Documentation on Raspberry Pi

Introduction

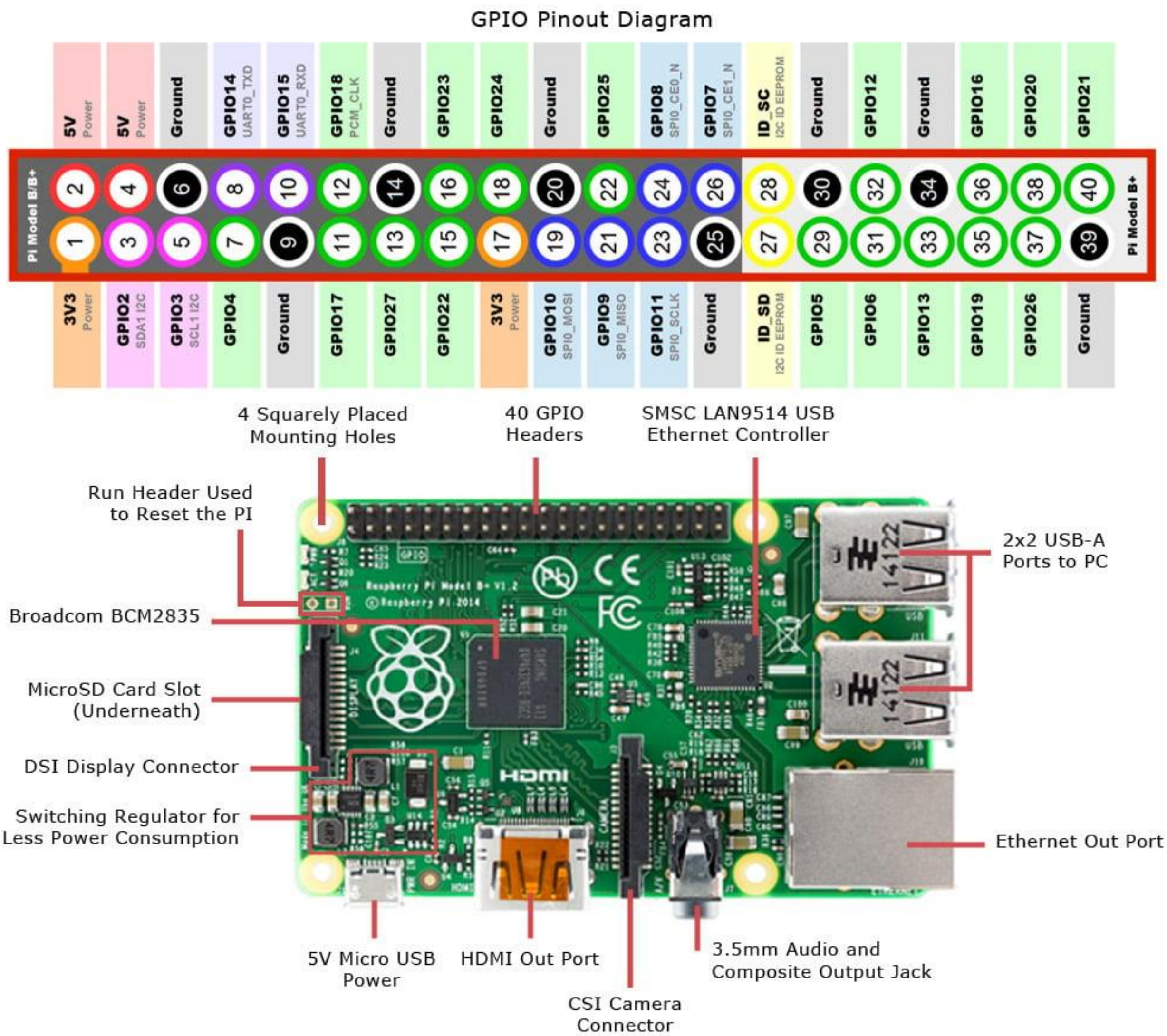
Raspberry is mini sized, low-cost and powerful device that is normally plugged into a computer monitor or TV along with a mouse and a keyboard. It almost acts like a normal desktop computer and can be used to emulate many of its functionalities. The device can used by people of any age group from kids to professionals. It was developed by the Raspberry Pi Foundation, a UK based educational charity organization with the motive of familiarizing kids as well as adults in the field of computer, computer science and related subjects. The GPIO pins of the device allows to control electronic components for physical computing and explore the Internet of Things.

Over the years there have been many generations of Raspberry Pi. The below mentioned are various different series of Raspberry Pi.

1. Raspberry Pi
2. Raspberry Pi 2
3. Raspberry Pi Zero
4. Raspberry Pi 3
5. Raspberry Pi 4
6. Raspberry Pi Pico

Type of series	Processor	RAM	I/O ports	Connectivity
Raspberry Pi	Single-core ARM	256-512 MB	USB, HDMI, Ethernet and GPIO	No integrated Wi-Fi or Bluetooth
Raspberry Pi 2	Quad-core ARM Cortex-A7	1GB	USB, HDMI, Ethernet and GPIO	No integrated Wi-Fi or Bluetooth
Raspberry Pi 3	Quad-core ARM Cortex-A53	1 - 1.5GB	USB, HDMI, Ethernet and GPIO	Integrated Wi-Fi and Bluetooth
Raspberry Pi 4	Quad-core ARM Cortex-A72	2 – 8 GB	USB 3.0 ports, dual HDMI outputs, Gigabit Ethernet, and GPIO	Integrated Wi-Fi and Bluetooth
Raspberry Pi Zero	Single-core ARM	512 MB	mini-HDMI, micro-USB, and GPIO	No integrated Wi-Fi or Bluetooth (Raspberry Pi Zero W is an exception)
Raspberry Pi Pico	Dual-core ARM Cortex-M0+	264 kB	GPIO pins, UART, SPI, I2C, and more	No integrated Wi-Fi or Bluetooth

Pinout diagram of Raspberry Pi 3b



Pin specification and their functions

Power pins

Pin number 01 – 3.3V power pin

Pin number 02 – 5V power pin

Ground Pins

Pin numbers 6, 9 , 14 , 20 , 25 , 30 , 34 and 39 – 0V ground pins

*The above-mentioned power and ground pins are unconfigurable

Outputs

A GPIO pin designated as an output pin can be set to high (3.3V) or low (0V).

Inputs

A GPIO pin which is assigned as input can read as high as 3.3V or low as 0V(3.3-1.8V is considered HIGH while 1.8-0V is considered LOW). This specific functionality is made easier with the use of internal pullup and pulldown resistors. (GPIO2 and GPIO3 have fixed pullup resistors, while for others this can be setup using the software)

Other Special features of GPIO pins

Pulse Width Modulation

PWM stands for Pulse Width Modulation. It is a technique used to control the average power delivered to a load by rapidly switching a digital signal on and off. By varying the width of the pulse, the average voltage or power supplied to the load can be adjusted.

- Software PWM available on all pins
- Hardware PWM available on GPIO12, GPIO13, GPIO18, GPIO19

SPI – Serial Peripheral Interface

SPI stands for Serial Peripheral Interface. It is a synchronous serial communication interface that allows the Raspberry Pi to communicate with other devices, such as sensors, displays, and memory chips. SPI is commonly used for short-distance communication between devices on the same circuit board or within a small system.

This specific model of Raspberry Pi has 4 separate connections to communicate with the target device. These connections are the serial clock (CLK), Master Input Slave Output (MISO), Master Output Slave Input (MOSI) and Chip Select (CS). The module has a dedicated SPI interface that supports full-duplex communication, allowing data to be simultaneously transmitted and received.

- MOSI (Master Out Slave In): This line is used for data transmission from the Raspberry Pi (master) to the connected device (slave).
- MISO (Master In Slave Out): This line is used for data transmission from the connected device (slave) to the Raspberry Pi (master).
- SCLK (Serial Clock): This line provides the clock signal that synchronizes the data transfer between the Raspberry Pi and the connected device.
- CE0 (Chip Enable 0): This line is used to select the specific device with which the Raspberry Pi wants to communicate. Multiple devices can be connected to the SPI bus, and each device is selected by setting the corresponding chip enable line.

SPI0: MOSI (GPIO10); MISO (GPIO9); SCLK (GPIO11); CE0 (GPIO8), CE1 (GPIO7)

SPI1: MOSI (GPIO20); MISO (GPIO19); SCLK (GPIO21); CE0 (GPIO18); CE1 (GPIO17); CE2 (GPIO16)

I2C – Inter Integrated Circuit

I2C (Inter Integrated Circuit) is a synchronous serial protocol that communicates data between two devices. It is a master-slave protocol which may have one master or many master and many slaves whereas SPI has only one master. It is generally used for communication over short distance. The I2C device has 7-bit or 10-bit unique address. So, to access these devices, master should address them by the 7-bit or 10-bit unique address. I2C is used in many applications like reading RTC (Real time clock), accessing external EEPROM memory. It is also used in sensor modules like gyro, magnetometer etc.

The Raspberry Pi 3 Model B has dedicated I2C pins that support I2C communication. These pins are as follows:

- SDA1 (Serial Data Line): This is the data line for I2C communication. It carries the actual data being transmitted between the Raspberry Pi and the connected devices.
- SCL1 (Serial Clock Line): This is the clock line for I2C communication. It provides the synchronization signal for the data transfer between the Raspberry Pi and the connected devices.

I2C

- Data: (GPIO2); Clock (GPIO3)
- EEPROM Data: (GPIO0); EEPROM Clock (GPIO1)

UART

Raspberry Pi has two in-built UART which are as follows:

- PL011 UART
- mini UART

PL011 UART is an ARM based UART. This UART has better throughput than mini UART. In Raspberry Pi 3, mini UART is used for Linux console output whereas PL011 is connected to the On-board Bluetooth module.

Mini UART uses the frequency which is linked to the core frequency of GPU. So as the GPU core frequency changes, the frequency of UART will also change which in turn will change the baud rate for UART. This makes the mini UART unstable which may lead to data loss or corruption. To make mini UART stable, fix the core frequency. mini UART doesn't have parity support.

The PL011 is a stable and high performance UART. For better and effective communication use PL011 UART instead of mini UART. It is recommended to enable the UART of Raspberry Pi for serial communication. Otherwise, we are not able to communicate serially as UART ports are used for Linux console output and Bluetooth module.

UART pins of Raspberry Pi 3 b module are.

- UART_TXD0 – GPIO14
- UART_RXD0 – GPIO15

Ways in which Raspberry Pi communicate with external devices

GPIO (General Purpose Input/Output): The module has a set of GPIO pins that can be used for general-purpose digital input and output. These pins can be used to communicate with external devices by sending and receiving digital signals.

Serial Communication: The module supports UART (Universal Asynchronous Receiver-Transmitter) or serial communication. It has dedicated TXD and RXD pins that can be used to establish serial communication with other devices using protocols like RS-232, RS-485, or TTL-level serial.

I2C (Inter-Integrated Circuit): The device has dedicated I2C pins that support the I2C communication protocol. I2C allows for multi-device communication using a master-slave architecture, where multiple devices can be connected to the same bus and controlled by the Raspberry Pi.

SPI (Serial Peripheral Interface): The device supports the SPI communication protocol. It has dedicated SPI pins that allow for full-duplex communication with SPI devices such as sensors, displays, and memory chips.

USB (Universal Serial Bus): The device has USB ports that can be used to communicate with a wide range of USB devices, including keyboards, mice, storage devices, and other peripherals. USB provides a versatile and standardized method of communication.

Ethernet: It also has an Ethernet port that enables communication with other devices over a local network or the internet. It can be used for various networking applications, including file sharing, remote access, and web-based interactions.

Wi-Fi and Bluetooth: Unlike certain other modules, this specific module also have built-in Wi-Fi and Bluetooth capabilities. These wireless technologies allow the Raspberry Pi to communicate with other devices wirelessly, opening up possibilities for IoT (Internet of Things) applications, wireless connectivity, and data exchange.

Diversified usage of Raspberry Pi modules

Replace Your Desktop PC With a Raspberry Pi

The low-cost device can be used as a basic desktop computer for web browsing, document editing, programming, and other day-to-day tasks. Raspberry Pi OS provides a user-friendly desktop environment for such usage.

Print With Your Raspberry Pi

Irrespective of whether you have an old printer that doesn’t have wireless, or one that is difficult to connect to network, you can avoid sending it to landfill by employing a Raspberry Pi.

Team up the Samba file sharing software, and CUPS print software, and you can make that printer wireless. The Common Unix Printing System provides drivers for your printer and provides an administration console. Once this is set up, any computer on your home network can access the printer.

Learning and Education

The Raspberry Pi is an excellent tool for learning programming, electronics, and computer science. It provides a platform for experimentation, coding projects, and educational resources. Since Raspberry Pi is also being used in the professional world, having hands on experience with this module would be great.

Act as Game Servers

Raspbian, the default OS of pi comes with a special version of Minecraft game pre-installed. But, the applications of Raspberry Pi can be used as a game server as well. It is an excellent game server for Minecraft. If multiple Raspberry Pis are used, making one as a dedicated server, a great gaming experience can be achieved. Other multiplayer network games can be set up on the Raspberry Pi.

Retro Gaming Machine

As well as streaming media, the Raspberry Pi is ideal as a retro gaming machine. Compact and powerful enough to be used in several ways, the device is suitable as a full-size arcade cabinet, or even as part of a Game Boy-esque handheld.

Various retro gaming operating systems are available, all with controller support. Many classic gaming platforms can be emulated, from MS-DOS and 16-bit consoles to the Commodore 64.

Internet of Things (IoT) Applications

Utilize the Raspberry Pi's networking capabilities to create IoT projects. Connect sensors, actuators, and other devices to the Pi and enable data collection, remote control, and monitoring.

Robot controller

Combine the Raspberry Pi with motors, sensors, and a chassis to build a robot. Program the Raspberry Pi to control the robot's movements, interact with its environment, and perform tasks.

Setup a stop-motion camera

Stop-motion video is becoming increasingly popular as an art form, with uploaders of all ages sharing their movies on YouTube and social media. But how is stop-motion made? You can find out with a Raspberry Pi and a dedicated camera module.

Using the Python programming language, a suitable mount (overhead for Gilliam-esque paper craft animation, a standard tripod for clay- or toy-based), and a well-lit area, you'll also need to rig a button to the Pi's GPIO.

Personal Cloud Server

Transform your Raspberry Pi into a personal cloud server using software like Nextcloud or OwnCloud. You can store and access your files, host websites, manage calendars, and more.

Setting up a time-lapse camera

The Raspberry Pi camera modulandfferent script creates another use that captures movies. This can be achieved by taking single frames with a time delay. Also needed is, perhaps a portable battery solution, and a tripod can be used. A smartphone tripod is most preferred to ensure the device remains sturdy.

Home Automation

Use the Raspberry Pi along with sensors, relays, and actuators to build a home automation system. Control lights, appliances, temperature, and security systems using your Raspberry Pi as the central controller.

FM radio station

Raspberry Pi can also be used to broadcast on FM radio. Pi can broadcast only over a short-range. A portable battery and soldering skills may be required here. Any audio which needs to broadcast will need to be loaded beforehand to the microSD card.

Web servers

Another great application of Raspberry Pi are to create a web server out of it. What this means is that it can be configured to host a website much like any other server. It can host blogs too. First of all, the right software needs to be installed and that is Apache and its dependent libraries. A full LAMP stack can also be installed with PHP, MySQL, and Apache too. Setting up FTP is also helpful.

Once all these steps as mentioned are completed, HTML files can be saved into the /www/ directory, and the webserver is ready to be used. Specific web software like WordPress can also be used once the server setup is complete.