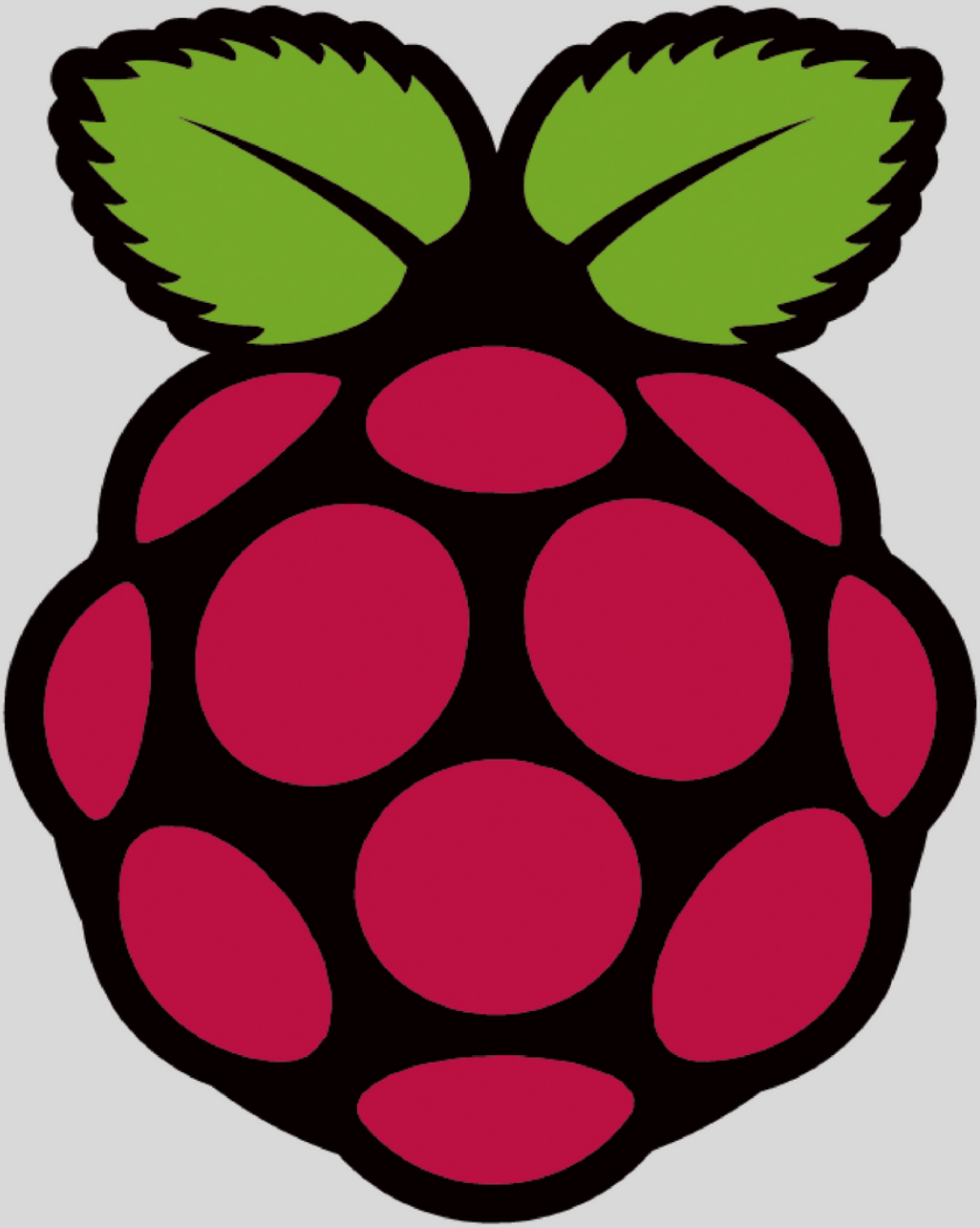

INSTANT RASPBERRY PI

ASHWIN PAJANKAR

Instant Raspberry Pi

The Beginner's Guide to Raspberry Pi setup

Ashwin Pajankar

This book is for sale at http://leanpub.com/InstantRPi

This version was published on 2016-09-25

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Also By Ashwin Pajankar

Instant Python Testing

Instant Raspberry Pi Supercomputer

Instant Raspberry Pi Computer Vision

I dedicate this book to my wife, Kavitha, and my elder sister, Savita Gadhave.

Contents

Preface

When I first saw a bunch of kids booting up a strange-looking PCB (Printed Circuit Board) with Linux, I literally jumped in excitement. When I asked them what it was, they said, "Raspberry Pi". This is how I was introduced to Raspberry Pi. The occasion was a Hackathon organized at my former workspace for the specially abled kids. When I saw those lovely and creative kids using a little computer, I immediately decided to explore it and after six months my first book on Raspberry Pi[1] got published.

It has been a while since my first book got published. Raspberry Pi underwent major revisions since then. Multiple newer and more powerful models of Pi have been introduced. When people approach me for guest lectures and talks on this topic, they have a common complaint. And the complaint is that they find it very difficult to get started with the concept the of the Single Board Computers and first setup of Raspberry Pi. I do agree with this, as I found it a bit tedious to overcome the first hurdle of unfamiliarity with the Single Board Computers. So I decided to write and publish a dedicated book on introducing Raspberry Pi to the beginners. Leanpub's continuous publishing model is truly revolutionary. It allows me to update and correct the book often. This book has all the much-needed information for the beginners to get started with Raspberry Pi. I intend to update the book continuously as and when needed. I hope that this book will serve as the one stop shop for all the Raspberry Pi setup related queries for all the Raspberry Pi beginners. The book is and, will always be free for all. That's my promise to all of my readers!

The book also has the references to the material available on various websites where readers can further explore the topics in detail.

Why am I writing this book?

As I said earlier, I found it quite difficult to get started with Raspberry Pi and I do not want the same to happen to other beginners. I have been told many times that due to lack of reliable material for the setup, many enthusiasts have abandoned the dreams to learn and to innovate with Raspberry Pi. It is really disheartening to see this happen. Because Raspberry Pi is such an excellent platform, that once we get started with this, there is no looking back. With Python as its companion, it is a very powerful tool for learning and innovation. It can either be used as a general purpose Linux computer, or as an IoT (Internet of Things) platform. I use it to explore various advanced topics in Computer Science like Machine Learning, Parallel Programming, Digital Image Processing, and Computer Vision. I hope this book will be all a novice need to get started with Raspberry Pi. I am planning to write a series of books with Raspberry Pi exploring various areas in Computer Science. This book serves as the forerunner for the other upcoming books which I intend to write.

[1] https://www.packtpub.com/hardware-and-creative/raspberry-pi-computer-vision-programming

Who this book is for?

This book is addressed to beginners of the Raspberry Pi, interested to learn in less time how to get started with this family of wonderful Single Board Computers. However, this book is not for people completely new to the world of Computer Science. I assume that you have a decent knowledge of computers and you are not new to most fundamental concepts related to it. The perfect reader of this book may be both, a hobbyist and a student, who is familiar with the computers, and wants to learn a more powerful tool to explore Computer Science further. Makers and hackers will also find this book interesting. Finally, you are someone who has no idea why (s)he is reading the book, you might get interested in Raspberry Pi. I hope all the readers will enjoy reading this book as much as I enjoyed writing this.

How is this book organized?

This book is and will always be an *In Progress* book (this is the basis of Leanpub). I will often update the book. Also, all the chapters in this book will be reused in all the books I intend to write on Raspberry Pi. This book covers following topics as of December 2016.

Chapter 1 introduces readers to the philosophy of single board computers. It covers history, applications, advantages, and limitations of Single Board computers. It mentions other popular Single Board Computer platforms.

Chapter 2 introduces readers to Raspberry Pi family. It discusses various popular models and their hardware specifications. This chapter covers Raspberry Pi 1 Model B+, Raspberry Pi 2 Model B, and Raspberry Pi 3 Model B.

Chapter 3 is a complete guide to the setup of Raspberry Pi from scratch. After following this chapter, readers will have a functioning Raspberry Pi computer with them.

Chapter 4 is about Raspbian and useful linux commands. It also has instructions to connect Raspberry Pi to a network.

Chapter 5 explores various methods to connect to Raspberry Pi remotely.

Chapter 6 introduces the other models of Pi which are not covered in the second chapter. This chapter covers Raspberry Pi 1 Model A, Raspberry Pi 1 Model B, Raspberry Pi 1 Model A+, and Raspberry Pi Zero.

Chapter 7 has few tips for taking backup and configuration options of Pi.

Chapter 8 introduces user to the concept of overclocking. We will overclock Raspberry Pi 1 Model B+, Raspberry Pi 2 Model B, and Raspberry Pi 3 Model B in this chapter.

You will also find several asides, each one starting with an icon on the left. Let me explain them.

This a warning box. The text contained explains important aspects or gives important instructions. It is strongly recommended to read the text carefully and follow the instructions.

This is an information box. This may contain link to an external webpage relevant to the topic under discussion.

This is a tip box. It has suggestions to the reader that could simplify the learning process.

This is an exercise box. This will contain an exercise which will aid the readers to explore the topic further.

What this book is not?

This is not a cookbook of projects for intermediate or advanced learners. This book is not for learning Python programming from scratch. It does not have any tips or tricks for Python. It does not explore any Python library. It is also not a book for IoT (Internet of Things), Home Automation, or Robotics applications. I have written other books on these topics. Readers can go through my profile page on Leanpub[2] to check the other books I have written.

[2] https://leanpub.com/u/ashwinpajankar

About the Author

When someone asks me about my career, I like to say I am someone who loves to work on Automation, Software Testing, Single Board Computers, and IoT. I am also interested and have worked in the areas of Computer Science like Parallel Programming, Image Processing, and Wireless Communications.

I was raised in a small town in India. Like thousands of other folks of my age, I finished my undergraduate studies in Computer Science and Engineering and joined workforce when I was in my early twenties. After couple of years of stint in a multinational IT services company, I decided to pursue further studies. I took admission to IIIT Hyderabad[3] and graduated with MTech in Computer Science & Engineering. I was lucky enough to able to fund my graduate studies with various grants, loans, and scholarships. After finishing graduate studies I joined workforce again. I am planning to work till my brain is working (which is an awful lot of time :)).

I have work experience in software development and testing till now. Recently, I find myself increasingly involved in Software Design, Architecture, and Innovation in IoT space. Till now, I have trained more than a thousand professionals for technical skills. More than tens of thousands of copies of my books published through Packt and Leanpub have been purchased till now.

I have work experience in various programming platforms like C, C++, Java, Python, and bash scripting. I have also worked with all the major databases like Microsoft SQL Server, Oracle, IBM DB2, Teradata, MySQL, and sqlite. In IoT domain, I have worked on Raspberry Pi, Arduino, Banana Pro, Intel Edison, and Grove sensors.

I have never had privilege of working on web or mobile programming. Yet, I have rudimentary understanding of XML, HTTP protocol, and web-services. Recently, I have started learning PHP by myself to be able to code for the web.

This is my fifth book and I am planning to write at least three to four books per year. All the books will be free and published on Leanpub. This is link to my LinkedIn[4] profile. Please feel free to contact me for providing your valuable feedback on my writing style.

[3] www.iiit.ac.in

[4] https://in.linkedin.com/in/ashwinpajankar

About the Reviewer

Prasad Gadhave is a freelance programmer and a tech enthusiast. His professional experiences include diverse technical areas like Programming, 4G communications, Computer Hardware, Networking, and Vehicle assembly automation. He had brief stint as a young owner of an independent tech business and he is aspiring to be a tech entrepreneur. He has finished his high school with commerce as major and currently pursuing his studies towards earning an undergraduate degree in commerce.

I would like to thank my mother Savita Gadhave for encouraging me to share my knowledge with the world.

Errata and Suggestions

I am aware of the fact that there are several errors in the text. Unfortunately, English is not my mother language and this is one of the main reasons I prefer lean publishing: being an in-progress book I have all the time to check and correct them. I have decided that once this book reaches the end, I will look for a professional editor that helps me to fix all the errors in my English. However, feel free to contact me to let know every type of mistake. On the other end, I am totally open to suggestions and improvements about book content. I like to think that this book will save your day every time you need to understand an aspect related to Raspberry Pi Setup. So, please feel free to suggest any related topic you want me to add to the book or to let me know book parts that are not clear or well explained.

You can contact me on LinkedIn[5].

[5] https://in.linkedin.com/in/ashwinpajankar

How to Help the Author

This is my fourth technical book. As I mentioned earlier, English is not my mother language. I am really pleased when I hear any feedback from my dear readers on any aspect of the book.

If you really want to help me, you may consider to:

- give me your valuable feedback about unclear things or errors in the text and the examples
- write a small review about what you think of this book in the feedback section[6]
- use your favorite social network or blog to spread the word. The suggested hashtag for this book on Twitter is #InstantRPi[7]

Also, if you want to collaborate with me on any technical project, you can reach me on LinkedIn[8].

[6] https://leanpub.com/InstantRPi/feedback
[7] https://twitter.com/search?q=#InstantRPi
[8] https://in.linkedin.com/in/ashwinpajankar

1. Single Board Computers

A single-board computer (will be referred as SBC from henceforward throughout the book) is a fully functional computer system built on a single printed circuit board. A SBC has microprocessor(s), memory, input/output, and other features required of a functional computer.

Unlike a desktop personal computer, most of the SBCs do not have expansion slots for peripheral functions or expansion. As all the components are integrated on a single PCB, we cannot upgrade a SBC.

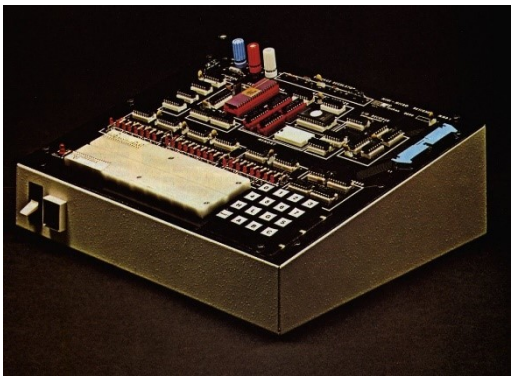
Few SBCs are made to plug into a backplane for system expansion. SBCs come in many varieties, sizes, shapes, form factors, and set of features. Due to the advances in the electronics and semiconductor technologies, prices of most SBCs are very low. One of the most important features of SBCs is being cost effective. With a prices around $50 a piece, we have in our hand a development tool suitable for new applications, hacking, debugging, testing, hardware development, and automation systems.

SBCs usually come in following form factors,

- AdvancedTCA
- CompactPCI
- Embedded Compact Extended (ECX)
- Mini-ITX
- PC/104
- PICMG
- Pico-ITX
- PXI
- Qseven
- VMEbus
- VPX
- VXI

1.1 History of SBCs

Dyna-Micro was the first true SBC. It was based on the Intel C8080A and used Intel's first EPROM, the C1702A. The dyna-micro was re-branded and marketed by E&L Instruments of Derby, CT in 1976 as the **MMD-1** (Mini-Micro Designer 1). It became famous all around as the leading example of microcomputers.



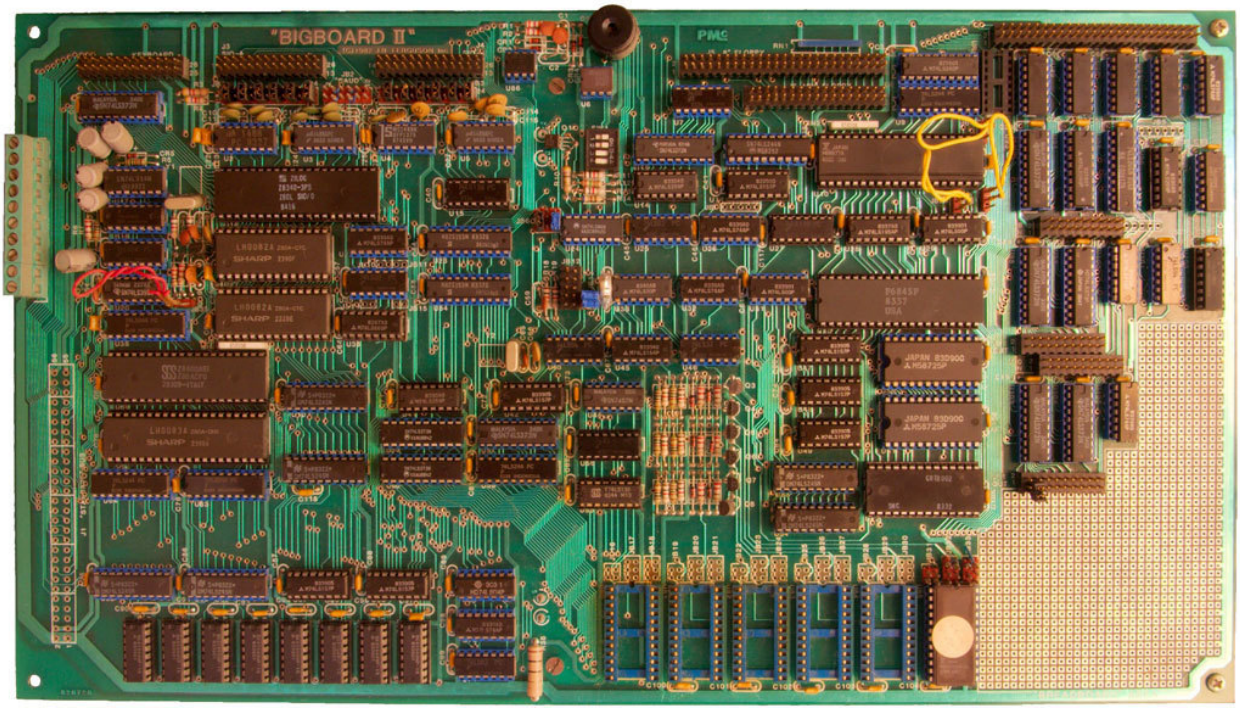
MMD-1

SBCs were very popular in the earlier days of computing, as many of the home computers were actually SBCs. However, with the rise of PCs, the popularity of SBCs declined. Since 2010, there is resurgence in the popularity of SBCs again due to lower production costs associated with SBCs.

BBC Micro was built around a MOS Technology 6502A processor running at 2 MHz.

BBC Micro

Ferguson Big Board II was a Zilog Z80 based computer running at 4MHz.



Ferguson Big Board II

Nascom was another Zilog Z80 based computer.

Nascom

This link[1] has a nice article on SBCs in PDF format.

[1] http://www.newark.com/wcsstore/ExtendedSitesCatalogAssetStore/cms/asset/pdf/americas/common/NE14-ElectronicDesignUncovered-Dec14.pdf

1.2 Various popular SBC families

Let's have a look at various SBC families.

1.2.1 Raspberry Pi

It is a credit-card sized computer designed by Raspberry Pi Foundation, UK. It is the best-selling computer of UK.

Raspberry Pi

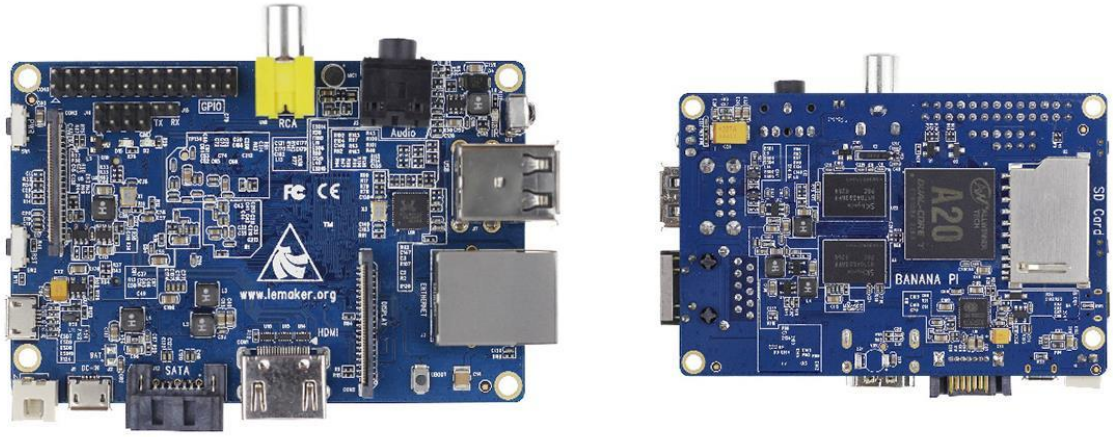
Visit Raspberry Pi Homepage[2] for more information.

[2] https://www.raspberrypi.org/

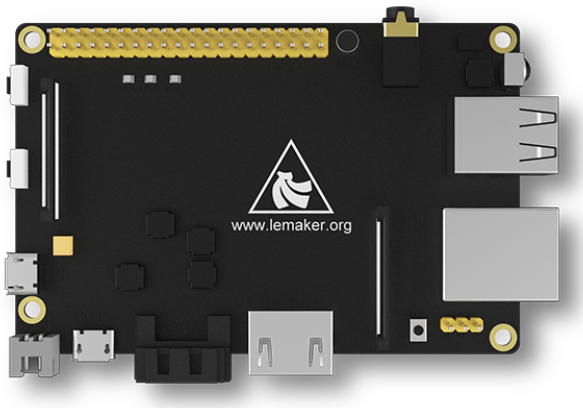
1.2.2 Banana Pi

The **Banana Pi** is a series of credit card-sized low cost SBCs. Its design is influenced by Raspberry Pi.

Banana Pi software is compatible with Raspberry Pi boards. Banana Pi also can run NetBSD, Android, Ubuntu, Debian, Archlinux, and Raspbian OS images. It uses the Allwinner system on chip.



Banana Pi



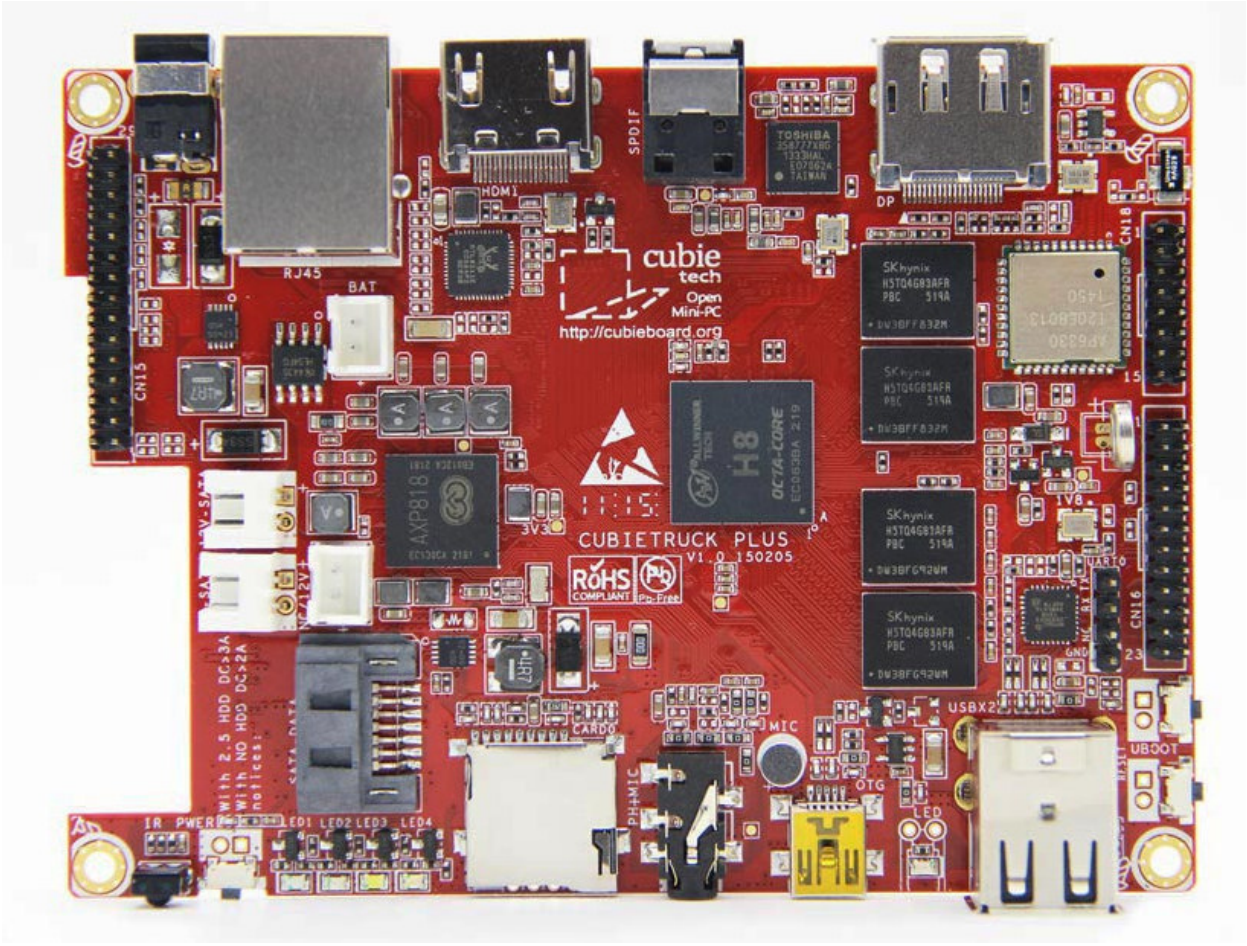
Banana Pro

This[3] is the link to Banana Pi's developer's website.

[3] http://www.lemaker.org

1.2.3 Cubieboard

Cubieboard is a single-board computer, made in Zhuhai, Guangdong, China. It can run Android 4 ICS, Ubuntu 12.04 desktop, Fedora 19 ARM Remix desktop, Arch Linux ARM, a Debian-based Cubian distribution, and OpenBSD. It uses the AllWinner A10 SoC.



Cubieboard 5

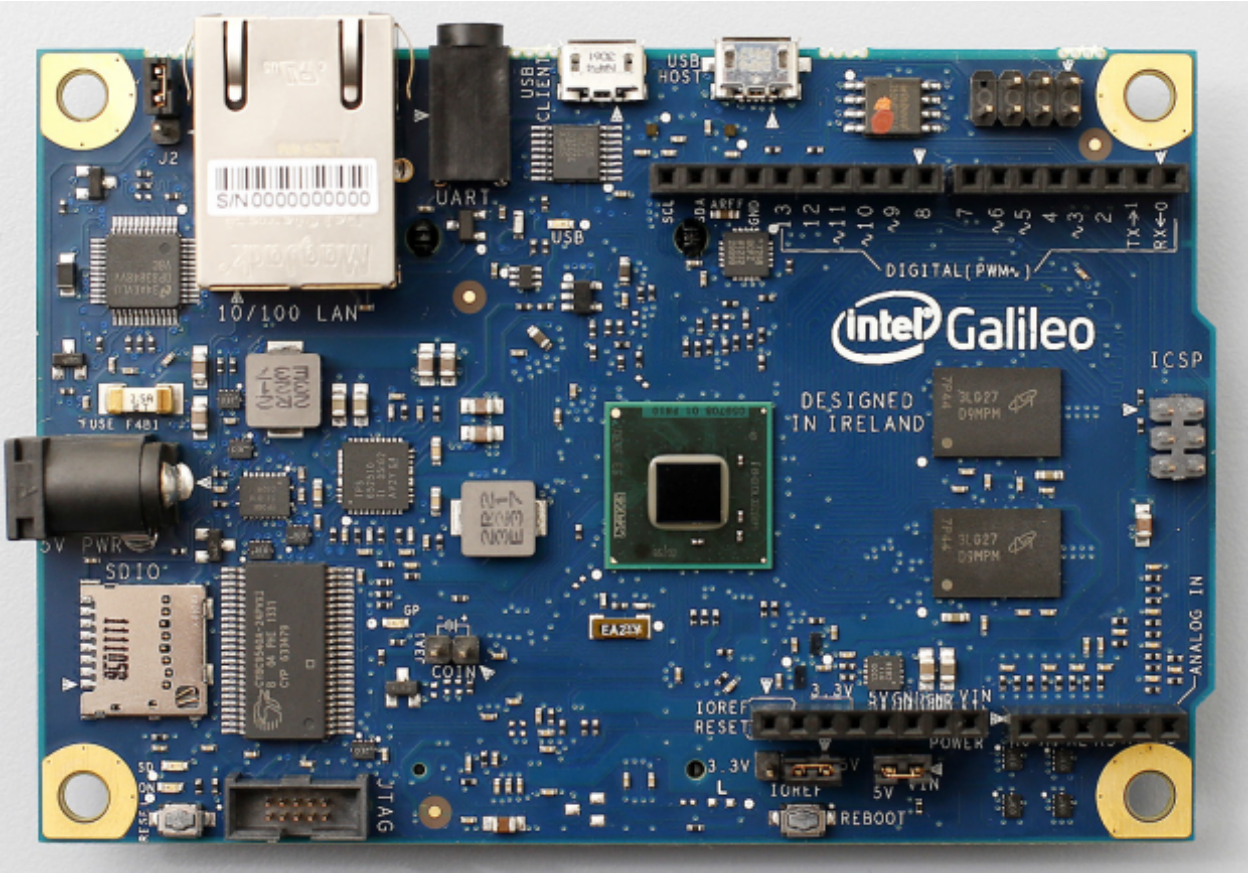
This[4] is the link to Cubieboard's website.

[4] http://cubieboard.org

1.2.4 Intel Galileo

Intel Galileo is the first in a line of development boards based on Intel x86 architecture and is designed for the maker and education communities. Intel released two versions of Galileo, referred to as Gen 1 and Gen 2.

The Intel® Galileo Gen 2 development board is a microcontroller board based on the Intel Quark SoC X1000 application processor, a 32-bit Intel Pentium brand system on a chip.



Intel Galileo Gen 2

This[5] is the link to Galileo's webpage on Intel website.

[5] http://www.intel.in/content/www/in/en/embedded/products/galileo/galileo-overview.html

1.3 SoC

You must have noticed the abbreviation **SoC** in the earlier text. A **system on a chip** or **system on chip** (SoC or SOC) is an integrated circuit (IC) that has all the components of a computer on a single chip. SoCs are very common in the mobile electronic devices because of their low power consumption, and versatility. SoCs are widely used in mobile phones, SBCs, and embedded hardware. A SoC has both, the hardware and the software needed for its operation.

1.4 Summary

In this chapter we familiarised ourselves with SBCs. We also got to know few of the most popular SBCs of the past and the future.

As an exercise to this chapter, explore all the hyperlinks mentioned in the chapter.

2. Introduction to Raspberry Pi

The Raspberry Pi is a family of credit card-sized SBCs developed in the United Kingdom by the Raspberry Pi Foundation. Raspberry Pi Foundation was founded in 2009. The aim behind developing Raspberry Pi is to promote the teaching of basic computer science in schools and developing countries by providing a low cost computing platform.

You can read more about Raspberry Pi Foundation at their website[1].

Raspberry Pi Foundation's **Raspberry Pi** was released in 2012. It was a massive hit which sold over two million units in two years. Subsequently, Raspberry Pi Foundation revised versions of the Raspberry Pi. They also released other accessories for the Pi.

Check Raspberry Pi Product Page[2] for more information.

[1] https://www.raspberrypi.org/about
[2] https://www.raspberrypi.org/products

2.1 Popular Raspberry Pi models

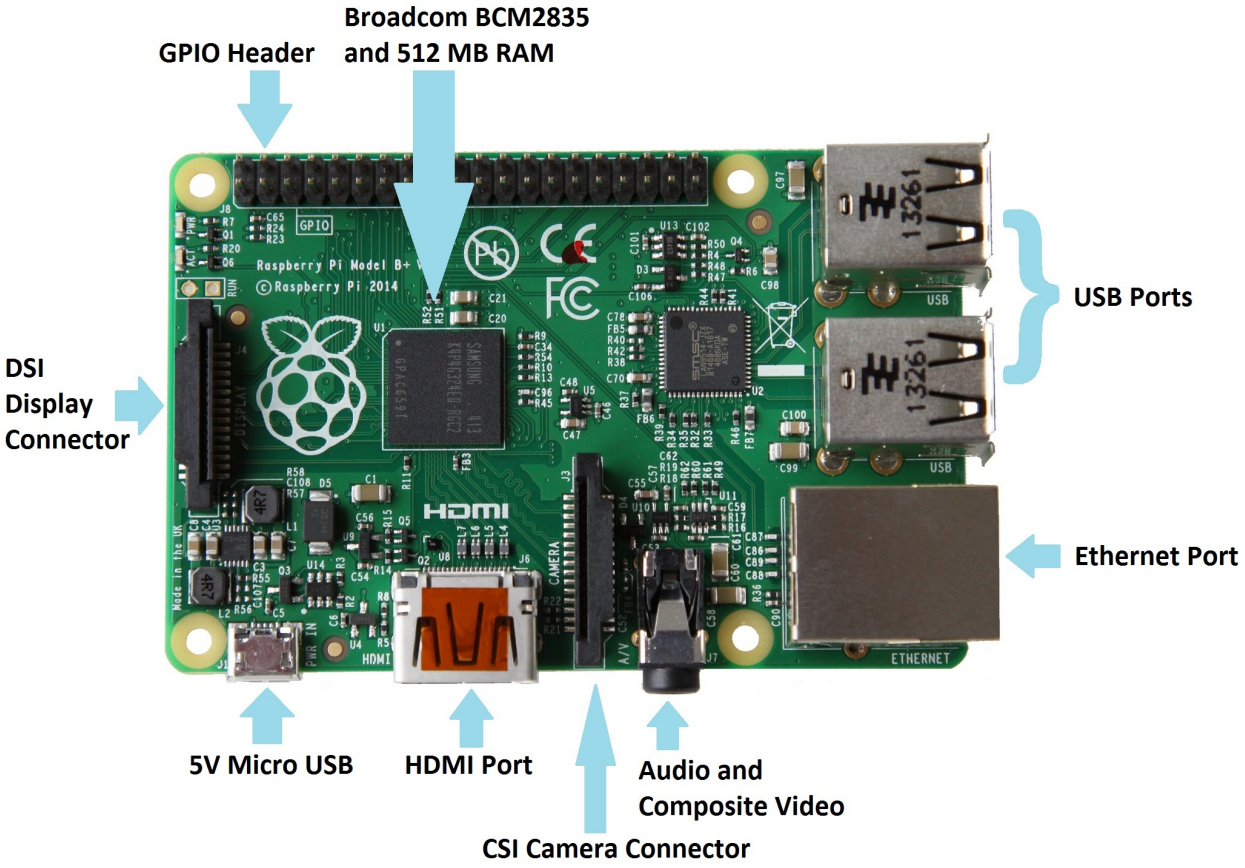
Let's have a look at few most popular models of Raspberry Pi.

2.1.1 Raspberry Pi 1 Model B+

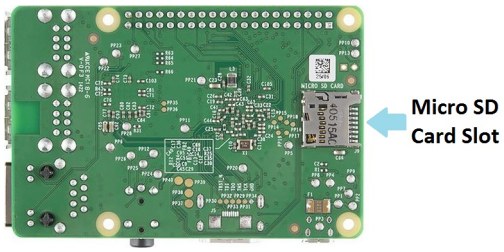
Specifications of Raspberry Pi 1 Model B+ are as follows,

Type	Raspberry Pi Model 1 B+
Release Date	July 2014
Architecture	ARMv6
SoC	Broadcom BCM2835
CPU	700 MHz single-core ARM1176JZF-S
GPU	Broadcom VideoCore IV @ 250 MHz
Memory	512 MB (shared with GPU)
USB 2.0 ports	4
Video Output	HDMI rev 1.3 and Composite Video RCA jack
On-board storage	Micro SDHC slot
On-board network	10/100 Mbps Ethernet
Power source	5V via MicroUSB
Power ratings	800 mA (4W)

Following is the top view of B+ model.



Following is the bottom view of B+ model.

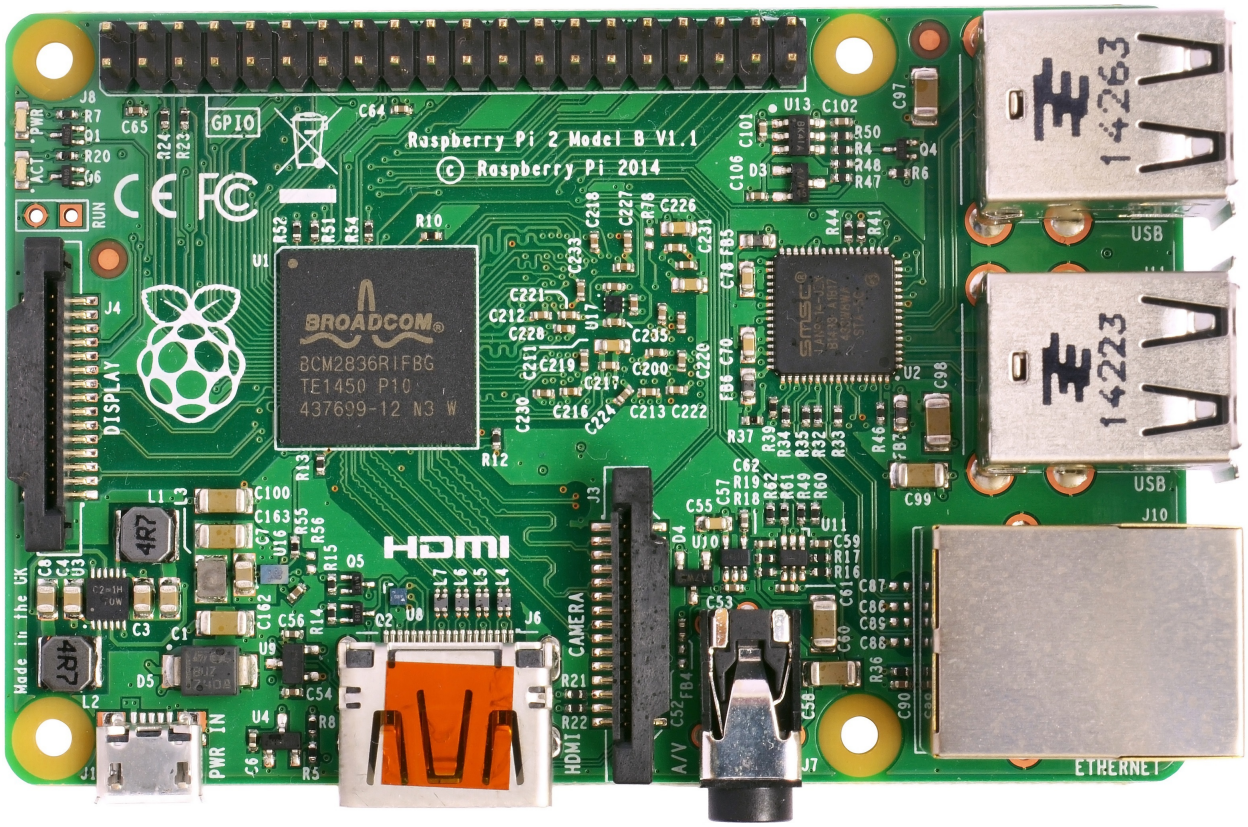


2.1.2 Raspberry Pi 2 Model B

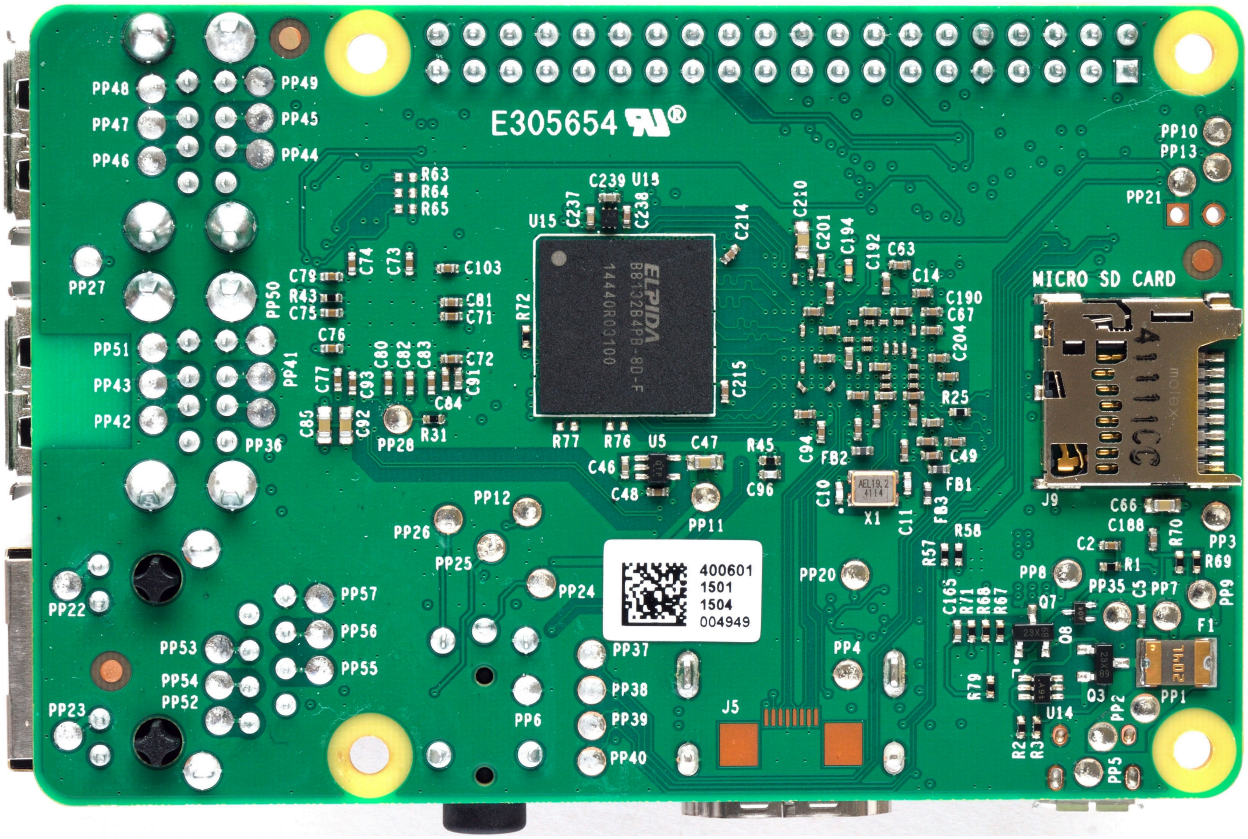
Specifications of Raspberry Pi 2 Model B are as follows,

Type	Raspberry Pi Model 2 B
Release Date	February 2015
Architecture	ARMv7
SoC	Broadcom BCM2836
CPU	900 MHz 32-bit quad-core ARM Cortex-A7
GPU	Broadcom VideoCore IV @ 250 MHz
Memory	1 GB (shared with GPU)
USB 2.0 ports	4
Video Output	HDMI rev 1.3 and Composite Video RCA jack
On-board storage	Micro SDHC slot
On-board network	10/100 Mbps Ethernet
Power source	5V via MicroUSB
Power ratings	800 mA (4W)

Following is the top view of 2B model. Locations of all the components are same. The difference between B+ and 2B is the processor (Broadcom BCM2836) and the RAM (1GB).



Following is the bottom view of 2B model.

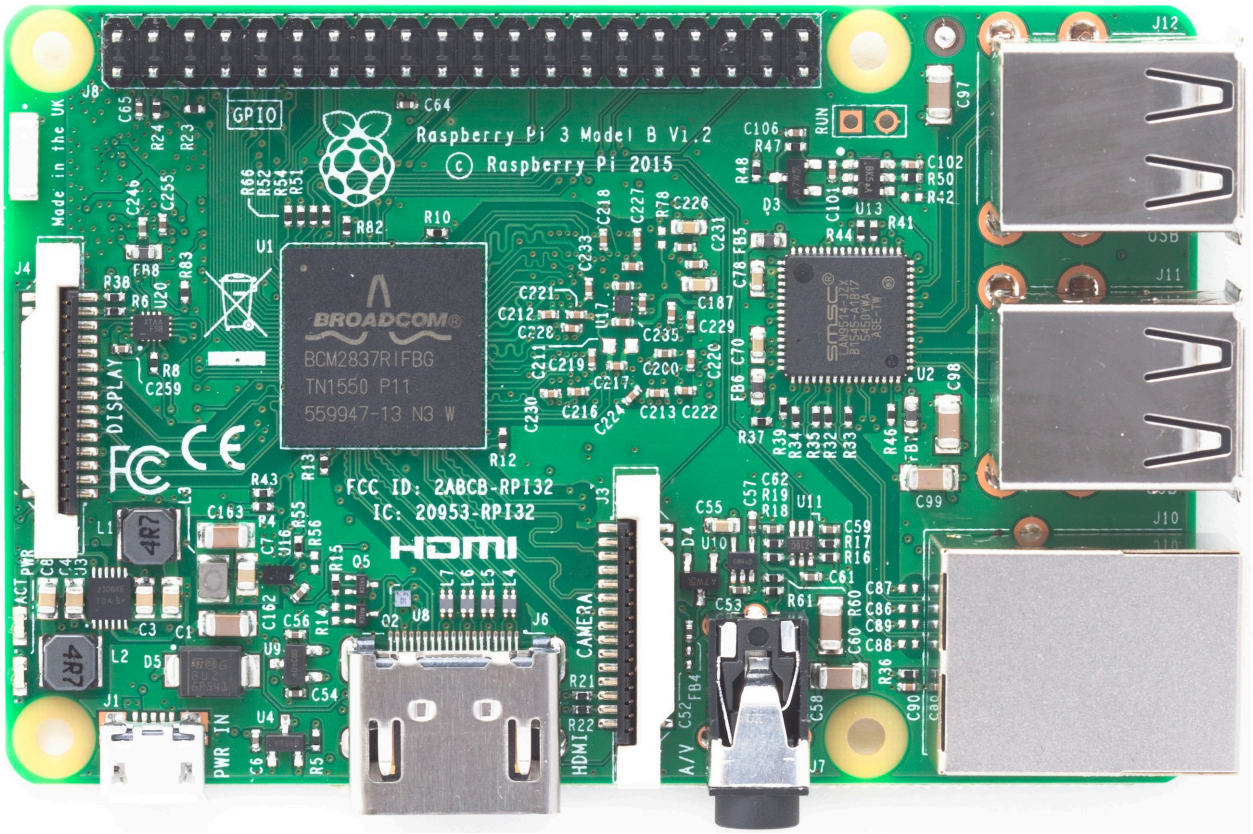


2.1.3 Raspberry Pi 3 Model B

Specifications of Raspberry Pi 3 Model B are as follows,

Type	Raspberry Pi Model 3 B
Release Date	February 2016
Architecture	ARMv8
SoC	Broadcom BCM2837
CPU	1.2 GHz 64-bit quad-core ARM Cortex-A53
GPU	Broadcom VideoCore IV (3D part of GPU @ 300 MHz, video part of GPU @ 400 MHz)
Memory	1 GB (shared with GPU)
USB 2.0 ports	4
Video Output	HDMI rev 1.3 and Composite Video RCA jack
On-board storage	Micro SDHC slot
On-board network	10/100 Mbps Ethernet, Bluetooth, and WiFi
Power source	5V via MicroUSB
Power ratings	800 mA (4W)

Following is the top view of 3B model. Again, locations of all the components are same. The major difference between 2B and 3B is the processor (Broadcom BCM2837) and the RAM (1GB). It also has on-board bluetooth and WiFi. Its GPU runs at higher frequencies.



There is no significant difference between the bottom view of 2B and 3B.

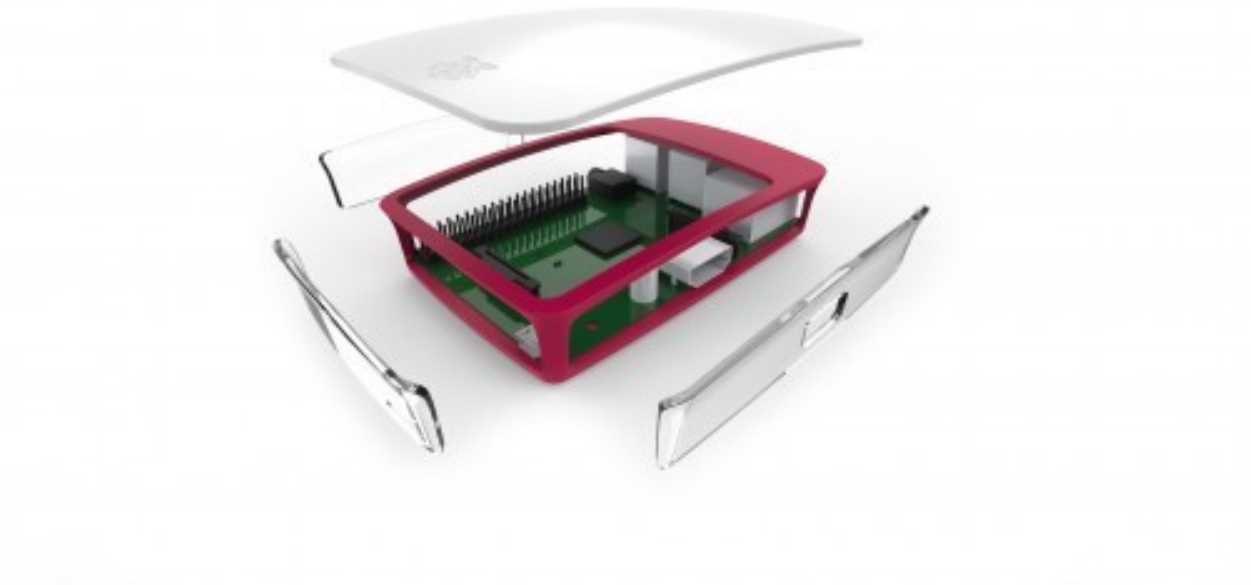
2.2 Raspberry Pi cases

We have seen the physical layout of Raspberry Pi 1 B+, Raspberry Pi 2 B, and Raspberry Pi 3 B. A noticable similarity is the form factor of all the three models. It is same for all the models! So, the same case fits all the three models. In this section, we will have a look at various cases available for these models.

2.2.1 Raspberry Pi Official case

This case is designed by the Raspberry Pi Foundation. We find following features for the case on Raspberry Pi's webpage for the case[3].

- High-quality ABS construction
- Removable side panels and lid for easy access to GPIO, camera, and display connectors
- Light pipes for power and activity LEDs
- Extraordinarily handsome



Various components of the case

[3] https://www.raspberrypi.org/products/raspberry-pi-case

Front and back of the case

Case with display attached

2.2.2 Pimoroni Pibow case

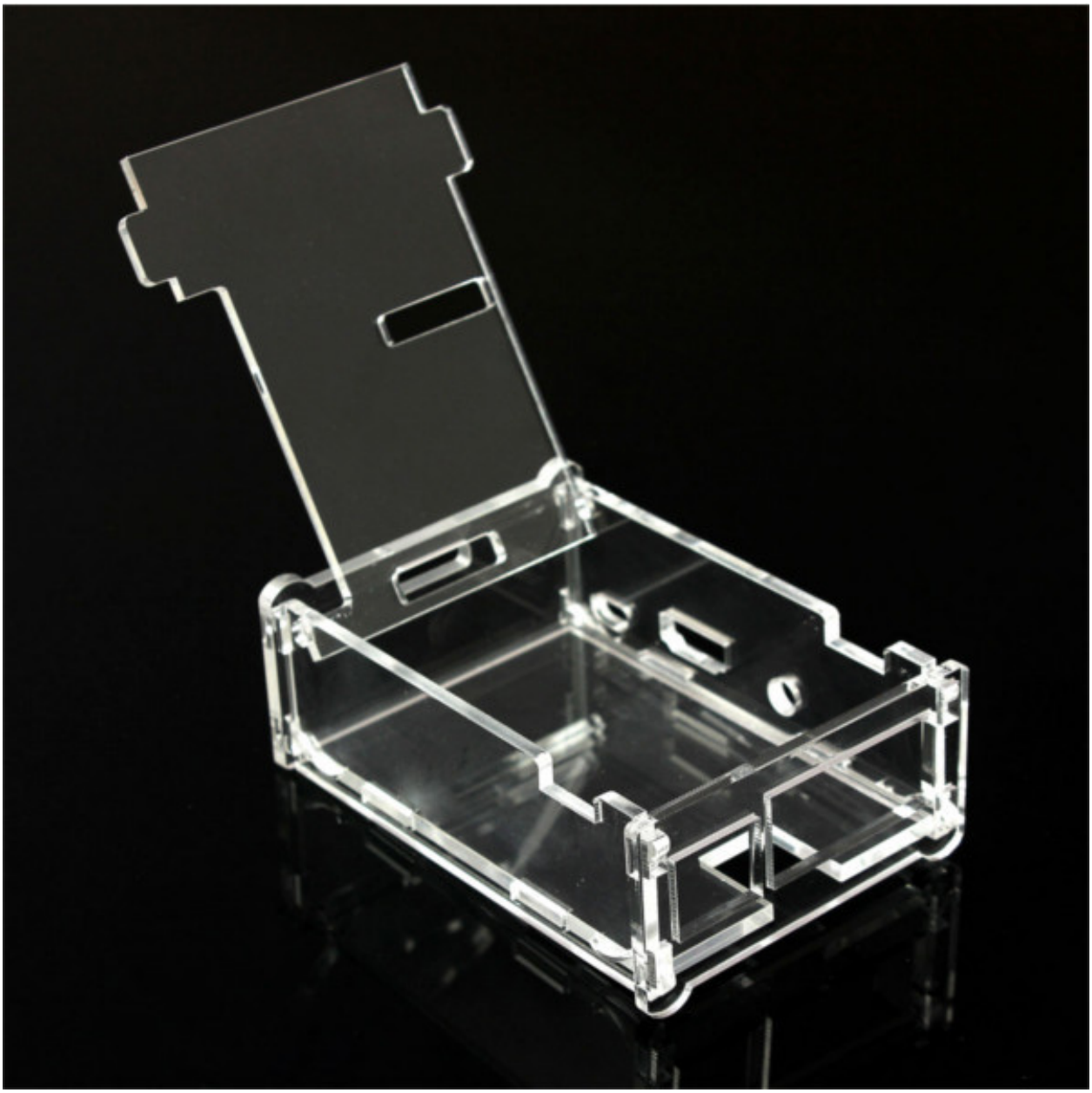
Colorful and eye-catching **Pibow** cases for all the versions of Raspberry Pi can be found at Pimoroni Pibow shop[4].

Following are the images of various Pibow images.

[4] https://shop.pimoroni.com/collections/raspberry-pi/pibow

2.2.3 Raspberry Pi acrylic case

It's probably the cheapest case available in the market. You can search for it on Amazon[5].



[5] www.amazon.com

2.2.4 Other cases

Following are the images of the few other cases available for Raspberry Pi in the market.

This[6] online article lists top 15 Raspberry Pi cases.

[6] http://beebom.com/raspberry-pi-cases

2.3 Where to buy Raspberry Pi and the cases

We can buy various Raspberry Pi models, cases, and related accessories online at following reputed distributors.

- Element14[7]
- RS devlivers[8]
- Adafruit[9]
- SparkFun Electronics[10]
- Pimoroni[11]

[7] https://www.element14.com
[8] http://www.rsdelivers.com
[9] https://www.adafruit.com
[10] https://www.sparkfun.com
[11] https://shop.pimoroni.com

2.4 Summary

In this chapter we familiarised ourselves with hardware specifications of Raspberry Pi models B+, 2B, and 3B.

Explore all the distributor sites for Raspberry Pi and various accessories.

3. Buy the book

I hope that you loved the preface, and the sample chapters. Please do visit Leanpub[1] for purchasing the complete book. Rest of the book helps you to setup a Raspberry Pi and explore it further.

You also might want to check my other technical books. You can find them at my Leanpub profile page[2].

[1] https://leanpub.com/instantRPi

[2] https://leanpub.com/u/ashwinpajankar