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MIT WORLD PEACE UNIVERSITY | PUNE
TECHNOLOGY, RESEARCH, SOCIAL INNOVATION & PARTNERSHIPS

Second Year B. Tech (EL & CE)

Semester: IV **Subject:** Basic IoT Laboratory

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Roll No: 29 **Batch: A2**

Experiment No: 06

Name of the Experiment: Understanding Raspberry-Pi as single board Computer and exploring GPIO.

Performed on: 15/03/2023

Submitted on: 19/03/2023

Marks	Teacher's Signature with date

Aim: Understanding Raspberry-Pi as single board Computer and exploring GPIO.

Prerequisite: Basics of Raspberry Pi.

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Objective:

1. Understand basics of Raspberry Pi as single board computer
2. Understand the layout of Raspberry pi
3. Understand the GPIO pin out of Raspberry Pi

Components and equipment required:

Raspberry Pi Board.

Theory:

Raspberry Pis are single-board computers (SBCs), meaning the memory, interface as well as processor are soldered into one circuit board that numbers 4 revisions and a minimalistic zero variant. The pocket-size computers are built to make learning programming languages fun. Raspberry Pi is a series of SBCs developed in the United Kingdom by the Raspberry Pi Foundation in association with Broadcom. The Raspberry Pi project originally leaned towards the promotion of teaching basic computer science in schools and in developing countries. The original model became more popular than anticipated, selling outside its target market for uses such as robotics. It is widely used in many areas, such as for weather monitoring, because of its low cost, modularity, and open design. It is typically used by computer and electronic hobbyists, due to its adoption of HDMI and USB devices. The main difference between a Raspberry Pi (tiny computer) and other computers is the GPIO (General Purpose Input Output) pins. The GPIO pins are one way in which the Raspberry Pi can control and monitor the outside world by being connected to electronic circuits.

Hardware

- A Raspberry Pi computer with an SD card or micro SD card
- A monitor with a cable (and, if needed, an HDMI adaptor)
- A USB keyboard and mouse
- A power supply
- Headphones or speakers (optional)
- An ethernet cable (optional)

Software

Raspberry Pi OS, installed using the Raspberry Pi Imager

Series and generations:

There are three series of Raspberry Pi, and several generations of each have been released. Raspberry Pi SBCs feature a Broadcom system on a chip (SoC) with an integrated ARM-compatible central processing unit (CPU) and on-chip graphics processing unit (GPU).

Figure 6.1: Raspberry Pi 4 Model B

Raspberry Pi Family with specification

Family	Model	SoC	Memory	Form Factor	Ethernet	Wireless	GPIO	Released	Discontinued
Raspberry Pi	B	BCM2835	256 MB	Standard	Yes	No	26-pin	2012	Yes
Raspberry Pi	A	BCM2835	256 MB	Standard	No	No	26-pin	2013	No
Raspberry Pi	B+	BCM2835	512 MB	Standard	Yes	No	40-pin	2014	No
Raspberry Pi	A+	BCM2835	512 MB	Compact	No	No	40-pin	2014	No

Raspberry Pi Zero	Zero	BCM2835	512 MB	Ultra-Compact	No	No	40-pin	2015	No
Raspberry Pi 2	B	BCM2836/7	1 GB	Standard	Yes	No	40-pin	2015	No
Raspberry Pi 3	B	BCM2837A0/B0	1 GB	Standard	Yes	Yes	40-pin	2016	No
Raspberry Pi Zero	W/WH	BCM2835	512 MB	Ultra-Compact	No	Yes	40-pin	2017	No
Raspberry Pi 3	A+	BCM2837B0	512 MB	Compact	No	Yes (dual band)	40-pin	2018	No
Raspberry Pi 3	B+	BCM2837B0	1 GB	Standard]	Yes (Gigabit Ethernet)	Yes (dual band)	40-pin	2018	No
Raspberry Pi 4	B	BCM2711	1 GB	Standard	Yes (Gigabit Ethernet)	Yes (dual band)	40-pin	2019[43]	March 2020[1]
Raspberry Pi 4	B	BCM2711	2 GB	Standard	Yes (Gigabit Ethernet)	Yes (dual band)	40-pin	2019[43]	No
Raspberry Pi 4	B	BCM2711	4 GB	Standard	Yes (Gigabit Ethernet)	Yes (dual band)	40-pin	2019[43]	No
Raspberry Pi 4	B	BCM2711	8 GB	Standard	Yes (Gigabit Ethernet)	Yes (dual band)	40-pin	2020	No

Raspberry Pi 4	400	BCM2711	4 GB	Keyboard	Yes (Gigabit Ethernet)	Yes (dual band)	40-pin	2020	No
Raspberry Pi Pico	N/A	RP2040	264 KB	Pico (21 mm × 51 mm)	No	No	26-pin	2021	?

The Pi can control LEDs, turning them on or off, drive motors, and interact with many other objects. It can also detect the pressing of a switch, change in temperature, or light, etc, by attaching kinds of sensors. These pins are a physical interface between the Raspberry Pi and the outside world. Using them, you can program the Raspberry Pi to switch devices on and off (output), or receive data from sensors and switches (input). Of the 40 pins, 26 are GPIO pins and the others are power or ground pins (plus two ID EEPROM pins which you should not play with unless you know your stuff!)

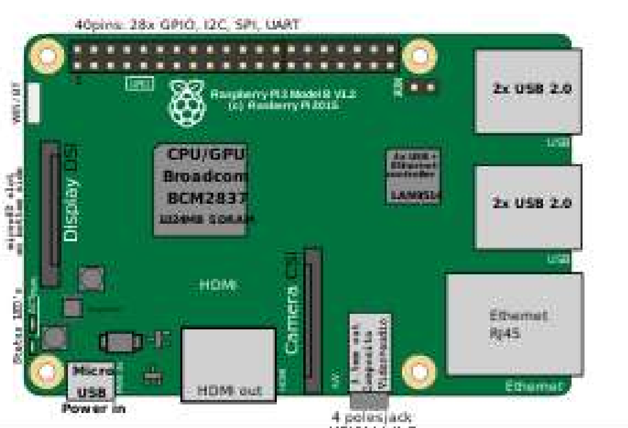


Figure 6.2: Location of Connectors & main ICs on Raspberry Pi 3

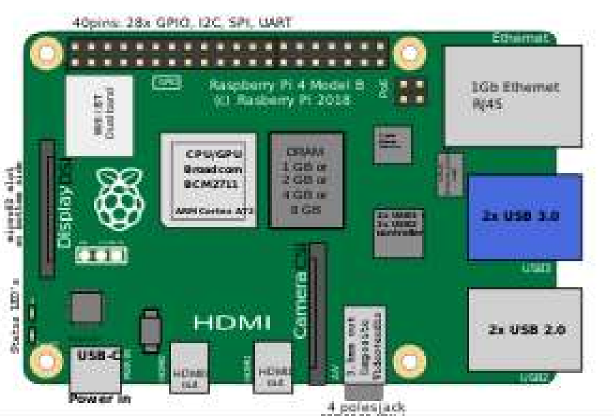


Figure 6.3: Location of Connectors & main ICs on Raspberry Pi 4

General purpose input-output (GPIO) connector

Raspberry Pi 1 Models A+ and B+, Pi 2 Model B, Pi 3 Models A+, B and B+, Pi 4, and Pi Zero, Zero W, and Zero WH GPIO J8 have a 40-pin pinout. Raspberry Pi 1 Models A and B have only the first 26 pins.

In the Pi Zero and Zero W, the 40 GPIO pins are unpopulated, having the through-holes exposed for soldering instead. The Zero WH (Wireless + Header) has the header pins preinstalled.

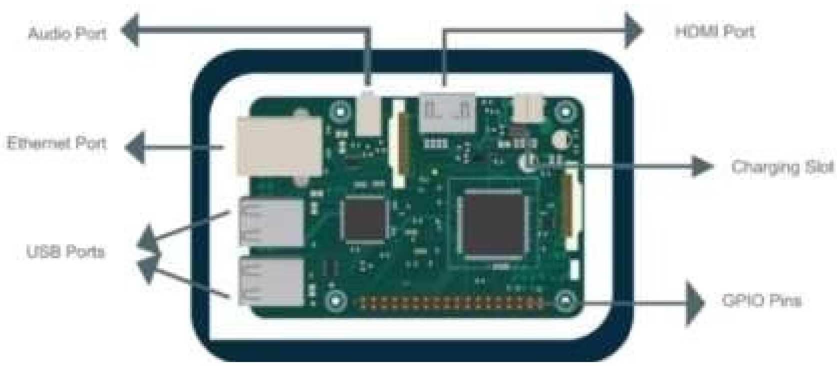
GPIO#	2nd func.	Pin#	Pin#	2nd func.	GPIO#
	+3.3 V	1	2	+5 V	
2	SDA1 (I^2C)	3	4	+5 V	
3	SCL1 (I^2C)	5	6	GND	
4	GCLK	7	8	TXD0 (UART)	14
	GND	9	10	RXD0 (UART)	15
17	GEN0	11	12	GEN1	18
27	GEN2	13	14	GND	
22	GEN3	15	16	GEN4	23
	+3.3 V	17	18	GEN5	24
10	MOSI (SPI)	19	20	GND	
9	MISO (SPI)	21	22	GEN6	25
11	SCLK (SPI)	23	24	CE0_N (SPI)	8
	GND	25	26	CE1_N (SPI)	7
(Pi 1 Models A and B stop here)					
0	ID_SD (I^2C)	27	28	ID_SC (I^2C)	1
5	N/A	29	30	GND	
6	N/A	31	32	N/A	12
13	N/A	33	34	GND	
19	N/A	35	36	N/A	16
26	N/A	37	38	Digital IN	20
	GND	39	40	Digital OUT	21

Model B rev. 2 also has a pad (called P5 on the board and P6 on the schematics) of 8 pins offering access to an additional 4 GPIO connections. These GPIO pins were freed when the four board version identification links present in revision 1.0 were removed.

GPIO#	2nd func.	Pin#		Pin#	2nd func.	GPIO#
	+5 V	1		2	+3.3 V	
28	GPIO_GEN7	3		4	GPIO_GEN8	29
30	GPIO_GEN9	5		6	GPIO_GEN10	31
	GND	7		8	GND	

Raspberry Pi Tutorial: Raspberry Pi Components

Now, let’s have a look at the different components of the Raspberry Pi 3 – B model:



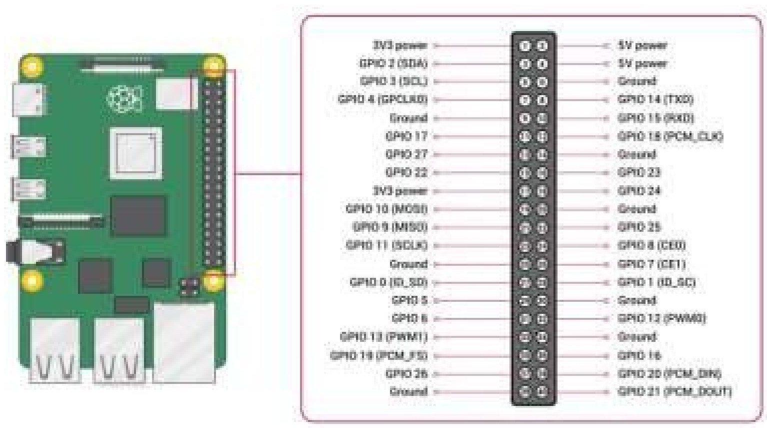


Figure 6.4: GPIO Pinout Diagram

GPIO Functions

Both the Raspberry Pi3 and Pi4 offer these functions:

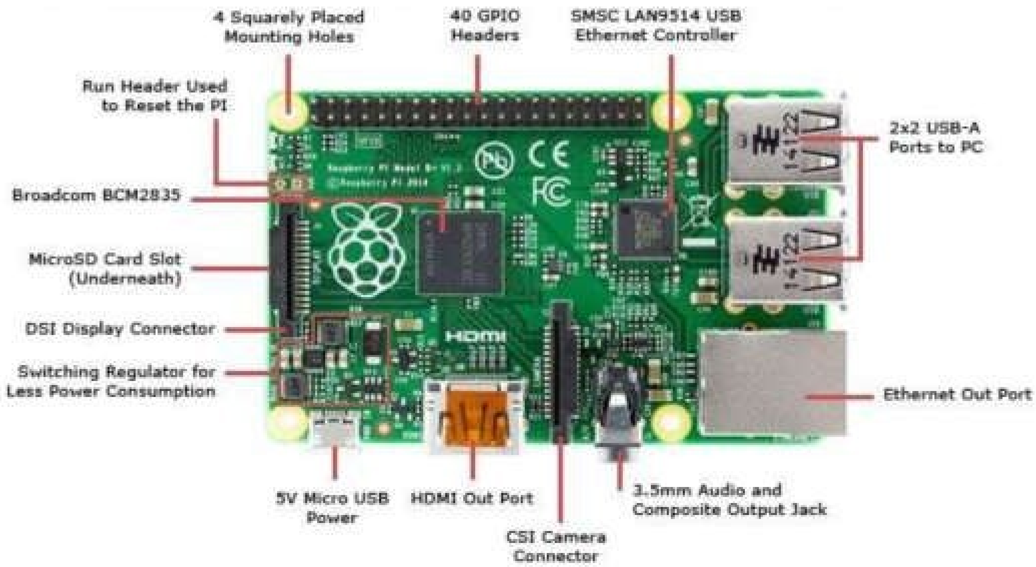


Figure 6.5: Raspberry Pi Board Layout

- **GPIO** is your standard pins that simply be used to turn devices on and off. For example, a LED.
- **I2C** (Inter-Integrated Circuit) pins allow you to connect and talk to hardware modules that support this protocol (I2C Protocol). This protocol will typically take up two pins. The GPIO 2 SDA and GPIO 3 SCL allow the connection via the I2C protocol. I2C creates a serial, synchronous communication with multiple server/client connection of up to 128 devices.
- **SPI** (Serial Peripheral Interface Bus) pins can be used to connect and talk to SPI devices. Pretty much the same as I2C but makes use of a different protocol. The SPI protocol is a synchronous serial communication between one server and several clients, where both can actively send data. To make an SPI outbound connection, 4 pins are needed. The Raspberry Pi allows to make either 2 separate Server connections, or one server, one client connections. For the 1st GPIO subsystem, GPIO 9, 19, 11, 8 and 16 are used, and for the 2nd GPIO subsystem its 19, 20, 21 and 16.
- **UART** (Universal asynchronous receiver/transmitter) is the serial pins used to communicate with other devices. GPIO 10 (RX) and GPIO 8 TX can be used to directly connect two devices with the UART protocol, which enables serial, asynchronous communication.
- **PWM:** Pulse width modulation is a signaling technique in which a digital signal is switching rapidly between two states high and low in a certain frequency. The Raspberry pi has no native support for PWM, but there are Libraries that provide Software PWM, although with restrictions compared to Arduino.
- **DNC** stands for do not connect, this is pretty self-explanatory.

- The **power** pins pull power directly from the Raspberry Pi.
- **GND** are the pins you use to ground your devices. It doesn't matter which pin you use as they are all connected to the same line.

Connect your Raspberry Pi

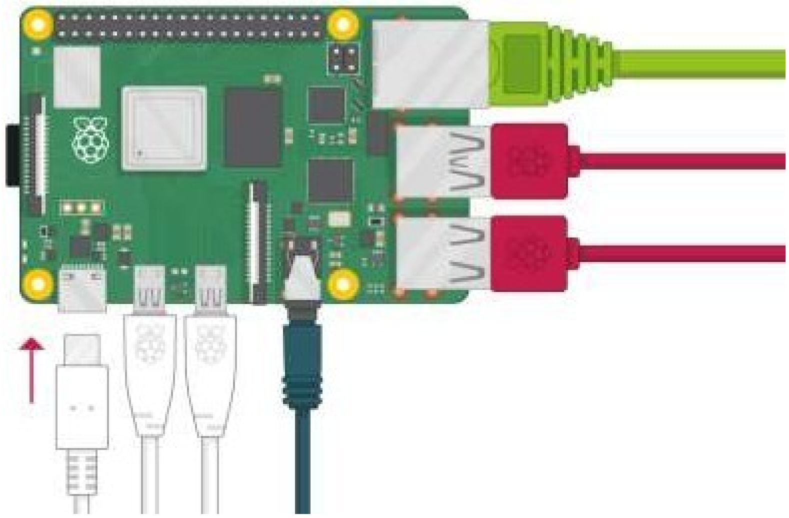


Figure 6.6: Raspberry Pi Connectors

- Check the slot on the underside of your Raspberry Pi to see whether an SD card is inside. If no SD card is there, then insert an SD card with Raspbian installed (via NOOBS).
- Find the USB connector end of your mouse's cable, and connect the mouse to a USB port on your Raspberry Pi (it doesn't matter which port you use).
- Connect the keyboard in the same way.
- Make sure your screen is plugged into a wall socket and switched on.
- Look at the HDMI port(s) on your Raspberry Pi — notice that they have a flat side on top.
- Use a cable to connect the screen to the Raspberry Pi's HDMI port — use an adapter if necessary.
- Connect your screen to the single HDMI port.
- If you want to connect the Pi to the internet via Ethernet, use an Ethernet cable to connect the Ethernet port on the Raspberry Pi to an Ethernet socket on the wall or on your internet router. You don't need to do this if you want to use wireless connectivity, or if you don't want to connect to the internet.
- If your screen has speakers, your Raspberry Pi can play sound through these. Or you could connect headphones or speakers to the audio port.
- Plug the power supply into a socket and then connect it to your Raspberry Pi's USB power port.
- You should see a red light on your Raspberry Pi and raspberries on the monitor.

Figure 6.7: Raspberry Pi Graphical Desktop

- Your Raspberry Pi then boots up into a graphical desktop.

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Conclusion:

Post Lab Questions:

1. What is Raspberry Pi? How does it works?
2. What are the different components of the Raspberry Pi board?
3. How is Raspberry Pi used in IoT?
4. How is Raspberry pi different from Arduino and NodeMCU?

Additional links for more information:

1. Raspberry Pi Documentation
   https://www.raspberrypi.com/documentation/computers/os.html
2. Getting Started with Raspberry Pi
   https://projects.raspberrypi.org/en/projects/raspberry-pi-getting-started/3
3. The Raspberry Pi Platform and Python Programming for the Raspberry Pi
   https://www.coursera.org/learn/raspberry-pi-platform#about

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* Post Lab Questions -

Q1) what is Raspberry Pi? How does it works?

→ Raspberry Pi is a small, single-board computer that was created with the goal of promoting computer science education and programming skills among people of all ages. It is a credit card-sized computer that can be connected to a keyboard, mouse, and monitor or TV. The Raspberry Pi is based on ARM processors and is designed to run various Linux-based operating systems. It has a set of GPIO pins that allow it to interact with external devices and sensors, making it ideal for projects involving robotics, automation, and IOT.

The Raspberry Pi works by running code written in programming languages such as Python, C++, and scratch. The code can be written on the Raspberry Pi itself or on another computer and transferred to the Raspberry Pi via the internet or a USB flash drive. Once the code is loaded onto the Raspberry Pi, it can be executed to perform various tasks.

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Q2) What are the different components of the Raspberry Pi board?

→ ① Processor - The Raspberry Pi uses a Broadcom system-on-chip (soc) that includes a CPU, GPU, and other components.

② Memory - The board has between 1 GB to 8GB of RAM, depending on the model.

③ Storage - Uses a microSD card to store the operating system and user data.

④ Input/output (I/O) ports - The board has several I/O ports, including USB, Ethernet, HDMI, audio and a 40-pin GPIO header for interfacing

⑤ Power supply - It can be powered using a micro-USB port or GPIO pins.

⑥ Ethernet & wifi - Some models have Ethernet and/or wifi built-in for network connectivity.

⑦ Camera & display connectors - The board has a dedicated connector for connecting a Raspberry Pi camera module, as well as a connector for connecting a display via the Display Serial Interface (DSI).

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Q3) How is Raspberry used in IoT?

-> uses -

① Home automation -

The Raspberry Pi can be used to control smart home devices, such as lights, thermostats, and security cameras. It can be connected to sensors and actuators to monitor and control various aspects of home.

② Industrial automation -

The Raspberry Pi can be used to control machinery, monitor environmental conditions, and automate production lines in industrial settings.

③ Environmental monitoring -

The Raspberry Pi can be used to collect data from sensors that measure environmental conditions, such as temp, humidity & air quality.

④ Smart agriculture -

The Raspberry Pi can be used to monitor soil moisture levels, temp, & humidity in agricultural settings. This data can be used to optimize crop yield and reduce water usage.

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Q4) How is Raspberry Pi different from Arduino and NodeMCU?

→ Differences -

① Processing power -

The Raspberry Pi have significantly more processing power than Arduino or NodeMCU, as it is based on a full-fledged CPU and can run a full operating system. This makes it well-suited for applications that require complex computations or multitasking

② GPIO pins -

All three platforms have GPIO pins that can be used to connect sensors, actuators, and other devices. However, the Raspberry Pi has a larger number of GPIO pins (40) than Arduino or NodeMCU, which have 20 and 11 pins, respectively.

③ Programming languages:

Arduino uses a simplified version of C++ while NodeMCU uses Lua, a lightweight scripting languge. The Raspberry Pi can run a wide variety of programming languages, including Python, C++, Java, and more.

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