Welcome

Thank you for choosing Freenove products!

How to Start

When reading this, you should have downloaded the ZIP file for this product.
Unzip it and you will get a folder containing tutorials and related files. Please start with this PDF tutorial.

! Unzip the ZIP file instead of opening the file in the ZIP file directly.
! Do not move, delete or rename files in the folder just unzipped.

Get Support

Encounter problems? Don't worry! Refer to “TroubleShooting.pdf” or contact us.

When there are packaging damage, quality problems, questions encountering in use, etc., just send us an email. We will reply to you within one working day and provide a solution.

support@freenove.com

Attention

Pay attention to safety when using and storing this product:

- This product is not suitable for children under 12 years of age because of small parts and sharp parts.
- Minors should use this product under the supervision and guidance of adults.
- This product contains small and sharp parts. Do not swallow, prick and scratch to avoid injury.
- This product contains conductive parts. Do not hold them to touch power supply and other circuits.
- To avoid personal injury, do not touch parts rotating or moving while working.
- The wrong operation may cause overheat. Do not touch and disconnect the power supply immediately.
- Operate in accordance with the requirements of the tutorial. Fail to do so may damage the parts.
- Store this product in a dry and dark environment. Keep away from children.
- Turn off the power of the circuit before leaving.

About

Freenove provides open source electronic products and services.

Freenove is committed to helping customers learn programming and electronic knowledge, quickly implement product prototypes, realize their creativity and launch innovative products. Our services include:

- Kits for learning programming and electronics
- Kits compatible with Arduino®, Raspberry Pi®, micro:bit®, ESP32®, etc.
- Kits for robots, smart cars, drones, etc.
- Components, modules and tools
- Design and customization

To learn more about us or get our latest information, please visit our website:

http://www.freenove.com

Copyright

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Contents

Prepare

ESP32 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 Micyoco(SCM) chip, or connected to the Internet and used as an Internet of Things device.

ESP32 can be developed both either with C/C++ language or micropython language. In this tutorial, we use micropython. With Micropython is as easy to learn as Python with little code, making it ideal for beginners. Moreover, the code of ESP32 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.

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 ESP32 and its 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

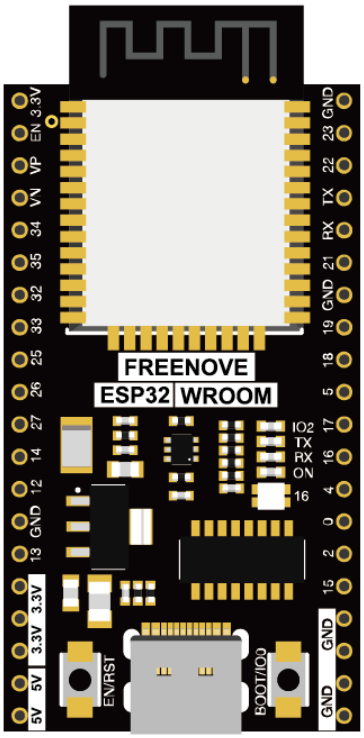
ESP32-WROOM

ESP32-WROOM 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.

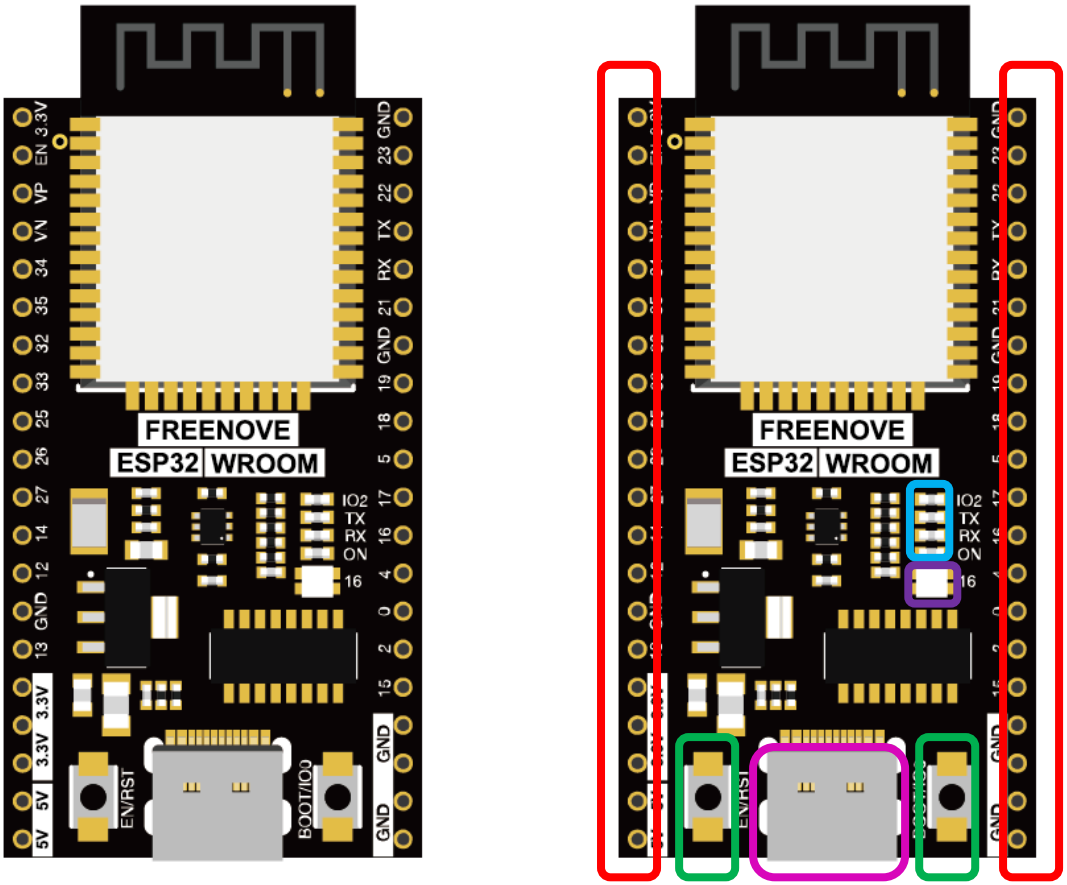
PCB on-board antenna	IPEX antenna
	

In this tutorial, the ESP32-WROOM is designed based on the PCB on-board antenna-packaged ESP32-WROOM-32E module.

ESP32-WROOM



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



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

Box color	Corresponding resources introduction
	GPIO pin
	LED indicator
	WS2812
	Reset button, Boot mode selection button
	Type C port

For more information, please visit: https://www.espressif.com/sites/default/files/documentation/esp32-wroom-32e_esp32-wroom-32ue_datasheet_en.pdf

Chapter 0 Ready (Important)

Before starting building the projects, you need to make some preparation first, which is so crucial that you must not skip.

0.1 Installing Thonny (Important)

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 during the whole process.
Thonny supports various operating system, including Windows、Mac OS、Linux.

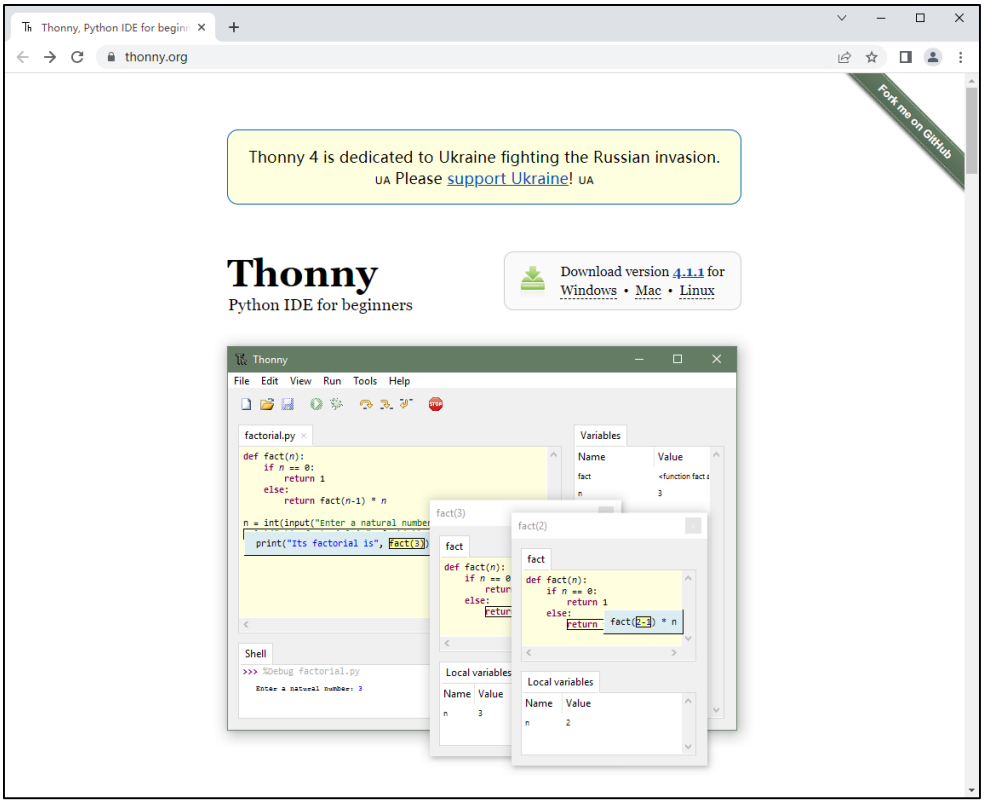
Downloading Thonny

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.)

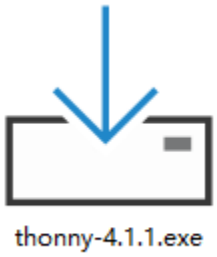
Operating System	Download links/methods
Windows	https://github.com/thonny/thonny/releases/download/v4.1.1/thonny-4.1.1.exe
Mac OS	https://github.com/thonny/thonny/releases/download/v4.1.1/thonny-4.1.1.pkg
Linux	**The latest version:** **Binary bundle for PC (Thonny+Python):** bash <(wget -O - https://thonny.org/installer-for-linux) **With pip:** pip3 install thonny **Distro packages (may not be the latest version):** **Debian, Rasbian, Ubuntu, Mint and others:** sudo apt install thonny **Fedora:** sudo dnf install thonny

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

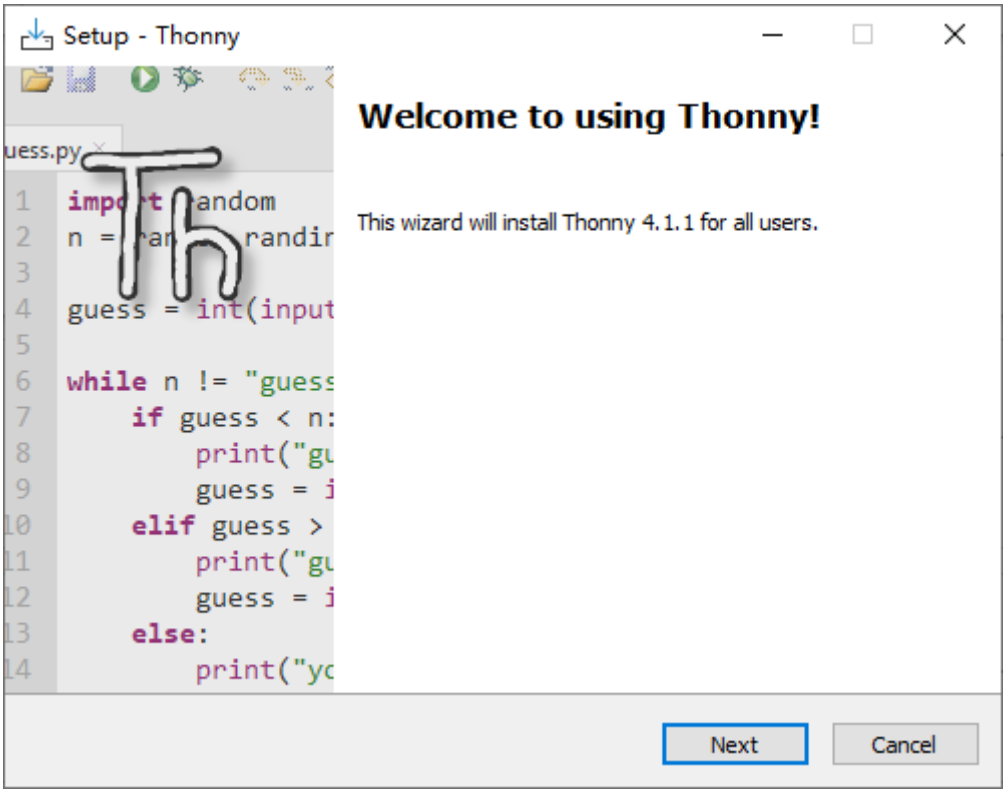


Installing on Windows

The icon of Thonny after downloading is as below. Double click “thonny-4.1.1.exe”.

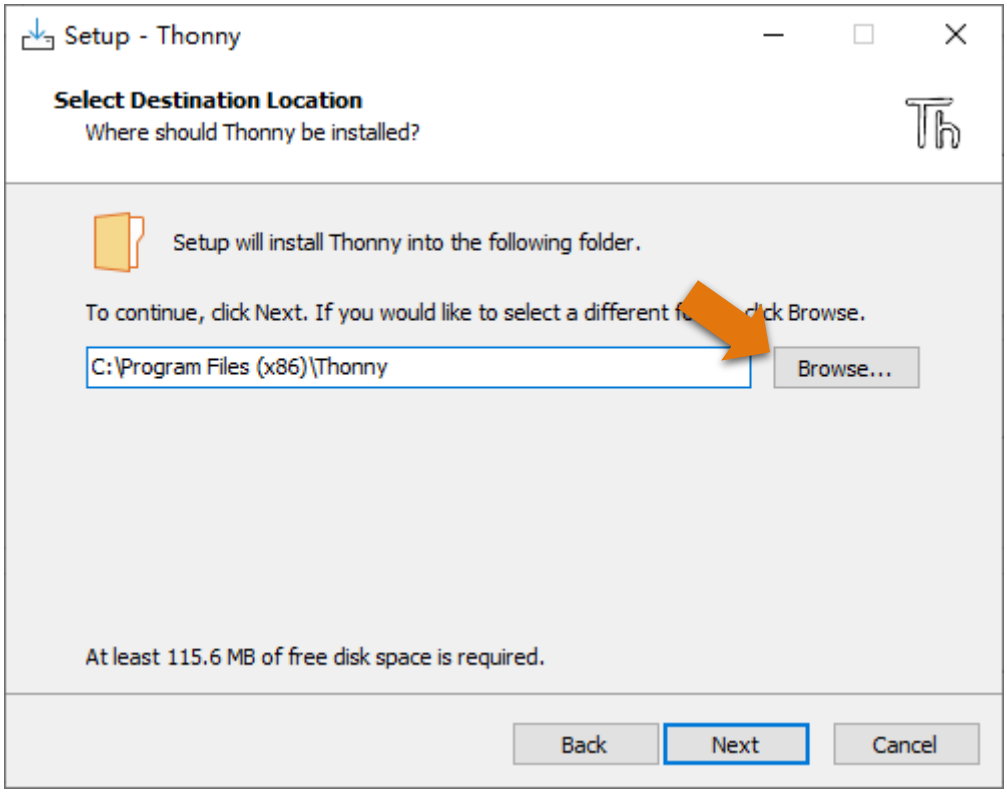


If you're not familiar with computer software installation, you can simply keep clicking "Next" until the installation completes.

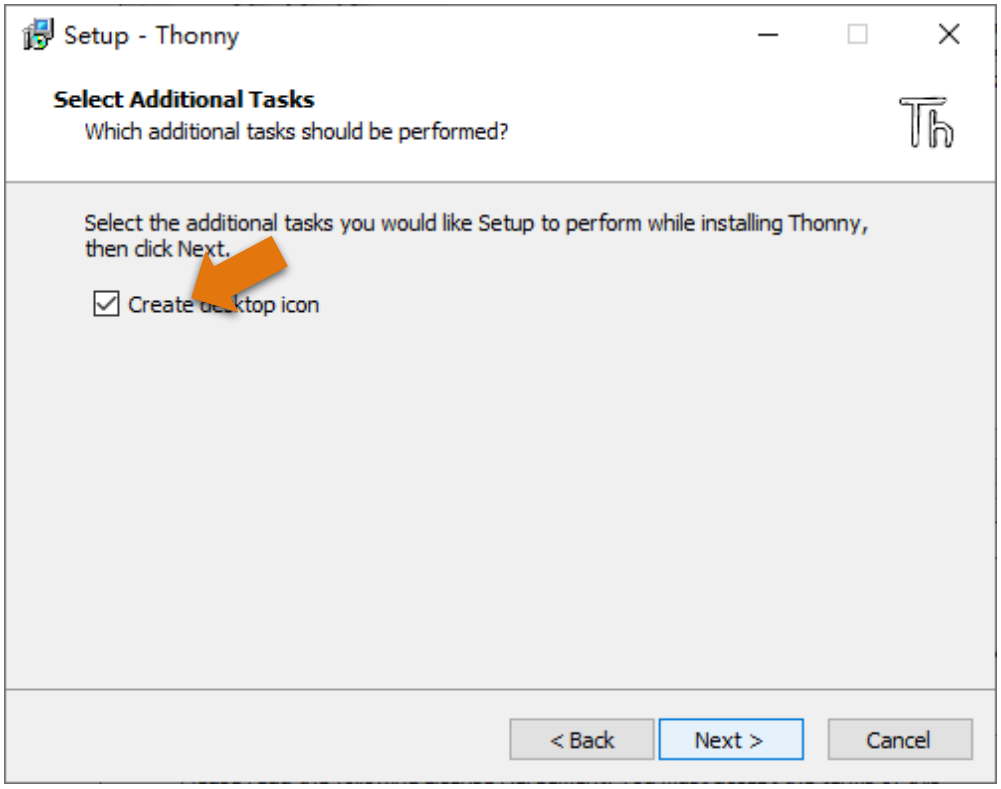


If you want to change Thonny's installation path, you can click "Browse" to modify it. After selecting installation path, click "OK".

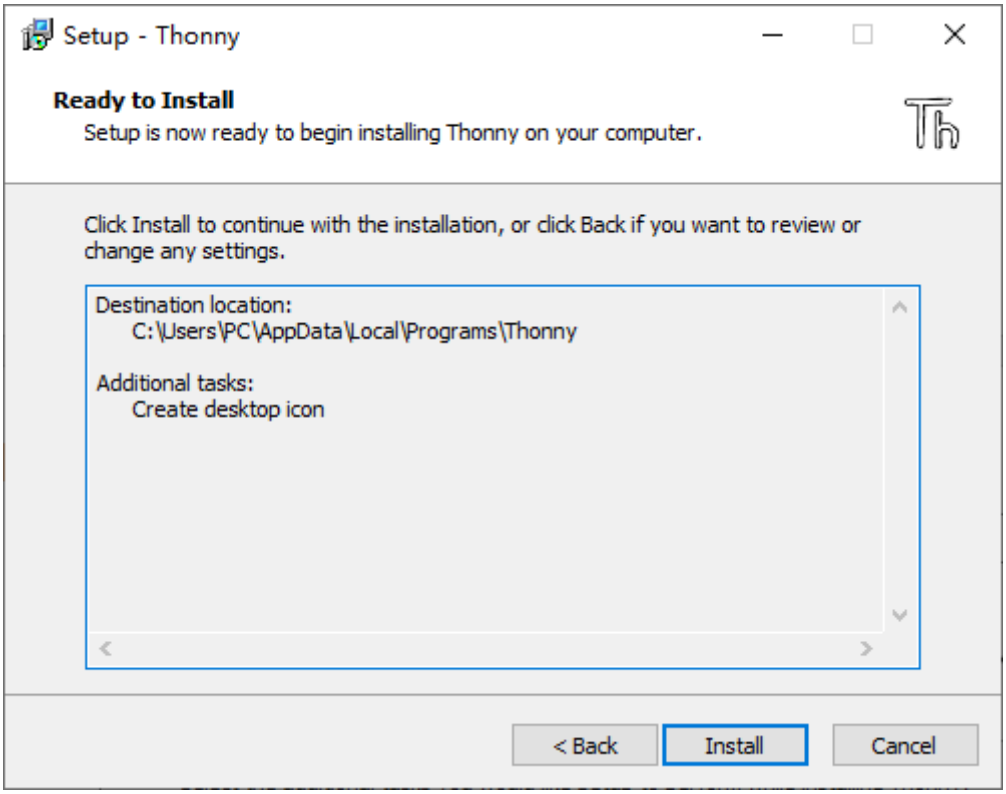
If you do not want to change it, just click "Next".



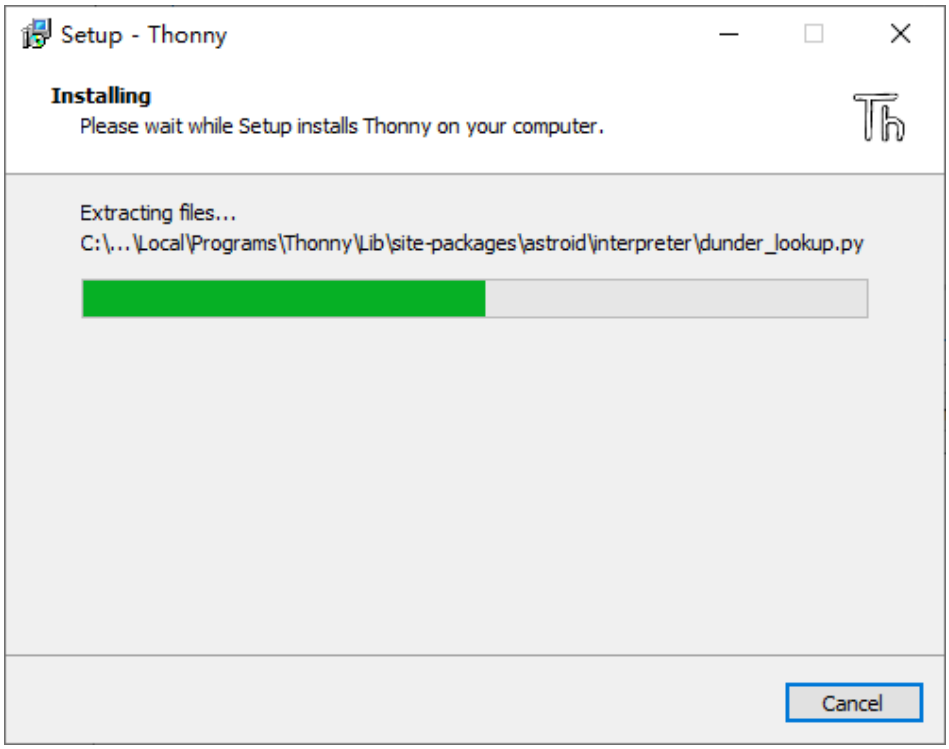
Check "Create desktop icon" and then it will generate a shortcut on your desktop to facilitate you to open Thonny later.



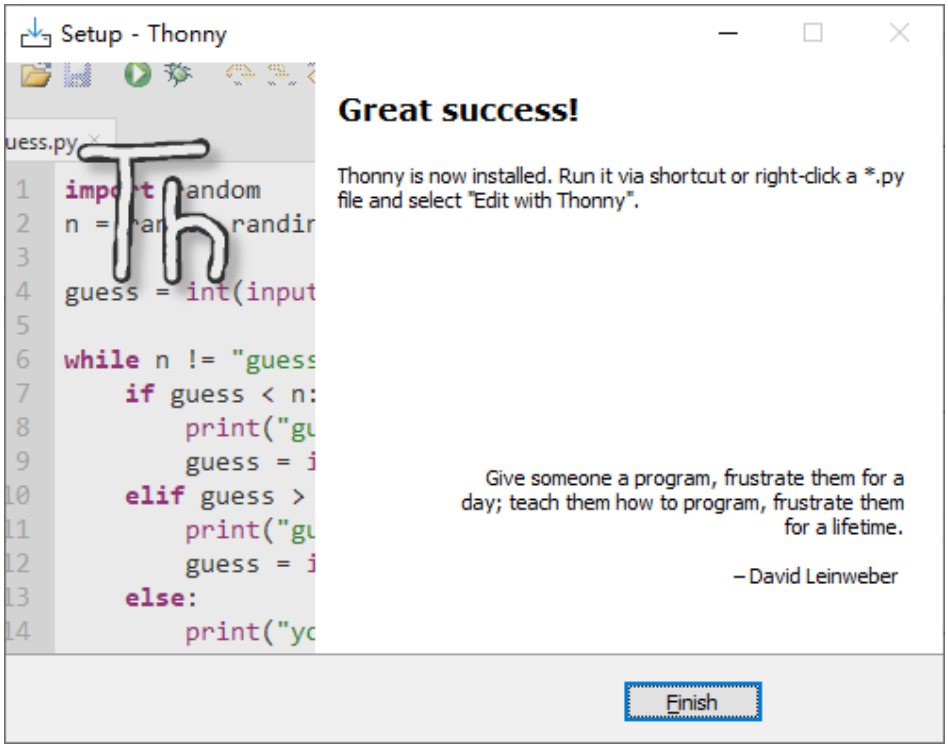
Click "install" to install the software.



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



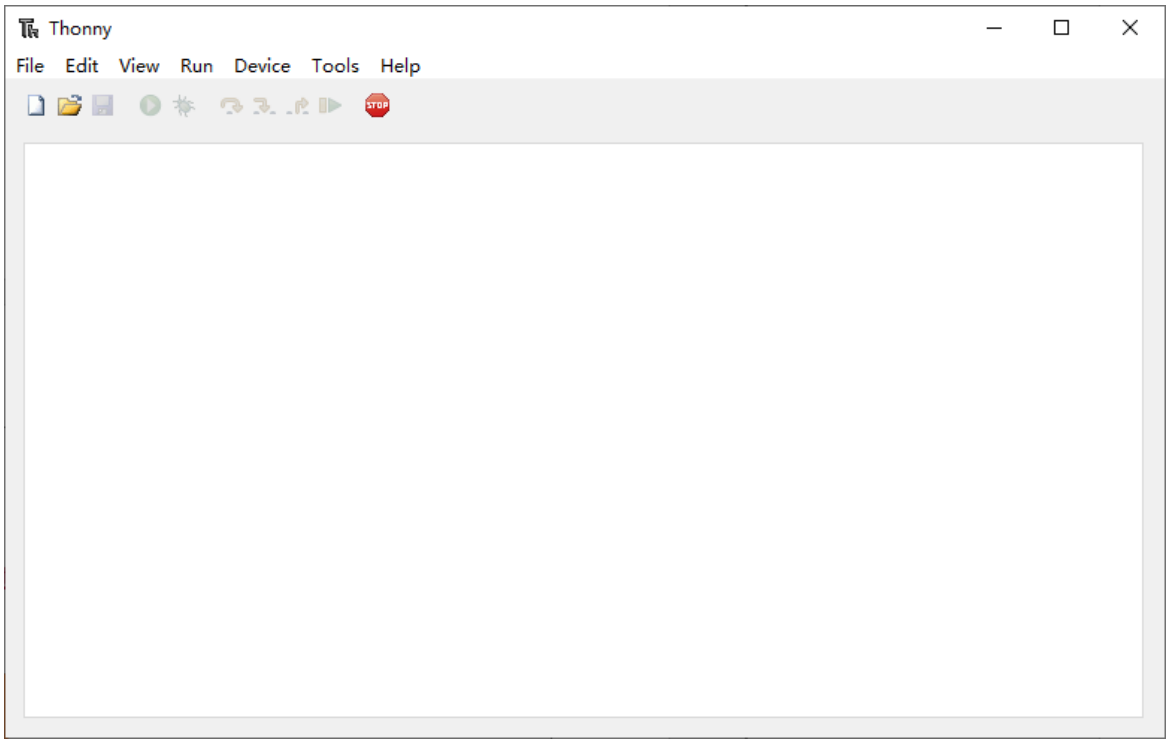
Once you see the interface as below, Thonny has been installed successfully.



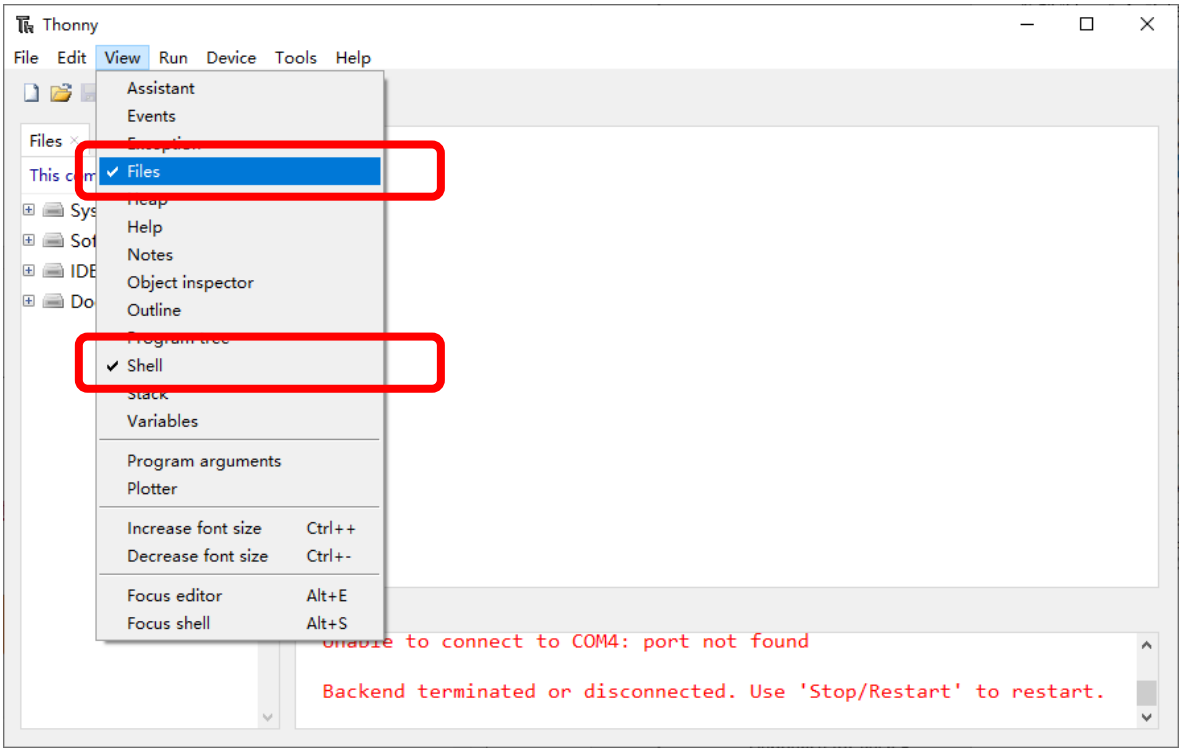
If you've check "Create desktop icon" during the installation process, you can see the below icon on your desktop.

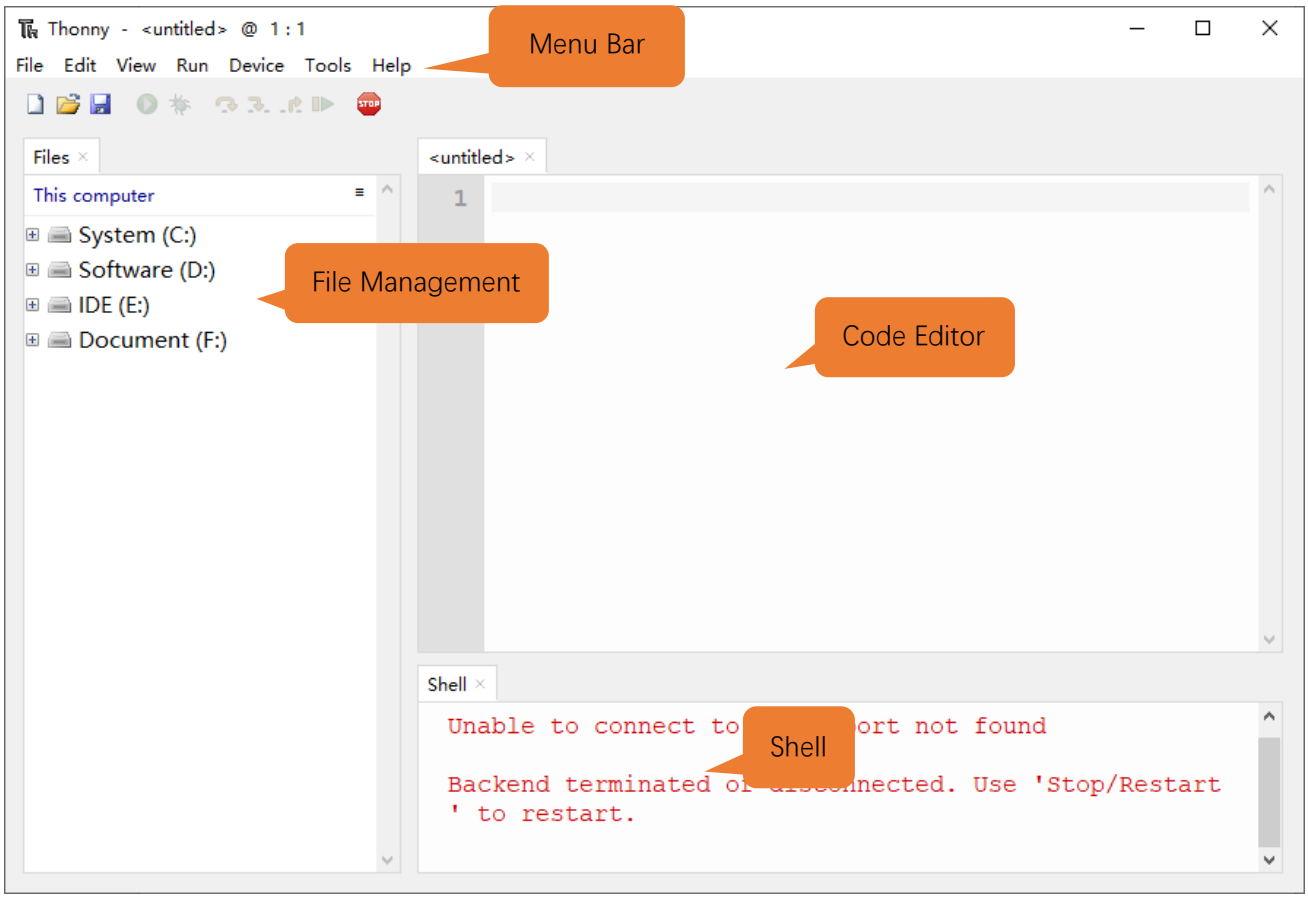
0.2 Basic Configuration of Thonny

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



Select "View"→ "Files" and "Shell".




Thonny - <untitled> @ 1 : 1
File Edit View Run Device Tools Help
Menu Bar
Files
This computer
System (C:)
Software (D:)
IDE (E:)
Document (F:)
File Management
<untitled>
1
Code Editor
Shell
Unable to connect to ort not found
Backend terminated or disconnected. Use 'Stop/Restart ' to restart.
Shell

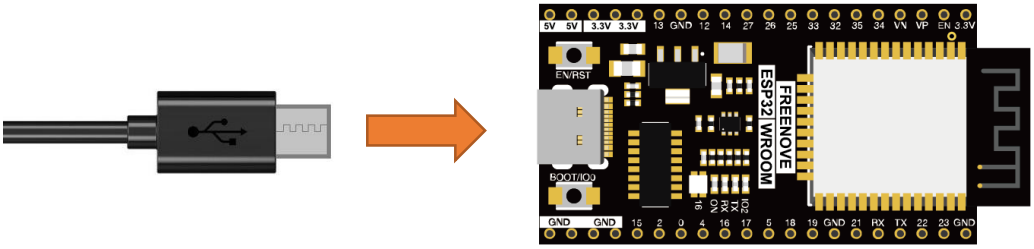
03. CH340 (Importance)

ESP32 uses CH340 to download codes. So before using it, we need to install CH340 driver in our computers.

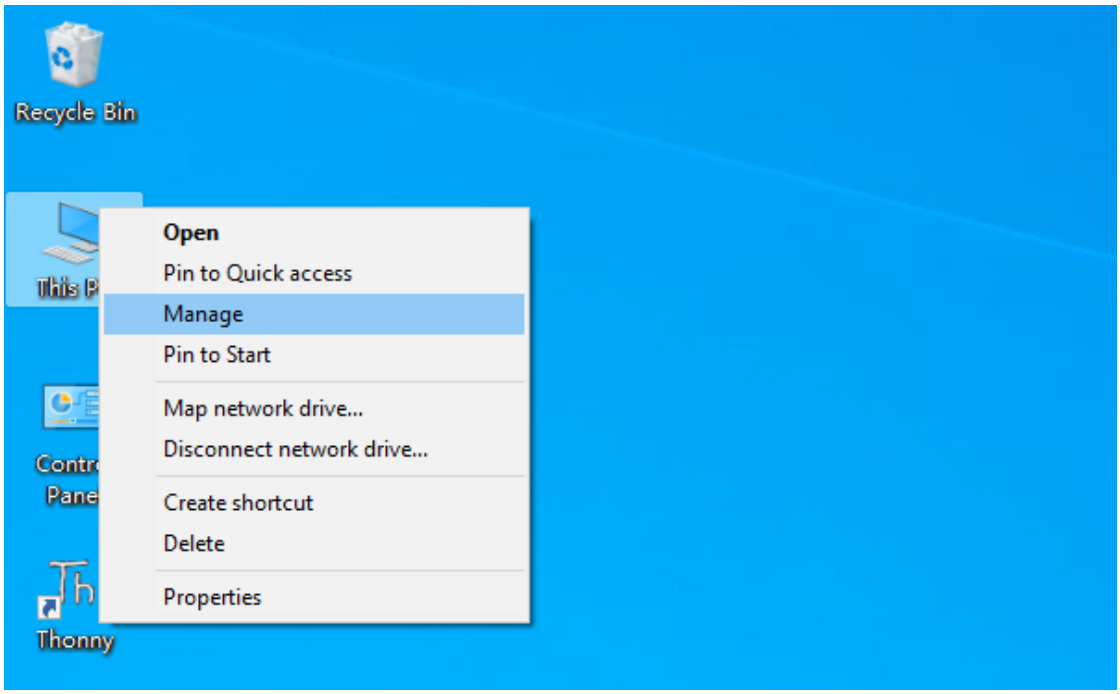
Windows

Check whether CH340 has been installed

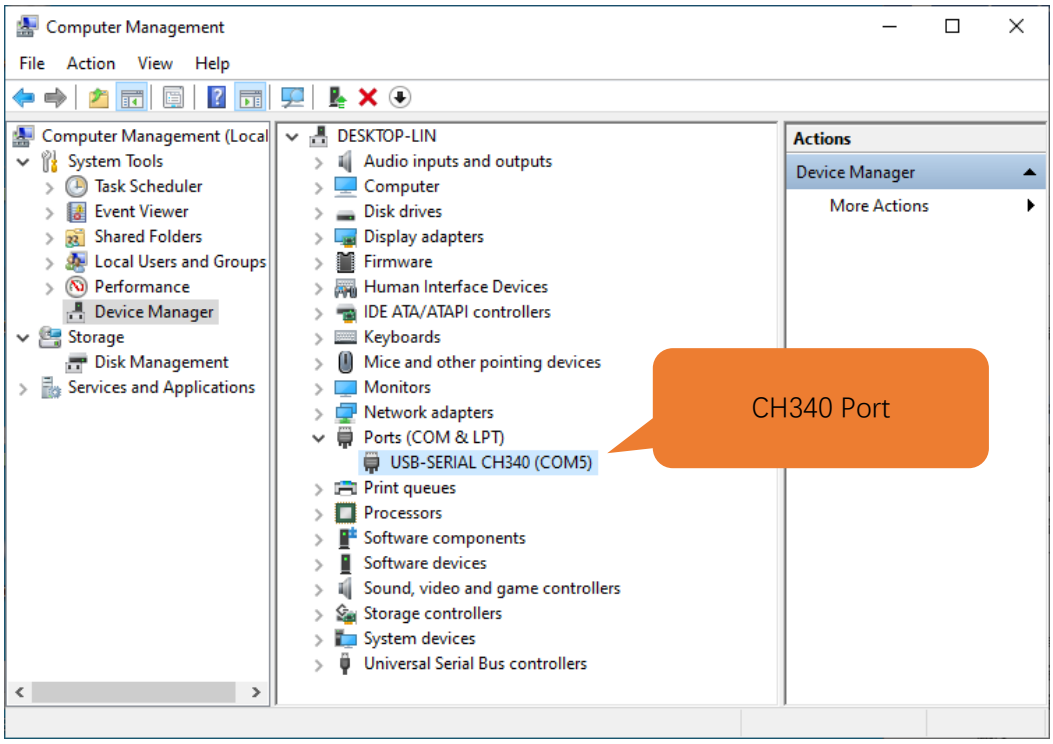
1. Connect your computer and ESP32 with a USB cable.



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

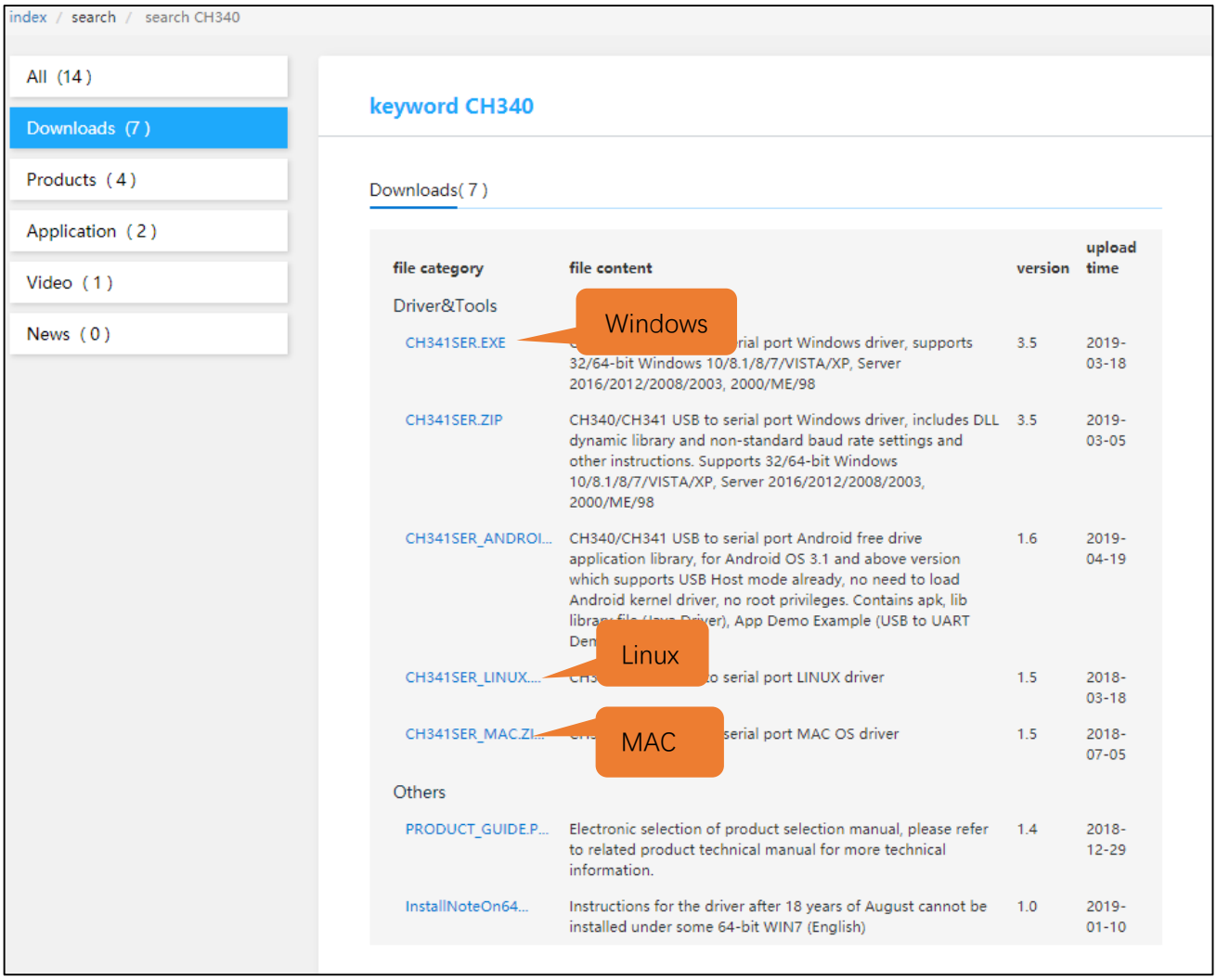


3. Click "Device Manager". If your computer has installed CH340, you can see"USB-SERIAL CH340 (COMx)". And you can click here to move to the next step.

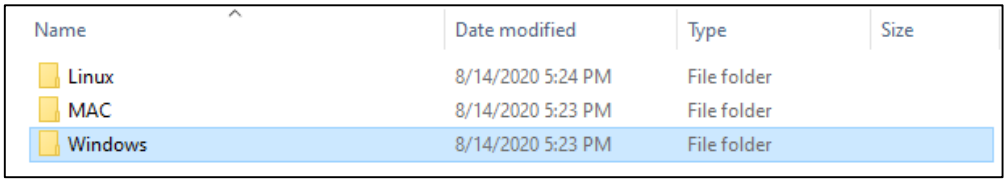


Installing CH340

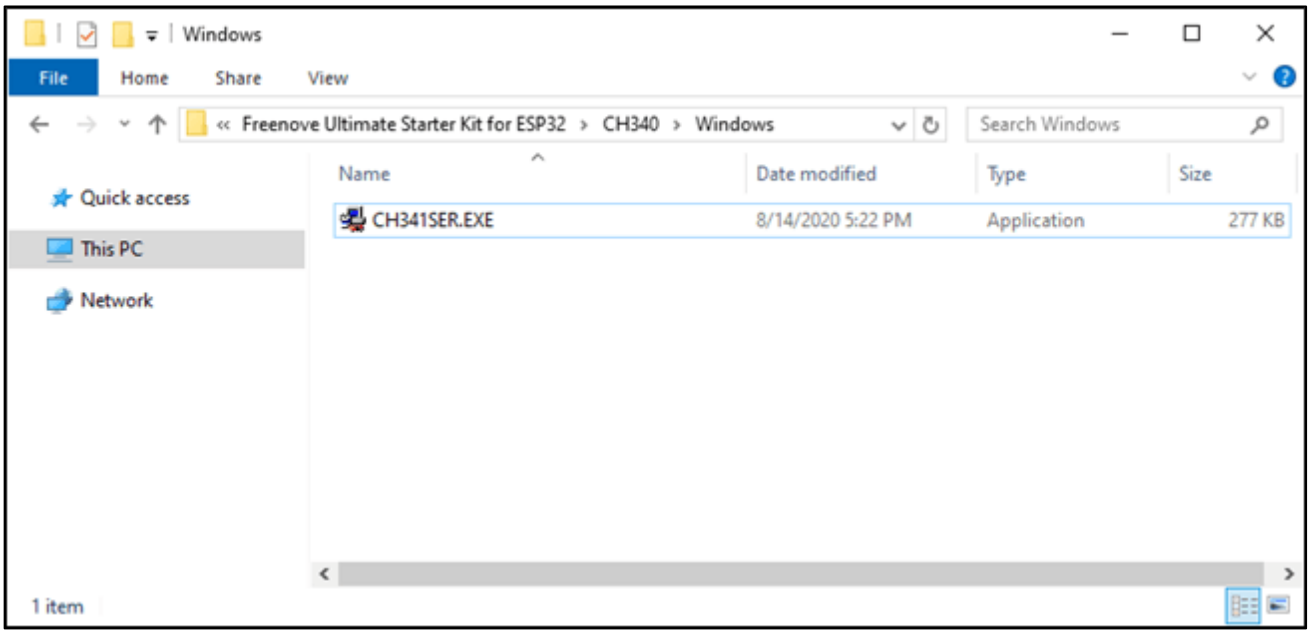
1. First, download CH340 driver, click http://www.wch-ic.com/search?q=CH340&t=downloads to download the appropriate one based on your operating system.



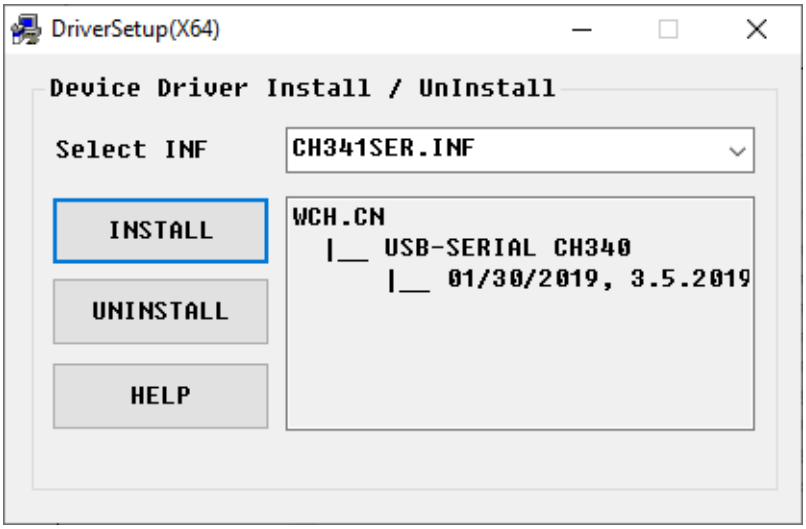
If you would not like to download the installation package, you can open **"Freenove_ESP32_WROOM_Board/CH340"**, we have prepared the installation package.



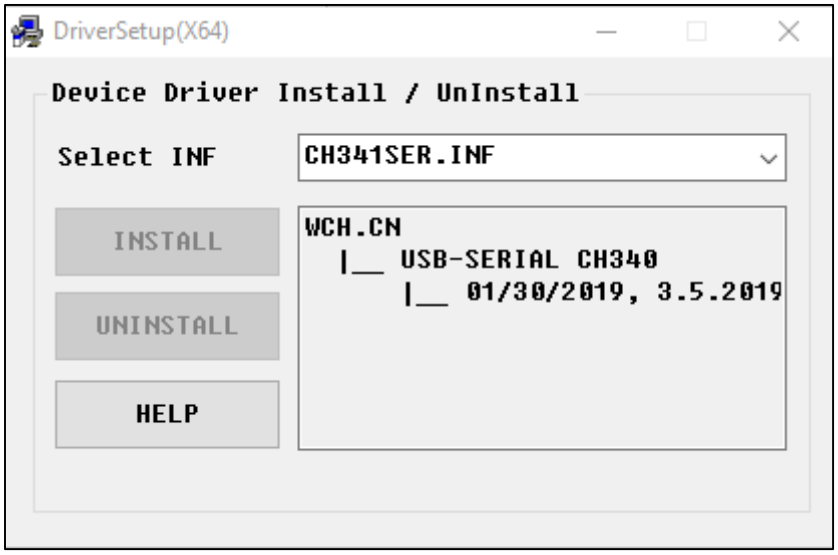
2. Open the folder "**Freenove_ESP32_WROOM_Board/CH340/Windows/**"



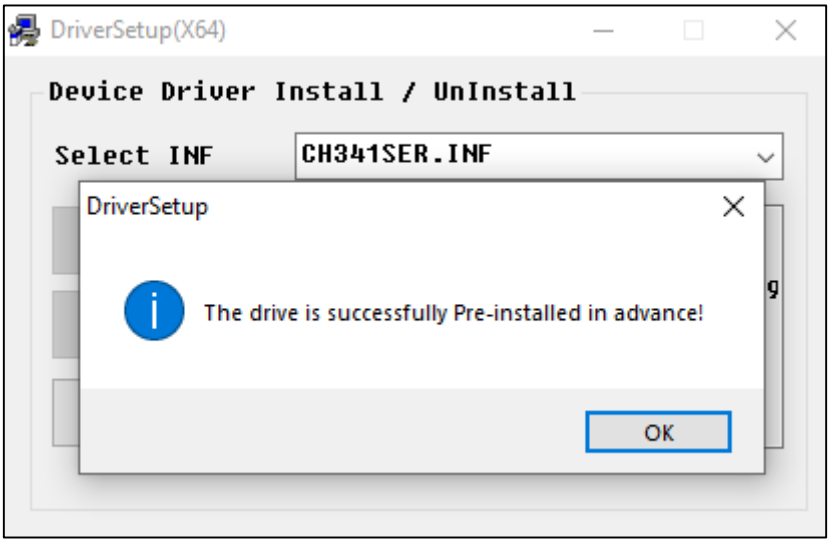
3. Double click "**CH341SER.EXE**".



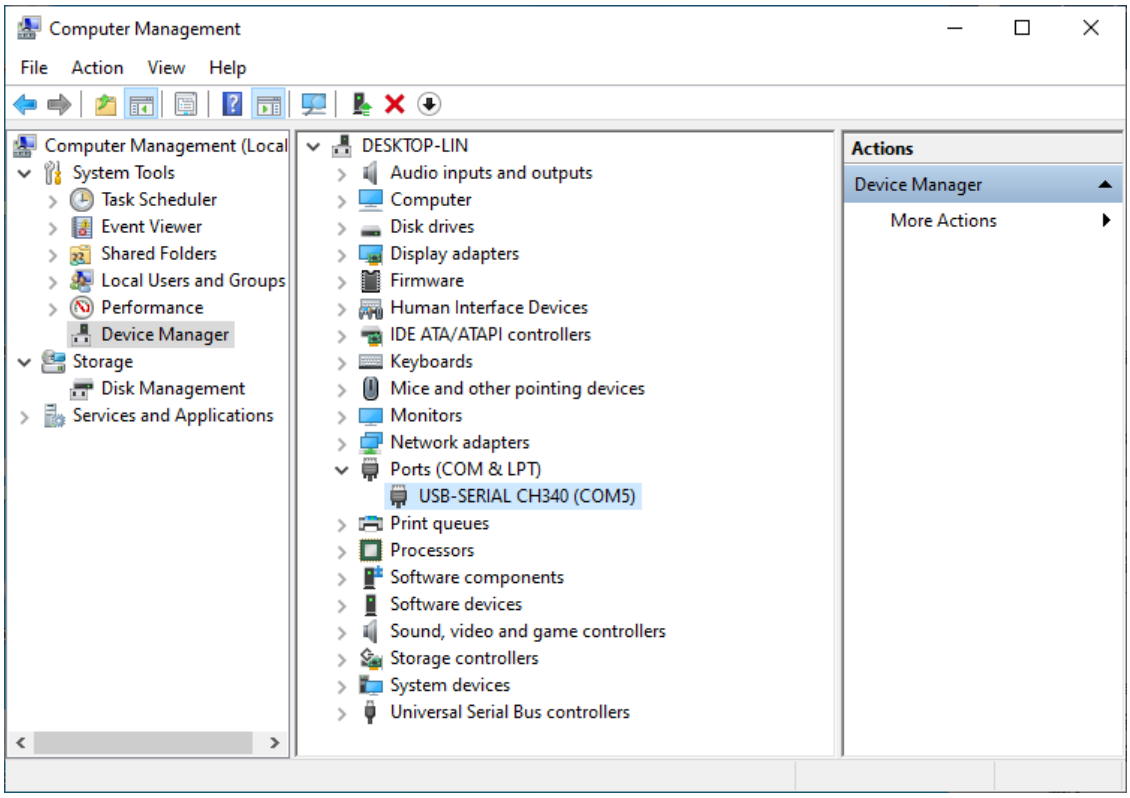
4. Click “INSTALL” and wait for the installation to complete.



5. Install successfully. Close all interfaces.



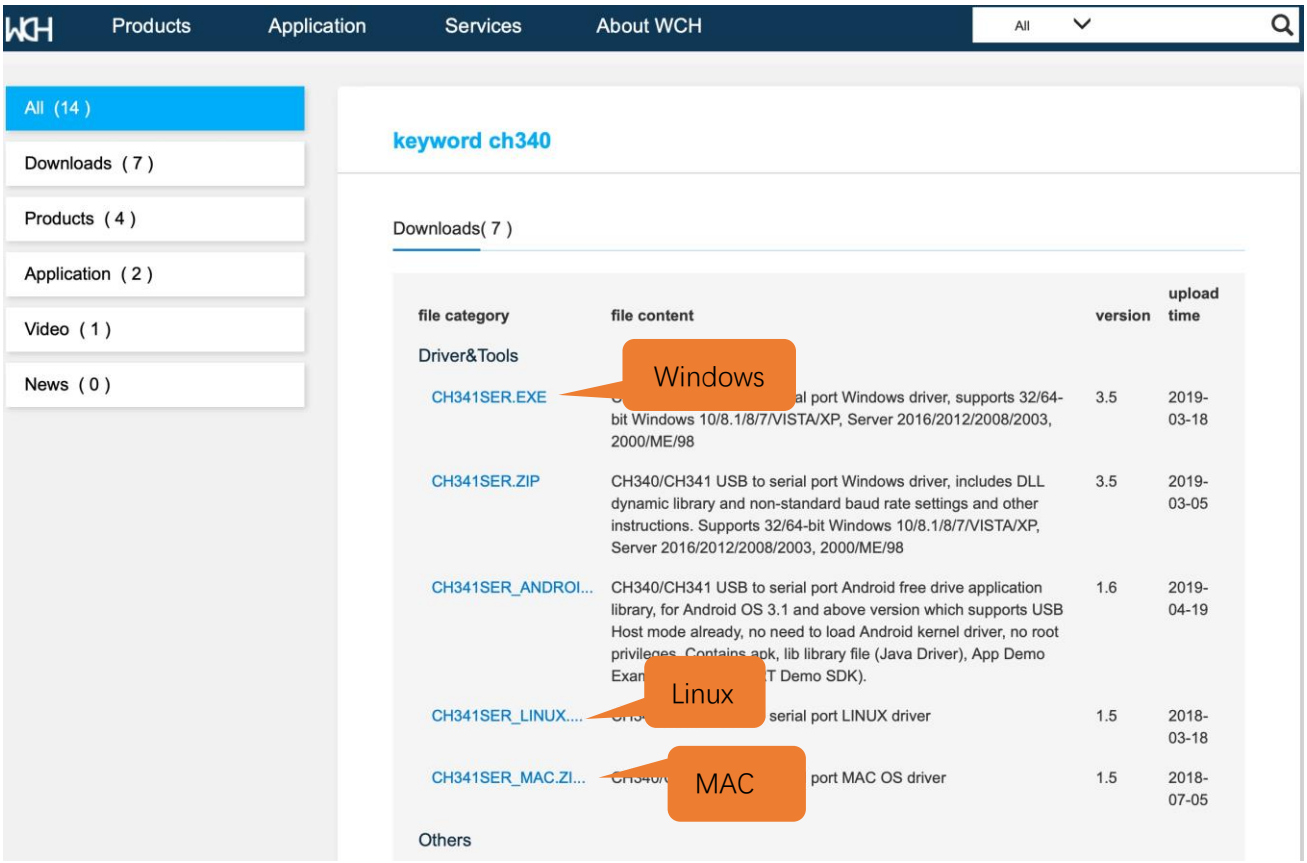
6. When ESP32 is connected to computer, select “This PC”, right-click to select “Manage” and click “Device Manager” in the newly pop-up dialog box, and you can see the following interface.



7. So far, CH340 has been installed successfully. Close all dialog boxes.

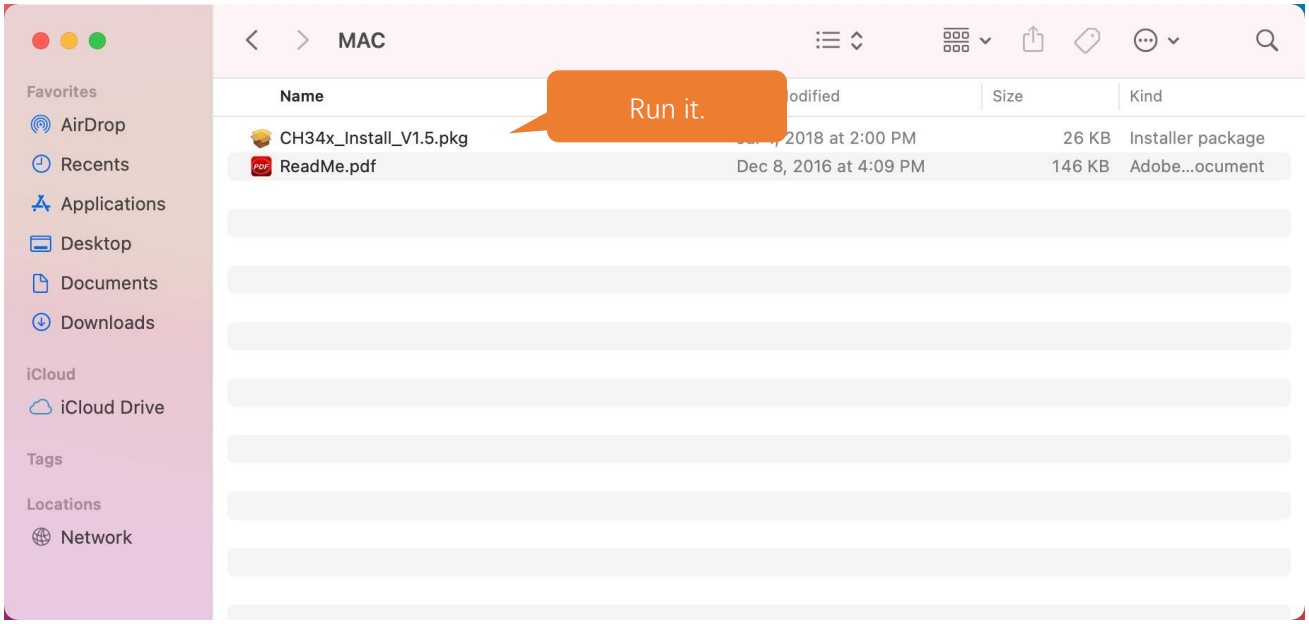
MAC

First, download CH340 driver, click http://www.wch-ic.com/search?q=CH340&t=downloads to download the appropriate one based on your operating system.

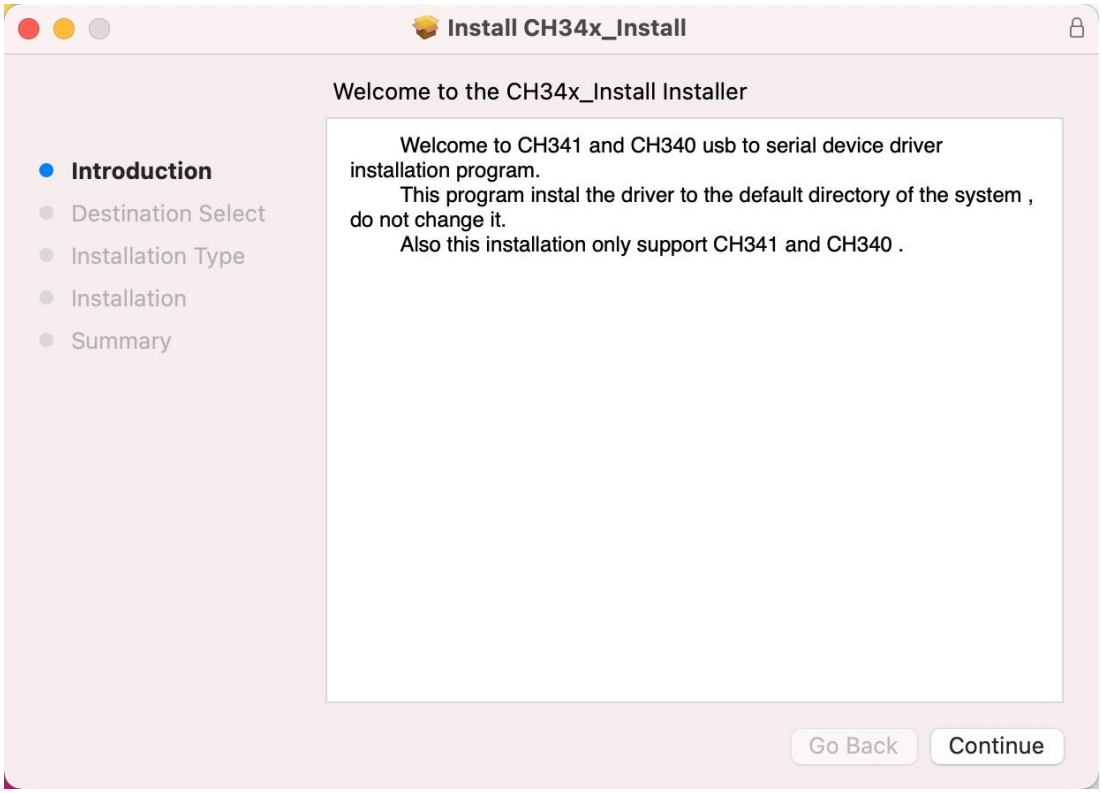


If you would not like to download the installation package, you can open **"Freenove_ESP32_WROOM_Board/CH340"**, we have prepared the installation package.

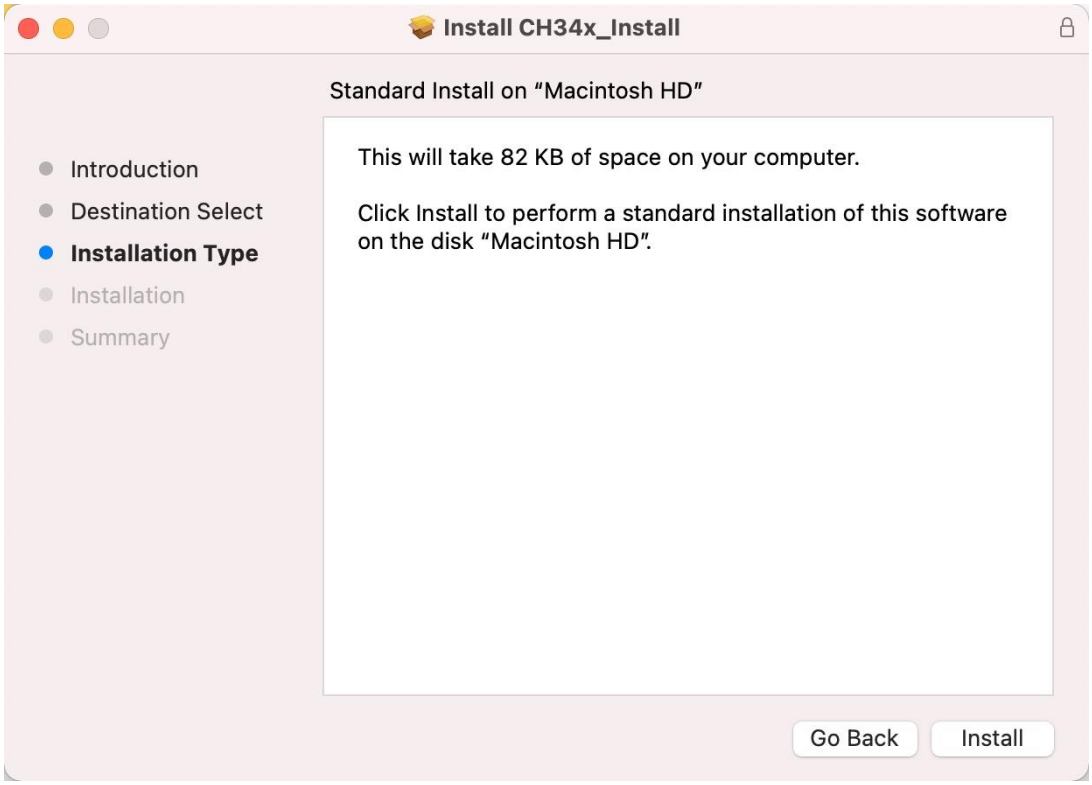
Second, open the folder "**Freenove_ESP32_WROOM_Board/CH340/MAC/**"



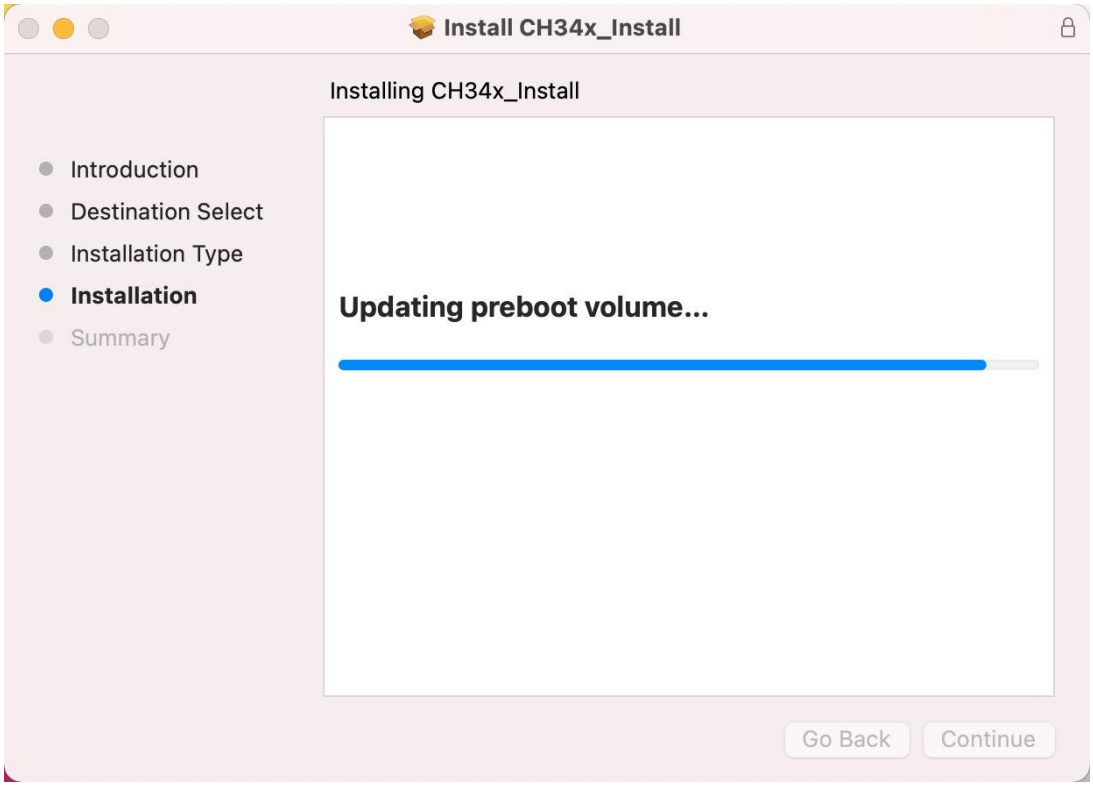
Third, click Continue.



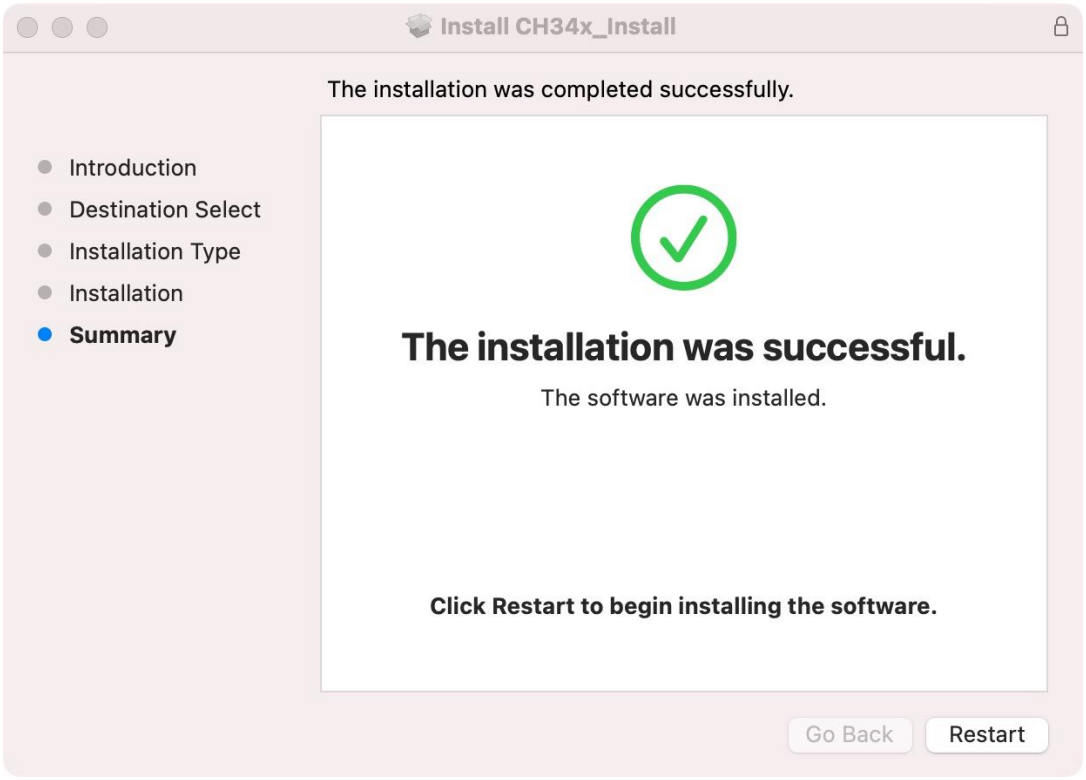
Fourth, click Install.



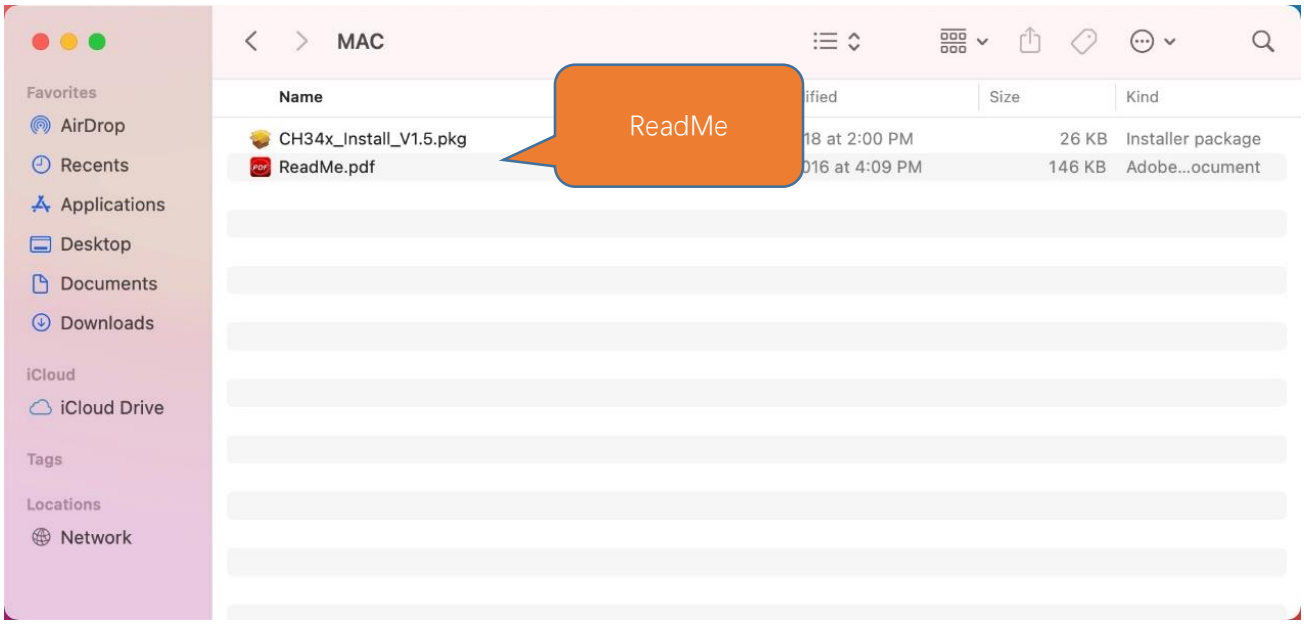
Then, waiting Finsh.



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.

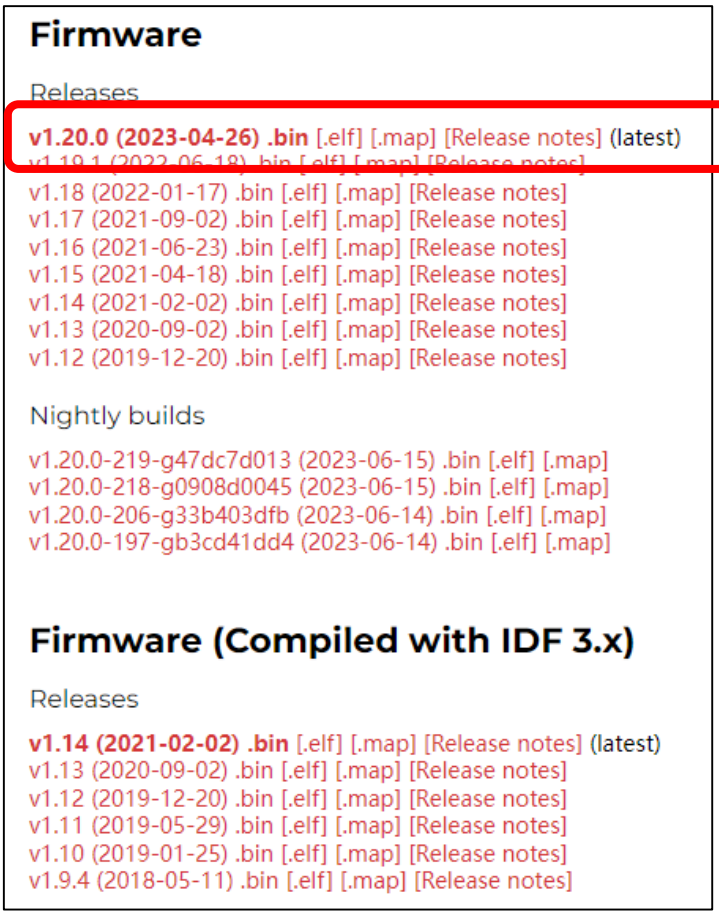


0.4 Burning Micropython Firmware (Important)

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

Downloading Micropython Firmware

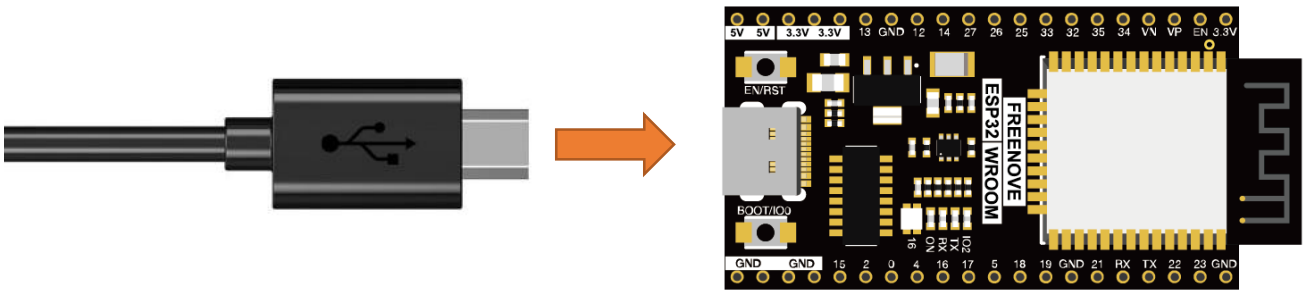
Official website of microPython: http://micropython.org/
Webpage listing firmware of microPython for ESP32: https://micropython.org/download/esp32/



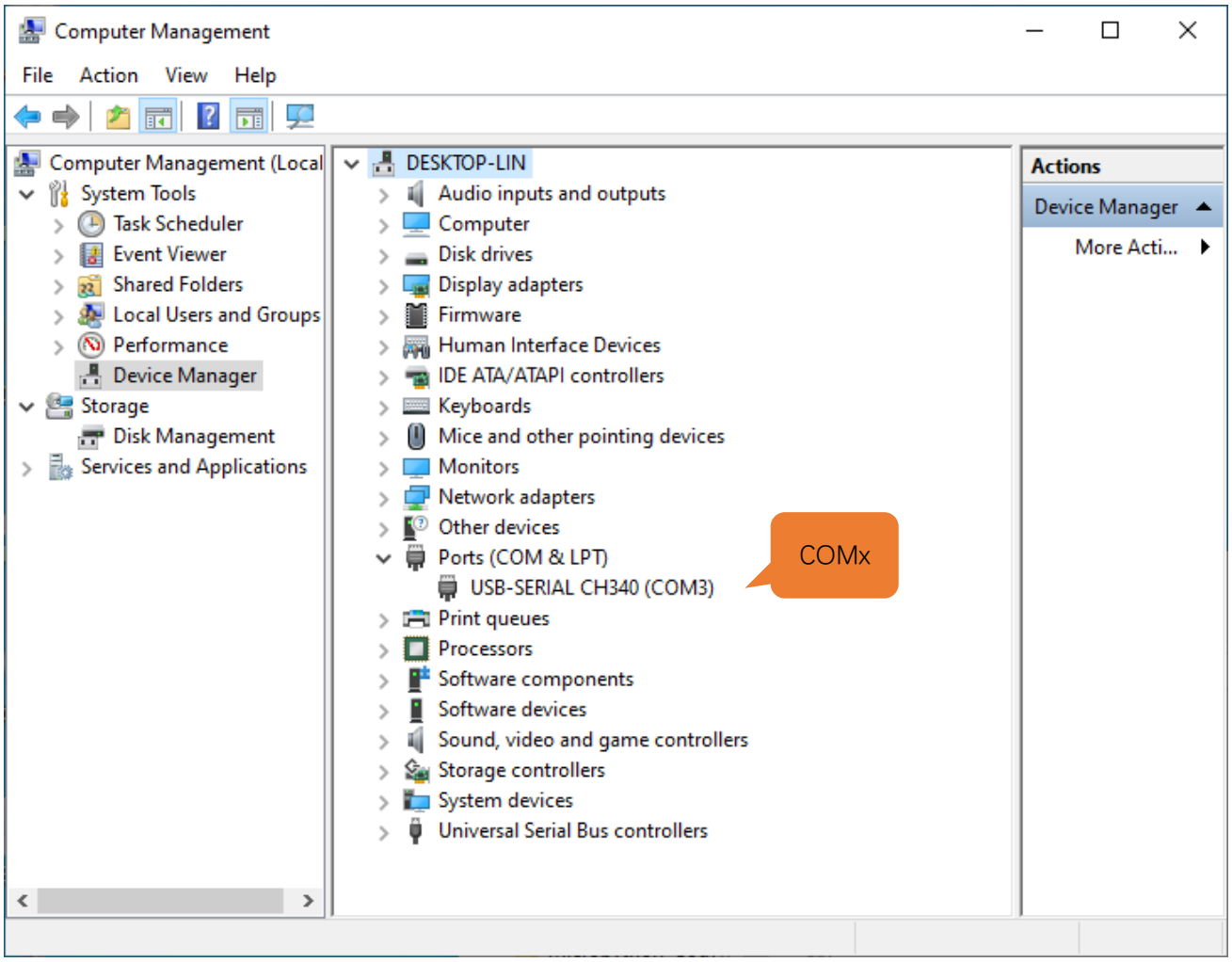
Firmware used in this tutorial is **esp32-20230426-v1.20.0.bin**
This file is also provided in our data folder "**Freenove_ESP32_WROOM_Board /Python/Python_Firmware**".。

Burning a Micropython Firmware

Connect your computer and ESP32 with a USB cable.

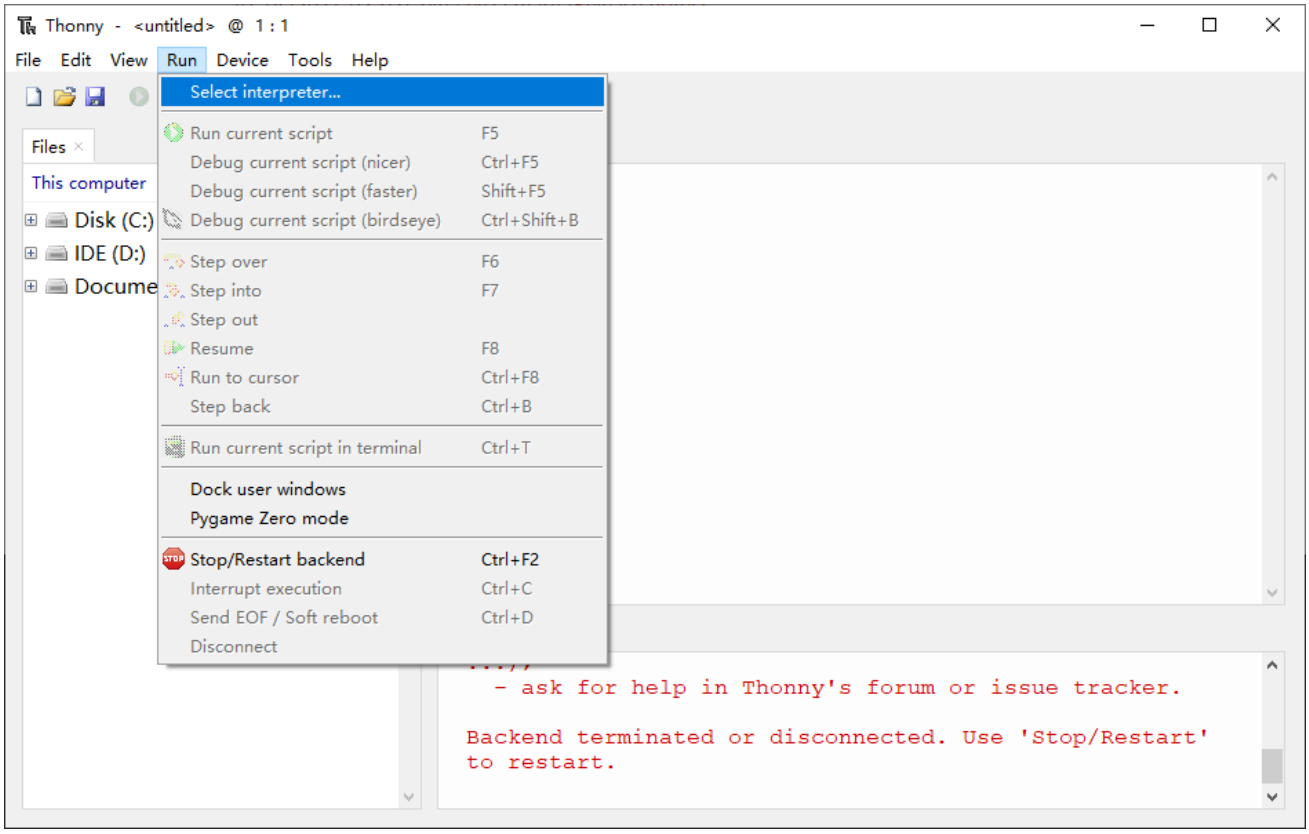


Make sure that the driver has been installed successfully and that it can recognize COM port correctly. Open device manager and expand "Ports".

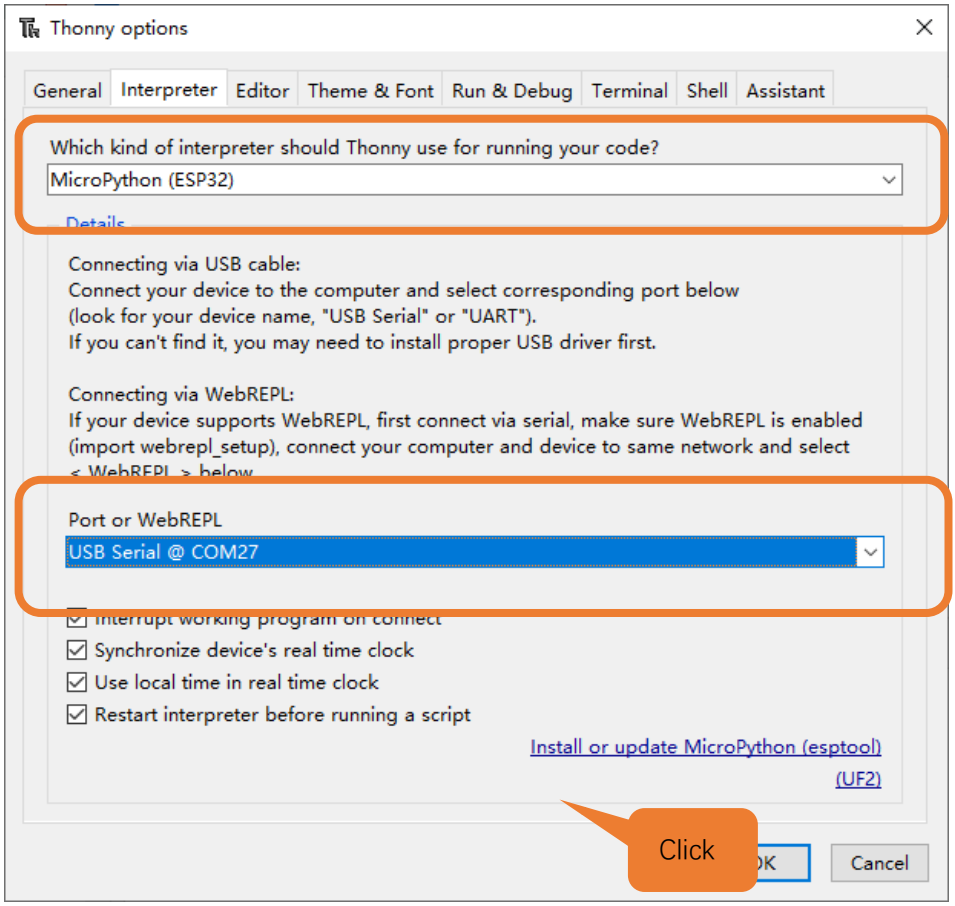


Note: the port of different people may be different, which is a normal situation.

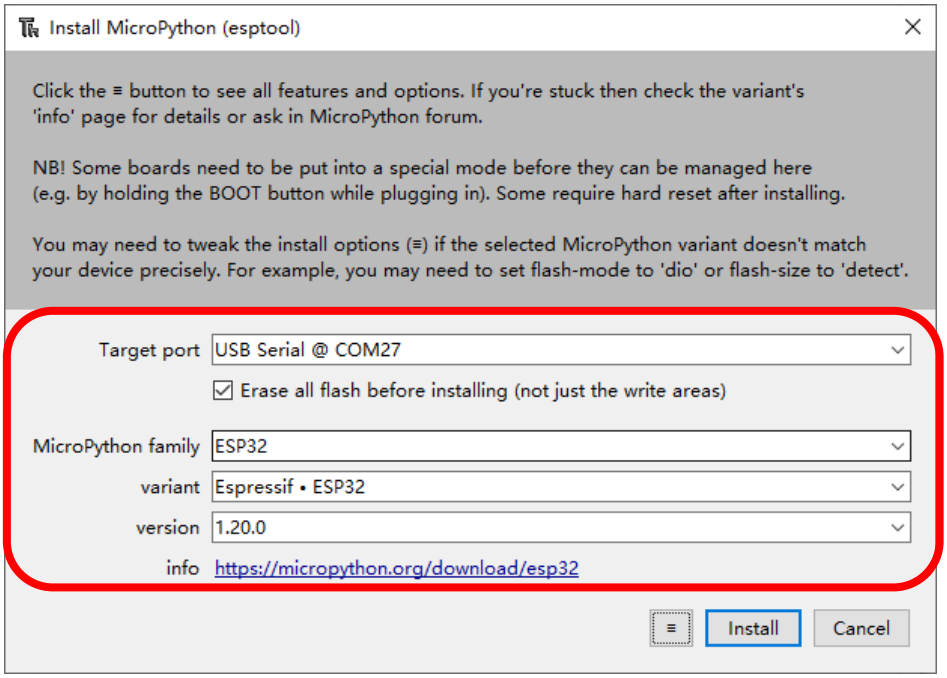
1. Open Thonny, click “run” and select “Select interpreter...””



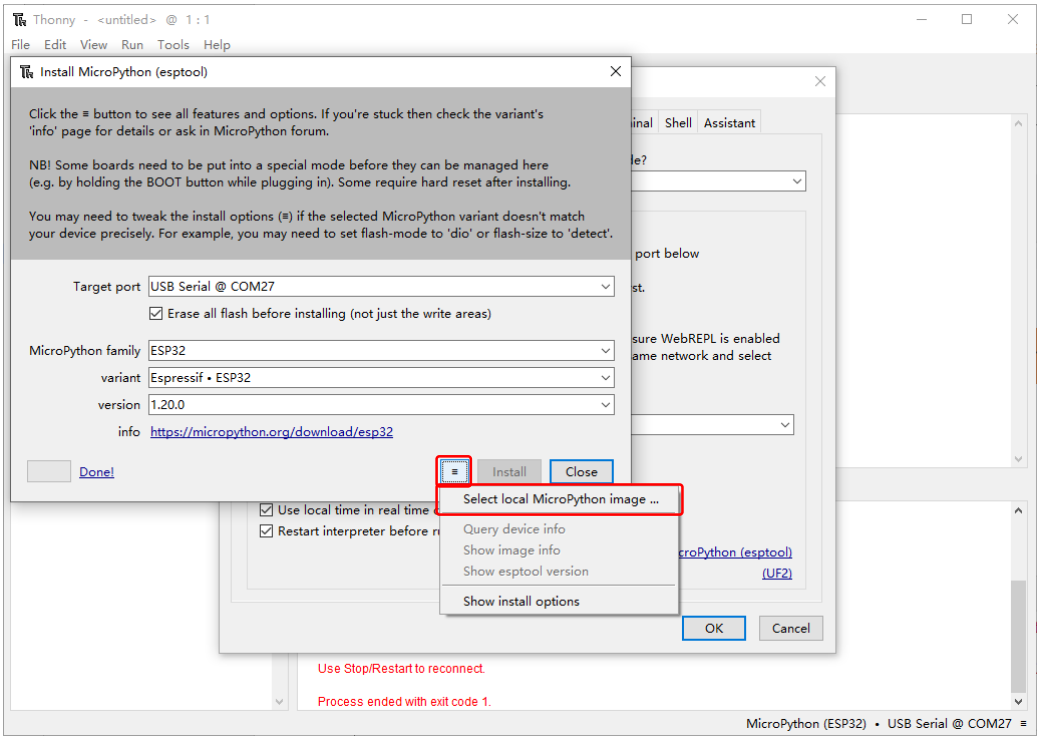
2. Select "Micropython (ESP32)", select "USB-SERIAL @ COM27", and then click "Install or update Micropython(esptool)"

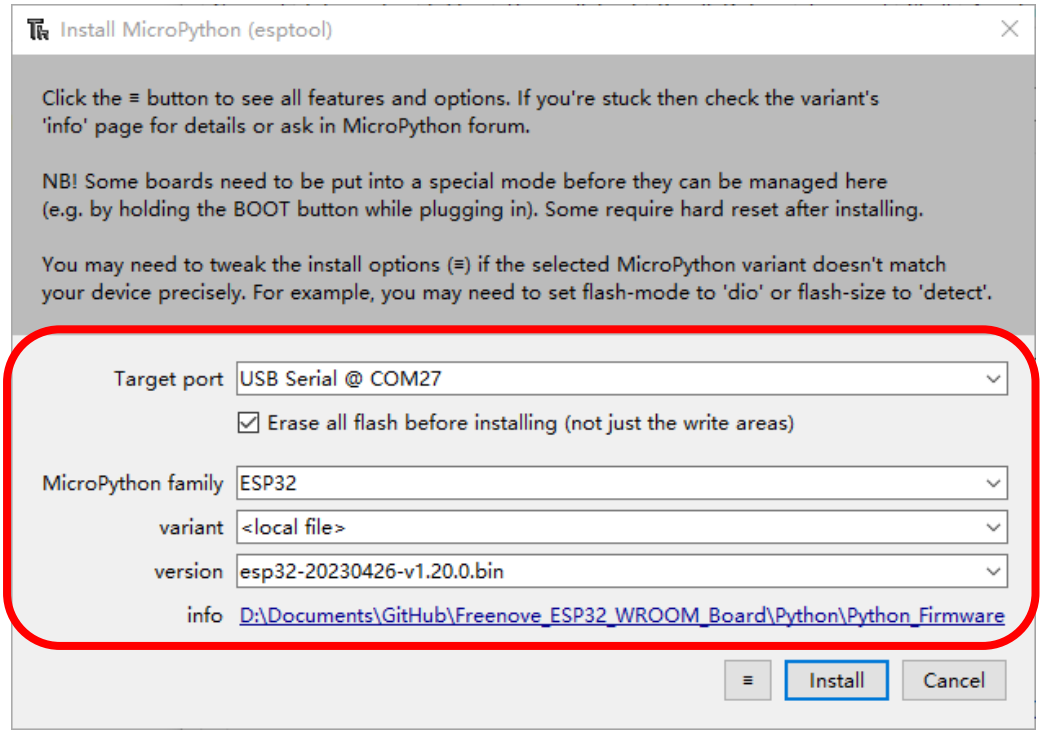


3. The following dialog box pops up. Select "USB-SERIAL @ COM27" for "Target port". For configuration information, see the following image

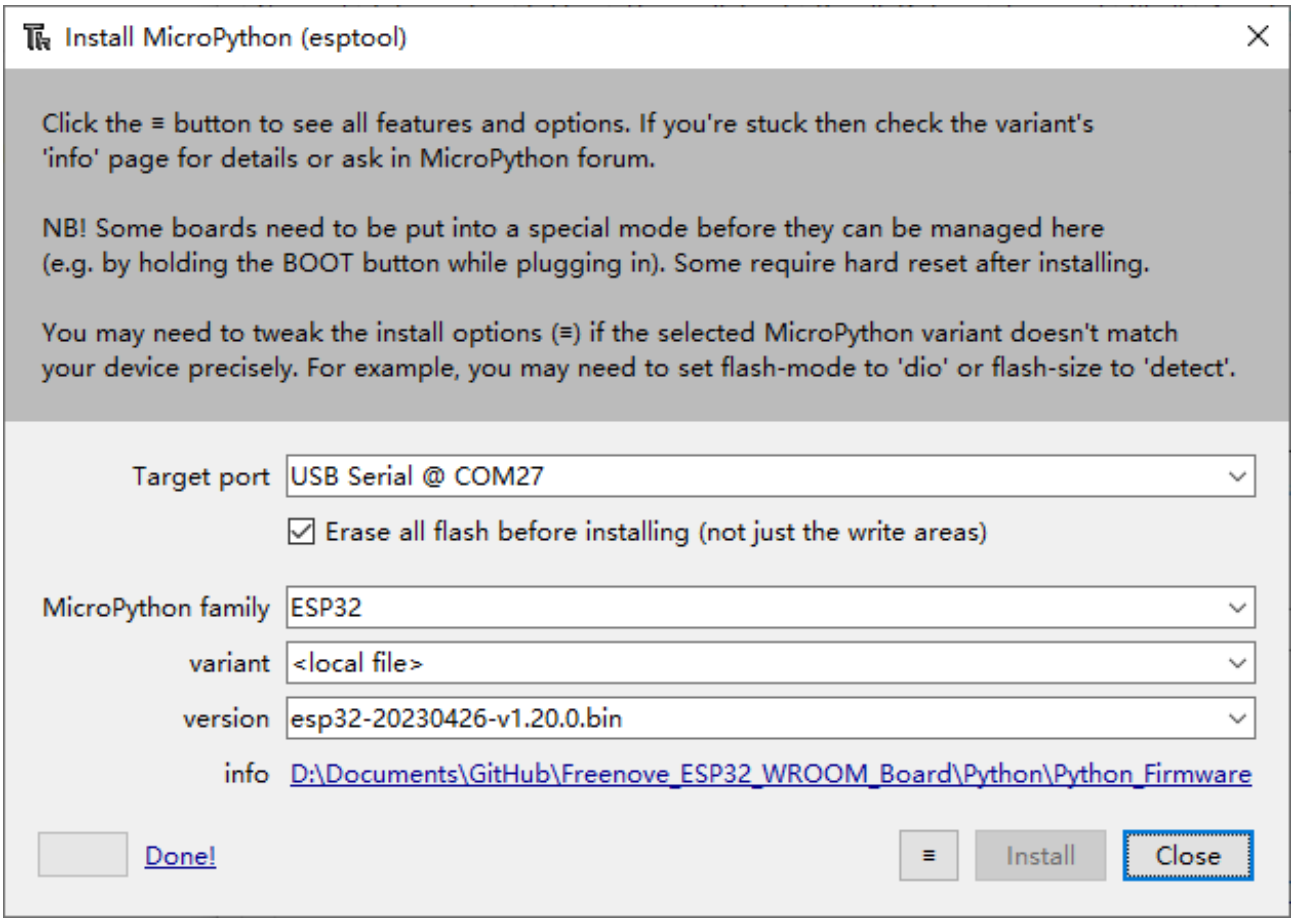


You can click the icon to the left of Install, then click Select local MicroPython image, and select the file we provide.

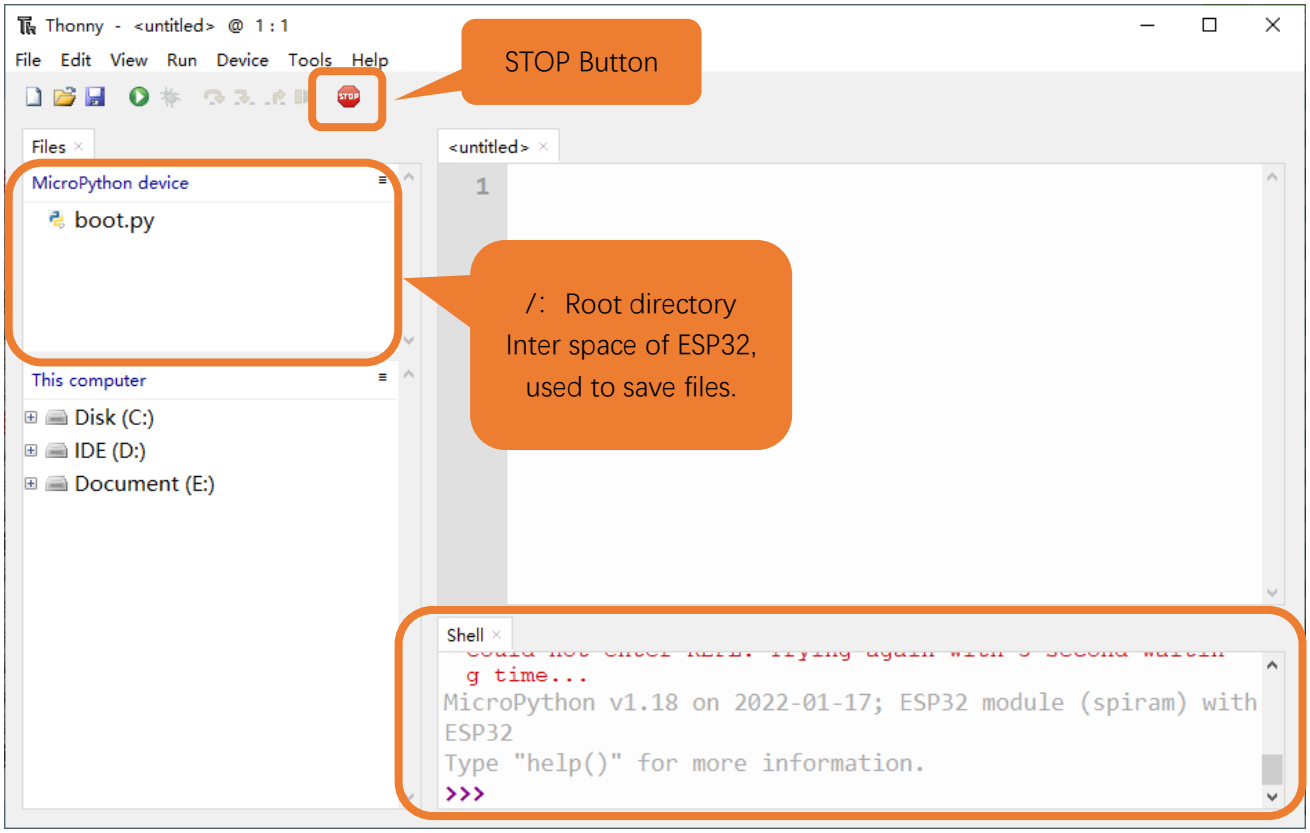




4. Wait for the installation to be done.



5. Close all dialog boxes, turn to main interface and click “STOP”. As shown in the illustration below

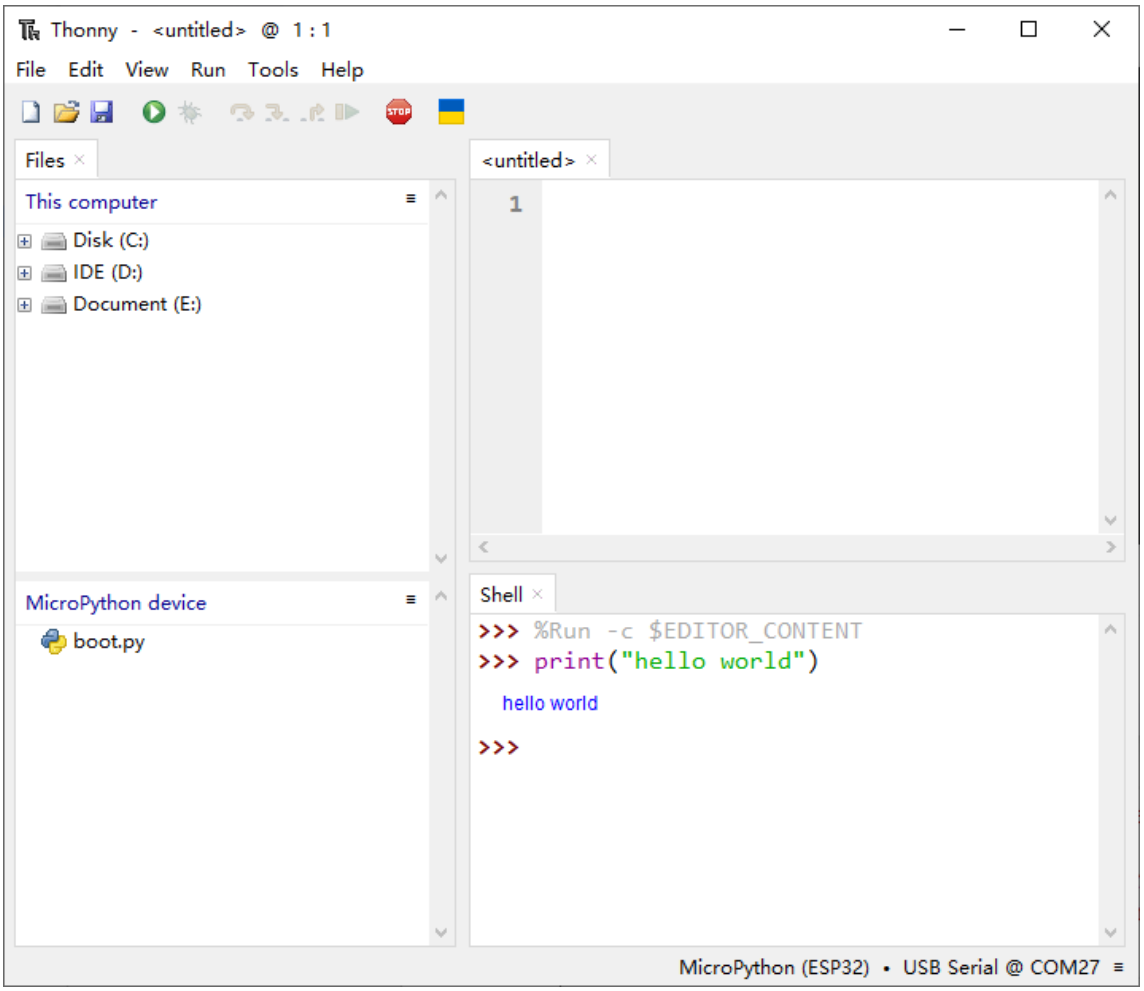


6. So far, all the preparations have been made.

0.5 Testing codes (Important)

Testing Shell Command

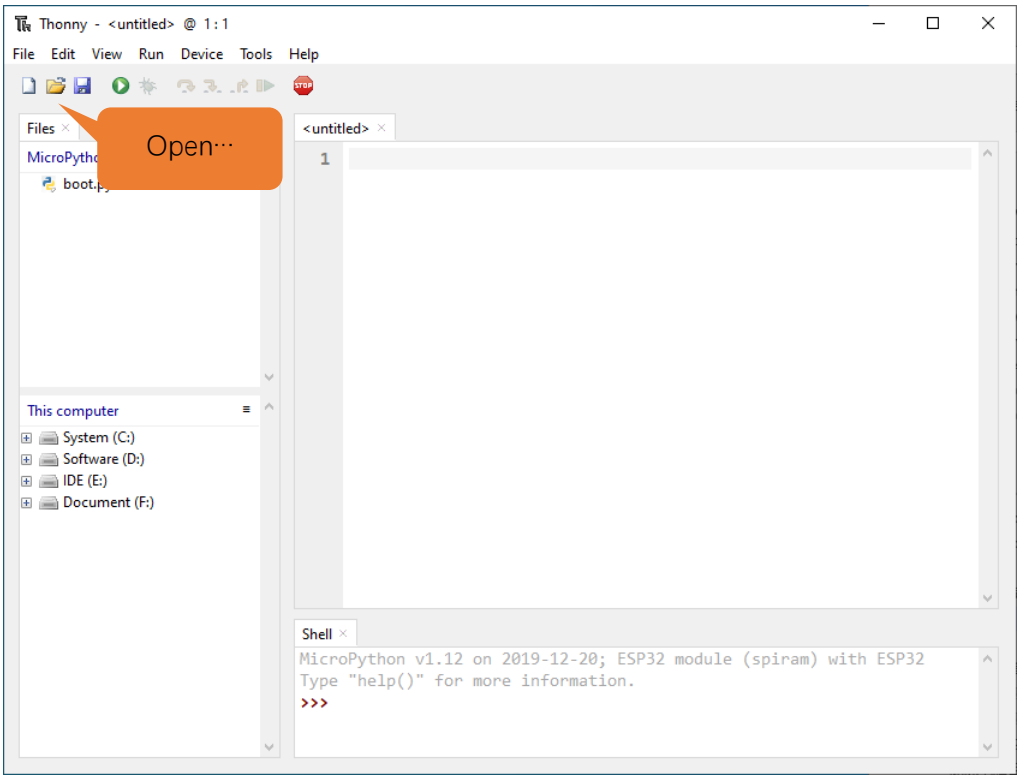
Enter "print('hello world')" in "Shell" and press Enter.



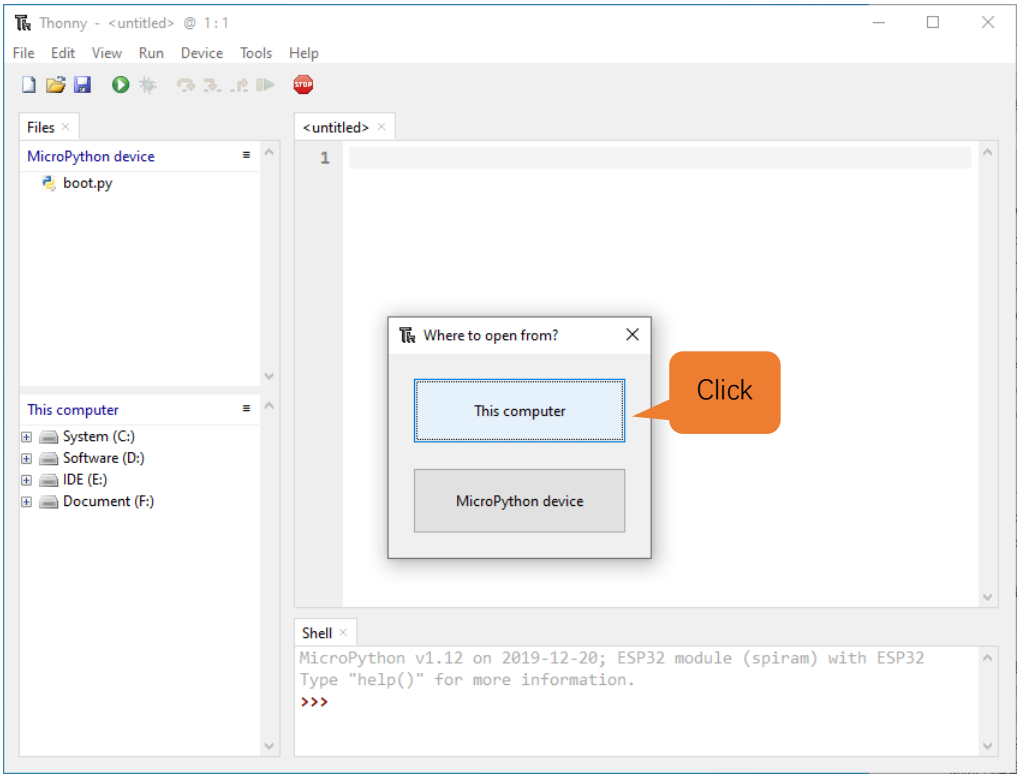
Running Online

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

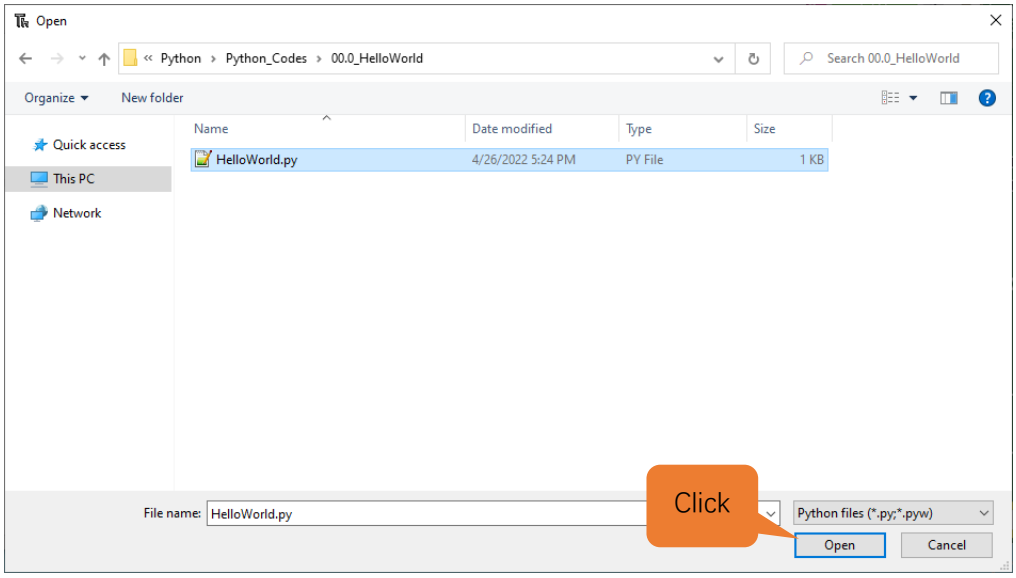
1. Open Thonny and click “Open···”.



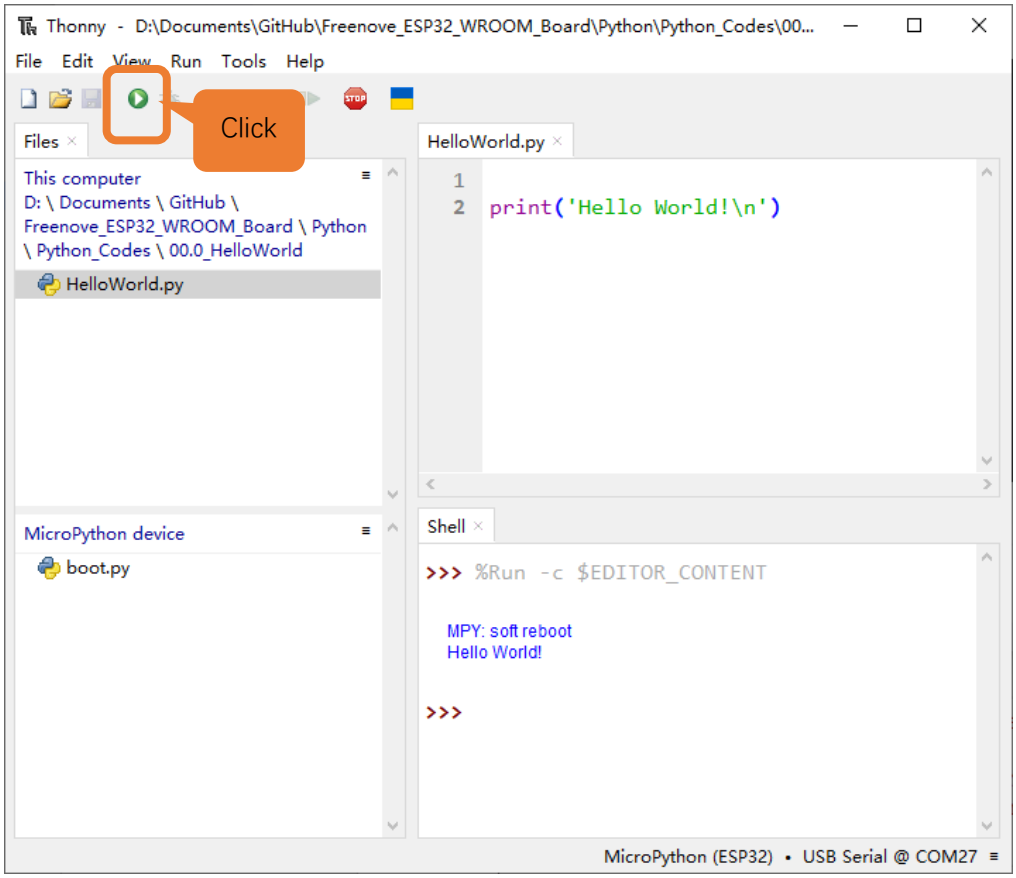
2. On the newly pop-up window, click “This computer”.



In the new dialog box, select "**HelloWorld.py**" in "**Freenove_ESP32_WROOM_Board/Python/Python_Codes/00.0_HelloWorld**" folder.



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

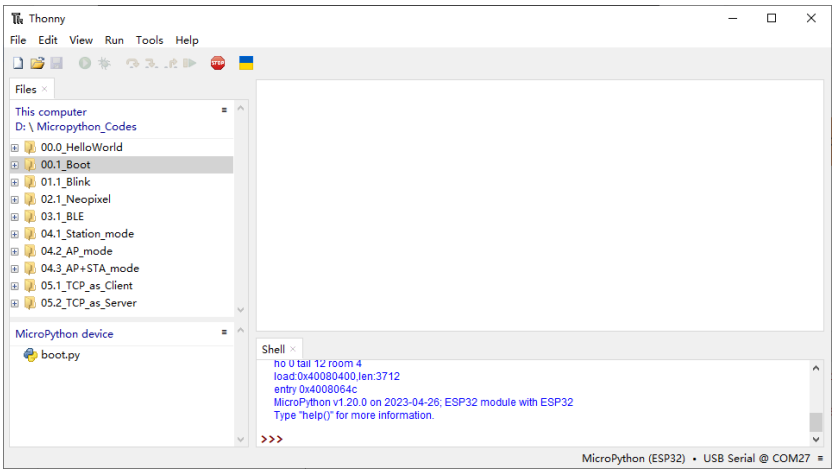


Note: When running online, if you press the reset key of ESP32, user's code will not be executed again. If you wish to run the code automatically after resetting the code, please refer to the following Running Offline.

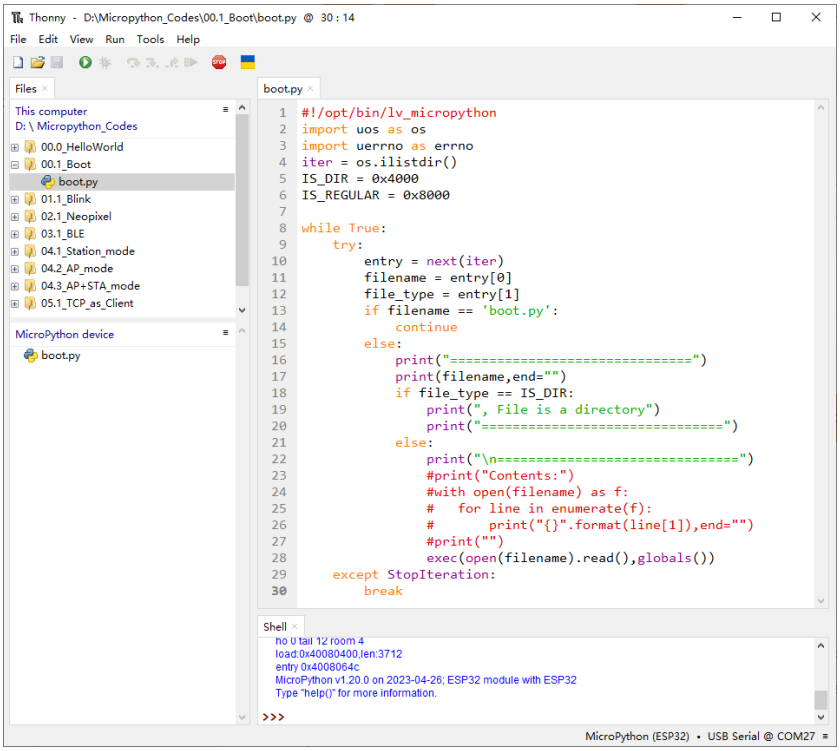
Running Offline （Importance）

After ESP32 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 execute user’s programs after resetting, we need to add a guiding program in boot.py to execute user’s code.

1. Move the program folder “**Freenove_ESP32_WROOM_Board/Python/Python_Codes**” to disk(D) in advance with the path of “**D:/Micropython_Codes**”. Open “Thonny”。

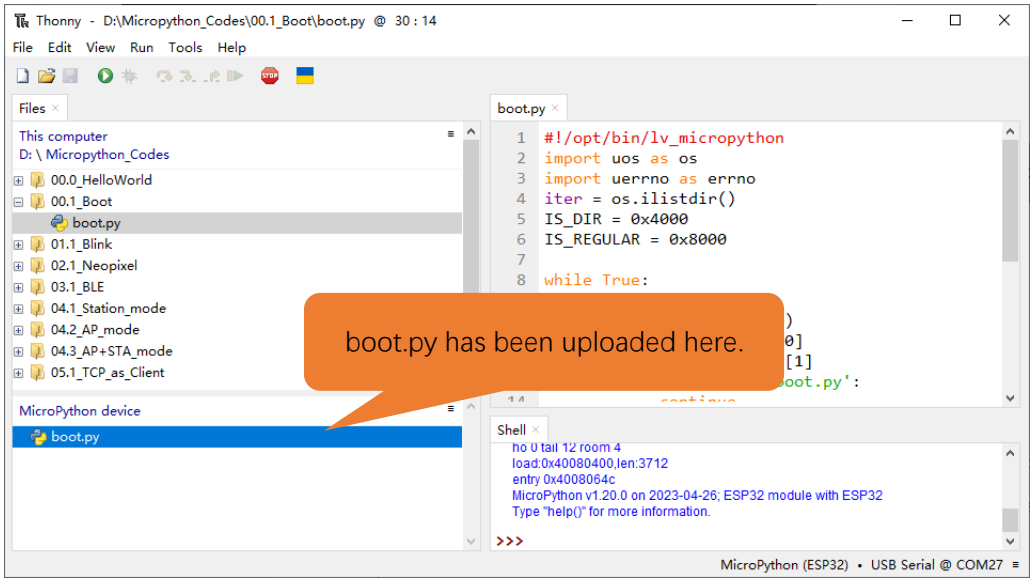


2. Expand “00.1_Boot” in the “Micropython_Codes” in the directory of disk(D), and double-click boot.py, which is provided by us to enable programs in “MicroPython device” to run offline.

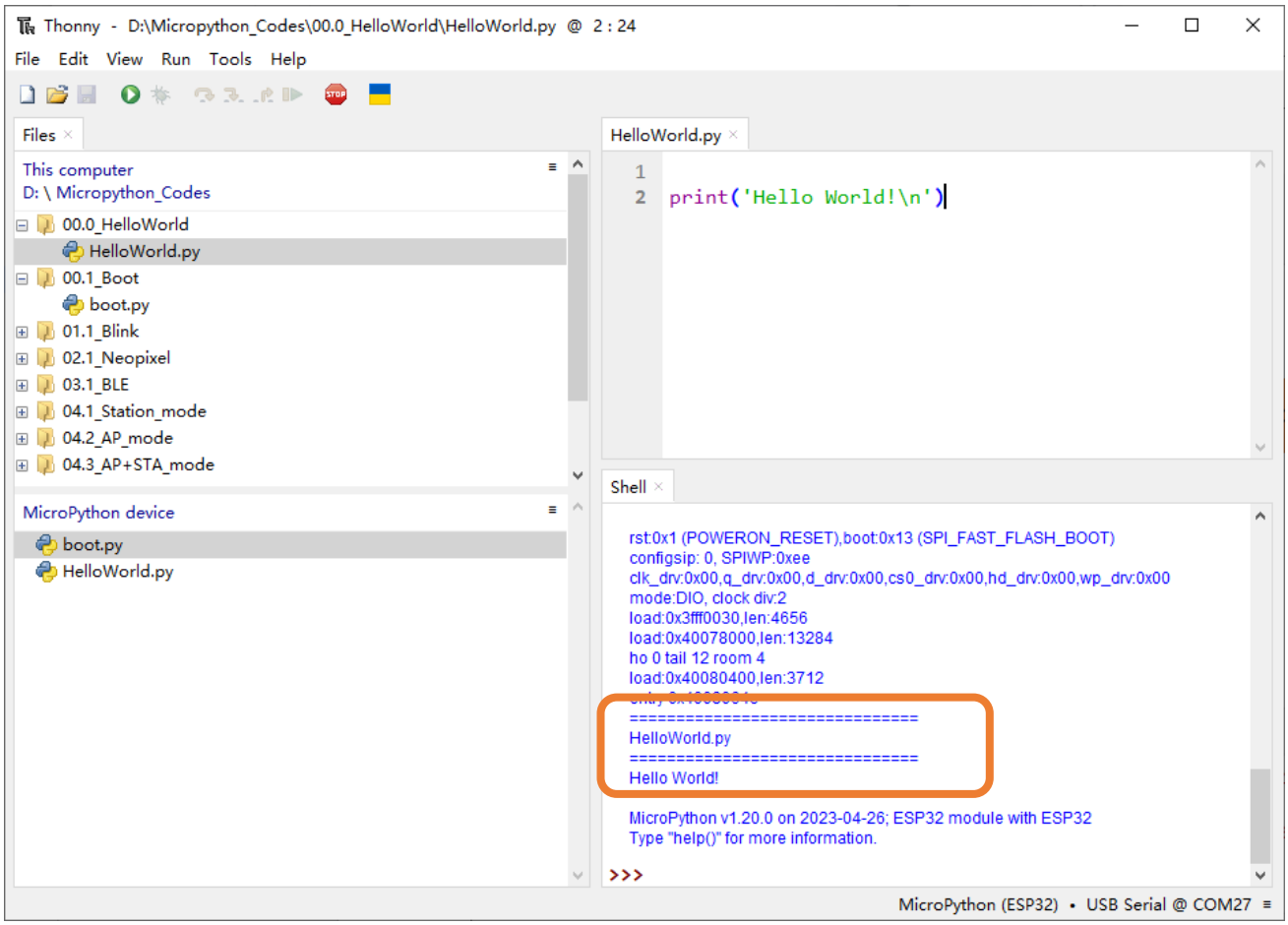


If you want your written programs to run offline, you need to upload boot.py we provided and all your codes to “MicroPython device” and press ESP32’s reset key. Here we use programs 00.0 and 00.1 as examples. Select “boot.py”, right-click to select “Upload to /”.

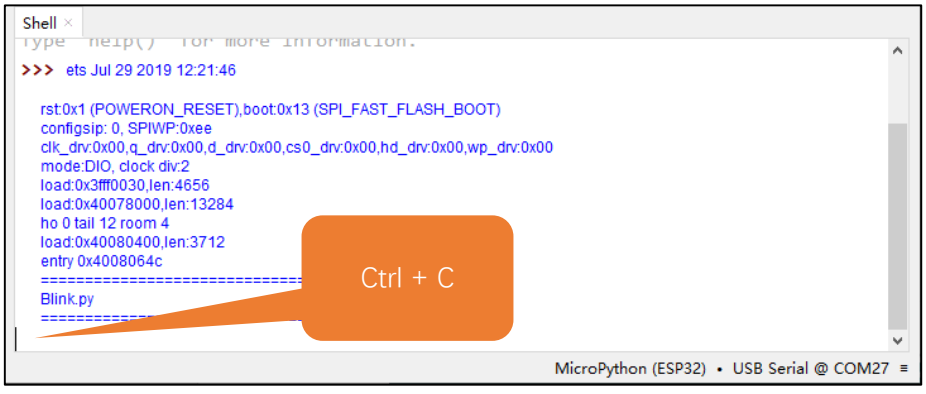
Similarly, upload “HelloWorld.py” to “MicroPython device”.

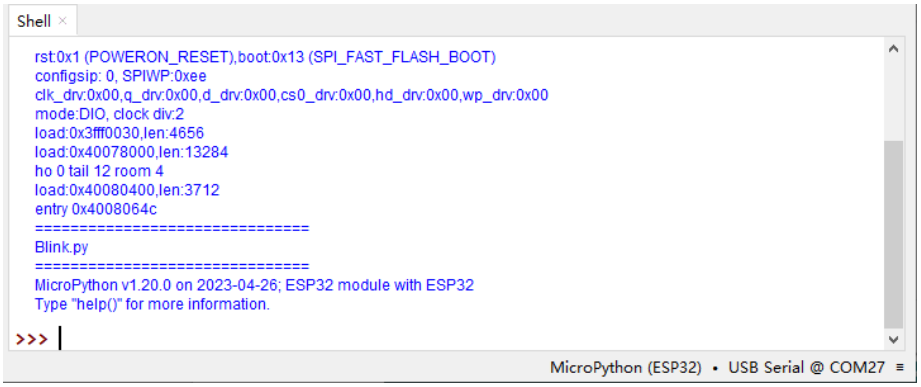


3. Press the reset key and in the box of the illustration below, you can see the code is executed.



Note: To exit Offline mode, press ctrl + C in the Shell at the same time.

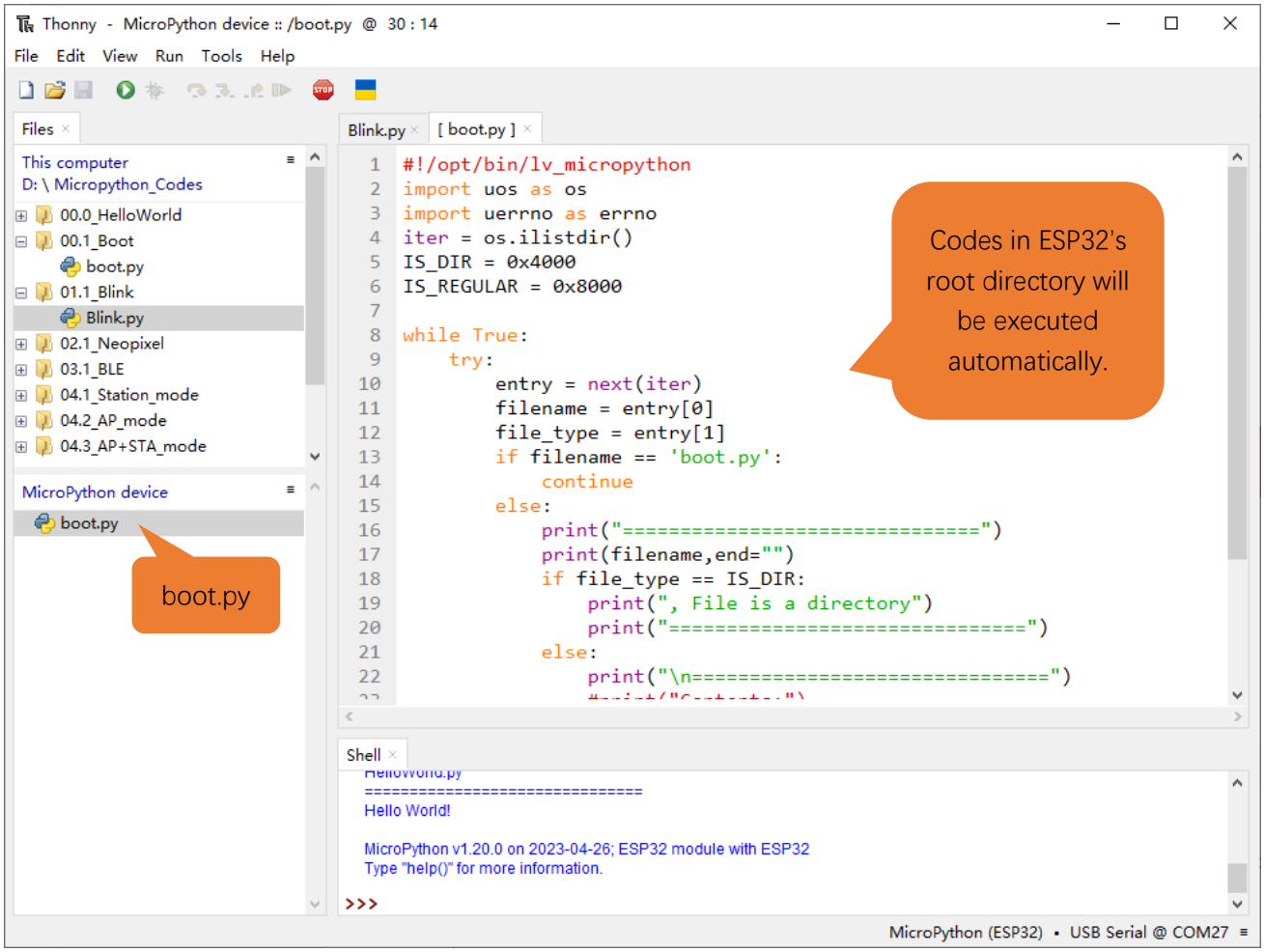




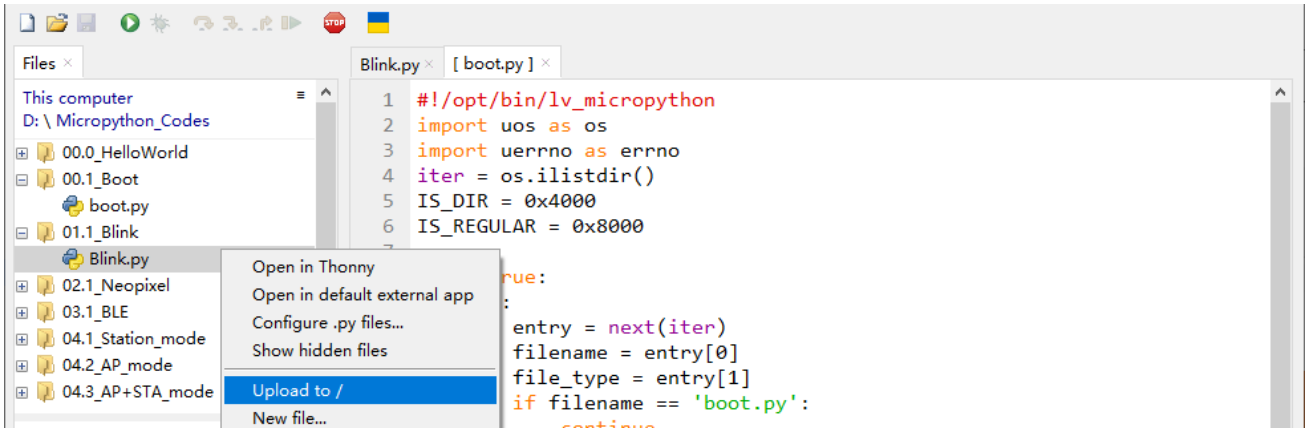
0.6 Thonny Common Operation

Uploading Code to ESP32

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

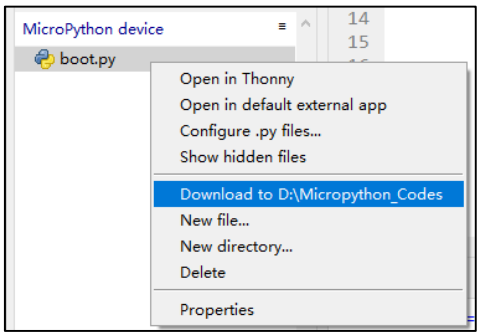


Select "Blink.py" in "01.1_Blink", right-click your mouse and select "Upload to /" to upload code to ESP32's root directory.



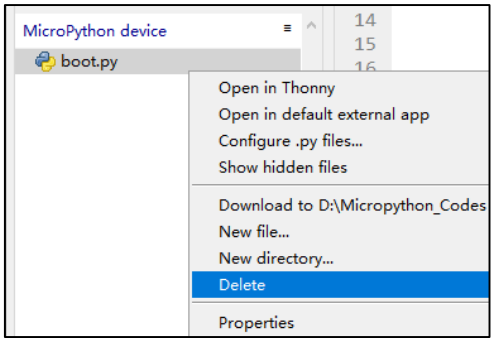
Downloading Code to Computer

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



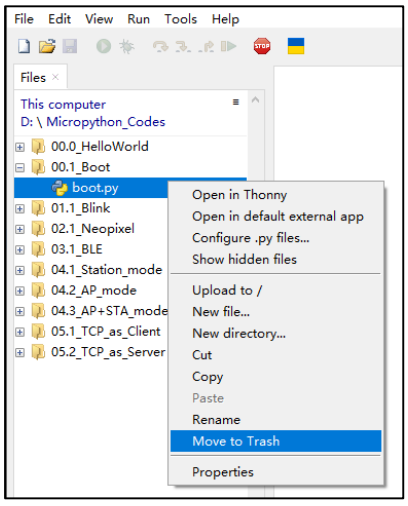
Deleting Files from ESP32's Root Directory

Select "boot.py" in "MicroPython device", right-click it and select "Delete" to delete "boot.py" from ESP32's root directory.



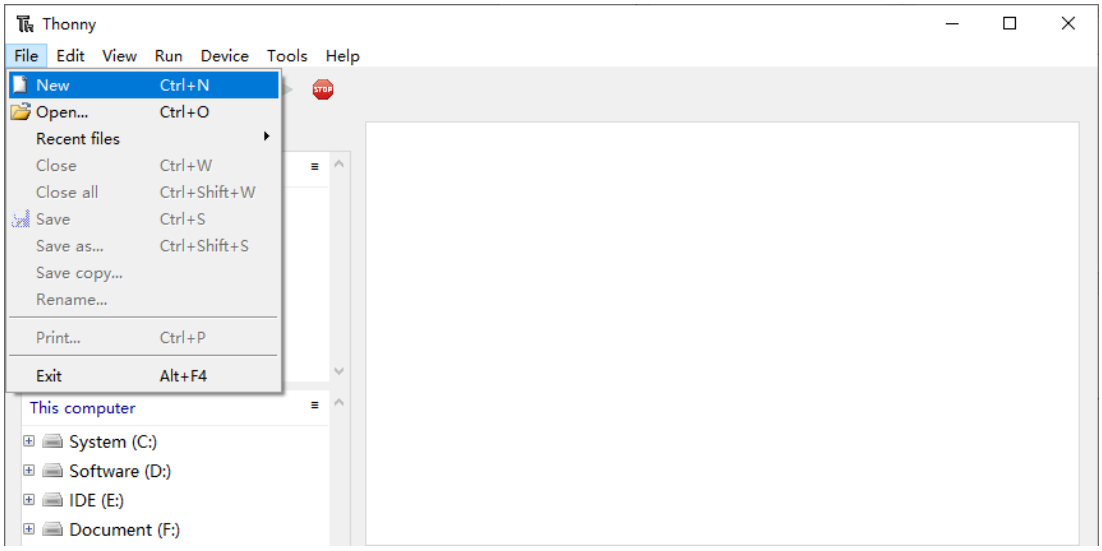
Deleting Files from your Computer Directory

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

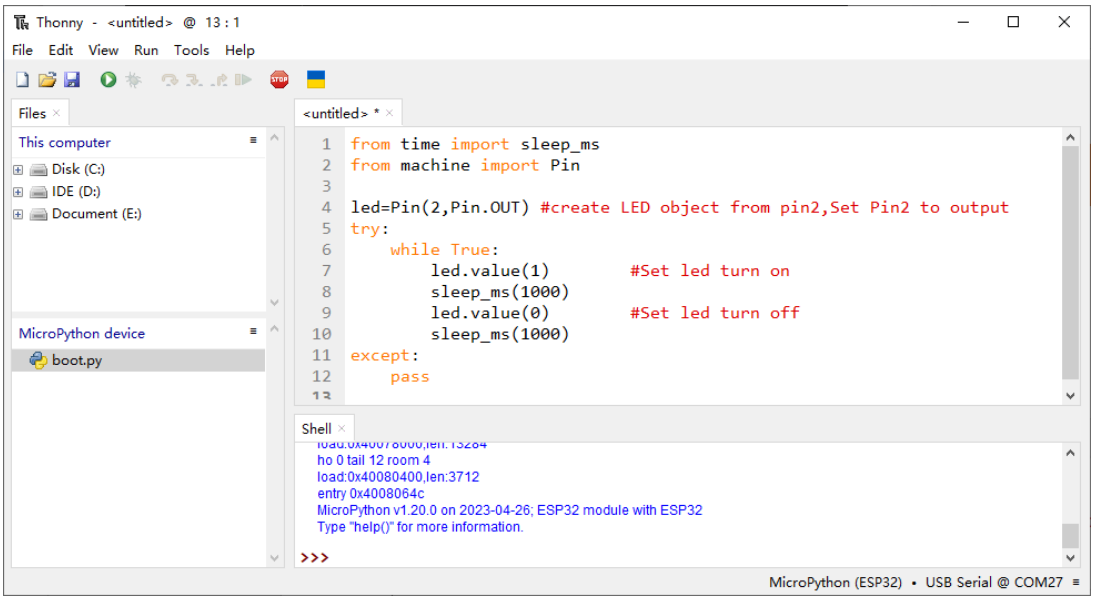


Creating and Saving the code

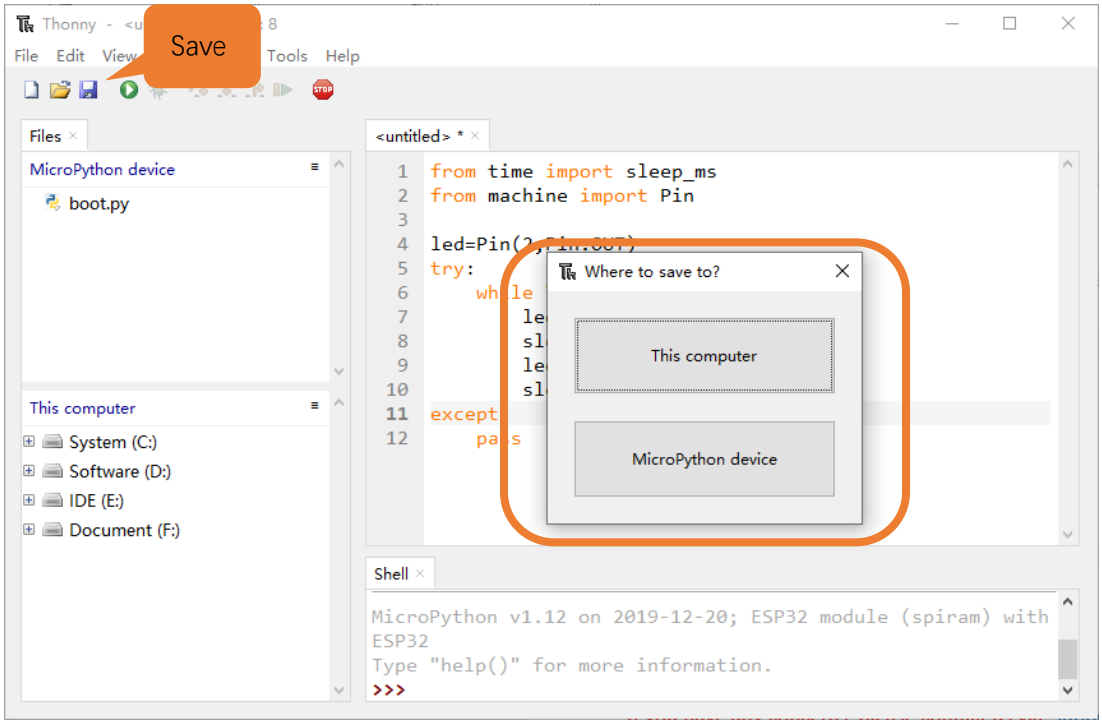
Click "File"→"New" to create and write codes.



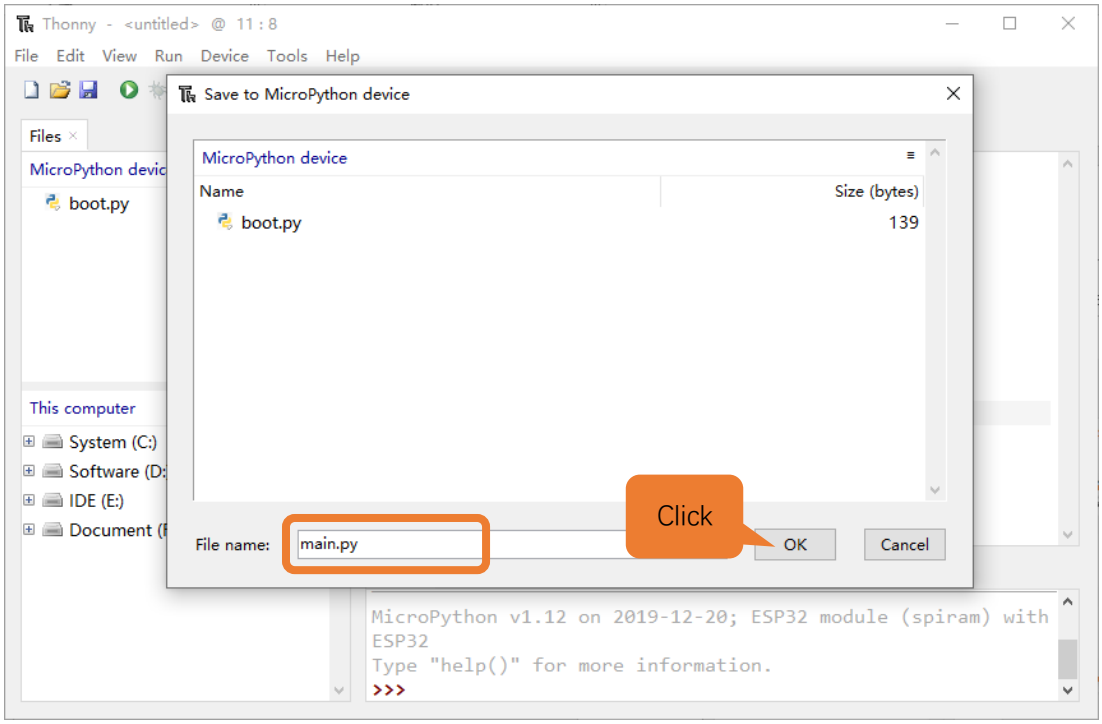
Enter codes in the newly opened file. Here we use codes of "01.1_Blink.py" as an example.



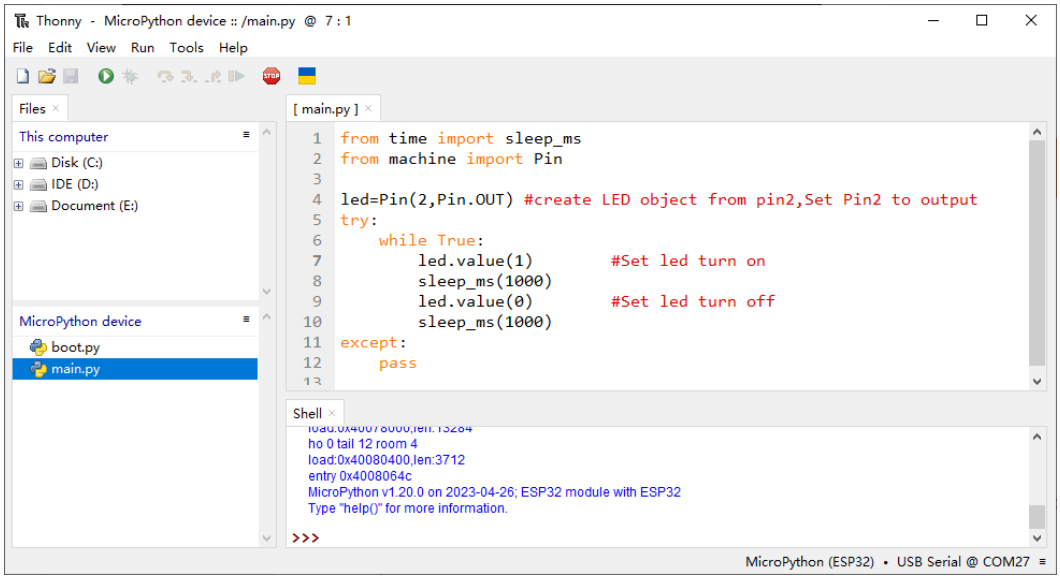
Click “Save” on the menu bar. You can save the codes either to your computer or to ESP32-WROOM.



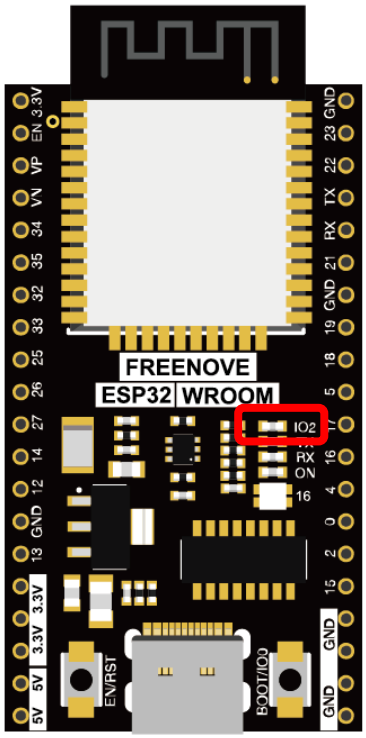
Select “MicroPython device”, enter “main.py” in the newly pop-up window and click “OK”.

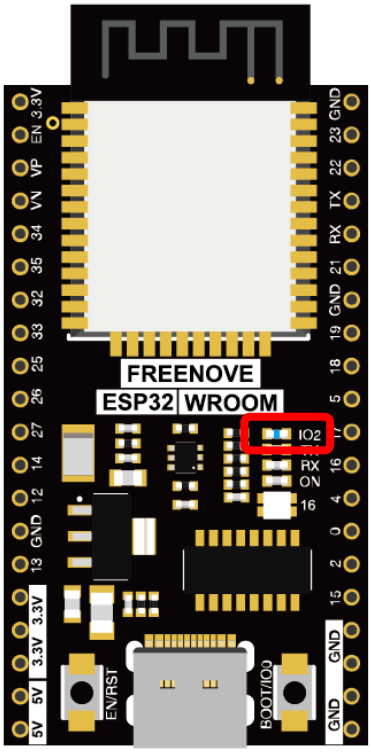


You can see that codes have been uploaded to ESP32-WROOM.



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.





0.7 Note

Though there are many pins available on ESP32, some of them have been connected to peripheral equipment, so we should avoid using such pins to prevent pin conflicts. For example, when downloading programs, make sure that the pin state of Strapping Pin, when resetting, is consistent with the default level; do NOT use Flash Pin; Do NOT use Cam Pin when using Camera function.

Strapping Pin

The state of Strapping Pin can affect the functions of ESP32 after it is reset, as shown in the table below.

Voltage of Internal LDO (VDD_SDIO)			
Pin	Default	3.3 V	1.8 V
MTDI	Pull-down	0	1
Booting Mode			
Pin	Default	SPI Boot	Download Boot
GPIO0	Pull-up	1	0
GPIO2	Pull-down	Don't-care	0
Enabling/Disabling Debugging Log Print over U0TXD During Booting			
Pin	Default	U0TXD Active	U0TXD Silent
MTDO	Pull-up	1	0

Timing of SDIO Slave					
Pin	Default	Falling-edge Sampling Falling-edge Output	Falling-edge Sampling Rising-edge Output	Rising-edge Sampling Falling-edge Output	Rising-edge Sampling Rising-edge Output
MTDO	Pull-up	0	0	1	1
GPIO5	Pull-up	0	1	0	1

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.

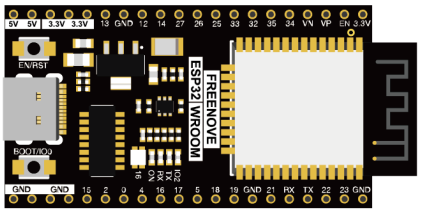
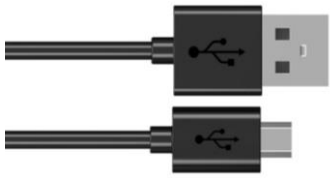
Chapter 1 LED (Important)

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

Project 1.1 Blink

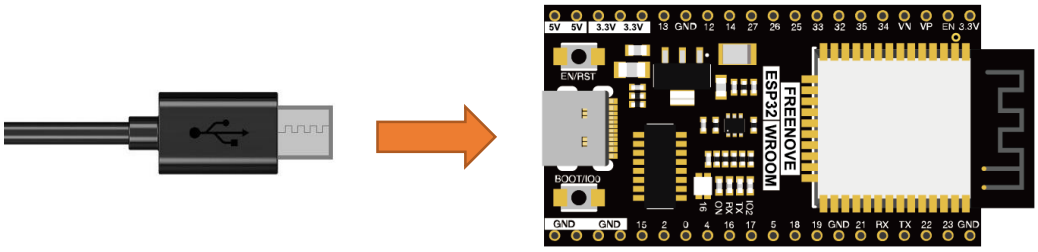
In this project, we will use ESP32 to control blinking a common LED.
If you have not yet installed Thonny, click here.
If you have not yet downloaded Micropython Firmware, click here.
If you have not yet loaded Micropython Firmware, click here.

Component List

ESP32-WROOM x1 	USB cable 

Power

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



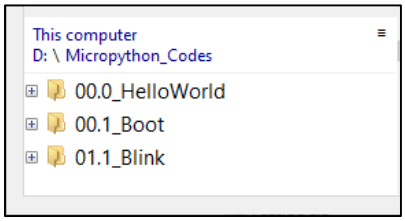
In the following projects, we only use USB cable to power ESP32-WROOM by default.

Code

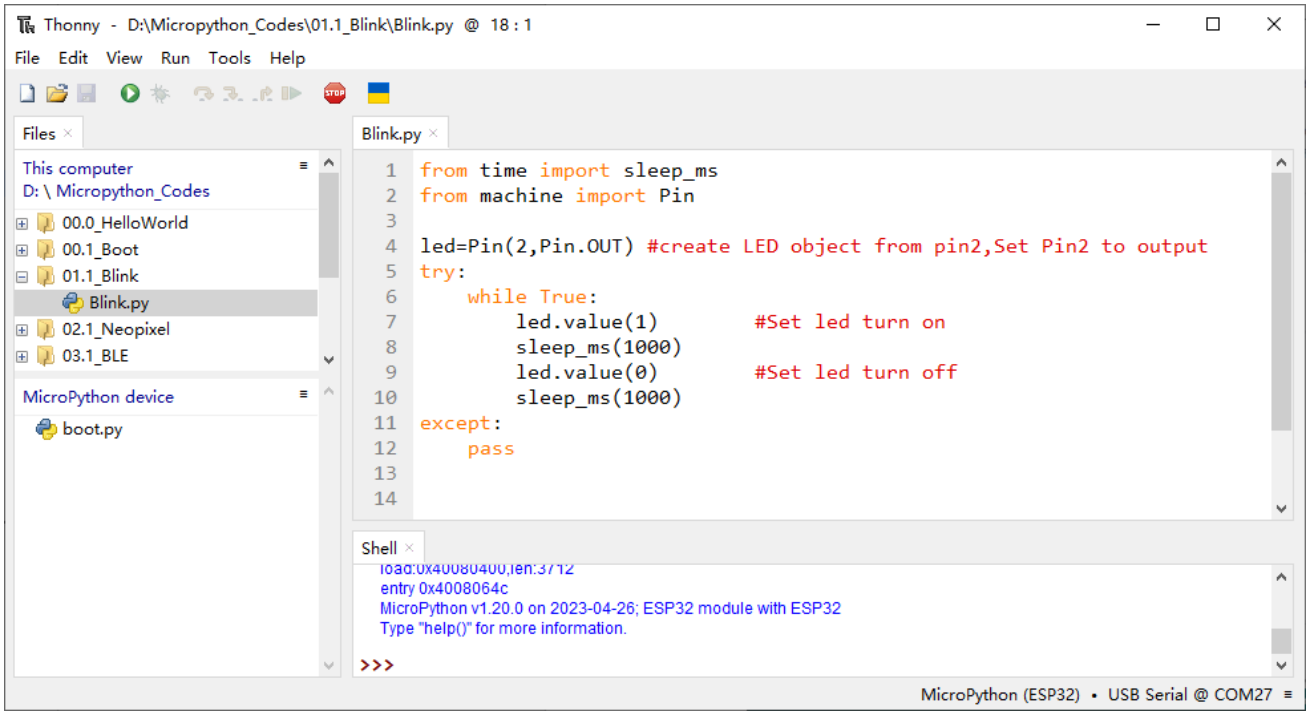
Codes used in this tutorial are saved in "**Freenove_ESP32_WROOM_Board/Python/Python_Codes**". You can move the codes to any location. For example, we save the codes in Disk(D) with the path of "**D:/Micropython_Codes**".

01.1_Blink

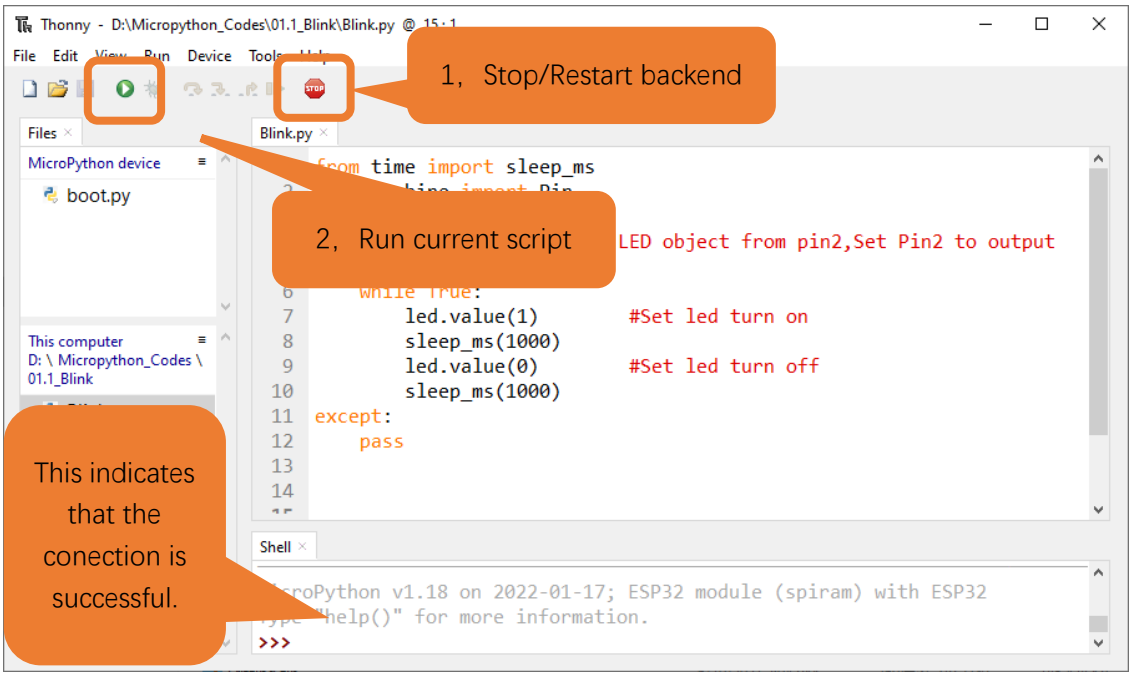
Open "Thonny", click "This computer"→"D:"→"Micropython_Codes".



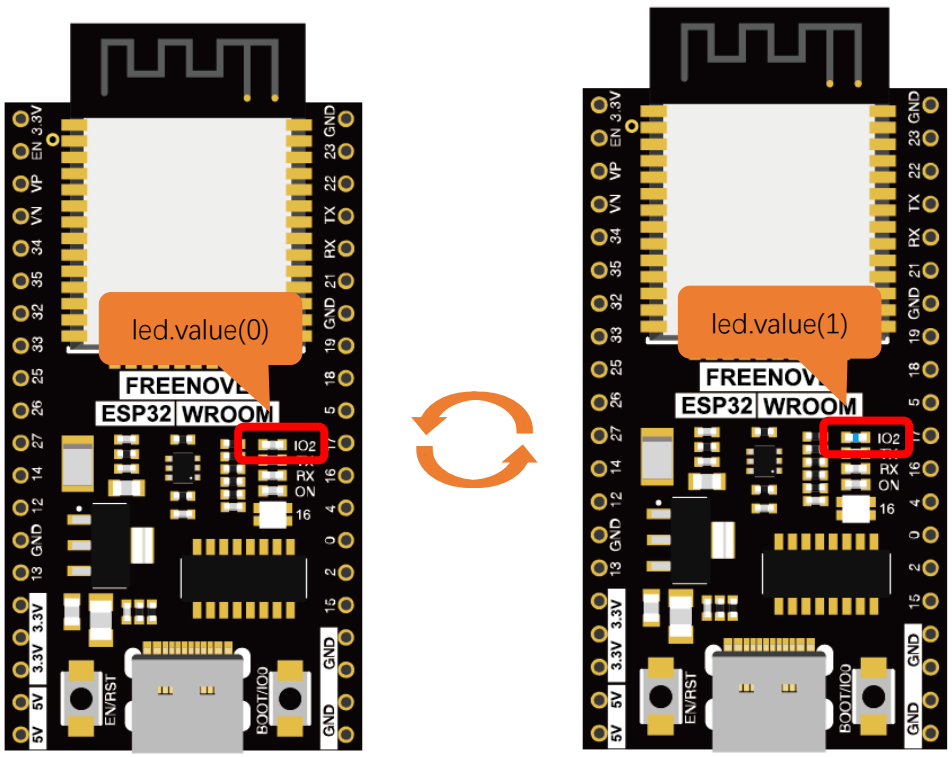
Expand folder "01.1_Blink" and double click "Blink.py" to open it. As shown in the illustration below.



Make sure ESP32 has been connected with the computer with ESP32 correctly. Click "Stop/Restart 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.

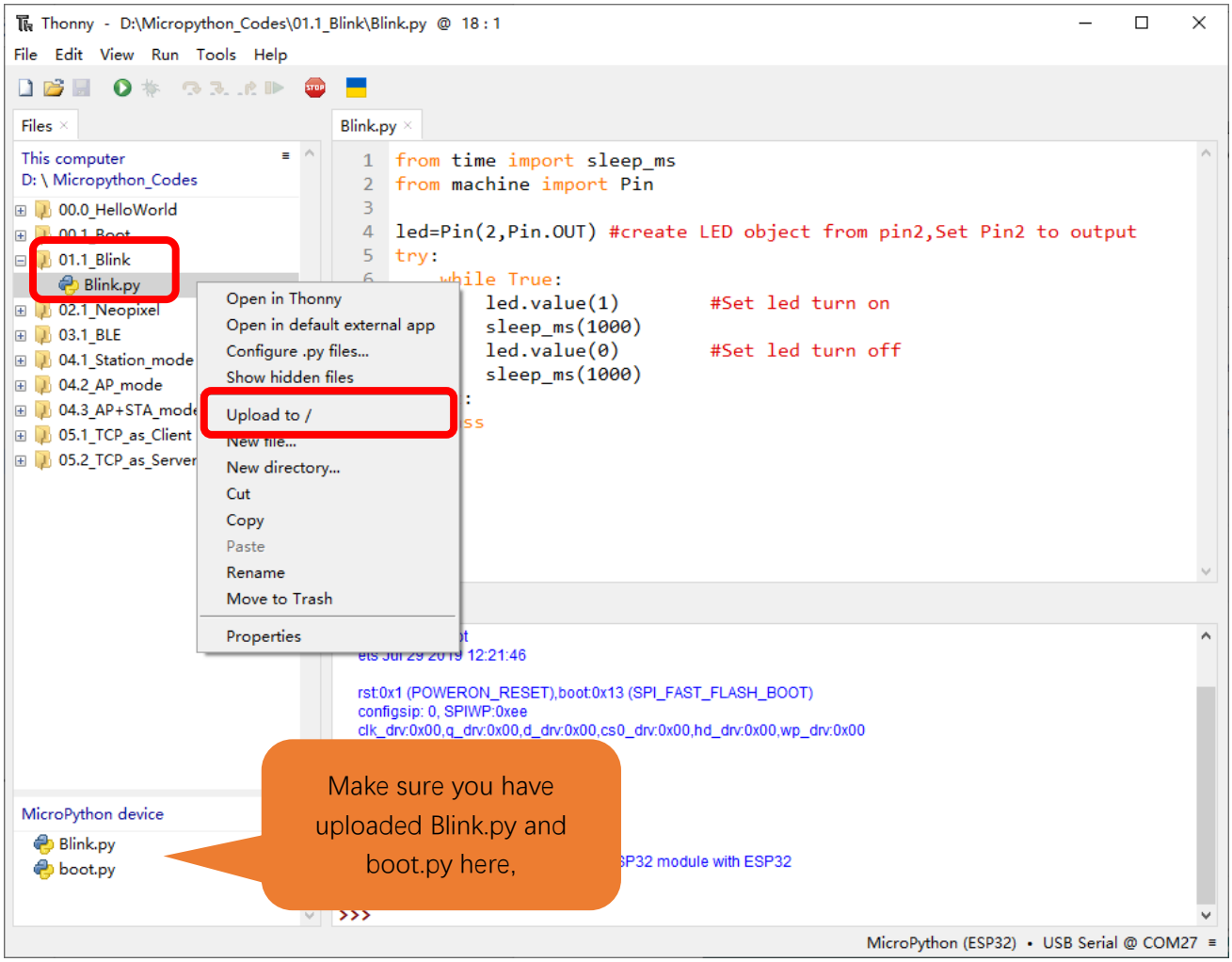


Note:

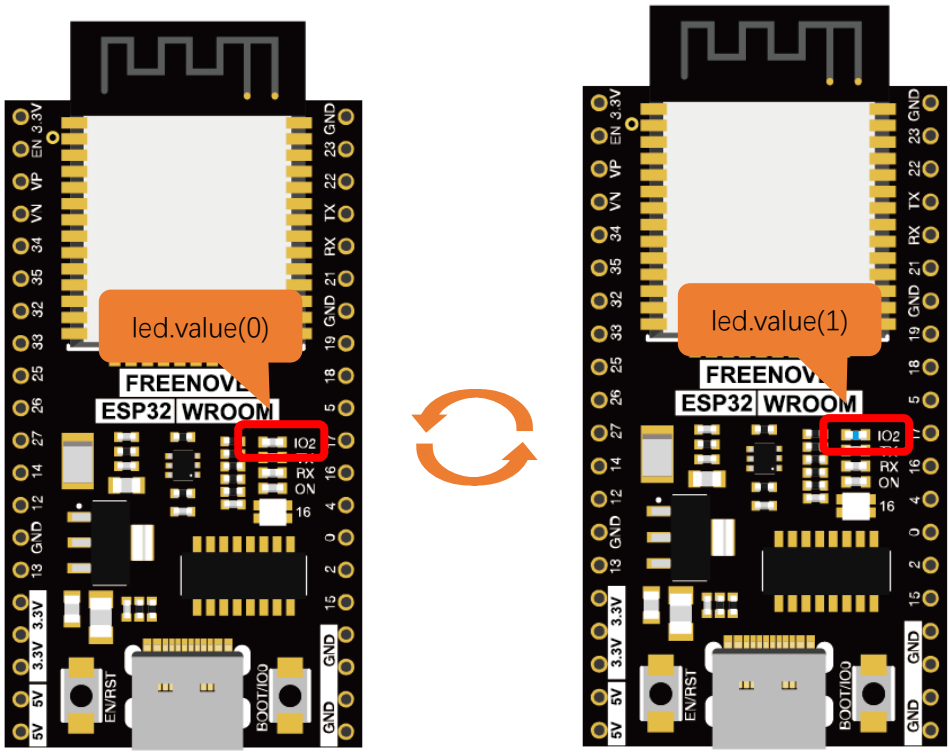
This is the code running online. If you disconnect USB cable and repower ESP32 or press its reset key, LED stops blinking and the following messages will be displayed in Thonny.

Uploading code to ESP32

As shown in the following illustration, right-click the file Blink.py and select "Upload to /" to upload code to ESP32.

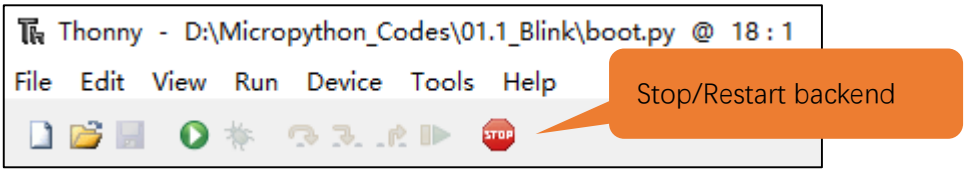


Press the reset key of ESP32 and you can see LED is ON for one second and then OFF for one second, which repeats in an endless loop.



Note:

Codes here is run offline. If you want to stop running offline and enter Shell, just click "Stop" in Thonny.

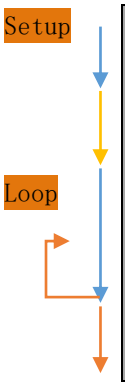


If you have any concerns, please contact us via: support@freenove.com

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.




```
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:
…          ...
11 except:
12     pass
```

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 ESP32, 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-WROOM 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 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   except:
12       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().

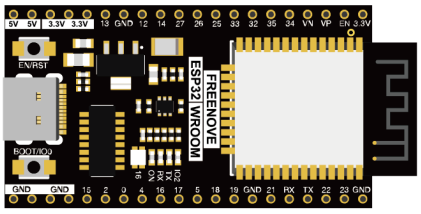
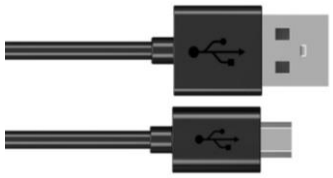
old_t: Starting time

new_t: Ending time

Chapter 2 WS2812

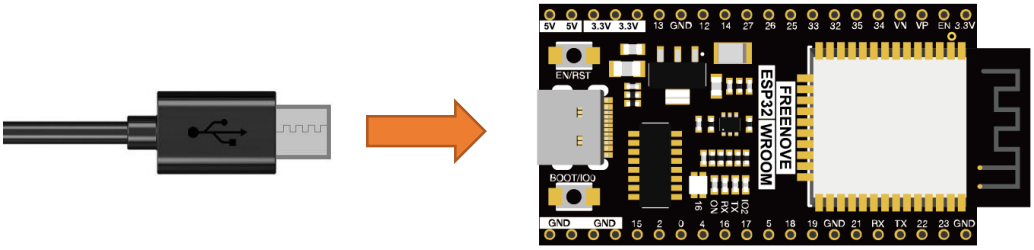
This chapter will help you learn to use a more convenient RGB LED lamp, which requires only one GPIO control and can be connected in infinite series in theory. Each LED can be controlled independently.

Component List

ESP32-WROOM x1 	USB cable 

Circuit

Connect your computer and ESP32 with a USB cable.

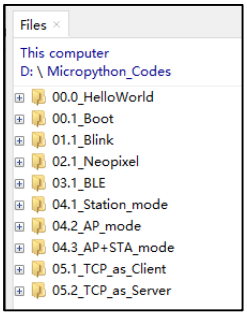


Code

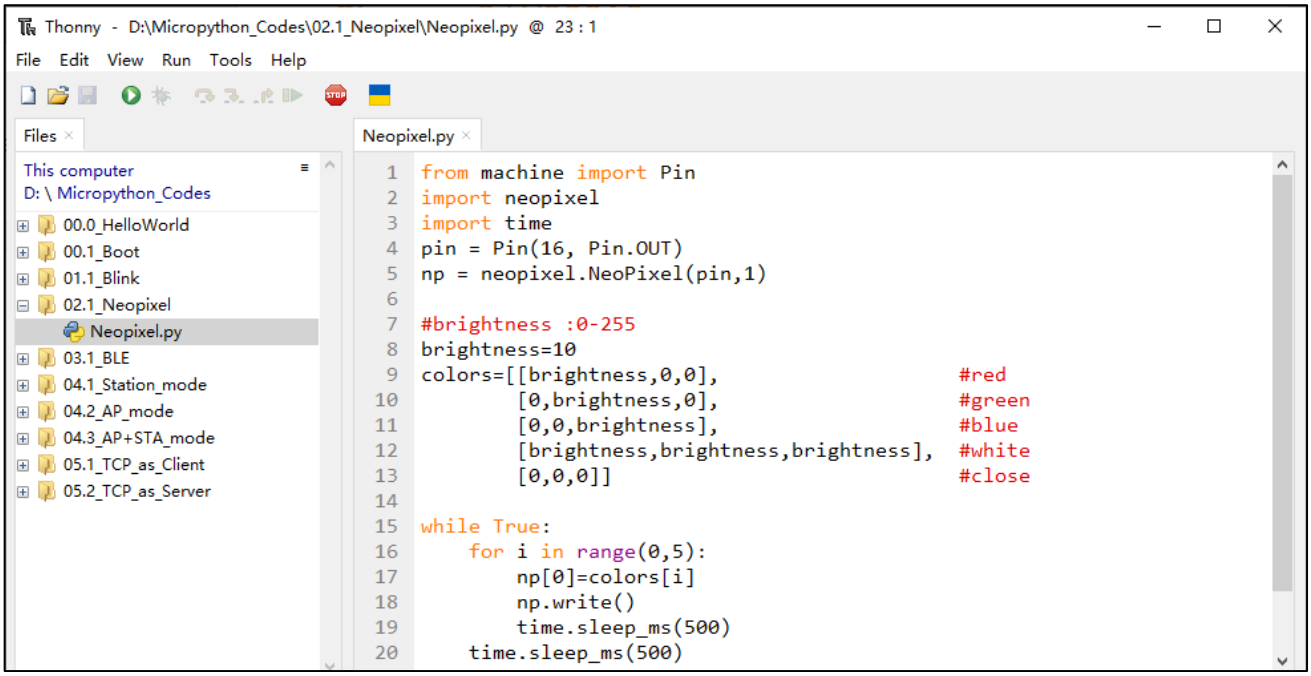
Codes used in this tutorial are saved in "**Freenove_ESP32_WROOM_Board/Python/Python_Codes**". You can move the codes to any location. For example, we save the codes in Disk(D) with the path of "**D:/Micropython_Codes**".

02.1_Neopixels

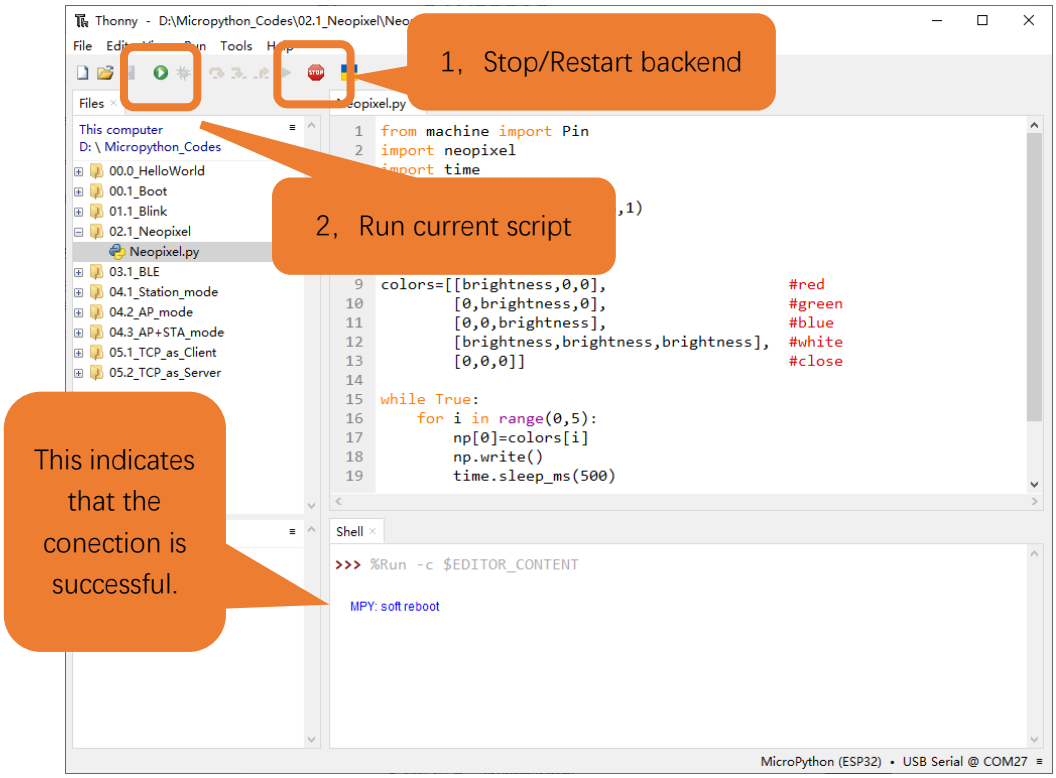
Open "Thonny", click "This computer"→"D:"→"Micropython_Codes".



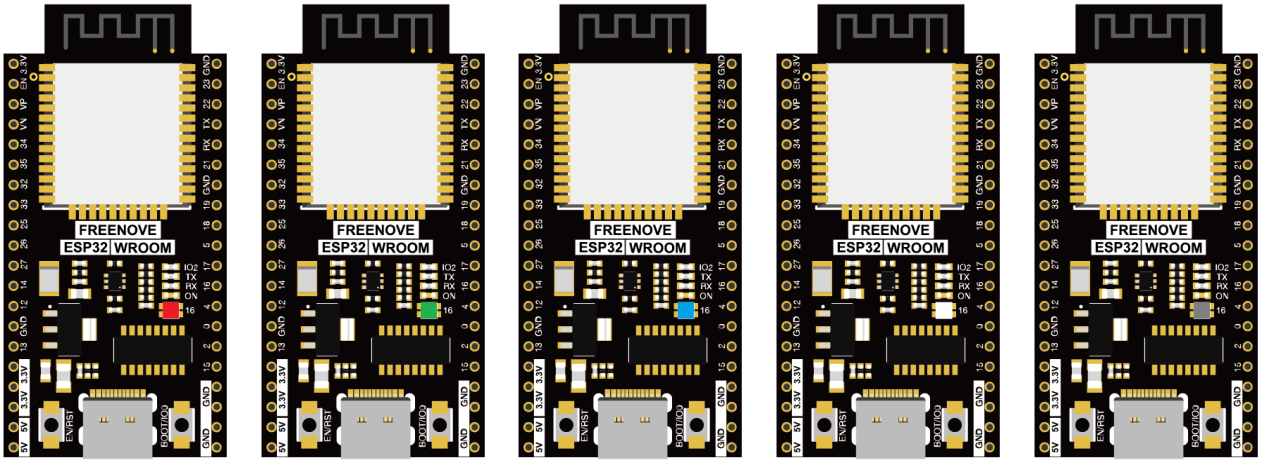
Expand folder “02.1_Neopixel” and double click “Neopixel.py” to open it. As shown in the illustration below.



Make sure ESP32 has been connected with the computer with ESP32 correctly. Click “Stop/Restart 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, and RGB LED begins to light up in red, green, blue, white and black.



The following is the program code:

```
from machine import Pin
import neopixel
import time
pin = Pin(16, Pin.OUT)
np = neopixel.NeoPixel(pin,1)

#brightness :0-255
brightness=10
colors=[[brightness,0,0],                       #red
        [0,brightness,0],                       #green
        [0,0,brightness],                       #blue
        [brightness,brightness,brightness],     #white
        [0,0,0]]                                #close

while True:
    for i in range(0,5):
        np[0]=colors[i]
        np.write()
        time.sleep_ms(500)
    time.sleep_ms(500)
```

Each time when using the functions of ESP32, you need to import modules corresponding to those functions: Import sleep_ms module of time module and Pin module of machine module.

```
from machine import Pin
import neopixel
import time
```

Initializes the neopixel pin.

```
pin = Pin(16, Pin.OUT)
np = neopixel.NeoPixel(pin,1)
```

Define the color values to be used, as red, green, blue, white, and black.

```
colors=[[brightness,0,0],                       #red
        [0,brightness,0],                       #green
```

```
11          [0,0,brightness],                   #blue
12          [brightness,brightness,brightness], #white
13          [0,0,0]]                            #close
```

Displays a color every 500 milliseconds. After each execution of the for loop, wait 500 milliseconds. Each time the write() function is called, the corresponding color sample is displayed.

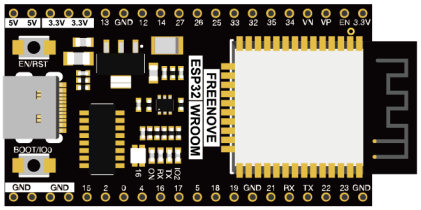
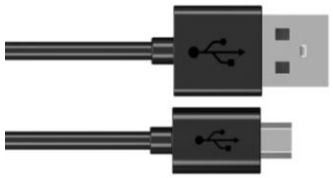
```
15  while True:
16      for i in range(0,5):
17          np[0]=colors[i]
18          np.write()
19          time.sleep_ms(500)
20      time.sleep_ms(500)
```

Chapter 3 Bluetooth

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

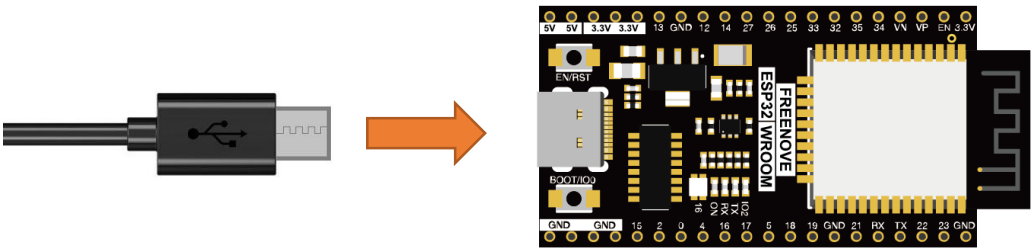
Project 3.1 Bluetooth Low Energy Data Passthrough

Component List

ESP32-WROOM x1 	USB cable 

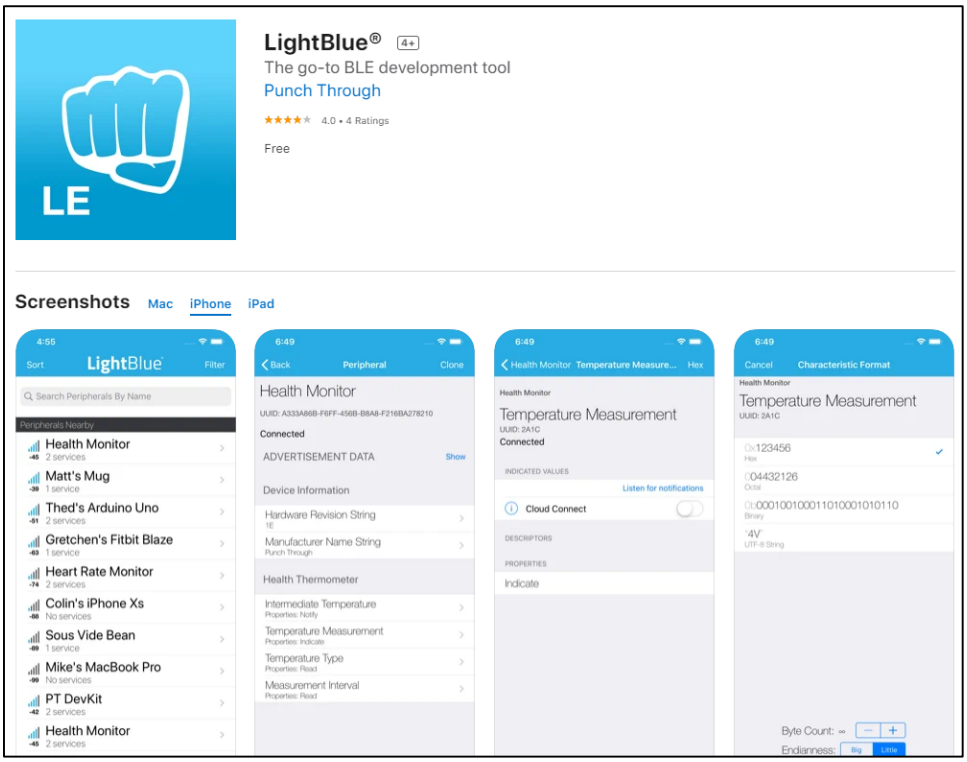
Circuit

Connect your computer and ESP32 with a USB cable.



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

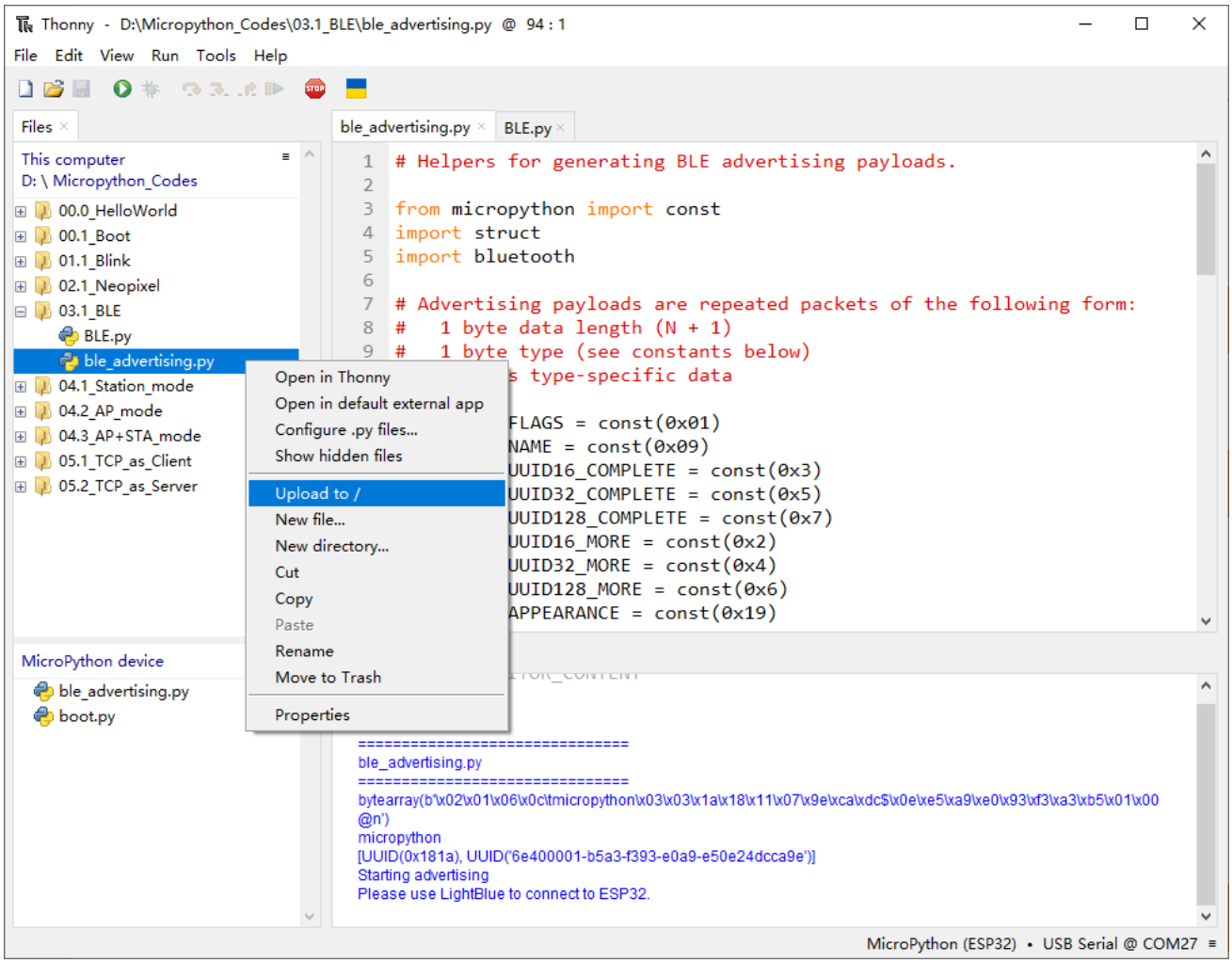


Code

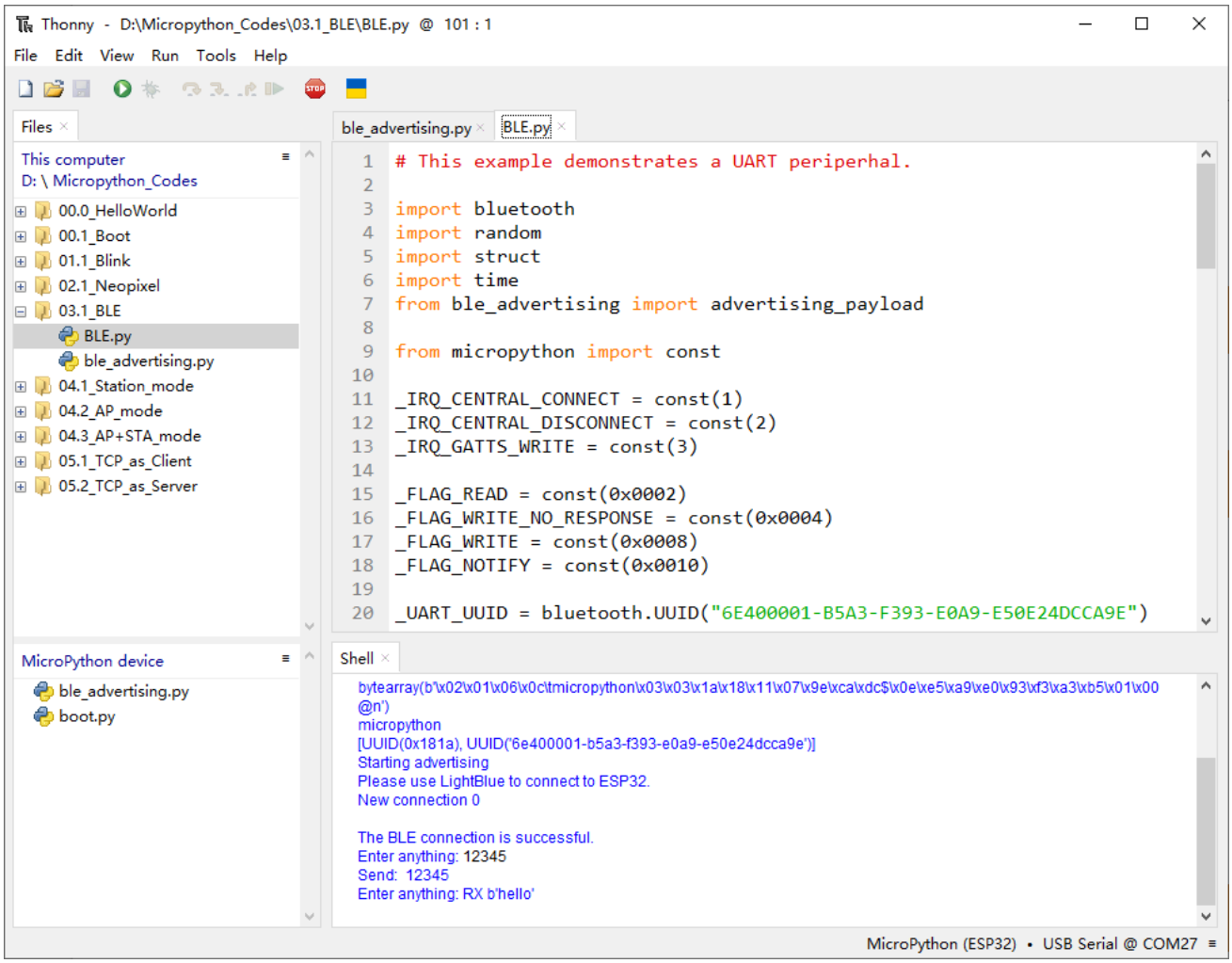
Move the program folder "**Freenove_ESP32_WROOM_Board/Python/Python_Codes**" to disk(D) in advance with the path of "**D:/Micropython_Codes**".

Open "Thonny", click "This computer" → "D:" → "Micropython_Codes" → "03.1_BLE". Select "ble_advertising.py", right click your mouse to select "Upload to /", wait for "ble_advertising.py" to be uploaded to ESP32-WROOM and then double click "BLE.py".

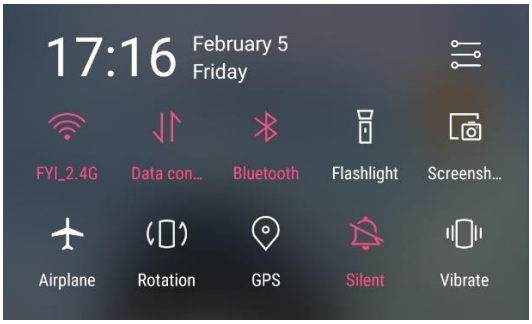
03.1_BLE


Thonny - D:\Micropython_Codes\03.1_BLE\ble_advertising.py @ 94 : 1
File Edit View Run Tools Help
Files
This computer
D: \ Micropython_Codes
00.0_HelloWorld
00.1_Boot
01.1_Blink
02.1_Neopixel
03.1_BLE
BLE.py
ble_advertising.py
04.1_Station_mode
04.2_AP_mode
04.3_AP+STA_mode
05.1_TCP_as_Client
05.2_TCP_as_Server
Open in Thonny
Open in default external app
Configure .py files...
Show hidden files
Upload to /
New file...
New directory...
Cut
Copy
Paste
Rename
Move to Trash
Properties
MicroPython device
ble_advertising.py
boot.py
ble_advertising.py BLE.py
1 # Helpers for generating BLE advertising payloads.
2
3 from micropython import const
4 import struct
5 import bluetooth
6
7 # Advertising payloads are repeated packets of the following form:
8 # 1 byte data length (N + 1)
9 # 1 byte type (see constants below)
s type-specific data
FLAGS = const(0x01)
NAME = const(0x09)
UUID16_COMPLETE = const(0x3)
UUID32_COMPLETE = const(0x5)
UUID128_COMPLETE = const(0x7)
UUID16_MORE = const(0x2)
UUID32_MORE = const(0x4)
UUID128_MORE = const(0x6)
APPEARANCE = const(0x19)
==========
ble_advertising.py
==========
bytearray(b'\x02\x01\x06\x0c\tmicropython\x03\x03\x1a\x18\x11\x07\x9e\xca\xdc$\x0e\xe5\xa9\xe0\x93\xf3\xa3\xb5\x01\x00
@n')
micropython
[UUID(0x181a), UUID('6e400001-b5a3-f393-e0a9-e50e24dcca9e')]
Starting advertising
Please use LightBlue to connect to ESP32.
MicroPython (ESP32) • USB Serial @ COM27

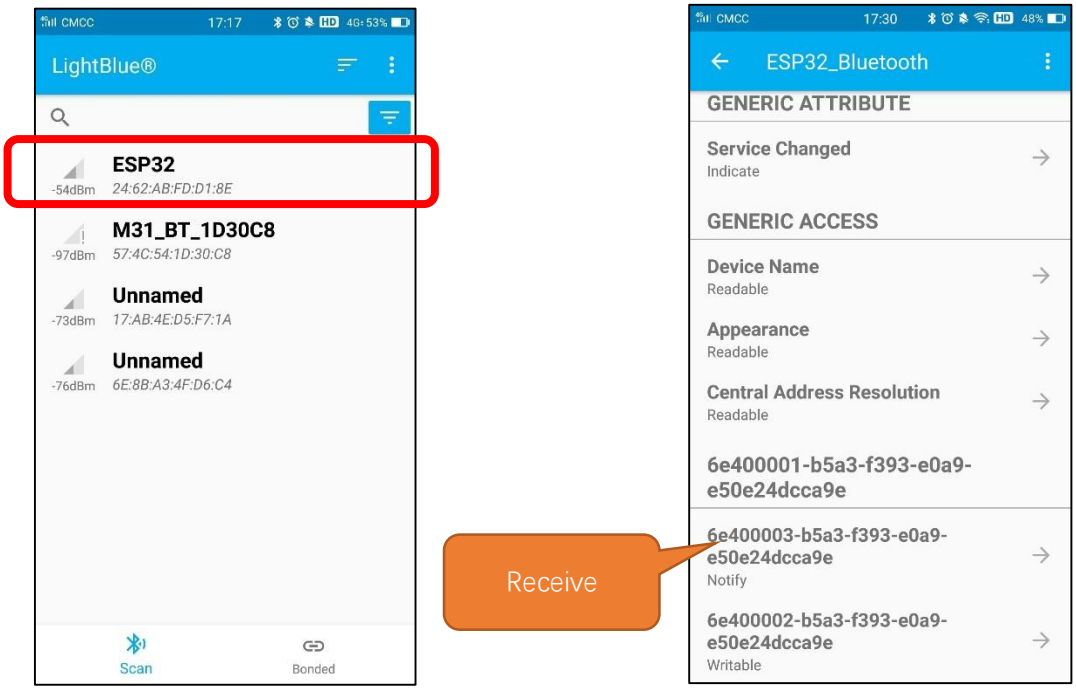
Click run for BLE.py.



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 ESP32.

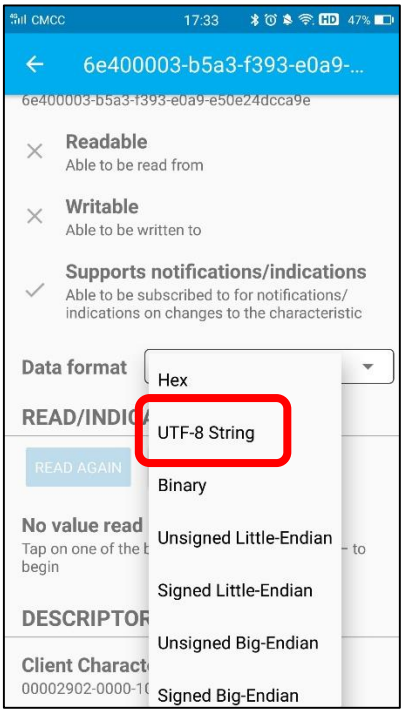


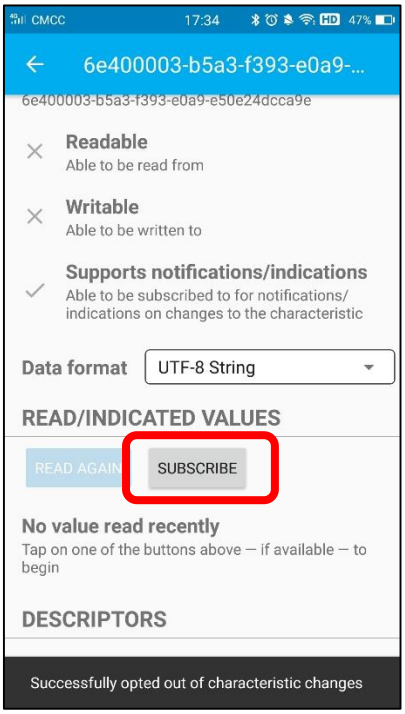
After Bluetooth is connect successfully, Shell will printer the information.

```
MicroPython v1.18 on 2022-01-17; ESP32 module (spiram) with ESP32
Type "help()" for more information.
>>> %Run -c $EDITOR_CONTENT
 Disconnected 0
 Starting advertising
 Traceback (most recent call last):
   File "<stdin>", line 58, in _irq
   File "<stdin>", line 74, in _advertise
 OSError: [Errno 19] ENODEV
 Starting advertising
 Please use LightBlue to connect to ESP32.
 New connection 0

 The BLE connection is successful.
 Enter anything:
```

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.



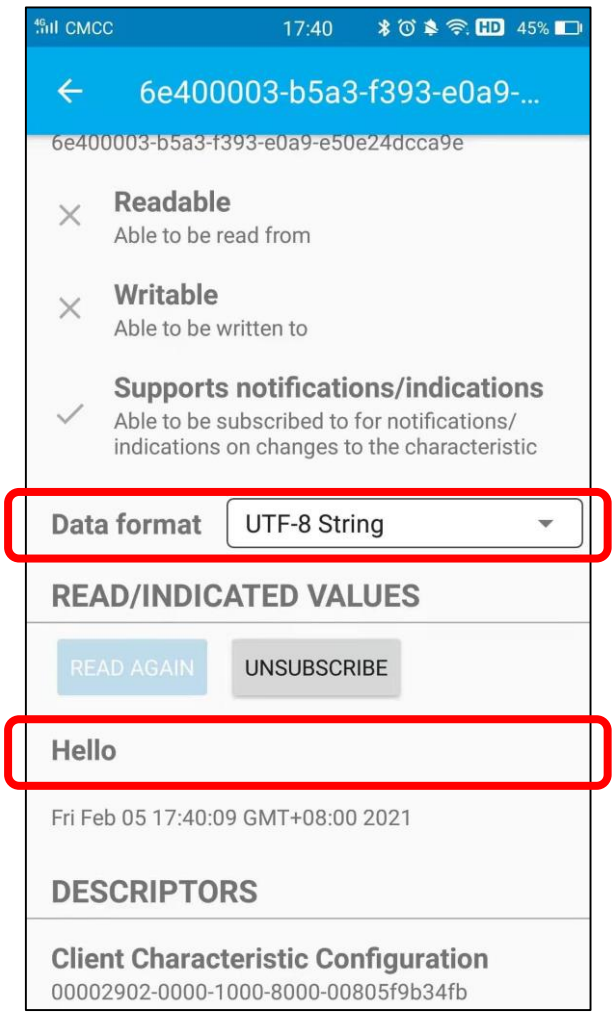


You can type "12345" in Shell and press "Enter" to send.

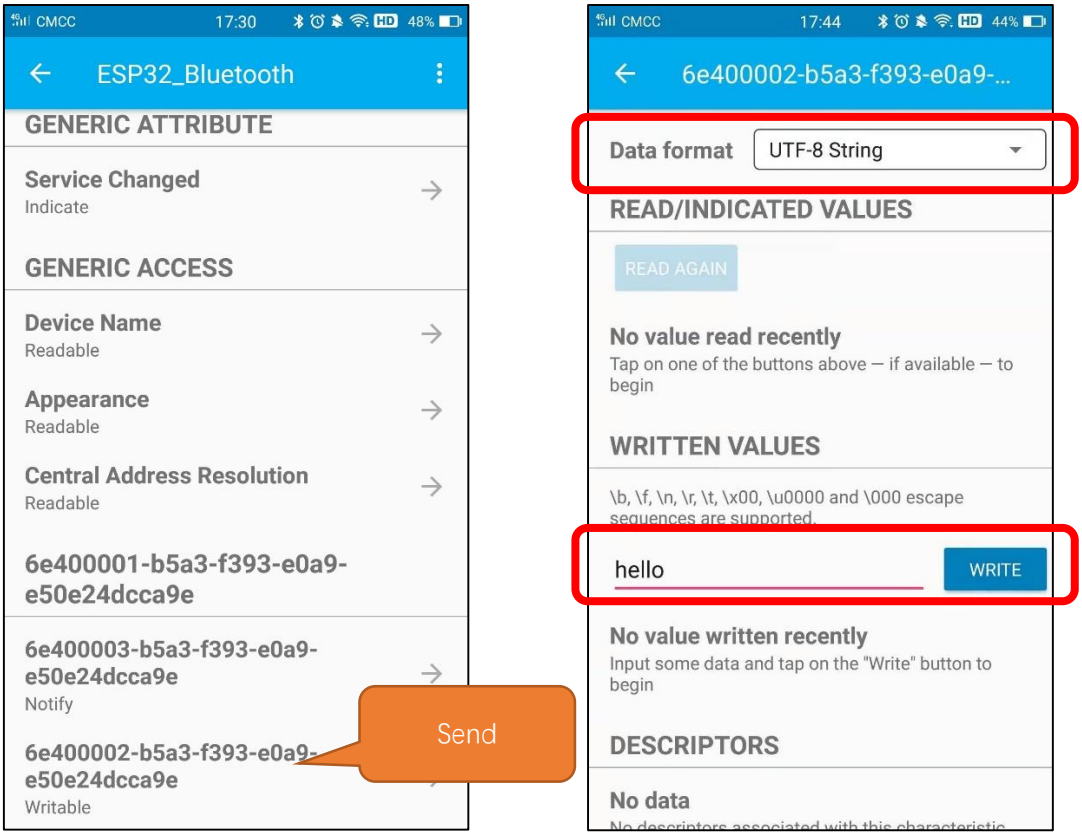
```
MicroPython v1.18 on 2022-01-17; ESP32 module (spiram) with ESP32
Type "help()" for more information.
>>> %Run -c $EDITOR_CONTENT
 Disconnected 0
 Starting advertising
 Traceback (most recent call last):
   File "<stdin>", line 58, in _irq
   File "<stdin>", line 74, in _advertise
 OSError: [Errno 19] ENODEV
 Starting advertising
 Please use LightBlue to connect to ESP32.
 New connection 0

 The BLE connection is successful.
 Enter anything: Hello
 Send:  Hello
 Enter anything:
```

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".

```
The BLE connection is successful.
Enter anything: 12345
Send:  12345
Enter anything: RX b'hello'
```

And now data can be transferred between your mobile phone and computer via ESP32-WROOM.
The following is the program code:

```
import bluetooth
import random
import struct
import time
from ble_advertising import advertising_payload
from micropython import const

_IRQ_CENTRAL_CONNECT = const(1)
_IRQ_CENTRAL_DISCONNECT = const(2)
_IRQ_GATTS_WRITE = const(3)
_FLAG_READ = const(0x0002)
_FLAG_WRITE_NO_RESPONSE = const(0x0004)
_FLAG_WRITE = const(0x0008)
_FLAG_NOTIFY = const(0x0010)

_UART_UUID = bluetooth.UUID("6E400001-B5A3-F393-E0A9-E50E24DCCA9E")
_UART_TX = (
    bluetooth.UUID("6E400003-B5A3-F393-E0A9-E50E24DCCA9E"),
    _FLAG_READ | _FLAG_NOTIFY,
)
_UART_RX = (
    bluetooth.UUID("6E400002-B5A3-F393-E0A9-E50E24DCCA9E"),
    _FLAG_WRITE | _FLAG_WRITE_NO_RESPONSE,
)
_UART_SERVICE = (
    _UART_UUID,
    (_UART_TX, _UART_RX),
)
class BLESimplePeripheral:
    def __init__(self, ble, name="ESP32"):
        self._ble = ble
        self._ble.active(True)
        self._ble.irq(self._irq)
        ((self._handle_tx, self._handle_rx),) =
self._ble.gatts_register_services((_UART_SERVICE,))
        self._connections = set()
        self._write_callback = None
        self._payload = advertising_payload(name=name, services=[_UART_UUID])
        self._advertise()
    def _irq(self, event, data):
        # Track connections so we can send notifications.
        if event == _IRQ_CENTRAL_CONNECT:
```

```
            conn_handle, _, _ = data
            print("New connection", conn_handle)
            print("\nThe BLE connection is successful.")
            self._connections.add(conn_handle)
        elif event == _IRQ_CENTRAL_DISCONNECT:
            conn_handle, _, _ = data
            print("Disconnected", conn_handle)
            self._connections.remove(conn_handle)
            # Start advertising again to allow a new connection.
            self._advertise()
        elif event == _IRQ_GATTS_WRITE:
            conn_handle, value_handle = data
            value = self._ble.gatts_read(value_handle)
            if value_handle == self._handle_rx and self._write_callback:
                self._write_callback(value)
    def send(self, data):
        for conn_handle in self._connections:
            self._ble.gatts_notify(conn_handle, self._handle_tx, data)
    def is_connected(self):
        return len(self._connections) > 0
    def _advertise(self, interval_us=500000):
        print("Starting advertising")
        self._ble.gap_advertise(interval_us, adv_data=self._payload)
    def on_write(self, callback):
        self._write_callback = callback
def demo():
    ble = bluetooth.BLE()
    p = BLESimplePeripheral(ble)
    def on_rx(rx_data):
        print("RX", rx_data)
    p.on_write(on_rx)
    print("Please use LightBlue to connect to ESP32.")
    while True:
        if p.is_connected():
            # Short burst of queued notifications.
            tx_data = input("Enter anything: ")
            print("Send: ", tx_data)
            p.send(tx_data)
if __name__ == "__main__":
    demo()
```

Define the specified UUID number for BLE vendor.

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

```
    _FLAG_READ | _FLAG_NOTIFY,
)
_UART_RX = (
    bluetooth.UUID("6E400002-B5A3-F393-E0A9-E50E24DCCA9E"),
    _FLAG_WRITE | _FLAG_WRITE_NO_RESPONSE,
)
```

Write an _irq function to manage BLE interrupt events.

```
    def _irq(self, event, data):
        # Track connections so we can send notifications.
        if event == _IRQ_CENTRAL_CONNECT:
            conn_handle, _, _ = data
            print("New connection", conn_handle)
            print("\nThe BLE connection is successful.")
            self._connections.add(conn_handle)
        elif event == _IRQ_CENTRAL_DISCONNECT:
            conn_handle, _, _ = data
            print("Disconnected", conn_handle)
            self._connections.remove(conn_handle)
            # Start advertising again to allow a new connection.
            self._advertise()
        elif event == _IRQ_GATTS_WRITE:
            conn_handle, value_handle = data
            value = self._ble.gatts_read(value_handle)
            if value_handle == self._handle_rx and self._write_callback:
                self._write_callback(value)
```

Initialize the BLE function and name it.

```
def __init__(self, ble, name="ESP32"):
```

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

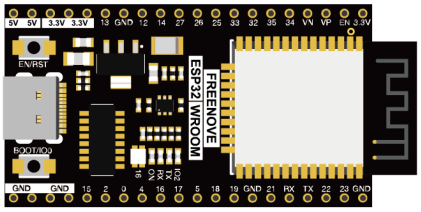
```
  def demo():
    ble = bluetooth.BLE()
    p = BLESimplePeripheral(ble)
    def on_rx(rx_data):
        print("RX", rx_data)
    p.on_write(on_rx)
    print("Please use LightBlue to connect to ESP32.")
    while True:
        if p.is_connected():
            # Short burst of queued notifications.
            tx_data = input("Enter anything: ")
            print("Send: ", tx_data)
            p.send(tx_data)
    lastMsg = now;
  }
```

Chapter 4 WiFi Working Modes

In this chapter, we'll focus on the WiFi infrastructure for ESP32-WROOM.
ESP32-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 4.1 Station mode

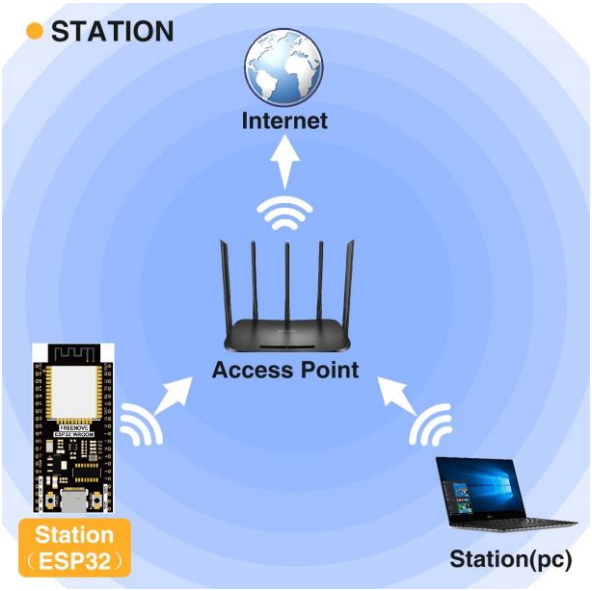
Component List

ESP32-WROOM x1 	USB cable 

Component knowledge

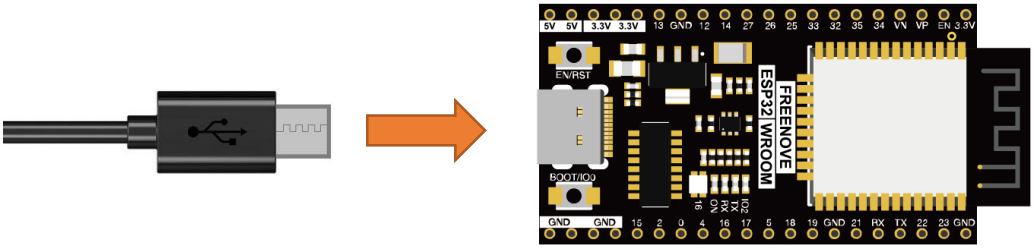
Station mode

When ESP32 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 wants to communicate with the PC, it needs to be connected to the router.



Circuit

Connect your computer and ESP32 with a USB cable.

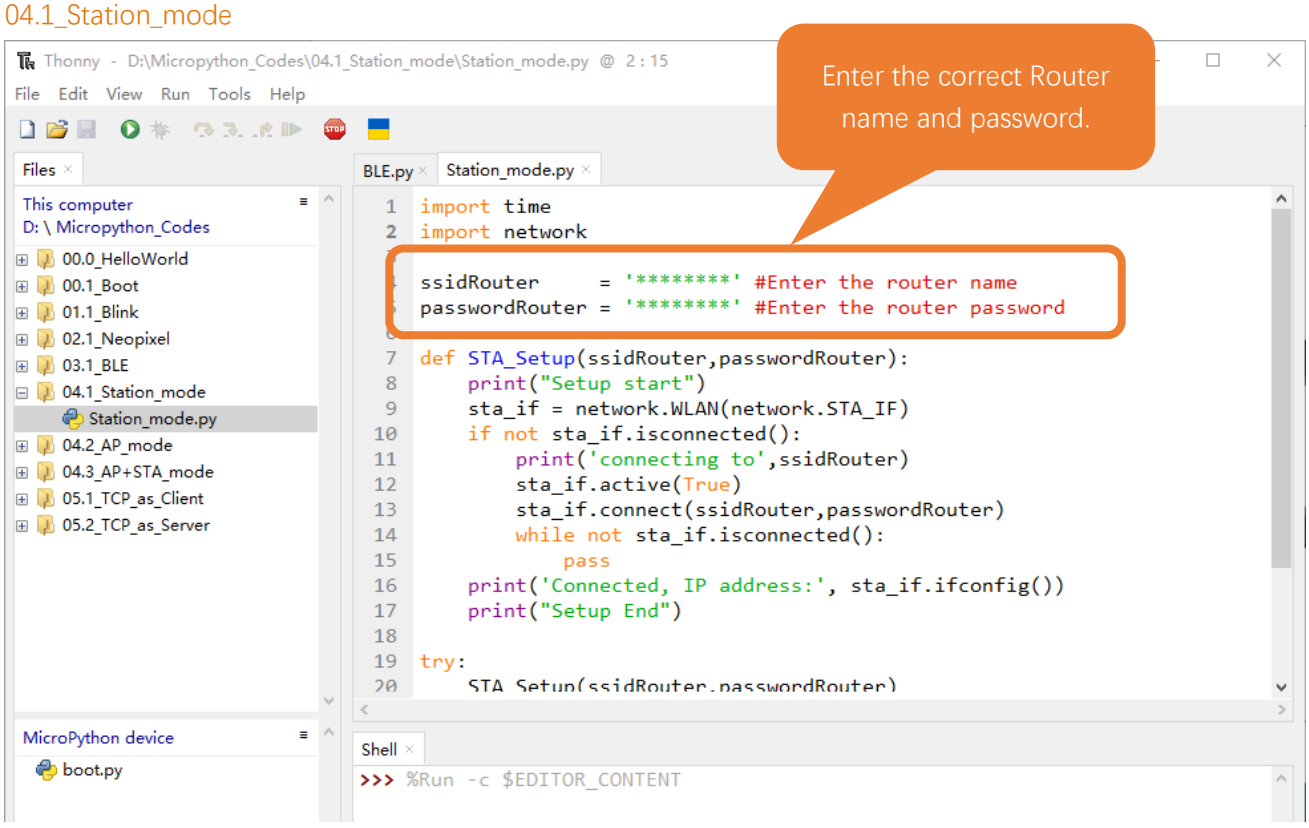


Code

Move the program folder "**Freenove_ESP32_WROOM_Board/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_Station_mode" and double click "Station_mode.py".

04.1_Station_mode



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 ESP32-WROOM, wait for ESP32 to connect to your router and print the IP address assigned by the router to ESP32 in "Shell".

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 in Station mode.

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

Activate ESP32'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 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-WROOM 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 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: WiFiname

password: WiFipassword

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

Project 4.2 AP mode

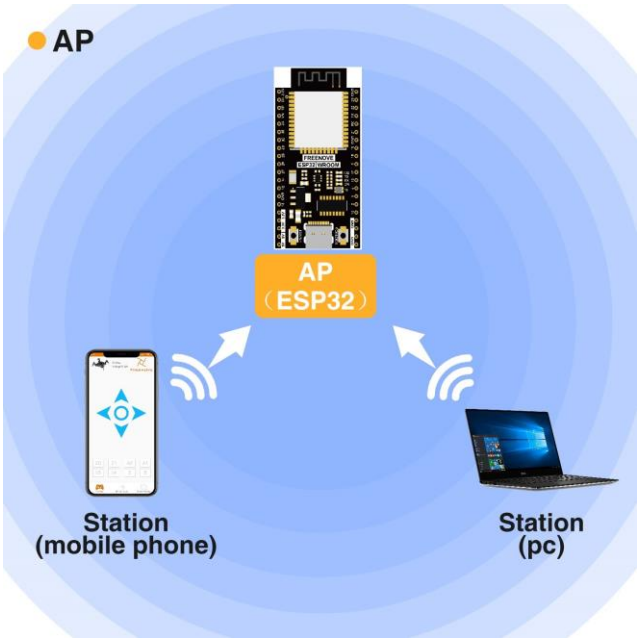
Component List & Circuit

Component List & Circuit are the same as in Section 04.1.

Component knowledge

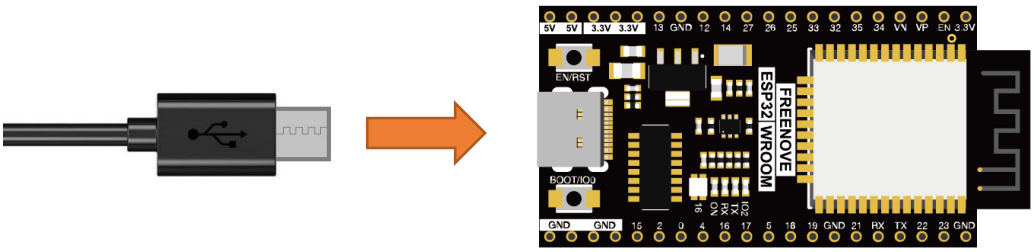
AP mode

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



Circuit

Connect your computer and ESP32 with a USB cable.

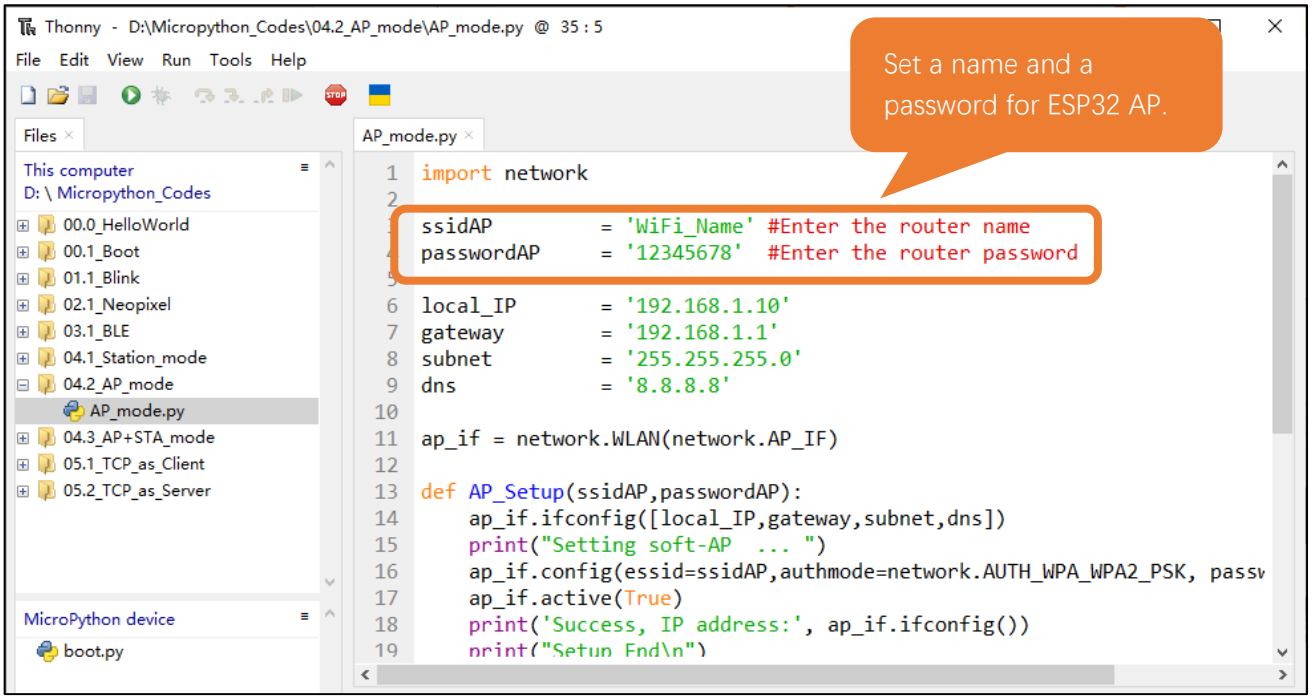


Code

Move the program folder "**Freenove_ESP32_WROOM_Board/Python/Python_Codes**" to disk(D) in advance with the path of "**D:/Micropython_Codes**".

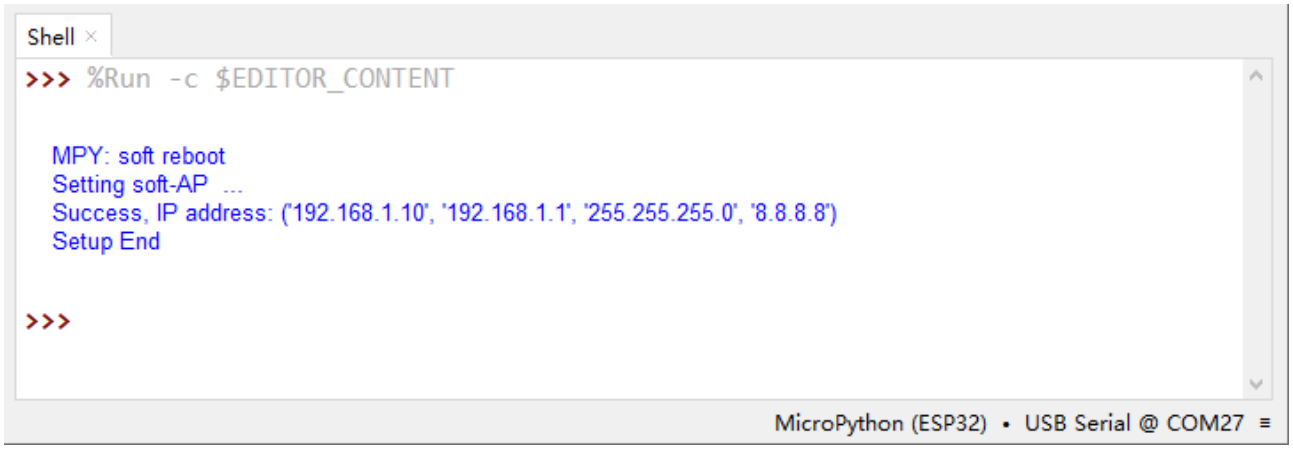
Open "Thonny", click "This computer" → "D:" → "Micropython_Codes" → "04.2_AP_mode". and double click "AP_mode.py".

04.2_AP_mode

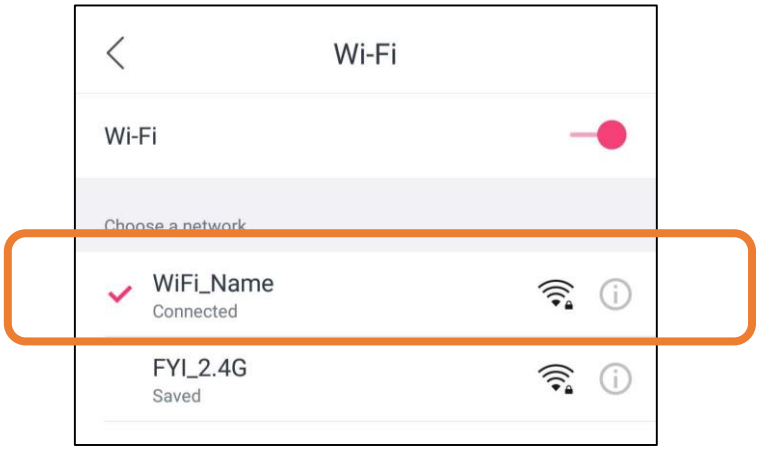


Before the Code runs, you can make any changes to the AP name and password for ESP32 in the box as shown in the illustration above. Of course, you can leave it alone by default.

Click "Run current script", open the AP function of ESP32 and print the access point information.



Turn on the WiFi scanning function of your phone, and you can see the ssid_AP on ESP32, 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 in AP mode.

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

Configure IP address, gateway and subnet mask for ESP32.

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

Turn on an AP in ESP32, 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: WiFiname

password: WiFipassword

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: WiFichannel

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: IPaddress

subnet_mask: subnet mask

gateway: gateway

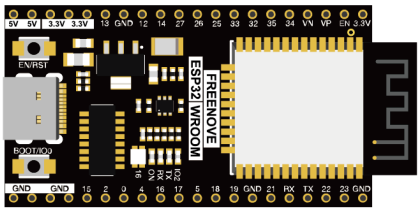
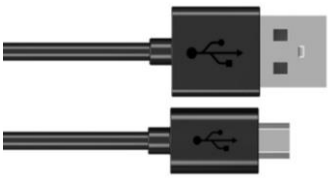
DNS_server: DNSserver

disconnect(): Disconnect from the currently connected wireless network

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

Project 4.3 AP+Station mode

Component List

ESP32-WROOM x1 	USB cable 

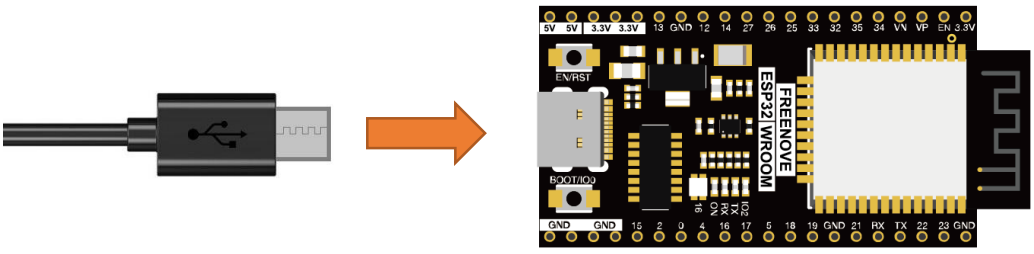
Component knowledge

AP+Station mode

In addition to AP mode and Station mode, ESP32 can also use AP mode and Station mode at the same time. This mode contains the functions of the previous two modes. Turn on ESP32'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 ESP32.

Circuit

Connect your computer and ESP32 with a USB cable.

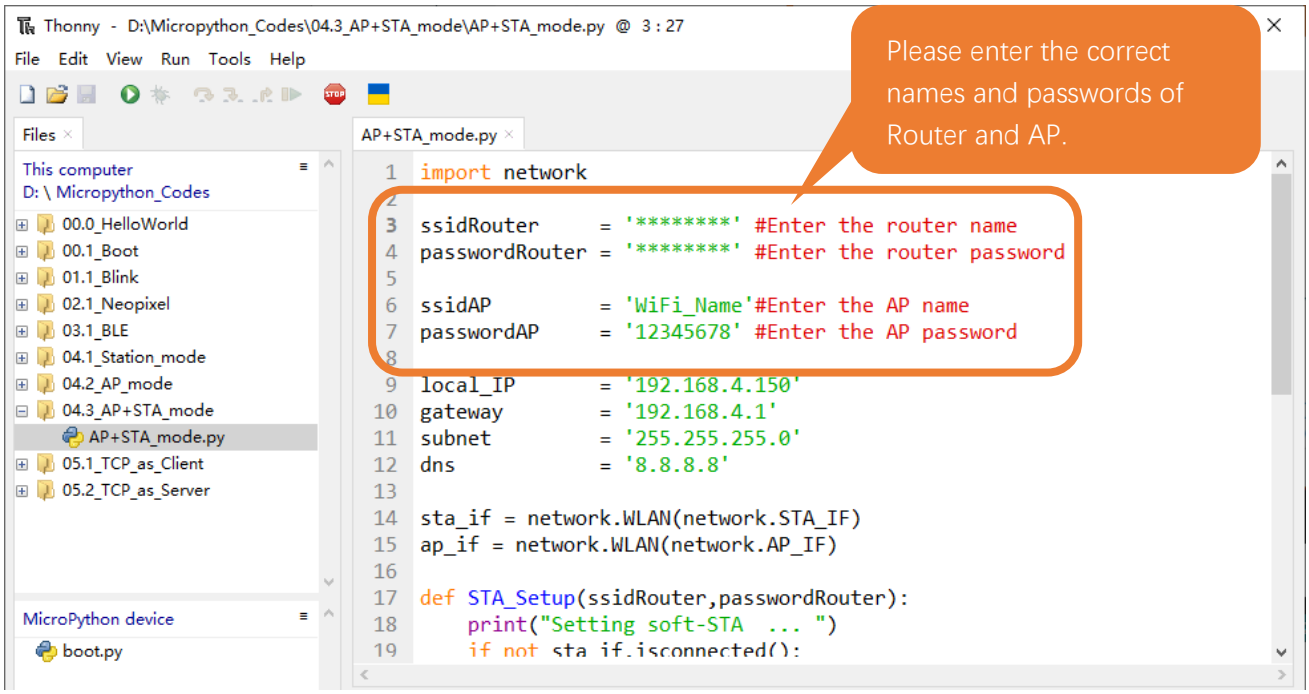


Code

Move the program folder "**Freenove_ESP32_WROOM_Board/Python/Python_Codes**" to disk(D) in advance with the path of "**D:/Micropython_Codes**".

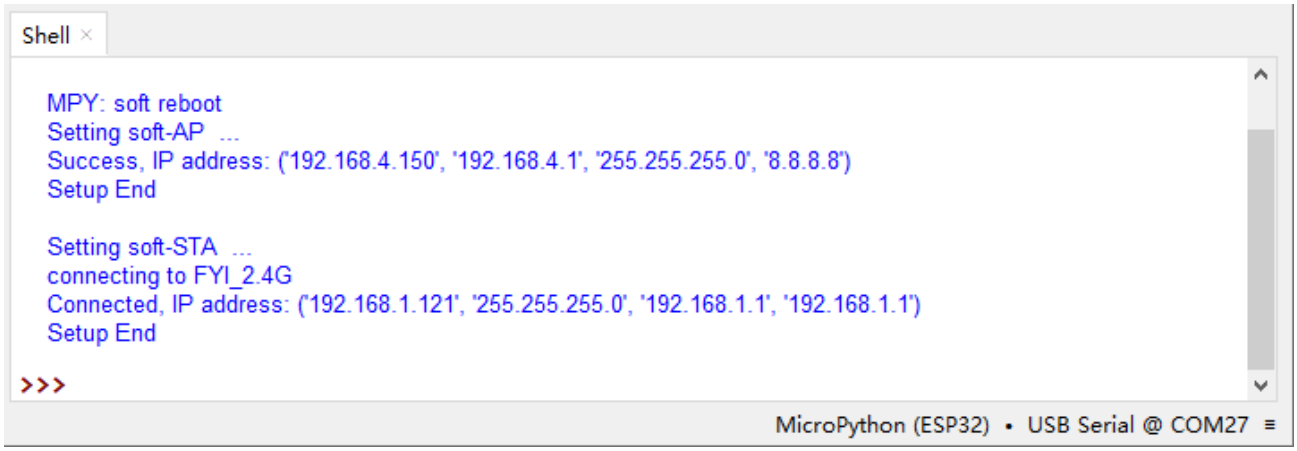
Open "Thonny", click "This computer" → "D:" → "Micropython_Codes" → "04.3_AP+STA_mode"and double click "AP+STA_mode.py".

04.3_AP+STA_mode

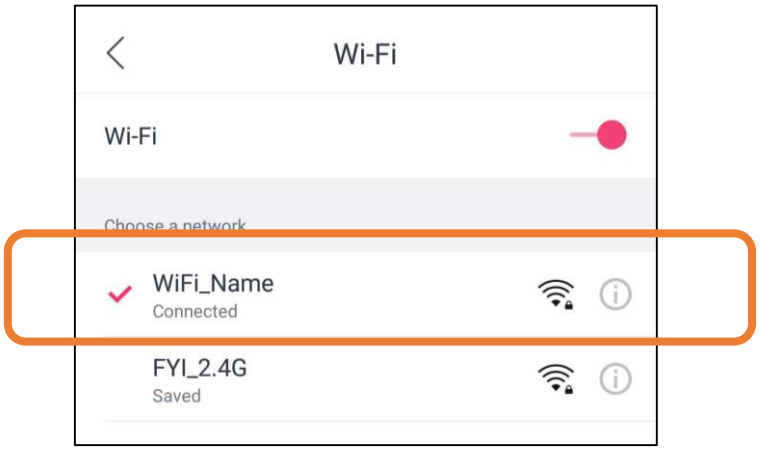


It is analogous to Project 4.1 and Project 4.2. Before running the Code, you need to modify ssidRouter, passwordRouter, ssidAP and passwordAP shown in the box of the illustration above.

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



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



The following is the program code:

```
import network

ssidRouter     = '********' #Enter the router name
passwordRouter = '********' #Enter the router password

ssidAP         = 'WiFi_Name'#Enter the AP name
passwordAP     = '12345678' #Enter the AP password

local_IP       = '192.168.4.150'
gateway        = '192.168.4.1'
subnet         = '255.255.255.0'
dns            = '8.8.8.8'

sta_if = network.WLAN(network.STA_IF)
ap_if = network.WLAN(network.AP_IF)

def STA_Setup(ssidRouter,passwordRouter):
    print("Setting soft-STA  ... ")
    if not sta_if.isconnected():
        print('connecting to',ssidRouter)
        sta_if.active(True)
        sta_if.connect(ssidRouter,passwordRouter)
        while not sta_if.isconnected():
            pass
    print('Connected, IP address:', sta_if.ifconfig())
    print("Setup End")

def AP_Setup(ssidAP,passwordAP):
    ap_if.ifconfig([local_IP,gateway,subnet,dns])
    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.idsconnect()
```

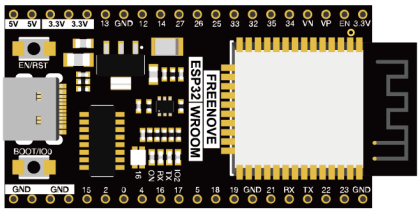
Chapter 5 TCP/IP

In this chapter, we wil introduce how ESP32 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 chaper.

Project 5.1 As Client

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

Component List

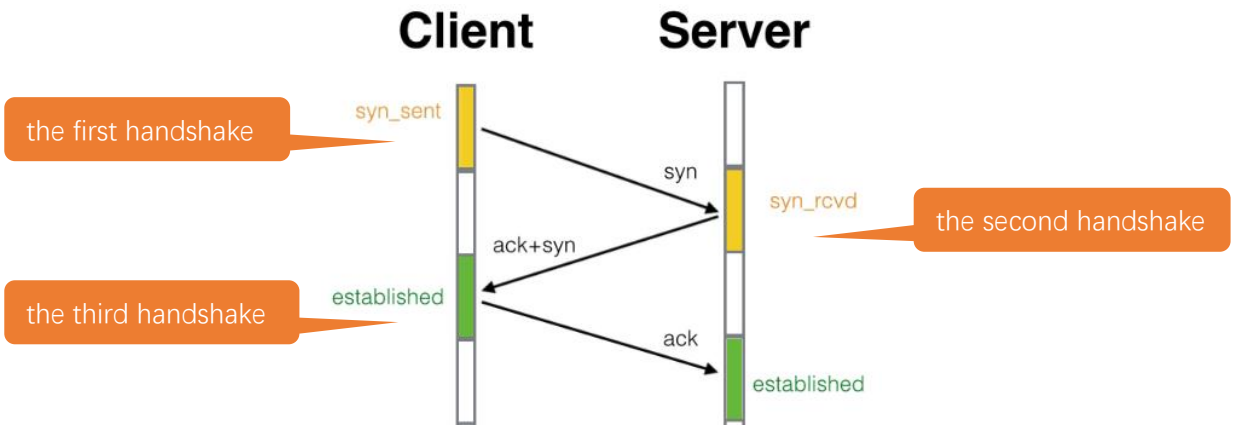
ESP32-WROOM x1 	USB cable 

Component knowledge

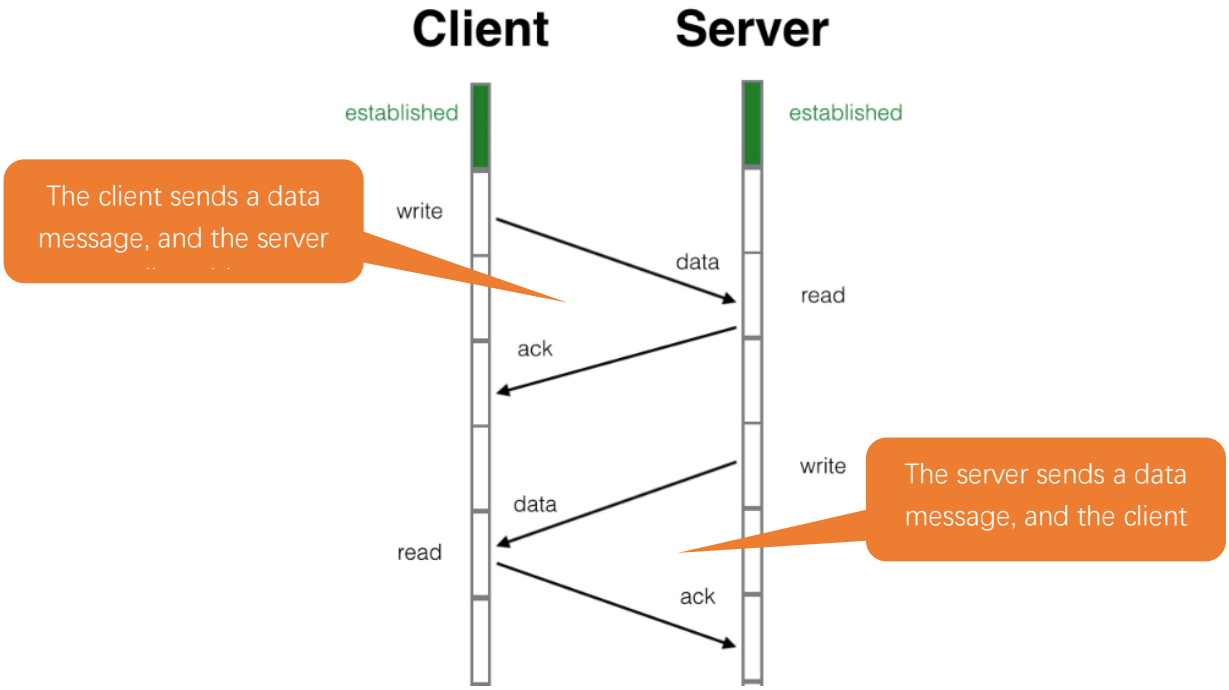
TCP connection

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.

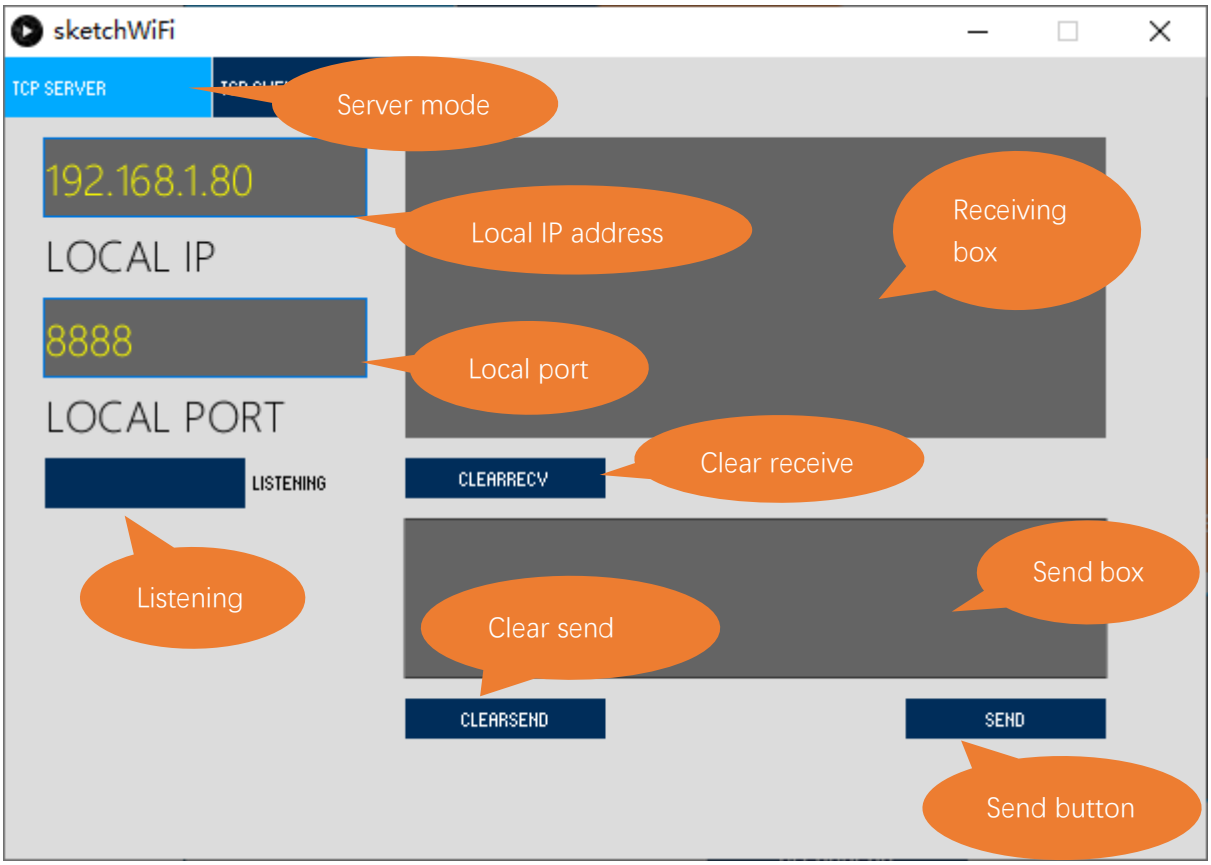
If you've not installed Processing, you can download it by clicking https://processing.org/download/. You can choose an appropriate version to download according to your PC system.

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

Use Server mode for communication

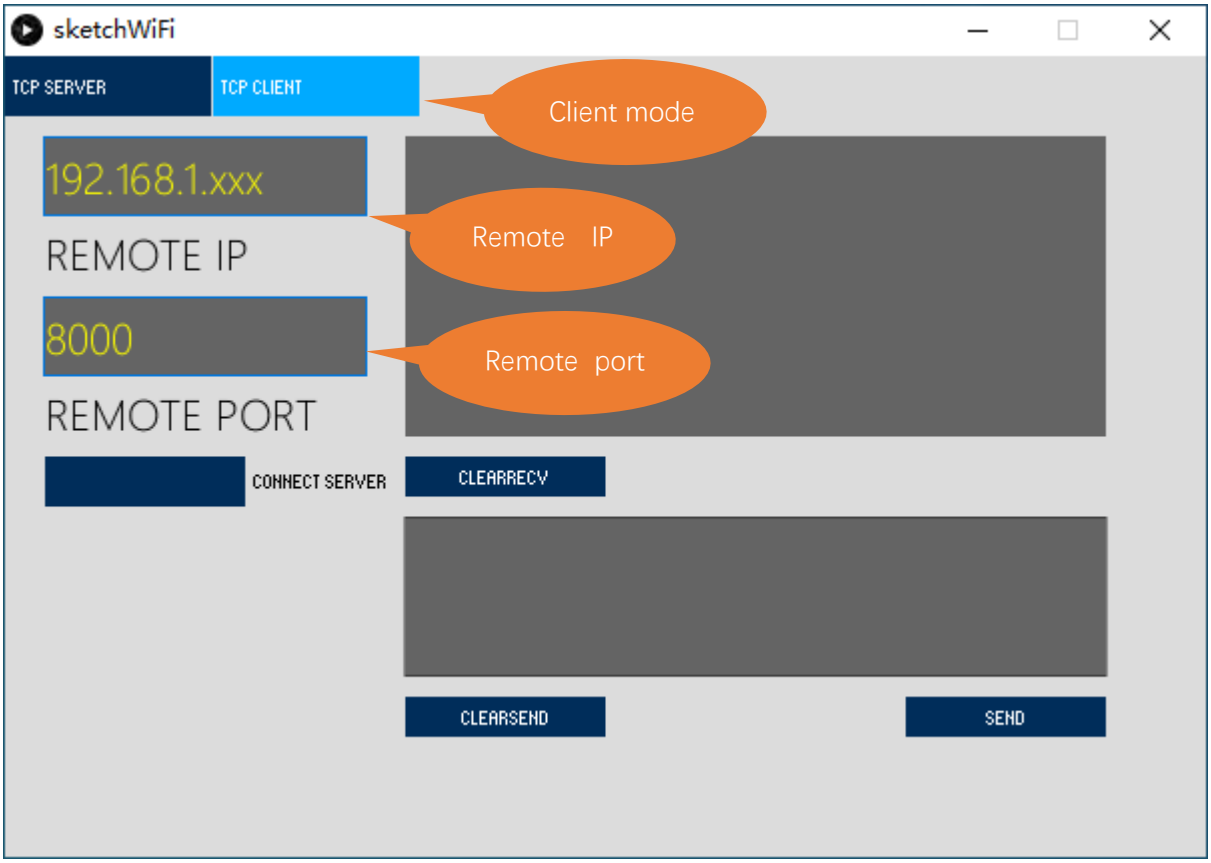
Open the "**Freenove_ESP32_WROOM_Board/Codes/Micropython_Codes/05.1_TCP_as_Client/sketchWiFi/sketchWiFi.pde**". Click "Run".

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



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

If ESP32 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, and 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.

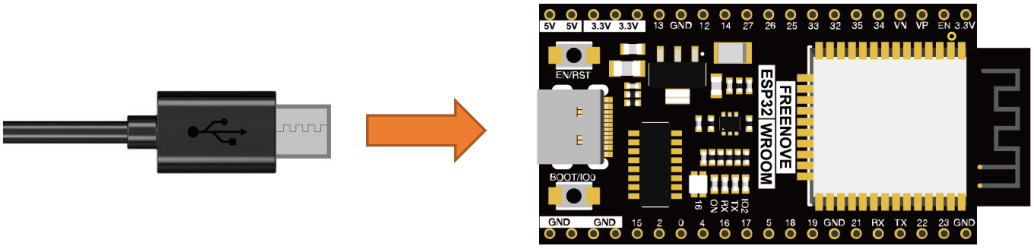
clear receive: clear out the content in the receiving text box

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.

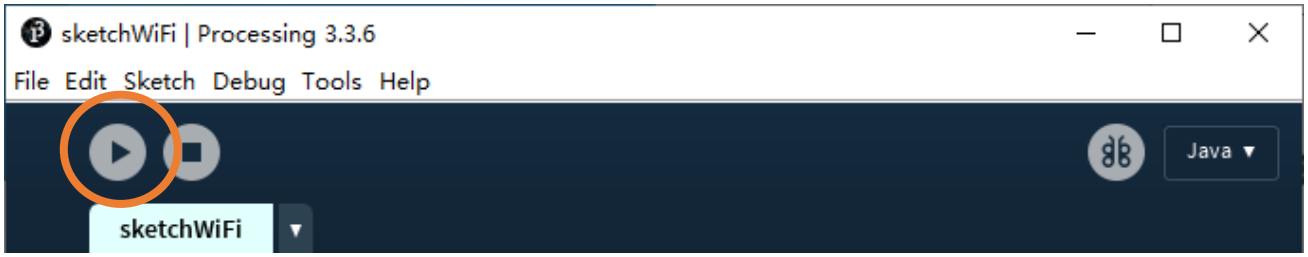
Circuit

Connect your computer and ESP32 with a USB cable.

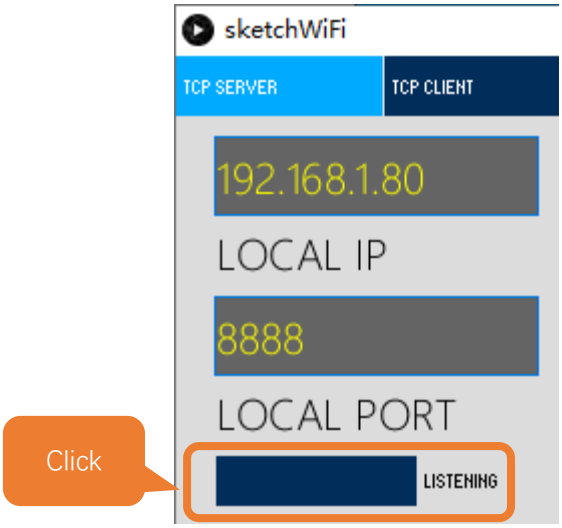


Code

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"。

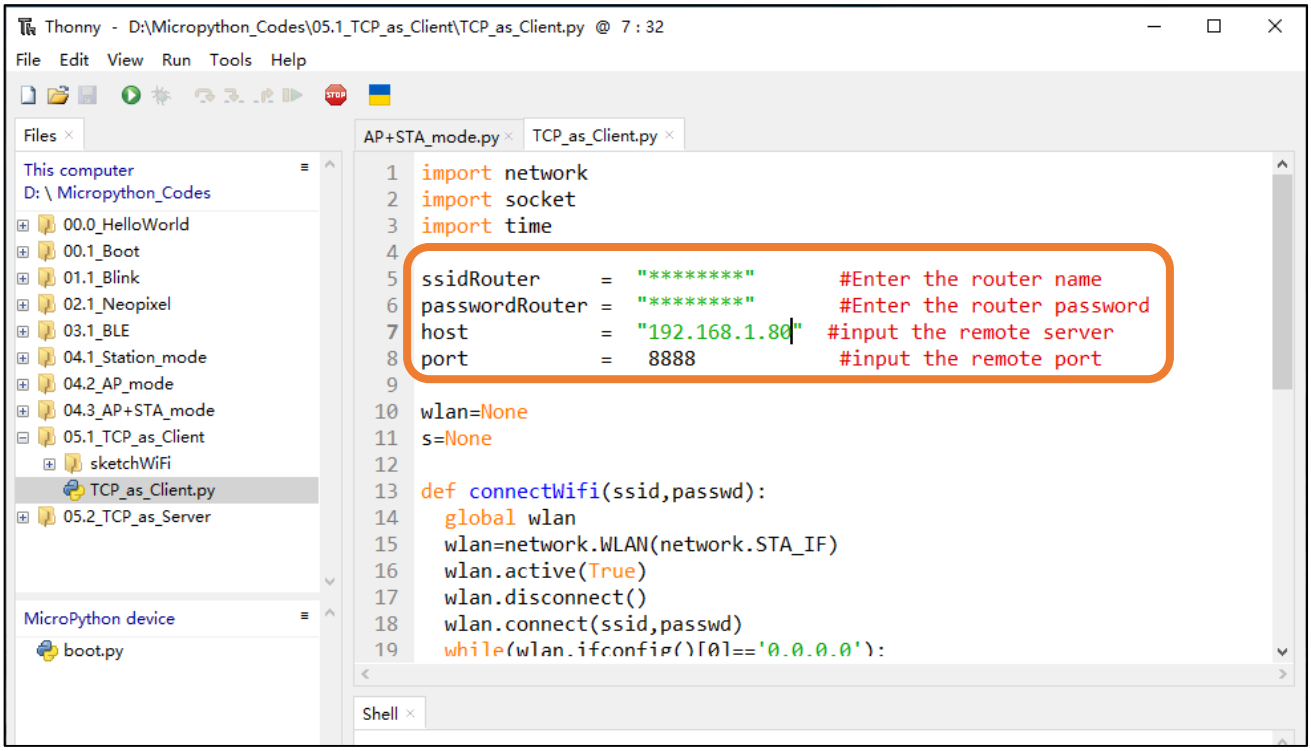


Move the program folder "**Freenove_ESP32_WROOM_Board/Python/Python_Codes**" to disk(D) in advance with the path of "**D:/Micropython_Codes**".

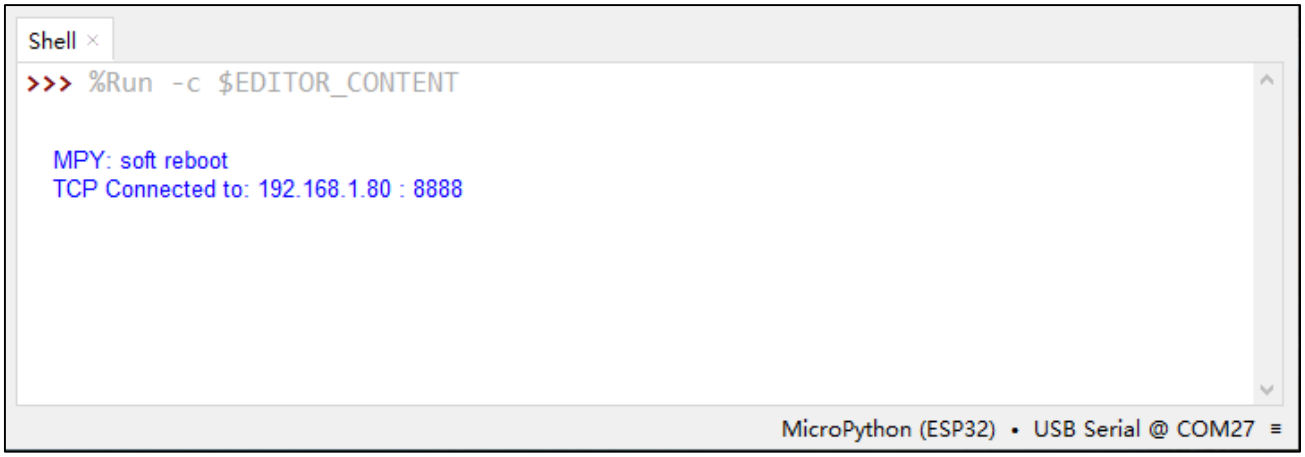
Open "Thonny", click "This computer" → "D:" → "Micropython_Codes" → "05.1_TCP_as_Client" and double click "TCP_as_Client.py".

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:

05.1_TCP_as_Client



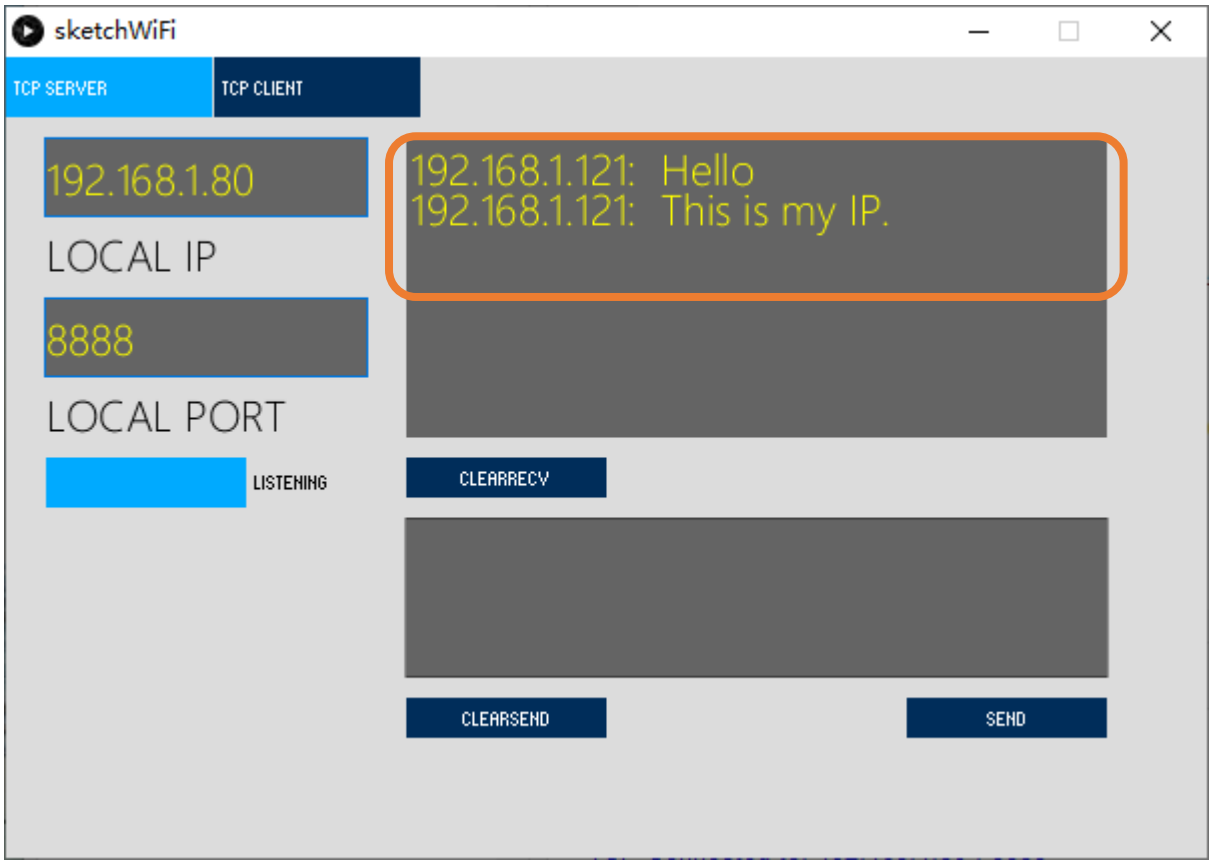
Click "Run current script" and in "Shell", you can see ESP32-WROOM automatically connects to sketchWiFi.



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

```
Shell
  Close socket
>>> %Run -c $EDITOR_CONTENT
  TCP close, please reset!
>>>
```

ESP32 connects with TCP SERVER, and TCP SERVER receives messages from ESP32, as shown in the figure below.



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
```

```
12
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.

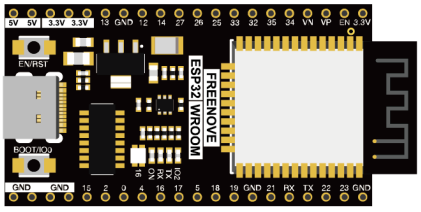
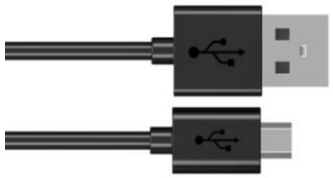
close(): Close socket.

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

Project 5.2 As Server

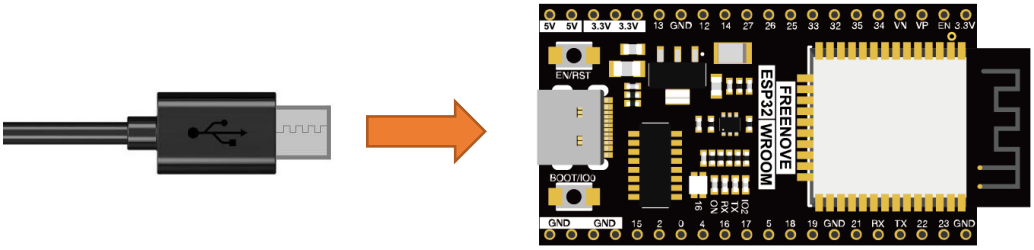
In this section, ESP32 is used as a Server to wait for the connection and communication with Client on the same LAN.

Component List

ESP32-WROOM x1 	USB cable 

Circuit

Connect your computer and ESP32 with a USB cable.



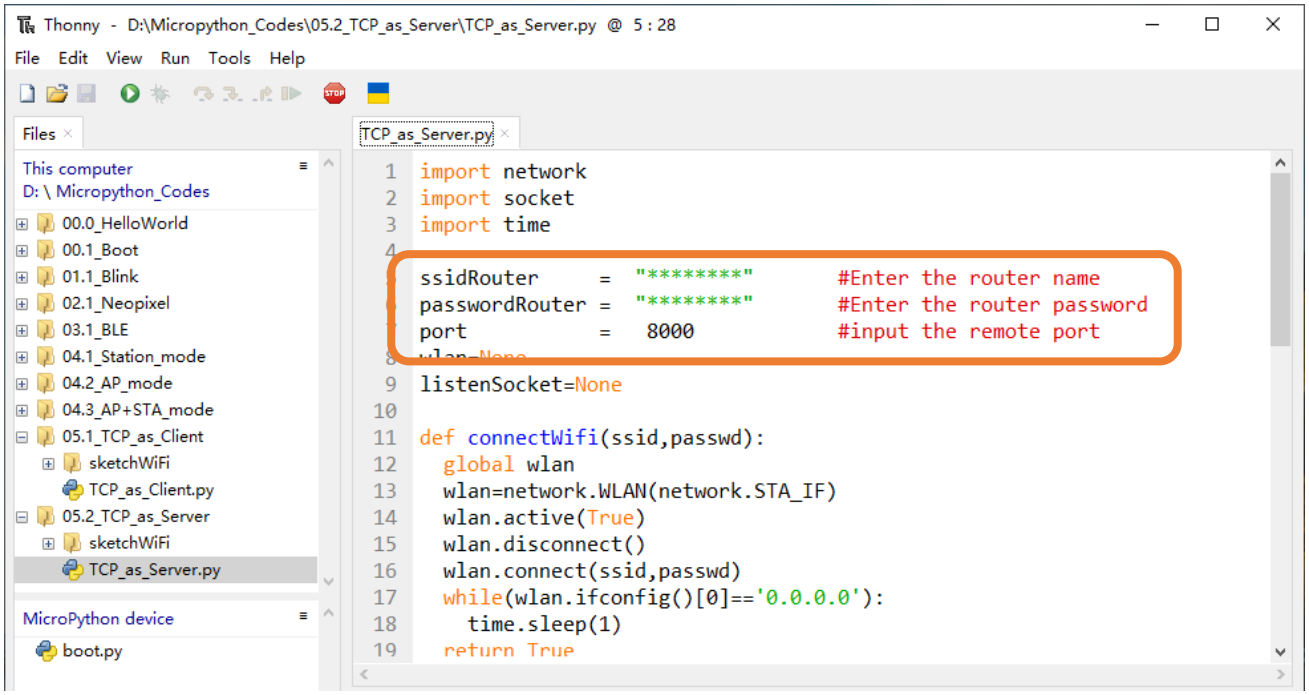
Code

Move the program folder "**Freenove_ESP32_WROOM_Board/Python/Python_Codes**" to disk(D) in advance with the path of "**D:/Micropython_Codes**".

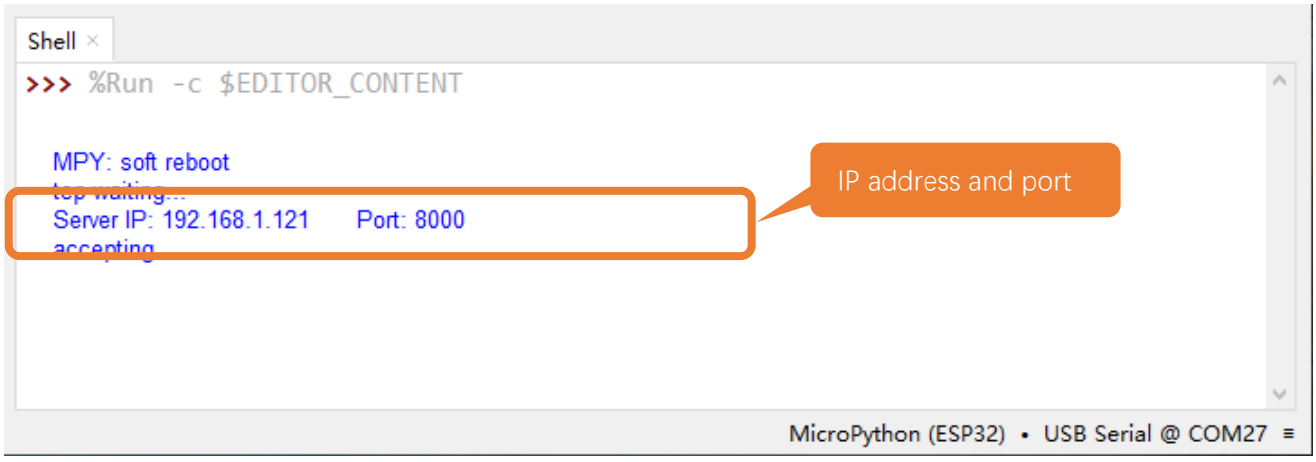
Open "Thonny", click "This computer" → "D:" → "Micropython_Codes" → "05.2_TCP_as_Server" and double click "TCP_as_Server.py".

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

05.2_TCP_as_Server



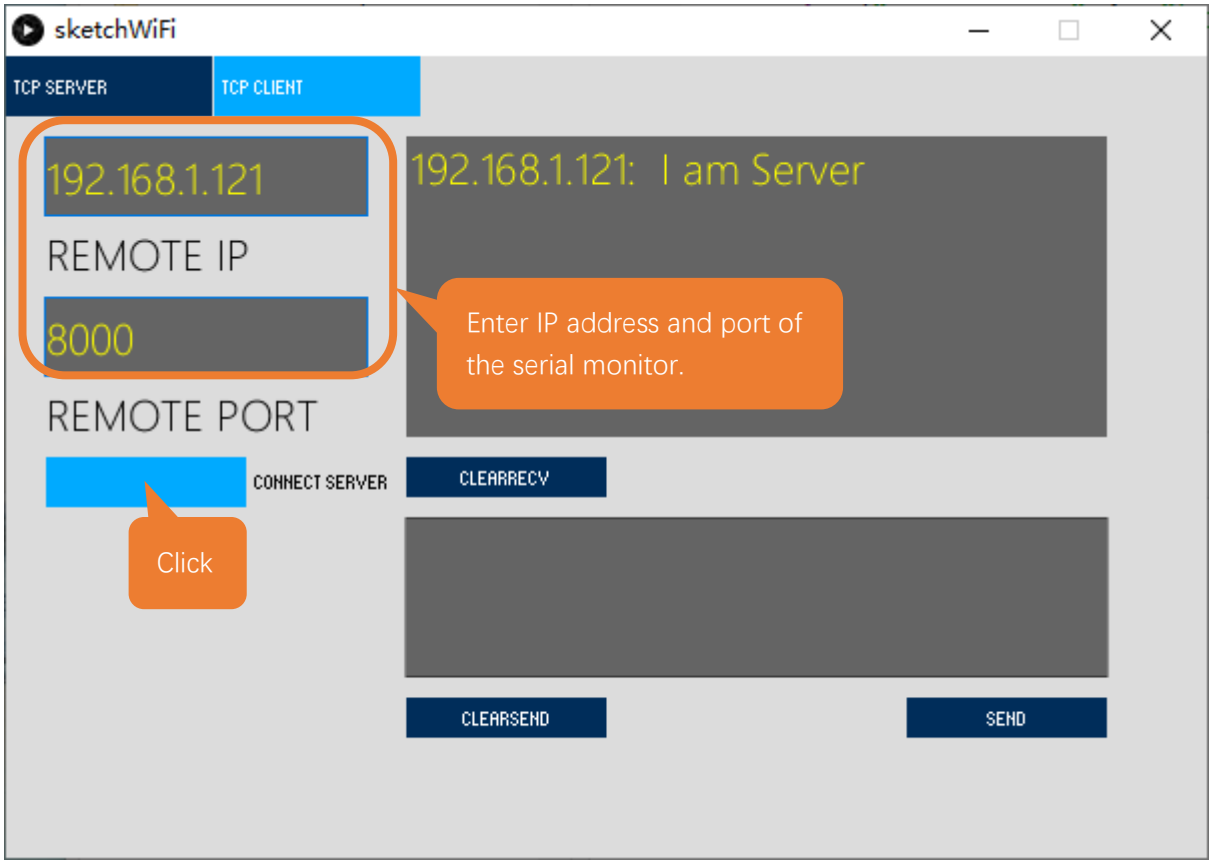
After making sure that the router's name and password are correct, click "Run current script" and in "Shell", you can see a server opened by the ESP32- WROVER waiting to connecting to other network devices.



Processing:

Open the "**Freenove_ESP32_WROOM_Board/Codes/MicroPython_Codes/05.2_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 to communicate.



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

The following is the program code:

```
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

try:
  connectWifi(ssidRouter,passwordRouter)
  ip=wlan.ifconfig()[0]
  listenSocket = socket.socket()
  listenSocket.bind((ip,port))
  listenSocket.listen(1)
  listenSocket.setsockopt(socket.SOL_SOCKET, socket.SO_REUSEADDR, 1)
  print('tcp waiting...')
  while True:
    print("Server IP:",ip,"\tPort:",port)
    print("accepting.....")
    conn,addr = listenSocket.accept()
    print(addr,"connected")
    break
  conn.send('I am Server')
  while True:
    data = conn.recv(1024)
    if(len(data) == 0):
      print("close socket")
      listenSocket.close()
      wlan.disconnect()
      wlan.active(False)
      break
```

```
    else:
      print(data)
      ret = conn.send(data)
except:
  print("Close TCP-Server, please reset.")
  if(listenSocket):
    listenSocket.close()
  wlan.disconnect()
  wlan.active(False)
```

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

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

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

```
  listenSocket = socket.socket()
  listenSocket.bind((ip,port))
  listenSocket.listen(1)
  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.

```
  while True:
    print("Server IP:",ip,"\tPort:",port)
    print("accepting.....")
    conn,addr = listenSocket.accept()
    print(addr,"connected")
    break
```

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

```
  while True:
    data = conn.recv(1024)
    if(len(data) == 0):
      print("close socket")
      listenSocket.close()
      wlan.disconnect()
      wlan.active(False)
      break
    else:
      print(data)
      ret = conn.send(data)
```

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

```
except:
  print("Close TCP-Server, please reset.")
  if(listenSocket):
    listenSocket.close()
  wlan.disconnect()
  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 ESP32, you view our ultimate tutorial:
https://github.com/Freenove/Freenove_ESP32_WROOM_Board/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.