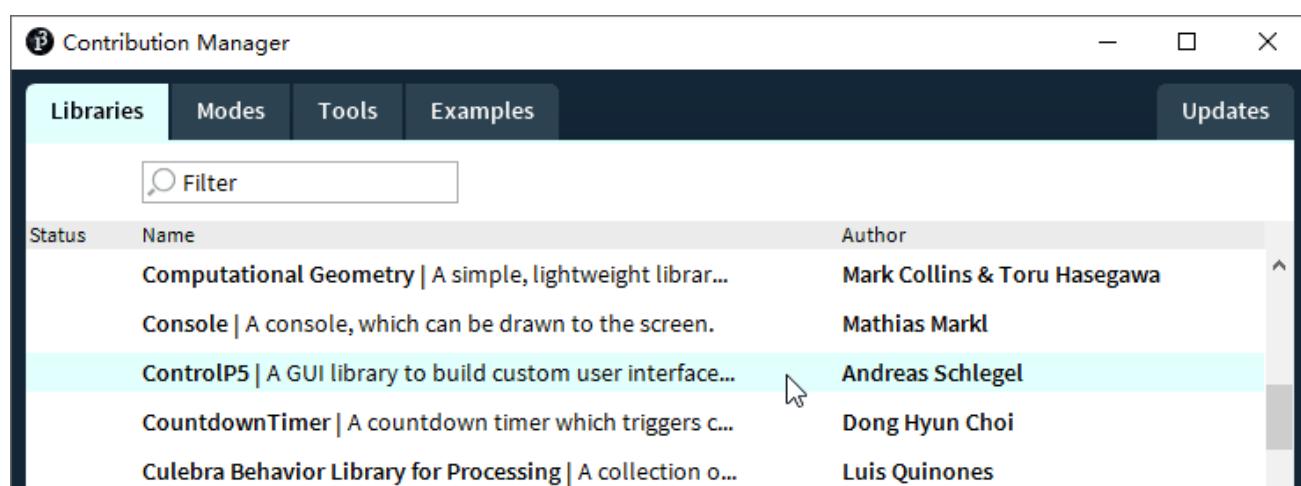
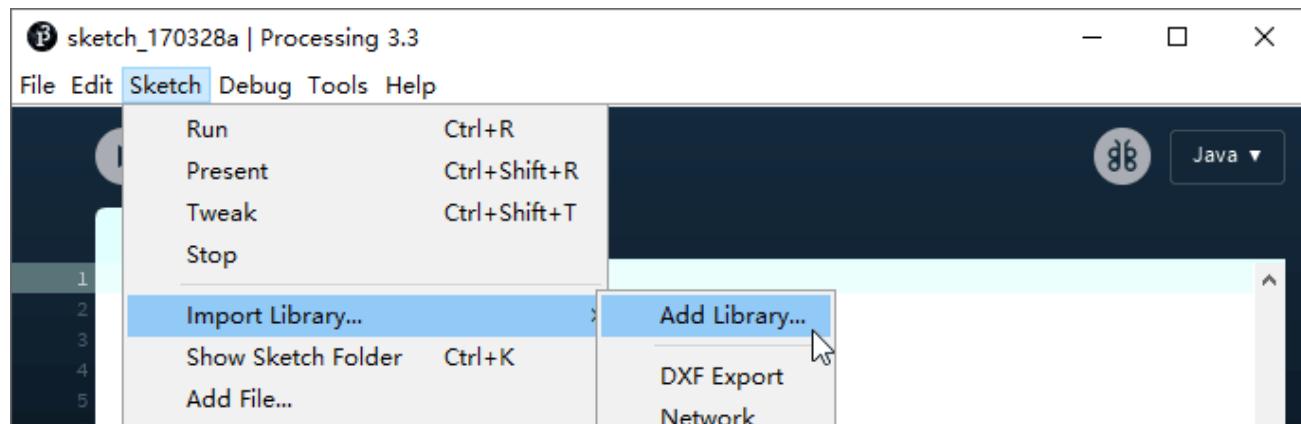
The screenshot shows the official Processing website's download section. At the top, there's a navigation bar with links for "Processing", "p5.js", "Processing.py", "Processing for Android", "Processing for Pi", and "Processing Foundation". Below the navigation is a large "Processing" logo with a geometric background. To the right is a search bar. On the left, there's a sidebar with links: "Cover", "Download", "Donate", "Exhibition", "Reference", "Libraries", "Tools", "Environment", "Tutorials", "Examples", "Books", "Overview", and "People". The main content area is titled "Download Processing". It states: "Processing is available for Linux, Mac OS X, and Windows. Select your choice to download the software below." It shows the release "3.5.4 (17 January 2020)". Below this, there are download links for "Windows 64-bit", "Windows 32-bit", "Linux 64-bit", and "Mac OS X".

Unzip the downloaded file to your computer. Click "processing.exe" as the figure below to run this software.

	core	2020/1/17 12:16
	java	2020/1/17 12:17
	lib	2020/1/17 12:16
	modes	2020/1/17 12:16
	tools	2020/1/17 12:16
	processing.exe	2020/1/17 12:16
	processing-java.exe	2020/1/17 12:16
	revisions.txt	2020/1/17 12:16

Use Server mode for communication

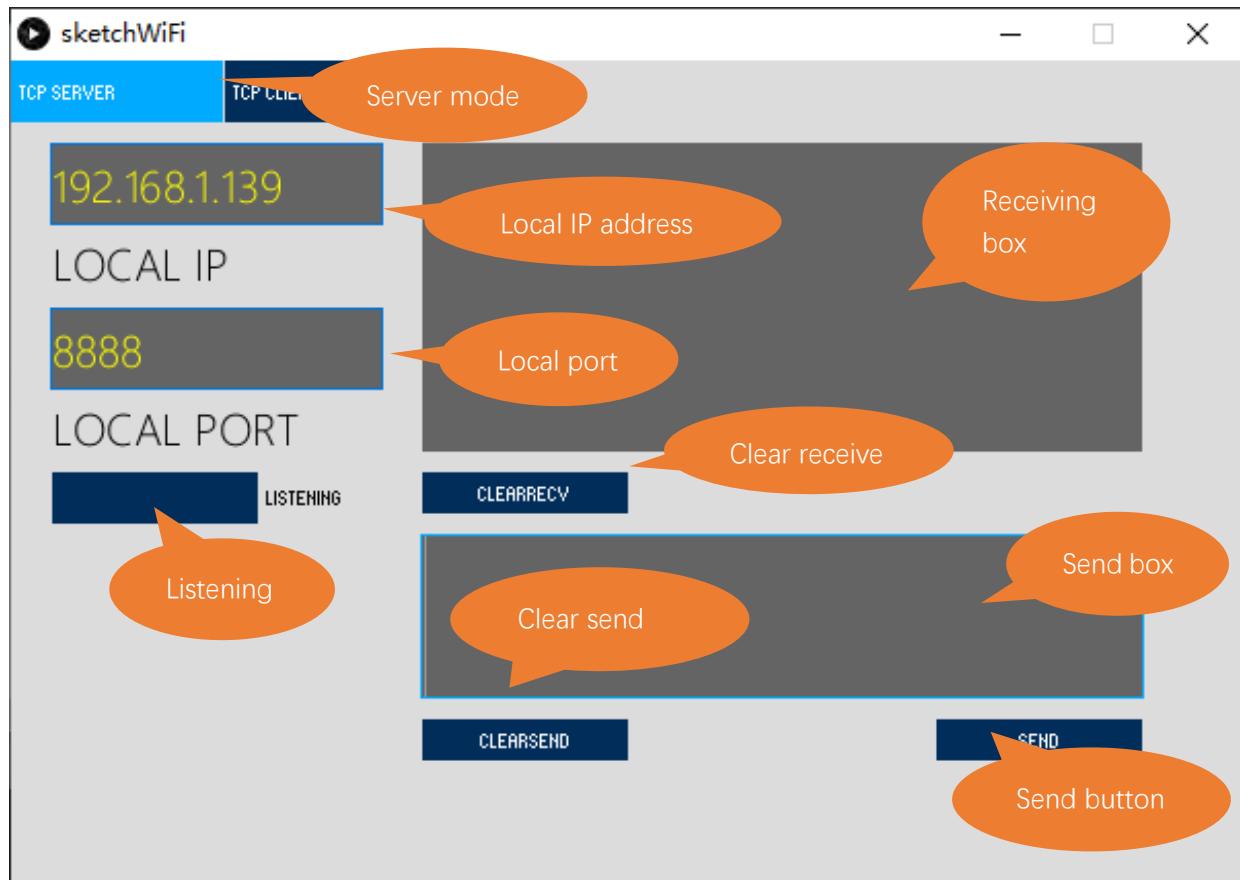
Install ControlP5.



Open the “**Freenove_Basic_Starter_Kit_for_ESP32_S3\Sketches\Sketches\Sketch_13.1_WiFiClient\sketchWiFi\sketchWiFi.pde**”, and click “Run”.

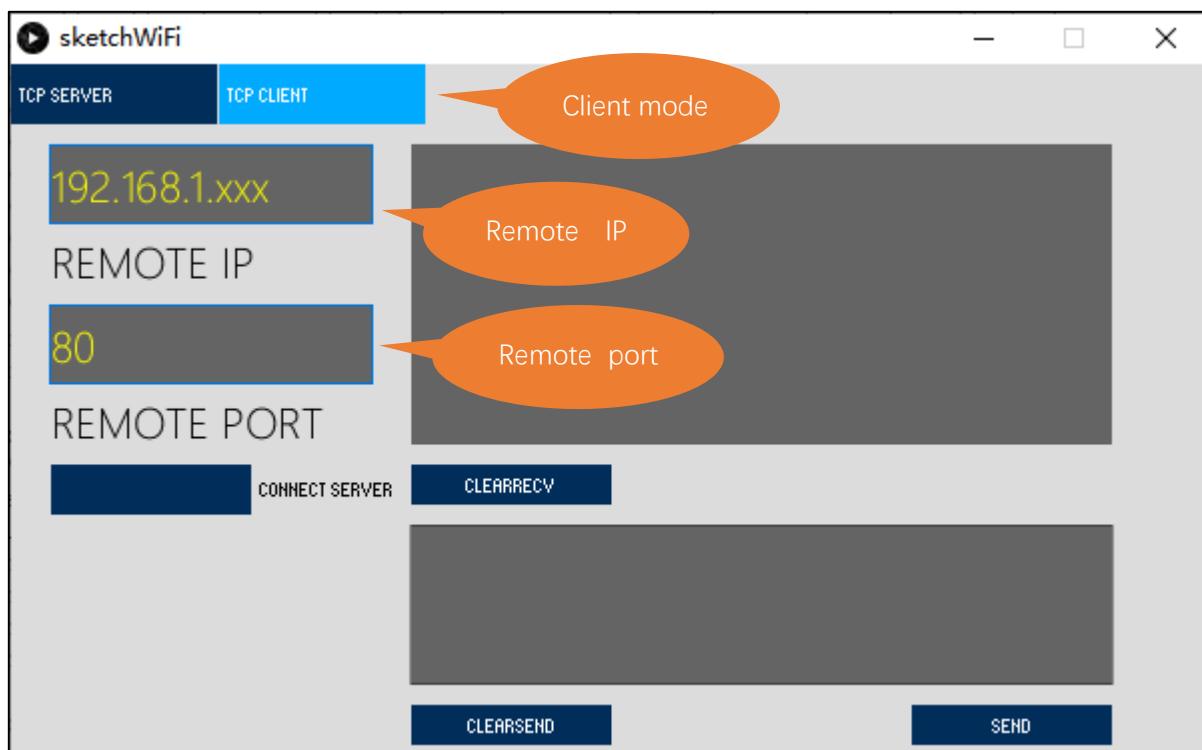


The new pop-up interface is as follows. If ESP32-S3 is used as client, select TCP SERVER mode for sketchWiFi.



When sketchWiFi selects TCP SERVER mode, ESP32-S3 Sketch needs to be changed according to sketchWiFi's displaying of LOCAL IP or LOCAL PORT.

If ESP32-S3 serves as server, select TCP CLIENT mode for sketchWiFi.



When sketchWiFi selects TCP CLIENT mode, the LOCAL IP and LOCAL PORT of sketchWiFi need to be changed according to the IP address and port number printed by the serial monitor.

Mode selection: select **Server mode/Client mode**.

IP address: In server mode, this option does not need to be filled in, and the computer will automatically obtain the IP address.

In client mode, fill in the remote IP address to be connected.

Port number: In server mode, fill in a port number for client devices to make an access connection.

In client mode, fill in port number given by the Server devices to make an access connection.

Start button: In server mode, push the button, then the computer will serve as server and open a port number for client to make access connection. During this period, the computer will keep monitoring.

In client mode, before pushing the button, please make sure the server is on, remote IP address and remote port number is correct; push the button, and the computer will make access connection to the remote port number of the remote IP as a client.

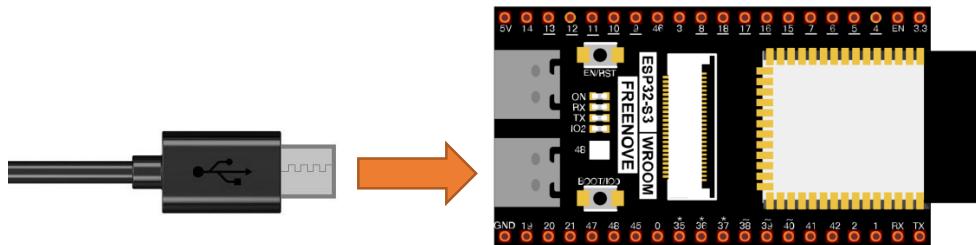
clear receive: clear out the content in the receiving text box

clear send: clear out the content in the sending text box

Sending button: push the sending button, the computer will send the content in the text box to others.

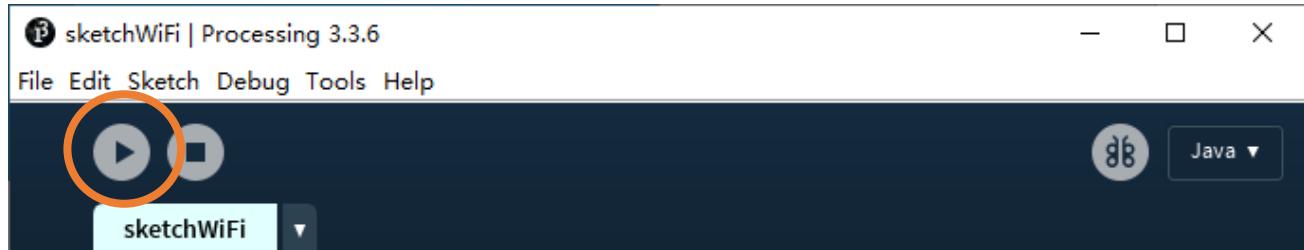
Circuit

Connect Freenove ESP32-S3 to the computer using the USB cable.

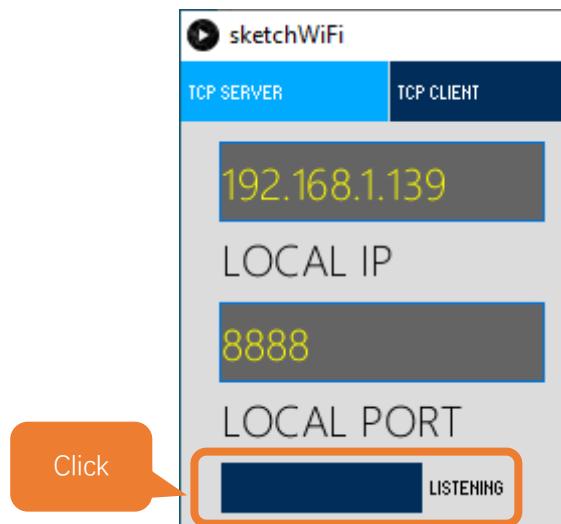


Code

Before running the Code, please open “sketchWiFi.pde.” first, and click “Run”.



The newly pop up window will use the computer's IP address by default and open a data monitor port. Click “Listening”.

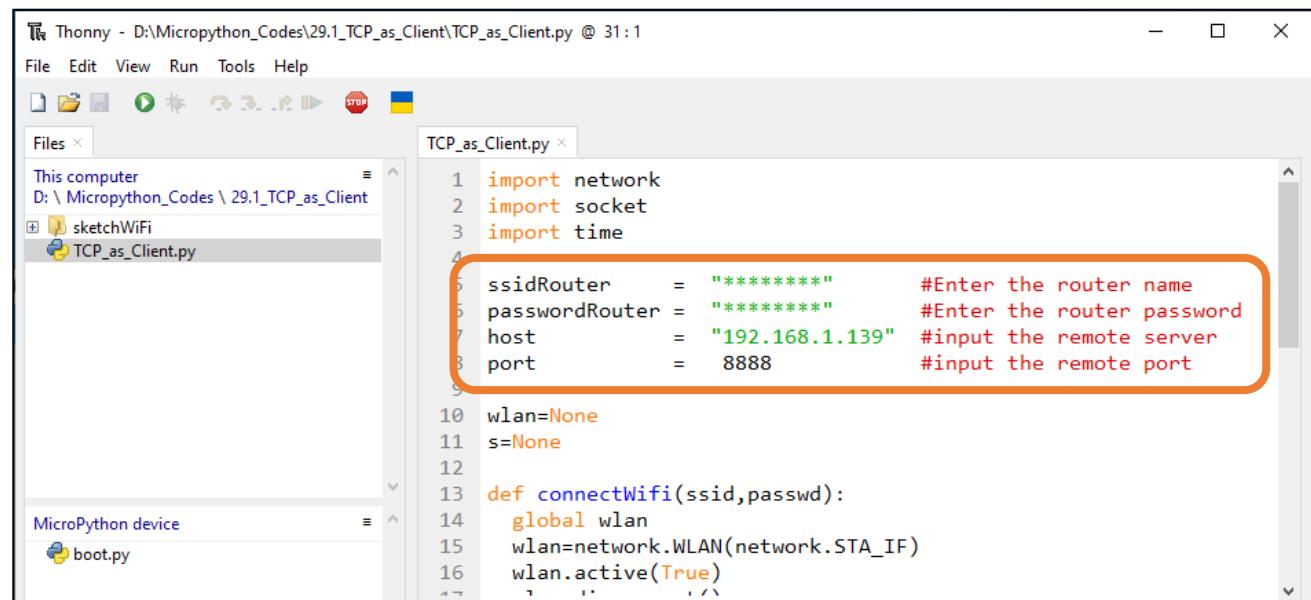


Move the program folder “**Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Codes**” to disk(D) in advance with the path of “**D:/Micropython_Codes**”.

Open “Thonny”, click “This computer” → “D:” → “Micropython_Codes” → “14.1_TCP_as_Client” and double click “TCP_as_Client.py”.

Before clicking “Run current script”, please modify the name and password of your router and fill in the “host” and “port” according to the IP information shown in the box below:

14.1_TCP_as_Client



```
1 import network
2 import socket
3 import time
4
5 ssidRouter      = "*****"          #Enter the router name
6 passwordRouter = "*****"          #Enter the router password
7 host            = "192.168.1.139"    #input the remote server
8 port            = 8888             #input the remote port
9
10 wlan=None
11 s=None
12
13 def connectWifi(ssid,passwd):
14     global wlan
15     wlan=network.WLAN(network.STA_IF)
16     wlan.active(True)
```

Click “Run current script” and in “Shell”, you can see ESP32-S3 automatically connects to sketchWiFi.

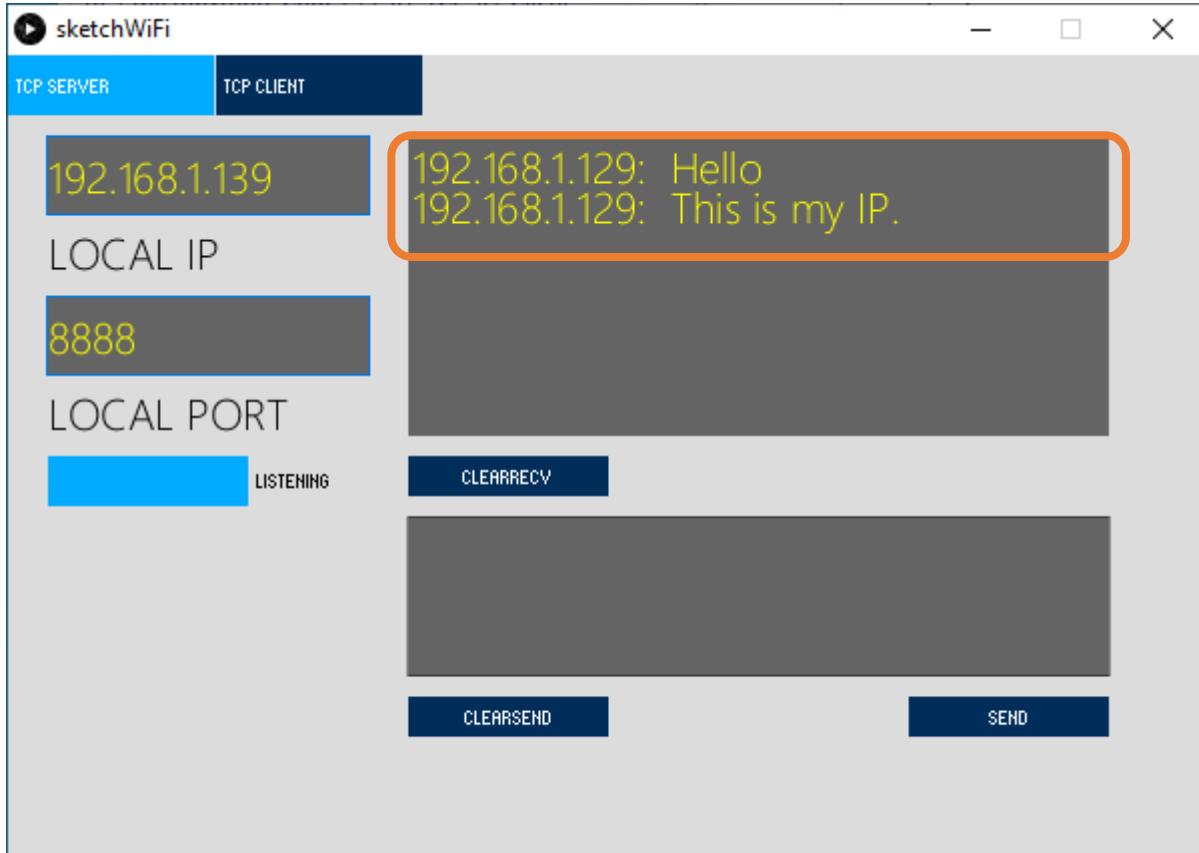


```
Shell < 
>>> %Run -c $EDITOR_CONTENT
TCP Connected to: 192.168.1.139 : 8888
```

If you don't click "Listening" for sketchWiFi, ESP32-S3 will fail to connect and will print information as follows:

```
Shell x
TCP CONNECTED TO: 192.168.1.142 : 8888
Close socket
>>> %Run -c $EDITOR_CONTENT
TCP close, please reset!
>>>
```

ESP32-S3 connects with TCP SERVER, and TCP SERVER receives messages from ESP32S3, as shown in the figure below. You can enter any content in TCP SERVER, click SEND, and ESP32-S3 will receive this message



The following is the program code:

```
1 import network
2 import socket
3 import time
4
5 ssidRouter      = "*****"      #Enter the router name
6 passwordRouter = "*****"      #Enter the router password
7 host           = "*****"      #input the remote server
8 port           = 8888         #input the remote port
9
10 wlan=None
11 s=None
```

```

13 def connectWifi(ssid,passwd):
14     global wlan
15     wlan= network.WLAN(network.STA_IF)
16     wlan.active(True)
17     wlan.disconnect()
18     wlan.connect(ssid,passwd)
19     while(wlan.ifconfig()[0]=='0.0.0.0'):
20         time.sleep(1)
21     return True
22 try:
23     connectWifi(ssidRouter,passwordRouter)
24     s = socket.socket()
25     s.setsockopt(socket.SOL_SOCKET, socket.SO_REUSEADDR, 1)
26     s.connect((host,port))
27     print("TCP Connected to:", host, ":", port)
28     s.send('Hello')
29     s.send('This is my IP.')
30     while True:
31         data = s.recv(1024)
32         if(len(data) == 0):
33             print("Close socket")
34             s.close()
35             break
36         print(data)
37         ret=s.send(data)
38 except:
39     print("TCP close, please reset!")
40     if (s):
41         s.close()
42     wlan.disconnect()
43     wlan.active(False)

```

Import network、socket、time modules.

```

1 import network
2 import socket
3 import time

```

Enter the actual router name, password, remote server IP address, and port number.

```

5 ssidRouter      = "*****"      #Enter the router name
6 passwordRouter = "*****"      #Enter the router password
7 host           = "*****"      #input the remote server
8 port           = 8888          #input the remote port

```



Connect specified Router until it is successful.

```

13 def connectWifi(ssid,passwd):
14     global wlan
15     wlan= network.WLAN(network.STA_IF)
16     wlan.active(True)
17     wlan.disconnect()
18     wlan.connect(ssid,passwd)
19     while(wlan.ifconfig()[0]=='0.0.0.0'):
20         time.sleep(1)
21     return True

```

Connect router and then connect it to remote server.

```

23 connectWifi(ssidRouter,passwordRouter)
24 s = socket.socket()
25 s.setsockopt(socket.SOL_SOCKET, socket.SO_REUSEADDR, 1)
26 s.connect((host,port))
27 print("TCP Connected to:", host, ":", port)

```

Send messages to the remote server, receive the messages from it and print them out, and then send the messages back to the server.

```

28 s.send('Hello')
29 s.send('This is my IP.')
30 while True:
31     data = s.recv(1024)
32     if(len(data) == 0):
33         print("Close socket")
34         s.close()
35         break
36     print(data)
37     ret=s.send(data)

```

If an exception occurs in the program, for example, the remote server is shut down, execute the following program, turn off the socket function, and disconnect the WiFi.

```

39 print("TCP close, please reset!")
40 if (s):
41     s.close()
42     wlan.disconnect()
43     wlan.active(False)

```

Reference

Class socket

Before each use of **socket**, please add the statement “**import socket**” to the top of the python file.

socket([af, type, proto]): Create a socket.

af: address

socket.AF_INET: IPv4

socket.AF_INET6: IPv6

type: type

socket.SOCK_STREAM : TCP stream

socket.SOCK_DGRAM : UDP datagram

socket.SOCK_RAW : Original socket

socket.SO_REUSEADDR : socket reusable

proto: protocol number

socket.IPPROTO_TCP: TCPmode

socket.IPPROTO_UDP: UDPmode

socket.setsockopt(level, optname, value): Set the socket according to the options.

Level: Level of socket option

socket.SOL_SOCKET: Level of socket option. By default, it is 4095.

optname: Options of socket

socket.SO_REUSEADDR: Allowing a socket interface to be tied to an address that is already in use.

value: The value can be an integer or a bytes-like object representing a buffer.

socket.connect(address): To connect to server.

Address: Tuple or list of the server's address and port number

send(bytes): Send data and return the bytes sent.

recv(bufsize): Receive data and return a bytes object representing the data received.

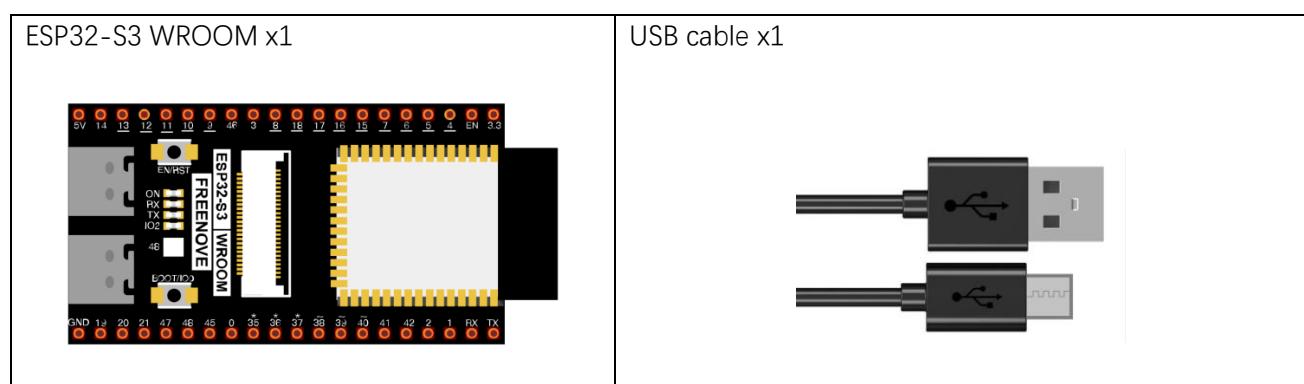
close(): Close socket.

To learn more please visit: <http://docs.micropython.org/en/latest/>

Project 14.2 As Server

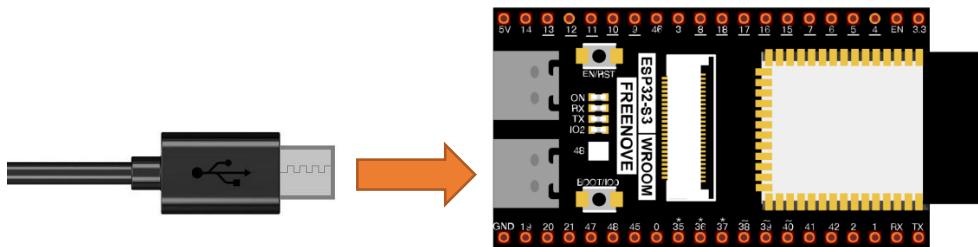
In this section, ESP32-S3 is used as a server to wait for the connection and communication of client on the same LAN

Component List



Circuit

Connect Freenove ESP32-S3 to the computer using a USB cable.



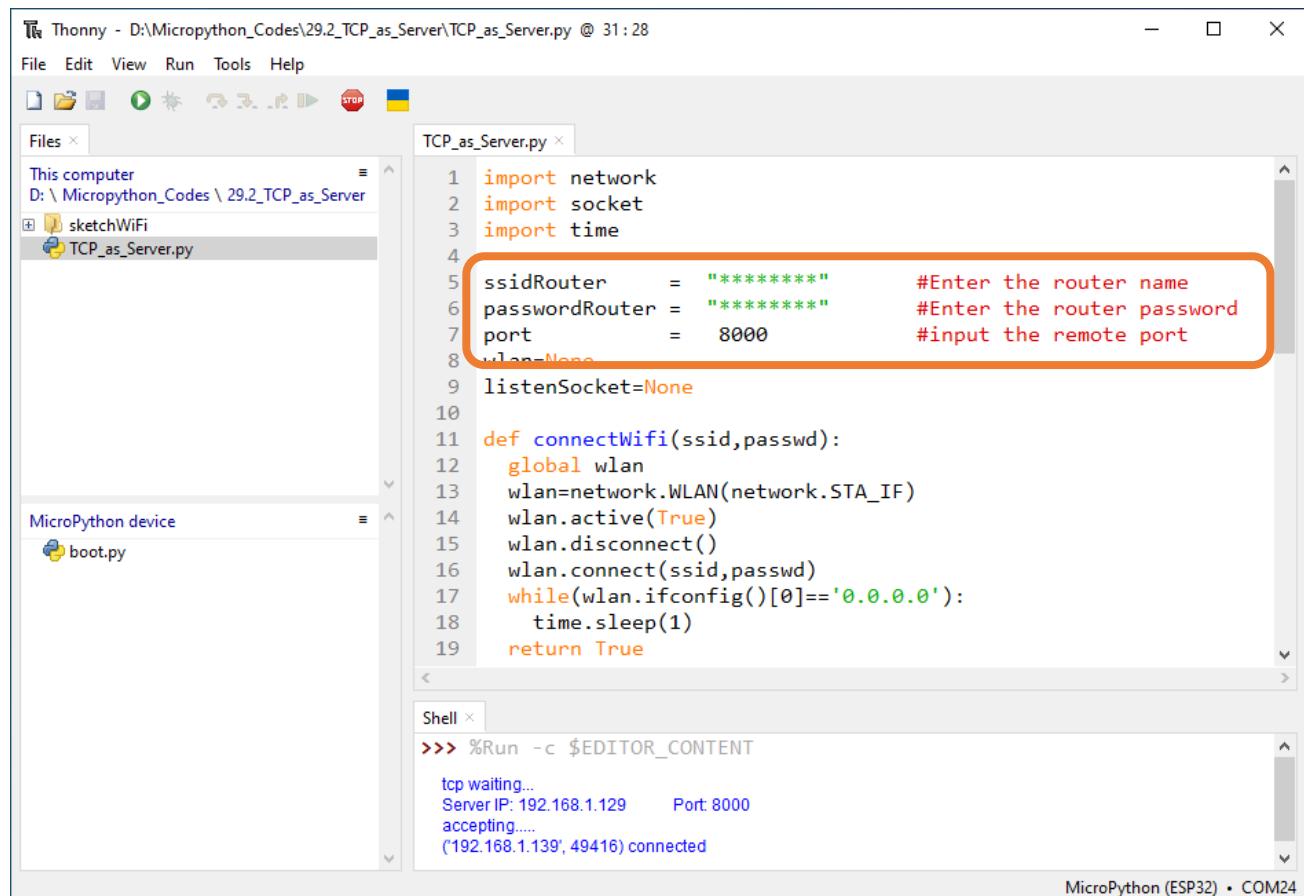
Code

Move the program folder “**Freenove_Basic_Starter_Kit_for_ESP32_S3/Python/Python_Codes**” to disk(D) in advance with the path of “**D:/Micropython_Codes**”.

Open “Thonny”, click “This computer” → “D:” → “Micropython_Codes” → “14.2_TCP_as_Server” and double click “TCP_as_Server.py”.

Before clicking “Run current script”, please modify the name and password of your router shown in the box below.

14.2_TCP_as_Server



```

import network
import socket
import time

ssidRouter      = "*****"          #Enter the router name
passwordRouter = "*****"          #Enter the router password
port            = 8000              #input the remote port
wlan=None

listenSocket=None

def connectWifi(ssid,passwd):
    global wlan
    wlan=network.WLAN(network.STA_IF)
    wlan.active(True)
    wlan.disconnect()
    wlan.connect(ssid,passwd)
    while(wlan.ifconfig()[0]=='0.0.0.0'):
        time.sleep(1)
    return True

```

After making sure that the router's name and password are correct, click “Run current script” and in “Shell”, you can see a server opened by the ESP32-S3 waiting to connecting to other network devices.



```

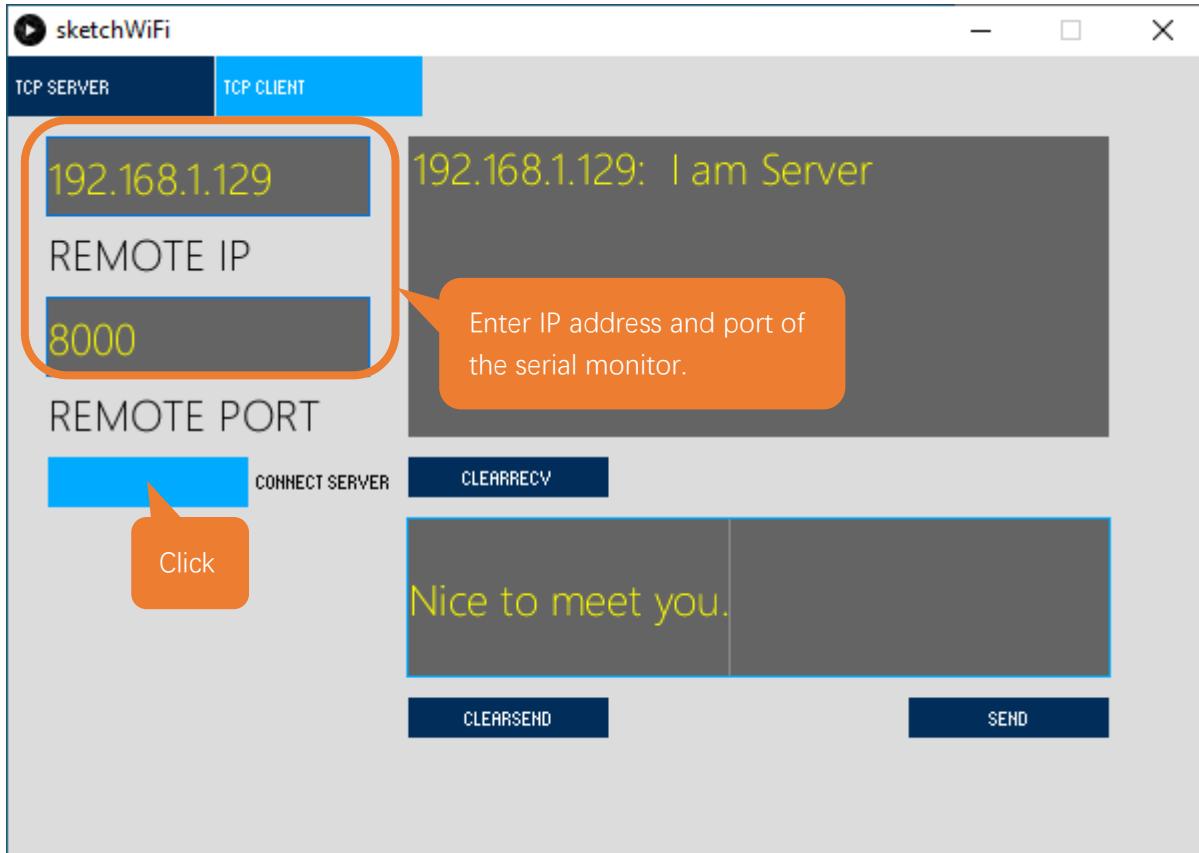
>>> %Run -c $EDITOR_CONTENT
tcp waiting...
Server IP: 192.168.1.129      Port: 8000
accepting....
(192.168.1.139, 49416) connected

```

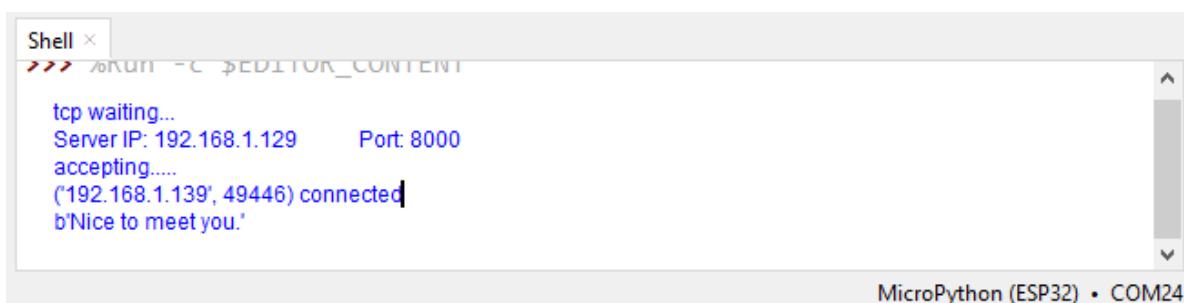
Processing:

Open the “Freenove_Basic_Starter_Kit_for_ESP32_S3/Codes/MicroPython_Codes/14.2_TCP_as_Server/sketchWiFi/sketchWiFi.pde”.

Based on the message printed in "Shell", enter the correct IP address and port when processing, and click to establish a connection with ESP32-S3 to communicate.



You can enter any information in the “Send Box” of sketchWiFi. Click “Send” and ESP32-S3 will print the received messages to “Shell” and send them back to sketchWiFi.



The following is the program code:

```
1 import network
2 import socket
3 import time
4
5 ssidRouter      = "*****"          #Enter the router name
6 passwordRouter = "*****"          #Enter the router password
7 port           = 8000             #input the remote port
8 wlan            = None
9 listenSocket    = None
10
11 def connectWifi(ssid,passwd):
12     global wlan
13     wlan=network.WLAN(network.STA_IF)
14     wlan.active(True)
15     wlan.disconnect()
16     wlan.connect(ssid,passwd)
17     while(wlan.ifconfig()[0]=='0.0.0.0'):
18         time.sleep(1)
19     return True
20
21 try:
22     connectWifi(ssidRouter,passwordRouter)
23     ip=wlan.ifconfig()[0]
24     listenSocket = socket.socket()
25     listenSocket.bind((ip,port))
26     listenSocket.listen(1)
27     listenSocket.setsockopt(socket.SOL_SOCKET, socket.SO_REUSEADDR, 1)
28     print('tcp waiting...')
29     while True:
30         print("Server IP:",ip,"\tPort:",port)
31         print("accepting.....")
32         conn,addr = listenSocket.accept()
33         print(addr,"connected")
34         break
35     conn.send('I am Server')
36     while True:
37         data = conn.recv(1024)
38         if(len(data) == 0):
39             print("close socket")
40             listenSocket.close()
41             wlan.disconnect()
42             wlan.active(False)
43             break
```

Any concerns? ✉ support@freenove.com

```

44     else:
45         print(data)
46         ret = conn.send(data)
47     except:
48         print("Close TCP-Server, please reset.")
49         if(listenSocket):
50             listenSocket.close()
51             wlan.disconnect()
52             wlan.active(False)

```

Call function connectWifi() to connect to router and obtain the dynamic IP that it assigns to ESP32-S3.

```

22     connectWifi(ssidRouter, passwordRouter)
23     ip=wlan.ifconfig()[0]

```

Open the socket server, bind the server to the dynamic IP, and open a data monitoring port.

```

24     listenSocket = socket.socket()
25     listenSocket.bind((ip, port))
26     listenSocket.listen(1)
27     listenSocket.setsockopt(socket.SOL_SOCKET, socket.SO_REUSEADDR, 1)

```

Print the server's IP address and port, monitor the port and wait for the connection of other network devices.

```

29     while True:
30         print("Server IP:",ip,"\tPort:",port)
31         print("accepting.....")
32         conn,addr = listenSocket.accept()
33         print(addr, "connected")
34         break

```

Each time receiving data, print them in "Shell" and send them back to the client.

```

36     while True:
37         data = conn.recv(1024)
38         if(len(data) == 0):
39             print("close socket")
40             listenSocket.close()
41             wlan.disconnect()
42             wlan.active(False)
43             break
44         else:
45             print(data)
46             ret = conn.send(data)

```

If the client is disconnected, close the server and disconnect WiFi.

```

47     except:
48         print("Close TCP-Server, please reset.")
49         if(listenSocket):
50             listenSocket.close()
51             wlan.disconnect()
52             wlan.active(False)

```

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:

support@freenove.com

We will check and correct it as soon as possible.

If you want learn more about ESP32S3, you view our ultimate tutorial:

https://github.com/Freenove/Freenove_Ultimate_Starter_Kit_for_ESP32_S3/archive/master.zip

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/>

End of the Tutorial

Thank you again for choosing Freenove products.

Any concerns? ✉ support@freenove.com