Internet of Things

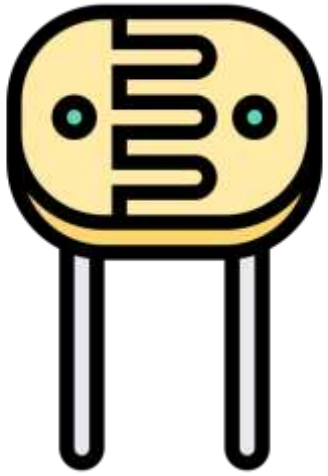
Raspberry Pi & Arduino Serial Communication

Abdallah El Ghamry

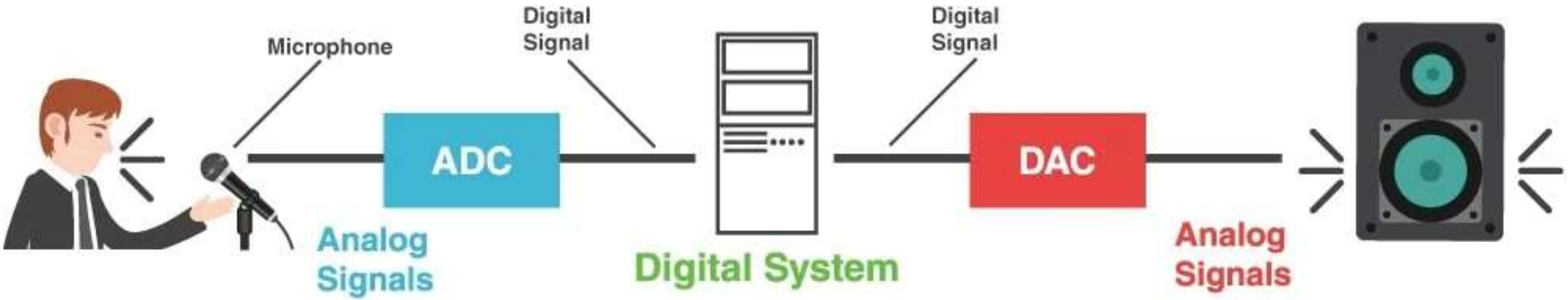
Sensors

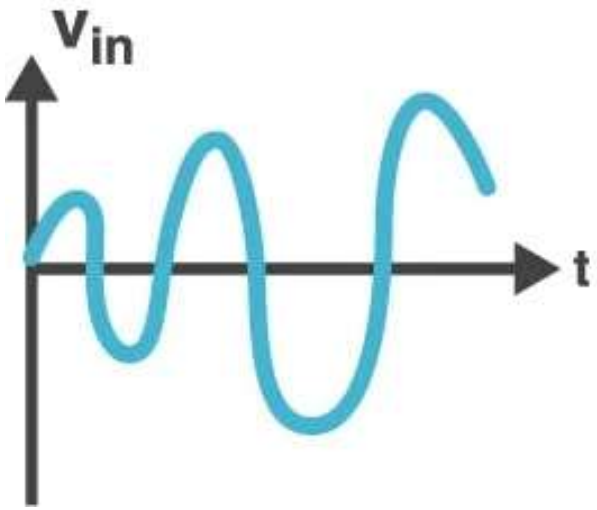
- A sensor is a device that detects some type of input from the physical environment.
- The input can be light, heat, motion, pressure or any number of other environmental phenomena.



ADC vs. DAC


Microphone
Digital Signal
Digital Signal
ADC
DAC
Analog Signals
Digital System
Analog Signals


Vin
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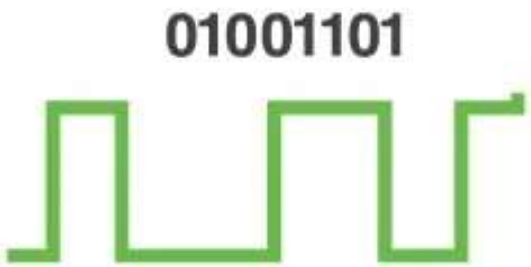
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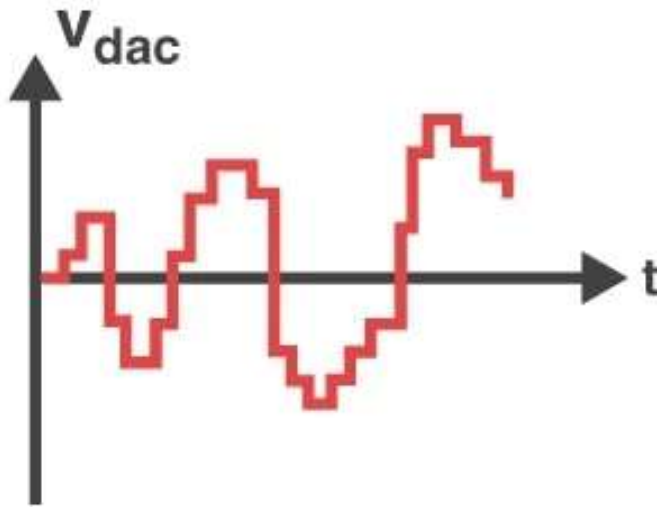

Vdac
t

Read Analog Voltage

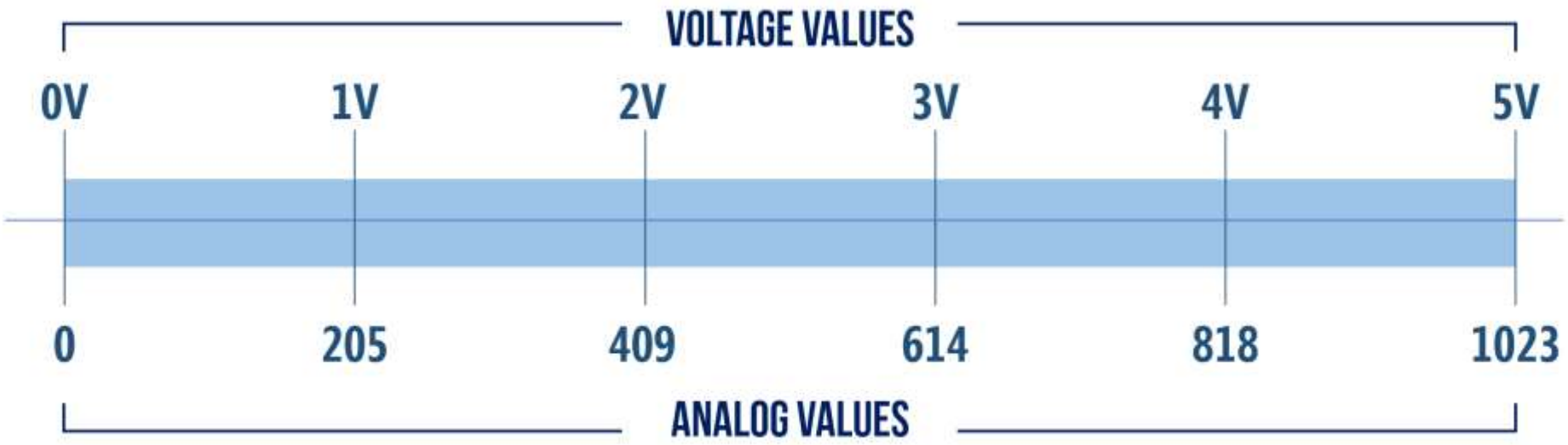
- The microcontroller of the board has a circuit inside called an analog-to-digital converter (ADC) that reads this changing voltage and converts it to a number between 0 and 1023.
- The ADC in Arduino is 10-bit.

0	0	0	0	0	0	0	0	0	0	0V
1	1	1	1	1	1	1	1	1	1	5V

Read Analog Voltage

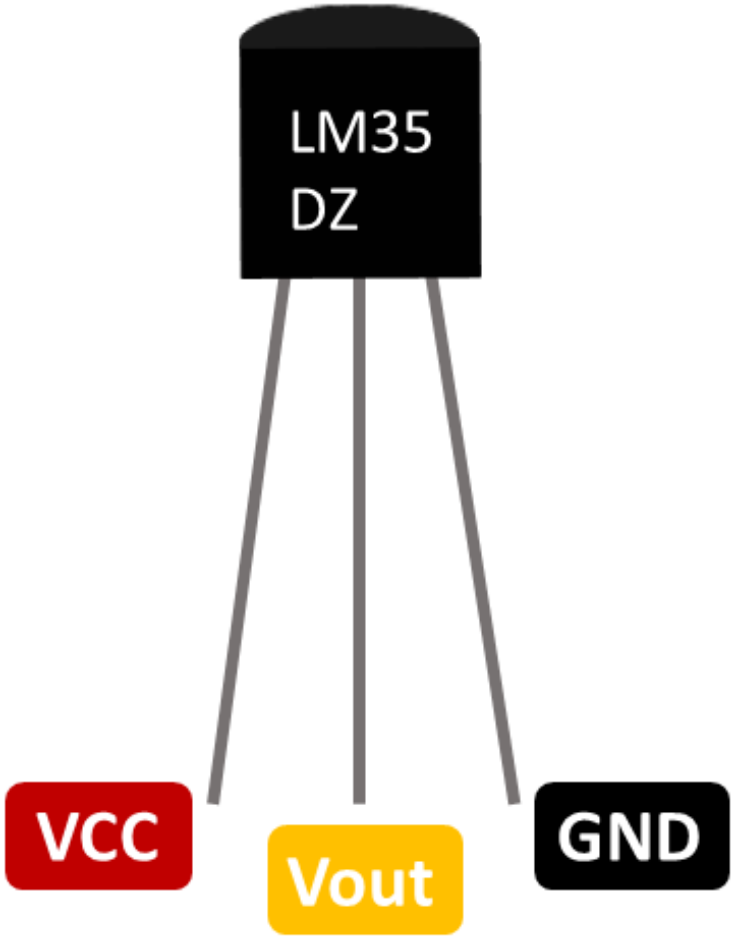
- The `analogRead()` returns a number between 0 and 1023 that is proportional to the amount of voltage being applied to the pin.
- To scale the numbers between 0 and 5, divide 5 by 1023 and multiply that by `sensorValue` :

```
voltage = sensorValue * (5.0 / 1023.0);
```



LM35 Temperature Sensor

- The LM35 sensor is an analog temperature sensor.
- The LM35 can measure temperature in the range of -55°C to 150°C.



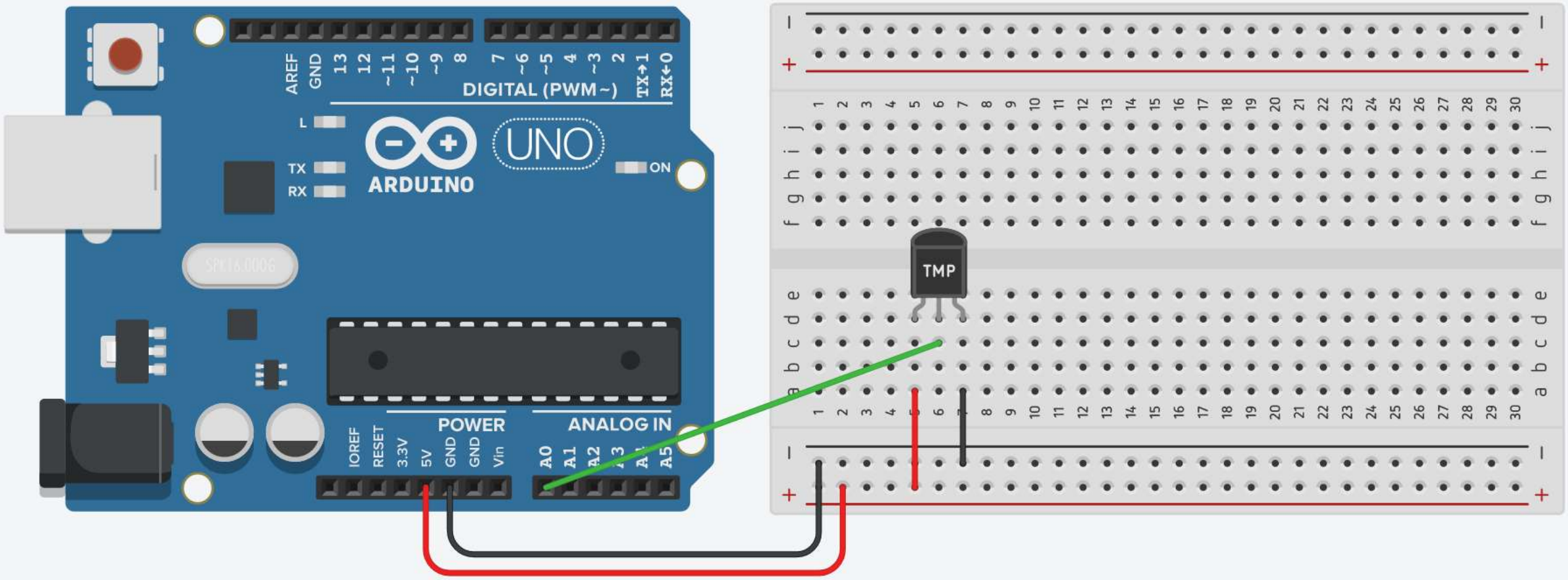
LM35 Temperature Sensor: Specifications

Criteria	Description
Power supply	4V to 30V
Temperature Range	−55°C to +155°C
Accuracy	±0.5°C
Output Scale Factor	10mV/°C
Output at 25°C	250mV

LM35 Temperature Sensor: Components

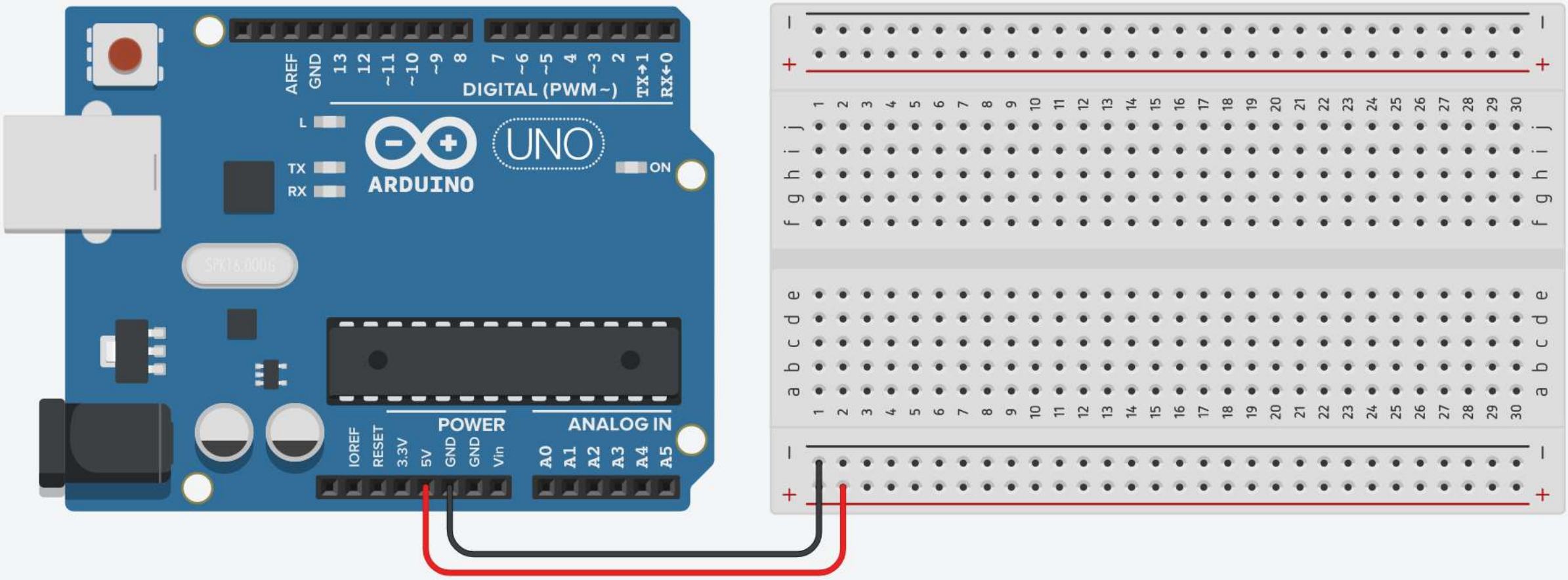
- You need
  - Arduino
  - LM35 Sensor
  - Jumpers
  - Breadboard

LM35 Temperature Sensor: Circuit



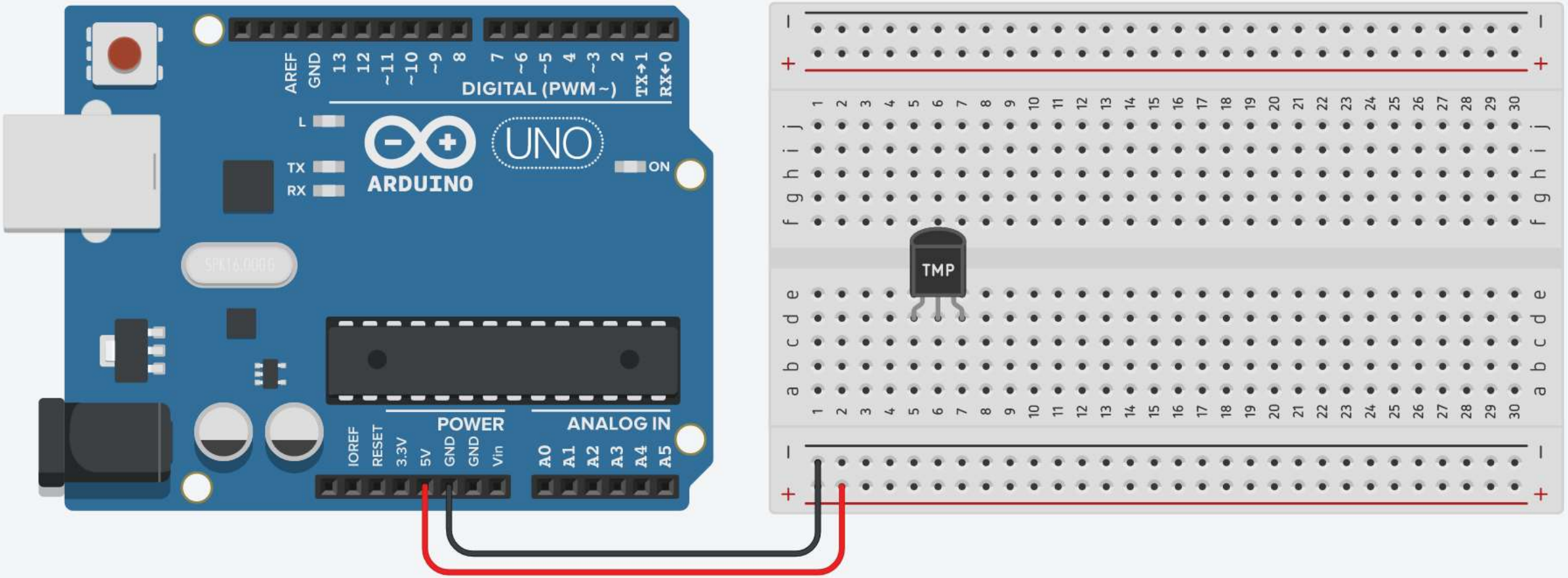
LM35 Temperature Sensor: Steps

1. Connect breadboard power (+) and ground (-) rails to Arduino 5V and ground (GND), respectively.



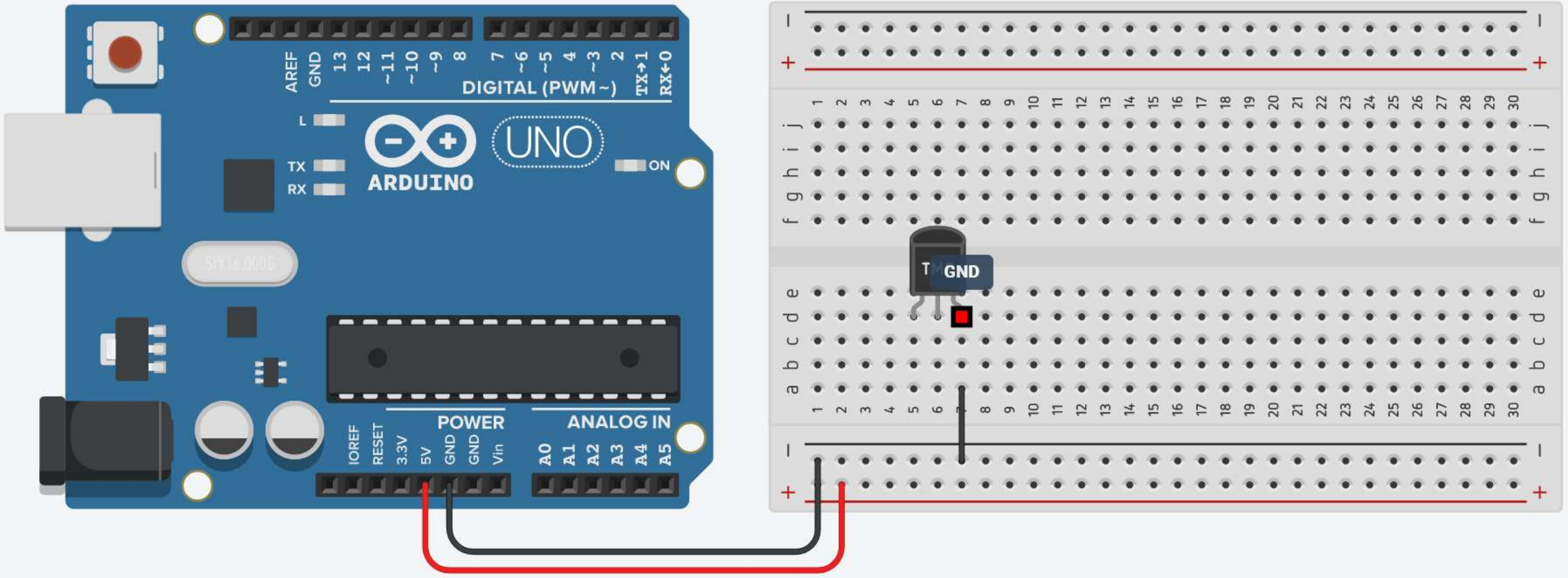
LM35 Temperature Sensor: Steps

2. Plug the LM35 sensor into the breadboard.



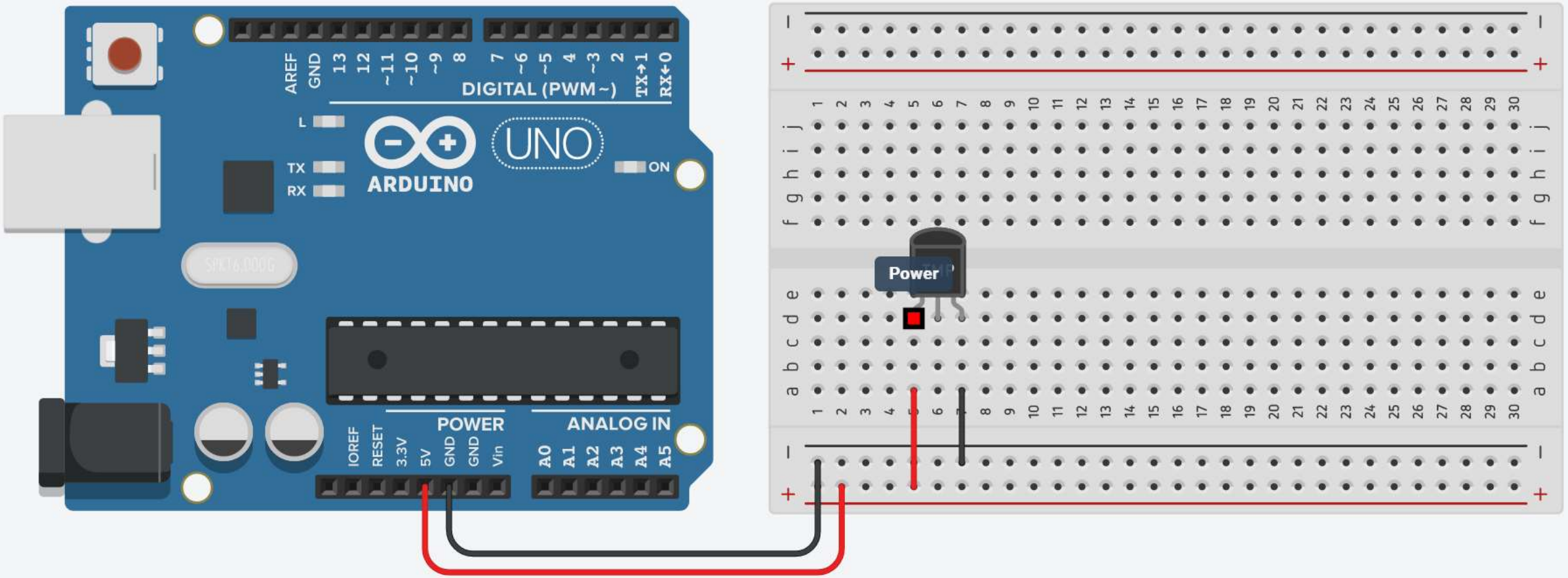
LM35 Temperature Sensor: Steps

3. The sensor GND pin connects to the ground on Arduino.



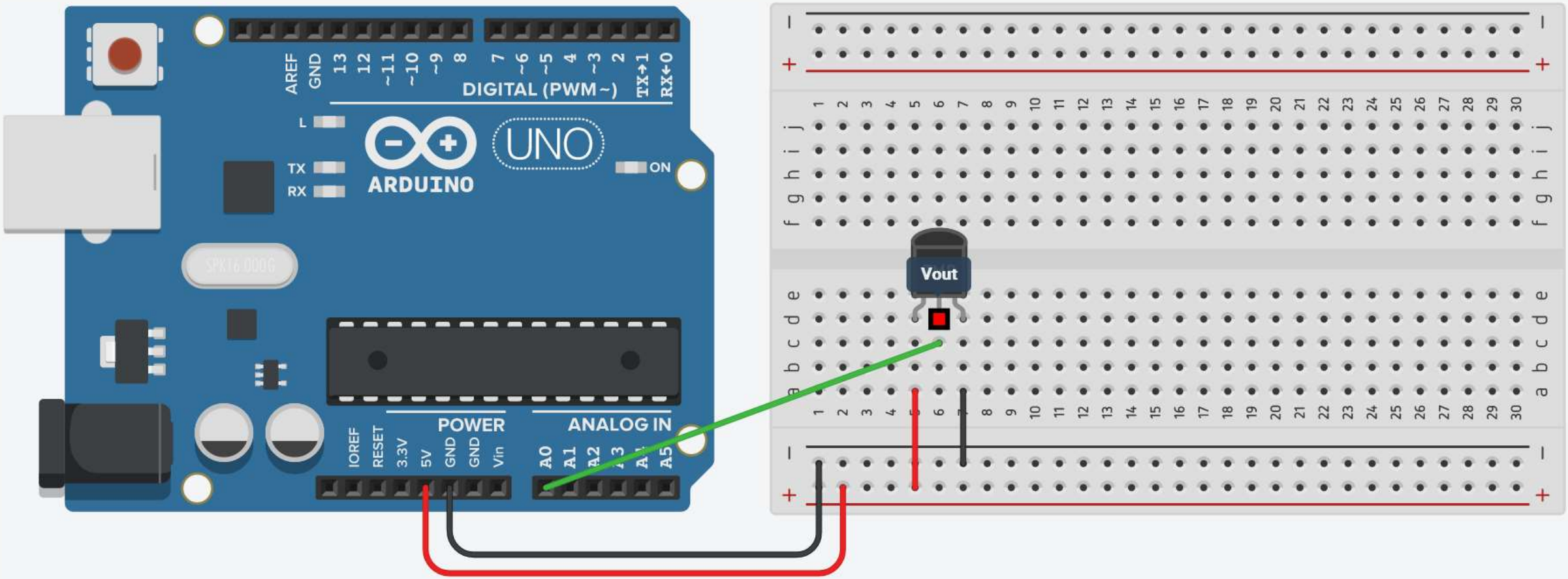
LM35 Temperature Sensor: Steps

4. The sensor Power pin connects to the 5V on Arduino.



LM35 Temperature Sensor: Steps

5. Wire up the sensor Vout pin to the analog pin A0 on Arduino.



LM35 Temperature Sensor: Code

```
int sensor_value;          // Variable to store sensor reading
float volt;                // Variable to store the voltage
float temp;                // Variable to store temperature (Celsius)

void setup() {
  Serial.begin(9600);      // Begin serial communication at 9600 baud rate
}

void loop() {
  sensor_value = analogRead(A0);              // Reading the value from sensor
  volt = sensor_value * (5.0 / 1023.0);       // Convert sensor reading into voltage
  temp = volt * 100;                          // Convert voltage into temperature

  // Print the temperature in Celsius
  Serial.print(temp);
  Serial.println(" C");

  delay(500);                                 // Short delay
}
```

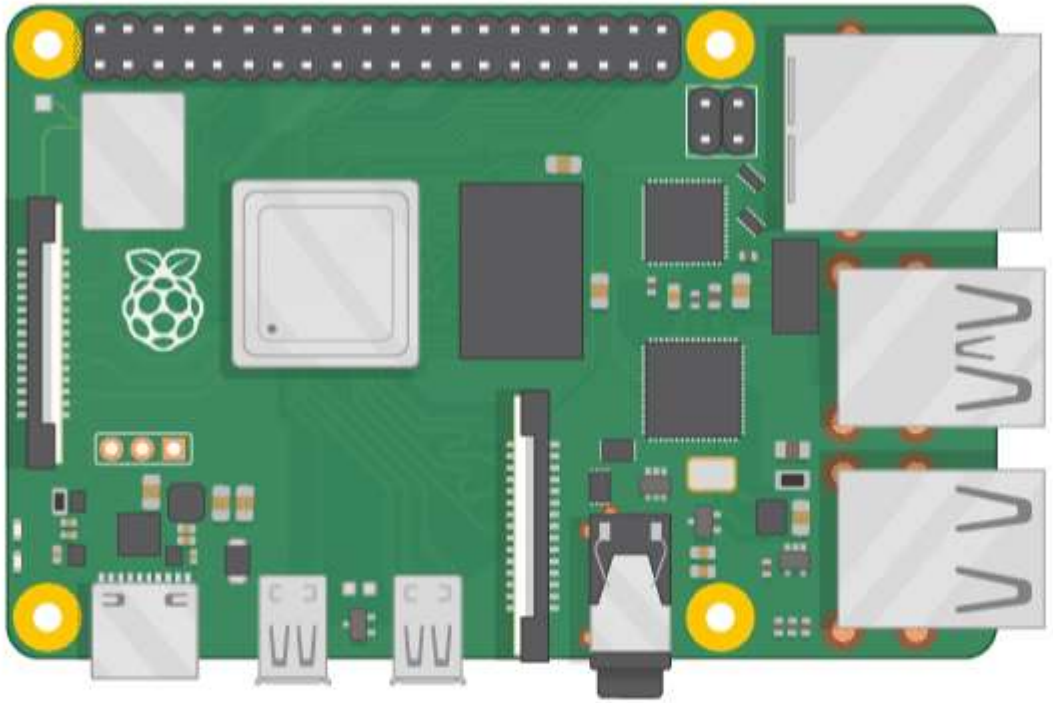
LM35 Temperature Sensor: Alternative Code

```
int sensor_value;          // Variable to store sensor reading
float temp;                // Variable to store temperature (Celsius)

void setup() {
  Serial.begin(9600);      // Begin serial communication at 9600 baud rate
}

void loop() {
  sensor_value = analogRead(A0);              // Reading the value from sensor
  temp = sensor_value * (500.0 / 1023.0);     // Convert sensor reading into voltage

  // Print the temperature in Celsius
  Serial.print(temp);
  Serial.println(" C");

  delay(500);                                 // Short delay
}
```

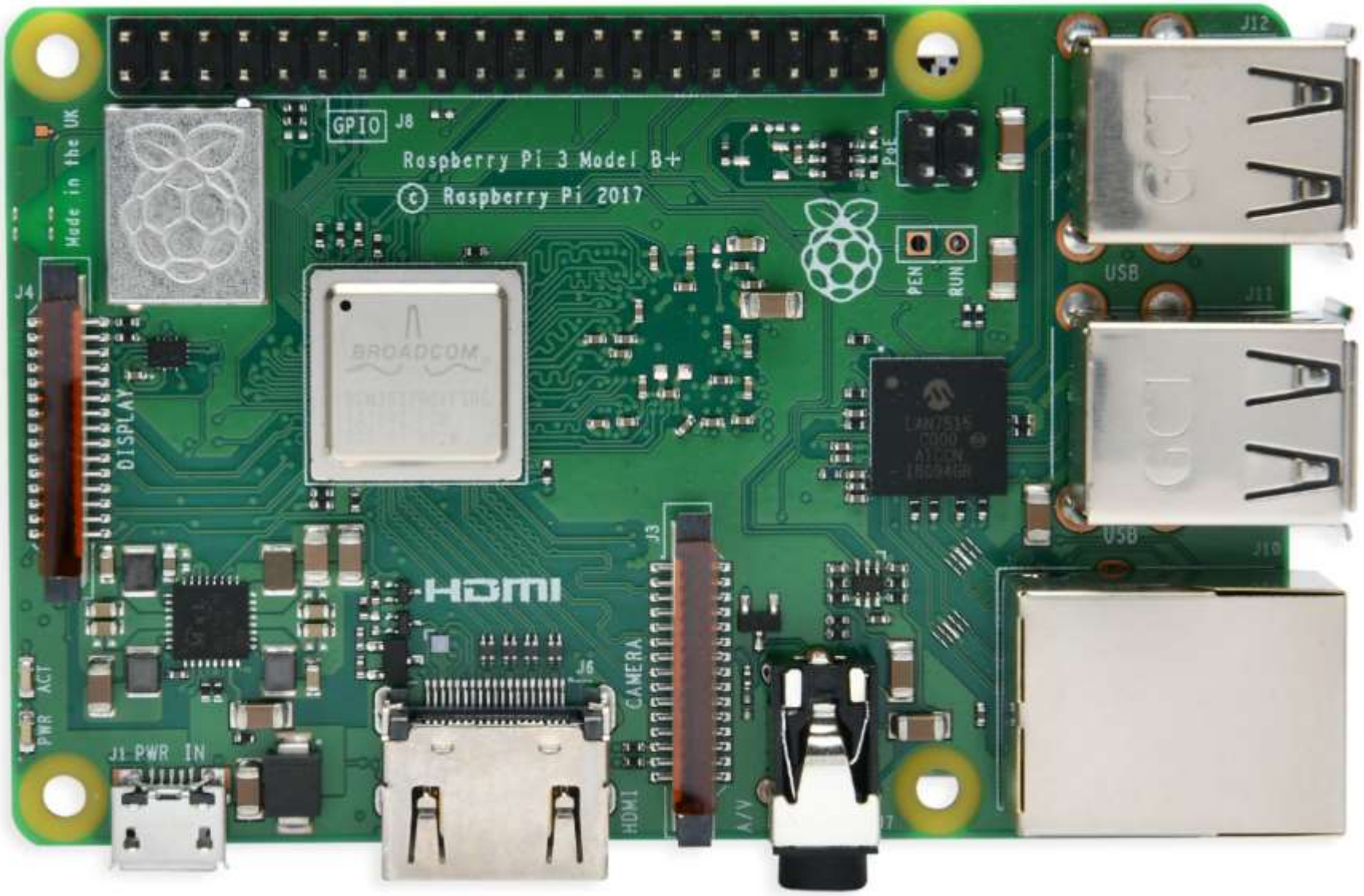
Raspberry Pi

- The Raspberry Pi is capable of doing all the things you'd expect from a computer.
- Everything from browsing the internet and playing games, to watching movies and listening to music.
- Raspberry Pi is known as a single-board computer, but that doesn't mean it's not powerful.
- Raspberry Pi can do anything a bigger computer can do.
- Over the years, the Raspberry Pi has evolved, increasing its memory, improving its performance, and adding features.

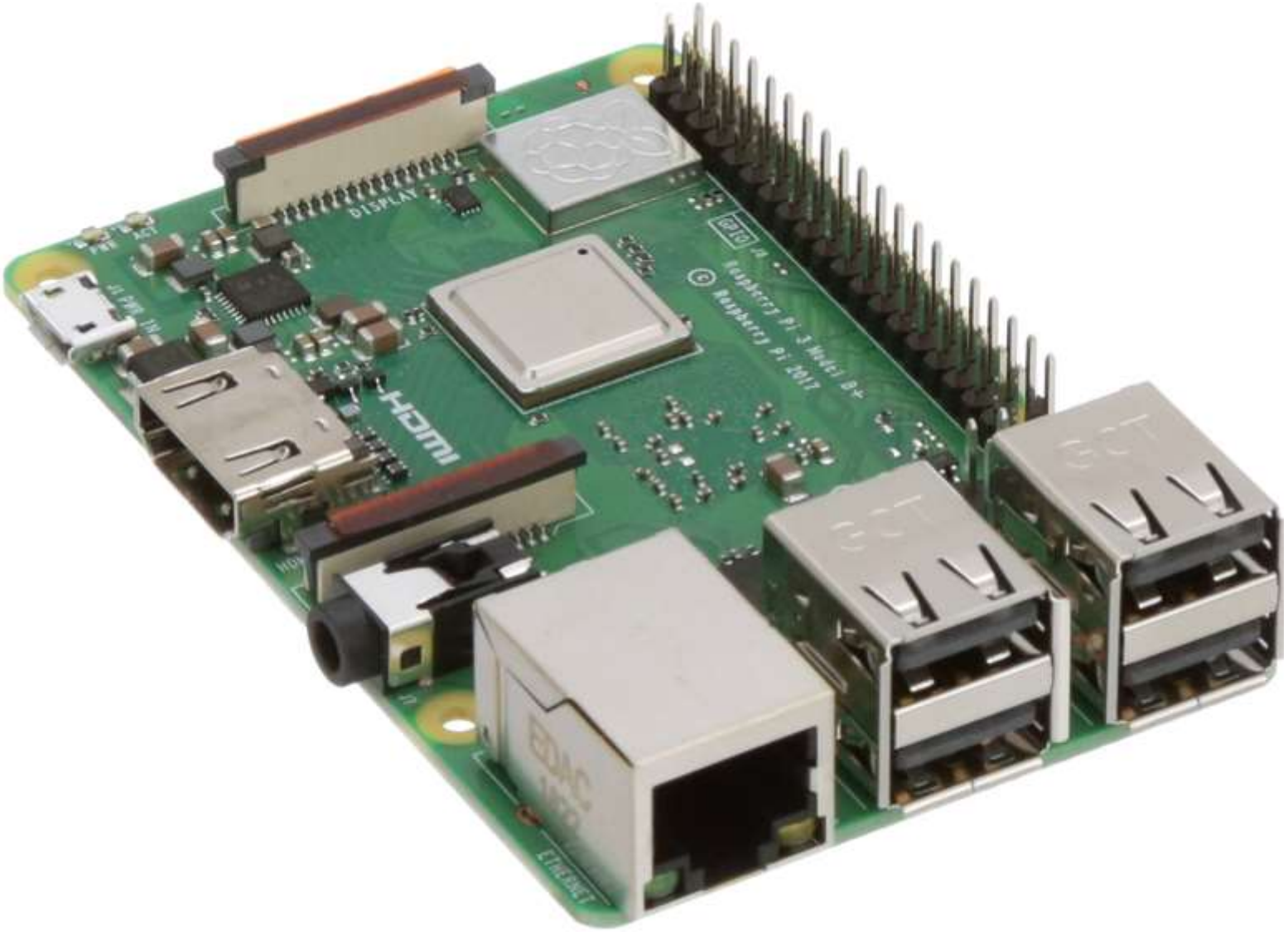
Raspberry Pi Ports



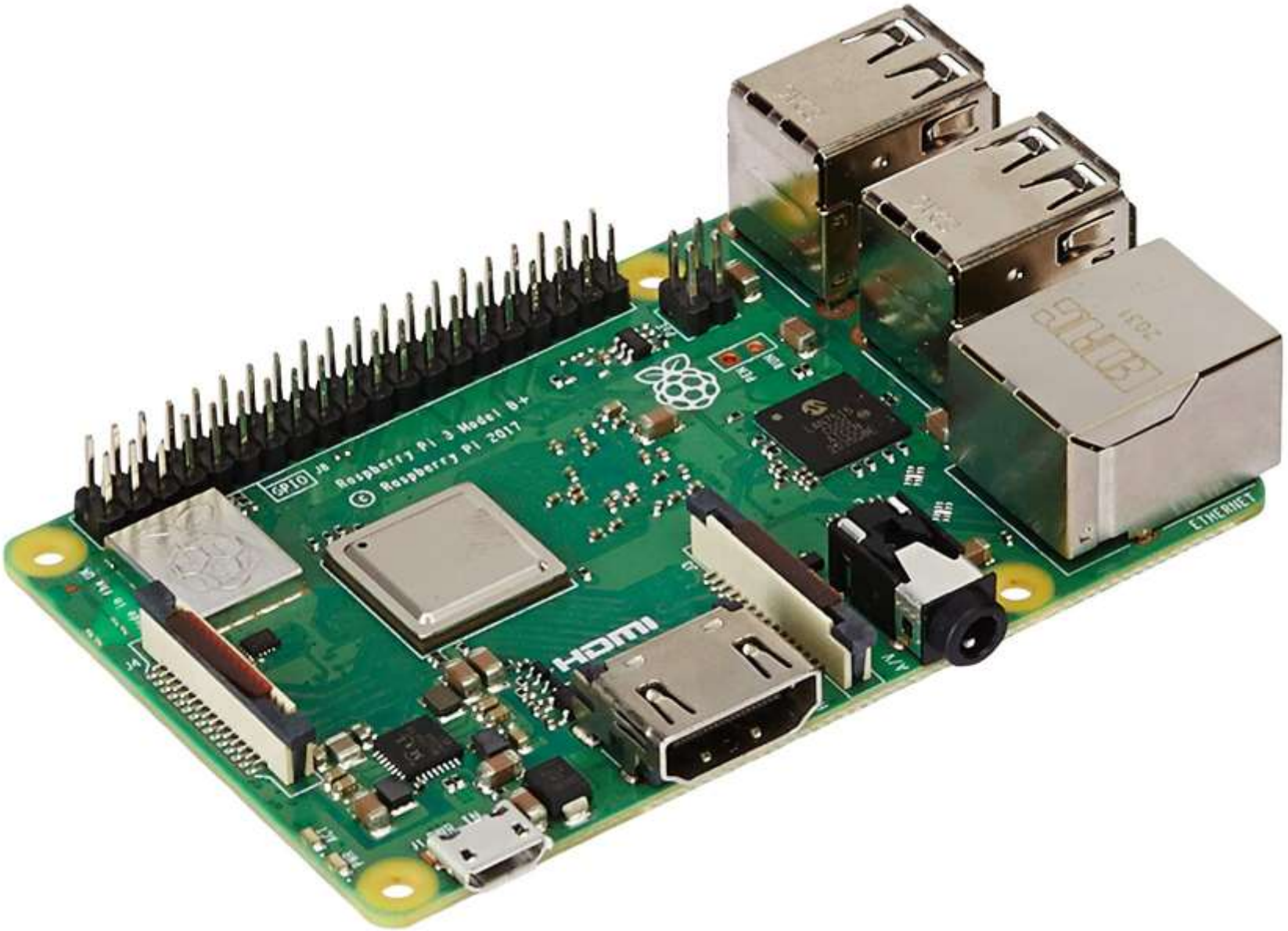
Raspberry Pi 3 Model B+



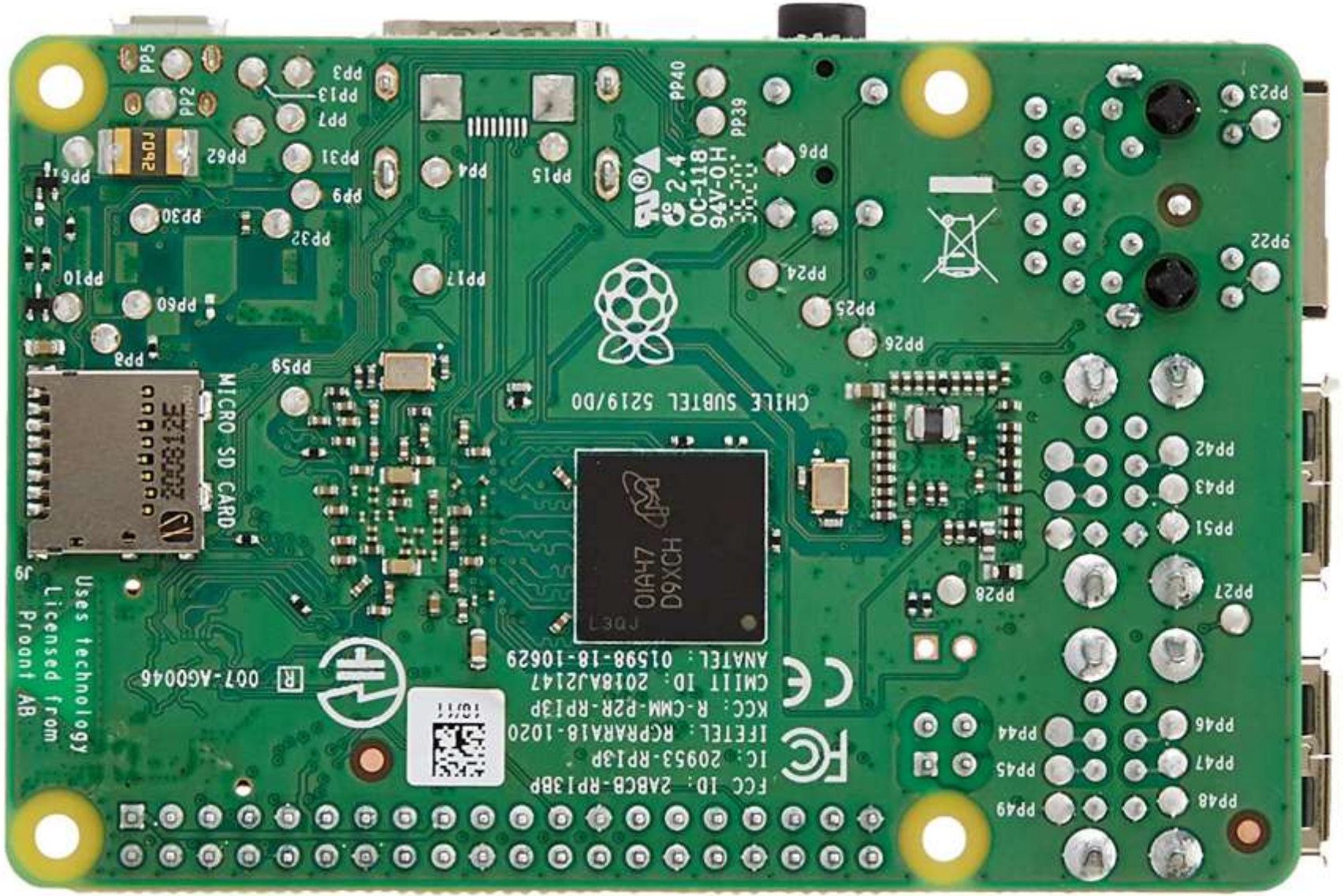
Raspberry Pi 3 Model B+



Raspberry Pi 3 Model B+



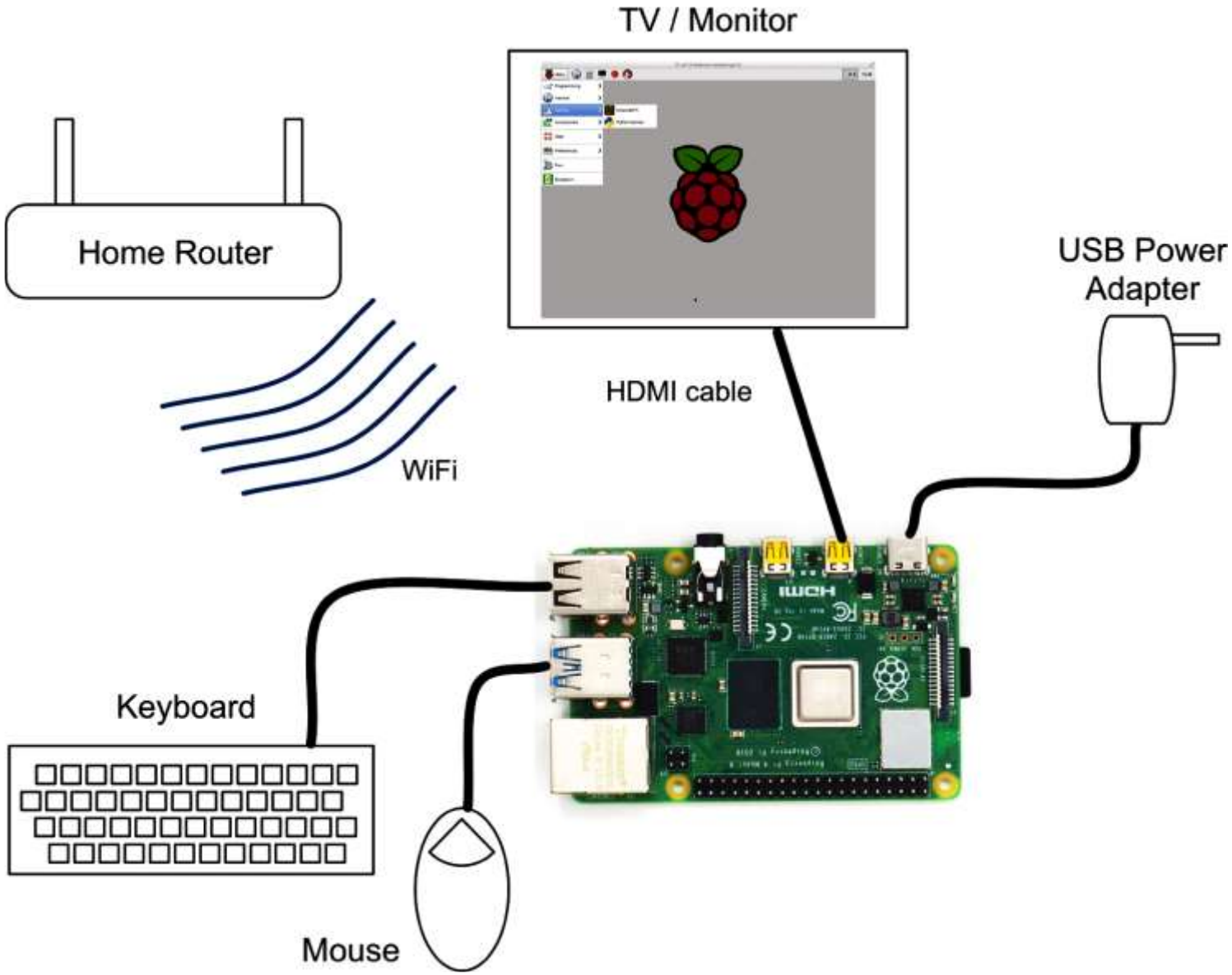
Raspberry Pi 3 Model B+



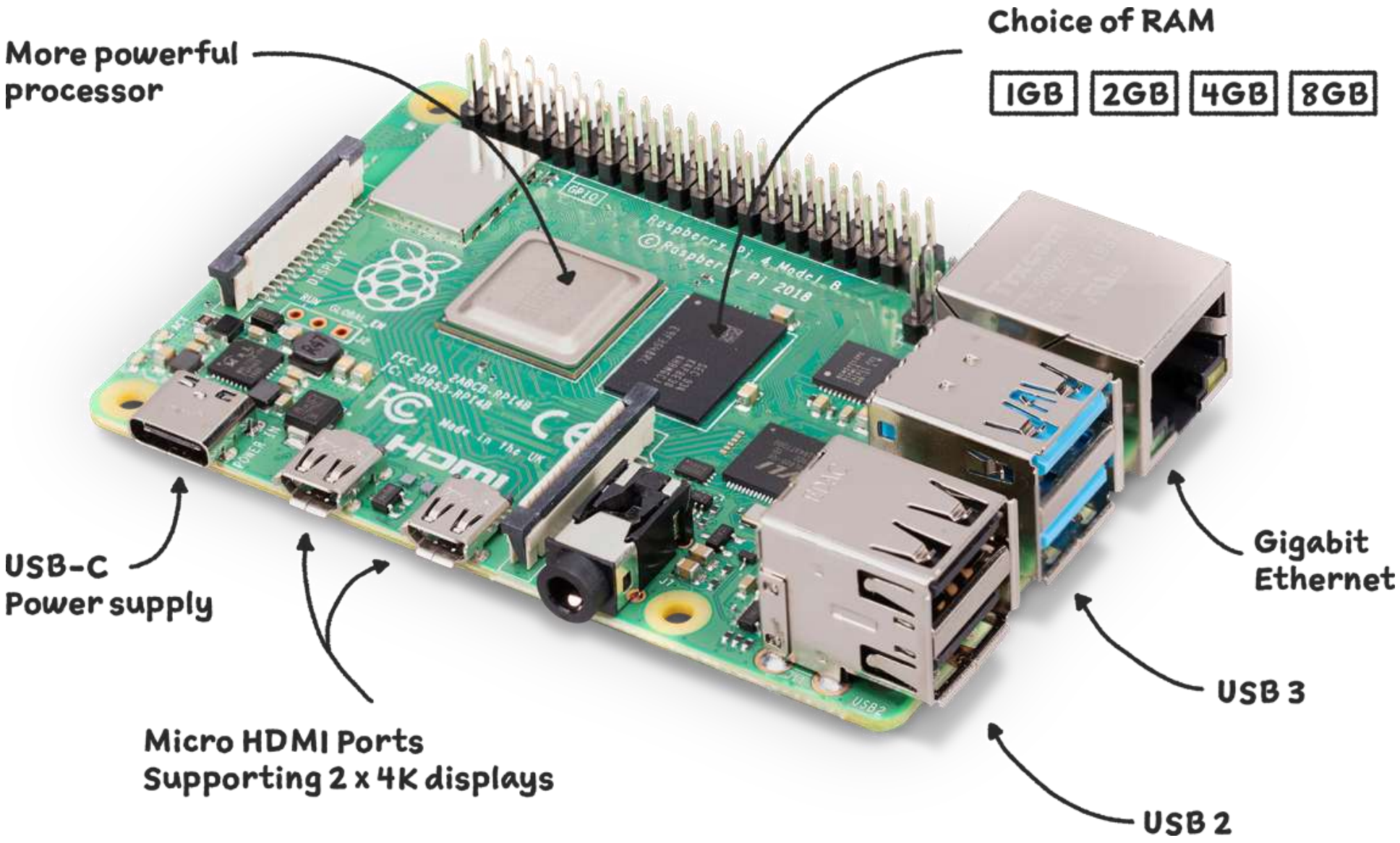
Raspberry Pi 3 Model B+: Specifications

Processor	Broadcom BCM2837B0, Cortex-A53 64-bit SoC @ 1.4GHz
Memory	1GB LPDDR2 SDRAM
Connectivity	▪ 2.4GHz and 5GHz wireless LAN, Bluetooth 4.2, BLE ▪ Gigabit Ethernet over USB 2.0 ▪ 4 × USB 2.0 ports
Access	Extended 40-pin GPIO header
Video & Sound	▪ 1 × full size HDMI ▪ MIPI DSI display port ▪ MIPI CSI camera port ▪ 4 pole stereo output and composite video port
SD Card Support	Micro SD format for operating system and data storage

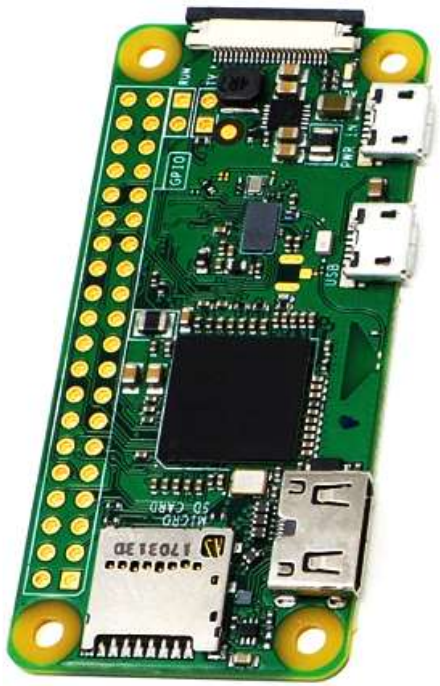
Raspberry Pi System

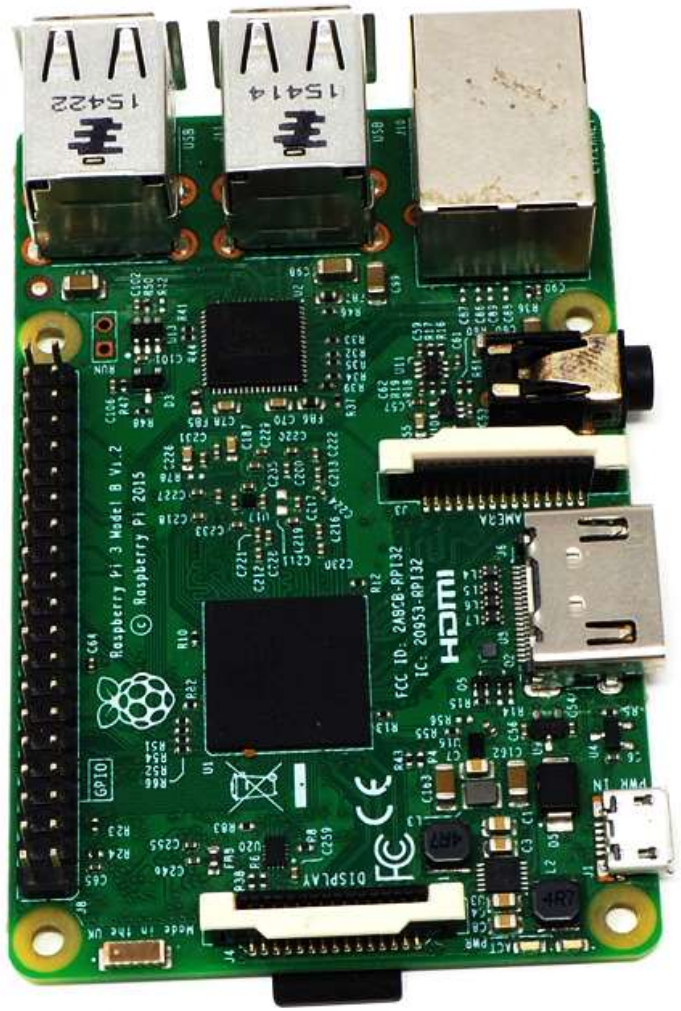


Raspberry Pi 4 Model B



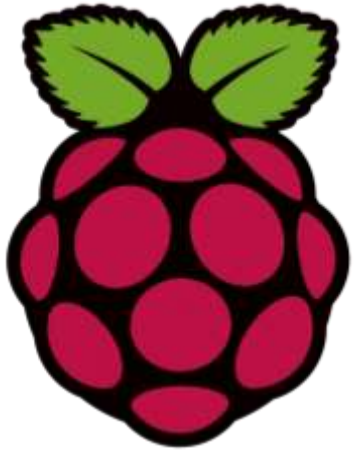
Raspberry Pi Models



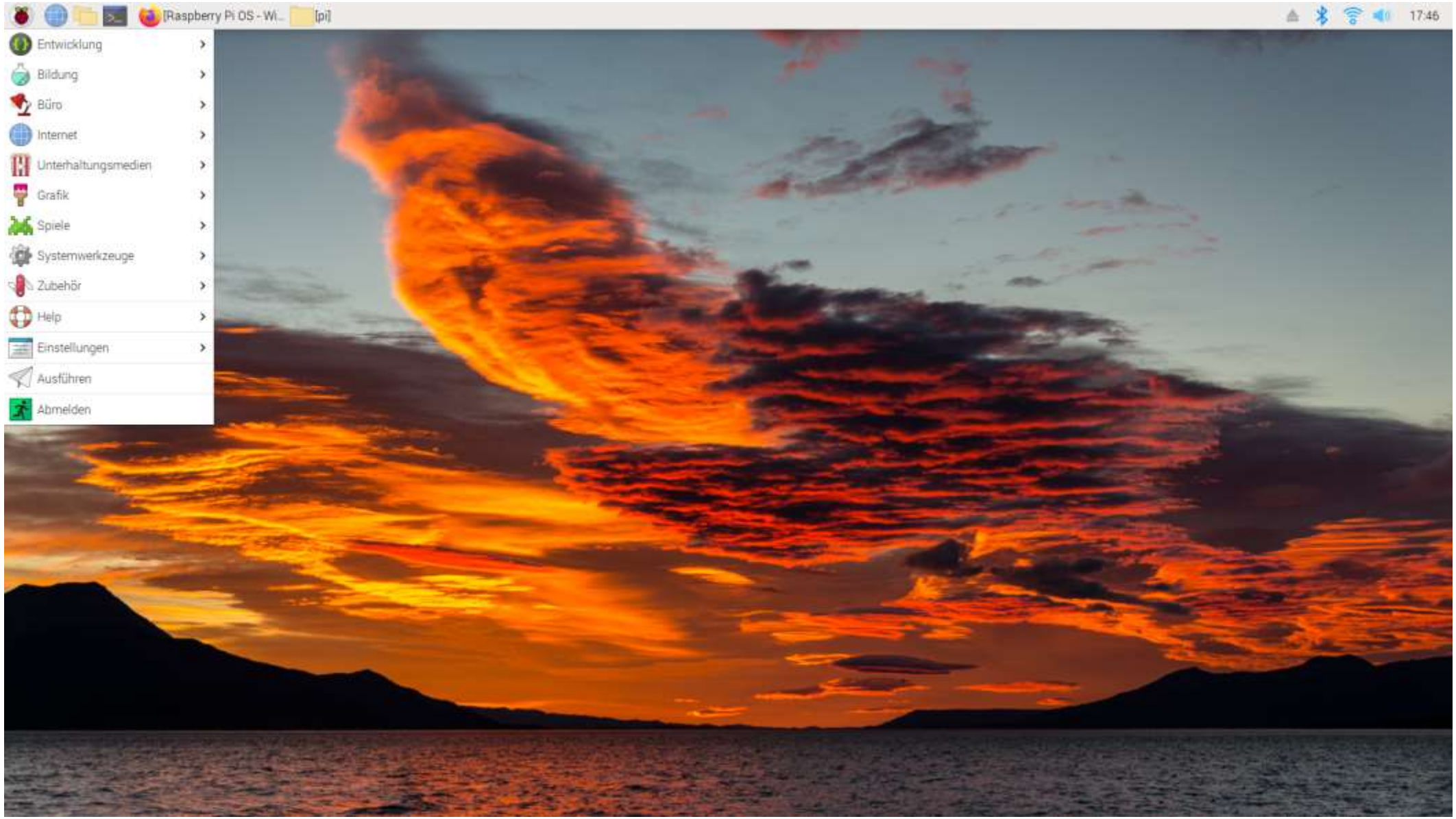


Raspberry Pi OS

- Raspberry Pi is able to run a wide range of software, including a number of different operating systems – the core software that makes a computer run.
- Raspberry Pi OS (previously called Raspbian) is our official supported operating system.
- The Raspberry Pi OS is based on Linux.

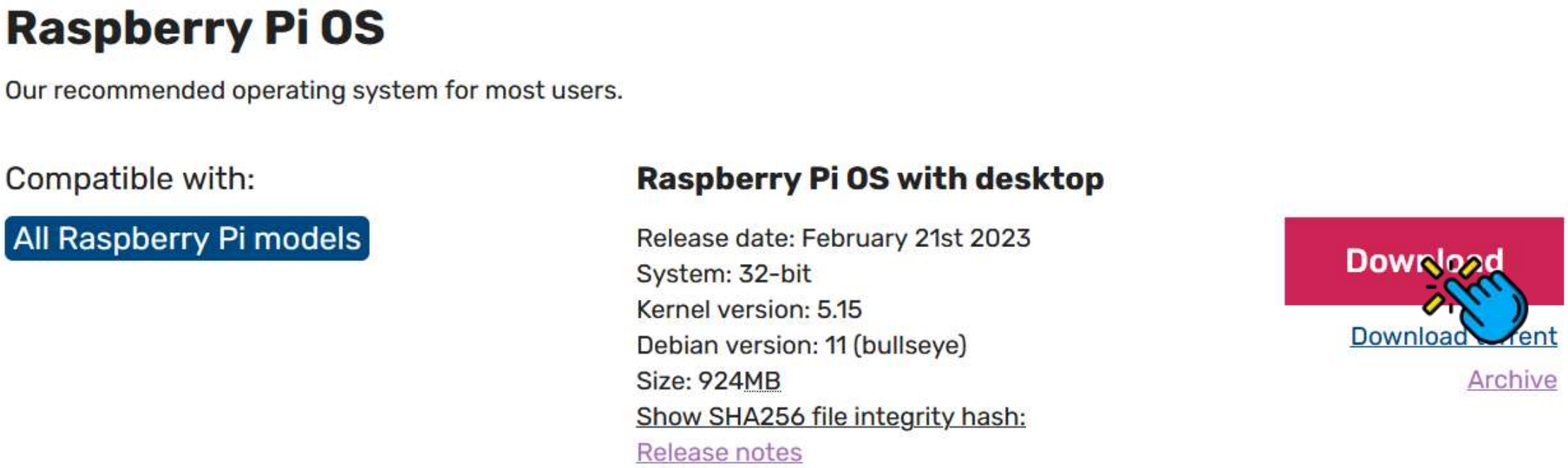


Raspberry Pi OS



Install Raspberry Pi OS

- Download Raspberry Pi OS.
  https://www.raspberrypi.com/software/operating-systems/



Install Raspberry Pi OS

- Download Pi Imager to install the OS.
  https://www.raspberrypi.com/software/

Install Raspberry Pi OS using Raspberry Pi Imager

Raspberry Pi Imager is the quick and easy way to install Raspberry Pi OS and other operating systems to a microSD card, ready to use with your Raspberry Pi. Watch our 45-second video to learn how to install an operating system using Raspberry Pi Imager.

Download and install Raspberry Pi Imager to a computer with an SD card reader. Put the SD card you'll use with your Raspberry Pi into the reader and run Raspberry Pi Imager.

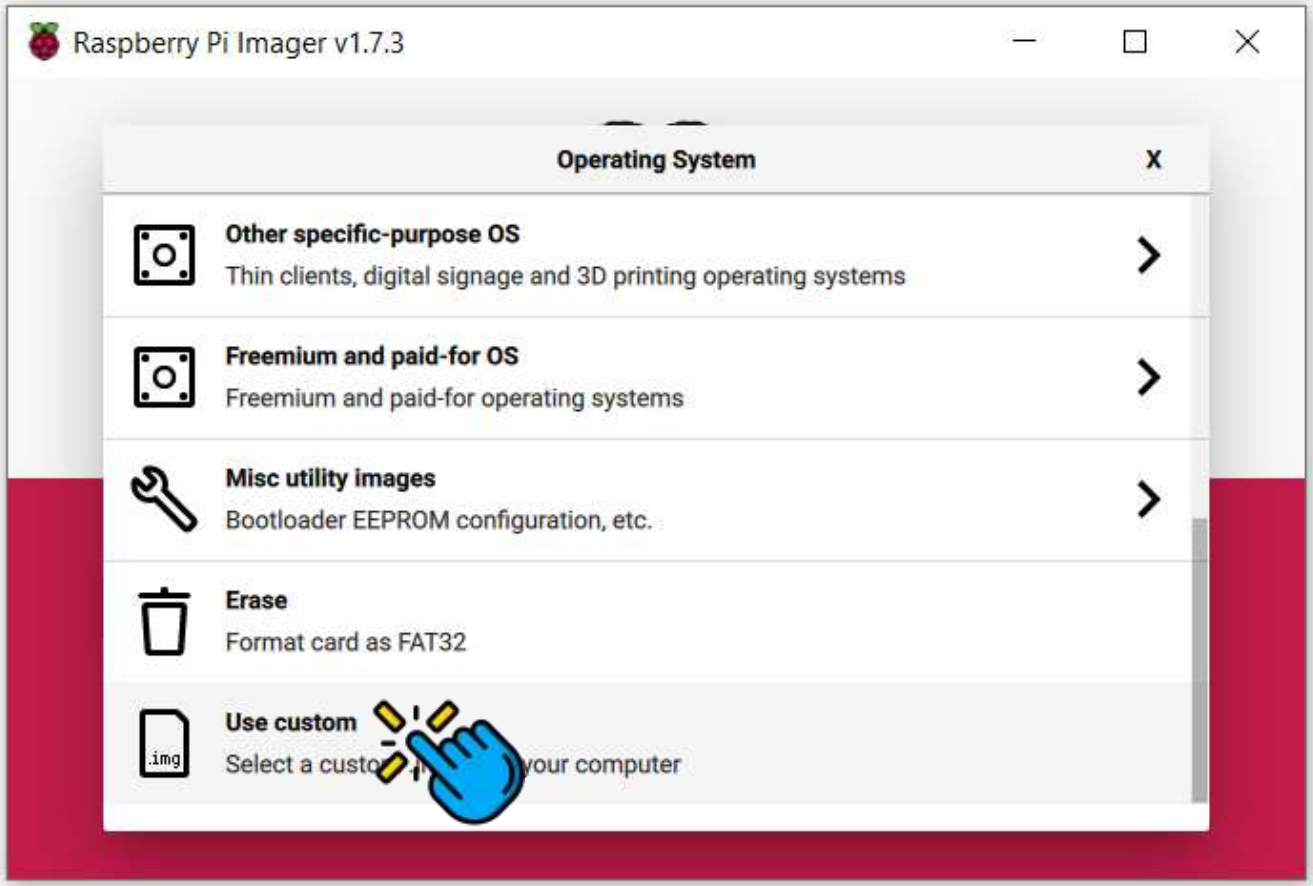
Download for Windows

Install Raspberry Pi OS

- Click Choose OS.

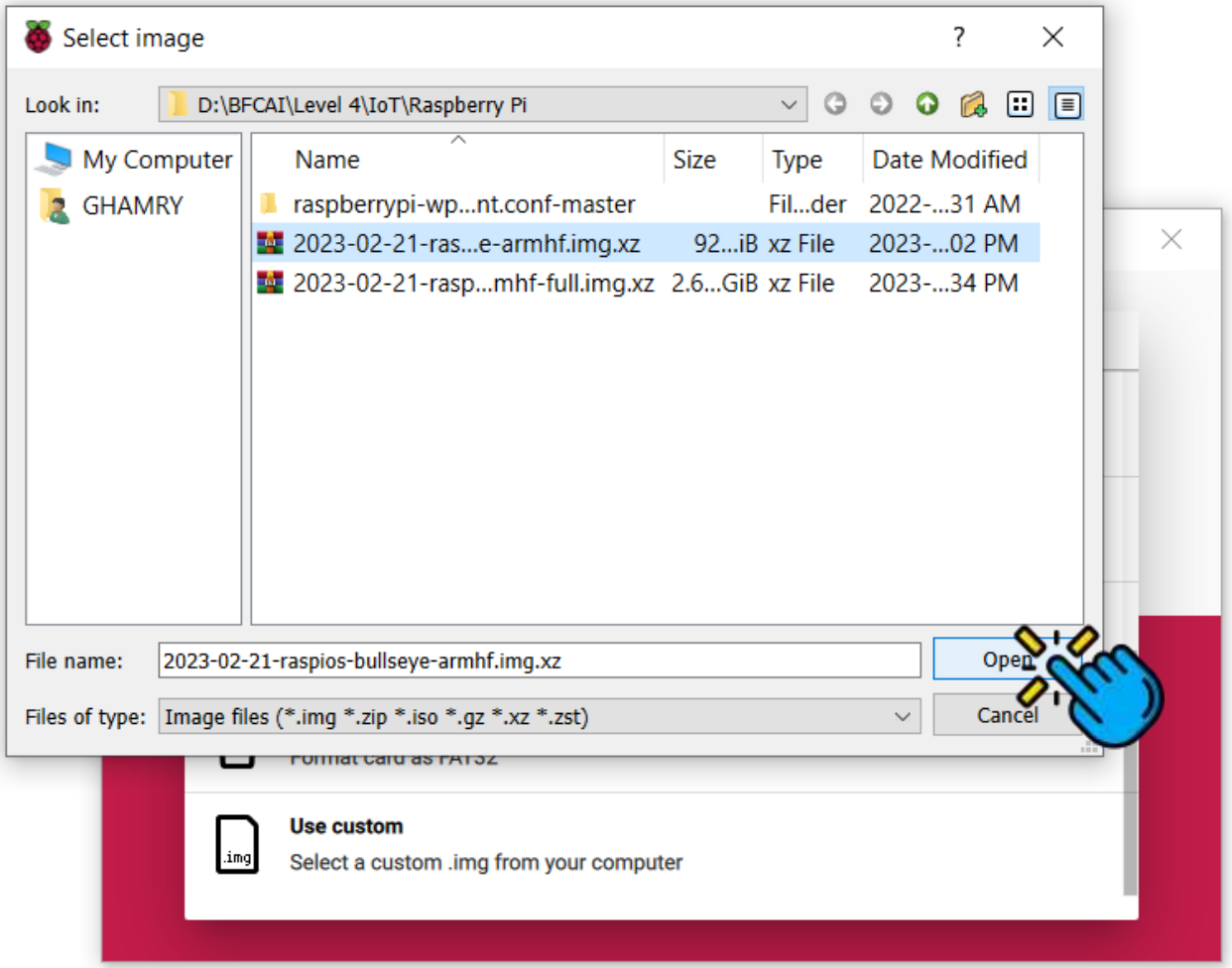
Install Raspberry Pi OS

- Click Use Custom.



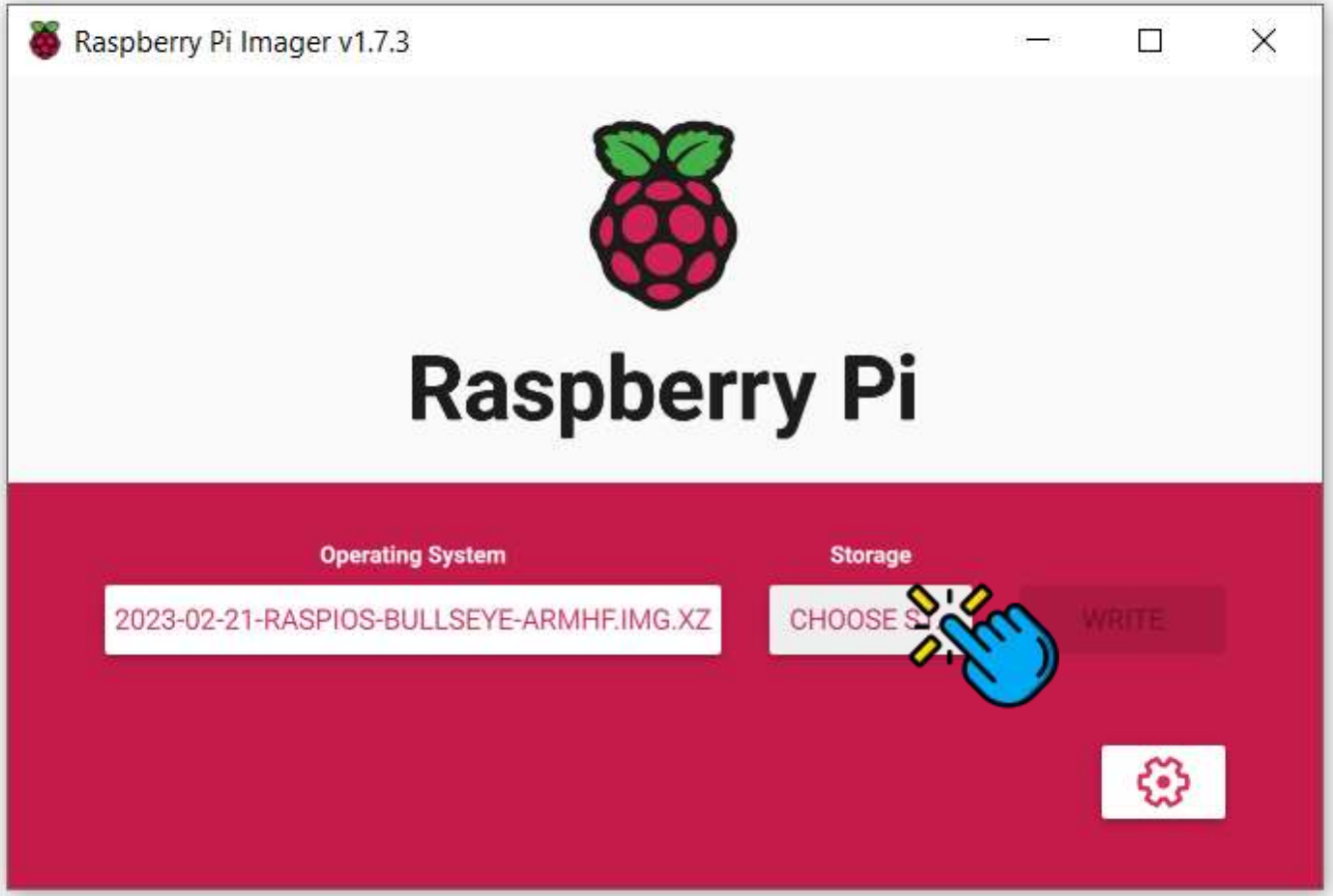
Install Raspberry Pi OS

- Choose the Raspberry Pi OS file, and Click Open.



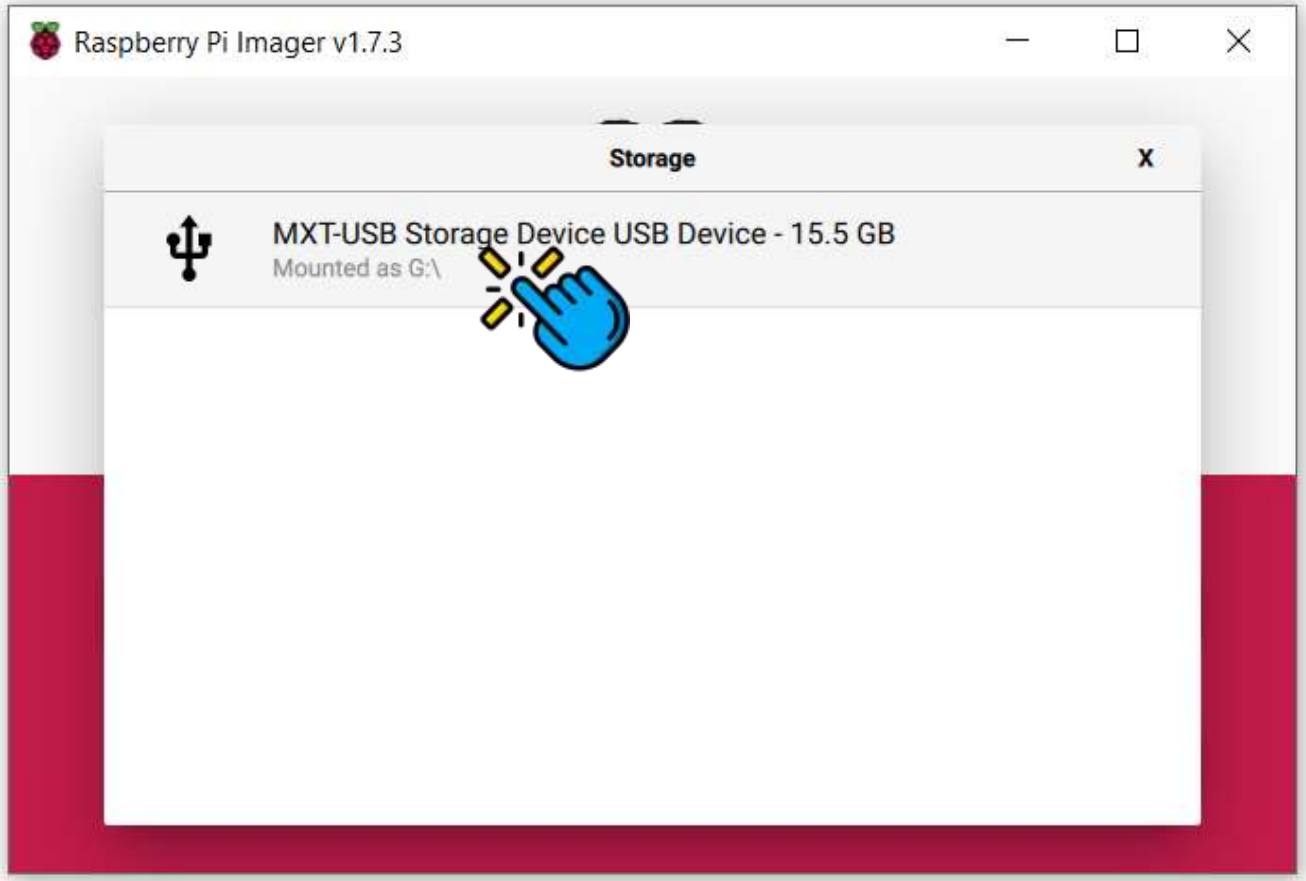
Install Raspberry Pi OS

- Insert the SD Card into you computer, and Click Choose Storage.



Install Raspberry Pi OS

- Choose your SD Card.

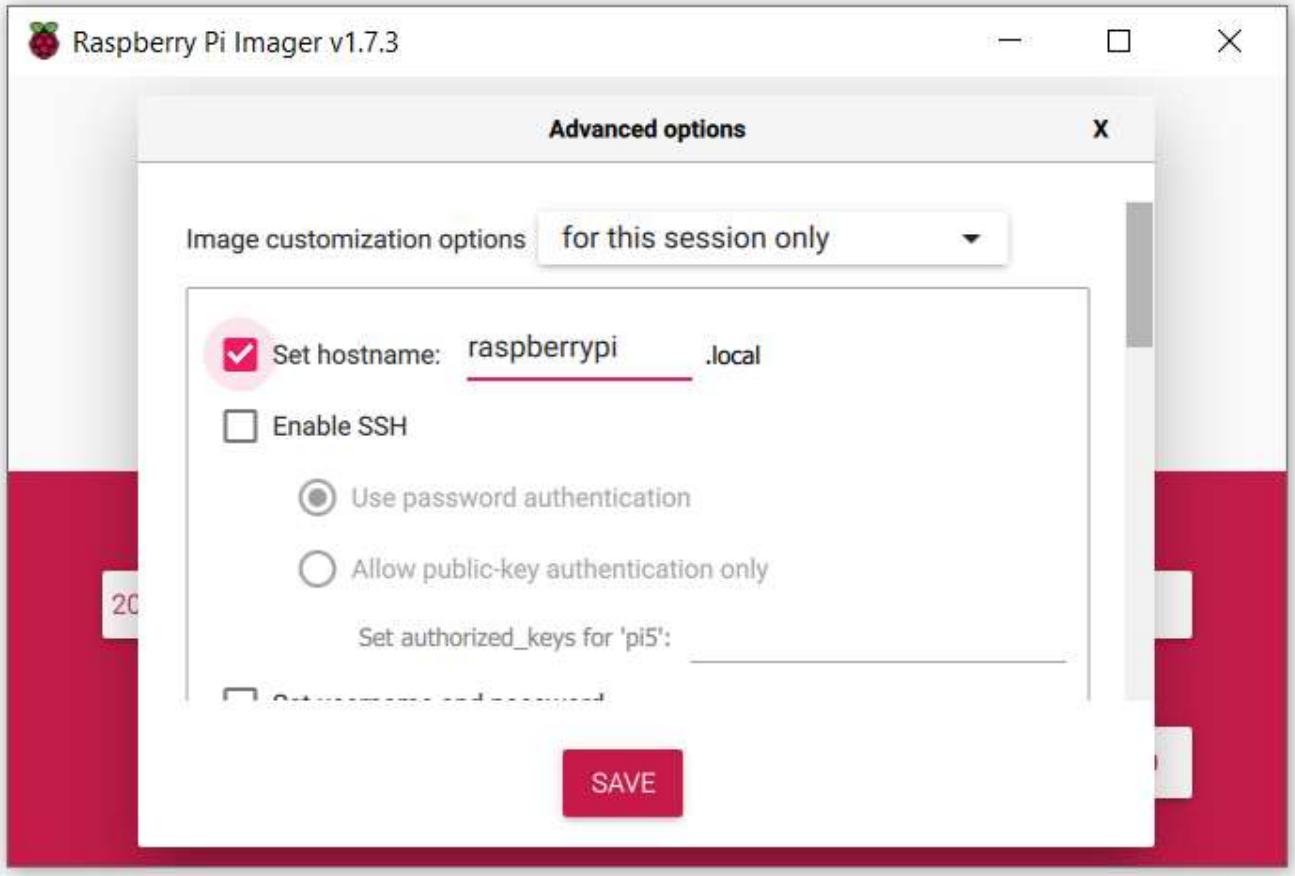


Install Raspberry Pi OS

- Click on Settings button.

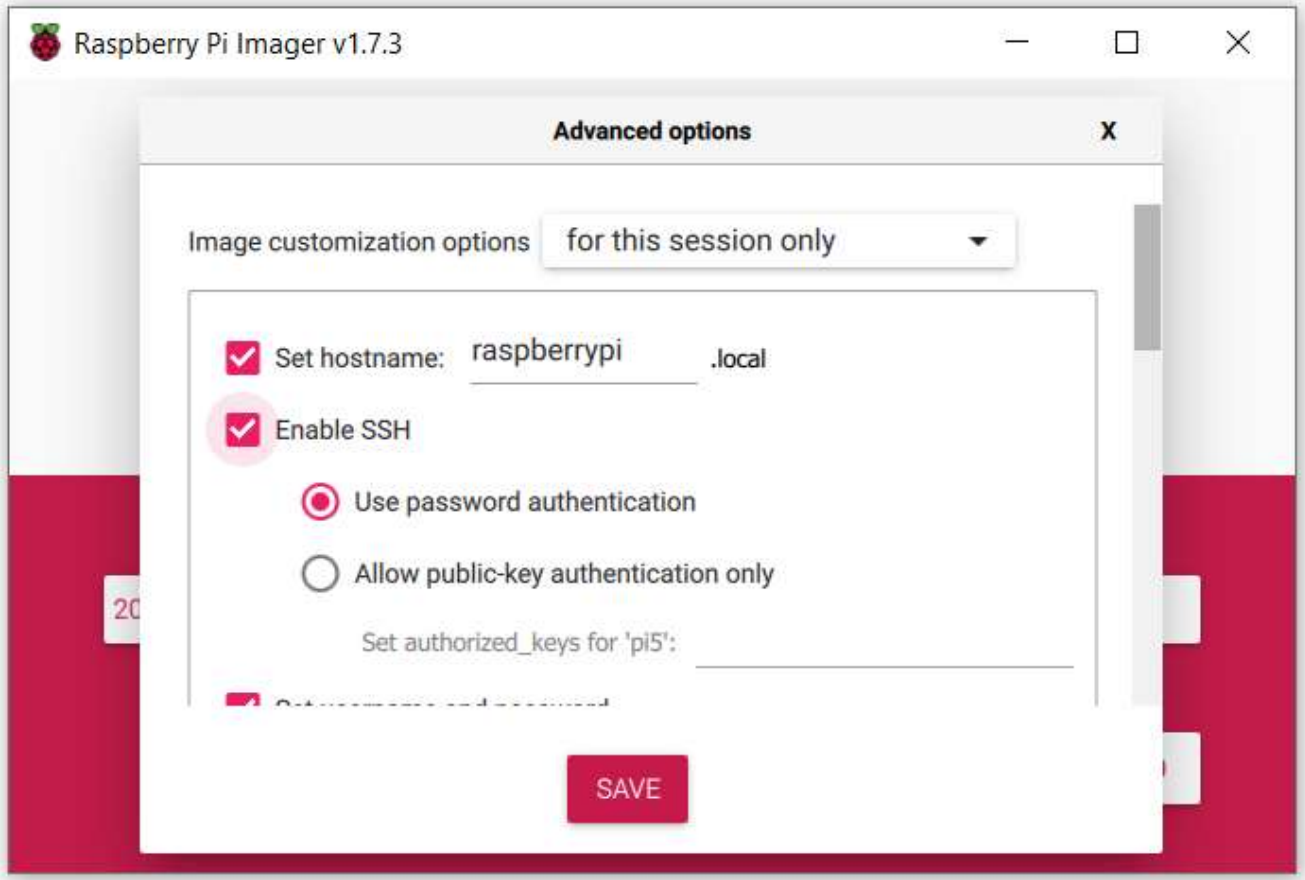
Install Raspberry Pi OS

- Check Set hostname.



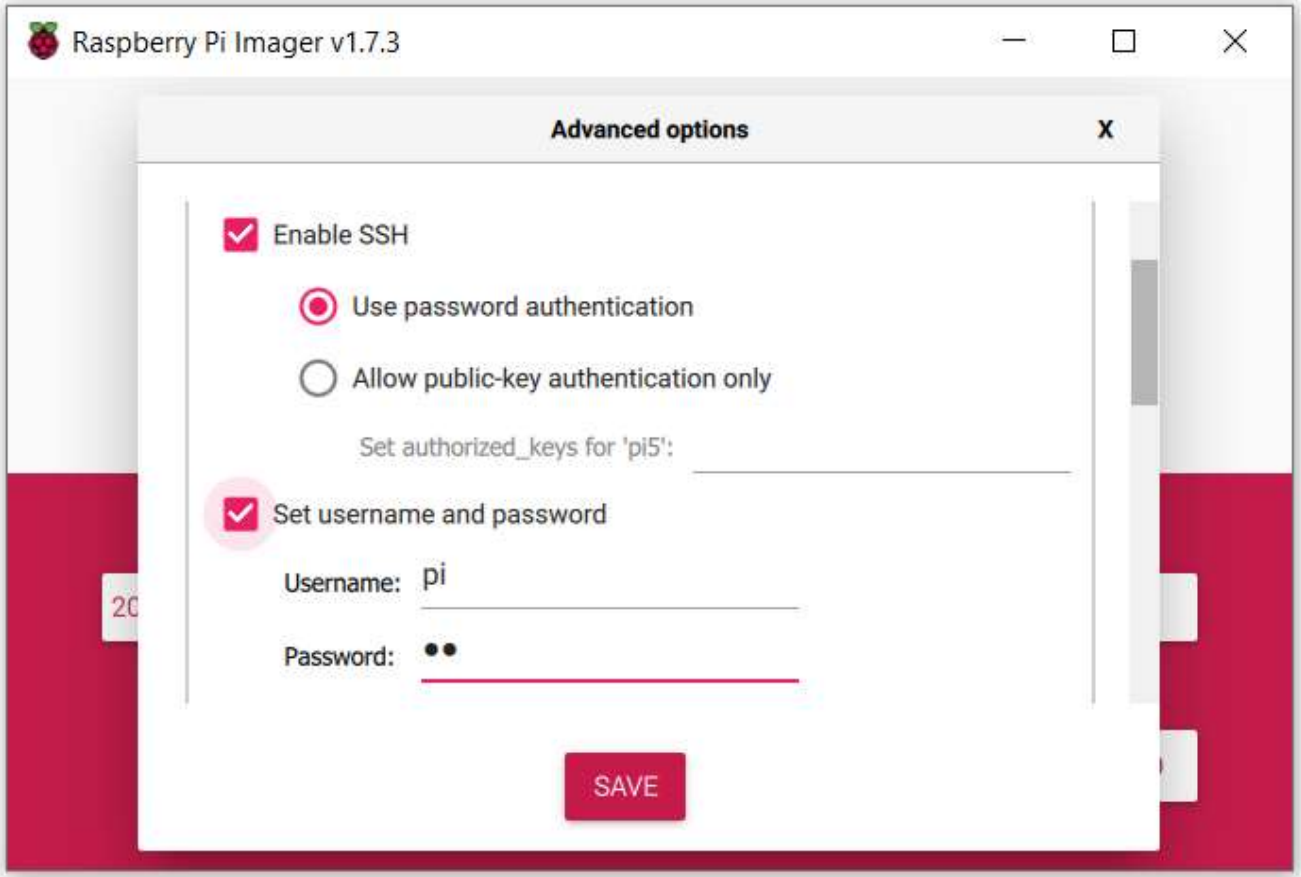
Install Raspberry Pi OS

- Check Enable SSH, as we will access the Raspberry Pi remotely.



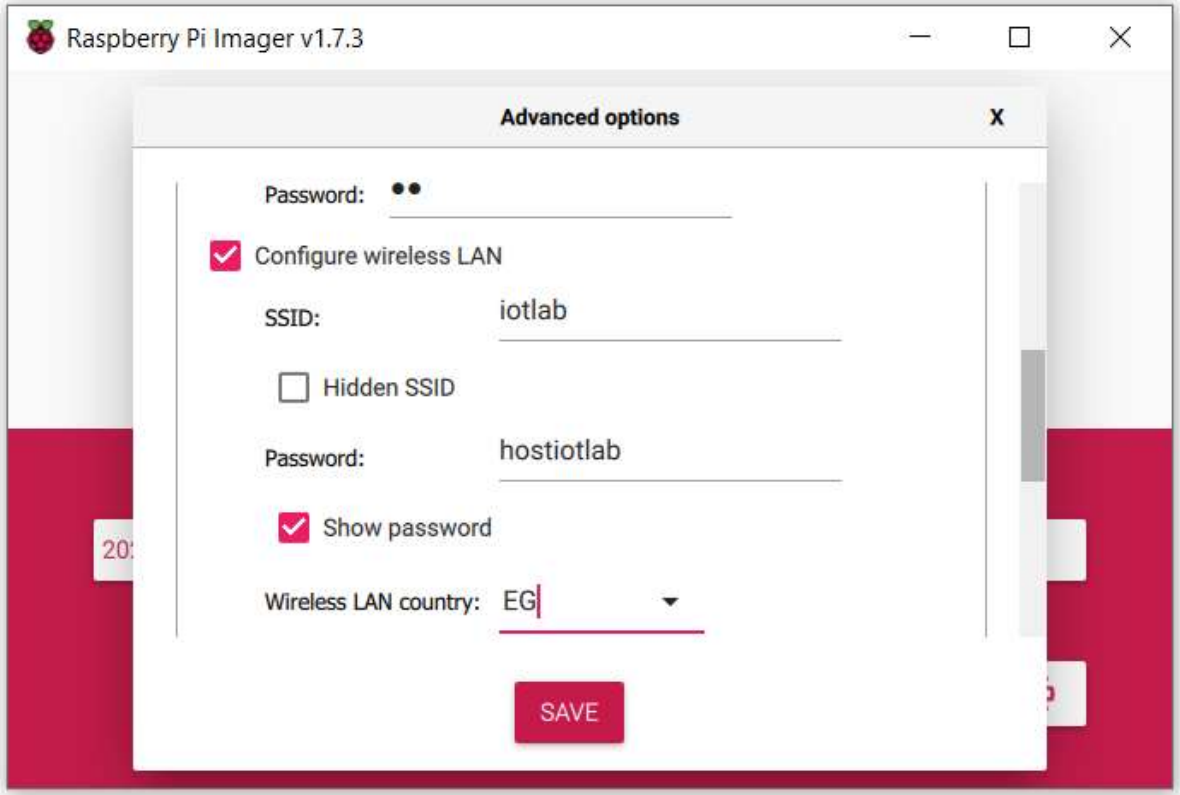
Install Raspberry Pi OS

- Set your username and password.



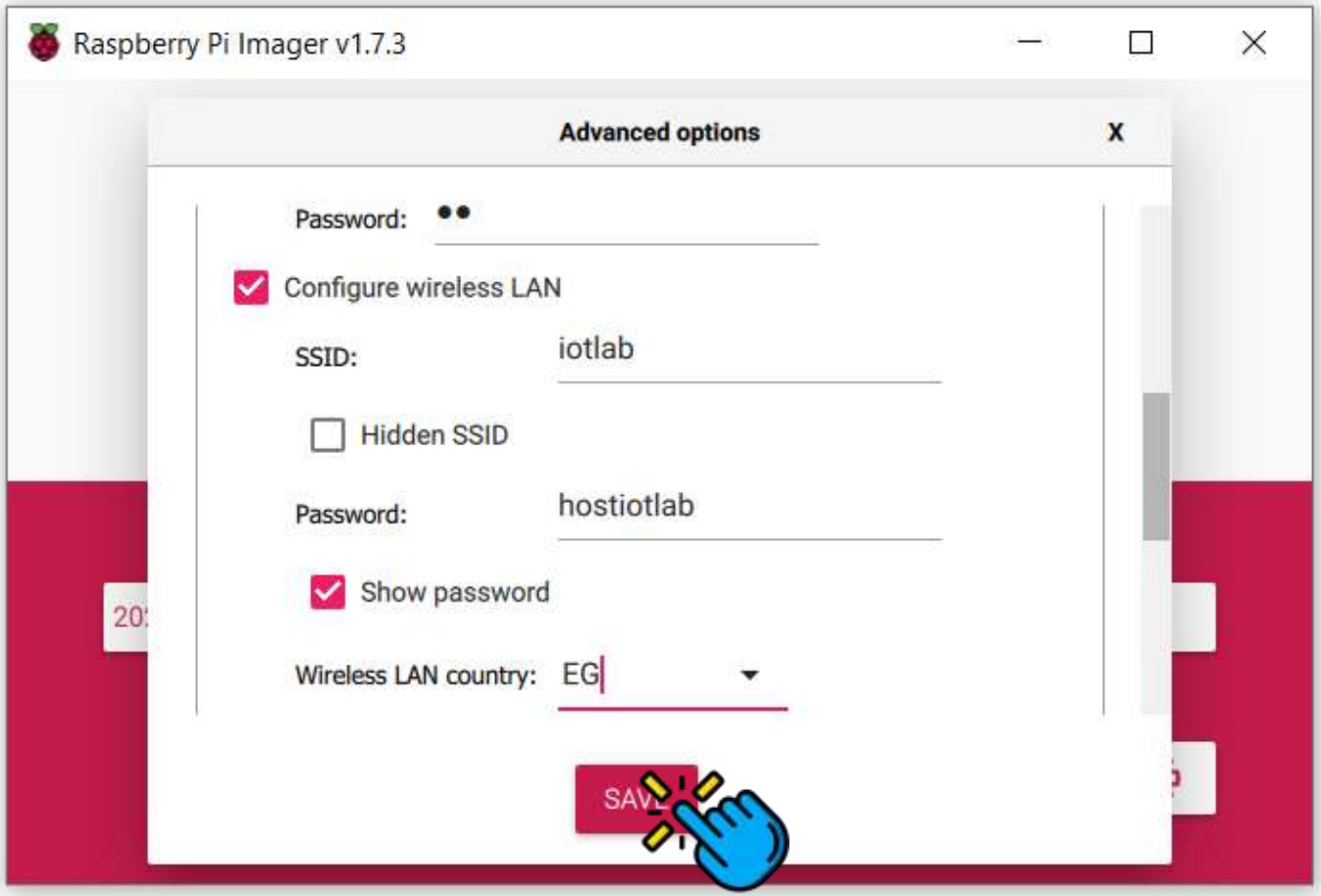
Install Raspberry Pi OS

- We will access the Raspberry Pi using Wi-Fi, so check Configure Wireless LAN and choose your SSID and Password, and choose the country EG.
- We will use “iotlab” and “hostiotlab” as SSID and password.



Install Raspberry Pi OS

- Click Save button.



Install Raspberry Pi OS

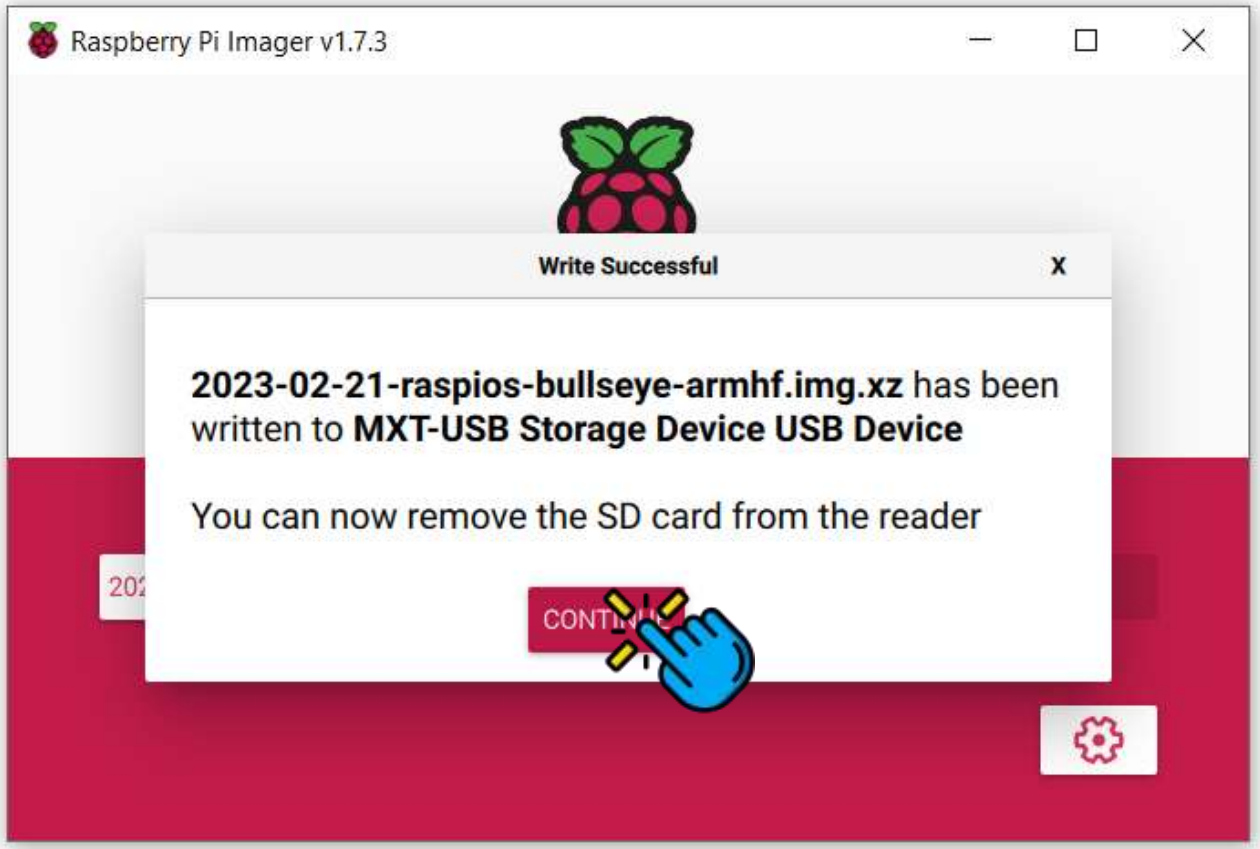
- Click Write.

Install Raspberry Pi OS

- Wait until writing is done.

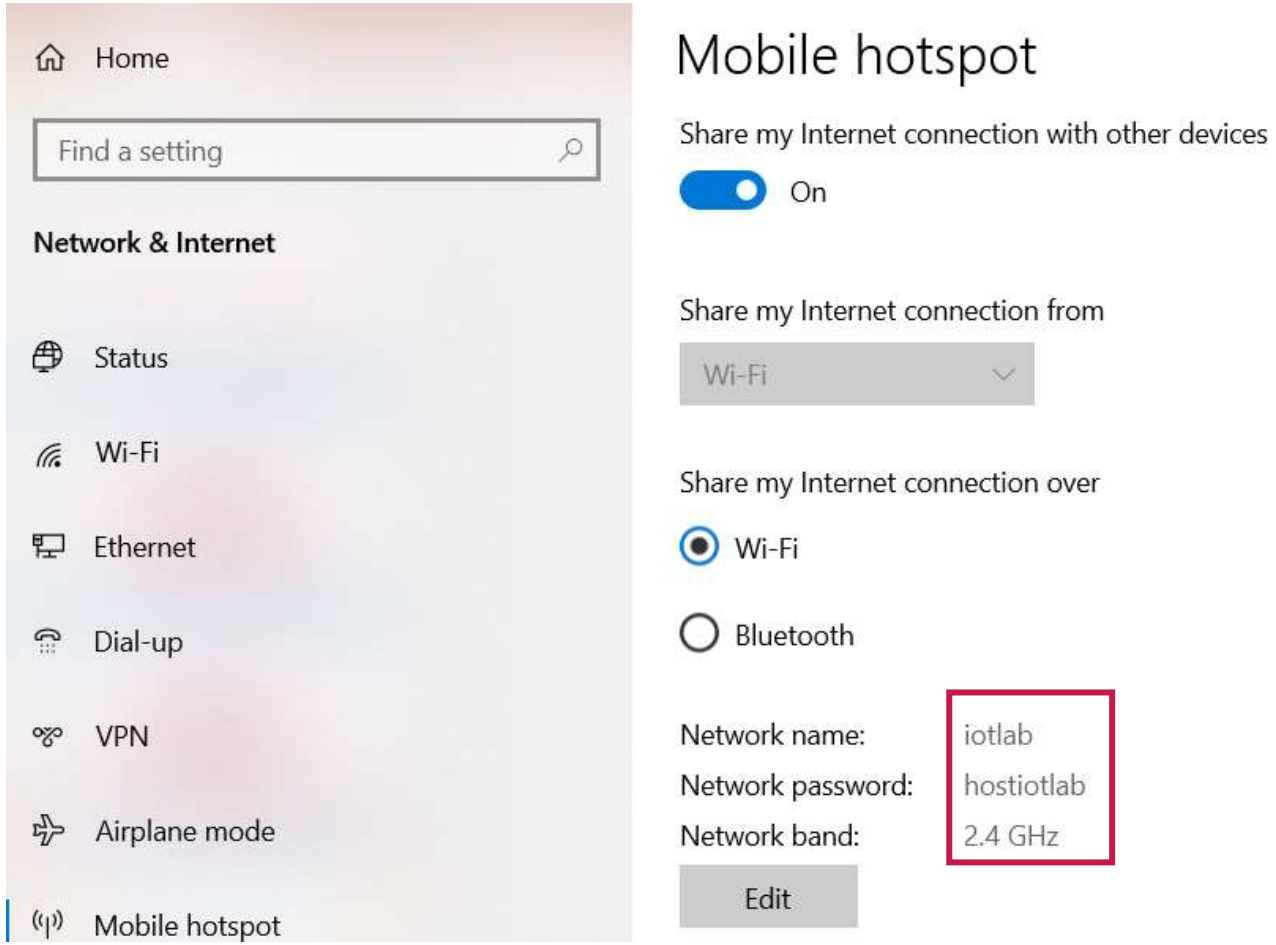
Install Raspberry Pi OS

- After writing is done, the SD Card will be ejected automatically, so reinsert the SD Card to complete the remaining steps.



Install Raspberry Pi OS

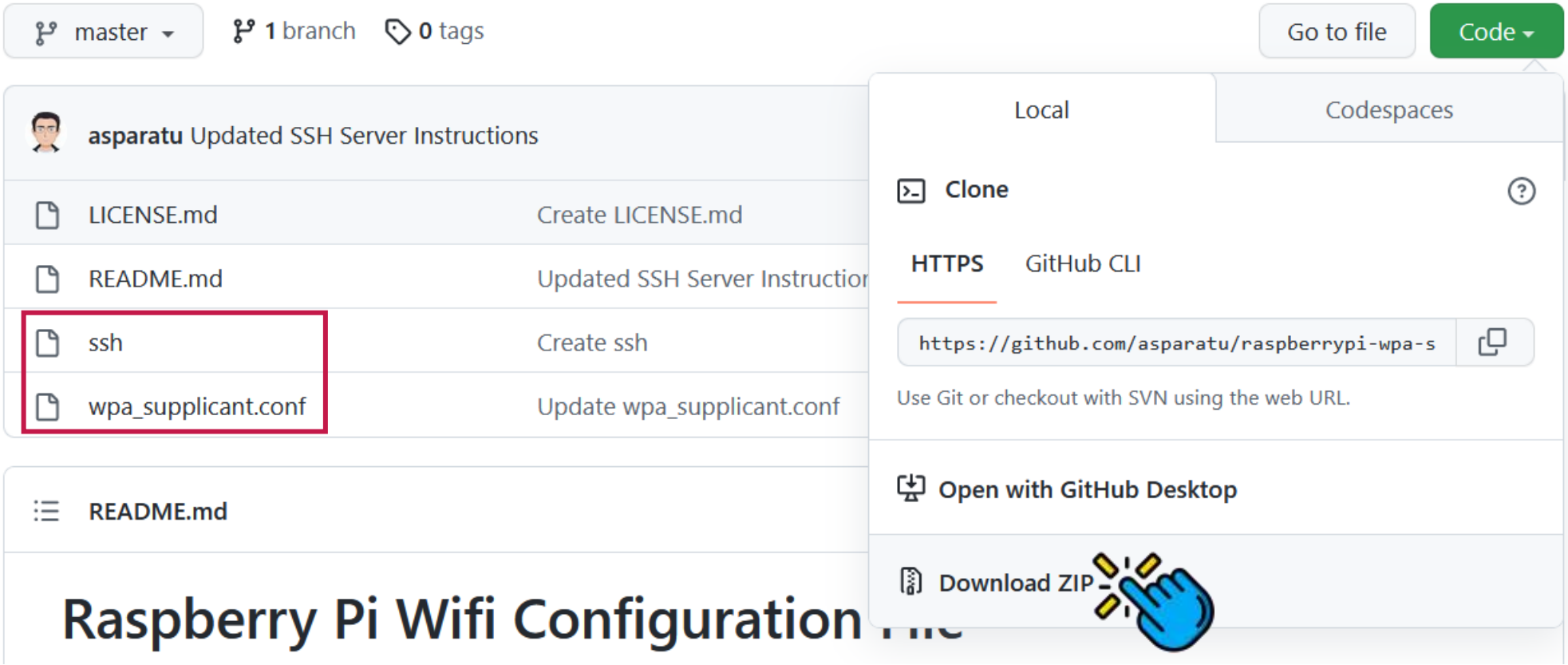
- Open Mobile hotspot, and make sure your Wi-Fi info is correct.
- Make sure to turn on the hotspot.



Install Raspberry Pi OS

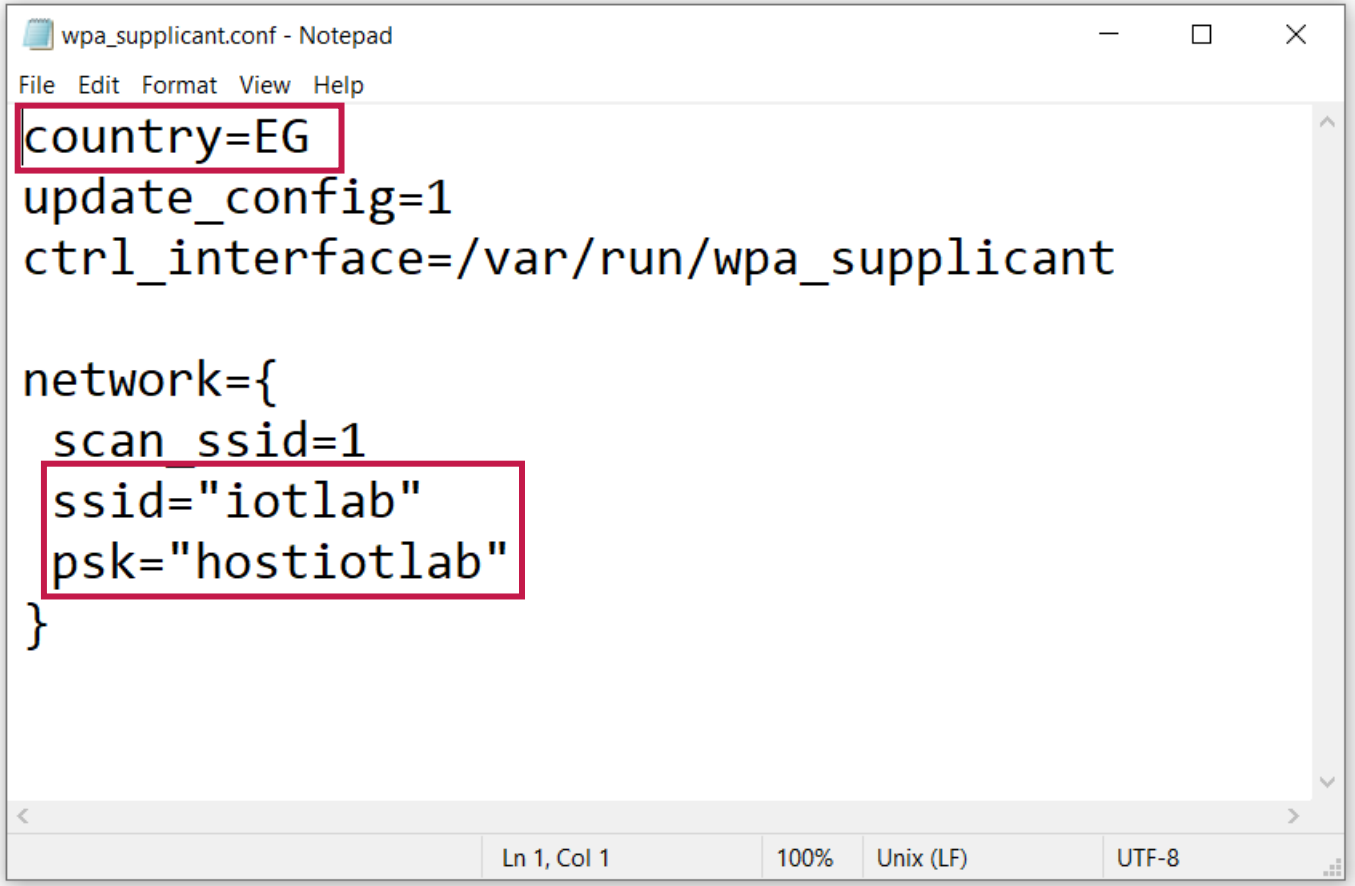
- Download the following files.

  https://github.com/asparatu/raspberrypi-wpa-supplicant.conf



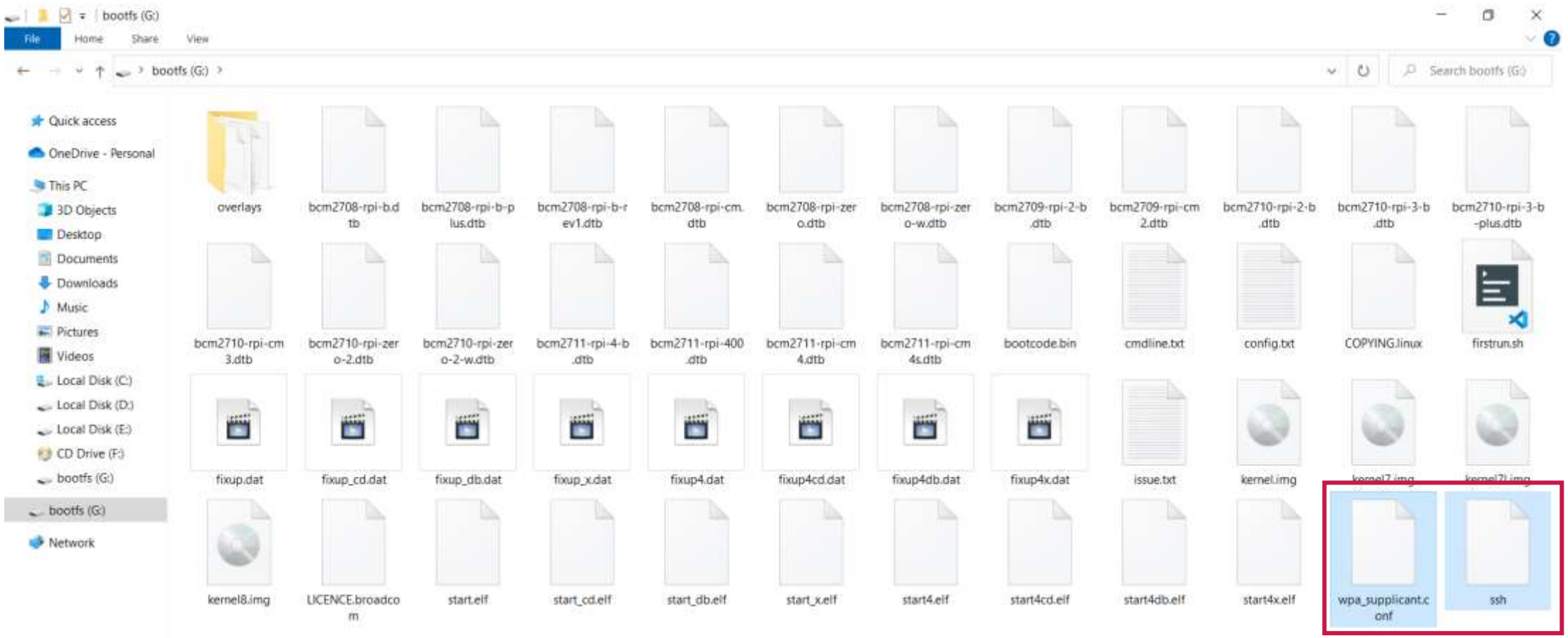
Install Raspberry Pi OS

- Open the file `wpa_supplicant.conf`, and edit it to your Wi-Fi info.
- Make sure to save changes.



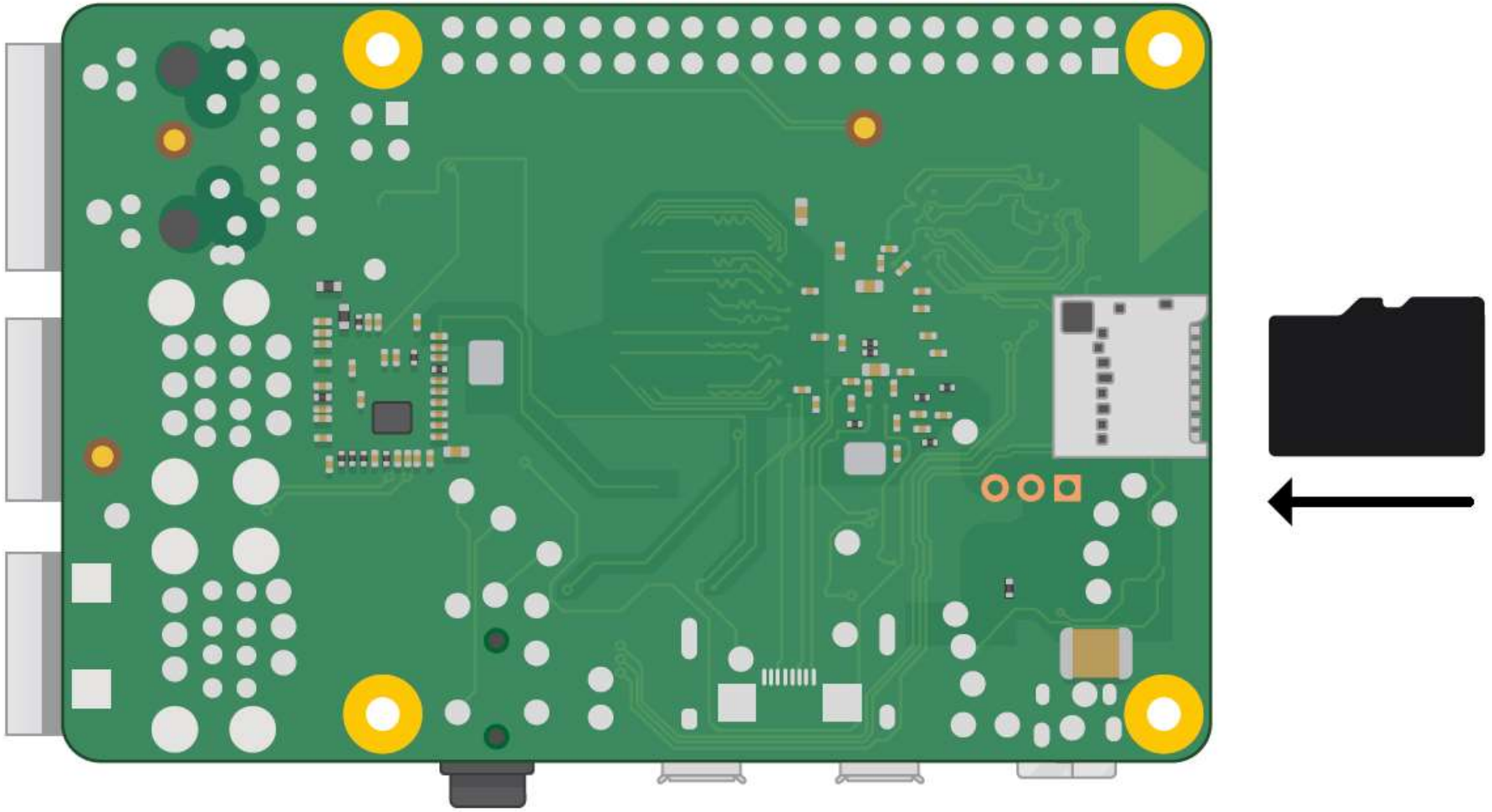
Install Raspberry Pi OS

- Copy the files `wpa_supplicant.conf` and `ssh` to your SD Card.



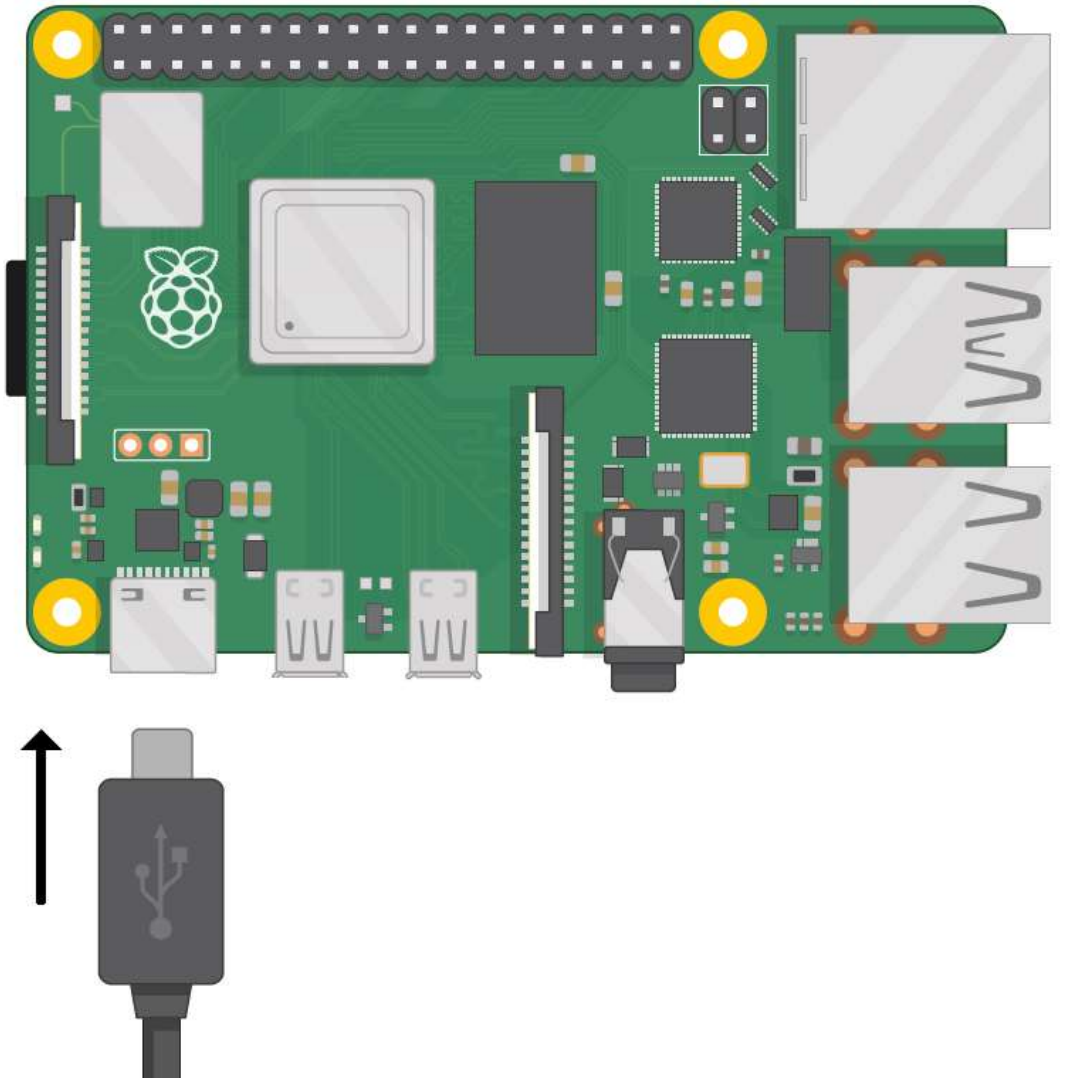
Install Raspberry Pi OS

- Eject the SD Card, and insert it into your Raspberry Pi.



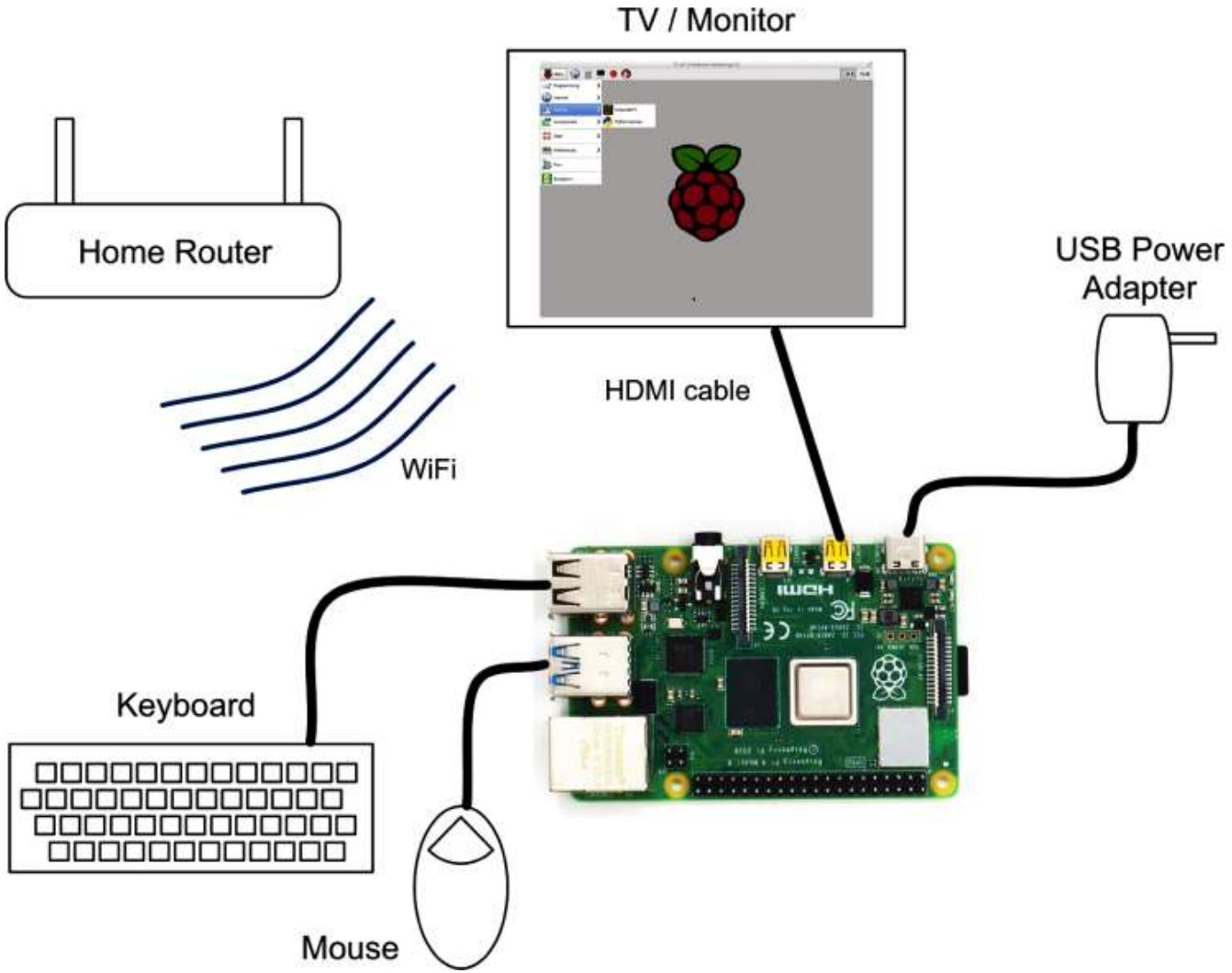
Install Raspberry Pi OS

- Connect your Raspberry Pi to the power supply.

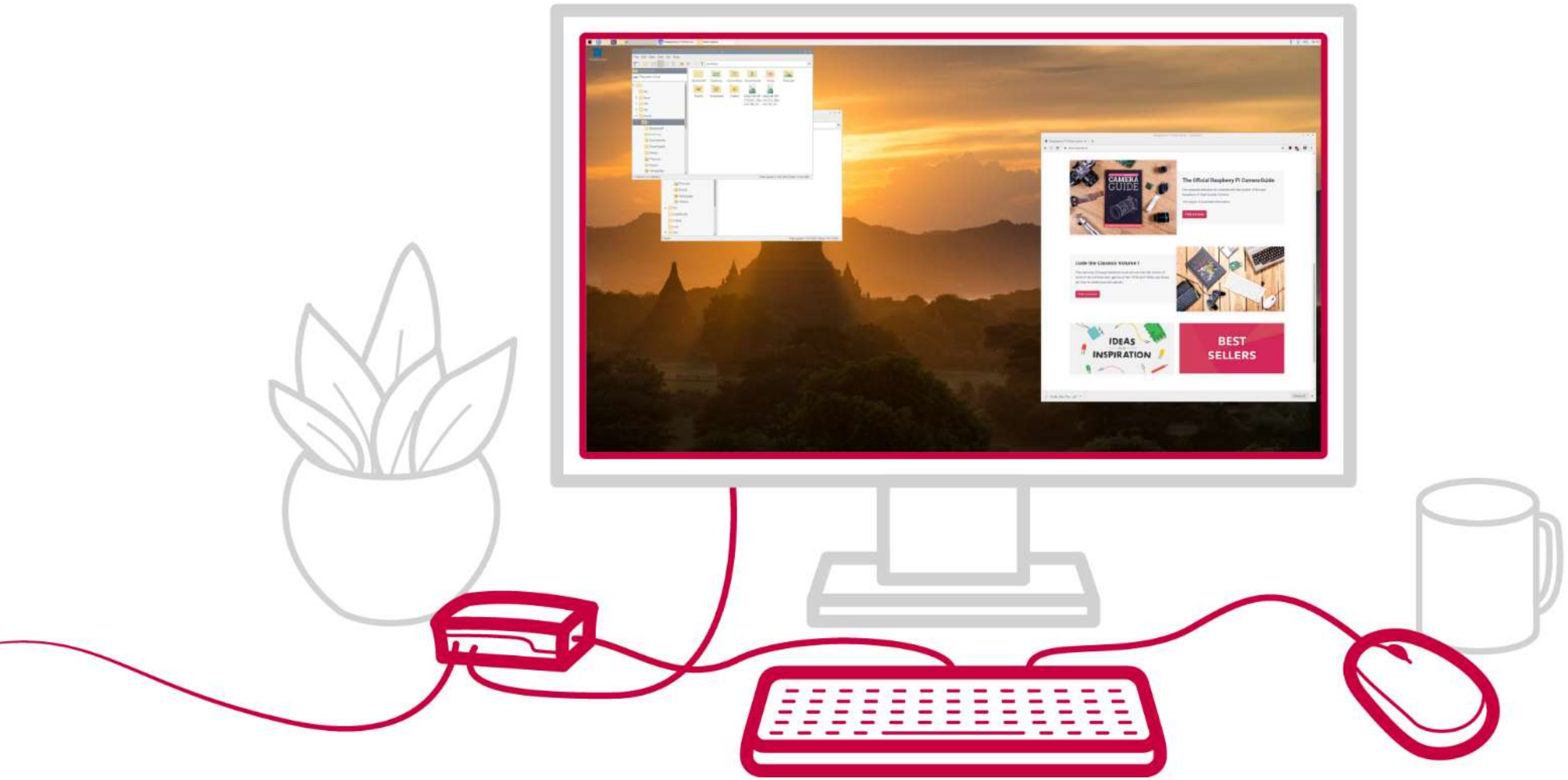


Raspberry Pi as PC

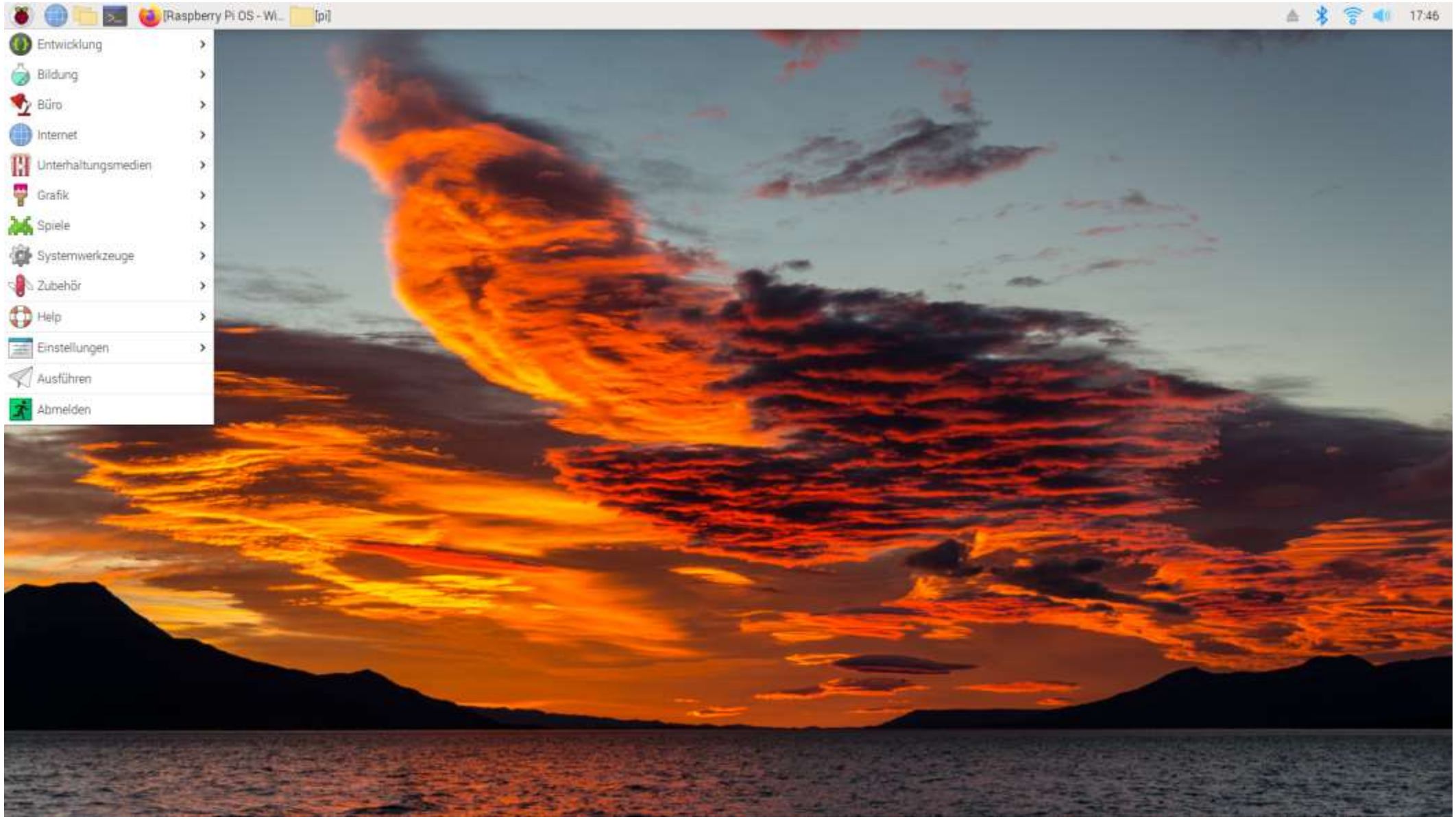
- You can connect mouse, keyboard and monitor as you use your PC.



Raspberry Pi as PC

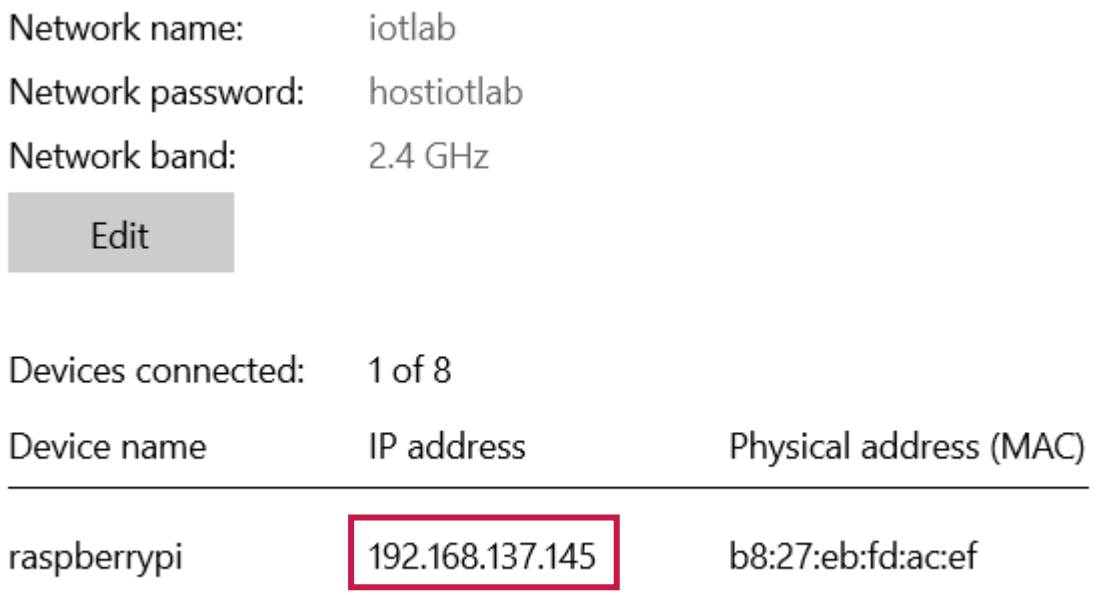


Raspberry Pi as PC



Accessing Raspberry Pi via SSH

- After connecting your Raspberry Pi to power, it will be connected to your Wi-Fi automatically and have an IP address.
- Open Mobile hotspot, and copy that IP address.



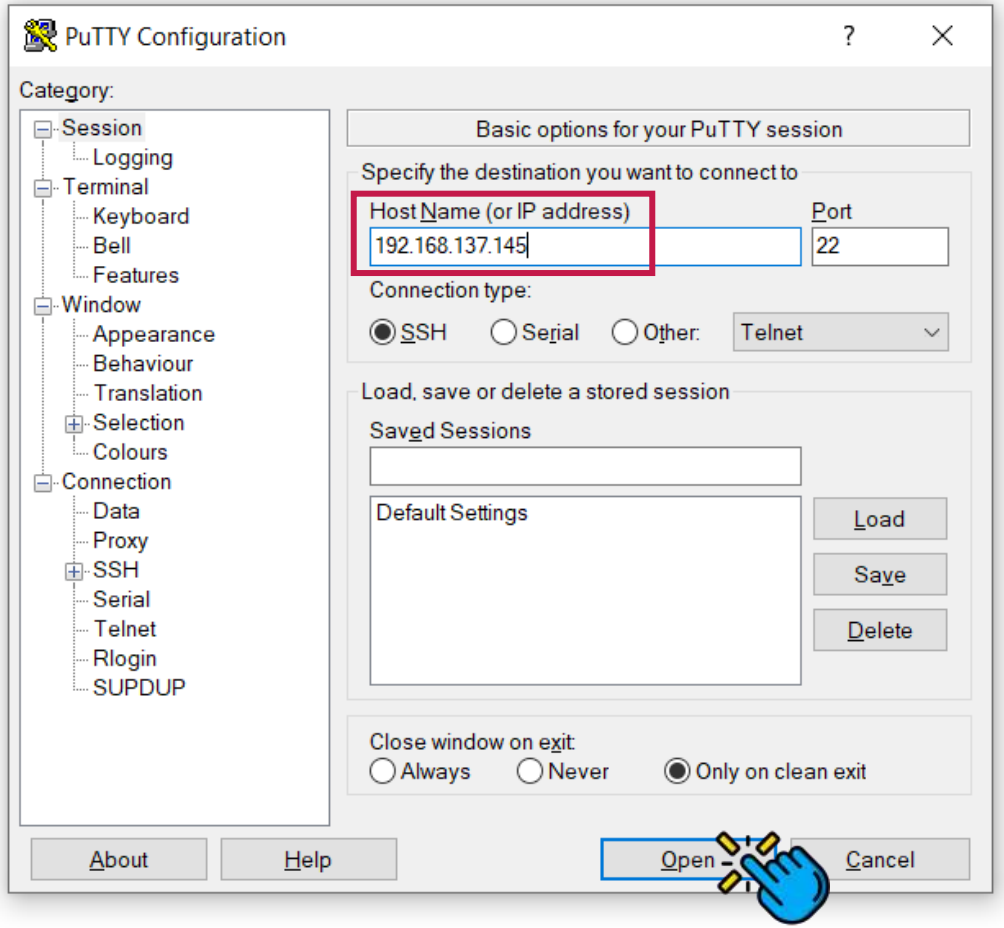
Accessing Raspberry Pi via SSH

- The Raspian OS on the Raspberry Pi allows for remote login and control via SSH (Secure Shell).
- Download & install the PuTTy application.

https://www.chiark.greenend.org.uk/~sgtatham/putty/latest.html

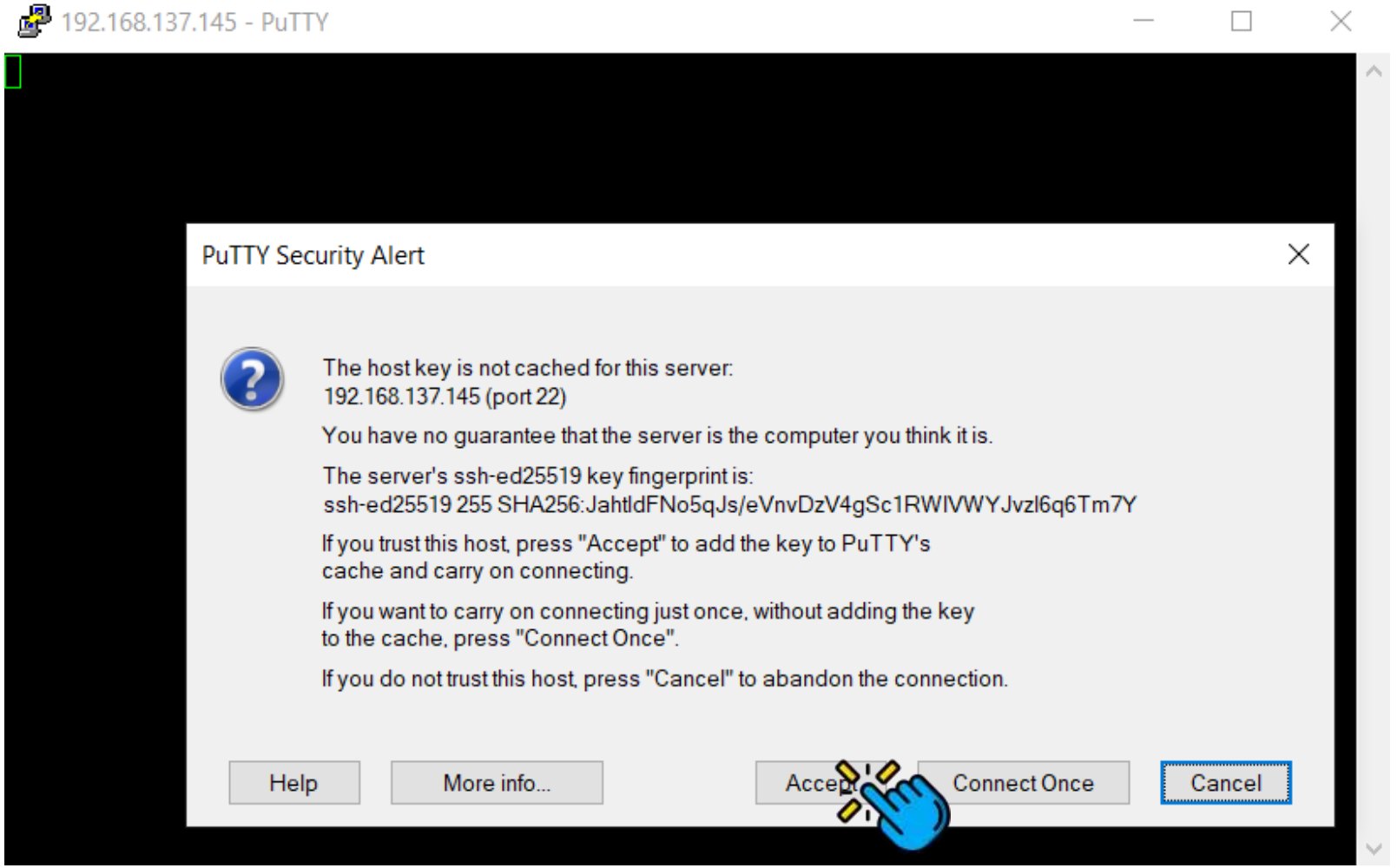
Accessing Raspberry Pi via SSH

- Open PuTTy, and enter the Raspberry Pi IP address in the Host Name.
- Click Open button.



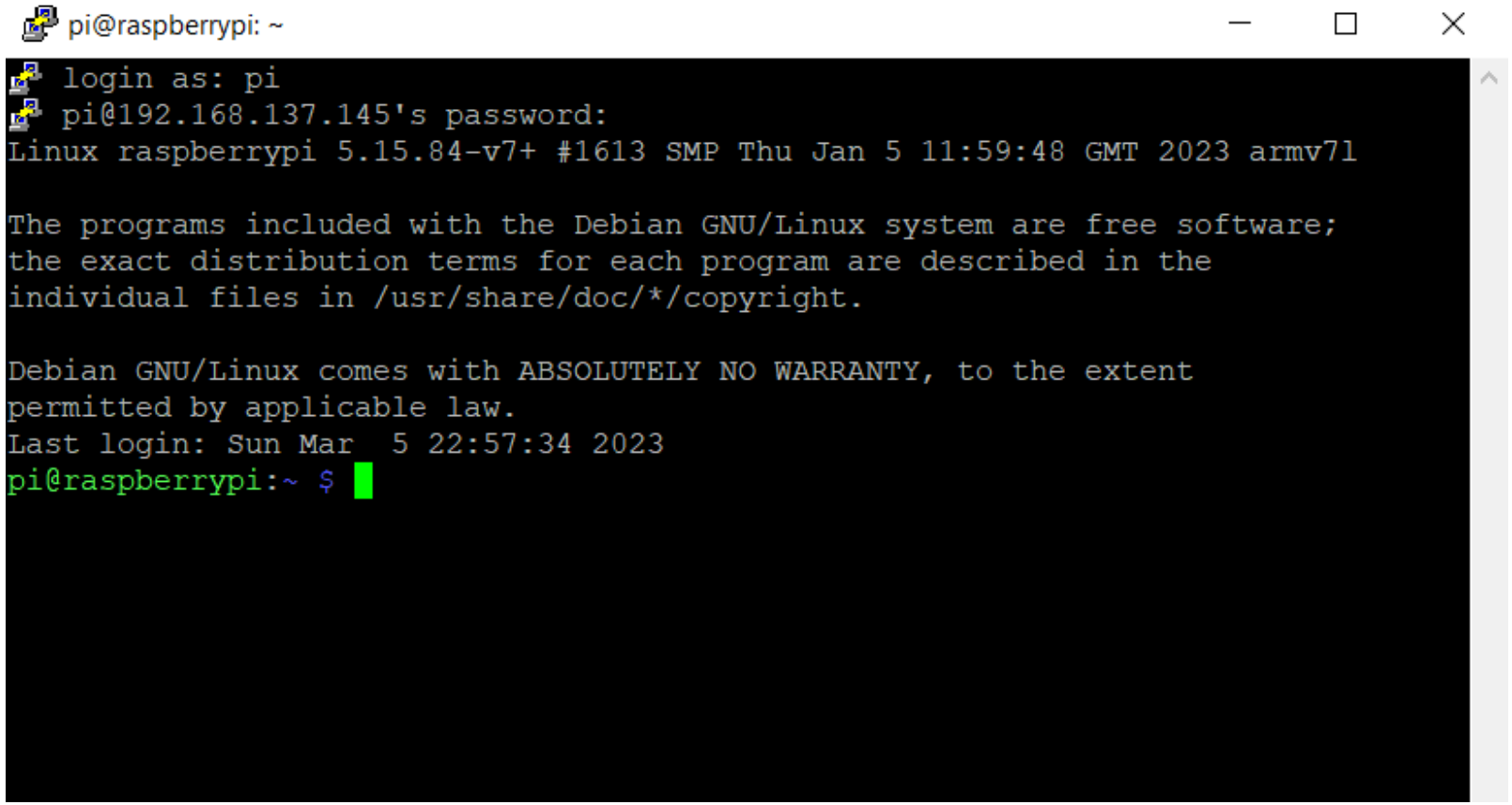
Accessing Raspberry Pi via SSH

- Click Accept button.



Accessing Raspberry Pi via SSH

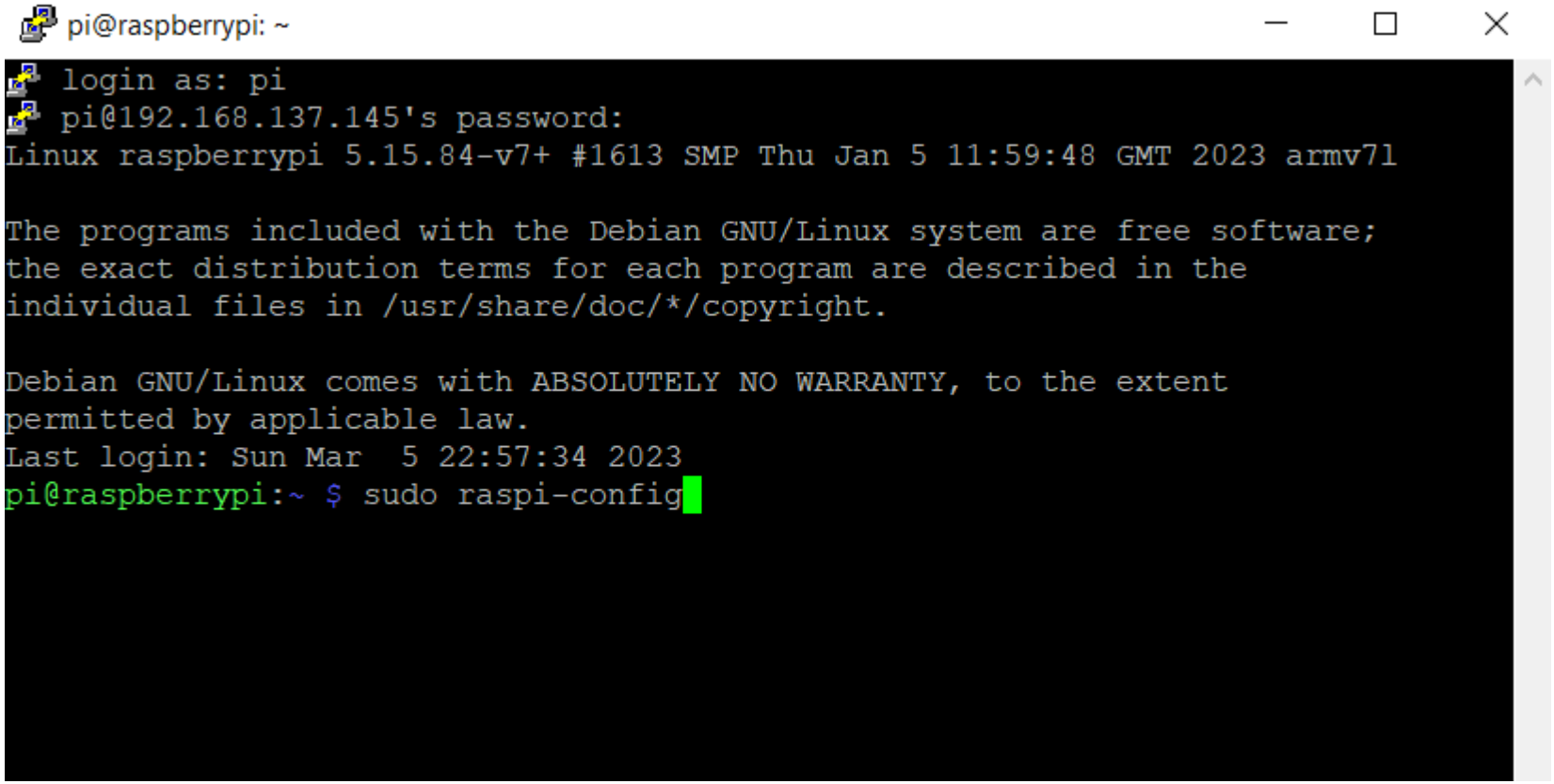
- Enter your username and password, and click Enter.
- Now, you can access your Raspberry Pi via Secure Shell.



Accessing Raspberry Pi via SSH

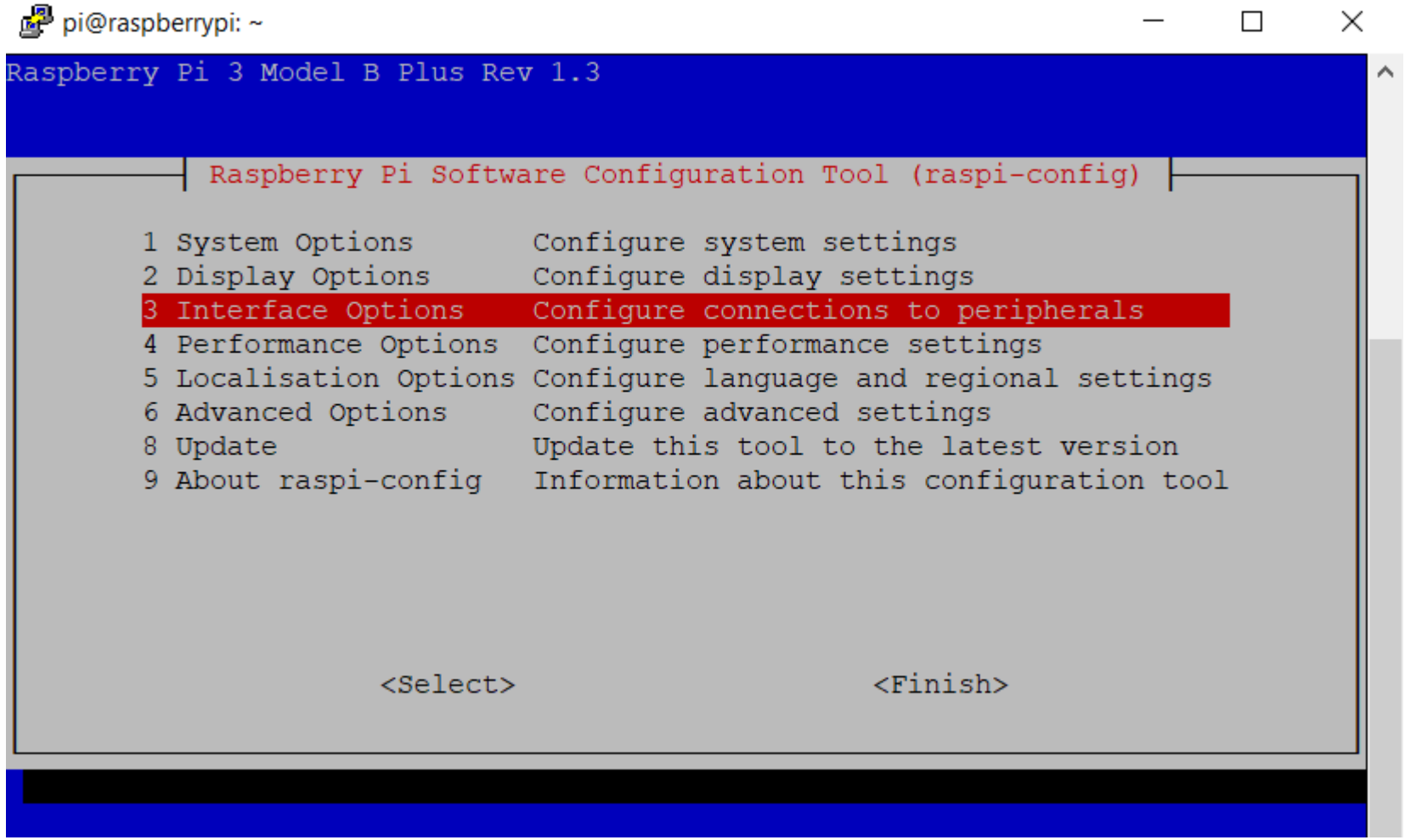
- To access your Raspberry Pi configurations, Enter the following command

```
sudo raspi-config
```



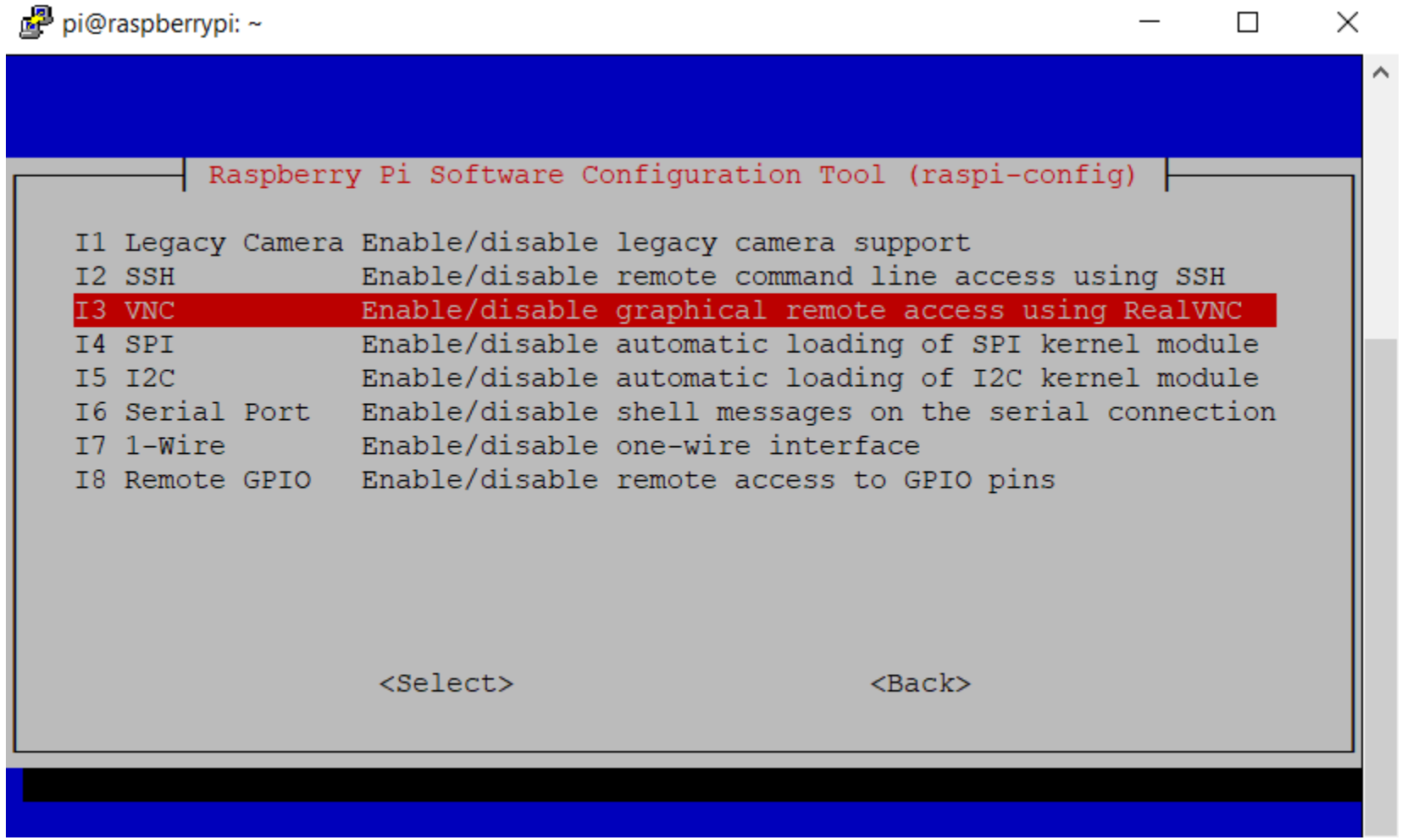
Accessing Raspberry Pi via SSH

- For example, to enable/disable Interface Options, select it and click Enter.



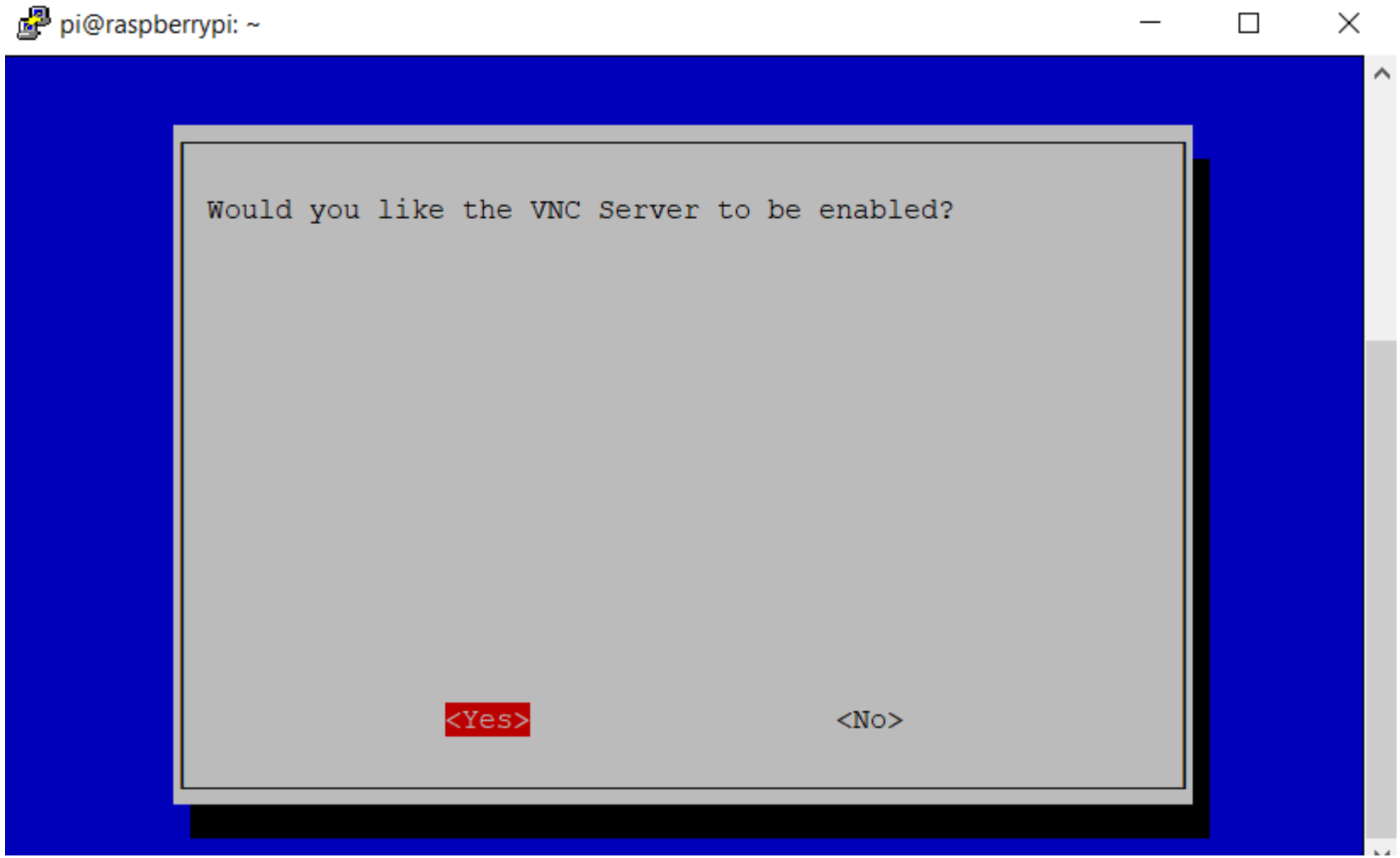
Accessing Raspberry Pi via SSH

- Select VNC, and click Enter.



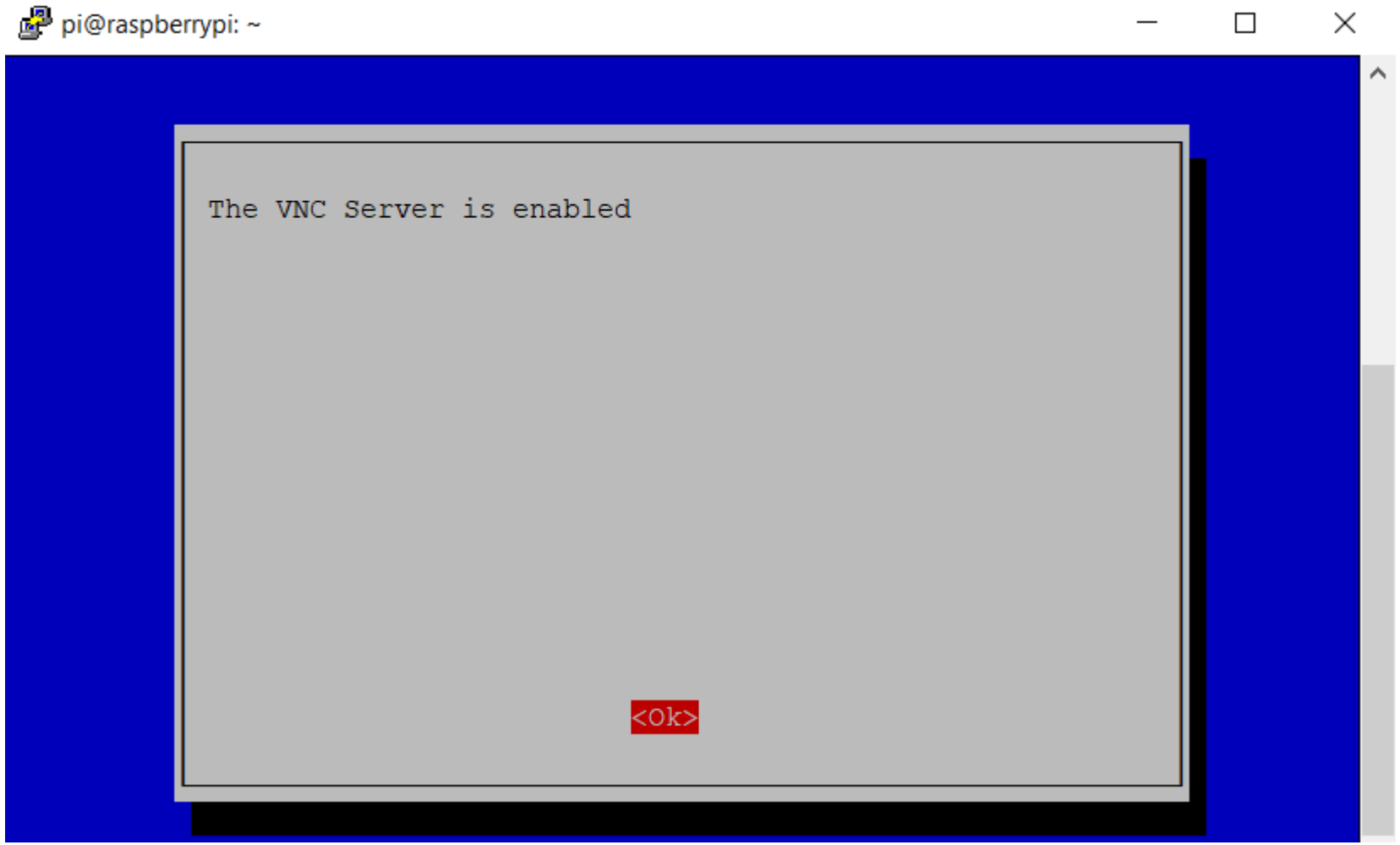
Accessing Raspberry Pi via SSH

- Select Yes, and click Enter.



Accessing Raspberry Pi via SSH

- Click Ok.

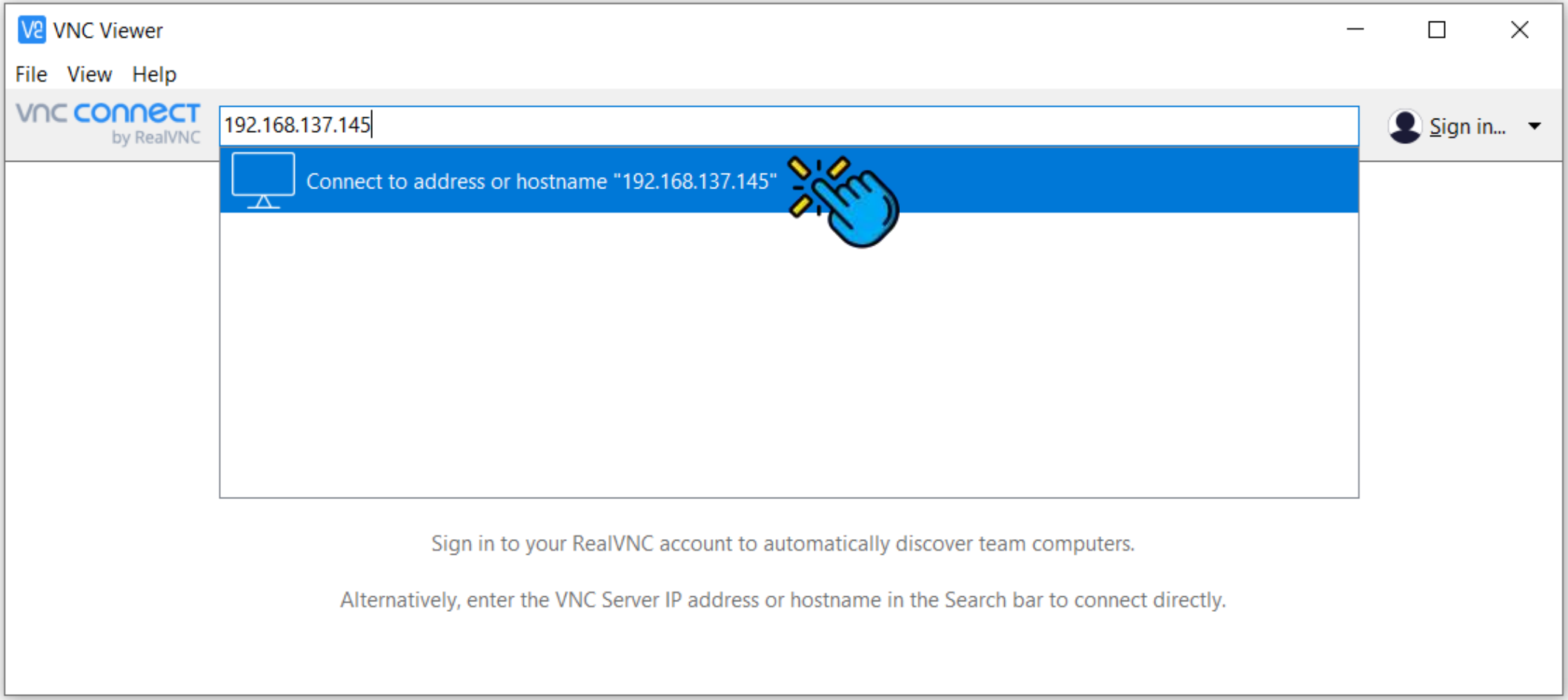


Accessing Raspberry Pi via VNC

- The Raspberry Pi can be controlled like any other desktop computer using a keyboard, mouse, and monitor.
- The VNC (Virtual Network Computing) allows you to remotely control the desktop interface of the Raspberry Pi from another computer or mobile device without the need for a monitor.
- The SSH only provides terminal access.

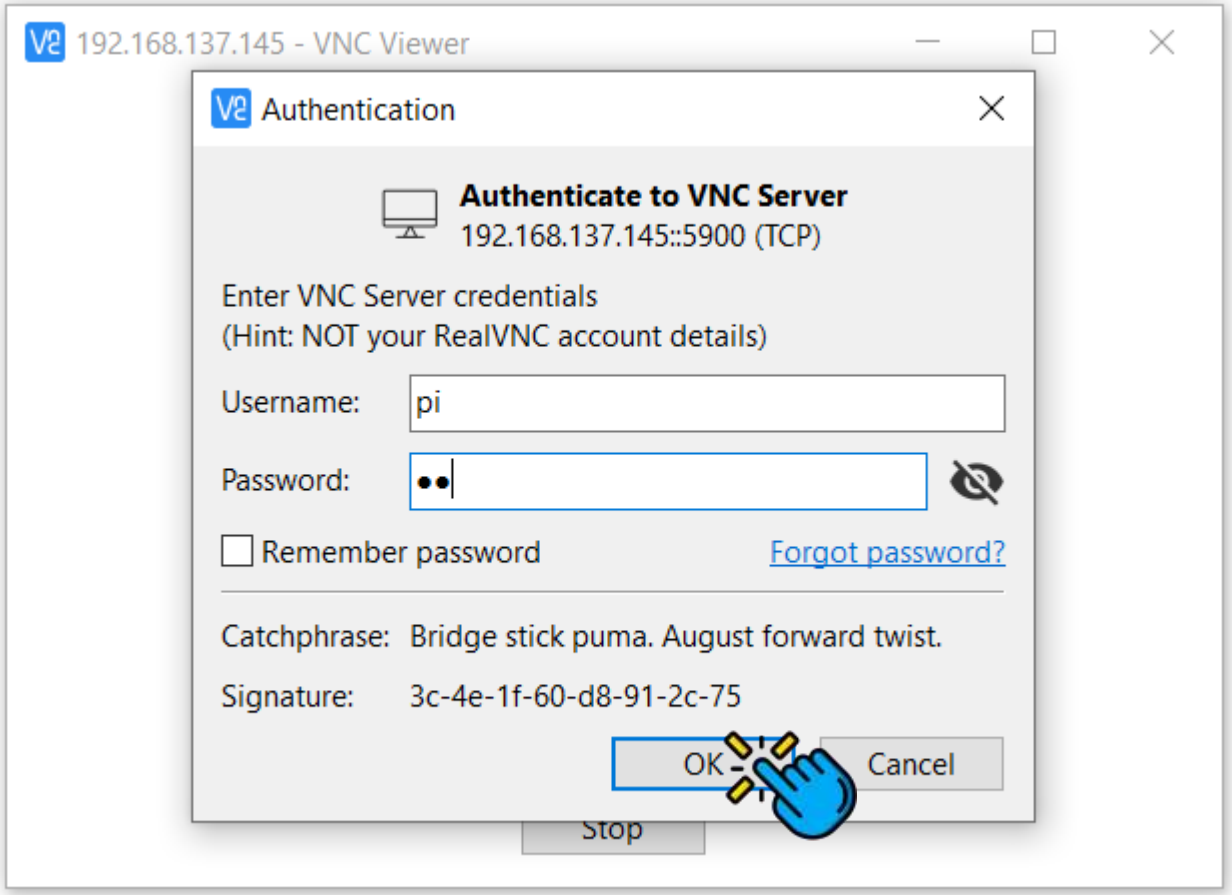
Accessing Raspberry Pi via VNC

- Download and Open VNC Viewer, and Enter the IP address of your Pi.



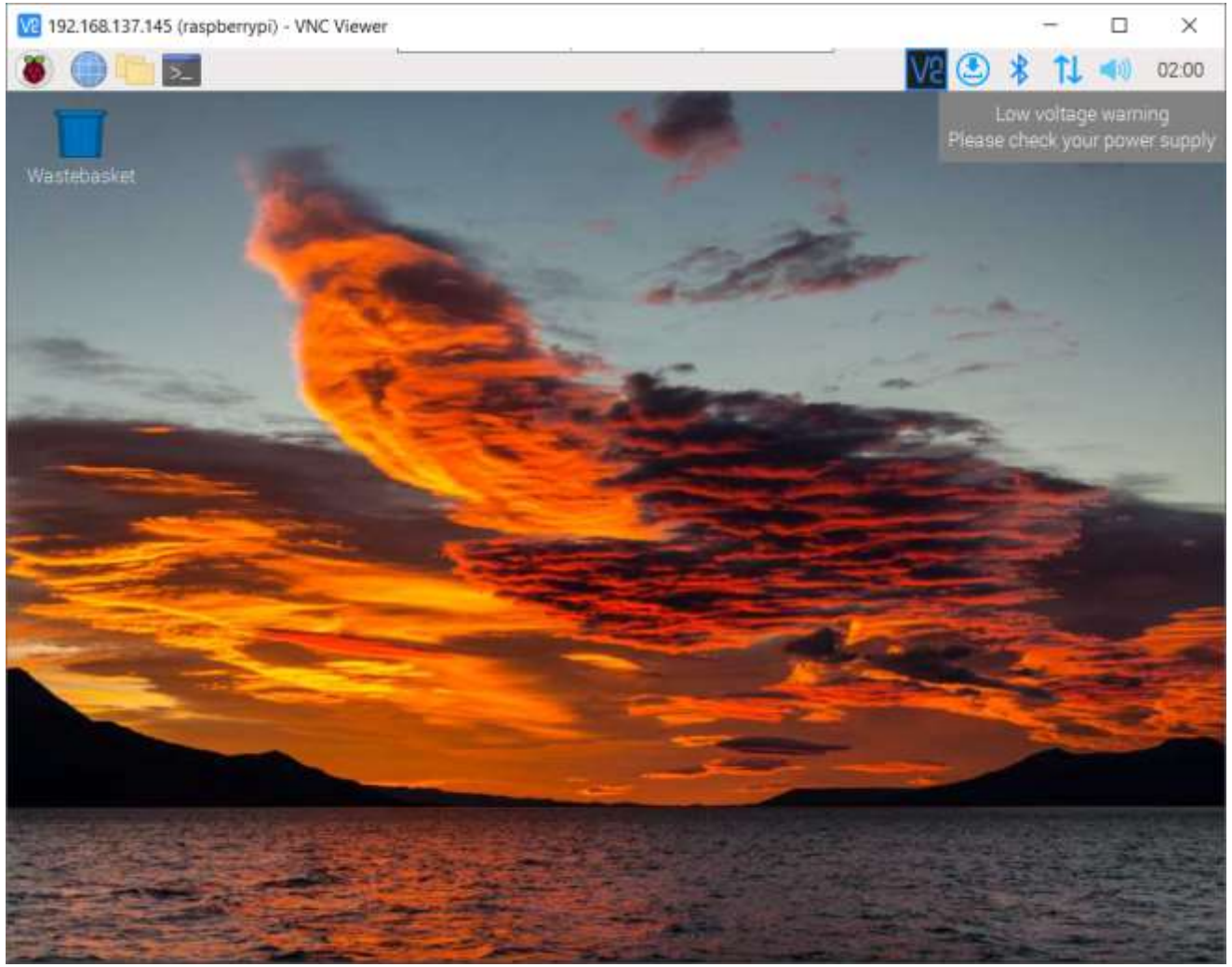
Accessing Raspberry Pi via VNC

- Enter your username and password, and click Ok.



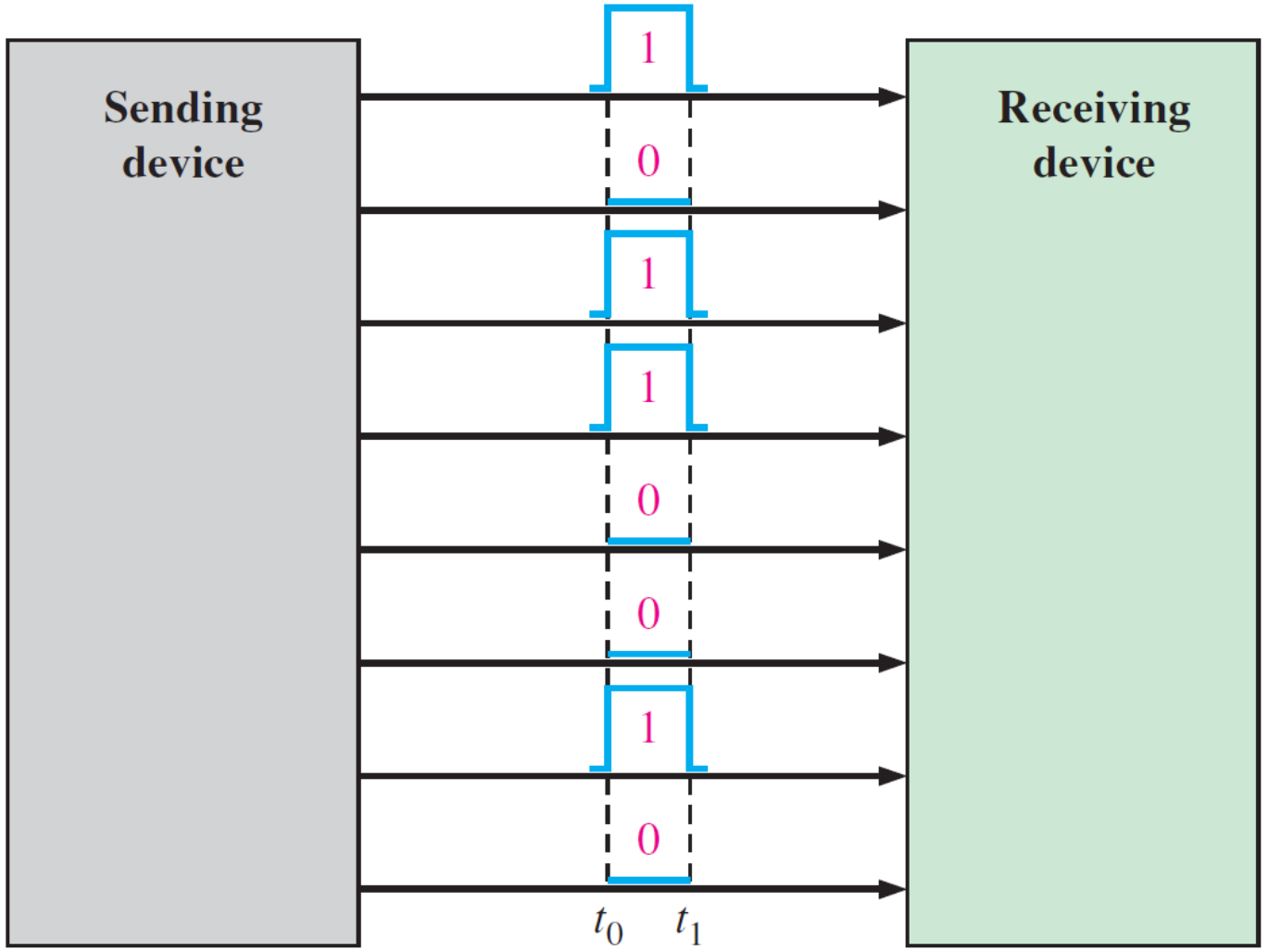
Accessing Raspberry Pi via VNC

- Now, you can graphically access your Raspberry Pi from anywhere.



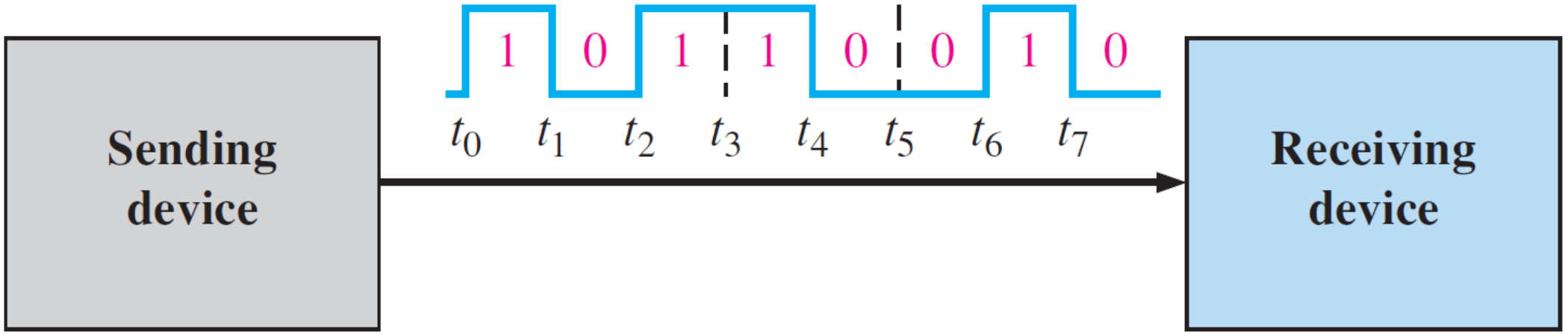
Parallel Communication

- In parallel communication, where many bits are sent at the same time.



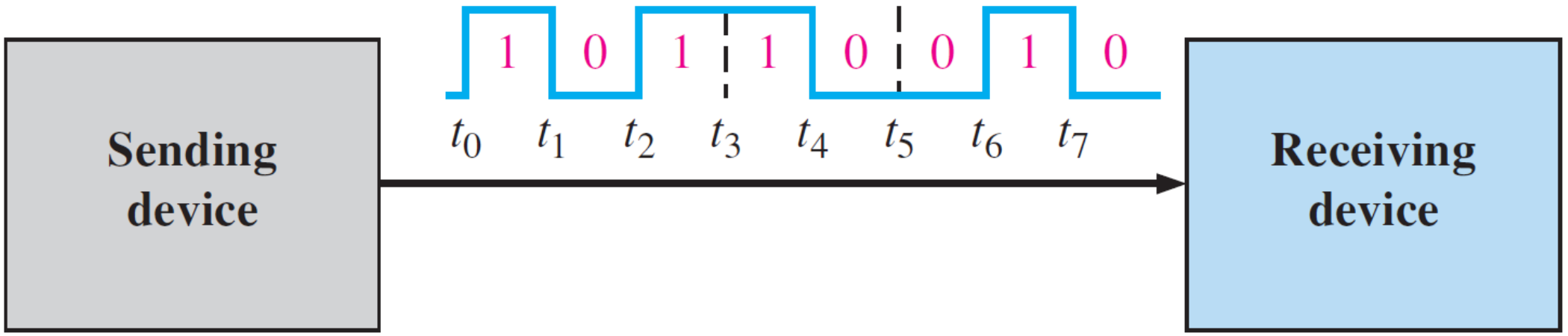
Serial Communication

- Serial communication is simply a way to transfer data.
- The data will be sent sequentially, one bit at a time.



Serial Communication: UART Protocol

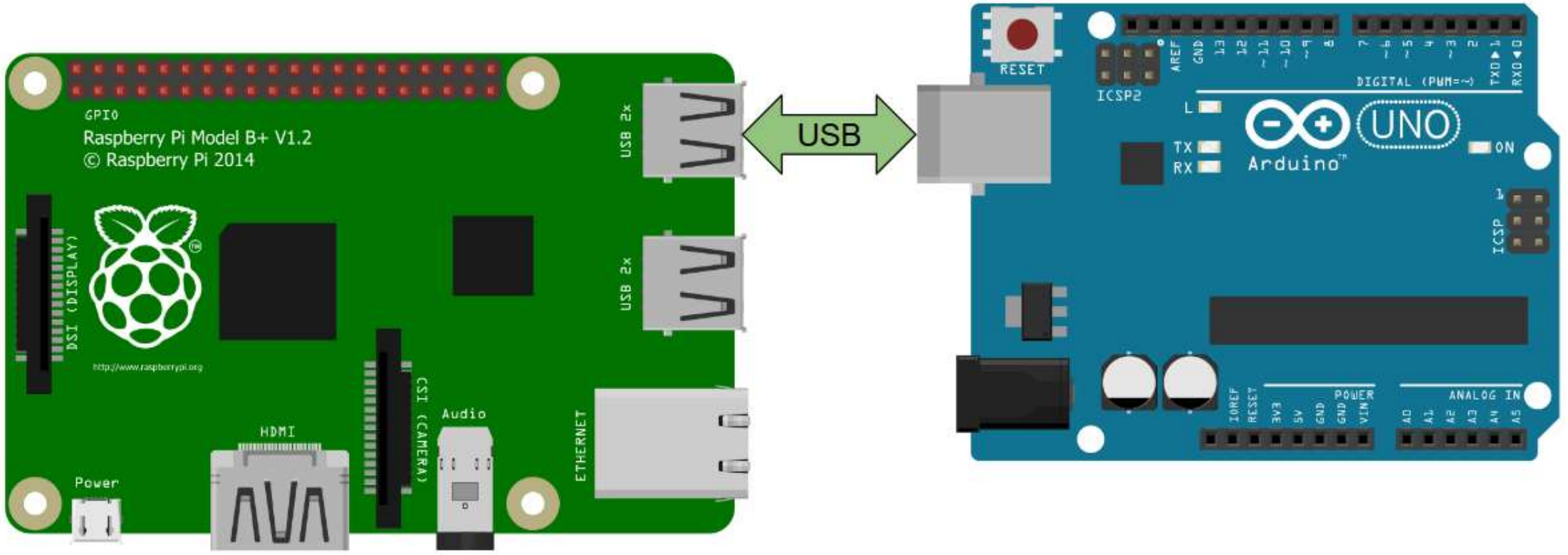
- UART means "Universal Asynchronous Receiver Transmitter".
- When you use serial communication between Arduino and Raspberry Pi, you're using the UART protocol.
- The UART protocol allows you to communicate between the 2 boards.



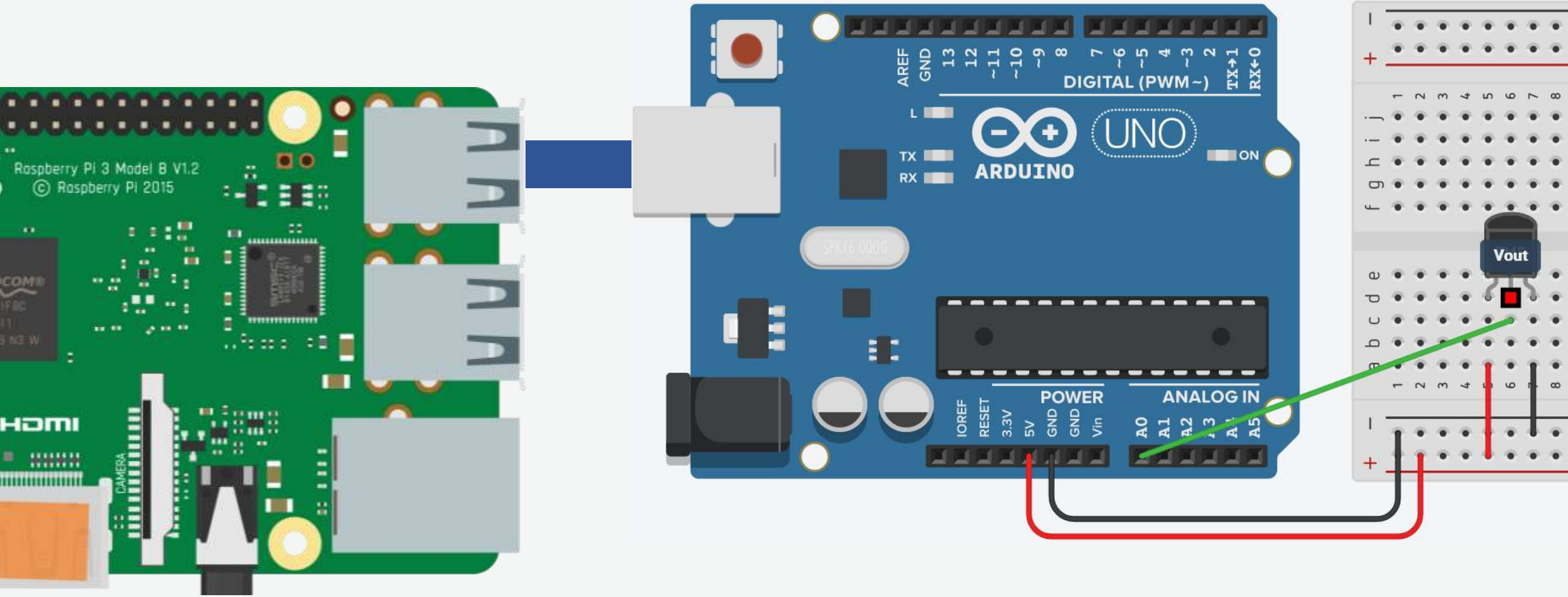
Raspberry Pi & Arduino Serial Communication

Raspberry Pi & Arduino Serial Communication

- The easiest way is to use a USB cable between both board.

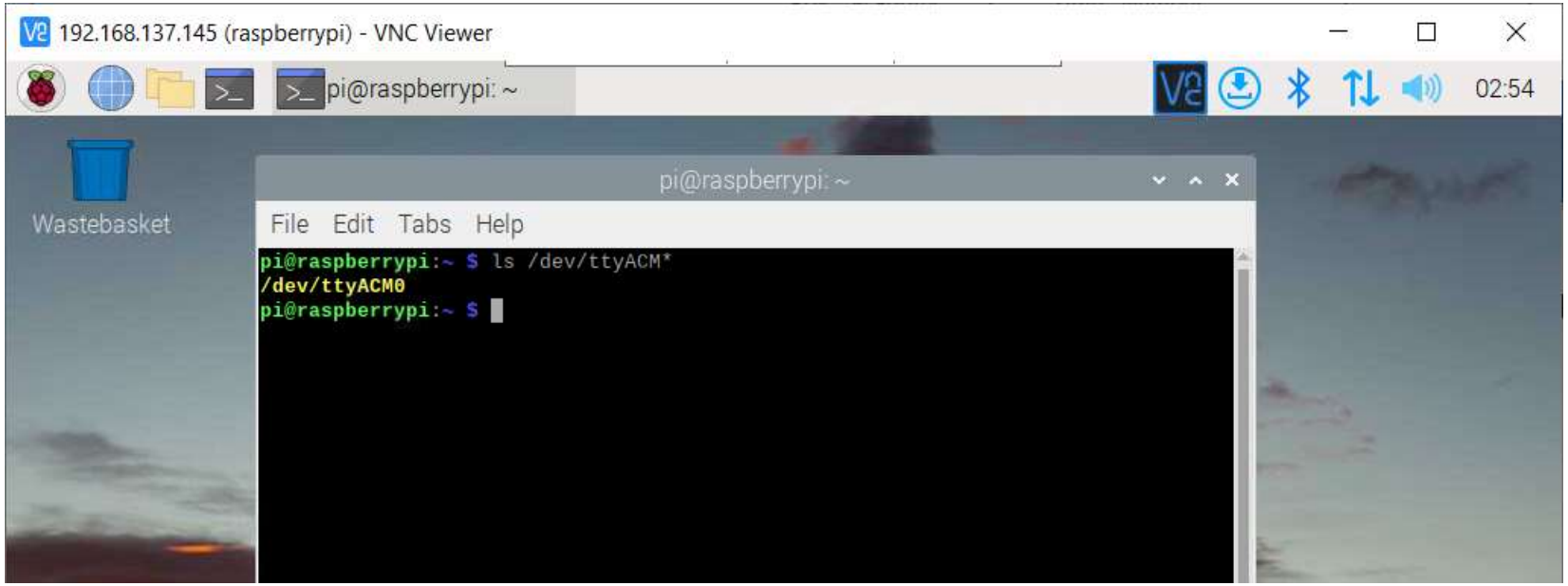


Raspberry Pi & Arduino Serial Communication



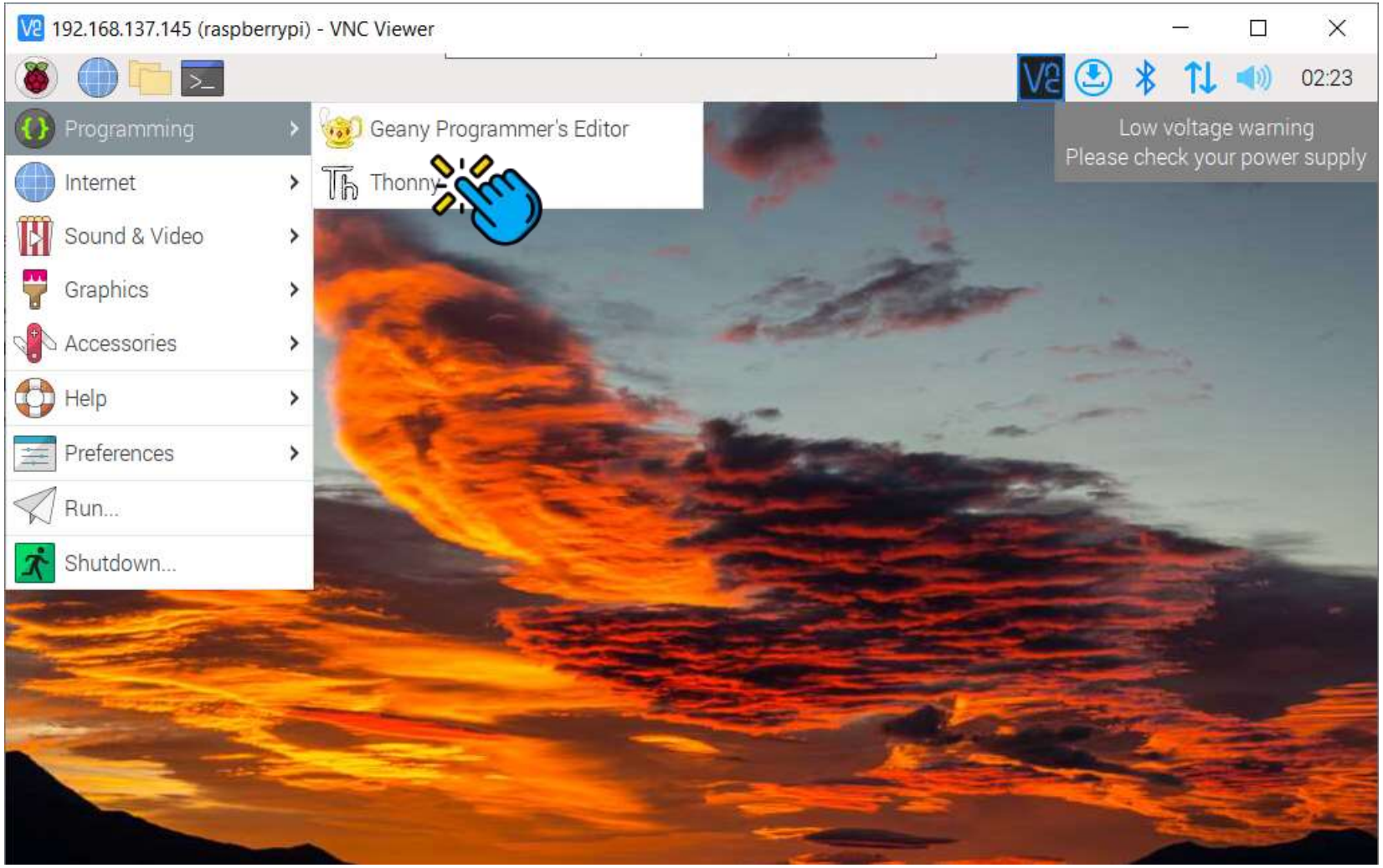
Raspberry Pi & Arduino Serial Communication

- When connecting the Arduino with a USB cable, you should see it appear as `/dev/ttyACM0`, or `/dev/ttyUSB0`.
- Sometimes the number can be different, for example `/dev/ttyACM1`.
- Simply run `ls /dev/ttyACM*` and you should see it.



Raspberry Pi & Arduino Serial Communication

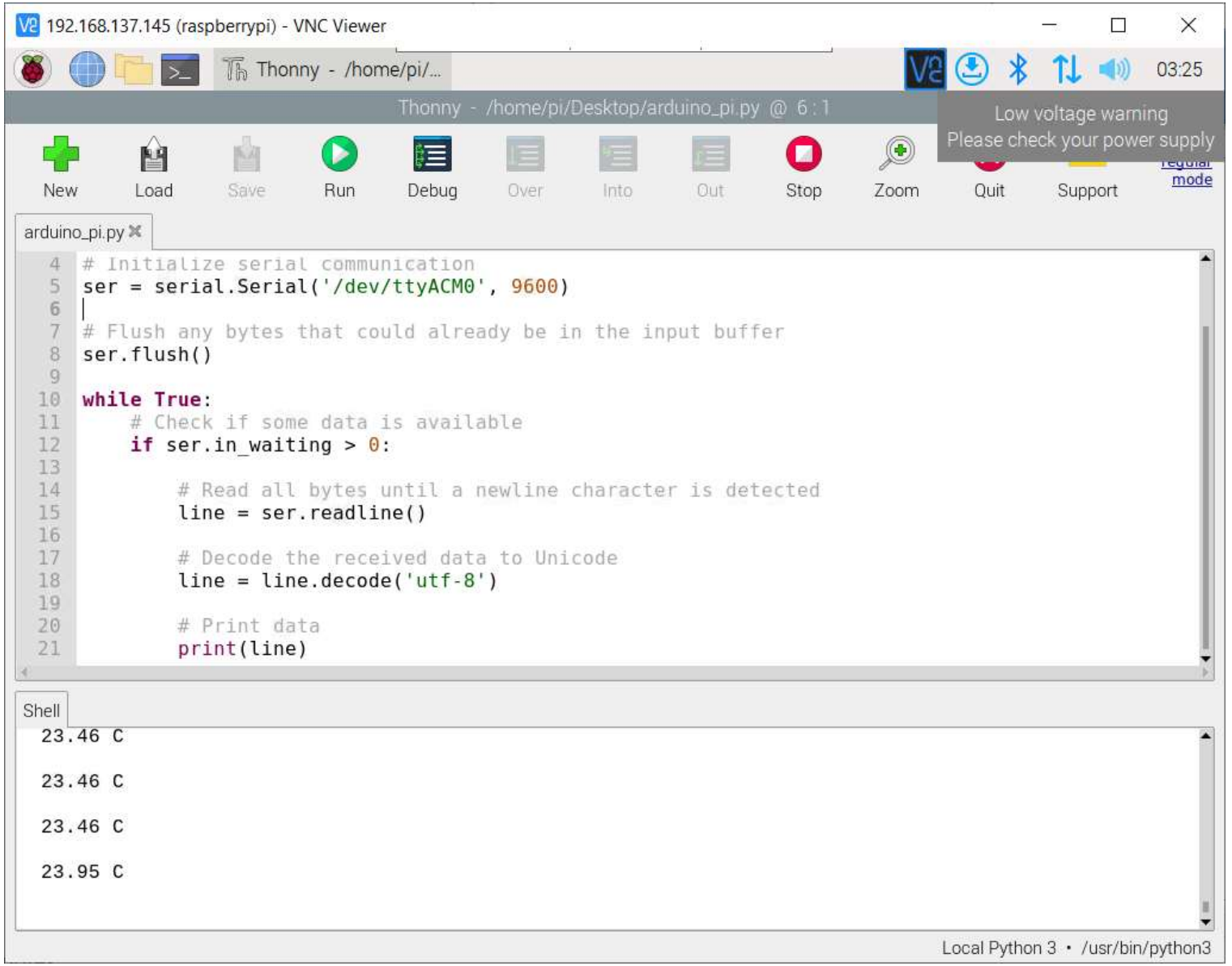
- Open Thonny Python IDE.



Raspberry Pi & Arduino Serial Communication

```
# Import the serial library
import serial

# Initialize serial communication
ser = serial.Serial('/dev/ttyACM0', 9600)

# Flush any bytes that could already be in the input buffer
ser.flush()

while True:
    # Check if some data is available
    if ser.in_waiting > 0:

        # Read all bytes until a newline character is detected
        line = ser.readline()

        # Decode the received data to Unicode
        line = line.decode('utf-8')

        # Print data
        print(line)
```

Raspberry Pi & Arduino Serial Communication



References

- Interfacing LM35 Temperature Sensor with Arduino
- Install Raspbian OS and Connect to Hotspot
- Raspberry Pi Arduino Serial Communication