

Lesson 1 Introduction to the Raspberry Pi

The Raspberry Pi is not included in the product kit. Recommended Raspberry Pi version: 3B, 3B+, 4B and 5.

1.1 Overview of Raspberry Pi

Raspberry Pi (Raspberry Pi, RasPi/RPi) is developed by the British charity organization "Raspberry Pi Foundation", based on ARM microcomputer motherboard, only the size of a credit card, but has the basic functions of a personal computer. The original purpose of the Foundation's development of the Raspberry Pi was to improve the teaching level of the school's computer science and related disciplines, and cultivate the youth's computer programming interest and ability. Nowadays, most people use the Raspberry Pi for embedded development, which is mostly used in the Internet of Things, smart home, and artificial intelligence.

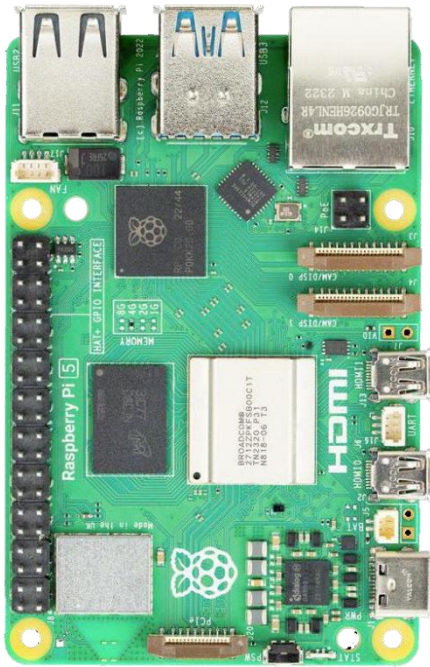
1.2 Raspberry Pi Motherboard

So far, at this writing, Raspberry Pi has advanced to its fifth generation product offering. Version changes are accompanied by increases in upgrades in hardware and capabilities.

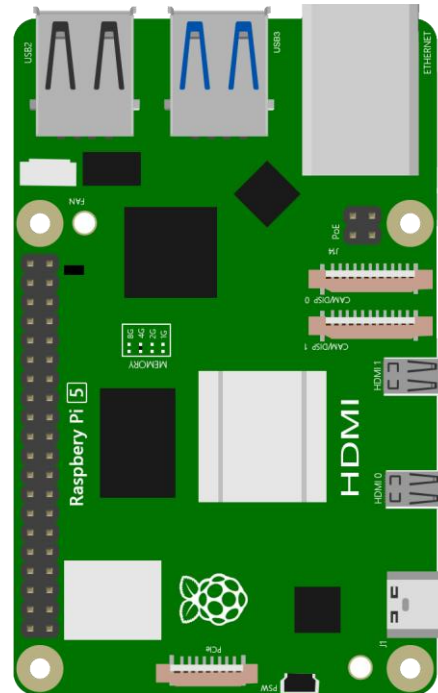
The A type and B type versions of the first generation products have been discontinued due to various reasons. What is most important is that other popular and currently available versions are consistent in the order and number of pins and their assigned designation of function, making compatibility of peripheral devices greatly enhanced between versions.

Below are the raspberry pi pictures and model pictures supported by this product. They have 40 pins.

Practicality picture of Raspberry Pi 5:



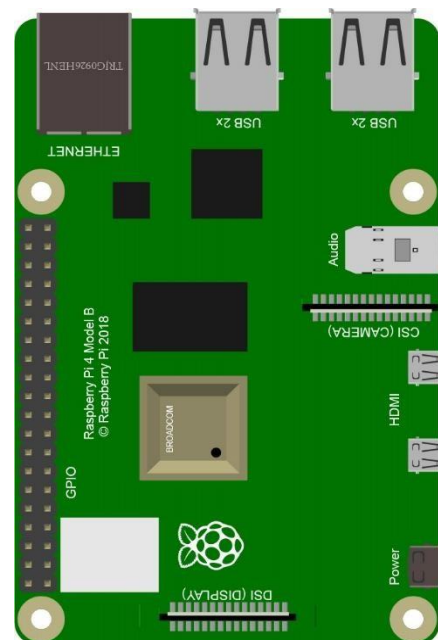
Model diagram of Raspberry Pi 5:



Actual image of Raspberry Pi 4 Model B:



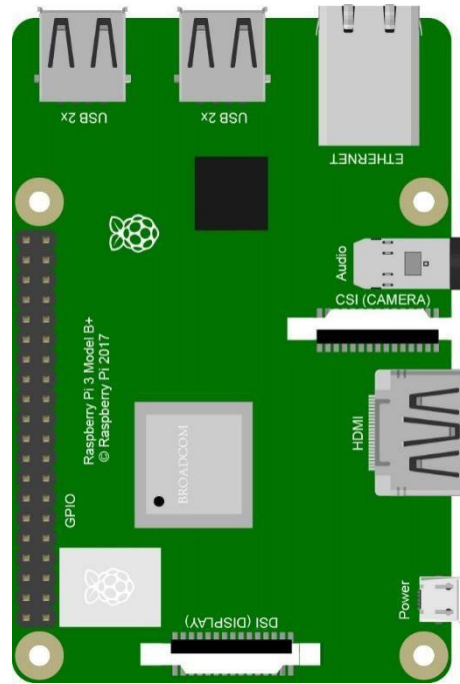
CAD image of Raspberry Pi 4 Model B:



Actual image of Raspberry Pi 3 Model B+ :



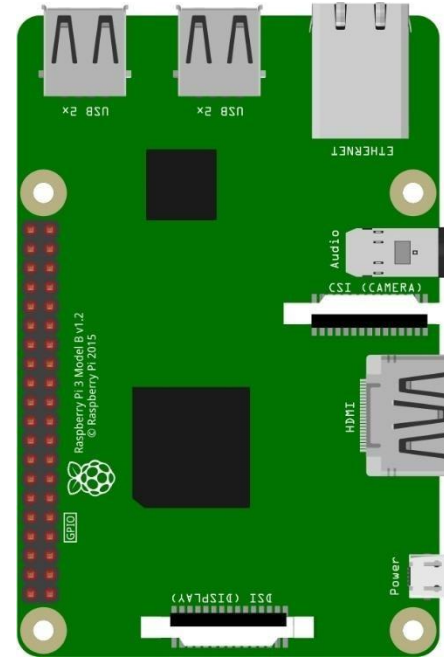
CAD image of Raspberry Pi 3 Model B+ :



Actual image of Raspberry Pi 3 Model B:



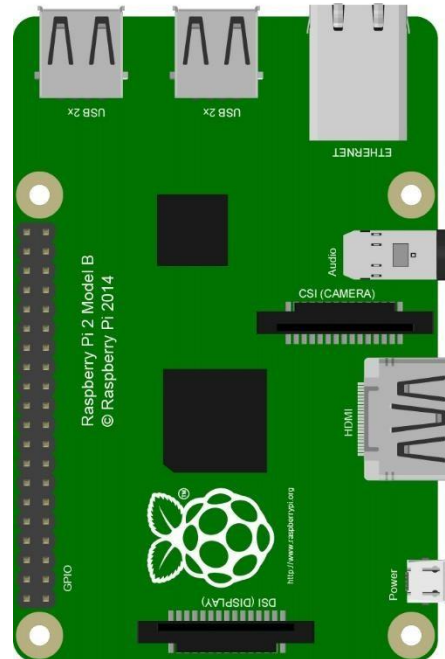
CAD image of Raspberry Pi 3 Model B:



Actual image of Raspberry Pi 2 Model B:



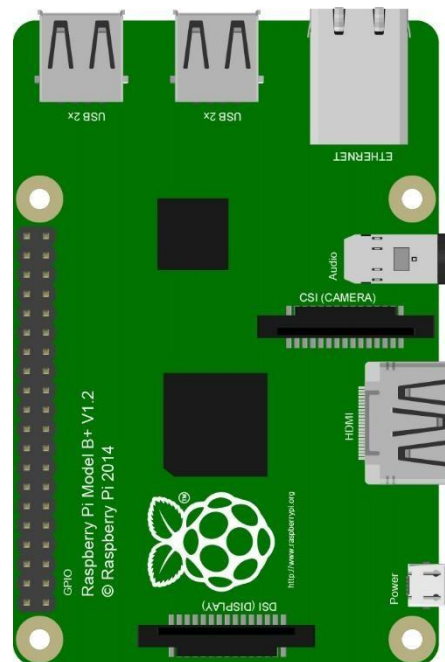
CAD image of Raspberry Pi 2 Model B:



Actual image of Raspberry Pi 1 Model B+:



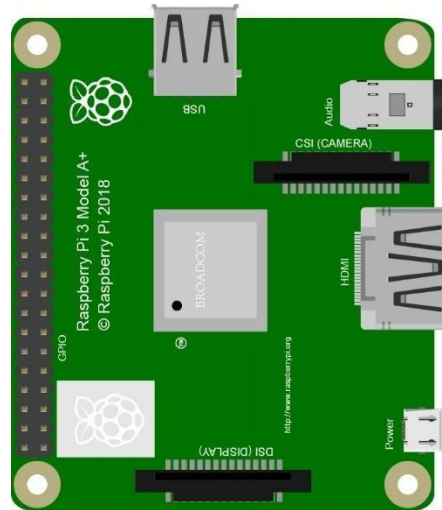
CAD image of Raspberry Pi 1 Model B+:



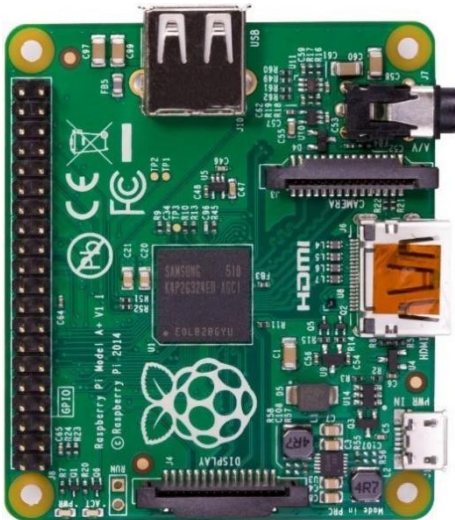
Actual image of Raspberry Pi 3 Model A+:



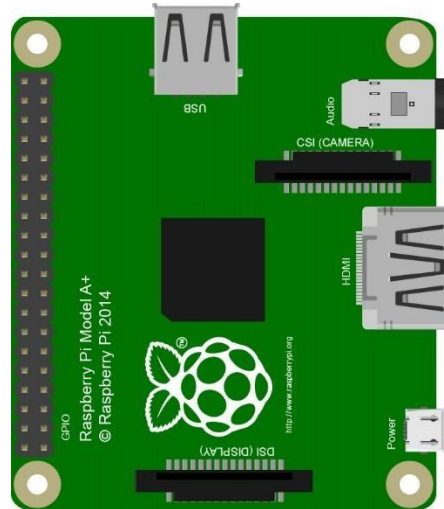
CAD image of Raspberry Pi 3 Model A+:



Actual image of Raspberry Pi 1 Model A+:



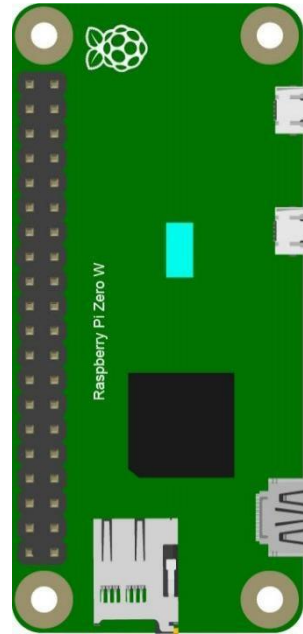
CAD image of Raspberry Pi 1 Model A+:



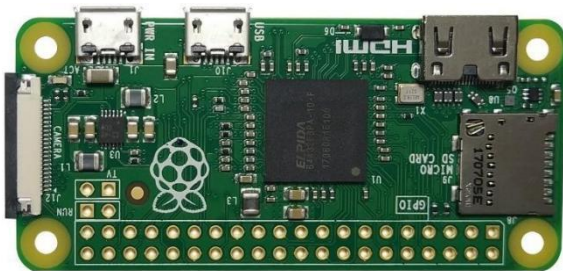
Actual image of Raspberry Pi Zero W:



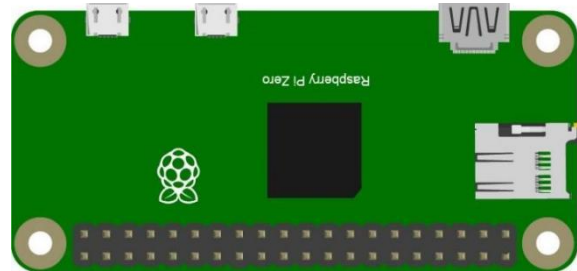
CAD image of Raspberry Pi Zero W:



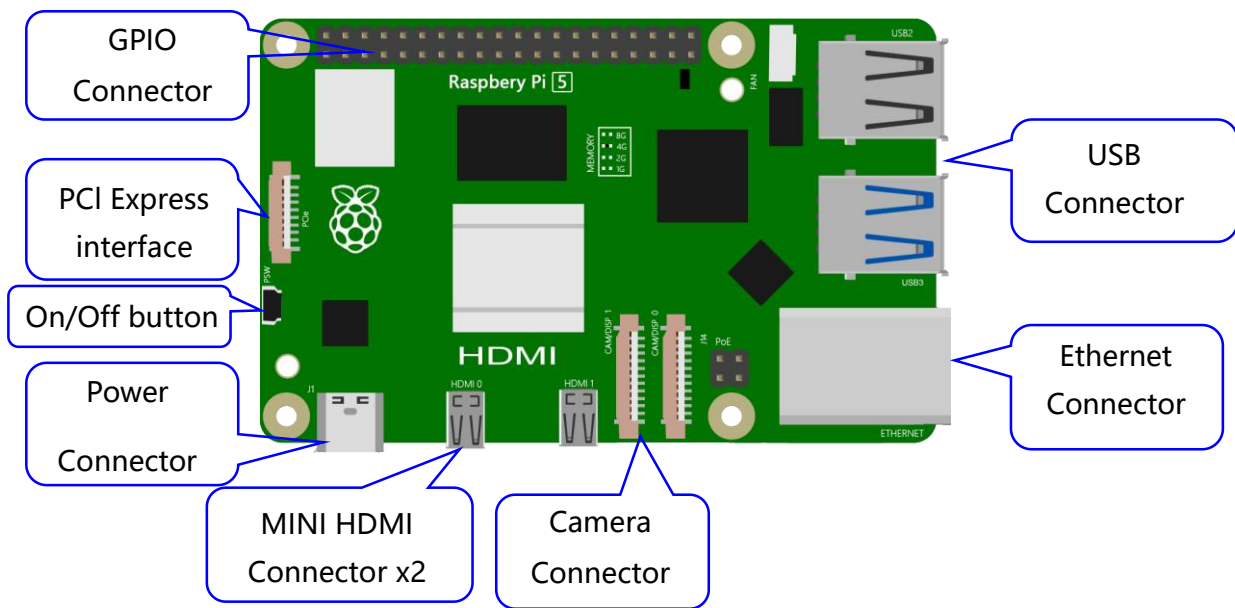
Actual image of Raspberry Pi Zero :



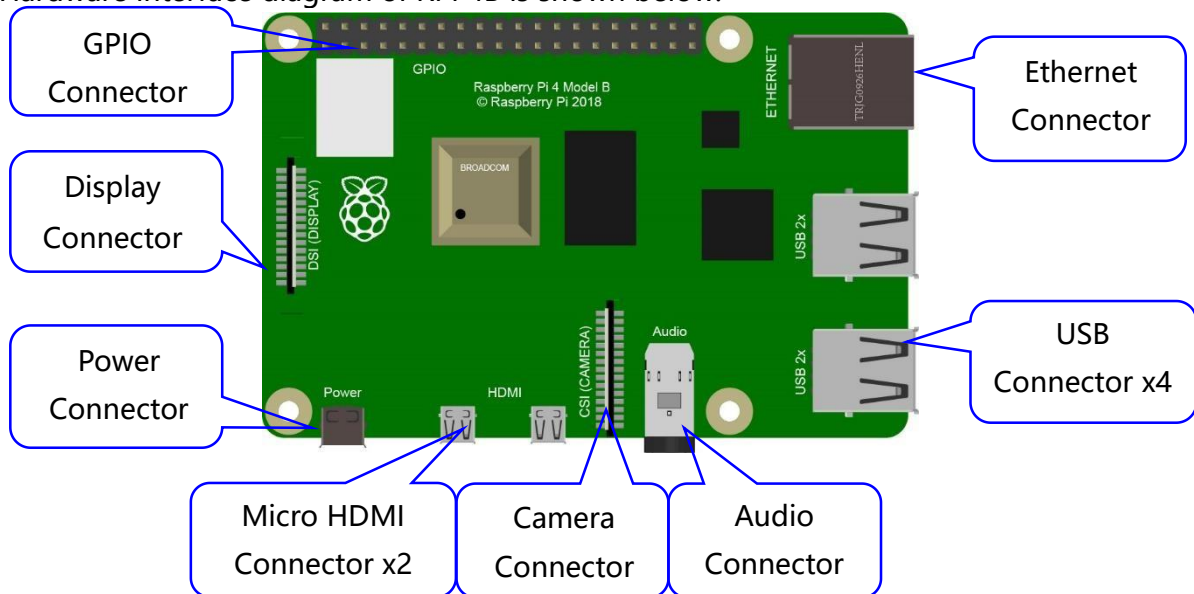
CAD image of Raspberry Pi Zero :



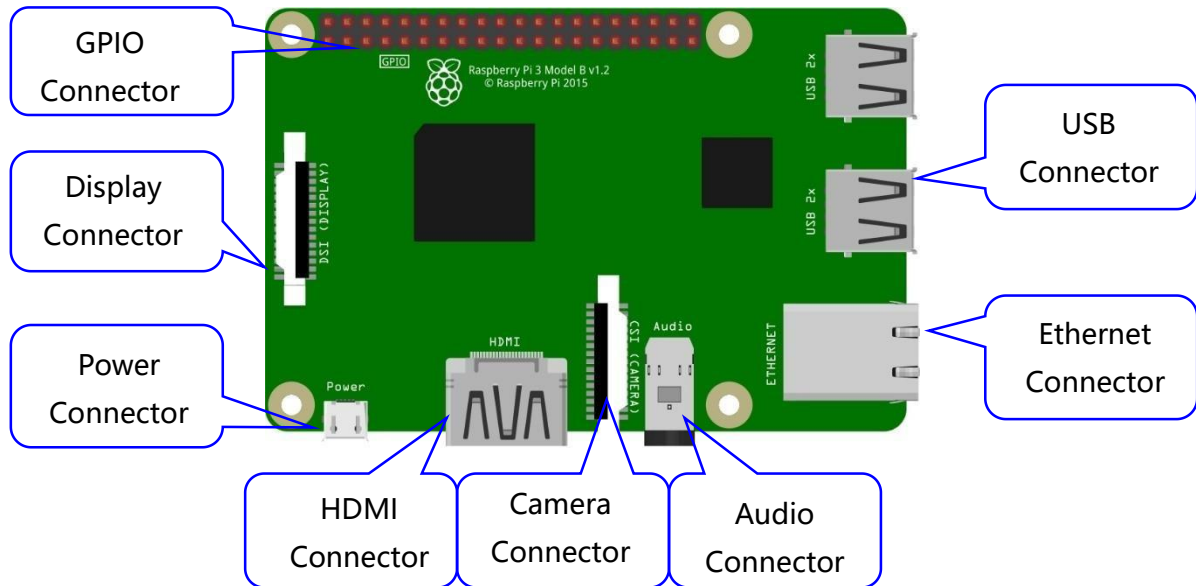
Below are the raspberry pi pictures and model pictures supported by this product. They have 40 pins. Hardware interface diagram of RPi 5 is shown below:



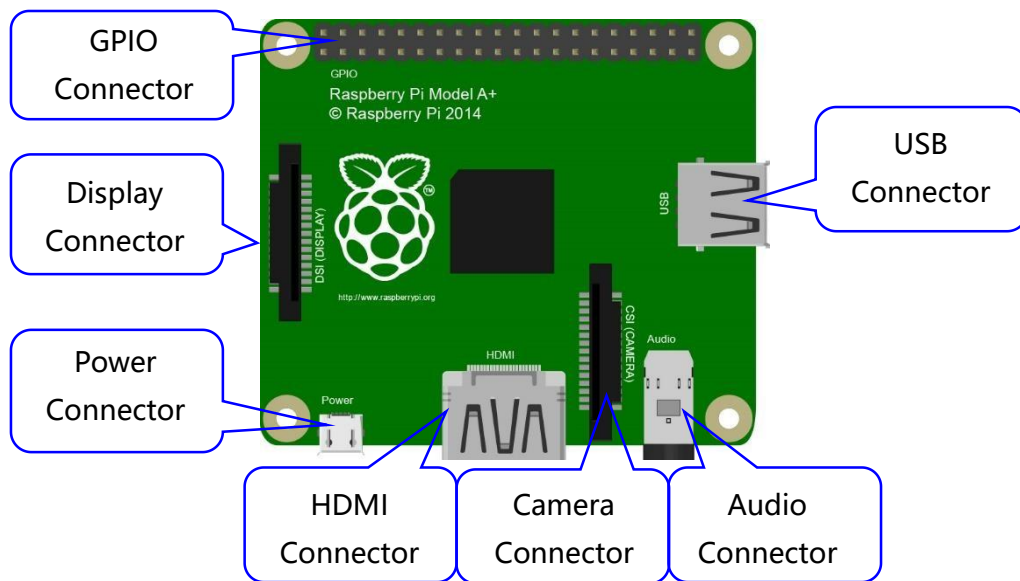
Hardware interface diagram of RPi 4B is shown below:



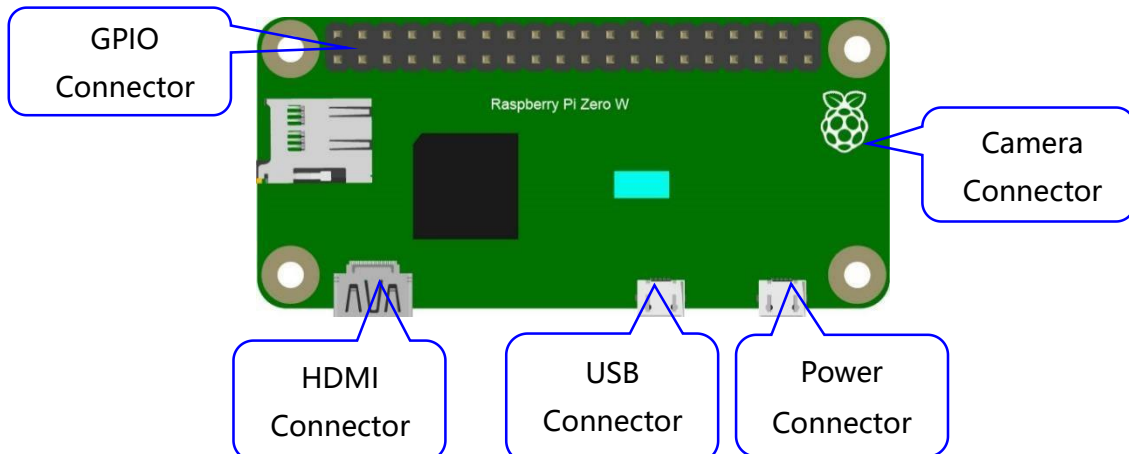
Hardware interface diagram of RPi 3B+/3B/2B/1B+:



Hardware interface diagram of RPi 3A+/A+:

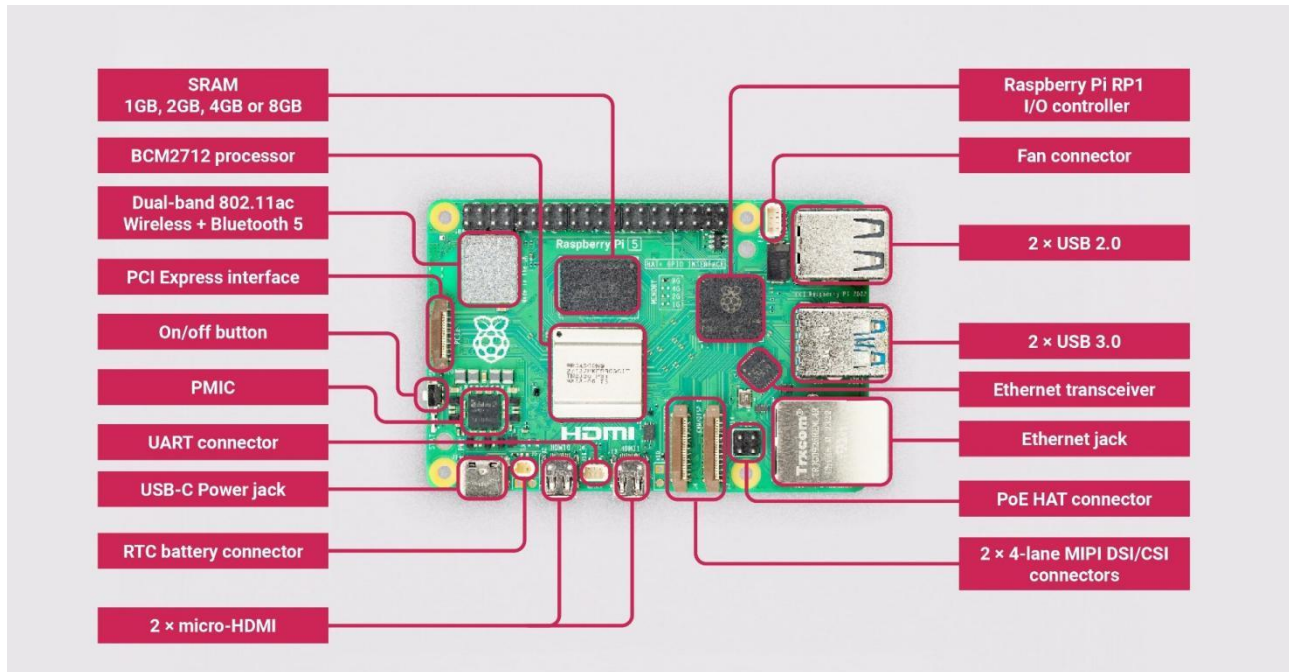


Hardware interface diagram of RPi Zero/Zero W



| Product | Recommended PSU current capacity | Maximum total USB peripheral current draw | Typical bare-board active current consumption |
|-------------------------|----------------------------------|--|---|
| Raspberry Pi 1 Model A | 700mA | 500mA | 200mA |
| Raspberry Pi 1 Model B | 1.2A | 500mA | 500mA |
| Raspberry Pi 1 Model A+ | 700mA | 500mA | 180mA |
| Raspberry Pi 1 Model B+ | 1.8A | 1.2A | 330mA |
| Raspberry Pi 2 Model B | 1.8A | 1.2A | 350mA |
| Raspberry Pi 3 Model B | 2.5A | 1.2A | 400mA |
| Raspberry Pi 3 Model A+ | 2.5A | Limited by PSU, board, and connector ratings only. | 350mA |
| Raspberry Pi 3 Model B+ | 2.5A | 1.2A | 500mA |
| Raspberry Pi 4 Model B | 3.0A | 1.2A | 600mA |
| Raspberry Pi 5 | 5.0A | 1.6A (600mA if using a 3A power supply). | 800mA |
| Raspberry Pi 400 | 3.0A | 1.2A | 800mA |
| Raspberry Pi Zero | 1.2A | Limited by PSU, board, and connector ratings only. | 100mA |
| Raspberry Pi Zero W | 1.2A | Limited by PSU, board, and connector ratings only. | 150mA |
| Raspberry Pi Zero 2 W | 2A | Limited by PSU, board, and connector ratings only. | 350mA |

Let's take a look at the structure of the Raspberry Pi 5 motherboard as shown below: (We recommend using Raspberry Pi 4, 3B+, 3B)



The Raspberry Pi motherboard mainly includes the following parts/ports:

1. GPIO 40-PIN GPIO

The General-Purpose Input Output (GPIO) is designed as a slot with two rows of pins on the board. It can be used to connect various peripheral electronic devices and sensors to control or monitor them through input/output level signals. For example, you can use GPIO to control the speed of a DC motor or read the distance measured of an ultrasonic sensor. These functions of GPIO differ the Raspberry Pi from common computer motherboards because it gives developers the freedom to operate manually. We will further introduce GPIO in the subsequent chapters and use them extensively.

2. Gigabit Ethernet port

The Ethernet interface allows the Raspberry Pi to connect to the computer network in a wired manner, which enables easy access to the Internet or logging in to the Raspberry Pi remotely. The Raspberry Pi's Ethernet interface is implemented by using a USB bus through which data is transferred. Most models of Raspberry Pi include an Ethernet interface.

3. Micro HDMI port

High-definition multimedia interface (HDMI) is a fully digital video and sound transmission interface used to transmit uncompressed audio and video signals. By connecting it to a display (or TV) equipped with an HDMI interface, you can display media data of the Raspberry Pi. The HDMI interface can transmit video and audio signals at the same time, meaning you don't need to connect speakers to the audio interface of the Raspberry Pi – unless you really want to play audio through the audio interface, then you may need to modify the operating system configuration accordingly.

4. USB2.0/3.0 port

The Universal Serial Bus (USB) interface is the most common interface on a computer. You can use it to connect devices such as keyboards, mice, USB flash drives, and wireless network cards. When the number of USB ports is not enough, we can also extend by a USB hub.

5. Audio port

Audio interface (3.5mm headphone jack). When HDMI connection is not used, you can connect speakers or headphones via the standard 3.5mm headphone jack to play audio. At the same time, the interface also integrates a composite video interface with a composite audio-visual output function, which is generally used to connect old models of TV, which is rarely used now.

6. MIPI CSI camera port

The CSI interface can be used to connect the CSI camera to the Raspberry Pi via a ribbon cable for easy video recording and image capture. Compared with the USB camera, this camera module has better performance.

7. USB-C 5V/3A power supply port

The Micro USB power supply interface is one of the most used supply methods of the Raspberry Pi. The rated voltage is 5V. The standard current requirements of different Raspberry Pi models are slightly different. For example: the 1B type only needs 700mA, while the 3B+ type requires 2.5A. The chargers of many Android mobile phones can provide flawless power to the Raspberry Pi. The current required for Raspberry Pi also depends on the external device connected. It is recommended to do the calculation before connecting. Choose a power supply with suitable current (power) for the Raspberry Pi. When the external device demands a large power, an extra power supply should be adopted.

8. Micro SD card slot

The SD card slot is located on the back of the Raspberry Pi motherboard. The SD/MicroSD card is an essential storage of the Raspberry Pi and usually used for operating system installation and data storage. Use an SD card above 2GB. For better experience, it is recommended to equip your Raspberry Pi with a large-capacity (above 16G), high-speed (Class10 or above) SD card.

9. Bluetooth port

The Bluetooth function allows the Raspberry Pi to connect with Bluetooth-enabled devices (such as a mouse, keyboard, and gaming console).

10. PoE HAT port

Active Ethernet (Power Over Ethernet, PoE) refers to a technology that uses Ethernet for power transmission. Besides the basic Micro USB and GPIO power supply, the Raspberry Pi 3B+ type adds a new method of power supply over Ethernet. User can connect a network cable to supply power to the Raspberry Pi without the need of configuring an additional power supply, which is convenient for certain application scenarios.

11. MIPI DSI display port

You can connect the LCD display to the Raspberry Pi, which is generally used for embedded product development. Under normal circumstances, the HDMI interface can already meet the demand.

1.3 Operating System

The Raspberry Pi supports a variety of operating systems, mainly based on Linux and Windows, and most of them can be found on the official website of the Raspberry Pi Foundation (www.raspberrypi.org). Two representative operating systems will be introduced here.

1. Raspbian

Raspbian is the official operating system of the Raspberry Pi Foundation. It is customized based on Debian GNU/Linux and can run on all versions of the Raspberry Pi motherboard. According to the experience, Raspbian and Raspberry Pi combine all the best: stable operation, powerful function, easy to use, being able to meet various application needs, etc. Therefore, it is strongly recommended to use Raspbian as the preferred operating system for Raspberry Pi. In the

following chapters, we will further introduce the use of Raspbian in detail and develop various applications on it.

2. Windows 10 IoT Core

Windows 10 IoT Core is an operating system specifically created by Microsoft for the Internet of Things ecosystem. Windows 10 IoT Core is the core version of the Windows 10 IoT operating system. It has relatively simple functions and can run on type 2B or above models of Raspberry Pi. The installation and use of Windows 10 IoT Core will not be described in detail here. For more information, visit Microsoft's website.

Apart from the two systems above, there are several more that support the Raspberry Pi, including Ubuntu MATE, OSMC, LibreELEC, PiNet, RISC OS, etc. As for which one to choose, it depends on what you want to use Raspberry for. If you want to use it as a computer or for electronic project development, then Raspbian is a very good choice. If you plan to use it as a media center, you can consider using OSMC or LibreELEC.

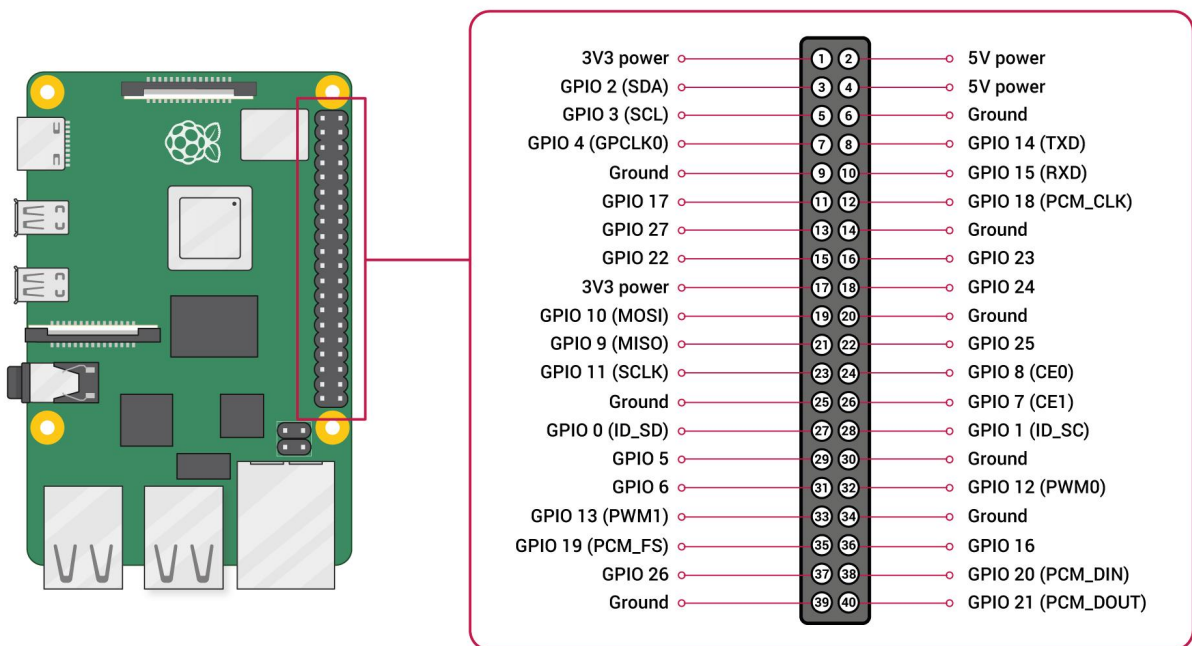
1.4 Programming Language

For the Raspberry Pi, there are many programming languages available. In fact, any language that can be compiled for the ARM architecture (such as the C language) can be used for the Raspberry Pi. The most popular language should be Python. In fact, the Pi in the name of the Raspberry Pi was inspired by the word Python.

Python is an interpretive, object-oriented, and dynamic data type high-level programming language with powerful functions, good compatibility, and high reliability. Python programs are easy to write and read. At present, there are two major versions of Python: Python 2 and Python 3. Both versions are updated and well maintained, but people still have disputes about which to use. You can visit Python's official website (www.python.org) to learn more about them. In the following tutorials we will mainly use Python 3 for development introduction. In addition, because of the Raspberry Pi's splendid compatibility, the program we wrote on the 3B+ model can be run on the Zero W model with little modification.

1.5 Demonstration

GPIO (General Purpose I/O Ports) are general-purpose input/output ports. In layman's terms, they are some pins with two rows of pins. They can be used to output high and low levels or to read the state of the pins – whether it is high or low. User can communicate with the hardware through the GPIO port (such as UART), control the hardware (such as LED, buzzer, etc.), read the working status signal of the hardware (such as interrupt signal), etc.



Introduction of GPIO pins

Raspberry Pi 40Pin Pin Comparison Table

| wiringPi Encoding | BCM Encoding | Function Name | BOARD Encoding of Physical Pins | | Function Name | BCM Encoding | wiringPi Encoding |
|----------------------|-----------------|------------------|------------------------------------|----|------------------|-----------------|----------------------|
| | | 3.3V | 1 | 2 | 5V | | |
| 8 | 2 | SDA.1 | 3 | 4 | 5V | | |
| 9 | 3 | SCL.1 | 5 | 6 | GND | | |
| 7 | 4 | GPIO.7 | 7 | 8 | TXD | 14 | 15 |
| | | GND | 9 | 10 | RXD | 15 | 16 |
| 0 | 17 | GPIO.0 | 11 | 12 | GPIO.1 | 18 | 1 |
| 2 | 27 | GPIO.2 | 13 | 14 | GND | | |
| 3 | 22 | GPIO.3 | 15 | 16 | GPIO.4 | 23 | 4 |
| | | 3.3V | 17 | 18 | GPIO.5 | 24 | 5 |
| 12 | 10 | MOSI | 19 | 20 | GND | | |
| 13 | 9 | MISO | 21 | 22 | GPIO.6 | 25 | 6 |
| 14 | 11 | SCLK | 23 | 24 | CE0 | 8 | 10 |
| | | GND | 25 | 26 | CE1 | 7 | 11 |
| 30 | 0 | SDA.0 | 27 | 28 | SCL.0 | 1 | 31 |
| 21 | 5 | GPIO.21 | 29 | 30 | GND | | |
| 22 | 6 | GPIO.22 | 31 | 32 | GPIO.26 | 12 | 26 |
| 23 | 13 | GPIO.23 | 33 | 34 | GND | | |
| 24 | 19 | GPIO.24 | 35 | 36 | GPIO.27 | 16 | 27 |
| 25 | 26 | GPIO.25 | 37 | 38 | GPIO.28 | 20 | 28 |
| | | GND | 39 | 40 | GPIO.29 | 21 | 29 |

About the Problem of Low Battery Restart of Raspberry Pi

When using 18650 battery for low voltage power supply:

Raspberry Pi 3B, 3B+, and 4 may restart the Raspberry Pi.

The Raspberry Pi 5 will shut down and remain in the state of waiting to be turned on. At this time, the Raspberry Pi indicator light will continue to light up in red. You need to briefly press the button next to the indicator light to reboot the Raspberry Pi 5.