

# Welcome

Thank you for choosing Freenove products!

## About Battery

First, read the document [About\\_Battery.pdf](#) in the extracted folder.

If you have not downloaded the zip file yet, please download it and unzip it via link below:

[https://github.com/Freenove/Freenove\\_Bipedal\\_Robot\\_Kit\\_for\\_Raspberry\\_Pi\\_Pico](https://github.com/Freenove/Freenove_Bipedal_Robot_Kit_for_Raspberry_Pi_Pico)

## 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.

## 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, micro:bit and Raspberry Pi Pico W.
- 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>

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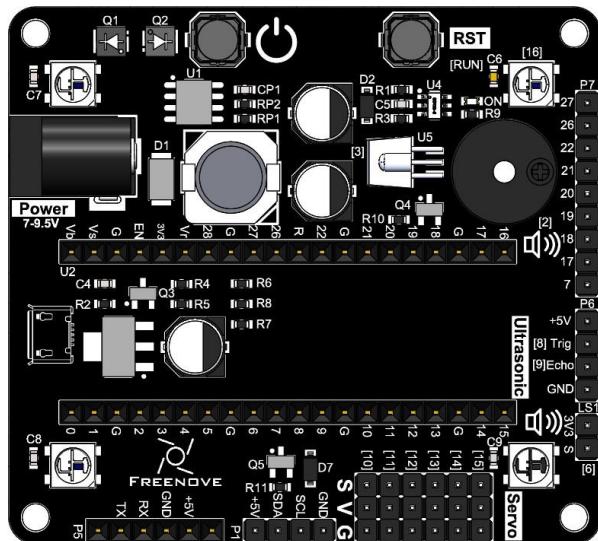
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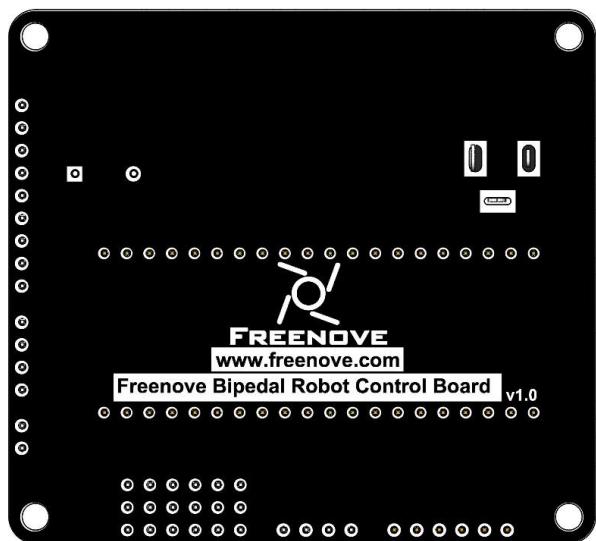
If you have any concerns, please feel free to contact us via [support@freenove.com](mailto:support@freenove.com)

## Raspberry Pi Pico (W) Robot Shield

Top



Bottom



## Machinery Parts

**M3\*8**

Screw

**x10**

Freenove

**M3\*18**

Screw

**x2**

Freenove

**M3**

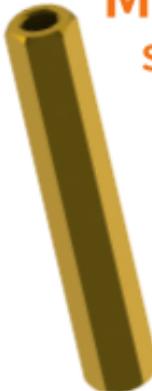
Nut

**x2**

Freenove

**M3\*35**

Standoff

**x4**

Freenove

**M2\*12**

Screw

**x14**

Freenove

**M2**

Nut

**x17**

Freenove

**M1.4\*5**self-tapping  
Screw**x10**

Freenove

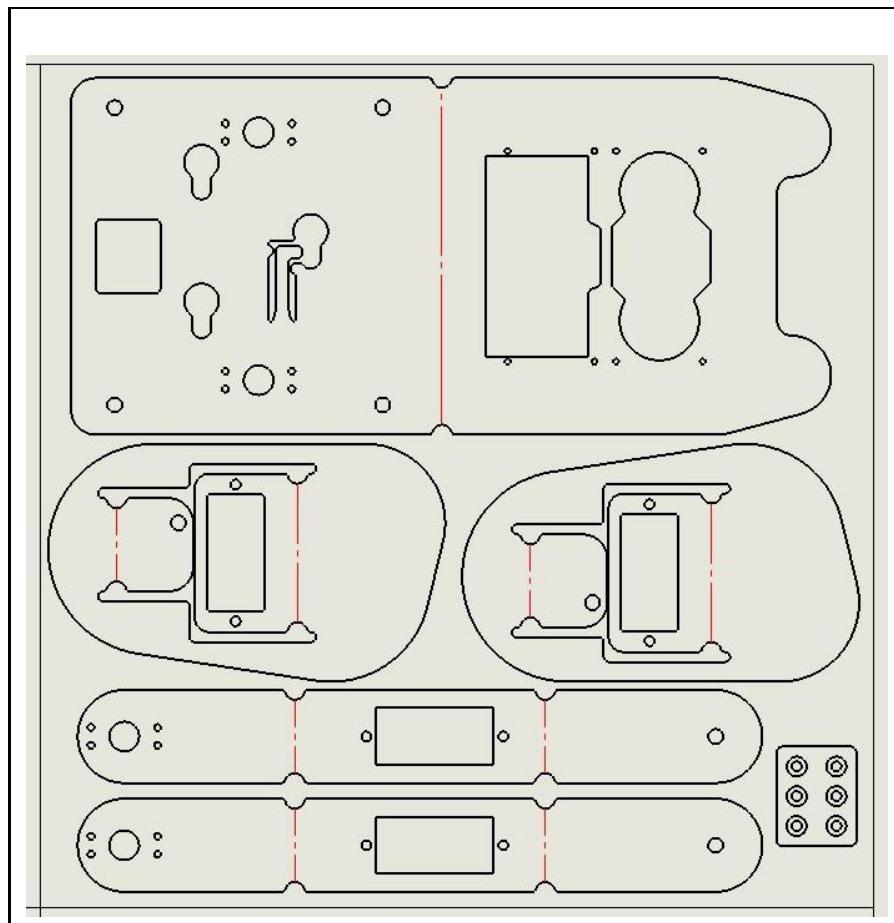
**M2\*6\*0.5**

Nut

**x4**

Freenove

## Acrylic Parts

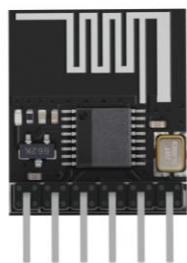


## Electronic Parts

Dot Matrix Module x1	Ultrasonic Module x1
A blue printed circuit board with a 16x16 dot matrix array of white circular pads. It has a grey header at the bottom with four pins.	A blue printed circuit board with two silver cylindrical components. One is a metal cup and the other is a cylindrical transducer element. They are connected by wires.
Speaker x1	
A black rectangular speaker with a circular hole in the center. It is connected to a red wire.	
Servo package x4	



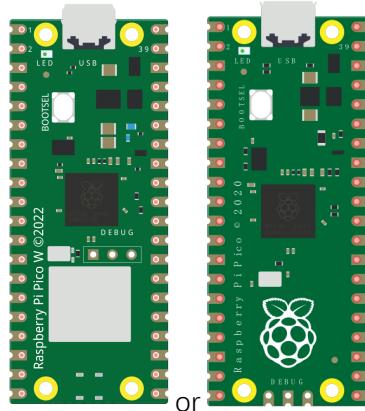
Bluetooth module x1



Infrared emitter x1



Raspberry Pi Pico W x1 or Raspberry Pi Pico x1



or

If you bought the kit without control board, please prepare one of the above board yourself.

## Wires

Jumper Wire F/F(4) x2



## Tools

Cross screwdriver (3mm) x1



Cross screwdriver (2mm)x1



Cable Tidy x40cm



M3 spanner



## Required but NOT Contained Parts

This robot is powered with **9V alkaline batteries** or **9V NIMH rechargeable batteries** as power supply.

Please note that 9V carbon batteries and 9V rechargeable lithium batteries **cannot** provide enough power for the robot. Therefore, it is important to pay attention to the battery model when purchasing batteries.

It is easy to find appropriate batteries on both eBay and Amazon. You can simply search 9V battery 6lr61 or 9V rechargeable NIMH battery on the platforms.



# Preface

Welcome to use Freenove Bipedal Robot Kit for Raspberry Pi Pico (W). Following this tutorial, you can make a very cool robot with many functions.

Based on the Raspberry Pi Pico (W) development board, a popular IoT control board, this kit uses the very popular Arduino IDE for programming, so you can share and exchange your experience and design ideas with enthusiasts all over the world. The parts in the kit include all electronic components, modules, and mechanical components required for making the robot. They are all individually packaged. There are detailed assembly and debugging instructions in this book. If you encounter any problems, please feel free to contact us for fast and free technical support.

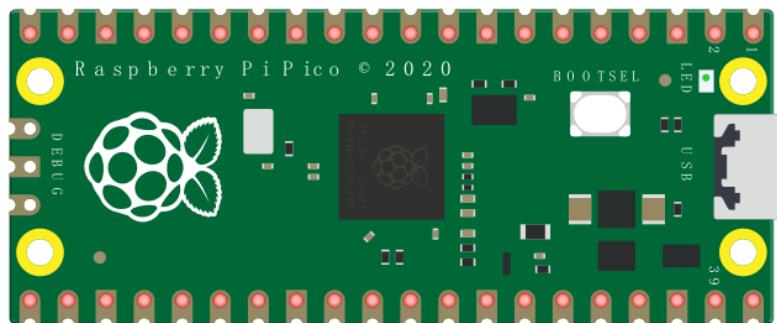
## [support@freenove.com](mailto:support@freenove.com)

This robot does not require a high threshold for users. Even if you know little professional knowledge, you can make your own smart robot easily with the guidance of the tutorial. If you're really interested in Raspberry Pi Pico (W) and hope to learn how to program and build circuits, please visit our website:

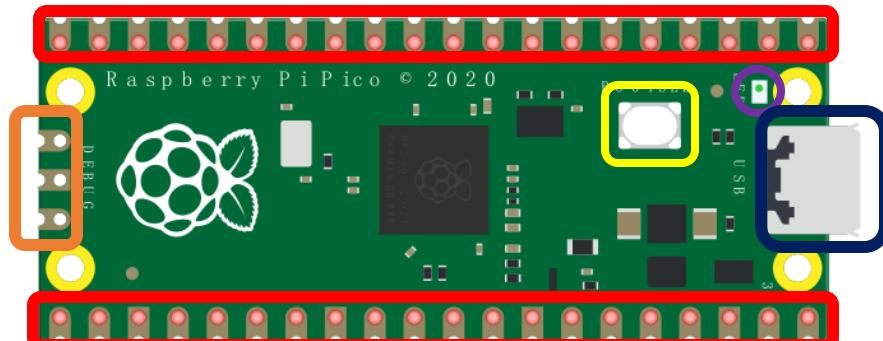
[www.freenove.com](http://www.freenove.com) or contact us to buy our kit designed for beginners: **Freenove Ultimate Kit for Raspberry Pi Pico.**

## Raspberry Pi Pico

Before learning Pico, we need to know about it. Here we use an imitated diagram of Pico, which resembles the actual Pico.

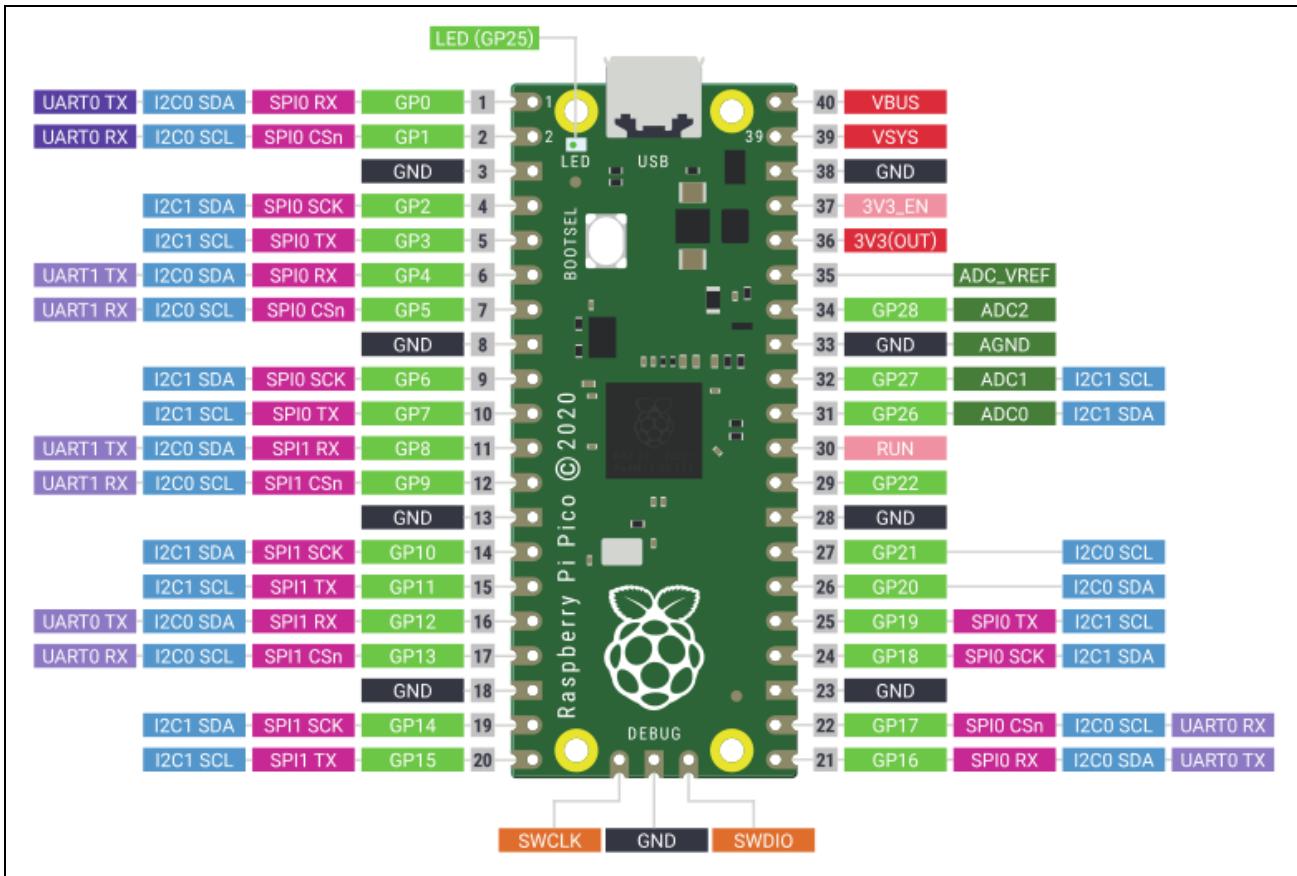


The hardware interfaces are distributed as follows:



Frame color	Description
	Pins
	BOOTSEL button
	USB port
	LED
	Debugging

Function definition of pins:



Color	Pins	Color	Pins
Black	GND	Red	Power
Green	GPIO	Dark Green	ADC
Purple	UART(defualt)	Lavender	UART
Magenta	SPI	Blue	I2C
Pink	System Control	Orange	Debugging

For details: <https://datasheets.raspberrypi.org/pico/pico-datasheet.pdf>

## UART, I2C, SPI Default Pin

In Arduino IDE, the default pins of serial port are Pin0 and Pin1.

Note: Serial port is virtualized by RP2040. Therefore, when using the serial port, please enable the verification function of DTR. It can work under any baud rate.

### UART

Function	Default
UART_BAUDRATE	X
UART_BITS	8
UART_STOP	1
UART_TX	Pin 0
UART_RX	Pin 1

### I2C

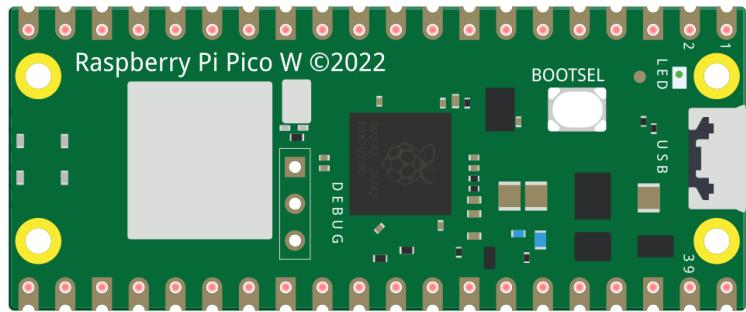
Function	Default
I2C Frequency	400000
I2C_SDA	Pin 4
I2C_SCL	Pin 5

### SPI

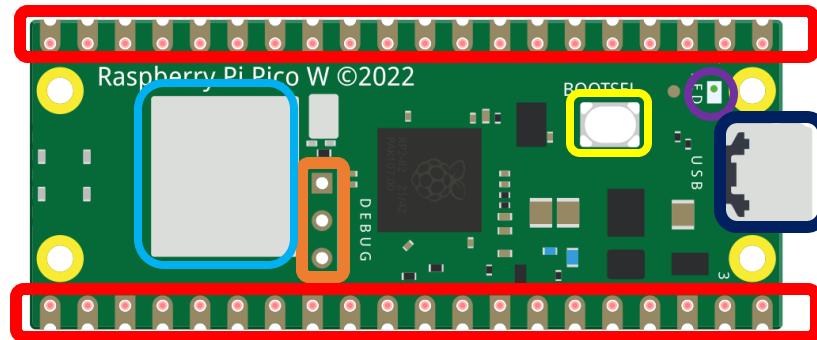
Function	Default
SPI_BAUDRATE	1000000
SPI_POLARITY	0
SPI_PHASE	0
SPI_BITS	8
SPI_FIRSTBIT	MSB
SPI_SCK	Pin 18
SPI_MOSI	Pin 19
SPI_MISO	Pin 16
SPI_SS	Pin 17

## Raspberry Pi Pico W

Raspberry Pi Pico W adds CYW43439 as the WiFi function on the basis of Raspberry Pi Pico. It is connected to RP2040 chip through SPI interface.

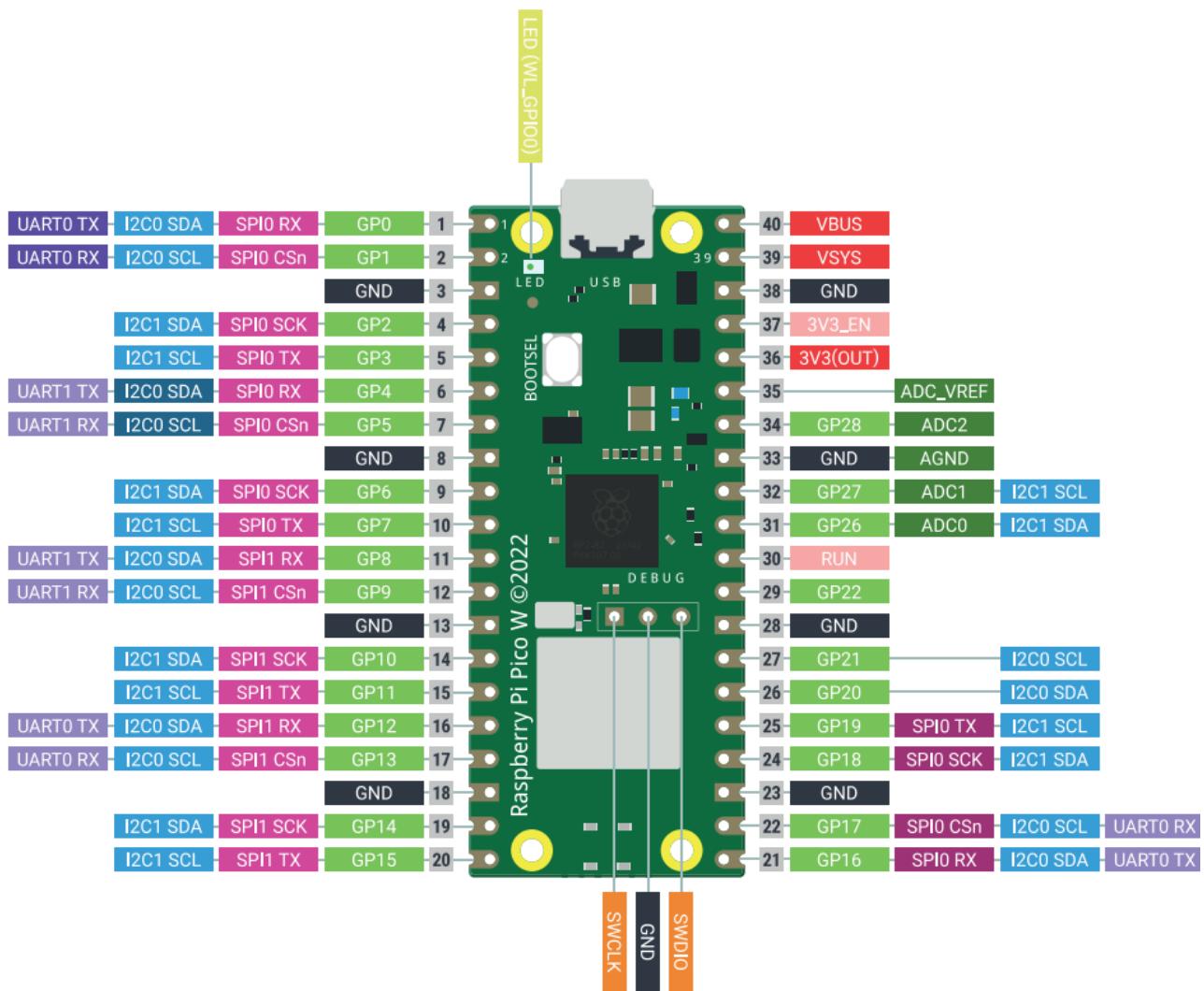


The hardware interfaces are distributed as follows:



Frame color	Description
Red	Pins
Yellow	BOOTSEL button
Blue	USB port
Purple	LED
Orange	Debugging
Cyan	Wireless

Function definition of pins:



Color	Pins	Color	Pins
Black	GND	Red	Power
Green	GPIO	Dark Green	ADC
Purple	UART(defualt)	Lavender	UART
Magenta	SPI	Cyan	I2C
Pink	System Control	Orange	Debugging

For details: <https://datasheets.raspberrypi.com/picow/pico-w-datasheet.pdf>



## UART, I2C, SPI, Wireless Default Pin

In Arduino IDE, the default pins of serial port are Pin0 and Pin1.

Note: Serial port is virtualized by RP2040. Therefore, when using the serial port, please enable the verification function of DTR. It can work under any baud rate.

### UART

Function	Default
UART_BAUDRATE	X
UART_BITS	8
UART_STOP	1
UART_TX	Pin 0
UART_RX	Pin 1

### I2C

Function	Default
I2C Frequency	400000
I2C_SDA	Pin 4
I2C_SCL	Pin 5

### SPI

Function	Default
SPI_BAUDRATE	1000000
SPI_POLARITY	0
SPI_PHASE	0
SPI_BITS	8
SPI_FIRSTBIT	MSB
SPI_SCK	Pin 18
SPI_MOSI	Pin 19
SPI_MISO	Pin 16
SPI_SS	Pin 17

### Wireless

Function	Default
WL_ON	GPIO23
WL_D	GPIO24
WL_CLK	GPIO29_ADC
WL_CS	GPIO25

## Pins of the Robot

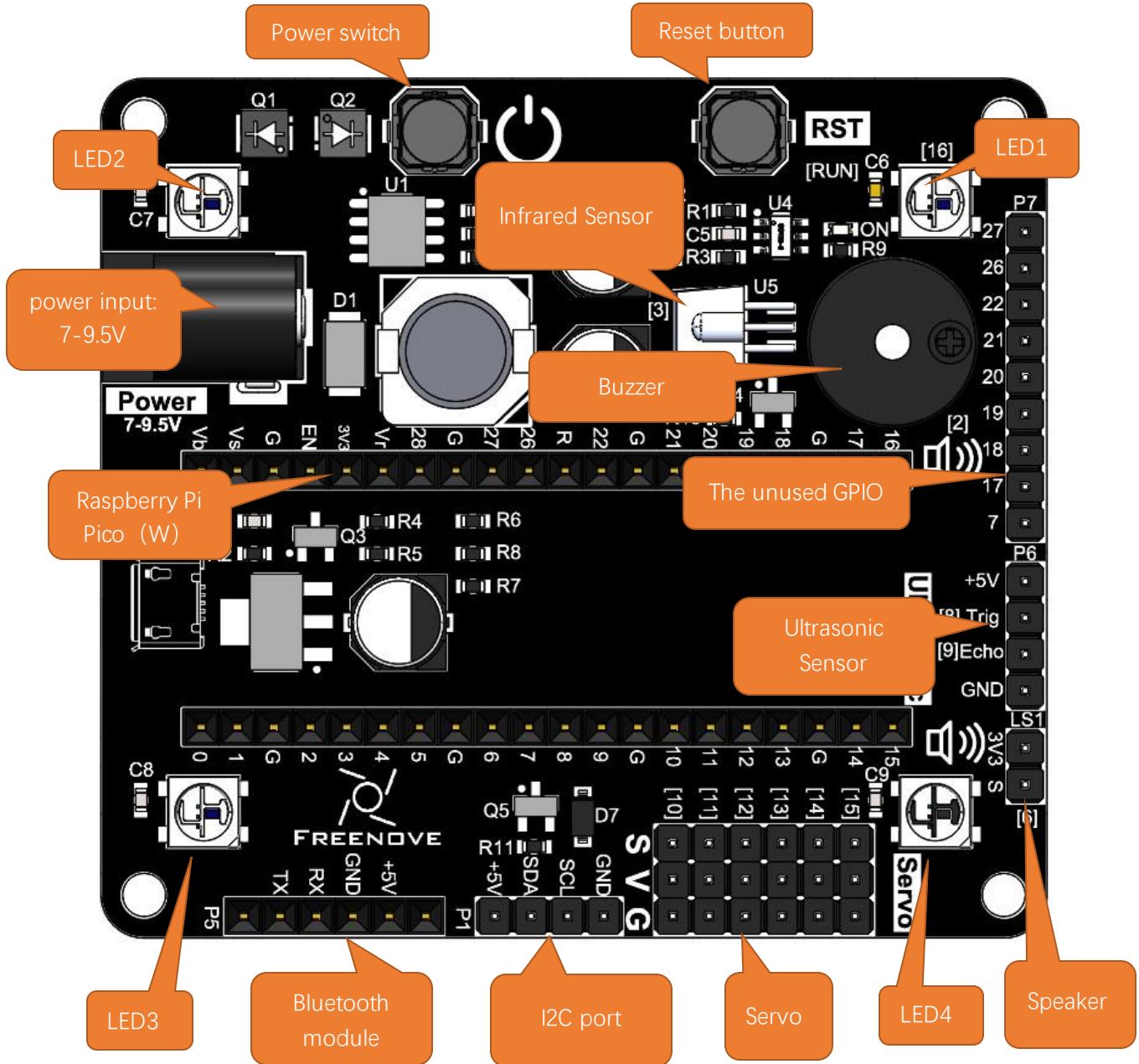
To learn what each GPIO corresponds to, please refer to the following table.

The functions of the pins are allocated as follows:

Pins of Raspberry Pi Pico W	Functions	Description
GPIO10	Servo	Servo1
GPIO11		Servo2
GPIO12		Servo3
GPIO13		Servo4
GPIO14		Servo5
GPIO15		Servo6
GPIO8	Ultrasonic module	Trig
GPIO9		Echo
GPIO4	I2C port	SDA
GPIO5		SCL
GPIO16	WS2812	WS2812
GPIO28	Battery detection	A2
GPIO6	Speaker interface	Speaker
GPIO3	Infrared receiver port	IR
GPIO2	Buzzer port	Buzzer
GPIO1	Bluetooth module	RX
GPIO0		TX
GPIO7	Unused GPIO	GPIO7
GPIO17		GPIO17
GPIO18		GPIO18
GPIO19		GPIO19
GPIO20		GPIO20
GPIO21		GPIO21
GPIO22		GPIO22
GPIO26		GPIO26
GPIO27		GPIO27

## Introduction to the Bipedal Robot

The function diagram of the Raspberry Pi Pico (W) bipedal robot is as follows:

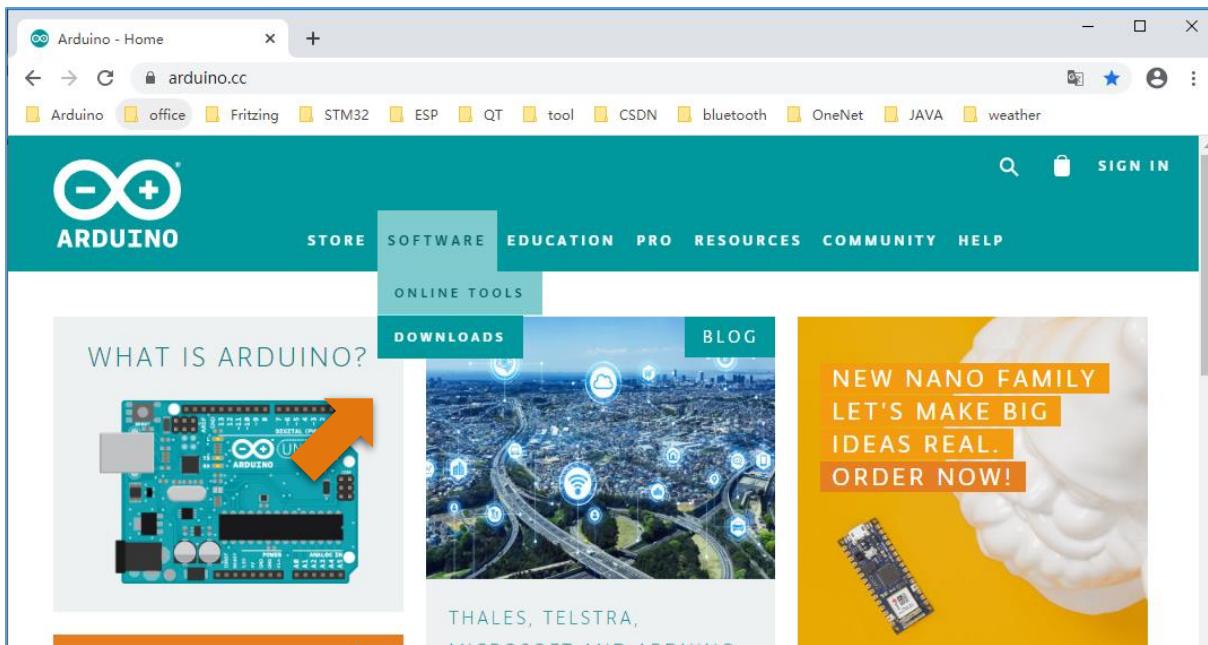


# Chapter 0 Installation of Arduino IDE

## Arduino 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 based on your operating system. If you are a Windows user, please select the "Windows Installer" to download and install the driver correctly.

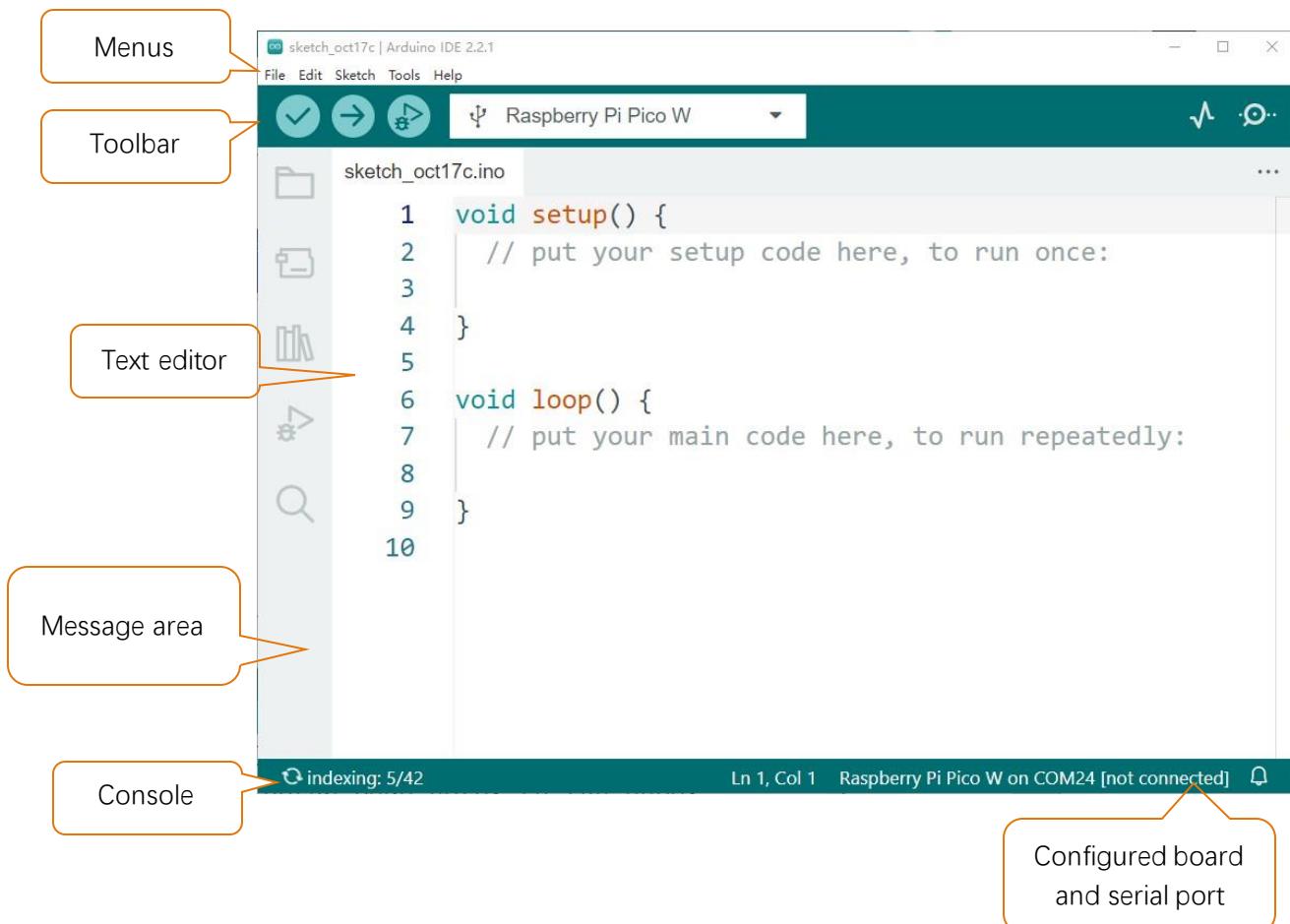
A screenshot of the Arduino IDE 2.2.1 download page. The page features a teal header with the Arduino logo and the text 'Arduino IDE 2.2.1'. Below the header, there is a brief description of the new release: 'The new major release of the Arduino IDE is faster and even more powerful! In addition to a more modern editor and a more responsive interface it features autocompletion, code navigation, and even a live debugger.' An orange arrow points from the text above to the 'DOWNLOAD OPTIONS' section on the right. The 'DOWNLOAD OPTIONS' section lists download links for Windows (Win 10 and newer, 64 bits, MSI installer, ZIP file), Linux (AppImage 64 bits (X86-64), ZIP file 64 bits (X86-64)), and macOS (Intel, 10.14: "Mojave" or newer, 64 bits, Apple Silicon, 11: "Big Sur" or newer, 64 bits). There is also a link to 'Release Notes'. At the bottom left, there are links for 'SOURCE CODE' and 'The Arduino IDE 2.0 is open source and its source code is hosted on GitHub.'

After the download completes, run the installer. For Windows users, there may pop up an installation dialog during the installation. When it pops up, please allow the installation.

After installation is completed, an Arduino Software shortcut will be generated on the desktop. Run the Arduino Software.



The interface of Arduino Software is as follows:



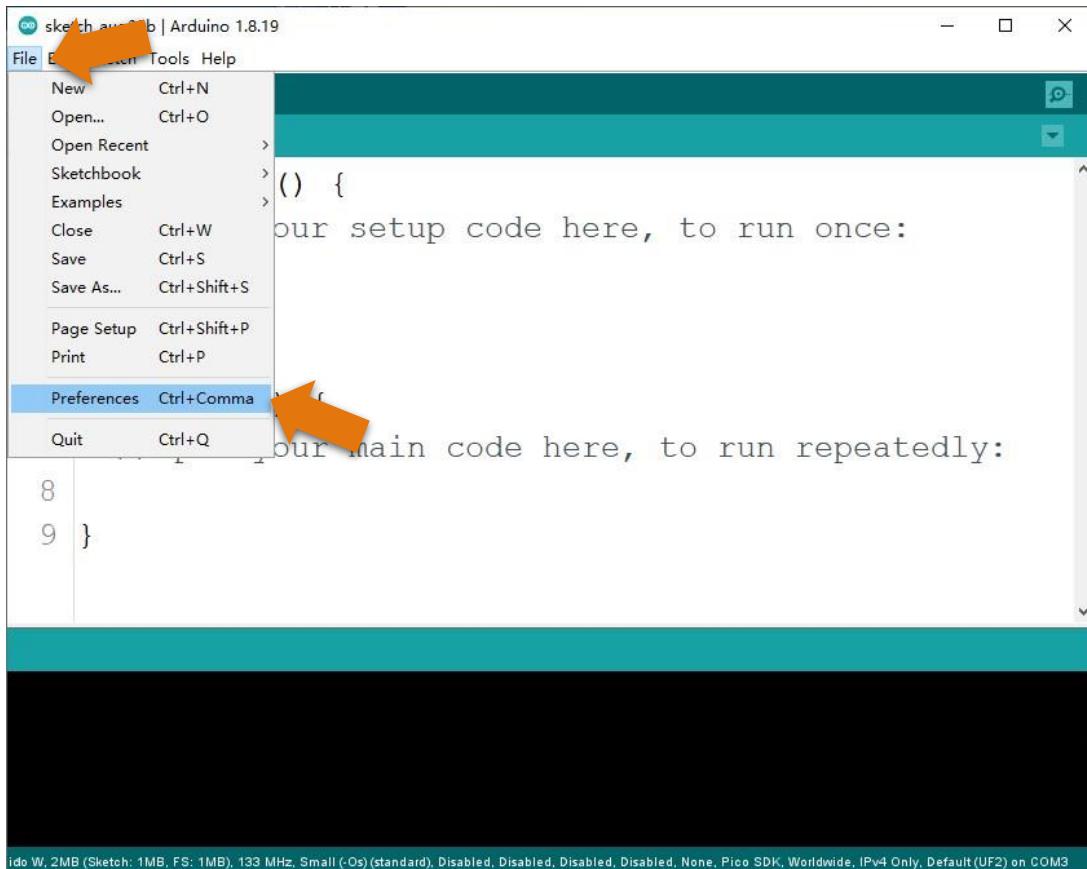
Programs written with Arduino Software (IDE) are called **sketches**. These sketches are written in the text editor and saved with the file extension **.ino**. The editor has features for cutting/pasting and searching/replacing text. The message area gives feedback while saving and exporting and also 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.  |

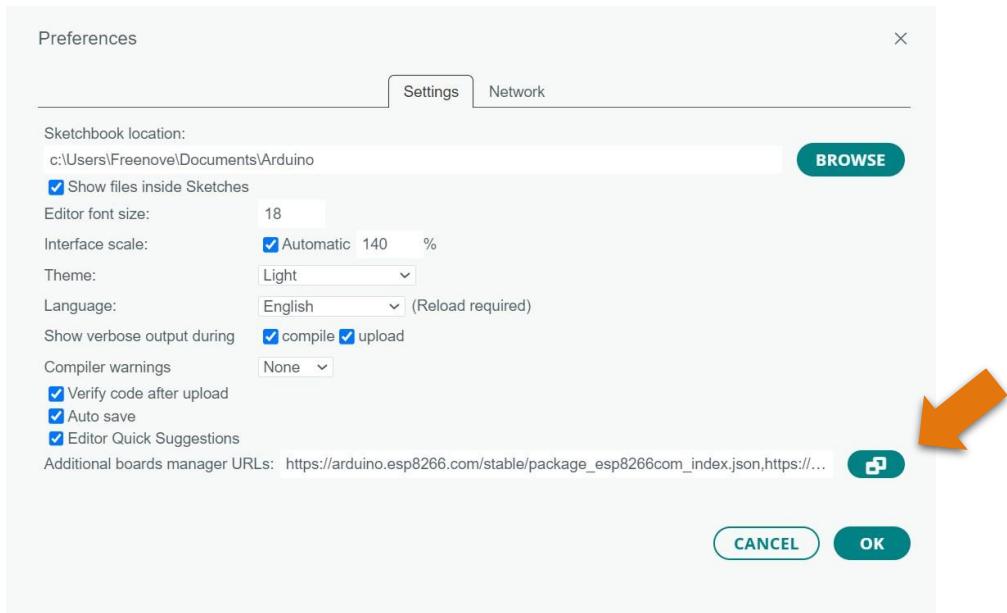
Additional commands are found within the five menus: File, Edit, Sketch, Tools, Help. The menus are context sensitive, which means only those items relevant to the work currently being carried out are available.

## Environment Configuration

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

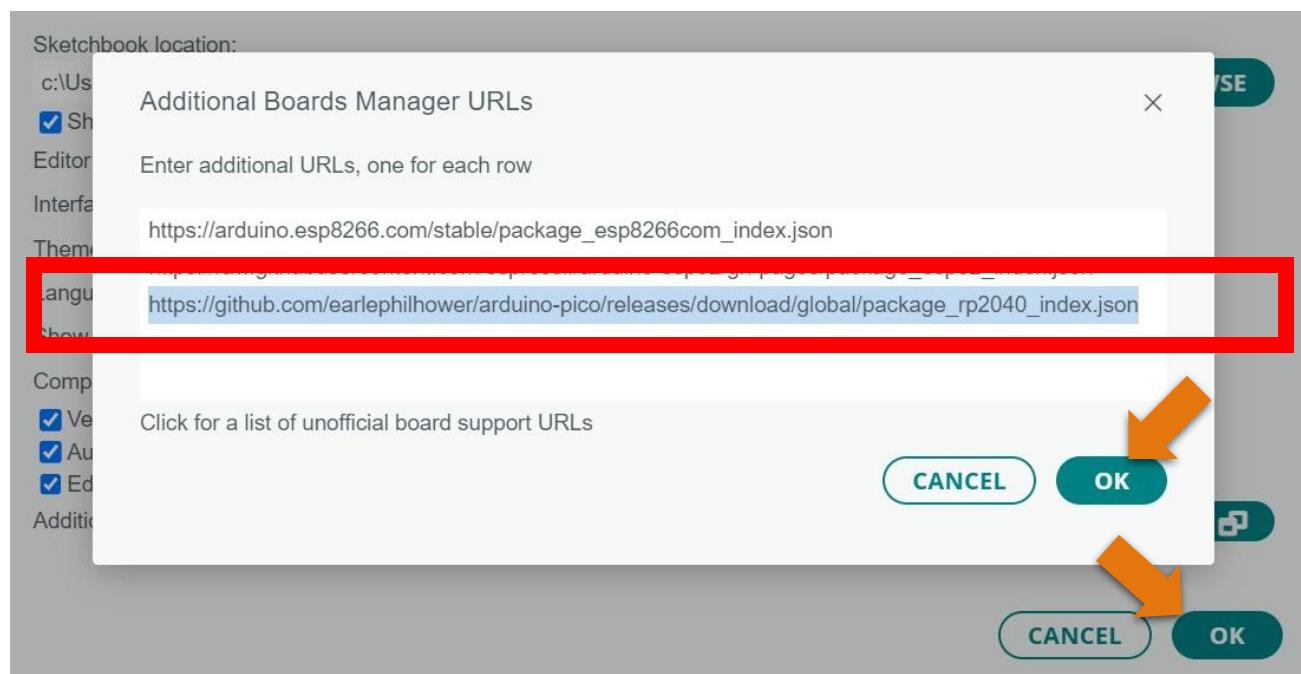


Second, click on the symbol behind "Additional Boards Manager URLs"

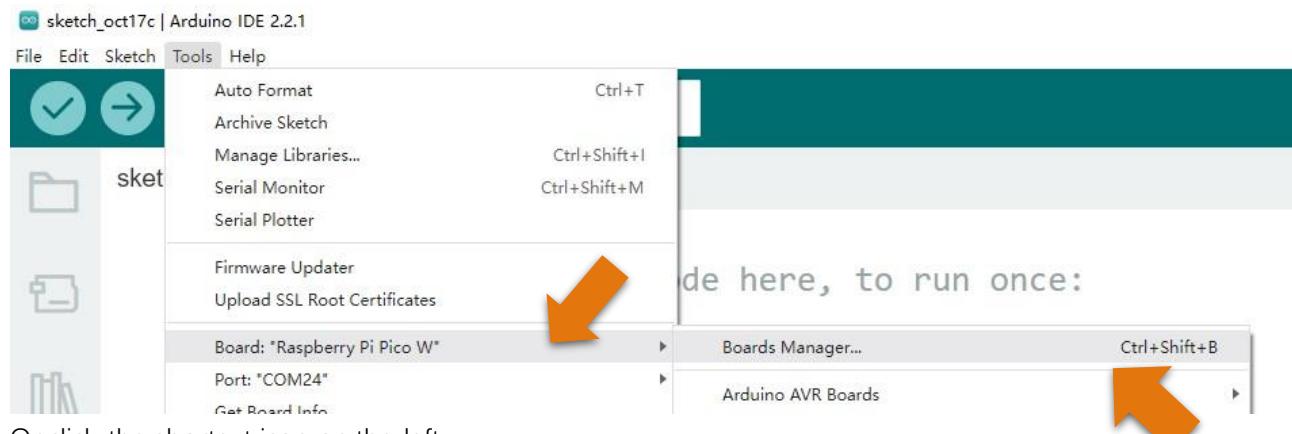


Third, fill in

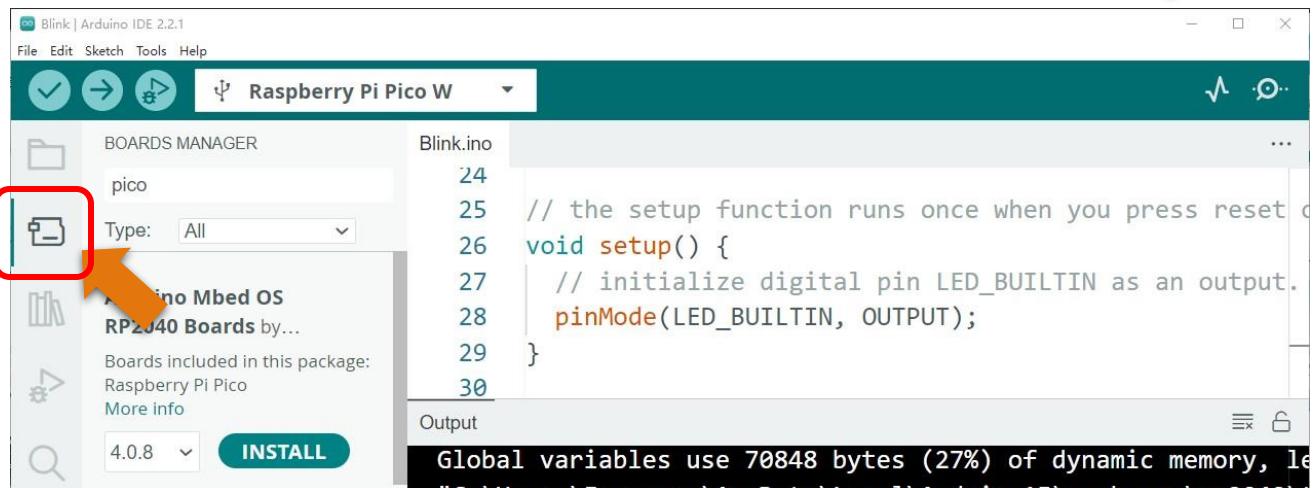
[https://github.com/earlephilhower/arduino-pico/releases/download/global/package\\_rp2040\\_index.json](https://github.com/earlephilhower/arduino-pico/releases/download/global/package_rp2040_index.json) in the new window, click OK, and click OK on the Preferences window again.



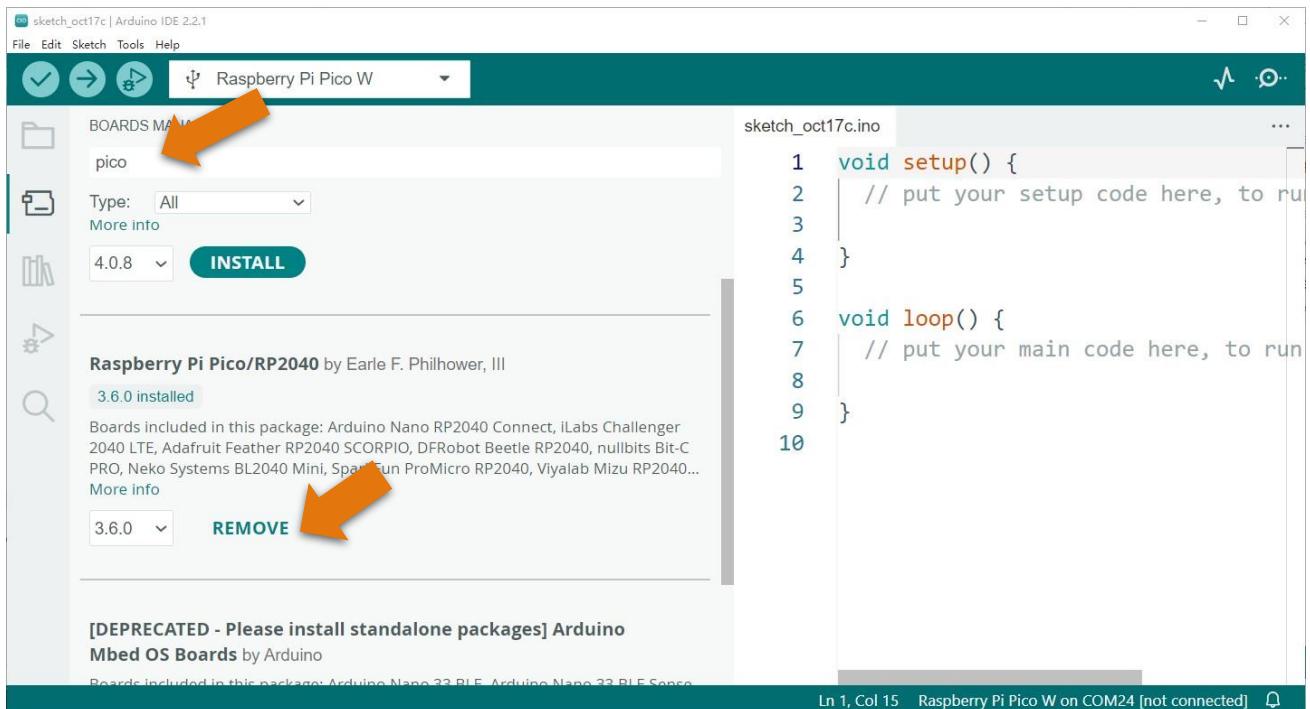
Fourth, click Tools on the Menu Bar > Board > "Boards Manager".



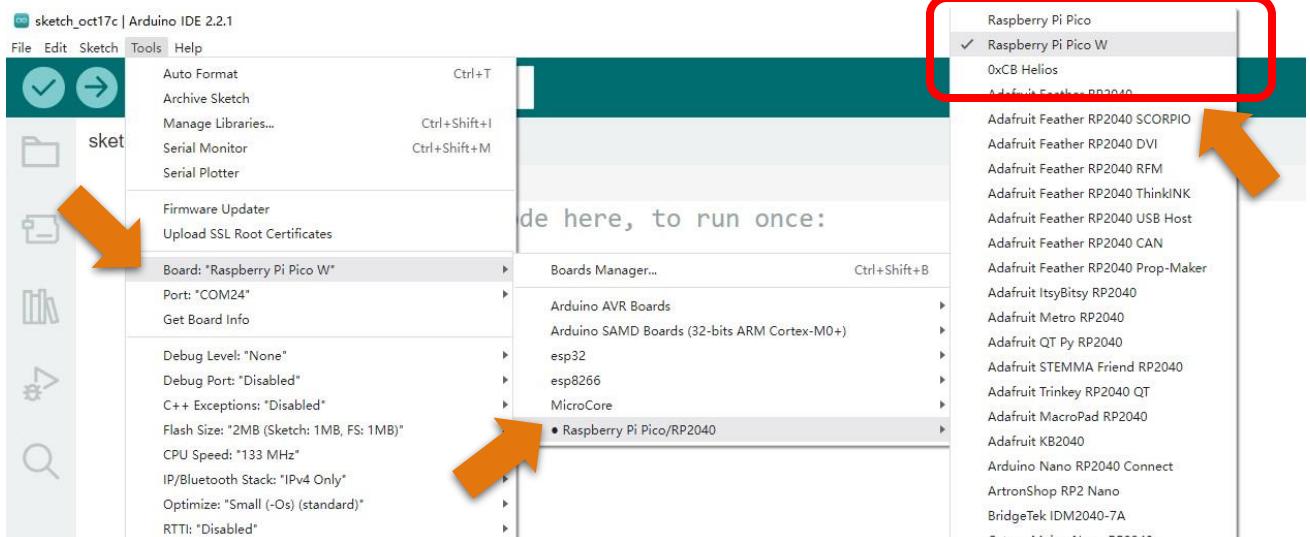
Or click the shortcut icon on the left.



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



When finishing installation, click Tools in the Menus again and select Board: "Raspberry Pi Pico/RP2040", and then you can see information of Raspberry Pi Pico (W). Click "Raspberry Pi Pico W" so that the Raspberry Pi Pico W programming development environment is configured.



## Additional Remarks

To finish this tutorial, you can use a Raspberry Pi Pico W or a Raspberry Pi Pico. The two boards have the same form factor, and their only difference is that Pico W features with an onboard single-band 4.802GHz wireless interface using Infineon CYW2. That is to say, the hardware Raspberry Pi Pico W is almost the same as the normal pico except for the wireless interface.

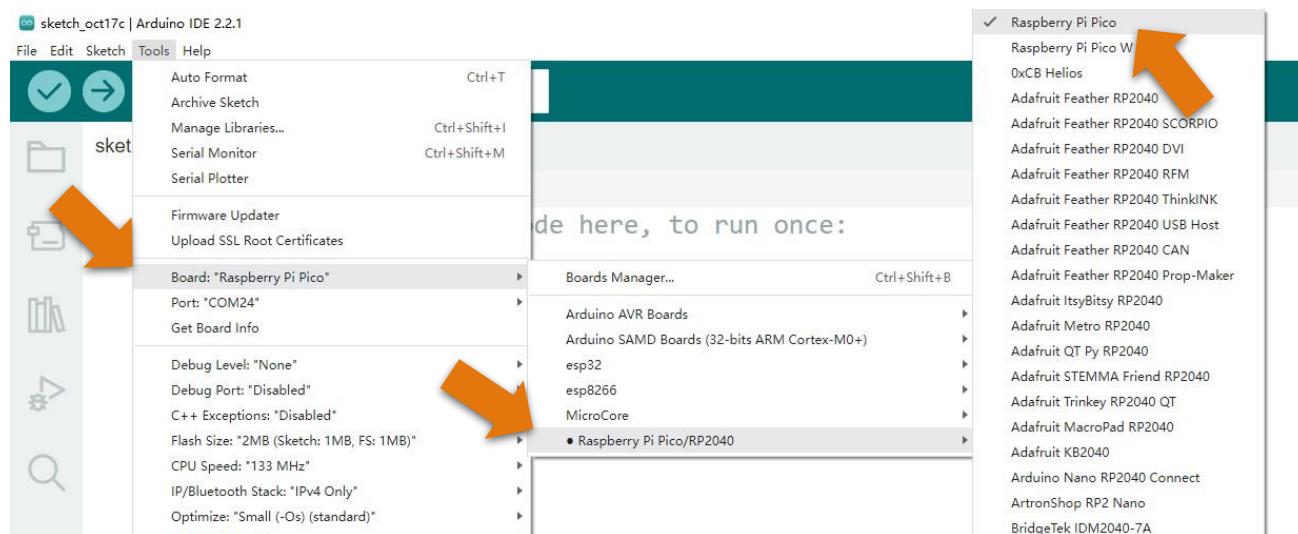
No matter which board you use, the procedure for each project is the same. You only need to select the correct board and upload the corresponding code based on the board you use.

In this book, we use Raspberry Pi Pico W to illustrate the operation.

The followings show the configuration on Arduino for the use of each board.

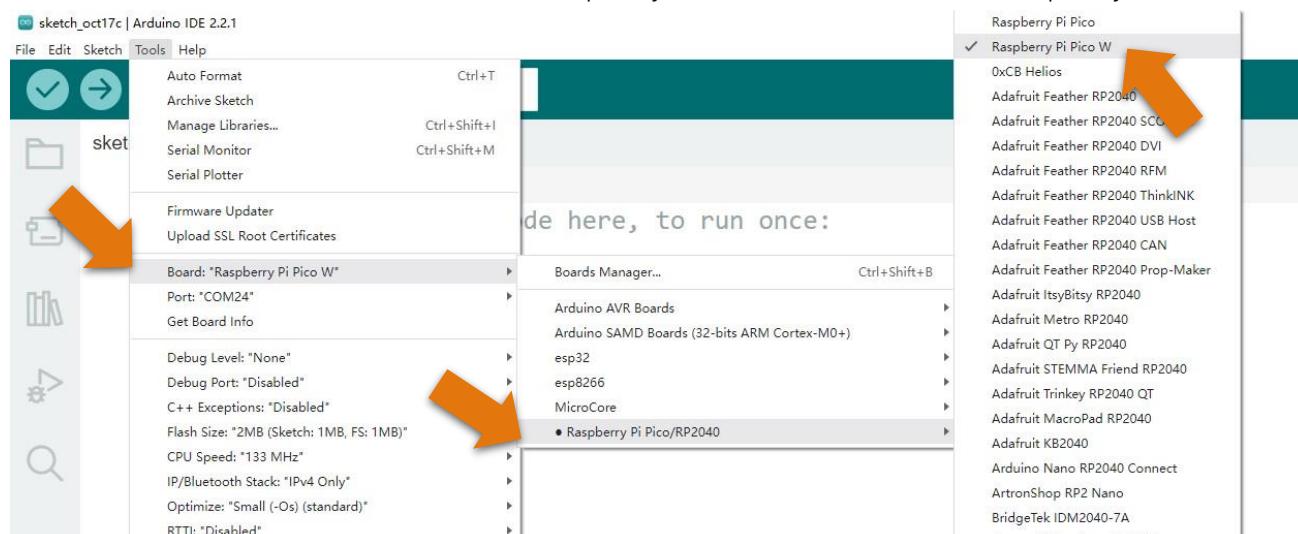
For Raspberry Pi Pico:

Click Tools on Menu bar, click Board, select “Raspberry Pi Pico/RP2040”, and select Raspberry Pi Pico.



For Raspberry Pi Pico W:

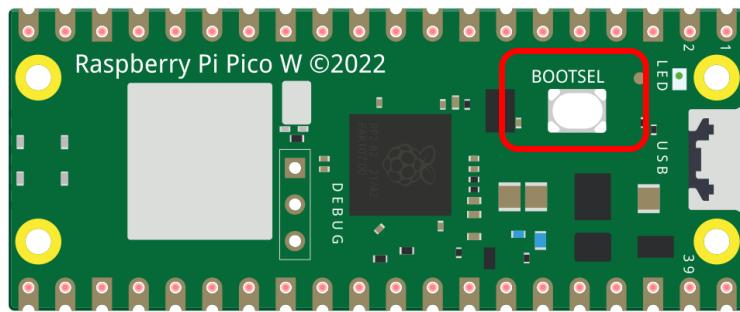
Click Tools on Menu bar, click Board, select “Raspberry Pi Pico/RP2040”, and select Raspberry Pi Pico W.



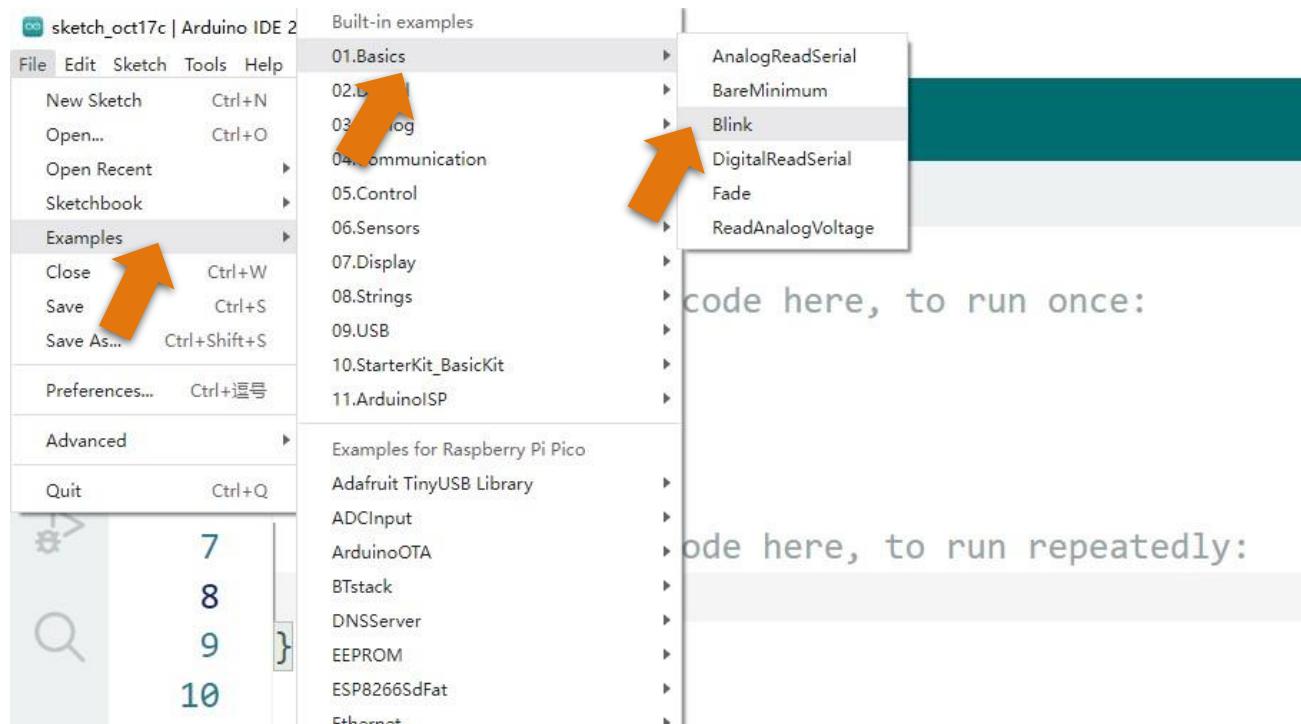
## Uploading Arduino-compatible Firmware for Raspberry Pi Pico (W)

To program a new Raspberry Pi Pico (W) with Arduino, you need to upload an Arduino-compatible Firmware for it. Please refer to the following steps to configure.

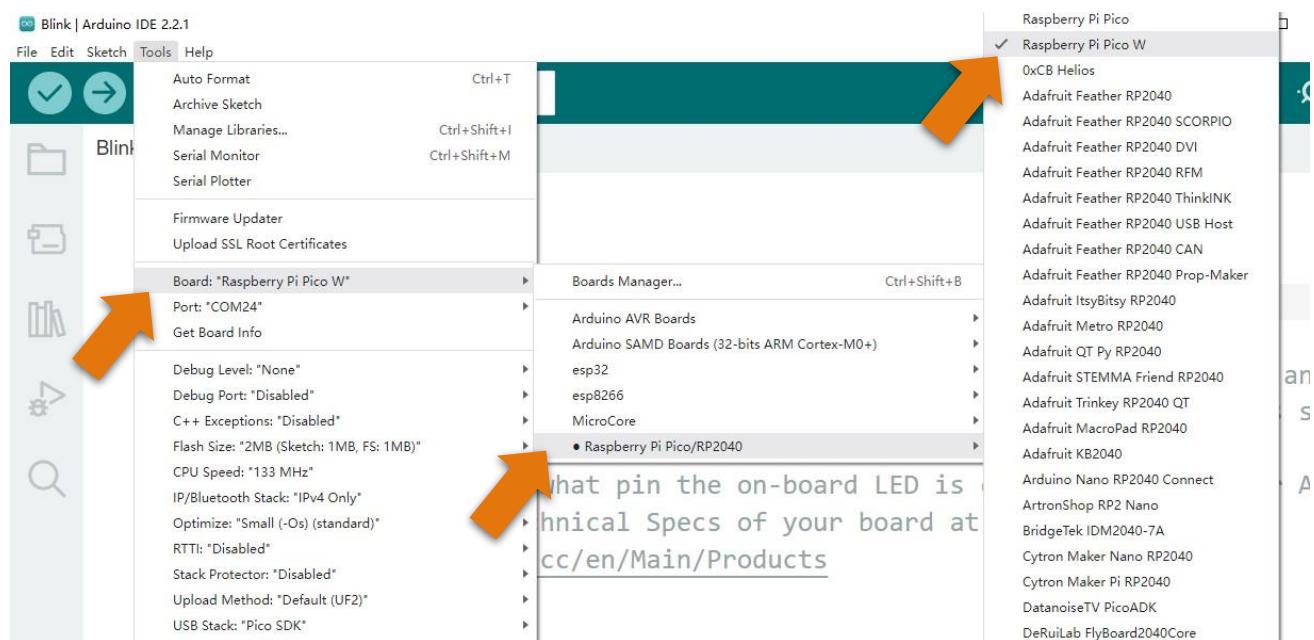
1. Disconnect Pico (W) from your computer. Press and hold the white button (BOOTSEL) on Pico (W) while connecting it to your computer. (Note: Be sure to hold the button before powering the Pico, otherwise the firmware will not download successfully.)



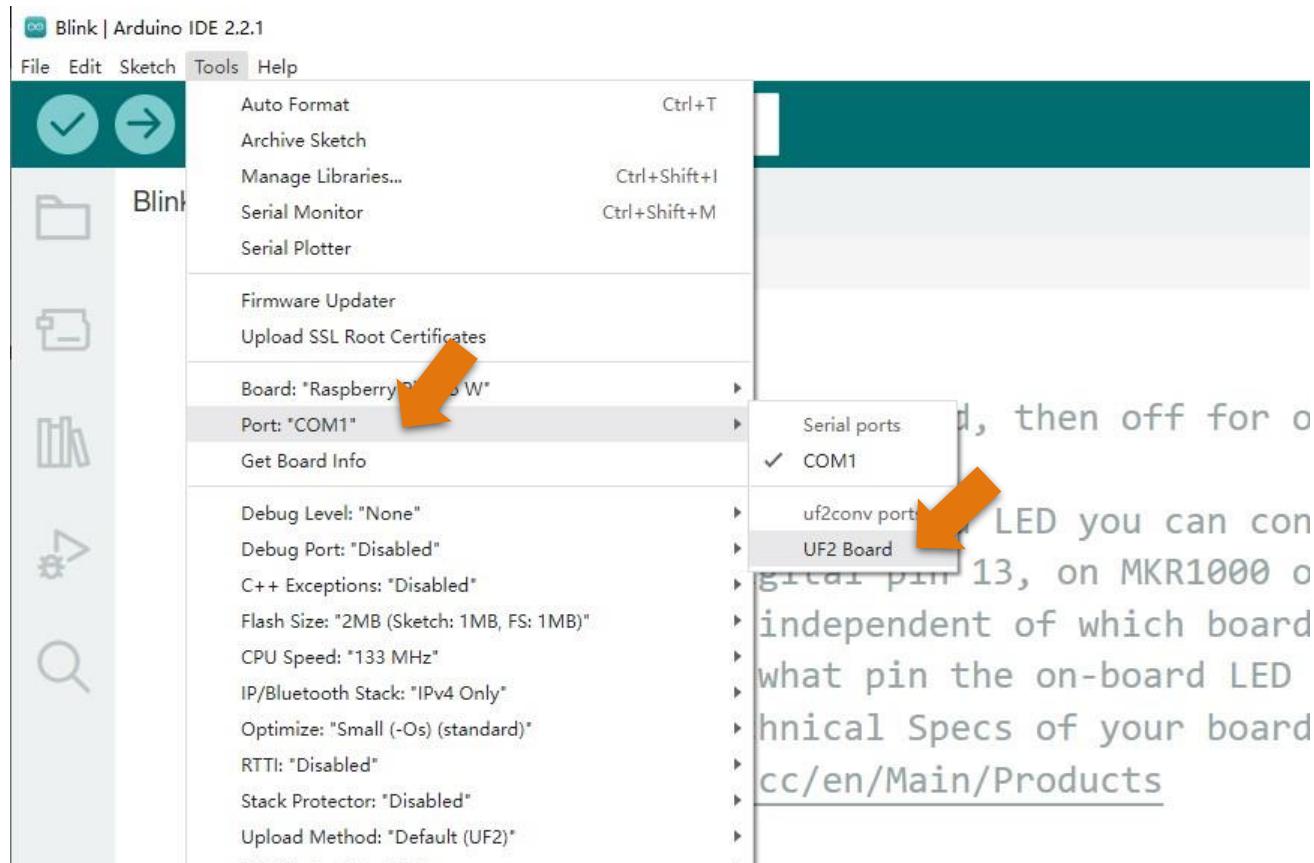
2. Open Arduino IDE. Click File>Examples>01.Basics>Blink.



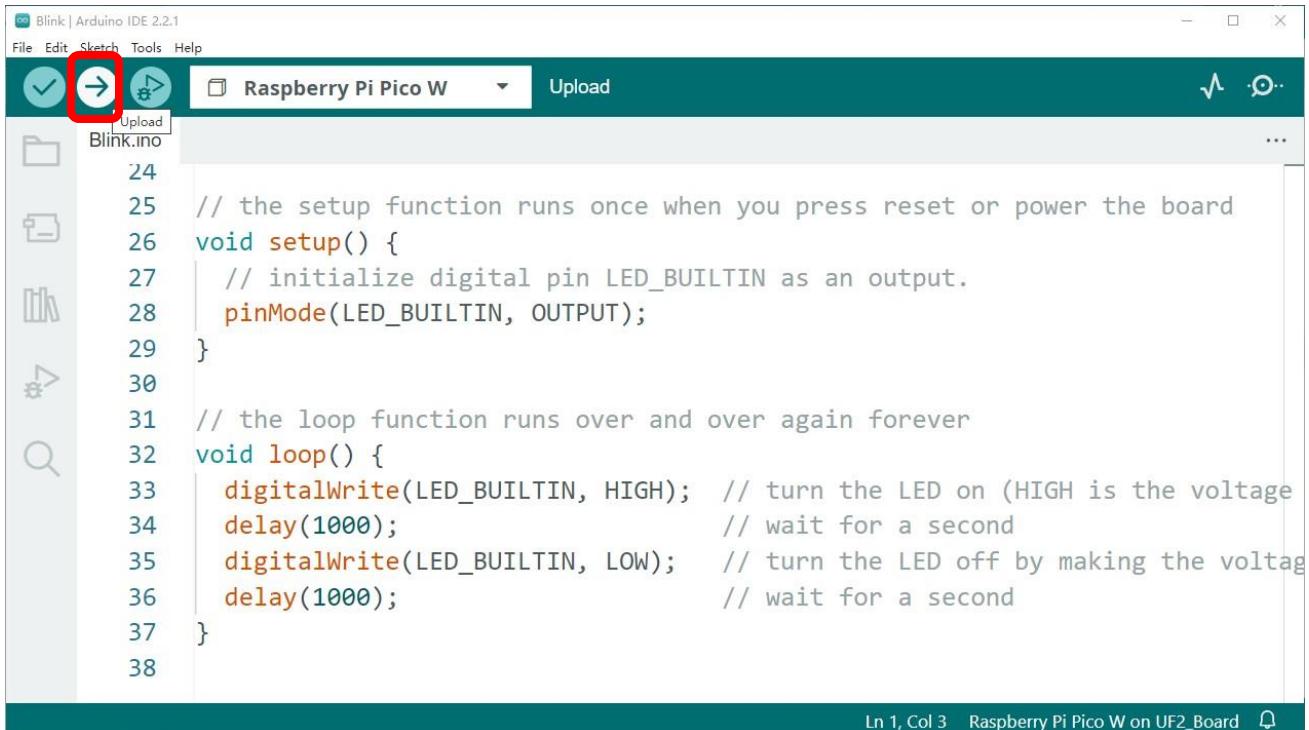
3. Click Tools>Board>Raspberry Pi RP2040 Boards>Raspberry Pi Pico W.



4. Click Tools>Port>UF2 Board.



5. Upload sketch to Raspberry Pi Pico W.



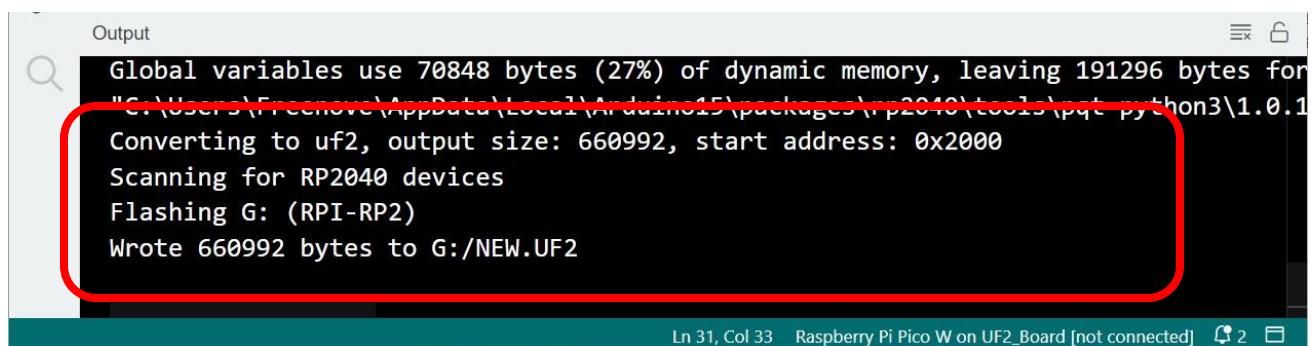
```

Blink | Arduino IDE 2.2.1
File Edit Sketch Tools Help
Upload → Raspberry Pi Pico W Upload ...
Blink.ino ...
24
25 // the setup function runs once when you press reset or power the board
26 void setup() {
27     // initialize digital pin LED_BUILTIN as an output.
28     pinMode(LED_BUILTIN, OUTPUT);
29 }
30
31 // the loop function runs over and over again forever
32 void loop() {
33     digitalWrite(LED_BUILTIN, HIGH);    // turn the LED on (HIGH is the voltage
34     delay(1000);                      // wait for a second
35     digitalWrite(LED_BUILTIN, LOW);    // turn the LED off by making the voltage
36     delay(1000);                      // wait for a second
37 }
38

```

Ln 1, Col 3 Raspberry Pi Pico W on UF2\_Board

When the sketch finishes uploading, you can see messages as below.



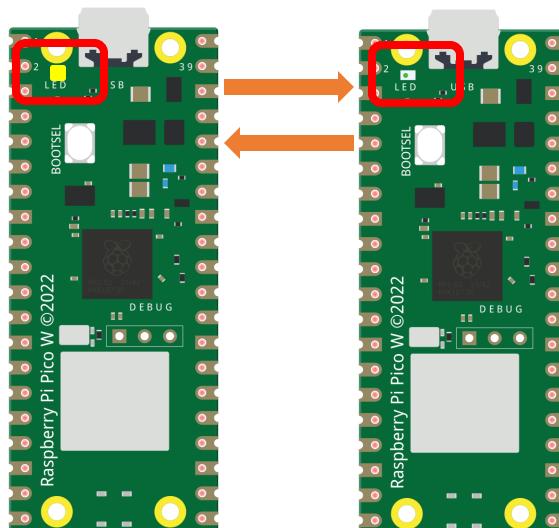
```

Output
Global variables use 70848 bytes (27%) of dynamic memory, leaving 191296 bytes for
"C:\Users\Freanove\AppData\Local\Arduino15\packages\RP2040\tools\pyuf2\python3\1.0.1"
Converting to uf2, output size: 660992, start address: 0x2000
Scanning for RP2040 devices
Flashing G: (RPI-RP2)
Wrote 660992 bytes to G:/NEW.UF2

```

Ln 31, Col 33 Raspberry Pi Pico W on UF2\_Board [not connected]

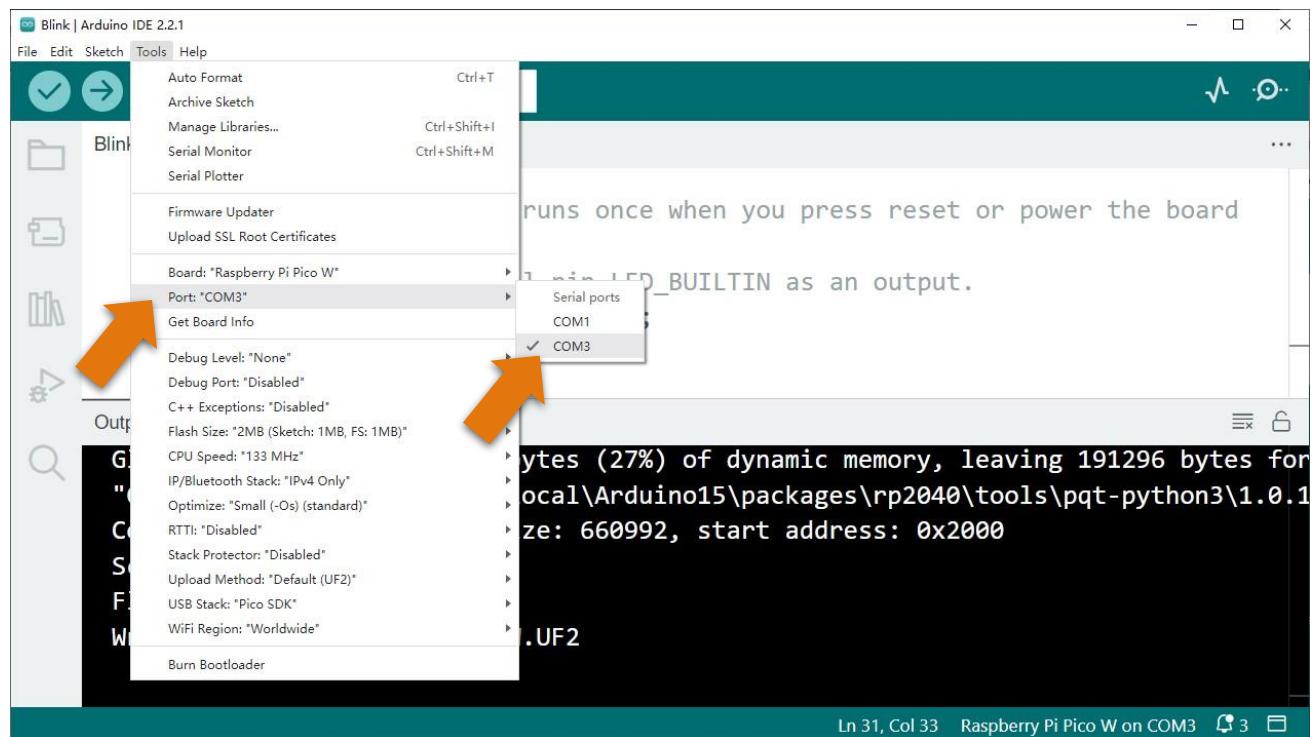
The indicator on Pico W starts to flash.



5. Click **Tools>Port>COMx (Raspberry Pi Pico W)**. X of COMx varies from different computers. Please select

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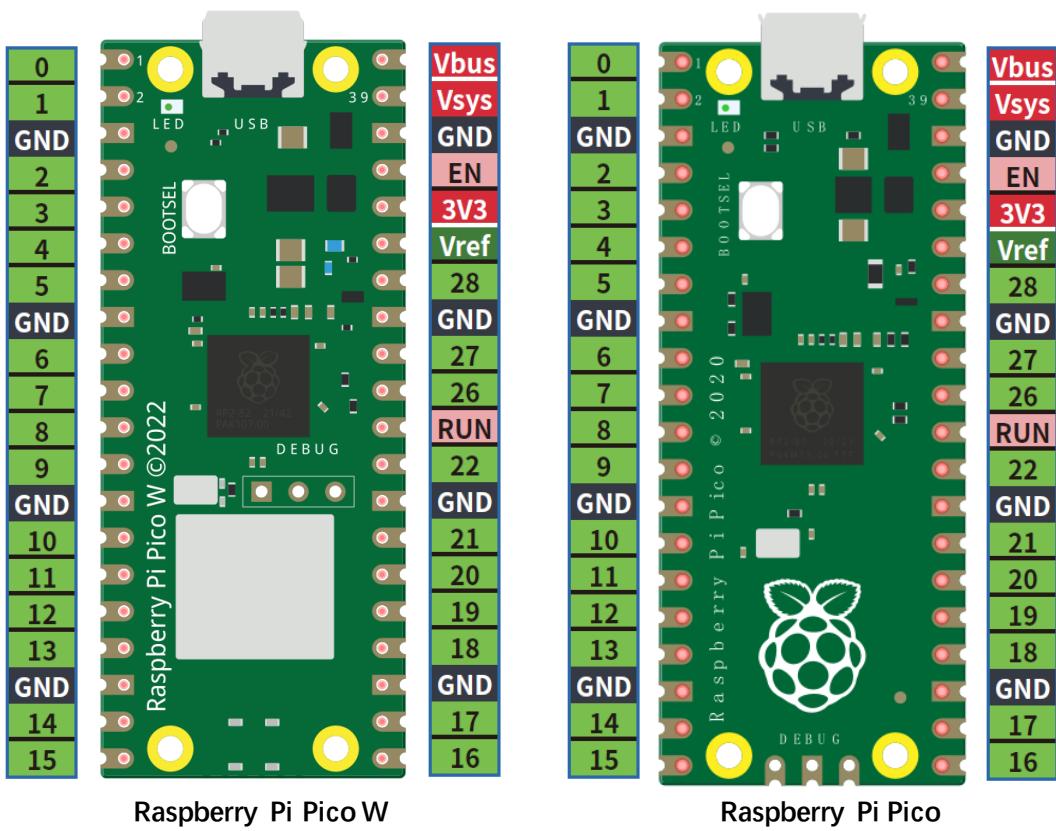
the correct one on your computer. In our case, it is COM26.



**Note:**

1. At the first use of Arduino to upload sketch for Pico (W), you need to select a port on the UF2 board. After that, each time before uploading sketch, please check whether the port has been selected; otherwise, the downloading may fail.
2. Sometimes when used, Pico (W) may lose firmware due to the code and fail to work. At this point, you can upload firmware for Pico (W) as mentioned above.

To facilitate your learning, the pins of Pico W and Pico are shown below:



## Uploading the First Code

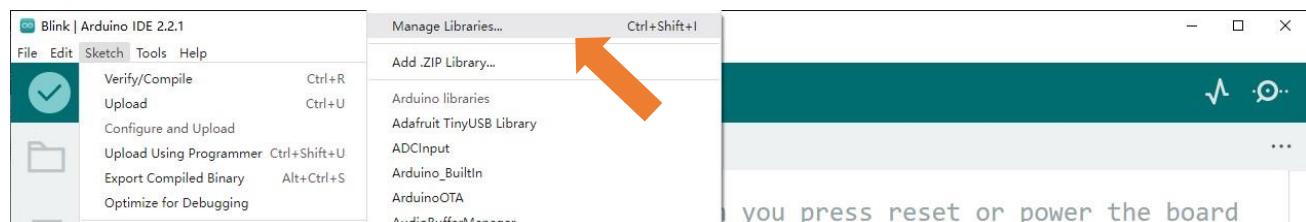
Here we take "00.0\_Servo\_90" in "**Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Sketches**" as an example.

## How to Add Libraries

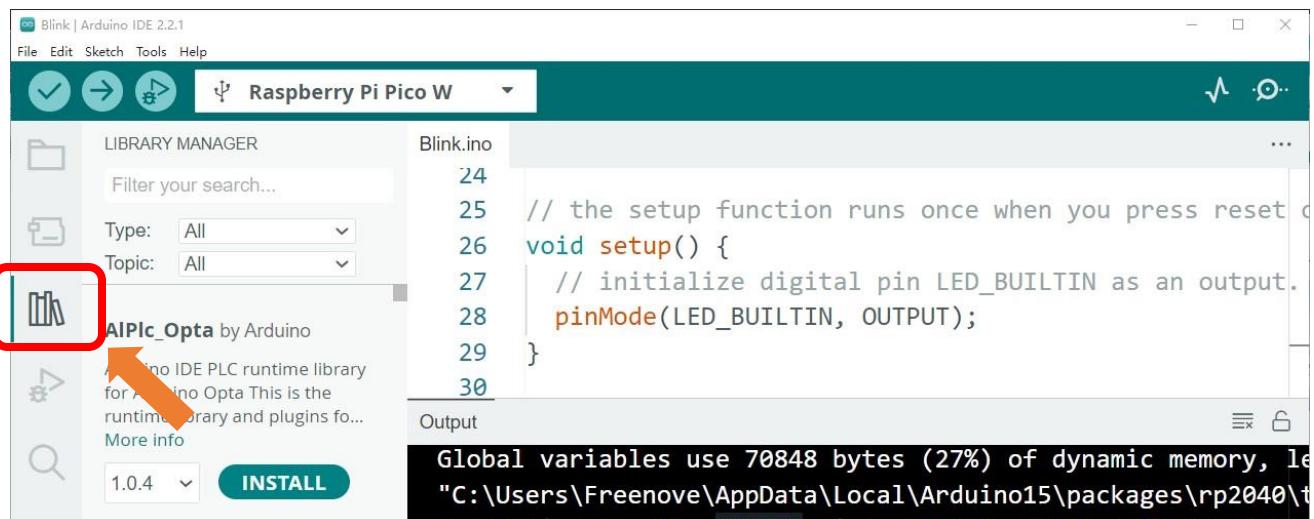
**Method 2 is preferred.**

**Method 1**

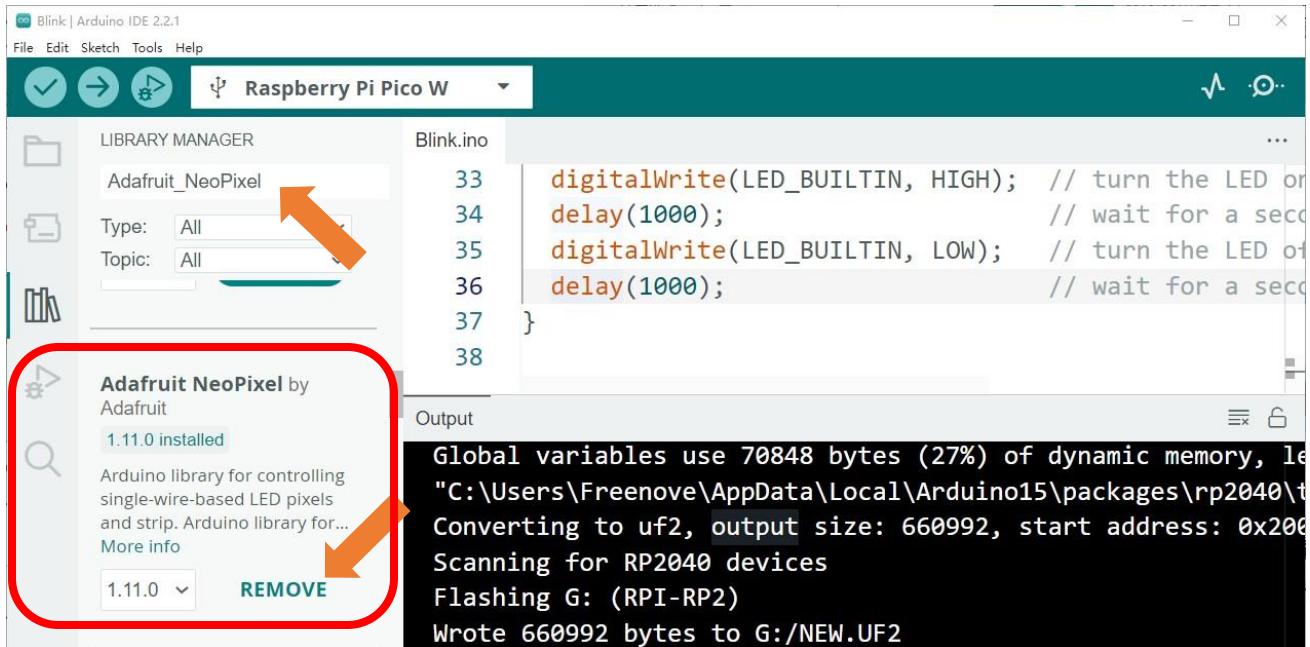
Open Arduino IDE, click Sketch on Menu bar ->Include Library -> Manage Libraries.



Or click the shortcut icon on the left.



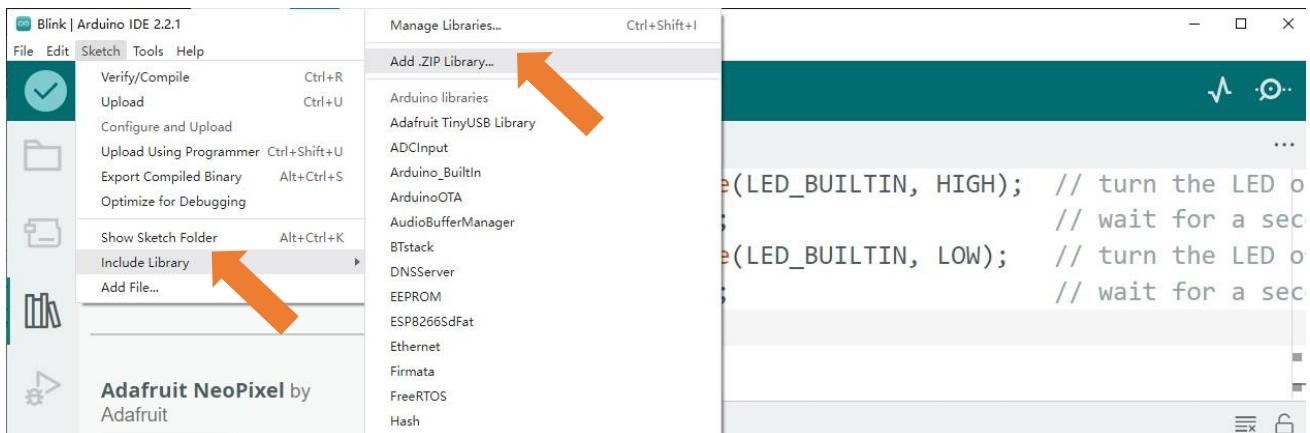
There is an input field on the right top of the pop-up window. Enter Adafruit\_NeoPixel there and click to install the library boxed in the following figure.



Wait for the installation to finish.

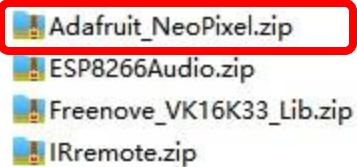
## Method 2

Open Arduino IDE, click Sketch on Menu bar ->Include Library ->Add .ZIP library.



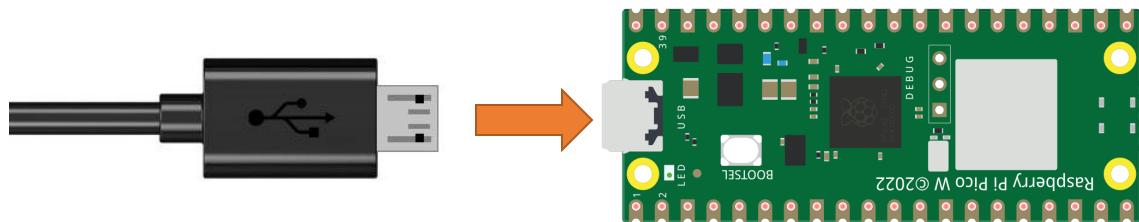
On the pop-up window, select Adafruit\_NeoPixel.zip in Libraries folder under "Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Libraries", and then click Open.

Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico > Libraries



## Upload the First Code

Step 1. Connect your computer and Raspberry Pi Pico W with a USB cable.



Step 2. Open “00.0\_Servo\_90” folder in “**Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Sketches**”, and double-click “00.0\_Servo\_90.ino”. The code is to rotate the servo motors to 90°.

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

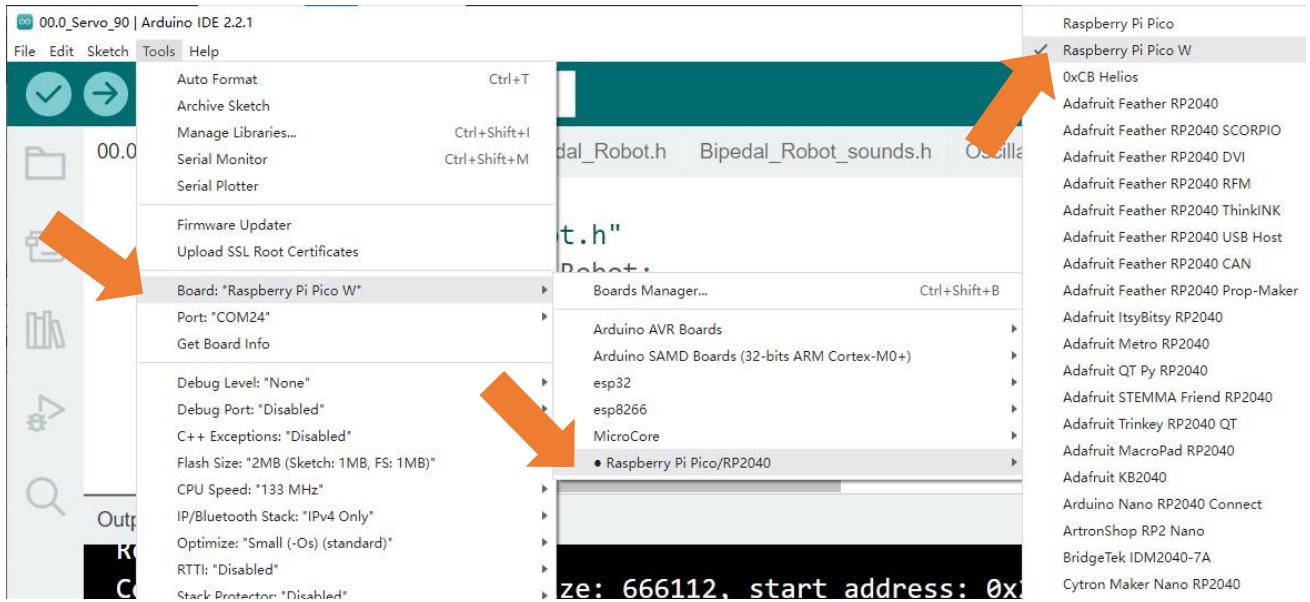
- Title Bar:** 00.0\_Servo\_90 | Arduino IDE 2.2.1
- File Menu:** File Edit Sketch Tools Help
- Tool Selection:** Raspberry Pi Pico W
- Code Editor:** Displays the contents of the 00.0\_Servo\_90.ino file:

```
1 #include <Arduino.h>
2 #include "Bipedal_Robot.h"
3 Bipedal_Robot Bipedal_Robot;
4
5 #define LeftLeg 10
6 #define RightLeg 12
7 #define LeftFoot 11
8 #define RightFoot 13
```
- Output Window:** Shows the terminal output during the upload process:

```
Resetting COM24
Converting to uf2, output size: 666112, start address: 0x2000
Scanning for RP2040 devices
Flashing G: (RPI-RP2)
Wrote 666112 bytes to G:/NEW.UF2
```
- Status Bar:** Ln 4, Col 1 Raspberry Pi Pico W on COM24

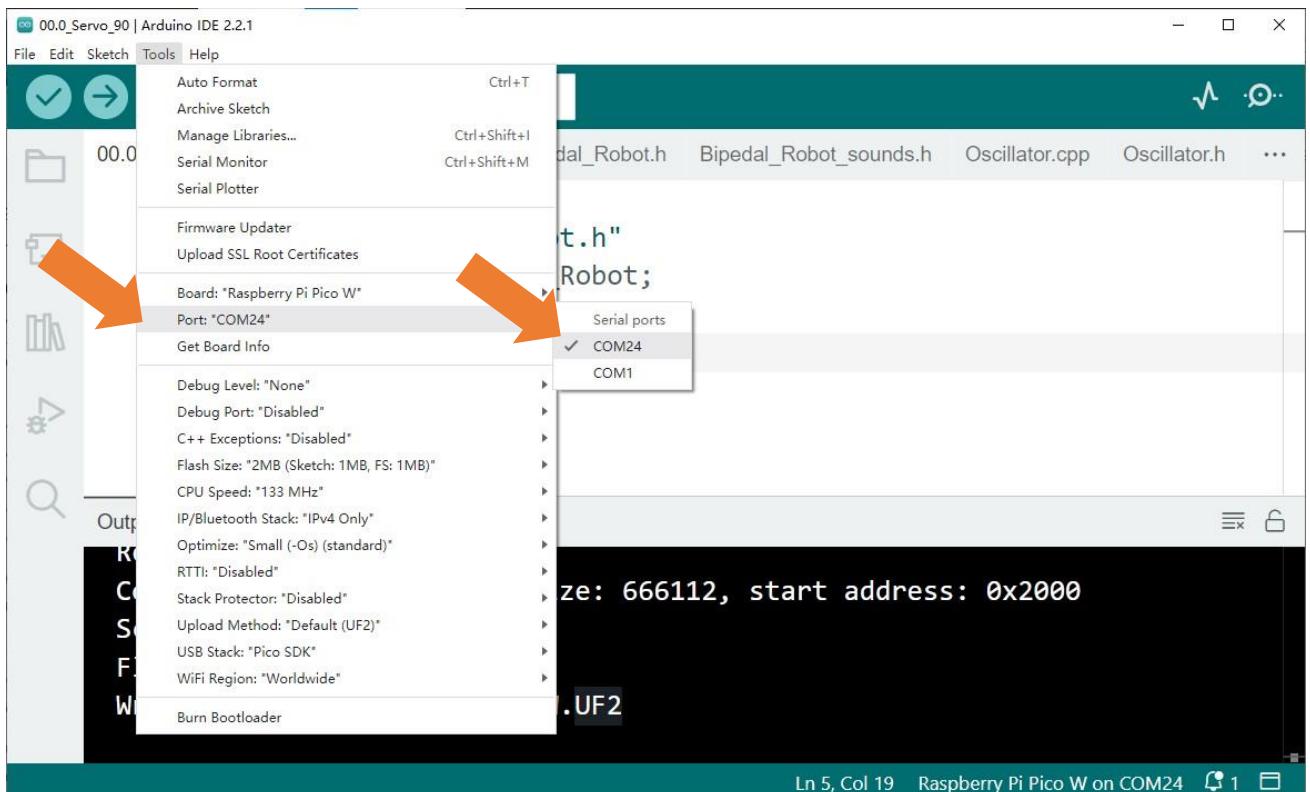
Step 3. Select development board.

Click Tools on Menu bar, click Board -> "Raspberry Pi Pico/RP2040" -> Raspberry Pi Pico W.

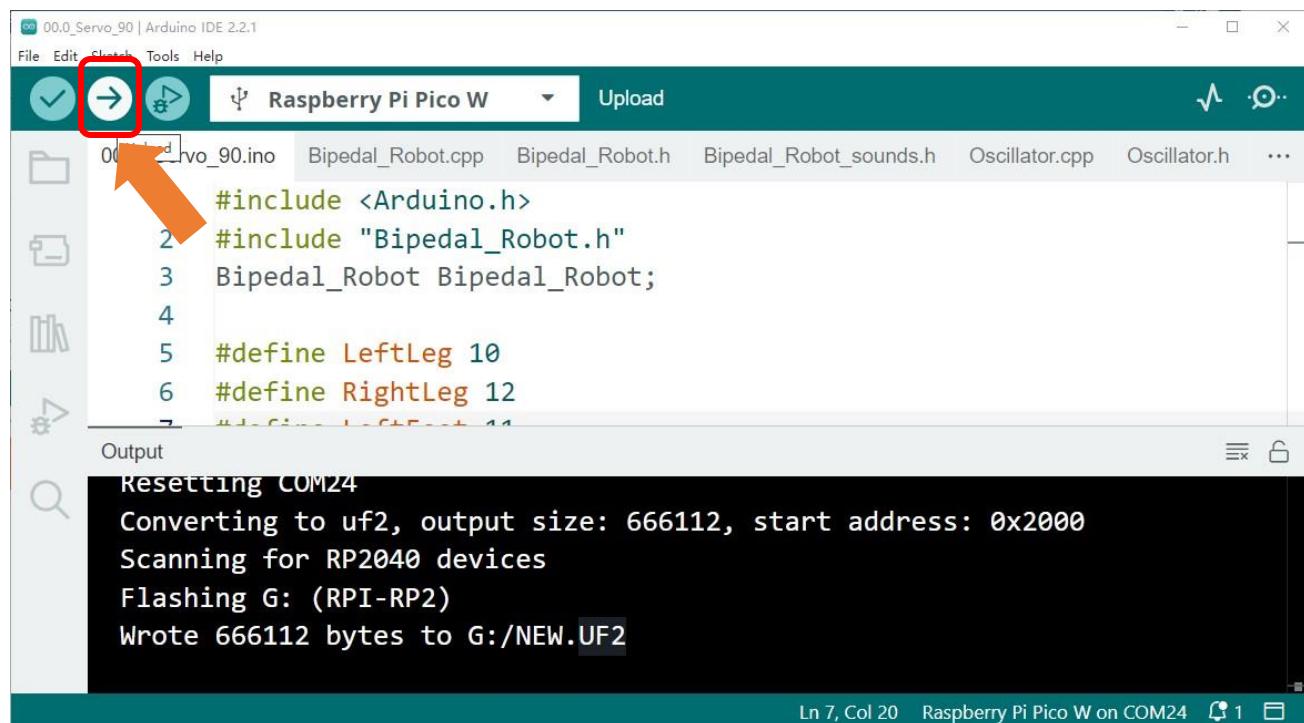


Step 4. Select serial port.

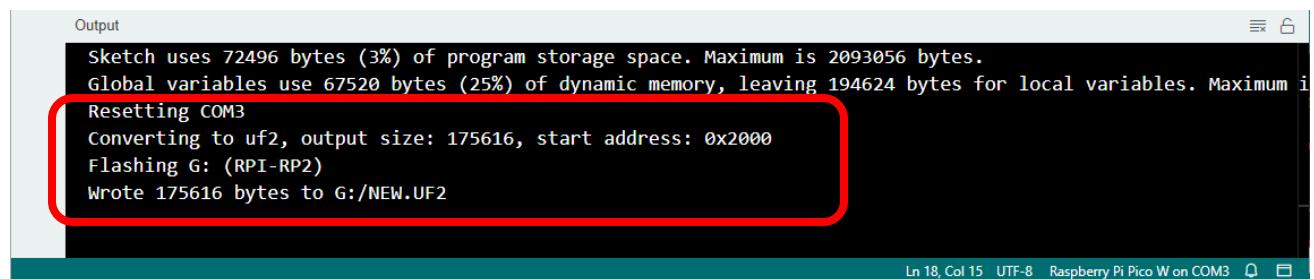
Click Tools on Menu bar, navigate your mouse to Port and select COMx on your computer. The value of COMx varies in different computers, but it will not affect the download function of Raspberry Pi Pico (W), as long as you select the correct one.



Click “Upload Using Programmer” and the program will be downloaded to Raspberry Pi Pico (W).



When you see the following content, it indicates that the program has been uploaded to Raspberry Pi Pico (W).



Connect the servo cables to the robot board, install the battery and press the power switch. The gears of the four servos will rotate to 90°.



# Chapter 1 Assembling Bipedal Robot

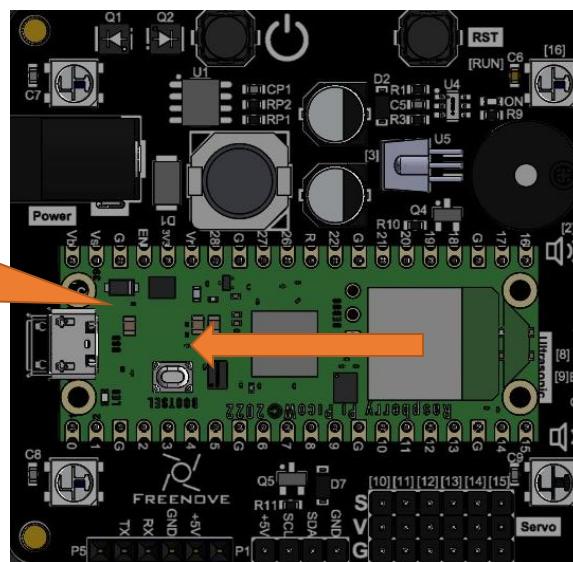
If you have any concerns, please feel free to contact us via [support@freenove.com](mailto:support@freenove.com)

## Assembling the Robot

### Plugging in Raspberry Pi Pico (W)

Plug Raspberry Pi Pico (W) into the shield.

Pay attention to the orientation of Raspberry Pi Pico (W).



Please pay attention to the orientation of Raspberry Pi Pico (W). Do NOT reverse it; Otherwise, it may burn the Raspberry Pi Pico (W).

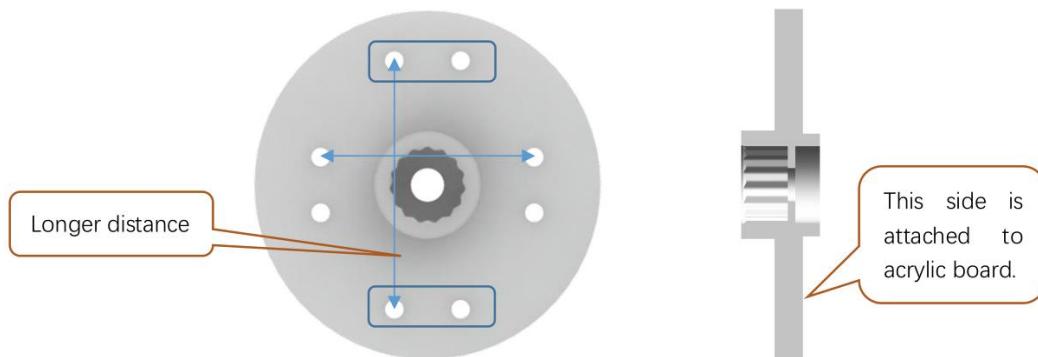
## Installing Disk Servo Arm

Take out four disk servo arms from the servo packages.



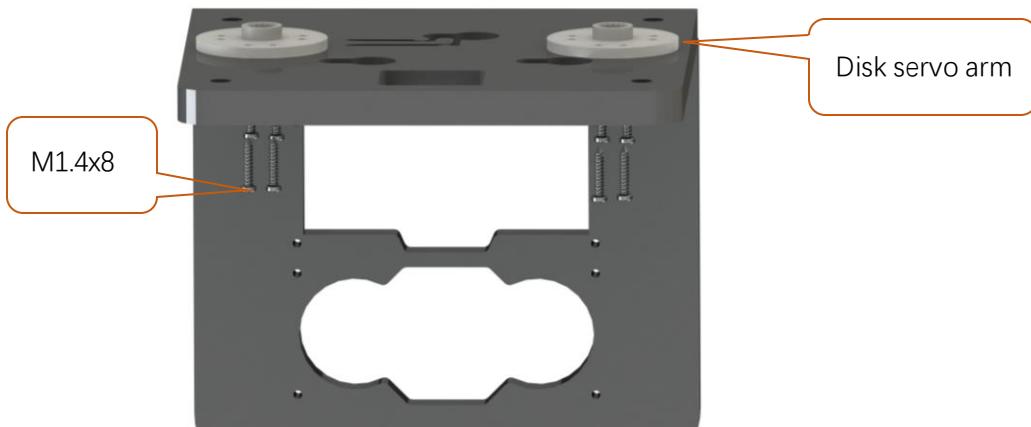
Each servo package includes five M1.4x8 screws and two black servo screws.

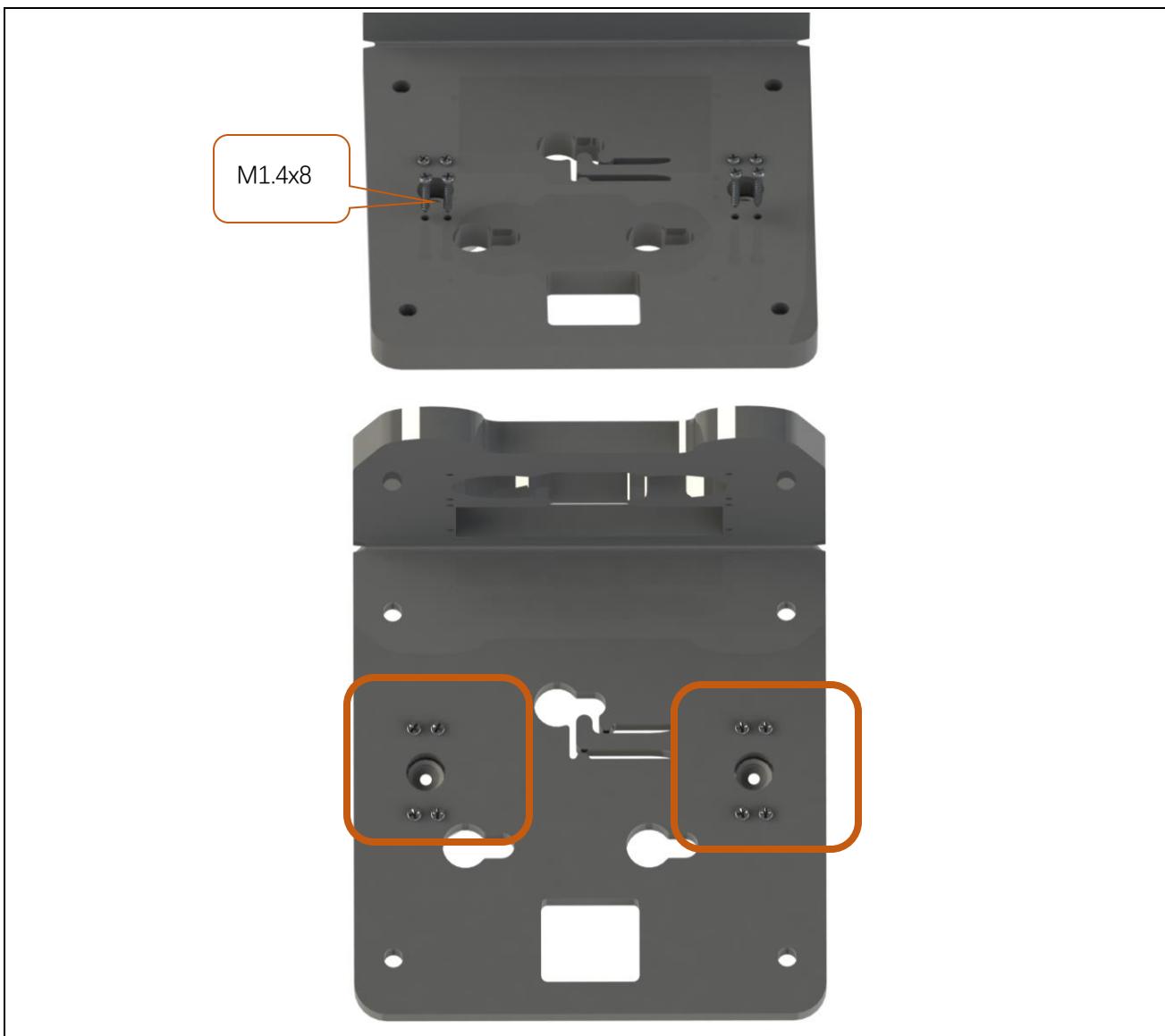
There are 4 pairs of opposite holes on the disk servo arm, and the distance between each pair is different. Please use the 2 pairs of holes with **longer distance**.



Installation steps:

Step 1 The following illustrates the installation of the disc servo arms of the servos for the body. Use the M1.4x8 screws in the servo package.





Step 2 The following illustrates the installation of the disc servo arms of the servos for the leg. Use the M1.4x8 screws in the servo package.

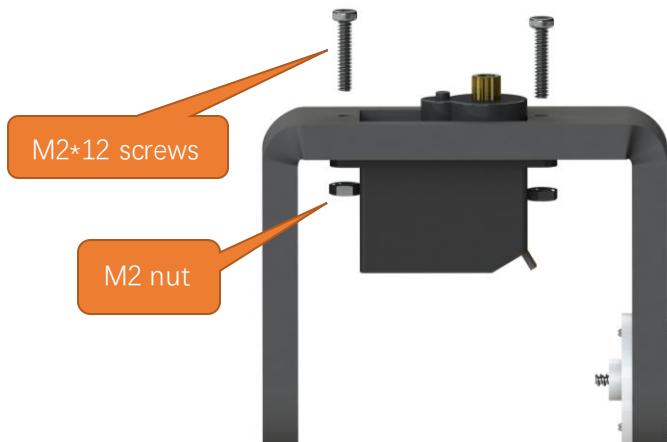




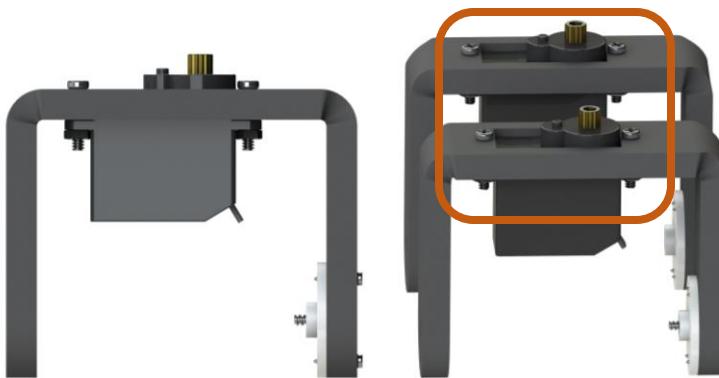
## Installing Servo

Installation steps:

Step 1 Assemble the servos to the two legs with M2\*12 screws and M2 nuts.

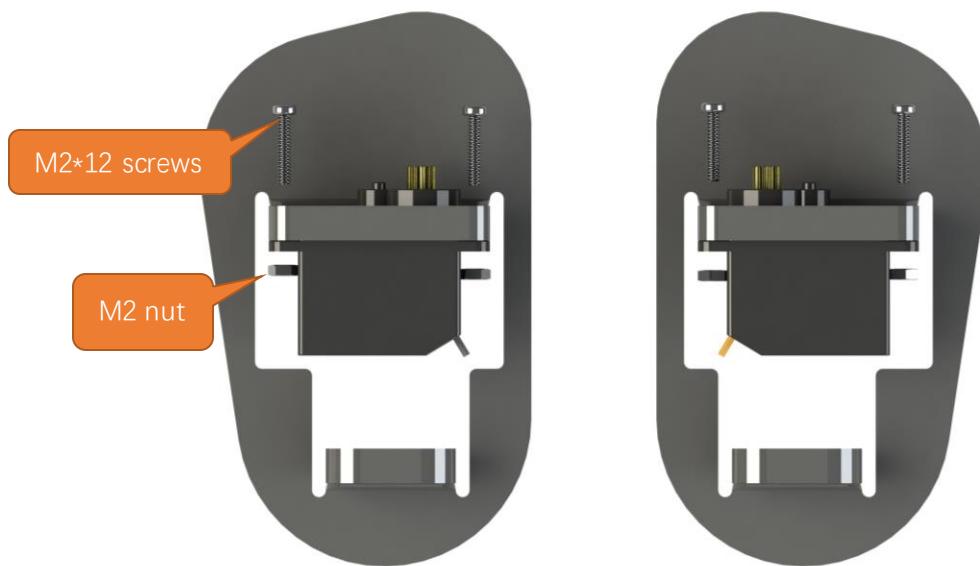


Finished:

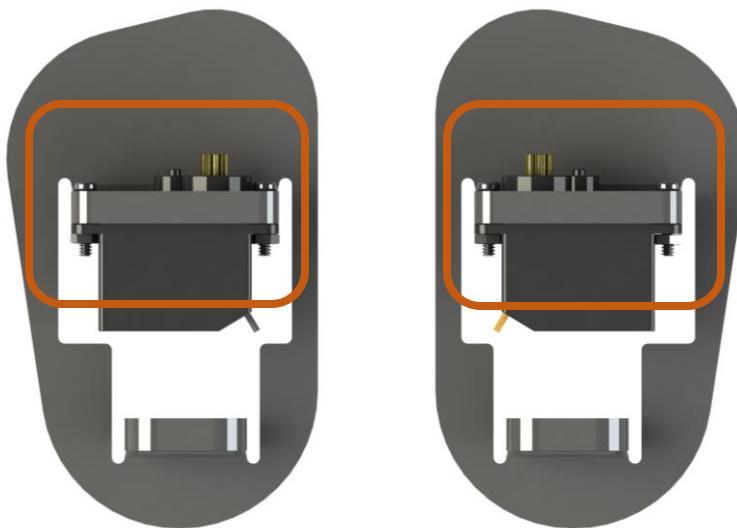


Step 2 Assemble the servos to both feet with M2\*12 screws and M2 nuts.

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Finished:



Step 3 Assemble the servos to the robot. Connect Servos 1, 2, 3, and 4 to the corresponding port on the robot board, which are GPIO10, GPIO11, GPIO12, and GPIO13 respectively. Pay attention to the colors of the cables. Connect the yellow cable to the yellow pin, red to red and brown to black. Do not misalign the cables.

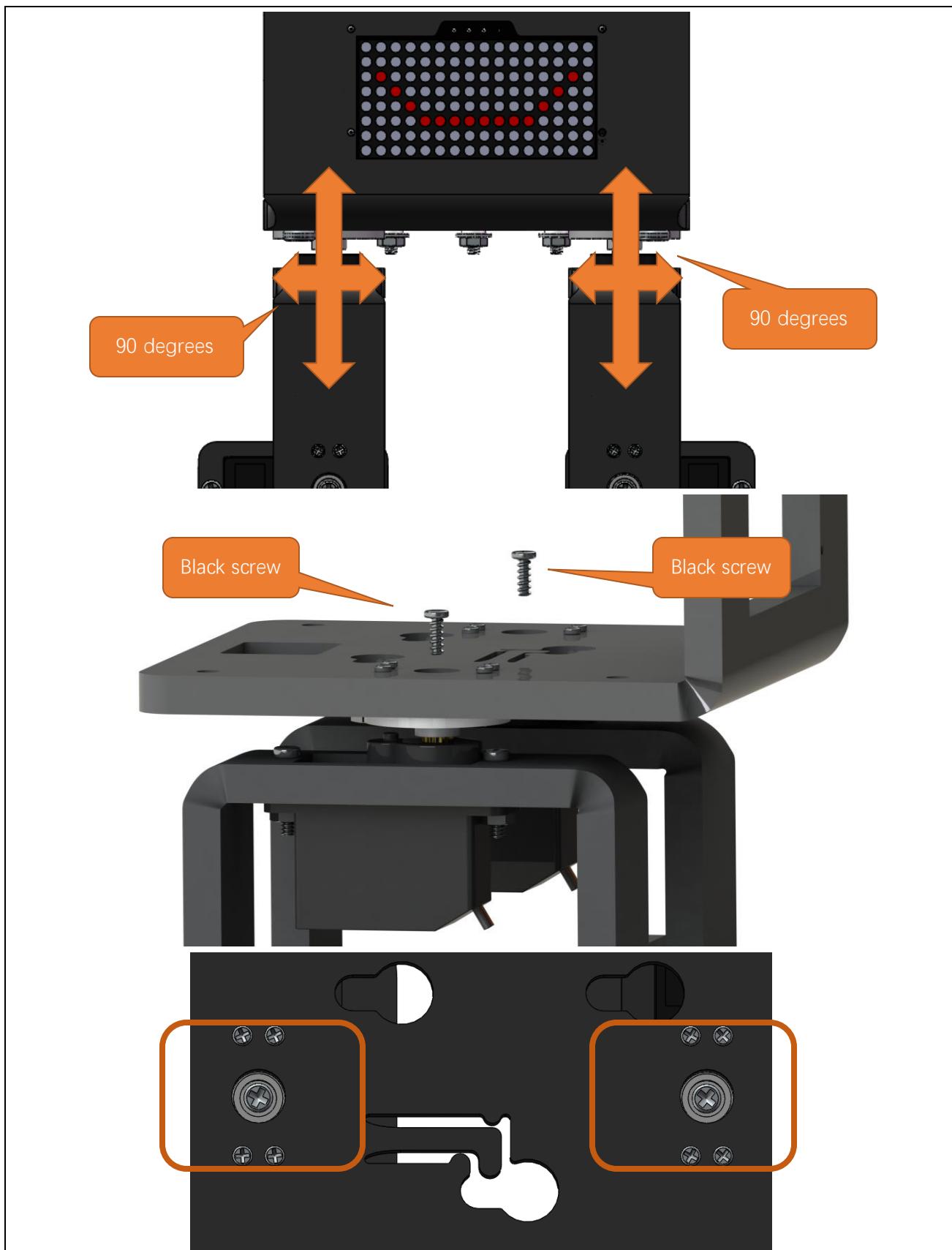


Open “00.0\_Servo\_90” in “Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Sketches” and double-click “00.0\_Servo\_90.ino”. For details, please refer to [here](#).

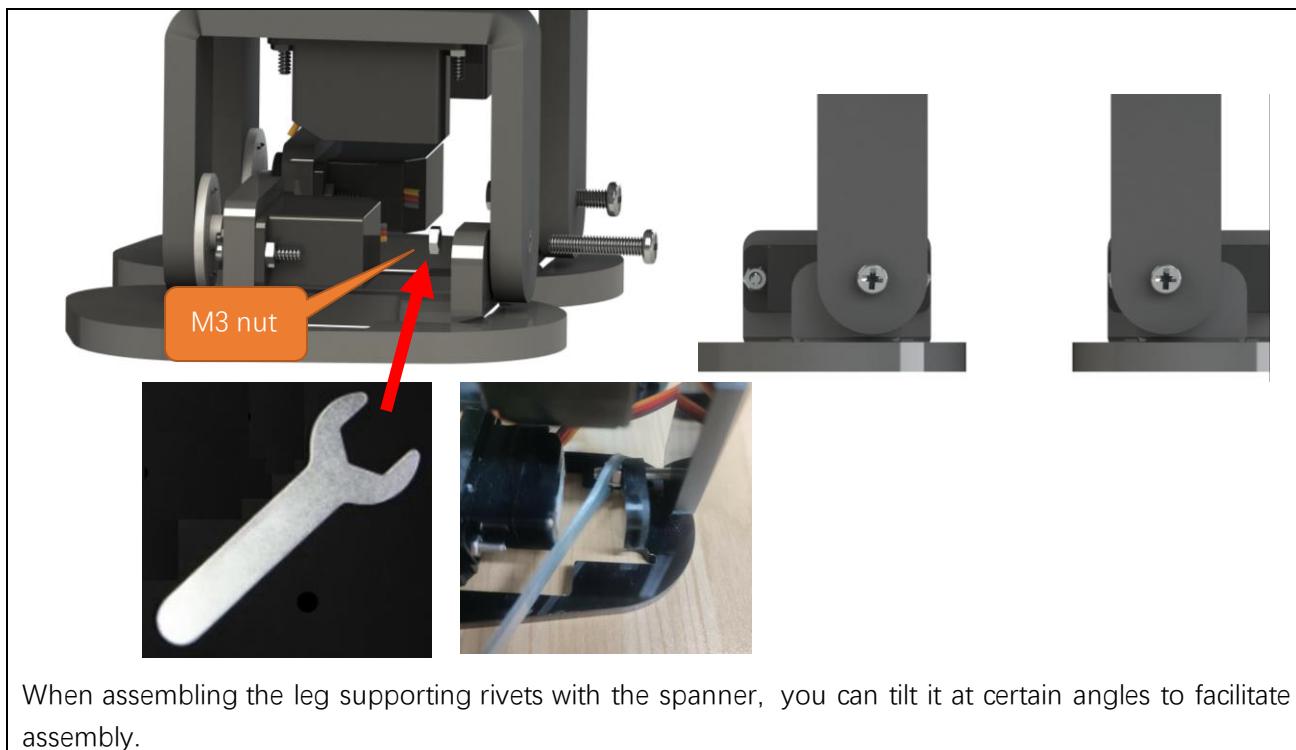
Turn ON the power switch, run the servo installation program, and the servos will keep at 90°.

Assemble the servos to the acrylic parts with the black screws in the servo packages.

Make them as close to 90° as possible. It is acceptable that the angle is in the range of 80 – 100 degrees.



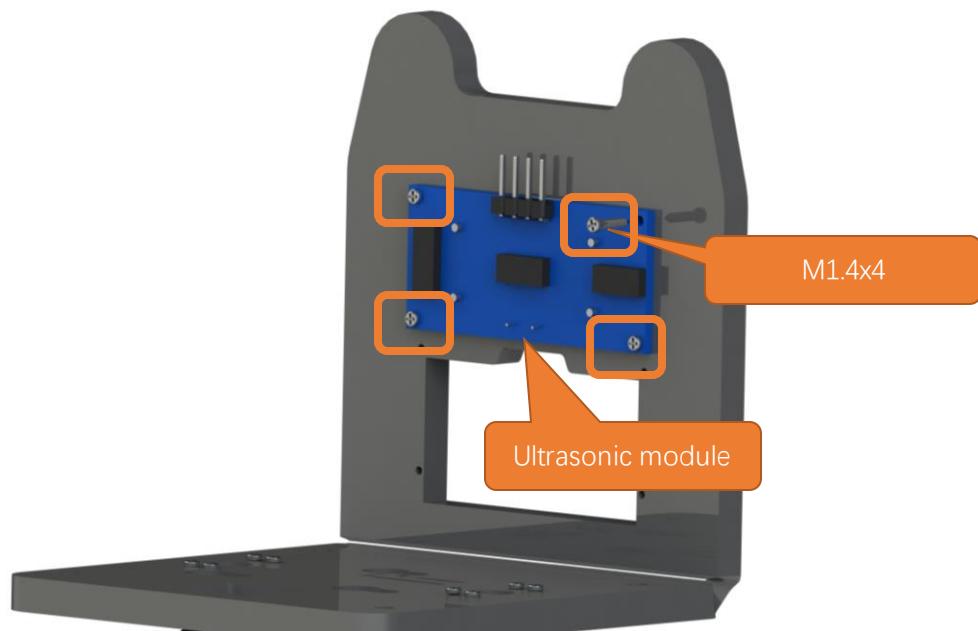




When assembling the leg supporting rivets with the spanner, you can tilt it at certain angles to facilitate assembly.

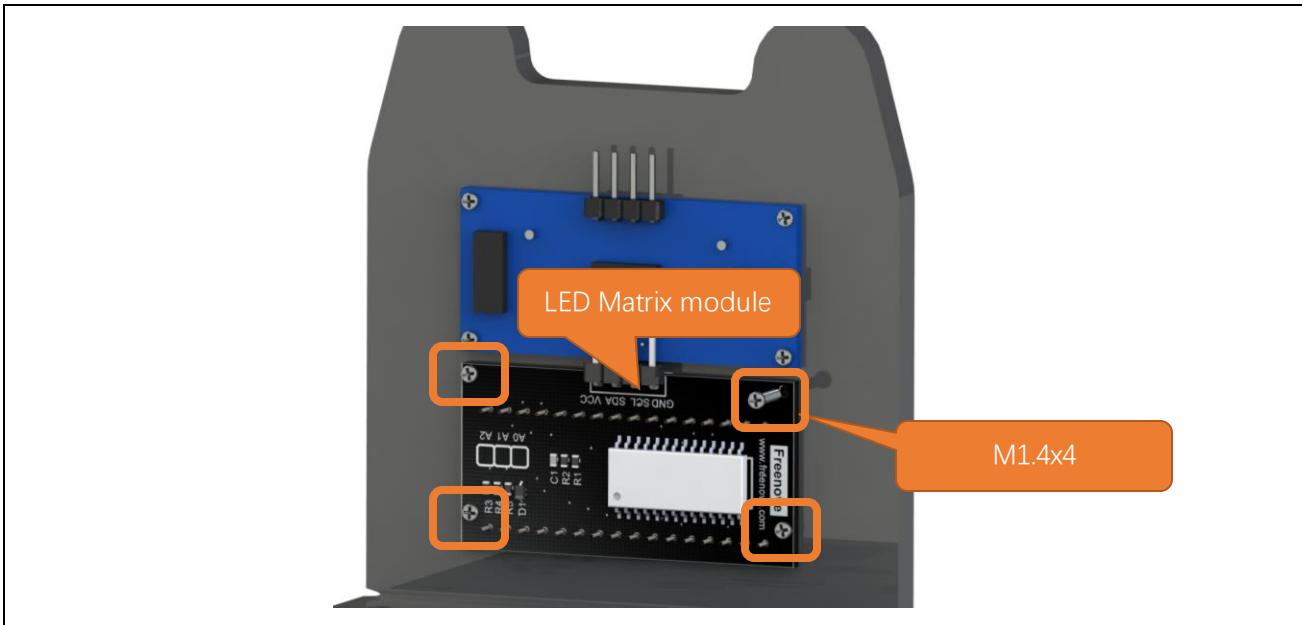
## Installing Ultrasonic Module

Step 1 Install ultrasonic module.



## Installing LED Matrix Module

Step 1 Install LED matrix module.



## Installing 9V Batteries

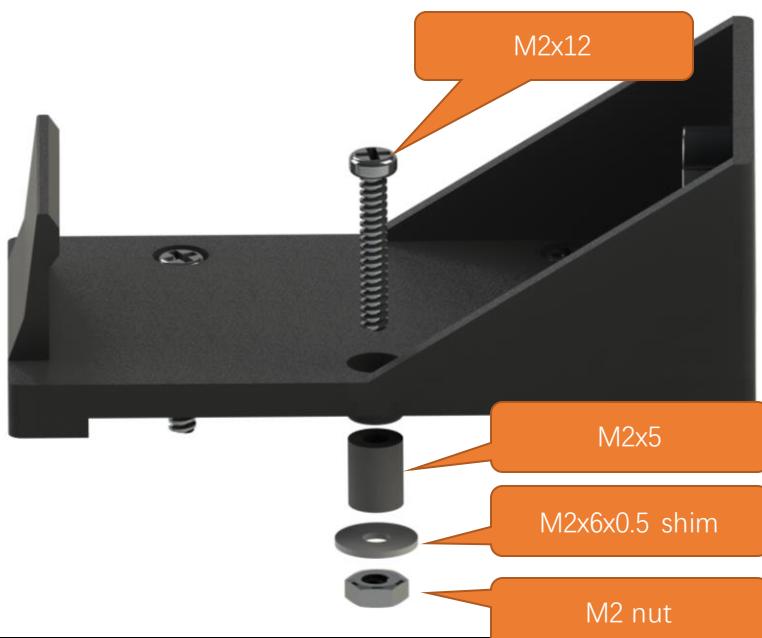
This robot is powered with **9V alkaline batteries** or **9V NIMH rechargeable batteries** as power supply. Please note that 9V carbon batteries and 9V rechargeable lithium batteries **cannot** provide enough power for the robot. Therefore, it is important to pay attention to the battery model when purchasing batteries.

Step 1 Installed with batteries.

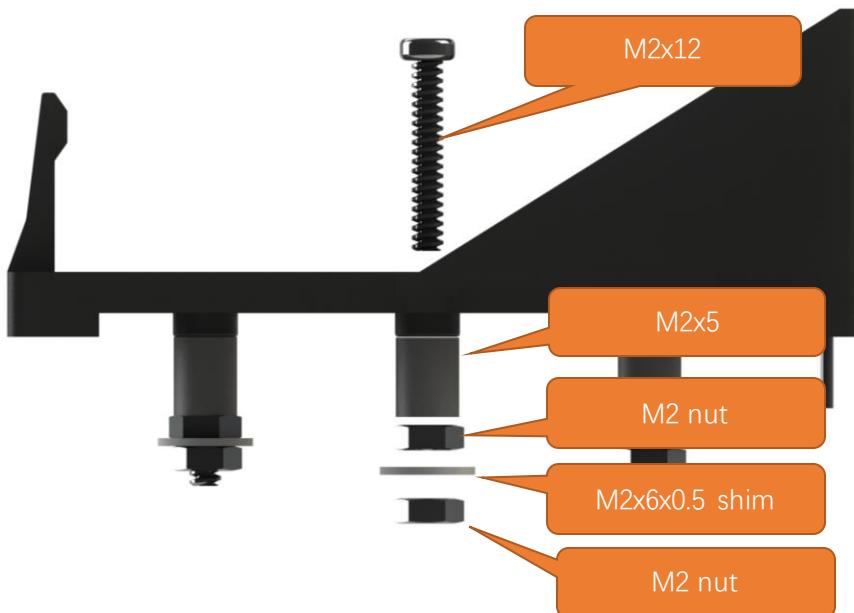
Correctly install the batteries.

Here we provide two installation methods:

Method 1:



Method 2:



Among them, M2x5 is the acrylic element, and there are 6 M2x5 rings in the acrylic fitting. Only three are used here, and the remaining three are reserved for use.



## Connecting Servo Cables

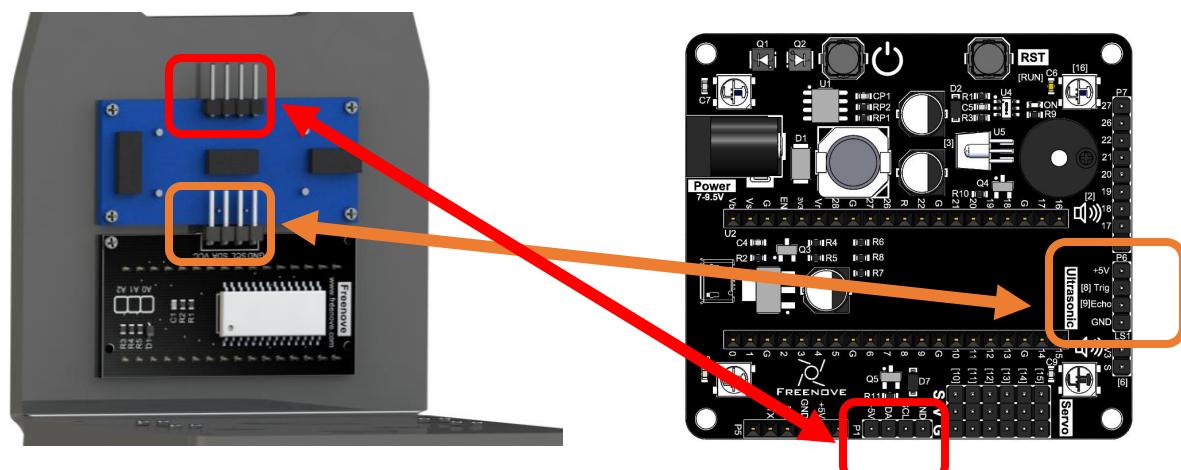
Step 1 Connect the servo cables. Thread the servo wires through the hole on the acrylic part and connect them to the servo port on the robot shield.





## Connect the Ultrasonic Sensor and LED Matrix Module

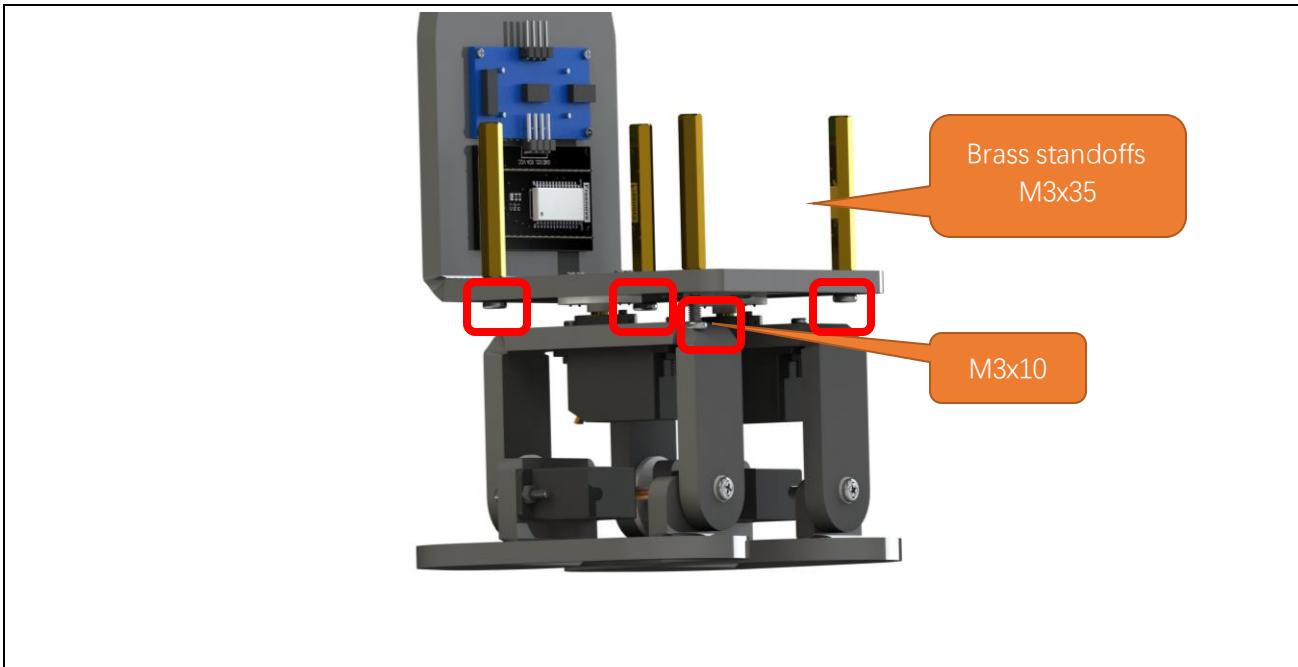
Step 1 Connect the ultrasonic sensor and LED matrix module. It is important that the pins be connected in line with the silk print on the robot shield.



## Installing the Standoffs for Robot Shield

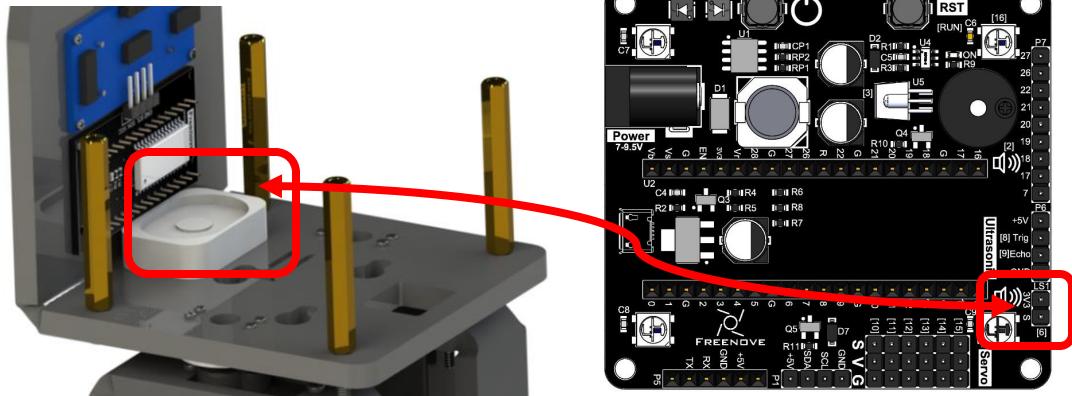
Fix the robot shield.

Step 1



## Installing the Speaker

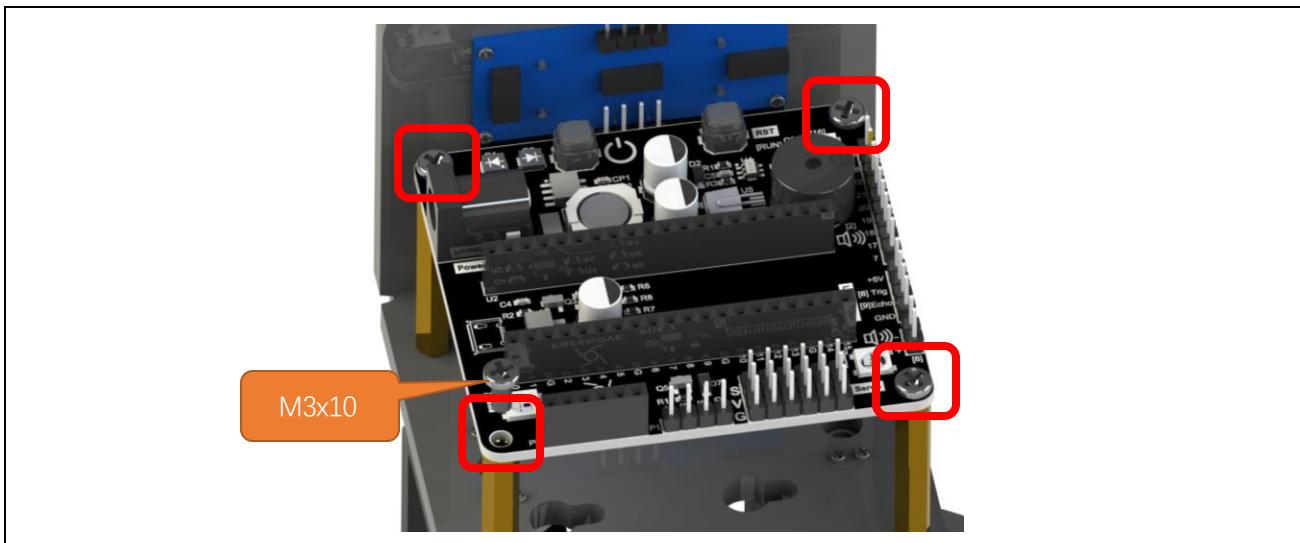
Step 1 Attach the speaker to the robot.



The red line of the speaker here is connected to the interface marked 3V3 on the control board.

## Installing Robot Shield

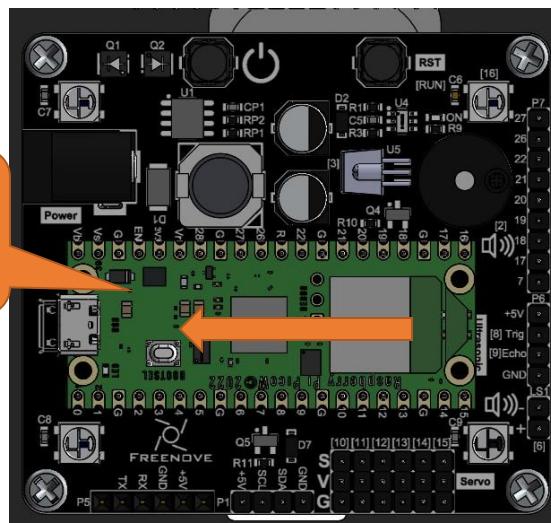
Step 1 Install the robot shield.



## Plugging in Raspberry Pi Pico (W)

Plug Raspberry Pi Pico (W) into the shield.

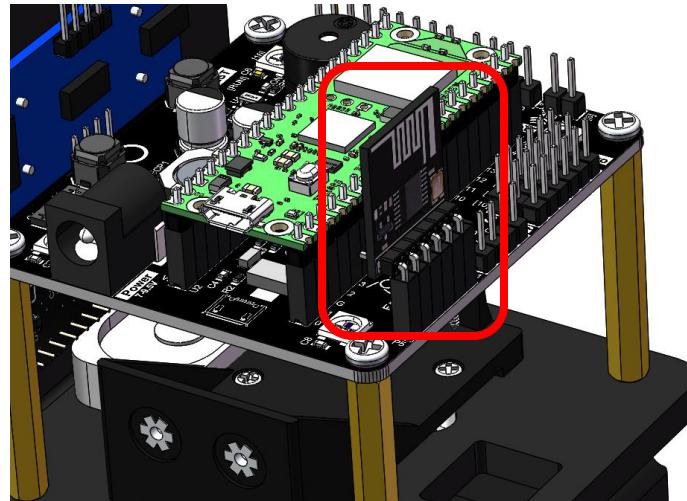
Pay attention to the orientation of Raspberry Pi Pico (W).



Please pay attention to the orientation of Raspberry Pi Pico (W). Do NOT reverse it; Otherwise, it may burn the Raspberry Pi Pico (W).

## Installing Bluetooth Module

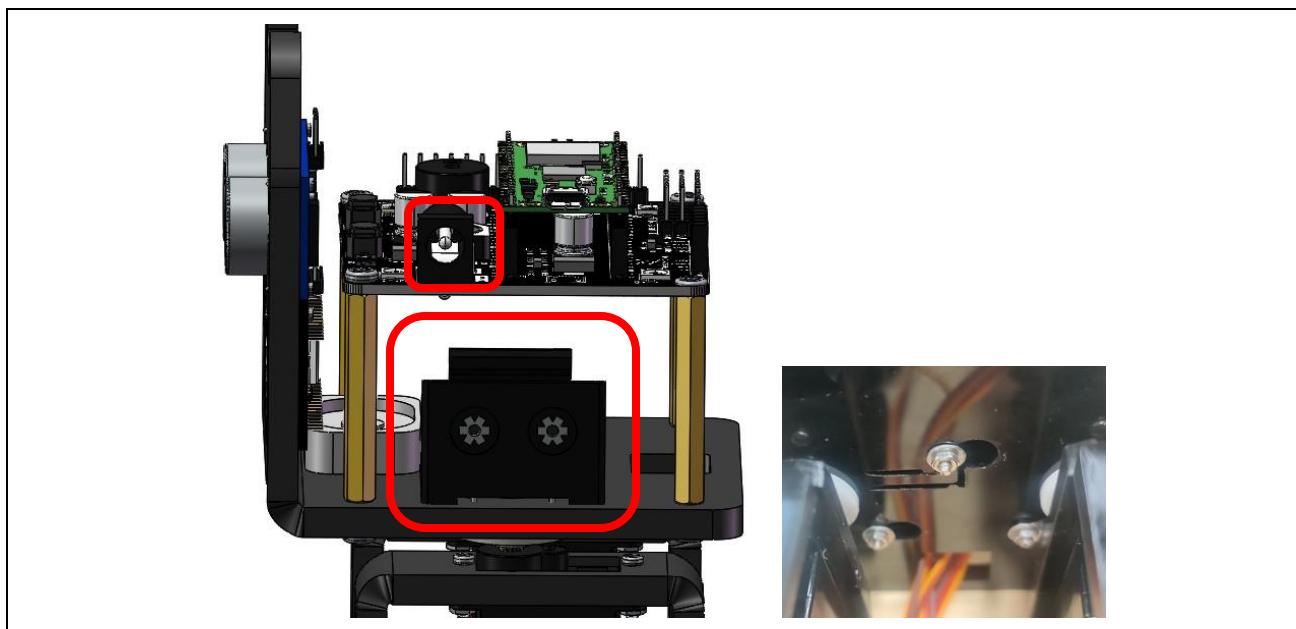
Plug the Bluetooth module to the board. Pay attention to the direction.



## Installing 9V Battery Holder (with batteries installed)

Install the batteries to power the robot. Please note that the input voltage should be 7-9.5V. Although it is a 9V battery, its actual voltage can exceed this number. It is acceptable as long as the voltage is within 10V. When installing the batteries, you may press the battery down and push it to the end.

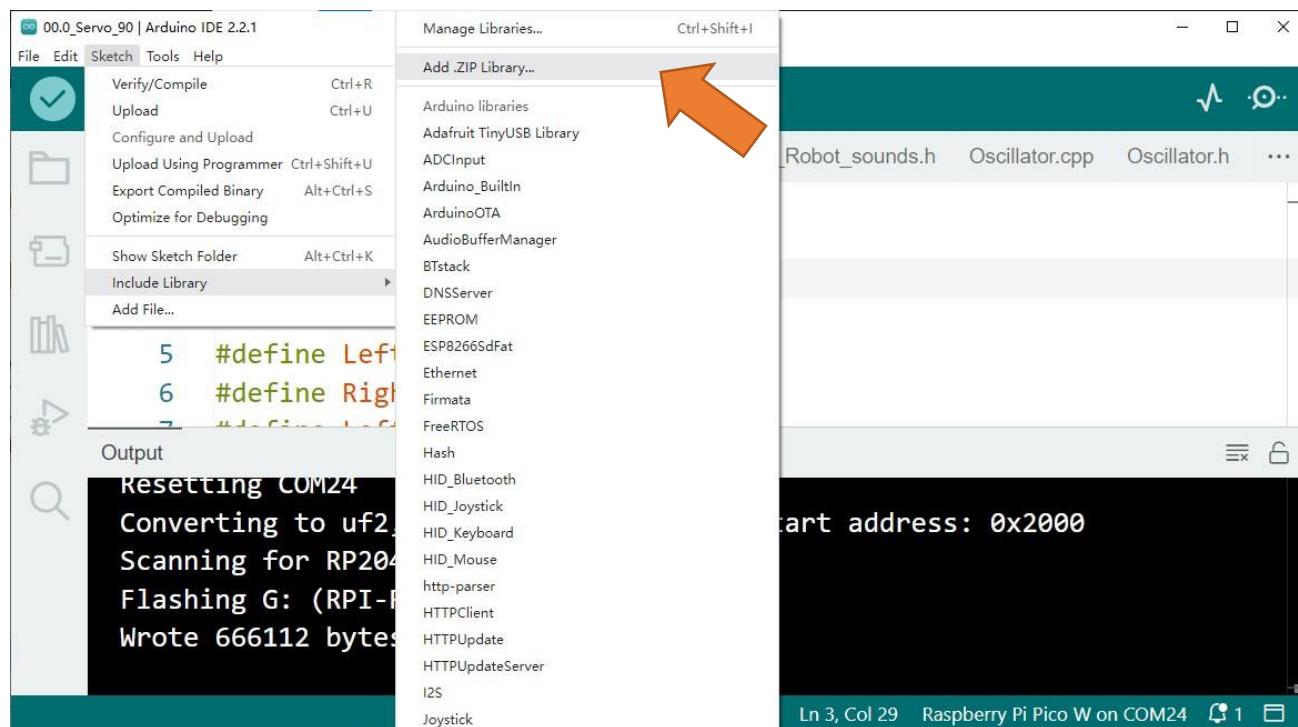




## How to Play

### Add libraries

Open the **Arduino IDE**, Click **Sketch** on the menu bar ->**Include Library** -> **Add .ZIP Library...**



In the new pop-up window, select **Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Libraries**, select every Library, click **Open**, and repeat this process until you have installed all six Libraries into the Arduino.

[Freenove\\_Bipedal\\_Robot\\_Kit\\_for\\_Raspberry\\_Pi\\_Pico](#) > [Libraries](#)

-  [Adafruit\\_NeoPixel.zip](#)
-  [ESP8266Audio.zip](#)
-  [Freenove\\_VK16K33\\_Lib.zip](#)
-  [IRremote.zip](#)

These libraries are used for this robot. Before uploading code, please make sure they have been added.

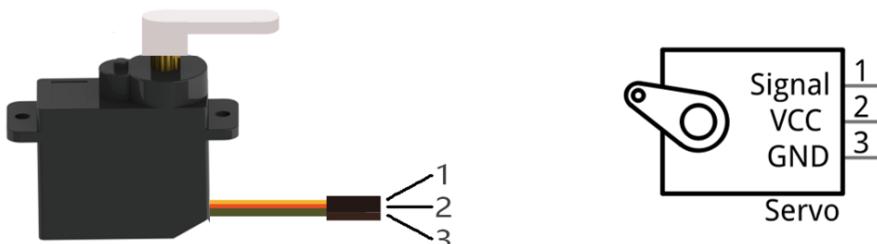
# Chapter 2 Module test

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

## 2.1 Servo

### Servo

Servo is a compact package, which consists of a DC motor, a set of reduction gears to provide torque, a sensor and control circuit board. Most servos only have a 180-degree range of motion via their "horn". Servos can output higher torque than a simple DC motor alone and they are widely used to control motion in model cars, model airplanes, robots, etc. Servos have three wire leads that usually terminate to a male or female 3-pin plug. Two leads are for electric power: positive (2-VCC, Red wire), negative (3-GND, Brown wire), and the signal line (1-Signal, Orange wire), as represented in the Servo provided in your Kit.

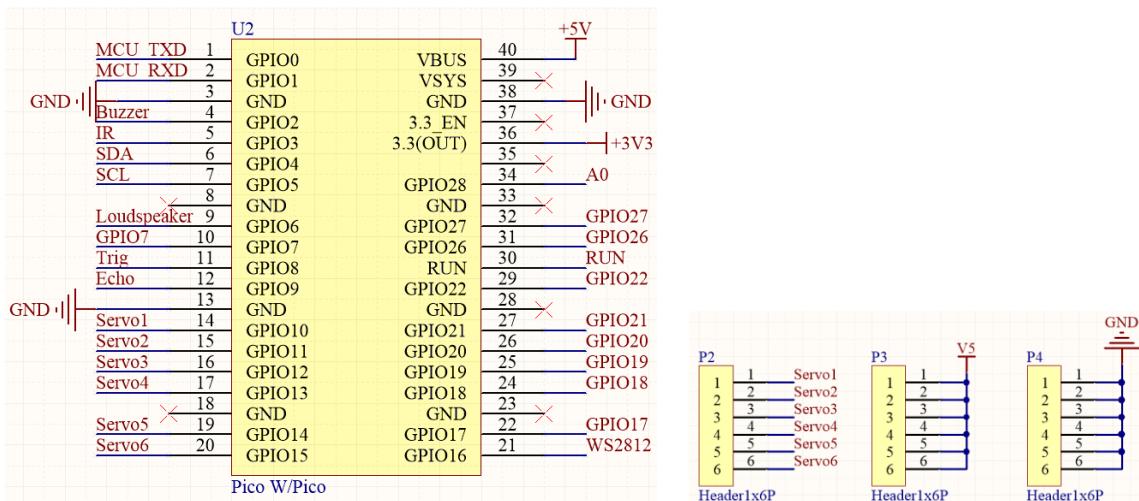


We will use a 50Hz PWM signal with a duty cycle in a certain range to drive the Servo. The lasting time of 0.5ms-2.5ms of PWM single cycle high level corresponds to the servo angle 0 degrees - 180 degree linearly. Part of the corresponding values are as follows:

High level time	Servo angle
0.5ms	0 degree
1ms	45 degree
1.5ms	0 degree
2ms	45 degree
2.5ms	180 degree

When you change the servo signal value, the servo will rotate to the designated angle.

## Schematic



## Sketch

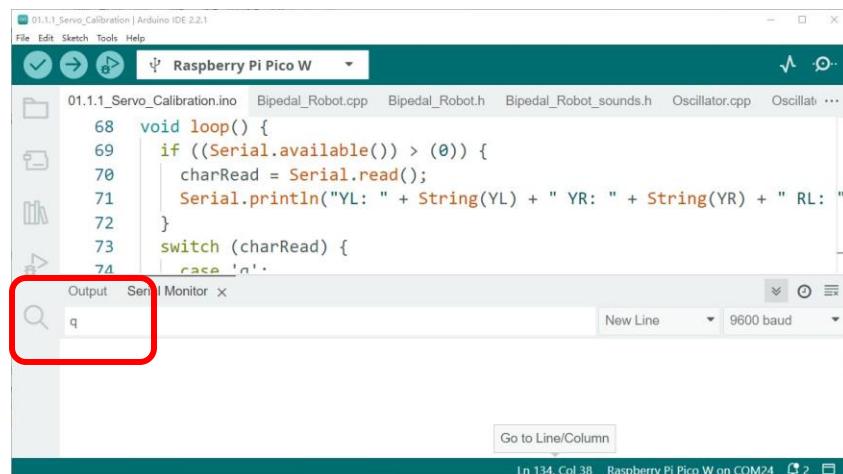
Upload the sketch to Raspberry Pi Pico (W). This sketch is for servo calibration. You can adjust the robot's status via keyboard input, until the robot can stand up normally. After calibration, you can send the character **t** for the robot to move forward. Pay attention to the robot's movement, if it does not walk well, you can adjust each servo again until the robot's movement is normal. After the calibration finishes, you need to modify the code according to the calibration data and upload the sketch again. Refer to the sketch for more details.

Open “01.1.1\_Servo\_Calibration” in “Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Sketches” and double-click “01.1.1\_Servo\_Calibration.ino”.

Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico > Sketches

- 00.0\_Servo\_90
- 01.1.1\_Servo\_Calibration**
- 01.1.2\_Servo
- 01.2\_Buzzer
- 01.3.1\_Loudspeaker

As indicated below, a character is sent via the serial monitor to calibrate the robot.



The specific calibration command characters are as follows:

Servo interface	The servo was increased by 1°	The servo is reduced by 1°
LeftLeg [10]	q	a
RightLeg [12]	e	d
LeftFoot [11]	w	s
RightFoot [13]	r	f

### Code

```

1  include <Arduino.h>
2  #include <Wire.h>
3  #include <SoftwareSerial.h>
4  #include <EEPROM.h>
5  #include "Bipedal_Robot.h"
6  Bipedal_Robot Bipedal_Robot;
7
8  #define LeftLeg 10
9  #define RightLeg 12
10 #define LeftFoot 11
11 #define RightFoot 13
12
13 int calibratePosition[4] = { -17, -10, -15, 12 };
14 // Used to save the servo offset, in radians
15 int YL;
16 int YR;
17 int RL;
18 int RR;
19 char charRead;
20 void setup() {
21     EEPROM.begin(512);
22     Serial.begin(9600);
23     for (int i = 0; i < 4; i++) {
24         EEPROM.write(i, calibratePosition[i]);

```

```
25 }
26 Bipedal_Robot.init(LeftLeg, RightLeg, LeftFoot, RightFoot, true); //Set the servo pins
27 YL = EEPROM.read(0);
28 if (YL > 128) YL -= 256;
29 YR = EEPROM.read(1);
30 if (YR > 128) YR -= 256;
31 RL = EEPROM.read(2);
32 if (RL > 128) RL -= 256;
33 RR = EEPROM.read(3);
34 if (RR > 128) RR -= 256;
35 calib_homePos();
36 Bipedal_Robot.saveTrimsOnEEPROM();
37 EEPROM.commit();
38 Bipedal_Robot.home();
39 Serial.println("ROBOT CALIBRATION PROGRAM");
40 Serial.println("PRESS q or a for adjusting Left Leg");
41 Serial.println("PRESS w or s for adjusting Left Foot");
42 Serial.println("PRESS e or d for adjusting Right Leg");
43 Serial.println("PRESS r or f for adjusting Right Foot");
44 Serial.println();
45 Serial.println("PRESS t to test Otto walking");
46 Serial.println("PRESS g to return servos to home position");
47 }
48
49 void loop() {
50 if ((Serial.available() > 0)) {
51     charRead = Serial.read();
52     Serial.println("YL: " + String(YL) + " YR: " + String(YR) + " RL: " + String(RL) + " RR: "
53     + String(RR));
54 }
55 switch (charRead) {
56 case 'q':
57     YL++;
58     Bipedal_Robot.setTrims(YL, YR, RL, RR);
59     calib_homePos();
60     Bipedal_Robot.saveTrimsOnEEPROM();
61     break;
62 case 'a':
63     YL--;
64     Bipedal_Robot.setTrims(YL, YR, RL, RR);
65     calib_homePos();
66     Bipedal_Robot.saveTrimsOnEEPROM();
67     break;
68 case 'w':
```

```
69      RL++;
70      Bipedal_Robot.setTrims(YL, YR, RL, RR);
71      calib_homePos();
72      Bipedal_Robot.saveTrimsOnEEPROM();
73      break;
74  case 's':
75      RL--;
76      Bipedal_Robot.setTrims(YL, YR, RL, RR);
77      calib_homePos();
78      Bipedal_Robot.saveTrimsOnEEPROM();
79      break;
80  case 'e':
81      YR++;
82      Bipedal_Robot.setTrims(YL, YR, RL, RR);
83      calib_homePos();
84      Bipedal_Robot.saveTrimsOnEEPROM();
85      break;
86  case 'd':
87      YR--;
88      Bipedal_Robot.setTrims(YL, YR, RL, RR);
89      calib_homePos();
90      Bipedal_Robot.saveTrimsOnEEPROM();
91      break;
92  case 'r':
93      RR++;
94      Bipedal_Robot.setTrims(YL, YR, RL, RR);
95      calib_homePos();
96      Bipedal_Robot.saveTrimsOnEEPROM();
97      break;
98  case 'f':
99      RR--;
100     Bipedal_Robot.setTrims(YL, YR, RL, RR);
101     calib_homePos();
102     Bipedal_Robot.saveTrimsOnEEPROM();
103     break;
104  case 't':
105     Bipedal_Robot.walk(1, 2000, 1);
106     Bipedal_Robot.home();
107     break;
108  case 'g':
109     Bipedal_Robot.home();
110     EEPROM.commit();
111     break;
112  case '2':
```

```

113     Bipedal_Robot.walk(5, 2000, -1);
114     break;
115     case '3':
116         Bipedal_Robot.turn(5, 2000, 1);
117         break;
118     case '4':
119         Bipedal_Robot.turn(5, 2000, -1);
120         break;
121     default:
122         break;
123     }
124 }
125
126 void calib_homePos() {
127     int servoPos[4];
128     servoPos[0] = 90;
129     servoPos[1] = 90;
130     servoPos[2] = 90;
131     servoPos[3] = 90;
132     Bipedal_Robot._moveServos(500, servoPos);
133     Bipedal_Robot.detachServos();
134 }
```

### Code Explanation

Include the header files for controlling the robot. Each time before the servos being controlled, the header files need to be included first.

```

#include <Arduino.h>
#include <Wire.h>
#include <SoftwareSerial.h>
#include <EEPROM.h>
#include "Bipedal_Robot.h"
```

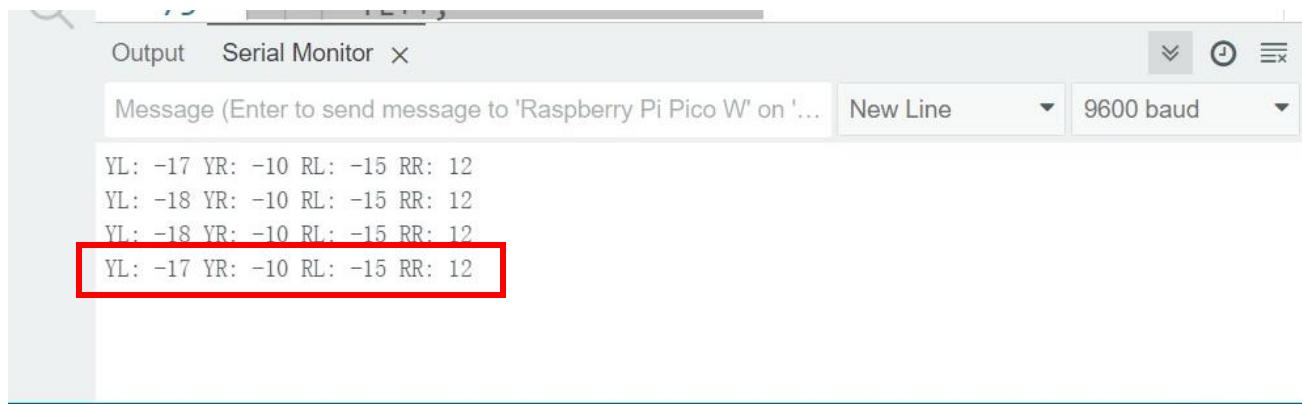
The serial monitor prints the current servo calibration value when receiving data.

```

if ((Serial.available() > (0))) {
    charRead = Serial.read();
    Serial.println("YL: " + String(YL) + " YR: " + String(YR) + " RL: " + String(RL) + " RR: "
+ String(RR));
}
```

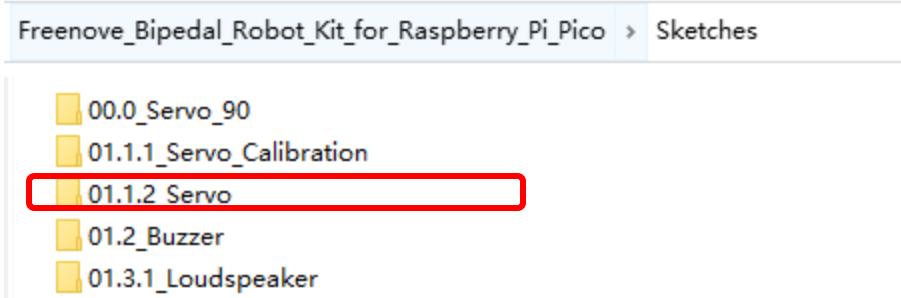
After finish calibration, it will record the final calibration data. Please modify the code according to the final data and upload the code again.

```
int calibratePosition[4] = { -17, -10, -15, 12 };
```



## Sketch

Open “01.1.2\_Servo” in “**Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Sketches**” and double-click “01.1.2\_Servo.ino”.



Please check whether the calibration is completed. If the calibration operation is not performed, please carry out the corresponding calibration steps and upload the code.

Upload the code to Raspberry Pi Pico (W). After the code uploads successfully, the robot will walk forward, backward, turn left and turn right, which repeats in a cycle.

### Code

```

1 #include <Arduino.h>
2 #include <EEPROM.h>
3 #include "Bipedal_Robot.h"
4 Bipedal_Robot Bipedal_Robot;
5
6 #define LeftLeg 10
7 #define RightLeg 12
8 #define LeftFoot 11
9 #define RightFoot 13
10
11 int calibratePosition[4] = { -17, -10, -15, 12 };
12
13 void setup() {
14     Serial.begin(115200);
15     EEPROM.begin(512);
16     Bipedal_Robot.init(LeftLeg, RightLeg, LeftFoot, RightFoot, true); //Set the servo pins
17     // Bipedal_Robot.setTrims(calibratePosition[0], calibratePosition[1], calibratePosition[2],
18     calibratePosition[3]);
19     calib_homePos();
20     Bipedal_Robot.saveTrimsOnEEPROM();
21     EEPROM.commit();
22     Bipedal_Robot.home();
23 }
```

```
24 void loop() {  
25     Serial.println("loop....");  
26     Bipedal_Robot.walk(2, 2000, 1);  
27     Bipedal_Robot.home();  
28     delay(1000);  
29     Bipedal_Robot.walk(2, 2000, -1);  
30     Bipedal_Robot.home();  
31     delay(1000);  
32     Bipedal_Robot.turn(2, 2000, 1);  
33     Bipedal_Robot.home();  
34     delay(1000);  
35     Bipedal_Robot.turn(2, 2000, -1);  
36     Bipedal_Robot.home();  
37     delay(1000);  
38 }  
39 void calib_homePos() {  
40     int servoPos[4];  
41     servoPos[0] = 90;  
42     servoPos[1] = 90;  
43     servoPos[2] = 90;  
44     servoPos[3] = 90;  
45     Bipedal_Robot._moveServos(500, servoPos);  
46     Bipedal_Robot.detachServos();  
47 }
```

#### Code Explanation

In the main loop, the robot moves forward and backward, turns left, and turns right repeatedly.

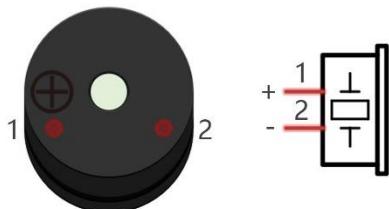
```
Serial.println("loop....");  
Bipedal_Robot.walk(2, 2000, 1);  
Bipedal_Robot.home();  
delay(1000);  
Bipedal_Robot.walk(2, 2000, -1);  
Bipedal_Robot.home();  
delay(1000);  
Bipedal_Robot.turn(2, 2000, 1);  
Bipedal_Robot.home();  
delay(1000);  
Bipedal_Robot.turn(2, 2000, -1);  
Bipedal_Robot.home();  
delay(1000);
```

## 2.2 Buzzer

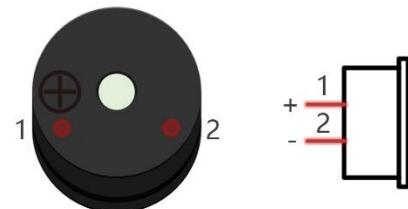
### Buzzer

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

Active buzzer



Passive buzzer



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

#### How to identify active and passive buzzer

1. Usually, there is a label on the surface of active buzzer covering the vocal hole, but this is not an absolute judgment method.
2. Active buzzers are more complex than passive buzzers in their manufacture. There are many circuits and crystal oscillator elements inside active buzzers; all of this is usually protected with a waterproof coating (and a housing) exposing only its pins from the underside. On the other hand, passive buzzers do not have protective coatings on their underside. From the pin holes viewing of a passive buzzer, you can see the circuit board, coils, and a permanent magnet (all or any combination of these components depending on the model).

Active buzzer



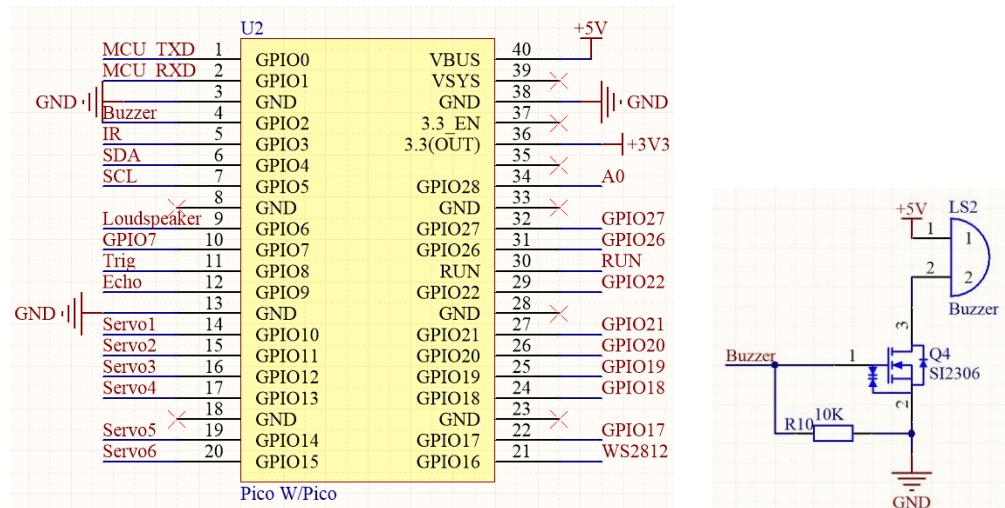
Passive buzzer



The buzzer used in this robot is a passive buzzer that can make sounds with different frequency.

## Schematic

As we can see, the buzzer is controlled by GPIO2 of Raspberry Pi Pico W. When the buzzer receives PWM signal, NPN will be activated to make the buzzer sound. When the buzzer receives no signal, it will be controlled at low level by R2 and NPN will not be activated, so the buzzer will not make any sounds.



## Sketch

In this section, we will test the buzzer to make it sound like an alarm.

Open “01.2\_Buzzer” folder in the “Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Sketches”, and then double-click “01.2\_Buzzer.ino”.

Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico > Sketches

- 00.0\_Servo\_90
- 01.1\_Servo
- 01.2\_Buzzer**
- 01.3.1\_Loudspeaker
- 01.3.2\_Music
- 01.4\_Battery\_level
- 01.5\_Matrix
- 01.6\_WS2812
- 02.1\_Ultrasonic\_Ranging
- 02.2\_Ultrasonic\_Ranging\_Robot

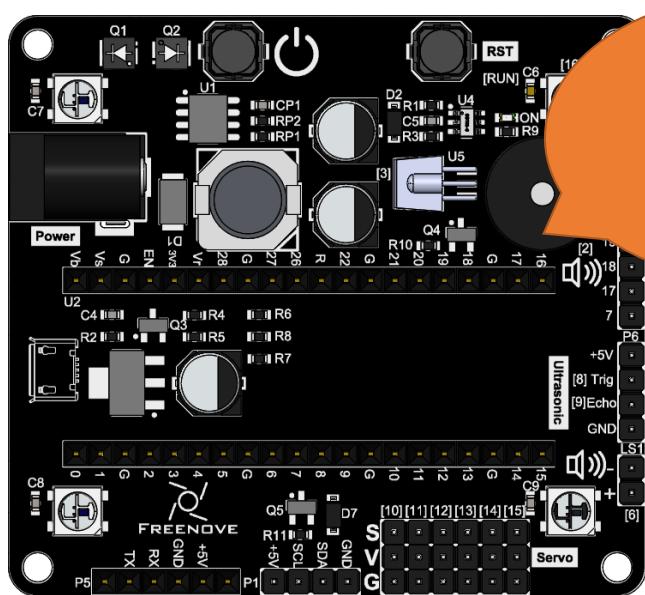
## Code

```

1 #include "Freenove_Robot_For_Pico_W.h"
2
3 void setup() {
4     Buzzer_Setup();      //Buzzer initialization function
5     Buzzer_Alert(4, 3); //Control the buzzer to sound
6 }
7
8 void loop() {
9     delay(1000);
10}

```

After the program is downloaded to Raspberry Pi Pico (W), the buzzer emits four short beeps, repeating for three times.



## Code Explanation

Configure the PWM of Raspberry Pi Pico (W) to associate it with GPIO2 pin to control the buzzer to make sounds.

	void Buzzer_Setup(void);	//Buzzer initialization
--	--------------------------	-------------------------

Control the buzzer to sound regularly. Parameter beat represents the number of times the buzzer sounds in each sounding cycle and rebeat represents how many cycles the buzzer sounds.

	void Buzzer_Alert(int beat, int rebeat); //Buzzer alarm function
--	--

## 2.3 Loudspeaker

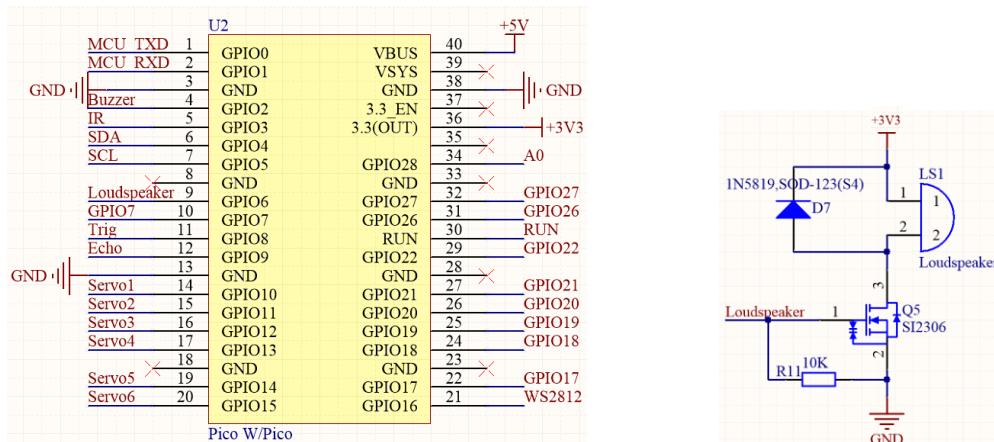
### Loudspeaker

Besides the buzzer, we still have a loud speaker as sound device, which is directly controlled by the Raspberry Pi Pico. However, please note that its sound quality is not so good. If you want better sound quality, you can connect audio converter module to spare GPIO pins for extended use.

In this project, we use the speaker to play a piece of music. If you just use the speaker to make simple sounds, you can refer to the example of the buzzer and modify the pins accordingly.

### Schematic

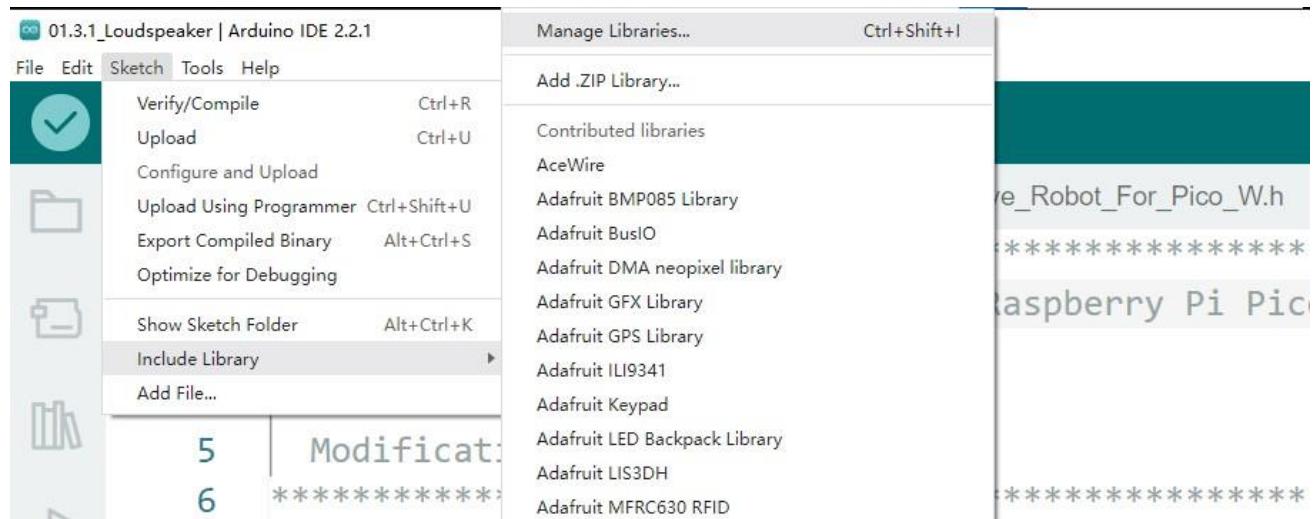
As can be seen, the robot plays audio via GPIO6 of Raspberry Pi Pico (W).



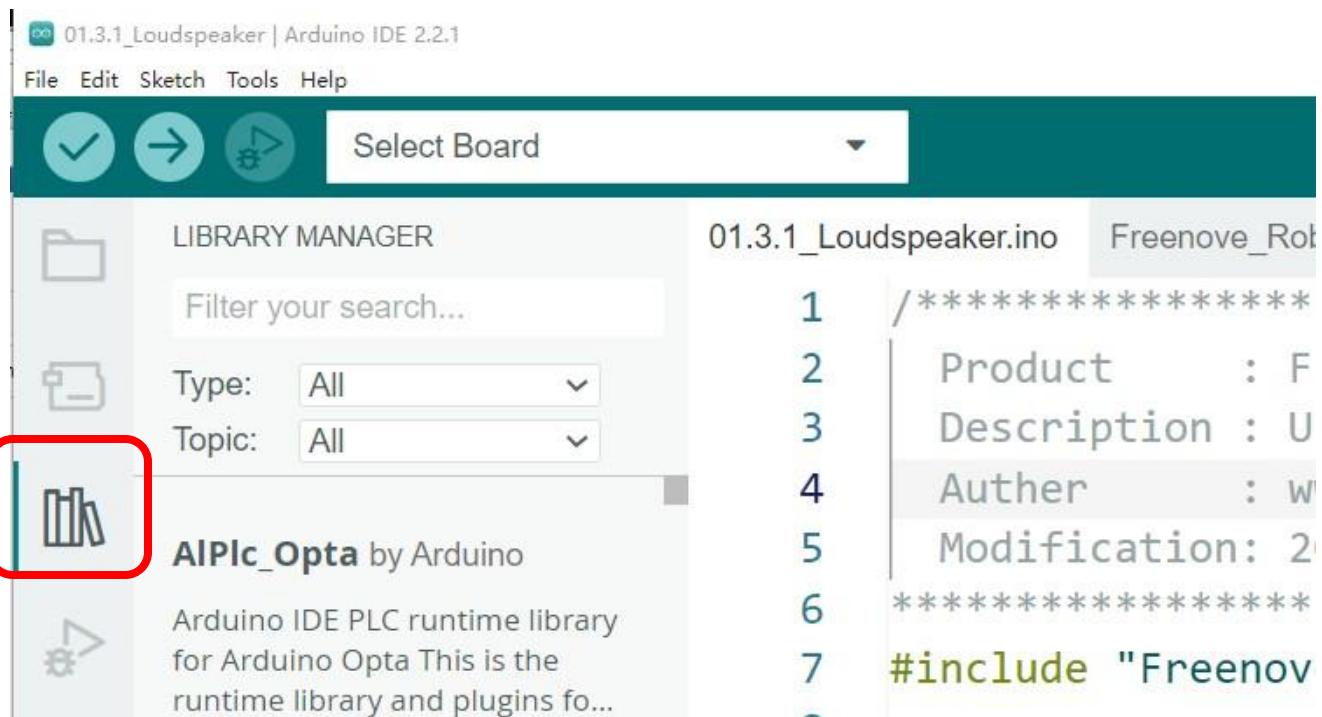
## Add libraries

### Method 1

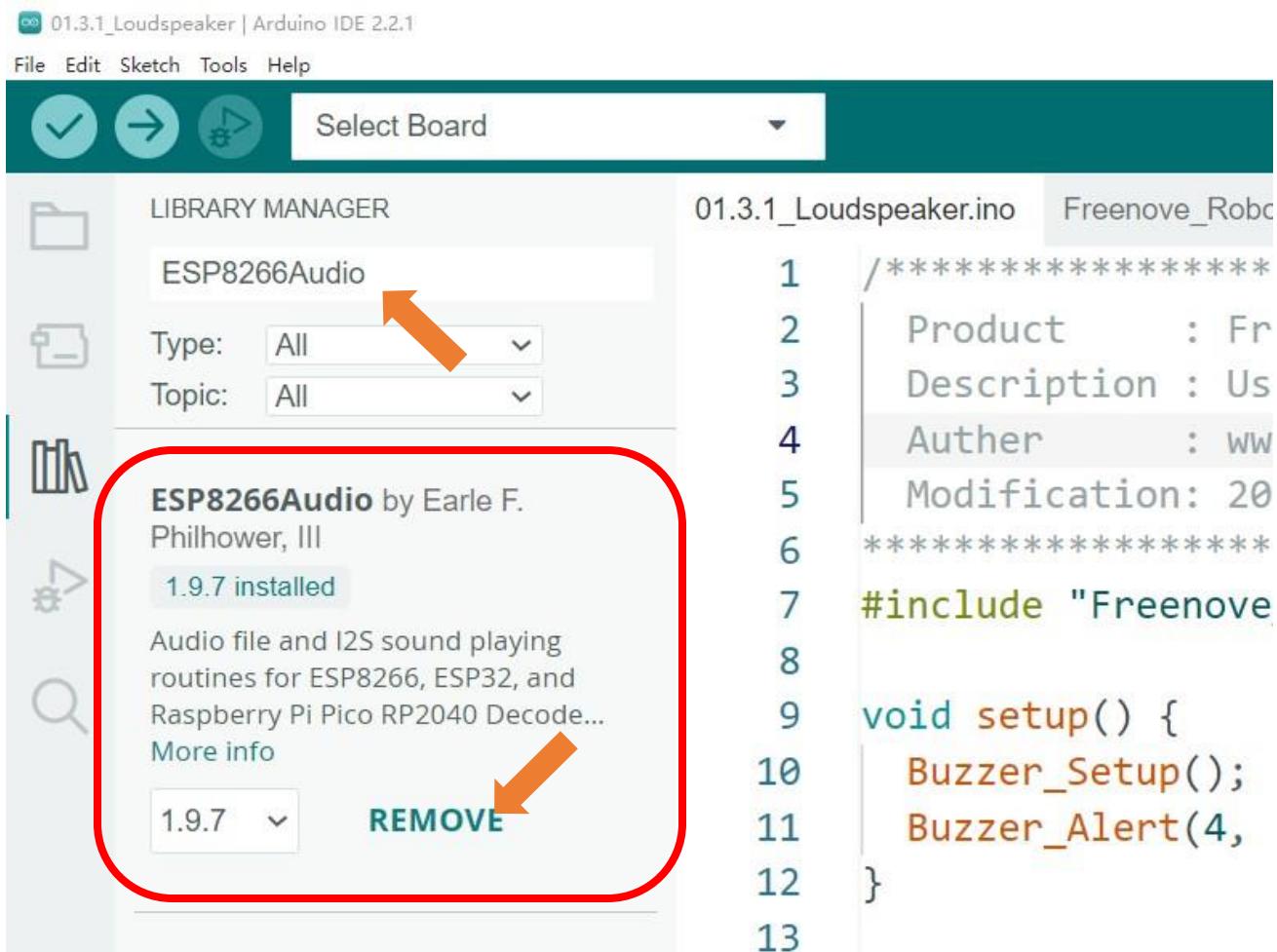
Open Arduino IDE, click Sketch on Menu bar ->Include Library -> Manage Libraries.



Or click the shortcut icon on the left.



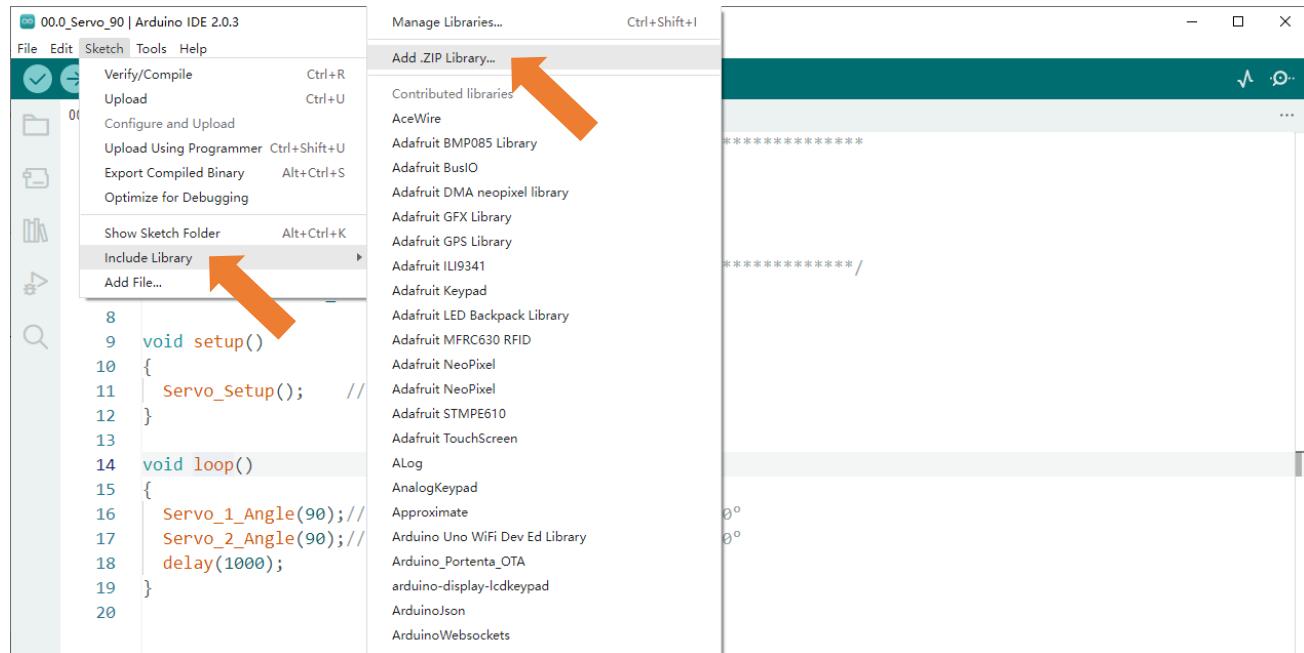
There is an input field on the right top of the pop-up window. Enter ESP8266Audio there and click to install the library boxed in the following figure.



Wait for the installation to finish.

## Method 2

Open Arduino IDE, click Sketch on Menu bar ->Include Library ->Add .ZIP library.



On the pop-up window, select **ESP8266Audio.zip** in Libraries folder under

“Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Libraries”, and then click Open.

Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico > Libraries

- Adafruit\_NeoPixel.zip
- ESP8266Audio.zip**
- Freenove\_VK16K33\_Lib.zip
- IRremote.zip

## Sketch

### 01.3.1\_Loudspeaker

In this section, we use GPIO6 of the Raspberry Pi Pico (W). This example is the same as the buzzer example, so the result is the same.

Open “01.3.1\_Loudspeaker” folder in “**Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Sketches**” and then double-click “01.3.1\_Loudspeaker.ino”.

Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico > Sketches

- 00.0\_Servo\_90
- 01.1\_Servo
- 01.2\_Buzzer
- 01.3.1\_Loudspeaker**
- 01.3.2\_Music
- 01.4\_Battery\_level
- 01.5\_Matrix
- 01.6\_WS2812
- 02.1\_Ultrasonic\_Ranging
- 02.2\_Ultrasonic\_Ranging\_Robot

### Code

```
1 #include "Freenove_4WD_Car_For_Pico_W.h"
2
3 void setup() {
4     Buzzer_Setup();      //Buzzer initialization function
5     Buzzer_Alert(4, 3); //Control the buzzer to sound
6 }
7
8 void loop() {
9     delay(1000);
10 }
```

### Code Explanation

This code is the same as the buzzer code, except for the different GPIO used. In the buzzer example, we use GPIO 2 and in this one, we use GPIO 6.

```
#define PIN_BUZZER 6
```



### 01.3.2\_Music

In this section, we will use GPIO6t of the Raspberry Pi Pico to play audio. After the code upload successfully, it will play a piece of music.

Open “01.3.2\_Music” folder in “**Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Sketches**” and then double-click “01.3.2\_Music.ino”.

#### Install the PicoLittleFS tool

The latest Arduino IDE has supported LittleFS plugins.

The steps to install PicoLittleFS is as follows:

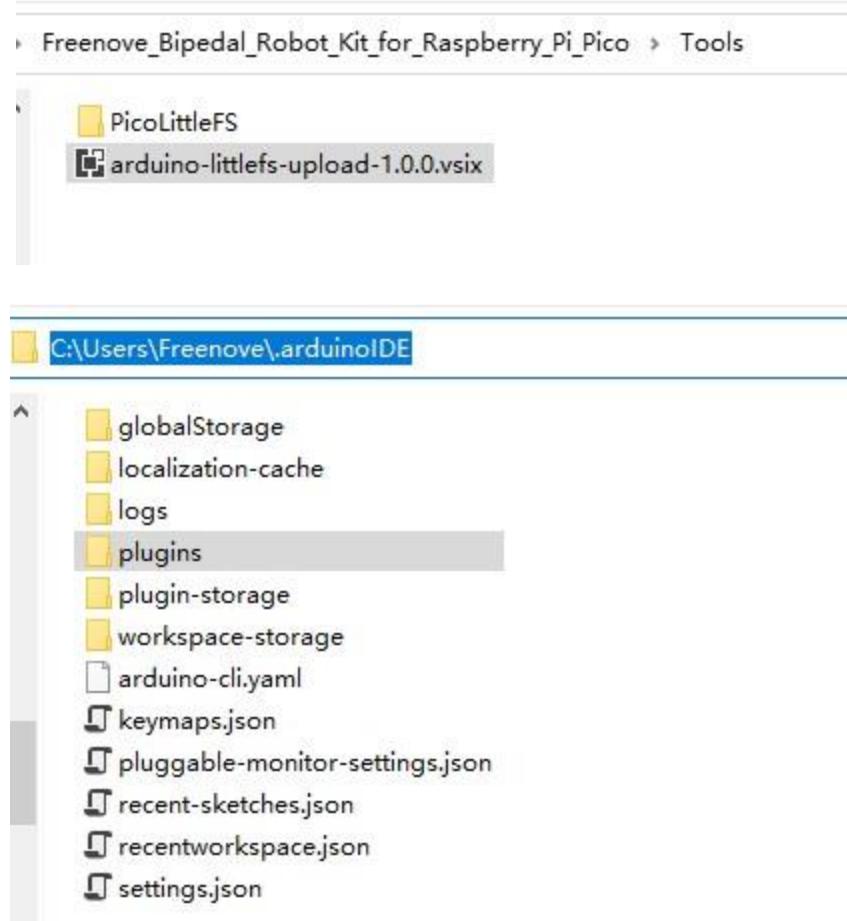
**Copy** the file **arduino-littlefs-upload-1.0.0.vsix** under the directory

“**Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Tools**” to the computer’s directory

**~/arduinoIDE/plugins/**

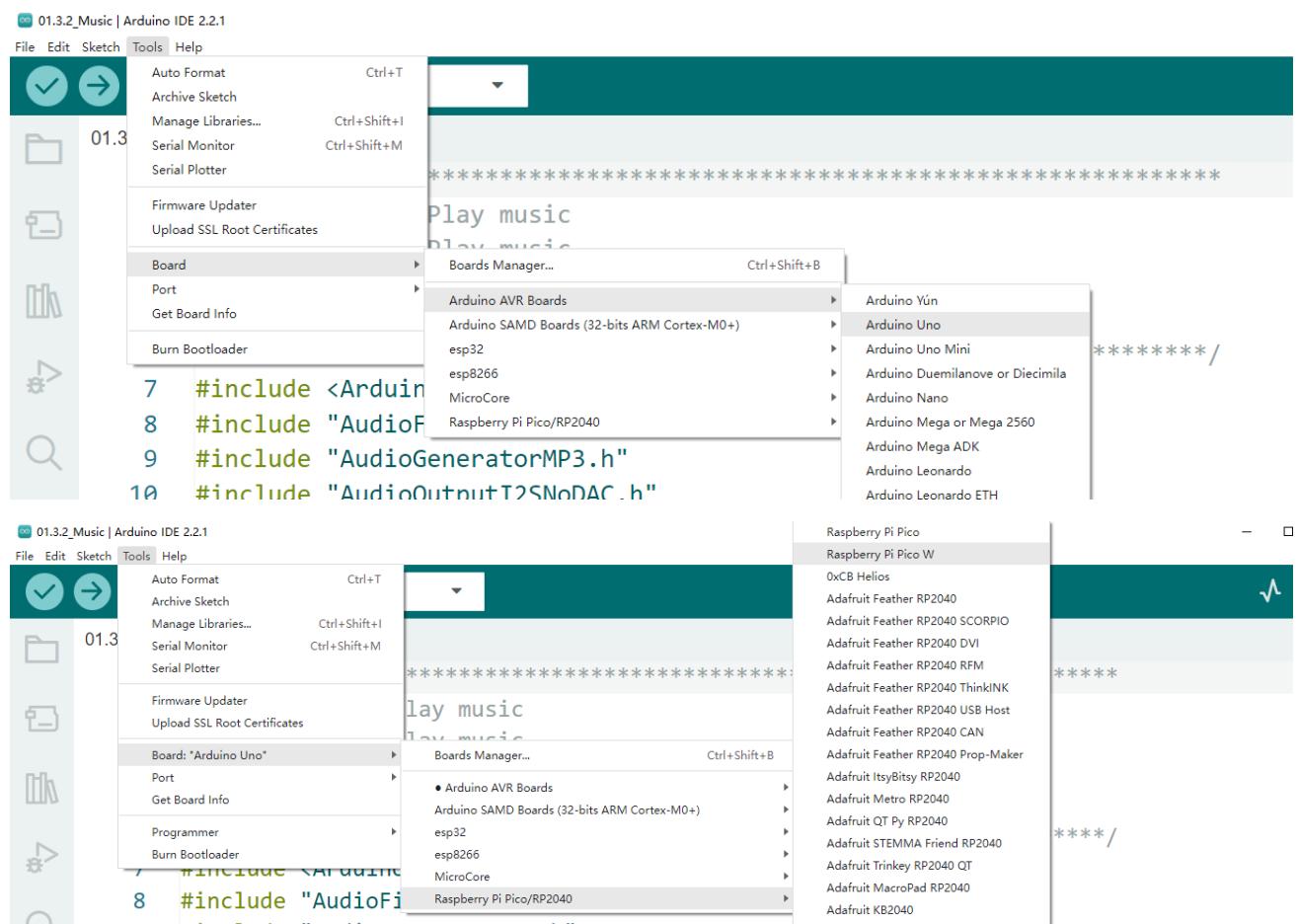
If there is no a folder name **plugins** in your computer, please create the folder before copying the file.

After copying the file, restart Arduino IDE.

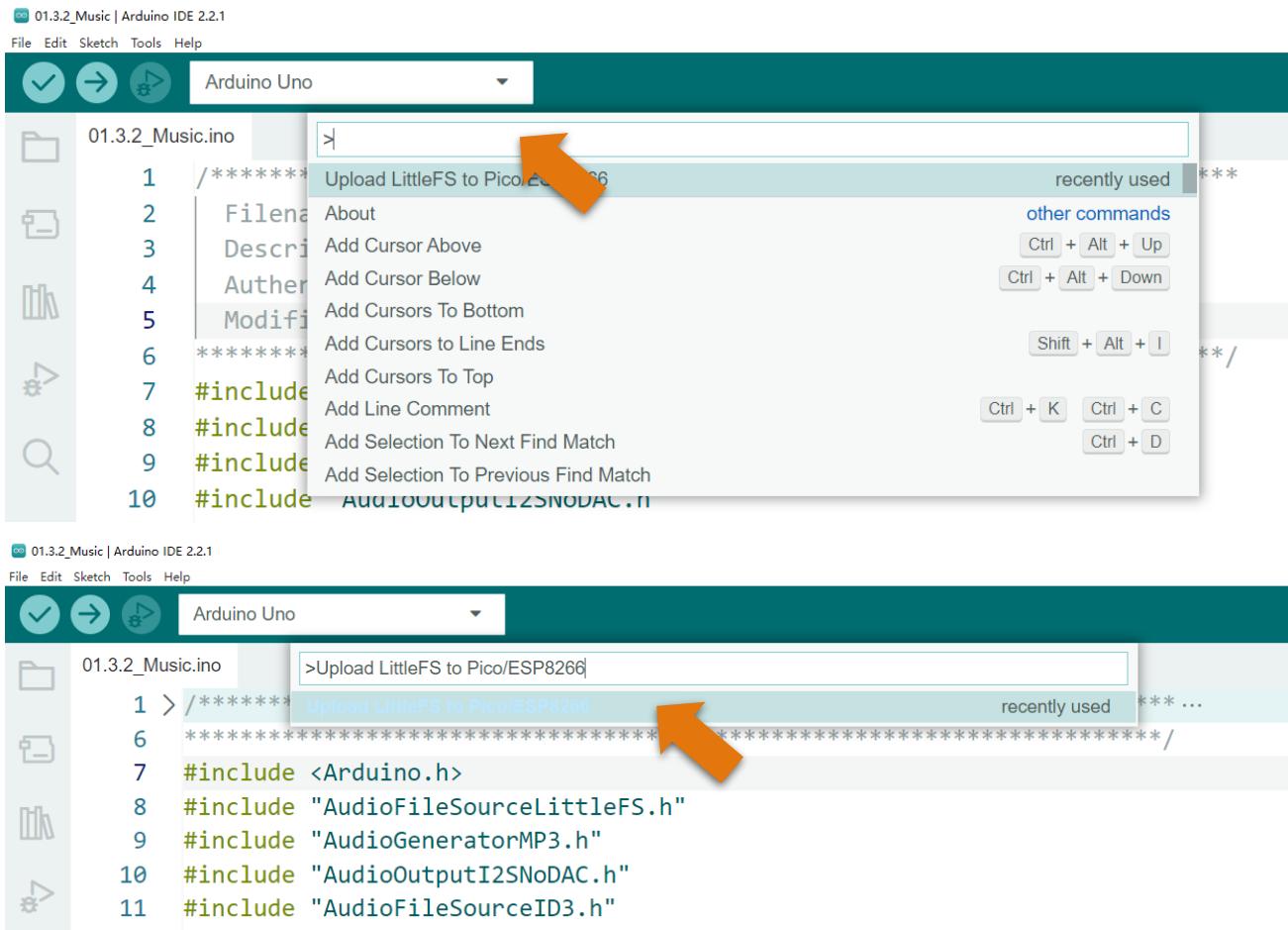




The sketch opened with the start of the Arduino IDE may be corrupted, which can lead to code uploading failure. To address this issue, you can change the board selection (switching to any board), and then select back the pico board. Alternatively, you can close the opened sketch and reopen it.



Here is how to use the PicoLittleFS tool, press [Ctrl]+[Shift]+[P] simultaneously, enter ***Upload LittleFS to Pico/ESP8266*** on the input field.

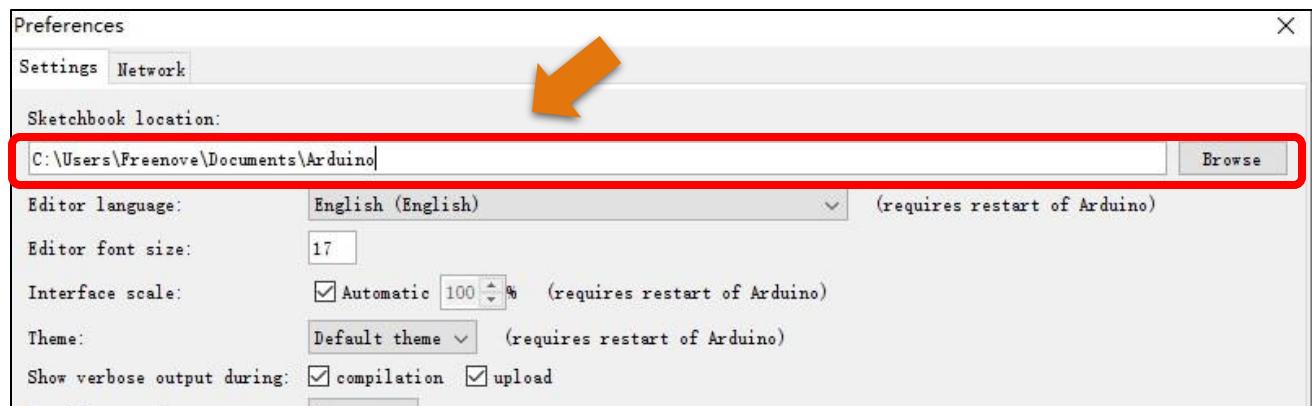


If your Arduino IDE is an old version one, like Arduino 1.x.x, please refer to the following steps to install the PicoLittleFS tool.

First, open the Arduino IDE, and then click File in Menus and select Preferences.



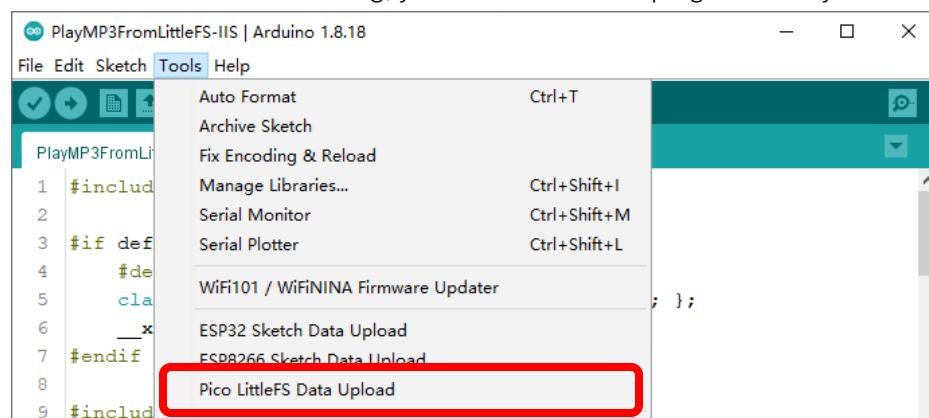
Find the Arduino IDE environment directory location.



Copy the tools folder in the code folder to your Sketchbook location.



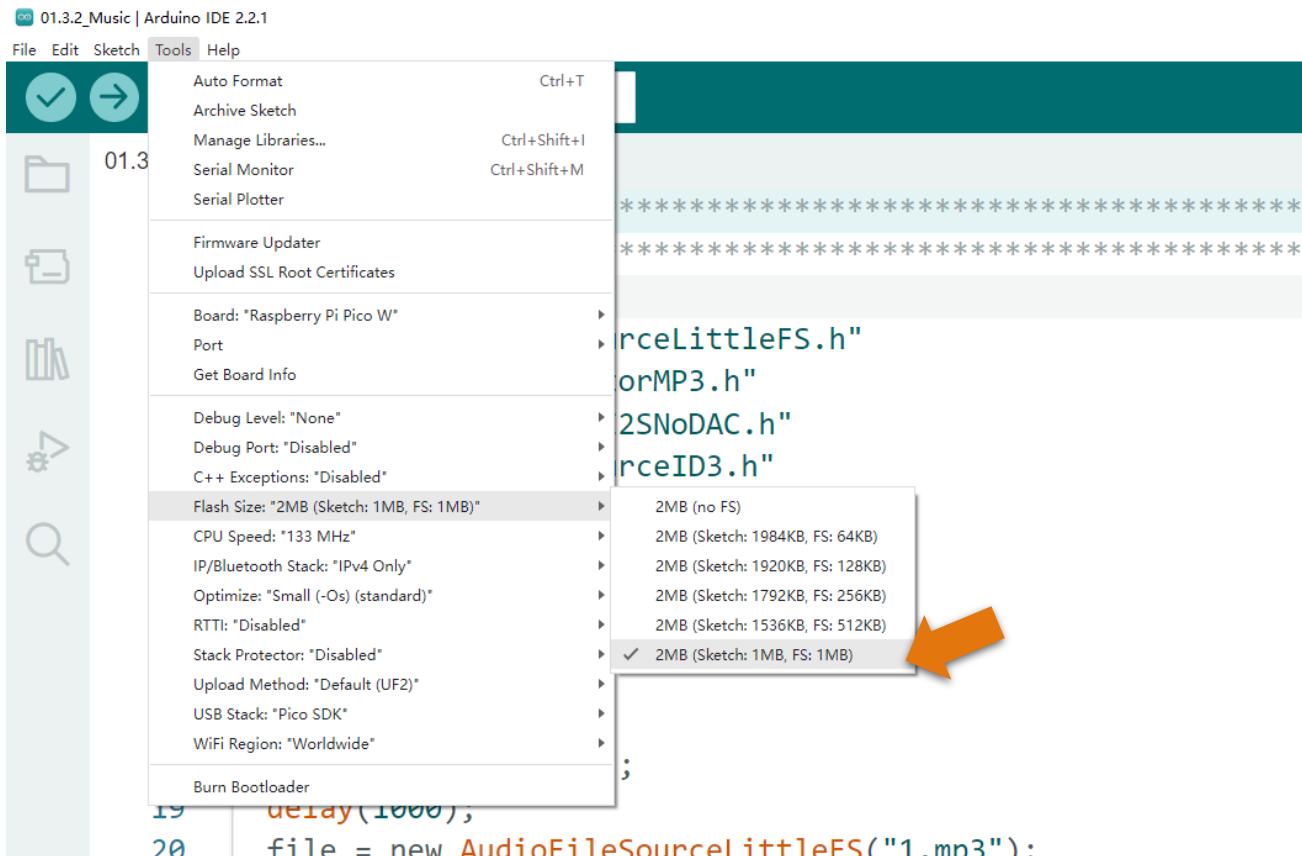
Finally, restart the Arduino IDE. After restarting, you can see that the plug-in already exists in the interface.



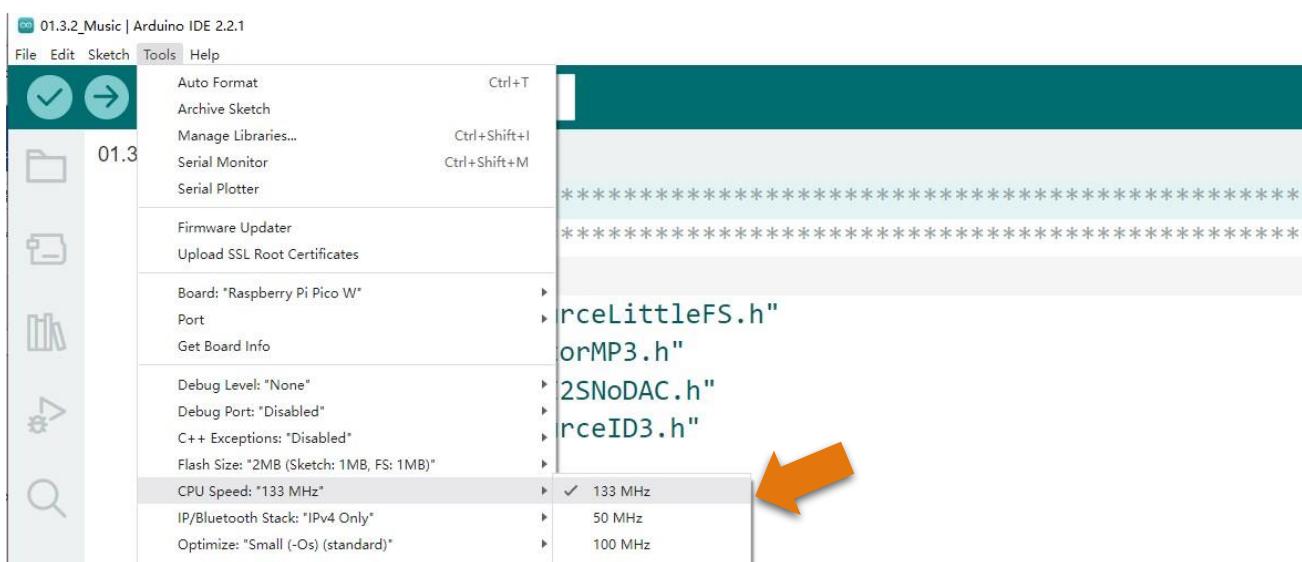
### Upload music

Pico of Raspberry Pie has 2M Flash space. Generally, Arduino mode allocates it to the code area. Therefore, before starting, we need to modify the configuration of Flash Size.

Open Arduino, select Tools from the menu bar, select Flash Size, and allocate 1MB of Flash space to store codes and 1MB to store audio files.

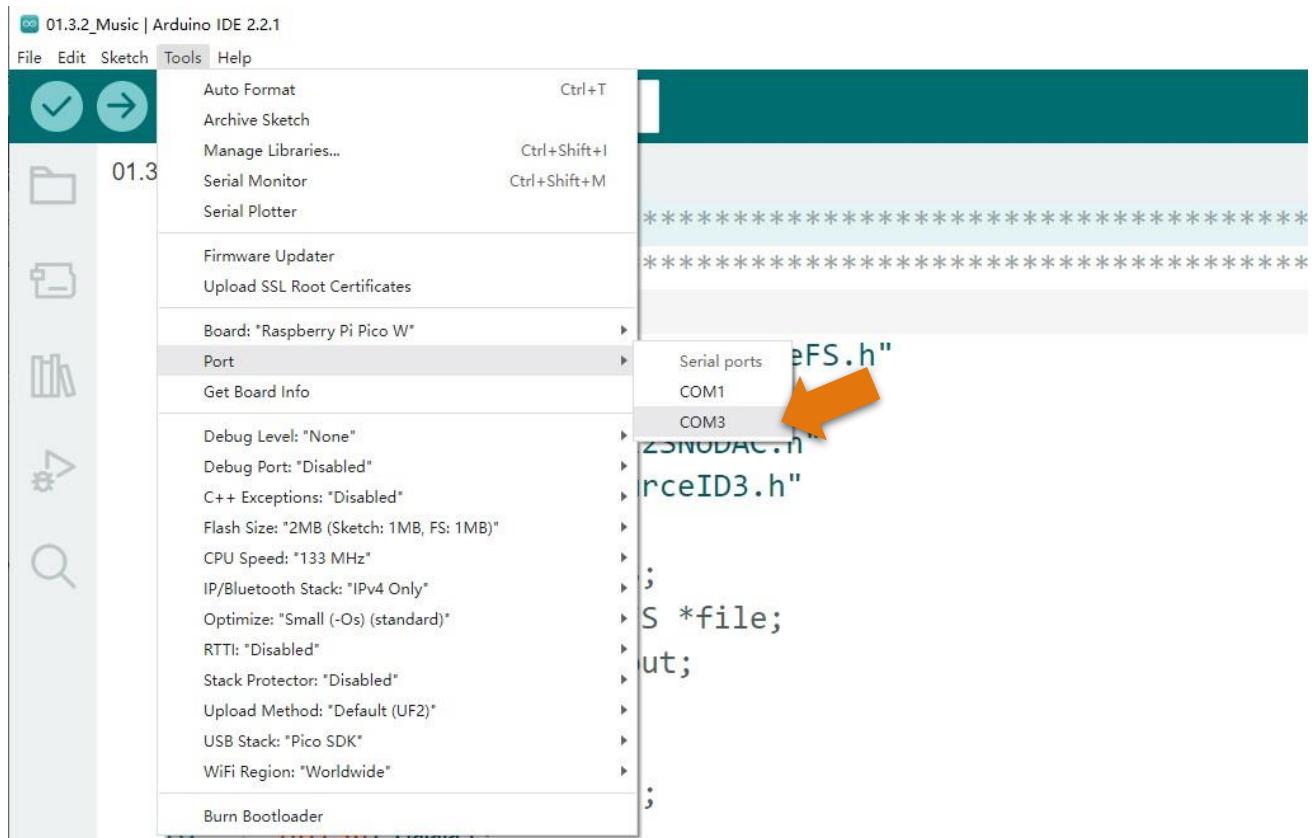


Make sure the CPU Speed of Raspberry Pie is 133MHz. If the frequency is too low, the audio decoding speed may be too slow and the audio playback may not be continuous.

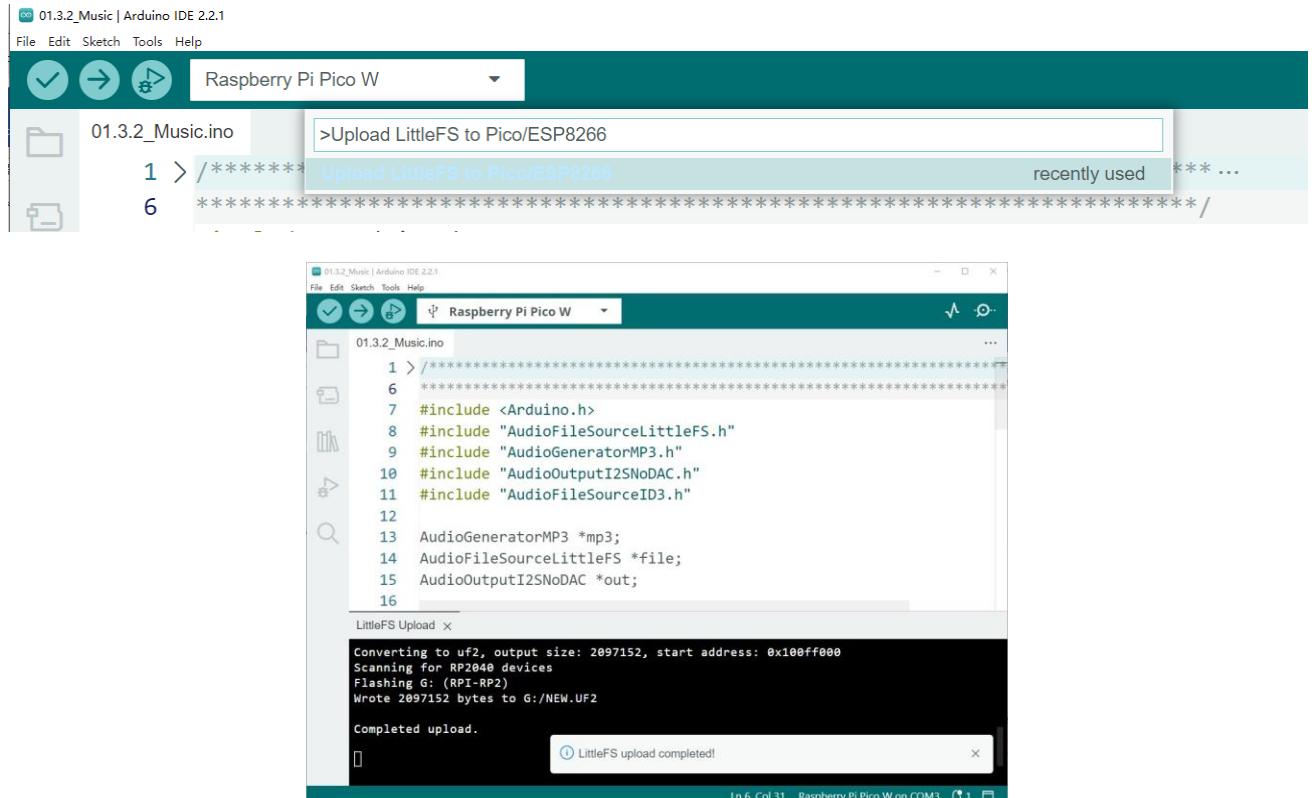


Select the correct port.

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Press [Ctrl]+[Shift]+[P] simultaneously. Enter **Upload LittleFS to Pico/ESP8266** on the input field, click Upload LittleFS to Pico/ESP8266, and wait for it to finish.



Check the code file and audio file. We create a folder named data under the same level directory of the code file, and place the audio file directly in this folder.

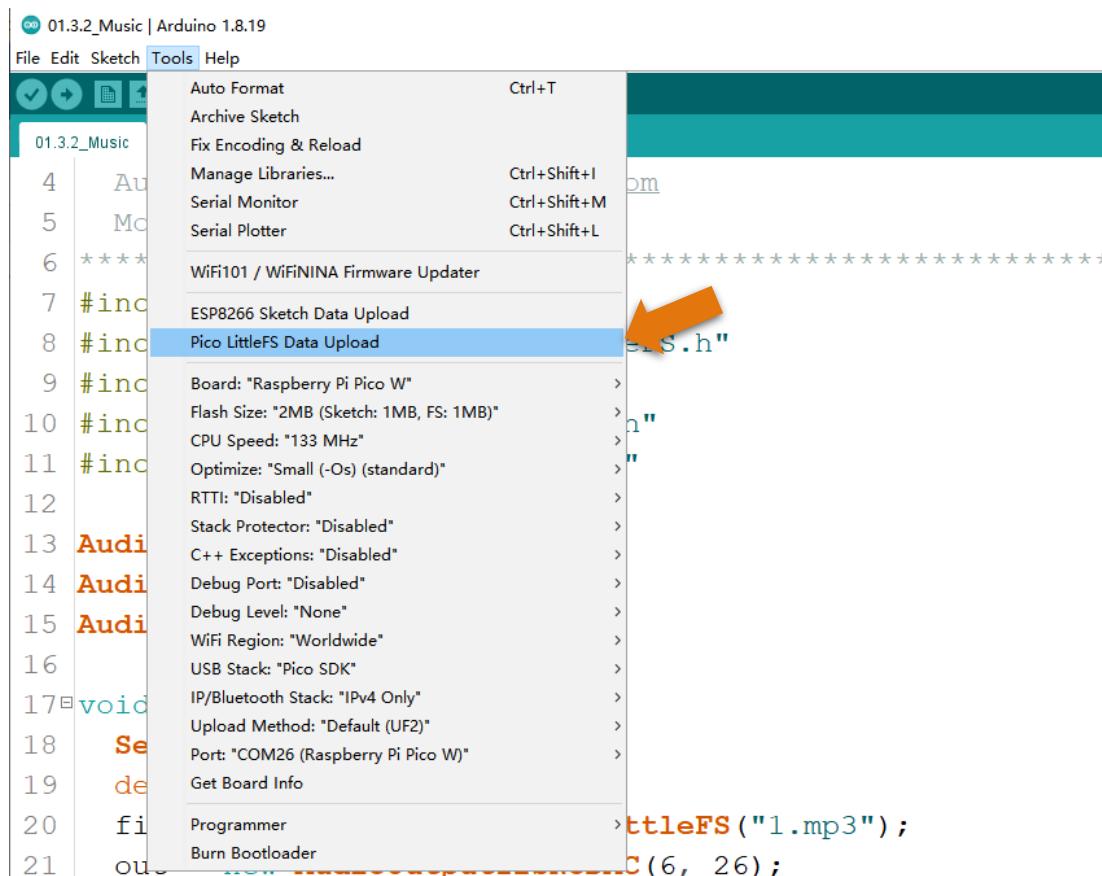
Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico → Sketches → 01.3.2\_Music



- Note:
1. The name of the data folder cannot be changed, otherwise the plug-in cannot be used to upload audio files to Pico.
  2. The number of audio files in the data folder is unlimited, but the total size cannot exceed 1MB. If the file upload fails, please check whether the data folder size exceeds the range.

If your Arduino IDE is an old version one, like Arduino 1.x.x, please upload the music as below:

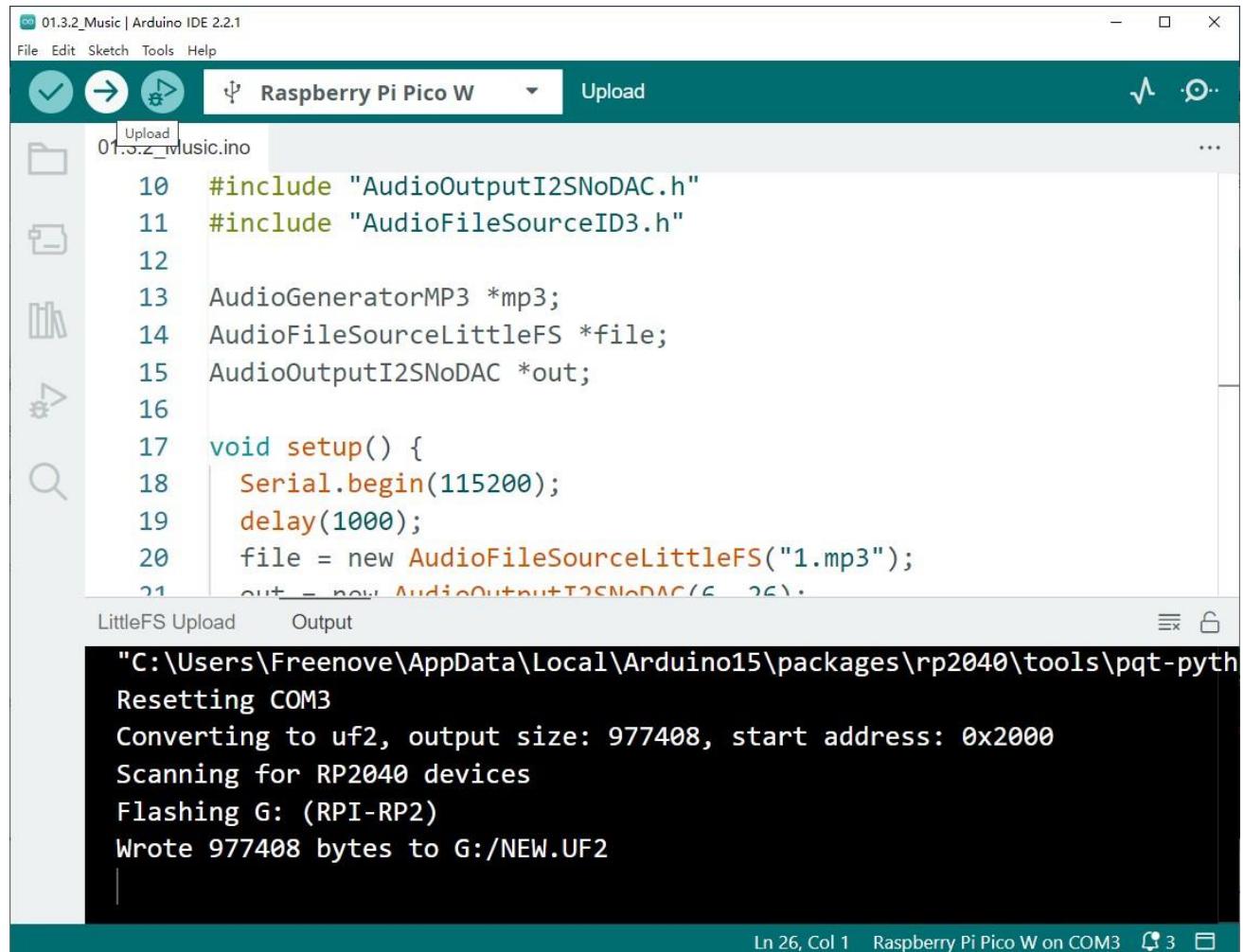
Click Arduino IDE Tools and click following content:



```
LittleFS Image Uploaded
[LittleFS] size      : 1024KB
[LittleFS] page      : 256
[LittleFS] block     : 4096
/1.mp3
/Hello.mp3
[LittleFS] upload    : C:\Users\Freenove\AppData\Local\Temp\arduino_build_527188/01.3.2_Music.mk
[LittleFS] address   : 269479936
[LittleFS] swerrial  : COM26
[LittleFS] python    : C:\Users\Freenove\AppData\Local\Arduino15\packages\rp2040\tools\pqt-pytho
[LittleFS] uploader   : C:\Users\Freenove\AppData\Local\Arduino15\packages\rp2040\hardware\rp2040\00

Resetting COM26
Converting to uf2, output size: 2097152, start address: 0x100ff000
Scanning for RP2040 devices
Flashing G: (RPI-RP2)
Wrote 2097152 bytes to G:/NEW.UF2
```

After the music uploads successfully, click the upload button to upload the sketch to Pico (W). The compilation of this sketch takes longer time, please wait with patience.



The effect of this example is that the speaker plays a piece of audio once. After the code finishes uploading, the speaker will play the audio file you uploaded.

[Code](#)

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

```
2 #include "AudioFileSourceLittleFS.h"
3 #include "AudioGeneratorMP3.h"
4 #include "AudioOutputI2SNoDAC.h"
5 #include "AudioFileSourceID3.h"
6
7 AudioGeneratorMP3 *mp3;
8 AudioFileSourceLittleFS *file;
9 AudioOutputI2SNoDAC *out;
10
11 void setup() {
12     Serial.begin(115200);
13     delay(1000);
14     file = new AudioFileSourceLittleFS("1.mp3");
15     out = new AudioOutputI2SNoDAC(6);
16     out->SetGain(3); //Volume Setup
17     mp3 = new AudioGeneratorMP3();
18     mp3->begin(file, out);
19 }
20 int a = 0;
21
22 void loop() {
23     Serial.printf("loop1..\n");
24     if (mp3->isRunning()) {
25         if (!mp3->loop()) {
26             mp3->stop();
27             Serial.printf("Hello done\n");
28             delete file;
29             delete mp3;
30             mp3 = new AudioGeneratorMP3();
31
32         }
33     } else {
34         Serial.printf("MP3 done\n");
35         pinMode(6, OUTPUT);
36         digitalWrite(6, LOW);
37     }
38 }
```

### Code Explanation

Set the audio file to be played.

```
file = new AudioFileSourceLittleFS("1.mp3");
```

Set the volume of the audio at the range of 0.0-4.0.

```
out->SetGain(3); //Volume Setup
```

Check whether the audio is being played.

```
if (mp3->isRunning()) {}
```

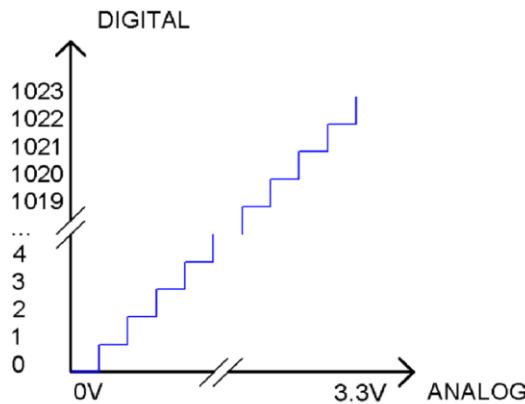
Check whether the audio has finished playing. If so, clear the audio file.

```
if (!mp3->loop()) {  
    mp3->stop();  
    Serial.printf("Hello done\n");  
    delete file;  
    delete mp3;  
    mp3 = new AudioGeneratorMP3();  
  
}
```

## 2.4 ADC Module

### ADC

ADC is an electronic integrated circuit used to convert analog signals such as voltages to digital or binary form consisting of 1s and 0s. The range of our ADC on Raspberry Pi Pico (W) is 10 bits, that means the resolution is  $2^{10}=1024$ , and it represents a range (at 3.3V) will be divided equally to 1024 parts. The range of analog values corresponds to ADC values. So the more bits the ADC has, the denser the partition of analog will be and the greater the precision of the resulting conversion.



Subsection 1: the analog in range of 0V --- 3.3/1023 V corresponds to digital 0;

Subsection 2: the analog in range of 3.3/1023 V --- 2\*3.3 /1023V corresponds to digital 1;

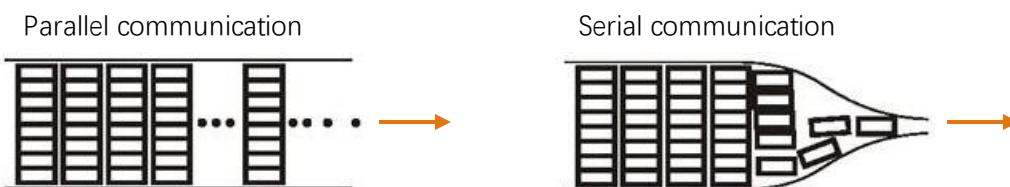
The following analog will be divided accordingly.

The conversion formula is as follows:

$$ADC\ Value = \frac{\text{Analog\ Voltage}}{3.3} * 1023$$

### Serial Communication

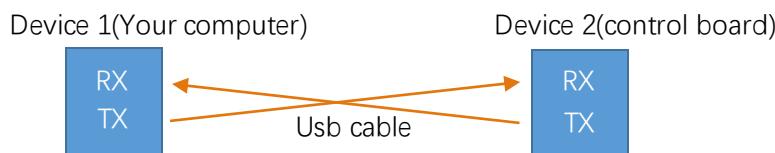
Serial communication uses one data cable to transfer data one bit by another in turn. Parallel communication means that the data is transmitted simultaneously on multiple cables. Serial communication takes only a few cables to exchange information between systems, which is especially suitable for computers to computers, long distance communication between computers and peripherals. Parallel communication is faster, but it requires more cables and higher cost, so it is not appropriate for long distance communication.



Serial communication generally refers to the Universal Asynchronous Receiver/Transmitter (UART), which is commonly used in electronic circuit communication. It has two communication lines; one is responsible for

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sending data (TX line) and the other for receiving data (RX line). The serial communication connections of two devices use is as follows:

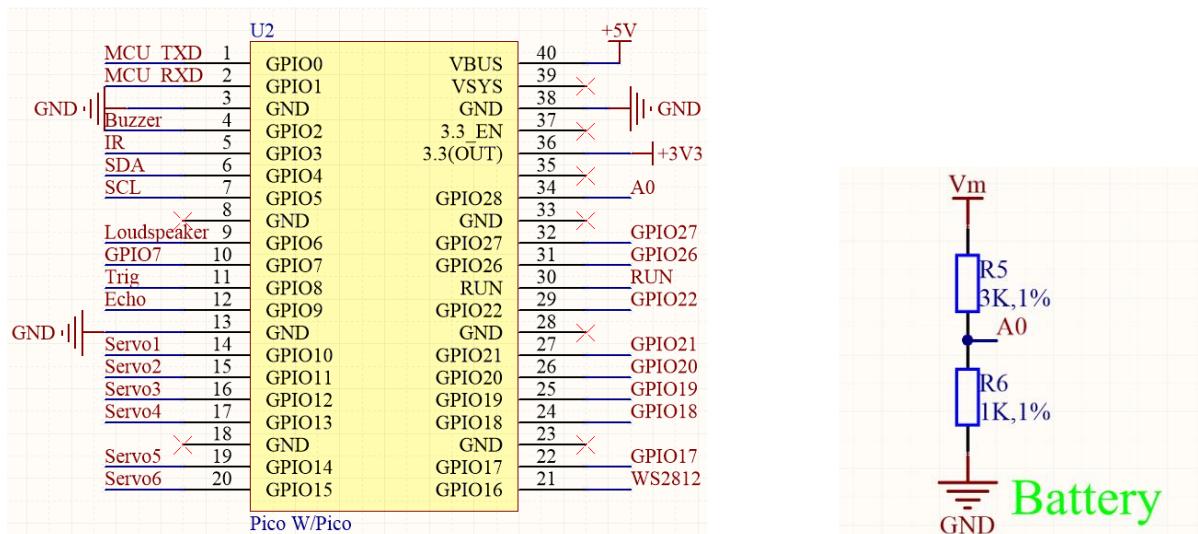


For serial communication, the **baud rate in both sides must be the same**. The baud rates commonly used are 9600 and 115200.

Computer identifies serial devices connected to your computer as COMx. We can use the Serial Monitor window of Arduino Software to communicate with Freenove control board.

## Schematic

As we can see, the robot reads the voltage of the batteries through GPIO28 of Raspberry Pi Pico (W).



The voltage acquisition range of GPIO28 on the Raspberry Pi Pico W is 0-3.3V. However, the robot is powered with a 9V battery, and the voltage can reach 9.5V when fully charged, far exceeding the acquisition range of the pico (W). Therefore, a voltage divider circuit consisted of R3 and R4 is designed here. After passing the circuit, the voltage of A0 is about one quarter of the battery voltage. Say the battery voltage is 9.5V, the voltage of A0 is  $9.5/4 = 2.375V$ , which is within the voltage acquisition range of GPIO28.

## Sketch

In this section, we will use GPIO28 of Raspberry Pi Pico (W) to read the voltage value of the batteries and print it on serial monitor. Open “01.4\_Battery\_level” folder in “Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Sketches” and then double-click “01.4\_Battery\_level.ino”.

Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico > Sketches

- 00.0\_Servo\_90
- 01.1\_Servo
- 01.2\_Buzzer
- 01.3.1\_Loudspeaker
- 01.3.2\_Music
- 01.4\_Battery\_level**
- 01.5\_Matrix
- 01.6\_WS2812
- 02.1\_Ultrasonic\_Ranging
- 02.2\_Ultrasonic\_Ranging\_Robot

### Code

```

1 #include "Freenove_Robot_For_Pico_W.h"
2
3 void setup() {
4     Serial.begin(115200); //Set the Serial Baud rate
5 }
6 void loop() {
7     Serial.print("Battery ADC : ");
8     Serial.println(Get_Battery_Voltage_ADC()); //Gets the battery ADC value
9     Serial.print("Battery Voltage : ");
10    Serial.print(Get_Battery_Voltage()); //Get the battery voltage value
11    Serial.println("V");
12    delay(300);
13 }
```

### Code Explanation

Activate the serial port and set the baud rate to 115200.

4	Serial.begin(115200); //Set the Serial Baud rate
---	--

Get ADC sampling value of GPIO28 and return it. The ADC has a range of 0-1023. The voltage range collected is 0-3.3V.

	int Get_Battery_Voltage_ADC(void); //Gets the battery ADC value
--	---

Calculate the voltage of batteries and return it.

	float Get_Battery_Voltage(void); //Get the battery voltage value
--	--

The default battery voltage coefficient is 3. Users can modify it by calling this function.

	void Set_Battery_Coefficient(float coefficient); //Set the partial pressure coefficient
--	---

Click “Upload” to upload the code to Pico (W). After uploading successfully, click Serial Monitor, Set baud rate to 115200.

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

- Title Bar:** 01.4\_Battery\_Level | Arduino IDE 2.2.1
- Toolbar:** File, Edit, Sketch, Tools, Help, Upload (highlighted with an orange callout), and a refresh icon.
- Sketch Area:** Displays the code for "Battery\_Level.ino". The code prints battery ADC and voltage values every 300ms.

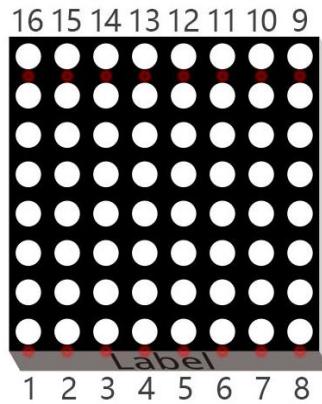
```
loop() {
    Serial.print("Battery ADC : ");
    Serial.println(Get_Battery_Voltage_ADC()); //Gets the battery
    16   Serial.print("Battery Voltage : ");
    17   Serial.print(Get_Battery_Voltage());      //Get the battery voltage value
    18   Serial.println("V");
    19   delay(300);
  20 }
  21
```
- Serial Monitor Area:** Shows the output window with a red border around it. It displays the following text:

```
Battery Voltage : 9.35V
Battery ADC : 736
Battery Voltage : 9.40V
Battery ADC : 738
Battery Voltage : 9.34V
Battery ADC : 733
Battery Voltage : 9.39V
Battery ADC : 734
Battery Voltage : 9.40V
Battery ADC : 735
Battery Voltage : 9.35V
```
- Serial Monitor Settings:** A dropdown menu next to the baud rate selector is highlighted with an orange callout, labeled "Serial Monitor". The baud rate is set to 115200 baud.

## 2.5 LED Matrix

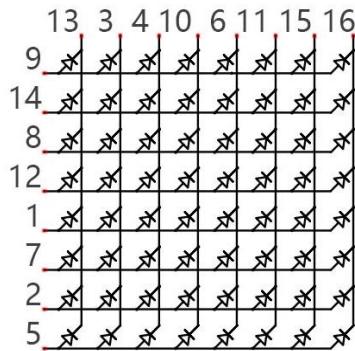
### LED Matrix

An LED matrix is a rectangular display module that consists of a uniform grid of LEDs. The following is an 8X8 monochrome LED matrix containing 64 LEDs (8 rows by 8 columns).

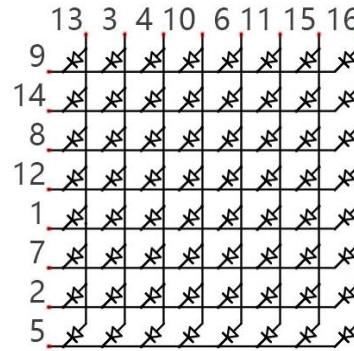


In order to facilitate the operation and reduce the number of ports required to drive this component, the positive poles of the LEDs in each row and negative poles of the LEDs in each column are respectively connected together inside the LED matrix module, which is called a common anode. There is another arrangement type. Negative poles of the LEDs in each row and the positive poles of the LEDs in each column are respectively connected together, which is called a common cathode.

Connection mode of common anode

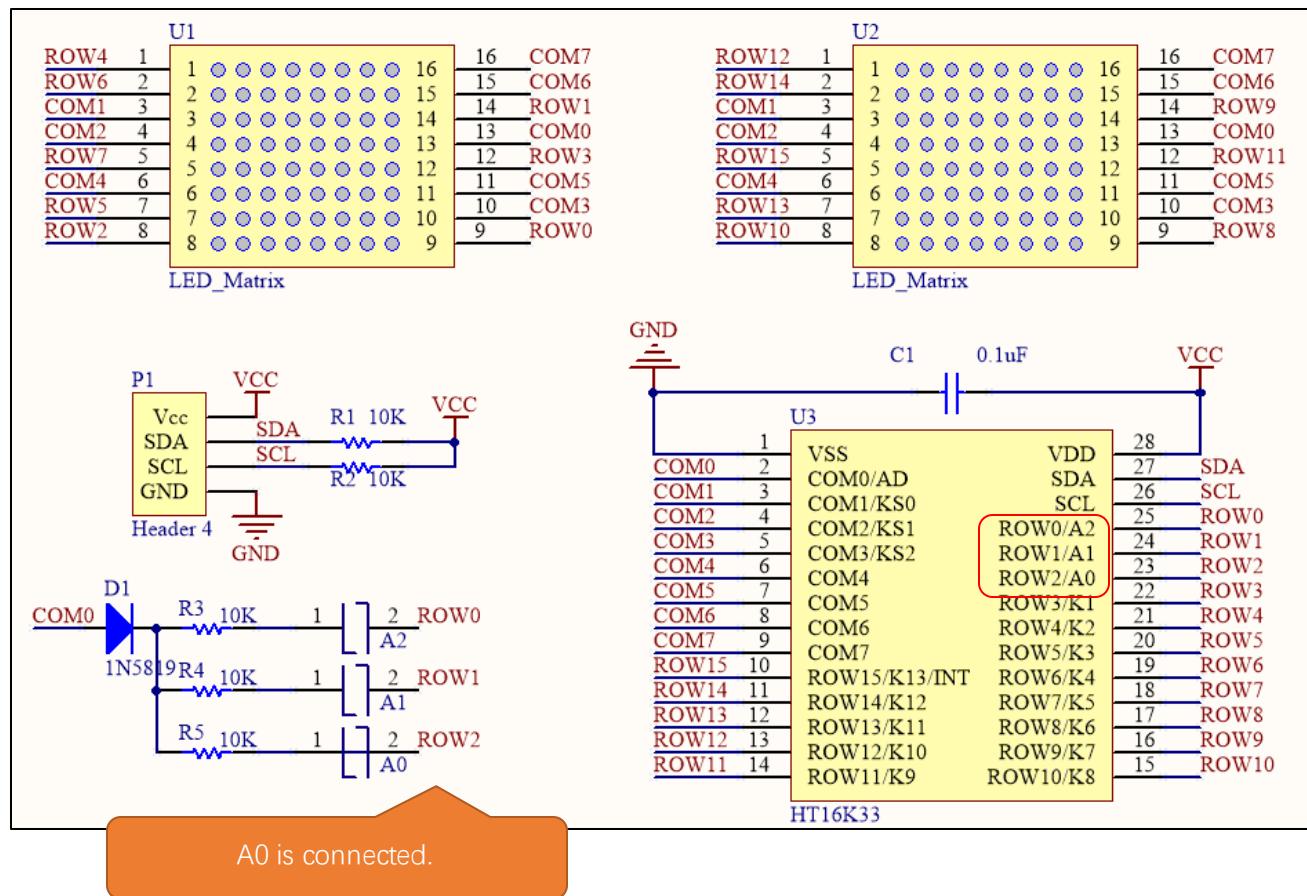


Connection mode of common cathode

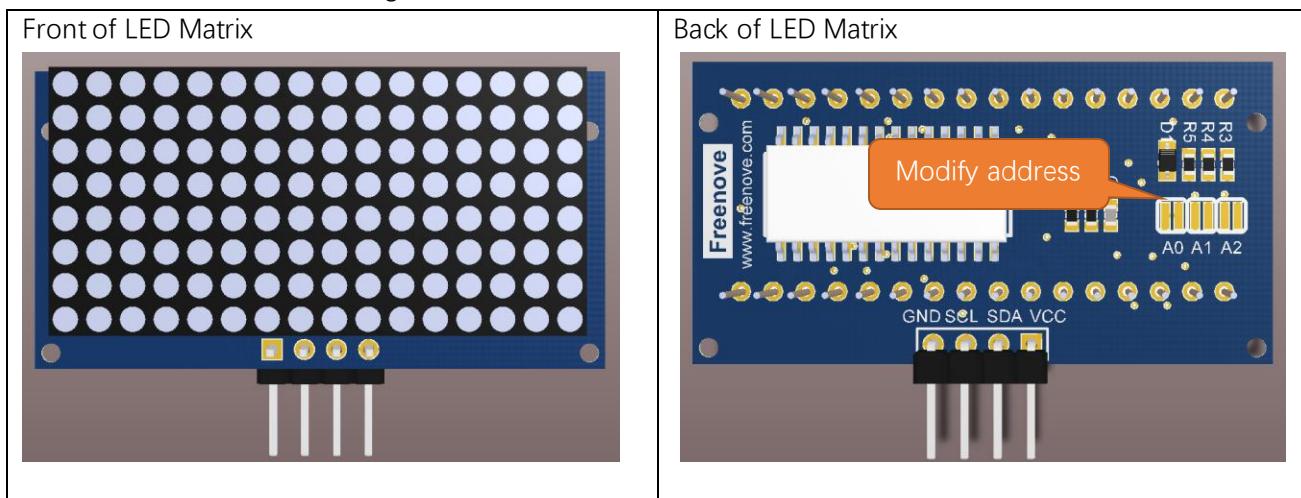


## Schematic

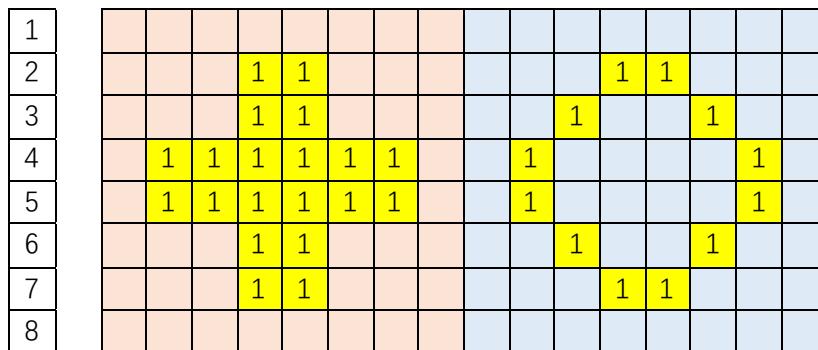
For this tutorial, the LED matrix module is individual and it is driven by IIC chip.



The LED matrix is common anode. As we can see from the schematic above, the anode of LED matrix is connected to ROWx of HT16K33 chip, and the cathode is connected to COMx. The address of HT16K33 chip is  $(0x70+[A2:A0])$ , and the default address of LED matrix is 0x71. If you want to change the address, you can use a knife to cut the connecting line in the middle of A0, or connect A1/A2.



We divide the LED matrix into two sides and display “+” on the left and “o” on the right. As shown below, yellow stands for lit LED while other colors represent the OFF LED.



Below, the table on the left corresponds to the "+" above, and the table on the right corresponds to the "o" above.

Row	Binary	Hexadecimal
1	0000 0000	0x00
2	0001 1000	0x18
3	0001 1000	0x18
4	0111 1110	0x7e
5	0111 1110	0x7e
6	0001 1000	0x18
7	0001 1000	0x18
8	0000 0000	0x00

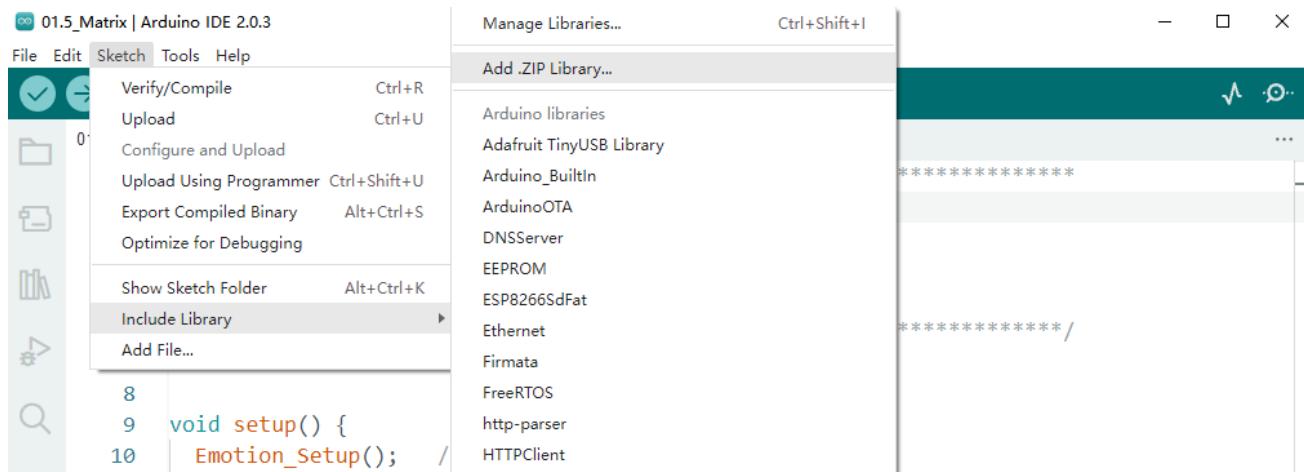
Row	Binary	Hexadecimal
1	0000 0000	0x00
2	0001 1000	0x18
3	0010 0100	0x24
4	0100 0010	0x42
5	0100 0010	0x42
6	0010 0100	0x24
7	0001 1000	0x18
8	0000 0000	0x00

## Sketch

The LED matrix is controlled by HT16K33 chip. Therefore, before opening the program, we need to install Freenove\_VK16K33\_Lib library in advance.

### Install Freenove\_VK16K33\_Lib Library

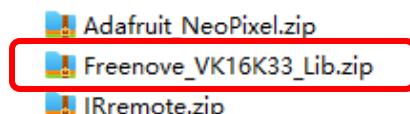
Click Sketch and select Add .ZIP Library in Include.



Select “Freenove\_VK16K33\_Lib.zip” in the folder Libraries of the folder.

Need support? [✉ support.freenove.com](mailto:support.freenove.com)

"Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico".



### Install Processing

In this tutorial, we use Processing to build a simple LED Matrix platform.

If you have not installed Processing, you can download it from the official website: <https://processing.org/>.

Download an appropriate version to download corresponding to your PC system.

**Cover**

**Download**

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**Reference**

**Libraries**

**Tools**

**Environment**

**Tutorials**

**Examples**

**Books**

**Overview**

**People**

**Download Processing.** Processing is available for Linux, Mac OS X, and Windows. Select your choice to download the software below.

**3.5.4 (17 January 2020)**

**Windows** 64-bit      **Linux** 64-bit      **Mac OS X**

**Windows** 32-bit

» [Github](#)

» [Report Bugs](#)

» [Wiki](#)

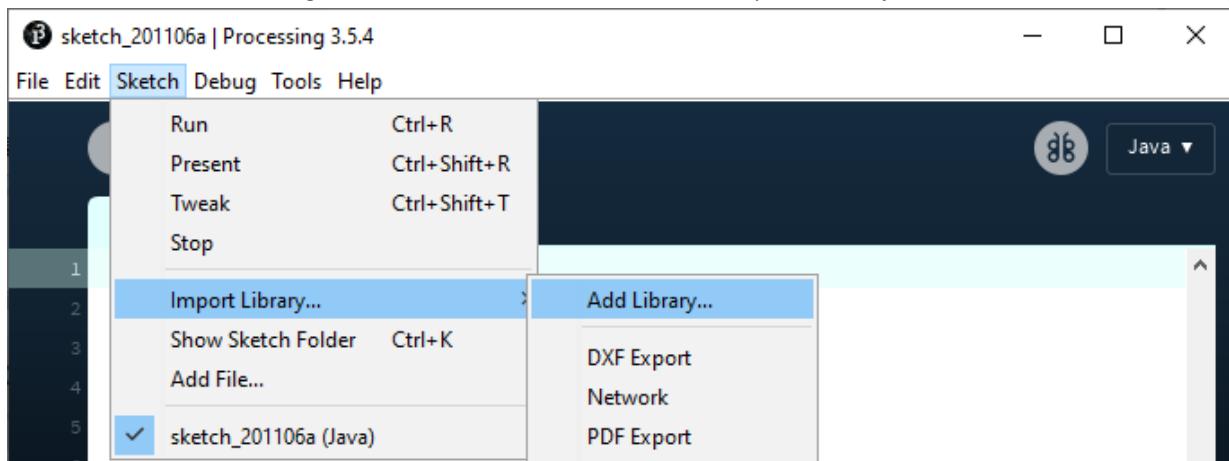
» [Supported Platforms](#)

Read about the [changes in 3.0](#). The list of revisions covers the differences between releases in detail.

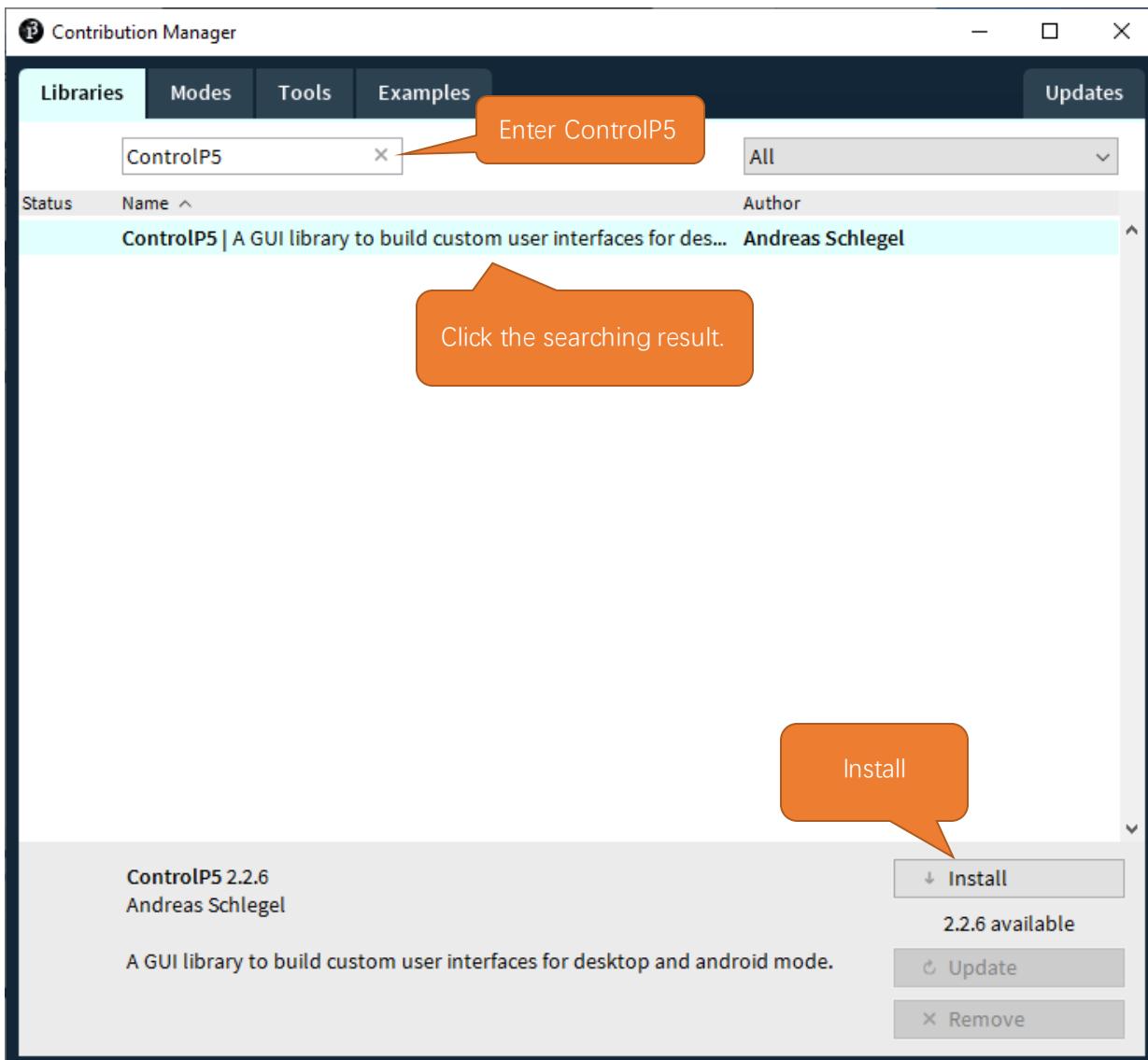
Unzip the downloaded file to your computer. Click "processing.exe" as the figure below to run this software.

	<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

In the interface of Processing, click Sketch on Menu bar, select "Import Library..." and then click "Add Library...".

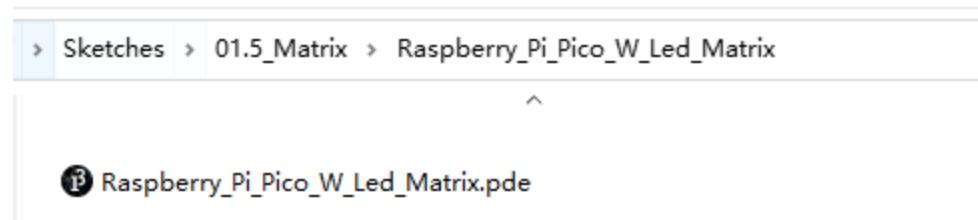


Enter "ControlP5" in the input field of the pop-up window. Click the searching result and then click "install"

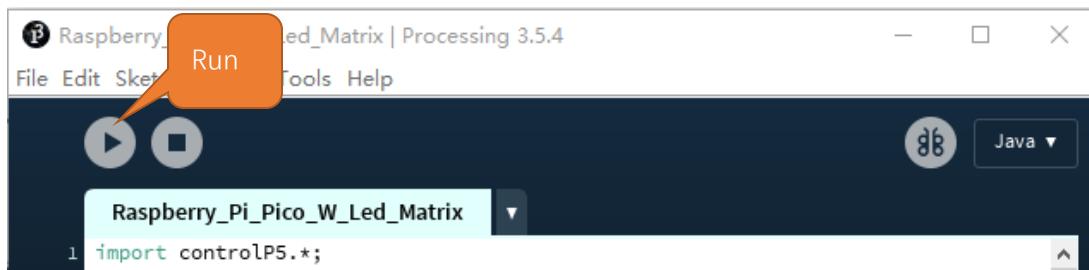


When the installation finishes, restart Processing.

Open the folder Raspberry\_Pi\_Pico\_W\_Led\_Matrix in 01.5\_Matrix of the “**Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Sketches**”. Here we take Windows as an example. Click to open Raspberry\_Pi\_Pico\_W\_Led\_Matrix.pde.



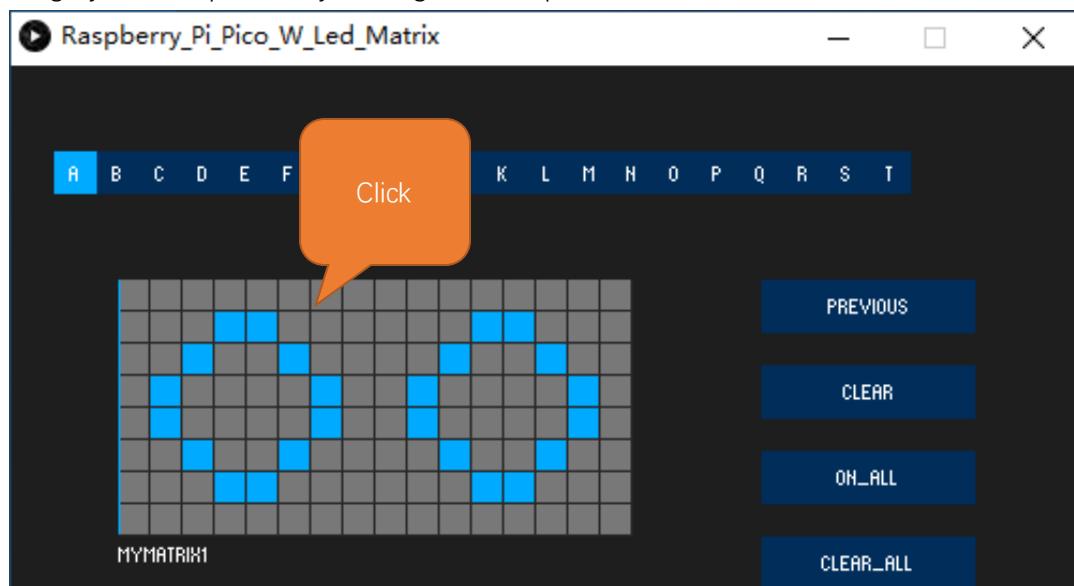
Click “Run”



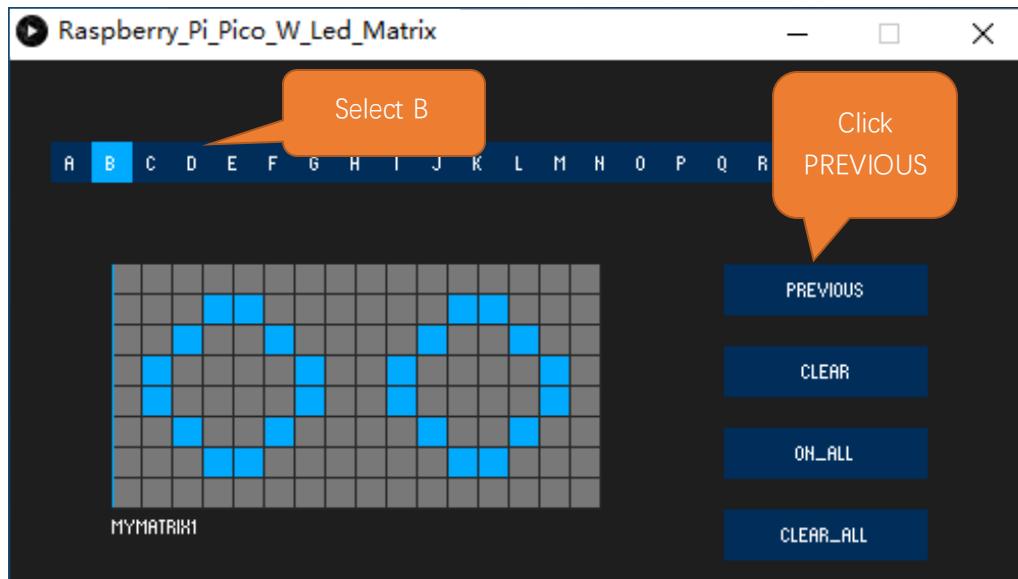
There are 20 pages from A to T. Select Page A.



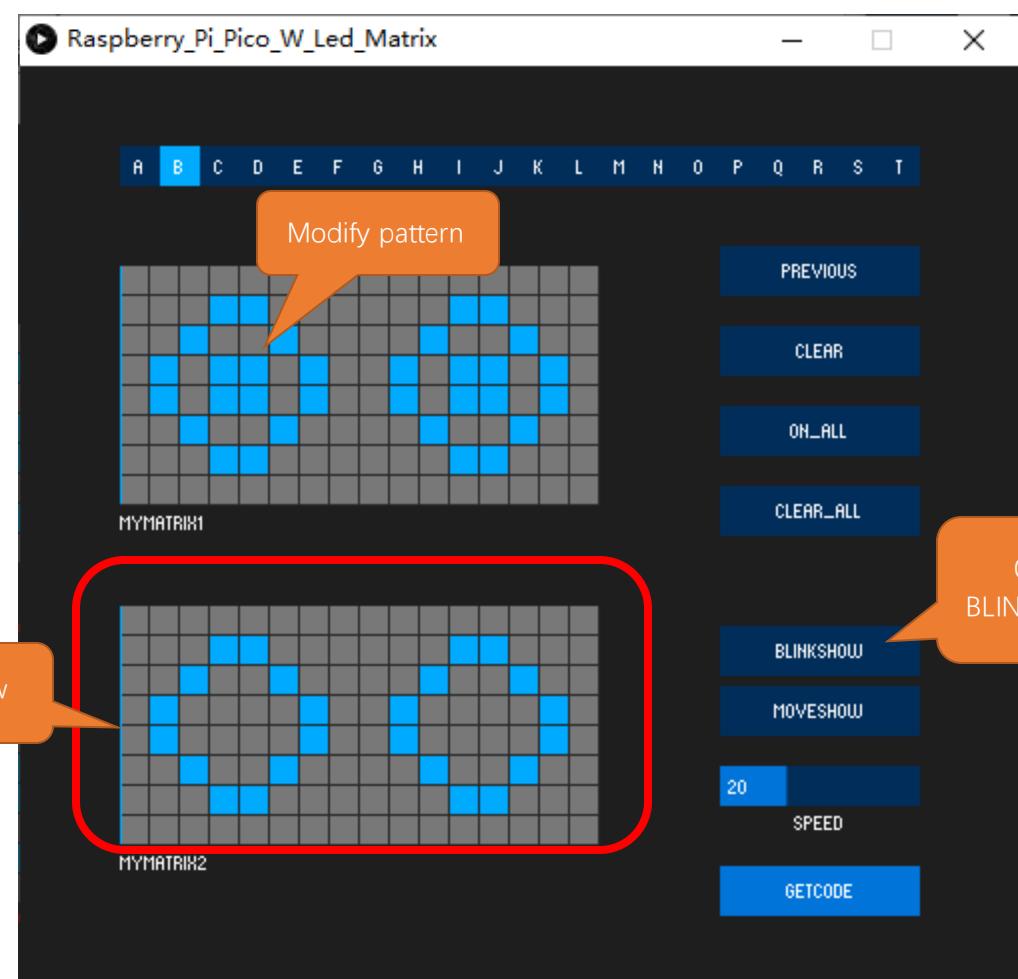
You can design your own pattern by clicking on the squares.



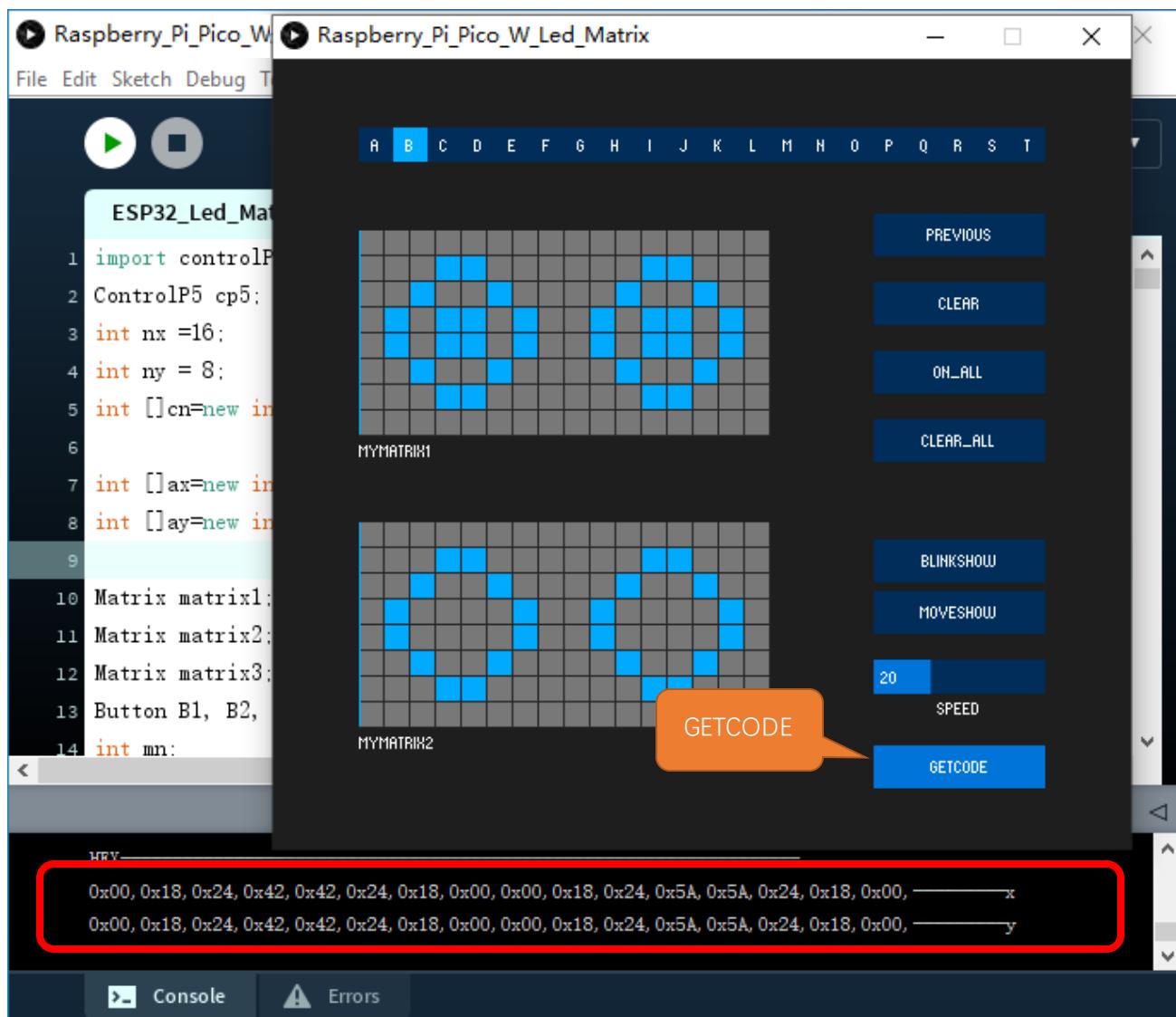
Next select Page B and click PREVIOUS, which copies the previous pattern to B.



Click the squares to modify the pattern, and then click BLINKSHOW, you can browse the overlay effect of different pages.



Click GETCODE to generate array.



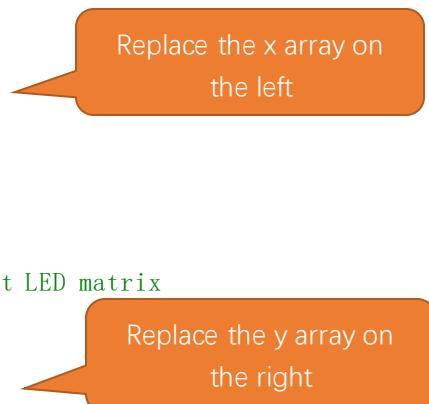
The data on the left of the LED matrix are stored together and end with "----x", and the data on the right are stored together and end with "----y". Copy these two sets of dot matrix data and replace the array content in "01.5\_Matrix.ino".

Open the folder “01.5\_Matrix” in the “**Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Sketches**” and double click “01.5\_Matrix.ino”

### Code

```

1 #include "Freenove_VK16K33_Lib.h"
2
3 Freenove_VK16K33 matrix = Freenove_VK16K33();
4
5 byte x_array[][][8] = { //Put the data into the left LED matrix
6     /////////////////////////////////
7     0x00, 0x18, 0x24, 0x42, 0x42, 0x24, 0x18, 0x00,
8     0x00, 0x18, 0x24, 0x5A, 0x5A, 0x24, 0x18, 0x00,
9     /////////////////////////////////
10    } ;
11
12 byte y_array[][][8] = { //Put the data into the right LED matrix
13     /////////////////////////////////
14     0x00, 0x18, 0x24, 0x42, 0x42, 0x24, 0x18, 0x00,
15     0x00, 0x18, 0x24, 0x5A, 0x5A, 0x24, 0x18, 0x00,
16     /////////////////////////////////
17    } ;
18
19 void setup()
20 {
21     matrix.init(0x71);
22     matrix.flipVertical(); //Flips the vertical orientation of the matrices.
23     matrix.flipHorizontal(); //Flips the horizontal orientation of the matrices.
24     matrix.setBrightness(15);
25     matrix.setBlink(VK16K33_BLINK_OFF);
26 }
27
28 void loop()
29 {
30     showArray(500);
31 }
32
33 void showArray(int delay_ms)
34 {
35     int count = sizeof(x_array) / sizeof(x_array[0]);
36     for (int i = 0; i < count; i++)
37     {
38         matrix.showStaticArray(x_array[i], y_array[i]);
39         delay(delay_ms);
40     }
41 }
```



Copy and paste the array generated by the auxiliary applet to the program, and then click upload.

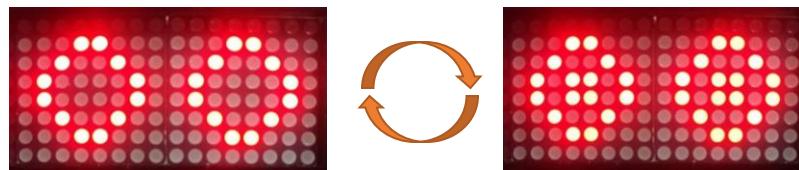


```

01.5_Matrix | Arduino 1.8.19
File Edit Sketch 01.5_Matrix Freenove_VK16K33_Lib.cpp Freenove_VK16K33_Lib.h
33
34 void loop()
35 {
36     showArray(500);
37 }
38
39 void showArray(int delay_ms)
40 {
41     int count = sizeof(x_array) / sizeof(x_array[0]);

```

You can see the LED matrix keep blinking.



### Code Explanation

Add the header file of LED matrix. Each time before controlling LED matrix, please add its header file first.

```
1 #include "Freenove_VK16K33_Lib.h"
```

Apply for an Freenove\_VK16K33 object and name it matrix.

```
3 Freenove_VK16K33 matrix = Freenove_VK16K33();
```

Define the IIC address and IIC pin of the HT16K33 chip. Call the init() function to initialize it. Set the flip direction of the LED matrix on both vertical and horizontal directions. Call the setBlink function to stop the the blink.

```

3 Freenove_VK16K33 matrix = Freenove_VK16K33();
...
21     matrix.init(0x71);
22     matrix.flipVertical(); //Flips the vertical orientation of the matrices.
23     matrix.flipHorizontal(); //Flips the horizontal orientation of the matrices.
24     matrix.setBrightness(15);
25     matrix.setBlink(VK16K33_BLINK_OFF);

```

Define count to calculate the number of one-dimensional arrays contained in the two-dimensional x\_array, and use the for loop to call the showStaticArray() function to continuously display the content of LED matrix.

```

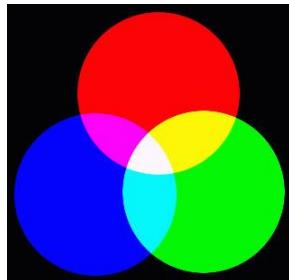
35     int count = sizeof(x_array) / sizeof(x_array[0]);
36     for (int i = 0; i < count; i++)
37     {
38         matrix.showStaticArray(x_array[i], y_array[i]);
39         delay(delay_ms);
40     }

```

## 2.6 LED

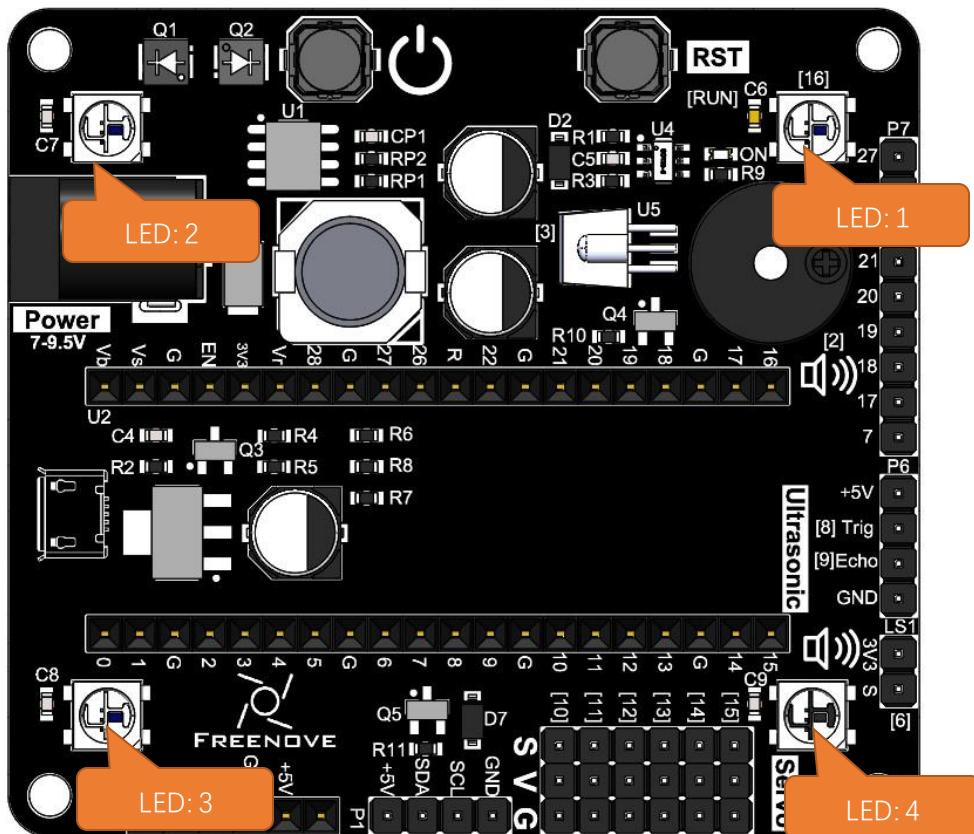
### LED

Red, green, and blue are called the three primary colors. When you combine these three primary colors of different brightness, it can produce almost all kinds of visible light.



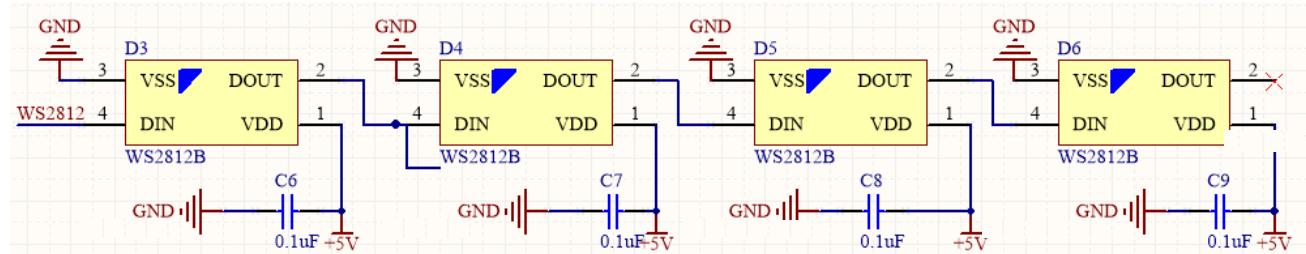
RGB

The LED of the car is composed of eight LED, each of which is controlled by one pin and supports cascading. Each LED can emit three basic colors of red, green and blue, and supports 256-level brightness adjustment, which means that each LED can emit  $2^{24} = 16,777,216$  different colors.



## Schematic

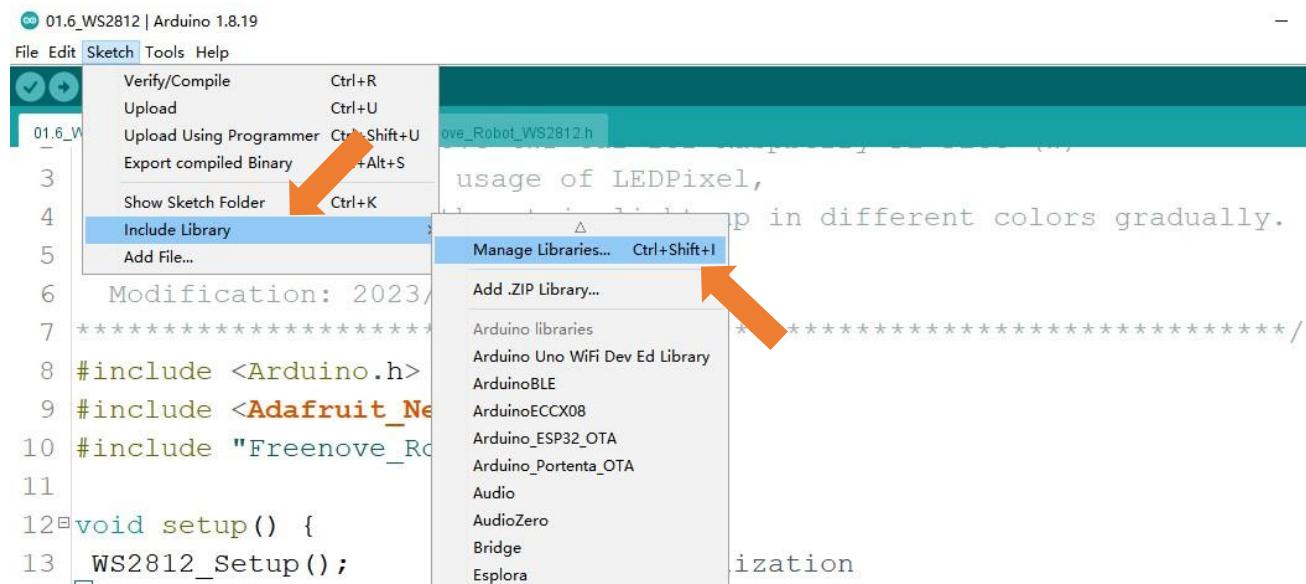
As shown below, the DOUT of each LED is connected with DIN of the next LED, and the 4 LED can be controlled to emit colorful colors by inputting control signals through LED.



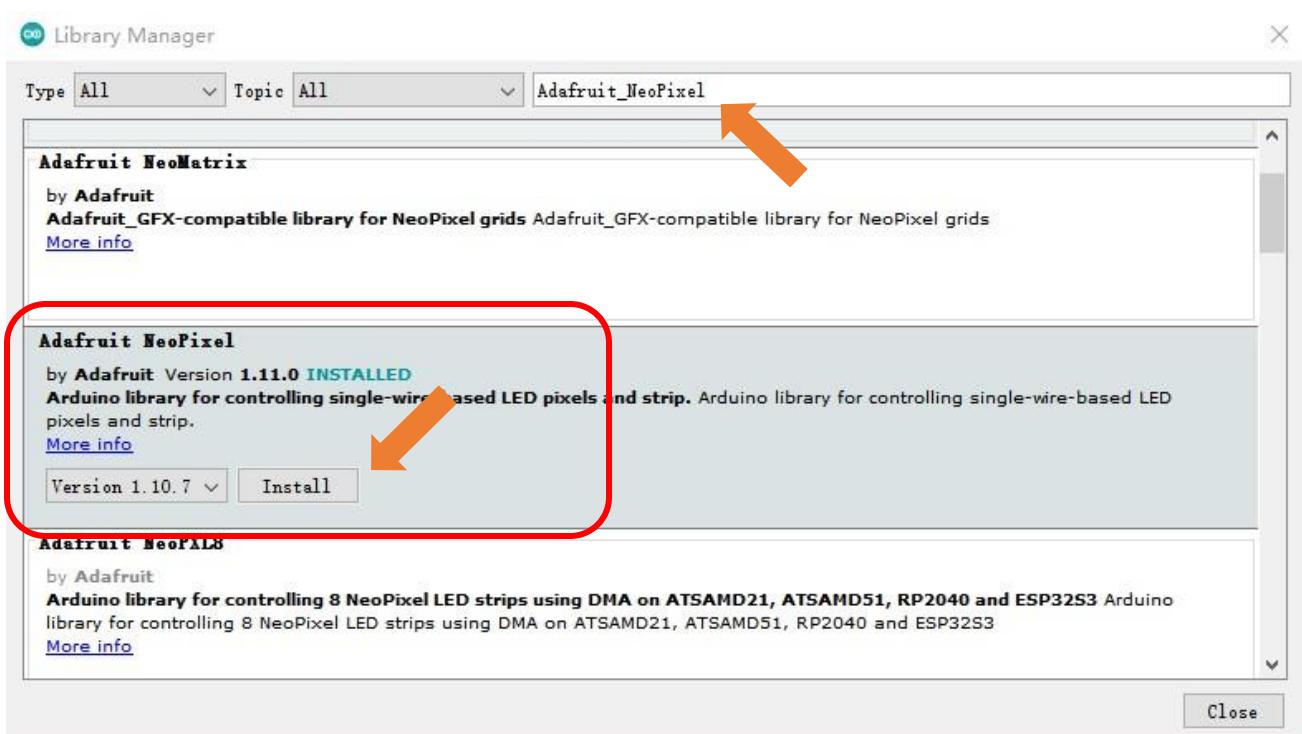
## Sketch

Before programming, please make sure the LED driver library has been installed. If not, please install it as follows

Open Arduino IDE, select Sketch on Menu bar, navigate the mouse to Include library and click Manage Libraries.



Enter "Adafruit\_NeoPixel" in the input field of the pop-up window, find it and then click Install.



Wait for the installation to finish.

Next, we will download the code to Raspberry Pi Pico W to test the LED. Open the folder "01.6\_WS2812" in the "Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Sketches" and then double click "01.6\_WS2812.ino".

#### Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico > Sketches

- 00.0\_Servo\_90
- 01.1\_Servo
- 01.2\_Buzzer
- 01.3.1\_Loudspeaker
- 01.3.2\_Music
- 01.4\_Battery\_level
- 01.5\_Matrix
- 01.6\_WS2812
- 02.1\_Ultrasonic\_Ranging
- 02.2\_Ultrasonic\_Ranging\_Robot

## Code

```
1 #include <Arduino.h>
2 #include <Adafruit_NeoPixel.h>
3 #include "Freenove_Robot_WS2812.h"
4
5 void setup() {
6     WS2812_Setup();      //WS2812 initialization
7 }
8
9 void loop() {
10    WS2812_Show(5);
11 }
```

## Another part of the code

```
1 #define WS2812_PIN 16      //Control pins for Pico W
2 #define LEDS_COUNT 8
3 Adafruit_NeoPixel ws2812_strip(LEDs_Count, WS2812_PIN, NEO_GRB + NEO_KHZ800);
4 //WS2812 initialization function
5 void WS2812_Setup(void)
6 {
7     ws2812_strip.begin();
8     ws2812_strip.setBrightness(20);
9     ws2812_close();
10 }
11 //WS2812 non-blocking display function
12 void WS2812_Show(int mode)
13 {
14     switch (mode)
15     {
16         case 0://Close the WS2812
17             ws2812_close();
18             break;
19         case 1:
20             ws2812_rgb();
21             break;
22         case 2:
23             ws2812_following();
24             break;
25         case 3:
26             ws2812_blink();
27             break;
28         case 4:
29             ws2812_breathe();
30             break;
31         case 5:
```

```

32     ws2812_rainbow() ;
33     break;
34     default:
35     break;
36   }
37 }
38 int rainbow_count = 0;
39 //WS2812 rainbow display
40 void ws2812_rainbow(void)
41 {
42   ws2812_strip.setBrightness(20);
43   ws2812_strip_time_next = millis();
44   if (ws2812_strip_time_next - ws2812_strip_time_now > 5)
45   {
46     ws2812_strip_time_now = ws2812_strip_time_next;
47     rainbow_count++;
48     for (int i = 0; i < 12; i++)
49       ws2812_strip.setPixelColor(11 - i, Wheel((i * 256 / 12 + rainbow_count) & 255));
50   ws2812_strip.show();
51   if (rainbow_count > 255)
52     rainbow_count = 0;
53 }
54 }
```

Download the code to the Raspberry Pi Pico W, turn ON the power switch and the LED on the car will emit lights like rainbow.

#### Code Explanation:

Add the header file of LED. Each time before controlling LED, please add its header file.

```
2 #include <Adafruit_NeoPixel.h>
```

Set the number of LED, define the control pin and channel. Instantiate a LED object and name it strip.

```
#define WS2812_PIN 16      //Control pins for Pico W
#define LEDS_COUNT 8
Adafruit_NeoPixel ws2812_strip(LEDS_COUNT, WS2812_PIN, NEO_GRB + NEO_KHZ800);
```

Initialize LED, set their brightness to be 10. The range of brightness is 0-255.

```
ws2812_strip.begin();           //Initialize LED
ws2812_strip.setBrightness(10); //Set the brightness of LED
```

Set the color of LED. Note: The color will not be displayed immediately after it is set.

```
ws2812_strip.setPixelColor(11 - i, Wheel((i * 256 / 12 + rainbow_count) & 255));
```

Display the color of LED. After setting the color, you need to call show function to display it.

```
ws2812_strip.show();
```

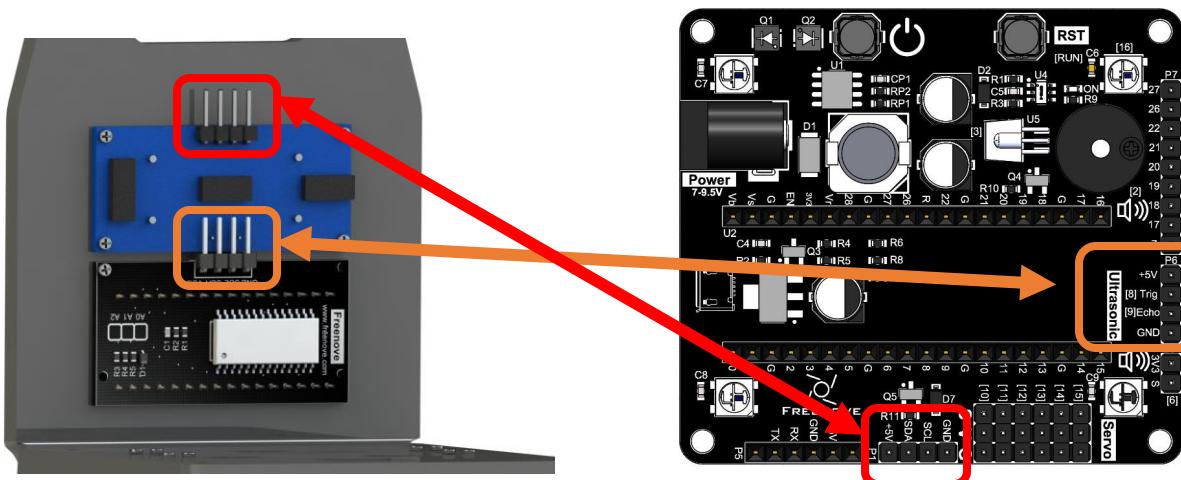
# Chapter 3 Ultrasonic Obstacle Avoidance Robot

In this chapter, the robot will achieve the function of ultrasonic obstacle avoidance.

## 3.1 Ultrasonic Module

Replace the ultrasonic module.

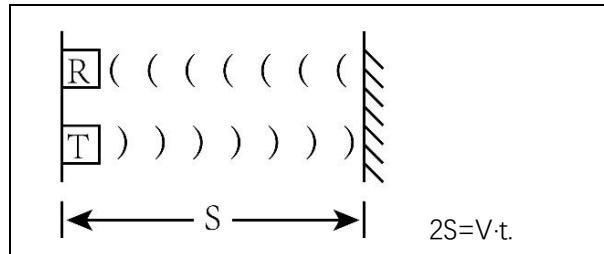
Step 1 Connect the ultrasonic module and the LED matrix module. It is important that the modules be connected in line with the silkprint of the pins.



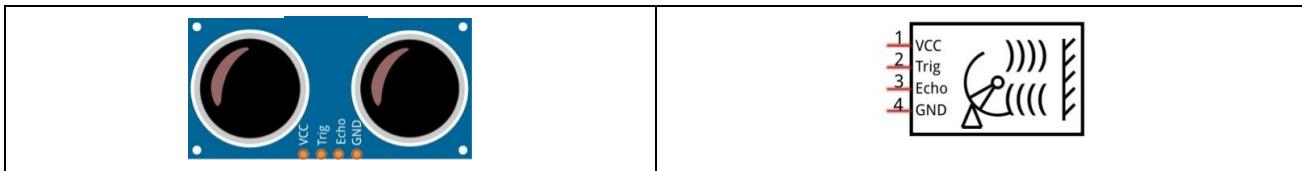
Module	Gnd	Echo	Trig	Vcc
Robot	GND	ECHO	TRIG	VCC
	GND	8	9	VCC

## Ultrasonic Module

The ultrasonic ranging module uses the principle that ultrasonic waves will be sent back when encounter obstacles. We can measure the distance by counting the time interval between sending and receiving of the ultrasonic waves, and the time difference is the total time of the ultrasonic wave's journey from being transmitted to being received. Because the speed of sound in air is a constant, about  $v=340\text{m/s}$ , we can calculate the distance between the ultrasonic ranging module and the obstacle:  $s=vt/2$ .



The ultrasonic ranging module integrates both an ultrasonic transmitter and a receiver. The transmitter is used to convert electrical signals (electrical energy) into high frequency (beyond human hearing) sound waves (mechanical energy) and the function of the receiver is opposite of this. The picture and the diagram of the ultrasonic ranging module are shown below:



Pin description:

Pin	Description
VCC	Power supply pin
Trig	Trigger pin
Echo	Echo pin
GND	GND

### Technical specs:

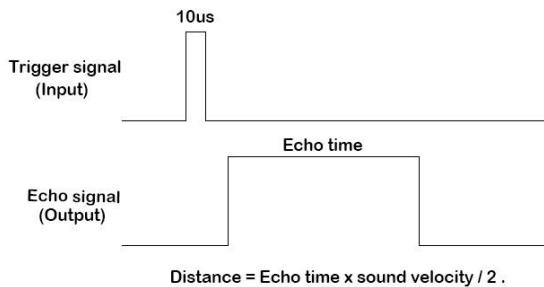
Working voltage: 5V

Working current: 12mA

Minimum measured distance: 2cm

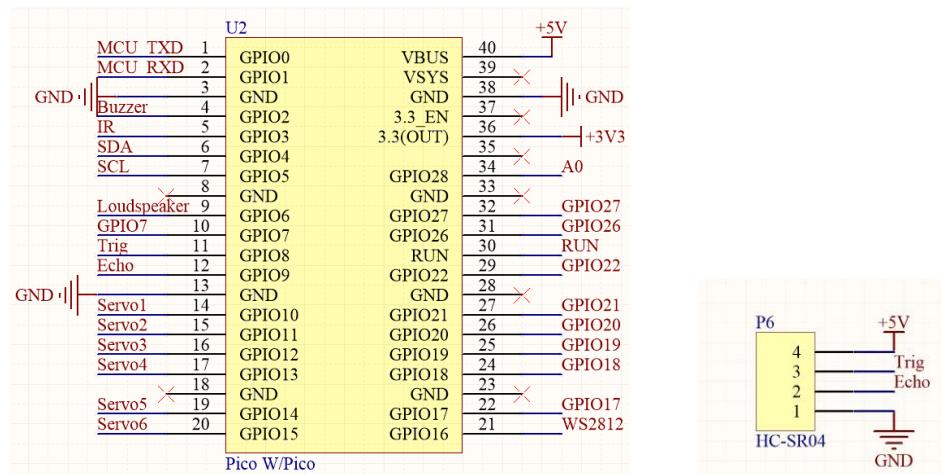
Maximum measured distance: 200cm

Instructions for use: output a high-level pulse in Trig pin lasting for least 10us, the module begins to transmit ultrasonic waves. At the same time, the Echo pin is pulled up. When the module receives the returned ultrasonic waves from encountering an obstacle, the Echo pin will be pulled down. The duration of high level in the Echo pin is the total time of the ultrasonic wave from transmitting to receiving,  $s=vt/2$ .



## Schematic

The ultrasonic module is plugged in the front of the car and is connected to the Raspberry Pi Pico (W) development board by means of wiring. As can be seen from the figure below, Raspberry Pi Pico (W) uses GPIO8 and GPIO9 to control the Trig and Echo pins of the ultrasonic module.



## Sketch

Turn ON the power switch of the robot, after the ultrasonic sensor finishes initialization, obtain and print the ultrasonic data on the serial monitor.

Open the folder "02.1\_Ultrasonic\_Ranging" in

"Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Sketches"

and double click "02.1\_Ultrasonic\_Ranging.ino"

### Code

```

1 #include <Arduino.h>
2 #include "Freenove_Robot_For_Pico_W.h"
3
4 void setup() {
5     Serial.begin(115200); //Open the serial port and set the baud rate to 115200
6     Ultrasonic_Setup(); //Ultrasonic module initialization
7     delay(500); //Wait for the servo to arrive at the specified location
8 }
9
10 void loop() {
11     Serial.print("Distance: " + String(Get_Sonar()) + "\n"); //Print ultrasonic distance
12     delay(500);
13 }
```

### Code Explanation :

Initialize ultrasonic module.

6	Ultrasonic_Setup(); //Ultrasonic module initialization
---	--

Obtain the distance between ultrasonic module and the obstacle and return a real number data in cm.

15	Get_Sonar()
----	-------------

Obtain and print the ultrasonic data via the serial port, which is updated every 0.5 seconds.

11	Serial.print("Distance: " + String(Get_Sonar()) + "\n"); //Print ultrasonic distance
12	delay(500); Servo_1_Angle(30); //Turn servo 1 to 30 degrees

Click “Upload” to upload the code to Raspberry Pi Pico (W). After uploading successfully, open Serial Monitor.

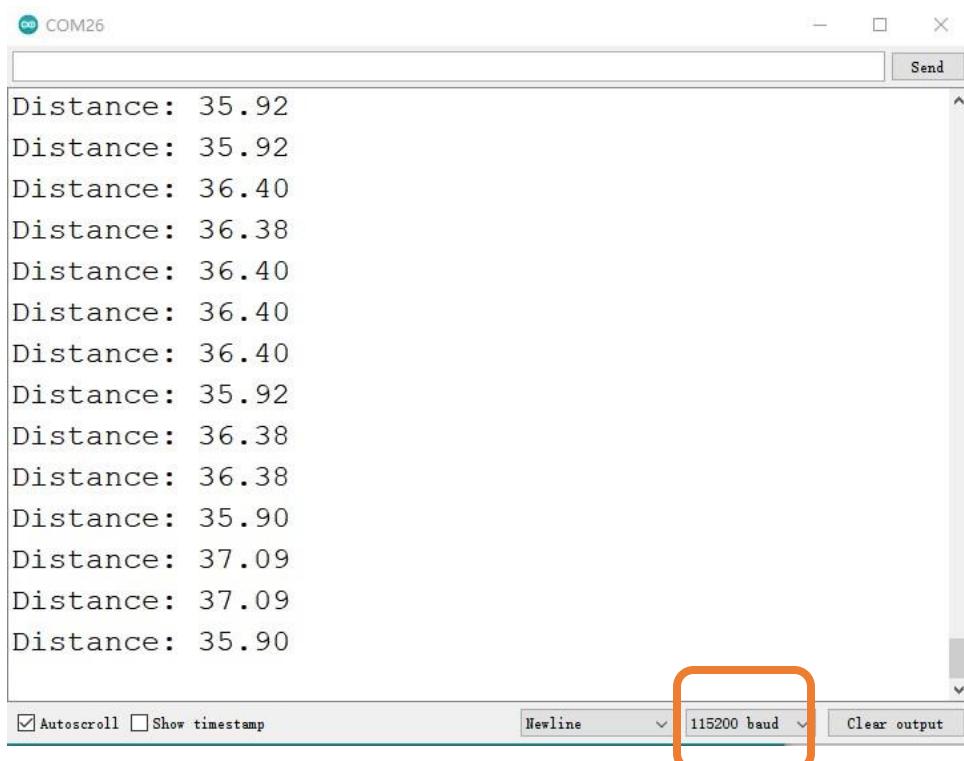
The screenshot shows the Arduino IDE interface. A red arrow points to the "Upload" button in the toolbar. Another red arrow points to the "Serial Monitor" tab in the top menu bar. The code editor contains the following sketch:

```
02.1_Ultrasonic_Ranging | Arduino 1.8.19
File Edit Sketch Tools Help
02.1_Ultrasonic_Ranging Freenove_Robot_For_Pico_W.cpp Freenove_Robot_For_Pico_W.h
6
7  ***** 
8  Arduino.h
9  Freenove_Robot_For_Pico_W.h"
10 void setup() {
11   Serial.begin(115200); //Open the serial port and set the baud rate to 115200
12   Ultrasonic_Setup(); //Ultrasonic module initialization
13   delay(500); //Wait for the servo to arrive at the specified location
14 }
15
16 void loop() {
17   Serial.print("Distance: " + String(Get_Sonar()) + "\n"); //Print ultrasonic distance
18 }
```

The status bar at the bottom indicates "Done uploading. Resetting COM26". The serial monitor window shows the output of the uploaded code, which prints the distance measured by the ultrasonic sensor every loop iteration. The output text is as follows:

```
Converting to uf2, output size: 142848, start address: 0x2000
Scanning for RP2040 devices
Flashing G: (RPI-RP2)
Wrote 142848 bytes to G:/NEW.UF2
```

Set the baud rate as 115200.



## 3.2 Obstacle Avoidance Robot

After the robot activates, the ultrasonic module collects data between it and the obstacles in the front. Then make judgements according to the data and control the robot to avoid the obstacles.

### Sketch

Open the folder “02.2\_Ultrasonic\_Ranging\_Robot” in  
“**Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Sketches**” and double click  
“02.2\_Ultrasonic\_Ranging\_Robot.ino”.

#### Code

```
1 #include <Arduino.h>
2 #include "Freenove_Robot_For_Pico_W.h"
3 #include "Bipedal_Robot.h"
4 Bipedal_Robot Bipedal_Robot;
5
6 #define LeftLeg 10
7 #define RightLeg 12
8 #define LeftFoot 11
9 #define RightFoot 13
10 #define Buzzer 6
11
12
13 void setup() {
14     Serial.begin(115200);
15     Ultrasonic_Setup();           //Initialize the ultrasonic module
16     Bipedal_Robot.init(LeftLeg, RightLeg, LeftFoot, RightFoot, true); //Set the servo pins
17     Bipedal_Robot.home();
18     delay(50);
19 }
20 void loop()
21 {
22     if (Get_Sonar() <= 20)
23     {
24         Bipedal_Robot.sing(S_surprise);
25         Bipedal_Robot.walk(2, 1000, -1); // BACKWARD x2
26         Bipedal_Robot.turn(3, 1000, 1); // LEFT x3
27     }
28     Bipedal_Robot.walk(1, 1200, 1); // FORWARD x1
29 }
30 }
```



### Code Explanation:

Check whether there is any obstacle in front of the robot with the ultrasonic wave. When the distance between the robot and the obstacles is smaller than the set number, the robot move backwards and turn left to avoid the obstacle.

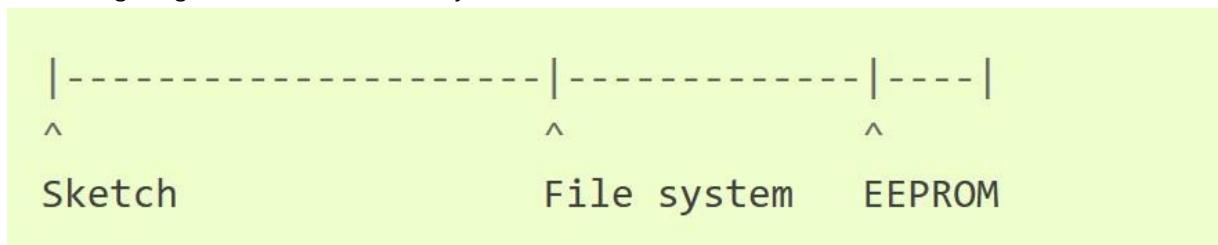
```
21 void loop()
22 {
23     if (Get_Sonar() <= 20)
24     {
25         Bipedal_Robot.sing(S_surprise);
26         Bipedal_Robot.walk(2, 1000, -1); // BACKWARD x2
27         Bipedal_Robot.turn(3, 1000, 1); // LEFT x3
28     }
29     Bipedal_Robot.walk(1, 1200, 1); // FORWARD x1
30 }
```

# Chapter 4 Sing and Dance

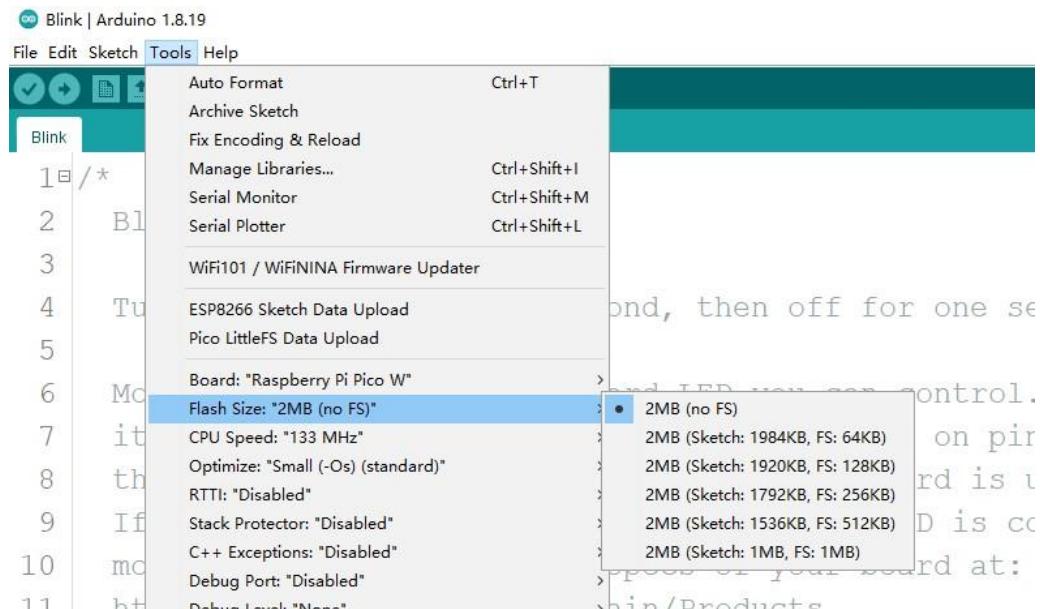
## 4.1 Playing Music

In this chapter, we use the speaker to play a piece of music. Please note that to play the music, it requires the use of file system. The raspberry pi pico (W) has built-in 264KB SRAM and 2MB of onboard flash, and the Arduino-Pico core supports using some of the onboard flash as a file system, useful for storing configuration data, output strings, logging, and more. It also supports using SD cards as another (FAT32) filesystem, with an API that's compatible with the onboard flash file system.

The following diagram shows the flash layout used in Arduino-Pico:



The storage of the raspberry pi pico (W) file system can be configured via the Arduino IDE menu bar, ranging from 0KB to 1MB.



Due to the limitation of the storage, the file uploaded to pico (W) should not exceed 1024Kb (1M). Therefore, we need to restrict the file scale; otherwise, it may fail to upload.

Upload the file to LittleFS file system.

LittleFS is an onboard file system that sets aside some program flash memory for use as a file system, without requiring any external hardware.

It is also a tool integrated into the Arduino IDE, adding an item to the Tools menu for uploading the contents of a sketch data directory to a new LittleFS flash file system.

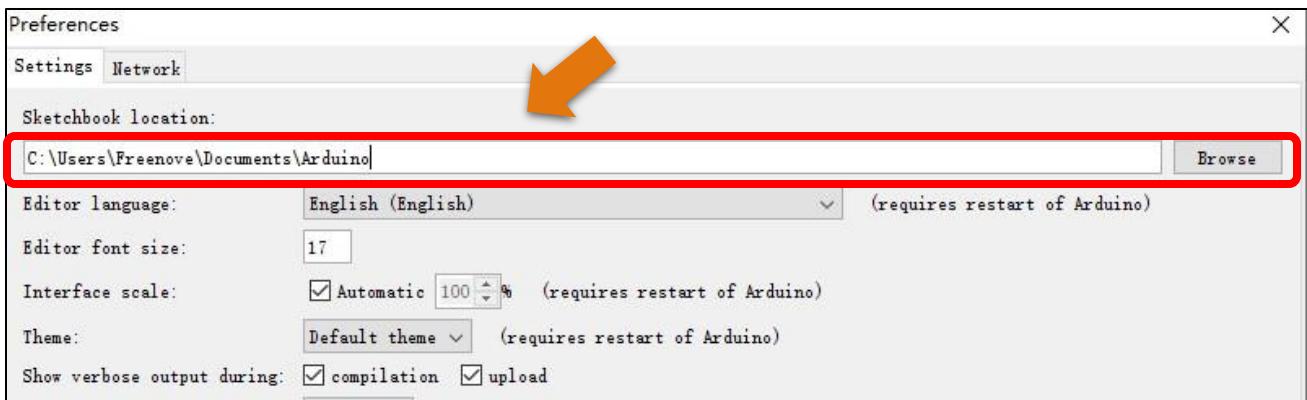
## Installing PicoLittleFS Tool

The steps to install PicoLittleFS tools are as follows:

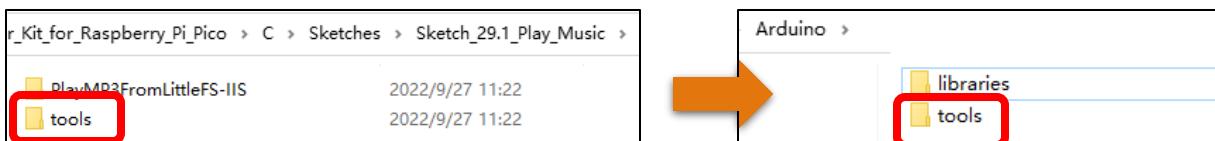
First, open the Arduino IDE, and then click File in Menus and select Preferences.



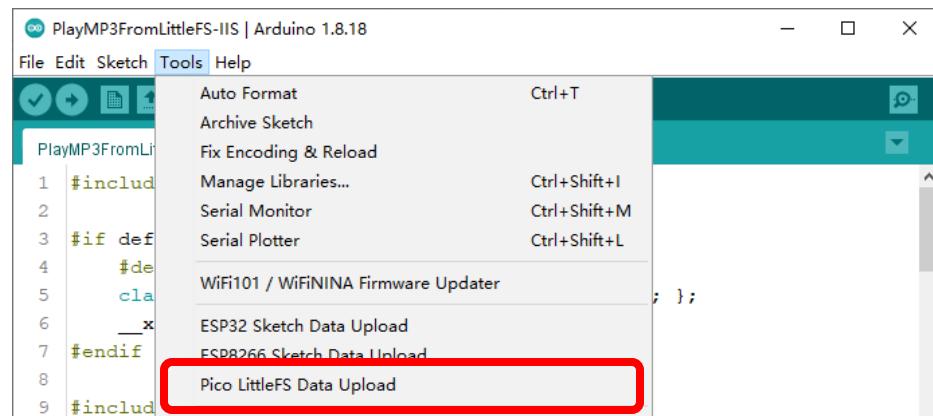
Find the Arduino IDE environment directory location.



Copy the tools folder in the code folder to your Sketchbook location.



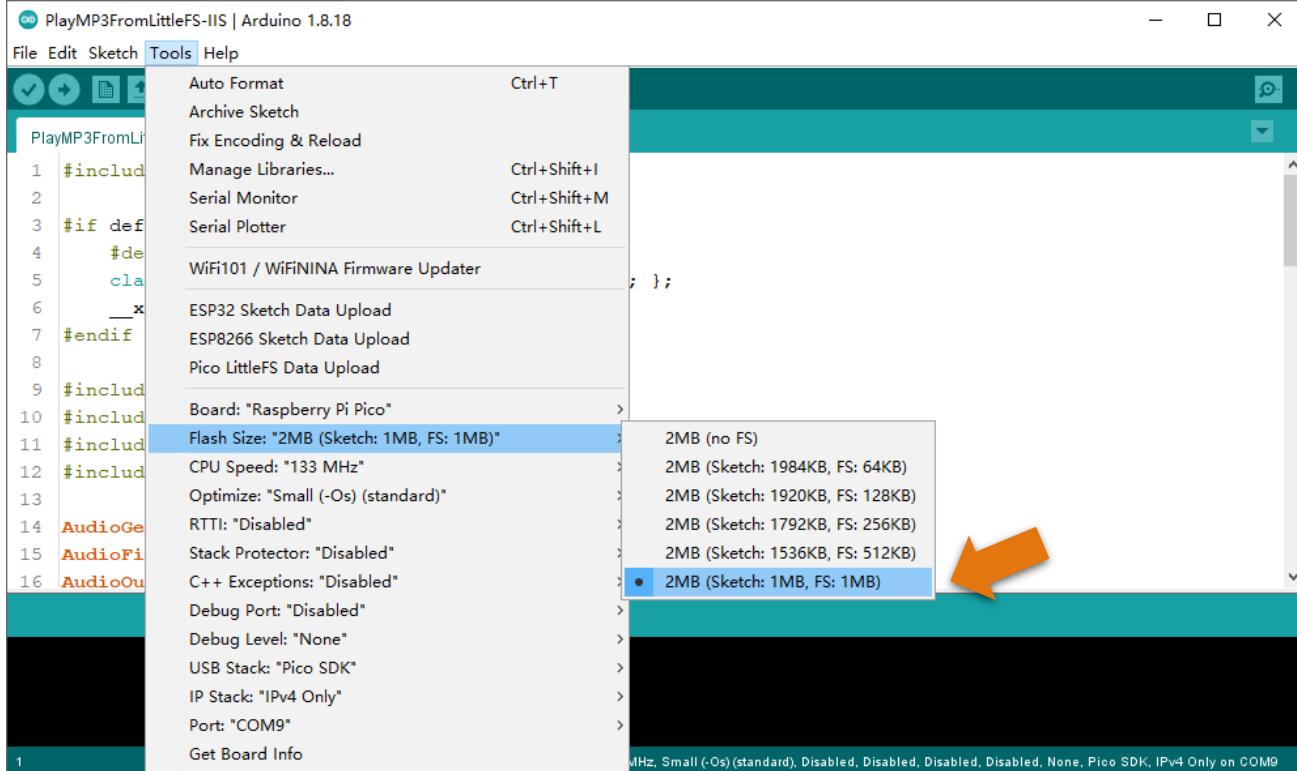
Finally, restart the Arduino IDE. After restarting, you can see that the plug-in already exists in the interface.



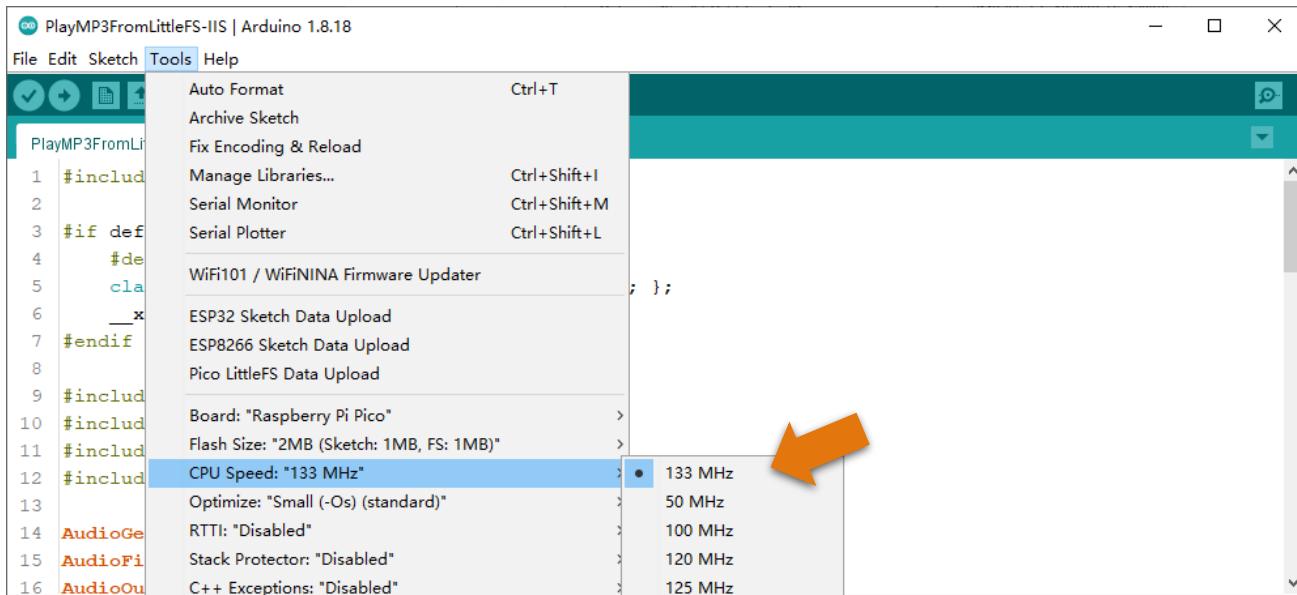
### Upload music

Pico of Raspberry Pie has 2M Flash space. Generally, Arduino mode allocates it to the code area. Therefore, before starting, we need to modify the configuration of Flash Size.

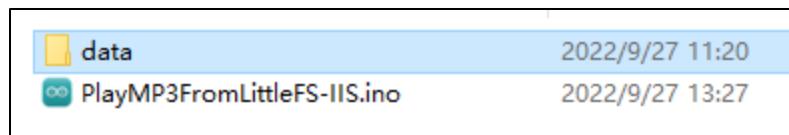
Open Arduino, select Tools from the menu bar, select Flash Size, and allocate 1MB of Flash space to store codes and 1MB to store audio files.



Make sure the CPU Speed of Raspberry Pie is 133Mhz. If the frequency is too low, the audio decoding speed may be too slow and the audio playback may not be continuous.



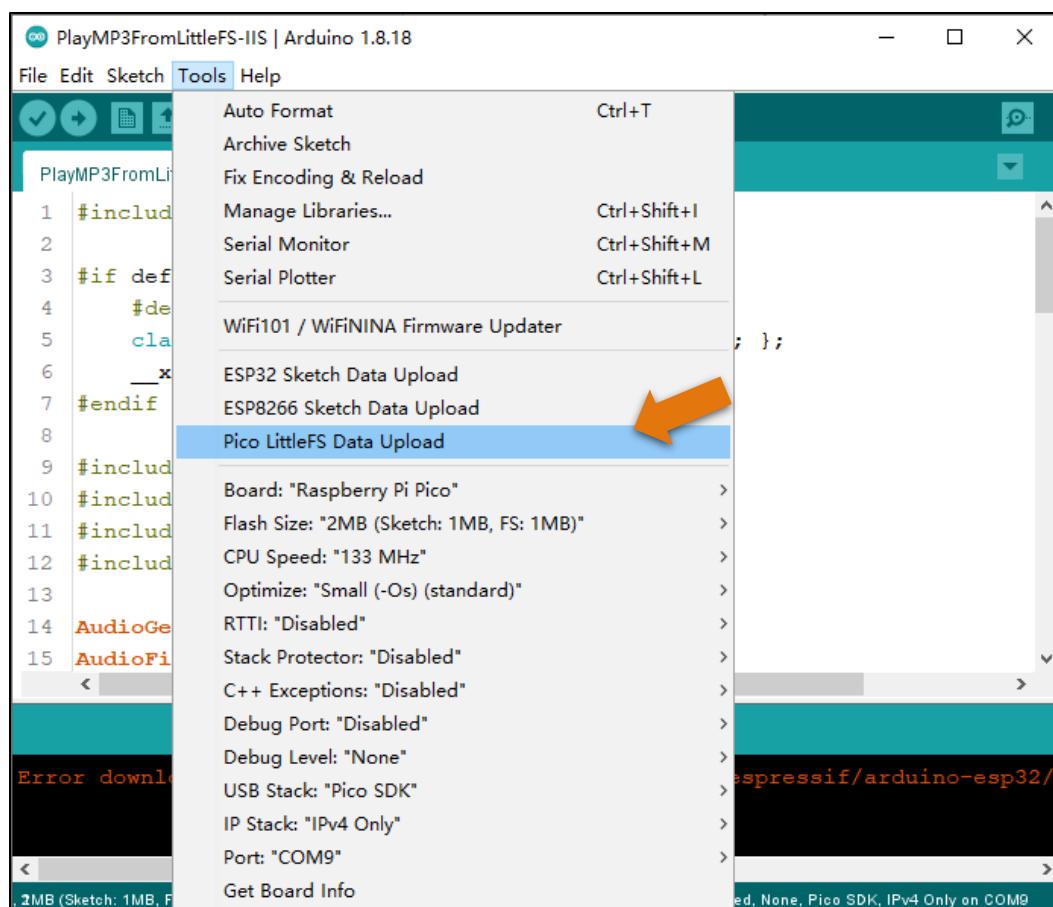
Check the code file and audio file. We create a folder named data under the same level directory of the code file, and place the audio file directly in this folder.



Note: 1. The name of the data folder cannot be changed, otherwise the plug-in cannot be used to upload audio files to Pico.

2. The number of audio files in the data folder is unlimited, but the total size cannot exceed 1MB. If the file upload fails, please check whether the data folder size exceeds the range.

Click Arduino IDE Tools and click following content:



```
LittleFS Image Uploaded
[LittleFS] data      : C:\Users\DESKTOP-LIN\Desktop\clear\Freenove_Ultimate_Starter_Kit_for_Raspberry_Pi_Pico\C\Sketches\Sketch_29.1_Pl
[LittleFS] size       : 1024KB
[LittleFS] page       : 256
[LittleFS] block      : 4096
/1.mp3
[LittleFS] upload     : C:\Users\DESKTOP-LIN\AppData\Local\Temp\arduino_build_331339\PlayMP3FromLittleFS-IIS.mklittlefs.bin
[LittleFS] address    : 269479936
[LittleFS] sserial    : COM9
[LittleFS] python     : C:\Users\DESKTOP-LIN\AppData\Local\Arduino15\packages\rp2040\tools\pgt-python3\1.0.1-base-3a57aed\python3.exe
[LittleFS] uploader   : C:\Users\DESKTOP-LIN\AppData\Local\Arduino15\packages\rp2040\hardware\rp2040\2.5.4\tools\uf2conv.py

Resetting COM9
Converting to uf2, output size: 2097152, start address: 0x100ff000
Flashing F: (RPI-RP2)
Wrote 2097152 bytes to F:/NEW.UF2
```

After uploading the music, click the upload button to upload the code to Pico.

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

- Title Bar:** PlayMP3FromLittleFS-II | Arduino 1.8.18
- Menu Bar:** File Edit Sketch Tools Help
- Toolbar:** Includes icons for Save, Undo, Redo, Open, Upload, and others.
- Sketch Area:** Displays the C++ code for the sketch:

```
1 #include <Arduino.h>
2
3 #if defined(ARDUINO_ARCH_RP2040)
4     #define WIFI_OFF
5     class __x { public: __x() {}; void mode() {}; };
6     __x WiFi;
7 #endif
8
9 #include "AudioFileSourceLittleFS.h"
10 #include "AudioFileSourceID3.h"
11 #include "AudioGeneratorMP3.h"
12 #include "AudioOutputI2S.h"
13
14 AudioGeneratorMP3 *mp3;
```
- Serial Monitor:** Shows the upload status:

```
Done uploading.
Resetting COM4
Converting to uf2, output size: 446464, start address: 0x2000
Flashing F: (RPI-RP2)
Wrote 446464 bytes to F:/NEW.UF2
```
- Status Bar:** Shows the board configuration: Raspberry Pi Pico, 2MB (Sketch: 1MB, FS: 1MB), 133 MHz, Small (-Os) (standard), Disabled, Disabled, Disabled, Disabled, None, Pico SDK, IPv4 Only on COM4

After the code upload is completed, the speaker will play the audio file you uploaded.

## Sketch

Open the folder “03.1\_Music” in “**Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Sketches**” and double click “03.1\_Music.ino.ino”

The sketch is the same as 01.3.2\_Music.ino. Now, let's upload the code to Pico (W) to play the music.

### Code

```
1 #include <Arduino.h>
2 #include "AudioFileSourceLittleFS.h"
3 #include "AudioGeneratorMP3.h"
4 #include "AudioOutputI2SNoDAC.h"
5 #include "AudioFileSourceID3.h"
6
7 AudioGeneratorMP3 *mp3;
8 AudioFileSourceLittleFS *file;
9 AudioOutputI2SNoDAC *out;
10
11 void setup() {
12     Serial.begin(115200);
13     delay(1000);
14     file = new AudioFileSourceLittleFS("1.mp3");
15     out = new AudioOutputI2SNoDAC(6);
16     out->SetGain(3); //Volume Setup
17     mp3 = new AudioGeneratorMP3();
18     mp3->begin(file, out);
19 }
20 int a = 0;
21
22 void loop() {
23     Serial.printf("loop1..\n");
24     if (mp3->isRunning()) {
25         if (!mp3->loop()) {
26             mp3->stop();
27             Serial.printf("Hello done\n");
28             delete file;
29             delete mp3;
30             mp3 = new AudioGeneratorMP3();
31
32         }
33     } else {
34         Serial.printf("MP3 done\n");
35         pinMode(6, OUTPUT);
36         digitalWrite(6, LOW);
37     }
}
```

38 }

## 4.2 Sing and dance

In this chapter, we will have the robot sing while dancing.

### Sketch

Upload the code and you will get a robot that is singing while dancing.

Open the folder “03.2\_Photosensitive\_Car” in  
“**Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Sketches**” and double click  
“03.2\_Photosensitive\_Car.ino”

#### Part of code

```
1 #include <Arduino.h>
2 #include <EEPROM.h>
3 #include "Bipedal_Robot.h"
4 #include "AudioFileSourceLittleFS.h"
5 #include "AudioGeneratorMP3.h"
6 #include "AudioOutputI2SNoDAC.h"
7 #include "AudioFileSourceID3.h"
8 #include "AudioOutputI2S.h"
9
10 Bipedal_Robot Bipedal_Robot;
11 AudioGeneratorMP3 *mp3;
12 AudioFileSourceLittleFS *file;
13 AudioOutputI2SNoDAC *out;
14 AudioFileSourceID3 *id3;
15
16 #define LeftLeg 10
17 #define RightLeg 12
18 #define LeftFoot 11
19 #define RightFoot 13
20 #define Buzzer 6
21
22 int calibratePosition[4] = { -17, -10, -15, 12 } ;
23
24 void setup() {
25     Serial.begin(115200);
26     EEPROM.begin(512); //Initialize the
27     ultrasonic module
28     Bipedal_Robot.init(LeftLeg, RightLeg, LeftFoot, RightFoot, true); //Set the servo pins
```

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```
29 //Bipedal_Robot.setTrims(calibratePosition[0], calibratePosition[1], calibratePosition[2],  
calibratePosition[3]);  
30 calib_homePos();  
Bipedal_Robot.saveTrimsOnEEPROM();  
31 EEPROM.commit();  
32 Bipedal_Robot.home();  
33 delay(50);  
34 }  
35 void loop() {  
36   dance();  
37 }  
38  
39 void setup() {  
40   playmusic(1, 2);  
41   pinMode(6, OUTPUT);  
42   digitalWrite(6, LOW);  
43 }  
44 void loop1() {  
45   palymusic(1, 4);  
46 }  
47  
48 }
```

#### Code Explanation:

The Raspberry Pi pico (W) is equipped with a dual-core ARM Cortex M0+ processor. Core 0 is used to run the robot's dancing movements, and core 1 is for music playback. The two cores are independent and do not affect each other when running code.

```
void loop() {  
  dance();  
}  
  
void loop1() {  
  palymusic(1, 4);  
}
```

# Chapter 5 Infrared Robot

## 5.1 Introduction of infrared reception function

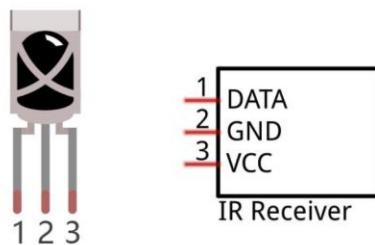
### Infrared Remote

An infrared (IR) remote control is a device with a certain number of buttons. Pressing down different buttons will make the infrared emission tube, which is located in the front of the remote control, send infrared ray with different command. Infrared remote control technology is widely used in electronic products such as TV, air conditioning, etc. Thus making it possible for you to switch TV programs and adjust the temperature of the air conditioning when away from them. The remote control we use is shown below:



### Infrared receiver

An infrared (IR) receiver is a component which can receive the infrared light, so we can use it to detect the signal emitted by the infrared remote control. DATA pin here outputs the received infrared signal.



When you use the infrared remote control, the infrared remote control sends a key value to the receiving circuit according to the pressed keys. We can program the Raspberry Pi Pico W to do things like lighting, when a key value is received.

The following is the key value that the receiving circuit will receive when each key of the infrared remote control is pressed.

ICON	KEY Value	ICON	KEY Value
	BA45FF00		F20DFF00
	B847FF00		F30CFF00
	BB44FF00		E718FF00
	BF40FF00		A15EFF00
	BC43FF00		F708FF00
	F807FF00		E31CFF00
	EA15FF00		A55AFF00
	F609FF00		BD42FF00
	E916FF00		AD52FF00
	E619FF00		B54AFF00

This sketch uses the infrared receiving tube to receive the value sent from the infrared remote control, and print it out via the serial port.

## Sketch

Each time when you press the infrared remote control, the car will print the received infrared coding value through serial port.

Open the folder “04.1\_IR\_Receiver” in

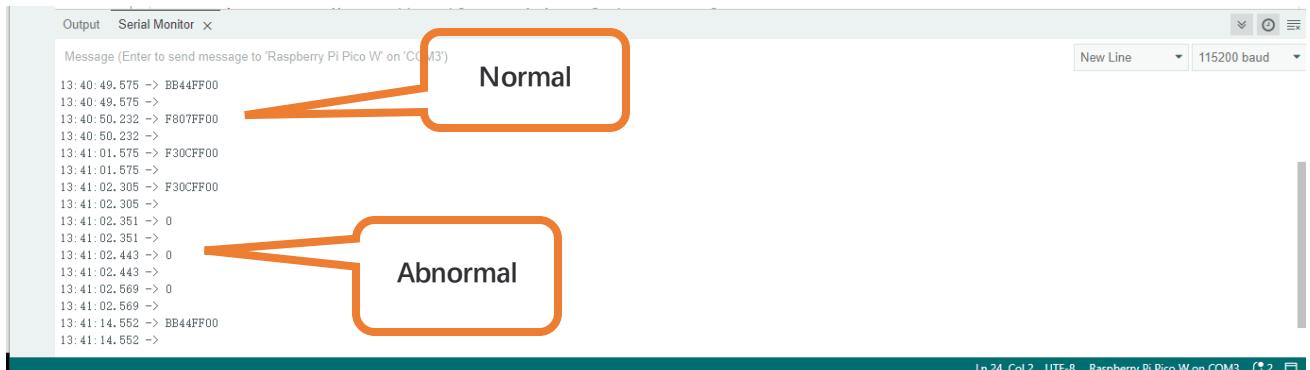
“Freenove\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Ordinary\_wheels\Sketches” and double click “04.1\_IR\_Receiver.ino”.

## Code

```

1 #include <IRremote.hpp>
2 #define IR_Pin 3 // Infrared receiving pin
3 #define ENABLE_LED_FEEDBACK true
4 #define DISABLE_LED_FEEDBACK false
5
6 void setup() {
7     Serial.begin(115200); // Initialize the serial port and set the baud rate to 115200
8     IrReceiver.begin(IR_Pin, DISABLE_LED_FEEDBACK); // Start the receiver
9     Serial.print("IRrecvDemo is now running and waiting for IR message on Pin ");
10    Serial.println(IR_Pin); //print the infrared receiving pin
11 }
12
13 void loop() {
14     if (IrReceiver.decode()) {
15         unsigned long value = IrReceiver.decodedIRData.decodedRawData;
16         Serial.println(value, HEX); // Print "old" raw data
17         IrReceiver.resume(); // Enable receiving of the next value
18     }
19 }
```

Download the code to Raspberry Pi Pico (W), open the serial port monitor and set the baud rate to 115200. Press any keys on the IR remote and their corresponding values will be printed out through the serial port. As shown in the following figure: (Note that if the remote control button is long pressed, the infrared receiving circuit receives a "0".)



First, include header file. Each time you use the infrared sensor, you need to include the header file at the beginning of the program.

```
1 #include <IRremote.hpp>
```

Second, define an infrared receive pin and the infrared sensor is initialized.

```

2 #define IR_Pin 3 // Infrared receiving pin
...
8     IrReceiver.begin(IR_Pin, DISABLE_LED_FEEDBACK); // Start the receiver
```

Finally, **IrReceiver.decode()** is used to determine whether an infrared signal has been received, returning true/1 if an infrared signal has been received, or false/0 if no infrared signal has been received; If an infrared signal is received, the received infrared coded value is printed through the serial port.

Please note that **IrReceiver.resume()** must be applied to release the infrared receiver function each time data

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are received. Otherwise, the infrared receiver function can only be used once and data cannot be received next time.

```
14 if (IrReceiver.decode ()) {  
15     unsigned long value = IrReceiver.decodedIRData.decodedRawData;  
16     Serial.println(value, HEX); // Print "old" raw data  
17     IrReceiver.resume(); // Enable receiving of the next value  
18 }
```

## 5.2 Infrared Robot

On the basis of the previous section, we further controls the robot via the infrared remote controller. Press the black buttons on the remote, the robot will move forward, move backward, turn left and turn right accordingly. Press other buttons will stop the robot.

### Sketch

Open the folder “04.2\_IR\_Receiver\_Robot” in the “**Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Sketches**” and double click “04.2\_IR\_Receiver\_Robot.ino”.

#### Code

```

1 #include <Arduino.h>
2 #include <IRremote.hpp>
3 #include <EEPROM.h>
4 #include "Bipedal_Robot.h"
5
6 #define LeftLeg 10
7 #define RightLeg 12
8 #define LeftFoot 11
9 #define RightFoot 13
10
11 #define IR_Pin 3
12 #define ENABLE_LED_FEEDBACK true
13 #define DISABLE_LED_FEEDBACK false
14
15 // #define USE_NO_SEND_PWM
16
17 int move_flag = 0;
18
19 Bipedal_Robot Bipedal_Robot;
20 int calibratePosition[4] = { -17, -10, -15, 12 };
21
22 void calib_homePos() {
23     int servoPos[4];
24     servoPos[0] = 90;
25     servoPos[1] = 90;
26     servoPos[2] = 90;
27     servoPos[3] = 90;
28     Bipedal_Robot._moveServos(500, servoPos);
29     Bipedal_Robot.detachServos();
30 }
```

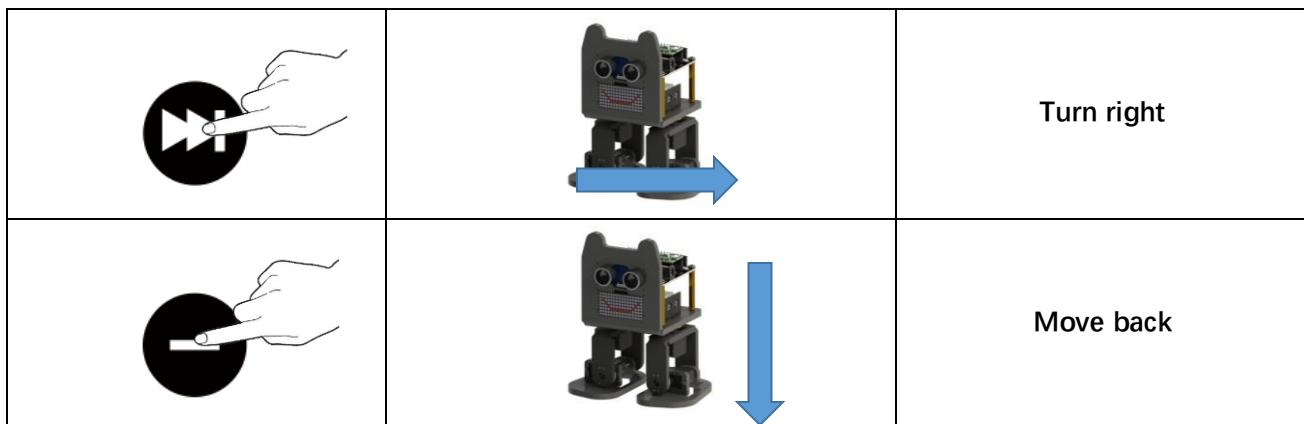
```
31
32 void setup() {
33   Serial.begin(115200);
34   EEPROM.begin(512);
35   Bipedal_Robot.init(LeftLeg, RightLeg, LeftFoot, RightFoot, true); //Set the servo pins
36   //Bipedal_Robot.setTrims(calibratePosition[0], calibratePosition[1], calibratePosition[2],
37   calibratePosition[3]);
38   calib_homePos();
39   Bipedal_Robot.saveTrimsOnEEPROM();
40   EEPROM.commit();
41   Bipedal_Robot.home();
42   IrReceiver.begin(IR_Pin, DISABLE_LED_FEEDBACK); // Start the receiver
43 }
44
45 void loop() {
46   if (IrReceiver.decode()) {
47     unsigned long value = IrReceiver.decodedIRData.decodedRawData;
48     handleControl(value); // Handle the commands from remote control
49     Serial.println(value, HEX); // Print "old" raw data
50     Serial.println();
51     IrReceiver.resume(); // Enable receiving of the next value
52   }
53   Move(move_flag);
54 }
55
56 void handleControl(unsigned long value) {
57   // Handle the commands
58   switch (value) {
59     case 0xBF40FF00: // Receive the number '+'
60       move_flag = 1;
61       break;
62     case 0xE619FF00: // Receive the number '-'
63       move_flag = 2;
64       break;
65     case 0xF807FF00: // Receive the number '|<<|'
66       move_flag = 3;
67       break;
68     case 0xF609FF00: // Receive the number '|>>|'
69       move_flag = 4;
70       break;
71     case 0xEA15FF00: // Receive the number '▶'
72       move_flag = 0;
73       break;
74     default:
```

```

75     move_flag = 0;
76     break;
77 }
78 }
79 void Move(int data) {
80     // Handle the commands
81     switch (data) {
82         case 1: // Receive the number '+'
83             Bipedal_Robot.walk(2, 1500, 1);
84             break;
85         case 2: // Receive the number '-'
86             Bipedal_Robot.walk(2, 1500, -1);
87             break;
88         case 3: // Receive the number '|<<|'
89             Bipedal_Robot.turn(2, 1500, 1);
90             break;
91         case 4: // Receive the number '|>>|'
92             Bipedal_Robot.turn(2, 1500, -1);
93             break;
94         case 0: // Receive the number '▶'
95             Bipedal_Robot.home();
96             break;
97     default:
98         move_flag = 0;
99         Bipedal_Robot.home();
100        break;
101    }
102 }
103 }
```

Compile and upload the code to Raspberry Pi Pico (W). When pressing "0" of the infrared remote control, the expression module will randomly display the content dynamically.

		Move forward
		Turn left

**Code Explanation:**

Variable **IrReceiver.DecodedIRData.DecodedRawData** holds the infrared remote control encoding information; call handlecontrol function performs different code value corresponding action. After each execution of the program, call the **IrReceiver.resume()** function to release the infrared pin. If you do not call this function, you cannot use the infrared receiving and decoding functions again.

```
void loop() {
    if (IrReceiver.decode ()) {
        unsigned long value = IrReceiver.decodedIRData.decodedRawData;
        handleControl (value);           // Handle the commands from remote control
        Serial.println (value, HEX);    // Print "old" raw data
        Serial.println ();
        IrReceiver.resume();           // Enable receiving of the next value
    }
    showEmotion (emotionMode);
}
```

Infrared key code value processing function, receives instructions sent by the infrared remote control, and execute the corresponding program.

```
void handleControl (unsigned long value) {
    // Handle the commands
    switch (value) {
        case 0xBF40FF00: // Receive the number '+'
            ...
        case 0xE619FF00: // Receive the number '-'
            ...
        case 0xF807FF00: // Receive the number '|<<|'
            ...
        case 0xF609FF00: // Receive the number '|>>|'
            ...
        case 0xE916FF00: // Receive the number '0'
            ...
        default:          // Control the car to stop moving
            ...
    }
}
```

## 5.3 Multi-Functional Infrared Robot

Now we integrated other functions to the infrared remote, so that most functions of the robot can be controlled via the infrared remote.

### Sketch

Open the folder “05.3\_Multi\_Functional\_Robot” in the

“**Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Sketches**” and double click “04.3\_Multi\_Functional\_Robot.ino”.

Part of code

```

1 #include <Arduino.h>
2 #include <Adafruit_NeoPixel.h>
3 #include <IRremote.hpp>
4 #include <EEPROM.h>
5 #include "Freenove_Robot_For_Pico_W.h"
6 #include "Freenove_Robot_Emotion.h"
7 #include "Freenove_VK16K33_Lib.h"
8 #include "Freenove_Robot_WS2812.h"
9 #include "Bipedal_Robot.h"

10
11 #define LeftLeg 10
12 #define RightLeg 12
13 #define LeftFoot 11
14 #define RightFoot 13

15
16 #define IR_Pin 3 // Infrared receiving pin
17 #define ENABLE_LED_FEEDBACK true
18 #define DISABLE_LED_FEEDBACK false

19
20 int move_flag = 0;
21 extern int move_flag;

22
23 Bipedal_Robot Bipedal_Robot;
24 int calibratePosition[4] = { -17, -10, -15, 12 };
25 int emotion_flag = 0;
26 int ws2812_flag = 0;

27
28 void calib_homePos() {
29     int servoPos[4];
30     servoPos[0] = 90;
31     servoPos[1] = 90;

```

```
32     servoPos[2] = 90;
33     servoPos[3] = 90;
34     Bipedal_Robot._moveServos(500, servoPos);
35     Bipedal_Robot.detachServos();
36 }
37
38 void setup() {
39     Serial.begin(115200); //Turn on the serial port monitor and set the baud rate to 115200
40     WS2812_Setup(); //WS2812 initialization
41     Buzzer_Setup(); //Initialize the buzzer
42     Ultrasonic_Setup();
43     EEPROM.begin(512);
44     Bipedal_Robot.init(LeftLeg, RightLeg, LeftFoot, RightFoot, true); //Set the servo pins
45     //Bipedal_Robot.setTrims(calibratePosition[0], calibratePosition[1], calibratePosition[2],
46     calibratePosition[3]);
47     calib_homePos();
48     Bipedal_Robot.saveTrimsOnEEPROM();
49     EEPROM.commit();
50     Bipedal_Robot.home();
51     IrReceiver.begin(IR_Pin, DISABLE_LED_FEEDBACK); // Start the receiver
52     delay(100);
53 }
54
55 void loop() {
56     if (IrReceiver.decode()) {
57         unsigned long value = IrReceiver.decodedIRData.decodedRawData;
58         handleControl(value); // Handle the commands from remote control
59         Serial.println(value, HEX); // Print "old" raw data
60         Serial.println();
61         IrReceiver.resume(); // Enable receiving of the next value
62     }
63     Emotion_Detection();
64     Emotion_Show(emotion_task_mode); //Led matrix display function
65     WS2812_Show(ws2812_task_mode); //Car color lights display function
66 }
67
68 void setup1() {
69 }
70 void loop1() {
71     Move(move_flag);
72 }
73
74 void handleControl(unsigned long value) {
75     // Handle the commands
```

```
76     switch (value) {  
77         case 0xBF40FF00: // Receive the number '+'  
78             move_flag = 1;  
79             break;  
80         case 0xE619FF00: // Receive the number '-'  
81             move_flag = 2;  
82             break;  
83         case 0xF807FF00: // Receive the number '|<<'  
84             move_flag = 3;  
85             break;  
86         case 0xF609FF00: // Receive the number '|>>'  
87             move_flag = 4;  
88             break;  
89         case 0xEA15FF00: // Receive the number '▶'  
90             move_flag = 0;  
91             break;  
92         case 0xE916FF00: // Receive the number '0'  
93             break;  
94         case 0xF30CFF00: // Receive the number '1'  
95             break;  
96         case 0xF708FF00: // Receive the number '4'  
97             break;  
98         case 0xF20DFF00: // Receive the number 'C'  
99             break;  
100        case 0xA15EFF00: // Receive the number '3'  
101            move_flag = 5;  
102            break;  
103        case 0xA55AFF00: // Receive the number '6'  
104            move_flag = 6;  
105            break;  
106        case 0xB54AFF00: // Receive the number '9'  
107            break;  
108        case 0xBB44FF00: // Receive the number 'TEST'  
109            Buzzer_Variable(2000, 100, 1);  
110            break;  
111        case 0xE718FF00: // Receive the number '2'  
112            emotion_flag = emotion_flag + 1;  
113            if (emotion_flag > 7) {  
114                emotion_flag = 0;  
115            }  
116            Emotion_SetMode(emotion_flag); //Display  
117            break;  
118        case 0xE31cff00: // Receive the number '5'  
119            emotion_flag = 0;
```

```
120 Emotion_SetMode(emotion_flag);
121 break;
122 case 0xBD42FF00: // Receive the number '7'
123 ws2812_flag = ws2812_flag + 1;
124 if (ws2812_flag >= 6) {
125 ws2812_flag = 0;
126 }
127 WS2812_SetMode(ws2812_flag);
128 break;
129 case 0xAD52FF00: // Receive the number '8'
130 ws2812_flag = 0;
131 WS2812_SetMode(ws2812_flag);
132 break;
133 case 0xFFFFFFFF: // Remain unchanged
134 break;
135 default:
136 break;
137 }
138 }
139
140 void Move(int data) {
141 // Handle the commands
142 switch (data) {
143 case 1: // Receive the number '+'
144 Bipedal_Robot.walk(1, 1500, 1);
145 break;
146 case 2: // Receive the number '-'
147 Bipedal_Robot.walk(1, 1500, -1);
148 break;
149 case 3: // Receive the number '|<<|'
150 Bipedal_Robot.turn(1, 1500, 1);
151 break;
152 case 4: // Receive the number '|>>|'
153 Bipedal_Robot.turn(1, 1500, -1);
154 break;
155 case 5: // Receive the number '|>>|'
156 Ultrasonic_Avoid();
157 break;
158 case 6: // Receive the number '|>>|'
159 dance();
160 break;
161 case 0: // Receive the number '▶'
162 Bipedal_Robot.home();
163 break;
```

```
164     default:  
165         move_flag = 0;  
166         Bipedal_Robot.home();  
167         break;  
168     }  
169 }  
170  
171 void dance() {  
172 }
```

After the code uploads successfully, turn on the power of the car and use the infrared remote to control the car and other functions. The corresponding keys and their functions are shown in the following table:



ICON	KEY Value	Function	ICON	KEY Value	Function
	BF40FF00	Move forward		E718FF00	Change the expression display mode
	F807FF00	Turn left		E31CFF00	Turn off emoticons
	F609FF00	Turn light		BD42FF00	Change the display mode of the WS2812
	E619FF00	Move back		AD52FF00	Turn off WS2812 display
	EA15FF00	Stop the robot		A15EFF00	Dancing Mode
	BB44FF00	Control the buzzer		A55AFF00	Ultrasonic obstacle avoidance mode

### Code Explanation:

Add the header file for the robot.

```
#include <Arduino.h>
#include <Adafruit_NeoPixel.h>
#include <IRremote.hpp>
#include <EEPROM.h>
#include "Freenove_Robot_For_Pico_W.h"
#include "Freenove_Robot_Emotion.h"
#include "Freenove_VK16K33_Lib.h"
#include "Freenove_Robot_WS2812.h"
#include "Bipedal_Robot.h"
```

Infrared key code value processing function receives instructions sent by the infrared remote control and execute the corresponding program.

```
void handleControl(unsigned long value) {
    // Handle the commands
    switch (value) {
        case 0xBF40FF00: // Receive the number '+'
            ...
        case 0xE619FF00: // Receive the number '-'
            ...
        case 0xF807FF00: // Receive the number '|<<|'
            ...
        case 0xF609FF00: // Receive the number '|>>|'
            ...
        case 0xEA15FF00: // Receive the number '▶'
            ...
        case 0xE916FF00: // Receive the number '0'
            ...
        case 0xF30CFF00: // Receive the number '1'
            ...
        case 0xF708FF00: // Receive the number '4'
            ...
        case 0xF20DFF00: // Receive the number 'C'
            ...
        case 0xA15EFF00: // Receive the number '3'
            ...
        case 0xA55AFF00: // Receive the number '6'
            ...
        case 0xB54AFF00: // Receive the number '9'
            ...
        case 0xBB44FF00: // Receive the number 'TEST'
            ...
        case 0xE718FF00: // Receive the number '2'
            ...
    }
}
```

```

case 0xE31CFF00: // Receive the number '5'
...
case 0xBD42FF00: // Receive the number '7'
...
case 0xAD52FF00: // Receive the number '8'
...
case 0xFFFFFFFF: // Remain unchanged
    break;
default:
    break;
}
}

```

Sketch 04.4\_Multi\_Functional\_Robot.ino is almost the same as 04.3\_Multi\_Functional\_Robot.ino, except that it is added with the music play function. You can find the function of each key in the table below.

ICON	KEY Value	Function	ICON	KEY Value	Function
	BF40FF00	Move forward		E718FF00	Change the expression display mode
	F807FF00	Turn left		E31CFF00	Turn off emoticons
	F609FF00	Turn light		BD42FF00	Change the display mode of the WS2812
	E619FF00	Move back		AD52FF00	Turn off WS2812 display
	EA15FF00	Stop the robot		A15EFF00	Dancing Mode
	BB44FF00	Control the buzzer		A55AFF00	Ultrasonic obstacle avoidance mode
	E916FF00	Playing Music 1		F30CFF00	Playing Music 2
	F708FF00	Stop playing			

# Chapter 6 Bluetooth remote control robot

This section requires an Android or iPhone device with Bluetooth to control the robot.

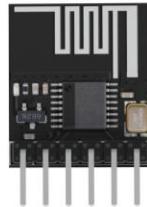
If you have any concerns, please feel free to contact us via [support@freenove.com](mailto:support@freenove.com)

## 6.1 Bluetooth Sending and Receiving Data

### Bluetooth Module

The Bluetooth module is a serial port transparent transmission module that supports Bluetooth Low Energy (BLE).

It has such advantages as small size, high performance, high-cost performance, low power consumption, and strong platform compatibility. The Bluetooth module we use is as shown below:

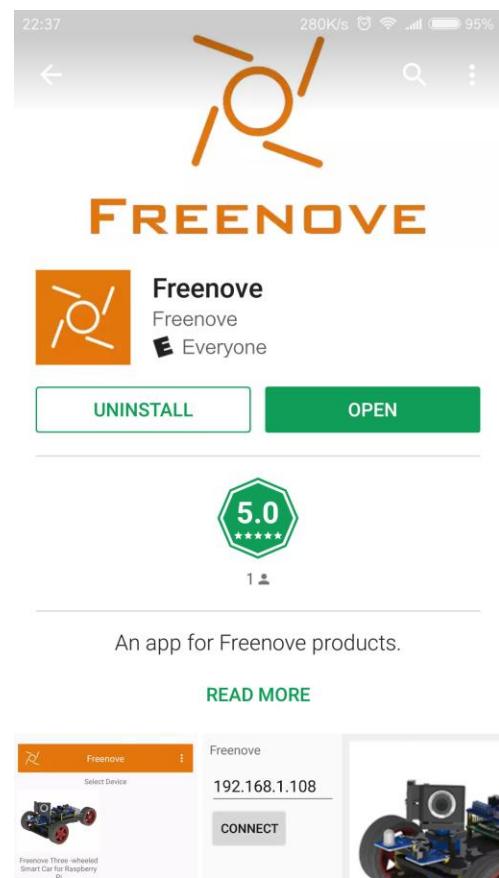


### Install Freenove app

There are three ways to install our app.

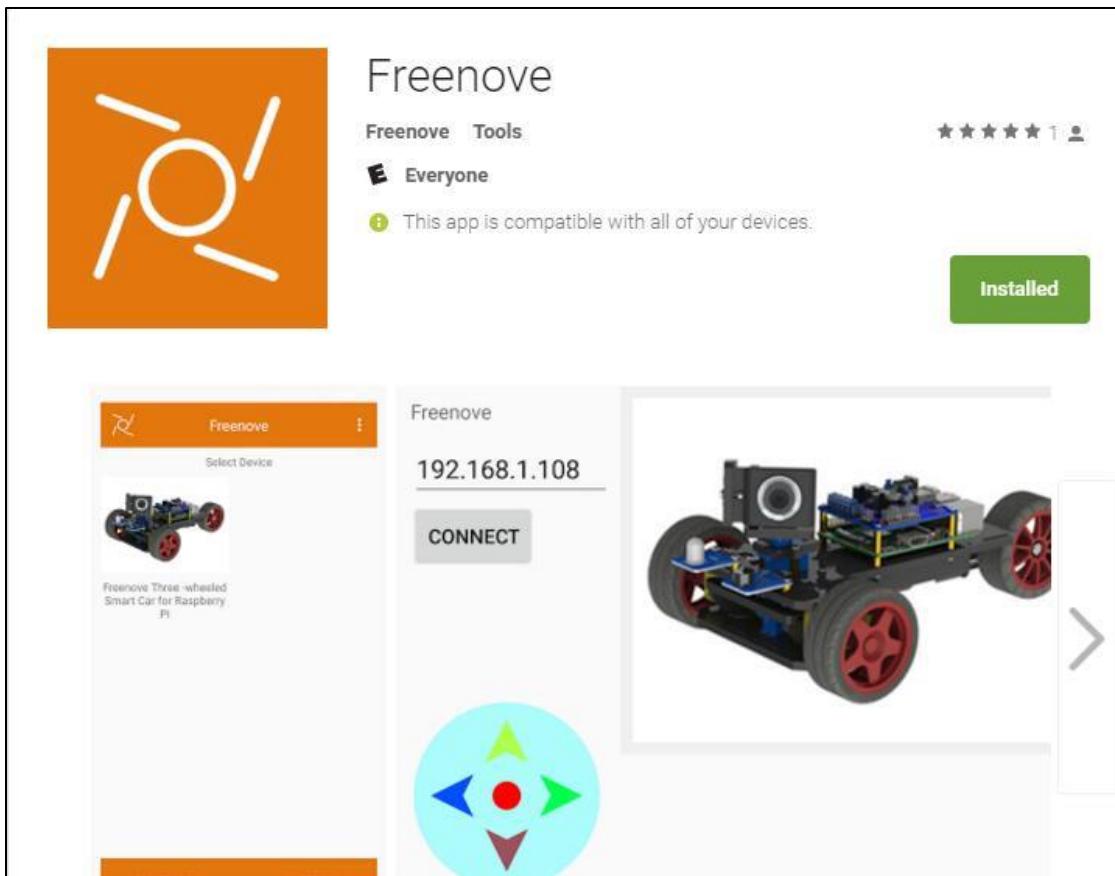
#### Method 1

Use Google play to search “Freenove”, download and install.



### Method 2

Visit <https://play.google.com/store/apps/details?id=com.freenove.suhayl.Freenove>, and click install.



### Method 3

Visit [https://github.com/Freenove/Freenove\\_app\\_for\\_Android](https://github.com/Freenove/Freenove_app_for_Android), download the files in this library, and install freenove.apk to your Android phone manually.

The screenshot shows the GitHub repository page for 'Freenove / Freenove\_app\_for\_Android'. At the top, there are links for 'Code', 'Issues 0', 'Pull requests 0', 'Projects 0', 'Wiki', 'Pulse', 'Graphs', and 'Settings'. Below this is a summary bar with '1 commit', '1 branch', '0 releases', and '1 contributor'. A navigation bar includes 'Branch: master', 'New pull request', 'Create new file', 'Upload files', 'Find file', and a prominent green 'Clone or download' button. A callout box with an orange border and arrow points to the 'Clone or download' button. The repository details show a commit from 'SuhaylZhao' with the message 'First Publish.' and a timestamp of '3 minutes ago'. There are also entries for 'Readme.txt' and 'freenove.apk'.

Need support? ✉ [support.freenove.com](mailto:support.freenove.com)

## Instructions for Using the Bluetooth Module

The Bluetooth module communicates with the Raspberry Pi Pico (W) through serial port, and the program is also uploaded to Pico (W) via the serial port. **Therefore, when uploading code to pico (W), if it fails, please remove the Bluetooth module and upload again.**

When the Bluetooth module is not connected by other device, it can be configured using the AT command. Once connected, the Bluetooth module acts as a data pipe and cannot be configured.

By default, the Bluetooth module has a baud rate of 115200, no parity, 8 data bits, and 1 stop bit. Bluetooth name "BT05", role mode is slave mode.

### Set name of bluetooth

If you have multiple Bluetooth modules with the same name around you, you will be confused when you connect. Which one is the Bluetooth module I want to connect to?

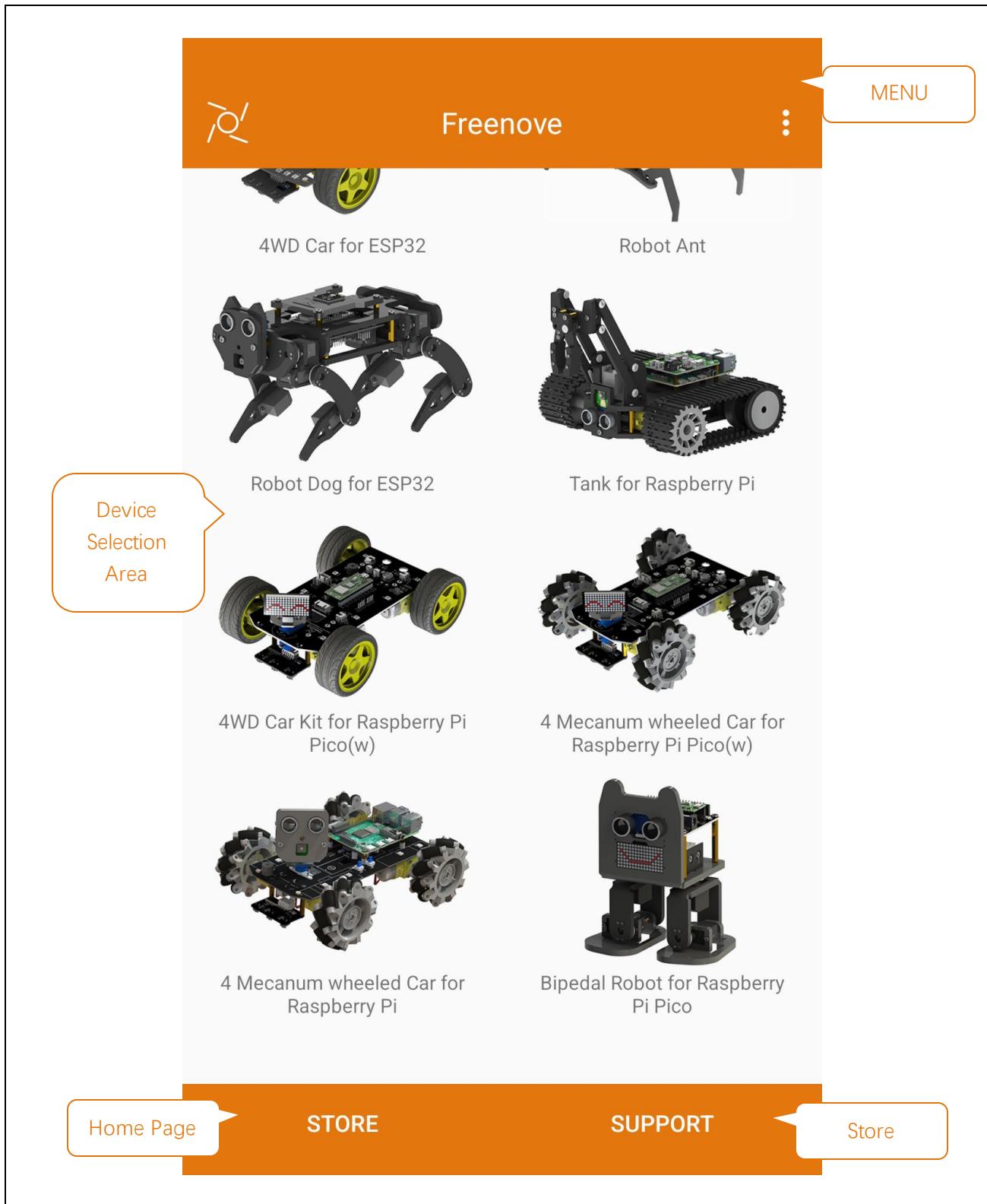
In the next project, we will introduce how to use the AT command to modify the name of the Bluetooth module and the master-slave role in the program.

For AT commands and more information about the Bluetooth module, refer to the documentation in the package for Datasheets/BT05-Instruction.pdf

This project uses the AT command to make some settings for the Bluetooth module, then uses the Bluetooth module to receive data from the app and print the data on the serial monitor.

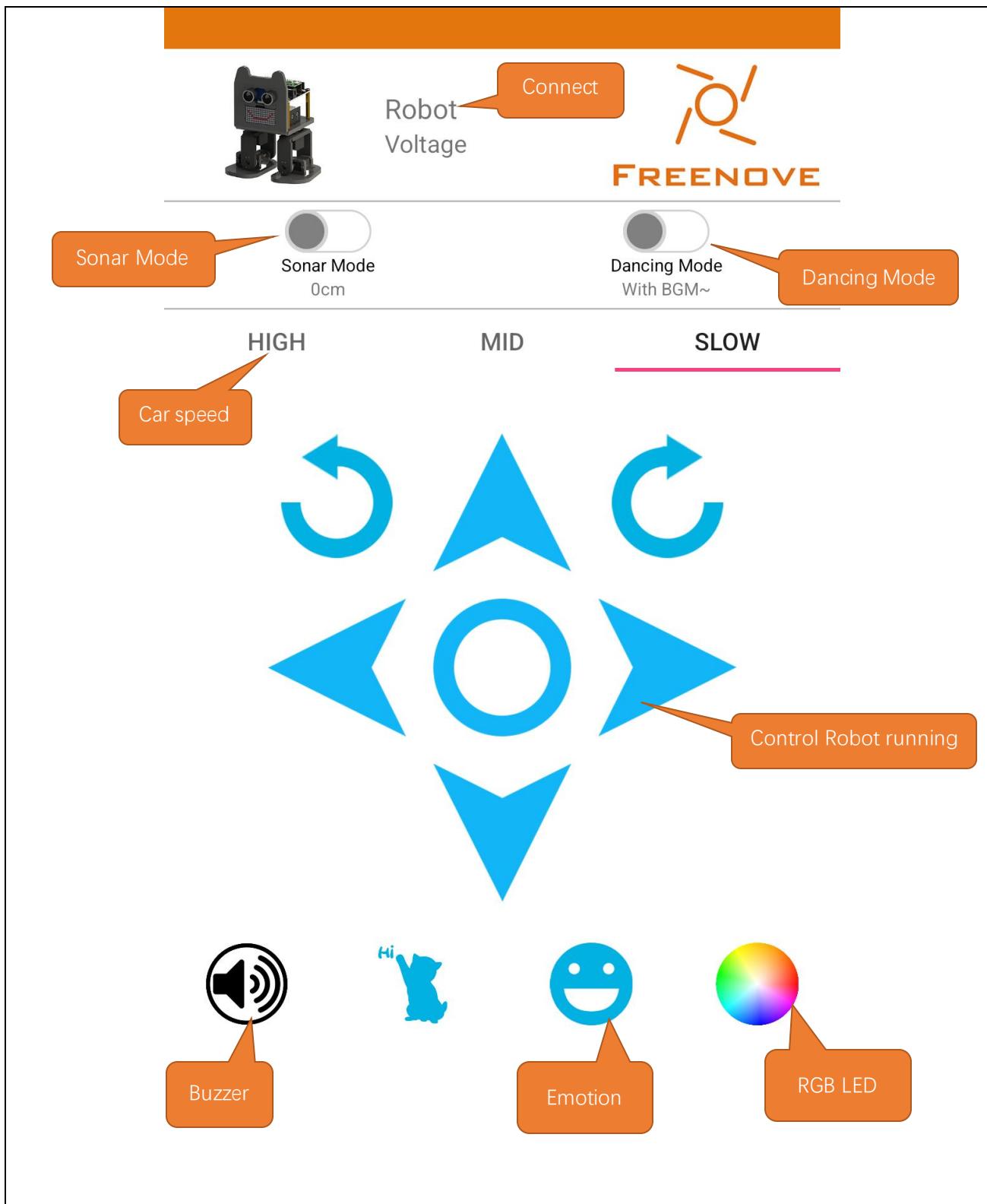
### Menu

Open application “Freenove”, as shown below:



## Introduction to the APP

In this chapter, we use the Freenove Bipedal robot for Raspberry Pi Pico (W) in the app, so let's learn its interface first, as shown below:





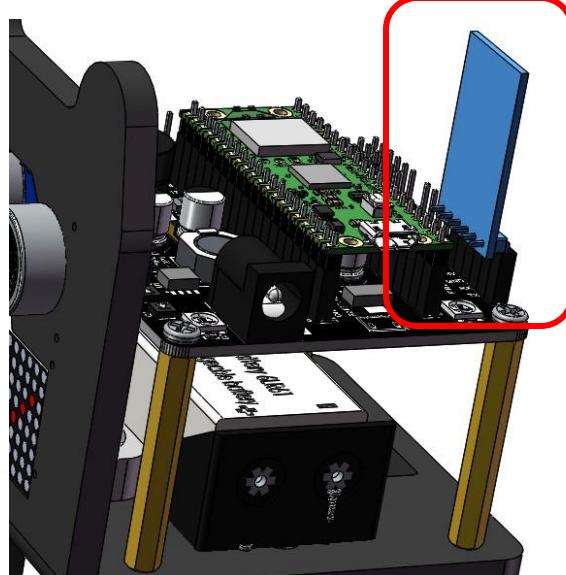
## Sketch

Open “05.1\_Bluetooth\_Robot” in “**Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Sketches**” and double click “05.1\_Bluetooth\_Robot.ino”.

Note: if the code fails to upload, please remove the Bluetooth and upload it again.

After the code is successfully uploaded, follow the steps below.

1. Plug the Bluetooth module to the car as shown below. **Don't reverse it. The wrong connection may damage your hardware.**

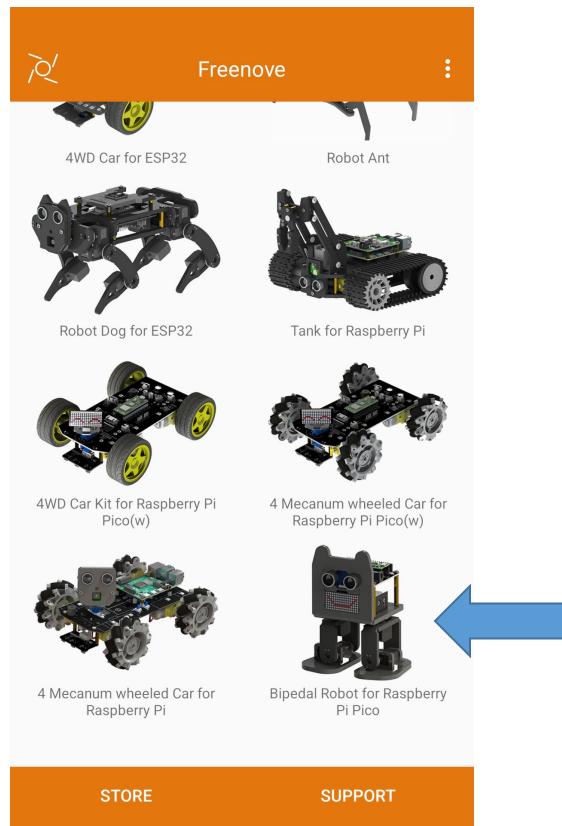


2. Open Arduino Serial Monitor, and reset the control board.

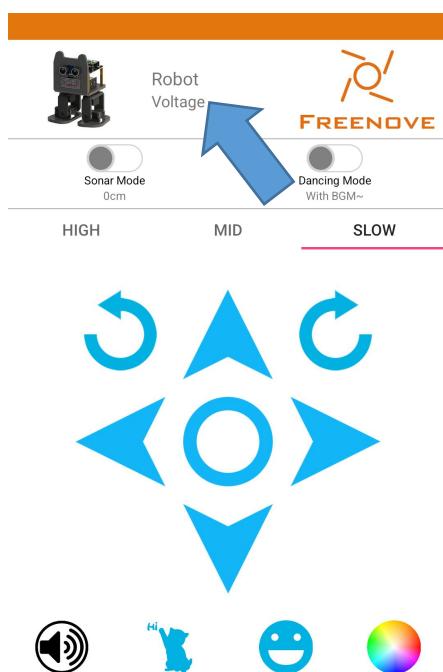
As shown in the figure below, the Bluetooth name is set to “BT05” and the Bluetooth mode is slave mode (ROLE=0).

```
COM4
11:15:10.099 -> AT+NAMEBT05-GEN
11:15:10.287 -> AT+NAMBBT05-BLE
11:15:10.473 -> AT+ROLE0
11:15:10.708 -> +OK
11:15:10.708 -> +OK
11:15:10.708 ->
```

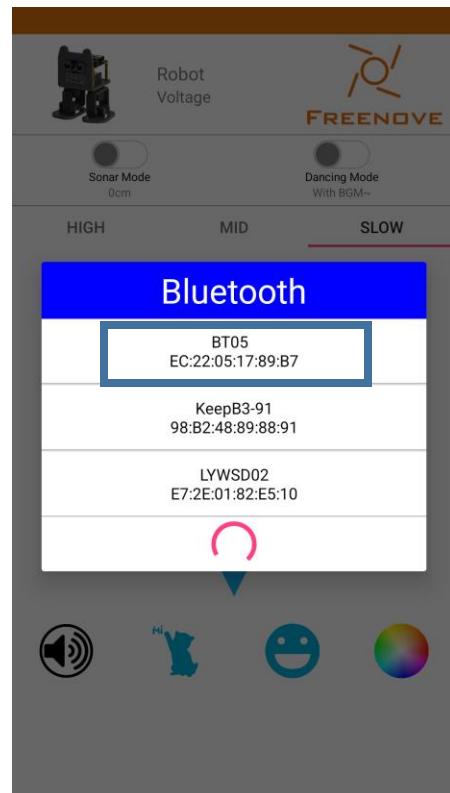
Next, open Freenove APP, tap e Freenove Bipedal Robot for Raspberry Pi Pico.



Click the following icon.

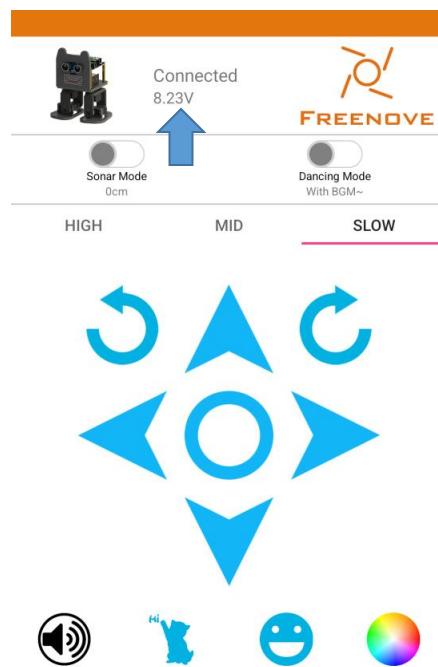


Click BT05.



If the connection successes, you can see "Connected".

Operate the app, and observe the monitor.



The monitor will show contents as below:

```
A#0#0#
D#2000#
D#0#
C#0#189#199#255#
C#0#189#199#255#
 Autoscroll  Show timestamp      Newline      9600 baud      Clear output
```

### Bluetooth data- robot action

The command format for communication between app and robot is A#xxx#xxx#...xxx#, where # is a separator, the first character A represents the action command, it can be other characters, such as B, C, D…The xxx represents the parameters of the action command. And different commands carry different parameters. The command list is as below:

Action command	Description	Command character	Number of parameters (app send/receive)	Format example (app send/receive)
MOVE	Under the MOVE mode, parameter 1 represents the movement mode, and parameter 2 indicates the moving speed.	A	2	A#100#100#
VOLTAGE	Get the batteries voltage, parameter is the voltage value, unit mV	P	0/1	P# /P#4100#
LED_RGB	Control RGBLED, parameters respectively are serial number of LED mode, red value, green value, blue value.	C	4	C#2#100#150#200#
BUZZER	Control buzzer, and parameter is the frequency.	D	1	D#2000#

### Code

```

1 #include <Arduino.h>
2 #include <SoftwareSerial.h> // Reference library
3
4 #include "SerialCommand.h"
5 SoftwareSerial BTserial = SoftwareSerial(1, 0); // RX pin to 0 and TX pin to 1 on the board
6 SerialCommand SCmd(BTserial);
7
8 String inputString = ""; // a String to hold incoming data
9 bool stringComplete = false; // whether the string is complete
10
11 void receiveStop() {
12     delay(10);
13     Serial.flush();
14 }
15
16 void setup() {
17     Serial.begin(115200);
18     BTserial.begin(115200);
19     BTserial.println("AT+UART?\r\n");

```

```
20 delay(200);
21 BTserial.println("AT+UART=115200\r\n");
22 delay(200);
23 BTserial.println("AT+NAME=BT05\r\n"); //Set the radio called Robot
24 delay(200);
25 // BTserial.println(" AT+ROLE=2\r\n "); //Set Bluetooth to slave mode.
26 // BTserial.println("AT+RESET\r\n"); //Reset (restart)
27
28 SCmd.addDefaultHandler(receiveStop);
29 inputString.reserve(200);
30 Serial.println("Set the name of the Bluetooth module to BT05.");
31 Serial.println("Set the Bluetooth baud rate to 115200.");
32 // Serial.println("Set Bluetooth to slave mode.");
33 }
34
35
36 void loop() {
37 while (BTserial.available()) {
38 // get the new byte:
39 char inChar = (char)BTserial.read();
40 // add it to the inputString:
41 inputString += inChar;
42 // if the incoming character is a newline, set a flag so the main loop can
43 // do something about it:
44 if (inChar == '\n') {
45 stringComplete = true;
46 }
47 if (stringComplete) {
48 Serial.println(inputString);
49 // clear the string:
50 inputString = "";
51 stringComplete = false;
52 }
53 }
54 }
```

Upload the code to Raspberry Pi Pico W car and open serial monitor.

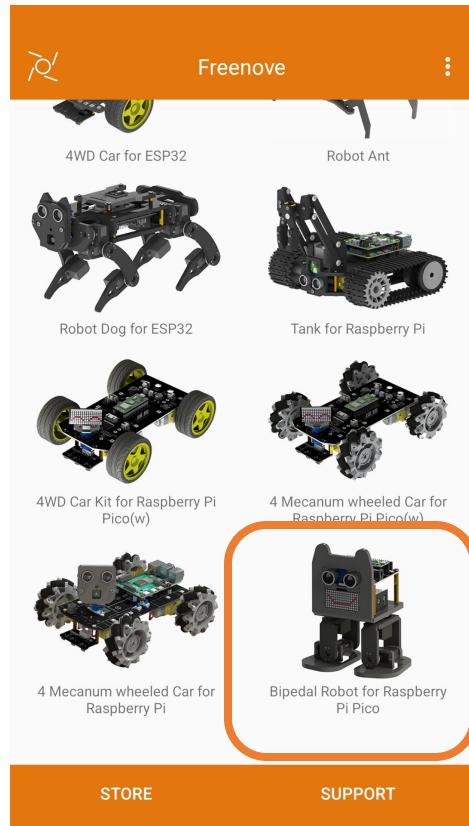
The screenshot shows the Arduino IDE interface. The top menu bar includes File, Edit, Sketch, Tools, Help, and a 'Select Board' dropdown. The left sidebar contains icons for file operations like Open, Save, and Print. The main workspace displays the code for '05\_1\_Bluetooth\_Robot.ino'. The code uses BTserial to handle incoming characters and print them to the serial port. Lines 49-61 are highlighted in light blue. The status bar at the bottom right shows 'Ln 60, Col 23' and 'No board selected'. Below the IDE is the Serial Monitor window, which has tabs for 'Output' and 'Serial Monitor'. It shows a message input field with 'Message (Enter to send message to 'Raspberry Pi Pico W' on 'COM3')', a 'New Line' dropdown, and a '115200 baud' dropdown. The status bar at the bottom of the Serial Monitor window shows 'Ln 71, Col 1' and 'Raspberry Pi Pico W on COM3'.

```
05_1_Bluetooth_Robot | Arduino IDE 2.2.1
File Edit Sketch Tools Help
Select Board
05_1_Bluetooth_Robot.ino SerialCommand.cpp SerialCommand.h
...
(BTserial.available()) {
    // get the new byte:
    inChar = (char)BTserial.read();
    // add it to the inputString:
    inputString += inChar;
    // if the incoming character is a newline, set a flag so the main loop can
    // do something about it:
    if (inChar == '\n') {
        stringComplete = true;
    }
    if (stringComplete) {
        Serial.println(inputString);
        // clear the string:
        inputString = "";
        stringComplete = false;
    }
}
}

Ln 60, Col 23 × No board selected

Output Serial Monitor ×
Message (Enter to send message to 'Raspberry Pi Pico W' on 'COM3')
New Line 115200 baud
Ln 71, Col 1 UTF-8 Raspberry Pi Pico W on COM3 2
```

Open Freenove app, and tap the bipedal robot for Raspberry Pi Pico (W).



#### Code Explanation:

Configure Bluetooth, set the Bluetooth name, baud rate and other parameters.

```
Serial.begin(115200);
BTserial.begin(115200);
BTserial.println("AT+UART?\r\n");
delay(200);
BTserial.println("AT+UART=115200\r\n");
delay(200);
BTserial.println("AT+NAME=BT05\r\n"); //Set the radio called Robot
delay(200);
```

After the Bluetooth module connects successfully, print the data it receives.

```
while (BTserial.available()) {
    // get the new byte:
    char inChar = (char)BTserial.read();
    // add it to the inputString:
    inputString += inChar;
    // if the incoming character is a newline, set a flag so the main loop can
    // do something about it:
    if (inChar == '\n') {
        stringComplete = true;
    }
    if (stringComplete) {
        Serial.println(inputString);
    }
}
```

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```
// clear the string:  
inputString = "";  
stringComplete = false;  
}  
}
```

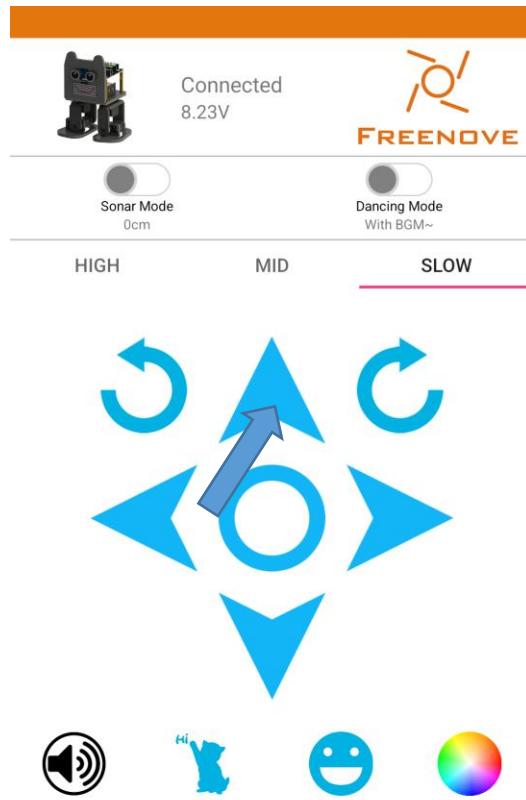
## 6.2 Bluetooth Remote Robot

In the previous section, we have learned how to receive the data of the app via Bluetooth, and the meanings of the data format. Next, let's use the data to control the robot to make some basic movements, like moving forward and backward, turning left and right, etc.

### Sketch

Open the folder "05.2\_Bluetooth\_Remote\_Robot" in Freenove\_Bipedal\_Robot\_Kit\_for\_Raspberry\_Pi\_Pico\Sketches and double click "05.2\_Bluetooth\_Remote\_Robot.ino".

As mentioned above, connect the APP to the robot via Bluetooth, and then control the robot by tapping or sliding the operation panel on the APP.



### Code

```

1 #include <Arduino.h>
2 #include <SoftwareSerial.h>
```

```
3 #include <EEPROM.h>
4 #include "Freenove_Robot_For_Pico_W.h"
5
6 #include "SerialCommand.h"
7 SoftwareSerial BTserial = SoftwareSerial(1, 0); // RX pin to 1 and TX pin
8 to 0 on the board
9 SerialCommand SCmd(BTserial);
10 #include "Bipedal_Robot.h"
11 Bipedal_Robot Bipedal_Robot;
12
13 #define LeftLeg 10
14 #define RightLeg 12
15 #define LeftFoot 11
16 #define RightFoot 13
17
18 #define Buzzer 21
19
20 int YL;
21 int YR;
22 int RL;
23 int RR;
24
25 int T = 1000;
26 int moveId = 0;
27 bool isServoResting = true;
28
29 extern int moveId;
30 extern bool isServoResting;
31
32 int moveSize = 15;
33
34 void receiveStop() {
35     sendAck();
36     sendFinalAck();
37 }
38
39 void recieveBuzzer() {
40     sendAck();
41     bool error = false;
42     int freq;
43     int duration;
44     char *arg;
45     arg = SCmd.next();
46     if (arg != NULL) freq = atoi(arg);
```

```
47     else error = true;
48     Serial.println("\nfrec is:");
49     Serial.println(frec);
50     tone(20, freq);
51     sendFinalAck();
52 }
53
54 void receiveMovement() {
55     sendAck();
56     Serial.print("move loop...");
57     if (Bipedal_Robot.getRestState() == true)
58         Bipedal_Robot.setRestState(false);
59     isServoResting = Bipedal_Robot.getRestState();
60     char *arg;
61     arg = SCmd.next();
62     if (arg != NULL) {
63         moveId = atoi(arg);
64         Serial.print("moveId:");
65         Serial.print(moveId);
66     } else {
67         moveId = 0;
68     }
69     arg = SCmd.next();
70     if (arg != NULL) {
71         T = atoi(arg);
72         if (T == 0) {
73             T = 1000;
74         } else if (T == 1) {
75             T = 1500;
76         } else if (T == 2) {
77             T = 2000;
78         }
79     } else T = 2000;
80     Serial.print("T is:");
81     Serial.print(T);
82     arg = SCmd.next();
83     if (arg != NULL) moveSize = atoi(arg);
84     else moveSize = 15;
85 }
86 void move(int moveId) {
87     // bool manualMode = false;
88     switch (moveId) {
89     case 0:
90         Bipedal_Robot.home();
```

```
91     // Serial.print("moveId 0 home");
92     break;
93 case 1:
94     Bipedal_Robot.walk(1, T, 1);
95     break;
96 case 2:
97     Bipedal_Robot.walk(1, T, -1);
98     break;
99 case 3:
100    Bipedal_Robot.turn(1, T, 1);
101    break;
102 case 4:
103    Bipedal_Robot.turn(1, T, -1);
104    break;
105 default:
106    break;
107 }
108 }

110 void sendAck() {
111     delay(10);
112     Serial.flush();
113 }
114 void sendFinalAck() {
115     delay(10);
116     Serial.flush();
117 }

119 void setup() {
120     Serial.begin(9600);
121     BTserial.begin(9600);
122     //初始化一些传感器
123     Buzzer_Setup(); //Initialize the buzzer
124     EEPROM.begin(512);
125     Bipedal_Robot.init(LeftLeg, RightLeg, LeftFoot, RightFoot, true); //Set
126     the servo pins
127
128     YL = EEPROM.read(0);
129     if (YL > 128) YL -= 256;
130     YR = EEPROM.read(1);
131     if (YR > 128) YR -= 256;
132     RL = EEPROM.read(2);
133     if (RL > 128) RL -= 256;
134     RR = EEPROM.read(3);
```

```

135 if (RR > 128) RR -= 256;
136 Bipedal_Robot.setTrims(YL, YR, RL, RR);
137 calib_homePos();
138 Bipedal_Robot.saveTrimsOnEEPROM();
139 Bipedal_Robot.home();
140 delay(100);
141 EEPROM.commit();
142 SCmd.addCommand("S", receiveStop);
143 SCmd.addCommand("D", recieveBuzzer);
144 SCmd.addCommand("A", receiveMovement);
145 SCmd.addDefaultHandler(receiveStop);
146 Bipedal_Robot.home();
147 }
148
149 void loop() {
150   SCmd.readSerial();
151 }
152
153 void calib_homePos() {
154   int servoPos[4];
155   servoPos[0] = 90;
156   servoPos[1] = 90;
157   servoPos[2] = 90;
158   servoPos[3] = 90;
159   Bipedal_Robot._moveServos(500, servoPos);
160   Bipedal_Robot.detachServos();
161 }
162
163 void setup1() {
164 }
165 void loop1() {
166   move(moveId);
167 }

```

#### Code Explanation:

Add the header files to drive the robot.

```

#include <Arduino.h>
#include <SoftwareSerial.h>
#include <EEPROM.h>
#include "Freenove_Robot_For_Pico_W.h"

#include "SerialCommand.h"

```

Upon receiving movement commands, the robot makes corresponding actions.

```

void move(int moveId) {
  // bool manualMode = false;

```

```
switch (moveId) {  
    case 0:  
        Bipedal_Robot.home();  
        // Serial.print("moveId 0 home");  
        break;  
    case 1:  
        Bipedal_Robot.walk(1, T, 1);  
        break;  
    case 2:  
        Bipedal_Robot.walk(1, T, -1);  
        break;  
    case 3:  
        Bipedal_Robot.turn(1, T, 1);  
        break;  
    case 4:  
        Bipedal_Robot.turn(1, T, -1);  
        break;  
    default:  
        break;  
}  
}
```

## 6.3 Multifunctional Bluetooth Remote Robot

In this section, we add more functions to the robot based on the previous section, making the robot more interested. The main functions include automatic obstacle avoidance, audio playing, LED displaying, and expressions on LED dot matrix.

### Upload Code and Running

Connect the robot to your computer with the USB cable.

As this section involves the audio playing function, please upload the audio data to the Raspberry Pi Pico (W) before uploading sketch. You can find the detailed steps [here](#).

After uploading the audio file, you can upload sketch 05.3\_Multi\_Functional\_Robot to the robot.

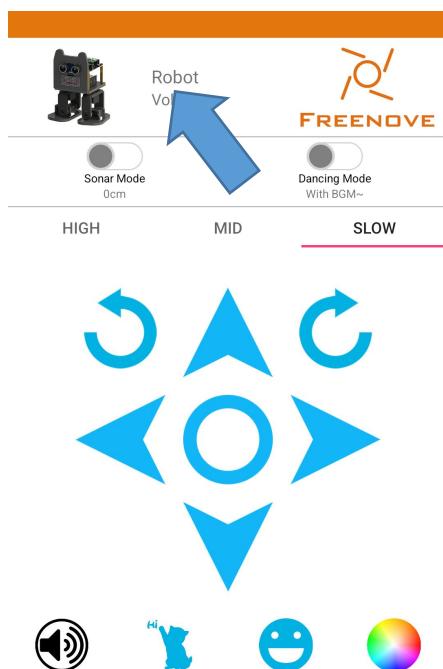
If the code fails to upload, please remove the Bluetooth module and upload again. Reconnect the Bluetooth module after the code uploads successfully.

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

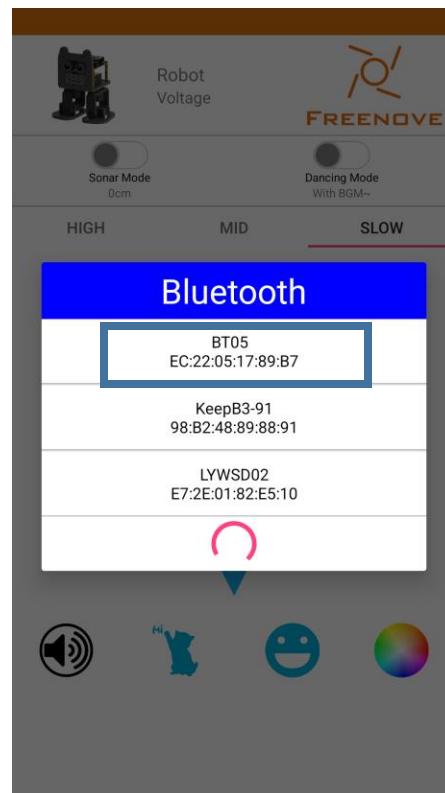
- Title Bar:** 05.3\_Multi\_Functional\_Robot | Arduino IDE 2.2.1
- Toolbar:** File, Edit, Sketch, Tools, Help
- Sketch Selection:** Raspberry Pi Pico W
- Code Editor:** Displays the C++ code for the sketch. The code includes functions for WS2812 LED control, ultrasonic sensor data handling, and matrix display. Lines 501-514 are highlighted.
- Output Window:** Shows the compilation and upload process. It lists the libraries used (Wire, SD, SDFS, SPI, ESP8266SdFat) and provides memory usage statistics: 491336 bytes (47%) of program storage space, 1044480 bytes maximum, and 75336 bytes (28%) of dynamic memory left.
- Status Bar:** Ln 18, Col 38 Raspberry Pi Pico W on COM3 [not connected]

After the code is successfully uploaded, unplug the USB cable and plug the Bluetooth module to the robot. Turn on the robot power switch.

**Click following icon.**



**Click BT05**



Connect the APP with the robot through Bluetooth. Tap or swipe the operation panels on the app to control the robot's movements. The color palette of the lower right corner can be clicked to control the display mode and color of the LED. Among them,  
Mode 0 is a flowing rainbow,  
Mode 1 is a flowing water LED with color changing.  
Mode 2 is a color-adjustable Blink.  
Mode 3 displays the selected color of the current color picker for all LEDs.

## Code

On the basis of the previous sketch, this one is added with more interesting functions.

### 05.3\_Multi\_Functional\_Robot

```
#include <Arduino.h>
#include <EEPROM.h>
#include "Bipedal_Robot.h"
#include "AudioFileSourceLittleFS.h"
#include "AudioGeneratorMP3.h"
#include "AudioOutputI2SNoDAC.h"
#include "AudioFileSourceID3.h"
```

```
#include "AudioOutputI2S.h"
#include <SoftwareSerial.h>
#include "SerialCommand.h"
#include "Freenove_Robot_For_Pico_W.h"
#include "Freenove_Robot_Emotion.h"
#include "Freenove_Robot_WS2812.h"
#include "Freenove_VK16K33_Lib.h"

SoftwareSerial BTserial = SoftwareSerial(1, 0); // RX pin to 0 and TX pin to 1 on the board
SerialCommand SCmd(BTserial);

Bipedal_Robot Bipedal_Robot;
AudioGeneratorMP3 *mp3;
AudioFileSourceLittleFS *file;
AudioOutputI2SNoDAC *out;
AudioFileSourceID3 *id3;

#define LeftLegPin 10
#define RightLegPin 12
#define LeftFootPin 11
#define RightFootPin 13
#define BuzzerPin 20

int motionFlag = 0;
int ultrasonicavoidMode = 0;
int playstartingmusic = 0;
int musicmode = 0;
int playsong = 0;
extern int playsong; //Set the proportional coefficient
int T = 1000;
int moveId = 0;
int dance_steps = 0;
int Ultrasonic_Avoid_steps = 0;
bool isServoResting = true;
extern int moveId;
extern bool isServoResting;
int moveSize = 15;
#define ACTION_GET_VOLTAGE 'P'
#define ACTION_GET_DISTANCE 'E'
#define INTERVAL_CHAR '#'
unsigned long lastUploadVoltageTime;
unsigned long lastUploadDistanceTime;
#define UPLOAD_VOL_TIME 2000
```

```
void upLoadVoltageToApp() {
    float voltage = 0;
    voltage = Get_Battery_Voltage();
    BTserial.print("P#");
    BTserial.println(int(voltage * 1000));
}

void upLoadDistanceToApp() {
    float Distance = 0;
    Distance = Get_Sonar();
    BTserial.print("E#");
    BTserial.println(Distance);
}

void receiveStop() {
    sendAck();
    sendFinalAck();
}

void recieveBuzzer() {
    sendAck();
    moveId = 0;
    playsong = 0;
    bool error = false;
    int freq;
    char *arg;
    arg = SCmd.next();
    if (arg != NULL) freq = atoi(arg);
    else error = true;
    tone(2, freq);
    sendFinalAck();
}

void receiveAvoid() {
    sendAck();
    ws2812_task_mode = 0;
    emotion_task_mode = 0;
    if (Bipedal_Robot.getRestState() == true) Bipedal_Robot.setRestState(false);
    isServoResting = Bipedal_Robot.getRestState();
    char *arg;
    arg = SCmd.next();
    if (arg != NULL) {
        ultrasonicavoidMode = atoi(arg);
        playsong = 0;
    }
}
```

```
if (ultrasonicavoidMode == 1) {  
    moveId = 21;  
    Ultrasonic_Avoid_steps = 0;  
    playsong = 0;  
}  
if (ultrasonicavoidMode == 2) {  
    dance_steps = 0;  
    moveId = 22;  
    playsong = 4;  
}  
if (ultrasonicavoidMode == 0) {  
    moveId = 0;  
    playsong = 0;  
}  
}  
sendFinalAck();  
  
void receiveEmotion() {  
    sendAck();  
    Emotion_Setup();  
    moveId = 0;  
    playsong = 0;  
    char *arg;  
    char *endstr;  
    arg = SCmd.next();  
    if (arg != NULL) {  
        String stringOne = String(arg); // converting a constant char into a String  
        emotion_task_mode = stringOne.toInt();  
        Emotion_SetMode(emotion_task_mode);  
    } else {  
    }  
    sendFinalAck();  
}  
  
void receiveLED() {  
    sendAck();  
    moveId = 0;  
    playsong = 0;  
    char *arg;  
    unsigned char paramters[3];  
    char *endstr;  
    arg = SCmd.next();  
    if (arg != NULL) {  
}
```

```
String stringOne = String(arg); // converting a constant char into a String
ws2812_task_mode = stringOne.toInt();
} else {
}
arg = SCmd.next();
String stringOne1 = String(arg);
paramters[0] = stringOne1.toInt();

arg = SCmd.next();
String stringOne2 = String(arg);
paramters[1] = stringOne2.toInt();

arg = SCmd.next();
String stringOne3 = String(arg);
paramters[2] = stringOne3.toInt();

WS2812_Set_Color_1(15, paramters[0], paramters[1], paramters[2]);
sendFinalAck();
}

void songmusic() {
if (playsong > 0) {
playmusic(1, playsong);
if (playsong != 4) {
playsong = 0;
}
} else {
pinMode(6, OUTPUT);
digitalWrite(6, LOW);
}
}
void receiveMusic() {
int music_song;
sendAck();
ws2812_task_mode = 0;
emotion_task_mode = 0;
if (Bipedal_Robot.getRestState() == true) Bipedal_Robot.setRestState(false);
isServoResting = Bipedal_Robot.getRestState();
char *arg;
arg = SCmd.next();
if (arg != NULL) {
music_song = atoi(arg);
playsong = music_song;
playstartingmusic = music_song;
}
```

```
clearEmtions();
if (playsong == 1) {
    moveId = 18;
} else if (playsong == 2) {
    moveId = 19;
} else if (playsong == 3) {
    moveId = 20;
} else if (playsong == 0) {
    moveId = 0;
}
} else {
    moveId = 0;
}
T = 2200;
}

void playmusic(int playtimes, int song) {
if (playtimes--) {
    if (song == 1) {
        file = new AudioFileSourceLittleFS("Hello.mp3");
    } else if (song == 2) {
        file = new AudioFileSourceLittleFS("Nicetomeetyou.mp3");
    } else if (song == 3) {
        file = new AudioFileSourceLittleFS("goodbye.mp3");
    } else if (song == 4) {
        file = new AudioFileSourceLittleFS("1.mp3");
    } else if (song == 5) {
        file = new AudioFileSourceLittleFS("onfoot.mp3");
    } else if (song == 6) {
        file = new AudioFileSourceLittleFS("hello_cn.mp3");
    } else if (song == 0) {
        file = new AudioFileSourceLittleFS("split.mp3");
    }
    out = new AudioOutputI2SNoDAC(6);
    out->SetGain(4.0); //Volume Setup (0-4.0)
    mp3 = new AudioGeneratorMP3();
    mp3->begin(file, out);
    if (mp3->isRunning() && song > 0) {
        if (!mp3->loop() && song > 0) {
            delete file;
            delete mp3;
            out->flush();
            out->stop();
        }
    }
}
```

```
    } else {
        delete file;
        delete mp3;
        out->flush();
        out->stop();
        pinMode(6, OUTPUT);
        digitalWrite(6, LOW);
    }
}

//Ultrasonic robot
void Ultrasonic_Avoid() {
    if (Get_Sonar() <= 15) {
        Serial.println(Get_Sonar());
        Bipedal_Robot.walk(2, 1500, -1);
        Bipedal_Robot.turn(3, 1500, 1);
    }
    Bipedal_Robot.walk(1, 2000, 1);
}

int avoidanceflag =0;

void avoidance() {
    if (ultrasonicavoidMode == 1) {
        Serial.println("ultrasonicavoidMode... ");
        Serial.println(ultrasonicavoidMode);
        Ultrasonic_Avoid_steps = Ultrasonic_Avoid_steps + 1;
        switch (Ultrasonic_Avoid_steps) {
            case 0:
                Ultrasonic_Avoid_steps = 0;
                break;
            case 1:
                Serial.println("steps1");
                Bipedal_Robot.walk(1, 1500, -1);
                break;
            case 2:
                Serial.println("steps2");
                Bipedal_Robot.walk(1, 1500, -1); // BACKWARD x2
                break;
            case 3:
                Serial.println("steps3");
                Bipedal_Robot.turn(1, 1500, 1);
                break;
        }
    }
}
```

```
    case 4:
        Serial.println("steps4");
        Bipedal_Robot.turn(1, 1500, 1);
        break;
    case 5:
        Serial.println("steps5");
        Bipedal_Robot.turn(1, 1500, 1); // LEFT x3
        avoidanceflag =0;
        break;
    }
    if (Ultrasonic_Avoid_steps > 6) {
        Ultrasonic_Avoid_steps = 0;
        avoidanceflag =0;
    }
    if (ultrasonicavoidMode != 1) {
        Ultrasonic_Avoid_steps = 0;
    }
}
}

void dance() {
    dance_steps = dance_steps + 1;
    staticEmtions(19);
    if (moveId > 0) {
        switch (dance_steps) {
            case 0:
                dance_steps = 0;
                break;
            case 1:
                Bipedal_Robot.jitter(1, 750, 20);
                break;
            case 2:
                Bipedal_Robot.jitter(1, 750, 20);
                break;
            case 3:
                Bipedal_Robot.crusaito(1, 800, 30, 1);
                break;
            case 4:
                Bipedal_Robot.crusaito(1, 800, 30, -1);
                break;
            case 5:
                Bipedal_Robot.crusaito(1, 800, 30, 1);
                delay(300);
        }
    }
}
```

```
        break;
    case 6:
        Bipedal_Robot.walk(1, 1500, -1);
        break;
    case 7:
        Bipedal_Robot.walk(1, 1000, 1);
        break;
    case 8:
        Bipedal_Robot.walk(1, 1000, 1);
        break;
    case 9:
        Bipedal_Robot.moonwalker(1, 600, 30, 1);
        break;
    case 10:
        Bipedal_Robot.moonwalker(1, 600, 30, -1);
        break;
    case 11:
        Bipedal_Robot.moonwalker(1, 600, 30, 1);
        break;
    case 12:
        Bipedal_Robot.moonwalker(1, 600, 30, -1);
        break;
    case 13:
        Bipedal_Robot.walk(1, 1500, -1);
        break;
    }
    if (dance_steps > 14) {
        dance_steps = 0;
    }
} else {
    dance_steps = 0;
}
}

void receiveMovement() {
    sendAck();
    ws2812_task_mode = 0;
    emotion_task_mode = 0;
    if (Bipedal_Robot.getRestState() == true) Bipedal_Robot.setRestState(false);
    isServoResting = Bipedal_Robot.getRestState();
    char *arg;
    arg = SCmd.next();
    if (arg != NULL) {
        moveId = atoi(arg);
```

```
playsong = 0;
} else {
    moveId = 0;
}
arg = SCmd.next();
if (arg != NULL) {
    T = atoi(arg);
    if (T == 0) {
        T = 1500;
    } else if (T == 1) {
        T = 2000;
    } else if (T == 2) {
        T = 2500;
    }
} else T = 2500;
arg = SCmd.next();
if (arg != NULL) moveSize = atoi(arg);
else moveSize = 15;
}

void move(int movemode) {
    switch (movemode) {
        case 0:
            Bipedal_Robot.home();
            break;
        case 1:
            Bipedal_Robot.walk(1, T, 1);
            Serial.print(T);
            break;
        case 2:
            Bipedal_Robot.walk(1, T, -1);
            break;
        case 3:
            Bipedal_Robot.turn(1, T, 1);
            break;
        case 4:
            Bipedal_Robot.turn(1, T, -1);
            break;
        case 5:
            Bipedal_Robot.updown(1, 2000, 30);
            break;
        case 18:
            staticEmtions(21);
            Bipedal_Robot.swing(1, 1100, 50); //1071
    }
}
```

```
Serial.print("music1");
moveId = 0;
clearEmtions();
break;
case 19:
    staticEmtions(22);
    Bipedal_Robot.moonwalker(1, 1550, 50, 1); //1541
    Serial.print("music2");
    moveId = 0;
    clearEmtions();
    break;
case 20:
    staticEmtions(23);
    Bipedal_Robot.jump(1, 1350); //1332
    moveId = 0;
    clearEmtions();
    Serial.print("music3");
    break;
case 21:
    Ultrasonic_Avoid();
    break;
case 22:
    dance();
    break;
default:
    break;
}
}

void sendAck() {
    delay(5);
    Serial.flush();
}
void sendFinalAck() {
    delay(5);
    Serial.flush();
}

void calib_homePos() {
    int servoPos[4];
    servoPos[0] = 90;
    servoPos[1] = 90;
    servoPos[2] = 90;
    servoPos[3] = 90;
```

```
Bipedal_Robot._moveServos(500, servoPos);
Bipedal_Robot.detachServos();
}

void setup() {
    Serial.begin(9600);
    BTserial.begin(9600);
    EEPROM.begin(512); //Initialize
    the ultrasonic module
    Bipedal_Robot.init(LeftLegPin, RightLegPin, LeftFootPin, RightFootPin, true); //Set the
    servo pins
    Bipedal_Robot.Buzzer_init(BuzzerPin);

    calib_homePos();
    Bipedal_Robot.saveTrimsOnEEPROM();
    EEPROM.commit();
    Bipedal_Robot.home();
    delay(50);
    Buzzer_Setup(); //Initialize the buzzer
    WS2812_Setup(); //WS2812 initialization
    Emotion_Setup();
    Ultrasonic_Setup();

    SCmd.addCommand("S", receiveStop);
    SCmd.addCommand("C", receiveLED);
    SCmd.addCommand("D", recieveBuzzer);
    SCmd.addCommand("A", receiveMovement);
    SCmd.addCommand("B", receiveEmotion);
    SCmd.addCommand("H", receiveAvoid);
    SCmd.addCommand("M", receiveMusic);
    SCmd.addHandler(receiveStop);
}

void loop() {
    SCmd.readSerial();
    Emotion_Detection();
    WS2812_Show(ws2812_task_mode); //Car color lights display function
    if (millis() - lastUploadVoltageTime > UPLOAD_VOL_TIME) {
        upLoadVoltageToApp();
        lastUploadVoltageTime = millis();
    }
    if (millis() - lastUploadDistanceTime > 200) {
        if (ultrasonicavoidMode == 1) {
            upLoadDistanceToApp();
        }
    }
}
```

```

        lastUploadDistanceTime = millis();
    }
    if (Check_Module_value == MATRIX_IS_EXIST) {
        Emotion_Show(emotion_task_mode); //Led matrix display function
    }
    move(moveId);
}

void setup() {
    playmusic(1, 2);
    pinMode(6, OUTPUT);
    digitalWrite(6, LOW);
}
void loop() {
    songmusic();
}

```

Same as in the previous project, when the corresponding command is received by Bluetooth, the corresponding function is executed.

```

void loop() {
    SCmd.readSerial();
    Emotion_Detection();
    WS2812_Show(ws2812_task_mode); //Car color lights display function
    if (millis() - lastUploadVoltageTime > UPLOAD_VOL_TIME) {
        upLoadVoltageToApp();
        lastUploadVoltageTime = millis();
    }
    if (millis() - lastUploadDistanceTime > 200) {
        if (ultrasonicavoidMode == 1) {
            upLoadDistanceToApp();
        }
        lastUploadDistanceTime = millis();
    }
    if (Check_Module_value == MATRIX_IS_EXIST) {
        Emotion_Show(emotion_task_mode); //Led matrix display function
    }
    move(moveId);
}

```

The decription of the commands and their functions are as shwon in the table below:

Commands	Description
A#parm1#parm2	Controls the robot's movements.

B#parm1	Expressions control command
C#parm1#parm2#parm3#parm4	RGB LEDs control command
D#parm1	Buzzer control command
Send battery data every 25s	Send the battery level to the APP. Format: P#Battery voltage
M#parm1	Audio playing command
H#parm1	Ultrasonic obstacle avoidance mode or dance mode
Send distance data under the obstacle avoidance mode	Send the ultrasonic data to the APP. Format: E# ultrasonic data

## What's next?

Thank you again for choosing Freenove products.

THANK YOU for participating in this learning experience!

We have reached the end of this Tutorial. If you find errors, omissions, or you have suggestions and/or questions about the Tutorial or component contents of this Kit, please feel free to contact us:  
support@freenove.com

We will make every effort to make changes and correct errors as soon as feasibly possible and publish a revised version.

If you want to learn more about Arduino, ESP32, Raspberry Pi Pico W, Raspberry Pi, Smart Cars, Robotics and other interesting products in science and technology, please continue to visit our website. We will continue to launch fun, cost effective, innovative and exciting products.

<http://www.freenove.com/>

Thank you again for choosing Freenove products.