

# Important Information

Thank you for choosing Freenove products!

## Getting Started

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

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

## Get Support and Offer Input

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

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

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

**[support@freenove.com](mailto:support@freenove.com)**

## Safety and Precautions

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

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

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



## About Freenove

Freenove provides open source electronic products and services worldwide.

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

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

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

<http://www.freenove.com>

[sale@freenove.com](mailto:sale@freenove.com)

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# Preface

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

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

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

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

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

## ESP32-WROVER

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

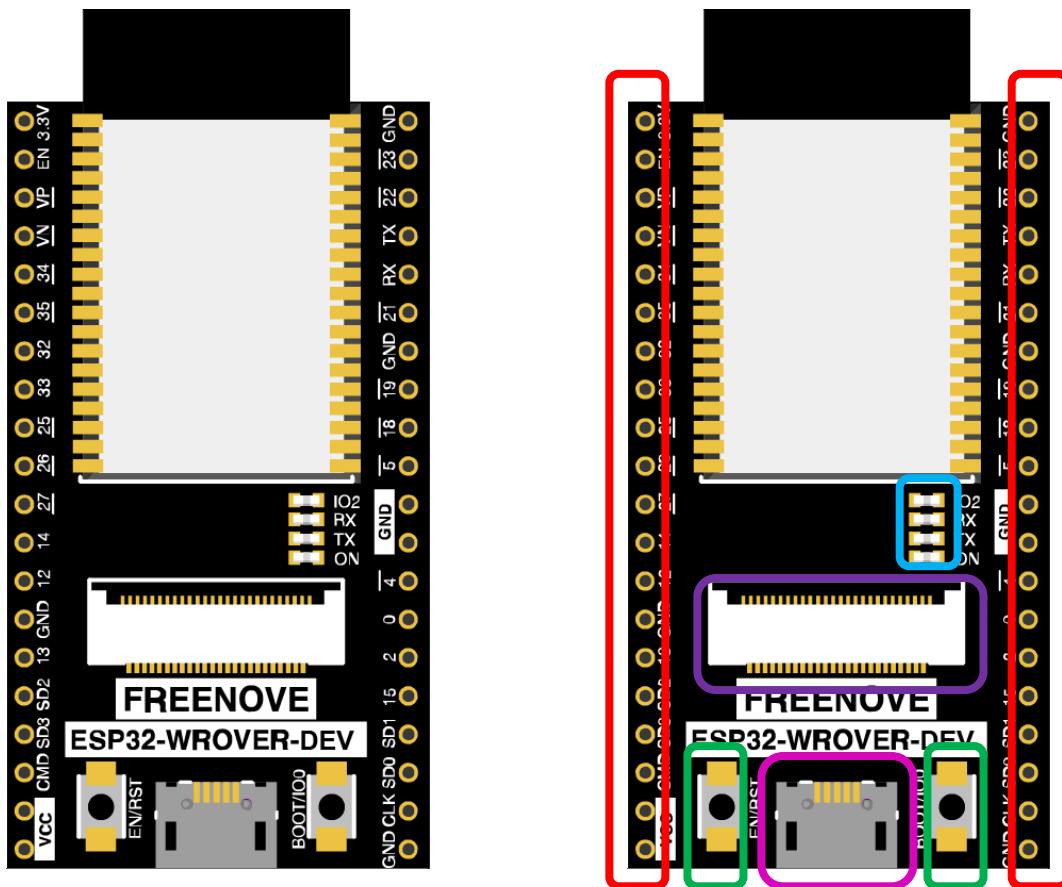


In this tutorial, the ESP32-WROVER is designed based on the PCB on-board antenna-packaged ESP32-WROVER module.

### ESP32-WROVER



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



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

Box color	Corresponding resources introduction
	<b>GPIO pin</b>
	<b>LED indicator</b>
	<b>Camera interface</b>
	<b>Reset button, Boot mode selection button</b>
	<b>USB port</b>

Name	No.	Type	Function
GND	1	P	Ground
3V3	2	P	Power supply
EN	3	I	Module-enable signal. Active high.
SENSOR_VP	4	I	GPIO36, ADC1_CH0, RTC_GPIO0
SENSOR_VN	5	I	GPIO39, ADC1_CH3, RTC_GPIO3
IO34	6	I	GPIO34, ADC1_CH6, RTC_GPIO4
IO35	7	I	GPIO35, ADC1_CH7, RTC_GPIO5
IO32	8	I/O	GPIO32, XTAL_32K_P (32.768 kHz crystal oscillator input), ADC1_CH4, TOUCH9, RTC_GPIO9
IO33	9	I/O	GPIO33, XTAL_32K_N (32.768 kHz crystal oscillator output), ADC1_CH5, TOUCH8, RTC_GPIO8
IO25	10	I/O	GPIO25, DAC_1, ADC2_CH8, RTC_GPIO6, EMAC_RXD0
IO26	11	I/O	GPIO26, DAC_2, ADC2_CH9, RTC_GPIO7, EMAC_RXD1
IO27	12	I/O	GPIO27, ADC2_CH7, TOUCH7, RTC_GPIO17, EMAC_RX_DV
IO14	13	I/O	GPIO14, ADC2_CH6, TOUCH6, RTC_GPIO16, MTMS, HSPICLK, HS2_CLK, SD_CLK, EMAC_TXD2
IO12 <sup>1</sup>	14	I/O	GPIO12, ADC2_CH5, TOUCH5, RTC_GPIO15, MTDI, HSPIQ, HS2_DATA2, SD_DATA2, EMAC_TXD3
GND	15	P	Ground
IO13	16	I/O	GPIO13, ADC2_CH4, TOUCH4, RTC_GPIO14, MTCK, HSPID, HS2_DATA3, SD_DATA3, EMAC_RX_ER
SHD/SD2 <sup>2</sup>	17	I/O	GPIO9, SD_DATA2, SPIHD, HS1_DATA2, U1RXD
SWP/SD3 <sup>2</sup>	18	I/O	GPIO10, SD_DATA3, SPIWP, HS1_DATA3, U1TXD
SCS/CMD <sup>2</sup>	19	I/O	GPIO11, SD_CMD, SPICS0, HS1_CMD, U1RTS
SCK/CLK <sup>2</sup>	20	I/O	GPIO6, SD_CLK, SPICLK, HS1_CLK, U1CTS
SDO/SD0 <sup>2</sup>	21	I/O	GPIO7, SD_DATA0, SPIQ, HS1_DATA0, U2RTS
SDI/SD1 <sup>2</sup>	22	I/O	GPIO8, SD_DATA1, SPID, HS1_DATA1, U2CTS
IO15	23	I/O	GPIO15, ADC2_CH3, TOUCH3, MTDO, HSPICS0, RTC_GPIO13, HS2_CMD, SD_CMD, EMAC_RXD3
IO2	24	I/O	GPIO2, ADC2_CH2, TOUCH2, RTC_GPIO12, HSPIWP, HS2_DATA0, SD_DATA0
IO0	25	I/O	GPIO0, ADC2_CH1, TOUCH1, RTC_GPIO11, CLK_OUT1, EMAC_TX_CLK
IO4	26	I/O	GPIO4, ADC2_CH0, TOUCH0, RTC_GPIO10, HSPIHD, HS2_DATA1, SD_DATA1, EMAC_TX_ER
NC1	27	-	-
NC2	28	-	-
IO5	29	I/O	GPIO5, VSPICS0, HS1_DATA6, EMAC_RX_CLK
IO18	30	I/O	GPIO18, VSPICLK, HS1_DATA7
IO19	31	I/O	GPIO19, VSPIQ, U0CTS, EMAC_TXD0
NC	32	-	-
IO21	33	I/O	GPIO21, VSPIHD, EMAC_TX_EN
RXD0	34	I/O	GPIO3, U0RXD, CLK_OUT2
TXD0	35	I/O	GPIO1, U0TXD, CLK_OUT3, EMAC_RXD2
IO22	36	I/O	GPIO22, VSPIWP, U0RTS, EMAC_TXD1
IO23	37	I/O	GPIO23, VSPID, HS1_STROBE
GND	38	P	Ground

**Notice:**

1. GPIO12 is internally pulled high in the module and is not recommended for use as a touch pin.
2. Pins SCK/CLK, SDO/SD0, SDI/SD1, SHD/SD2, SWP/SD3 and SCS/CMD, namely, GPIO6 to GPIO11 are connected to the SPI flash integrated on the module and are not recommended for other uses.

For more information, please visit: [https://www.espressif.com/sites/default/files/documentation/esp32-wrover\\_datasheet\\_en.pdf](https://www.espressif.com/sites/default/files/documentation/esp32-wrover_datasheet_en.pdf)

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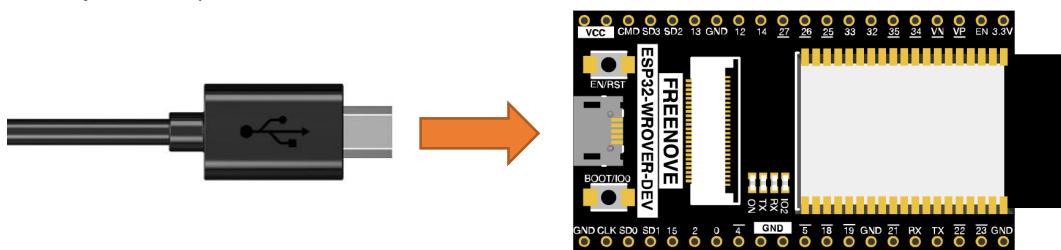
## CH340

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

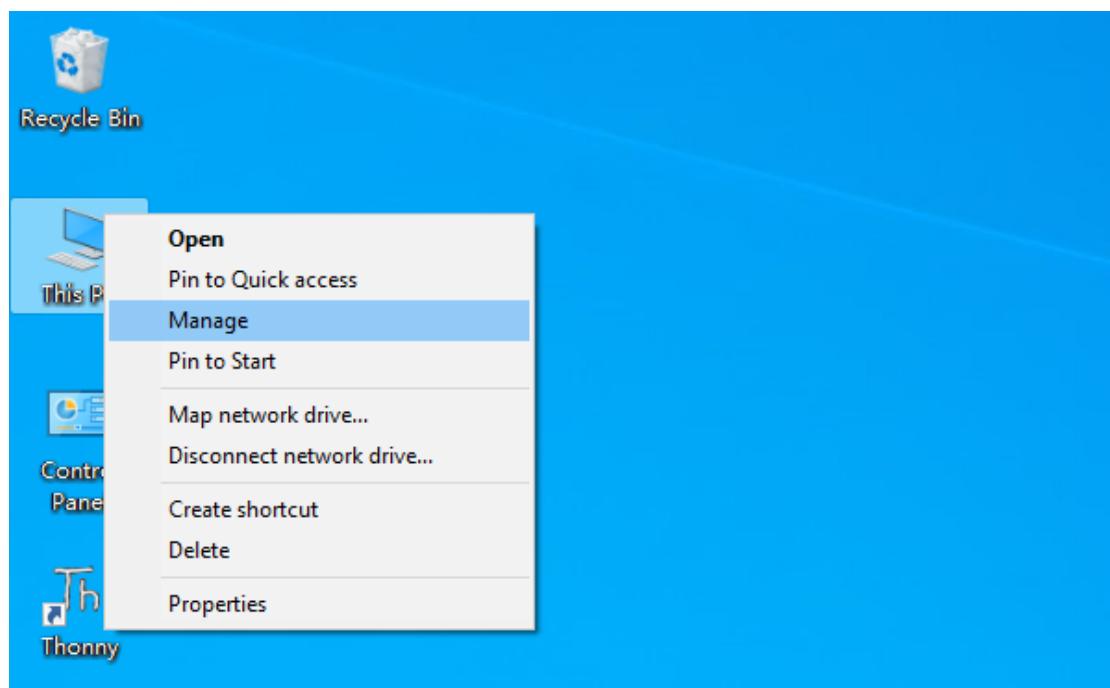
### Windows

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.

index / search / search CH340

All (14)

**Downloads (7)**

Products (4)

Application (2)

Video (1)

News (0)

### keyword CH340

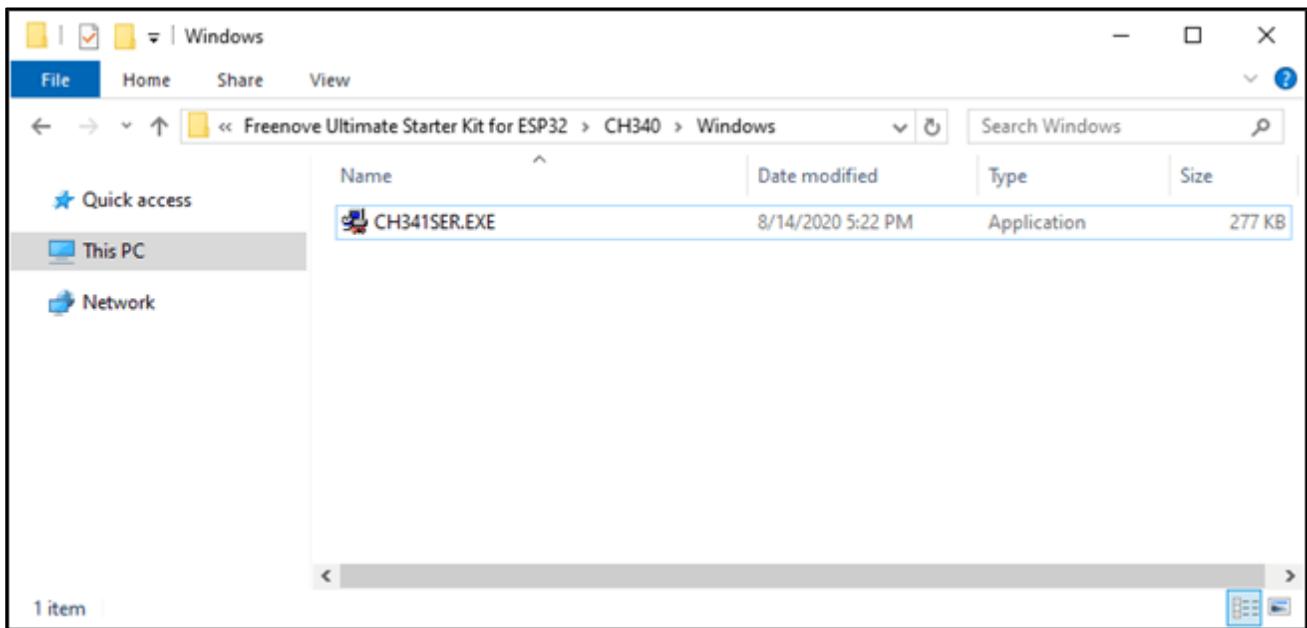
Downloads(7)

file category	file content	version	upload time
Driver&Tools	<b>Windows</b> CH341SER.EXE CH340/CH341 USB to serial port Windows driver, supports 32/64-bit Windows 10/8.1/8/7/VISTA/XP, Server 2016/2012/2008/2003, 2000/ME/98	3.5	2019-03-18
	<b>CH341SER.ZIP</b> CH340/CH341 USB to serial port Windows driver, includes DLL dynamic library and non-standard baud rate settings and other instructions. Supports 32/64-bit Windows 10/8.1/8/7/VISTA/XP, Server 2016/2012/2008/2003, 2000/ME/98	3.5	2019-03-05
	<b>CH341SER_ANDROID...</b> CH340/CH341 USB to serial port Android free drive application library, for Android OS 3.1 and above version which supports USB Host mode already, no need to load Android kernel driver, no root privileges. Contains apk, lib library file (Java Driver), App Demo Example (USB to UART Device)	1.6	2019-04-19
	<b>CH341SER_LINUX...</b> CH340/CH341 USB to serial port LINUX driver	1.5	2018-03-18
	<b>CH341SER_MAC.ZI...</b> CH340/CH341 USB to serial port MAC OS driver	1.5	2018-07-05
Others			
	<b>PRODUCT_GUIDE.P...</b> Electronic selection of product selection manual, please refer to related product technical manual for more technical information.	1.4	2018-12-29
	<b>InstallNoteOn64...</b> Instructions for the driver after 18 years of August cannot be installed under some 64-bit WIN7 (English)	1.0	2019-01-10

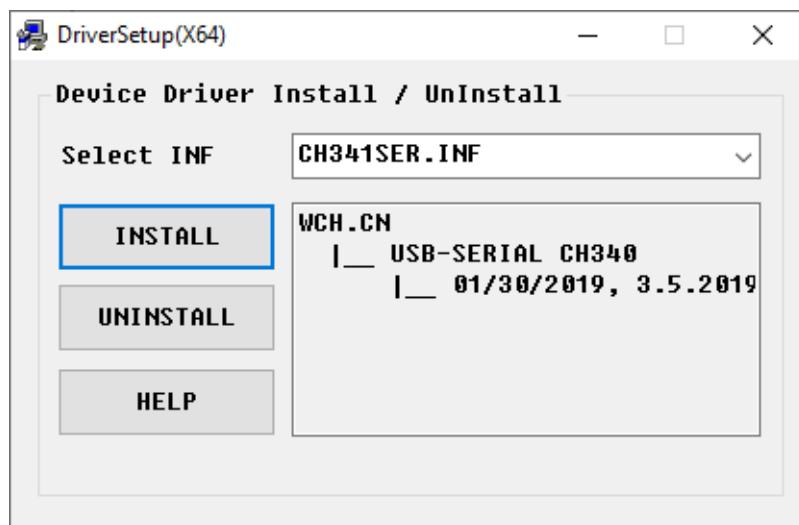
If you would not like to download the installation package, you can open “Freenove\_ESP32\_WROVER\_Board/CH340”, we have prepared the installation package.

Name	Date modified	Type	Size
Linux	8/14/2020 5:24 PM	File folder	
MAC	8/14/2020 5:23 PM	File folder	
<b>Windows</b>	8/14/2020 5:23 PM	File folder	

2. Open the folder “Freenove\_ESP32\_WROVER\_Board/CH340/Windows/”



3. Double click “CH341SER.EXE”.



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

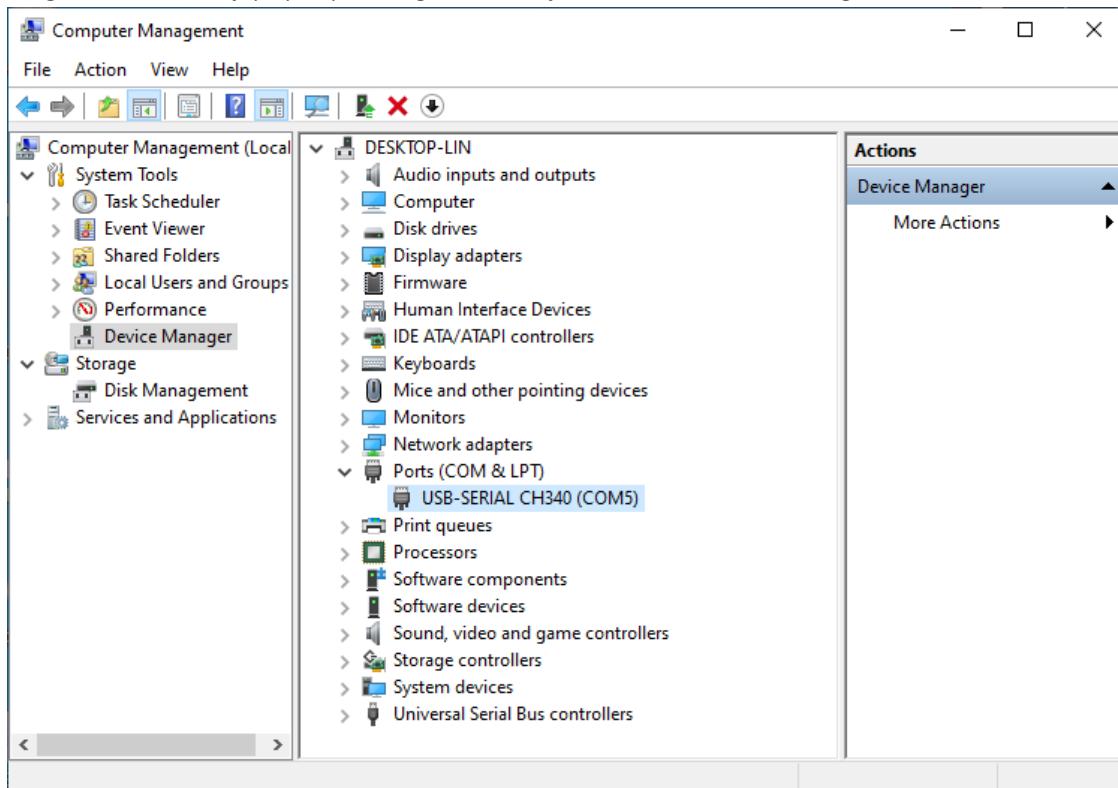


5. Install successfully. Close all interfaces.





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

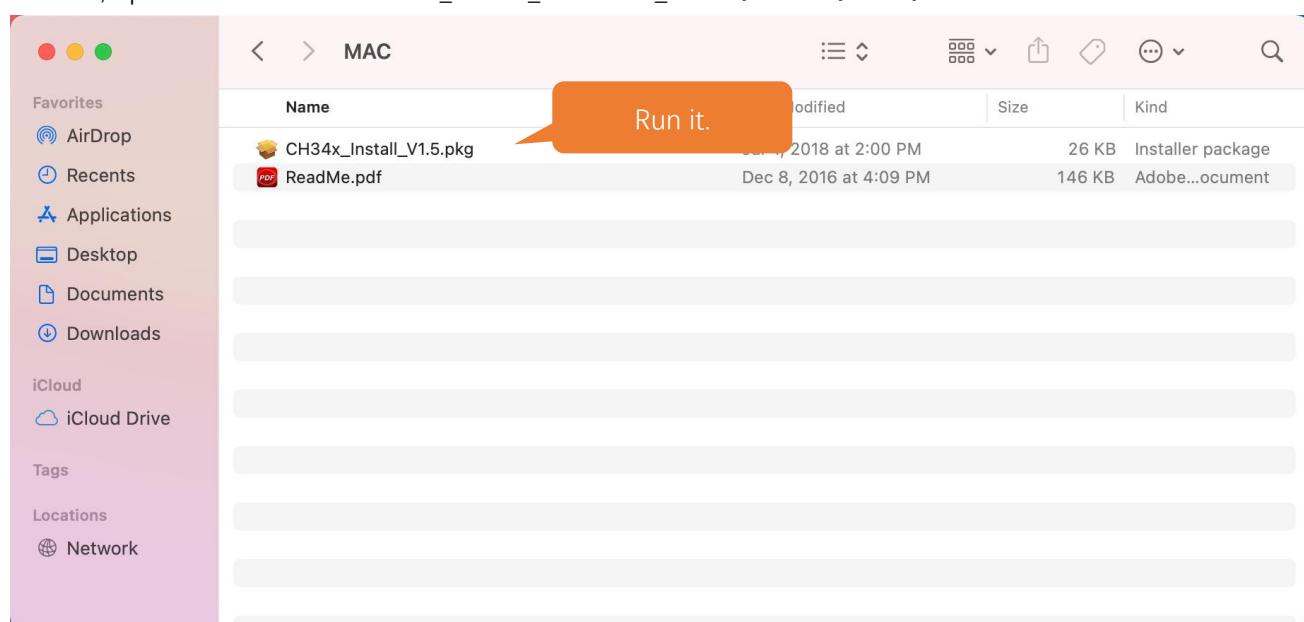
First, download CH340 driver, click <http://www.wch-ic.com/search?q=CH340&t=downloads> to download the appropriate one based on your operating system.

The screenshot shows a search results page for 'ch340' on the WCH website. The left sidebar has categories: All (14), Downloads (7), Products (4), Application (2), Video (1), and News (0). The main area shows search results for 'Downloads( 7 )'. There are three orange callout boxes pointing to specific files:

- A callout box labeled 'Windows' points to 'CH341SER.EXE' which is described as a USB to serial port Windows driver.
- A callout box labeled 'Linux' points to 'CH341SER\_LINUX...' which is described as a CH340/CH341 USB to serial port LINUX driver.
- A callout box labeled 'MAC' points to 'CH341SER\_MAC.ZIP' which is described as a CH340/CH341 USB to serial port MAC OS driver.

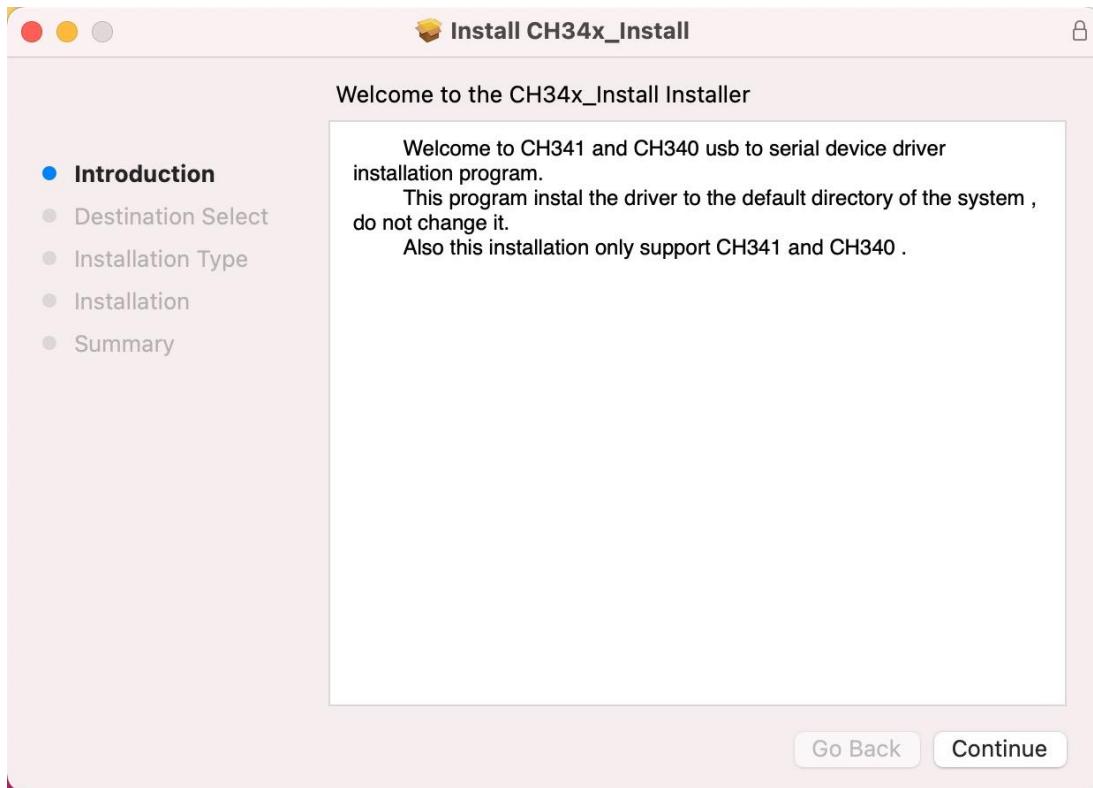
file category	file content	version	upload time
Driver&Tools	CH341SER.EXE	3.5	2019-03-18
	CH341SER.ZIP	3.5	2019-03-05
	CH341SER_ANDROID...	1.6	2019-04-19
	CH341SER_LINUX...	1.5	2018-03-18
	CH341SER_MAC.ZI...	1.5	2018-07-05
Others			

If you would not like to download the installation package, you can open "Freenove\_ESP32\_WROVER\_Board/CH340", we have prepared the installation package. Second, open the folder "Freenove\_ESP32\_WROVER\_Board/CH340/MAC/"

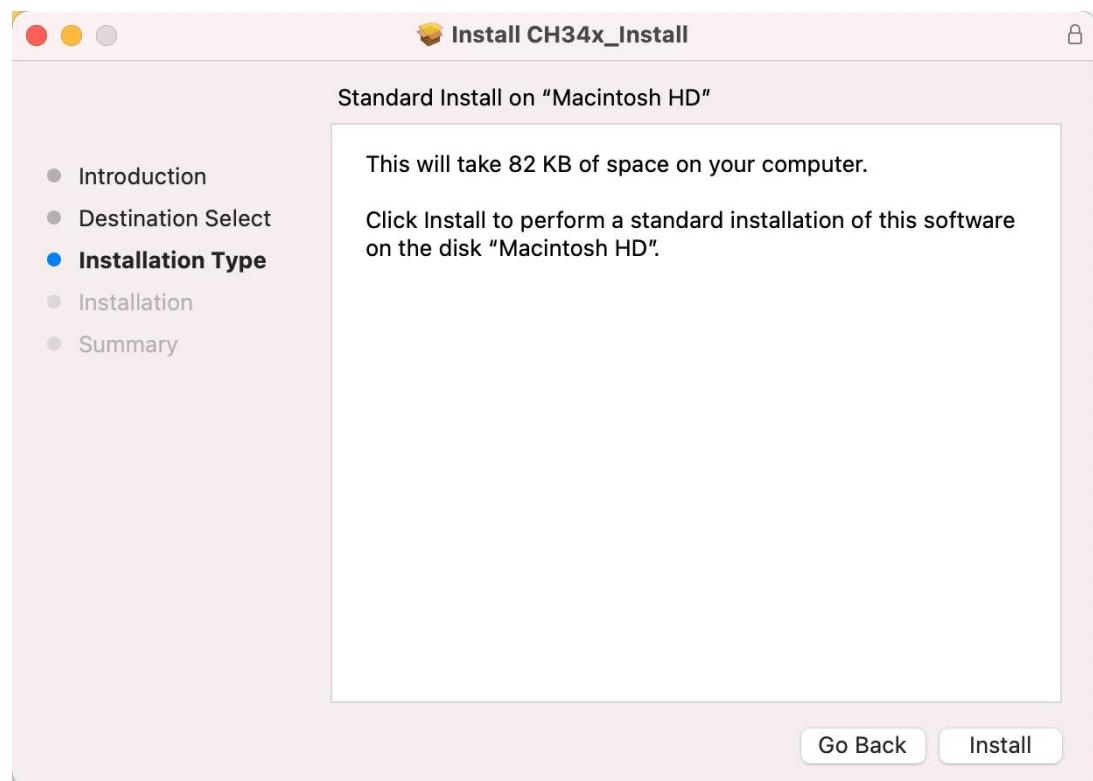




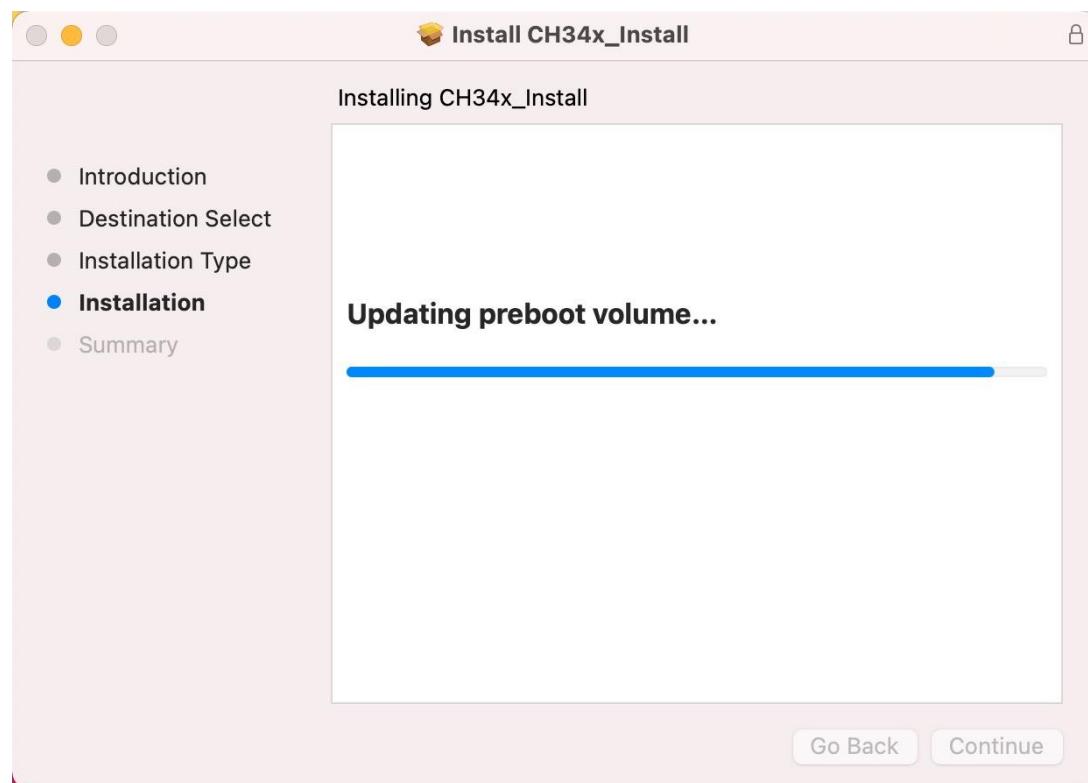
Third, click Continue.



Fourth, click Install.



Then, waiting Finsh.

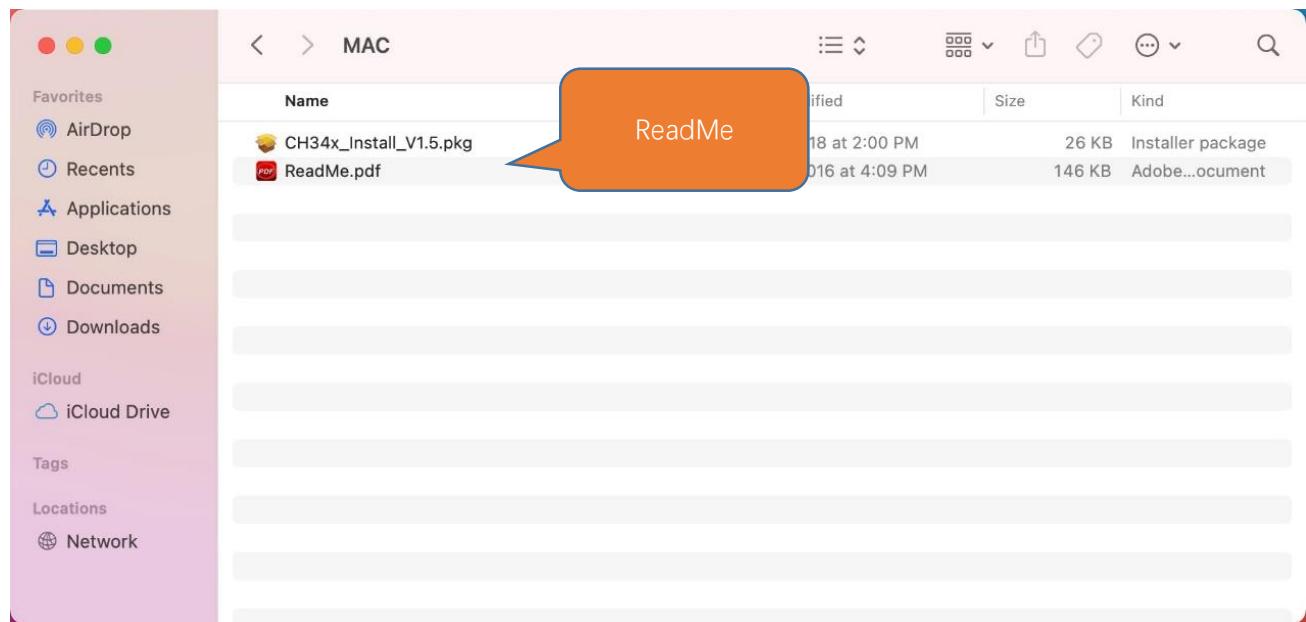


Finally, restart your PC.





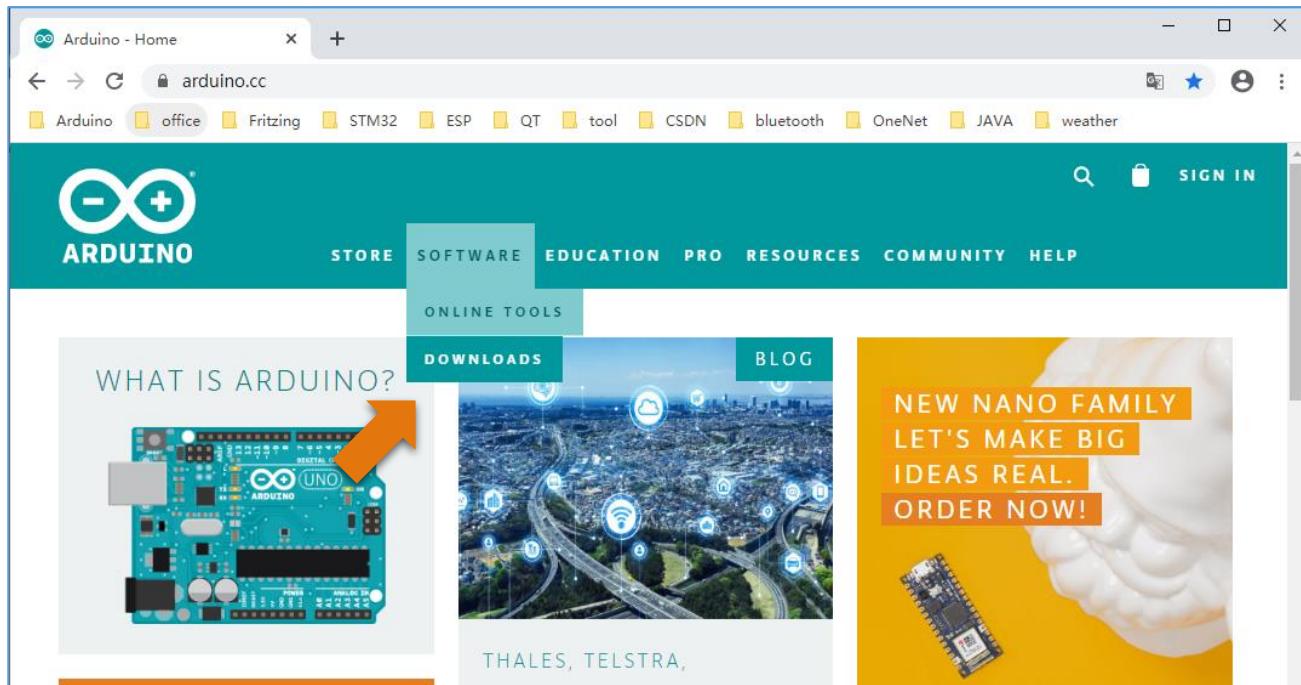
If you still haven't installed the CH340 by following the steps above, you can view `readme.pdf` to install it.



## Programming Software

Arduino Software (IDE) is used to write and upload the code for Arduino Board.

First, install Arduino Software (IDE): visit <https://www.arduino.cc>, click "Download" to enter the download page.



Select and download corresponding installer according to your operating system. If you are a windows user, please select the "Windows Installer" to download to install the driver correctly.

 A screenshot of the Arduino IDE download page. The main heading is 'Download the Arduino IDE'. Below it, there's a large circular Arduino logo. To the right, there's a detailed description of the software and its compatibility with Windows, Mac OS X, and Linux. On the far right, there's a sidebar with download links for different operating systems. A red arrow points to the 'Windows Installer' link in this sidebar.
 

**ARDUINO 1.8.12**

The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. It runs on Windows, Mac OS X, and Linux. The environment is written in Java and based on Processing and other open-source software.

This software can be used with any Arduino board. Refer to the [Getting Started](#) page for installation instructions.

**Windows** Installer, for Windows XP and up  
**Windows** ZIP file for non admin install

**Windows app** Requires Win 8.1 or 10  
[Get](#)

**Mac OS X** 10.8 Mountain Lion or newer

**Linux** 32 bits  
**Linux** 64 bits  
**Linux** ARM 32 bits  
**Linux** ARM 64 bits

[Release Notes](#)  
[Source Code](#)  
[Checksums \(sha512\)](#)

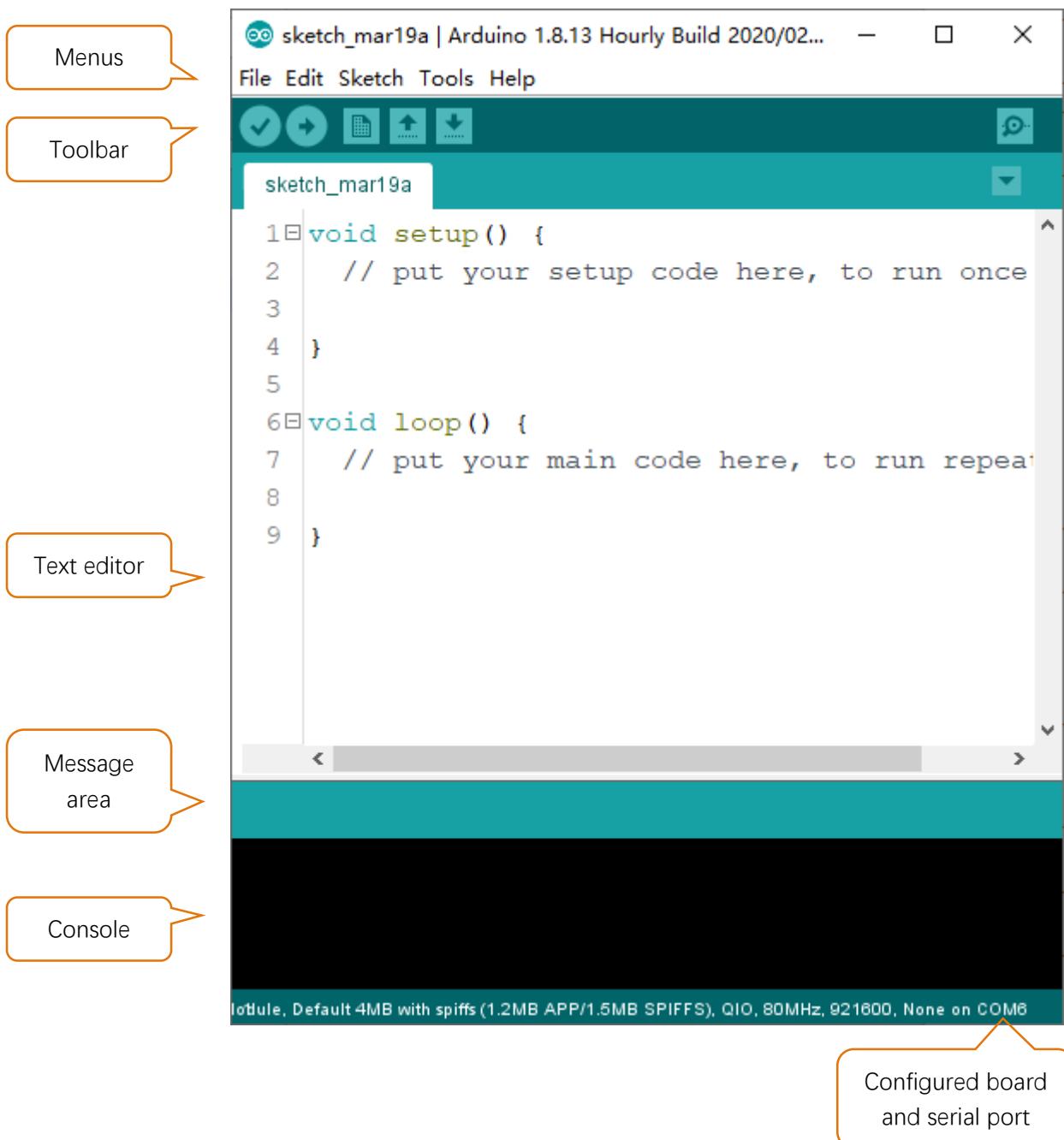
After the download completes, run the installer. For Windows users, there may pop up an installation dialog box of driver during the installation process. When it popes up, please allow the installation.

After installation is complete, an Arduino Software shortcut will be generated in the desktop. Run the Arduino Software.

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



The interface of Arduino Software is as follows:



---

Programs written with Arduino Software (IDE) are called **sketches**. These sketches are written in the text editor and saved with the file extension.**.ino**. The editor has features for cutting/pasting and searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom right-hand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.



Verify

Check your code for compile errors .



Upload

Compile your code and upload them to the configured board.



New

Create a new sketch.



Open

Present a menu of all the sketches in your sketchbook. Clicking one will open it within the current window and overwrite its content.



Save

Save your sketch.



Serial Monitor

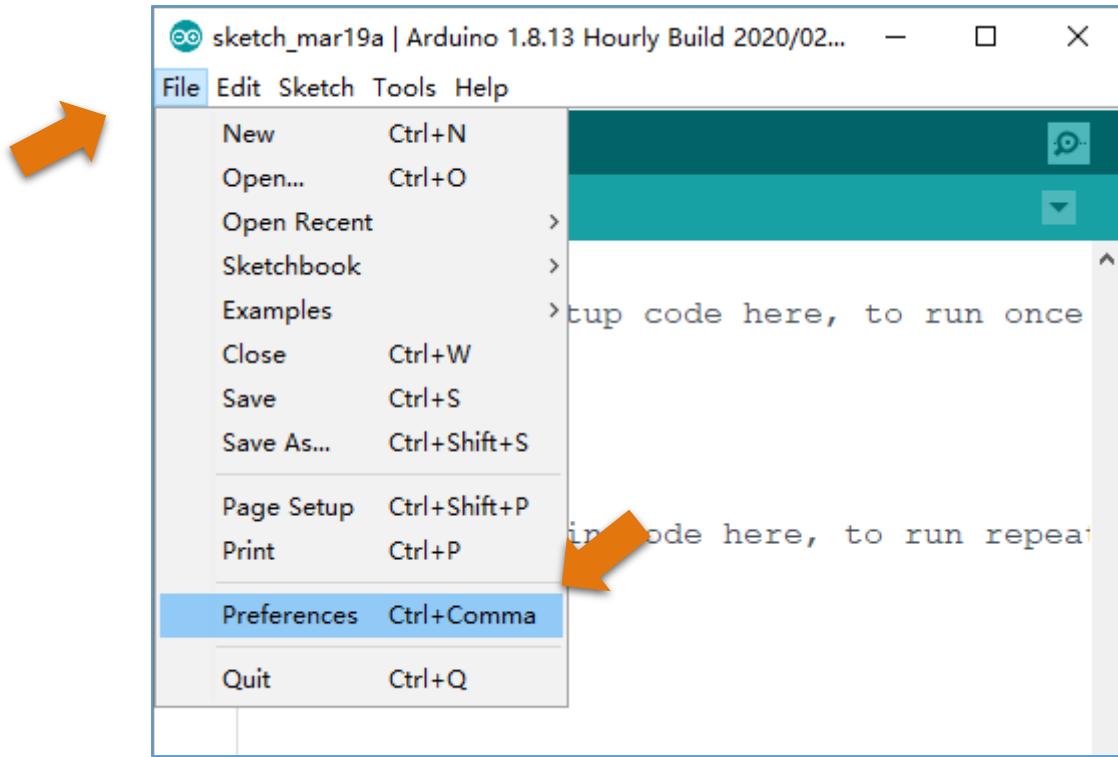
Open the serial monitor.

Additional commands are found within the five menus: File, Edit, Sketch, Tools, Help. The menus are context sensitive, which means only those items relevant to the work currently being carried out are available.

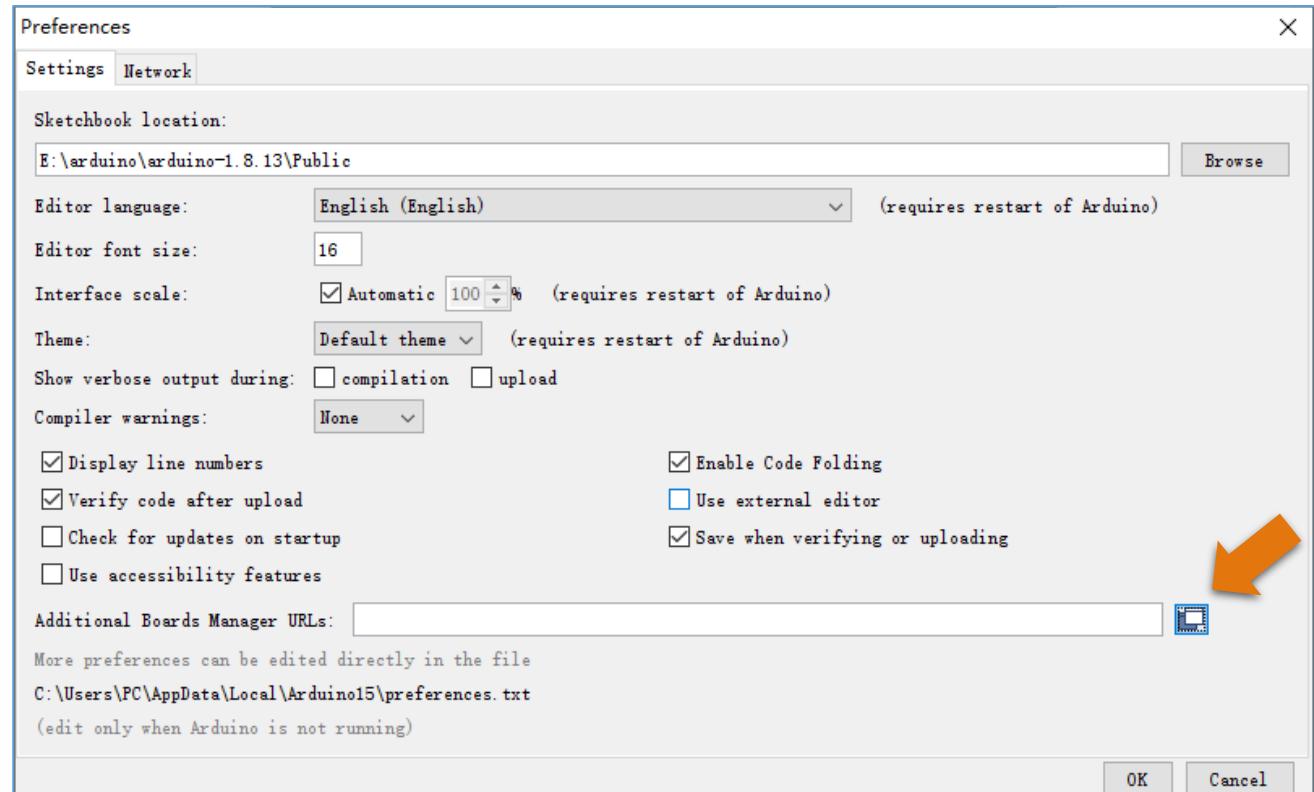


## Environment Configuration

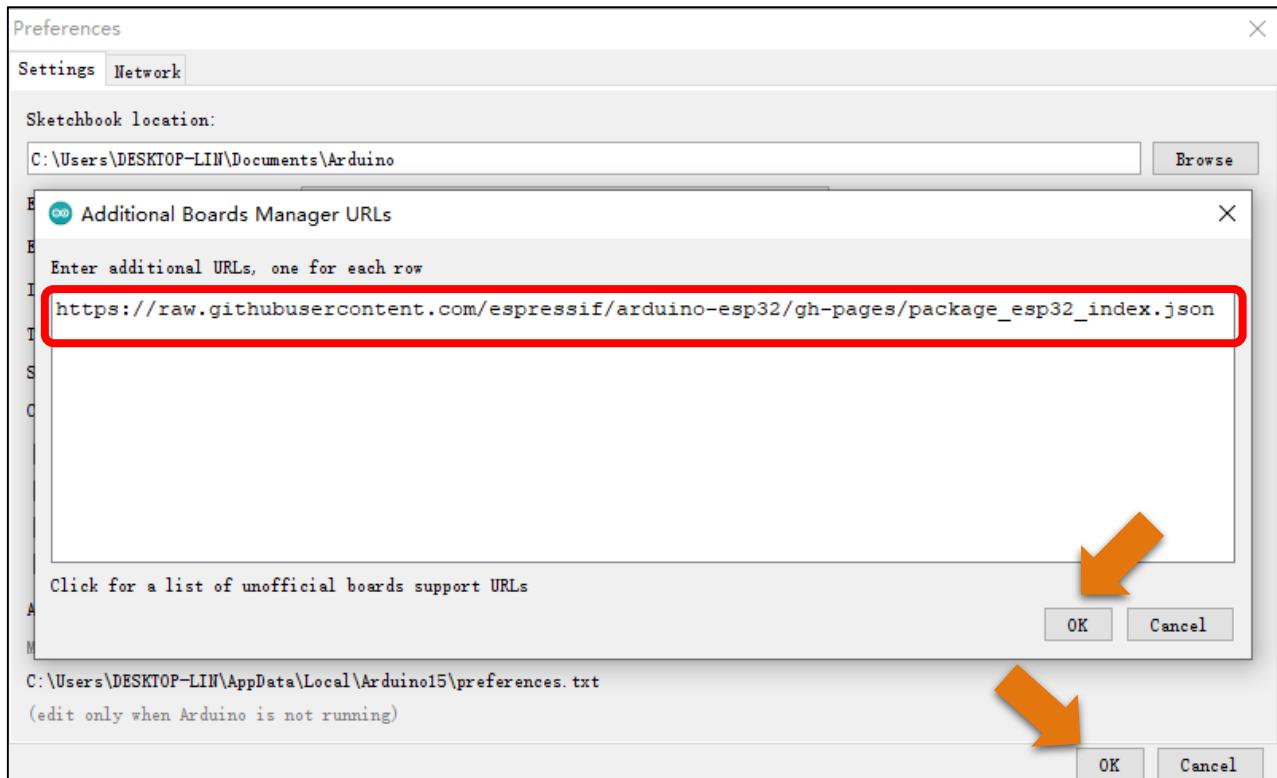
First, open the software platform arduino, and then click File in Menus and select Preferences.



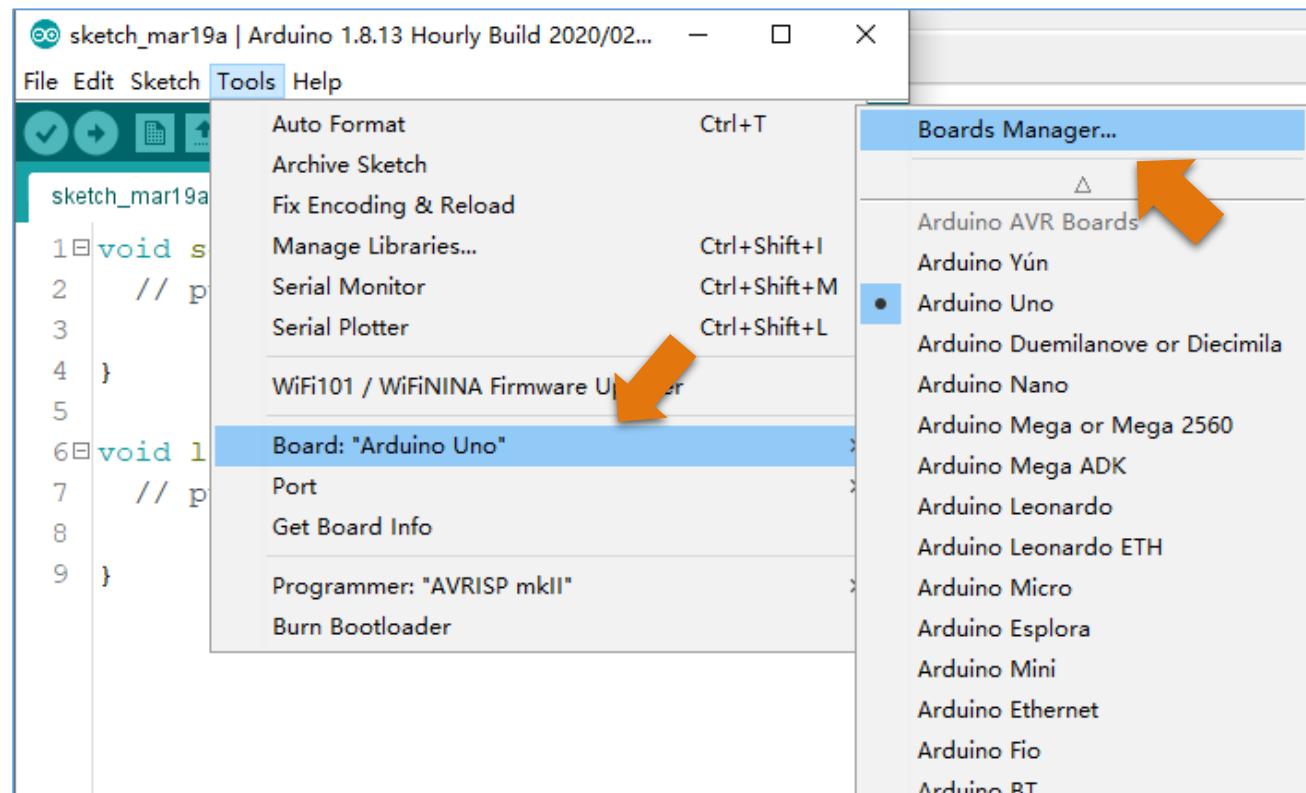
Second, click on the symbol behind "Additional Boards Manager URLs"



Third, fill in [https://raw.githubusercontent.com/espressif/arduino-esp32/gh-pages/package\\_esp32\\_index.json](https://raw.githubusercontent.com/espressif/arduino-esp32/gh-pages/package_esp32_index.json) in the new window, click OK, and click OK on the Preferences window again.



Fourth, click Tools in Menus, select Board:"ArduinoUno", and then select "Boards Manager".



Fifth, input "esp32" in the window below, and press Enter. click "Install" to install.



When finishing installation, click Tools in the Menus again and select Board: "Arduino Uno", and then you can see information of ESP32-WROVER. click "ESP32-WROVER" so that the ESP32 programming development environment is configured.



Any concerns? ✉ support@freenove.com

## Notes for GPIO

### Strapping Pin

There are five Strapping pins for ESP32: MTDI、GPIO0、GPIO2、MTDO、GPIO5.

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

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

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

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

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	Rising-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

**Note:**

- Firmware can configure register bits to change the settings of "Voltage of Internal LDO (VDD\_SDIO)" and "Timing of SDIO Slave" after booting.
- The MTDI is internally pulled high in the module, as the flash and SRAM in ESP32-WROVER only support a power voltage of 1.8 V (output by VDD\_SDIO).

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

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

or check: [https://www.espressif.com/sites/default/files/documentation/esp32-wrover\\_datasheet\\_en.pdf](https://www.espressif.com/sites/default/files/documentation/esp32-wrover_datasheet_en.pdf)

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

## Flash Pin

GPIO6-11 has been used to connect the integrated SPI flash on the module, and is used when GPIO 0 is power on and at high level. Flash is related to the operation of the whole chip, so the external pin GPIO6-11 cannot be used as an experimental pin for external circuits, otherwise it may cause errors in the operation of the program.

GPIO16-17 has been used to connect the integrated PSRAM on the module.

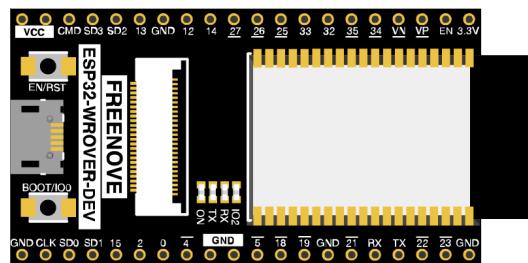
Because of external pull-up, MTDI pin is not suggested to be used as a touch sensor. For details, please refer to Peripheral Interface and Sensor chapter in "ESP32 Data\_Sheet".

For more relevant information, please check:

[https://www.espressif.com/sites/default/files/documentation/esp32-wrover\\_datasheet\\_en.pdf](https://www.espressif.com/sites/default/files/documentation/esp32-wrover_datasheet_en.pdf).

## Cam Pin

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



CAM_Pin	GPIO_pin
I2C_SDA	GPIO26
I2C_SCL	GPIO27
CSI_VSYNC	GPIO25
CSI_HREF	GPIO23
CSI_Y9	GPIO35
XCLK	GPIO21
CSI_Y8	GPIO34
CSI_Y7	GPIO39
CSI_PCLK	GPIO22
CSI_Y6	GPIO36
CSI_Y2	GPIO4
CSI_Y5	GPIO19
CSI_Y3	GPIO5
CSI_Y4	GPIO18

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

or check: [https://www.espressif.com/sites/default/files/documentation/esp32-wrover\\_datasheet\\_en.pdf](https://www.espressif.com/sites/default/files/documentation/esp32-wrover_datasheet_en.pdf).



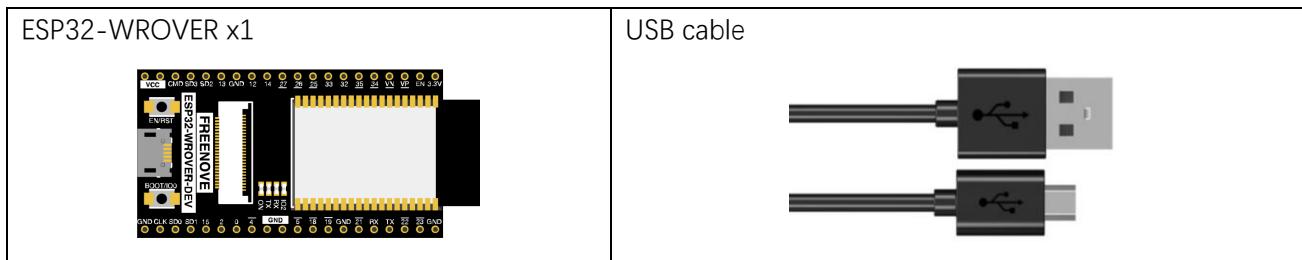
# Chapter 1 LED

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

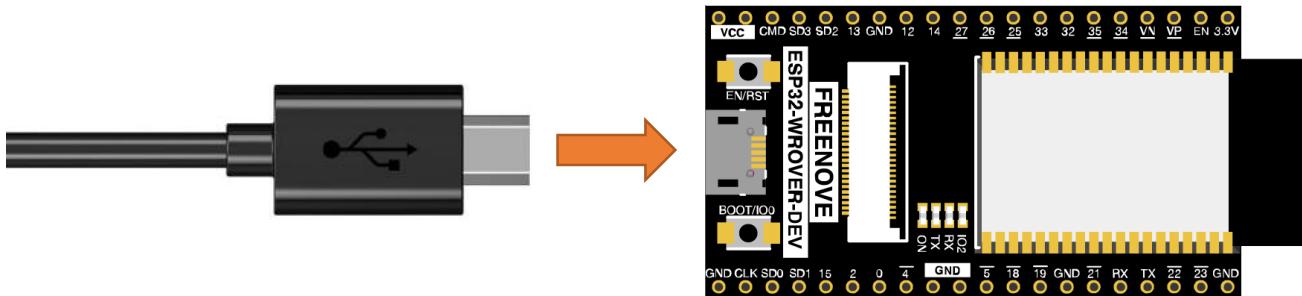
In this project, we will use ESP32 to control blinking a common LED.

### Component List



#### Power

ESP32-WROVER needs 5v power supply. In this tutorial, we need connect ESP32-WROVER 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-WROVER by default.

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

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

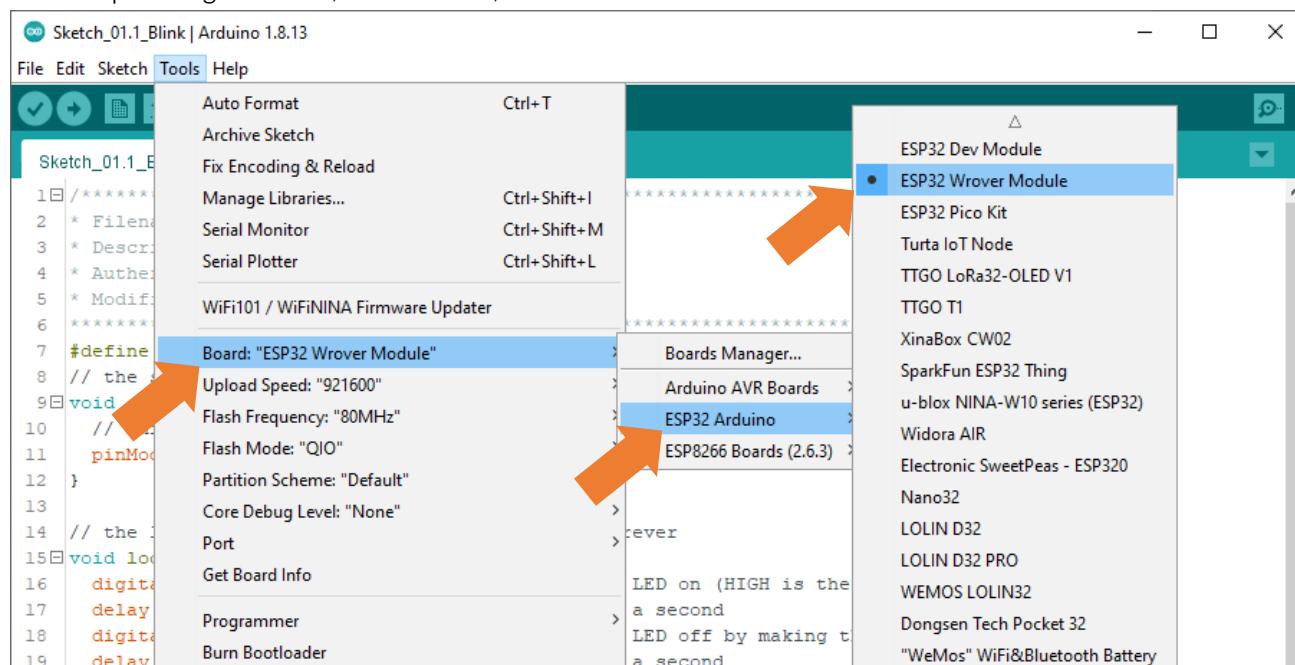
## Sketch

According to the circuit, when the GPIO2 of ESP32-WROVER output level is high, the LED turns ON. Conversely, when the GPIO2 ESP32-WROVER output level is low, the LED turns OFF. Therefore, we can let GPIO2 circularly output high and low level to make the LED blink.

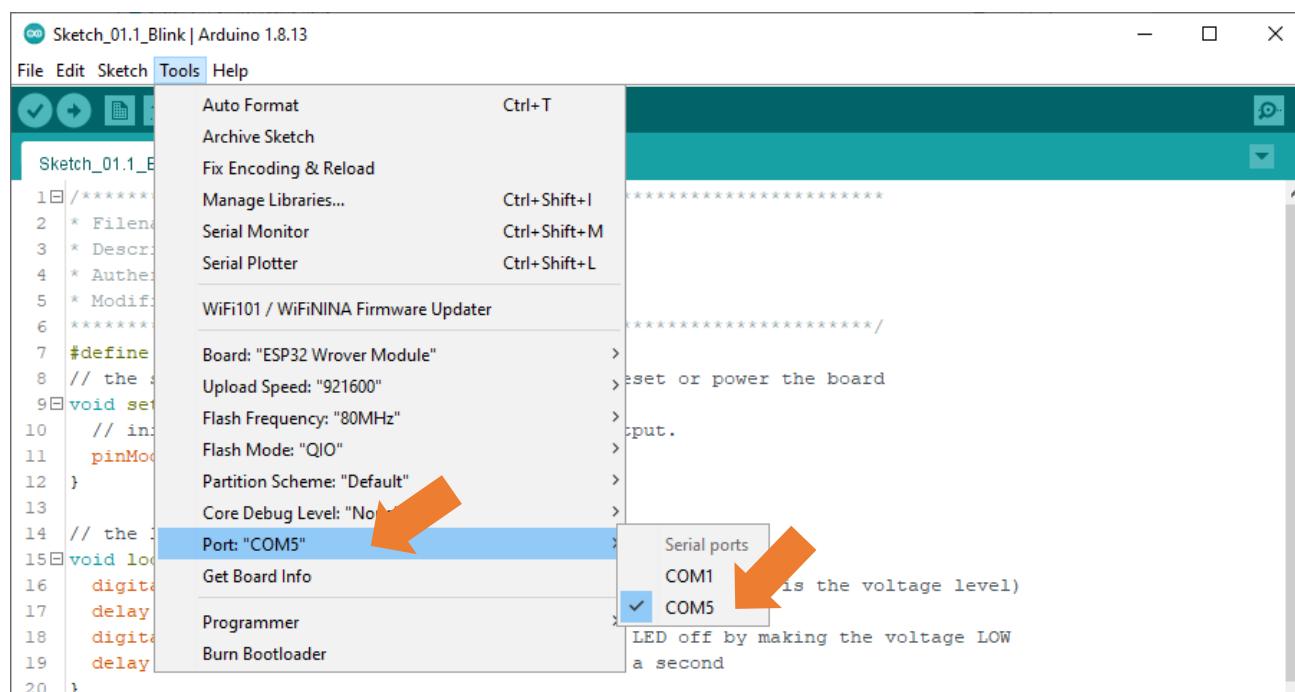
Upload the following Sketch:

**Freenove\_ESP32\_WROVER\_Board\Sketches\Sketch\_01.1\_Blink.**

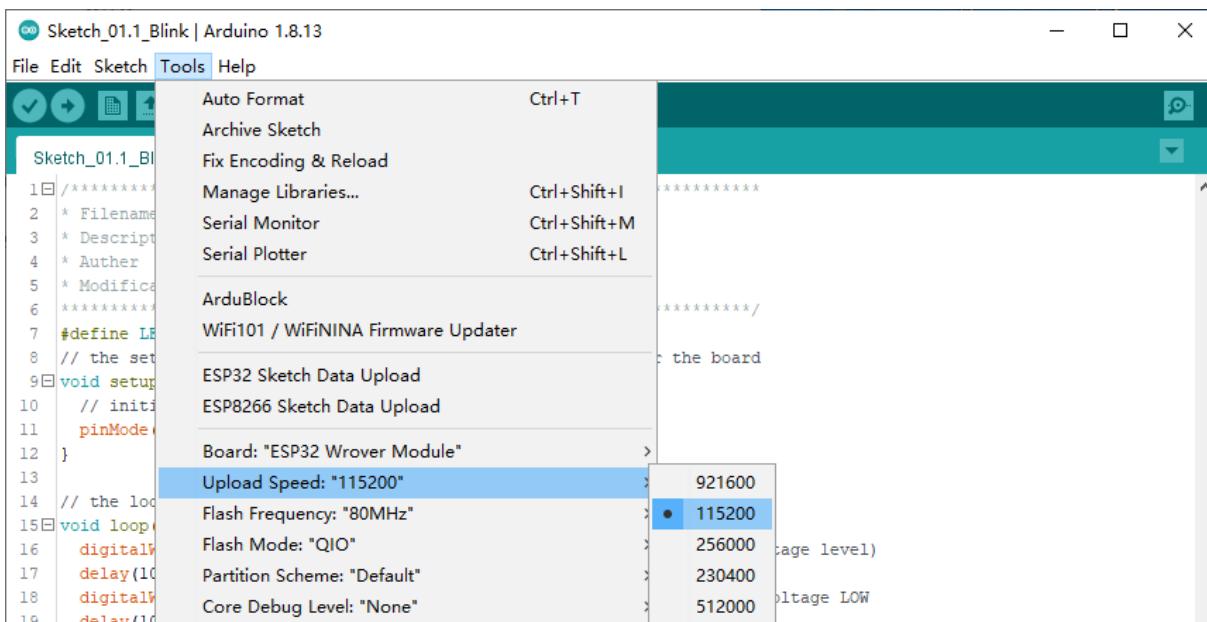
Before uploading the code, click "Tools", "Board" and select "ESP32 Wrover Module".



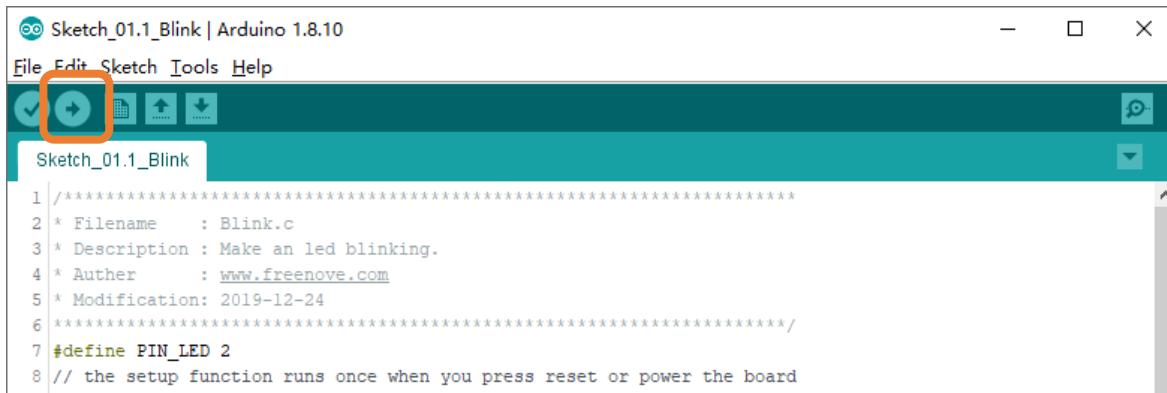
Select the serial port.



Note: For macOS users, if the uploading fails, please set the baud rate to 115200 before clicking “Upload Using Programmer”.



### Sketch\_01.1\_Blink



Click “Upload”, Download the code to ESP32-WROVER and your LED in the circuit starts Blink.



If you have any concerns, please contact us via: [support@freenove.com](mailto:support@freenove.com)

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

The following is the program code:

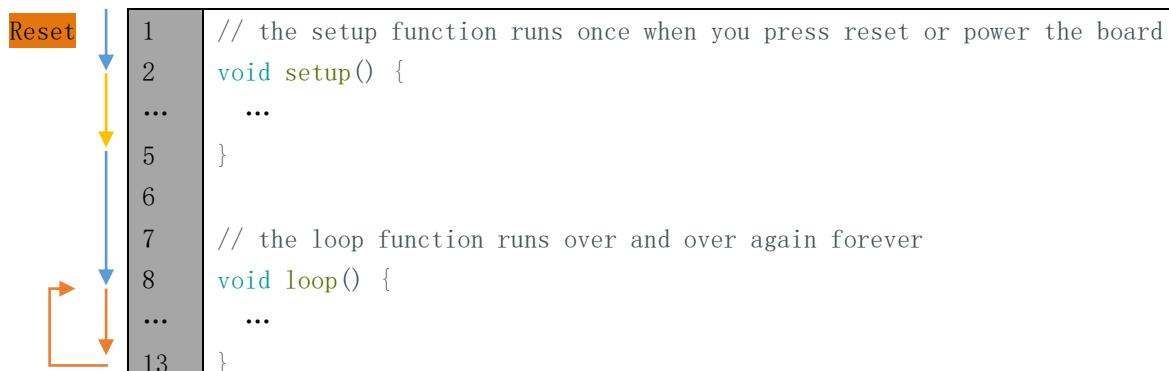
```

1 #define PIN_LED 2
2 // the setup function runs once when you press reset or power the board
3 void setup() {
4     // initialize digital pin LED_BUILTIN as an output.
5     pinMode(PIN_LED, OUTPUT);
6 }
7
8 // the loop function runs over and over again forever
9 void loop() {
10    digitalWrite(PIN_LED, HIGH);      // turn the LED on (HIGH is the voltage level)
11    delay(1000);                  // wait for a second
12    digitalWrite(PIN_LED, LOW);     // turn the LED off by making the voltage LOW
13    delay(1000);                  // wait for a second
14 }
```

The Arduino IDE code usually contains two basic functions: void setup() and void loop().

After the board is reset, the setup() function will be executed firstly, and then the loop() function.

setup() function is generally used to write code to initialize the hardware. And loop() function is used to write code to achieve certain functions. loop() function is executed repeatedly. When the execution reaches the end of loop(), it will jump to the beginning of loop() to run again.



### Reset

Reset operation will lead the code to be executed from the beginning. Switching on the power, finishing uploading the code and pressing the reset button will trigger reset operation.

In the circuit, ESP32-WROVER's GPIO2 is connected to the LED, so the LED pin is defined as 2.

```
1 #define PIN_LED 2
```

This means that after this line of code, all PIN\_LED will be treated as 2.

In the setup () function, first, we set the PIN\_LED as output mode, which can make the port output high level or low level.

```

4 // initialize digital pin PIN_LED as an output.
5 pinMode(PIN_LED, OUTPUT);
```

Then, in the loop () function, set the PIN\_LED to output high level to make LED light up.

```
10 digitalWrite(PIN_LED, HIGH); // turn the LED on (HIGH is the voltage level)
```

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Wait for 1000ms, that is 1s. Delay () function is used to make control board wait for a moment before executing the next statement. The parameter indicates the number of milliseconds to wait for.

```
11 delay(1000); // wait for a second
```

Then set the PIN\_LED to output low level, and LED light off. One second later, the execution of loop () function will be completed.

```
12 digitalWrite(PIN_LED, LOW); // turn the LED off by making the voltage LOW
13 delay(1000); // wait for a second
```

The loop() function is constantly being executed, so LED will keep blinking.

## Reference

```
void pinMode(int pin, int mode);
```

Configures the specified pin to behave either as an input or an output.

### Parameters

pin: the pin number to set the mode of.

mode: INPUT, OUTPUT, INPUT\_PULLDOWN, or INPUT\_PULLUP.

```
void digitalWrite (int pin, int value);
```

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

For more related functions, please refer to <https://www.arduino.cc/reference/en/>

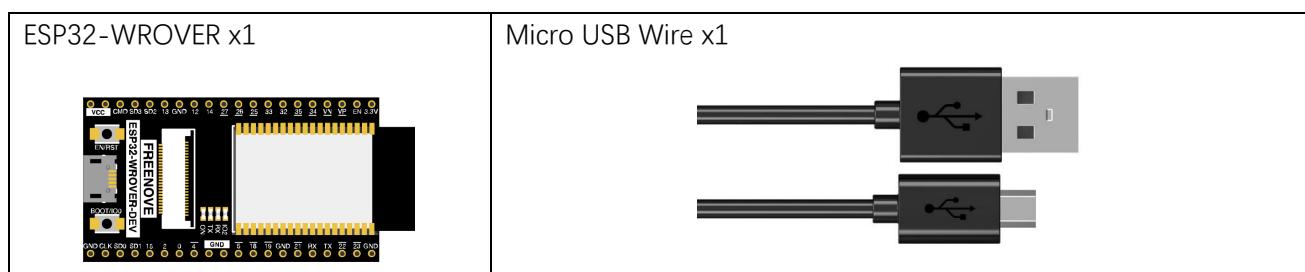
# Chapter 2 Bluetooth

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

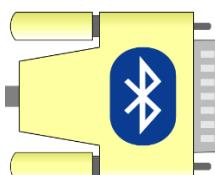
Project 2.1 is classic Bluetooth and Project 2.2 is low power Bluetooth. If you are an iPhone user, please start with Project 2.2.

# Project 2.1 Bluetooth Passthrough

## Component List



In this tutorial we need to use a Bluetooth APP called Serial Bluetooth Terminal to assist in the experiment. If you've not installed it yet, please do so by clicking: <https://www.appsapk.com/serial-bluetooth-terminal/> The following is its logo.



## Component knowledge

ESP32's integrated Bluetooth function Bluetooth is a short-distance communication system, which can be divided into two types, namely Bluetooth Low Energy(BLE) and Classic Bluetooth. There are two modes for simple data transmission: master mode and slave mode.

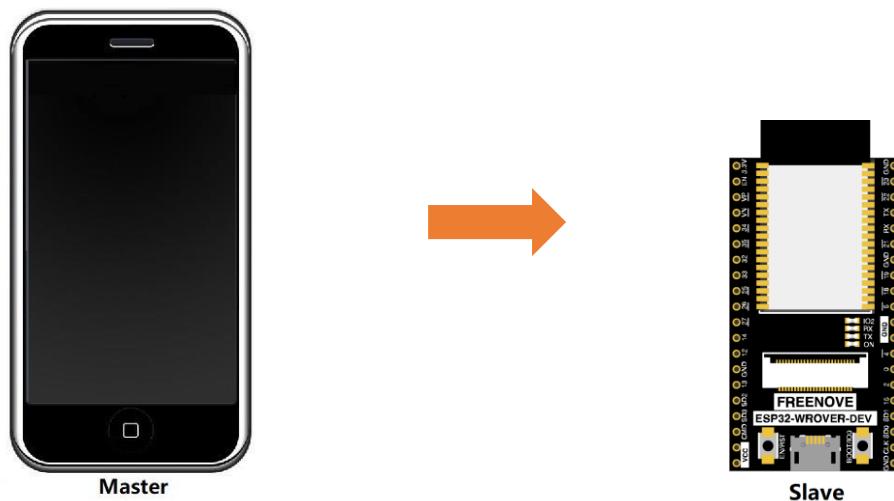
### Master mode

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

### Slave mode

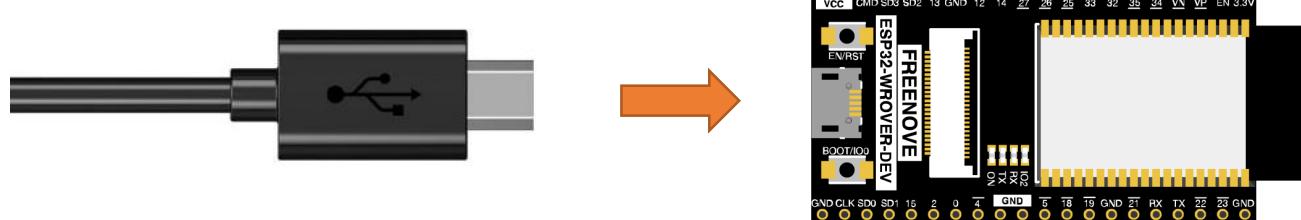
The Bluetooth module in slave mode can only accept connection request from a host computer, but cannot initiate a connection request. After connecting with a host device, it can send data to or receive from the host device.

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



# Circuit

Connect Freenove ESP32 to the computer using the USB cable.



## Sketch

Sketch 02.1 SerialToSerialBT

The screenshot shows the Arduino IDE interface with the following details:

- Title Bar:** SerialToSerialBT | Arduino 1.8.13 Hourly Build 2020/02/19 03:33
- Menu Bar:** File Edit Sketch Tools Help
- Toolbar:** Includes icons for Save, Upload, and Download.
- Sketch Name:** SerialToSerialBT
- Code Area:** The code is a simple serial-to-Bluetooth converter. It includes the `BluetoothSerial.h` header, initializes the `SerialBT` object, sets up the serial port at 115200 bps, and begins the Bluetooth device with the name "ESP32test". The `loop()` function reads from the serial port and writes to the Bluetooth port, and vice versa, with a 20ms delay between operations.

```
1 #include "BluetoothSerial.h"
2
3 BluetoothSerial SerialBT;
4 String buffer;
5 void setup() {
6     Serial.begin(115200);
7     SerialBT.begin("ESP32test"); //Bluetooth device name
8     Serial.println("\nThe device started, now you can pair it with bluetooth!");
9 }
10
11 void loop() {
12     if (Serial.available()) {
13         SerialBT.write(Serial.read());
14     }
15     if (SerialBT.available()) {
16         Serial.write(SerialBT.read());
17     }
18     delay(20);
19 }
20
```

- Status Bar:** Done Saving.
- Serial Monitor:** Displays the message "Leaving... Hard resetting via RTS pin...".

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Compile and upload the code to the ESP32-WROVER, open the serial monitor, and set the baud rate to 115200. When you see the serial printing out the character string as below, it indicates that the Bluetooth of ESP32 is ready and waiting to connect with the mobile phone.

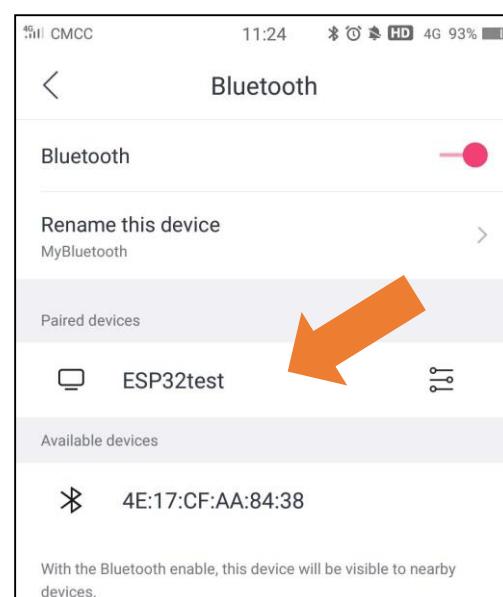
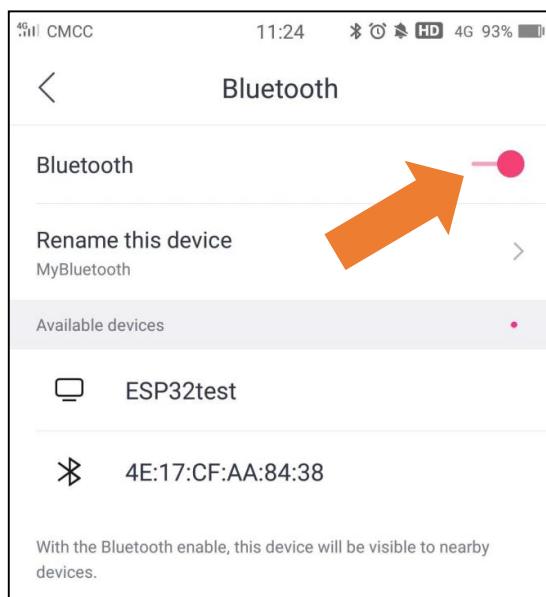
```
The device started, now you can pair it with bluetooth!
```

Autoscroll  Show timestamp    Newline    115200 baud    Clear output

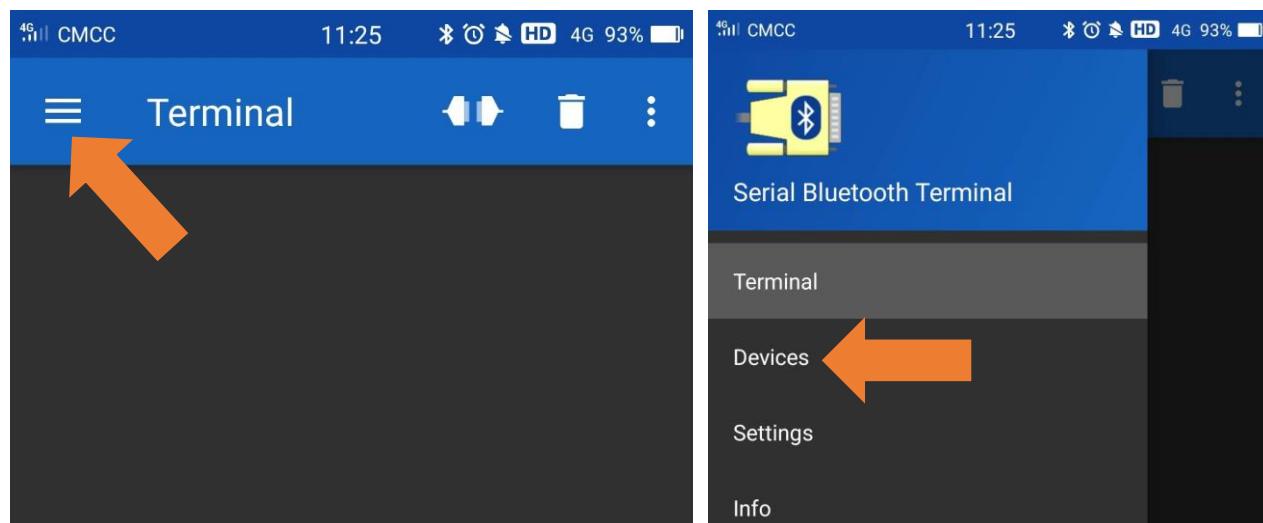
Make sure that the Bluetooth of your phone has been turned on and Serial Bluetooth Terminal has been installed.



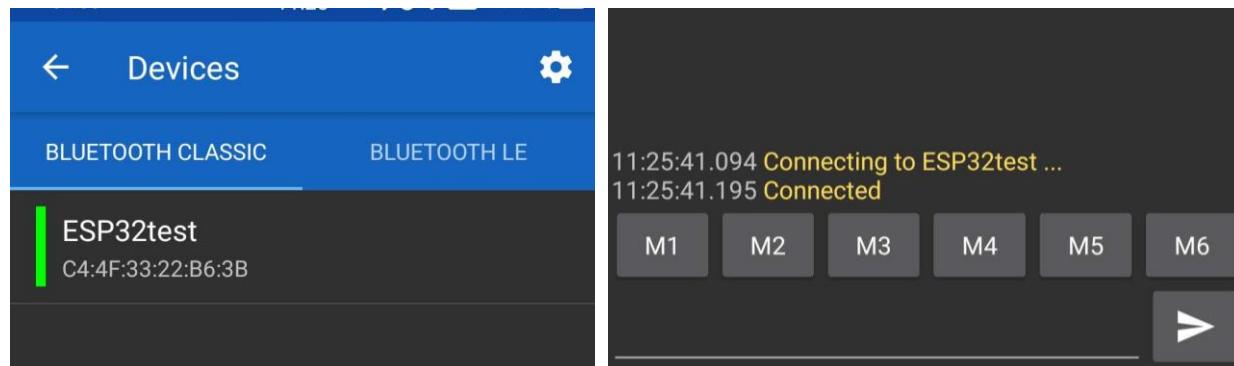
Click "Search" to search Bluetooth devices nearby and select "ESP32 test" to connect to.



Turn on software APP, click the left of the terminal. Select "Devices"

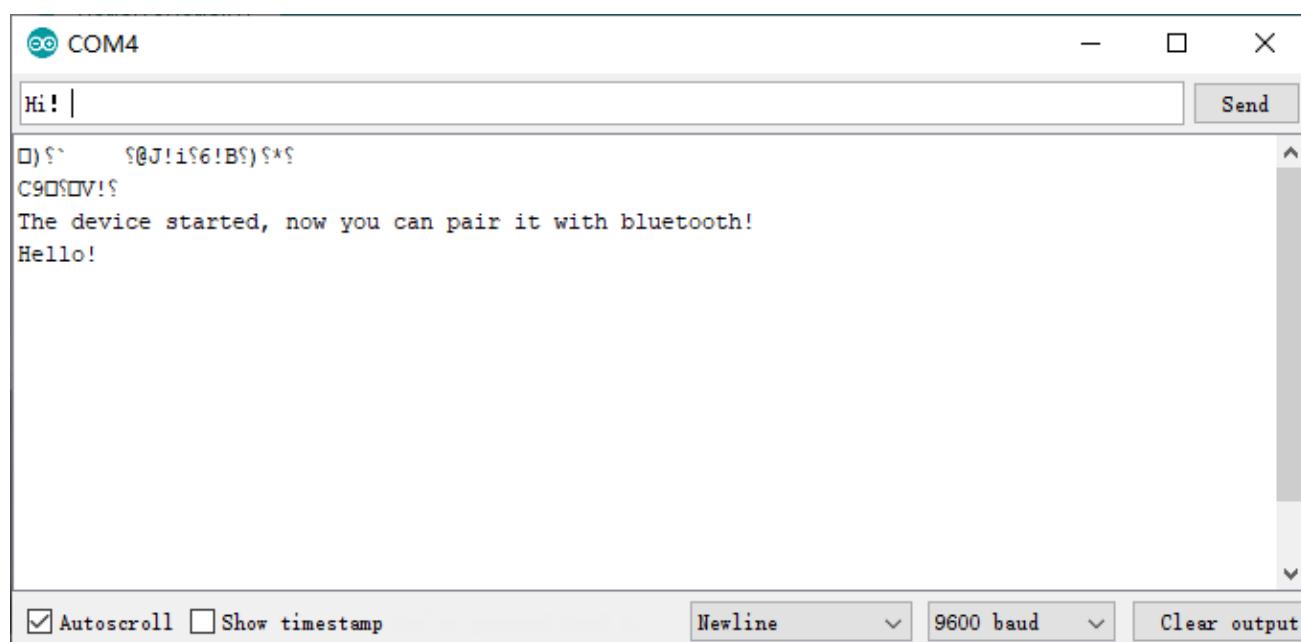


Select ESP32test in classic Bluetooth mode, and a successful connecting prompt will appear as shown on the right illustration.

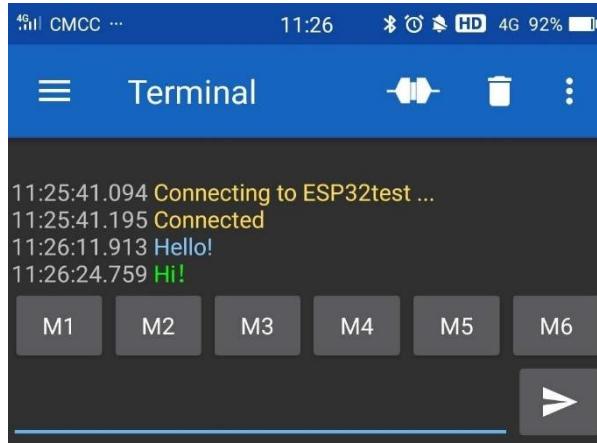


And now data can be transferred between your mobile phone and computer via ESP32-WROVER.

Send 'Hello!' from your phone, when the computer receives it, reply "Hi" to your phone.



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



Reference

### Class BluetoothSerial

This is a class library used to operate **BluetoothSerial**, which can directly read and set **BluetoothSerial**.

Here are some member functions:

**begin(localName, isMaster)**: Initialization function of the Bluetooth

name: name of Bluetooth module; Data type: String

**isMaster**: bool type, whether to set Bluetooth as Master. By default, it is false.

**available()**: acquire digits sent from the buffer, if not, return 0.

**read()**: read data from Bluetooth, data type of return value is int.

**readString()**: read data from Bluetooth, data type of return value is String.

**write(val)**: send an int data val to Bluetooth.

**write(str)**: send an SString data str to Bluetooth.

**write(buf, len)**: Sends the first len data in the buf Array to Bluetooth.

**setPin(const char \*pin)**: set a four-digit Bluetooth pairing code. By default, it is 1234

**connect(remoteName)**: connect a Bluetooth named remoteName, data type: String

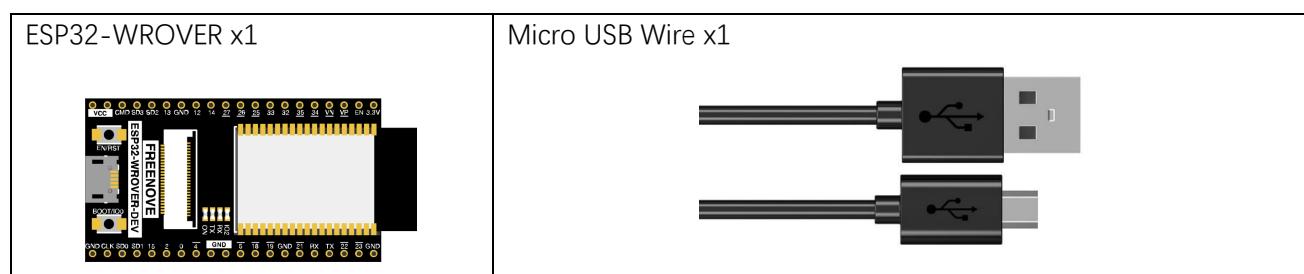
**connect(remoteAddress[])**: connect the physical address of Bluetooth, data type: uint8-t.

**disconnect()**: disconnect all Bluetooth devices.

**end()**: disconnect all Bluetooth devices and turn off the Bluetooth, release all occupied space

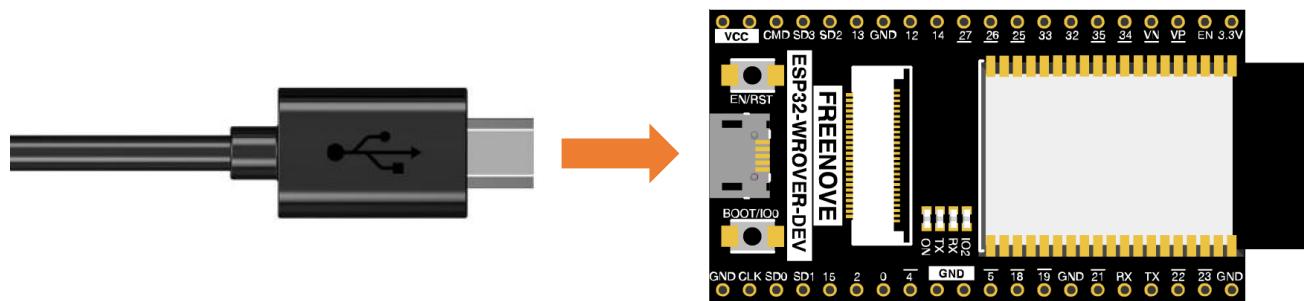
Project 2.2 Bluetooth Low Energy Data Passthrough

## Component List



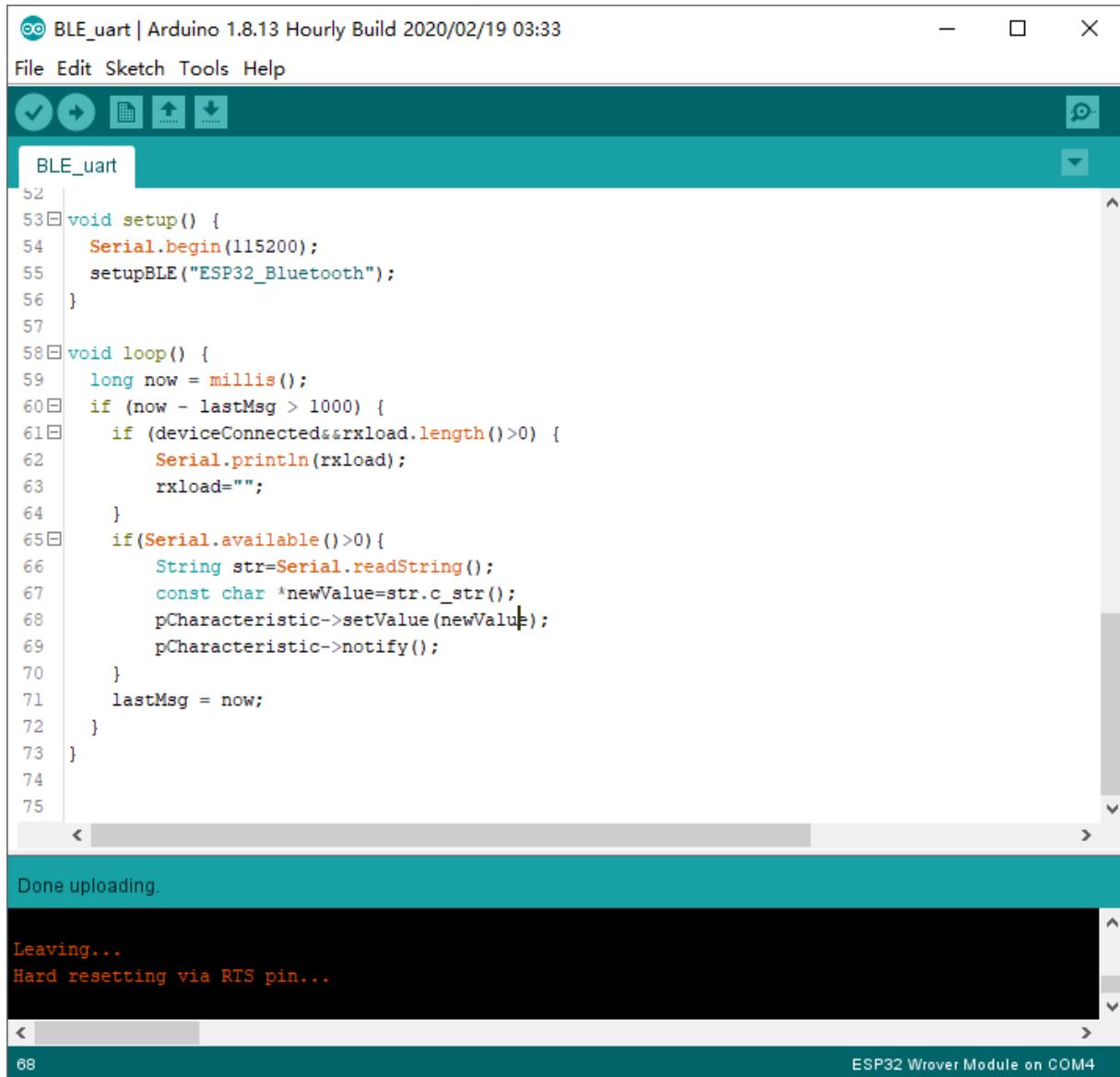
# Circuit

Connect Freenove ESP32 to the computer using the USB cable.



## Sketch

### Sketch\_02.2\_BLE



```

BLE_uart | Arduino 1.8.13 Hourly Build 2020/02/19 03:33
File Edit Sketch Tools Help
BLE_uart
52
53 void setup() {
54     Serial.begin(115200);
55     setupBLE("ESP32_Bluetooth");
56 }
57
58 void loop() {
59     long now = millis();
60     if (now - lastMsg > 1000) {
61         if (deviceConnected&&rxload.length()>0) {
62             Serial.println(rxload);
63             rxload="";
64         }
65         if(Serial.available()>0){
66             String str=Serial.readString();
67             const char *newValue=str.c_str();
68             pCharacteristic->setValue(newValue);
69             pCharacteristic->notify();
70         }
71         lastMsg = now;
72     }
73 }
74
75
Done uploading.

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

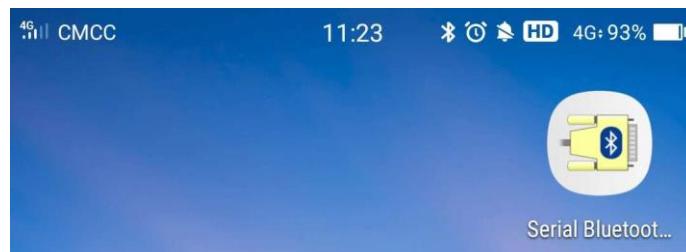
```

ESP32 Wrover Module on COM4

### Serial Bluetooth

Compile and upload code to ESP32, the operation is similar to the last section.

First, make sure you've turned on the mobile phone Bluetooth, and then open the software.



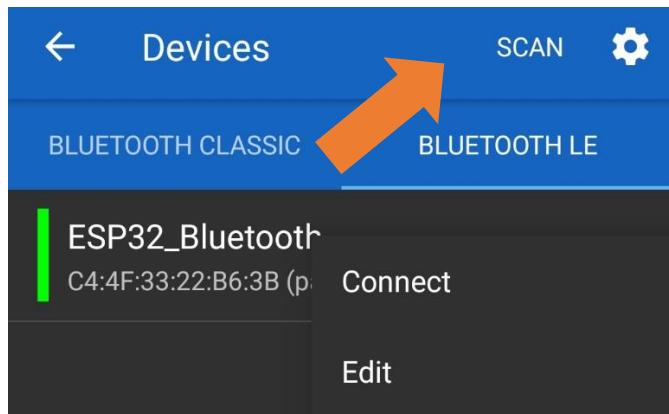
Click "Search" to search Bluetooth devices nearby and select "ESP32 test" to connect to.



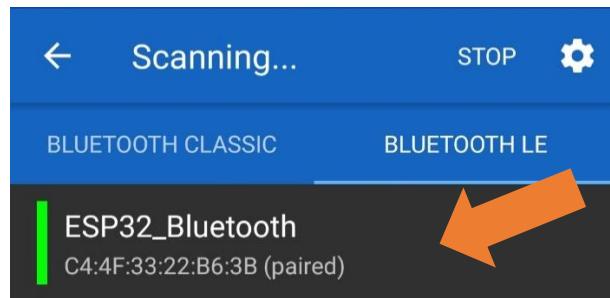
Turn on software APP, click the left of the terminal. Select "Devices"



Select BLUETOOTHLE, click SCAN to scan Low Energy Bluetooth devices nearby.



Select "ESP32-Bluetooth"



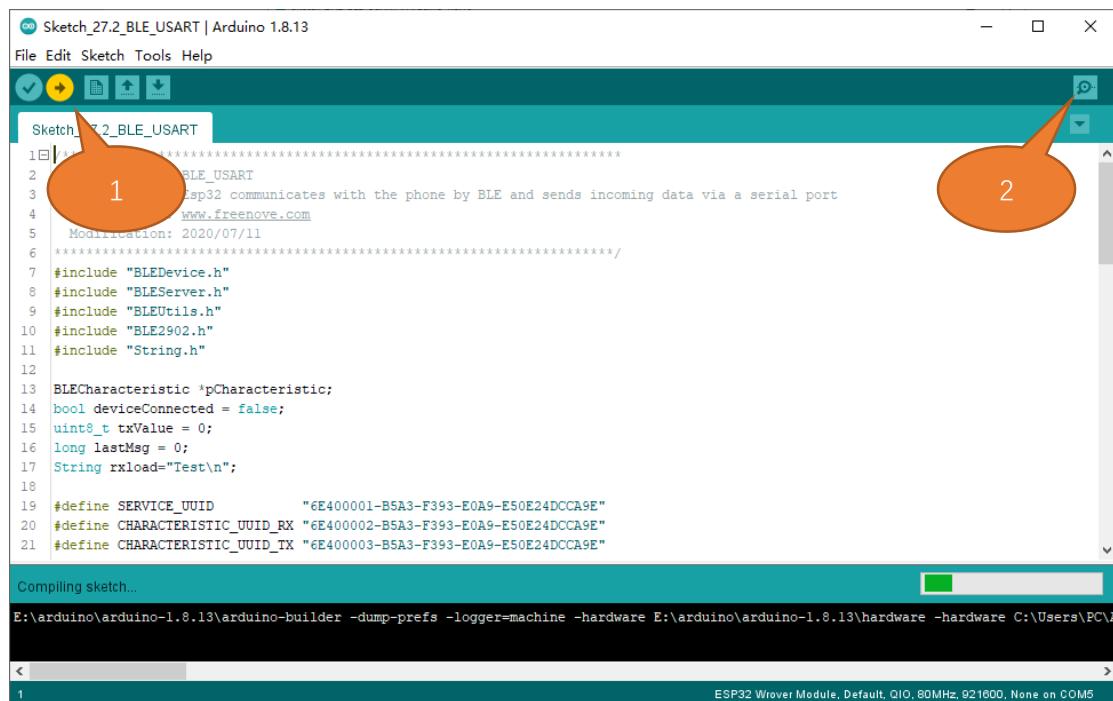
### Lightblue

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:

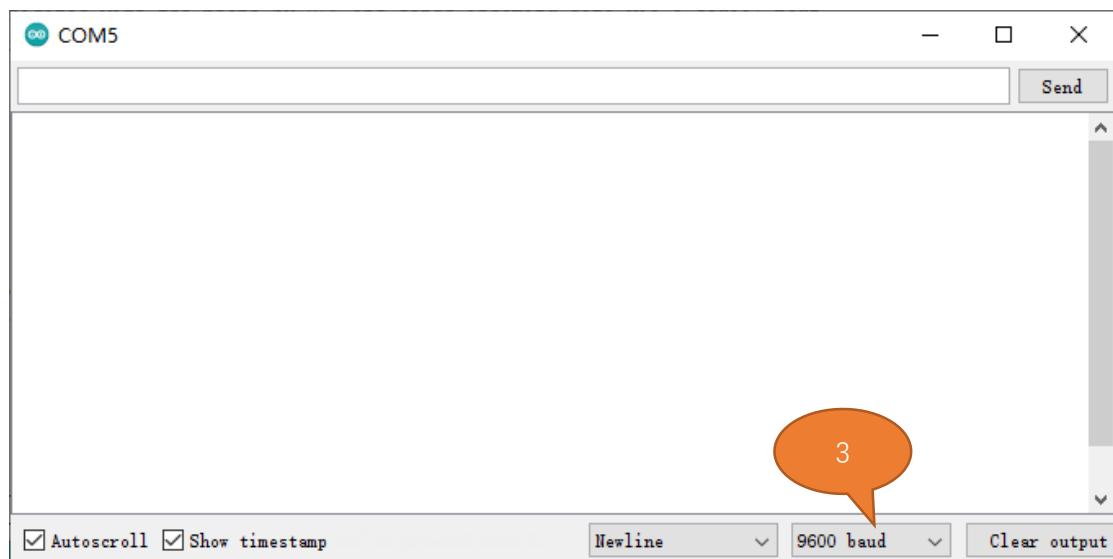
<https://apps.apple.com/us/app/lightblue/id557428110#?platform=iphone.>

Step1. Upload the code of Project27.2 to ESP32.

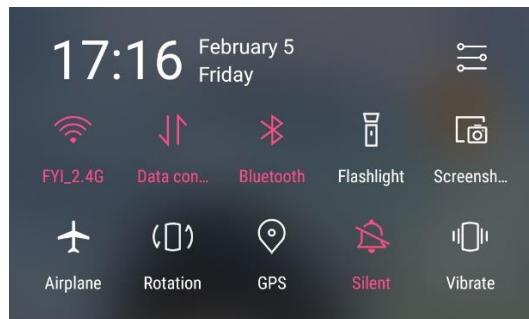
Step2. Click on serial monitor.



Step3. Set baud rate to 9600.

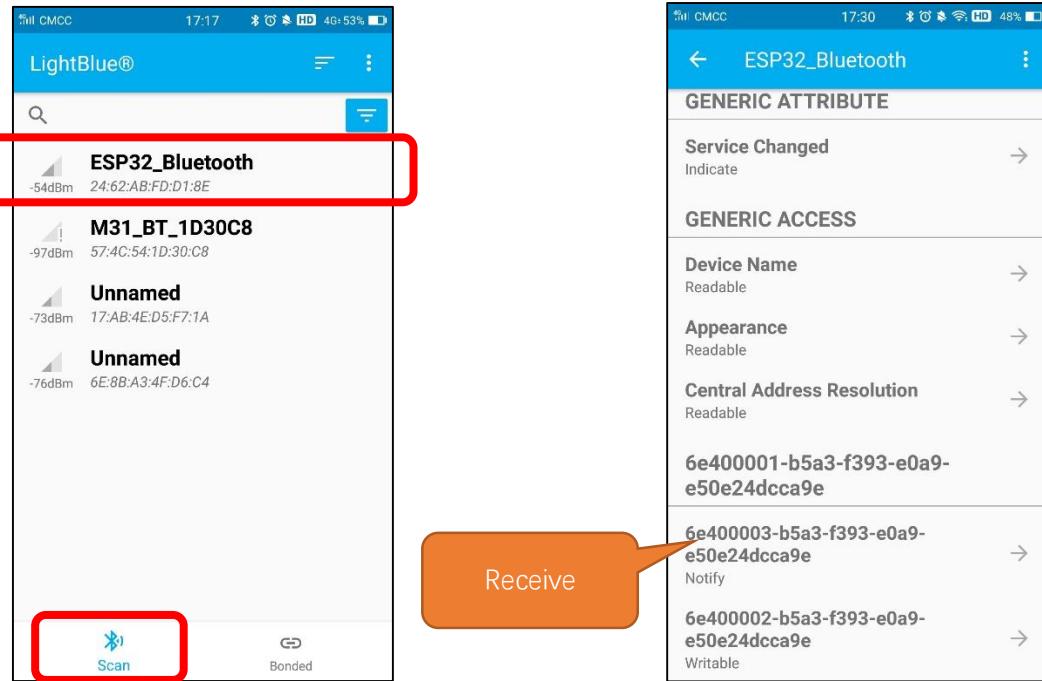


Turn ON Bluetooth on your phone, and open the Lightblue APP.

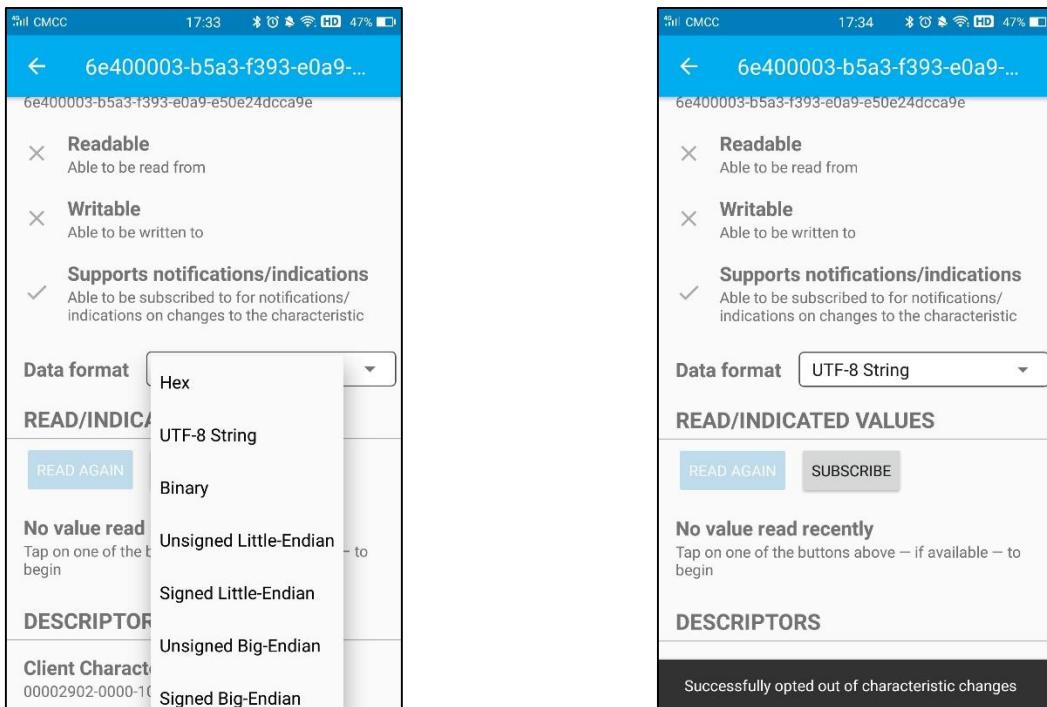


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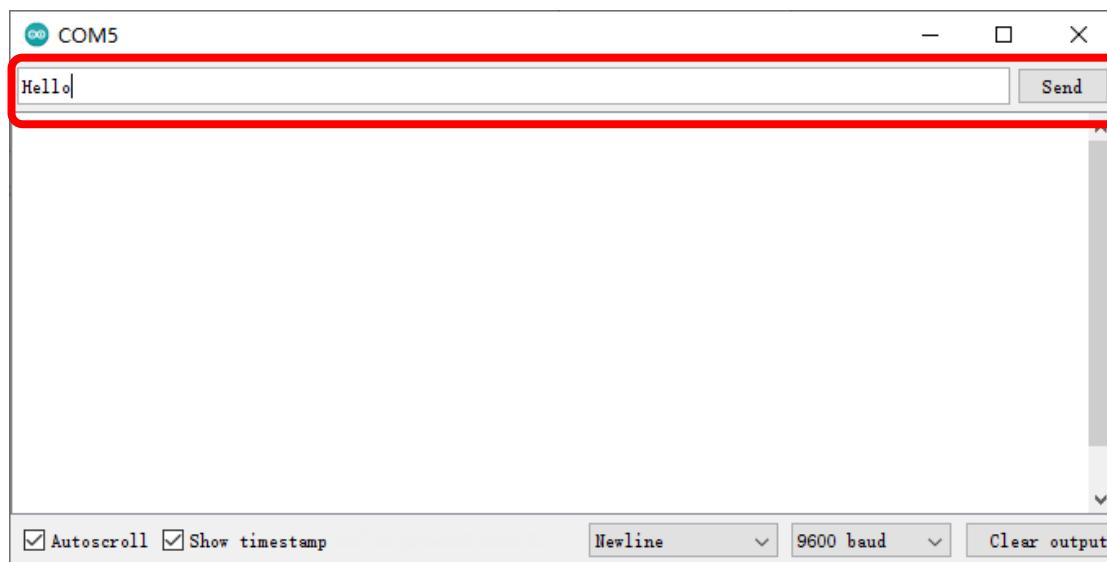
In the Scan page, swipe down to refresh the name of Bluetooth that the phone searches for. Click ESP32\_Bluetooth.



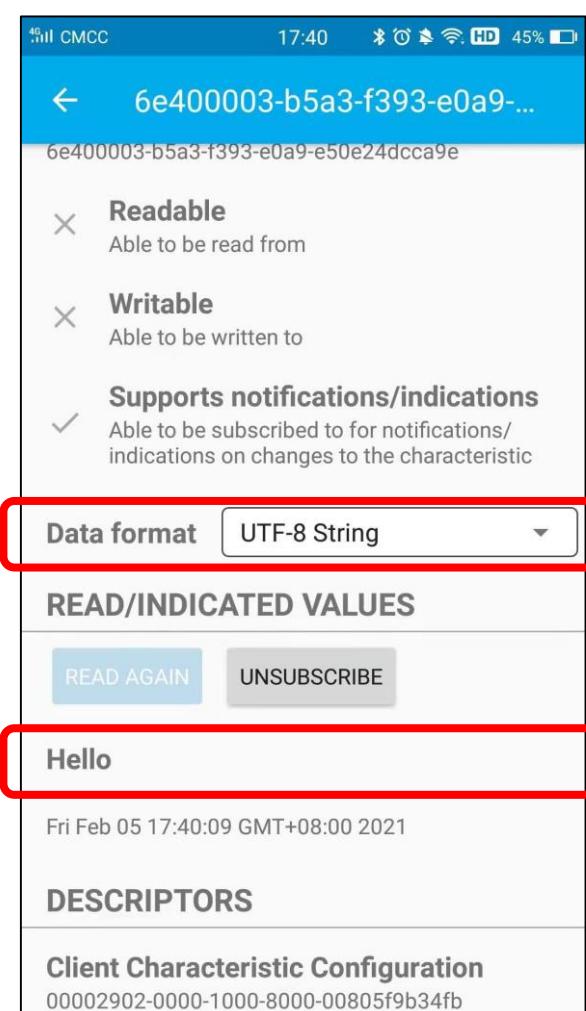
Click “Receive”. Select the appropriate Data format in the box to the right of Data Format. For example, HEX for hexadecimal, utf-string for character, Binary for Binary, etc. Then click SUBSCRIBE.



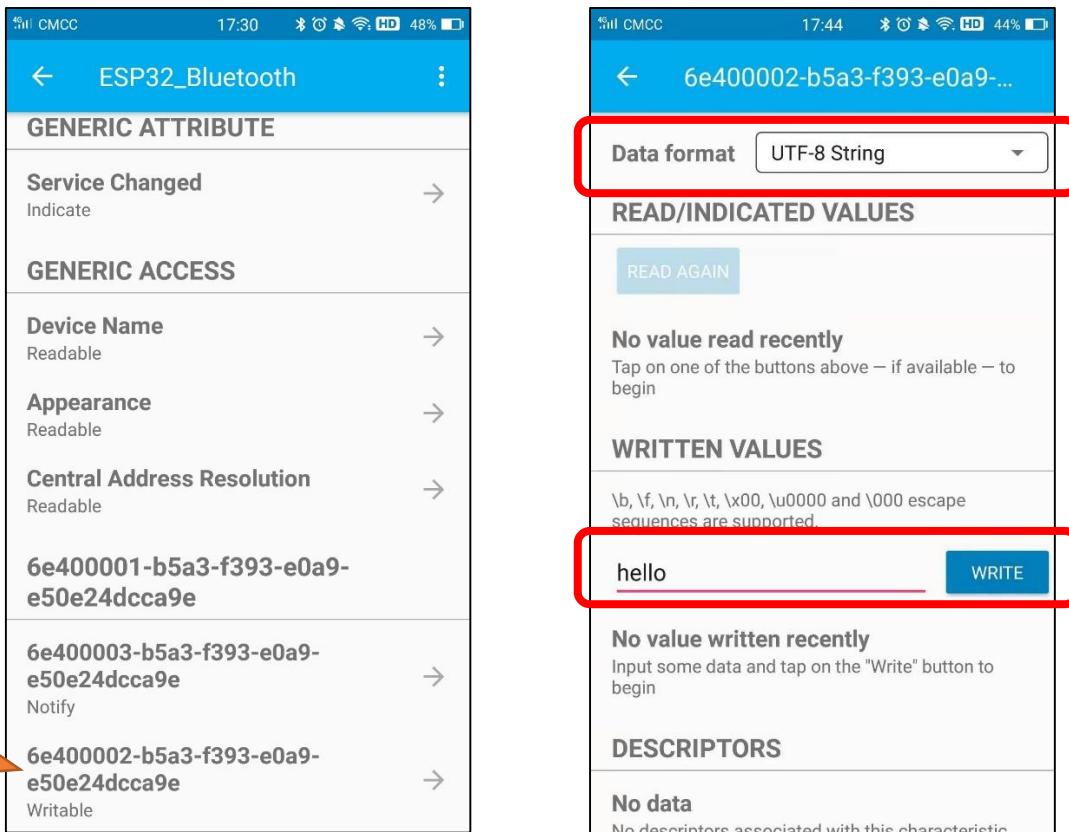
Back to the serial monitor on your computer. You can type anything in the left border of Send, and then click Send.



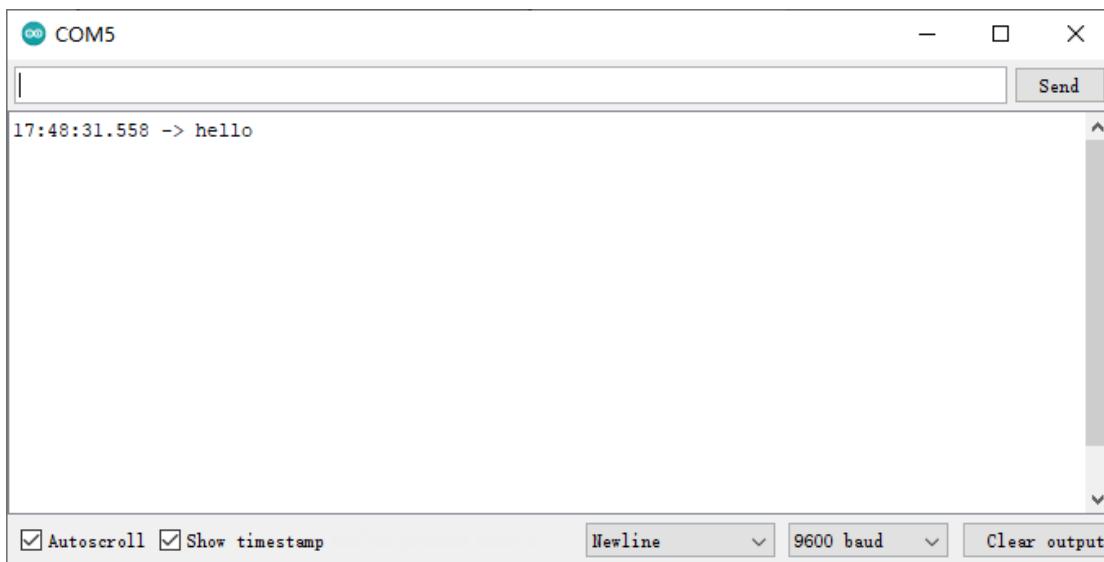
And then you can see the mobile Bluetooth has received the message.



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



And the computer will receive the message from the mobile Bluetooth.



And now data can be transferred between your mobile phone and computer via ESP32-WROVER.

The following is the program code:

```
1 #include <BLEDevice.h>
2 #include <BLEServer.h>
3 #include <BLEUtils.h>
4 #include <BLE2902.h>
5 #include <String.h>
6
7 BLECharacteristic *pCharacteristic;
8 bool deviceConnected = false;
9 uint8_t txValue = 0;
10 long lastMsg = 0;
11 String rxload="Test\n";
12
13 #define SERVICE_UUID "6E400001-B5A3-F393-E0A9-E50E24DCCA9E"
14 #define CHARACTERISTIC_UUID_RX "6E400002-B5A3-F393-E0A9-E50E24DCCA9E"
15 #define CHARACTERISTIC_UUID_TX "6E400003-B5A3-F393-E0A9-E50E24DCCA9E"
16
17 class MyServerCallbacks: public BLEServerCallbacks {
18     void onConnect(BLEServer* pServer) {
19         deviceConnected = true;
20     };
21     void onDisconnect(BLEServer* pServer) {
22         deviceConnected = false;
23     }
24 };
25
26 class MyCallbacks: public BLECharacteristicCallbacks {
27     void onWrite(BLECharacteristic *pCharacteristic) {
28         std::string rxValue = pCharacteristic->getValue();
29         if (rxValue.length() > 0) {
30             rxload="";
31             for (int i = 0; i < rxValue.length(); i++) {
32                 rxload +=(char)rxValue[i];
33             }
34         }
35     }
36 };
37
38 void setupBLE(String BLEName) {
39     const char *ble_name=BLEName.c_str();
40     BLEDevice::init(ble_name);
41     BLEServer *pServer = BLEDevice::createServer();
42     pServer->setCallbacks(new MyServerCallbacks());
```

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```

43    BLEService *pService = pServer->createService(SERVICE_UUID);
44    pCharacteristic=
45    pService->createCharacteristic(CHARACTERISTIC_UUID_RX,BLECharacteristic::PROPERTY_NOTIFY);
46    pCharacteristic->addDescriptor(new BLE2902());
47    BLECharacteristic *pCharacteristic =
48    pService->createCharacteristic(CHARACTERISTIC_UUID_RX,BLECharacteristic::PROPERTY_WRITE);
49    pCharacteristic->setCallbacks(new MyCallbacks());
50    pService->start();
51    pServer->getAdvertising()->start();
52    Serial.println("Waiting a client connection to notify..."); 
53 }
54
55 void setup() {
56   Serial.begin(9600);
57   setupBLE("ESP32_Bluetooth");
58 }
59
60 void loop() {
61   long now = millis();
62   if (now - lastMsg > 1000) {
63     if (deviceConnected&&rxload.length()>0) {
64       Serial.println(rxload);
65       rxload="";
66     }
67     if(Serial.available()>0) {
68       String str=Serial.readString();
69       const char *newValue=str.c_str();
70       pCharacteristic->setValue(newValue);
71       pCharacteristic->notify();
72     }
73     lastMsg = now;
74   }
75 }
```

Define the specified UUID number for BLE vendor.

13	#define SERVICE_UUID "6E400001-B5A3-F393-E0A9-E50E24DCCA9E"
14	#define CHARACTERISTIC_UUID_RX "6E400002-B5A3-F393-E0A9-E50E24DCCA9E"
15	#define CHARACTERISTIC_UUID_TX "6E400003-B5A3-F393-E0A9-E50E24DCCA9E"

Write a Callback function for BLE server to manage connection of BLE.

```

17 class MyServerCallbacks: public BLEServerCallbacks {
18     void onConnect(BLEServer* pServer) {
19         deviceConnected = true;
20     };
21     void onDisconnect(BLEServer* pServer) {
22         deviceConnected = false;
23     }
24 };

```

Write Callback function with BLE features. When it is called, as the mobile terminal send data to ESP32, it will store them into reload.

```

26 class MyCallbacks: public BLECharacteristicCallbacks {
27     void onWrite(BLECharacteristic *pCharacteristic) {
28         std::string rxValue = pCharacteristic->getValue();
29         if (rxValue.length() > 0) {
30             rxload="";
31             for (int i = 0; i < rxValue.length(); i++) {
32                 rxload +=(char)rxValue[i];
33             }
34         }
35     }
36 };

```

Initialize the BLE function and name it.

```
55 setupBLE("ESP32_Bluetooth");
```

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.

```

59 long now = millis();
60 if (now - lastMsg > 1000) {
61     if (deviceConnected&&rxload.length()>0) {
62         Serial.println(rxload);
63         rxload="";
64     }
65     if(Serial.available()>0) {
66         String str=Serial.readString();
67         const char *newValue=str.c_str();
68         pCharacteristic->setValue(newValue);
69         pCharacteristic->notify();
70     }
71     lastMsg = now;
72 }

```



The design for creating the BLE server is:

1. Create a BLE Server
2. Create a BLE Service
3. Create a BLE Characteristic on the Service
4. Create a BLE Descriptor on the characteristic
5. Start the service.
6. Start advertising.

```
38 void setupBLE(String BLEName) {  
39     const char *ble_name=BLEName.c_str();  
40     BLEDevice::init(ble_name);  
41     BLEServer *pServer = BLEDevice::createServer();  
42     pServer->setCallbacks(new MyServerCallbacks());  
43     BLEService *pService = pServer->createService(SERVICE_UUID);  
44     pCharacteristic=  
45         pService->createCharacteristic(CHARACTERISTIC_UUID_TX,BLECharacteristic::PROPERTY_NOTIFY);  
46     pCharacteristic->addDescriptor(new BLE2902());  
47     BLECharacteristic *pCharacteristic =  
48         pService->createCharacteristic(CHARACTERISTIC_UUID_RX,BLECharacteristic::PROPERTY_WRITE);  
49     pCharacteristic->setCallbacks(new MyCallbacks());  
50     pService->start();  
51     pServer->getAdvertising()->start();  
52     Serial.println("Waiting a client connection to notify...");  
53 }
```

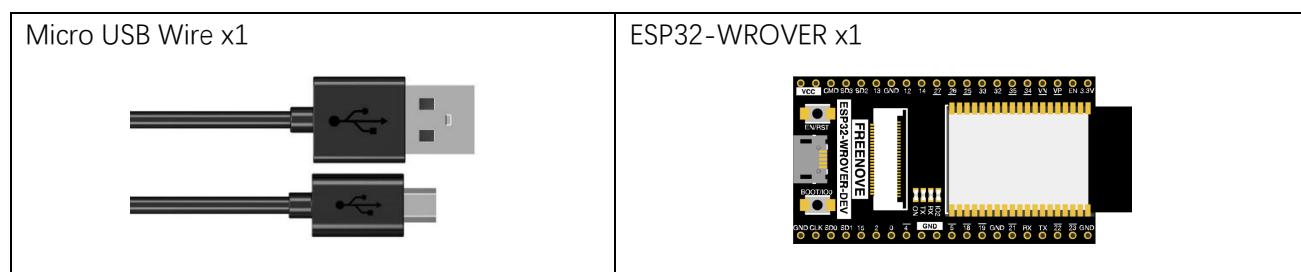
# Chapter 3 WiFi Working Modes

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

ESP32-WROVER 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 3.1 Station mode

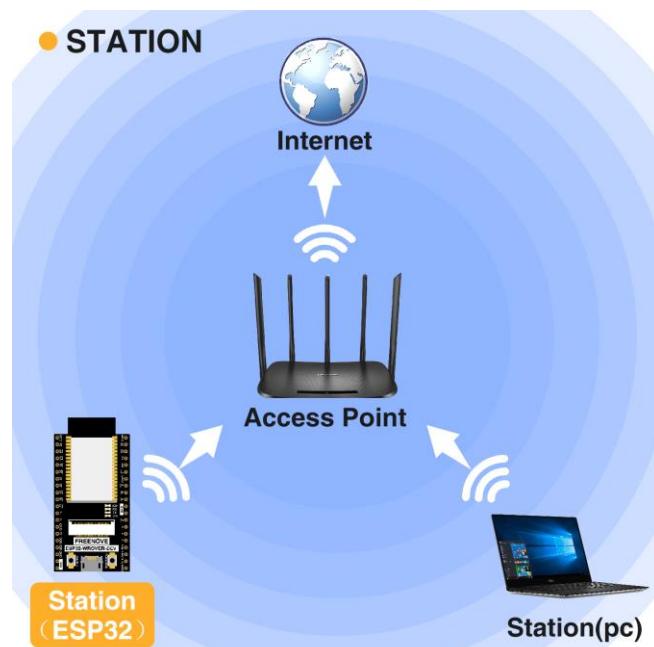
### Component List



### Component knowledge

#### Station mode

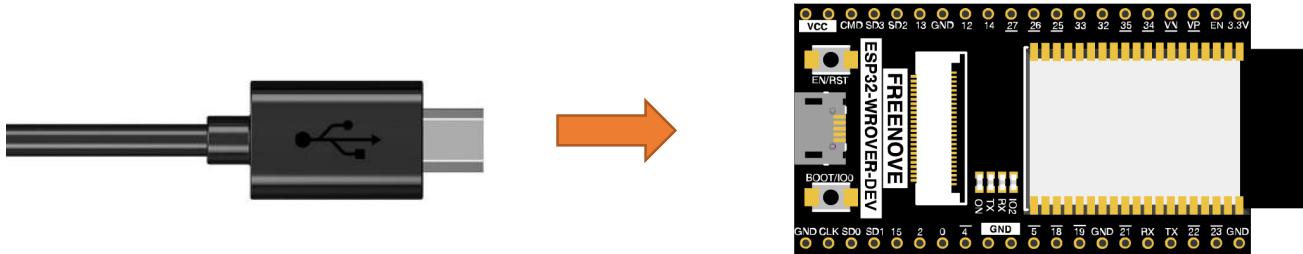
When ESP32 selects Station mode, it acts as a WiFi client. It can connect to the router network and communicate with other devices on the router via WiFi connection. As shown below, the PC is connected to the router, and if ESP32 wants to communicate with the PC, it needs to be connected to the router.



Any concerns? ✉ support@freenove.com

## Circuit

Connect Freenove ESP32 to the computer using the USB cable.



## Sketch

### Sketch\_03.1\_Station\_mode

The screenshot shows the Arduino IDE interface with the sketch named 'Sketch\_03.1\_WiFi\_Station'. The code is as follows:

```

1 #include <WiFi.h>
2
3 const char *ssid_Router = "*****"; //Enter the router name
4 const char *password_Router = "*****"; //Enter the router password
5
6 void setup() {
7     Serial.begin(115200);
8     delay(2000);
9     Serial.println("Setup start");
10    WiFi.begin(ssid_Router, password_Router);
11    Serial.println(String("Connecting to ") + ssid_Router);
12    while (WiFi.status() != WL_CONNECTED) {
13        delay(500);
14        Serial.print(".");
15    }
16    Serial.println("\nConnected, IP address: ");
17    Serial.println(WiFi.localIP());
18    Serial.println("Setup End");
19 }
20
21 void loop() {
22 }

```

A callout bubble points to the line `const char *ssid_Router = "*****"; //Enter the router name` with the text "Enter the correct Router name and password".

The status bar at the bottom of the IDE shows "Done uploading." and "Leaving... Hard resetting via RTS pin...". The bottom right corner indicates "ESP32 Wrover Module on COM5".

Because the names and passwords of routers in various places are different, before the Sketch 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-WROVER, open serial monitor and set baud rate to 115200. And then it will display as follows:



When ESP32-WROVER successfully connects to "ssid\_Router", serial monitor will print out the IP address assigned to ESP32-WROVER by the router.

The following is the program code:

```
1 #include <WiFi.h>
2
3 const char *ssid_Router      = "*****"; //Enter the router name
4 const char *password_Router = "*****"; //Enter the router password
5
6 void setup() {
7     Serial.begin(115200);
8     delay(2000);
9     Serial.println("Setup start");
10    WiFi.begin(ssid_Router, password_Router);
11    Serial.println(String("Connecting to ") + ssid_Router);
12    while (WiFi.status() != WL_CONNECTED) {
13        delay(500);
14        Serial.print(".");
15    }
16    Serial.println("\nConnected, IP address: ");
17    Serial.println(WiFi.localIP());
18    Serial.println("Setup End");
19 }
20
21 void loop() {
22 }
```

Include the WiFi Library header file of ESP32.

```
1 #include <WiFi.h>
```

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 and connect it to your router.

```
10 WiFi.begin(ssid_Router, password_Router);
```

Check whether ESP32 has connected to router successfully every 0.5s.

```
12 while (WiFi.status() != WL_CONNECTED) {
13     delay(500);
14     Serial.print(".");
15 }
```

Serial monitor prints out the IP address assigned to ESP32-WROVER

```
17 Serial.println(WiFi.localIP());
```

## Reference

### Class Station

Every time when using WiFi, you need to include header file "WiFi.h".

**begin(ssid, password,channel, bssid, connect):** ESP32 is used as Station to connect hotspot.

**ssid:** WiFi hotspot name

**password:** WiFi hotspot password

**channel:** WiFi hotspot channel number; communicating through specified channel; optional parameter

**bssid:** mac address of WiFi hotspot, optional parameter

**connect:** boolean optional parameter, defaulting to true. If set as false, then ESP32 won't connect WiFi.

**config(local\_ip, gateway, subnet, dns1, dns2):** set static local IP address.

**local\_ip:** station fixed IP address.

**subnet:** subnet mask

**dns1,dns2:** optional parameter. define IP address of domain name server

**status:** obtain the connection status of WiFi

**local IP():** obtian IP address in Station mode

**disconnect():** disconnect wifi

**setAutoConnect(boolean):** set automatic connection Every time ESP32 is power on, it will connect WiFi automatically.

**setAutoReconnect(boolean):** set automatic reconnection Every time ESP32 disconnects WiFi, it will reconnect to WiFi automatically.

## Project 3.2 AP mode

### Component List & Circuit

Component List & Circuit are the same as in Section 30.1.

### Component knowledge

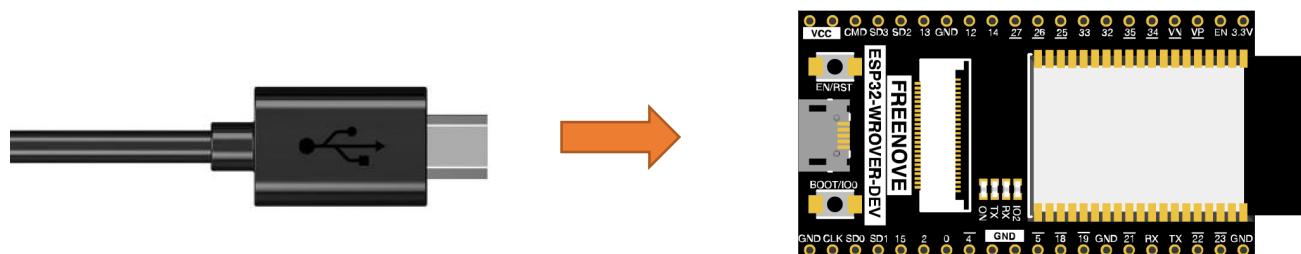
#### AP mode

When ESP32 selects AP mode, it creates a hotspot network that is separate from the Internet and waits for other WiFi devices to connect. As shown in the figure below, ESP32 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.



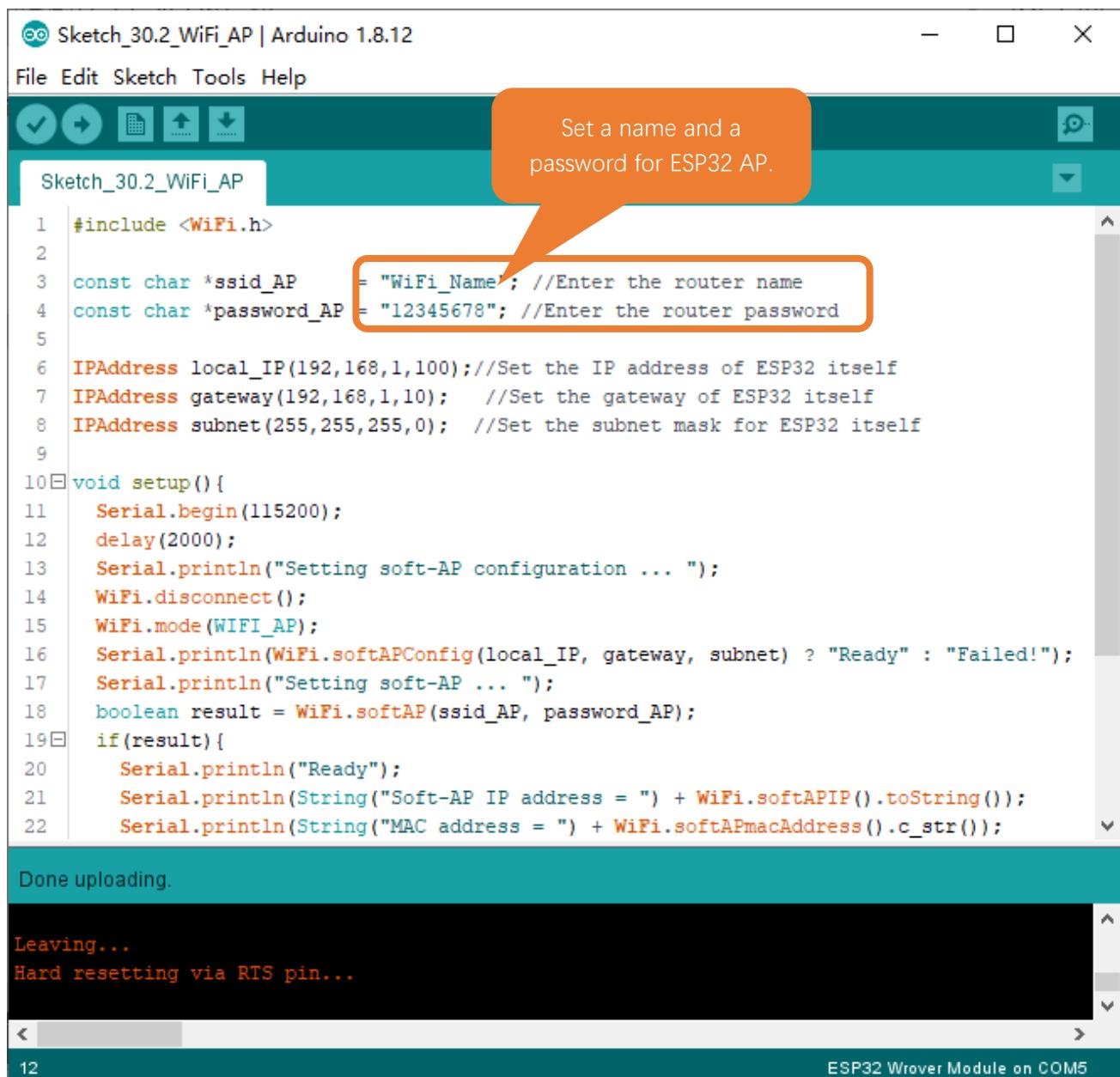
### Circuit

Connect Freenove ESP32 to the computer using the USB cable.



Any concerns? ✉ support@freenove.com

## Sketch



The screenshot shows the Arduino IDE interface with the sketch titled "Sketch\_30.2\_WiFi\_AP". The code is as follows:

```
#include <WiFi.h>

const char *ssid_AP      = "WiFi_Name"; //Enter the router name
const char *password_AP = "12345678"; //Enter the router password

IPAddress local_IP(192,168,1,100); //Set the IP address of ESP32 itself
IPAddress gateway(192,168,1,10);   //Set the gateway of ESP32 itself
IPAddress subnet(255,255,255,0);  //Set the subnet mask for ESP32 itself

void setup() {
    Serial.begin(115200);
    delay(2000);
    Serial.println("Setting soft-AP configuration ... ");
    WiFi.disconnect();
    WiFi.mode(WIFI_AP);
    Serial.println(WiFi.softAPConfig(local_IP, gateway, subnet) ? "Ready" : "Failed!");
    Serial.println("Setting soft-AP ... ");
    boolean result = WiFi.softAP(ssid_AP, password_AP);
    if(result){
        Serial.println("Ready");
        Serial.println(String("Soft-AP IP address = ") + WiFi.softAPIP().toString());
        Serial.println(String("MAC address = ") + WiFi.softAPmacAddress().c_str());
    }
}
```

A callout bubble points to the lines `const char *ssid_AP = "WiFi_Name";` and `const char *password_AP = "12345678";` with the text "Set a name and a password for ESP32 AP."

The serial monitor window shows the message "Done uploading." followed by "Leaving... Hard resetting via RTS pin...".

Before the Sketch 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.

Compile and upload codes to ESP32-WROVER, open the serial monitor and set the baud rate to 115200. And then it will display as follows.

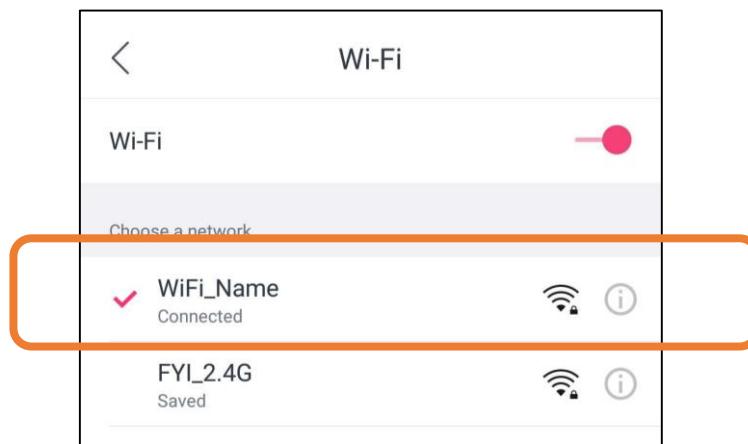


The screenshot shows a Windows-style serial monitor window titled "COM4". The text area contains the following output:

```
Setting soft-AP configuration ...
Ready
Setting soft-AP ...
Ready
Soft-AP IP address = 192.168.1.100
MAC address = 24:62:AB:FD:D1:8D
Setup End
```

At the bottom, there are several control buttons: "Autoscroll" (checked), "Show timestamp" (unchecked), "Newline" (dropdown menu), "115200 baud" (selected), and "Clear output".

When observing the print information of the serial monitor, 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 Sketch. You can enter the password "12345678" to connect it or change its AP name and password by modifying Sketch.



### Sketch\_03\_2\_AP\_mode

The following is the program code:

```

1 #include <WiFi.h>
2
3 const char *ssid_AP      = "WiFi_Name"; //Enter the router name
4 const char *password_AP = "12345678"; //Enter the router password
5
6 IPAddress local_IP(192, 168, 1, 100); //Set the IP address of ESP32 itself
7 IPAddress gateway(192, 168, 1, 10); //Set the gateway of ESP32 itself
8 IPAddress subnet(255, 255, 255, 0); //Set the subnet mask for ESP32 itself
9
10 void setup() {
11     Serial.begin(115200);
12     delay(2000);
13     Serial.println("Setting soft-AP configuration ... ");
14     WiFi.disconnect();
15     WiFi.mode(WIFI_AP);
16     Serial.println(WiFi.softAPConfig(local_IP, gateway, subnet) ? "Ready" : "Failed!");
17     Serial.println("Setting soft-AP ... ");
18     boolean result = WiFi.softAP(ssid_AP, password_AP);
19     if(result){
20         Serial.println("Ready");
21         Serial.println(String("Soft-AP IP address = ") + WiFi.softAPIP().toString());
22         Serial.println(String("MAC address = ") + WiFi.softAPmacAddress().c_str());
23     }else{
24         Serial.println("Failed!");
25     }
26     Serial.println("Setup End");
27 }
28
29 void loop() {
30 }
```

Include WiFi Library header file of ESP32.

```
1 #include <WiFi.h>
```

Enter correct AP name and password.

```

3 const char *ssid_AP      = "WiFi_Name"; //Enter the router name
4 const char *password_AP = "12345678"; //Enter the router password
```

Set ESP32 in AP mode.

```
15 WiFi.mode(WIFI_AP);
```

Configure IP address, gateway and subnet mask for ESP32.

```
16 WiFi.softAPConfig(local_IP, gateway, subnet)
```

Turn on an AP in ESP32, whose name is set by ssid\_AP and password is set by password\_AP.

```
18 WiFi.softAP(ssid_AP, password_AP);
```

Check whether the AP is turned on successfully. If yes, print out IP and MAC address of AP established by ESP32. If no, print out the failure prompt.

```
19 if(result){  
20     Serial.println("Ready");  
21     Serial.println(String("Soft-AP IP address = ") + WiFi.softAPIP().toString());  
22     Serial.println(String("MAC address = ") + WiFi.softAPmacAddress().c_str());  
23 }else{  
24     Serial.println("Failed!");  
25 }  
26 Serial.println("Setup End");
```

Reference

### Class AP

Every time when using WiFi, you need to include header file "WiFi.h".

**softAP(ssid, password, channel, ssid\_hidden, max\_connection):**

**ssid:** WiFi hotspot name

**password:** WiFi hotspot password

**channel:** Number of WiFi connection channels, range 1-13. The default is 1.

**ssid\_hidden:** Whether to hide WiFi name from scanning by other devices. The default is not hide.

**max\_connection:** Maximum number of WiFi connected devices. The range is 1-4. The default is 4.

**softAPConfig(local\_ip, gateway, subnet):** set static local IP address.

**local\_ip:** station fixed IP address.

**Gateway:** gateway IP address

**subnet:** subnet mask

**softAP():** obtain IP address in AP mode

**softAPdisconnect ():** disconnect AP mode.



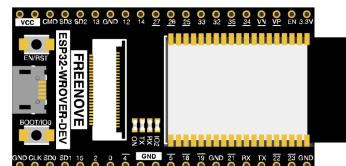
## Project 3.3 AP+Station mode

### Component List

Micro USB Wire x1



ESP32-WROVER x1



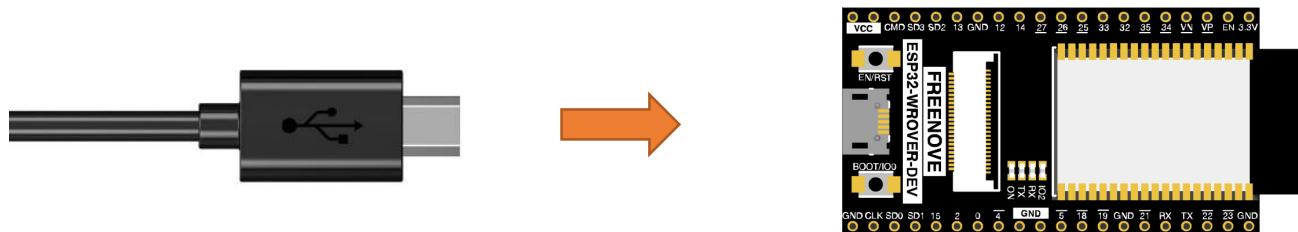
### Component knowledge

#### 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 Freenove ESP32 to the computer using the USB cable.



## Sketch

### Sketch\_03.3\_AP\_Station\_mode

Please enter the correct names and passwords of Router and AP.

```

7 #include <WiFi.h>
8
9 const char *ssid_Router      = "*****"; //Enter the router name
10 const char *password_Route: = "*****"; //Enter the router password
11 const char *ssid_AP         = "WiFi_Name"; //Enter the AP name
12 const char *password_AP     = "12345678"; //Enter the AP password
13
14 void setup(){
15   Serial.begin(115200);
16   Serial.println("Setting soft-AP configuration ... ");
17   WiFi.disconnect();
18   WiFi.mode(WIFI_AP);
19   Serial.println("Setting soft-AP ... ");
20   boolean result = WiFi.softAP(ssid_AP, password_AP);
21   if(result){
22     Serial.println("Ready");
23     Serial.println(String("Soft-AP IP address = ") + WiFi.softAPIP().toString());
24     Serial.println(String("MAC address = ") + WiFi.softAPmacAddress().c_str());
25   }else{
26     Serial.println("Failed!");
27   }
}

```

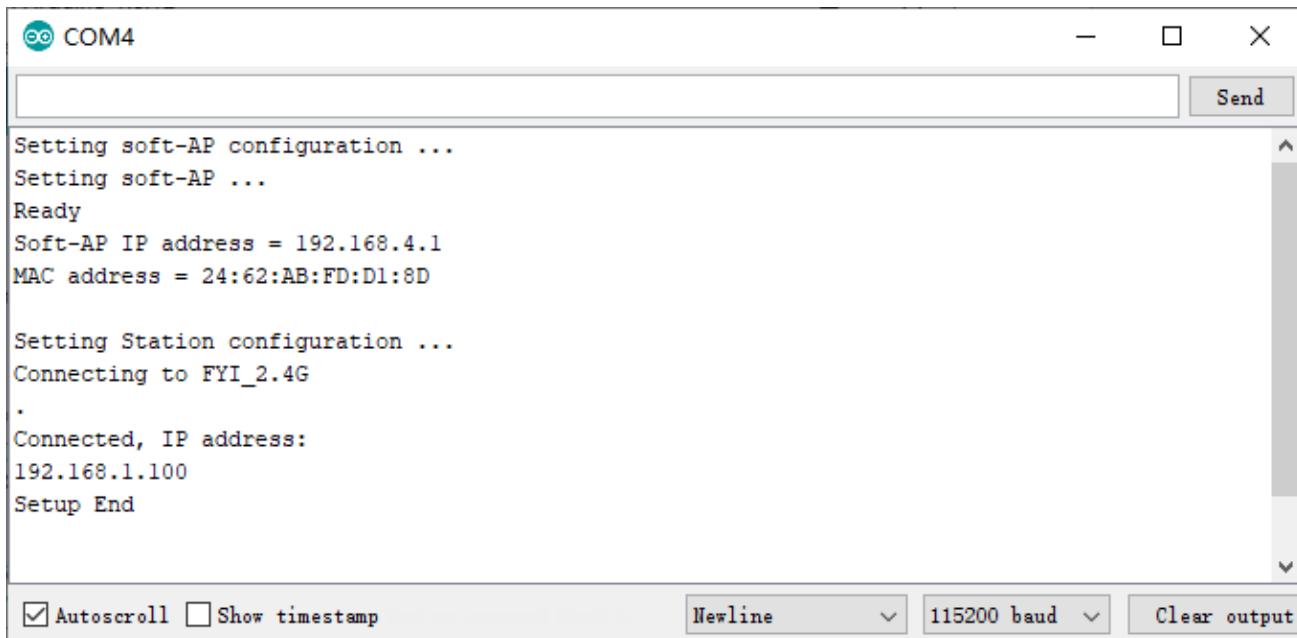
Done uploading.

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

It is analogous to Project 3.1 and Project 3.2. Before running the Sketch, you need to modify ssid\_Router, password\_Router, ssid\_AP and password\_AP shown in the box of the illustration above.

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

After making sure that Sketch is modified correctly, compile and upload codes to ESP32-WROVER, open serial monitor and set baud rate to 115200. And then it will display as follows:



```

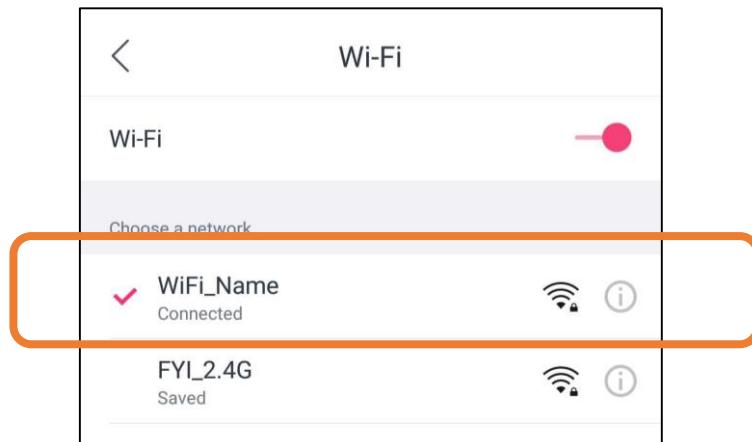
COM4
Setting soft-AP configuration ...
Setting soft-AP ...
Ready
Soft-AP IP address = 192.168.4.1
MAC address = 24:62:AB:FD:D1:8D

Setting Station configuration ...
Connecting to FYI_2.4G
.
Connected, IP address:
192.168.1.100
Setup End

Autoscroll Show timestamp Newline 115200 baud Clear output

```

When observing the print information of the serial monitor, turn on the WiFi scanning function of your phone, and you can see the ssid\_AP on ESP32.



The following is the program code:

```

1 #include <WiFi.h>
2
3 const char *ssid_Router      = "*****"; //Enter the router name
4 const char *password_Router = "*****"; //Enter the router password
5 const char *ssid_AP         = "WiFi_Name"; //Enter the AP name
6 const char *password_AP     = "12345678"; //Enter the AP password
7
8 void setup() {
9   Serial.begin(115200);
10  Serial.println("Setting soft-AP configuration ... ");
11  WiFi.disconnect();

```

```
12 WiFi.mode(WIFI_AP);
13 Serial.println("Setting soft-AP ... ");
14 boolean result = WiFi.softAP(ssid_AP, password_AP);
15 if(result){
16     Serial.println("Ready");
17     Serial.println(String("Soft-AP IP address = ") + WiFi.softAPIP().toString());
18     Serial.println(String("MAC address = ") + WiFi.softAPmacAddress().c_str());
19 }else{
20     Serial.println("Failed!");
21 }
22
23 Serial.println("\nSetting Station configuration ... ");
24 WiFi.begin(ssid_Router, password_Router);
25 Serial.println(String("Connecting to ") + ssid_Router);
26 while (WiFi.status() != WL_CONNECTED) {
27     delay(500);
28     Serial.print(".");
29 }
30 Serial.println("\nConnected, IP address: ");
31 Serial.println(WiFi.localIP());
32 Serial.println("Setup End");
33 }
34
35 void loop() {
36 }
```

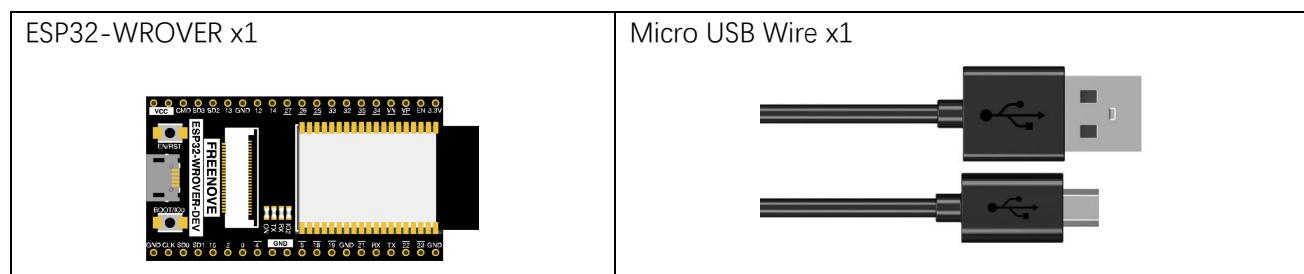
# Chapter 4 TCP/IP

In this chapter, we will 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 chapter.

## Project 4.1 As Client

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

### Component List



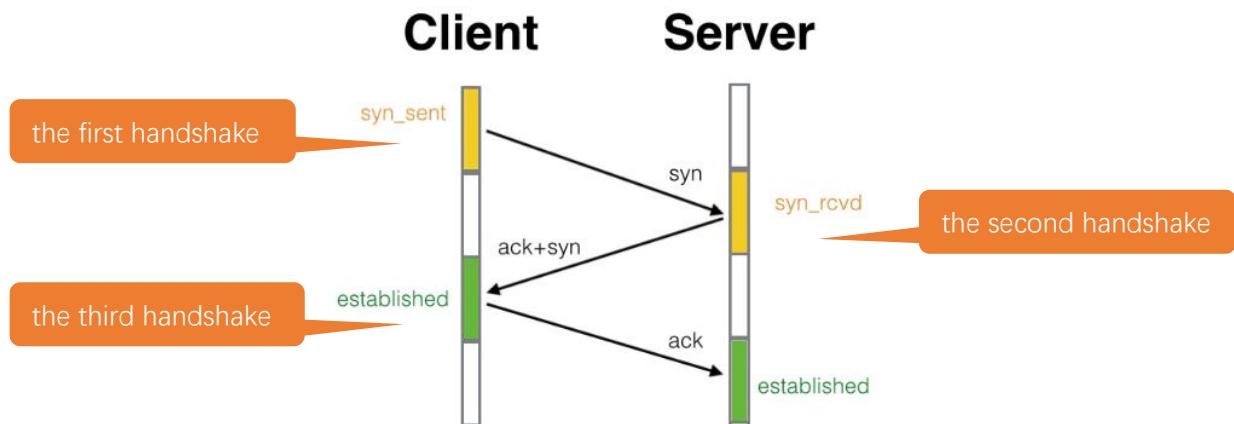
### Component knowledge

#### TCP connection

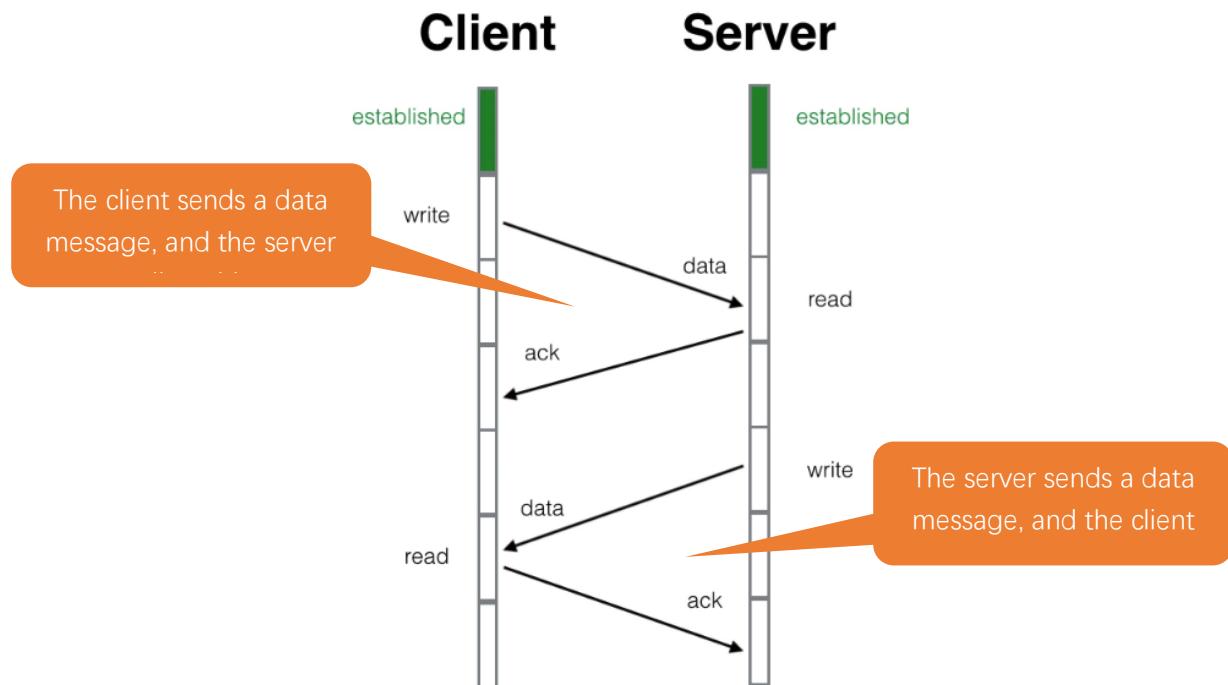
Before transmitting data, TCP needs to establish a logical connection between the sending end and the receiving end. It provides reliable and error-free data transmission between the two computers. In the TCP connection, the client and the server must be clarified. The client sends a connection request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

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

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



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





## Install Processing

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

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

The screenshot shows the official Processing website's download section. At the top, there are navigation links for "Processing", "p5.js", "Processing.py", "Processing for Android", "Processing for Pi", and "Processing Foundation". A search bar is located in the top right corner. The main content area features a large "Processing" logo on the left and a descriptive text on the right: "Download Processing. Processing is available for Linux, Mac OS X, and Windows. Select your choice to download the software below." Below this, there is a large circular logo with a stylized "P" inside. To the right of the logo, the version "3.5.4 (17 January 2020)" is listed, along with download links for "Windows 64-bit", "Windows 32-bit", "Linux 64-bit", and "Mac OS X". On the far left, a sidebar lists various links: "Cover", "Download", "Donate", "Exhibition", "Reference", "Libraries", "Tools", "Environment", "Tutorials", "Examples", "Books", "Overview", and "People". Under "Tutorials", there are links to "» Github", "» Report Bugs", "» Wiki", "» Supported Platforms", and a note about "Read about the changes in 3.0. The list of revisions covers the differences between releases in detail."

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

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

Use Server mode for communication

Install ControlP5.

The image consists of three vertically stacked screenshots from the Processing IDE and its Contribution Manager.

**Screenshot 1: Processing Sketch Menu**  
A screenshot of the Processing sketch window titled "sketch\_170328a | Processing 3.3". The "Sketch" menu is open, showing options like Run, Present, Tweak, Stop, Import Library..., Show Sketch Folder, and Add File... . The "Import Library..." option is highlighted with a blue selection bar. A mouse cursor is hovering over the "Add Library..." option.

**Screenshot 2: Contribution Manager**  
A screenshot of the Contribution Manager window. The "Libraries" tab is selected. A search bar labeled "Filter" is present. A table lists several libraries:

Status	Name	Author
	Computational Geometry   A simple, lightweight librar...	Mark Collins & Toru Hasegawa
	Console   A console, which can be drawn to the screen.	Mathias Markl
	ControlP5   A GUI library to build custom user interface...	Andreas Schlegel
	CountdownTimer   A countdown timer which triggers c...	Dong Hyun Choi
	Culebra Behavior Library for Processing   A collection o...	Luis Quinones

The "ControlP5" row is highlighted with a light blue selection bar. A mouse cursor is hovering over the "Andreas Schlegel" author name.

**Screenshot 3: ControlP5 Library Details**  
A screenshot of the ControlP5 library details page in the Contribution Manager. The library information is as follows:

**ControlP5 2.2.6**  
Andreas Schlegel  
A GUI library to build custom user interfaces for desktop and android mode.

Actions available:

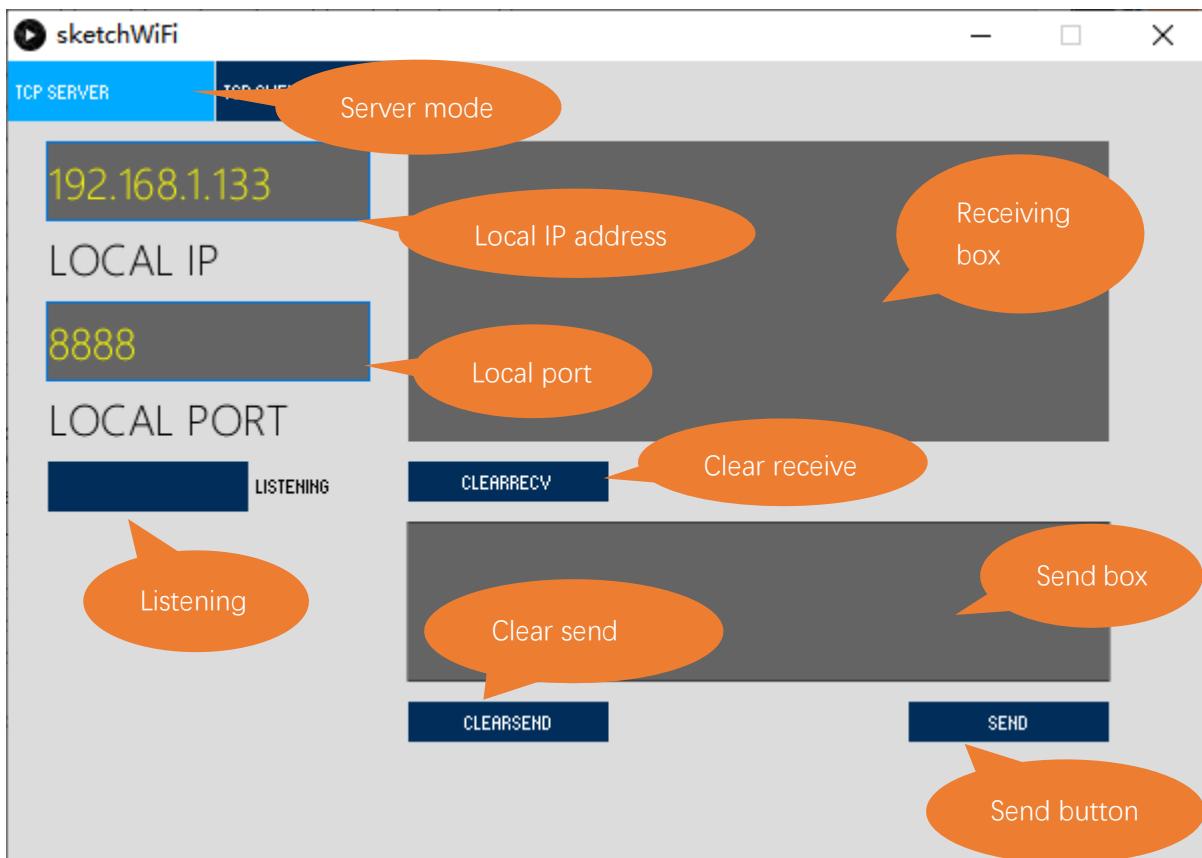
- Install (button with a downward arrow)
- 2.2.6 available
- Update (button with a circular arrow)
- Remove (button with a cross)

A mouse cursor is hovering over the "Install" button.

Open the “**Freenove\_ESP32\_WROVER\_Board\Sketches\Sketches\Sketch\_04.1\_WiFiClient\sketchWiFi\sketchWiFi.pde**”, and click “Run”.

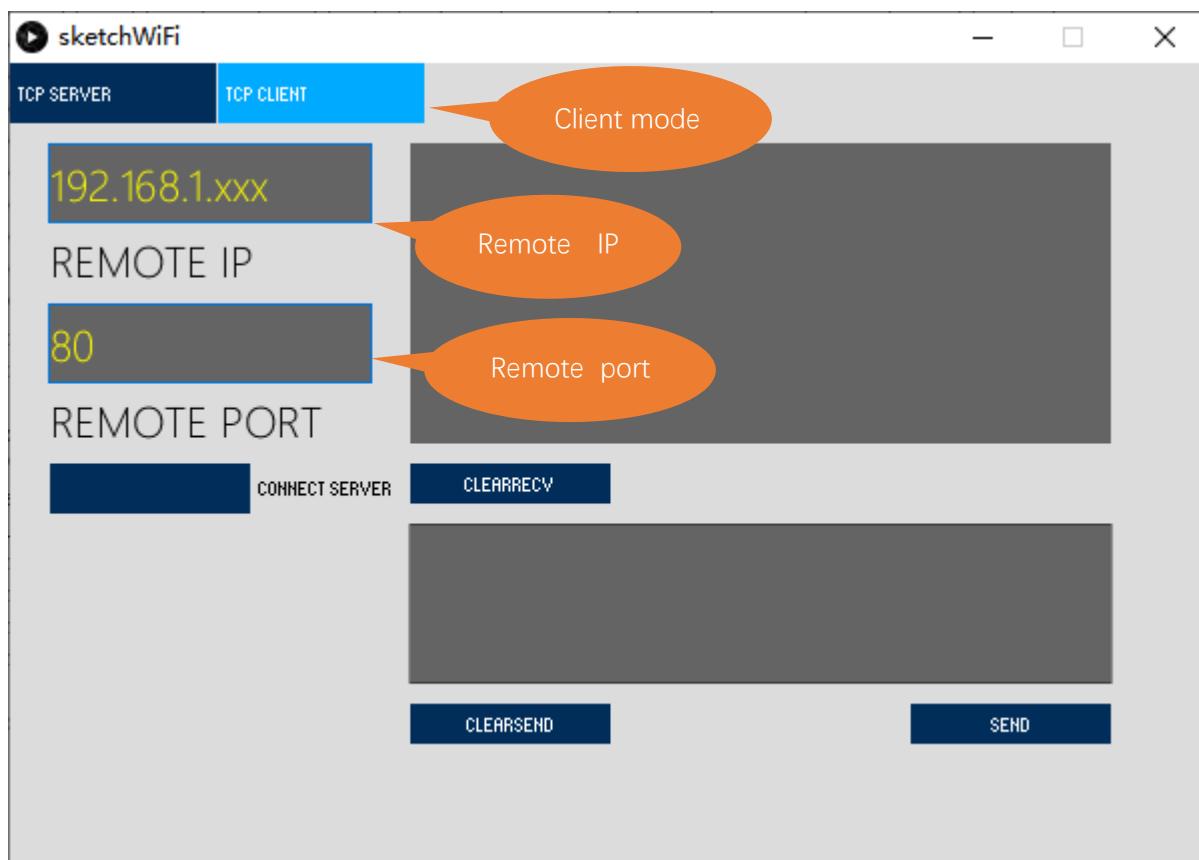


The new pop-up interface is as follows. If ESP32 is used as client, select TCP SERVER mode for sketchWiFi.



When sketchWiFi selects TCP SERVER mode, ESP32 Sketch 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, then the computer will serve as server and open a port number for client to make access connection. During this period, the computer will keep monitoring.

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

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

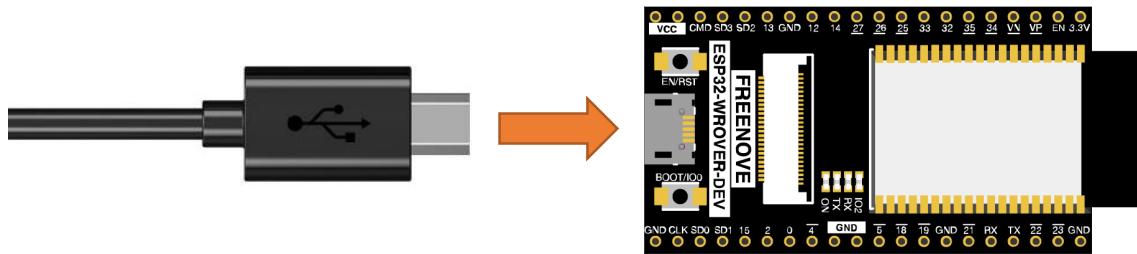
**clear send:** clear out the content in the sending text box

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

## Circuit

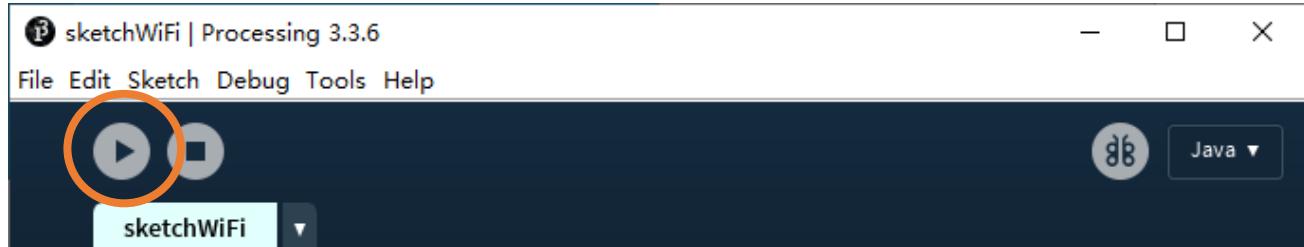
Connect Freenove ESP32 to the computer using USB cable.

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

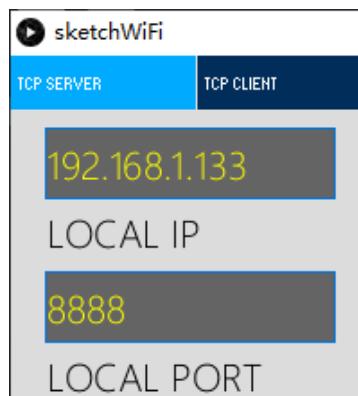


## Sketch

Before running the Sketch, 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.



Next, open Sketch\_04.1\_WiFiClient.ino. Before running it, please change the following information based on "LOCAL IP" and "LOCAL PORT" in the figure above.

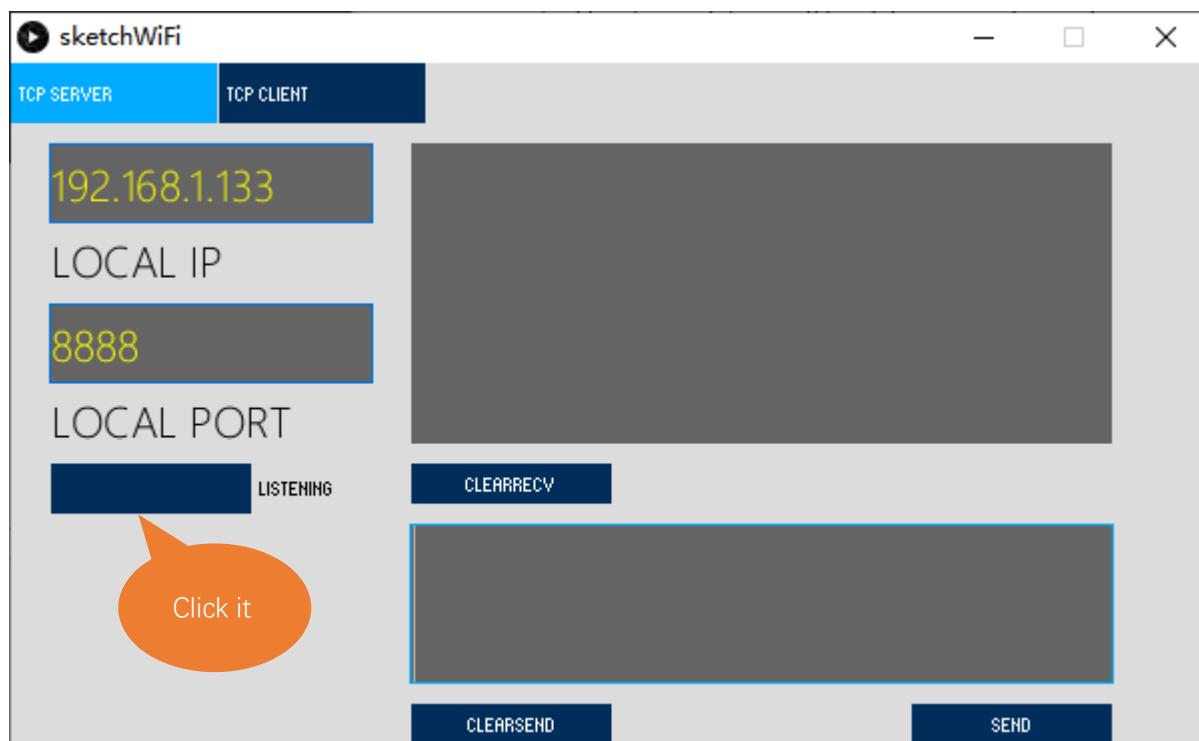
```

7 #include <WiFi.h>
8
9 const char *ssid_Router      = "*****"; //Enter the router name
10 const char *password_Router = "*****"; //Enter the router password
11 #define    REMOTE_IP        "*****"   //input the remote server which is you want to connect
12 #define    REMOTE_PORT       8888      //input the remote port which is the remote provide
13 WiFiClient client;
14

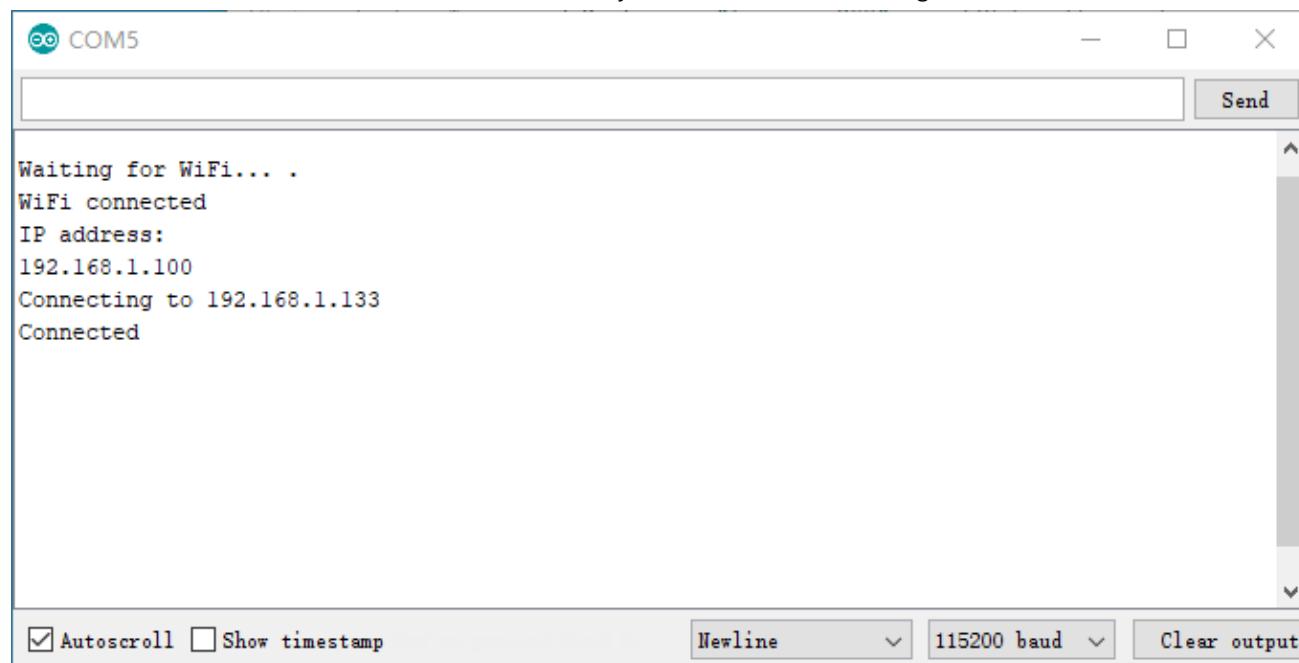
```

REMOTE\_IP needs to be filled in according to the interface of sketchWiFi.pde. Taking this tutorial as an example, its REMOTE\_IP is "192.168.1.133". Generally, by default, the ports do not need to change its value.

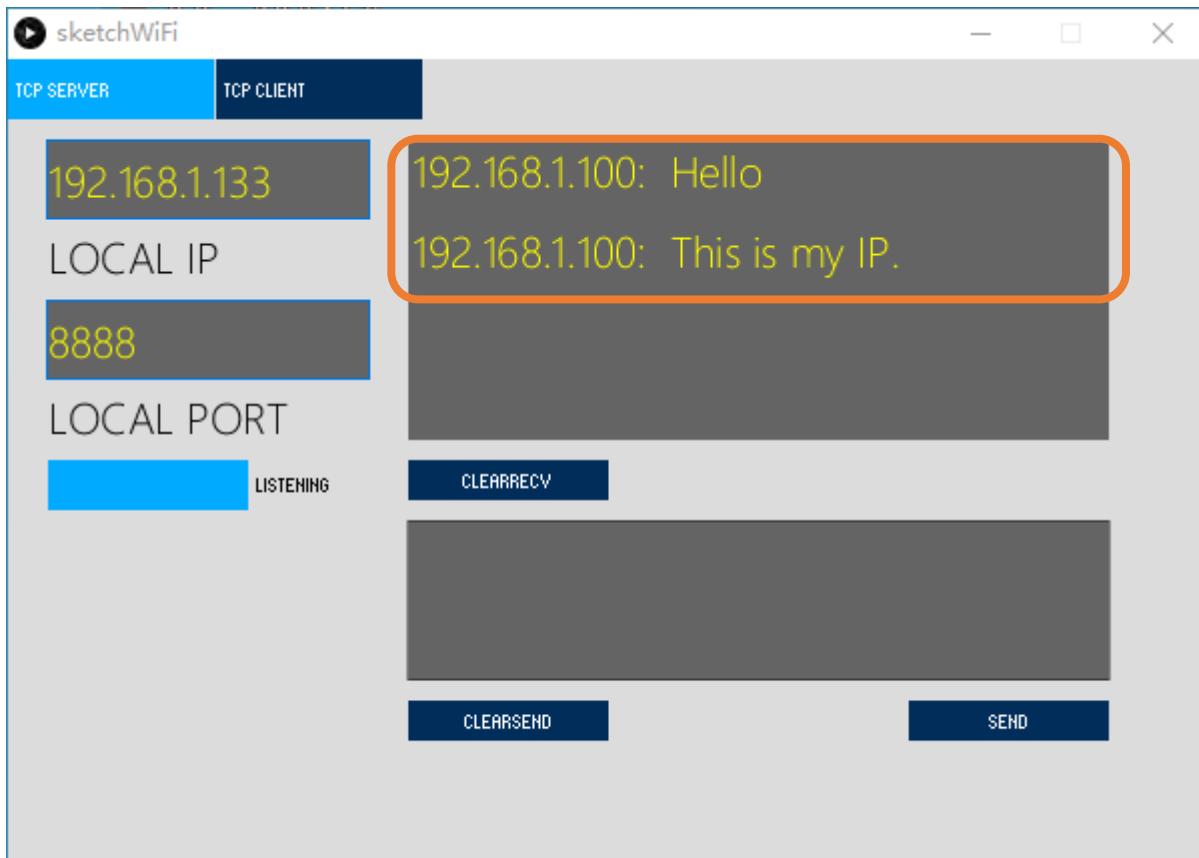
Click LISTENING, turn on TCP SERVER's data listening function and wait for ESP32 to connect.



Compile and upload code to ESP32-WROVER, open the serial monitor and set the baud rate to 115200. ESP32 connects router, obtains IP address and sends access request to server IP address on the same LAN till the connection is successful. When connect successfully, ESP32 can send messages to server.



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



### Sketch\_04\_1\_As Client

The following is the program code:

```
1 #include <WiFi.h>
2
3 const char *ssid_Router      = "*****"; //Enter the router name
4 const char *password_Router = "*****"; //Enter the router password
5 #define    REMOTE_IP        "*****"   //input the remote server which is you want to connect
6 #define    REMOTE_PORT       8888      //input the remote port which is the remote provide
7 WiFiClient client;
8
9 void setup() {
10     Serial.begin(115200);
11     delay(10);
12
13     WiFi.begin(ssid_Router, password_Router);
14     Serial.print("\nWaiting for WiFi... ");
15     while (WiFi.status() != WL_CONNECTED) {
16         Serial.print(".");
17         delay(500);
18     }
19     Serial.println("");
20     Serial.println("WiFi connected");
21     Serial.println("IP address: ");
22     Serial.println(WiFi.localIP());
23     delay(500);
24
25     Serial.print("Connecting to ");
26     Serial.println(REMOTE_IP);
27
28     while (!client.connect(REMOTE_IP, REMOTE_PORT)) {
29         Serial.println("Connection failed.");
30         Serial.println("Waiting a moment before retrying... ");
31     }
32     Serial.println("Connected");
33     client.print("Hello\n");
34     client.print("This is my IP.\n");
35
36 void loop() {
37     if (client.available() > 0) {
38         delay(20);
39         //read back one line from the server
40         String line = client.readString();
41         Serial.println(REMOTE_IP + String(":") + line);
```

```

42 }
43 if (Serial.available() > 0) {
44     delay(20);
45     String line = Serial.readString();
46     client.print(line);
47 }
48 if (client.connected () == 0) {
49     client.stop();
50     WiFi.disconnect();
51 }
52 }
```

Add WiFi function header file.

```
1 #include <WiFi.h>
```

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

```

3 const char *ssid_Router      = "*****"; //Enter the router name
4 const char *password_Router = "*****"; //Enter the router password
5 #define    REMOTE_IP        "*****"   //input the remote server which is you want to connect
6 #define    REMOTE_PORT       8888      //input the remote port which is the remote provide
```

Apply for the method class of WiFiClient.

```
7 WiFiClient client;
```

Connect specified WiFi until it is successful. If the name and password of WiFi are correct but it still fails to connect, please push the reset key.

```

13 WiFi.begin(ssid_Router, password_Router);
14 Serial.print("\nWaiting for WiFi... ");
15 while (WiFi.status() != WL_CONNECTED) {
16     Serial.print(".");
17     delay(500);
18 }
```

Send connection request to remote server until connect successfully. When connect successfully, print out the connecting prompt on the serial monitor and send messages to remote server.

```

28 while (!client.connect(REMOTE_IP, REMOTE_PORT)) { //Connect to Server
29     Serial.println("Connection failed.");
30     Serial.println("Waiting a moment before retrying... ");
31 }
32 Serial.println("Connected");
33 client.print("Hello\n");
```

When ESP32 receive messages from servers, it will print them out via serial port; Users can also send messages to servers from serial port.

```

37 if (client.available() > 0) {
38     delay(20);
39     //read back one line from the server
40     String line = client.readString();
41     Serial.println(REMOTE_IP + String(":") + line);
42 }
```

```
43 if (Serial.available() > 0) {  
44     delay(20);  
45     String line = Serial.readString();  
46     client.print(line);  
47 }
```

If the server is disconnected, turn off WiFi of ESP32.

```
48 if (client.connected () == false) {  
49     client.stop();  
50     WiFi.disconnect();  
51 }
```

#### Reference

##### Class Client

Every time when using Client, you need to include header file "WiFi.h."

**connect(ip, port, timeout)/connect(\*host, port, timeout)**: establish a TCP connection.

**ip, \*host**: ip address of target server

**port**: port number of target server

**timeout**: connection timeout

**connected()**: judge whether client is connecting. If return value is 1, then connect successfully; If return value is 0, then fail to connect.

**stop()**: stop tcp connection

**print()**: send data to server connecting to client

**available()**: return to the number of bytes readable in receive buffer, if no, return to 0 or -1.

**read()**: read one byte of data in receive buffer

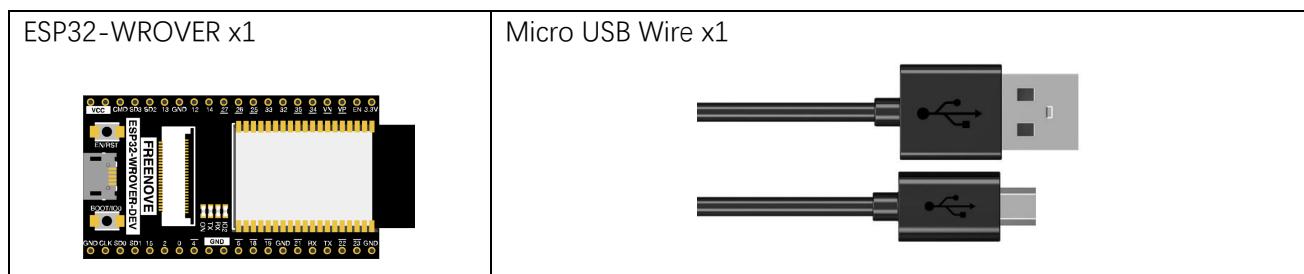
**readString()**: read string in receive buffer



## Project 4.2 As Server

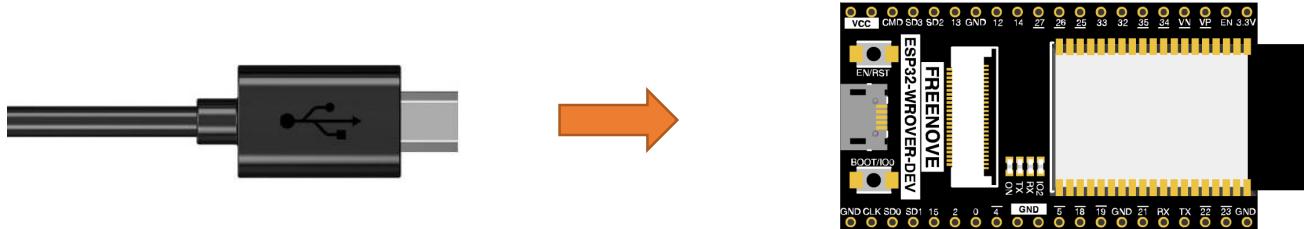
In this section, ESP32 is used as a server to wait for the connection and communication of client on the same LAN.

### Component List



### Circuit

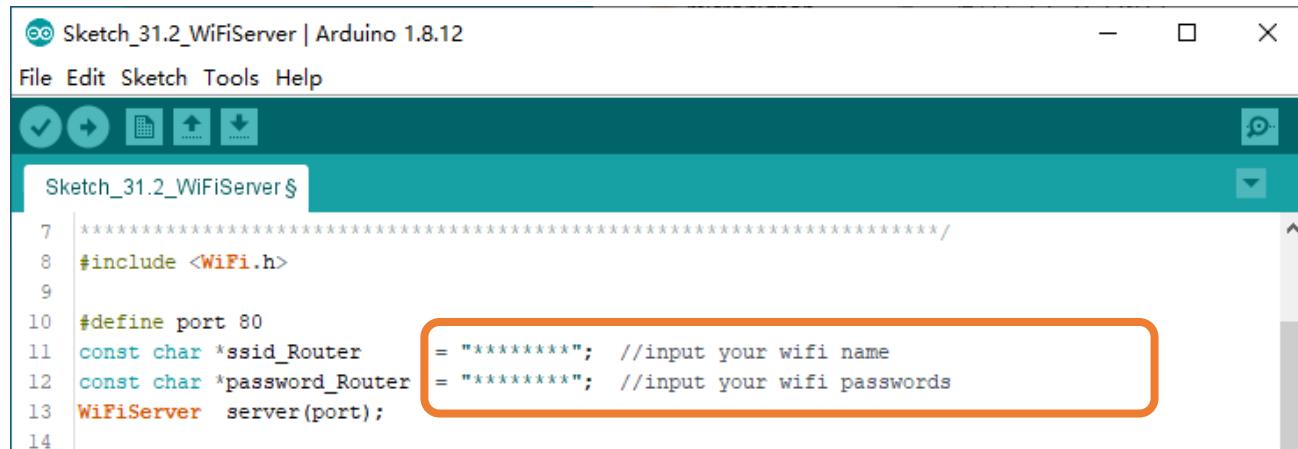
Connect Freenove ESP32 to the computer using a USB cable.



## Sketch

Before running Sketch, please modify the contents of the box below first.

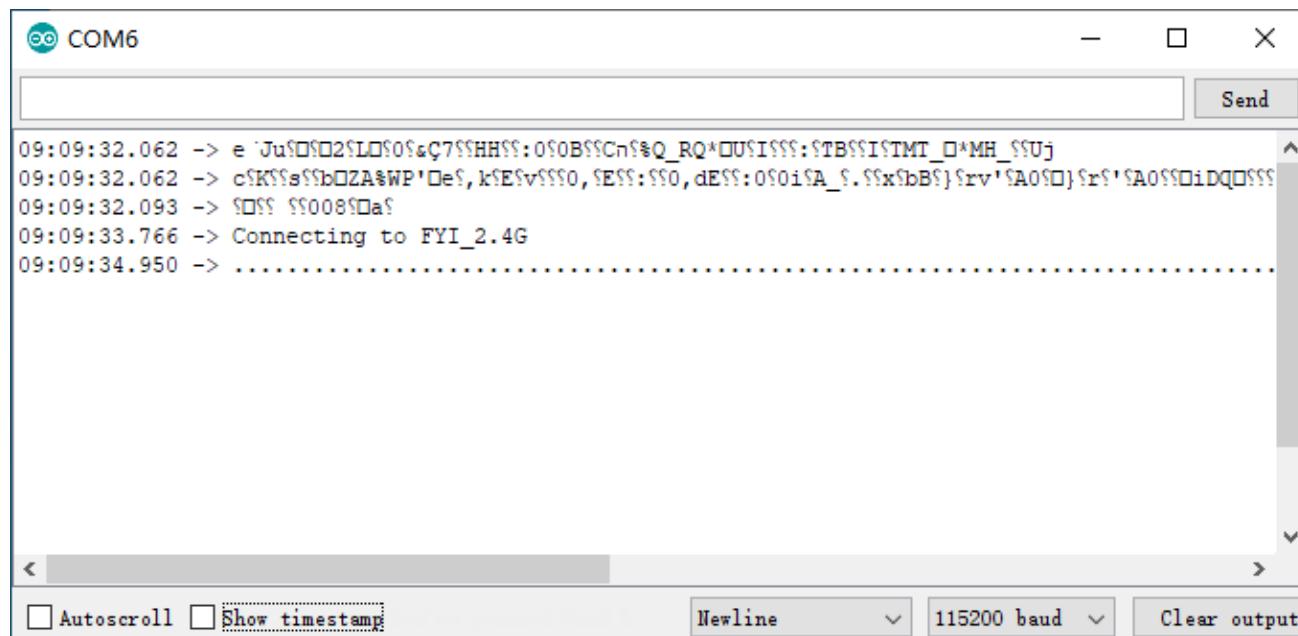
Sketch\_04.2\_As\_Server



```
Sketch_31.2_WiFiServer | Arduino 1.8.12
File Edit Sketch Tools Help
Sketch_31.2_WiFiServer §
7 ****
8 #include <WiFi.h>
9
10 #define port 80
11 const char *ssid_Router
12 const char *password_Router
13 WiFiServer server(port);
14
```

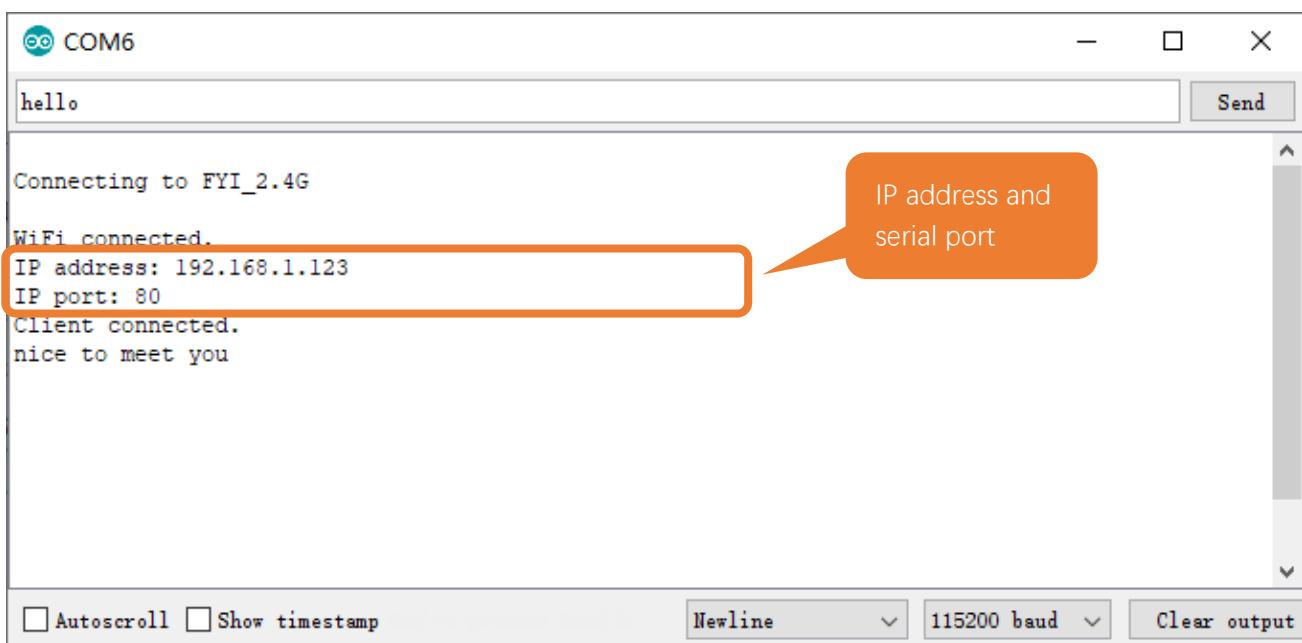
Compile and upload code to ESP32-WROVER board, open the serial monitor and set the baud rate to 115200. Turn on server mode for ESP32, waiting for the connection of other devices on the same LAN. Once a device connects to server successfully, they can send messages to each other.

If the ESP32 fails to connect to router, press the reset button as shown below and wait for ESP32 to run again.



```
09:09:32.062 -> e 'Ju{O{2{L{0{e{7{H{0{0B{Cn{Q_RQ*0U{I{TB{S{I{TMT_{MH_{SU{j
09:09:32.062 -> c{K{I{s{b{2A{WP'D{,k{E{v{SS{0,{E{S{0,{D{S{0{i{A{S.{S{x{b{B{}}{r{v{'{A{0{}}{r{'}{S{A{0{}}{i{D{Q{S{S{
09:09:32.093 -> S{S{ S{008{D{a{f
09:09:33.766 -> Connecting to FYI_2.4G
09:09:34.950 -> .....
```

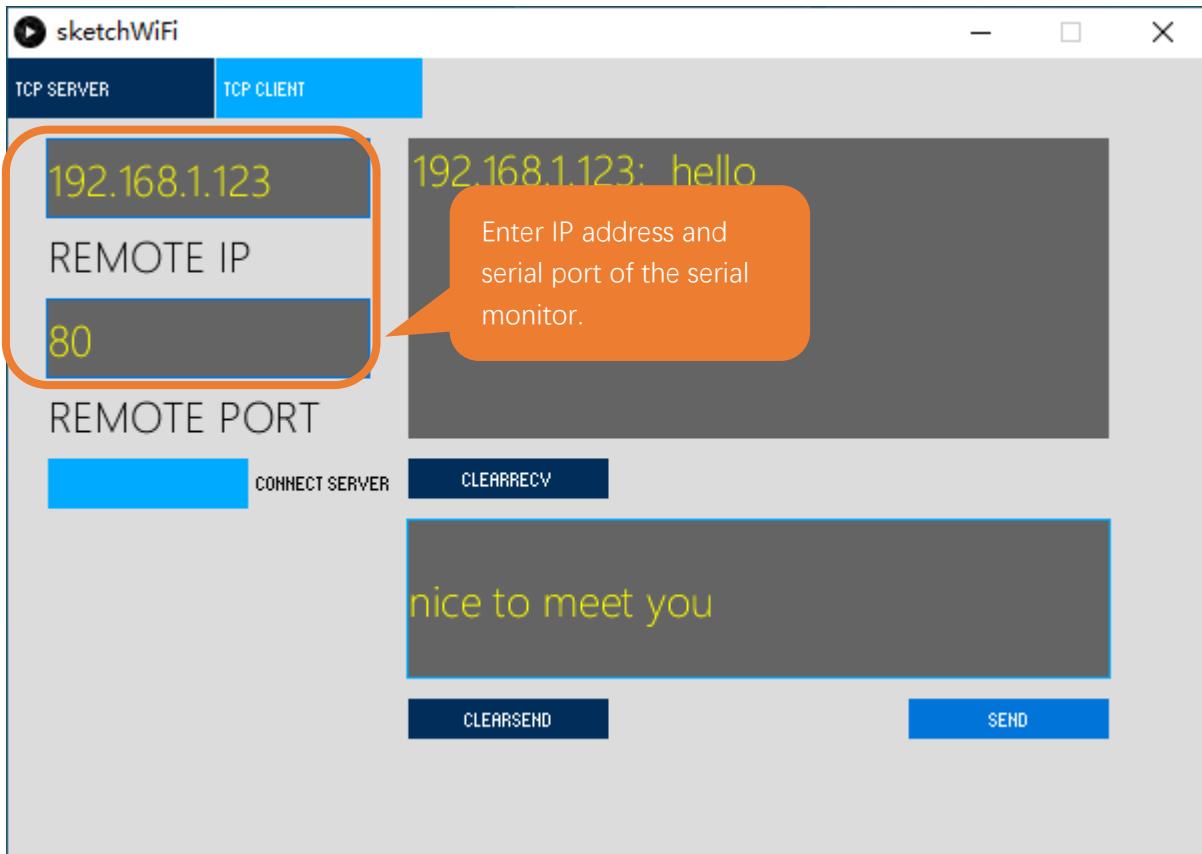
## Serial Monitor



Processing:

Open the "Freenove\_ESP32\_WROVER\_Board\Sketches\Sketches\Sketch\_04.2\_WiFiServer\sketchWiFi\sketchWiFi.pde".

Based on the messages printed by the serial monitor, enter correct IP address and serial port in Processing to establish connection and make communication.



The following is the program code:

```
1 #include <WiFi.h>
2
3 #define port 80
4 const char *ssid_Router      = "*****"; //input your wifi name
5 const char *password_Router  = "*****"; //input your wifi passwords
6 WiFiServer server(port);
7
8 void setup()
9 {
10     Serial.begin(115200);
11     Serial.printf("\nConnecting to ");
12     Serial.println(ssid_Router);
13     WiFi.disconnect();
14     WiFi.begin(ssid_Router, password_Router);
15     delay(1000);
16     while (WiFi.status() != WL_CONNECTED) {
17         delay(500);
18         Serial.print(".");
19     }
20     Serial.println("");
21     Serial.println("WiFi connected.");
22     Serial.print("IP address: ");
23     Serial.println(WiFi.localIP());
24     Serial.printf("IP port: %d\n", port);
25     server.begin(port);
26     WiFi.setAutoConnect(true);
27     WiFi.setAutoReconnect(true);
28 }
29
30 void loop() {
31     WiFiClient client = server.available();           // listen for incoming clients
32     if (client) {                                     // if you get a client
33         Serial.println("Client connected.");
34         while (client.connected()) {                  // loop while the client's connected
35             if (client.available()) {                 // if there's bytes to read from the
36                 Serial.println(client.readStringUntil('\n'));// print it out the serial monitor
37                 while(client.read()>0);                // clear the wifi receive area cache
38             }
39             if(Serial.available()){                   // if there's bytes to read from the
36             serial monitor
40                 client.print(Serial.readStringUntil('\n'));// print it out the client.
41                 while(Serial.read()>0);                  // clear the wifi receive area cache
42             }
43         }
44     }
45 }
```

Any concerns? ✉ support@freenove.com

```

42     }
43   }
44   client.stop();           // stop the client connecting.
45   Serial.println("Client Disconnected.");
46 }
47 }
```

Apply for method class of WiFiServer.

6	<code>WiFiServer server(port);</code> //Apply for a Server object whose port number is 80
---	---

Connect specified WiFi until it is successful. If the name and password of WiFi are correct but it still fails to connect, please push the reset key.

```

13   WiFi.disconnect();
14   WiFi.begin(ssid_Router, password_Router);
15   delay(1000);
16   while (WiFi.status() != WL_CONNECTED) {
17     delay(500);
18     Serial.print(".");
19   }
20   Serial.println("");
21   Serial.println("WiFi connected.");
```

Print out the IP address and port number of ESP32.

22	<code>Serial.print("IP address: ");</code>	
23	<code>Serial.println(WiFi.localIP());</code>	//print out IP address of ESP32
24	<code>Serial.printf("IP port: %d\n", port);</code>	//Print out ESP32's port number

Turn on server mode of ESP32, start automatic connection and turn on automatic reconnection.

25	<code>server.begin();</code>	//Turn ON ESP32 as Server mode
26	<code>WiFi.setAutoConnect(true);</code>	
27	<code>WiFi.setAutoReconnect(true);</code>	

When ESP32 receive messages from servers, it will print them out via serial port; Users can also send messages to servers from serial port.

35	<code>if (client.available()) {</code>	// if there's bytes to read from the
36	<code>  client</code>	
37	<code>    Serial.println(client.readStringUntil('\n'));</code>	// print it out the serial monitor
38	<code>    while(client.read()&gt;0);</code>	// clear the wifi receive area cache
39	<code>}</code>	
40	<code>if(Serial.available()){</code>	// if there's bytes to read from the
41	<code>  serial monitor</code>	
42	<code>  client.print(Serial.readStringUntil('\n'));</code>	// print it out the client.
	<code>  while(Serial.read()&gt;0);</code>	// clear the wifi receive area cache
	<code>}</code>	

## Reference

### Class Server

Every time use Server functionality, we need to include header file "WiFi.h".

**WiFiServer(uint16\_t port=80, uint8\_t max\_clients=4)**: create a TCP Server.

**port**: ports of Server; range from 0 to 65535 with the default number as 80.

**max\_clients**: maximum number of clients with default number as 4.

**begin(port)**: start the TCP Server.

**port**: ports of Server; range from 0 to 65535 with the default number as 0.

**setNoDelay(bool nodelay)**: whether to turn off the delay sending functionality.

**nodelay**: true stands for forbidden Nagle algorithm.

**close()**: close tcp connection.

**stop()**: stop tcp connection.

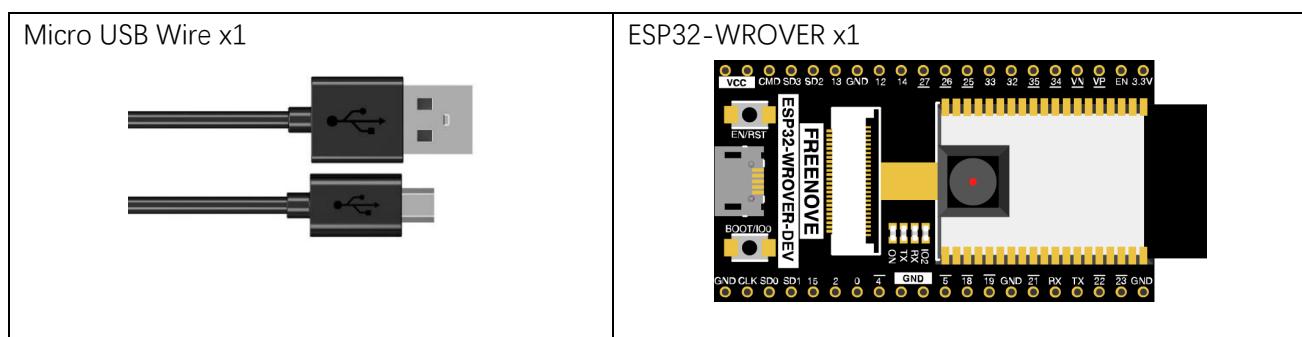
# Chapter 5 Camera Web Server

In this section, we'll use ESP32's video function as an example to study.

## Project 5.1 Camera Web Server

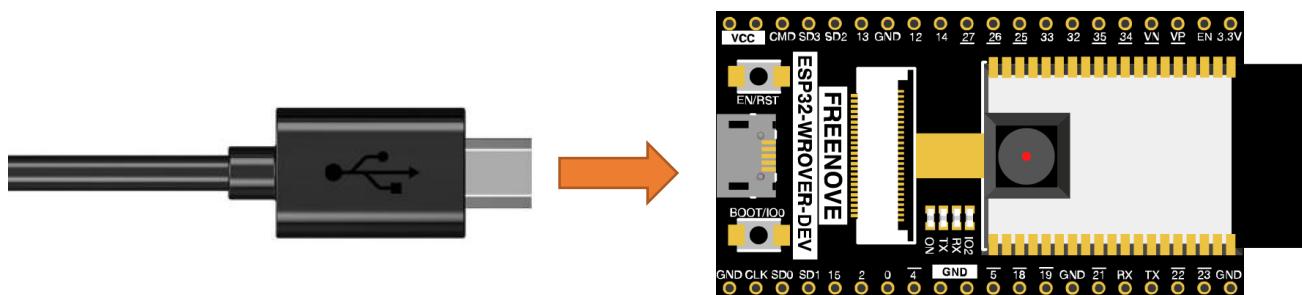
Connect ESP32 using USB and check its IP address through serial monitor. Use web page to access IP address to obtain video and image data.

### Component List



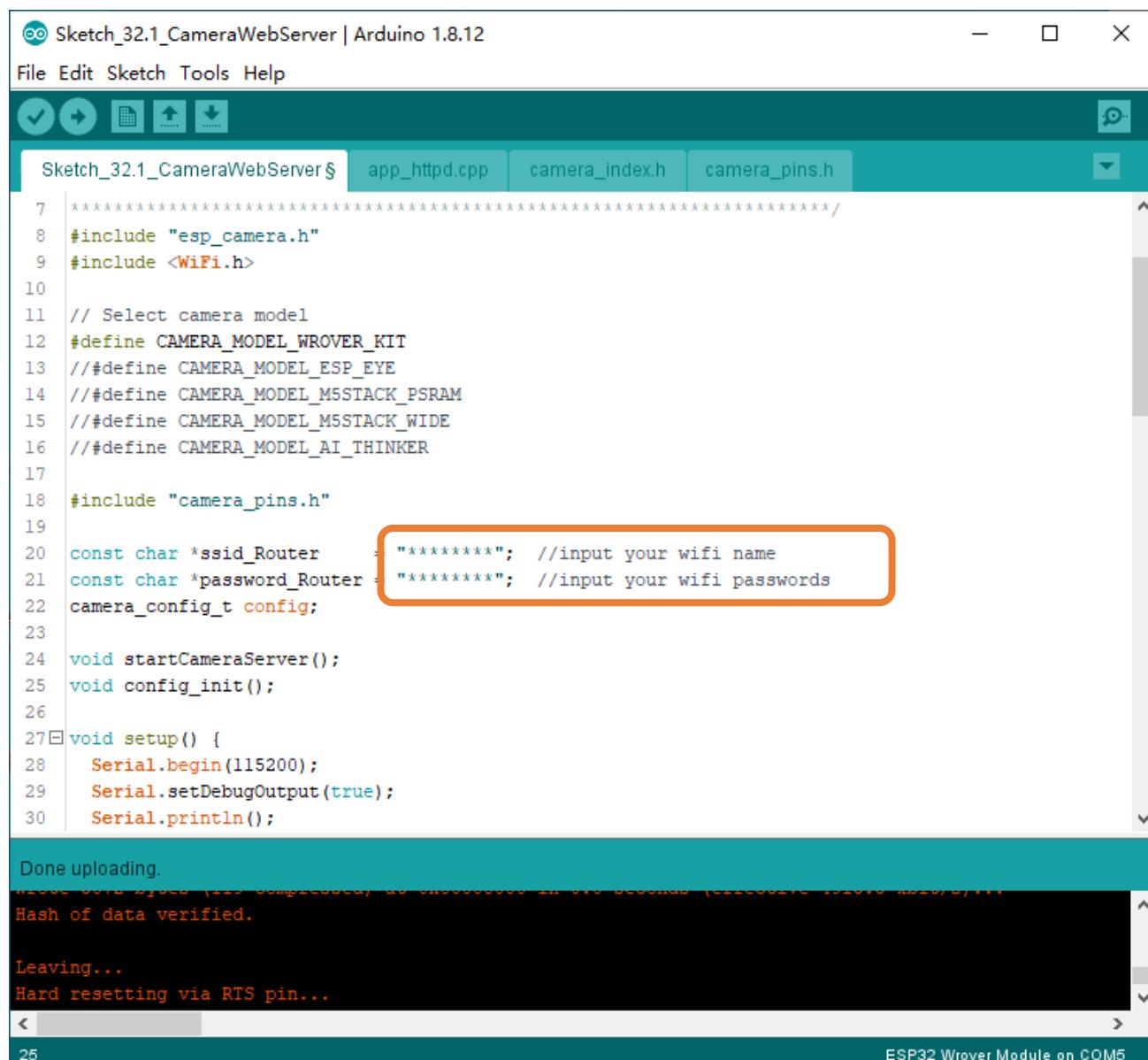
### Circuit

Connect Freenove ESP32 to the computer using USB cable.



## Sketch

### Sketch\_05.1\_As\_CameraWebServer



```
Sketch_32.1_CameraWebServer | Arduino 1.8.12
File Edit Sketch Tools Help
Sketch_32.1_CameraWebServer app_httpd.cpp camera_index.h camera_pins.h
7  ****
8 #include "esp_camera.h"
9 #include <WiFi.h>
10
11 // Select camera model
12 #define CAMERA_MODEL_WROVER_KIT
13 // #define CAMERA_MODEL_ESP_EYE
14 // #define CAMERA_MODEL_M5STACK_PSRAM
15 // #define CAMERA_MODEL_M5STACK_WIDE
16 // #define CAMERA_MODEL_AI_THINKER
17
18 #include "camera_pins.h"
19
20 const char *ssid_Router      = "*****"; //input your wifi name
21 const char *password_Router = "*****"; //input your wifi passwords
22 camera_config_t config;
23
24 void startCameraServer();
25 void config_init();
26
27 void setup() {
28     Serial.begin(115200);
29     Serial.setDebugOutput(true);
30     Serial.println();
```

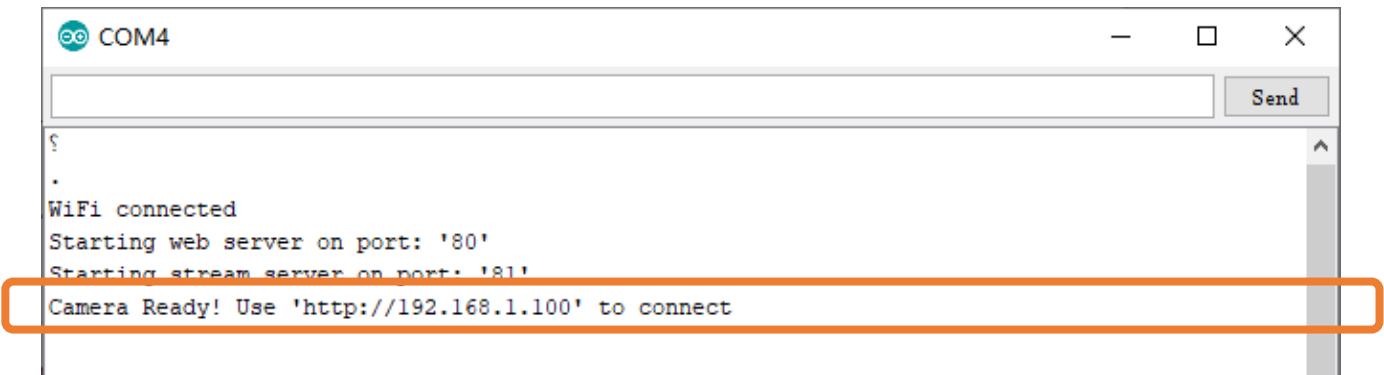
Done uploading.  
Hash of data verified.

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

ESP32 Wrover Module on COM5

Before running the program, please modify your router's name and password in the box shown in the illustration above to make sure that your Sketch can compile and work successfully.

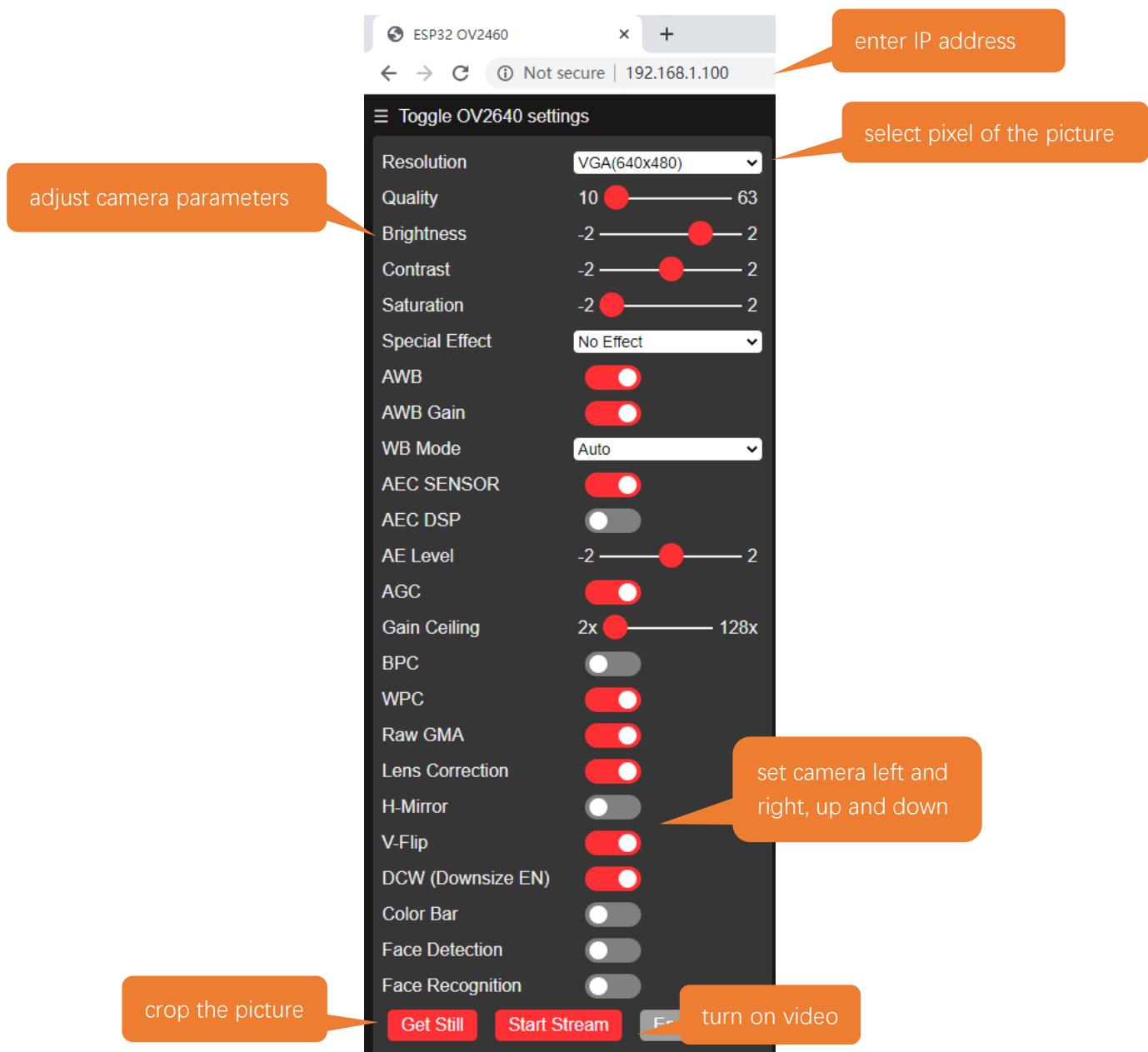
Compile and upload codes to ESP32, open the serial monitor and set the baud rate to 115200, and the serial monitor will print out a network link address.



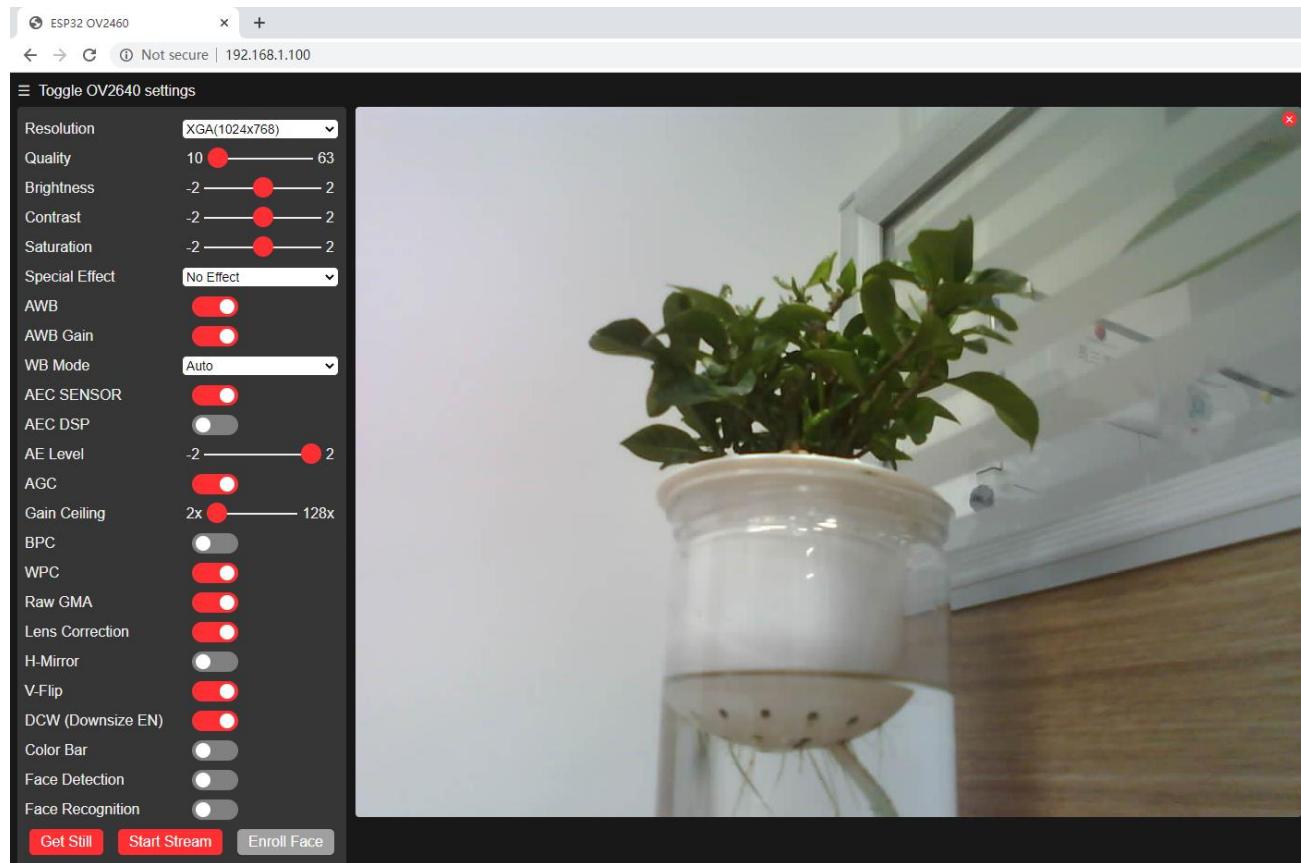
```
WiFi connected
Starting web server on port: '80'
Starting stream server on port: '81'
Camera Ready! Use 'http://192.168.1.100' to connect
```

If your ESP32 has been in the process of connecting to router, but the information above has not been printed out, please re-check whether the router name and password have been entered correctly and press the reset key on ESP32-WROVER to wait for a successful connection prompt.

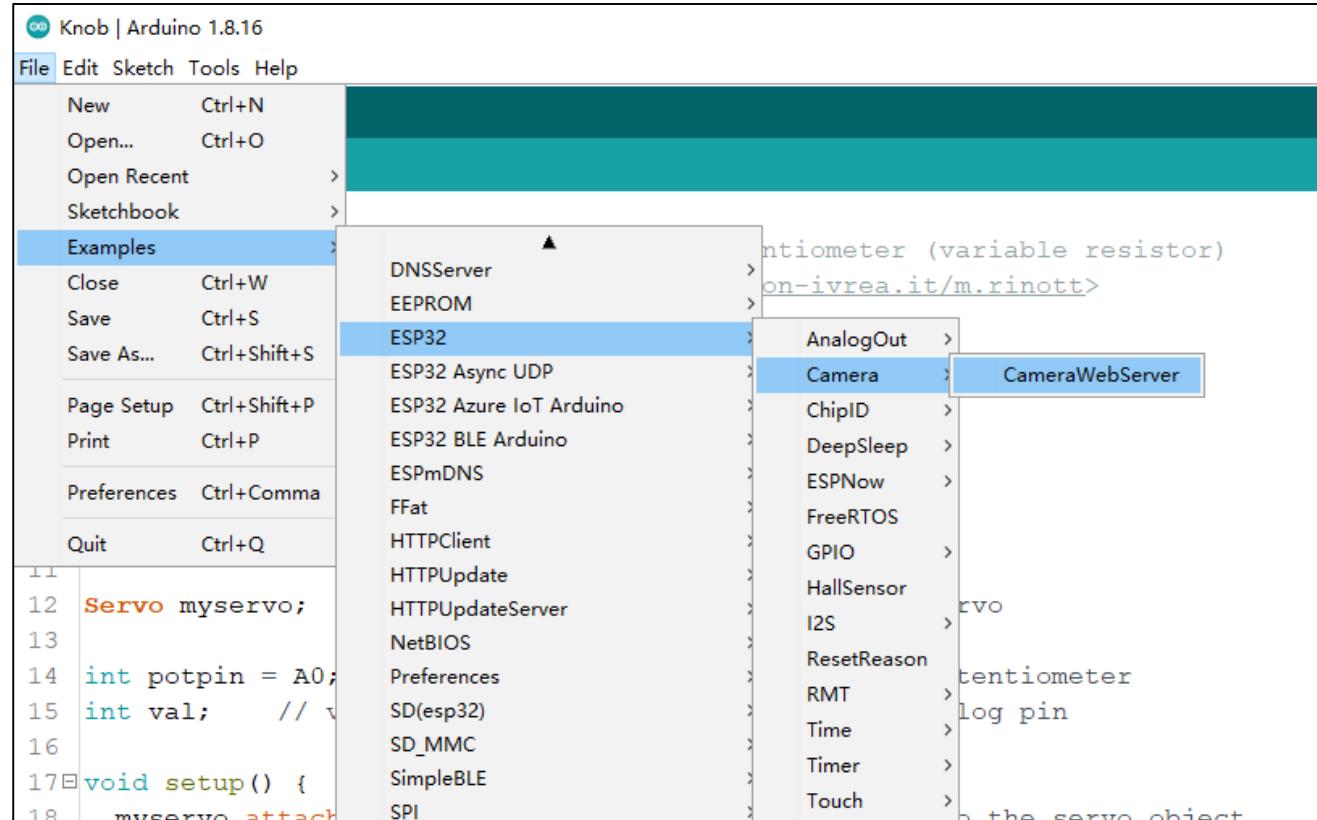
Open a web browser, enter the IP address printed by the serial monitor in the address bar, and access it. Taking the Google browser as an example, here's what the browser prints out after successful access to ESP32's IP.



Click on Start Stream. The effect is shown in the image below.



**Note:** If sketch compilation fails due to ESP32 support package, follow the steps of the image to open the CameraWebServer. This sketch is the same as described in the tutorial above.



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

The following is the main program code. You need include other code files in the same folder when write your own code.

```
1 #include "esp_camera.h"
2 #include <WiFi.h>
3
4 // Select camera model
5 #define CAMERA_MODEL_WROVER_KIT
6 // #define CAMERA_MODEL_ESP_EYE
7 // #define CAMERA_MODEL_M5STACK_PSRAM
8 // #define CAMERA_MODEL_M5STACK_WIDE
9 // #define CAMERA_MODEL_AI_THINKER
10
11 #include "camera_pins.h"
12
13 const char *ssid_Router      = "*****"; //input your wifi name
14 const char *password_Router = "*****"; //input your wifi passwords
15 camera_config_t config;
16
17 void startCameraServer();
18 void config_init();
19
20 void setup() {
21     Serial.begin(115200);
22     Serial.setDebugOutput(true);
23     Serial.println();
24
25     config_init();
26     config.frame_size = FRAMESIZE_VGA;
27     config.jpeg_quality = 10;
28
29     // camera init
30     esp_err_t err = esp_camera_init(&config);
31     if (err != ESP_OK) {
32         Serial.printf("Camera init failed with error 0x%x", err);
33         return;
34     }
35
36     sensor_t * s = esp_camera_sensor_get();
37     s->set_vflip(s, 1);           //flip it back
38     s->set_brightness(s, 1);     //up the brightness just a bit
39     s->set_saturation(s, -1);   //lower the saturation
40
41     WiFi.begin(ssid_Router, password_Router);
42     while (WiFi.status() != WL_CONNECTED) {
```

```
43     delay(500);
44     Serial.print(".");
45 }
46 Serial.println("");
47 Serial.println("WiFi connected");
48
49 startCameraServer();
50
51 Serial.print("Camera Ready! Use 'http://");
52 Serial.print(WiFi.localIP());
53 Serial.println(" to connect");
54 }
55
56 void loop() {
57 ;
58 }
59
60 void config_init() {
61 config.ledc_channel = LEDC_CHANNEL_0;
62 config.ledc_timer = LEDC_TIMER_0;
63 config.pin_d0 = Y2_GPIO_NUM;
64 config.pin_d1 = Y3_GPIO_NUM;
65 config.pin_d2 = Y4_GPIO_NUM;
66 config.pin_d3 = Y5_GPIO_NUM;
67 config.pin_d4 = Y6_GPIO_NUM;
68 config.pin_d5 = Y7_GPIO_NUM;
69 config.pin_d6 = Y8_GPIO_NUM;
70 config.pin_d7 = Y9_GPIO_NUM;
71 config.pin_xclk = XCLK_GPIO_NUM;
72 config.pin_pclk = PCLK_GPIO_NUM;
73 config.pin_vsync = VSYNC_GPIO_NUM;
74 config.pin_href = HREF_GPIO_NUM;
75 config.pin_sscb_sda = SIOD_GPIO_NUM;
76 config.pin_sscb_scl = SIOC_GPIO_NUM;
77 config.pin_pwdn = PWDN_GPIO_NUM;
78 config.pin_reset = RESET_GPIO_NUM;
79 config.xclk_freq_hz = 20000000;
80 config.pixel_format = PIXFORMAT_JPEG;
81 config.fb_count = 1;
82 }
```

Add procedure files and API interface files related to ESP32 camera.

```

1 #include "esp_camera.h"
2 #include <WiFi.h>
3
4 // Select camera model
5 #define CAMERA_MODEL_WROVER_KIT
6 // #define CAMERA_MODEL_ESP_EYE
7 // #define CAMERA_MODEL_M5STACK_PSRAM
8 // #define CAMERA_MODEL_M5STACK_WIDE
9 // #define CAMERA_MODEL_AI_THINKER
10
11 #include "camera_pins.h"
```

Enter the name and password of the router

```

13 const char *ssid_Router      = "*****"; //input your wifi name
14 const char *password_Router = "*****"; //input your wifi passwords
```

Initialize serial port, set baud rate to 115200; open the debug and output function of the serial.

```

21 Serial.begin(115200);
22 Serial.setDebugOutput(true);
23 Serial.println();
```

Configure parameters including interface pins of the camera. Note: It is generally not recommended to change them.

```

60 void config_init() {
61     config.ledc_channel = LEDC_CHANNEL_0;
62     config.ledc_timer = LEDC_TIMER_0;
63     config.pin_d0 = Y2_GPIO_NUM;
64     config.pin_d1 = Y3_GPIO_NUM;
65     config.pin_d2 = Y4_GPIO_NUM;
66     config.pin_d3 = Y5_GPIO_NUM;
67     config.pin_d4 = Y6_GPIO_NUM;
68     config.pin_d5 = Y7_GPIO_NUM;
69     config.pin_d6 = Y8_GPIO_NUM;
70     config.pin_d7 = Y9_GPIO_NUM;
71     config.pin_xclk = XCLK_GPIO_NUM;
72     config.pin_pclk = PCLK_GPIO_NUM;
73     config.pin_vsync = VSYNC_GPIO_NUM;
74     config.pin_href = HREF_GPIO_NUM;
75     config.pin_sscb_sda = SIOD_GPIO_NUM;
76     config.pin_sscb_scl = SIOC_GPIO_NUM;
77     config.pin_pwdn = PWDN_GPIO_NUM;
78     config.pin_reset = RESET_GPIO_NUM;
79     config.xclk_freq_hz = 20000000;
80     config.pixel_format = PIXFORMAT_JPEG;
81     config.fb_count = 1;
82 }
```

Any concerns? ✉ support@freenove.com



ESP32 connects to the router and prints a successful connection prompt. If it has not been successfully connected, press the reset key on the ESP32-WROVER.

```

41 WiFi.begin(ssid_Router, password_Router);
42 while (WiFi.status() != WL_CONNECTED) {
43     delay(500);
44     Serial.print(".");
45 }
46 Serial.println("");
47 Serial.println("WiFi connected");

```

Open the video streams server function of the camera and print its IP address via serial port.

```

49 startCameraServer();
50
51 Serial.print("Camera Ready! Use 'http://'");
52 Serial.print(WiFi.localIP());
53 Serial.println(" to connect");

```

Configure the display image information of the camera.

The `set_vflip()` function sets whether the image is flipped 180°, with 0 for no flip and 1 for flip 180°.

The `set_brightness()` function sets the brightness of the image, with values ranging from -2 to 2.

The `set_saturation()` function sets the color saturation of the image, with values ranging from -2 to 2.

```

36 sensor_t * s = esp_camera_sensor_get();
37 s->set_vflip(s, 1);           //flip it back
38 s->set_brightness(s, 1);      //up the brightness just a bit
39 s->set_saturation(s, -1);    //lower the saturation

```

Modify the resolution and sharpness of the images captured by the camera. The sharpness ranges from 10 to 63, and the smaller the number, the sharper the picture. The larger the number, the blurrier the picture. Please refer to the table below.

```

26 config.frame_size = FRAMESIZE_VGA;
27 config.jpeg_quality = 10;

```

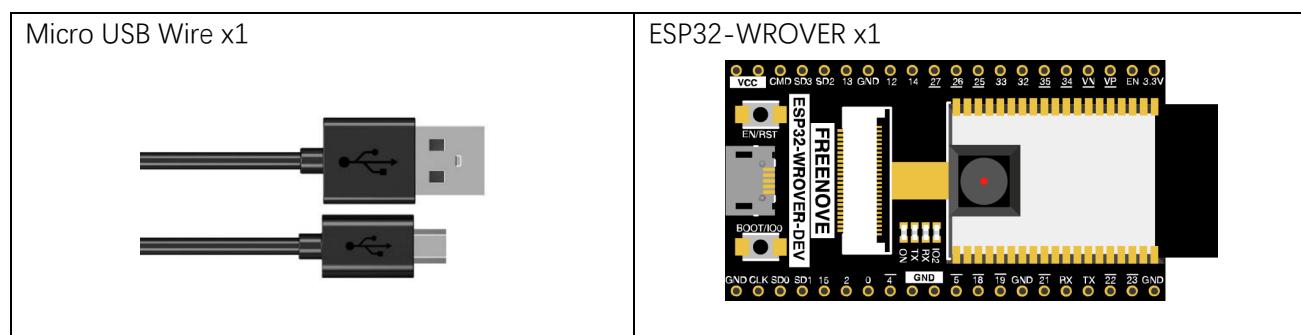
#### Reference

Image resolution	Sharpness	Image resolution	Sharpness
FRAMESIZE_QQVGA	160x120	FRAMESIZE_VGA	640x480
FRAMESIZE_QQVGA2	128x160	FRAMESIZE_SVGA	800x600
FRAMESIZE_QCIF	176x144	FRAMESIZE_XGA	1024x768
FRAMESIZE_HQVGA	240x176	FRAMESIZE_SXGA	1280x1024
FRAMESIZE_QVGA	320x240	FRAMESIZE_UXGA	1600x1200
FRAMESIZE_CIF	400x296	FRAMESIZE_QXGA	2048x1536

## Project 5.2 Video Web Server

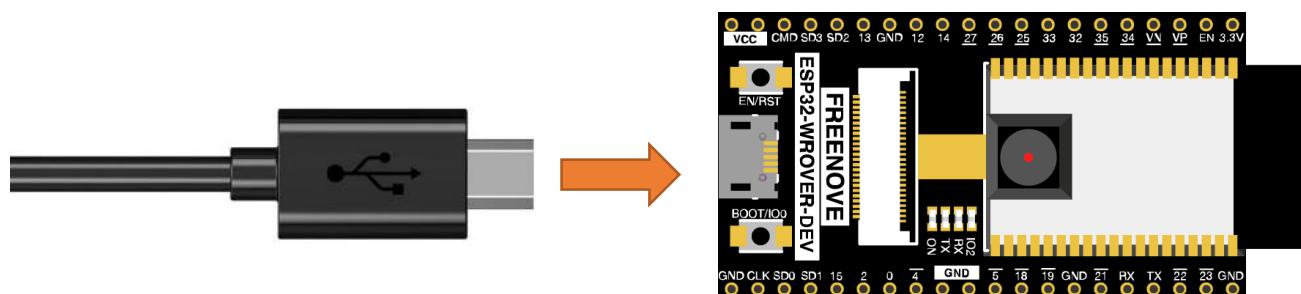
Connect to ESP32 using USB and view its IP address through a serial monitor. Access IP addresses through web pages to obtain real-time video data.

### Component List



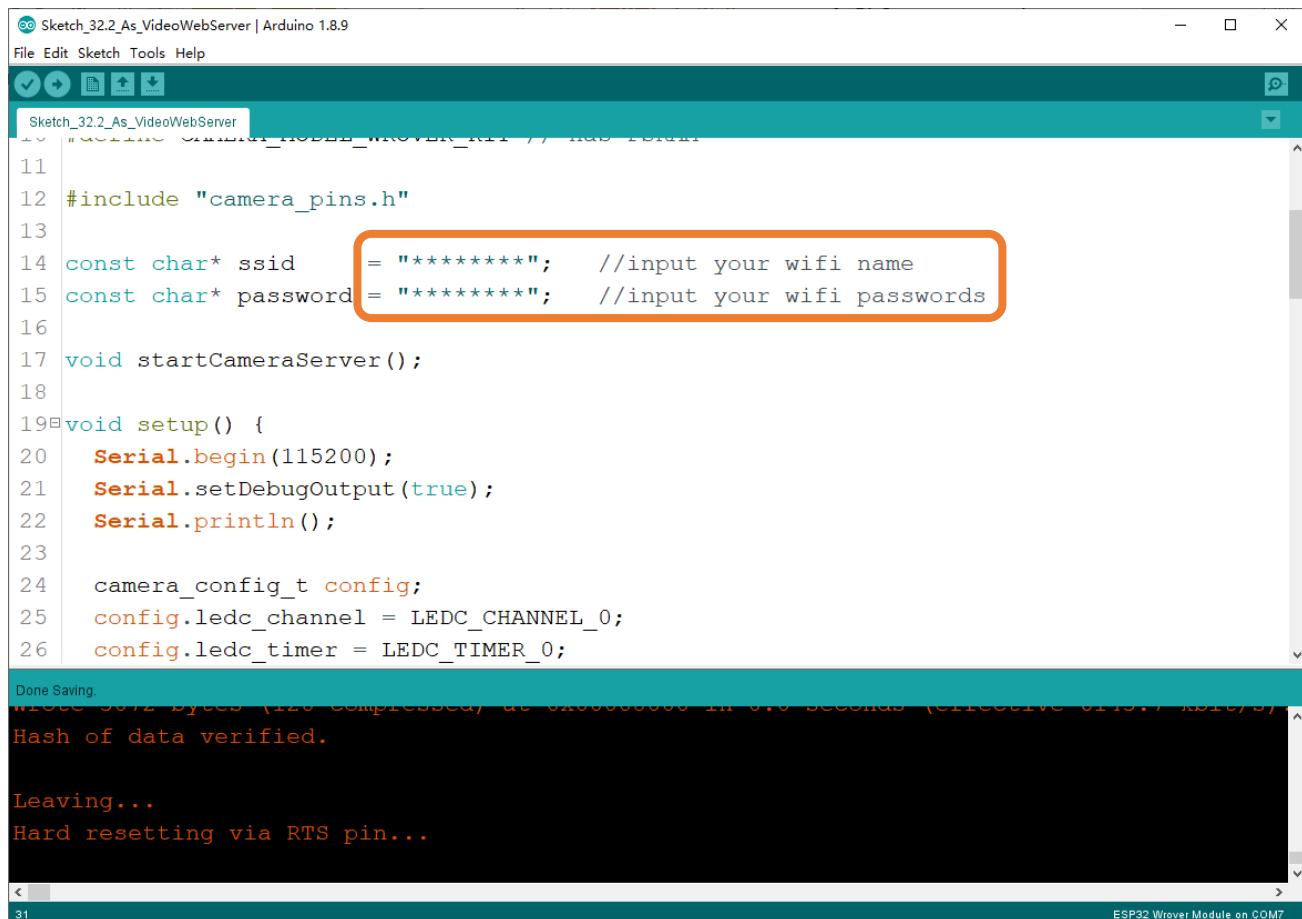
### Circuit

Connect Freenove ESP32 to the computer using USB cable.



## Sketch

### Sketch\_05.2\_As\_VideoWebServer



```

Sketch_32.2_As_VideoWebServer | Arduino 1.8.9
File Edit Sketch Tools Help
Sketch_32.2_As_VideoWebServer
11
12 #include "camera_pins.h"
13
14 const char* ssid      = "*****";      //input your wifi name
15 const char* password = "*****";      //input your wifi passwords
16
17 void startCameraServer();
18
19 void setup() {
20   Serial.begin(115200);
21   Serial.setDebugOutput(true);
22   Serial.println();
23
24   camera_config_t config;
25   config.ledc_channel = LEDC_CHANNEL_0;
26   config.ledc_timer = LEDC_TIMER_0;

```

Done Saving.  
Wrote 3072 bytes (120 compressed) at 0x00000000 in 0.0 seconds (effective 0.157 ms/sec).

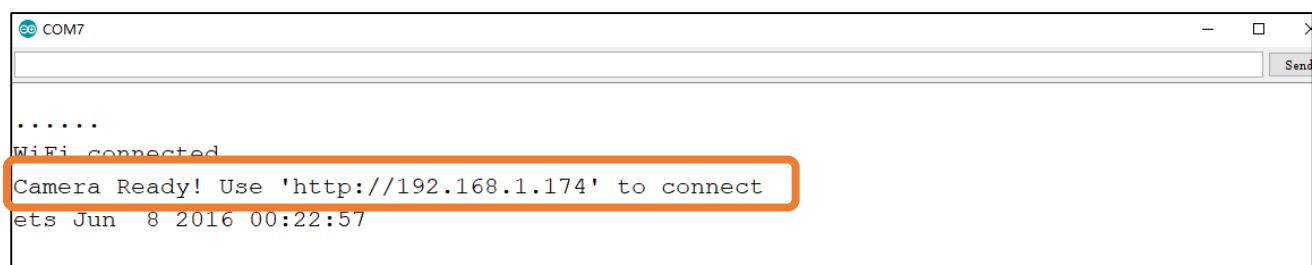
Hash of data verified.

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

ESP32 Wrover Module on COM7

Before running the program, please modify your router's name and password in the box shown in the illustration above to make sure that your Sketch can compile and work successfully.

Compile and upload codes to ESP32, open the serial monitor and set the baud rate to 115200, and the serial monitor will print out a network link address.



```

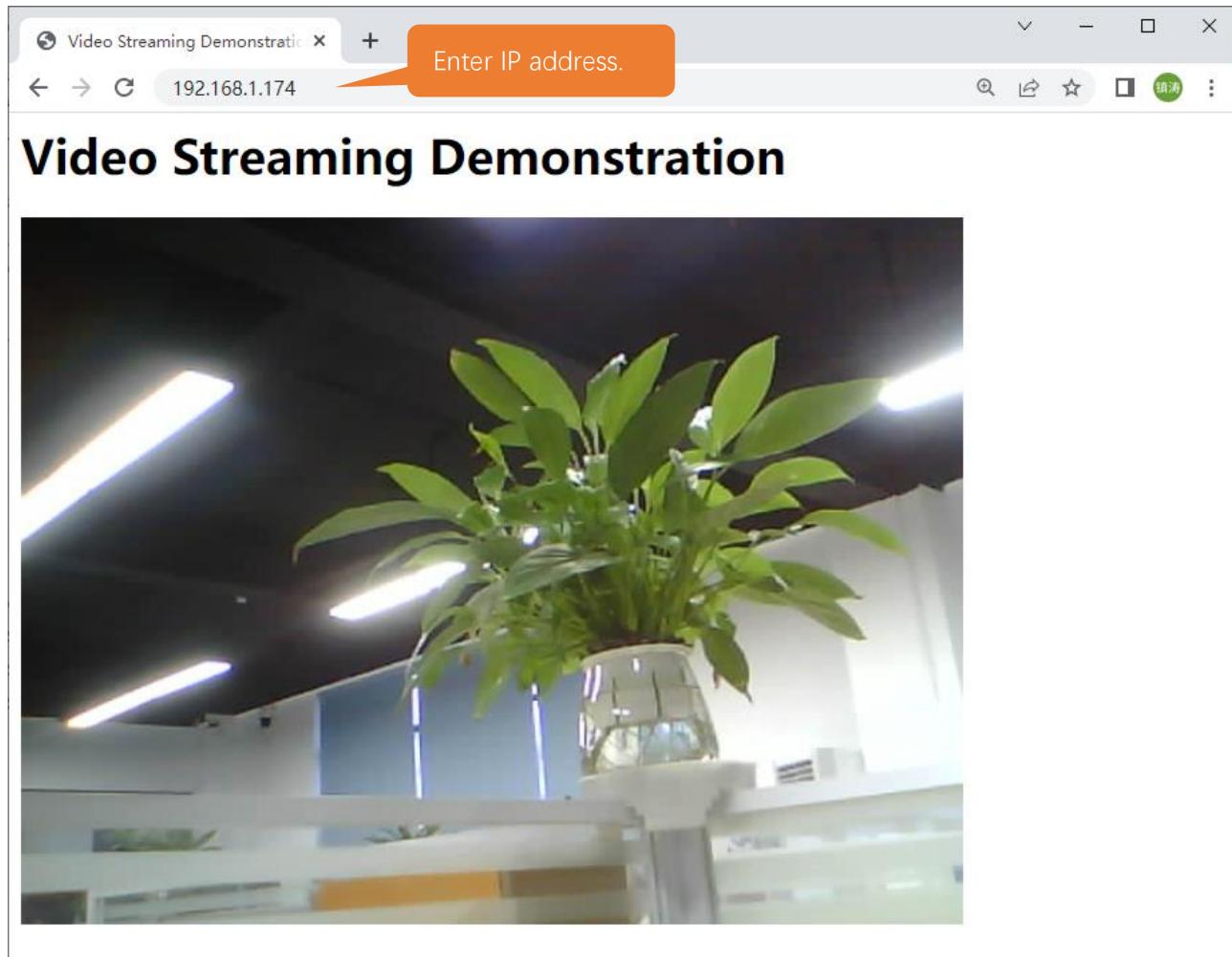
COM7
.....
WiFi connected
Camera Ready! Use 'http://192.168.1.174' to connect
ets Jun 8 2016 00:22:57

```

If your ESP32 has been in the process of connecting to router, but the information above has not been printed out, please re-check whether the router name and password have been entered correctly and press the reset key on ESP32-WROVER to wait for a successful connection prompt.

Open a web browser, enter the IP address printed by the serial monitor in the address bar, and access it. Taking the Google browser as an example, here's what the browser prints out after successful access to ESP32's IP.

The effect is shown in the image below.



The following is the main program code. You need include other code files in the same folder when write your own code.

```
1 #include "esp_camera.h"
2 #include <WiFi.h>
3 //
4 // WARNING!!! PSRAM IC required for UXGA resolution and high JPEG quality
5 //           Ensure ESP32 Wrover Module or other board with PSRAM is selected
6 //           Partial images will be transmitted if image exceeds buffer size
7 //
8
9 // Select camera model
10 #define CAMERA_MODEL_WROVER_KIT // Has PSRAM
11
```

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

```

12 #include "camera_pins.h"
13
14 const char* ssid      = "*****";    //input your wifi name
15 const char* password = "*****";    //input your wifi passwords
16
17 void startCameraServer();
18
19 void setup() {
20     Serial.begin(115200);
21     Serial.setDebugOutput(true);
22     Serial.println();
23
24     camera_config_t config;
25     config.ledc_channel = LEDC_CHANNEL_0;
26     config.ledc_timer = LEDC_TIMER_0;
27     config.pin_d0 = Y2_GPIO_NUM;
28     config.pin_d1 = Y3_GPIO_NUM;
29     config.pin_d2 = Y4_GPIO_NUM;
30     config.pin_d3 = Y5_GPIO_NUM;
31     config.pin_d4 = Y6_GPIO_NUM;
32     config.pin_d5 = Y7_GPIO_NUM;
33     config.pin_d6 = Y8_GPIO_NUM;
34     config.pin_d7 = Y9_GPIO_NUM;
35     config.pin_xclk = XCLK_GPIO_NUM;
36     config.pin_pclk = PCLK_GPIO_NUM;
37     config.pin_vsync = VSYNC_GPIO_NUM;
38     config.pin_href = HREF_GPIO_NUM;
39     config.pin_sscb_sda = SIOD_GPIO_NUM;
40     config.pin_sscb_scl = SIOC_GPIO_NUM;
41     config.pin_pwdn = PWDN_GPIO_NUM;
42     config.pin_reset = RESET_GPIO_NUM;
43     config.xclk_freq_hz = 20000000;
44     config.pixel_format = PIXFORMAT_JPEG;
45
46     // if PSRAM IC present, init with UXGA resolution and higher JPEG quality
47     //                                for larger pre-allocated frame buffer.
48     if(psramFound()){
49         config.frame_size = FRAMESIZE_UXGA;
50         config.jpeg_quality = 10;
51         config.fb_count = 2;
52     } else {
53         config.frame_size = FRAMESIZE_SVGA;
54         config.jpeg_quality = 12;
55         config.fb_count = 1;

```

```

56 }
57
58 // camera init
59 esp_err_t err = esp_camera_init(&config);
60 if (err != ESP_OK) {
61     Serial.printf("Camera init failed with error 0x%x", err);
62     return;
63 }
64
65 sensor_t * s = esp_camera_sensor_get();
66 // drop down frame size for higher initial frame rate
67 s->set_framesize(s, FRAMESIZE_QVGA);
68
69 WiFi.begin(ssid, password);
70
71 while (WiFi.status() != WL_CONNECTED) {
72     delay(500);
73     Serial.print(".");
74 }
75 Serial.println("");
76 Serial.println("WiFi connected");
77
78 startCameraServer();
79
80 Serial.print("Camera Ready! Use 'http://");
81 Serial.print(WiFi.localIP());
82 Serial.println(" to connect");
83 }
84
85 void loop() {
86     // put your main code here, to run repeatedly:
87     delay(10000);
88 }
```

Configure parameters including interface pins of the camera. Note: It is generally not recommended to change them.

```

24 camera_config_t config;
25 config.ledc_channel = LEDC_CHANNEL_0;
26 config.ledc_timer = LEDC_TIMER_0;
27 config.pin_d0 = Y2_GPIO_NUM;
28 config.pin_d1 = Y3_GPIO_NUM;
29 config.pin_d2 = Y4_GPIO_NUM;
30 config.pin_d3 = Y5_GPIO_NUM;
31 config.pin_d4 = Y6_GPIO_NUM;
```

```

32 config.pin_d5 = Y7_GPIO_NUM;
33 config.pin_d6 = Y8_GPIO_NUM;
34 config.pin_d7 = Y9_GPIO_NUM;
35 config.pin_xclk = XCLK_GPIO_NUM;
36 config.pin_pclk = PCLK_GPIO_NUM;
37 config.pin_vsync = VSYNC_GPIO_NUM;
38 config.pin_href = HREF_GPIO_NUM;
39 config.pin_sscb_sda = SIOD_GPIO_NUM;
40 config.pin_sscb_scl = SIOC_GPIO_NUM;
41 config.pin_pwdn = PWDN_GPIO_NUM;
42 config.pin_reset = RESET_GPIO_NUM;
43 config.xclk_freq_hz = 20000000;
44 config.pixel_format = PIXFORMAT_JPEG;

```

ESP32 connects to the router and prints a successful connection prompt. If it has not been successfully connected, press the reset key on the ESP32-WROVER.

```

69 WiFi.begin(ssid, password);
70
71 while (WiFi.status() != WL_CONNECTED) {
72     delay(500);
73     Serial.print(".");
74 }
75 Serial.println("");
76 Serial.println("WiFi connected");

```

Open the video streams server function of the camera and print its IP address via serial port.

```

78 startCameraServer();
79
80 Serial.print("Camera Ready! Use 'http://");
81 Serial.print(WiFi.localIP());
82 Serial.println(" to connect");

```

## 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](mailto: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\\_WROVER\\_Board/archive/master.zip](https://github.com/Freenove/Freenove_ESP32_WROVER_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.

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