Welcome

Thank you for choosing Freenove products!
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

Get Support and Offer Input

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

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

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

support@freenove.com

Safety and Precautions

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

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

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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FREENOVE™

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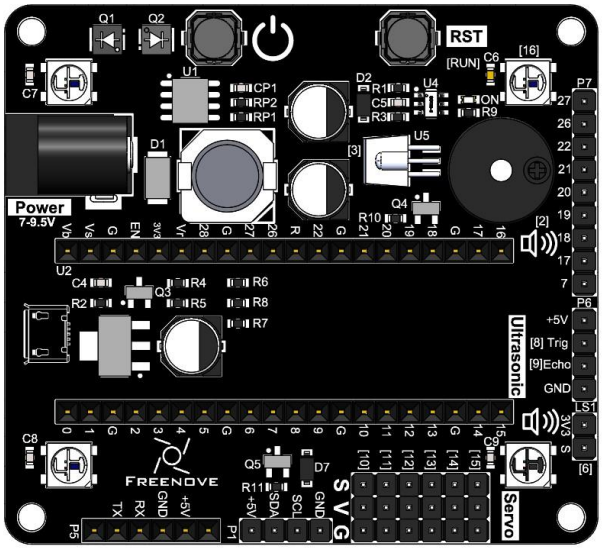
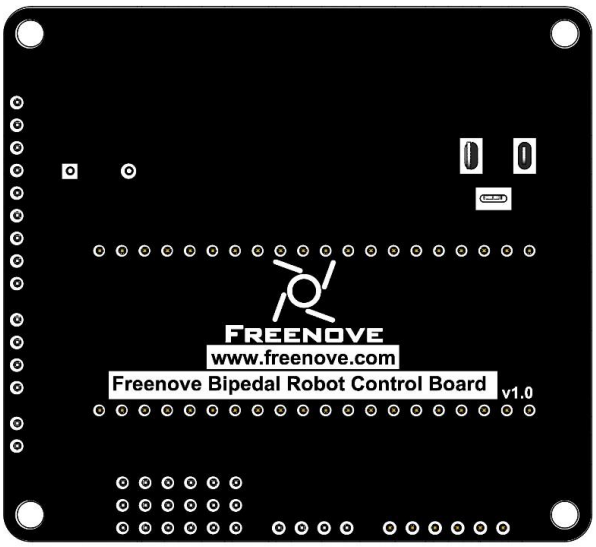
If you have any concerns, please feel free to contact us via support@freenove.com

Raspberry Pi Pico (W) Robot Shield

Top	Bottom
	

Machinery Parts

M3*8
Screw

x10
Freenove

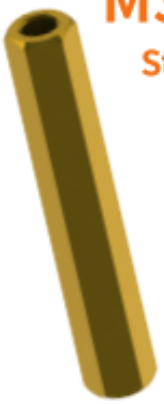
M3*18
Screw

x2
Freenove

M3
Nut

x2
Freenove

M3*35
Standoff



x4
Freenove

M2*12
Screw

x14
Freenove

M2
Nut

x17
Freenove

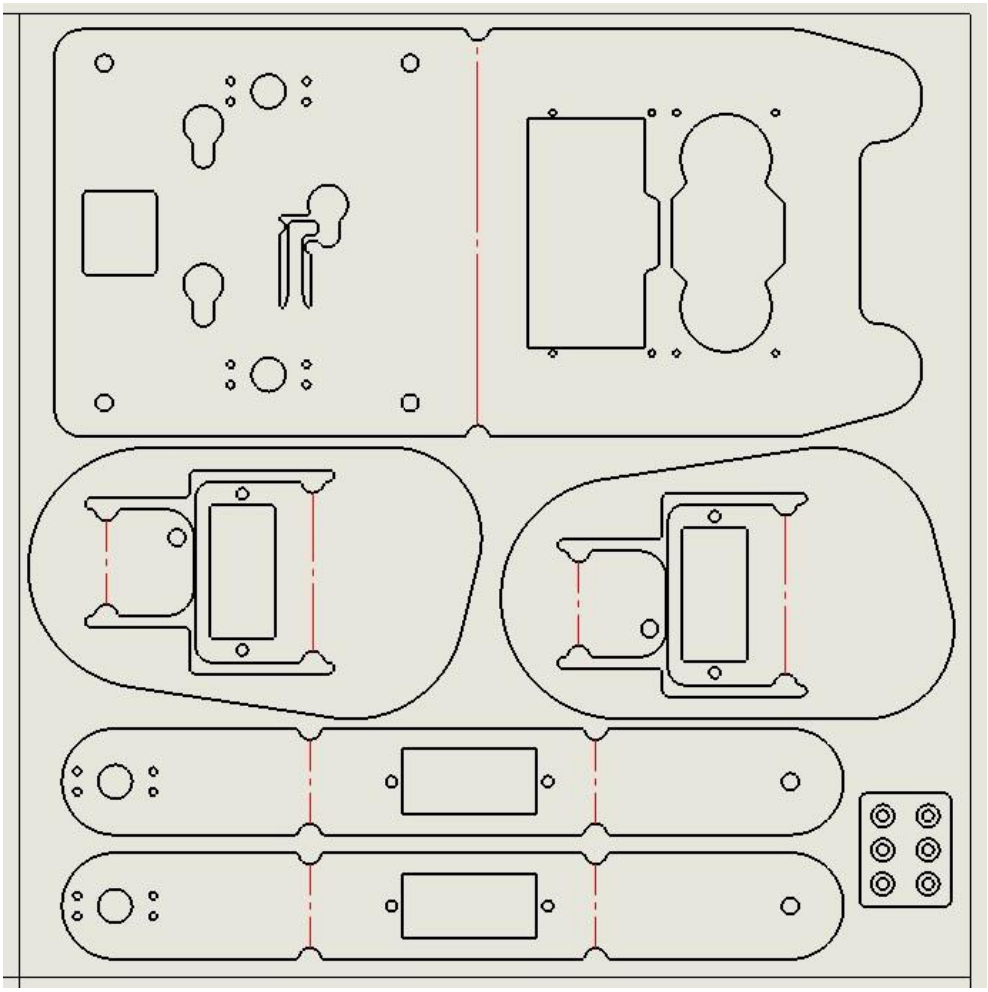
M1.4*5
self-tapping
Screw

x10
Freenove

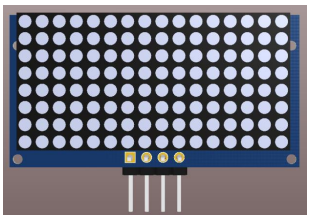
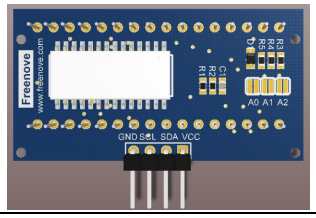
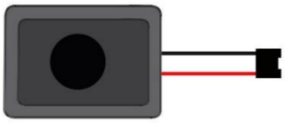
M2*6*0.5
Nut

x4
Freenove

Acrylic Parts



Electronic Parts

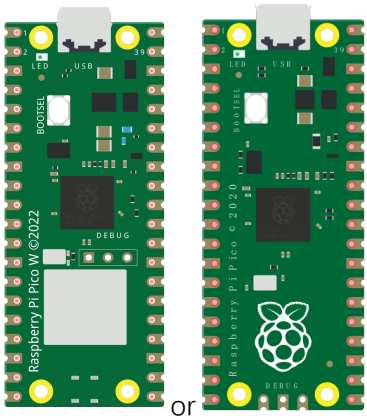
Dot Matrix Module x 1  	Ultrasonic Module x 1 
	Speaker x 1 

Servo package x 4

Bluetooth module x 1

Infrared emitter x 1

Raspberry Pi Pico x 1 or Raspberry Pi Pico W x 1



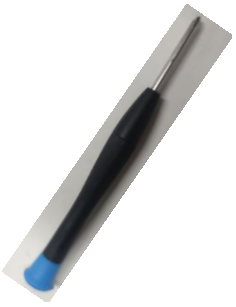
or

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

Wires

Jumper Wire F/F(4 pin) x 2

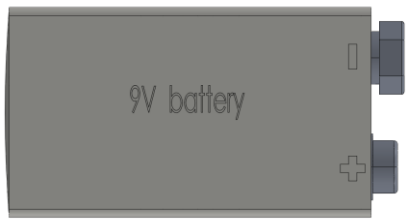
Tools

Cross screwdriver (3mm) x 1 	Cross screwdriver (2mm) x 1 	Cable Tidy x 40cm 
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.

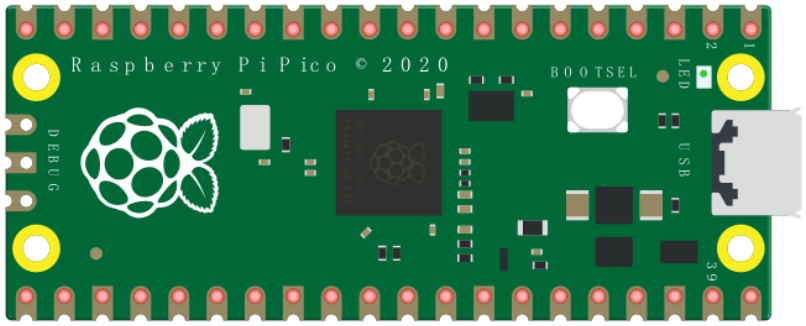
support@freenove.com

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:

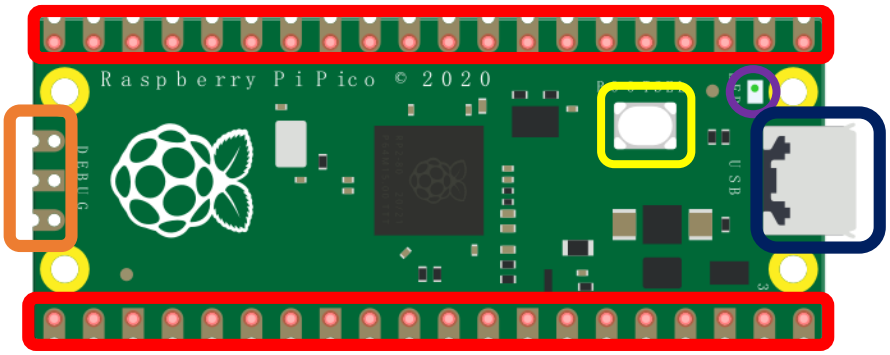
www.freenove.com or contact us to buy our kit designed for beginners: **Freenove Ultimate Kit for Raspberry Pi Pico.**

Raspberry Pi Pico

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

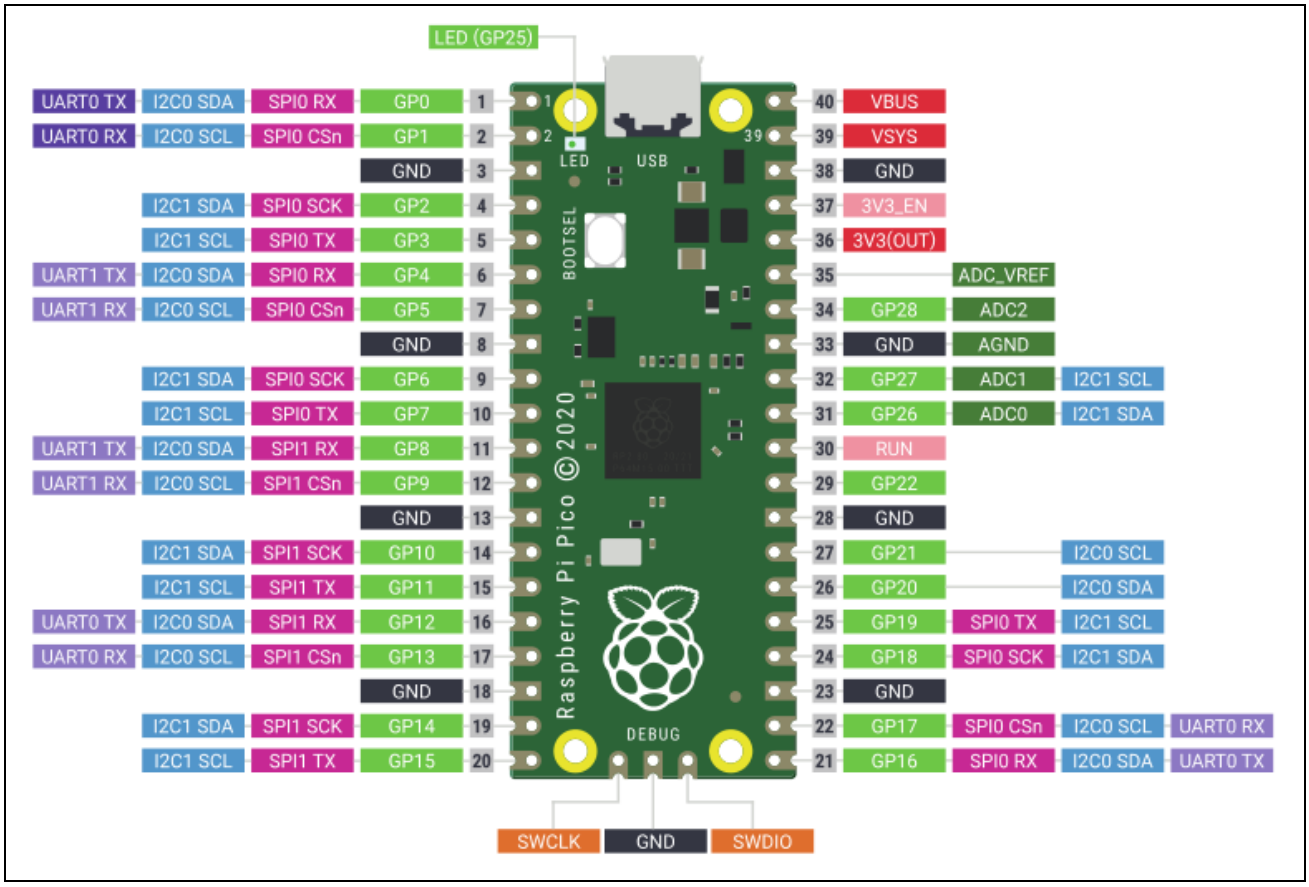


The hardware interfaces are distributed as follows:



Frame color	Description
	Pins
	BOOTSEL button
	USB port
	LED
	Debugging

Function definition of pins:



Color	Pins	Color	Pins
	GND		Power
	GPIO		ADC
	UART(default)		UART
	SPI		I2C
	System Control		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

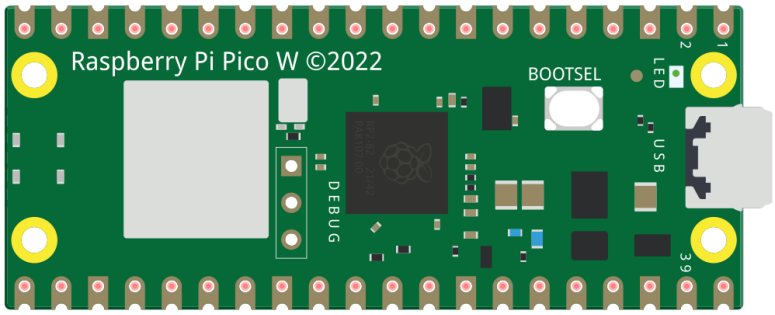
Function	Default
I2C Frequency	400000
I2C_SDA	Pin 4
I2C_SCL	Pin 5

SPI

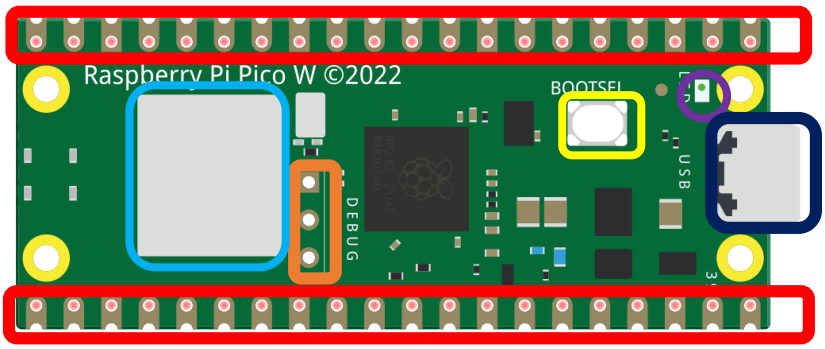
Function	Default
SPI_BAUDRATE	1000000
SPI_POLARITY	0
SPI_PHASE	0
SPI_BITS	8
SPI_FIRSTBIT	MSB
SPI_SCK	Pin 18
SPI_MOSI	Pin 19
SPI_MISO	Pin 16
SPI_SS	Pin 17

Raspberry Pi Pico W

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

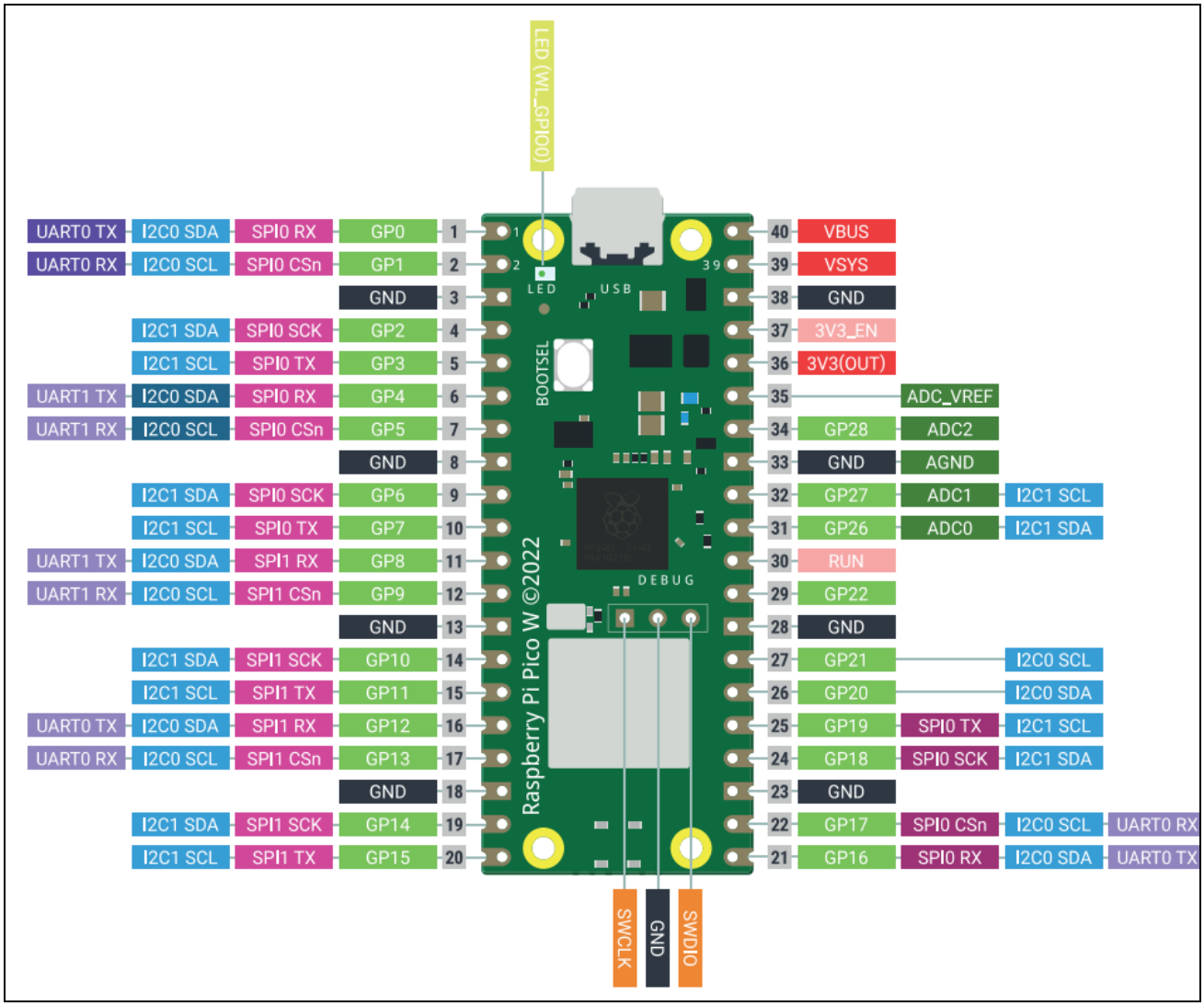


The hardware interfaces are distributed as follows:



Frame color	Description
	Pins
	BOOTSEL button
	USB port
	LED
	Debugging
	Wireless

Function definition of pins:



Color	Pins	Color	Pins
	GND		Power
	GPIO		ADC
	UART(default)		UART
	SPI		I2C
	System Control		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

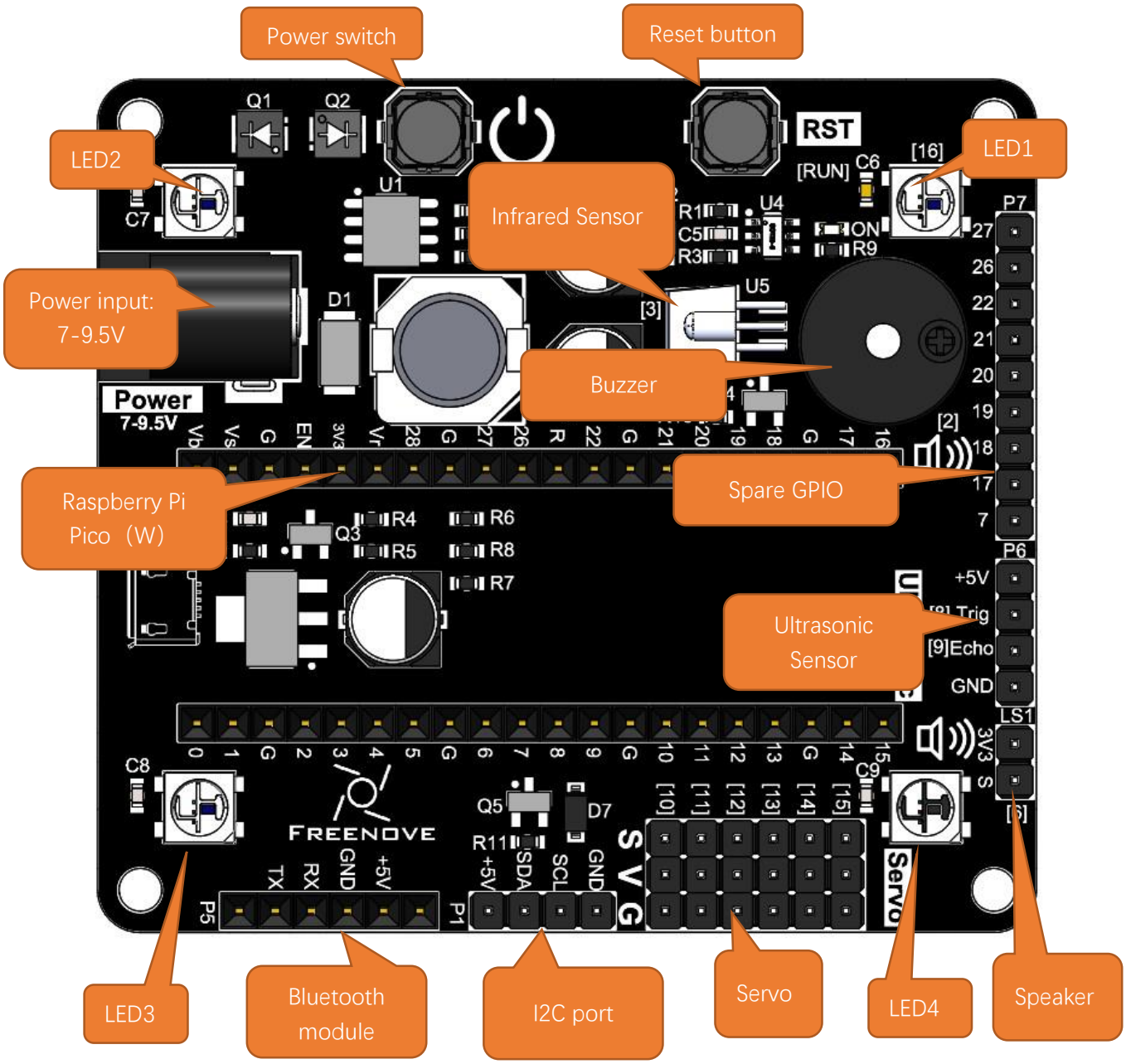
Pins of the Robot

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

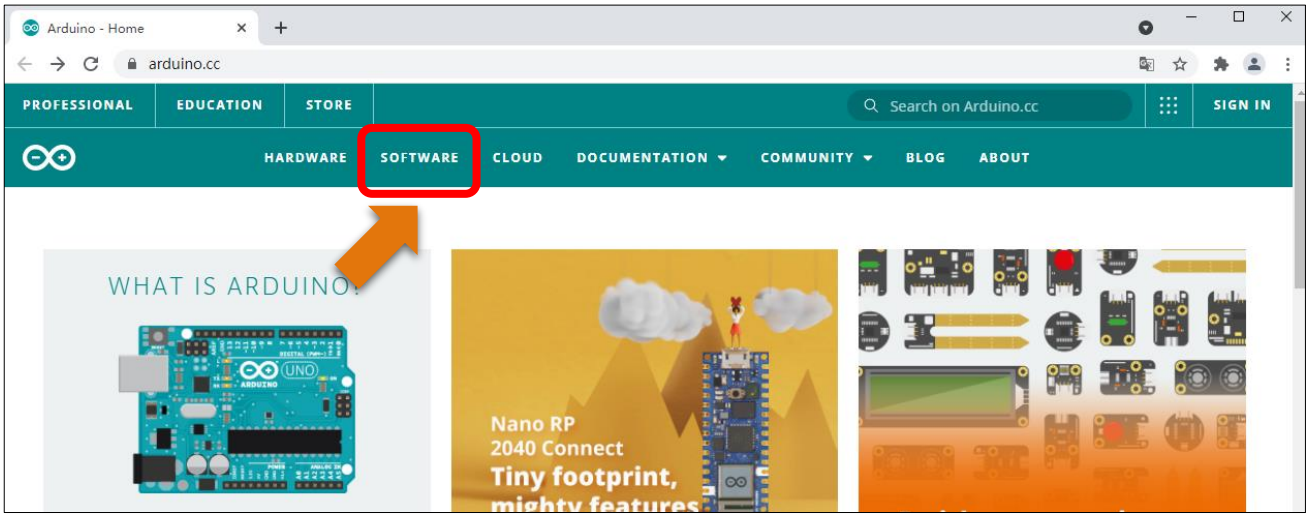
The function diagram of the Raspberry Pi Pico (W) bipedal robot is as follows:



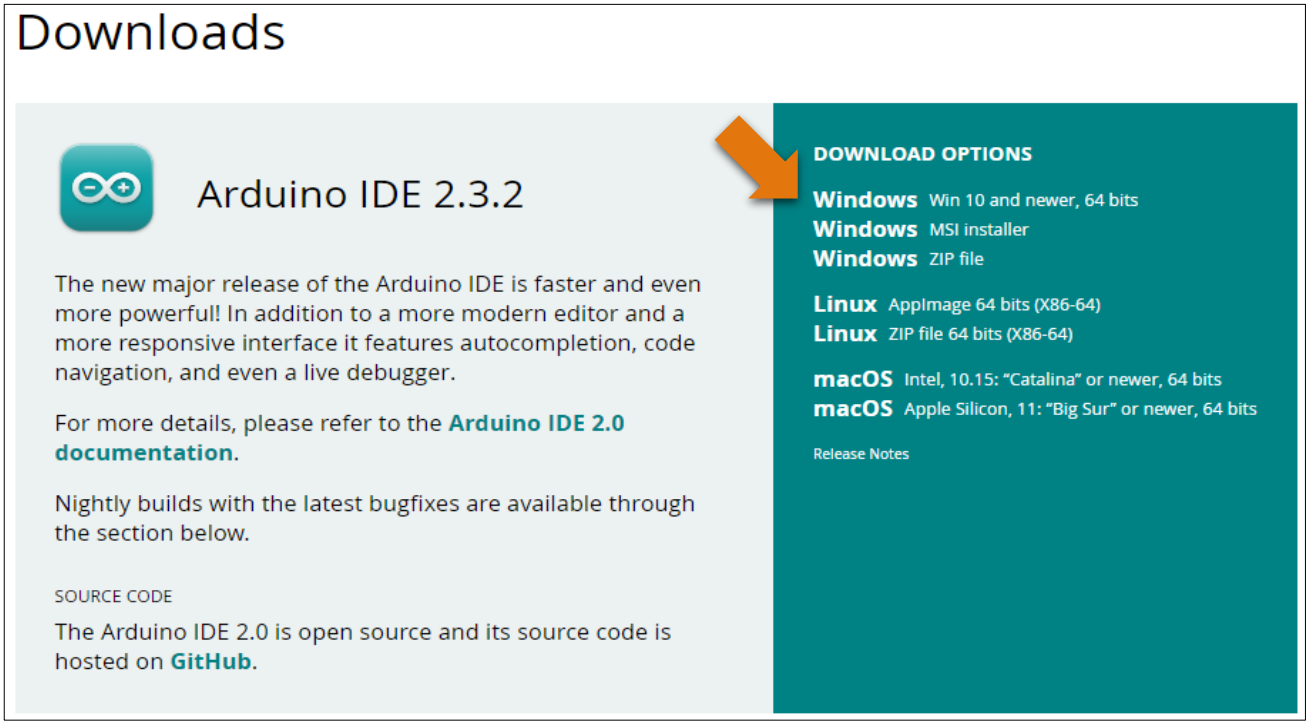
Installation of Arduino IDE

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.



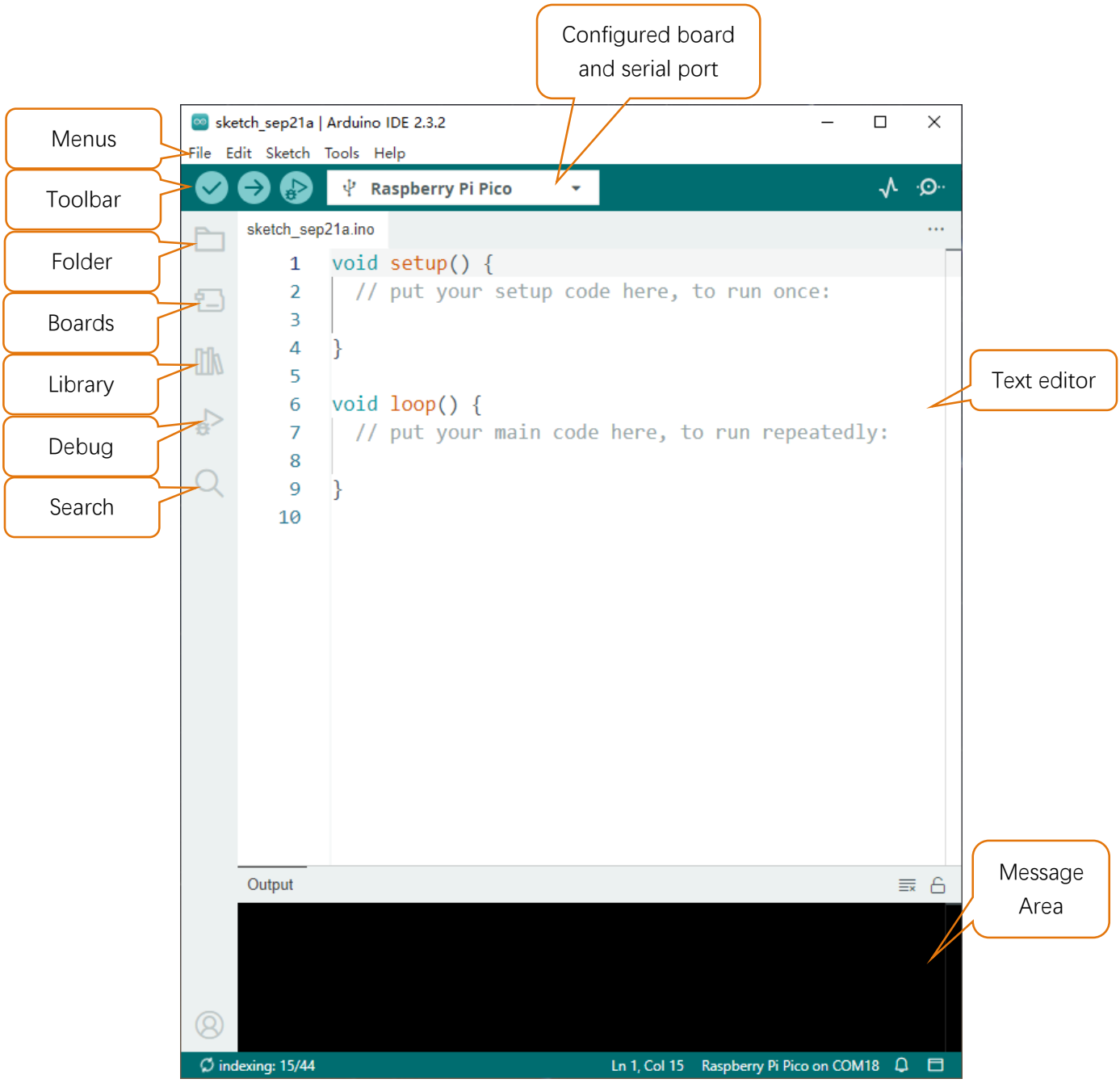
Select and download corresponding installer based on your operating system. If you are a Windows user, please select the "Windows Installer" to download and install the driver correctly.



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

Debug
Test and debug programs in real time.

Select Board & Port
Detected Arduino boards automatically show up here, along with the port number.

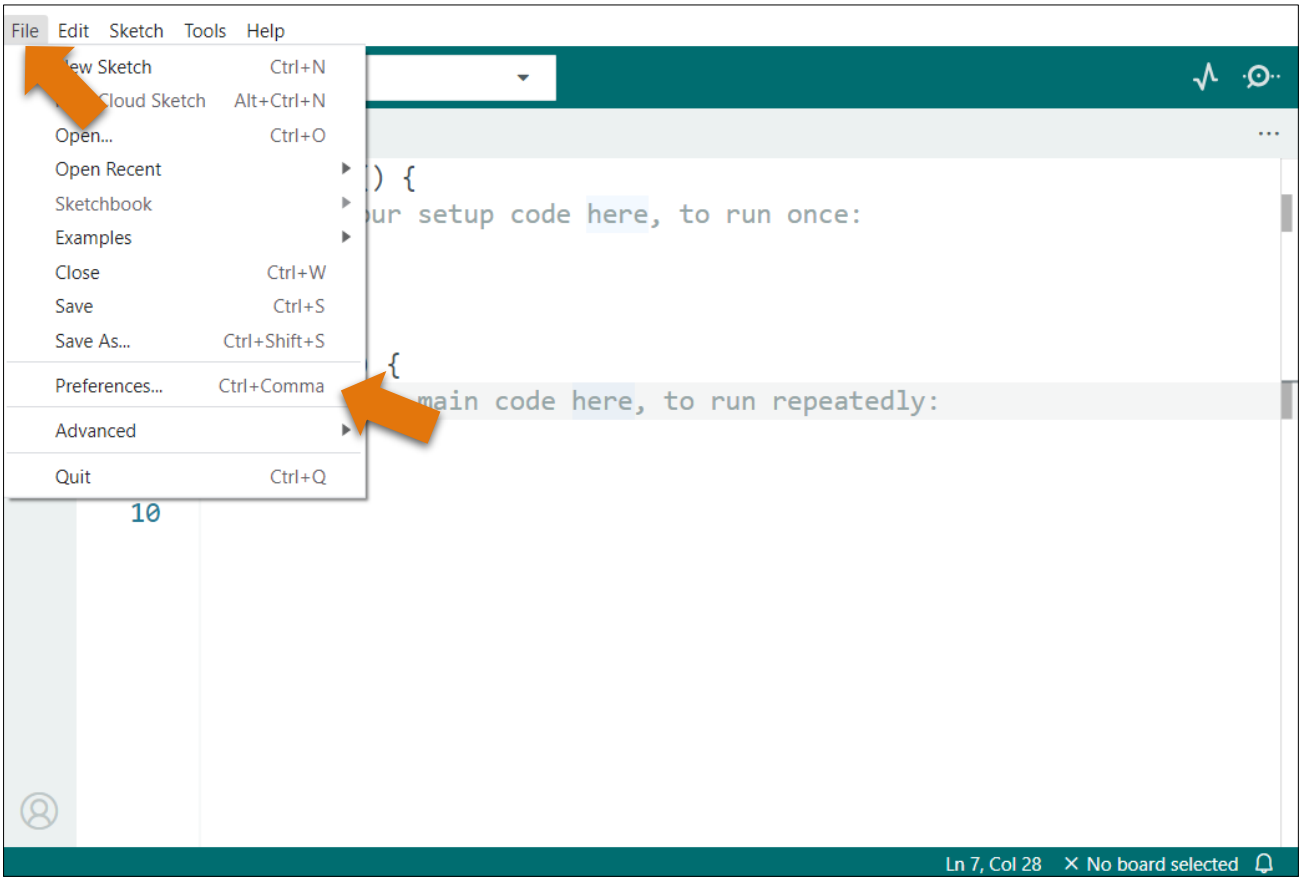
Serial Plotter
Open the serial plotter.

Serial Monitor
Open the serial monitor.

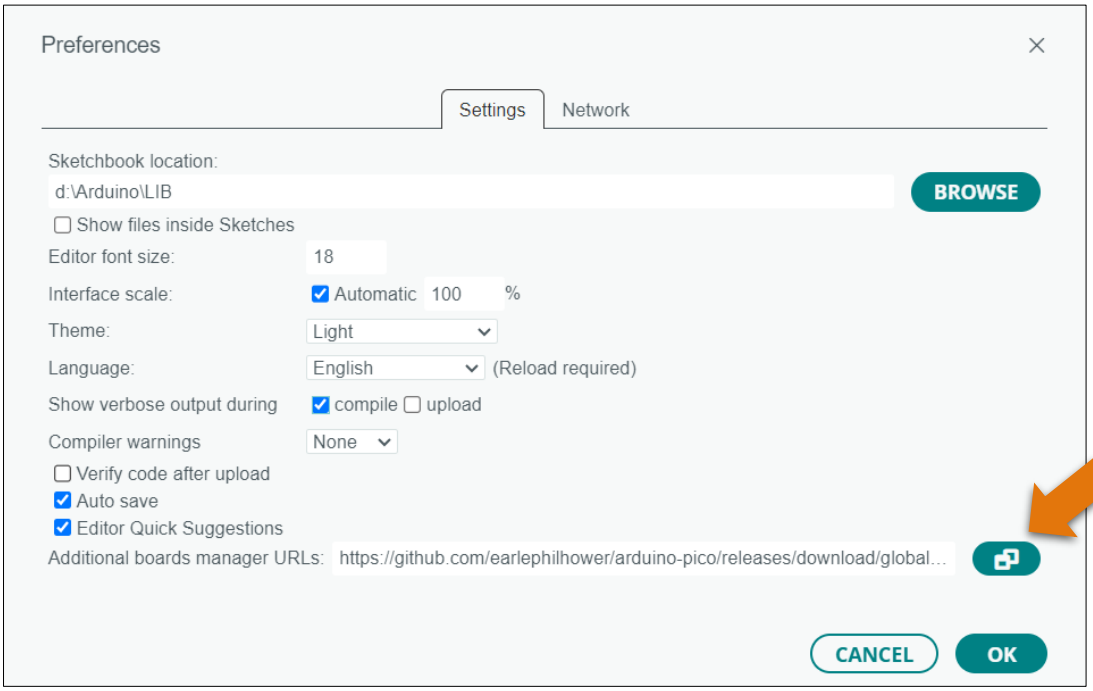
Additional commands are found within the five menus: File, Edit, Sketch, Tools, and Help. The menus are context sensitive, which means only those items relevant to the work currently being carried out are available.

Environment Configuration

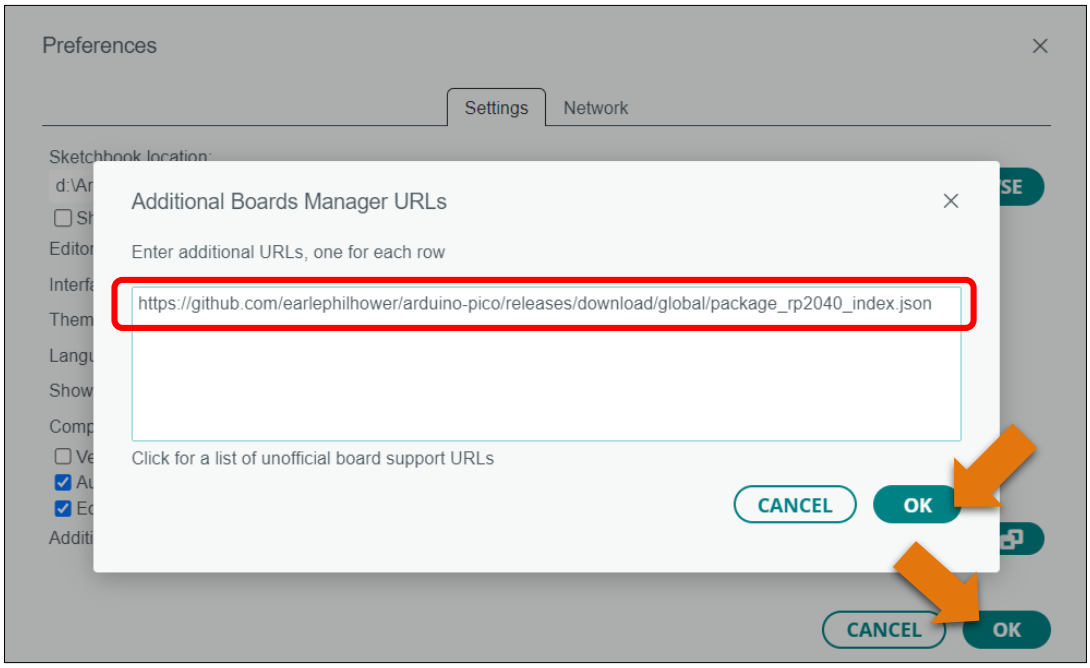
First, open the software platform Arduino IDE, and then click File in Menus and select Preferences.



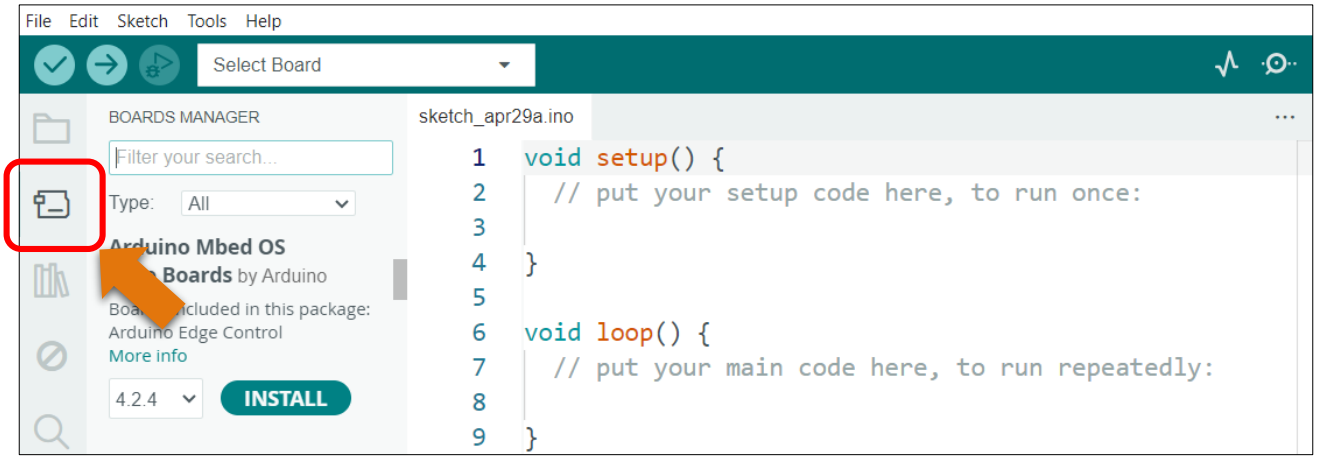
Second, click on the symbol behind "Additional Boards Manager URLs"



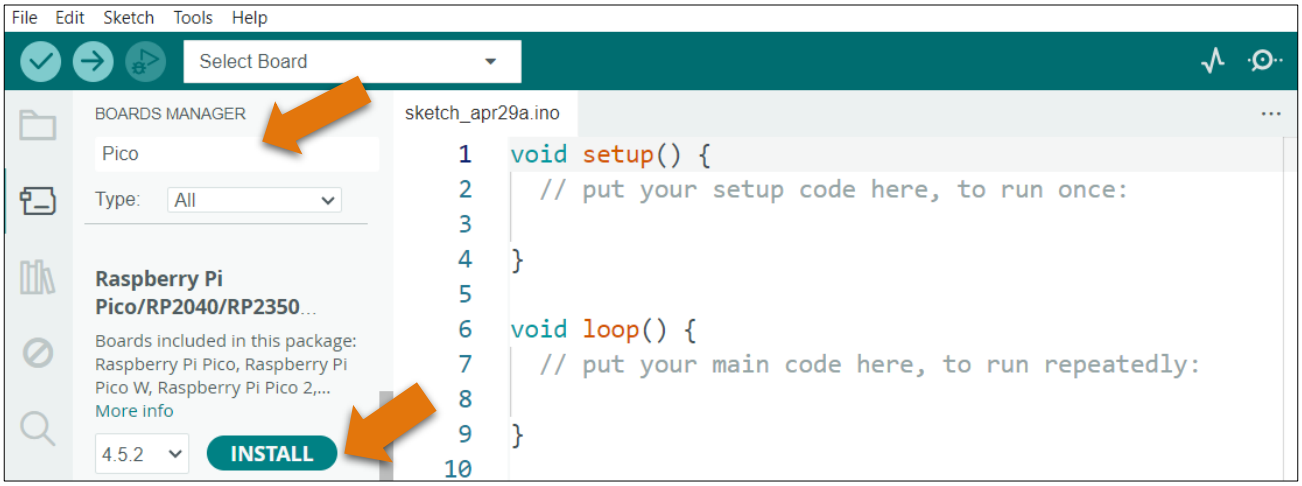
Third, fill in https://github.com/earlephilhower/arduino-pico/releases/download/global/package_rp2040_index.json in the new window, click OK, and click OK on the Preferences window again.



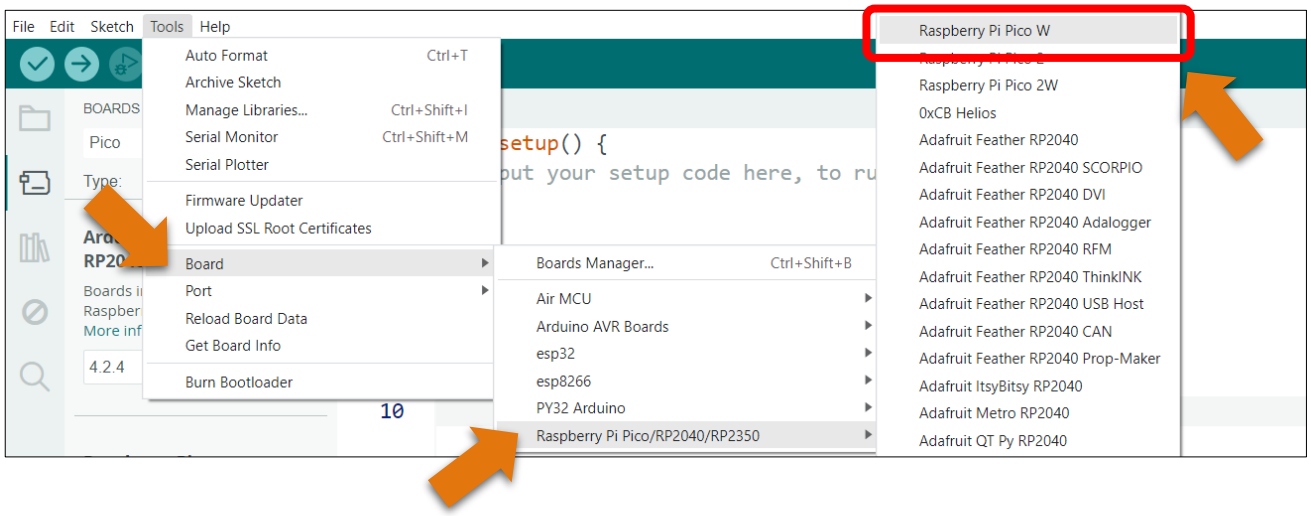
Fourth, click Boards Manager on the left.



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.

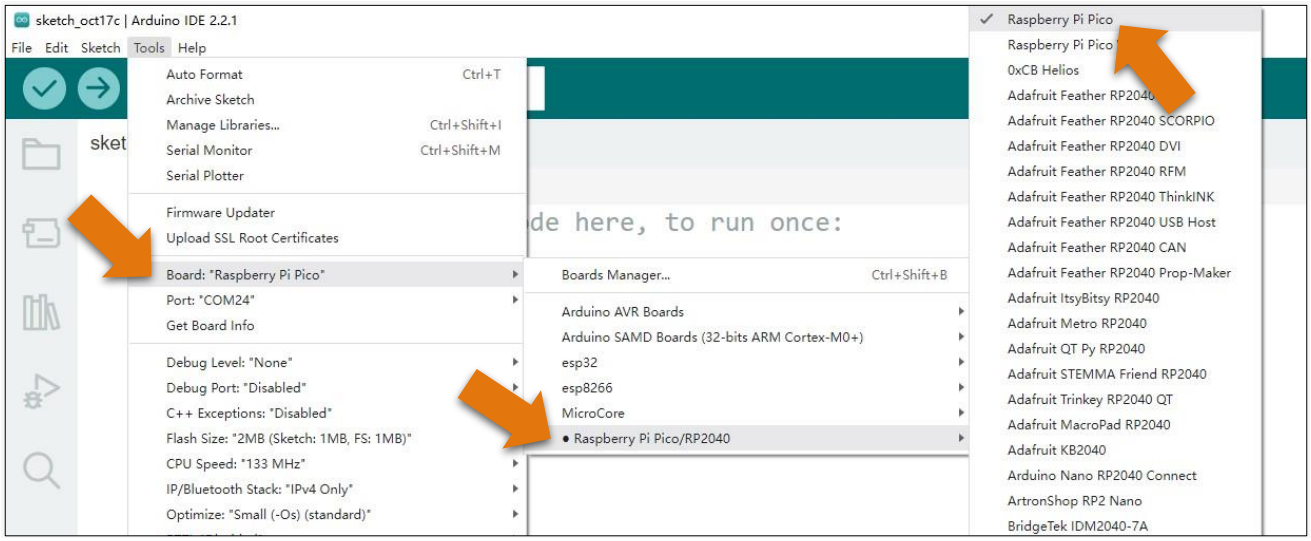


Additional Remarks

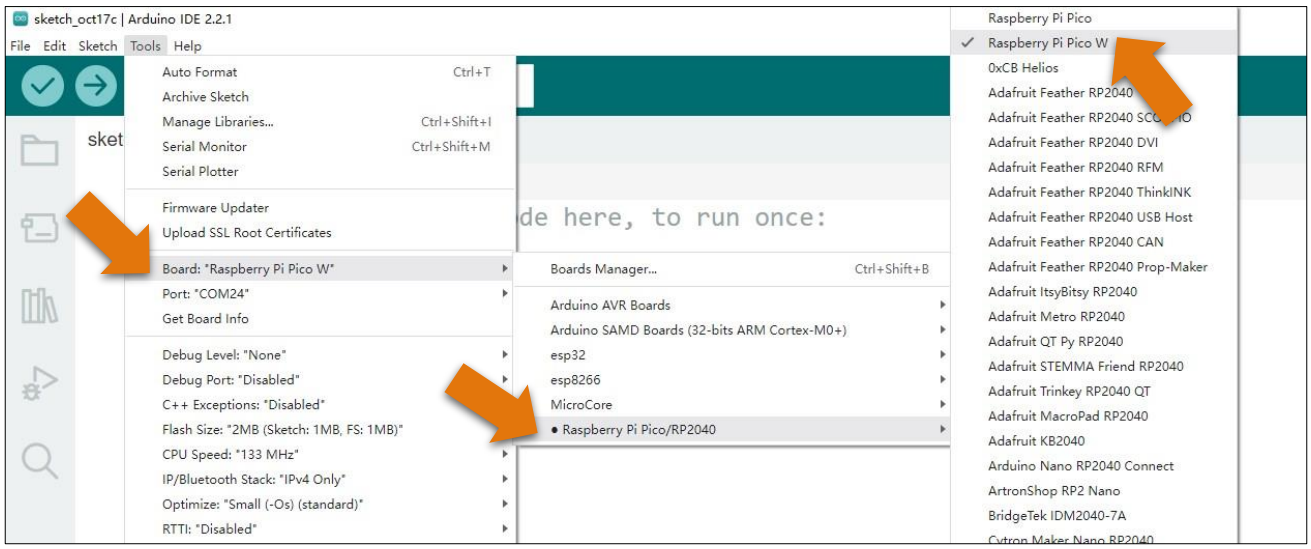
To finish this tutorial, you can use a Raspberry Pi Pico W or a Raspberry Pi Pico. The two boards have the same form factor, and their only difference is that Pico W features with an onboard single-band 2.4GHz wireless interface using Infineon CYW43439. That is to say, the hardware Raspberry Pi Pico 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.



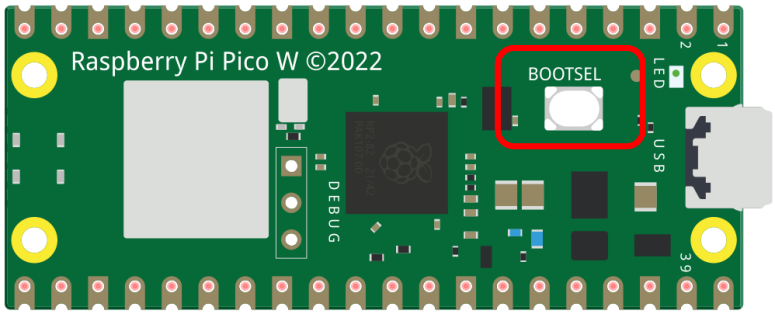
For Raspberry Pi Pico W:
Click Tools on Menu bar, click Board, select “Raspberry Pi Pico/RP2040”, and select Raspberry Pi Pico W.



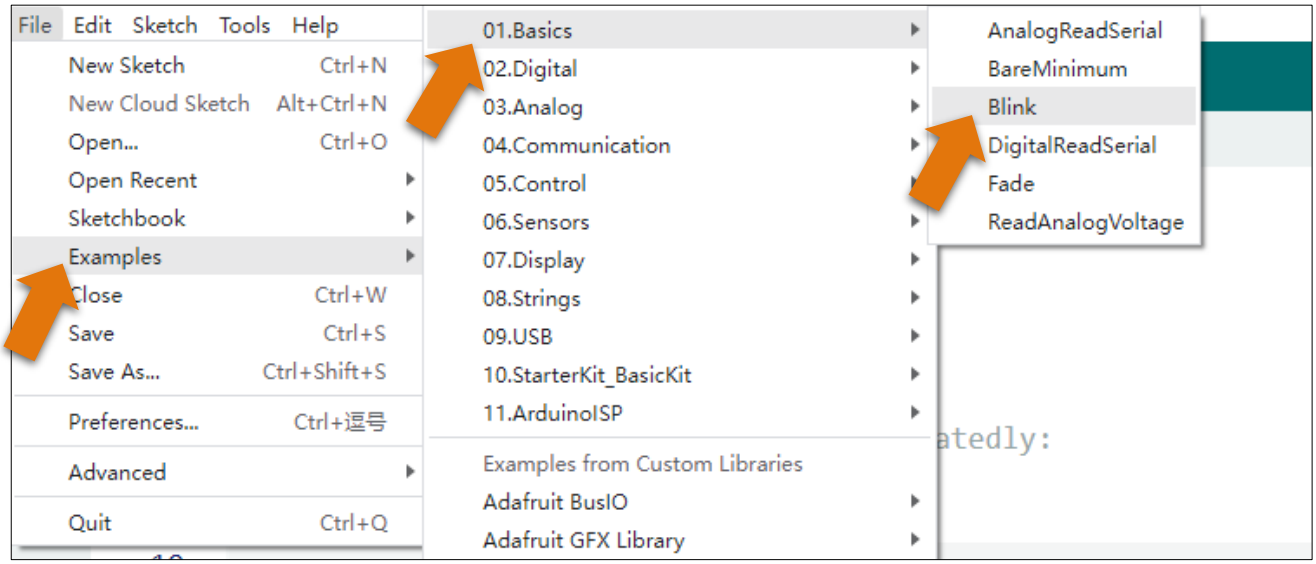
Uploading Arduino-compatible Firmware for Raspberry Pi Pico (W)

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.

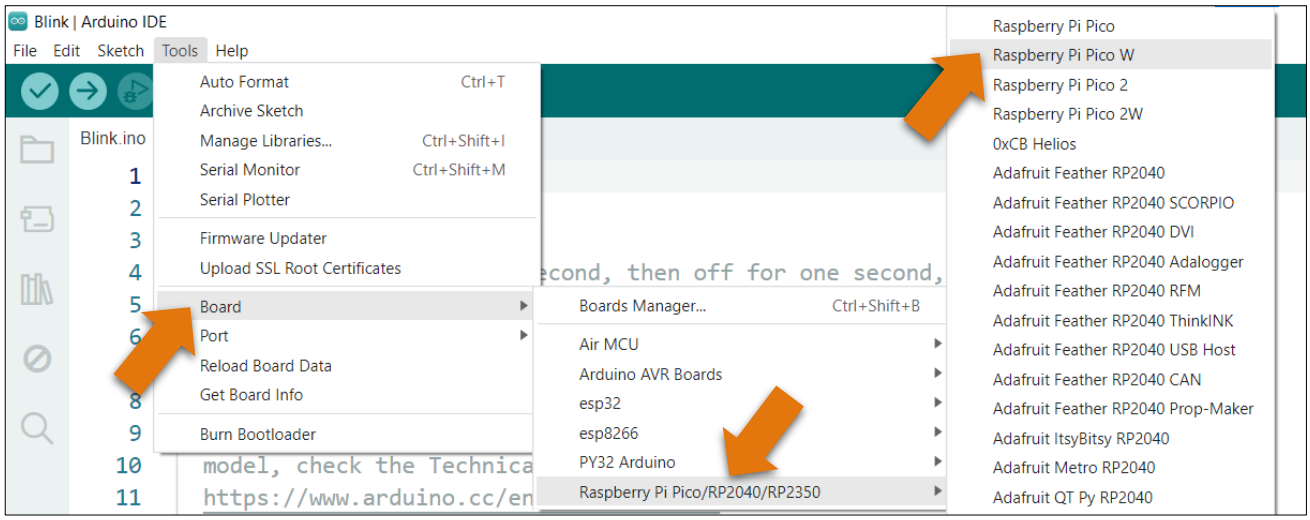
1. Disconnect Pico (W) from your computer. Press and hold the white button (BOOTSEL) on Pico (W) while connecting it to your computer. (Note: Be sure to hold the button before powering the Pico, otherwise the firmware will not download successfully.)



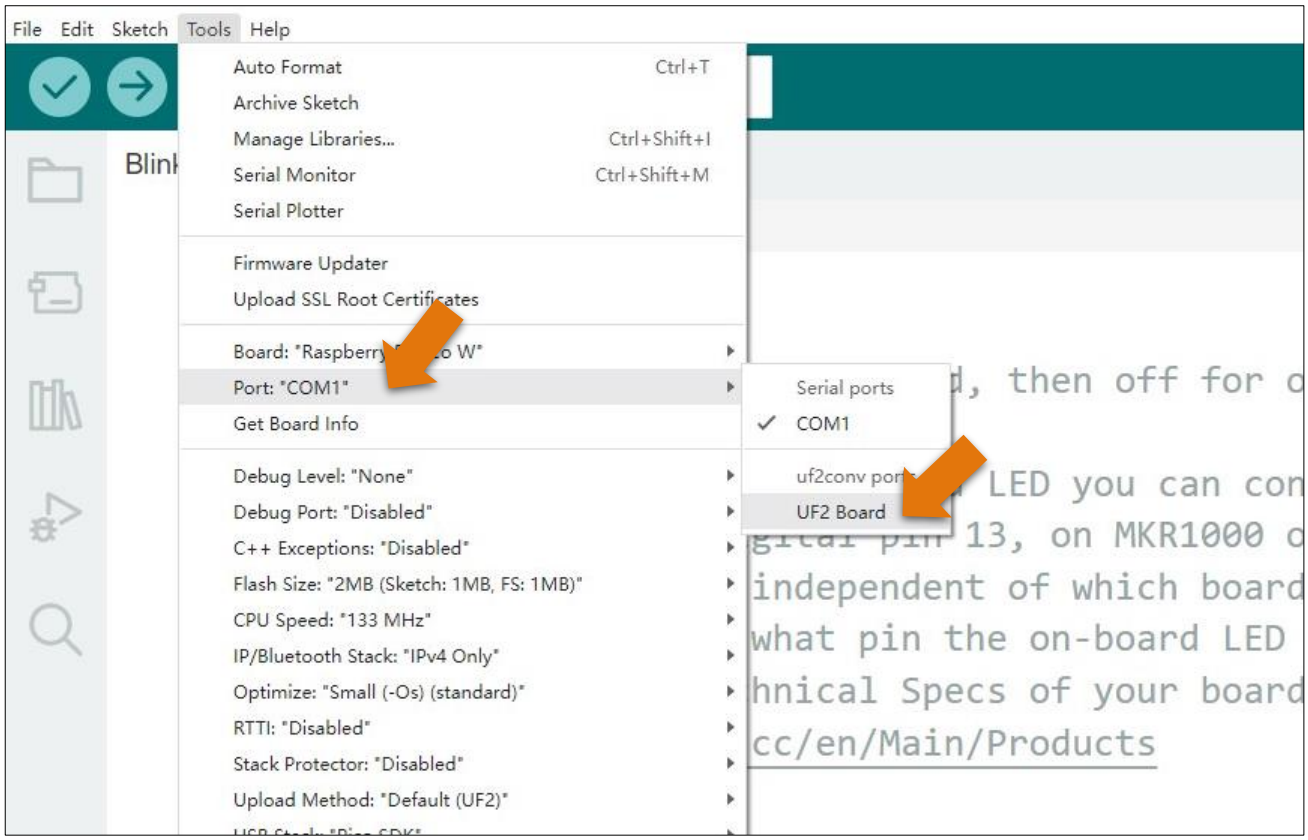
2. Open Arduino IDE. Click **File>Examples>01.Basics>Blink**.



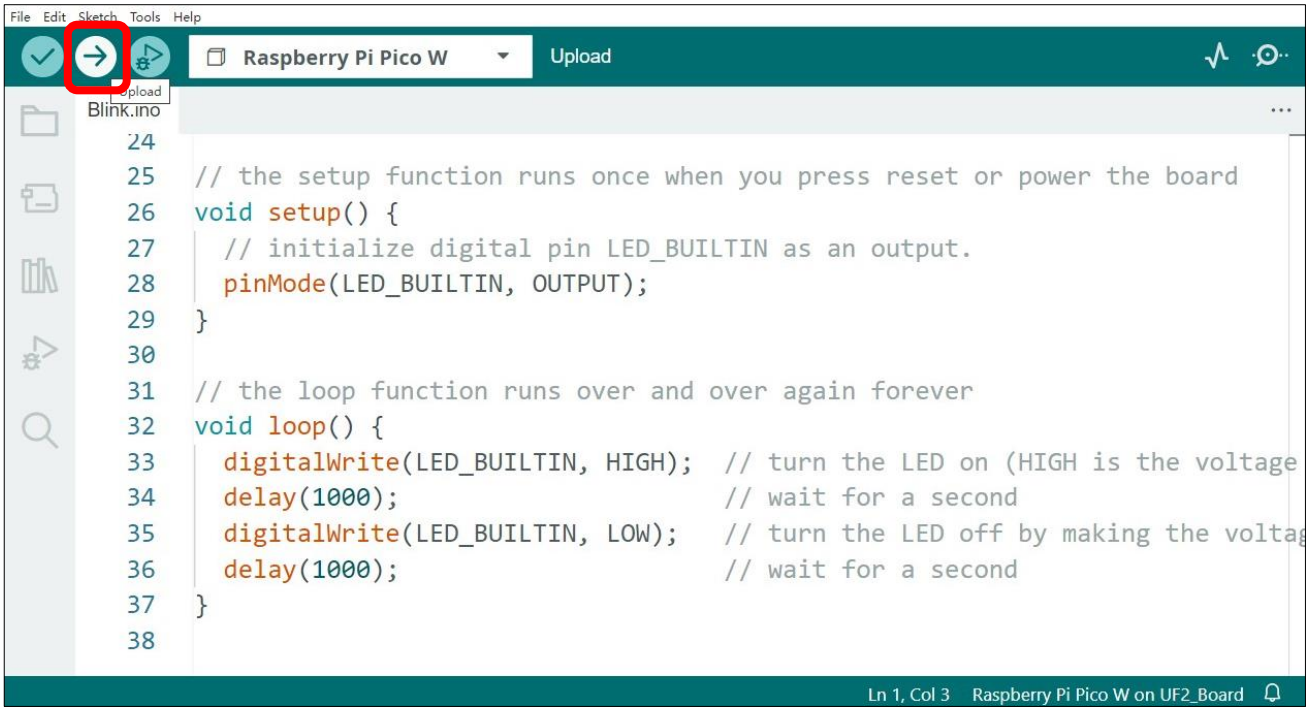
3. Click **Tools>Board>Raspberry Pi RP2040 Boards>Raspberry Pi Pico W**.



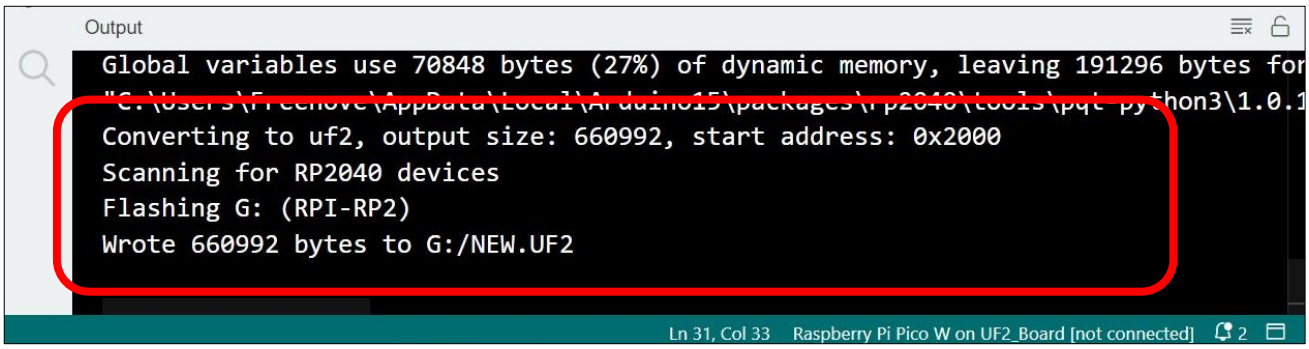
4. Click **Tools>Port>UF2 Board**.



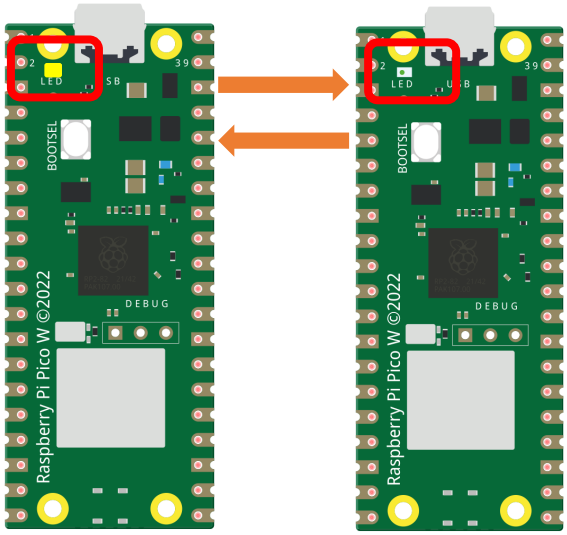
5. Upload sketch to Raspberry Pi Pico W.



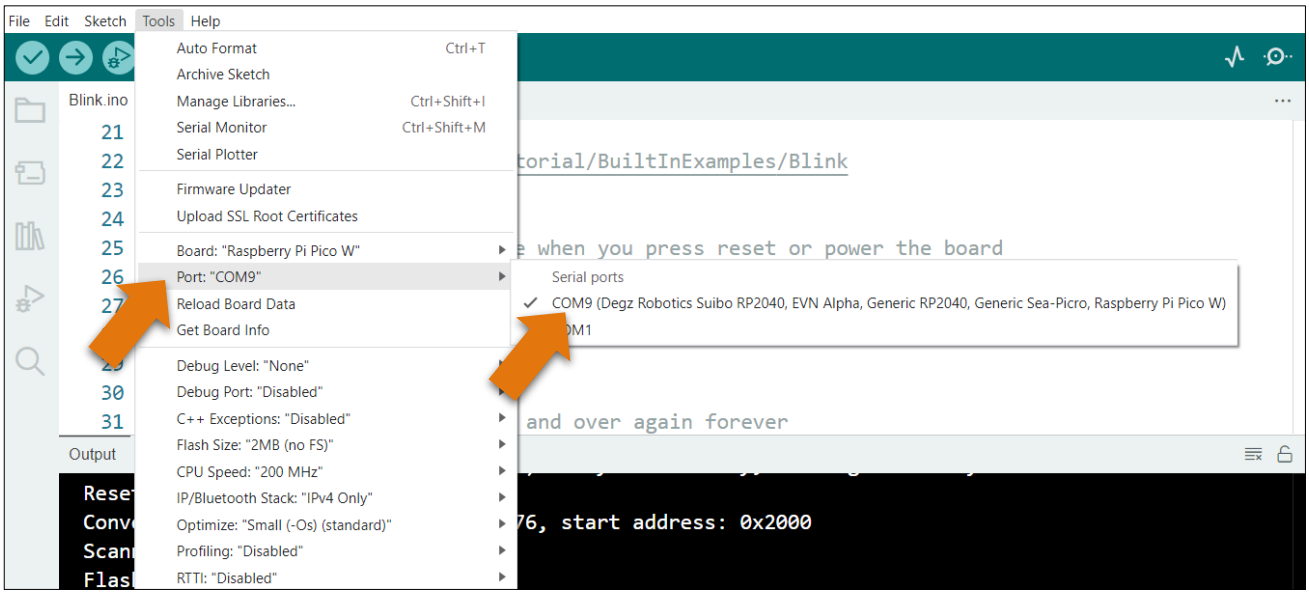
When the sketch finishes uploading, you can see messages as below.



The indicator on Pico W starts to flash.



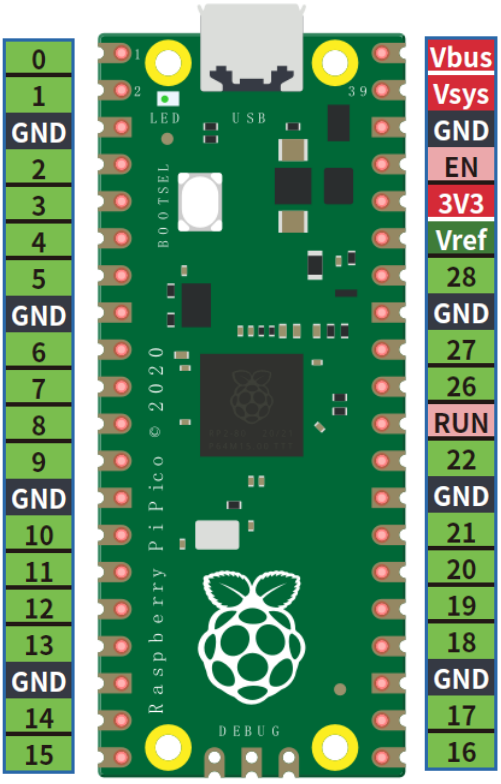
6. Click **Tools>Port>COMx (Raspberry Pi Pico W)**. X of COMx varies from different computers. Please select the correct one on your computer. In our case, it is COM9.



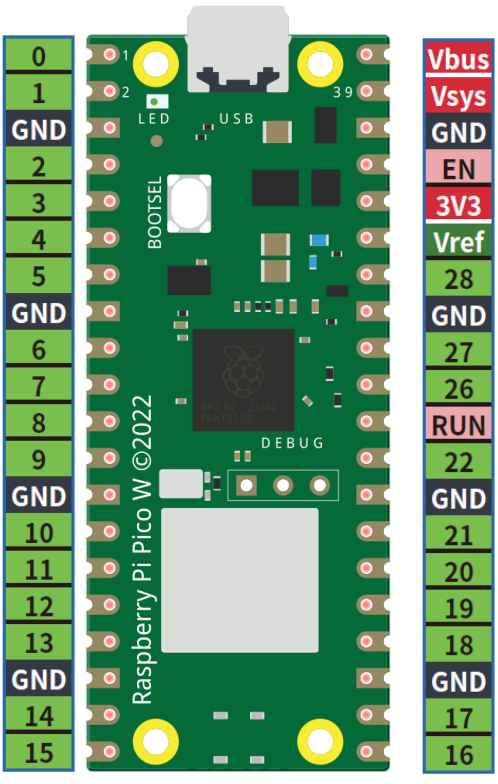
Note:

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:



Raspberry Pi Pico



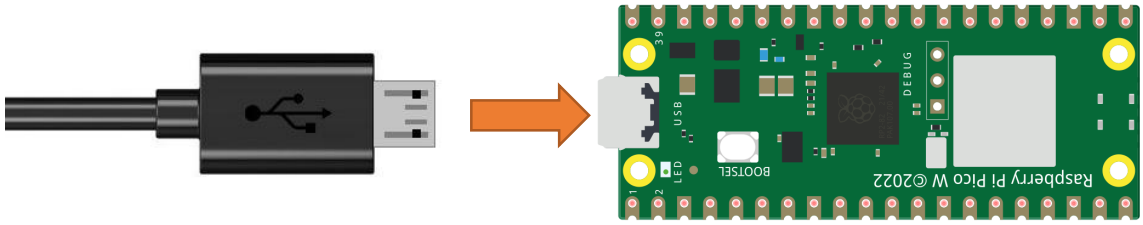
Raspberry Pi Pico W

Uploading the First Code

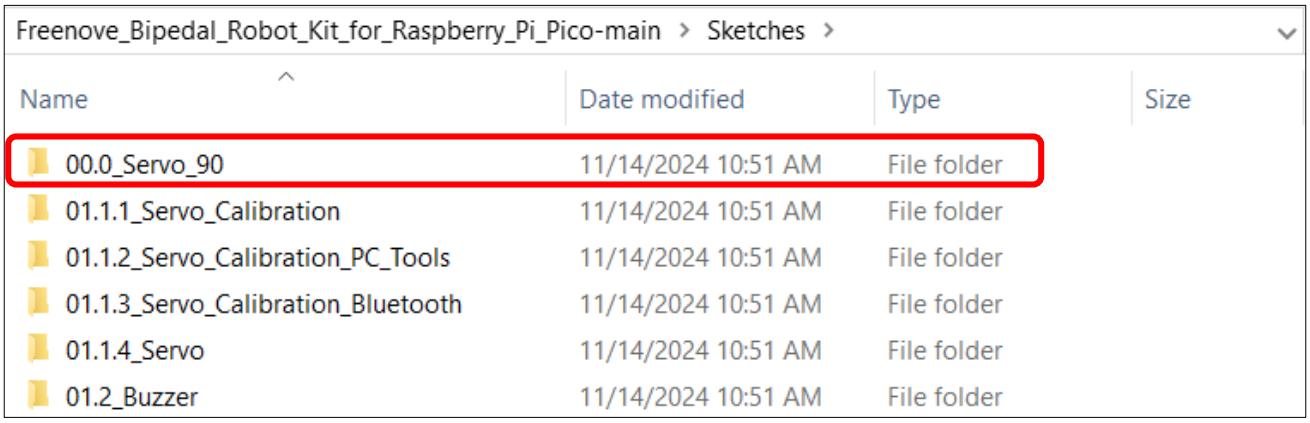
Here we take “00.0_Servo_90” in **“Freenove_Bipedal_Robot_Kit_for_Raspberry_Pi_Pico\Sketches”** as an example. The code is to rotate the servo motors to 90°.

Upload the First Code

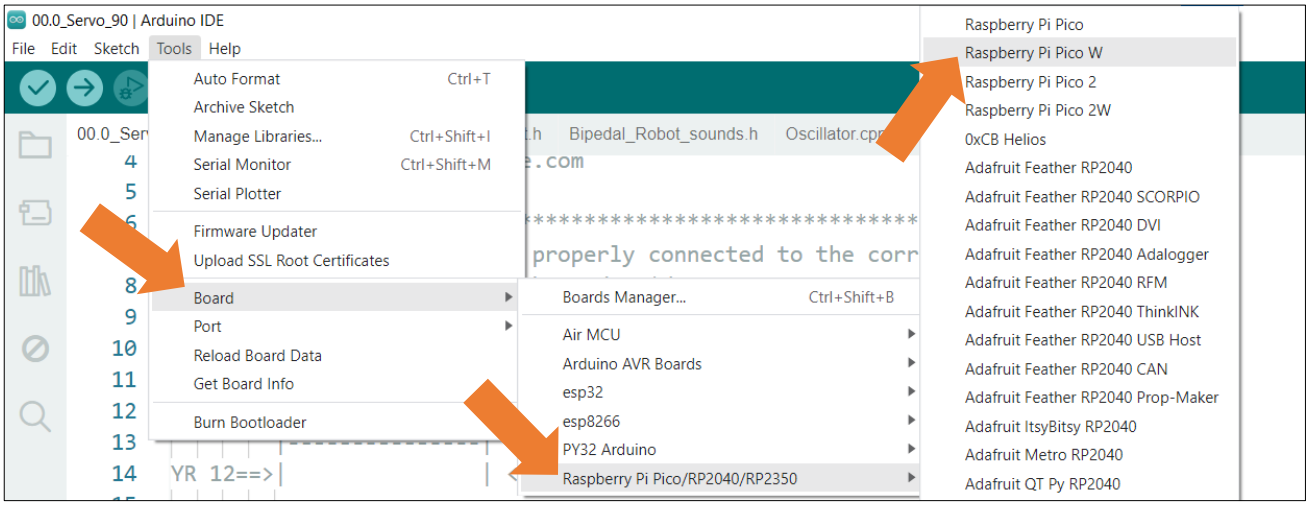
Step 1. Connect your computer and Raspberry Pi Pico W with a USB cable.



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”.

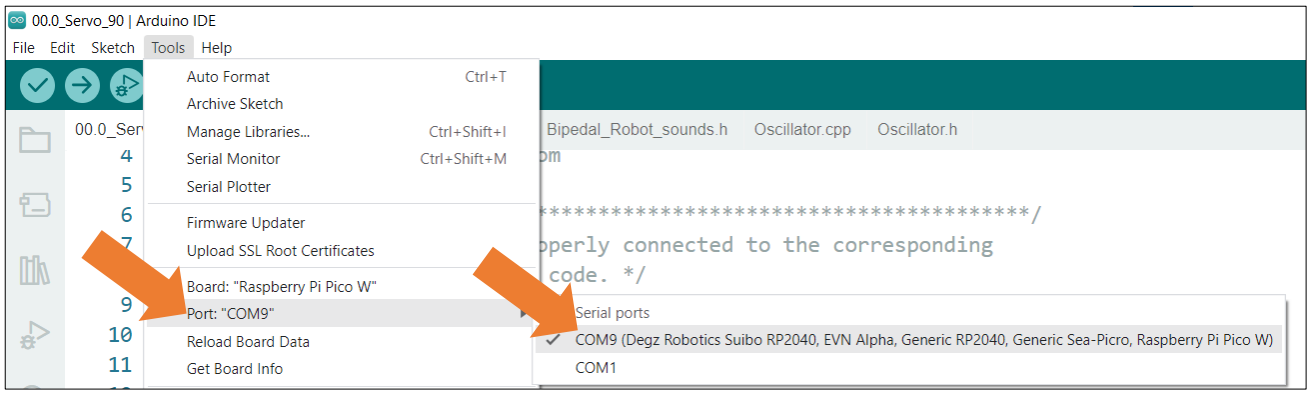


Step 3. Select development board.
Click Tools on Menu bar, click Board -> “Raspberry Pi Pico/RP2040” -> Raspberry Pi Pico W.

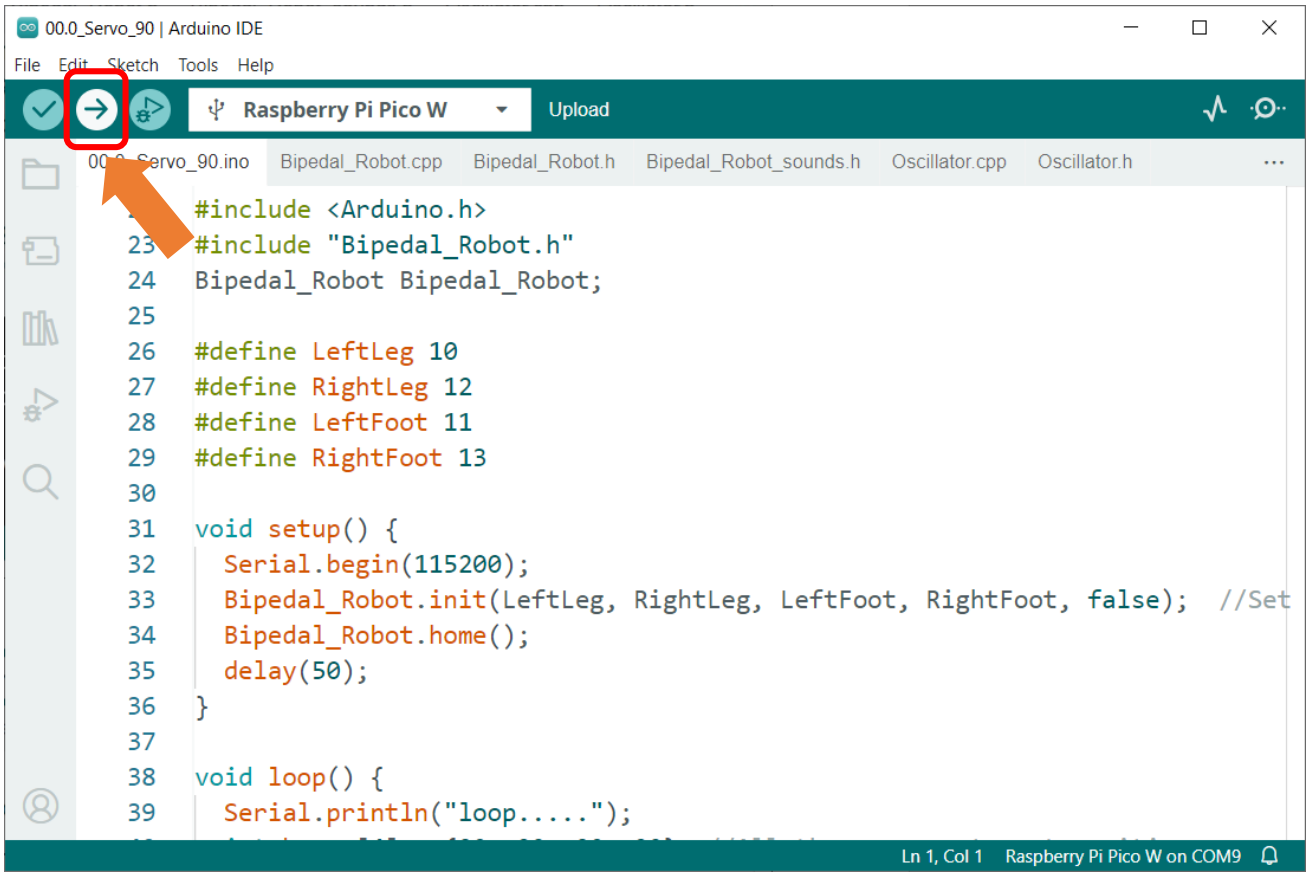


Step 4. Select serial port.

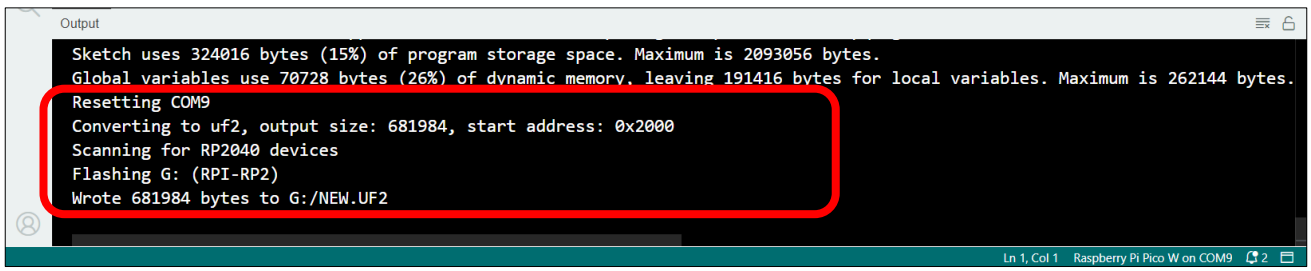
Click Tools on Menu bar, navigate your mouse to Port and select COMx on your computer. The value of COMx varies in different computers, but it will not affect the download function of Raspberry Pi Pico (W), as long as you select the correct one.



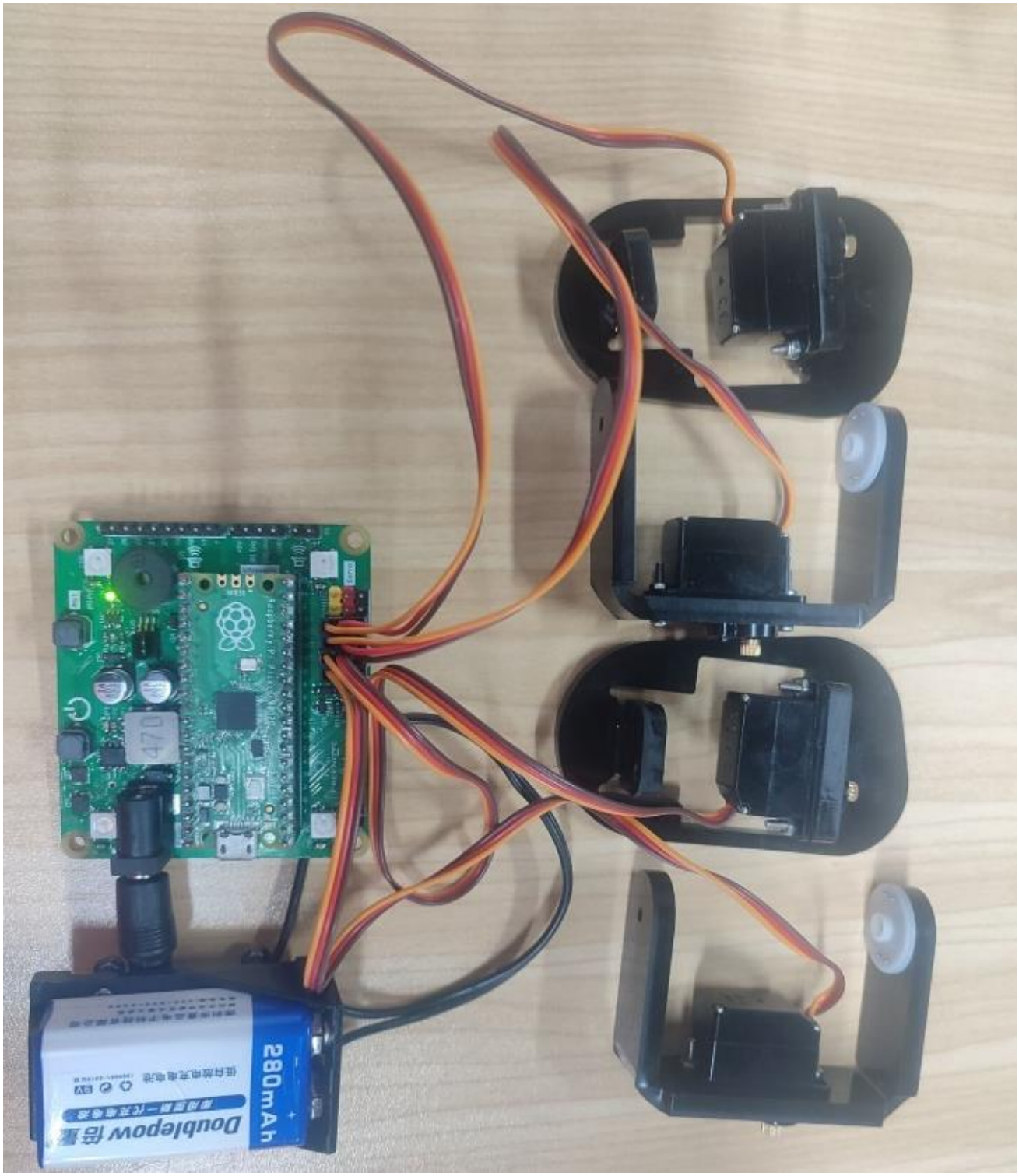
Click “Upload Using Programmer” and the program will be downloaded to Raspberry Pi Pico (W).



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. Align the cable to the pins, yellow cable to yellow pin, red to red, and brown to black. Incorrect wiring may damage the servos. Install the battery and press the power switch. The gears of the four servos will rotate to 90°.



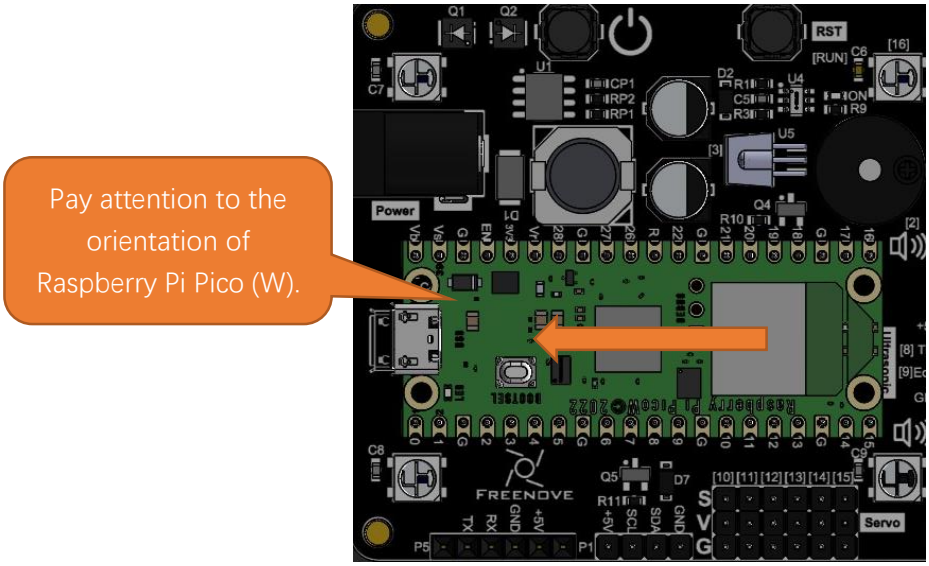
Chapter 0 Assembling Bipedal Robot

If you have any concerns, please feel free to contact us via support@freenove.com

Assembling the Robot

Plugging in Raspberry Pi Pico (W)

Plug Raspberry Pi Pico (W) into the shield.

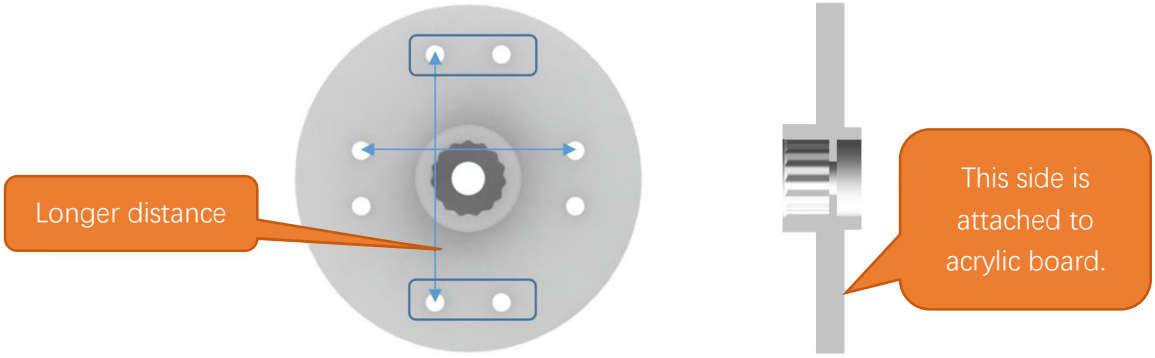


Please pay attention to the orientation of Raspberry Pi Pico (W). Do NOT reverse it; Otherwise, it may burn the Raspberry Pi Pico (W).

Installing Disk Servo Arm

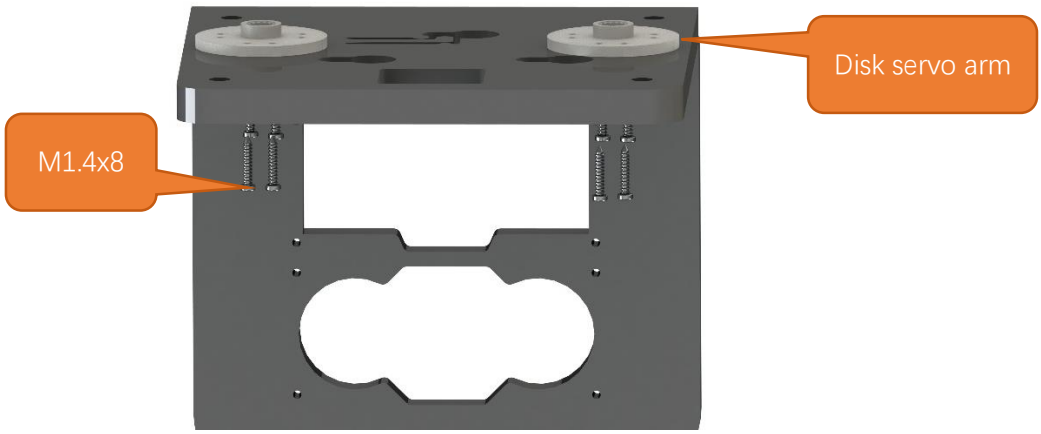
Take out four disk servo arms from the servo packages.

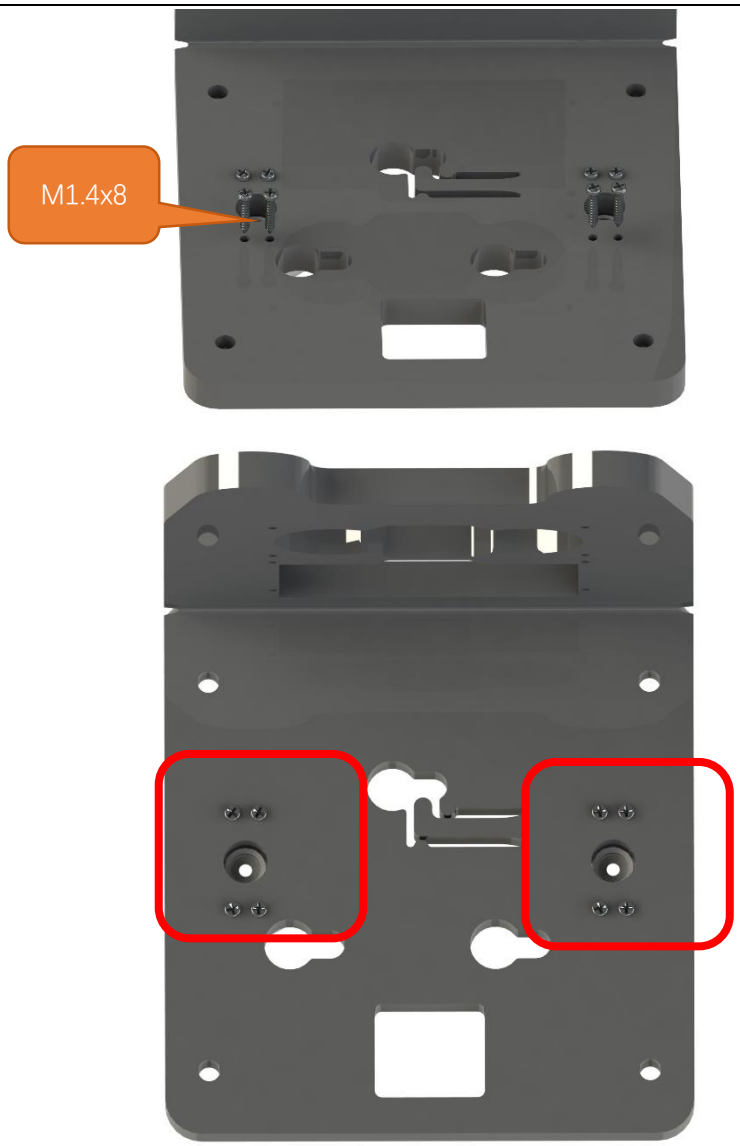
Each servo package includes five M1.4x8 screws and two black servo screws.
There are 4 pairs of opposite holes on the disk servo arm, and the distance between each pair is different.
Please use the 2 pairs of holes with **longer distance.**



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.



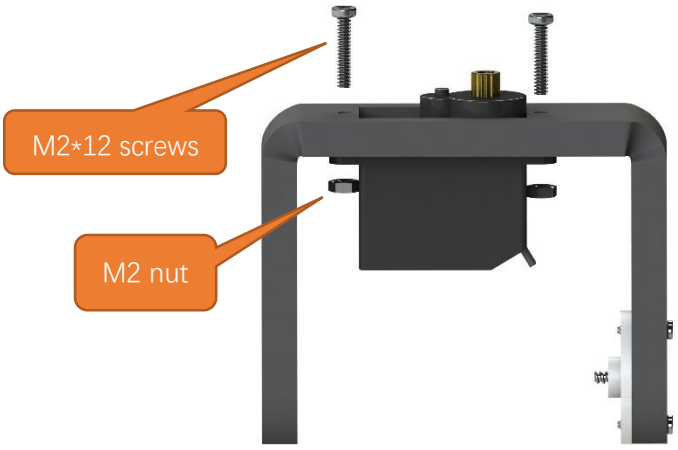


Step 2 The following illustrates the installation of the disc servo arms of the servos for the leg. Use the M1.4x8 screws in the servo package.

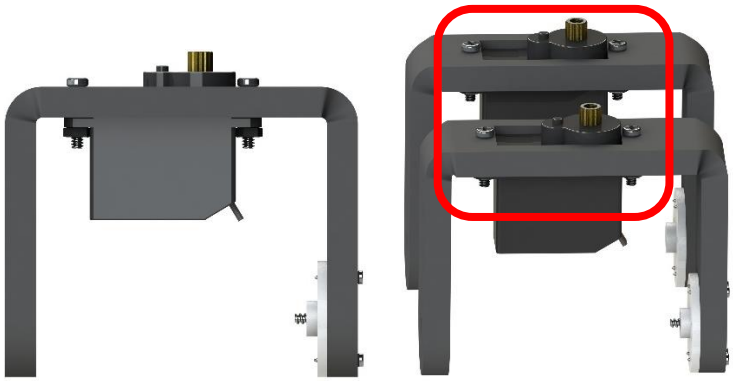
Installing Servo

Installation steps:

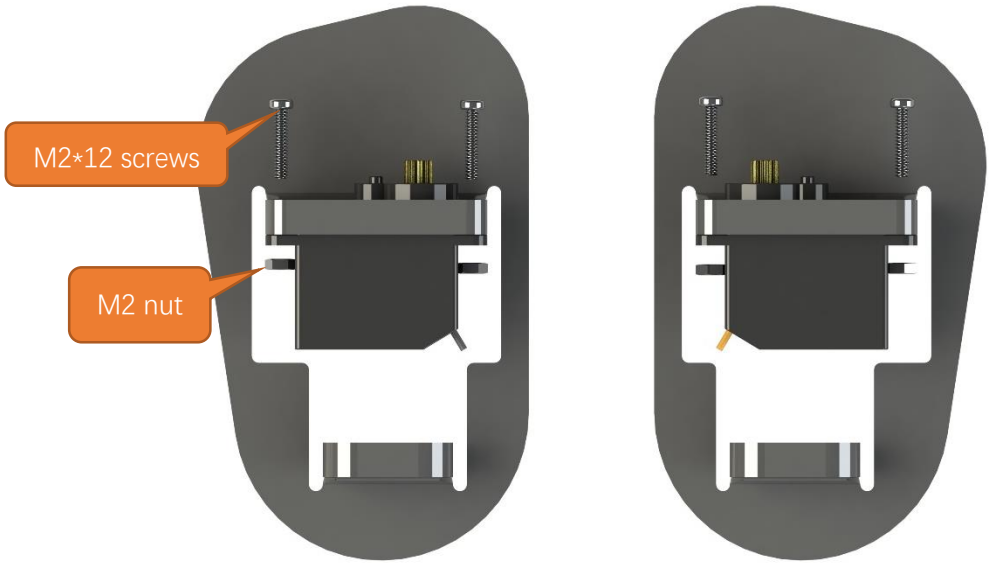
Step 1 Assemble the servos to the two legs with M2*12 screws and M2 nuts.



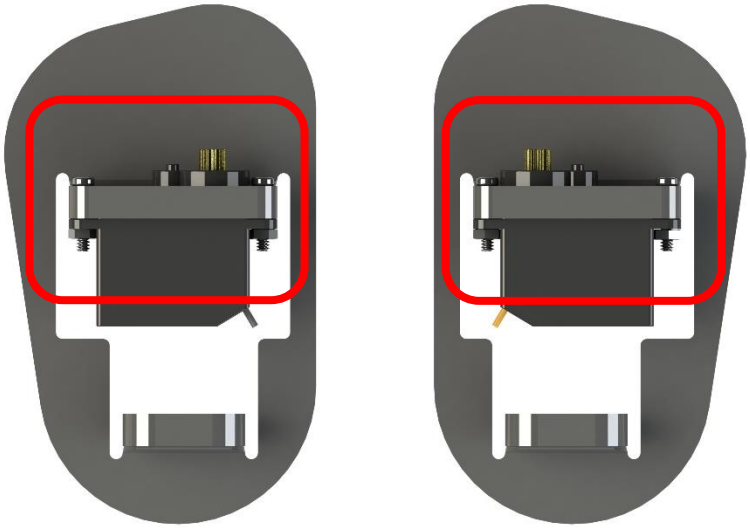
Finished:



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



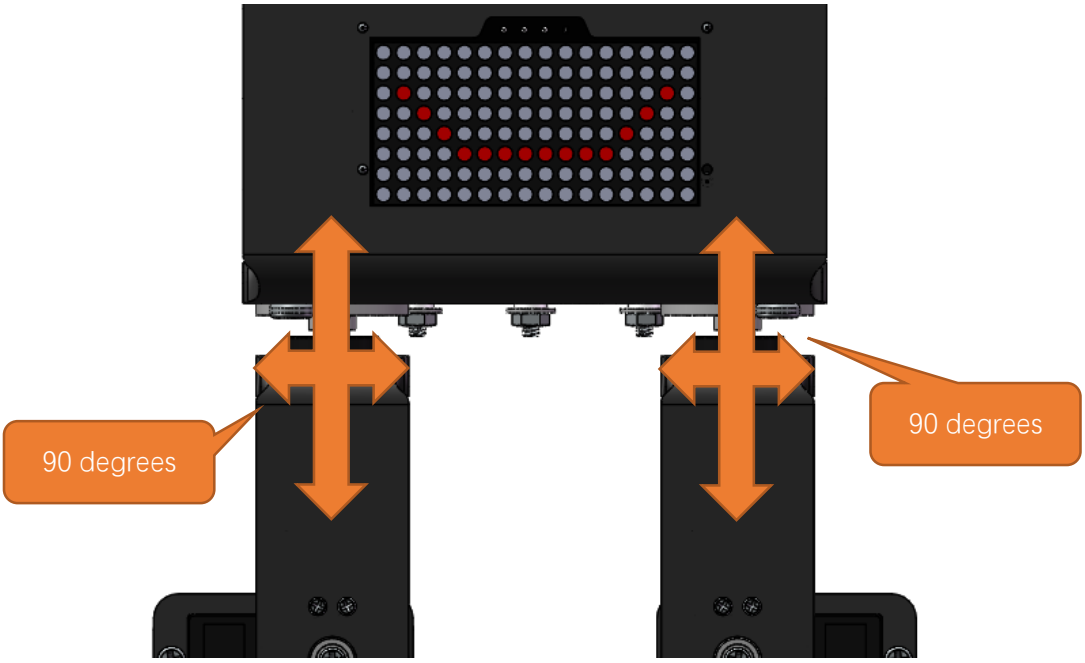
Finished:

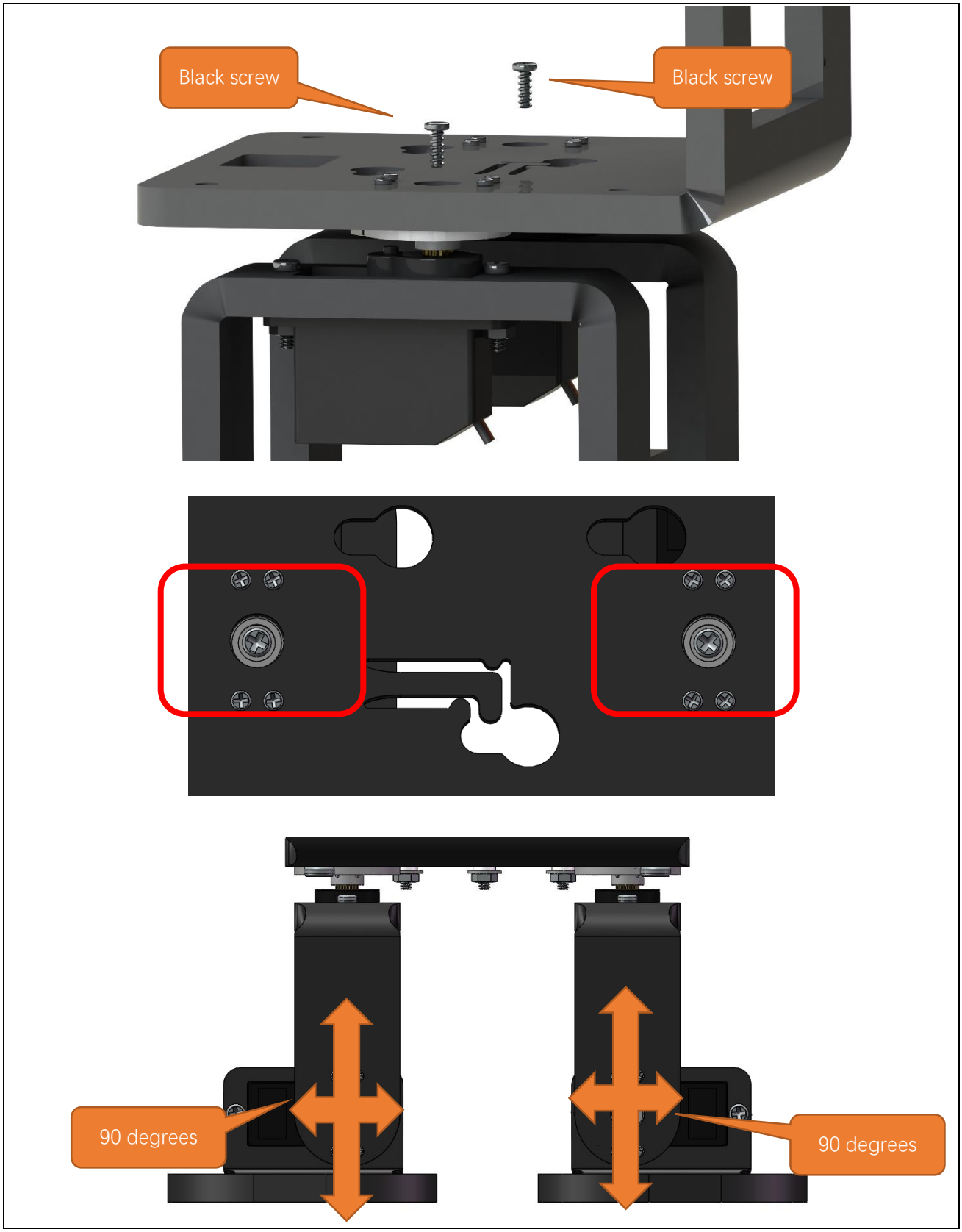


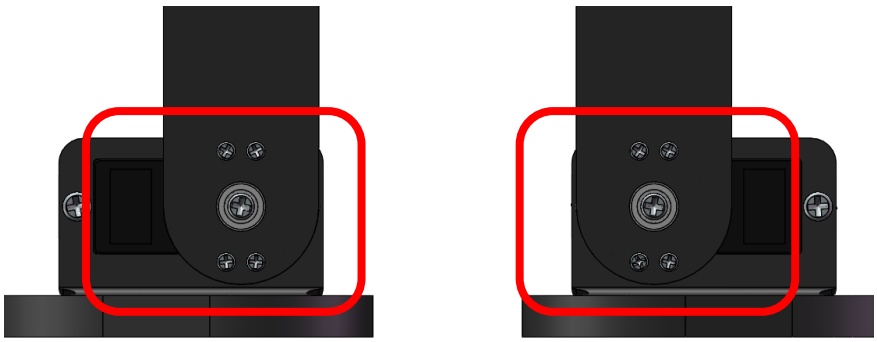
Step 3 Assemble the servos to the robot. Connect Servos 1, 2, 3, and 4 to the corresponding port on the robot board, which are GPIO10, GPIO11, GPIO12, and GPIO13 respectively. Align the cable to the pins, yellow cable to yellow pin, red to red, and brown to black. Incorrect wiring may damage the servos

Before assembling the servos, please make sure that the servos are already set to the 90-degree position. If you have not yet done this, please refer to this to upload the sketch 00.0_Servo_90.ino.

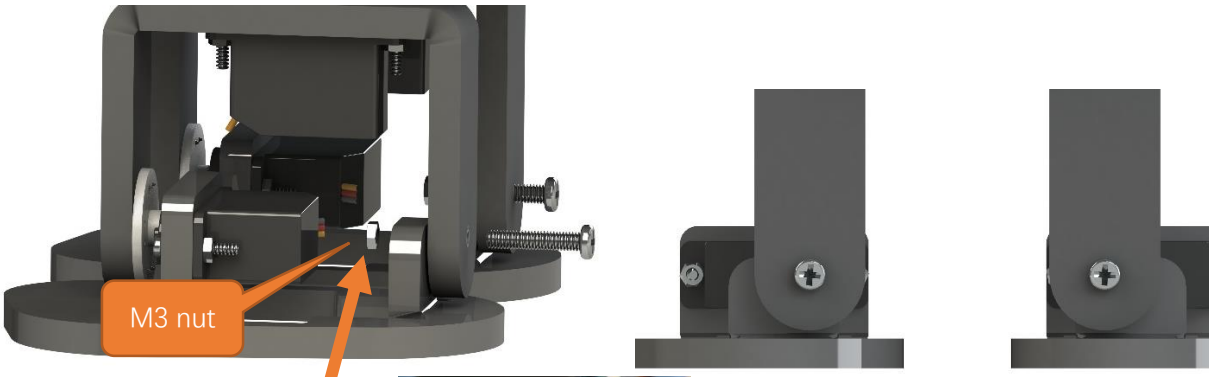
After uploading the sketch, assemble the servos to the designated position.




Black screw
Black screw
90 degrees
90 degrees



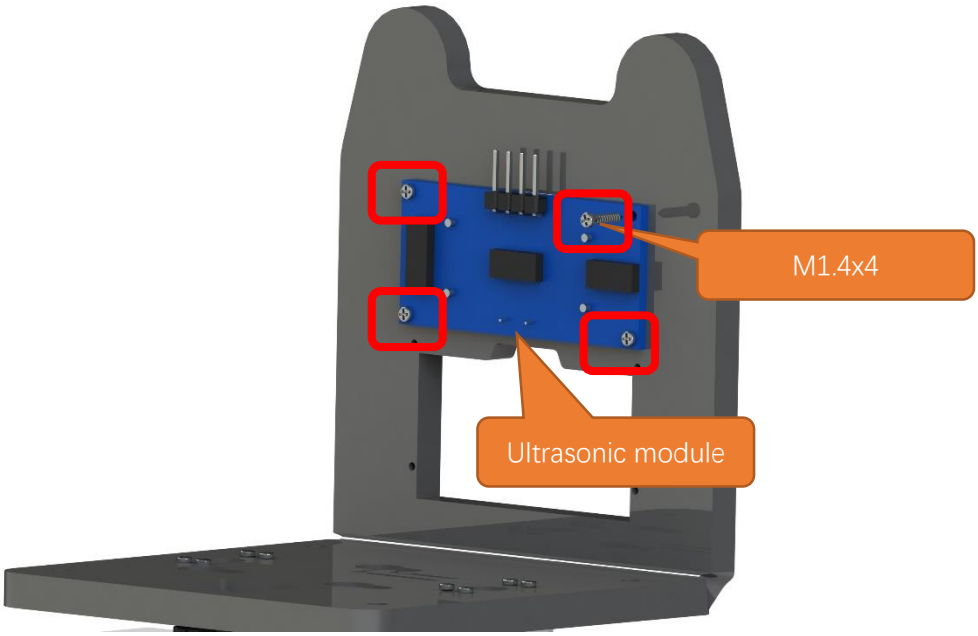
Assemble the leg support screws: Fix the M3 nut with the M3 spanner and screw the M3 screws in. Please note that the M3 nuts here are self-locking non-slip nuts and the screws serve as supports, so you do not need to screw them too tight and some space is needed, so that the feet can move more flexible.
If your robot is stuck when walking, please check if the screws are fixed too tight.



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

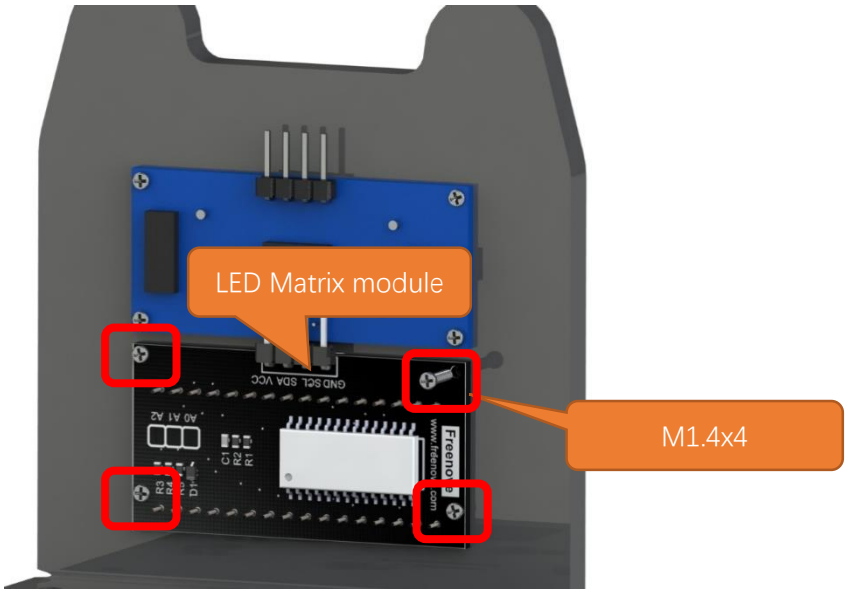
Installing Ultrasonic Module

Step 1 Install ultrasonic module.



Installing LED Matrix Module

Step 1 Install LED matrix module.



Installing 9V Batteries

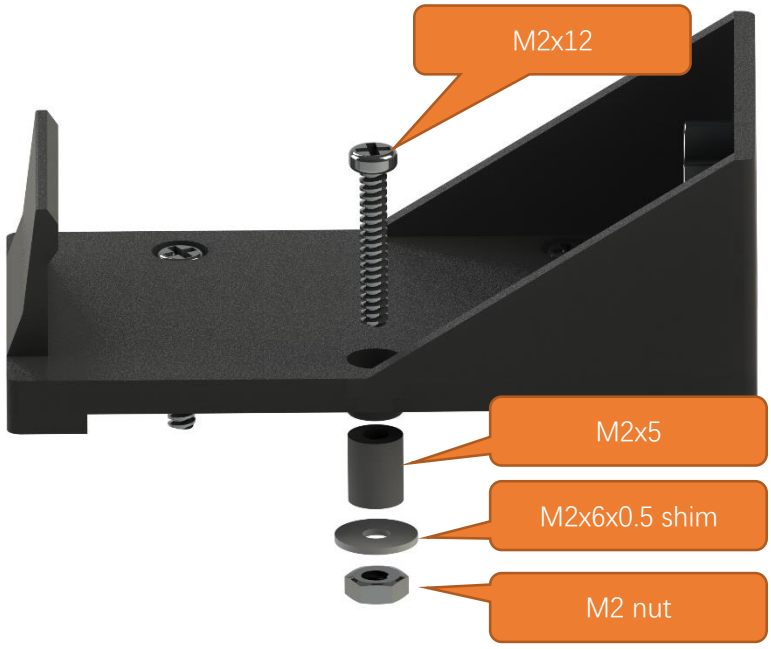
This robot is powered with **9V alkaline batteries** or **9V NIMH rechargeable batteries** as power supply. Please note that 9V carbon batteries and 9V rechargeable lithium batteries **cannot** provide enough power for the robot. Therefore, it is important to pay attention to the battery model when purchasing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

Step 1 Installed with batteries.

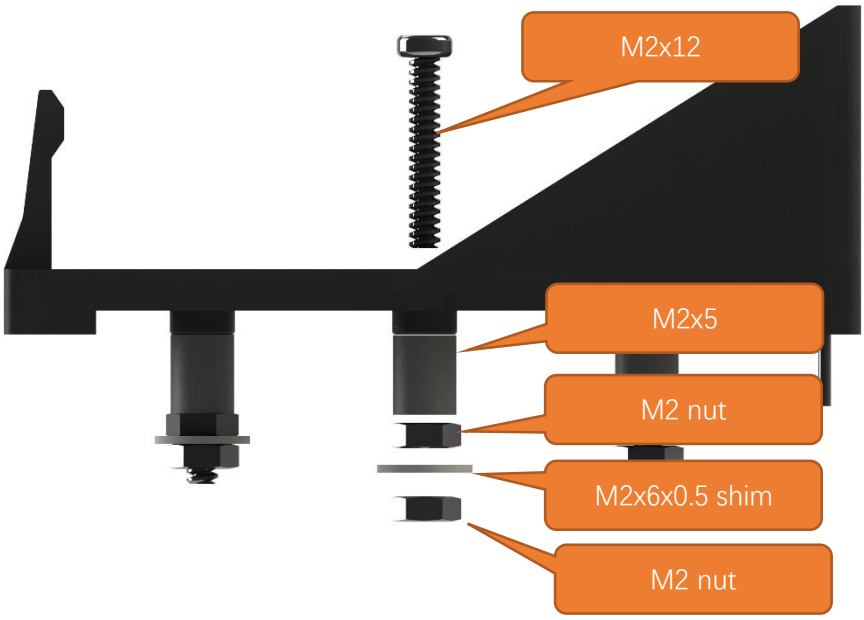
Correctly install the batteries.

Here we provide two installation methods:

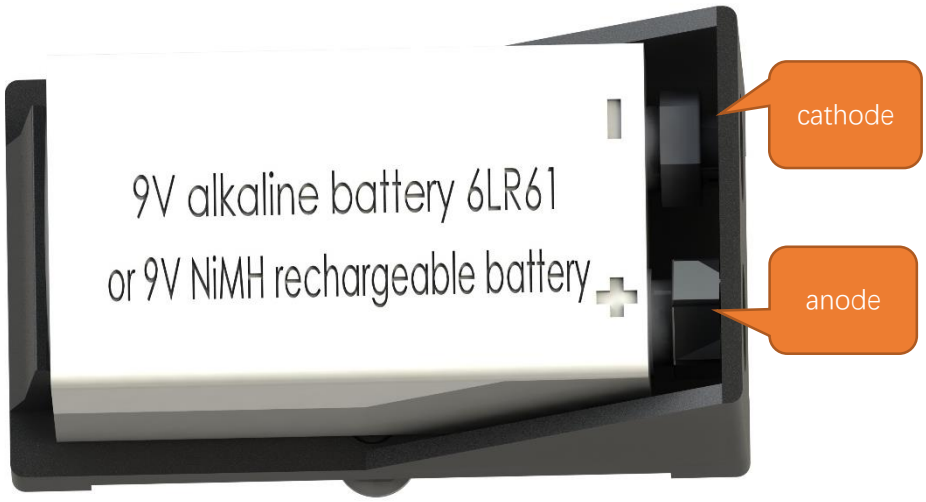
Method 1:



Method 2:

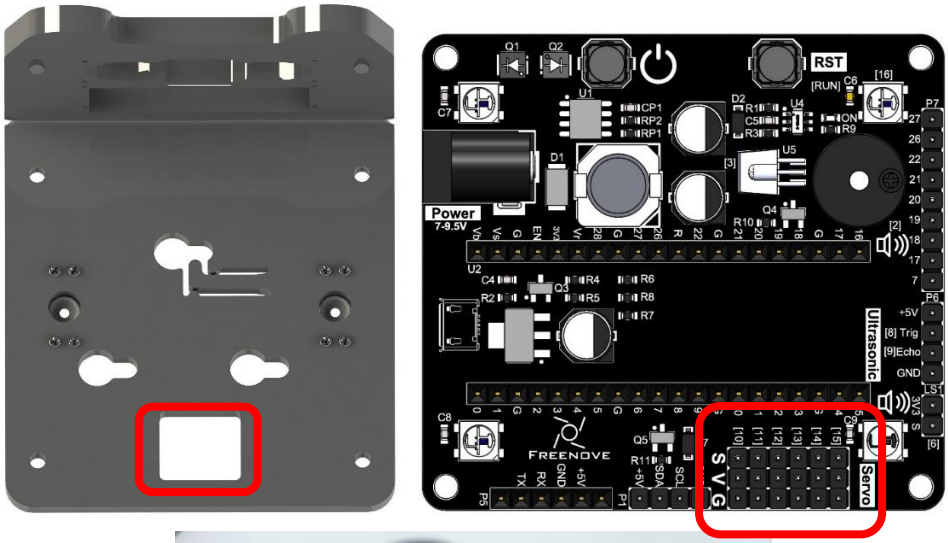


Among them, M2x5 is the acrylic element, and there are 6 M2x5 rings in the acrylic fitting. Only three are used here, and the remaining three are reserved for use.



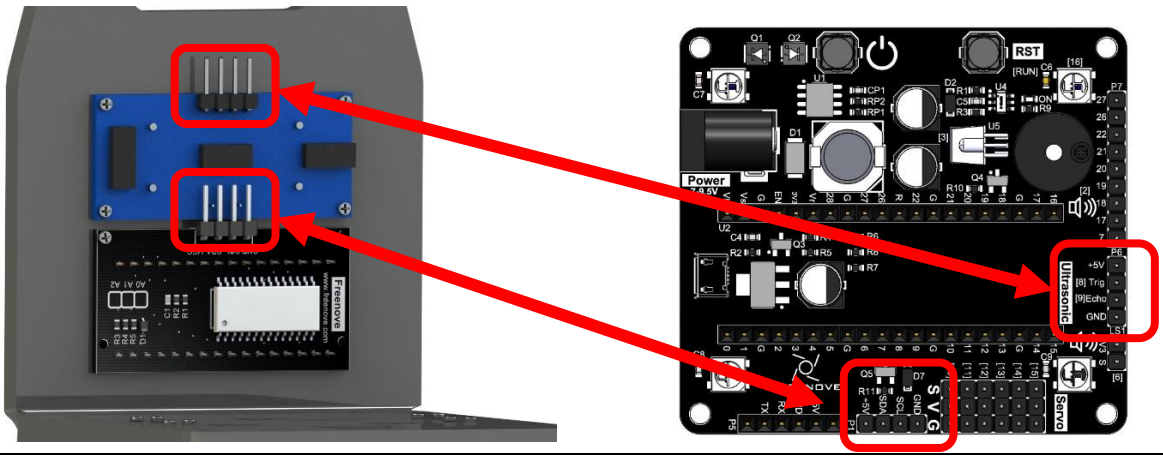
Connecting Servo Cables

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.



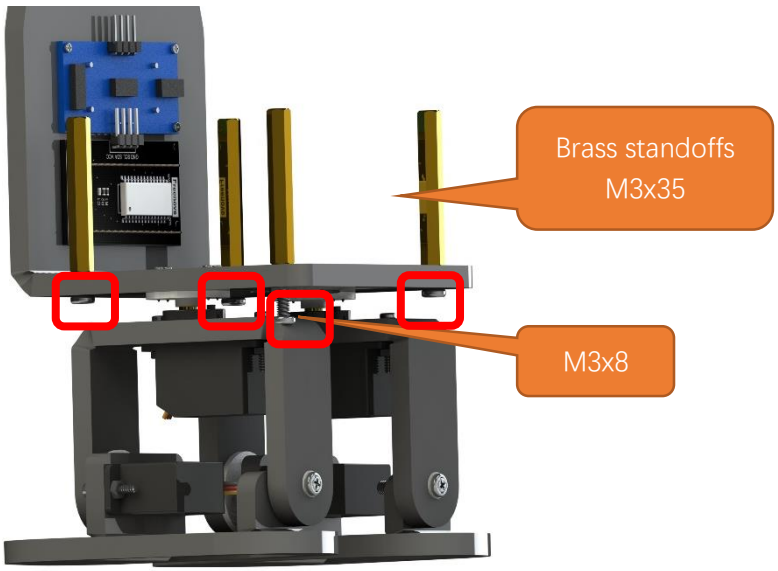
Connect the Ultrasonic Sensor and LED Matrix Module

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.



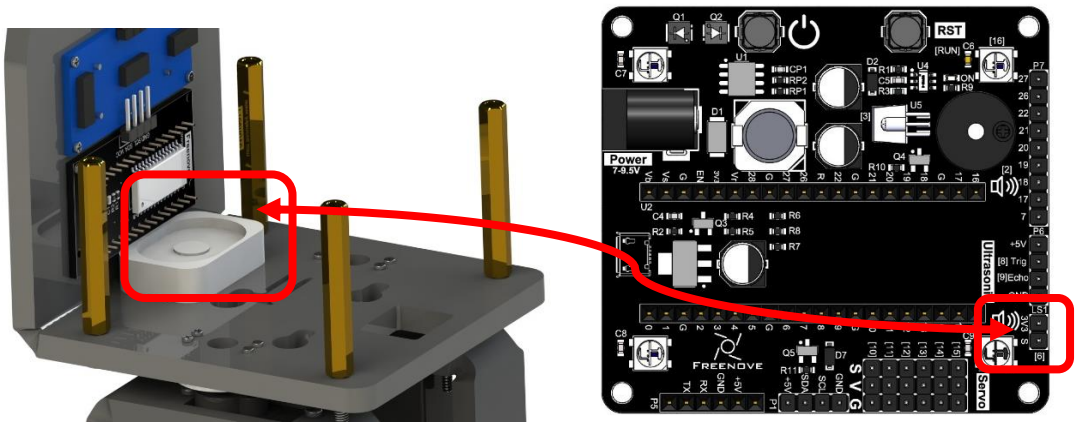
Installing the Standoffs for Robot Shield

Step 1



Installing the Speaker

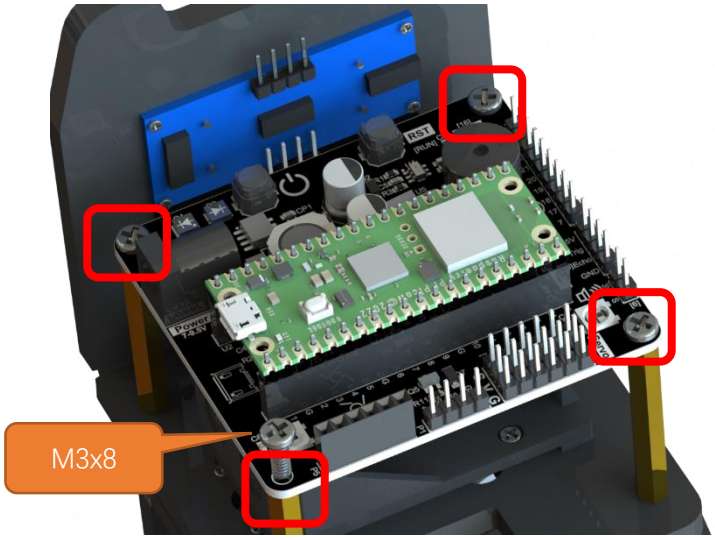
Step 1 Attach the speaker to the robot.



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

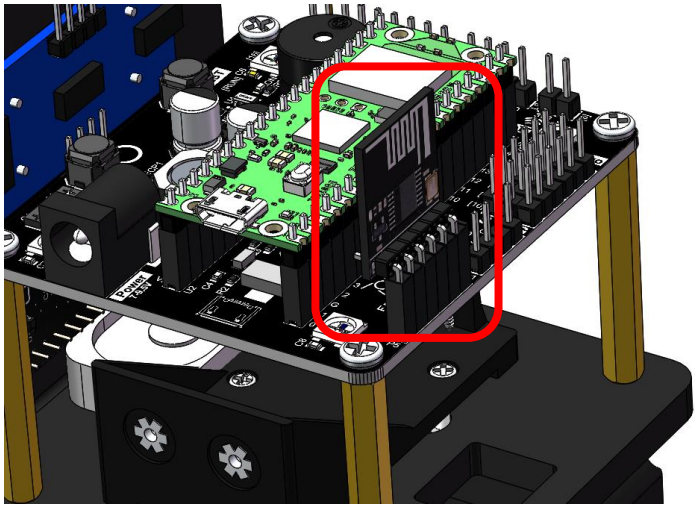
Installing Robot Shield

Step 1 Install the robot shield.



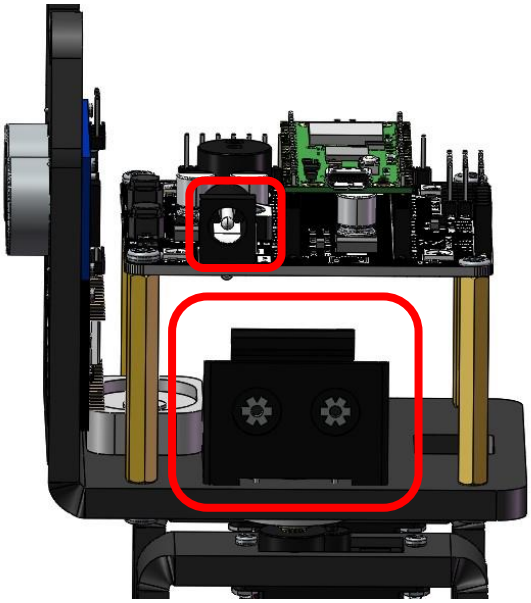
Installing Bluetooth Module

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.



Note: When the robot is not in use, please take out the batteries to avoid draining them.
It is recommended to buy rechargeable batteries; which is more environment-friendly.

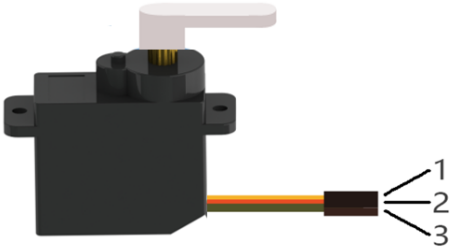
Chapter 1 Module test

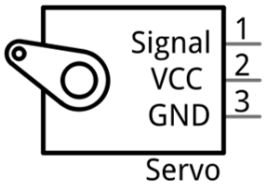
If you have any concerns, please feel free to contact us via support@freenove.com

1.1 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.



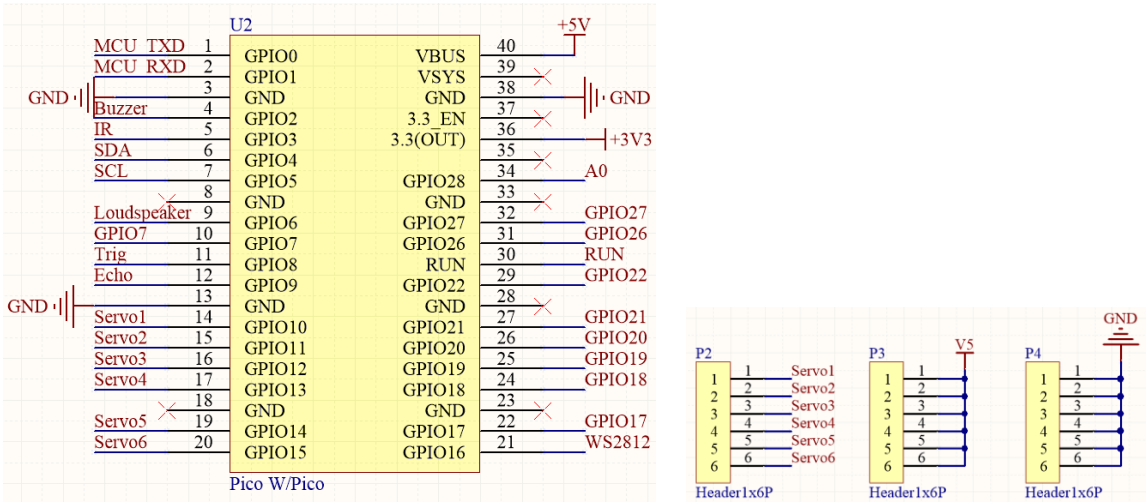


We will use a 50Hz PWM signal with a duty cycle in a certain range to drive the Servo. The lasting time of 0.5ms-2.5ms of PWM single cycle high level corresponds to the servo angle 0 degrees - 180 degree linearly. Part of the corresponding values are as follows:

High level time	Servo angle
0.5ms	0 degree
1ms	45 degree
1.5ms	90 degree
2ms	135 degree
2.5ms	180 degree

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

Schematic



Calibration for the Four Servos

To ensure stable movements of the robot, please calibrate the servos after assembling it. Here are three calibration methods for your reference. Please choose one at your preference.
Method 1: Calibrating via the serial monitor on Arduino IDE. Please refer to 1.1.1_Servo_Calibration.
Method 2: Calibrating with the PC tool, Refer to 1.1.2_Servo_Calibration_PC_Tools for details.
Method 3: Calibrating via Bluetooth. Refer to 1.1.3_Servo_Calibration_Bluetooth for details,

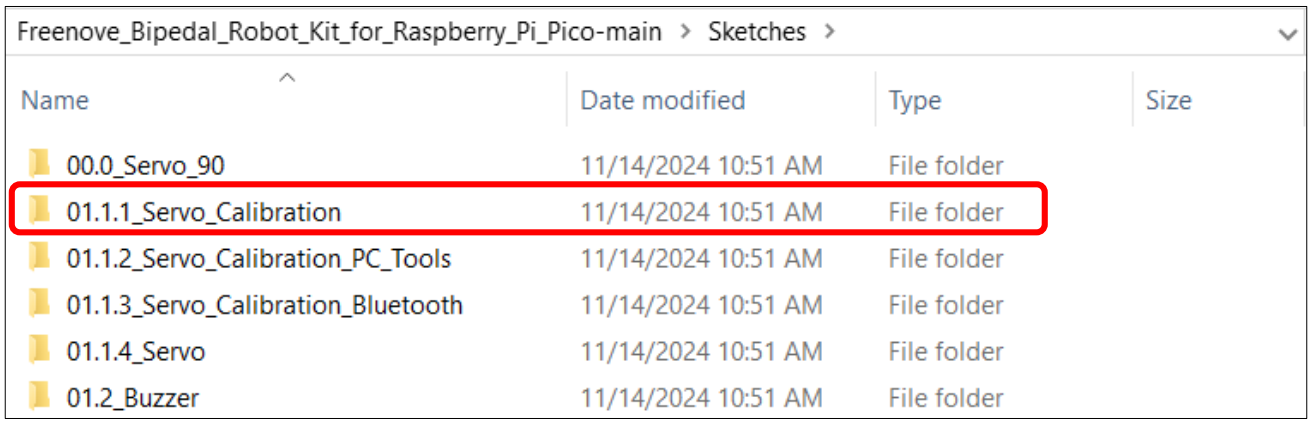
It is recommended using Method 3 to calibrate. As it is a wireless way, it can avoid the interruption of the USB cable to the robot's movements, and the operation is more convenient and efficient.

1.1.1_Servo_Calibration

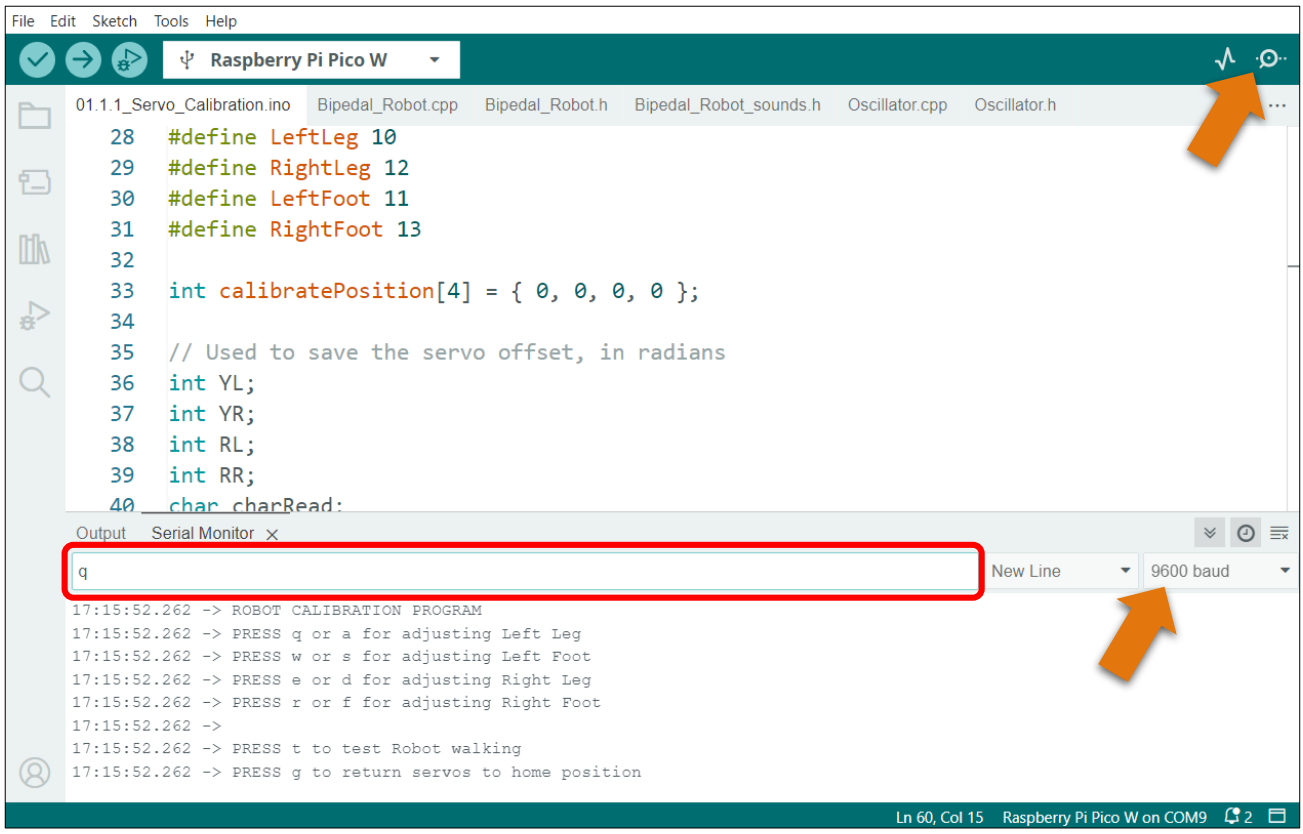
Sketch

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".



Open the Serial Monitor, set the baud rate to 9600, and input the designated values to calibrate the servos.



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

Press O to save the current servo angle data to the Pico board.

Code

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

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

int calibratePosition[4] = { 0, 0, 0, 0 };
// Used to save the servo offset, in radians
int YL;
int YR;
int RL;
int RR;
char charRead;
void setup() {
  EEPROM.begin(512);
  Serial.begin(9600);
  for (int i = 0; i < 4; i++) {
    EEPROM.write(i, calibratePosition[i]);
  }
  Bipedal_Robot.init(LeftLeg, RightLeg, LeftFoot, RightFoot, true);  //Set the servo pins
  YL = EEPROM.read(0);
  if (YL > 128) YL -= 256;
  YR = EEPROM.read(1);
  if (YR > 128) YR -= 256;
  RL = EEPROM.read(2);
  if (RL > 128) RL -= 256;
  RR = EEPROM.read(3);
  if (RR > 128) RR -= 256;
  calib_homePos();
  Bipedal_Robot.saveTrimsOnEEPROM();
  EEPROM.commit();
  Bipedal_Robot.home();
  Serial.println("ROBOT CALIBRATION PROGRAM");
  Serial.println("PRESS q or a for adjusting Left Leg");
  Serial.println("PRESS w or s for adjusting Left Foot");
  Serial.println("PRESS e or d for adjusting Right Leg");
  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 }
```

Code Explanation

Included the required header file.

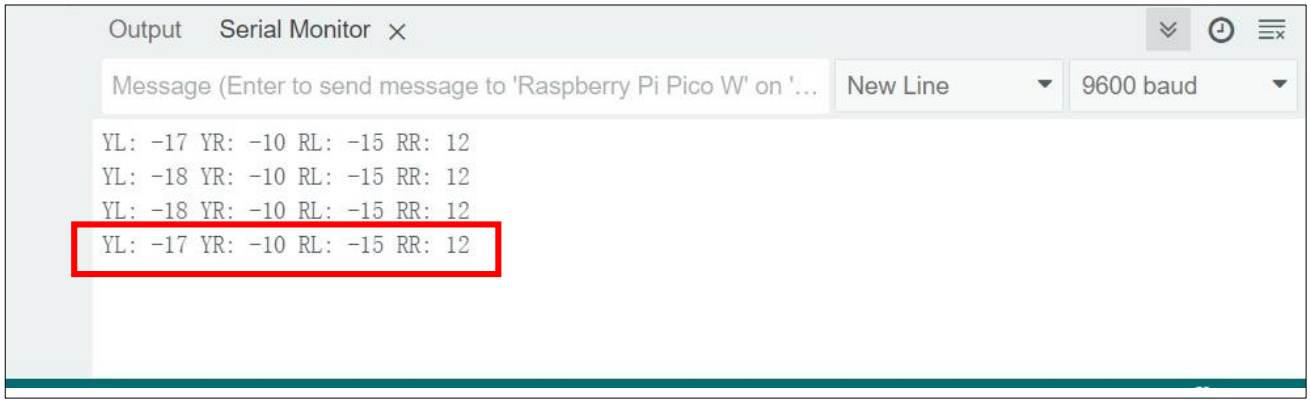
```
1  #include <Arduino.h>
2  #include <Wire.h>
3  #include <SoftwareSerial.h>
4  #include <EEPROM.h>
5  #include "Bipedal_Robot.h"
```

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

```
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   }
```

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 };
```



You have now finished calibrating the servos. You can skip other calibration methods.

1.1.2_Servo_Calibration_PC_Tools

This method also uses serial communication to calibrate the servos. There are two ways to achieve this.

1. Directly run the executable file to calibrate. You only need to double click the file to run it.
2. Enter commands to run the calibration tool. If you choose this, you need the following preparation:
   2.1 Install python on your computer.
   2.2 Install pyseiral library by running the command pip3 install pyserial.

```
C:\Users\Freenove>pip3 install pyserial
Defaulting to user installation because normal site-packages is not writeable
Collecting pyserial
  Downloading pyserial-3.5-py2.py3-none-any.whl.metadata (1.6 kB)
Using cached pyserial-3.5-py2.py3-none-any.whl (90 kB)
Installing collected packages: pyserial
Successfully installed pyserial-3.5

C:\Users\Freenove>
```

2.3 Enter the command to enter the directory where the file locates, and then run python calibration.py to run the calibration tool.

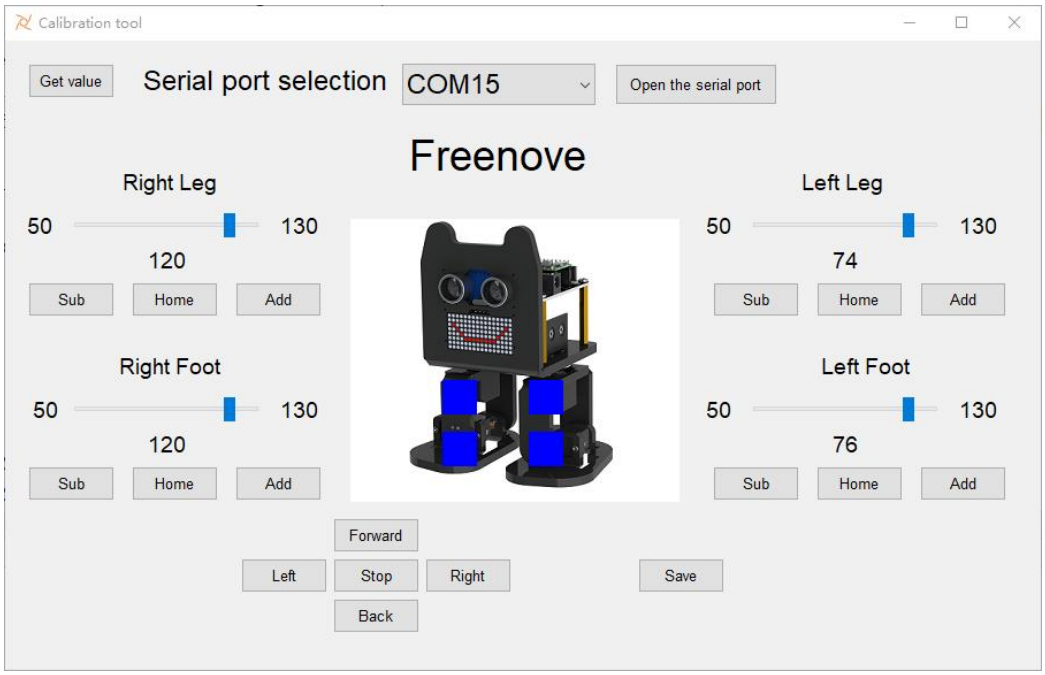
```
C:\Users\Freenove>cd C:\Users\Freenove\Desktop\Freenove_Bipedal_Robot_Kit_for_Raspberry_Pi_Pico\Calibration_tool\Code

C:\Users\Freenove\Desktop\Freenove_Bipedal_Robot_Kit_for_Raspberry_Pi_Pico\Calibration_tool\Code>python calibration.py
```

You will see the calibration tool open after the above steps.
Before using the calibration tool, you need to upload sketch 01.1.2_Servo_Calibration_PC_Tools to the Pico board.

The following shows you how to calibrate the servos with the tool.

1. Connect the Raspberry Pi Pico to your computer with the USB cable.
2. Select the serial port. (Make sure that the port is not occupied by your computer, and that the serial debugger tool on Arduino IDE is close, otherwise the connection will fail.)
3. Click the servo to calibrate. The four blue boxes represent the four servos. When one is selected, it will turn red. Calibrate the four servos one by one.
4. After all the four servos are calibrated, click the movement buttons (Forward, Back, Left, Right, Stop) to see if the servos work correctly.
5. If they work as expected, click the Save button.
6. If the servos does not work correctly in future operation, please recalibrate them.

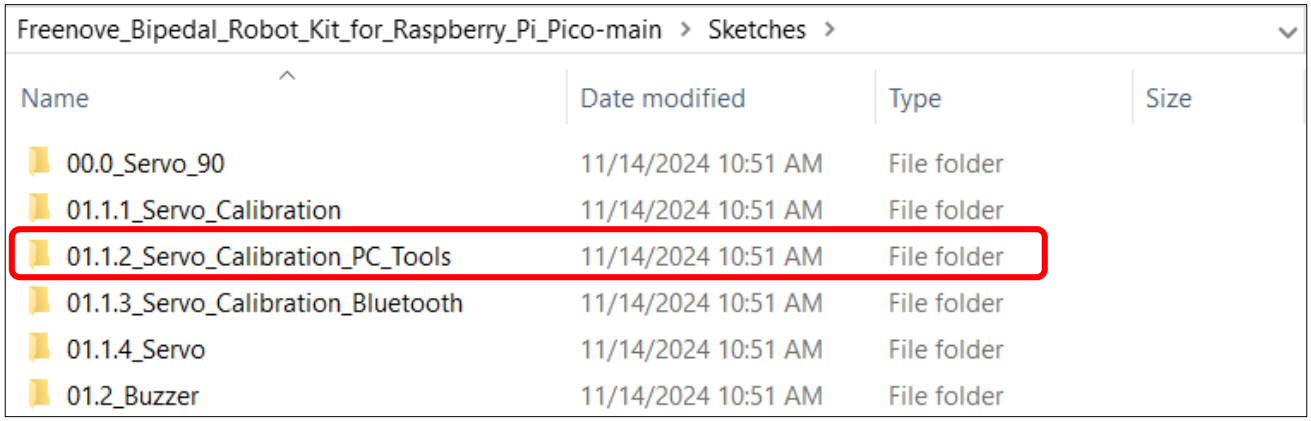
Note: When you open the calibration tool next time, you can click the Get value button to get the servo angle data saved on the Pico board. In this way, the servos can rotate back to the last calibration value. You can calibration based on this value.



Sketch

Upload this sketch to the Raspberry Pi Pico (W). This sketch corresponds to the PC Servo Calibration Tool. You can calibrate the servo angle by clicking the corresponding servo button. After the calibration is completed, click the Save button. When testing the robot's movement, if it does not move well, you can readjust each servo until the robot moves normally.

Open "01.1.2_Servo_Calibration_PC_Tools" in **"Freenove_Bipedal_Robot_Kit_for_Raspberry_Pi_Pico\Sketches"** and double-click "01.1.2_Servo_Calibration_PC_Tools.ino".



Code

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

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

int calibratePosition[4] = { 0, 0, 0, 0 };
// Used to save the servo offset, in radians
int YL;
int YR;
int RL;
int RR;

String inputString = "";      // a String to hold incoming data
bool stringComplete = false;  // whether the string is complete
```

```
22
23  #define COMMANDS_COUNT_MAX 8
24  char charRead;
25  String inputStringBLE = "";
26
27  int move = 0;
28
29  #define ACTION_calibratio 'G'  //Ant movement commands
30  #define ACTION_flag 'F'        //Expression control commands
31  #define ACTION_MOVE 'A'
32
33  #define INTERVAL_CHAR '#'       //The directive resolves the separator character
34  String inputCommandArray[COMMANDS_COUNT_MAX];
35  int paramters[COMMANDS_COUNT_MAX];
36
37  //Parses the Bluetooth data received by the serial port
38  void Deal_Serial_Data(void) {
39    String inputStringTemp = inputStringBLE;
40    int string_length = inputStringTemp.length();
41    for (int i = 0; i < COMMANDS_COUNT_MAX; i++) {
42      int index = inputStringTemp.indexOf(INTERVAL_CHAR);
43      if (index < 0) {
44        if (string_length > 0) {
45          inputCommandArray[i] = inputStringTemp;  //Get command
46          paramters[i] = inputStringTemp.toInt();  //Get parameters
47        }
48        break;
49      }
50      inputCommandArray[i] = inputStringTemp.substring(0, index);
51      inputStringTemp = inputStringTemp.substring(index + 1);
52      paramters[i] = inputCommandArray[i].toInt();
53    }
54    stringComplete = false;
55    inputStringBLE = "";
56  }
57
58  void setup() {
59    EEPROM.begin(512);
60    Serial.begin(9600);
61    // for (int i = 0; i < 4; i++) {
62    //   EEPROM.write(i, calibratePosition[i]);
63    // }
64    Bipedal_Robot.init(LeftLeg, RightLeg, LeftFoot, RightFoot, true);  //Set the servo pins
65    YL = EEPROM.read(0);
```

```
66    if (YL > 128) YL -= 256;
67    YR = EEPROM.read(1);
68    if (YR > 128) YR -= 256;
69    RL = EEPROM.read(2);
70    if (RL > 128) RL -= 256;
71    RR = EEPROM.read(3);
72    if (RR > 128) RR -= 256;
73    calib_homePos();
74    Bipedal_Robot.saveTrimsOnEEPROM();
75    EEPROM.commit();
76    Bipedal_Robot.home();
77  }
78
79  void loop() {
80    while (Serial.available()) {
81      inputStringBLE = Serial.readStringUntil('\n');
82      stringComplete = true;
83    }
84    if (stringComplete) {  //Get the Bluetooth command
85      Deal_Serial_Data();
86      char commandChar = inputCommandArray[0].charAt(0);
87      if (commandChar == ACTION_calibratio) {  //Control expression module display
88        // Serial.println("paramters[1]: " + String(paramters[1]) + " paramters[2]: " +
89  String(paramters[2]) + " paramters[3]: " + String(paramters[3]) + " paramters[4]: " +
90  String(paramters[4]) + " paramters[5]: " + String(paramters[5]));
91        YL = constrain(paramters[1] - 90, -40, 50);
92        YR = constrain(paramters[2] - 90, -40, 50);
93        RL = constrain(paramters[3] - 90, -40, 50);
94        RR = constrain(paramters[4] - 90, -40, 50);
95        Bipedal_Robot.setTrims(YL, YR, RL, RR);
96        calib_homePos();
97        if (paramters[5] = 1) {
98          Bipedal_Robot.setTrims(YL, YR, RL, RR);
99          calib_homePos();
100         Bipedal_Robot.saveTrimsOnEEPROM();
101       }
102     }
103     if (commandChar == ACTION_flag) {  //Control expression module display
104       if (paramters[1] = 1) {
105         YL = EEPROM.read(0);
106         if (YL > 128) YL -= 256;
107         YR = EEPROM.read(1);
108         if (YR > 128) YR -= 256;
109         RL = EEPROM.read(2);
```

```
110           if (RL > 128) RL -= 256;
111           RR = EEPROM.read(3);
112           if (RR > 128) RR -= 256;
113           YL = constrain(YL + 90, 50, 140);
114           YR = constrain(YR + 90, 50, 140);
115           RL = constrain(RL + 90, 50, 140);
116           RR = constrain(RR + 90, 50, 140);
117           Serial.print("F#"+String(YL)+"#"+String(YR)+"#"+String(RL)+"#"+String(RR));
118         }
119       }
120   if (commandChar == ACTION_MOVE) {  //Control expression module display
121       move = paramters[1];
122       }
123     }
124     if (move == 1) {
125         Bipedal_Robot.walk(1, 1500, 1);
126       }
127       if (move == 2) {
128         Bipedal_Robot.walk(1, 1500, -1);
129       }
130       if (move == 3) {
131         Bipedal_Robot.turn(1, 1500, 1);
132       }
133       if (move == 4) {
134         Bipedal_Robot.turn(1, 1500, -1);
135       }
136       if (move == 0) {
137         Bipedal_Robot.home();
138       }
139   }
140
141   void calib_homePos() {
142     int servoPos[4];
143     servoPos[0] = 90;
144     servoPos[1] = 90;
145     servoPos[2] = 90;
146     servoPos[3] = 90;
147     Bipedal_Robot._moveServos(500, servoPos);
148   }
```

Code Explanation

Parses the serial port data received by the serial port.

```
38   void Deal_Serial_Data(void) {
39     String inputStringTemp = inputStringBLE;
40     int string_length = inputStringTemp.length();
```

```
41    for (int i = 0; i < COMMANDS_COUNT_MAX; i++) {
42      int index = inputStringTemp.indexOf(INTERVAL_CHAR);
43      if (index < 0) {
44        if (string_length > 0) {
45          inputCommandArray[i] = inputStringTemp;  //Get command
46          paramters[i] = inputStringTemp.toInt();  //Get parameters
47        }
48        break;
49      }
50      inputCommandArray[i] = inputStringTemp.substring(0, index);
51      inputStringTemp = inputStringTemp.substring(index + 1);
52      paramters[i] = inputCommandArray[i].toInt();
53    }
54    stringComplete = false;
55    inputStringBLE = "";
56  }
```

Execute the corresponding task according to the received serial port command.

```
87        if (commandChar == ACTION_calibratio) {  //Control expression module display
103       if (commandChar == ACTION_flag) {  //Control expression module display
120   if (commandChar == ACTION_MOVE) {  //Control expression module display
```

You have now finished calibrating the servos. You can skip other calibration methods.

1.1.3_Servo_Calibration_Bluetooth

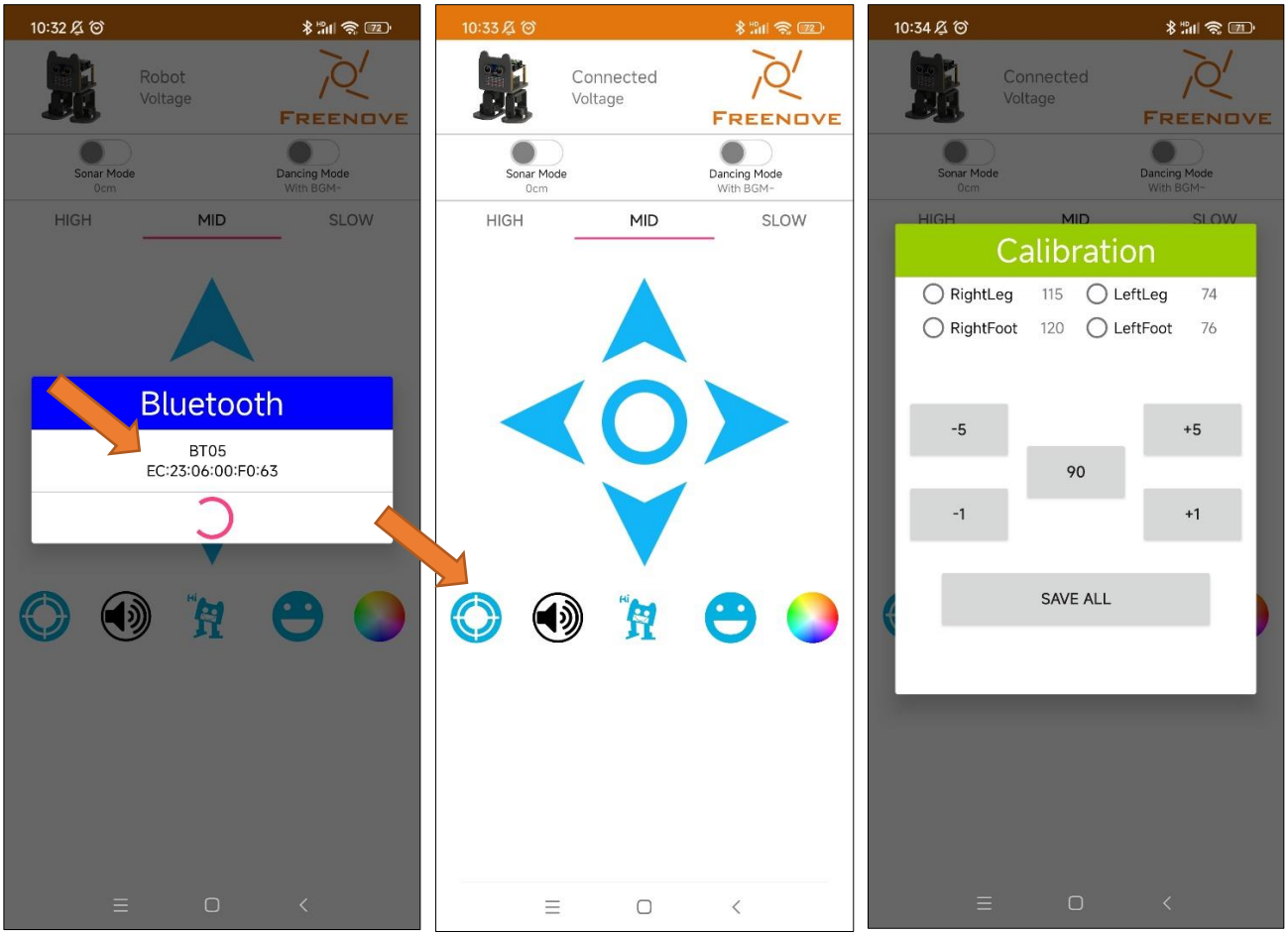
If you have not yet installed our APP, please do so first. You can download the app here.

This method calibrate the servo angles via Bluetooth wireless connection.

1. Upload the corresponding code to Pico (see the sketch section for detail). Open Freenove app on your phone and connect to the Bluetooth named "BT05".
2. After connecting successfully, tap the calibration icon on the app. At this point, it will get the angle data of the four servos.
3. Select each servo to calibrate.
4. Tap the SAVE ALL button after the four servos are calibrated, and close the calibration window.
5. Test the robot's movement by tapping the movement buttons on the homepage. Check whether the servos move in line with the button tapped.
6. Similarly, if the servos work abnormally, you can recalibrate them.

Notes:

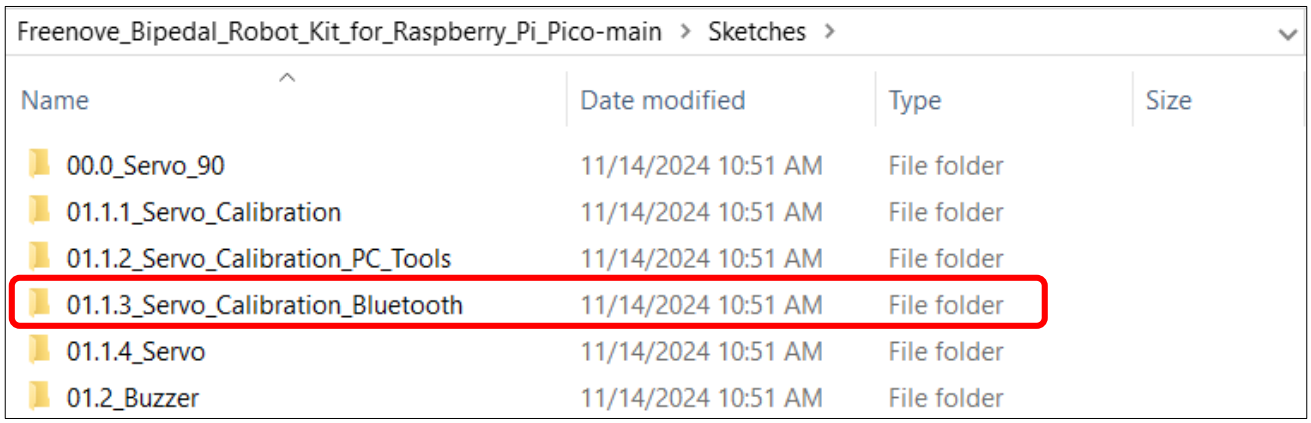
1. Please make sure the Bluetooth module is correctly connected to avoid burning it.
2. Please take out the batteries when the robot is put idle to avoid draining them.



Sketch

Upload this sketch to the Raspberry Pi Pico (W). This sketch corresponds to the way of calibration via phone app. You can calibrate the servo angle by clicking the corresponding servo button. After the calibration is completed, click the Save button. When testing the robot's movement, if it does not move well, you can readjust each servo until the robot moves normally.

Open “01.1.3_Servo_Calibration_Bluetooth” in **“Freenove_Bipedal_Robot_Kit_for_Raspberry_Pi_Pico\Sketches”** and double-click “01.1.3_Servo_Calibration_Bluetooth.ino”.



Code

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

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

int calibratePosition[4] = { 0, 0, 0, 0 };
// Used to save the servo offset, in radians
int YL;
int YR;
int RL;
int RR;

String inputString = "";      // a String to hold incoming data
bool stringComplete = false;  // whether the string is complete
int baudRate[] = {2400, 9600, 19200, 115200};
int baudRateCount = sizeof(baudRate) / sizeof(baudRate[0]);

#define COMMANDS_COUNT_MAX 5
char charRead;
String inputStringBLE = "";

#define ACTION_calibratio 'G'  //Ant movement commands
#define ACTION_flag 'F'        //Expression control commands
#define ACTION_MOVE 'A'
```

```
32
33  #define INTERVAL_CHAR '#'  //The directive resolves the separator character
34  String inputCommandArray[COMMANDS_COUNT_MAX];
35  int paramters[COMMANDS_COUNT_MAX];
36  int move = 0;
37  int movespeed = 1500;
38
39  SoftwareSerial BTserial = SoftwareSerial(1, 0);  // RX pin to 0 and TX pin to 1 on the board
40  SerialCommand SCmd(BTserial);
41  Bipedal_Robot Bipedal_Robot;
42
43  void receiveStop() {
44    delay(10);
45    Serial.flush();
46  }
47
48  //Parses the Bluetooth data received by the serial port
49  void Deal_Serial_Data(void) {
50    String inputStringTemp = inputStringBLE;
51    int string_length = inputStringTemp.length();
52    Serial.println(inputStringTemp);
53    for (int i = 0; i < COMMANDS_COUNT_MAX; i++) {
54      int index = inputStringTemp.indexOf(INTERVAL_CHAR);
55      if (index < 0) {
56        if (19 > string_length > 0) {
57          inputCommandArray[i] = inputStringTemp;  //Get command
58          paramters[i] = inputStringTemp.toInt();  //Get parameters
59        }
60        break;
61      }
62      inputCommandArray[i] = inputStringTemp.substring(0, index);
63      inputStringTemp = inputStringTemp.substring(index + 1);
64      paramters[i] = inputCommandArray[i].toInt();
65    }
66    stringComplete = false;
67    inputStringBLE = "";
68  }
69
70  void setup() {
71    EEPROM.begin(512);
72    Serial.begin(9600);
73    delay(2000);
74    // Loop through each baud rate and send commands
75    for(int i = 0; i < baudRateCount; i++){
```

```
76      BTserial.begin(baudRate[i]);
77      delay(200);
78      BTserial.println("AT+NAME=BT05");//Set the radio called Robot
79      delay(200);
80      BTserial.println("AT+ROLE=0");
81      delay(200);
82      BTserial.println("AT+UART=2");//1=2400 2=9600 3=19200 4=115200
83      delay(200);
84
85      //SoftwareSerial does not support dynamic adjustment of baud rate, so close the serial
86      BTserial.end();
87    }
88
89    BTserial.begin(9600);
90    delay(1500);
91
92    inputString.reserve(200);
93    SCmd.addDefaultHandler(receiveStop);
94    Serial.println("Set the name of the Bluetooth module to BT05.");
95    Serial.println("Set the Bluetooth baud rate to 9600.");
96
97    // for (int i = 0; i < 4; i++) {
98    //   EEPROM.write(i, calibratePosition[i]);
99    // }
100   Bipedal_Robot.init(LeftLeg, RightLeg, LeftFoot, RightFoot, true);  //Set the servo pins
101   YL = EEPROM.read(0);
102   if (YL > 128) YL -= 256;
103   YR = EEPROM.read(1);
104   if (YR > 128) YR -= 256;
105   RL = EEPROM.read(2);
106   if (RL > 128) RL -= 256;
107   RR = EEPROM.read(3);
108   if (RR > 128) RR -= 256;
109   calib_homePos();
110   Bipedal_Robot.saveTrimsOnEEPROM();
111   EEPROM.commit();
112   Bipedal_Robot.home();
113   Serial.println("start...");
114 }
115
116 void readservo(int parameter1, int parameter2, int parameter3, int parameter4) {
117   parameter1 = EEPROM.read(0);
118   parameter2 = EEPROM.read(1);
119   parameter3 = EEPROM.read(2);
```

```
  parameter4 = EEPROM.read(3);
}

void loop() {
  if (BTserial.available()) {
    inputStringBLE = BTserial.readStringUntil('\n');
    stringComplete = true;
  }
  if (stringComplete) {  //Get the Bluetooth command
    Deal_Serial_Data();
    char commandChar = inputCommandArray[0].charAt(0);
    if (commandChar == ACTION_calibratio) {  //Control expression module display
      YL = constrain(paramters[1] - 90, -40, 50);
      YR = constrain(paramters[2] - 90, -40, 50);
      RL = constrain(paramters[3] - 90, -40, 50);
      RR = constrain(paramters[4] - 90, -40, 50);
      Serial.println("F#" + String(YL) + "#" + String(YR) + "#" + String(RL) + "#" +
String(RR));
      Bipedal_Robot.setTrims(YL, YR, RL, RR);
      calib_homePos();
      if (paramters[5] = 1) {
        Bipedal_Robot.setTrims(YL, YR, RL, RR);
        calib_homePos();
        Bipedal_Robot.saveTrimsOnEEPROM();
      }
    }
    if (commandChar == ACTION_flag) {  //Control expression module display
      if (paramters[1] = 1) {
        YL = EEPROM.read(0);
        if (YL > 128) YL -= 256;
        YR = EEPROM.read(1);
        if (YR > 128) YR -= 256;
        RL = EEPROM.read(2);
        if (RL > 128) RL -= 256;
        RR = EEPROM.read(3);
        if (RR > 128) RR -= 256;
        YL = constrain(YL + 90, 50, 140);
        YR = constrain(YR + 90, 50, 140);
        RL = constrain(RL + 90, 50, 140);
        RR = constrain(RR + 90, 50, 140);
        Serial.println("F#" + String(YL) + "#" + String(YR) + "#" + String(RL) + "#" +
String(RR));
        BTserial.println("F#" + String(YL) + "#" + String(YR) + "#" + String(RL) + "#" +
String(RR));
```

```
164         }
165       }
166       if (commandChar == ACTION_MOVE) {  //Control expression module display
167         move = paramters[1];
168         movespeed = paramters[2];
169         if (movespeed == 0) {
170           movespeed = 1000;
171         } else if (movespeed == 1) {
172           movespeed = 1500;
173         } else if (movespeed == 2) {
174           movespeed = 2000;
175         } else
176           movespeed = 1500;
177       }
178     }
179     if (move == 1) {
180       Bipedal_Robot.walk(1, movespeed, 1);
181     }
182     if (move == 2) {
183       Bipedal_Robot.walk(1, movespeed, -1);
184     }
185     if (move == 3) {
186       Bipedal_Robot.turn(1, movespeed, 1);
187     }
188     if (move == 4) {
189       Bipedal_Robot.turn(1, movespeed, -1);
190     }
191     if (move == 0) {
192       Bipedal_Robot.home();
193     }
194   }
195
196   void calib_homePos() {
197     int servoPos[4];
198     servoPos[0] = 90;
199     servoPos[1] = 90;
200     servoPos[2] = 90;
201     servoPos[3] = 90;
202     Bipedal_Robot._moveServos(100, servoPos);
203   }
```

Code Explanation

Initialize the Bluetooth module, set the baud rate of the Bluetooth module and the Bluetooth name.

```
73     delay(2000);
```

```
74    // Loop through each baud rate and send commands
75    for(int i = 0; i < baudRateCount; i++){
76      BTserial.begin(baudRate[i]);
77      delay(200);
78      BTserial.println("AT+NAME=BT05");//Set the radio called Robot
79      delay(200);
80      BTserial.println("AT+ROLE=0");
81      delay(200);
82      BTserial.println("AT+UART=2");//1=2400 2=9600 3=19200 4=115200
83      delay(200);
84
85      //SoftwareSerial does not support dynamic adjustment of baud rate, so close the serial
86      BTserial.end();
87    }
88
89    BTserial.begin(9600);
90    delay(1500);
```

Similar to serial communication, according to the received Bluetooth data, the corresponding function is executed.

```
124   if (BTserial.available()) {
125     inputStringBLE = BTserial.readStringUntil('\n');
126     stringComplete = true;
127   }
128   if (stringComplete) {  //Get the Bluetooth command
129     Deal_Serial_Data();
130     char commandChar = inputCommandArray[0].charAt(0);
131     if (commandChar == ACTION_calibratio) {  //Control expression module display
132       YL = constrain(paramters[1] - 90, -40, 50);
133       YR = constrain(paramters[2] - 90, -40, 50);
134       RL = constrain(paramters[3] - 90, -40, 50);
135       RR = constrain(paramters[4] - 90, -40, 50);
136       Serial.println("F#" + String(YL) + "#" + String(YR) + "#" + String(RL) + "#" +
137 String(RR));
138       Bipedal_Robot.setTrims(YL, YR, RL, RR);
139       calib_homePos();
140       if (paramters[5] = 1) {
141         Bipedal_Robot.setTrims(YL, YR, RL, RR);
142         calib_homePos();
143         Bipedal_Robot.saveTrimsOnEEPROM();
144       }
145     }
146     if (commandChar == ACTION_flag) {  //Control expression module display
147       if (paramters[1] = 1) {
148         YL = EEPROM.read(0);
```

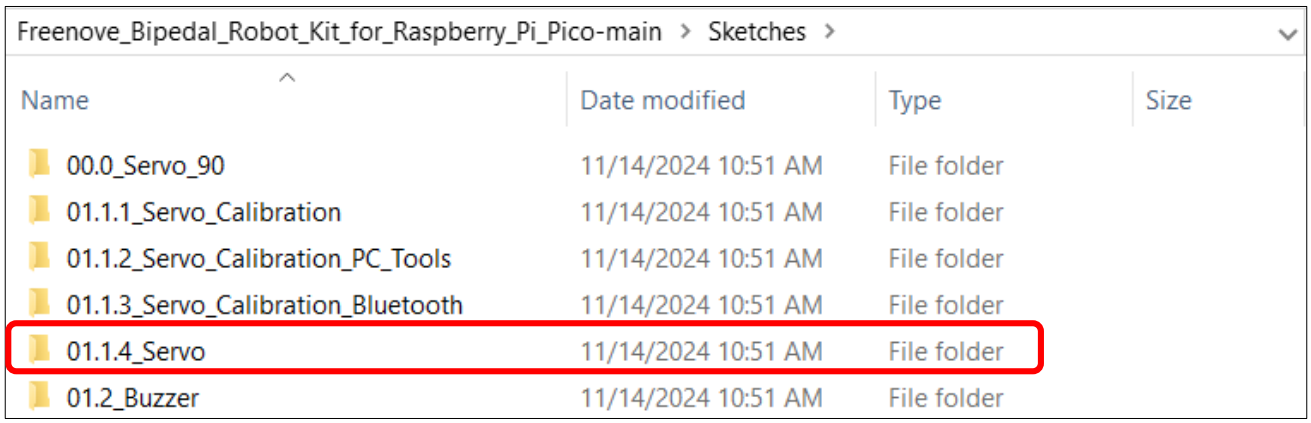
```
        if (YL > 128) YL -= 256;
        YR = EEPROM.read(1);
        if (YR > 128) YR -= 256;
        RL = EEPROM.read(2);
        if (RL > 128) RL -= 256;
        RR = EEPROM.read(3);
        if (RR > 128) RR -= 256;
        YL = constrain(YL + 90, 50, 140);
        YR = constrain(YR + 90, 50, 140);
        RL = constrain(RL + 90, 50, 140);
        RR = constrain(RR + 90, 50, 140);
        Serial.println("F#" + String(YL) + "#" + String(YR) + "#" + String(RL) + "#" +
String(RR));
        BTserial.println("F#" + String(YL) + "#" + String(YR) + "#" + String(RL) + "#" +
String(RR));
      }
    }
    if (commandChar == ACTION_MOVE) {  //Control expression module display
      move = paramters[1];
      movespeed = paramters[2];
      if (movespeed == 0) {
        movespeed = 1000;
      } else if (movespeed == 1) {
        movespeed = 1500;
      } else if (movespeed == 2) {
        movespeed = 2000;
      } else
        movespeed = 1500;
    }
  }
```

1.1.4_Servo

Sketch

If the robot has passed the tests of moving forward, backward, left, and right in the calibration section, you can skip this test.

Open "01.1.4_Servo" in **"Freenove_Bipedal_Robot_Kit_for_Raspberry_Pi_Pico\Sketches"** and double-click "01.1.4_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

```
#include <Arduino.h>
#include <EEPROM.h>
#include "Bipedal_Robot.h"
Bipedal_Robot Bipedal_Robot;

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

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

void setup() {
  Serial.begin(115200);
  EEPROM.begin(512);
  Bipedal_Robot.init(LeftLeg, RightLeg, LeftFoot, RightFoot, true);  //Set the servo pins
  // Bipedal_Robot.setTrims(calibratePosition[0], calibratePosition[1], calibratePosition[2], calibratePosition[3]);
  calib_homePos();
  Bipedal_Robot.saveTrimsOnEEPROM();
  EEPROM.commit();
  Bipedal_Robot.home();
  delay(50);
}
void loop() {
  Serial.println("loop.....");
  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, turn left, and turn right repeatedly.

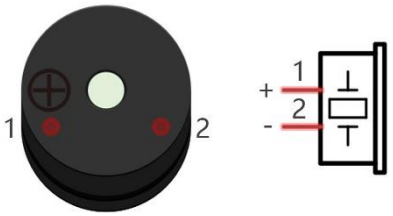
```
25    Serial.println("loop.....");
26    Bipedal_Robot.walk(2,2000,1);
27    Bipedal_Robot.home();
28    delay(1000);
29    Bipedal_Robot.walk(2,2000,-1);
30    Bipedal_Robot.home();
31    delay(1000);
32    Bipedal_Robot.turn(2,2000,1);
33    Bipedal_Robot.home();
34    delay(1000);
35    Bipedal_Robot.turn(2,2000,-1);
36    Bipedal_Robot.home();
37    delay(1000);
```

1.2 Buzzer

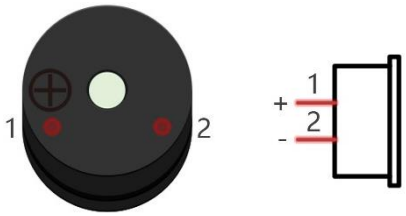
Buzzer

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 2 kHz, which means the passive buzzer is loudest when its resonant frequency is 2 kHz.

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.

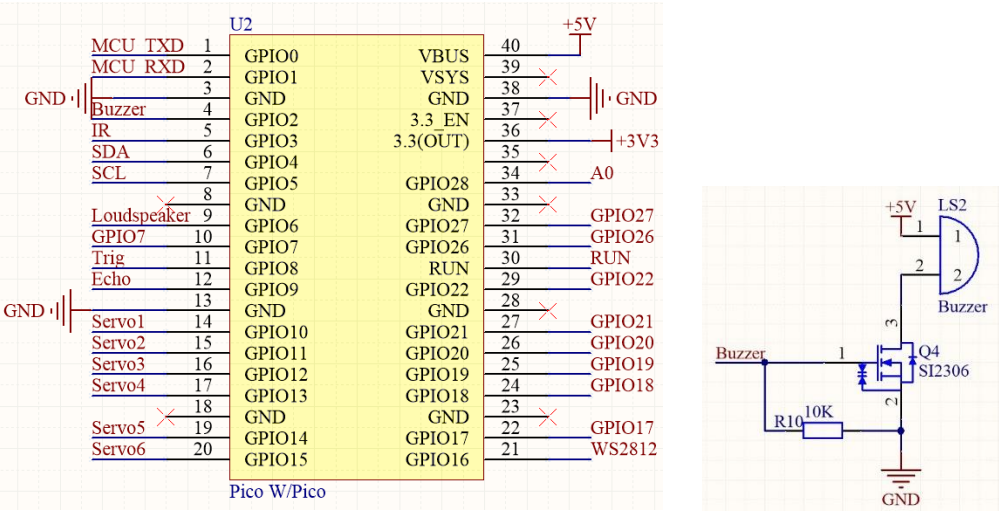
Active buzzer

Passive buzzer

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

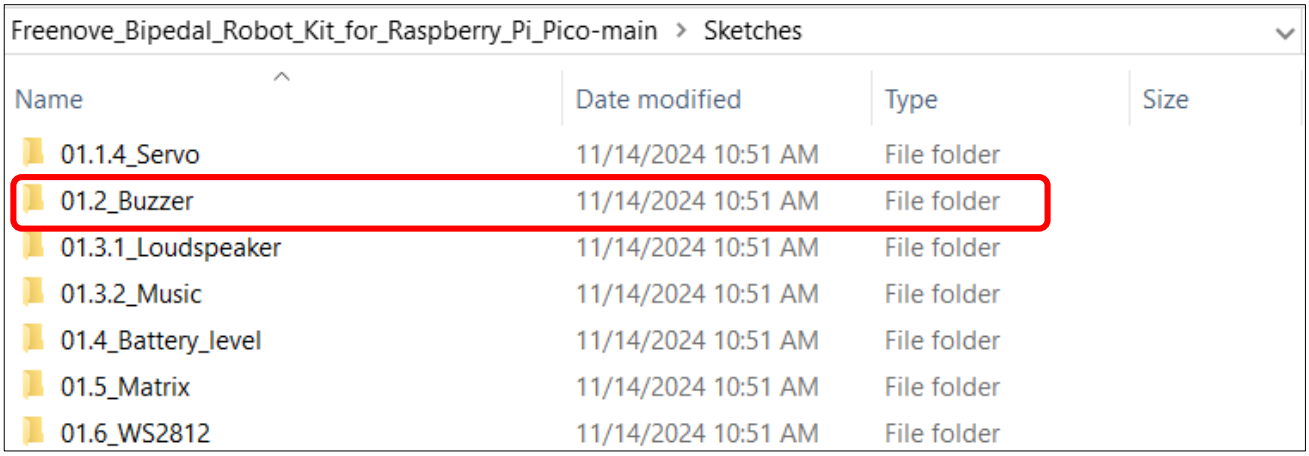
Schematic

As we can see, the buzzer is controlled by GPIO2 of Raspberry Pi Pico W. When the buzzer receives PWM signal, NMOS will be activated to make the buzzer sound. When the buzzer receives no signal, it will be controlled at low level by R10 and NMOS 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".

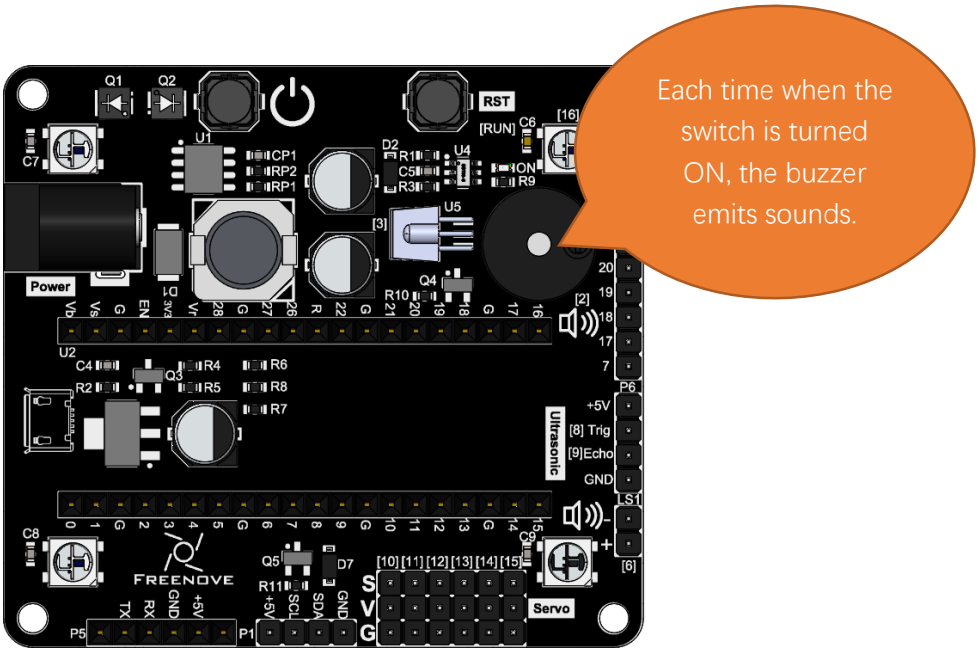


Code

```
#include "Freenove_Robot_For_Pico_W.h"

void setup() {
  Buzzer_Setup();       //Buzzer initialization function
  Buzzer_Alert(4, 3);   //Control the buzzer to sound 3 times, 4 sounds each time
```

```
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
```

1.3 Loudspeaker

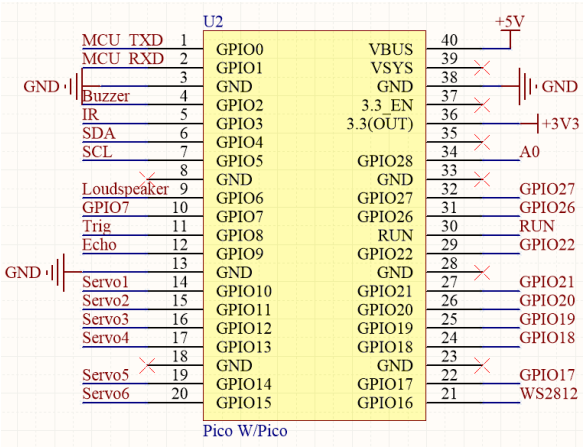
Loudspeaker

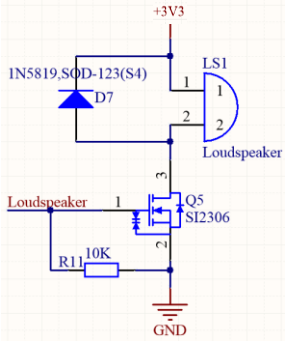
Besides the buzzer, we still have a loud speaker as sound device, which is directly controlled by the Raspberry Pi Pico. However, please note that its sound quality is not so good. If you want better sound quality, you can connect audio converter module to spare GPIO pins for extended use.

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).



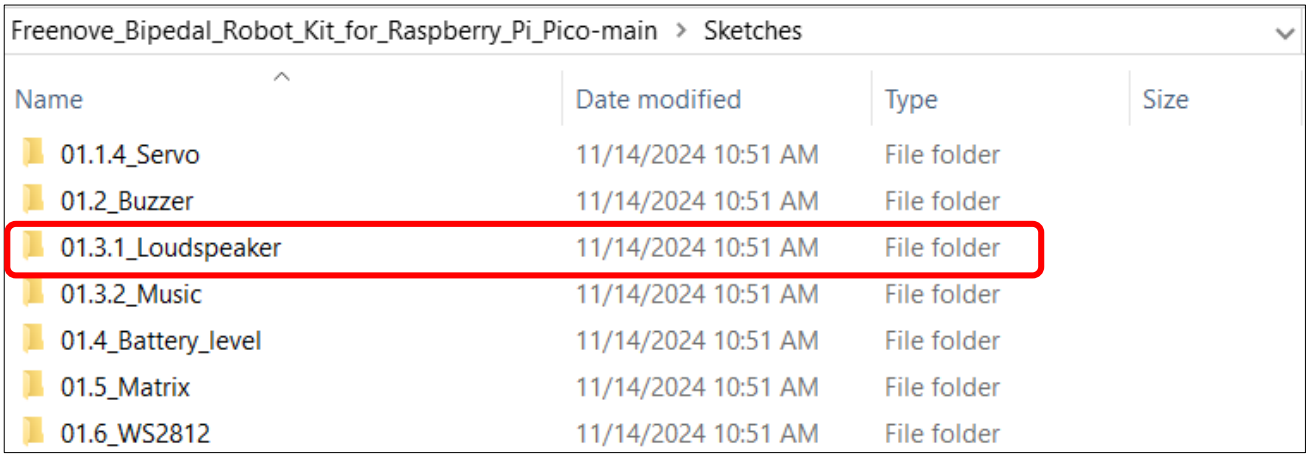


1.3.1_Loudspeaker

Sketch

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".



Code

```
#include "Freenove_Robot_For_Pico_W.h"

void setup() {
  Buzzer_Setup();       //Buzzer initialization function
  Buzzer_Alert(4, 3);  //Control the buzzer to sound 3 times, 4 sounds each time
}

void loop() {
  delay(1000);
}
```

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
```

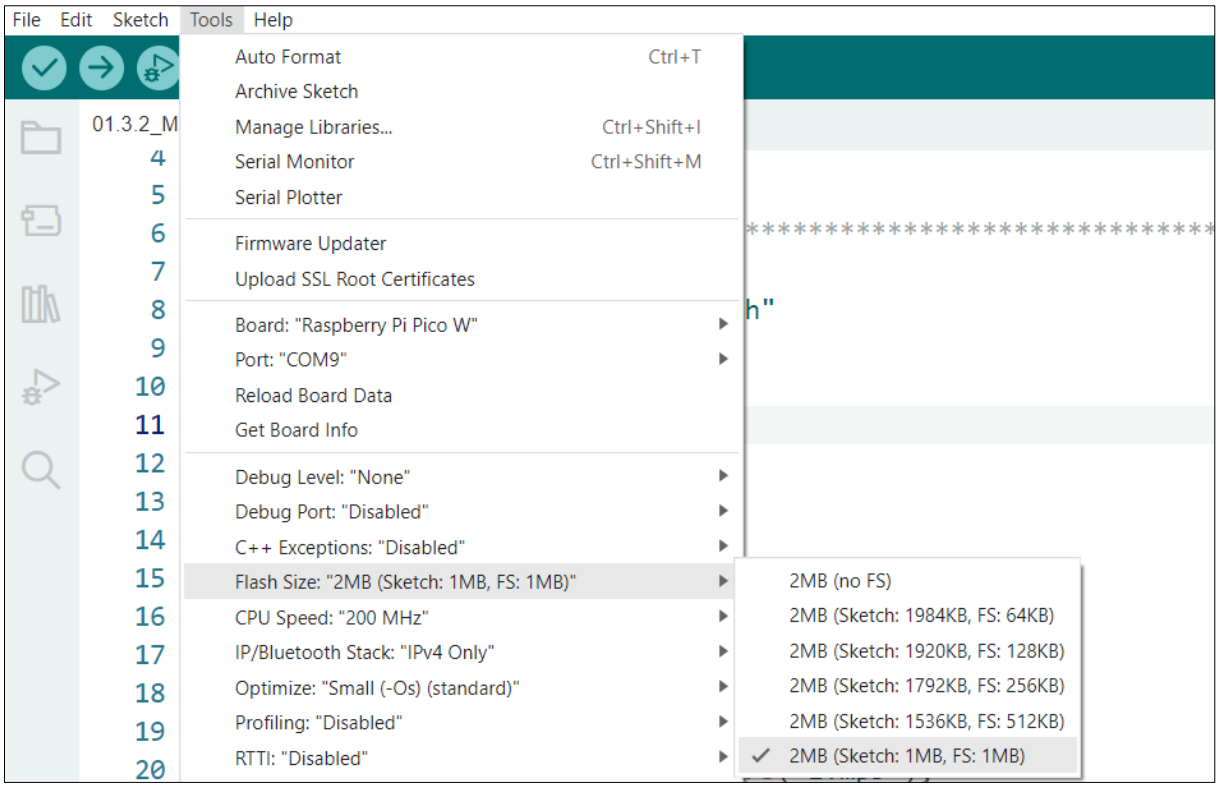
1.3.2_Music

In this section, we will use GPIO6 of the Raspberry Pi Pico to play audio. After the code upload successfully, it will 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) file system, with an API that's compatible with the onboard flash file system.

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

```
|--------------------|-------------|----|
^                    ^             ^
Sketch               File system   EEPROM
```

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

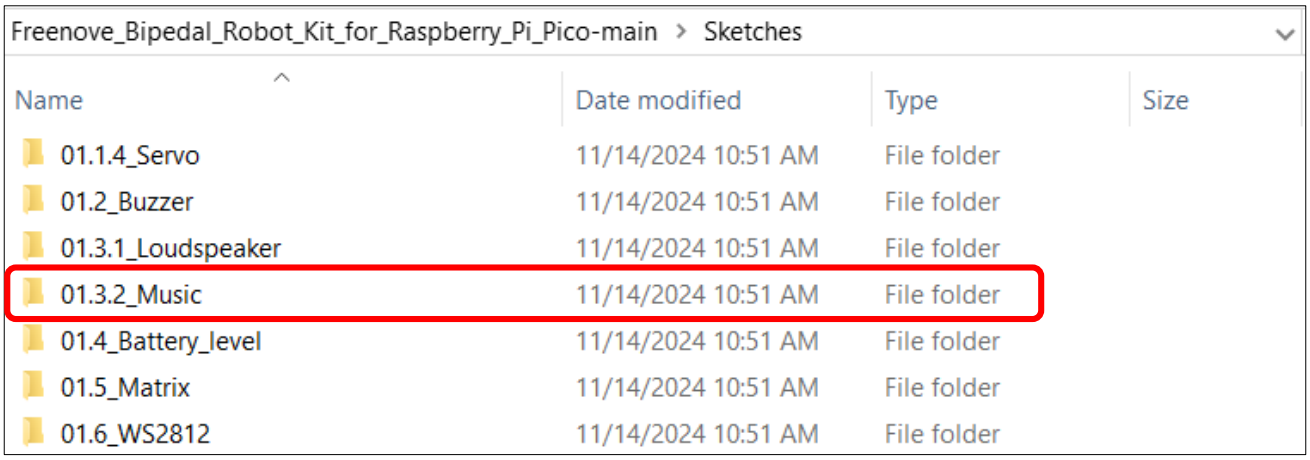


Due to the limitation of the storage, the file uploaded to Pico (W) should not exceed 1024Kb (1M). Therefore, we need to restrict the file scale; otherwise, it may fail to upload.

Upload the file to LittleFS file system.

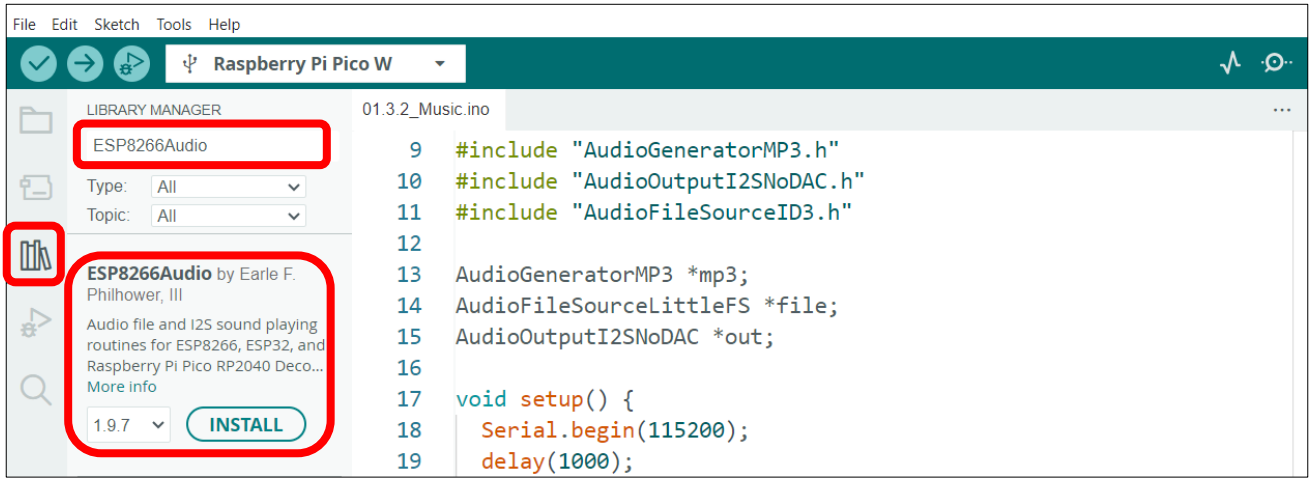
LittleFS is an onboard file system that sets aside some program flash memory for use as a file system, without requiring any external hardware.

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".

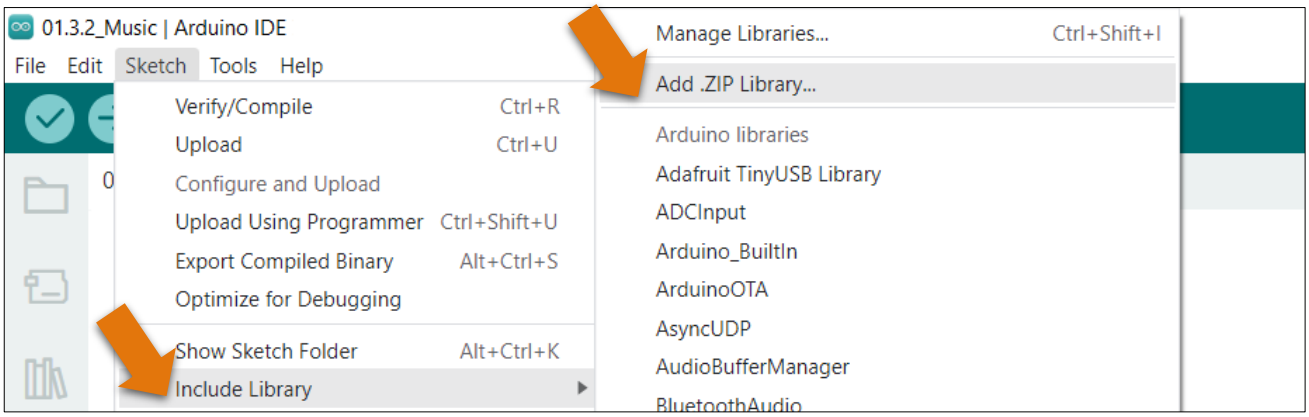


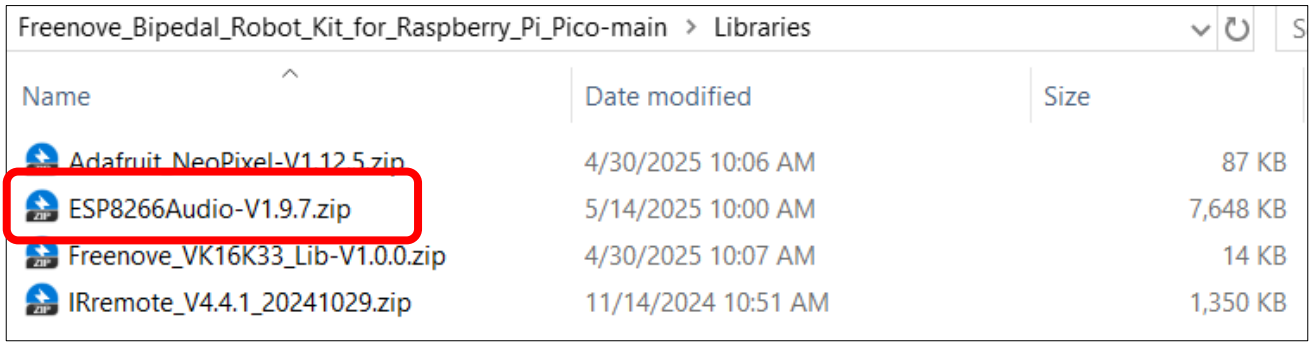
Install ESP8266Audio library

In this project, we use a third-party library named **ESP8266Audio**. Please install it first.
Open Arduino IDE, click **Library Manage** on the left, and search "**ESP8266Audio**" to install.
It is recommended to use version **1.9.7** of the ESP8266Audio library to avoid compatibility issues.



The second way, open Arduino IDE, click Sketch→Include Library→Add .ZIP Library. In the pop-up window, find the file named "./Libraries/**ESP8266Audio-V1.9.7.Zip**" which locates in this directory, and click OPEN.





Install the PicoLittleFS tool

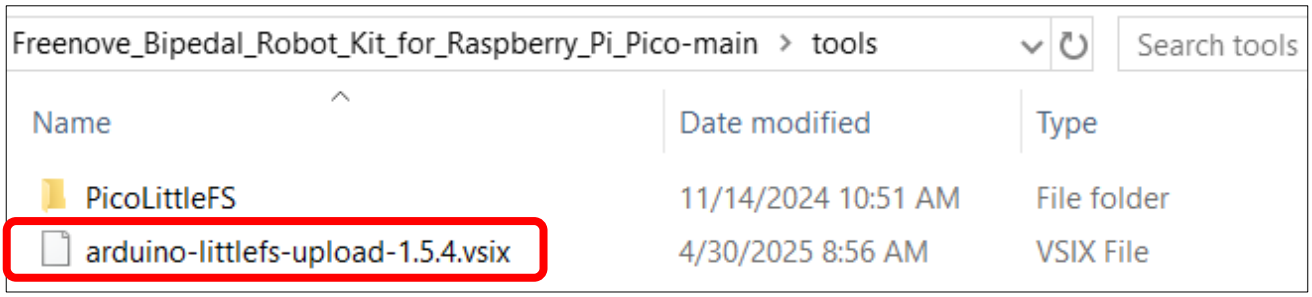
The latest Arduino IDE has supported LittleFS plugins.

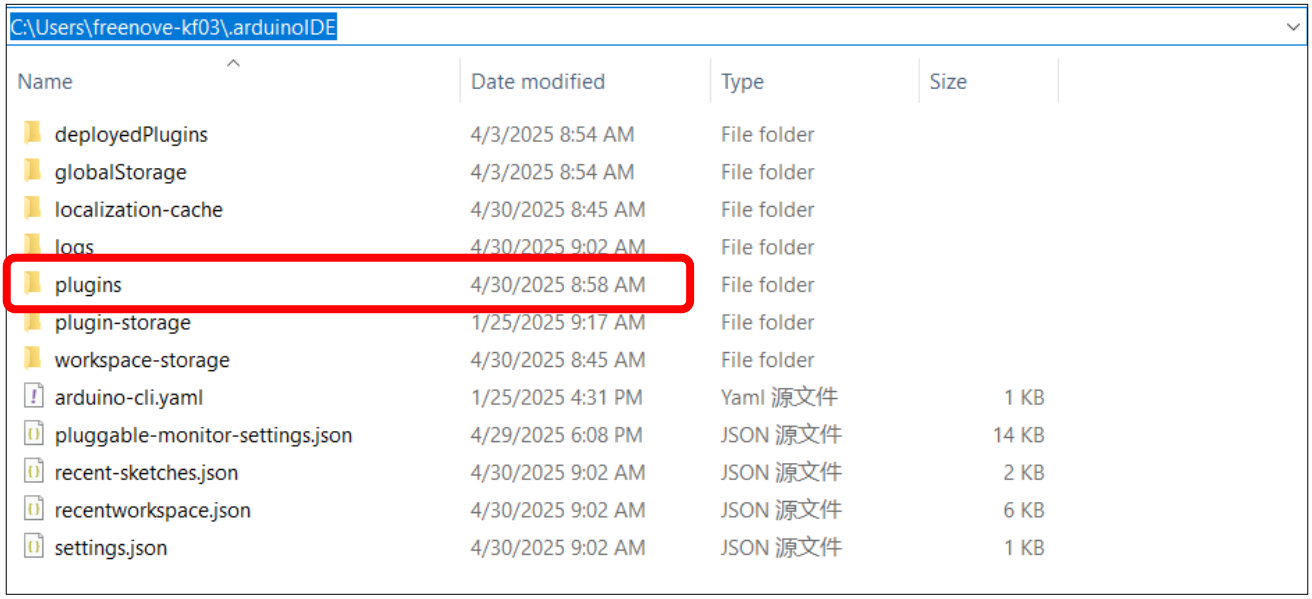
The steps to install PicoLittleFS is as follows:

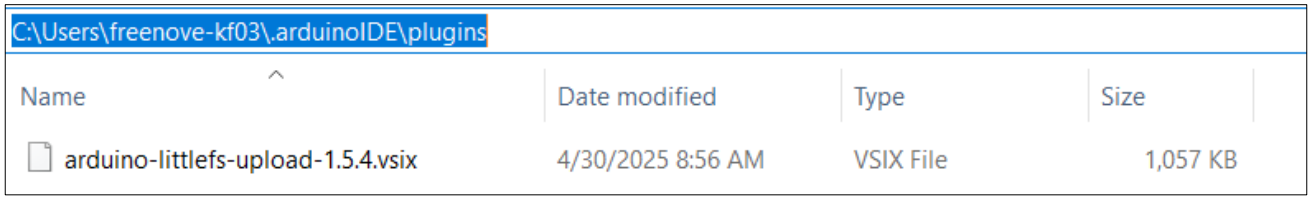
Copy the file **arduino-littlefs-upload-1.5.4.vsix** under the directory **"Freenove_Bipedal_Robot_Kit_for_Raspberry_Pi_Pico\Tools"** to the computer's directory **~/.arduinoIDE/plugins/**

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

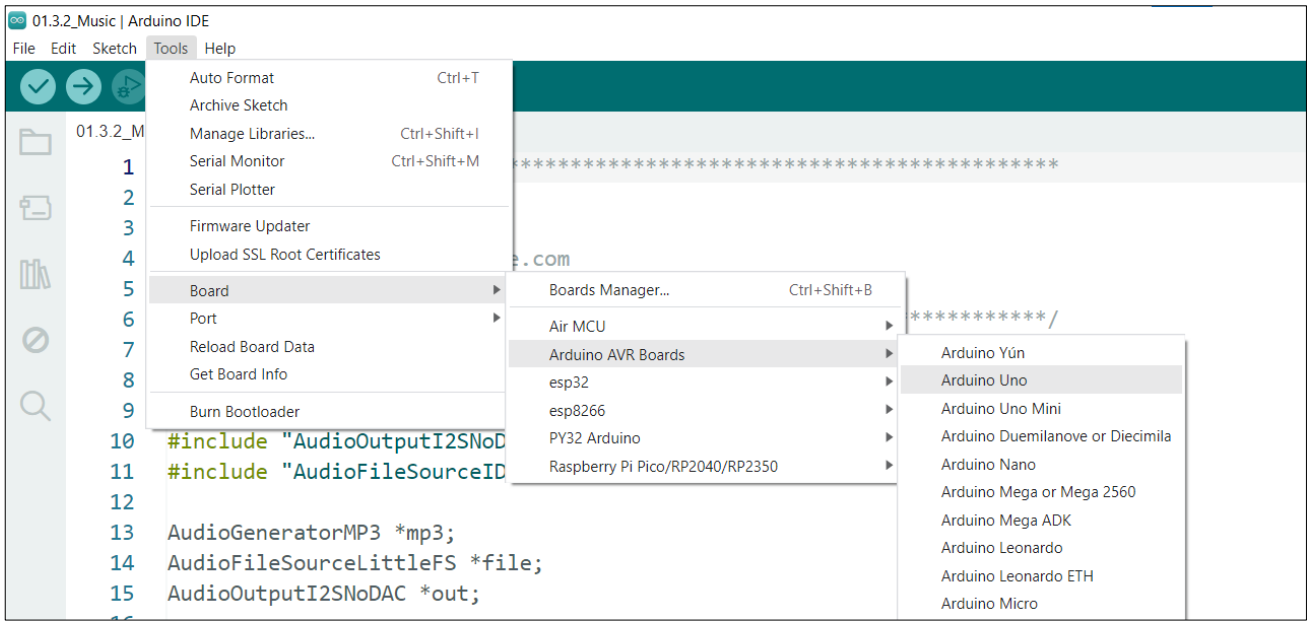
After copying the file, restart Arduino IDE.

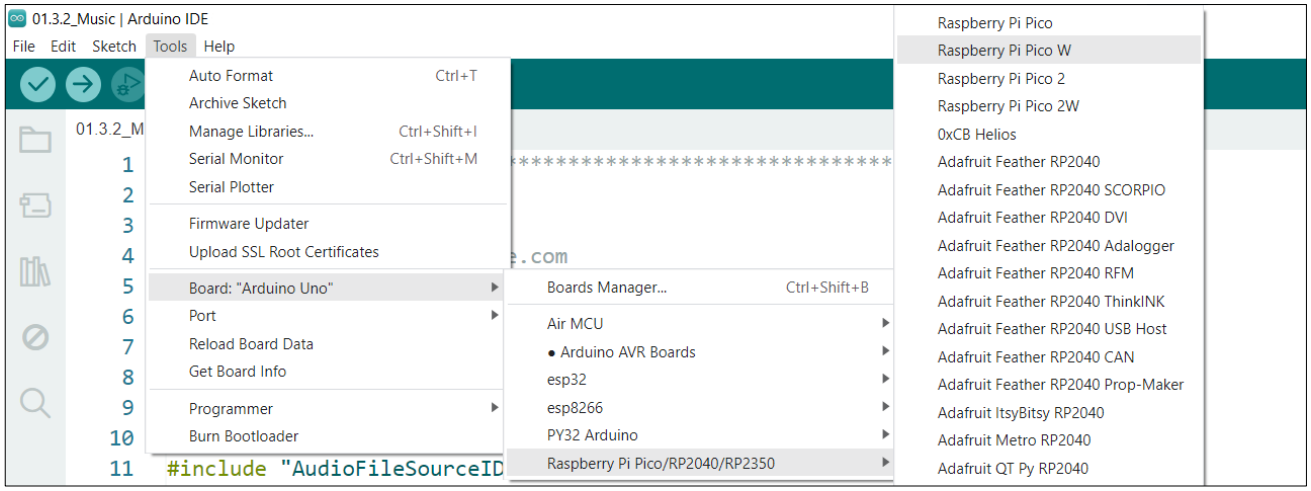




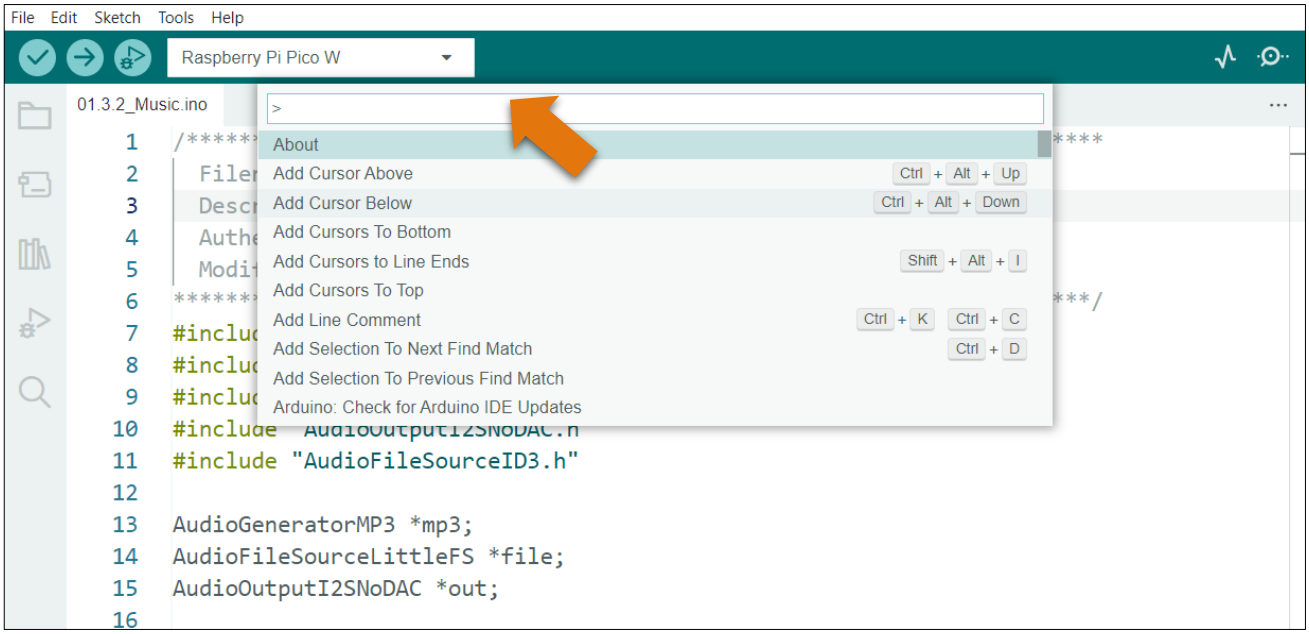


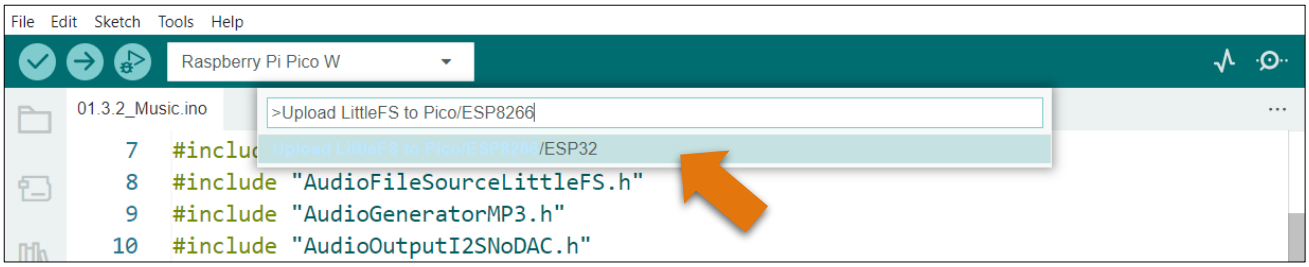
The sketch opened with the start of the Arduino IDE may be corrupted, which can lead to code uploading failure. To address this issue, you can change the board selection (switching to any board), and then select back the pico board. Alternatively, you can close the opened sketch and reopen it.





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

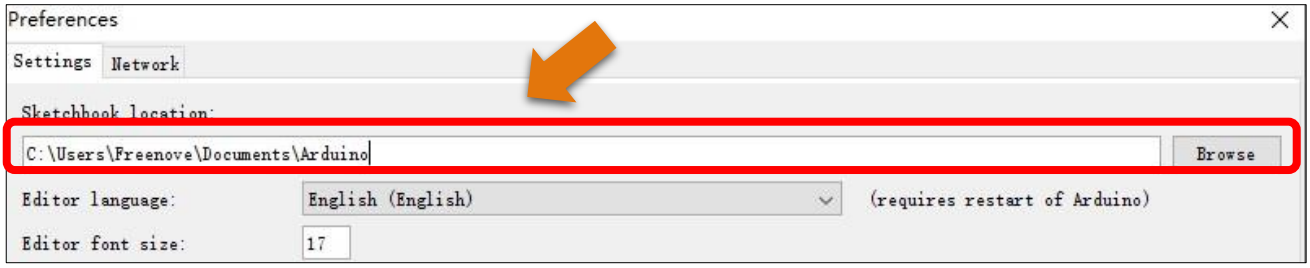

File Edit Sketch Tools Help
Raspberry Pi Pico W
01.3.2_Music.ino
>
About
Add Cursor Above Ctrl + Alt + Up
Add Cursor Below Ctrl + Alt + Down
Add Cursors To Bottom
Add Cursors to Line Ends Shift + Alt + I
Add Cursors To Top
Add Line Comment Ctrl + K Ctrl + C
Add Selection To Next Find Match Ctrl + D
Add Selection To Previous Find Match
Arduino: Check for Arduino IDE Updates
#include "AudioFileSourceID3.h"
AudioGeneratorMP3 *mp3;
AudioFileSourceLittleFS *file;
AudioOutputI2SNoDAC *out;


File Edit Sketch Tools Help
Raspberry Pi Pico W
01.3.2_Music.ino
>Upload LittleFS to Pico/ESP8266
/ESP32
#include "AudioFileSourceLittleFS.h"
#include "AudioGeneratorMP3.h"
#include "AudioOutputI2SNoDAC.h"

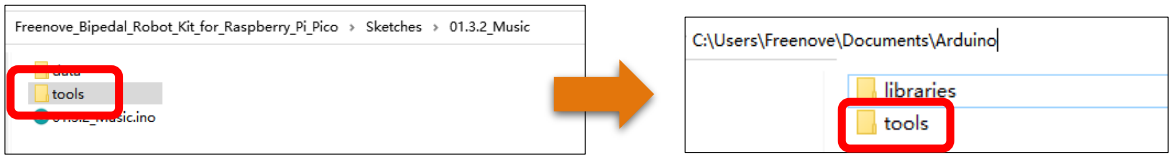
If your Arduino IDE is an old version one, like Arduino 1.x.x, please refer to the following steps to install the PicoLittleIFS tool.

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

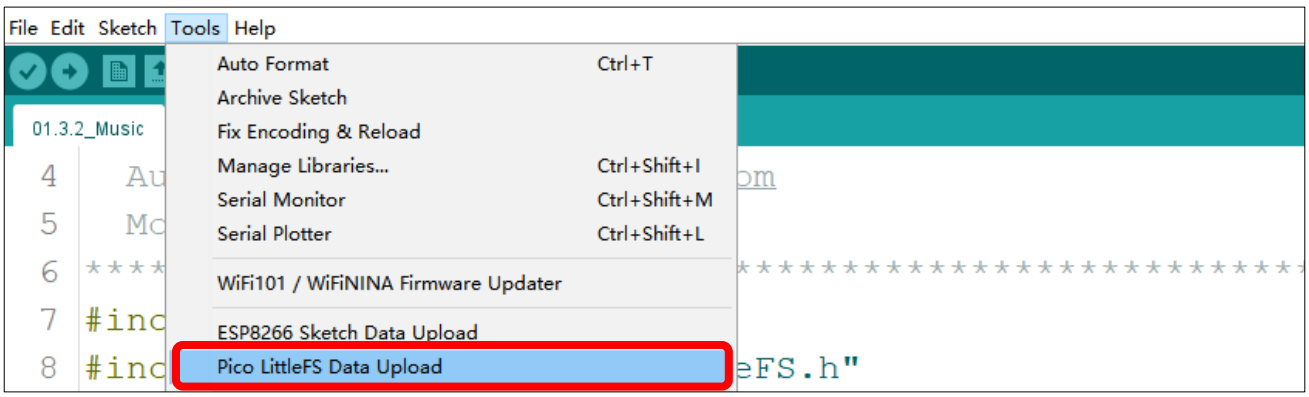
Find the Arduino IDE environment directory location.



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



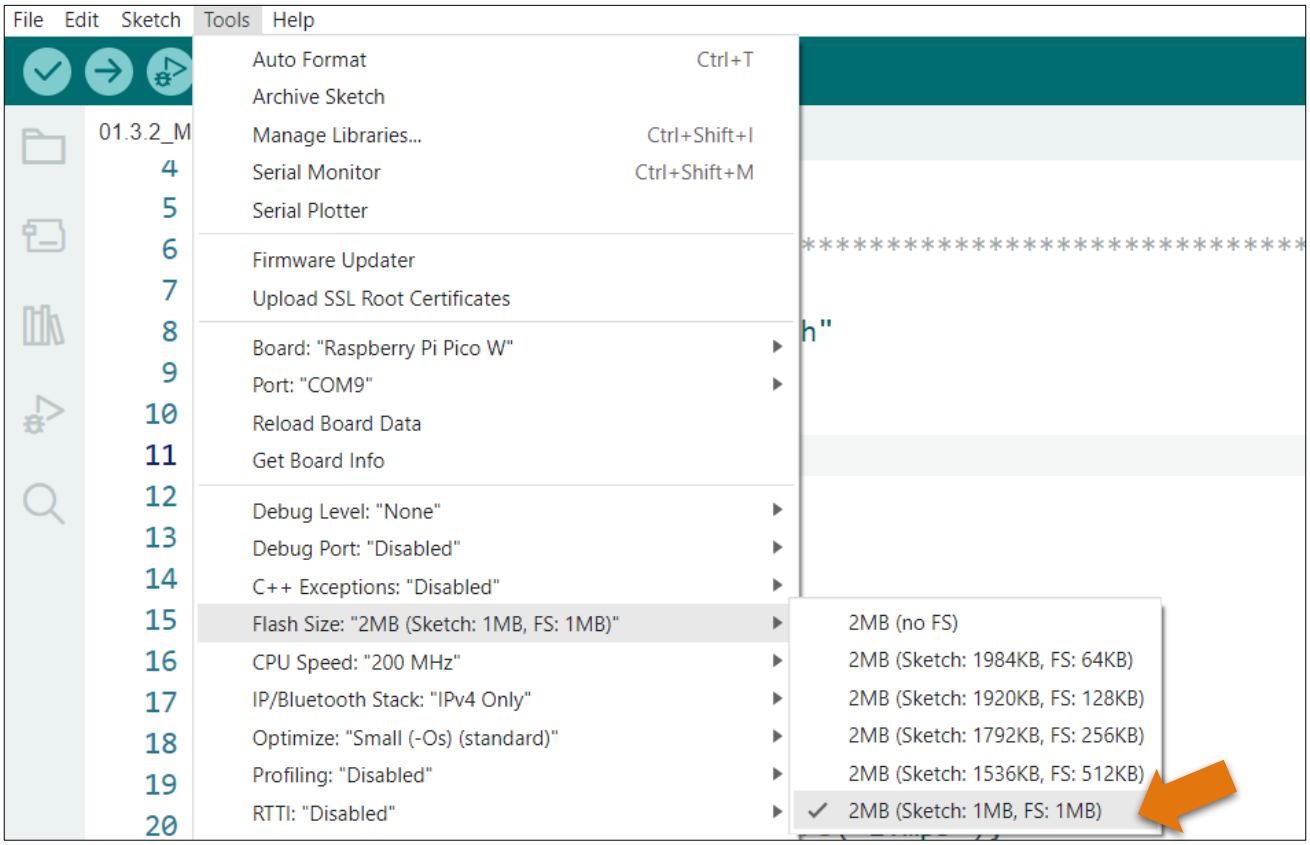
Finally, restart the Arduino IED. After restarting, you can see that the plug-in already exists in the interface.



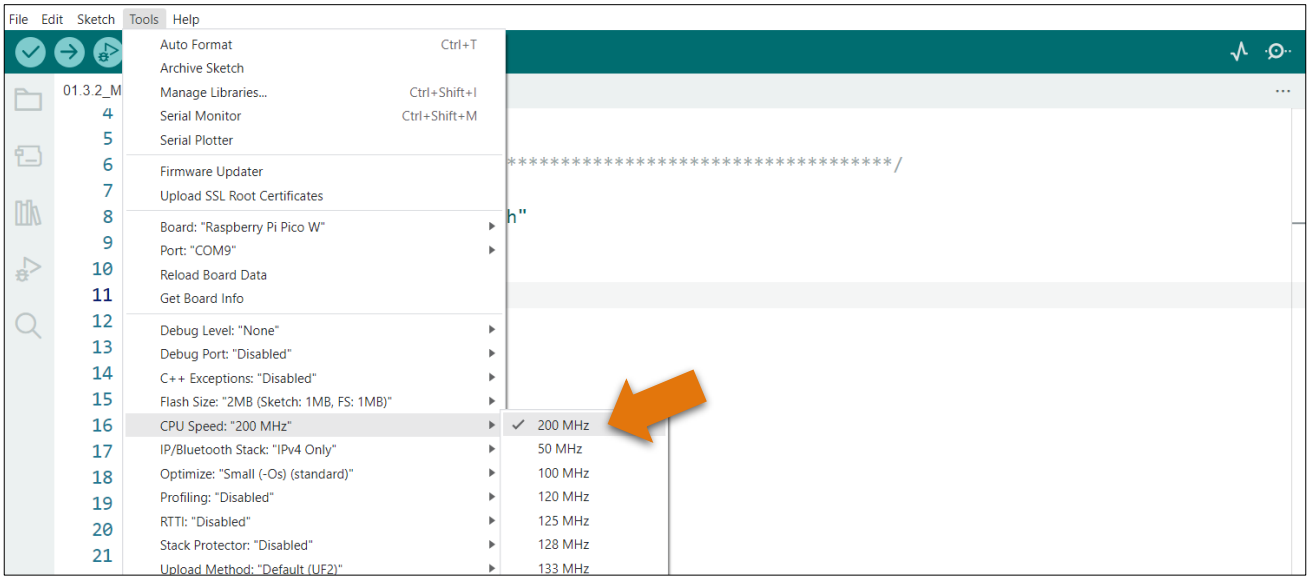
Upload music

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

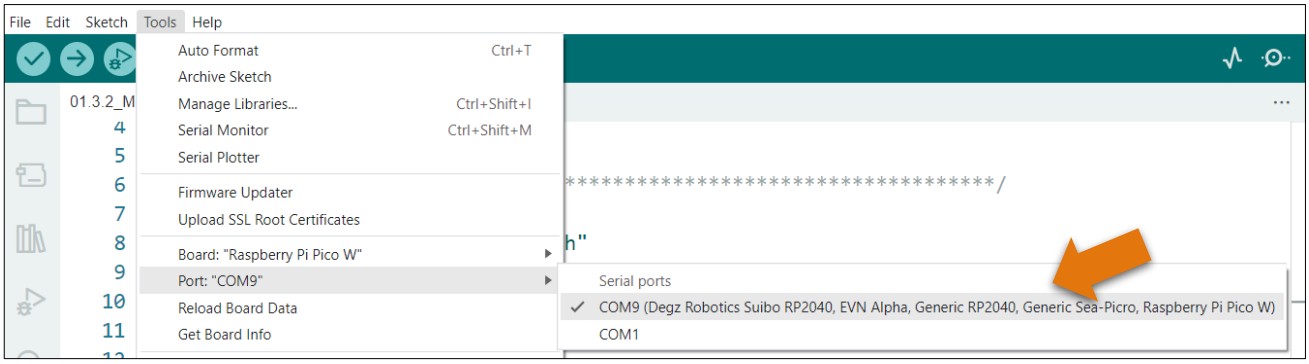
Open Arduino, select Tools from the menu bar, select Flash Size, and allocate 1MB of Flash space to store codes and 1MB to store audio files.



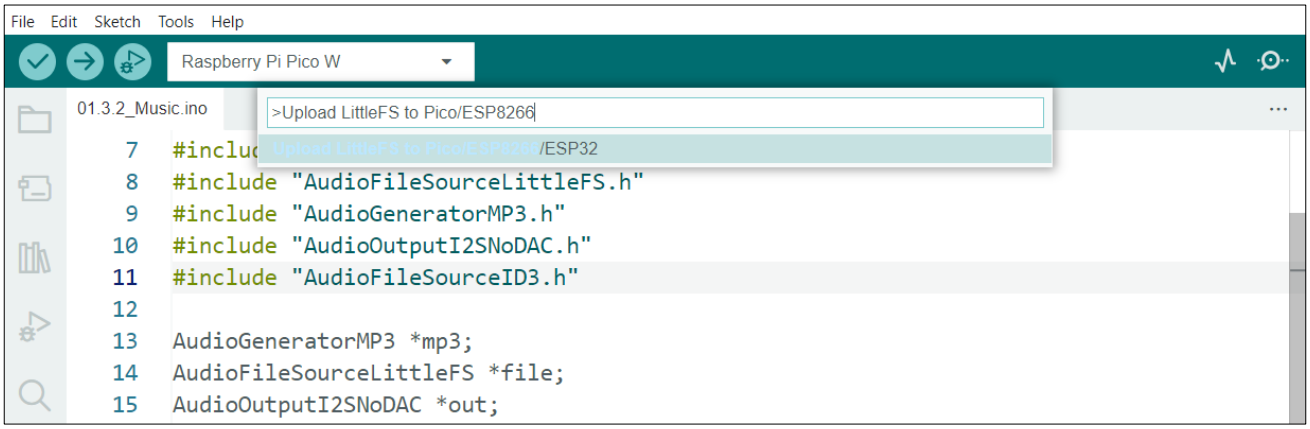
Ensure that the CPU speed is greater than 133MHz. If the frequency is too low, the audio decoding speed may be so slow that the audio playback may not be continuous.

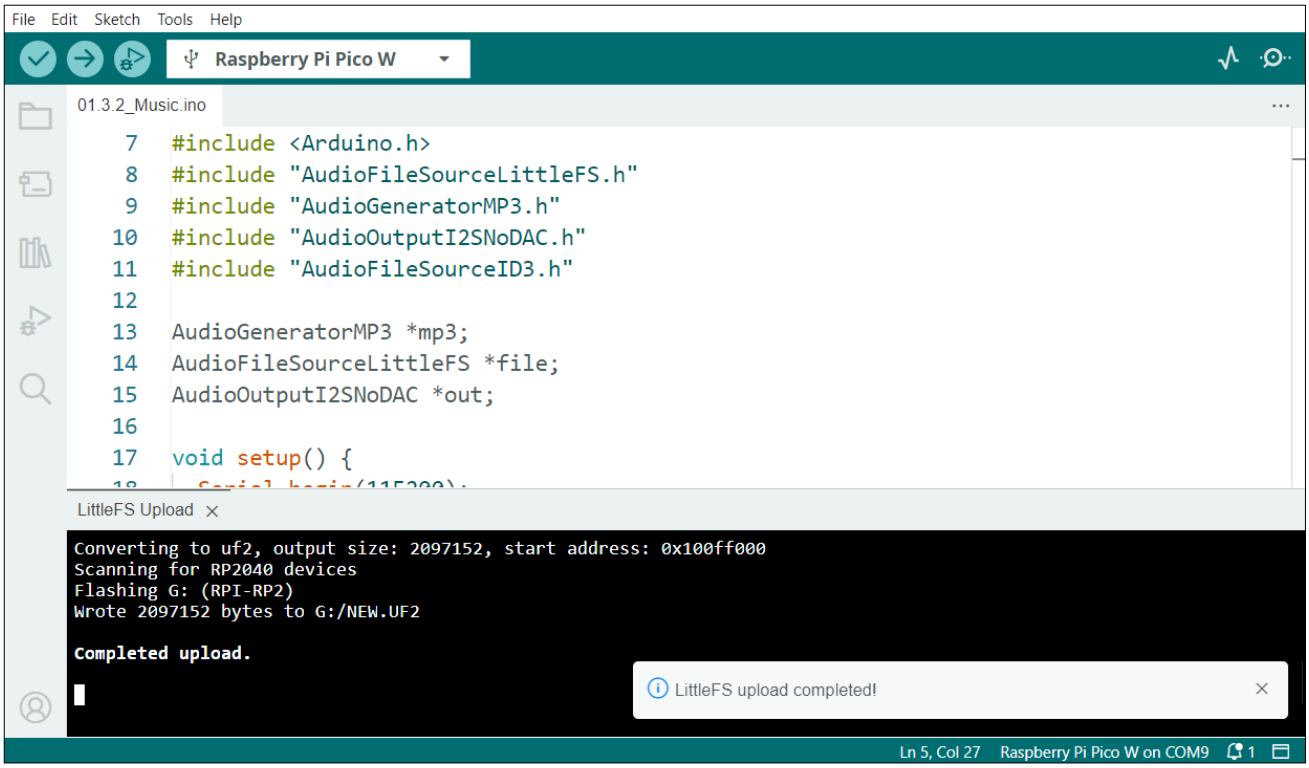


Select the correct port.

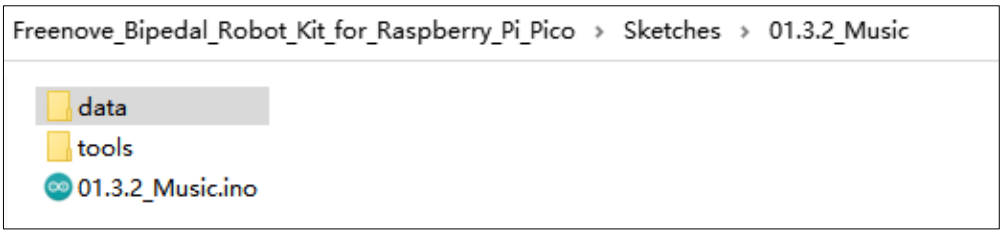


Press [Ctrl]+[Shift]+[P] simultaneously. Enter ***Upload LittleFS to Pico/ESP8266*** on the input field, click Upload LittleFS to Pico/ESP8266, and wait for it to finish.



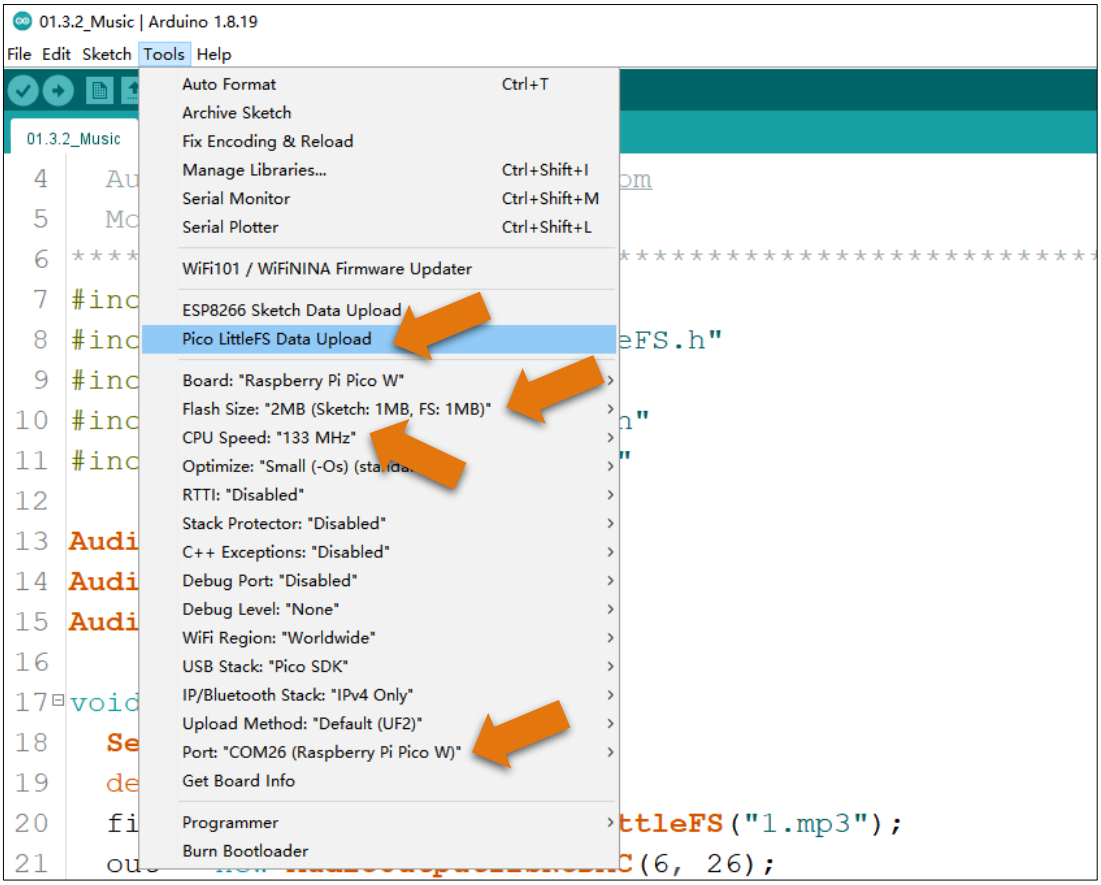


Check the code file and audio file. We create a folder named data under the same level directory of the code file, and place the audio file directly in this folder.



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.

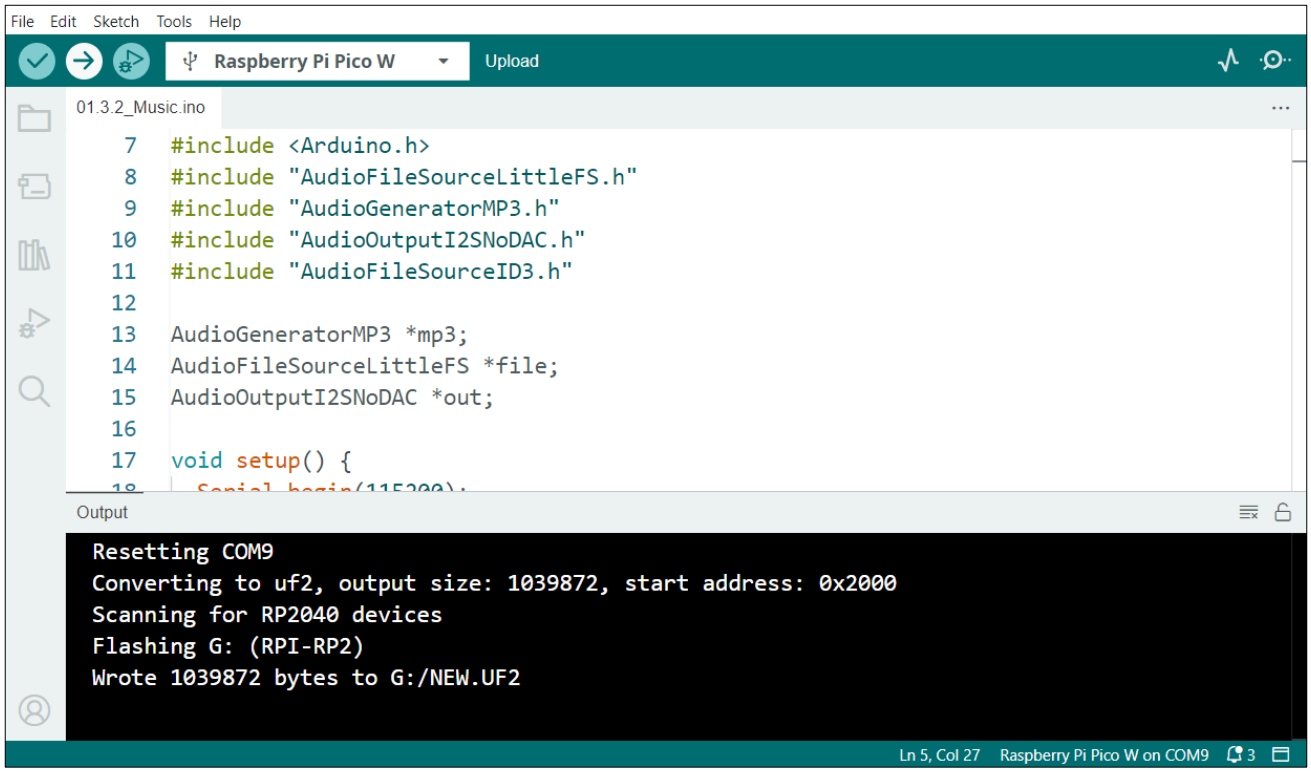
If your Arduino IDE is an old version one, like Arduino 1.x.x, please upload the music as below:
Click Arduino IDE Tools and click following content:



```
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] swerial  : 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

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
```

Sketch

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

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

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

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

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

Check whether the audio is being played.

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

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

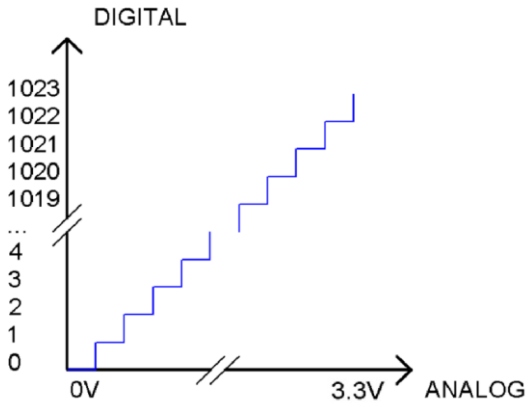
```
25      if (!mp3->loop()) {
26        mp3->stop();
```

```
27          Serial.printf("Hello done\n");
28          delete file;
29          delete mp3;
30          mp3 = new AudioGeneratorMP3();
31
32      }
```

1.4 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, which means the resolution is 2^10=1024, and it represents a range (at 3.3V) will be divided equally to 1024 parts. The rage of analog values corresponds to ADC values. So the more bits the ADC has, the denser the partition of analog will be and the greater the precision of the resulting conversion.



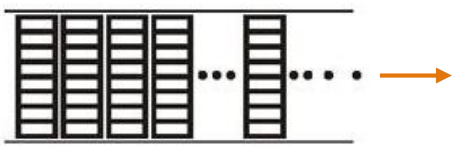
Subsection 1: the analog in rang of 0V---3.3/1023 V corresponds to digital 0;
Subsection 2: the analog in rang of 3.3/1023 V---2*3.3 /1023V corresponds to digital 1;
The following analog will be divided accordingly.
The conversion formula is as follows:

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

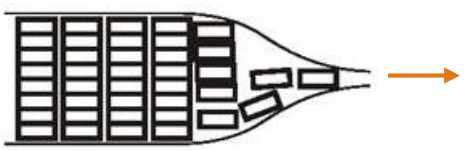
Serial Communication

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.

Parallel communication

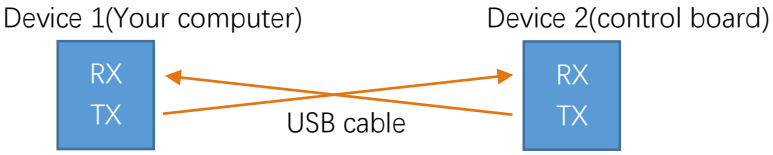


Serial communication



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

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

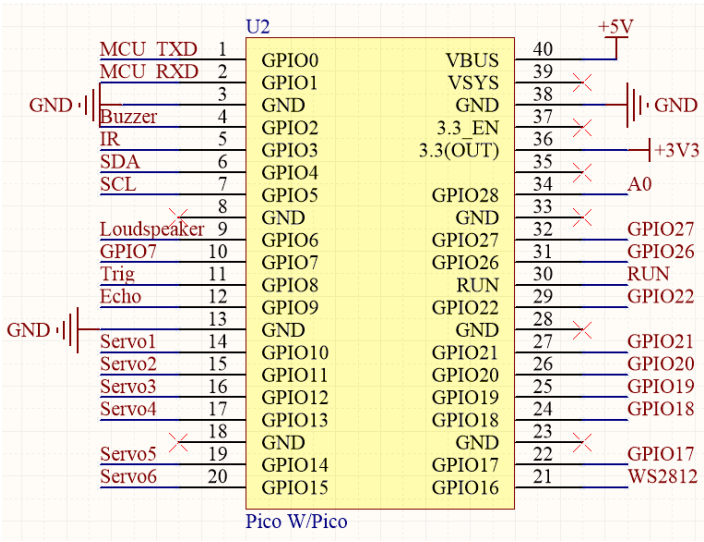


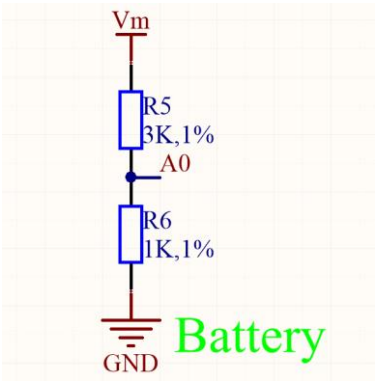
For serial communication, the **baud rate in both sides must be the same**. The baud rates commonly used are 9600 and 115200.

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).



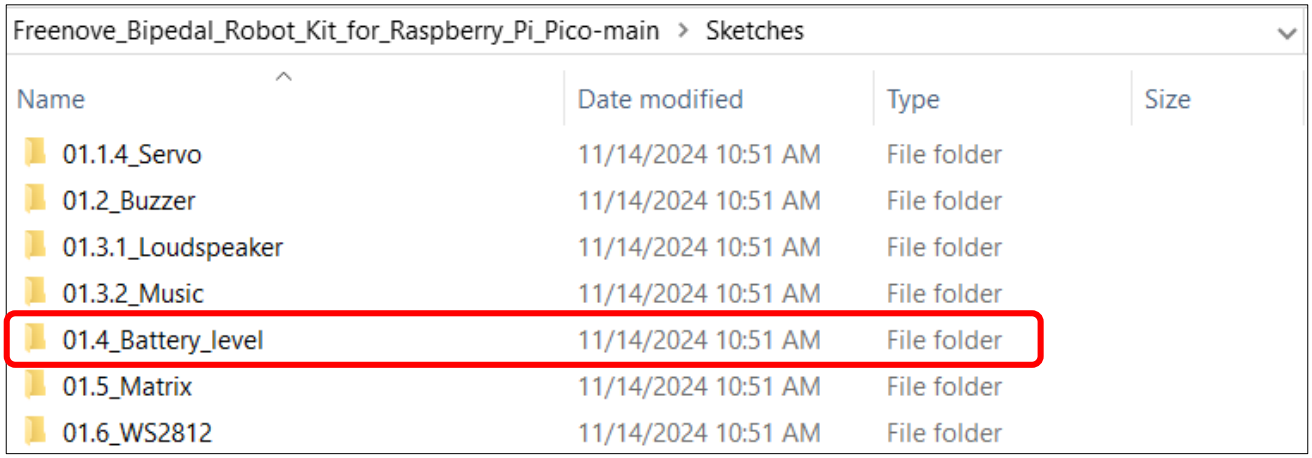


The voltage acquisition range of GPIO28 on the Raspberry Pi Pico W is 0-3.3V. However, the robot is powered with a 9V battery, and the voltage can reach 9.5V when fully charged, far exceeding the acquisition range of the Pico (W). Therefore, a voltage divider circuit consisted of R3 and R4 is designed 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".



Code

```
1  #include "Freenove_Robot_For_Pico_W.h"
2
3  void setup() {
4    Serial.begin(115200);                    //Set the Serial Baud rate
5  }
6
7  void loop() {
8    Serial.print("Battery ADC : ");
9    Serial.println(Get_Battery_Voltage_ADC());//Gets the battery ADC value
10   Serial.print("Battery Voltage : ");
11   Serial.print(Get_Battery_Voltage());      //Get the battery voltage value
12   Serial.println("V");
13   delay(300);
14 }
```

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
```

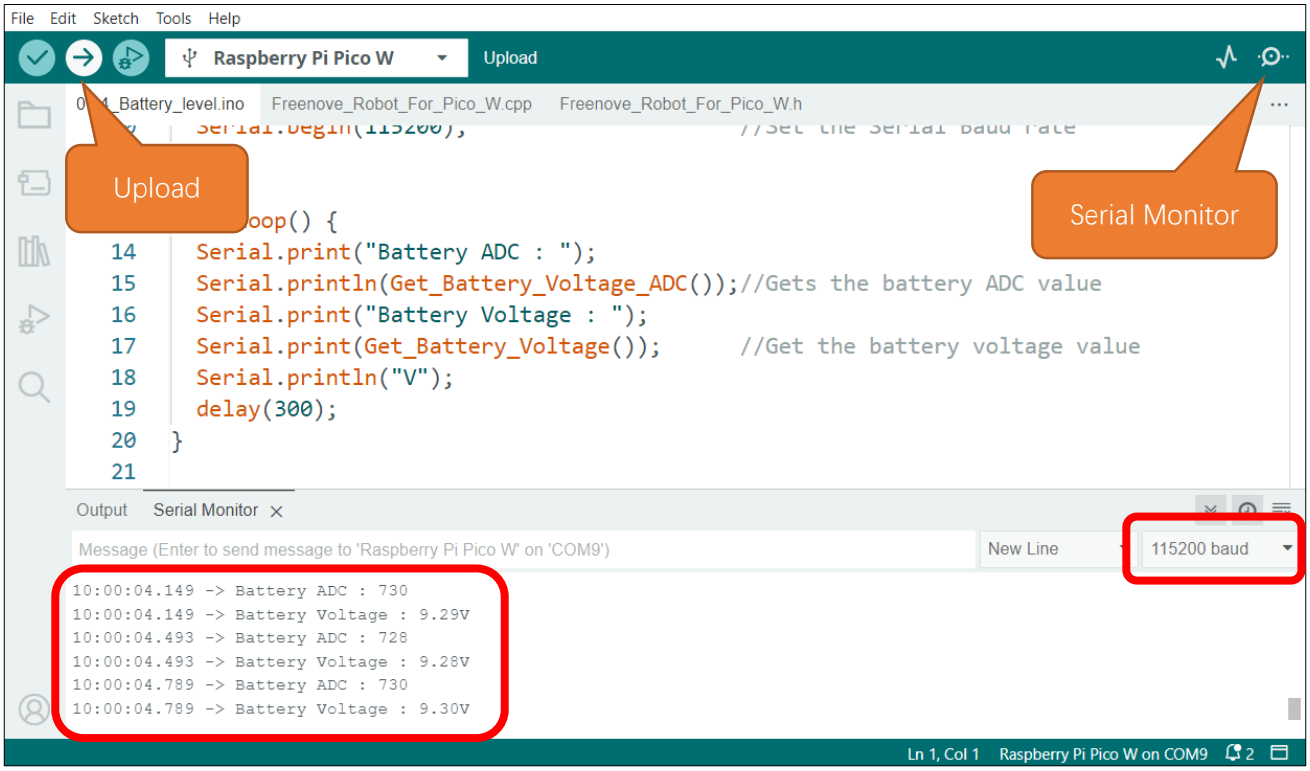
Calculate the voltage of batteries and return it.

```
     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
```

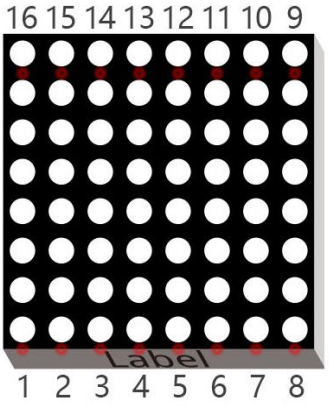
Click “Upload” to upload the code to Pico (W). After uploading successfully, click Serial Monitor, and set baud rate to 115200.



1.5 LED Matrix

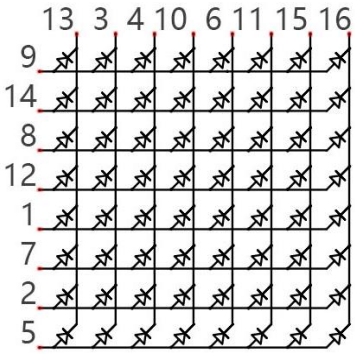
LED Matrix

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).

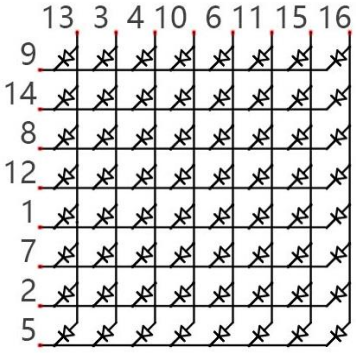


In order to facilitate the operation and reduce the number of ports required to drive this component, the positive poles of the LEDs in each row and negative poles of the LEDs in each column are respectively connected together inside the LED matrix module, which is called a common anode. There is another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

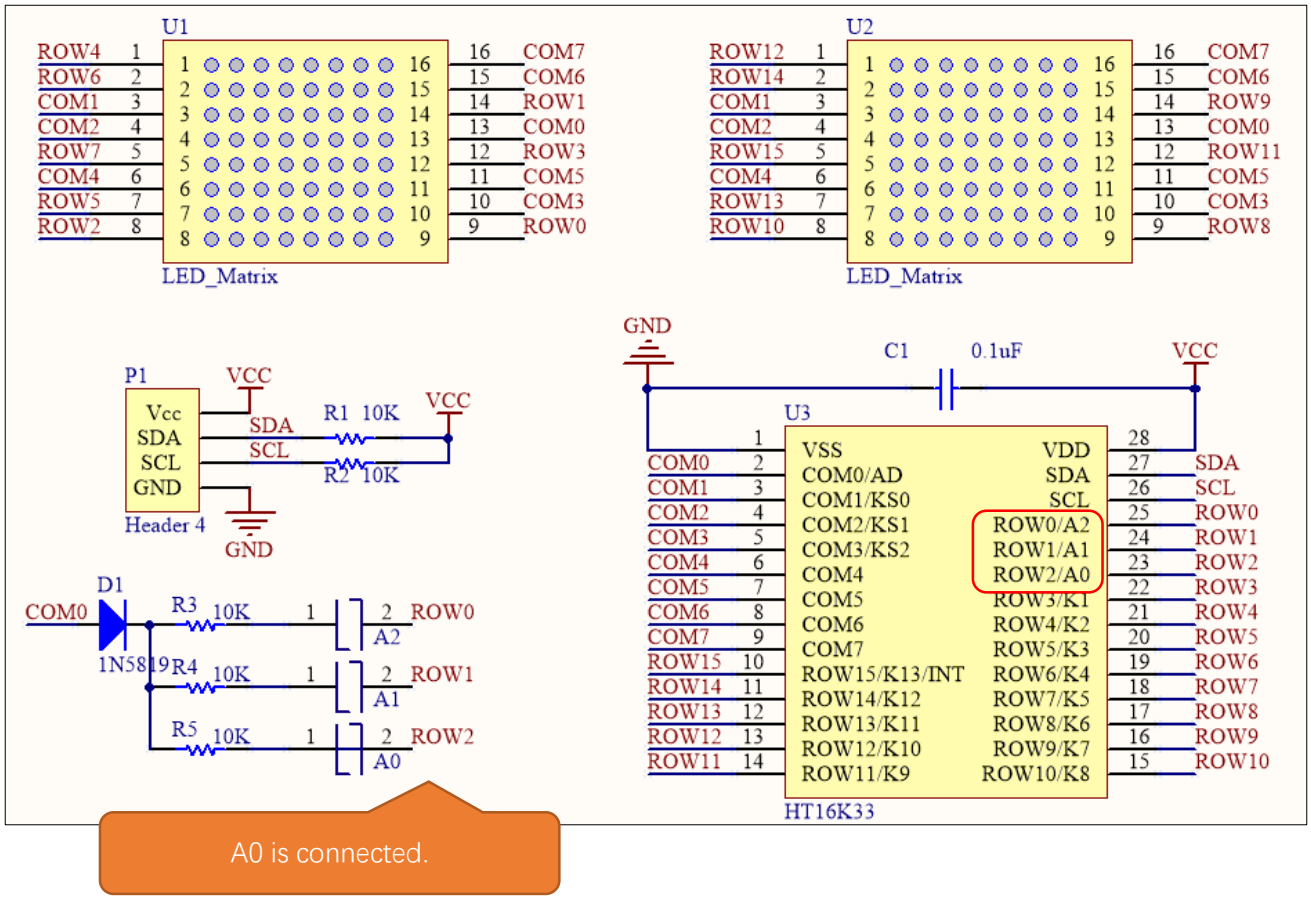


Connection mode of common cathode

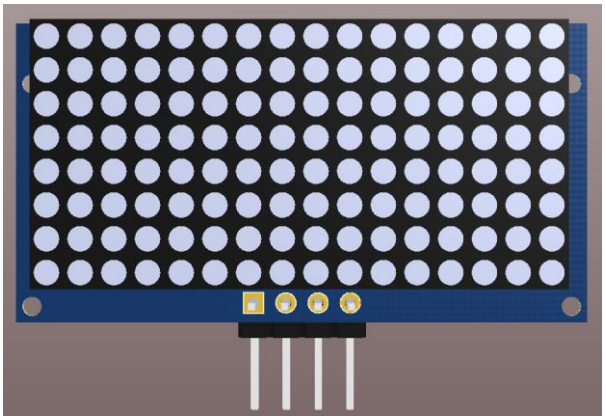
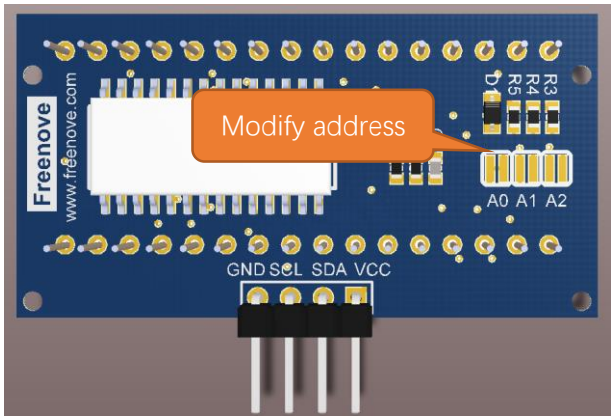


Schematic

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.

Front of LED Matrix	Back of LED Matrix
	

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.

1															
2				1	1							1	1		
3				1	1						1			1	
4		1	1	1	1	1	1			1					1	
5		1	1	1	1	1	1			1					1	
6				1	1						1			1		
7				1	1							1	1			
8																

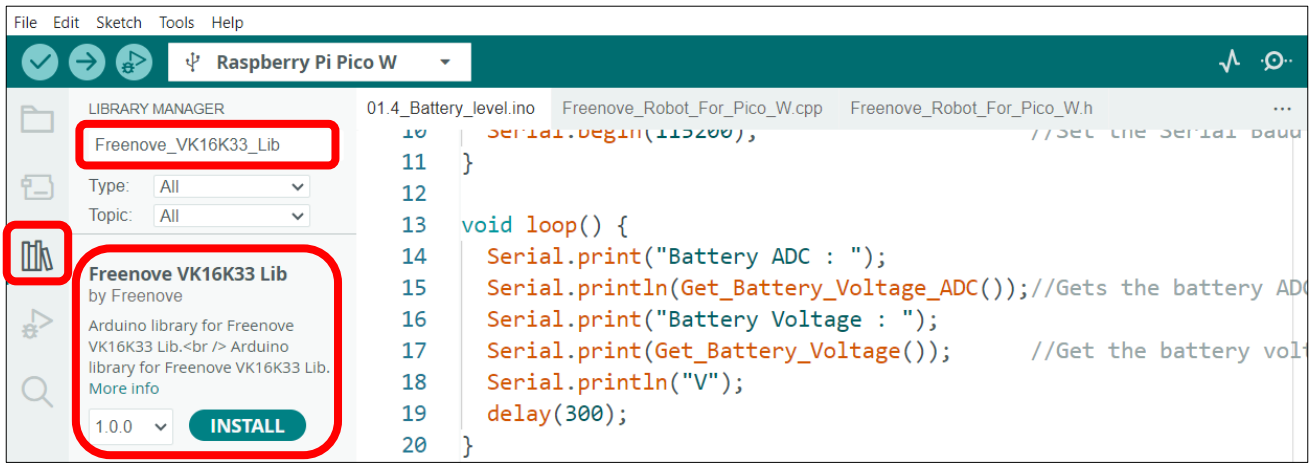
Below, the table on the left corresponds to the "+" above, and the table on the right corresponds to the "o" above.

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

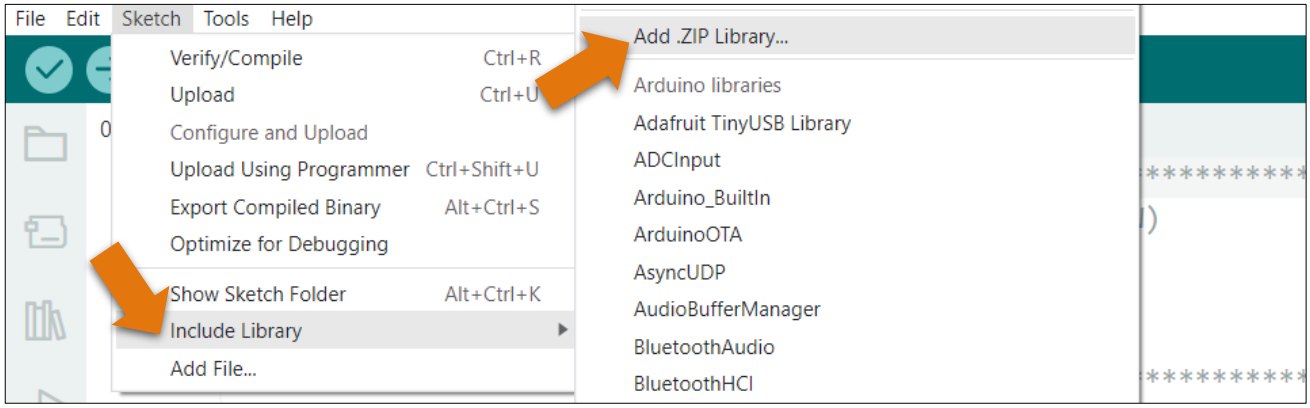
Install Freenove_VK16K33_Lib Library

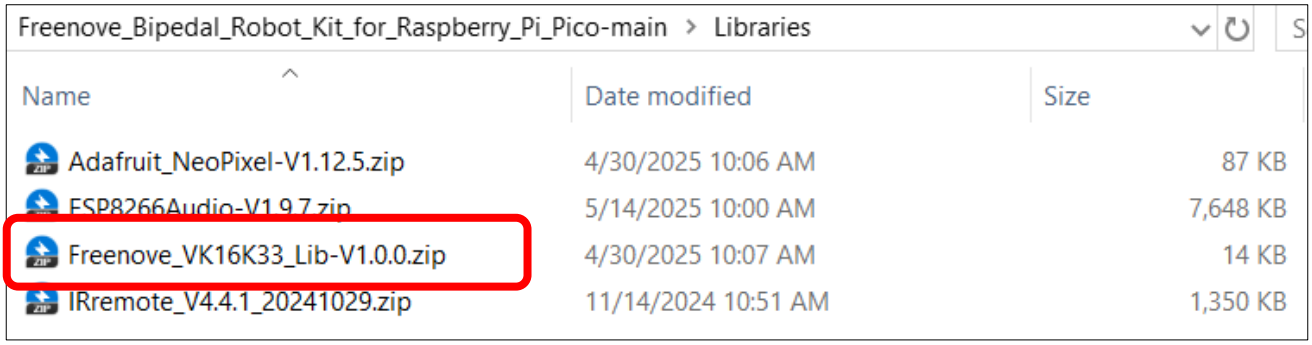
In this project, we use a third-party library named **Freenove_VK16K33_Lib**. Please install it first.
Open Arduino IDE, click **Library Manage** on the left, and search "**Freenove_VK16K33_Lib**" to install.
It is recommended to use version **1.0.0** of the Freenove_VK16K33_Lib library to avoid compatibility issues.



The second way, open Arduino IDE, click Sketch→Include Library→Add .ZIP Library. In the pop-up window, find the file named "./Libraries/ **Freenove_VK16K33_Lib-V1.0.0.Zip**" which locates in this directory, and click

OPEN.





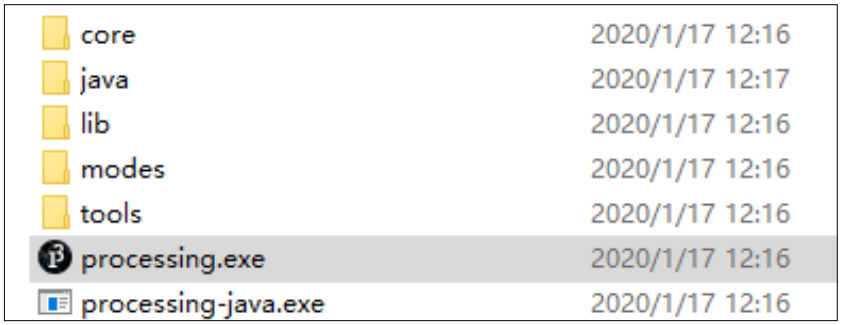
Install Processing

In this tutorial, we use Processing to build a simple LED Matrix platform. If you prefer to use the default expression, you can skip to the next step.

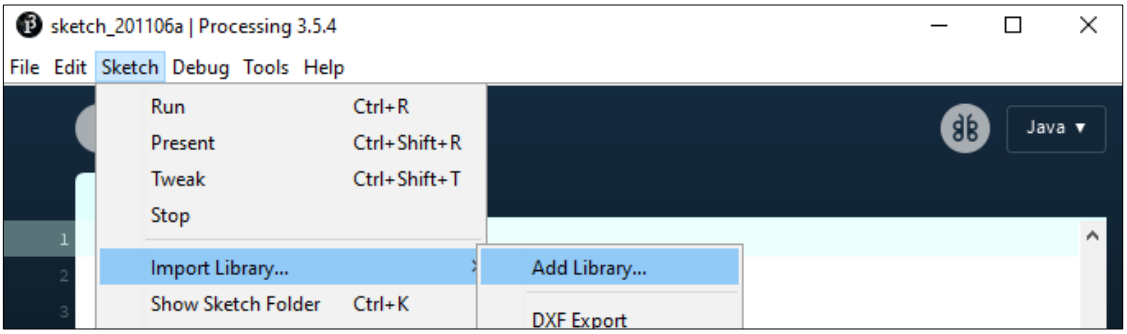
If you have not installed Processing, you can download it from the official website: https://processing.org/.

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

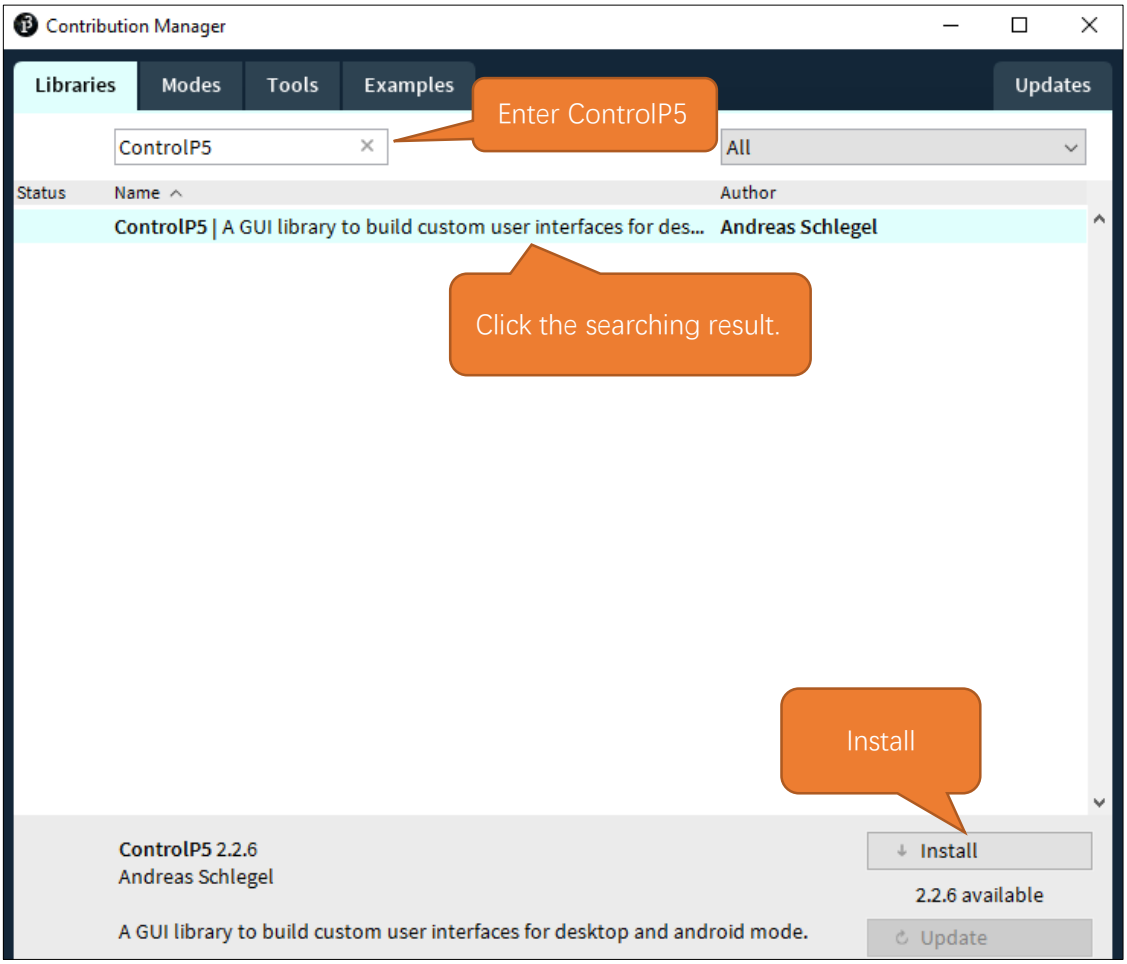
Unzip the downloaded file to your computer. Click "processing.exe" as the figure below to run this software.



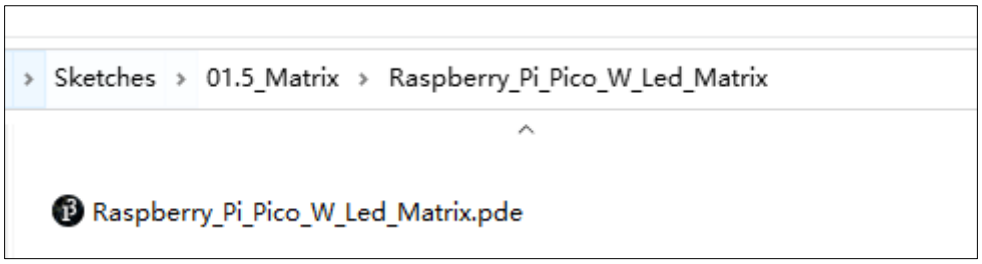
In the interface of Processing, click Sketch on Menu bar, select “Import Library...”and then click “Add Library...”.



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

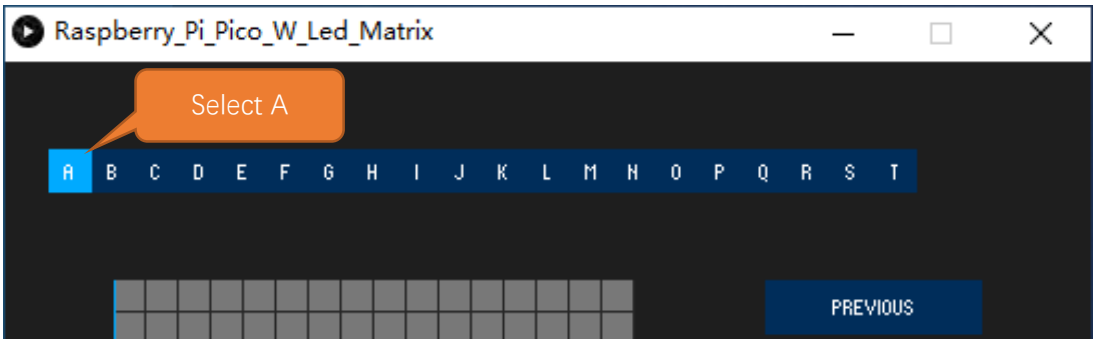


When the installation finishes, restart Processing.
Open the folder Raspberry_Pi_Pico_W_Led_Matrix in 01.5_Matrix of the **"Freenove_Bipedal_Robot_Kit_for_Raspberry_Pi_Pico\Sketches"**. Here we take Windows as an example.
Click to open Raspberry_Pi_Pico_W_Led_Matrix.pde.

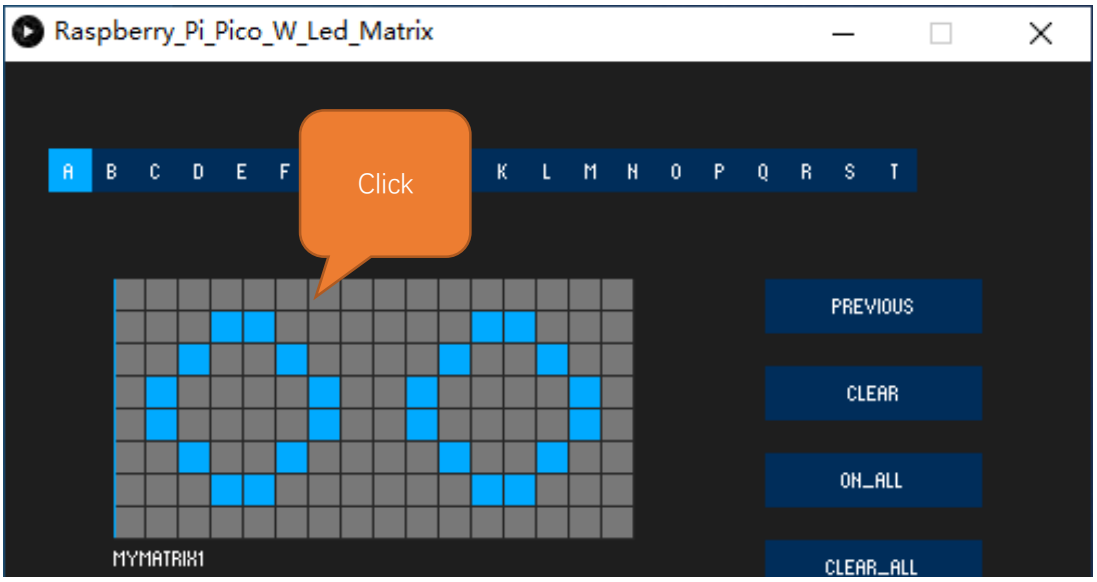


Click "Run"

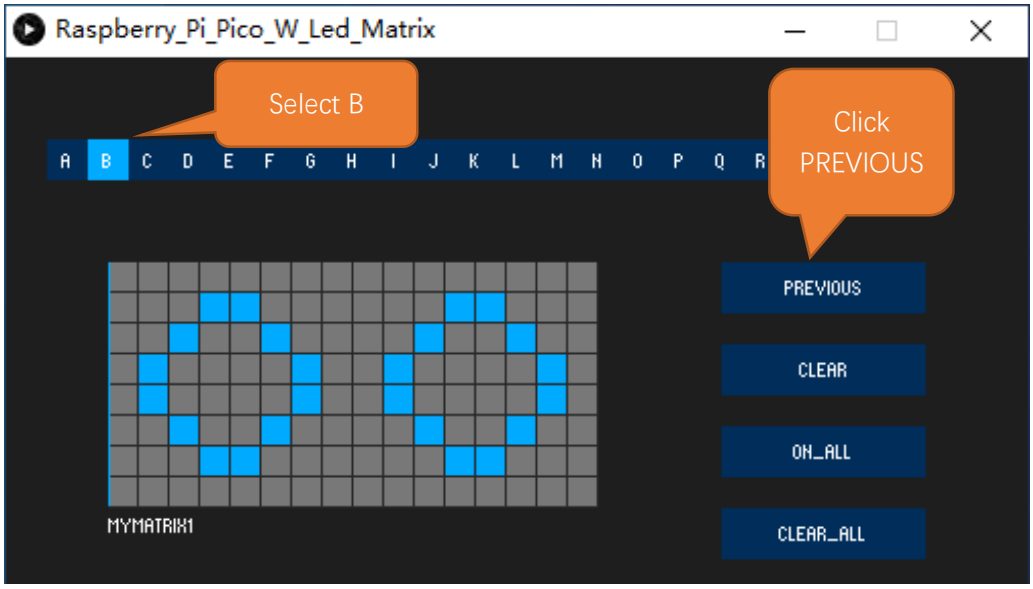
There are 20 pages from A to T. Select Page A.



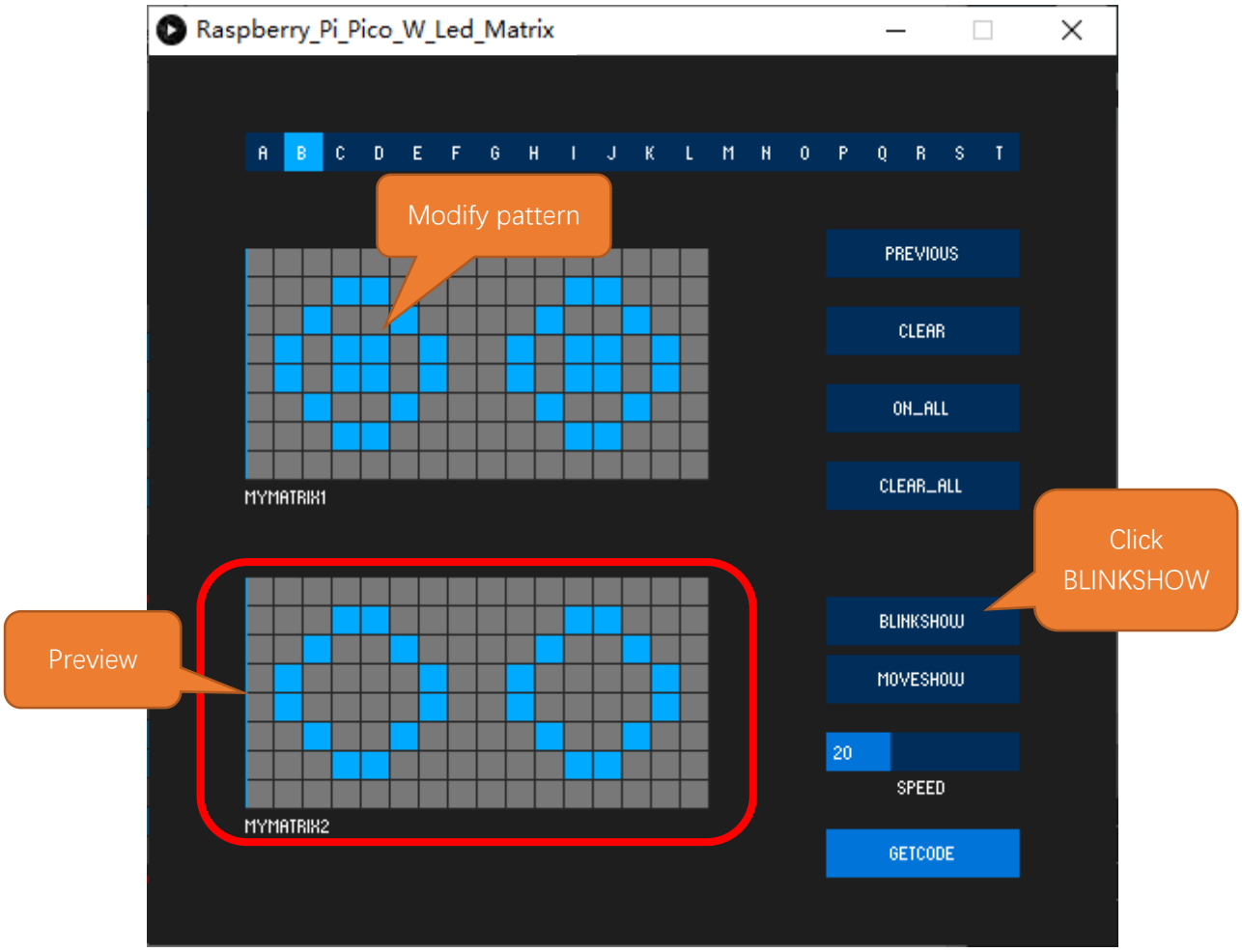
You can design your own pattern by clicking on the squares.



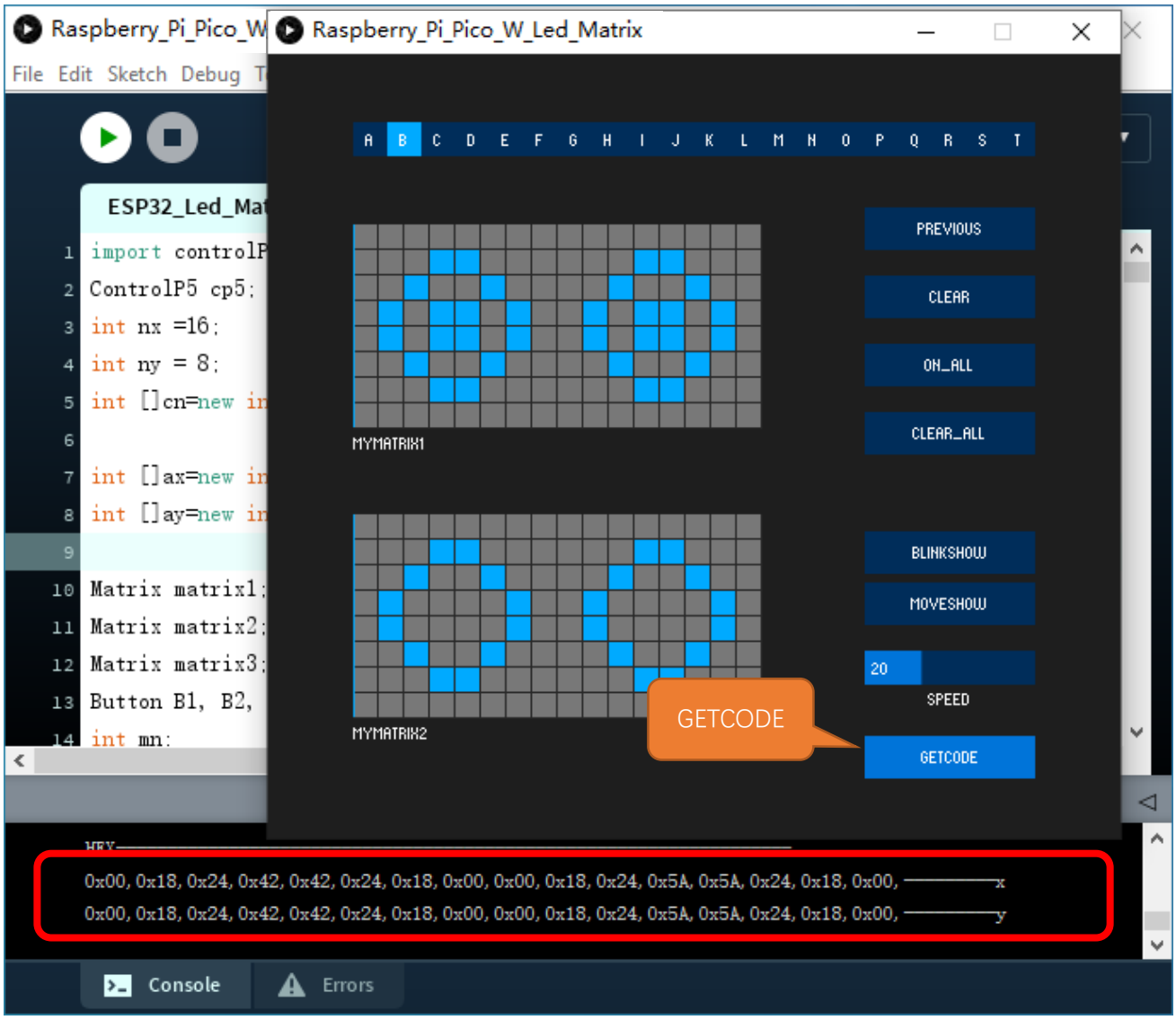
Next select Page B and click PREVIOUS, which copies the previous pattern to B.



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



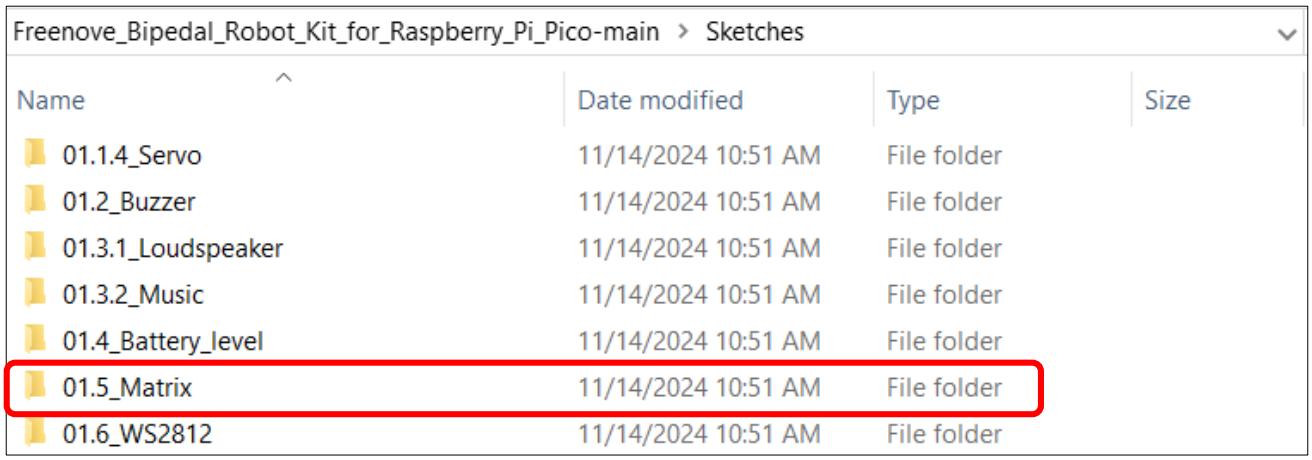
Chick GETCODE to generate array.



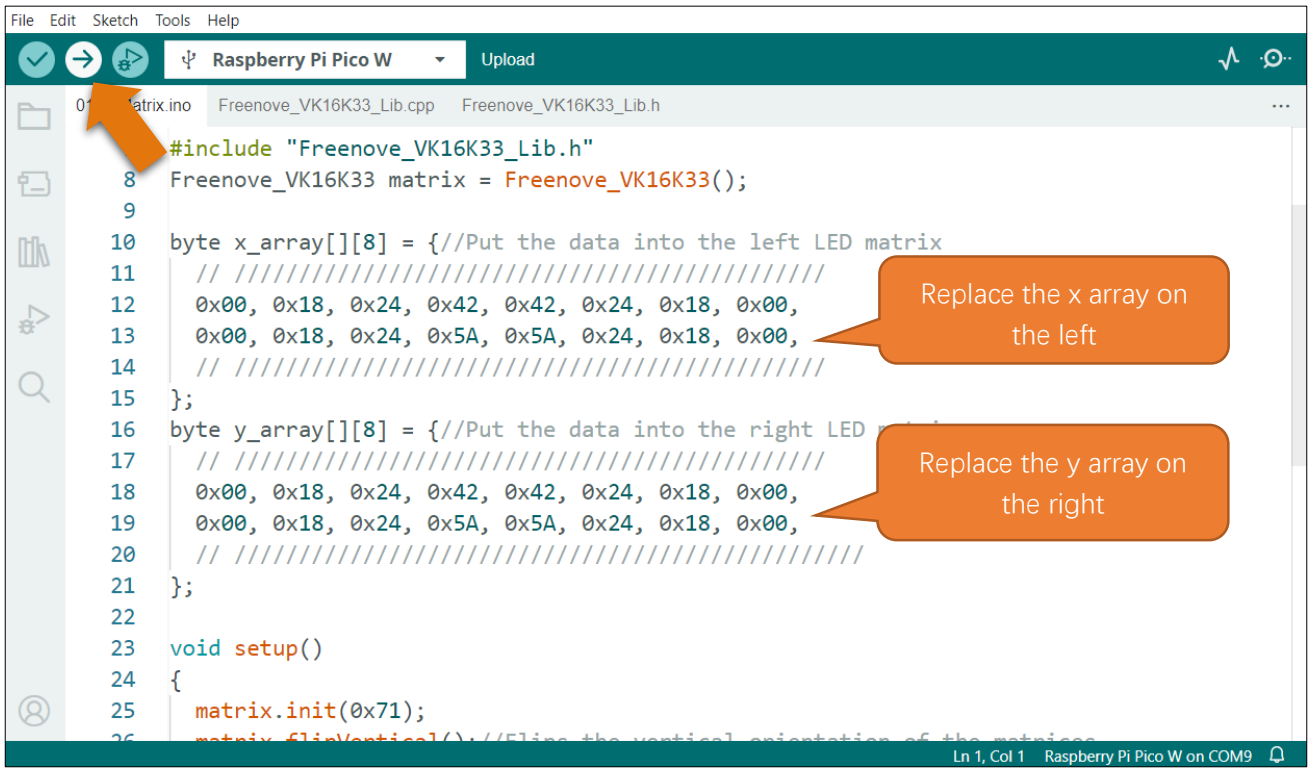
The data on the left of the LED matrix are stored together and end with "----x", and the data on the right are stored together and end with "----y". Copy these two sets of dot matrix data and replace the array content in "01.5_Matrix.ino".

Sketch

In this chapter, we will drive the LED matrix module via the I²C bus of the Raspberry Pi Pico (W).
Open the folder "01.5_Matrix" in the **"Freenove_Bipedal_Robot_Kit_for_Raspberry_Pi_Pico\Sketches"** and double click "01.5_Matrix.ino"



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

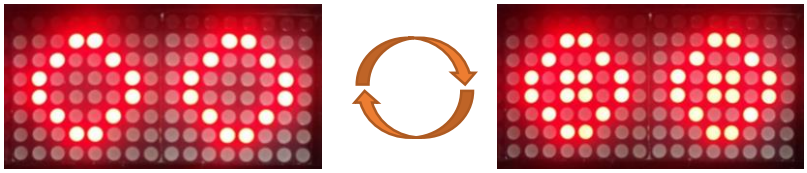


Code

```
#include "Freenove_VK16K33_Lib.h"
Freenove_VK16K33 matrix = Freenove_VK16K33();

byte x_array[][8] = {//Put the data into the left LED matrix
  // ////////////////////////////////////////////
```

```
  0x00, 0x18, 0x24, 0x42, 0x42, 0x24, 0x18, 0x00,
  0x00, 0x18, 0x24, 0x5A, 0x5A, 0x24, 0x18, 0x00,
  // ////////////////////////////////////////////
};
byte y_array[][8] = {//Put the data into the right LED matrix
  // ////////////////////////////////////////////
  0x00, 0x18, 0x24, 0x42, 0x42, 0x24, 0x18, 0x00,
  0x00, 0x18, 0x24, 0x5A, 0x5A, 0x24, 0x18, 0x00,
  // ////////////////////////////////////////////
};

void setup()
{
  matrix.init(0x71);
  matrix.flipVertical();//Flips the vertical orientation of the matrices.
  matrix.flipHorizontal();//Flips the horizontal orientation of the matrices.
  matrix.setBrightness(5);
  matrix.setBlink(VK16K33_BLINK_OFF);
}

void loop()
{
  showArray(500);
}

void showArray(int delay_ms)
{
  int count = sizeof(x_array) / sizeof(x_array[0]);
  for (int i = 0; i < count; i++)
  {
    matrix.showStaticArray(x_array[i], y_array[i]);
    delay(delay_ms);
  }
}
```

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 a Freenove_VK16K33 object and name it matrix.

```
2  Freenove_VK16K33 matrix = Freenove_VK16K33();
```

Define the I²C address and I²C 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 blink.

```
2  Freenove_VK16K33 matrix = Freenove_VK16K33();
…  ...
19   matrix.init(0x71);
20   matrix.flipVertical();//Flips the vertical orientation of the matrices.
21   matrix.flipHorizontal();//Flips the horizontal orientation of the matrices.
22   matrix.setBrightness(5);
23   matrix.setBlink(VK16K33_BLINK_OFF);
```

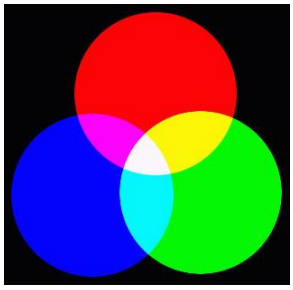
Define count to calculate the number of one-dimensional arrays contained in the two-dimensional x_array, and use the "for" loop to call the showStaticArray() function to continuously display the content of LED matrix.

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

1.6 LED

LED

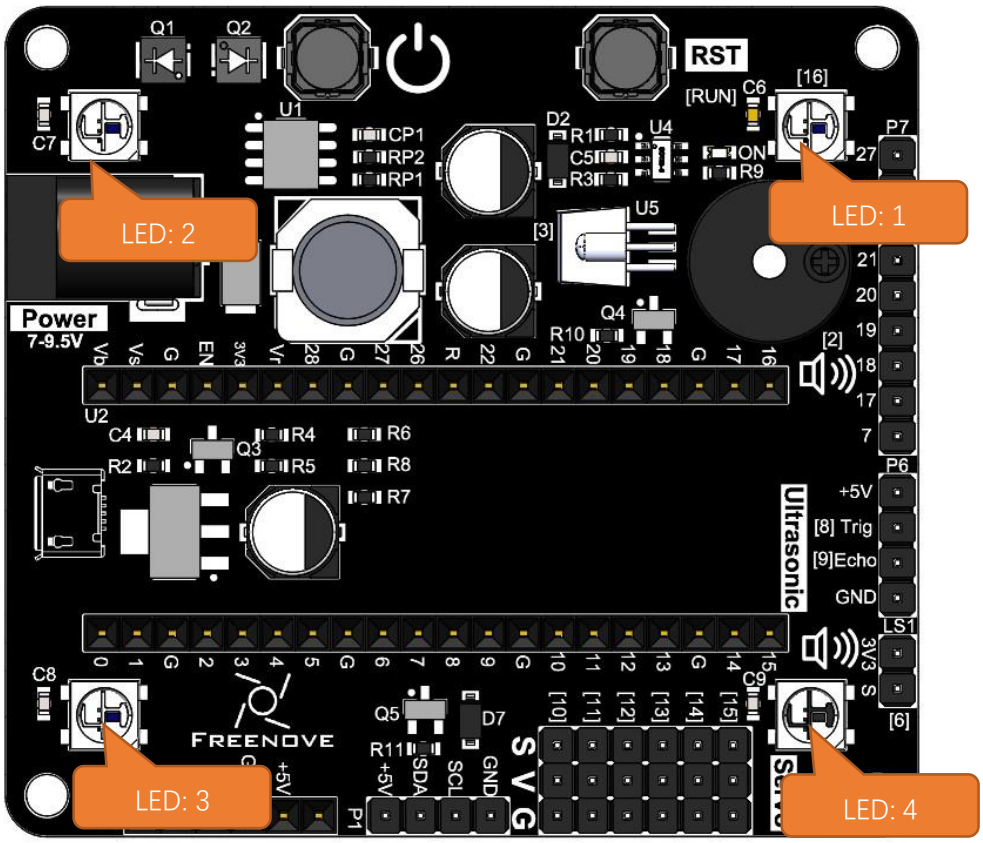
Red, green, and blue are called the three primary colors. When you combine these three primary colors of different brightness, it can produce almost all kinds of visible light.



RGB

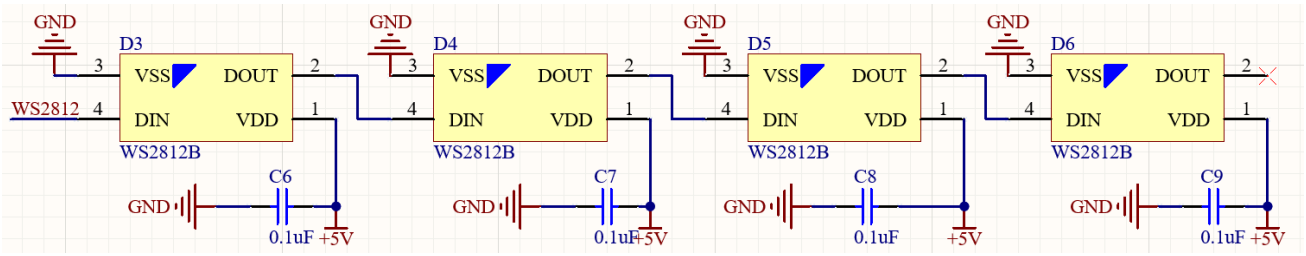
The main control board of the robot integrates 4 LEDs, each with an independent control pin and support for cascading expansion.

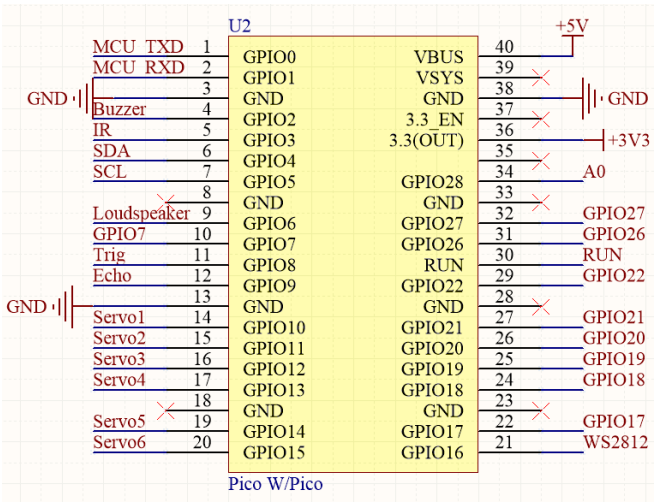
Each LED can emit three basic colors of red, green and blue, and supports 256-level brightness adjustment, which means that each LED can emit 2^24=16,777,216 different colors.



Schematic

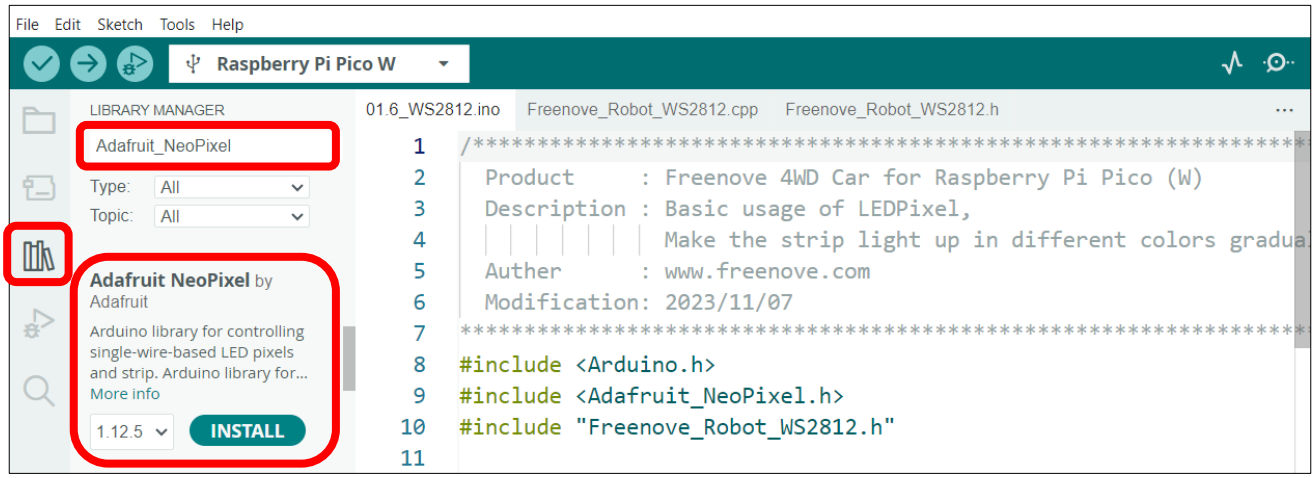
As shown below, the DOUT of each LED is connected with DIN of the next LED, and the 4 LED can be controlled to emit colorful colors by inputting control signals through LED. Control with the GPIO16 of the Raspberry Pi Pico (W).



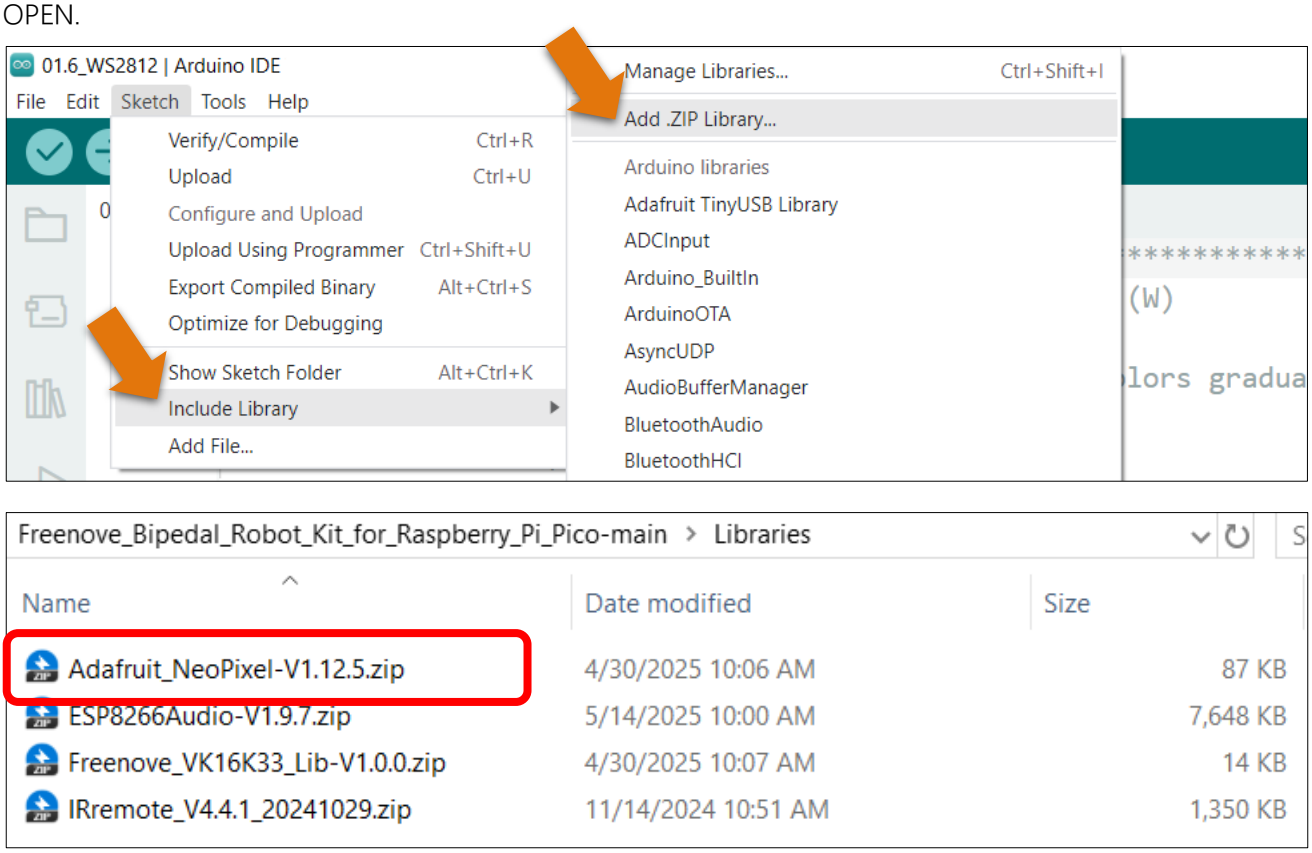


Install Adafruit_NeoPixel library

In this project, we use a third-party library named **Adafruit_NeoPixel**. Please install it first.
Open Arduino IDE, click **Library Manage** on the left, and search "**Adafruit_NeoPixel**" to install.
It is recommended to use version **1.12.5** of the Adafruit_NeoPixel library to avoid compatibility issues.

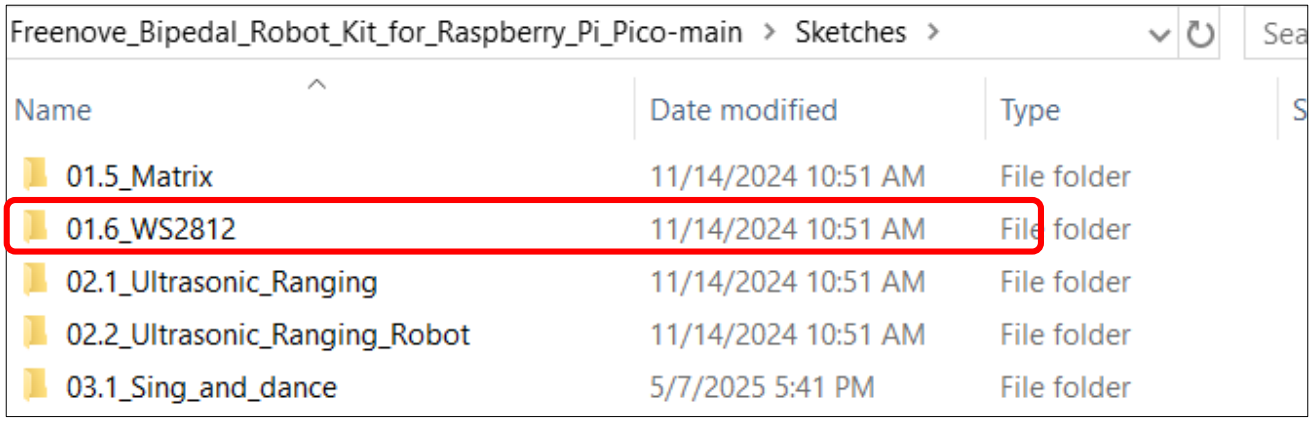


The second way, open Arduino IDE, click Sketch→Include Library→Add .ZIP Library. In the pop-up window, find the file named "./Libraries/ **Adafruit_NeoPixel-V1.12.5.Zip**" which locates in this directory, and click OPEN.



Sketch

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".



Code

```
#include <Arduino.h>
#include <Adafruit_NeoPixel.h>
#include "Freenove_Robot_WS2812.h"

void setup() {
 WS2812_Setup();      //WS2812 initialization
}

void loop() {
  WS2812_Show(5);
}
```

Another part of the code

```
#define WS2812_PIN 16        //Control pins for Pico W
#define LEDS_COUNT 4
Adafruit_NeoPixel ws2812_strip(LEDS_COUNT, WS2812_PIN, NEO_GRB + NEO_KHZ800);
//WS2812 initialization function
void WS2812_Setup(void)
{
  ws2812_strip.begin();
  ws2812_strip.setBrightness(20);
  ws2812_close();
  WS2812_Set_Color_1(4095, 0, 0, 100);
  WS2812_Set_Color_2(4095, 0, 0, 0);
  ws2812_strip_time_now = millis();

}
//WS2812 non-blocking display function
void WS2812_Show(int mode)
{
  switch (mode)
  {
    case 0://Close the WS2812
      ws2812_close();
      break;
    case 1:
      ws2812_rgb();
      break;
    case 2:
      ws2812_following();
      break;
    case 3:
```

```
30          ws2812_blink();
31          break;
32        case 4:
33          ws2812_breathe();
34          break;
35        case 5:
36          ws2812_rainbow();
37          break;
38        default:
39          break;
40    }
41  }
42  int rainbow_count = 0;
43  //WS2812 rainbow display
44  void ws2812_rainbow(void)
45  {
46    ws2812_strip.setBrightness(20);
47    ws2812_strip_time_next = millis();
48    if (ws2812_strip_time_next - ws2812_strip_time_now > 5)
49    {
50      ws2812_strip_time_now = ws2812_strip_time_next;
51      rainbow_count++;
52      for (int i = 0; i < LEDS_COUNT; i++)
53        ws2812_strip.setPixelColor(LEDS_COUNT-1 - i, Wheel((i * 256 / LEDS_COUNT +
54  rainbow_count) & 255));
55      ws2812_strip.show();
56      if (rainbow_count > 255)
57        rainbow_count = 0;
58    }
59  }
```

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.

```
1  #define WS2812_PIN 16        //Control pins for Pico W
2  #define LEDS_COUNT 4
3  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.

```
7    ws2812_strip.begin();
8    ws2812_strip.setBrightness(20);
```

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

```
53  ws2812_strip.setPixelColor(LEDS_COUNT-1 - i, Wheel((i * 256 / LEDS_COUNT + rainbow_count) &
54  255));
```

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

```
10    WS2812_Show(5);
```

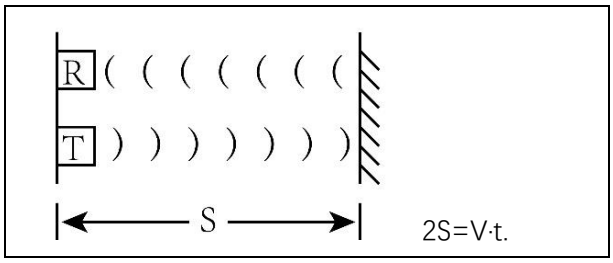
Chapter 2 Ultrasonic Obstacle Avoidance Robot

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

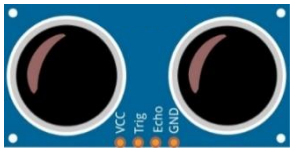
2.1 Ultrasonic Module

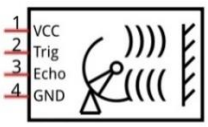
Ultrasonic Module

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=340m/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:

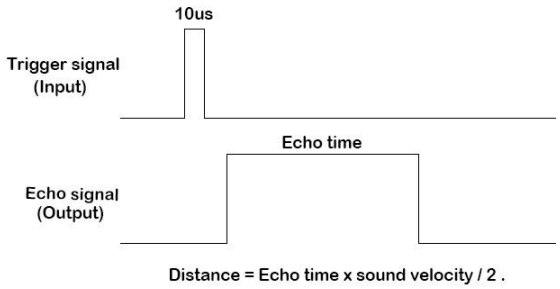
Pin	Description
VCC	Power supply pin
Trig	Trigger pin
Echo	Echo pin
GND	GND

Technical specs:

Working voltage: 5V Working current: 12mA

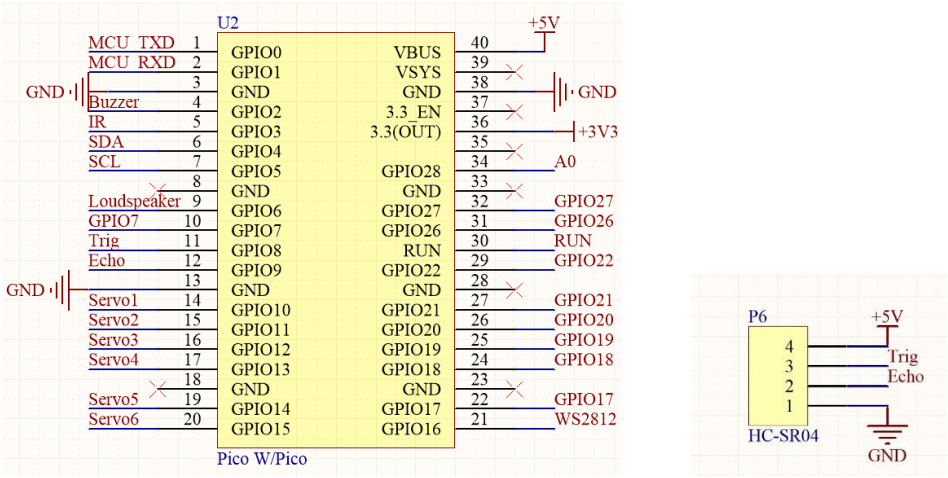
Minimum measured distance: 2cm Maximum measured distance: 200cm

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.



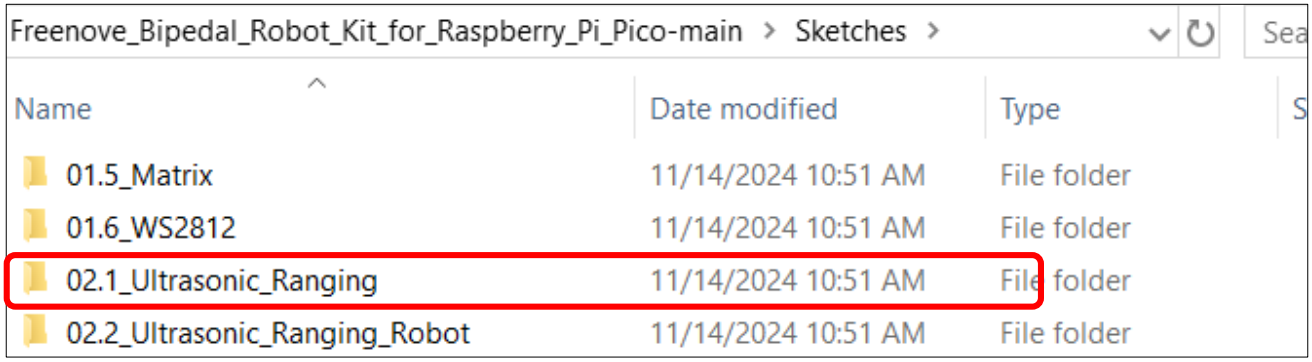
Sketch

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”

double click “02.1_Ultrasonic_Ranging.ino”.



Code

```
#include <Arduino.h>
#include "Freenove_Robot_For_Pico_W.h"

void setup() {
  Serial.begin(115200);//Open the serial port and set the baud rate to 115200
  Ultrasonic_Setup();  //Ultrasonic module initialization
  delay(500);          //Wait for the servo to arrive at the specified location
}

void loop() {
  Serial.print("Distance: " + String(Get_Sonar()) + "\n");//Print ultrasonic distance
  delay(500);
}
```

Code Explanation

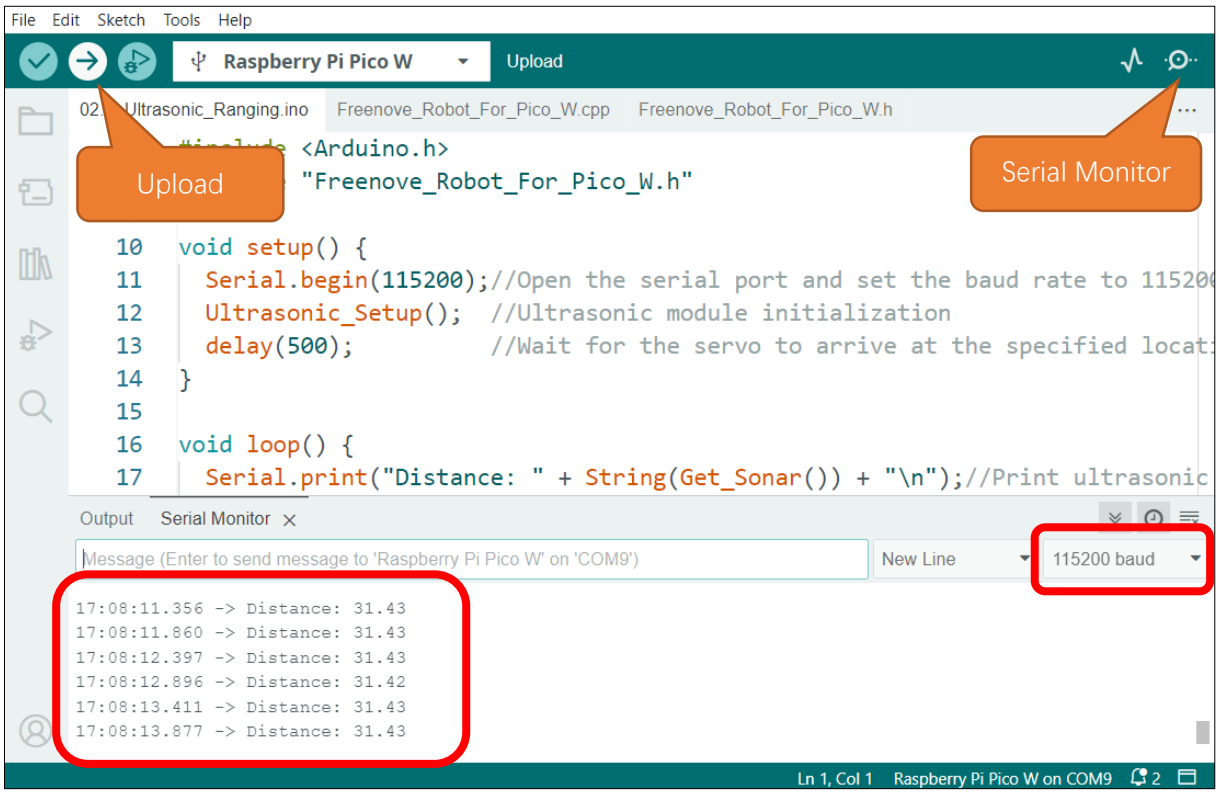
Initialize ultrasonic module.

```
  Ultrasonic_Setup();  //Ultrasonic module initialization
```

Retrieve the distance between the ultrasonic module and obstacles, returning real-time data in centimeters, and print it in the serial port every 0.5 seconds.

```
  Serial.print("Distance: " + String(Get_Sonar()) + "\n");//Print ultrasonic distance
  delay(500);
```

Click "Upload" to upload the code to Raspberry Pi Pico (W). After uploading successfully, open Serial Monitor and s set the baud rate as 115200.

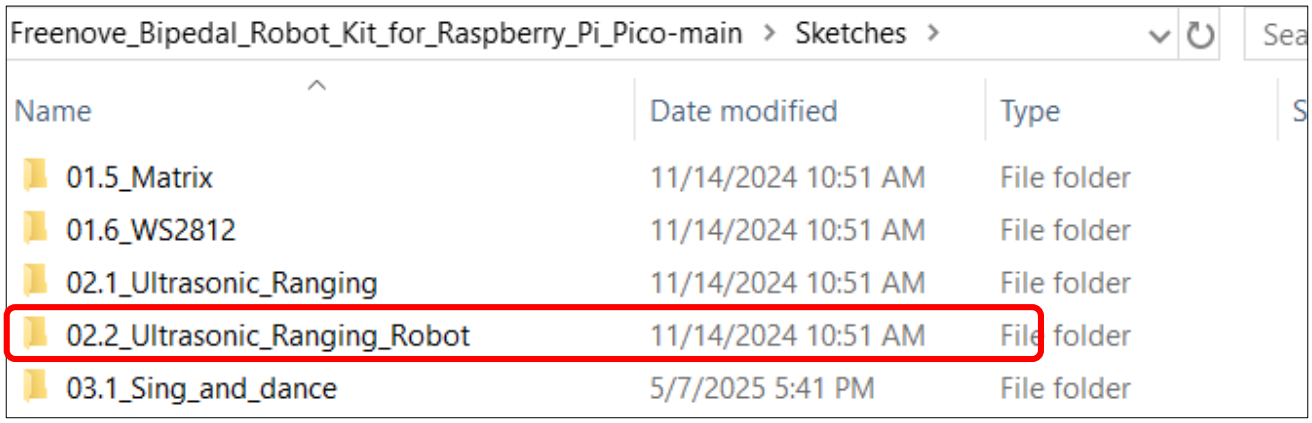


2.2 Obstacle Avoidance Robot

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

```
#include <Arduino.h>
#include "Freenove_Robot_For_Pico_W.h"
#include "Bipedal_Robot.h"
Bipedal_Robot Bipedal_Robot;

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


void setup() {
  Serial.begin(115200);
  Ultrasonic_Setup();           //Initialize the ultrasonic module
  Bipedal_Robot.init(LeftLeg, RightLeg, LeftFoot, RightFoot, true); //Set the servo pins
  Bipedal_Robot.home();
  delay(50);
}
void loop()
```

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

Code Explanation

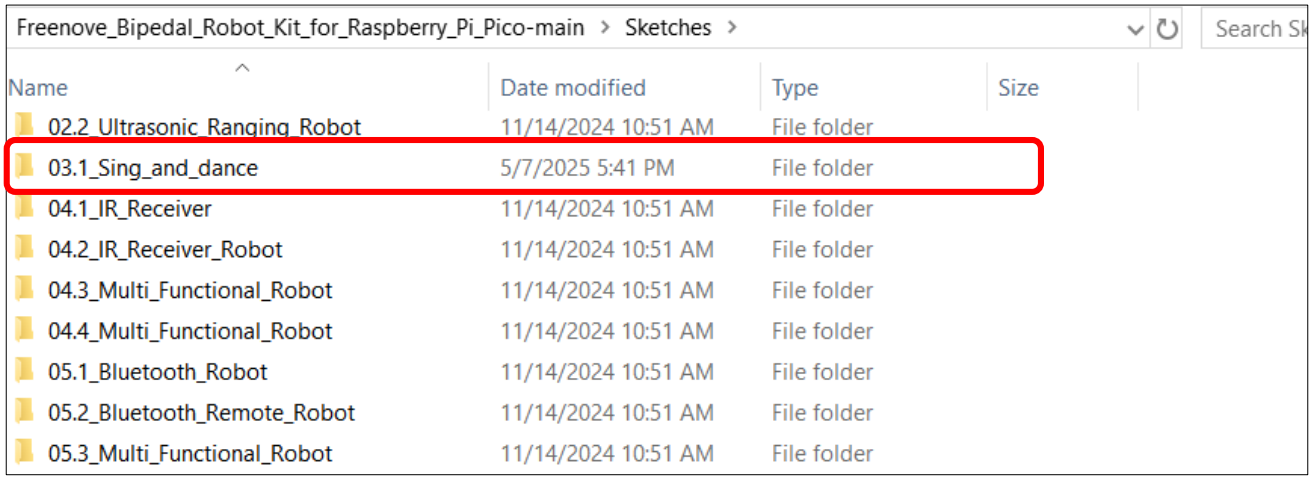
Check whether there is any obstacle in front of the robot with the ultrasonic wave. When the distance between the robot and the obstacles is smaller than the set number, the robot move backwards and turn left to avoid the obstacle.

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

Chapter 3 Sing and Dance

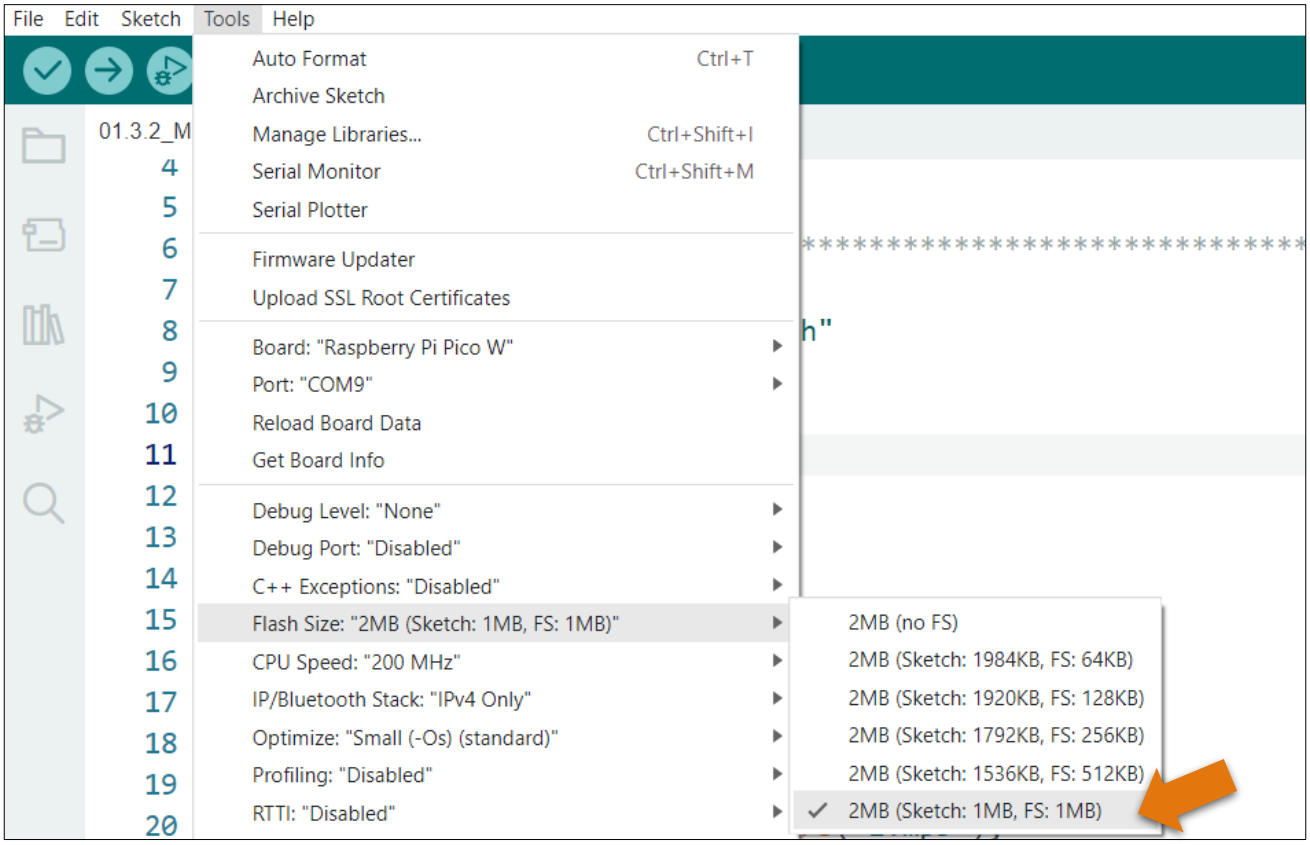
3.1 Sing and dance

In this chapter, we will have the robot sing while dancing.
Open the folder "03.1_Sing_and_dance" in **"Freenove_Bipedal_Robot_Kit_for_Raspberry_Pi_Pico\Sketches"** and double click "03.1_Sing_and_dance.ino".

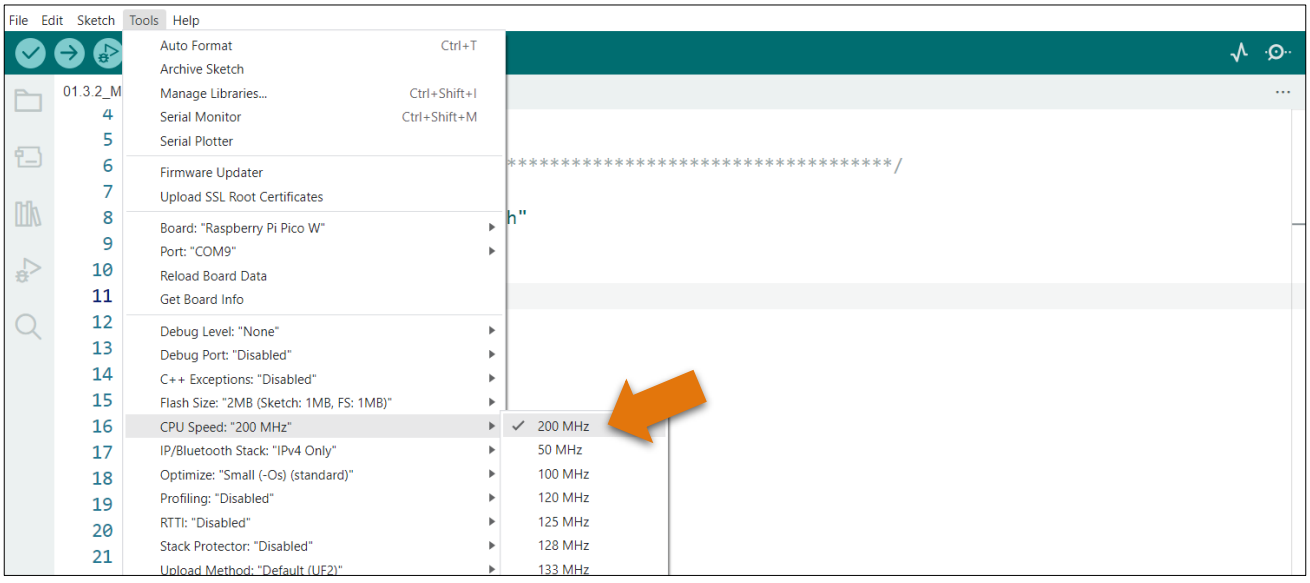


Upload music

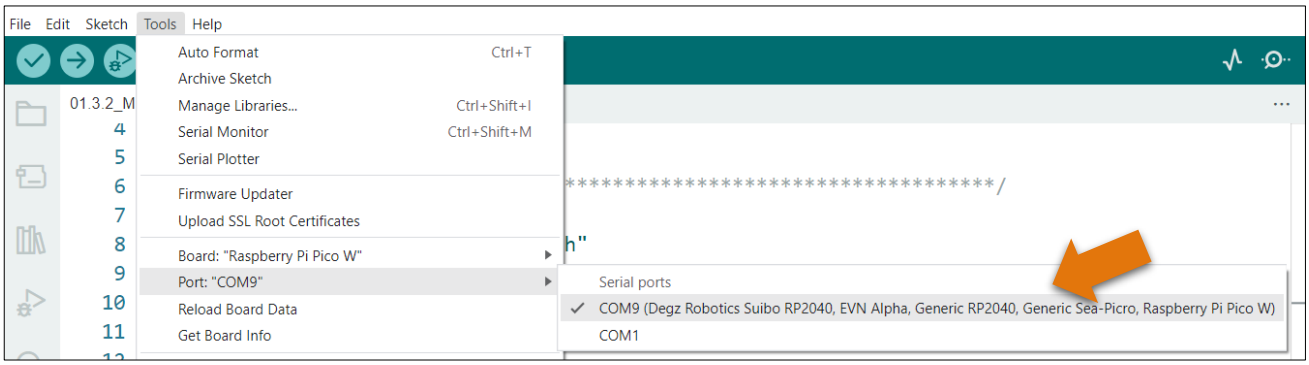
Before uploading the sketch, ensure that the following two libraries have been installed. If not, please do so first.
For ESP8266Audio library refer to here to install.
For PicoLittleFS tool library, refer to this.
Pico of Raspberry Pie has 2MB Flash space. Generally, Arduino mode allocates it to the 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.



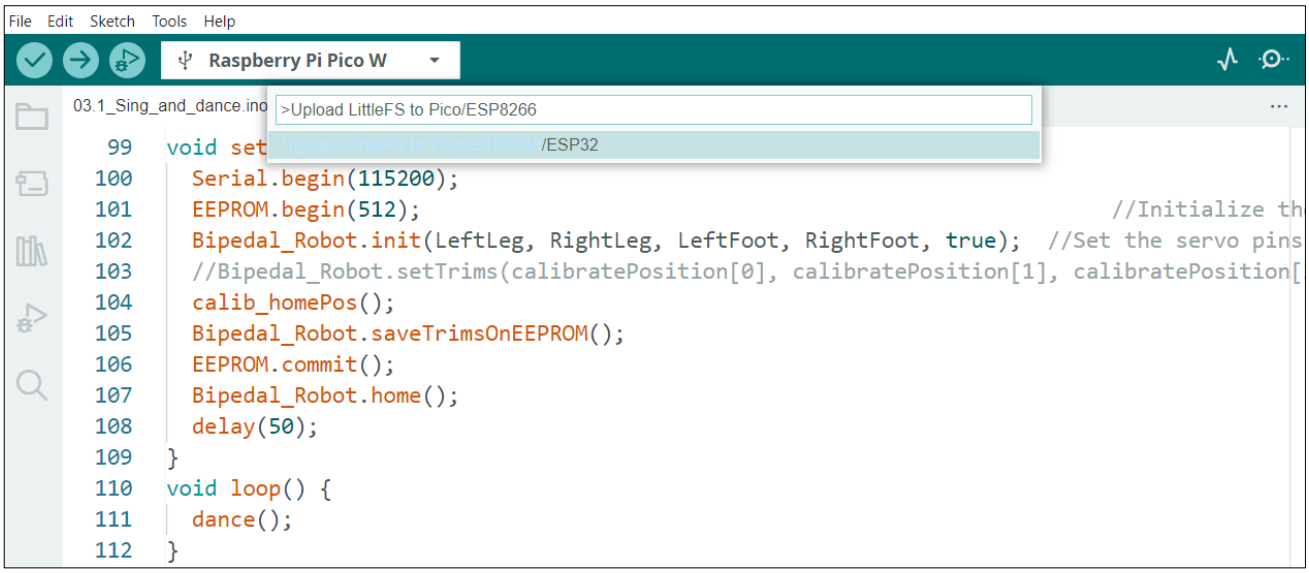
Ensure that the CPU speed is beyond 133MHz. If the frequency is too low, the audio decoding speed may be too slow and the audio playback may not be continuous.

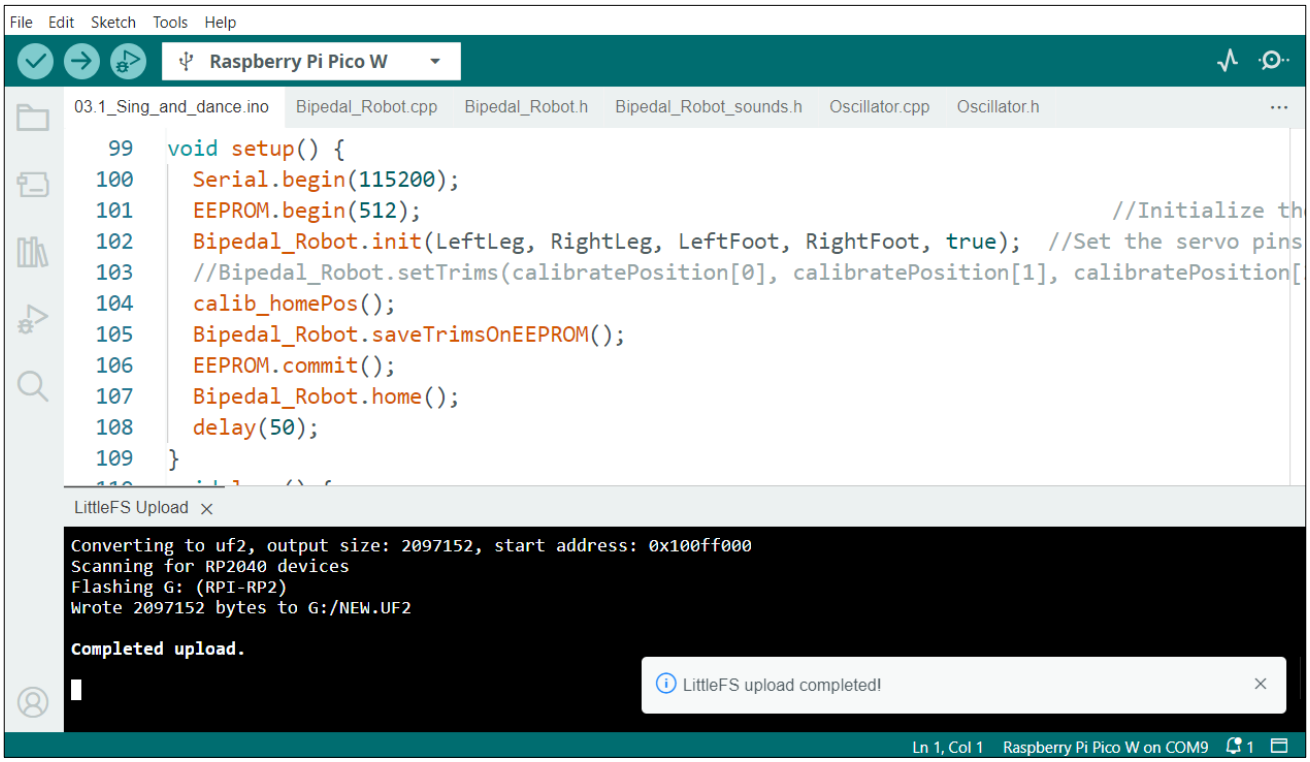


Select the correct port.

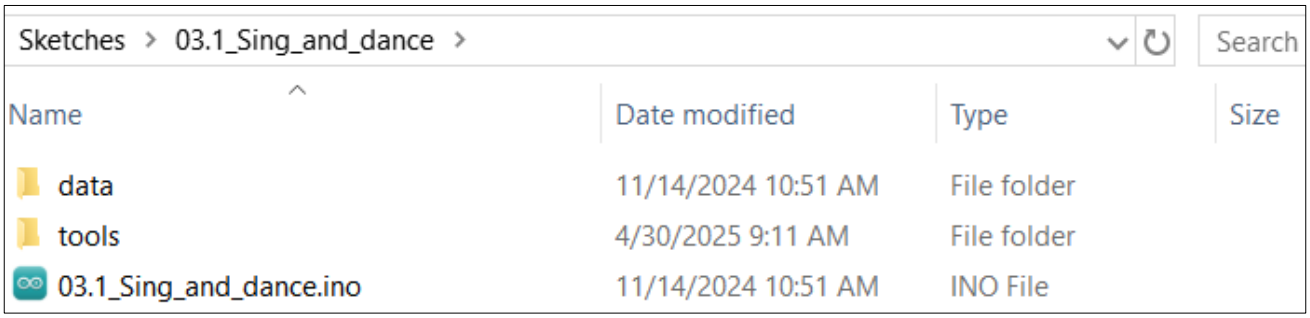


Press [Ctrl]+[Shift]+[P] simultaneously. Enter ***Upload LittleFS to Pico/ESP8266*** on the input field, click Upload LittleFS to Pico/ESP8266, and wait for it to finish.



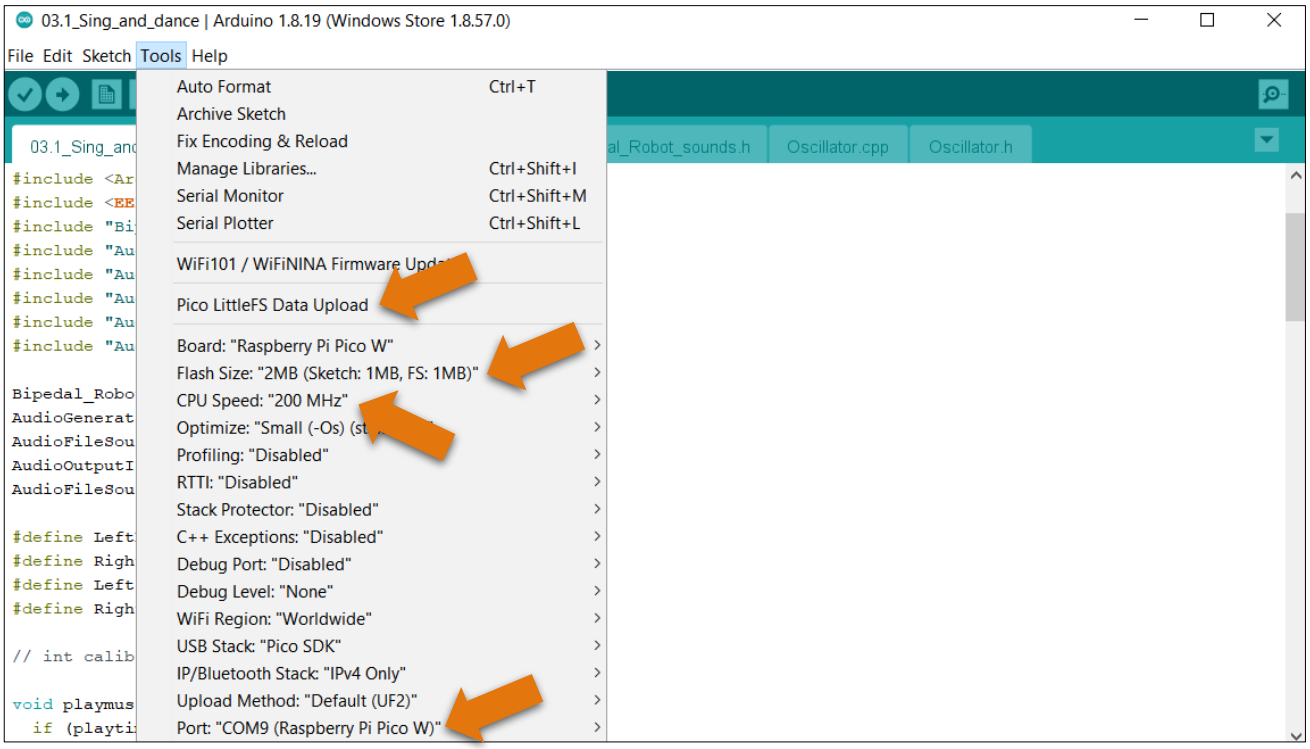


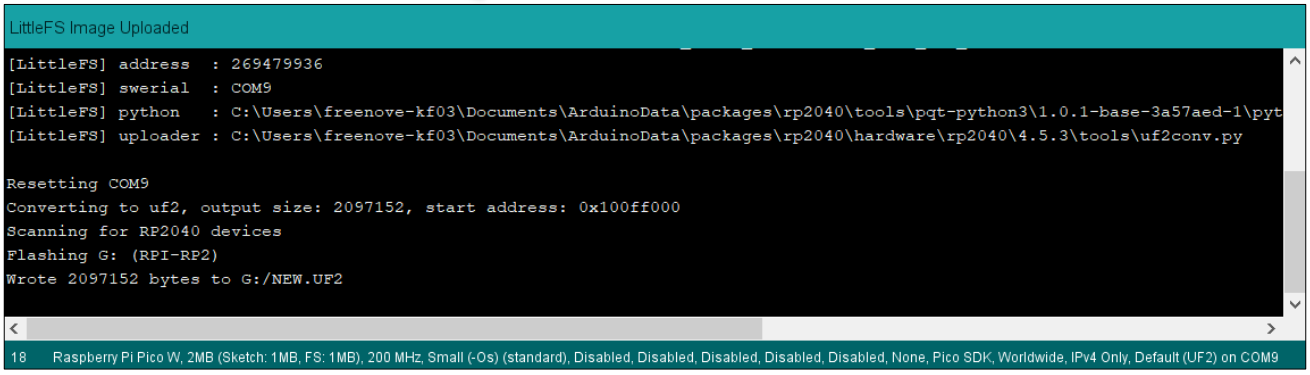
Check the code file and audio file. We create a folder named data under the same level directory of the code file, and place the audio file directly in this folder.



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.

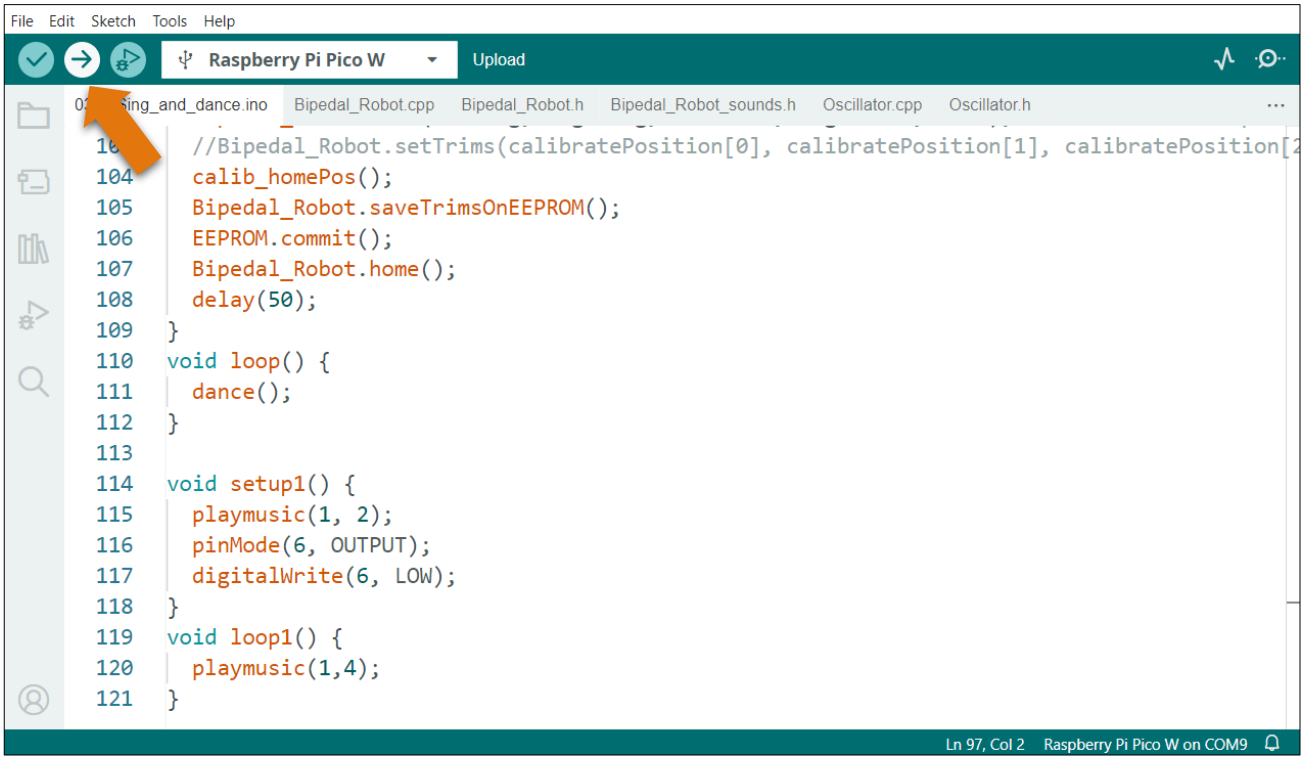
If your Arduino IDE is an old version one, like Arduino 1.x.x, please upload the music as below:
Click Arduino IDE Tools and click following content:





Sketch

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



Part of code

```
#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"

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

#define LeftLeg 10
#define RightLeg 12
#define LeftFoot 11
#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 ultrasonic module
27    Bipedal_Robot.init(LeftLeg, RightLeg, LeftFoot, RightFoot, true);  //Set the servo pins
28    //Bipedal_Robot.setTrims(calibratePosition[0], calibratePosition[1], calibratePosition[2],
29  calibratePosition[3]);
      calib_homePos();
30    Bipedal_Robot.saveTrimsOnEEPROM();
      EEPROM.commit();
31    Bipedal_Robot.home();
32    delay(50);
33  }
34  void loop() {
35    dance();
36  }
37
38  void setup1() {
39    playmusic(1, 2);
40    pinMode(6, OUTPUT);
41    digitalWrite(6, LOW);
42  }
43  void loop1() {
44    playmusic(1,4);
45  }
```

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.

```
34  void loop() {
35    dance();
36  }
...
43  void loop1() {
44    playmusic(1,4);
45  }
```

Chapter 4 Infrared Robot

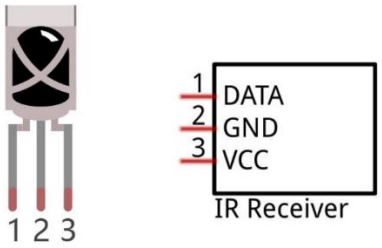
4.1 Introduction of infrared reception function

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.

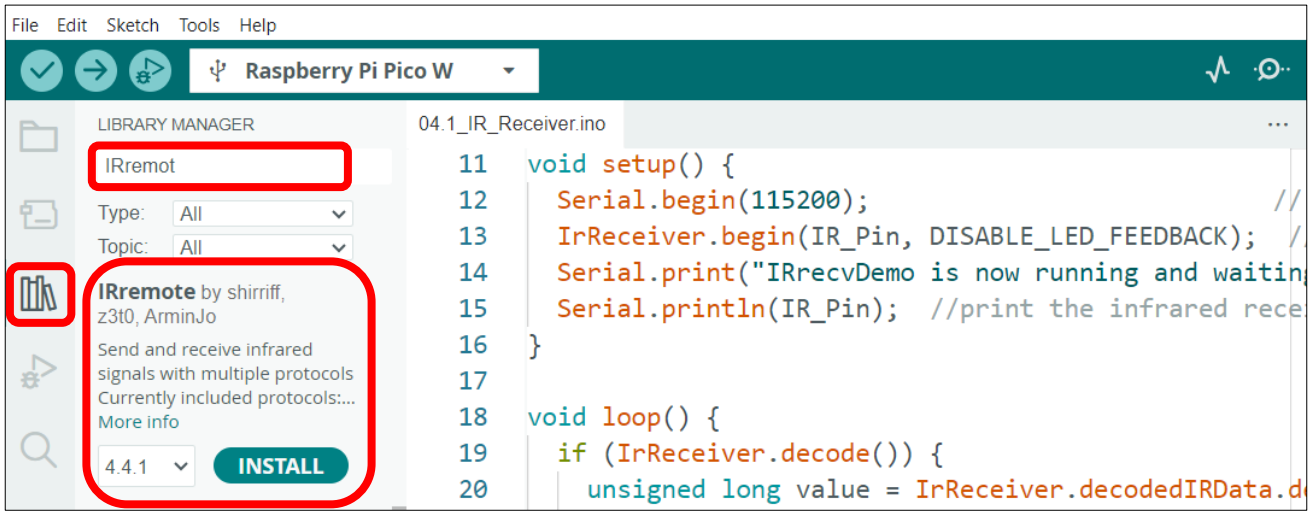


When you use the infrared remote control, the infrared remote control sends a key value to the receiving circuit according to the pressed keys. We can program the Raspberry Pi Pico W to do things like lighting, when a key value is received.
The following is the key value that the receiving circuit will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

ICON	KEY Value	ICON	KEY Value
	BA45FF00	C	F20DFF00
MENU	B847FF00	1	F30CFF00
TEST	BB44FF00	2	E718FF00
+	BF40FF00	3	A15EFF00
	BC43FF00	4	F708FF00
	F807FF00	5	E31CFF00
	EA15FF00	6	A55AFF00
	F609FF00	7	BD42FF00
0	E916FF00	8	AD52FF00
−	E619FF00	9	B54AFF00

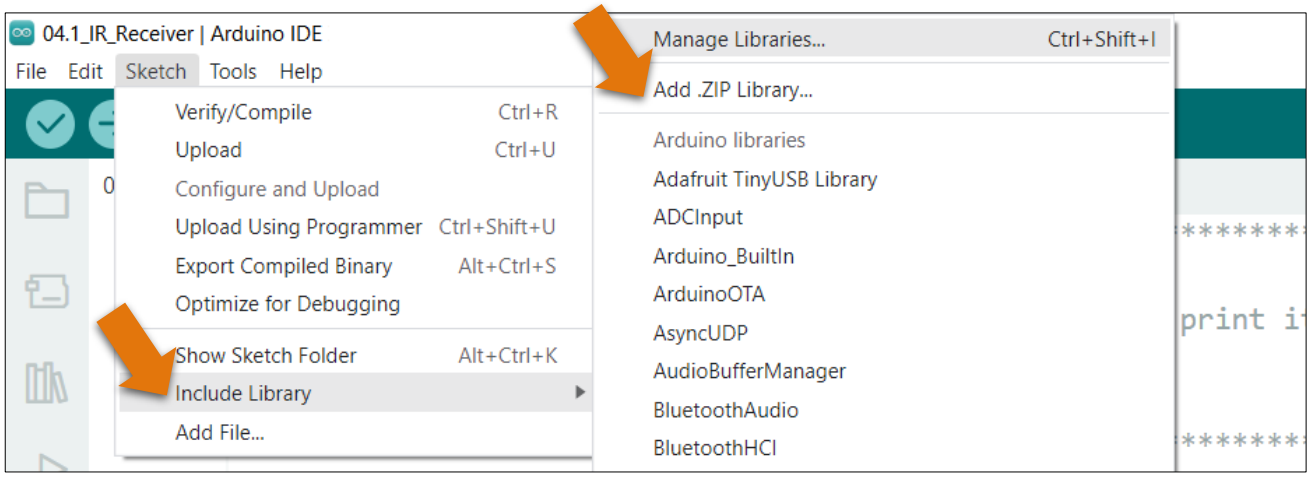
Install IRremote library

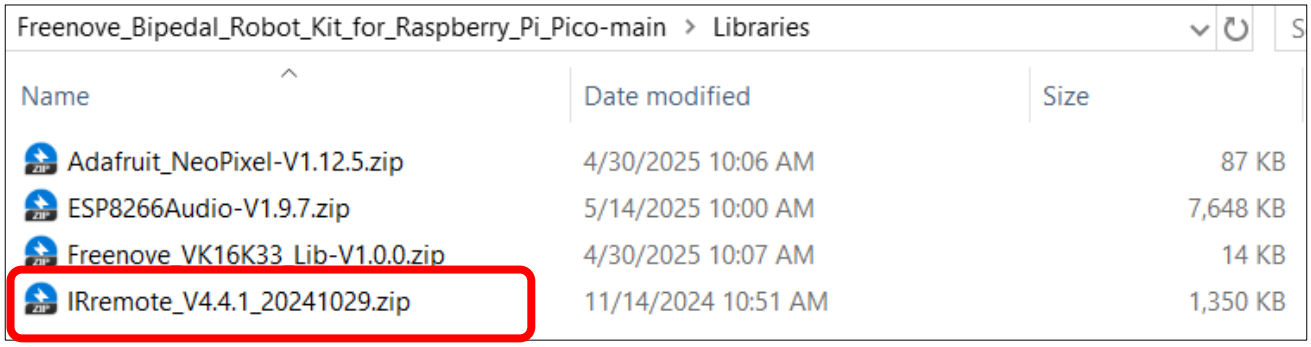
In this project, we use a third-party library named **IRremote**. Please install it first.
Open Arduino IDE, click **Library Manage** on the left, and search "**IRremote**" to install.
It is recommended to use version **4.4.1** of the IRremote library to avoid compatibility issues.



The second way, open Arduino IDE, click Sketch→Include Library→Add .ZIP Library. In the pop-up window, find the file named "./Libraries/ **IRremote_V4.4.1_20241029.Zip**" which locates in this directory, and click

OPEN.

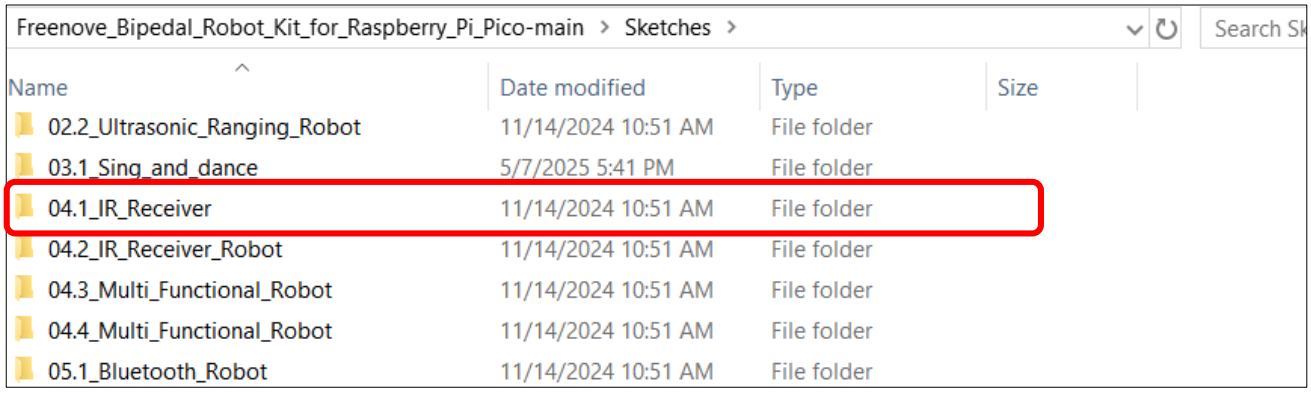




Sketch

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

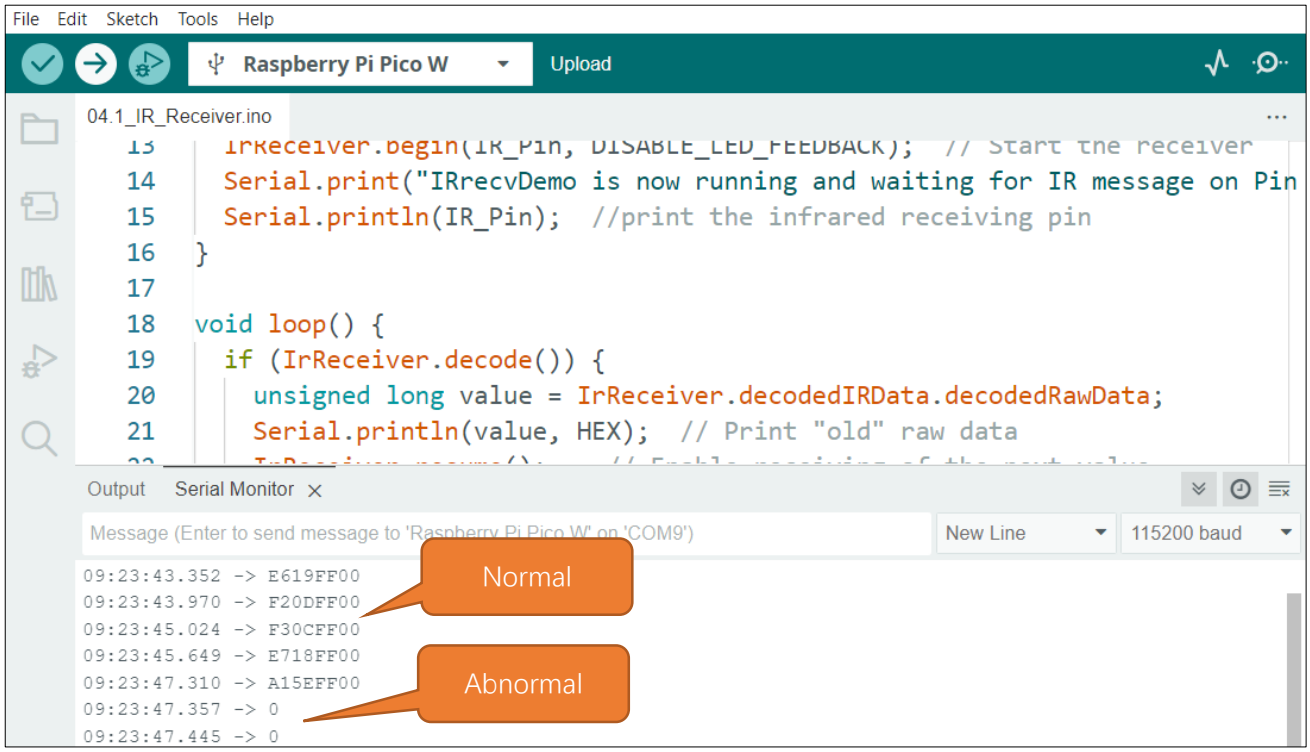
Open the folder “04.1_IR_Receiver”in **“Freenove_Robot_Kit_for_Raspberry_Pi_Pico\Ordinary_wheels\Sketches”** and double click “04.1_IR_Receiver.ino”.



Code

```
#include <IRremote.hpp>
#define IR_Pin 3  // Infrared receiving pin
#define ENABLE_LED_FEEDBACK true
#define DISABLE_LED_FEEDBACK false
void setup() {
  Serial.begin(115200);                          // Initialize the serial port and set the
baud rate to 115200
  IrReceiver.begin(IR_Pin, DISABLE_LED_FEEDBACK);  // Start the receiver
  Serial.print("IRrecvDemo is now running and waiting for IR message on Pin ");
  Serial.println(IR_Pin);  //print the infrared receiving pin
}

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

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

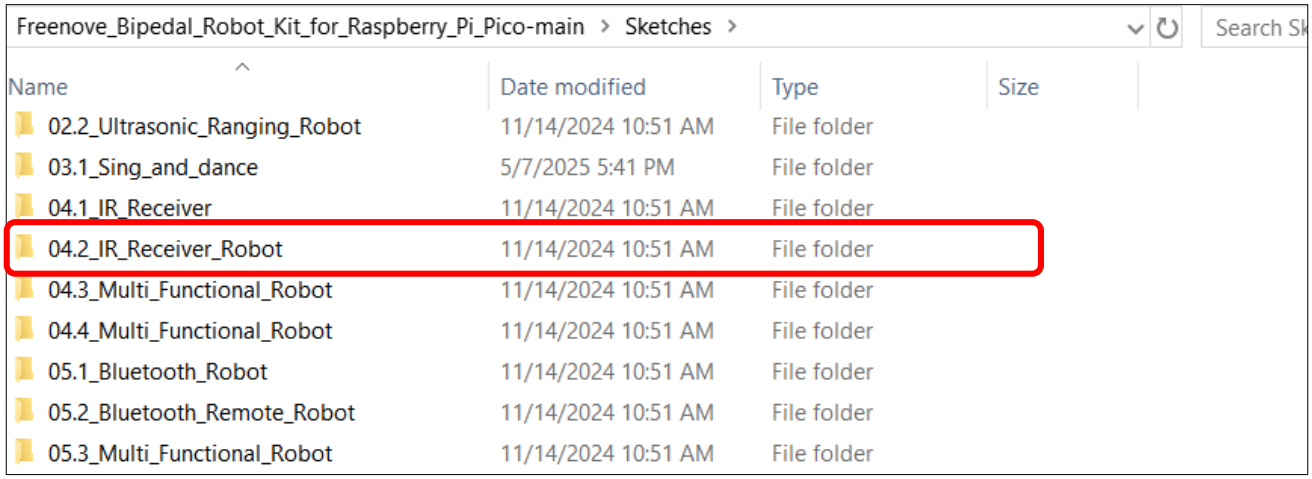
```
14    if (IrReceiver.decode()) {
15      unsigned long value = IrReceiver.decodedIRData.decodedRawData;
16      Serial.println(value, HEX);  // Print "old" raw data
17      IrReceiver.resume();     // Enable receiving of the next value
18    }
```

4.2 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".



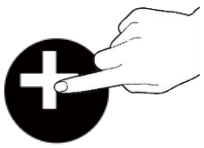
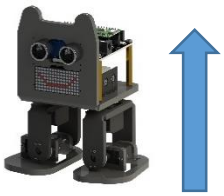
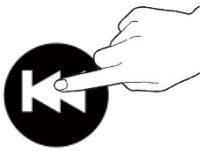
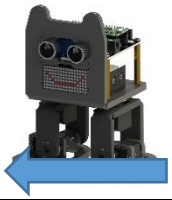
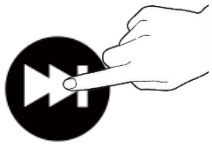
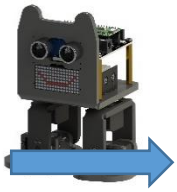
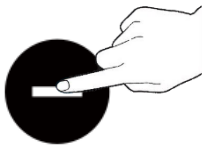
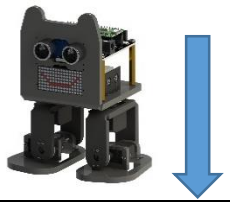
Code

```
#include <Arduino.h>
#include <IRremote.hpp>
#include <EEPROM.h>
#include "Bipedal_Robot.h"

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

#define IR_Pin 3
#define ENABLE_LED_FEEDBACK true
#define DISABLE_LED_FEEDBACK false

// #define USE_NO_SEND_PWM

int move_flag = 0;

```

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

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(115200);
  EEPROM.begin(512);
  Bipedal_Robot.init(LeftLeg, RightLeg, LeftFoot, RightFoot, true);  //Set the servo pins
  //Bipedal_Robot.setTrims(calibratePosition[0], calibratePosition[1], calibratePosition[2],
calibratePosition[3]);
  calib_homePos();
  Bipedal_Robot.saveTrimsOnEEPROM();
  EEPROM.commit();
  Bipedal_Robot.home();
  IrReceiver.begin(IR_Pin, DISABLE_LED_FEEDBACK);  // Start the receiver
}

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
  }
  Move(move_flag);
}

void handleControl(unsigned long value) {
  // Handle the commands
  switch (value) {
    case 0xBF40FF00:  // Receive the number '+'
      move_flag = 1;
      break;
    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 }
```

Compile and upload the code to Raspberry Pi Pico (W).

		**Move forward**
		**Turn left**
		**Turn right**
		**Move back**

Code Explanation:

Variable **IrReceiver.DecodedIRData.DecodedRawData** holds the infrared remote control encoding information; call handleccontrol 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.

```
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  }
```

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

```
56  void handleControl(unsigned long value) {
57    // Handle the commands
58    switch (value) {
59      case 0xBF40FF00:  // Receive the number '+'
…       ...
```

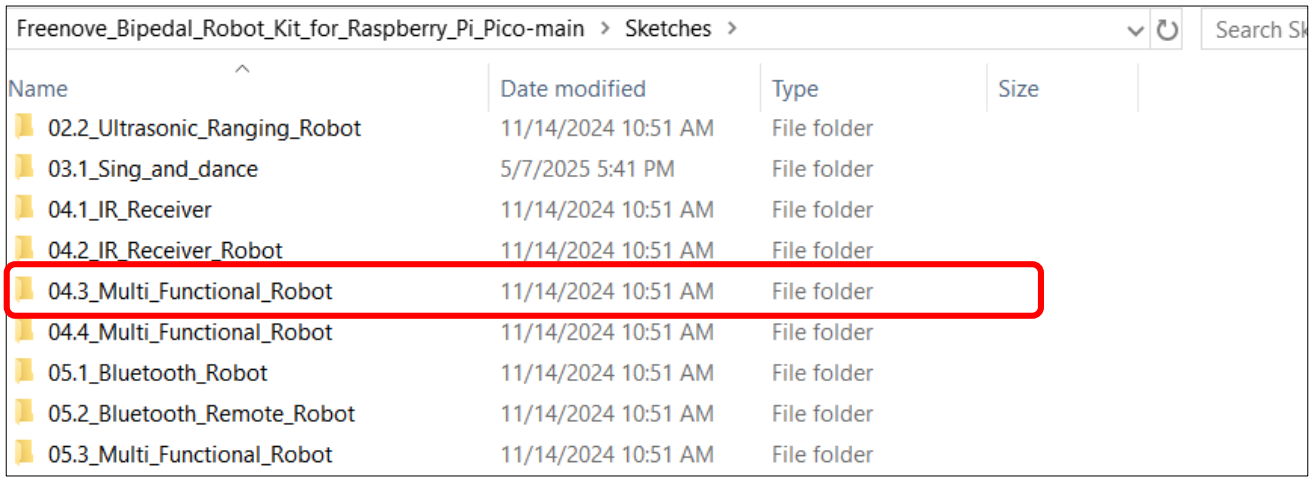
```
62      case 0xE619FF00:  // Receive the number '-'
...     ...
65      case 0xF807FF00:  // Receive the number '|<<'
...     ...
68      case 0xF609FF00:  // Receive the number '>>|'
...     ...
71      case 0xEA15FF00:  // Receive the number '▶'
...     ...
74      default:
...     ...
76    }
77  }
```

4.3 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 "04.3_Multi_Functional_Robot" in the **"Freenove_Bipedal_Robot_Kit_for_Raspberry_Pi_Pico\Sketches"** and double click "04.3_Multi_Functional_Robot.ino".



Code

```
#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"

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

#define IR_Pin 3  // Infrared receiving pin
#define ENABLE_LED_FEEDBACK true
#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    Move(move_flag);
67  }
68
69  void handleControl(unsigned long value) {
70    // Handle the commands
71    switch (value) {
72      case 0xBF40FF00:  // Receive the number '+'
73        move_flag = 1;
74        break;
75      case 0xE619FF00:  // Receive the number '-'
76        move_flag = 2;
77        break;
78      case 0xF807FF00:  // Receive the number '|<<'
79        move_flag = 3;
80        break;
81      case 0xF609FF00:  // Receive the number '>>|'
82        move_flag = 4;
83        break;
84      case 0xEA15FF00:  // Receive the number '►'
85        move_flag = 0;
86        break;
87      case 0xE916FF00:  // Receive the number '0'
88        break;
89      case 0xF30CFF00:  // Receive the number '1'
90        break;
91      case 0xF708FF00:  // Receive the number '4'
92        break;
93      case 0xF20DFF00:  // Receive the number 'C'
94        break;
95      case 0xA15EFF00:  // Receive the number '3'
96        move_flag = 5;
97        break;
98      case 0xA55AFF00:  // Receive the number '6'
99        move_flag = 6;
100       break;
101     case 0xB54AFF00:  // Receive the number '9'
102       break;
103     case 0xBB44FF00:  // Receive the number 'TEST'
104       Buzzer_Variable(2000, 100, 1);
105       break;
106     case 0xE718FF00:  // Receive the number '2'
```

```
107         emotion_flag = emotion_flag + 1;
108         if (emotion_flag > 7) {
109           emotion_flag = 0;
110         }
111         Emotion_SetMode(emotion_flag);  //Display
112         break;
113       case 0xE31CFF00:  // Receive the number '5'
114         emotion_flag = 0;
115         Emotion_SetMode(emotion_flag);
116         break;
117       case 0xBD42FF00:  // Receive the number '7'
118         ws2812_flag = ws2812_flag + 1;
119         if (ws2812_flag >= 6) {
120           ws2812_flag = 0;
121         }
122         WS2812_SetMode(ws2812_flag);
123         break;
124       case 0xAD52FF00:  // Receive the number '8'
125         ws2812_flag = 0;
126         WS2812_SetMode(ws2812_flag);
127         break;
128       case 0xFFFFFFFF:  // Remain unchanged
129         break;
130       default:
131         break;
132     }
133 }
134
135 void Move(int data) {
136   // Handle the commands
137   switch (data) {
138     case 1:  // Receive the number '+'
139       Bipedal_Robot.walk(2, 1500, 1);
140       move_flag = 0;
141       break;
142     case 2:  // Receive the number '-'
143       Bipedal_Robot.walk(2, 1500, -1);
144       move_flag = 0;
145       break;
146     case 3:  // Receive the number '|<<'
147       Bipedal_Robot.turn(2, 1500, 1);
148       move_flag = 0;
149       break;
150     case 4:  // Receive the number '>>|'
```

```
151         Bipedal_Robot.turn(2, 1500, -1);
152         move_flag = 0;
153         break;
154       case 5:  // Receive the number '3'
155         Ultrasonic_Avoid();
156         break;
157       case 6:  // Receive the number '6'
158         dance();
159         move_flag = 0;
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   Bipedal_Robot.jitter(1, 1000, 40);
173   Bipedal_Robot.home();
174   Bipedal_Robot.moonwalker(1, 1200, 30, 1);
175   Bipedal_Robot.home();
176   Bipedal_Robot.ascendingTurn(1, 1000, 50);
177   Bipedal_Robot.home();
178   Bipedal_Robot.tiptoeSwing(1, 1000, 30);
179   Bipedal_Robot.home();
180   Bipedal_Robot.flapping(1, 1000, 40, 1);
181   Bipedal_Robot.home();
182   Bipedal_Robot.crusaito(1, 3000, 40, 1);
183   Bipedal_Robot.home();
184   Bipedal_Robot.shakeLeg(1, 1000, 1);
185   Bipedal_Robot.home();
186 }
```

After the code uploads successfully, turn on the power of the robot and use the infrared remote to control the robot 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	2	E718FF00	Change the expression display mode
⏮	F807FF00	Turn left	5	E31CFF00	Turn off emoticons
⏭	F609FF00	Turn light	7	BD42FF00	Change the display mode of the WS2812
−	E619FF00	Move back	8	AD52FF00	Turn off WS2812 display
▶	EA15FF00	Stop the robot	3	A15EFF00	Ultrasonic obstacle avoidance mode
TEST	BB44FF00	Control the buzzer	6	A55AFF00	Dancing Mode

Code Explanation:

Add the header file for the robot.

```
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"
```

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

```
74  void handleControl(unsigned long value) {
```

```
75    // Handle the commands
76    switch (value) {
77      case 0xBF40FF00:  // Receive the number '+'
...       ...
80      case 0xE619FF00:  // Receive the number '-'
...       ...
83      case 0xF807FF00:  // Receive the number '|<<'
...       ...
86      case 0xF609FF00:  // Receive the number '>>|'
...       ...
89      case 0xEA15FF00:  // Receive the number '►'
...       ...
92      case 0xE916FF00:  // Receive the number '0'
...       ...
94      case 0xF30CFF00:  // Receive the number '1'
...       ...
96      case 0xF708FF00:  // Receive the number '4'
...       ...
98      case 0xF20DFF00:  // Receive the number 'C'
...       ...
100     case 0xA15EFF00:  // Receive the number '3'
...       ...
103     case 0xA55AFF00:  // Receive the number '6'
...       ...
106     case 0xB54AFF00:  // Receive the number '9'
...       ...
108     case 0xBB44FF00:  // Receive the number 'TEST'
...       ...
111     case 0xE718FF00:  // Receive the number '2'
...       ...
118     case 0xE31CFF00:  // Receive the number '5'
...       ...
122     case 0xBD42FF00:  // Receive the number '7'
...       ...
129     case 0xAD52FF00:  // Receive the number '8'
...       ...
133     case 0xFFFFFFFF:  // Remain unchanged
...       ...
135     default:
...       ...
137   }
138 }
```

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	2	E718FF00	Change the expression display mode
⏮	F807FF00	Turn left	5	E31CFF00	Turn off emoticons
⏭	F609FF00	Turn light	7	BD42FF00	Change the display mode of the WS2812
−	E619FF00	Move back	8	AD52FF00	Turn off WS2812 display
▶	EA15FF00	Stop the robot	3	A15EFF00	Ultrasonic obstacle avoidance mode
TEST	BB44FF00	Control the buzzer	6	A55AFF00	Dancing Mode
0	E916FF00	Playing Music 1	1	F30CFF00	Playing Music 2
4	F708FF00	Stop playing			

Chapter 5 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

5.1 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:

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 9600, 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?

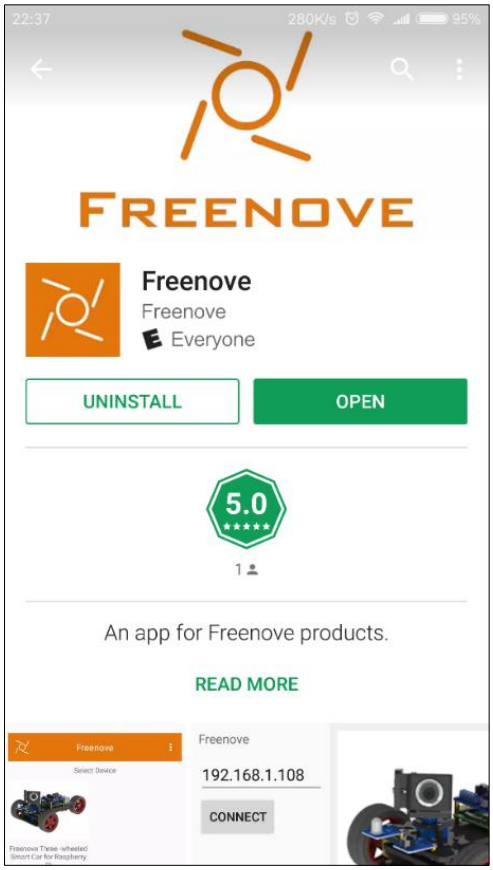
Use the command “AT+NAME?” to check the Bluetooth name or “AT+NAME=X” to set a new name (replace X with your desired name).

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

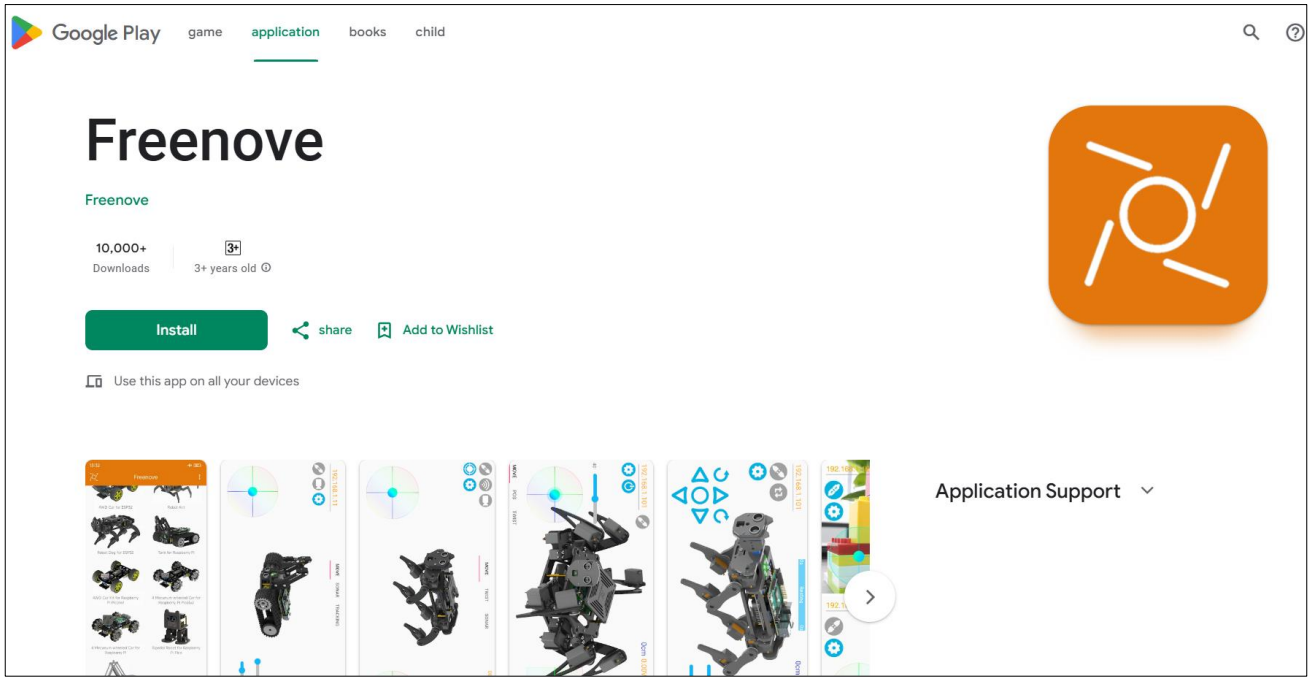
Install Freenove app

There are three ways to install our app.

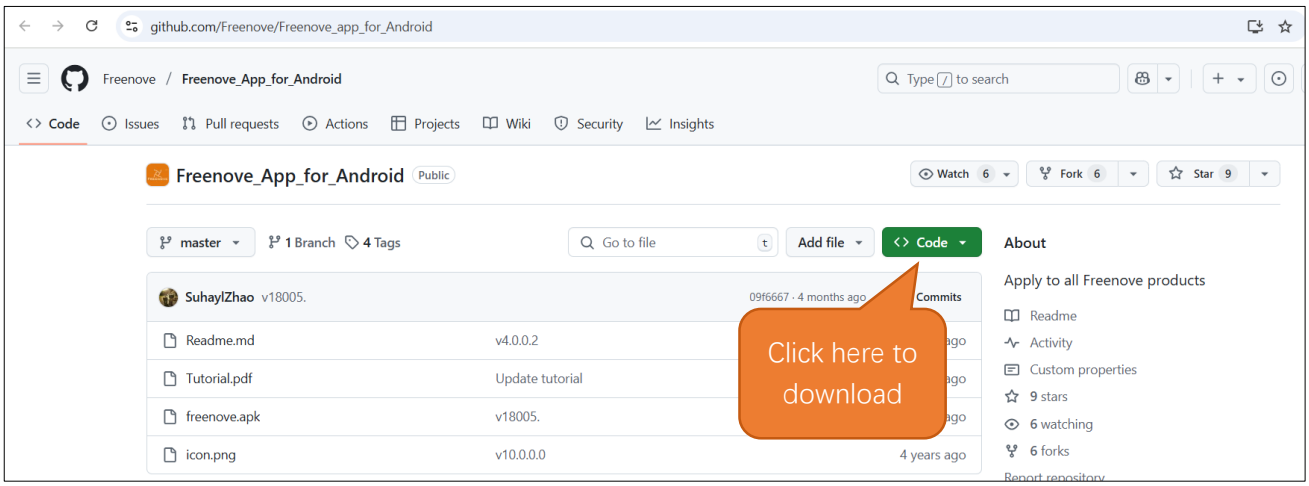
Method 1: Use Google play to search "Freenove", download and install.



Method 2: Visit https://play.google.com/store/apps/details?id=com.freenove.suhayl.Freenove, and click install.

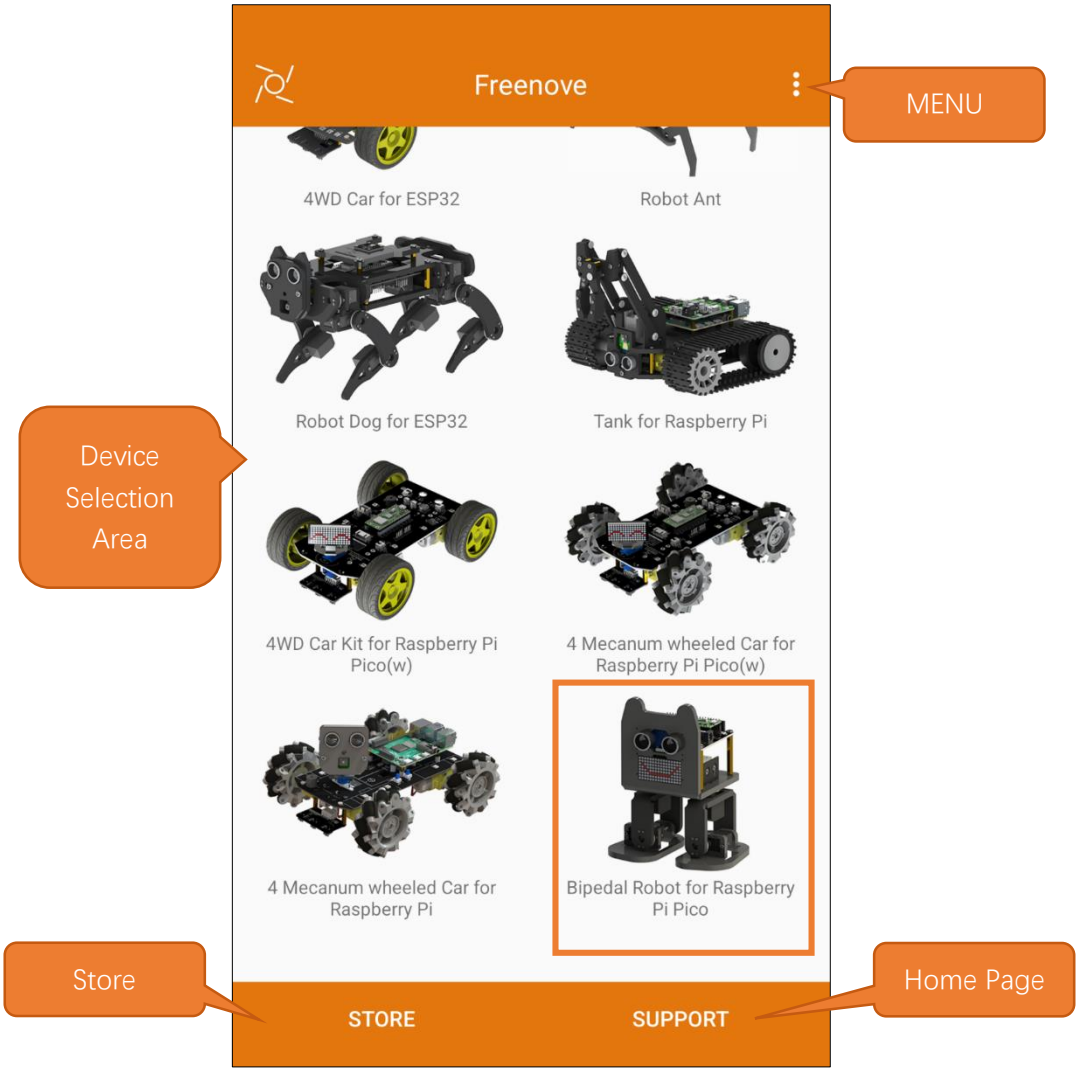


Method 3: Visit https://github.com/Freenove/Freenove_app_for_Android, download the files in this library, and install freenove.apk to your Android phone manually.

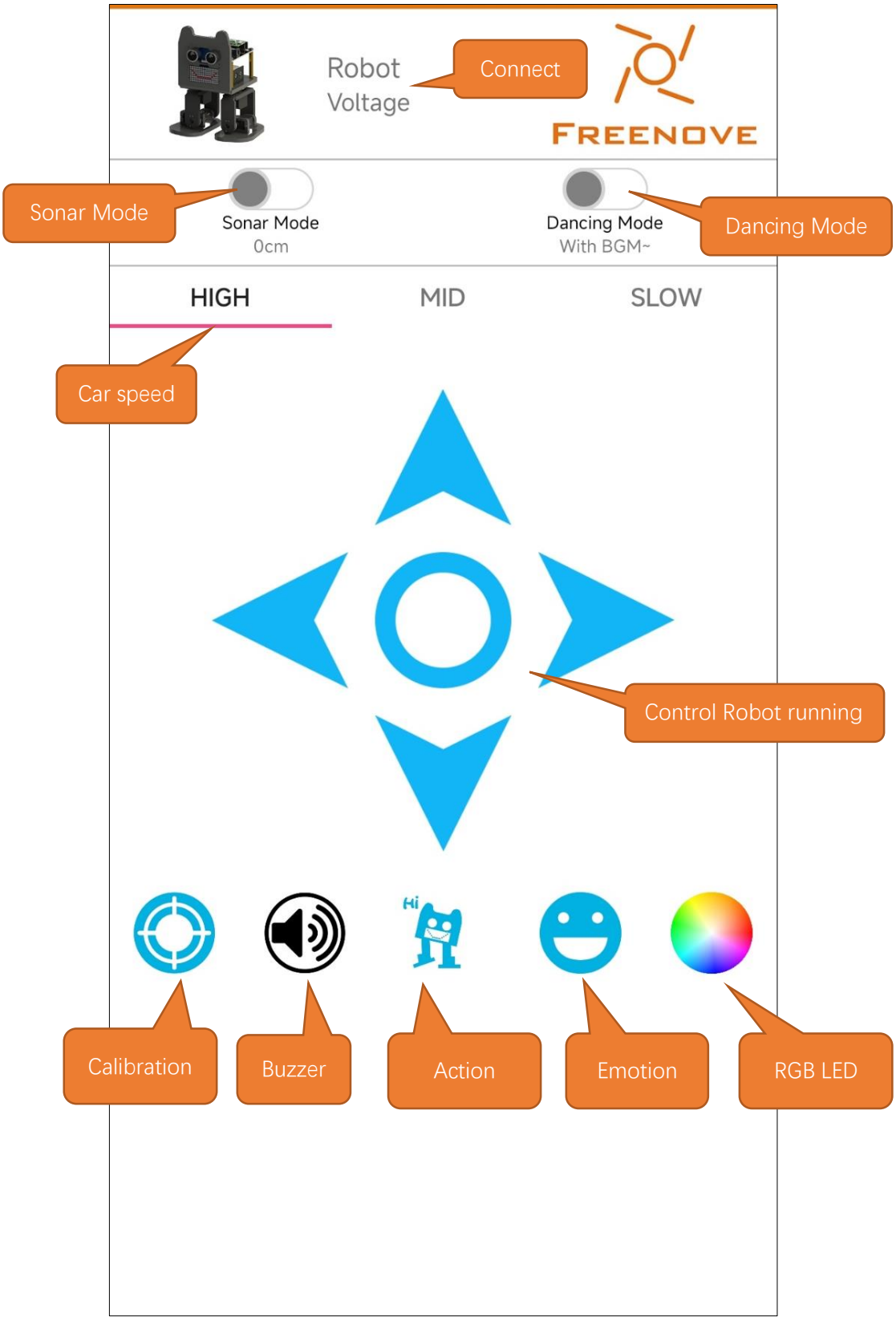


Introduction to the APP

In this chapter, we use the Freenove APP to control the robot. Open the APP on your phone, select "Bipedal Robot for Raspberry Pi Pico".

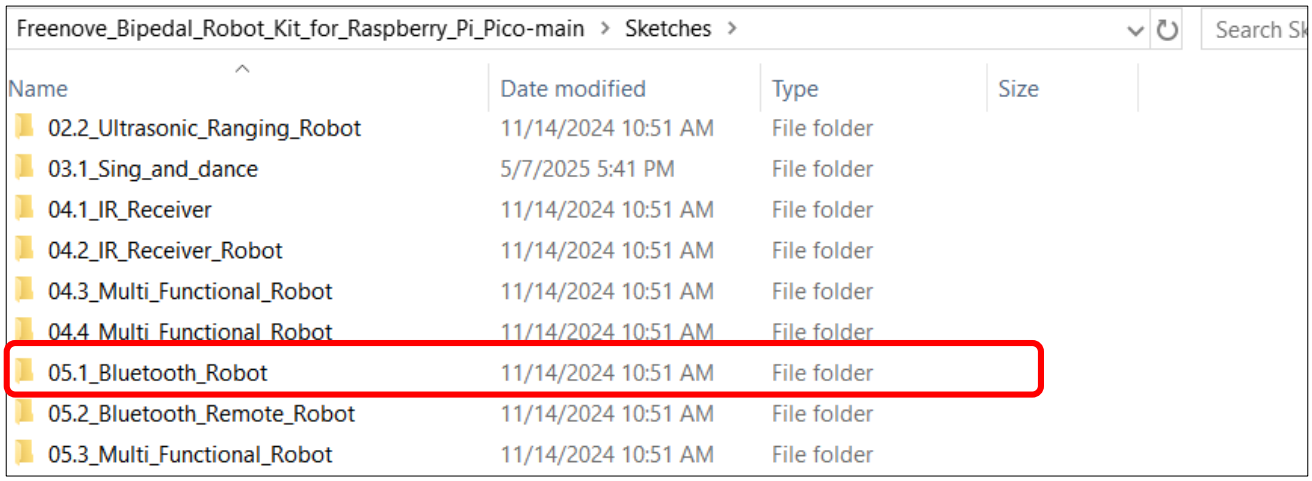


The interface is as shown below. Let's explore its features.



Sketch

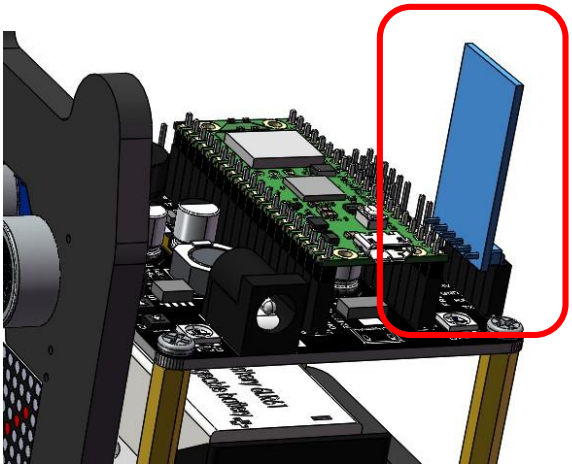
Open the folder “05.1_Bluetooth_Robot” in the **“Freenove_Bipedal_Robot_Kit_for_Raspberry_Pi_Pico\Sketches”** and double click “05.1_Bluetooth_Robot.ino”.



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

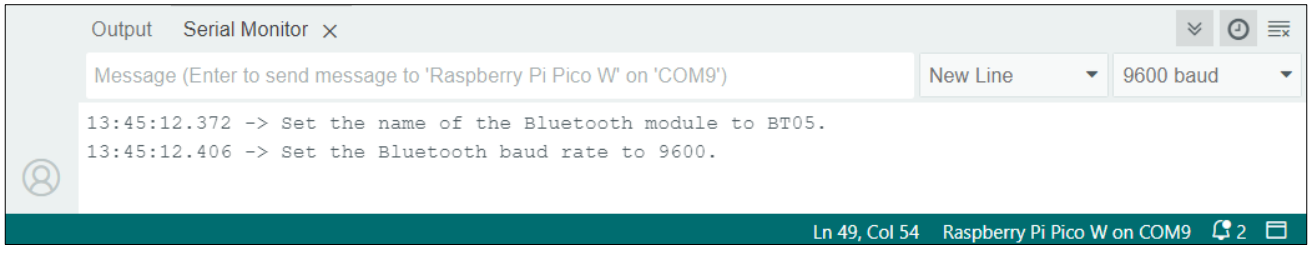
After the code is successfully uploaded, follow the steps below.

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

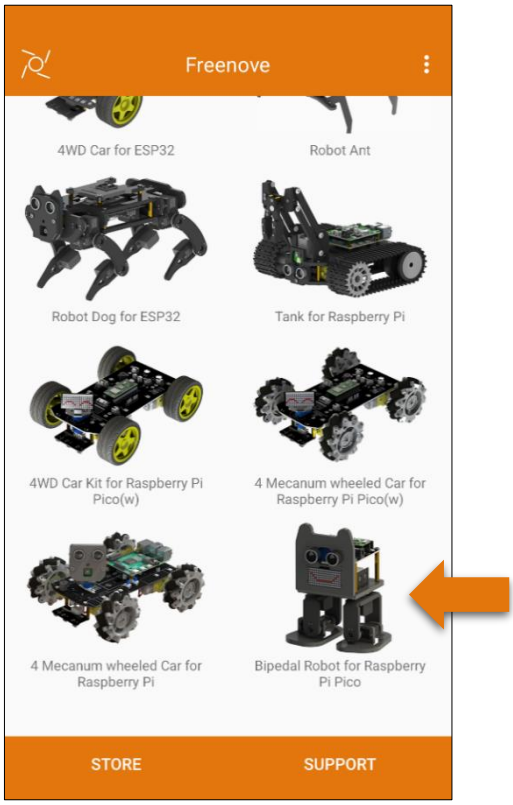


2. Open Arduino Serial Monitor, and reset the control board.

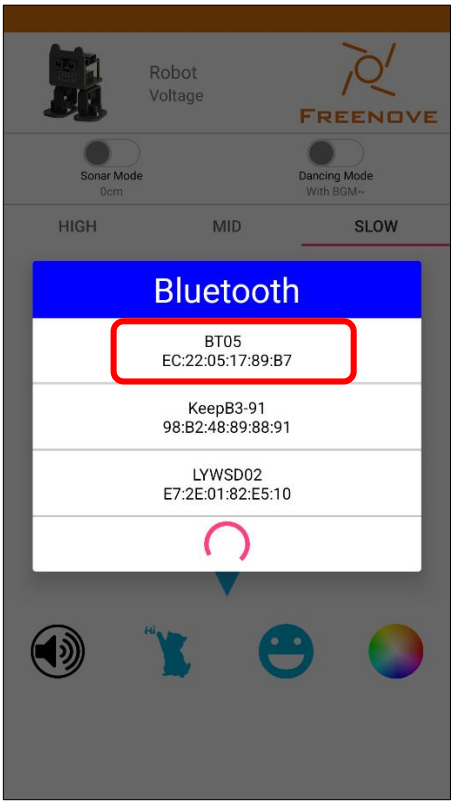
As shown in the figure below, the Bluetooth name is set to “BT05”, and set the baud rate to 9600.



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



Click the following icon and select BT05.



If the connection successes, you can see “Connected”. Operate the app, and observe the serial monitor.

The serial monitor will show contents as below:

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

```
#include <Arduino.h>
#include <SoftwareSerial.h>  // Reference library

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

String inputString = "";    // a String to hold incoming data
bool stringComplete = false;// whether the string is complete
int baudRate[] = {2400, 9600, 19200, 115200};
int baudRateCount = sizeof(baudRate) / sizeof(baudRate[0]);

void receiveStop() {
  delay(10);
  Serial.flush();
}

void setup() {
  Serial.begin(9600);
  delay(2000);
```

```
21    // Loop through each baud rate and send commands
22    for(int i = 0; i < baudRateCount; i++){
23      BTserial.begin(baudRate[i]);
24      delay(200);
25      BTserial.println("AT+NAME=BT05");//Set the radio called Robot
26      delay(200);
27      BTserial.println("AT+ROLE=0");
28      delay(200);
29      BTserial.println("AT+UART=2");//1=2400 2=9600 3=19200 4=115200
30      delay(200);
31
32      //SoftwareSerial does not support dynamic adjustment of baud rate, so close the serial
33      BTserial.end();
34    }
35
36    BTserial.begin(9600);
37    delay(2000);
38
39    SCmd.addDefaultHandler(receiveStop);
40    inputString.reserve(200);
41    Serial.println("Set the name of the Bluetooth module to BT05.");
42    Serial.println("Set the Bluetooth baud rate to 9600.");
43    // Serial.println("Set Bluetooth to slave mode.");
44  }
45
46  void loop() {
47    while (BTserial.available()) {
48      // get the new byte:
49      char inChar = (char)BTserial.read();
50      // add it to the inputString:
51      inputString += inChar;
52      // if the incoming character is a newline, set a flag so the main loop can
53      // do something about it:
54      if (inChar == '\n') {
55        stringComplete = true;
56      }
57      if (stringComplete) {
58        Serial.println(inputString);
59        // clear the string:
60        inputString = "";
61        stringComplete = false;
62      }
63    }
64  }
```

Code Explanation

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

```
21    // Loop through each baud rate and send commands
22    for(int i = 0; i < baudRateCount; i++){
23      BTserial.begin(baudRate[i]);
24      delay(200);
25      BTserial.println("AT+NAME=BT05");//Set the radio called Robot
26      delay(200);
27      BTserial.println("AT+ROLE=0");
28      delay(200);
29      BTserial.println("AT+UART=2");//1=2400 2=9600 3=19200 4=115200
30      delay(200);
31
32      //SoftwareSerial does not support dynamic adjustment of baud rate, so close the serial
33      BTserial.end();
34    }
35
36    BTserial.begin(9600);
37    delay(2000);
38
39    SCmd.addDefaultHandler(receiveStop);
40    inputString.reserve(200);
41    Serial.println("Set the name of the Bluetooth module to BT05.");
42    Serial.println("Set the Bluetooth baud rate to 9600.");
43    // Serial.println("Set Bluetooth to slave mode.");
```

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

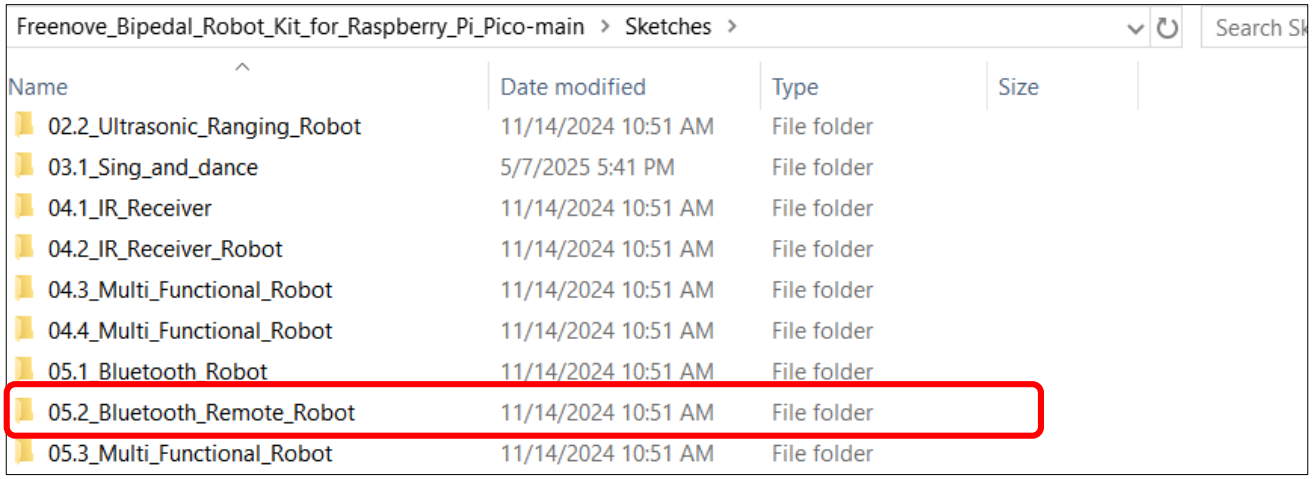
```
47  while (BTserial.available()) {
48      // get the new byte:
49      char inChar = (char)BTserial.read();
50      // add it to the inputString:
51      inputString += inChar;
52      // if the incoming character is a newline, set a flag so the main loop can
53      // do something about it:
54      if (inChar == '\n') {
55        stringComplete = true;
56      }
57      if (stringComplete) {
58        Serial.println(inputString);
59        // clear the string:
60        inputString = "";
61        stringComplete = false;
62      }
63    }
```

5.2 Bluetooth Remote Robot

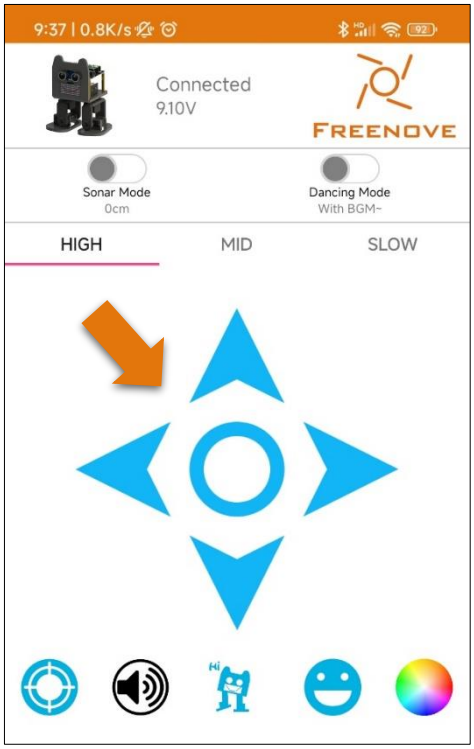
In the previous section, we have learned how to receive the data of the app via Bluetooth, and the meanings of the data format. Next, let's use the data to control the robot to make some basic movements, like moving forward and backward, turning left and right, etc.

Sketch

Open the folder "05.2_Bluetooth_Remote_Robot" in the **"Freenove_Bipedal_Robot_Kit_for_Raspberry_Pi_Pico\Sketches"** and double click "05.2_Bluetooth_Remote_Robot.ino".



Connect the App to the Bluetooth of the robot, and tap the directional keys to control its movements.



Code

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

#include "SerialCommand.h"
SoftwareSerial BTserial = SoftwareSerial(1, 0);  // RX pin to 1 and TX pin to 0 on the board
SerialCommand SCmd(BTserial);
#include "Bipedal_Robot.h"
Bipedal_Robot Bipedal_Robot;

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

int YL;
int YR;
int RL;
int RR;

int T = 1000;
int moveId = 0;
bool isServoResting = true;

extern int moveId;
extern bool isServoResting;

int moveSize = 15;

String inputString = "";    // a String to hold incoming data
bool stringComplete = false;// whether the string is complete
int baudRate[] = {2400, 9600, 19200, 115200};
int baudRateCount = sizeof(baudRate) / sizeof(baudRate[0]);

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

void recieveBuzzer() {
  sendAck();
```

```
43    bool error = false;
44    int frec;
45    int duration;
46    char *arg;
47    arg = SCmd.next();
48    if (arg != NULL) frec = atoi(arg);
49    else error = true;
50    Serial.println("\nfrec is:");
51    Serial.println(frec);
52    Buzzer_Variable(frec, 100, 1);
53    sendFinalAck();
54  }
55
56  void receiveMovement() {
57    sendAck();
58    Serial.print("move loop...");
59    if (Bipedal_Robot.getRestState() == true) Bipedal_Robot.setRestState(false);
60    isServoResting = Bipedal_Robot.getRestState();
61    char *arg;
62    arg = SCmd.next();
63    if (arg != NULL) {
64      moveId = atoi(arg);
65      Serial.print("moveId:");
66      Serial.print(moveId);
67    } else {
68      moveId = 0;
69    }
70    arg = SCmd.next();
71    if (arg != NULL) {
72      T = atoi(arg);
73      if (T == 0) {
74        T = 1000;
75      } else if (T == 1) {
76        T = 1500;
77      } else if (T == 2) {
78        T = 2000;
79      }
80    } else T = 2000;
81    Serial.print("T is:");
82    Serial.print(T);
83    arg = SCmd.next();
84    if (arg != NULL) moveSize = atoi(arg);
85    else moveSize = 15;
86  }
```

```
87  void move(int moveId) {
88    // bool manualMode = false;
89    switch (moveId) {
90      case 0:
91        Bipedal_Robot.home();
92        // Serial.print("moveId 0 home");
93        break;
94      case 1:
95        Bipedal_Robot.walk(1, T, 1);
96        break;
97      case 2:
98        Bipedal_Robot.walk(1, T, -1);
99        break;
100     case 3:
101       Bipedal_Robot.turn(1, T, 1);
102       break;
103     case 4:
104       Bipedal_Robot.turn(1, T, -1);
105       break;
106     default:
107       break;
108   }
109 }
110
111 void sendAck() {
112   delay(10);
113   Serial.flush();
114 }
115 void sendFinalAck() {
116   delay(10);
117   Serial.flush();
118 }
119
120 void setup() {
121   Serial.begin(9600);
122   delay(2000);
123   // Loop through each baud rate and send commands
124   for(int i = 0; i < baudRateCount; i++){
125     BTserial.begin(baudRate[i]);
126     delay(200);
127     BTserial.println("AT+NAME=BT05");//Set the radio called Robot
128     delay(200);
129     BTserial.println("AT+ROLE=0");
130     delay(200);
```

```
131       BTserial.println("AT+UART=2");//1=2400 2=9600 3=19200 4=115200
132       delay(200);
133
134       //SoftwareSerial does not support dynamic adjustment of baud rate, so close the serial
135       BTserial.end();
136     }
137
138     BTserial.begin(9600);
139     delay(1500);
140     Buzzer_Setup();  //Initialize the buzzer
141     EEPROM.begin(512);
142     Bipedal_Robot.init(LeftLeg, RightLeg, LeftFoot, RightFoot, true);  //Set the servo pins and
143 Buzzer pin
144
145     YL = EEPROM.read(0);
146     if (YL > 128) YL -= 256;
147     YR = EEPROM.read(1);
148     if (YR > 128) YR -= 256;
149     RL = EEPROM.read(2);
150     if (RL > 128) RL -= 256;
151     RR = EEPROM.read(3);
152     if (RR > 128) RR -= 256;
153     Bipedal_Robot.setTrims(YL, YR, RL, RR);
154     calib_homePos();
155     Bipedal_Robot.saveTrimsOnEEPROM();
156     Bipedal_Robot.home();
157     delay(100);
158     EEPROM.commit();
159     SCmd.addCommand("S", receiveStop);
160     SCmd.addCommand("D", recieveBuzzer);
161     SCmd.addCommand("A", receiveMovement);
162
163     inputString.reserve(200);
164     SCmd.addDefaultHandler(receiveStop);
165     Serial.println("Set the name of the Bluetooth module to BT05.");
166     Serial.println("Set the Bluetooth baud rate to 9600.");
167     Bipedal_Robot.home();
168 }
169
170 void loop() {
171     SCmd.readSerial();
172     move(moveId);
173 }
174
```

```
175 void calib_homePos() {
176   int servoPos[4];
177   servoPos[0] = 90;
178   servoPos[1] = 90;
179   servoPos[2] = 90;
180   servoPos[3] = 90;
181   Bipedal_Robot._moveServos(500, servoPos);
182   Bipedal_Robot.detachServos();
183 }
```

Code Explanation

Add the header files to drive the robot.

```
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"
```

Upon receiving movement commands, the robot makes corresponfing actions.

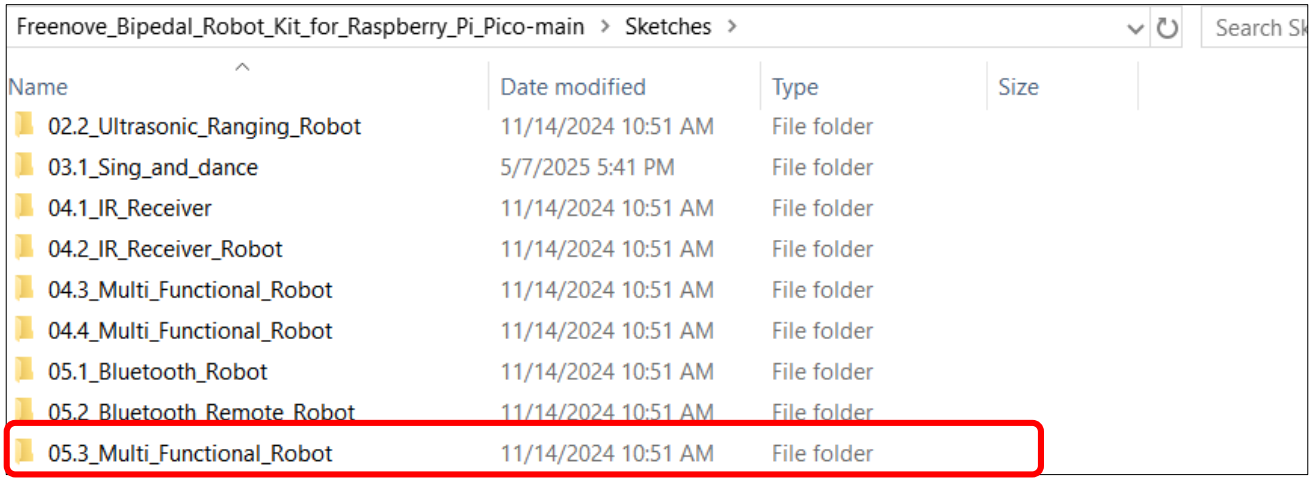
```
87  void move(int moveId) {
88    // bool manualMode = false;
89    switch (moveId) {
90      case 0:
91        Bipedal_Robot.home();
92        // Serial.print("moveId 0 home");
93        break;
94      case 1:
95        Bipedal_Robot.walk(1, T, 1);
96        break;
97      case 2:
98        Bipedal_Robot.walk(1, T, -1);
99        break;
100     case 3:
101       Bipedal_Robot.turn(1, T, 1);
102       break;
103     case 4:
104       Bipedal_Robot.turn(1, T, -1);
105       break;
106     default:
107       break;
108   }
109 }
```

5.3 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.

Sketch

Open the folder "05.3_Multi_Functional_Robot" in the **"Freenove_Bipedal_Robot_Kit_for_Raspberry_Pi_Pico\Sketches"** and double click "05.3_Multi_Functional_Robot.ino".

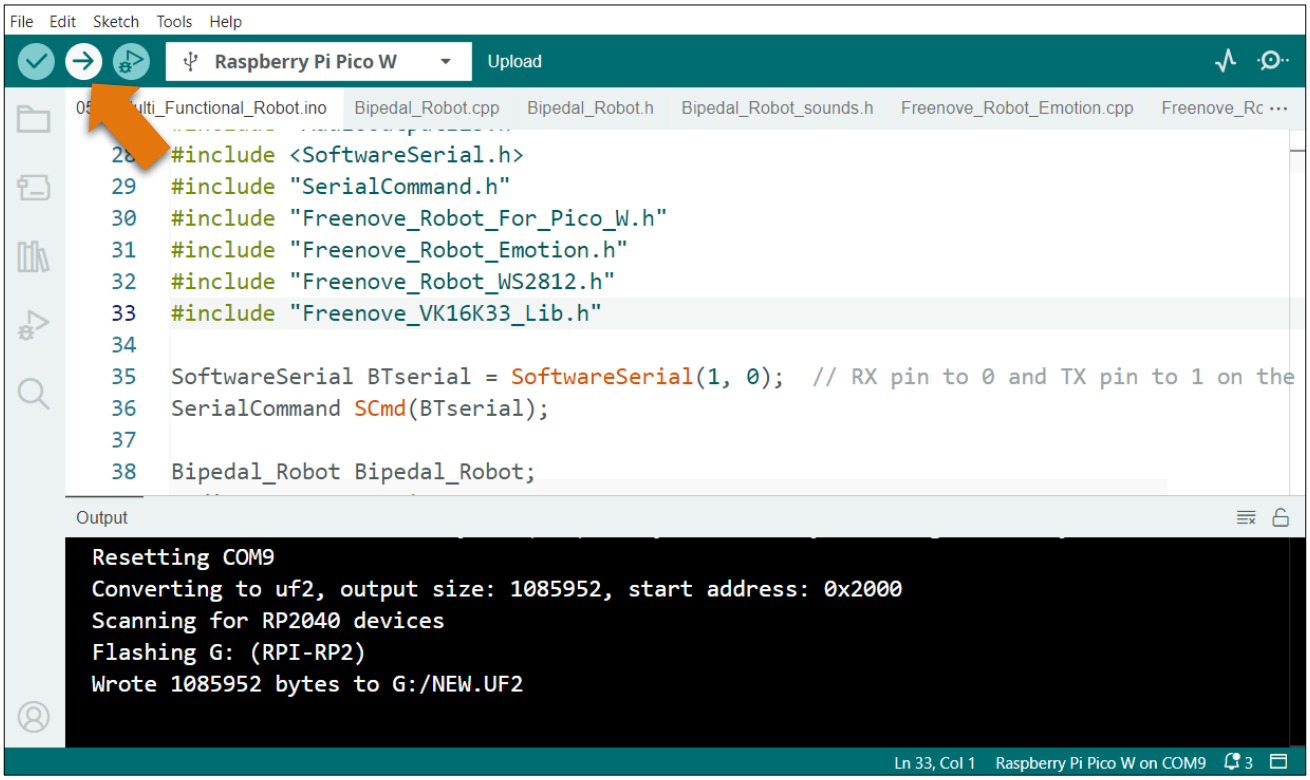


Connect the robot to your computer with the USB cable.

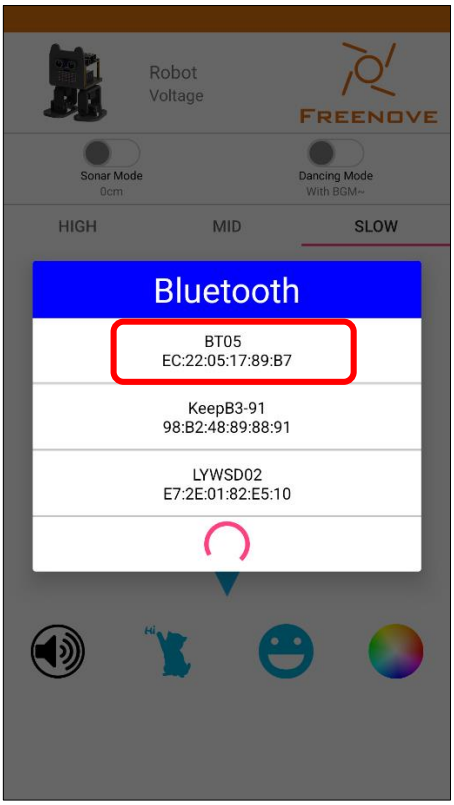
As this section involves the audio playing function, please upload the audio data to the Raspberry Pi Pico (W) before uploading sketch. You can find the detailed steps here.

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



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 the following icon and select 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 turns off all LED displays.
Mode 1 displays the selected color of the current color picker for all LEDs.
Mode 2 is a flowing water LED with color changing.
Mode 3 is a color-adjustable Blink.
Mode 4 is a breathing light effect with adjustable color.
Mode 5 is a flowing rainbow.

Code

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

```
#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;

String inputString = "";    // a String to hold incoming data
bool stringComplete = false;// whether the string is complete
int baudRate[] = {2400, 9600, 19200, 115200};
int baudRateCount = sizeof(baudRate) / sizeof(baudRate[0]);

#define ACTION_GET_VOLTAGE 'P'
#define ACTION_GET_DISTANCE 'E'
#define INTERVAL_CHAR '#'
unsigned long lastUploadVoltageTime;
unsigned long lastUploadDistanceTime;
#define UPLOAD_VOL_TIME 2000

int Resting = 0;
float Distance = 0;

// int calibratePosition[4] = { -17, -10, -15, 12 };
// int YL;
// int YR;
// int RL;
// int RR;

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

void upLoadDistanceToApp() {
  Distance = Get_Sonar();
  BTserial.print("E#");
```

```
77    BTserial.println(Distance);
78  }
79
80  void receiveStop() {
81    sendAck();
82    sendFinalAck();
83  }
84
85  void recieveBuzzer() {
86    sendAck();
87    moveId = 0;
88    playsong = 0;
89    bool error = false;
90    int frec;
91    char *arg;
92    arg = SCmd.next();
93    if (arg != NULL) frec = atoi(arg);
94    else error = true;
95    tone(2, frec);
96    sendFinalAck();
97  }
98
99  void receiveAvoid() {
100   sendAck();
101   ws2812_task_mode = 0;
102   emotion_task_mode = 0;
103   if (Bipedal_Robot.getRestState() == true) Bipedal_Robot.setRestState(false);
104   isServoResting = Bipedal_Robot.getRestState();
105   char *arg;
106   arg = SCmd.next();
107   if (arg != NULL) {
108     ultrasonicavoidMode = atoi(arg);
109     playsong = 0;
110     if (ultrasonicavoidMode == 1) {
111       moveId = 21;
112       Ultrasonic_Avoid_steps = 0;
113       playsong = 0;
114     }
115     if (ultrasonicavoidMode == 2) {
116       dance_steps = 0;
117       moveId = 22;
118       playsong = 4;
119     }
120     if (ultrasonicavoidMode == 0) {
```

```
121         moveId = 0;
122         Resting = 1;
123         playsong = 0;
124       }
125     }
126     sendFinalAck();
127 }
128 
129 void receiveEmotion() {
130     sendAck();
131     Emotion_Setup();
132     moveId = 0;
133     playsong = 0;
134     char *arg;
135     char *endstr;
136     arg = SCmd.next();
137     if (arg != NULL) {
138       String stringOne = String(arg);  // converting a constant char into a String
139       emotion_task_mode = stringOne.toInt();
140       Emotion_SetMode(emotion_task_mode);  //显示静态表情
141     } else {
142     }
143     sendFinalAck();
144 }
145 
146 void receiveLED() {
147     sendAck();
148     moveId = 0;
149     playsong = 0;
150     char *arg;
151     unsigned char paramters[3];
152     char *endstr;
153     arg = SCmd.next();
154     if (arg != NULL) {
155       String stringOne = String(arg);  // converting a constant char into a String
156       ws2812_task_mode = stringOne.toInt();
157     } else {
158     }
159     arg = SCmd.next();
160     String stringOne1 = String(arg);
161     paramters[0] = stringOne1.toInt();
162 
163     arg = SCmd.next();
164     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;  //play music  Hello.mp3
    } else if (playsong == 2) {
      moveId = 19;  //play music  Nicetomeetyou.mp3
    } else if (playsong == 3) {
      moveId = 20;  //play music  goodbye.mp3
      Serial.print("yundong");
    } else if (playsong == 0) {
      moveId = 0;
```

```
209       }
210       Serial.print("moveId:");
211       Serial.print(moveId);
212     } else {
213       moveId = 0;
214       Resting = 1;
215     }
216   }
217
218   void playmusic(int playtimes, int song) {
219     if (playtimes--) {
220       if (song == 1) {
221         file = new AudioFileSourceLittleFS("Hello.mp3");
222       } else if (song == 2) {
223         file = new AudioFileSourceLittleFS("Nicetomeetyou.mp3");
224       } else if (song == 3) {
225         file = new AudioFileSourceLittleFS("goodbye.mp3");
226       } else if (song == 4) {
227         file = new AudioFileSourceLittleFS("1.mp3");
228       } else if (song == 5) {
229         file = new AudioFileSourceLittleFS("onfoot.mp3");
230       } else if (song == 6) {
231         file = new AudioFileSourceLittleFS("hello_cn.mp3");
232       } else if (song == 0) {
233         file = new AudioFileSourceLittleFS("split.mp3");
234       }
235       out = new AudioOutputI2SNoDAC(6);
236       out->SetGain(4.0);  //Volume Setup (0-4.0)
237       mp3 = new AudioGeneratorMP3();
238       mp3->begin(file, out);
239       if (mp3->isRunning() && song > 0) {
240         if (!mp3->loop() && song > 0) {
241           delete file;
242           delete mp3;
243           out->flush();
244           out->stop();
245         }
246       } else {
247         delete file;
248         delete mp3;
249         out->flush();
250         out->stop();
251         pinMode(6, OUTPUT);
252         digitalWrite(6, LOW);
```

```
253       }
254     }
255   }
256
257   //Ultrasonic robot
258   void Ultrasonic_Avoid() {
259     if (Distance <= 15) {
260       Bipedal_Robot.walk(2, 1000, -1);  // BACKWARD x2
261       Bipedal_Robot.turn(3, 1000, -1);  // LEFT x3
262     }
263     Bipedal_Robot.walk(1, 1500, 1);  // FORWARD x1
264   }
265
266   void dance() {
267     dance_steps = dance_steps + 1;
268     staticEmtions(21);
269     if (moveId > 0) {
270       switch (dance_steps) {
271         case 0:
272           dance_steps = 0;
273           break;
274         case 1:
275           Bipedal_Robot.jitter(1, 750, 20);
276           break;
277         case 2:
278           Bipedal_Robot.jitter(1, 750, 20);
279           break;
280         case 3:
281           Bipedal_Robot.crusaito(1, 800, 30, 1);
282           break;
283         case 4:
284           Bipedal_Robot.crusaito(1, 800, 30, -1);
285           break;
286         case 5:
287           Bipedal_Robot.crusaito(1, 800, 30, 1);
288           Bipedal_Robot.home();
289           delay(300);
290           break;
291         case 6:
292           Bipedal_Robot.walk(1, 1500, -1);
293           break;
294         case 7:
295           Bipedal_Robot.walk(1, 1000, 1);
296           break;
```

```
297         case 8:
298           Bipedal_Robot.walk(1, 1000, 1);
299           Bipedal_Robot.home();
300           break;
301         case 9:
302           Bipedal_Robot.moonwalker(1, 600, 30, 1);
303           break;
304         case 10:
305           Bipedal_Robot.moonwalker(1, 600, 30, -1);
306           break;
307         case 11:
308           Bipedal_Robot.moonwalker(1, 600, 30, 1);
309           break;
310         case 12:
311           Bipedal_Robot.moonwalker(1, 600, 30, -1);
312           Bipedal_Robot.home();
313           delay(100);
314           break;
315         case 13:
316           Bipedal_Robot.walk(1, 1500, -1);
317           Bipedal_Robot.home();
318           delay(100);
319           break;
320       }
321       if (dance_steps > 14) {
322         dance_steps = 0;
323       }
324     } else {
325       Resting = 1;
326       moveId = 0;
327       dance_steps = 0;
328     }
329   }
330
331   void receiveMovement() {
332     sendAck();
333     ws2812_task_mode = 0;
334     emotion_task_mode = 0;
335     if (Bipedal_Robot.getRestState() == true) Bipedal_Robot.setRestState(false);
336     isServoResting = Bipedal_Robot.getRestState();
337     char *arg;
338     arg = SCmd.next();
339     if (arg != NULL) {
340       moveId = atoi(arg);
```

```
341       if (moveId == 0) {
342         Resting = 1;
343       }
344     } else {
345       moveId = 0;
346     }
347     arg = SCmd.next();
348     if (arg != NULL) {
349       T = atoi(arg);
350       if (T == 0) {
351         T = 1000;
352       } else if (T == 1) {
353         T = 1500;
354       } else if (T == 2) {
355         T = 2000;
356       }
357     } else T = 2000;
358     Serial.print("T is:");
359     Serial.print(T);
360     arg = SCmd.next();
361     if (arg != NULL) moveSize = atoi(arg);
362     else moveSize = 15;
363   }
364
365   void move(int movemode) {
366     // bool manualMode = false;
367     switch (movemode) {
368       case 0:
369         Bipedal_Robot.home();
370         if (Resting == 1) {
371           Bipedal_Robot.setRestState(false);
372           Bipedal_Robot.home();
373           Resting = 0;
374         }
375         break;
376       case 1:
377         staticEmtions(21);
378         Bipedal_Robot.walk(1, T, 1);
379         break;
380       case 2:
381         staticEmtions(21);
382         Bipedal_Robot.walk(1, T, -1);
383         break;
384       case 3:
```

```
385         staticEmtions(21);
386         Bipedal_Robot.turn(1, T, 1);
387         break;
388       case 4:
389         staticEmtions(21);
390         Bipedal_Robot.turn(1, T, -1);
391         break;
392       case 5:
393         Bipedal_Robot.updown(1, 2000, 30);
394         break;
395       case 6: Bipedal_Robot.moonwalker(1, T, moveSize, 1); break;
396       case 7: Bipedal_Robot.moonwalker(1, T, moveSize, -1); break;
397       case 8: Bipedal_Robot.swing(1, T, moveSize); break;
398       case 9: Bipedal_Robot.crusaito(1, T, moveSize, 1); break;
399       case 10: Bipedal_Robot.crusaito(1, T, moveSize, -1); break;
400       case 11: Bipedal_Robot.jump(1, T); break;
401       case 12: Bipedal_Robot.flapping(1, T, moveSize, 1); break;
402       case 13: Bipedal_Robot.flapping(1, T, moveSize, -1); break;
403       case 14: Bipedal_Robot.tiptoeSwing(1, T, moveSize); break;
404       case 15: Bipedal_Robot.bend(1, T, 1); break;
405       case 16: Bipedal_Robot.bend(1, T, -1); break;
406       case 17: Bipedal_Robot.shakeLeg(1, T, 1); break;
407       case 18:
408         staticEmtions(21);
409         Bipedal_Robot.swing(1, 1100, 50);
410         Bipedal_Robot.home();
411         Resting = 1;
412         moveId = 0;
413         clearEmtions();
414         break;
415       case 19:
416         staticEmtions(22);
417         Bipedal_Robot.moonwalker(1, 1550, 50, 1);  //1541
418         Bipedal_Robot.home();
419         Resting = 1;
420         moveId = 0;
421         clearEmtions();
422         break;
423       case 20:
424         staticEmtions(23);
425         Bipedal_Robot.ascendingTurn(2, 700, 12);  //1332
426         clearEmtions();
427         delay(100);
428         Bipedal_Robot.home();
```

```
429         Resting = 1;
430         moveId = 0;
431         break;
432       case 21:
433         Ultrasonic_Avoid();
434         break;
435       case 22:
436         dance();
437         break;
438       default:
439         break;
440     }
441 }
442
443 void sendAck() {
444   delay(5);
445   Serial.flush();
446 }
447 void sendFinalAck() {
448   delay(5);
449   Serial.flush();
450 }
451
452 void calib_homePos() {
453   int servoPos[4];
454   servoPos[0] = 90;
455   servoPos[1] = 90;
456   servoPos[2] = 90;
457   servoPos[3] = 90;
458   Bipedal_Robot._moveServos(500, servoPos);
459   Bipedal_Robot.detachServos();
460 }
461
462 void setup() {
463   Serial.begin(9600);
464   delay(2000);
465   // Loop through each baud rate and send commands
466   for(int i = 0; i < baudRateCount; i++){
467     BTserial.begin(baudRate[i]);
468     delay(200);
469     BTserial.println("AT+NAME=BT05");//Set the radio called Robot
470     delay(200);
471     BTserial.println("AT+ROLE=0");
472     delay(200);
```

```
473       BTserial.println("AT+UART=2");//1=2400 2=9600 3=19200 4=115200
474       delay(200);
475
476       //SoftwareSerial does not support dynamic adjustment of baud rate, so close the serial
477       BTserial.end();
478     }
479
480     BTserial.begin(9600);
481     delay(1500);
482     EEPROM.begin(512);                                                    //Initialize
483   the ultrasonic module
484     Bipedal_Robot.init(LeftLegPin, RightLegPin, LeftFootPin, RightFootPin, true);  //Set the
485   servo pins
486     Bipedal_Robot.Buzzer_init(BuzzerPin);
487
488     Bipedal_Robot.saveTrimsOnEEPROM();
489     Bipedal_Robot.home();
490     delay(50);
491     Buzzer_Setup();  //Initialize the buzzer
492     WS2812_Setup();  //WS2812 initialization
493     Emotion_Setup();
494     Ultrasonic_Setup();
495
496     SCmd.addCommand("S", receiveStop);
497     SCmd.addCommand("C", receiveLED);
498     SCmd.addCommand("D", recieveBuzzer);
499     SCmd.addCommand("A", receiveMovement);
500     SCmd.addCommand("B", receiveEmotion);
501     SCmd.addCommand("H", receiveAvoid);
502     SCmd.addCommand("M", receiveMusic);
503
504     inputString.reserve(200);
505     SCmd.addDefaultHandler(receiveStop);
506     Serial.println("Set the name of the Bluetooth module to BT05.");
507     Serial.println("Set the Bluetooth baud rate to 9600.");
508   }
509
510   void loop() {
511     SCmd.readSerial();
512     Emotion_Detection();
513     WS2812_Show(ws2812_task_mode);  //Car color lights display function
514     if (millis() - lastUploadVoltageTime > UPLOAD_VOL_TIME) {
515       upLoadVoltageToApp();
516       lastUploadVoltageTime = millis();
```

```
517     }
518     if (millis() - lastUploadDistanceTime > 200) {
519       if (ultrasonicavoidMode == 1) {
520         upLoadDistanceToApp();
521       }
522       lastUploadDistanceTime = millis();
523     }
524     if (Check_Module_value == MATRIX_IS_EXIST) {
525       Emotion_Show(emotion_task_mode);  //Led matrix display function
526     }
527     move(moveId);
528   }
529
530   void setup1() {
531     delay(2000);
532     playmusic(1, 2);
533     pinMode(6, OUTPUT);
534     digitalWrite(6, LOW);
535   }
536   void loop1() {
537     songmusic();
538   }
```

Code Explanation

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

```
510   void loop() {
511     SCmd.readSerial();
512     Emotion_Detection();
513     WS2812_Show(ws2812_task_mode);  //Car color lights display function
514     if (millis() - lastUploadVoltageTime > UPLOAD_VOL_TIME) {
515       upLoadVoltageToApp();
516       lastUploadVoltageTime = millis();
517     }
518     if (millis() - lastUploadDistanceTime > 200) {
519       if (ultrasonicavoidMode == 1) {
520         upLoadDistanceToApp();
521       }
522       lastUploadDistanceTime = millis();
523     }
524     if (Check_Module_value == MATRIX_IS_EXIST) {
525       Emotion_Show(emotion_task_mode);  //Led matrix display function
526     }
527     move(moveId);
```

```
528 }
```

Bluetooth command

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
M#parm1	Audio playing command
H#parm1	Ultrasonic obstacle avoidance mode or dance mode
Send battery data every 25s	Send the battery level to the APP. Format: P#Battery voltage
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.

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