

010123131

Software Development Practice I

Handout #4

<rawat.s@eng.kmutnb.ac.th>

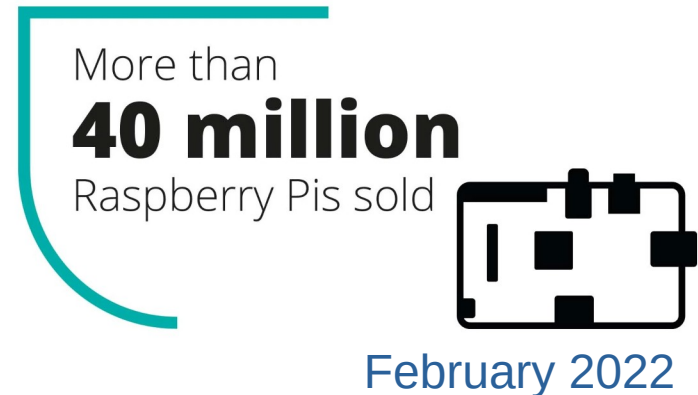
Last Update: 2024-07-09

Agenda

- Introduction to Raspberry Pi (RPI) SBCs
- OS Support for Raspberry Pi
- Raspberry Pi System Setup
- Raspberry OS Installation Process

Raspberry Pi SBCs

- **Raspberry Pi** is a series of small **Single-Board Computers** (SBCs).
 - It was developed in the United Kingdom (UK) by the **Raspberry Pi Foundation** (<https://raspberrypi.org/>) to promote teaching of basic Computer Science in schools and in developing countries.
- **Possible Applications:**
 - Use in hobby and DIY applications
 - Use in education and research
 - Use in home automation
 - Use in industrial automation
 - Use in commercial products



IMPACT

775
young
people
from

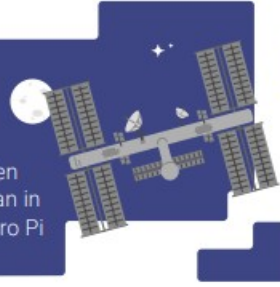


39 countries

showcased
projects in our
Coolest Projects
online gallery

6559

programs written
by young people ran in
space through Astro Pi



350
people

from 25 countries took
part in our research events



OVER
1M

questions answered on our
Isaac Computer Science
A level platform

36,000 & 10,000

subscribers to
Hello World



subscribers
to our other
magazines

4.9
MILLION

learners engaged with
our online projects



26k

teachers from 12,000 schools
in England supported through
the National Centre for
Computing Education

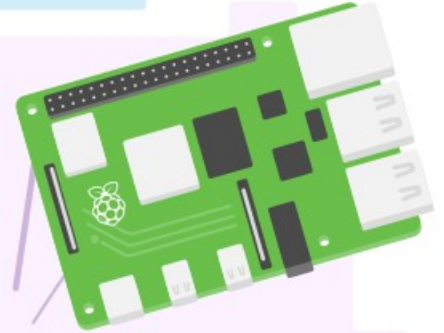
70,000

participants
in our online
courses in 2020



37.4 MILLION

Raspberry Pi computers
sold to date



220k
downloads

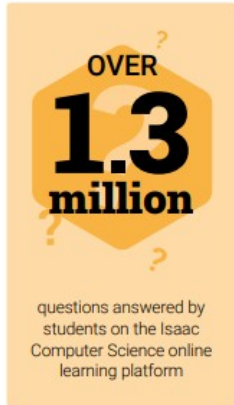
of our Teach Computing
Curriculum resources for
teachers

220
SCHOOLS

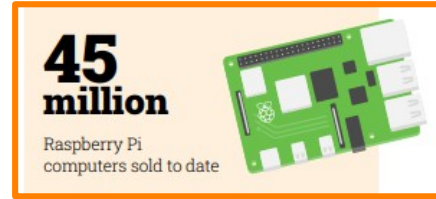
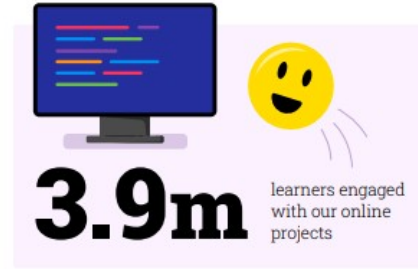
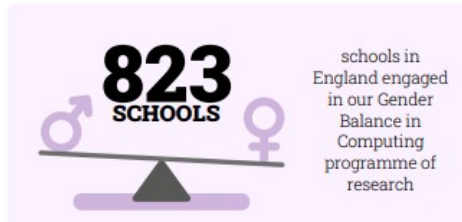
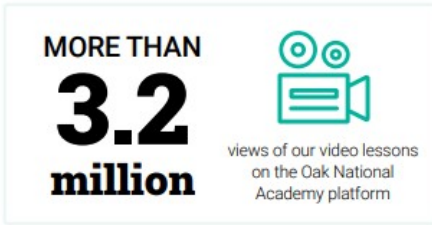
engaged in our research on
gender balance in computing



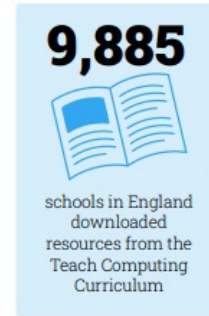
Our impact in 2021



1,385 young people from **54 countries** showcased tech projects in Coolest Projects



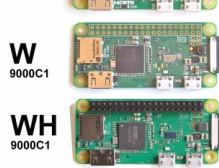
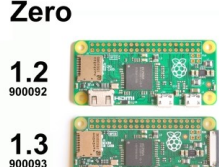
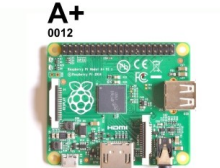
1,454 Code Clubs & 801 CoderDojos ran in-person sessions



Raspberry Pi Models

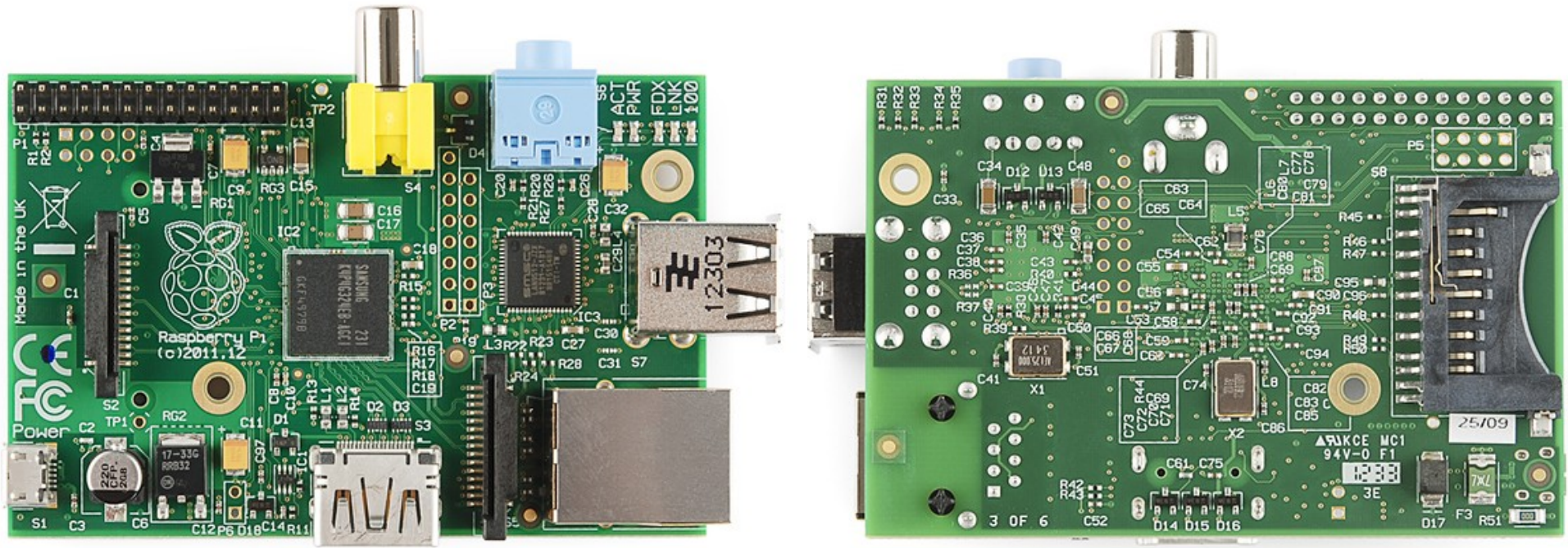
Last Update:
December 2018

<https://raspi.tv/rpifamily>



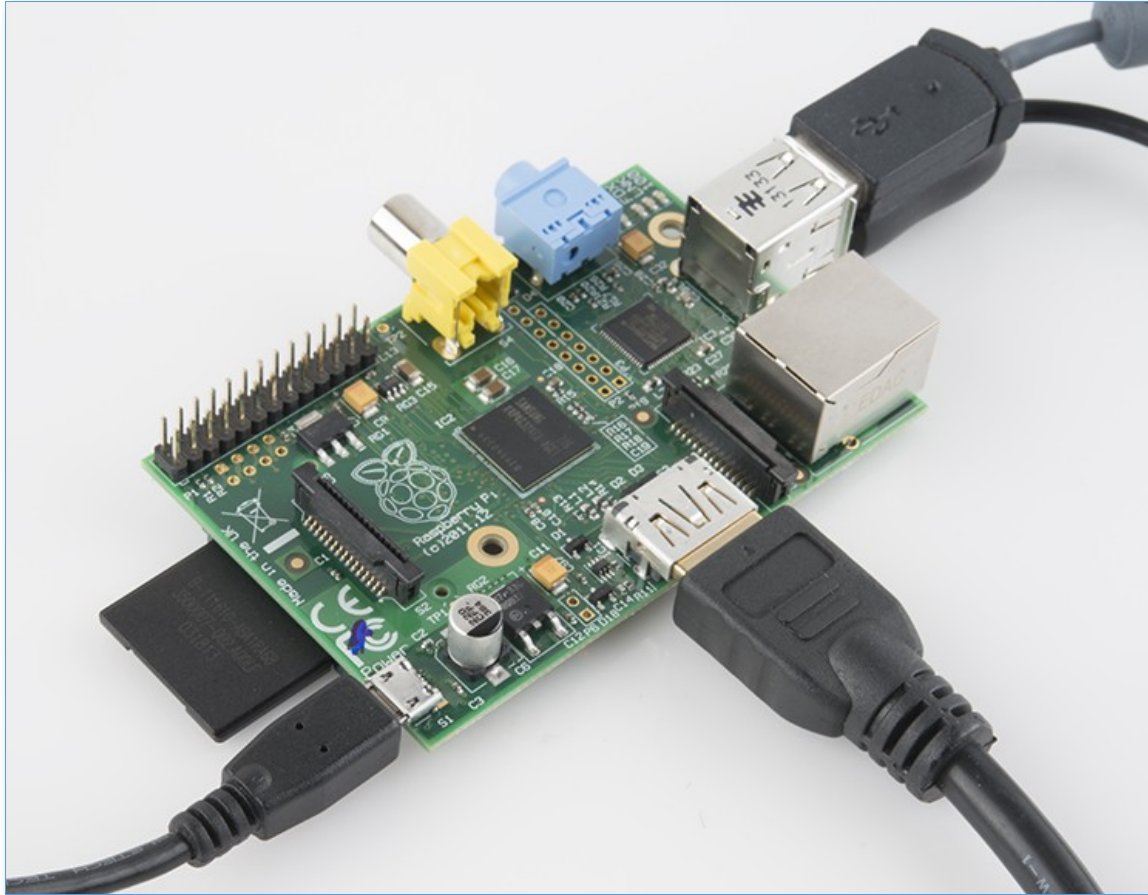
**Raspberry Pi®
Family**
December 8 2018
RasPi.TV

Raspberry Pi 1 Model B



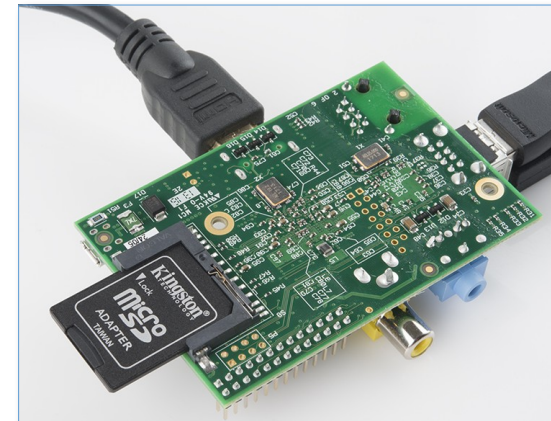
The first-generation Raspberry Pi Model B was released in February 2012.

Raspberry Pi 1 Model B



Features

- Broadcom BCM2835 SoC
- ARM1176JZF-S core CPU (700 MHz)
- Broadcom VideoCore IV GPU
- RAM: 512 MB
- 2 x USB2.0 Ports
- Video Out: Composite (PAL / NTSC), HDMI, DSI
- Audio Out: 3.5mm Jack or Audio over HDMI
- Storage: SD/MMC/SDIO
- 10/100 Ethernet (RJ45)
- Peripherals: GPIO, UART, I2C, SPI
- Power: 5V @ 700 mA via MicroUSB or GPIO Pins
- Dimension: 85.60mm x 56mm x 21mm



SoCs and Raspberry Pi Models

SoC: BCM2835 SoC: 32-bit ARM1176JZF-S, arm6hf

- Raspberry Pi 1 Models A, A+, B, B+
- Raspberry Pi Zero
- Raspberry Pi Zero W
- Raspberry Pi Compute Module 1

BCM2836 SoC: Quad-core 32-bit Cortex-A7, armhf

- Raspberry Pi 2 Model B

BCM2837 SoC: Quad-core 64-bit ARM Cortex A53, 1.2GHz, arm64

- Raspberry Pi 3 Model B
- Raspberry Pi Compute Module 3

Reference: <https://www.raspberrypi.com/documentation/computers/processors.html>

ARM Cortex-A53: <https://developer.arm.com/Processors/Cortex-A53>

SoCs and Raspberry Pi Models

BCM2837B0 SoC: Quad-core 64-bit ARM Cortex A53, 1.4GHz, arm64

- Raspberry Pi 3 Models A+, B+
- Raspberry Pi Compute Module 3+

RP3A0 System-in-Package (SiP)

with BCM2710A1: Quad-core 64-bit ARM Cortex A53, 1.5GHz, arm64

- Raspberry Pi Zero 2

BCM2711 SoC: Quad-core 64-bit ARM Cortex A72, 1.5GHz, arm64

- Raspberry Pi 4 Model B
- Raspberry Pi 400
- Raspberry Pi Compute Module 4 (CM4)

Reference: <https://www.raspberrypi.com/documentation/computers/processors.html>

ARM Cortex A72: <https://developer.arm.com/Processors/Cortex-A72>

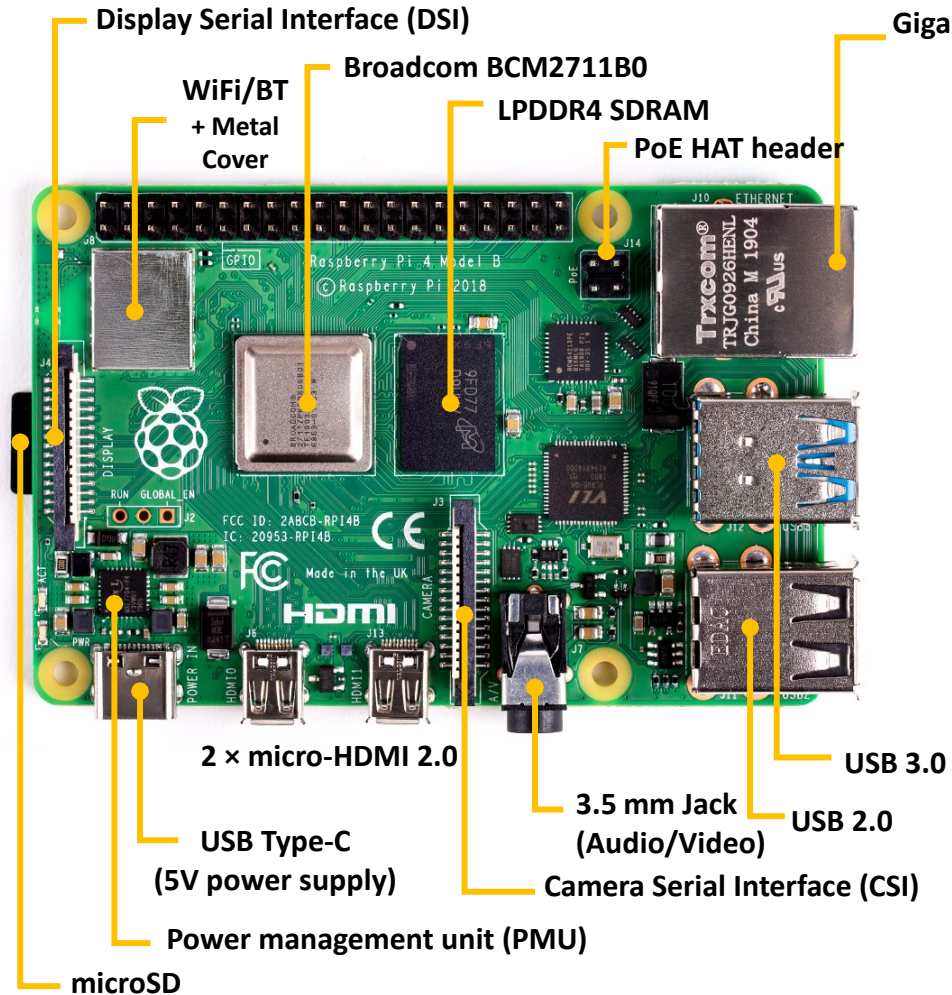
SoCs and Raspberry Pi Models

Product	Processor	ARM core	Debian/Raspbian ARM port (maximum)	Architecture width
Raspberry Pi 1	BCM2835	ARM1176	arm6hf	32 bit
Raspberry Pi 2	BCM2836	Cortex-A7	armhf	32 bit
Raspberry Pi Zero	BCM2835	ARM1176	arm6hf	32 bit
Raspberry Pi Zero 2	BCM2710	Cortex-A53	arm64	64 bit
Raspberry Pi 3	BCM2710	Cortex-A53	arm64	64 bit
Raspberry Pi 4	BCM2711	Cortex-A72	arm64	64 bit

Source: <https://www.raspberrypi.com/news/raspberry-pi-os-64-bit/>

Raspberry Pi 4 Model B

The Raspberry Pi 4 Model B was released in June 2019.



Raspberry Pi 4 specs

- **SoC**: Broadcom BCM2711B0 quad-core A72 (ARMv8-A) 64-bit @ 1.5GHz
- **GPU**: Broadcom VideoCore VI, 500MHz
- **RAM**: 1GB, 2GB, or 4GB LPDDR4 SDRAM
- **WiFi**: 2.4 GHz and 5 GHz 802.11b/g/n/ac
- **Bluetooth**: Bluetooth 5.0, Bluetooth Low Energy (BLE)
- **GPIO**: 40-pin GPIO header, populated
- **Storage**: microSD
- **Ports**: 2x micro-HDMI 2.0, 3.5 mm analog audio-video jack, 2x USB 2.0, 2x USB 3.0, Gigabit Ethernet, Camera Serial Interface (CSI), Display Serial Interface (DSI)
- **Dimensions**: 88 mm × 58 mm × 19.5 mm, 46 g

th.cytron.io/c-raspberry-pi/c-raspberry-pi-main-board/c-raspberry-pi-4

CATEGORIES HOT DEALS NEW ARRIVALS BEST SELLERS LOCAL WAREHOUSE PROJECTS TUTORIALS INDUSTRY

Home » All Categories » Raspberry Pi Main Board » Raspberry Pi 4


Price Range **X ▶** Raspberry Pi 4 Sort By: Popularity Show: 20


Availability
 In Stock
 Out of Stock


Shipped From
 Local (5)


Brands
 Raspberry Pi (5)


Change Category
> Projects
> Raspberry Pi

Out of Stock

★★★★★
Raspberry Pi 4 Model B 8GB and Kits
THB3,310.00++
Login to Purchase

Out of Stock

★★★★★
Raspberry Pi 4 Model B 2GB and Kits
THB1,990.00++
Login to Purchase

Out of Stock

★★★★★
Raspberry Pi 4 Model B 1GB and Kits
THB1,550.00++
Login to Purchase

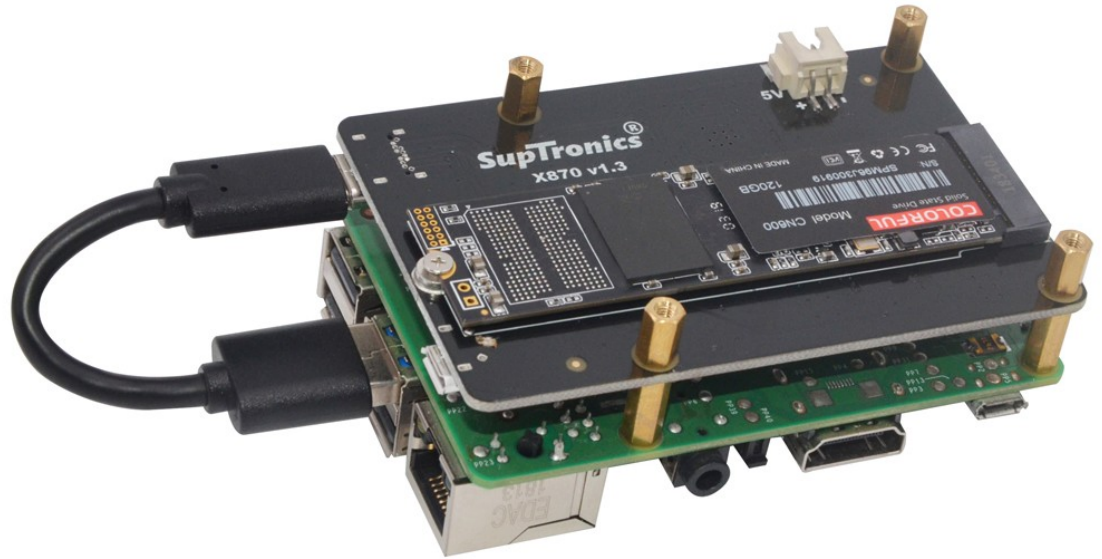

★★★★★
Raspberry Pi 400 Keyboard Computer-US Layout (L...
THB3,070.00
Login to Purchase

Out of Stock

★★★★★
Raspberry Pi 4 Model B 4GB and Kits
THB2,520.00++
Login to Purchase

Showing 1 to 5 of 5 (1 Pages)

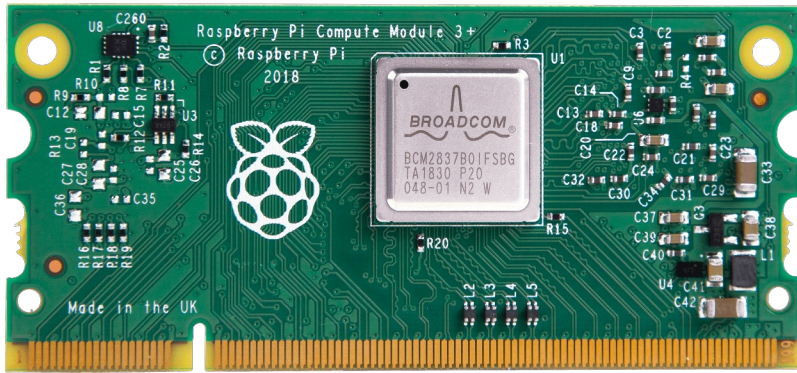
The chip shortage situation (due to COVID'19) has affected directly the production and availability of Raspberry Pi 4 boards.

Raspberry Pi 4 Model B + USB-SSD or NVMe SSD Shield



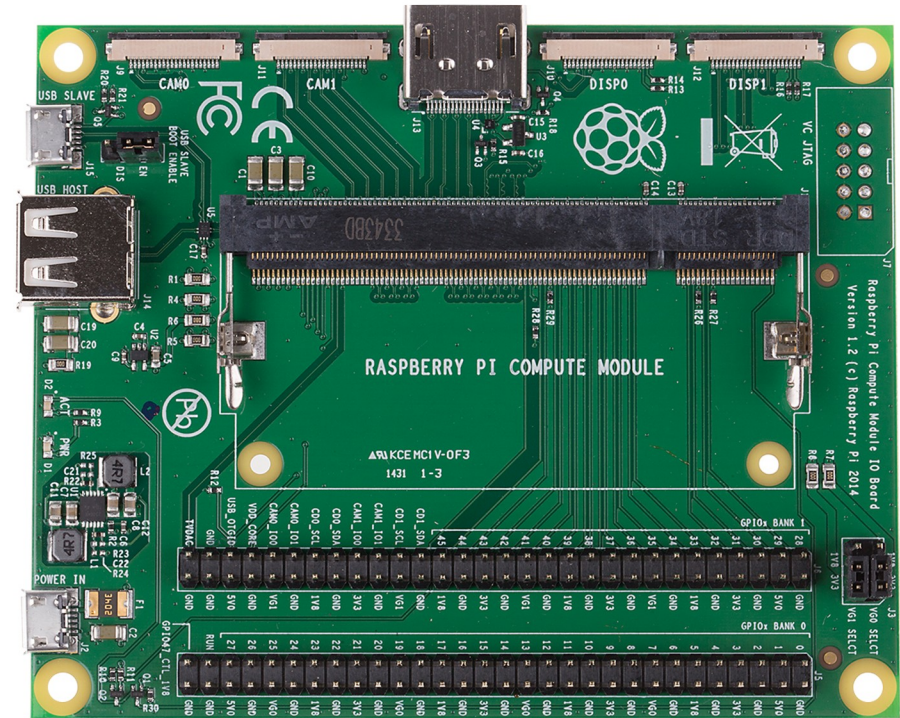
<http://www.suptronics.com/miniPCkits/x870.html>

Raspberry Pi Compute Modules (RPI CMs) & Dev. Kit



Raspberry Pi Compute Module 3 + (CM3+) with 8GB eMMC

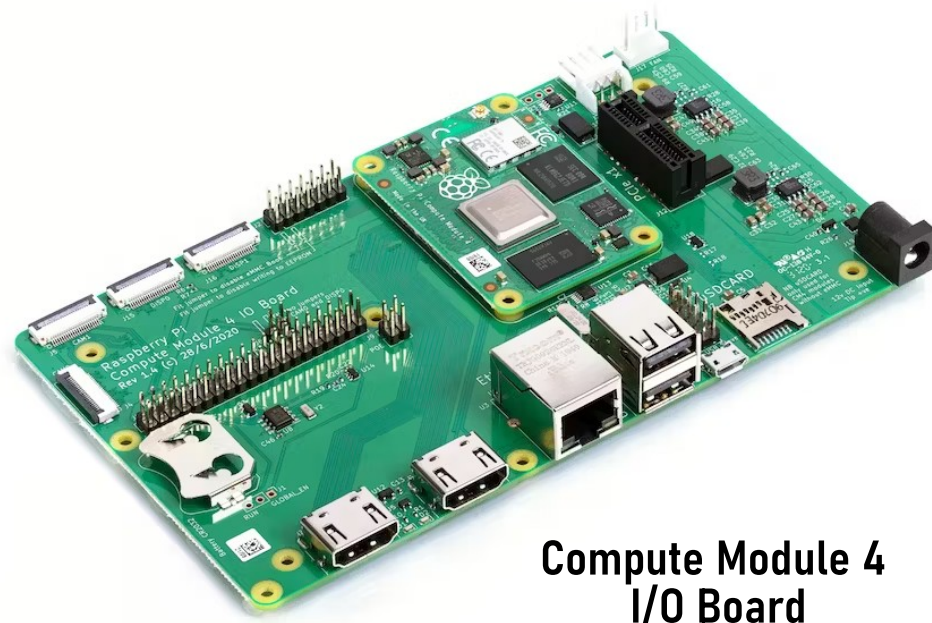
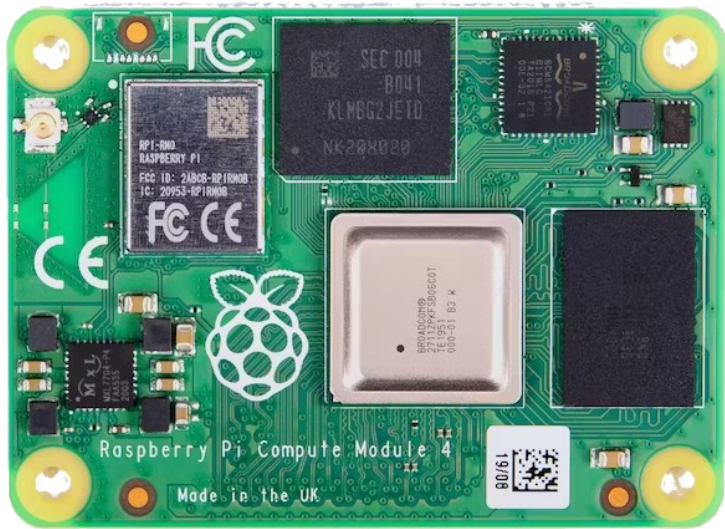
<https://www.raspberrypi.org/products/compute-module-3/>



Raspberry Pi Compute Module Development Kit for CM3+, CM3+/Lite, CM3, CM3 Lite, and CM1

<https://www.raspberrypi.com/products/compute-module-development-kit-2/>

Raspberry Pi Compute Modules 4



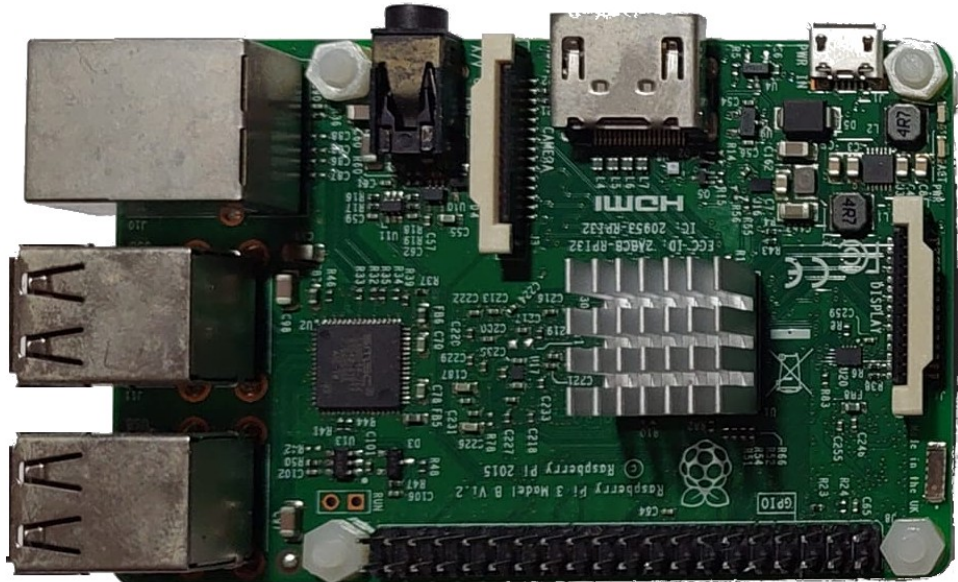
Compute Module 4
I/O Board

RPi CMs (pin-compatible SODIMM modules)

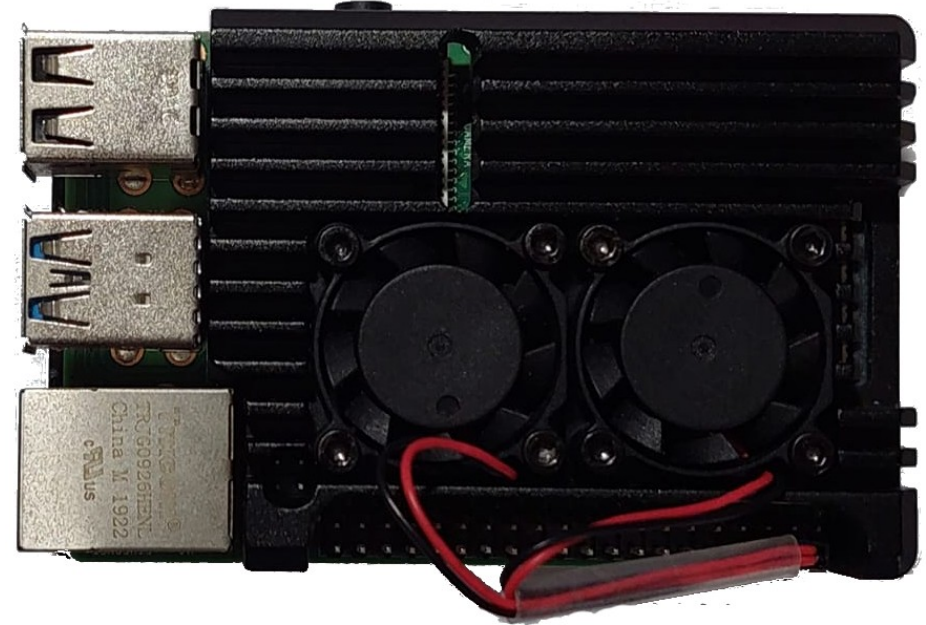
- 2014: **CM1** [BCM2835, 700MHz, 512MB RAM, 4GB eMMC Flash storage]
- 2017: **CM3** [BCM2837, 1.2GHz, 1GB RAM, 4GB eMMC] and **CM3L** [no eMMC]
- 2019: **CM3+** [BCM2837B0, 1.2GHz, 1GB RAM, 8GB/16GB/32GB eMMC] and **CM3+L** [no eMMC]
- 2020: **CM4** [BCM2711, 1.5GHz, 1GB/2GB/4GB/8GB LPDDR4, 8GB/16GB/32GB eMMC]

Raspberry Pi 4 Model B

RPi 4 Board with a Heatsink



RPi 4 Metal Case + 5V DC Fan



Raspberry Pi 5



Raspberry Pi 5 Computer

- 8GB RAM: THB3,325.00
- 4GB RAM: THB2,495.00

Source: <https://th.cytron.io/c-raspberry-pi>



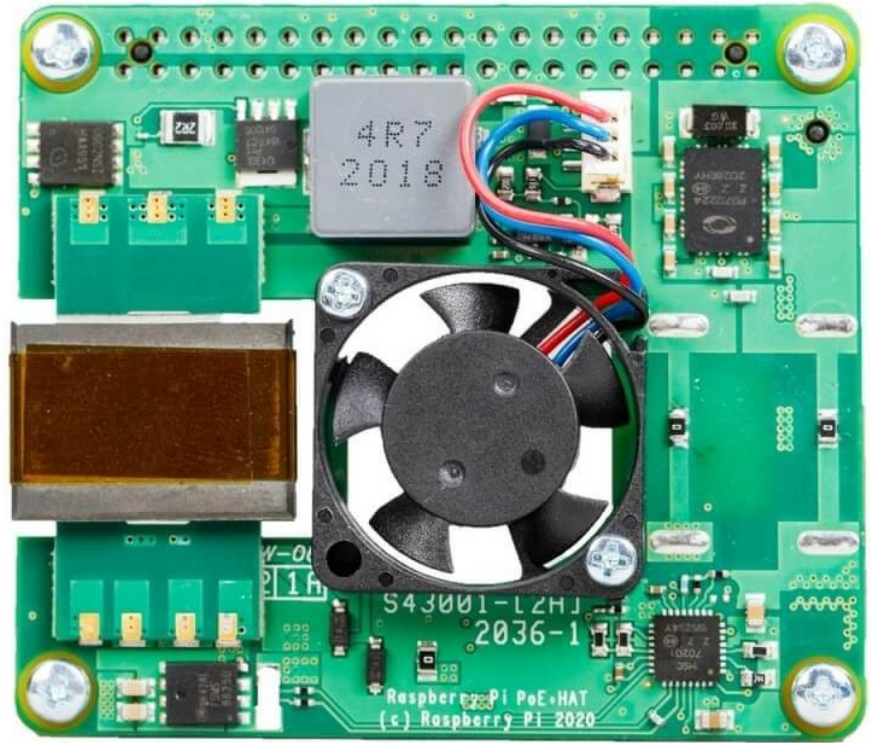
Active Cooler for RPi5
THB200.00



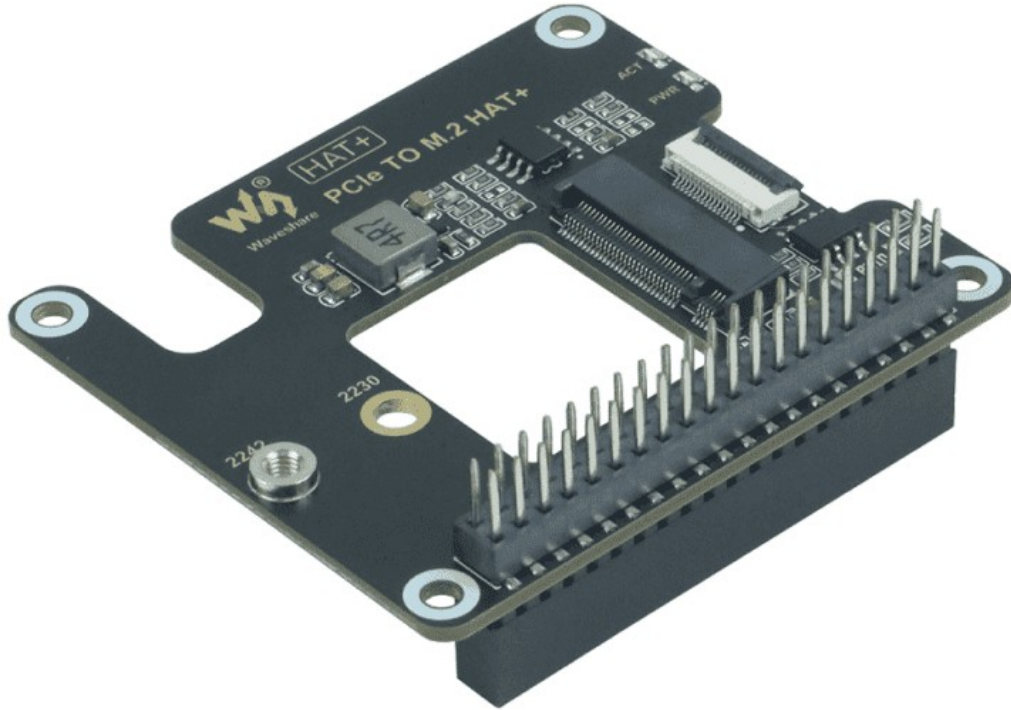
Black Active Cooler for RPi5
THB230.00



Raspberry Pi USB-C PD 27W PSU
THB500.00



5V 5A Power over Ethernet Plus (PoE+)
THB1,100.00



PCIe M.2 M-Key HAT+ for RPi 5
THB 380.00



PCIe Hat for RPi 5
with MakerDisk NVMe SSD

Raspberry Pi System Setup

- Raspberry Pi 3 or 4 Model B Board
- MicroSD Card (at least 8GB, Class 10)
 - MicroSD Card Reader / USB Adapter (for installing the OS image)
- 5V Power Supply Adapter
 - MicroUSB Connector for RPi 3
 - USB Type-C Connector for RPi 4
- Ethernet Cable / Network Switch / WiFi-Internet Router
- Desktop Mode: USB HID (keyboard, mouse), HDMI LCD Monitor

5Vdc Power Supply for Raspberry Pi SBCs

Power Supply 5V / 3A
(AC-to-DC Adapter) for RPi 4



MicroUSB Connector
(for RPi 3)



USB Type-C Connector
(for RPi 4)

Power Supply 5V / 3A
Type-C Adapter with
ON/OFF Switch for RPi 4



Raspberry Pi Accessories



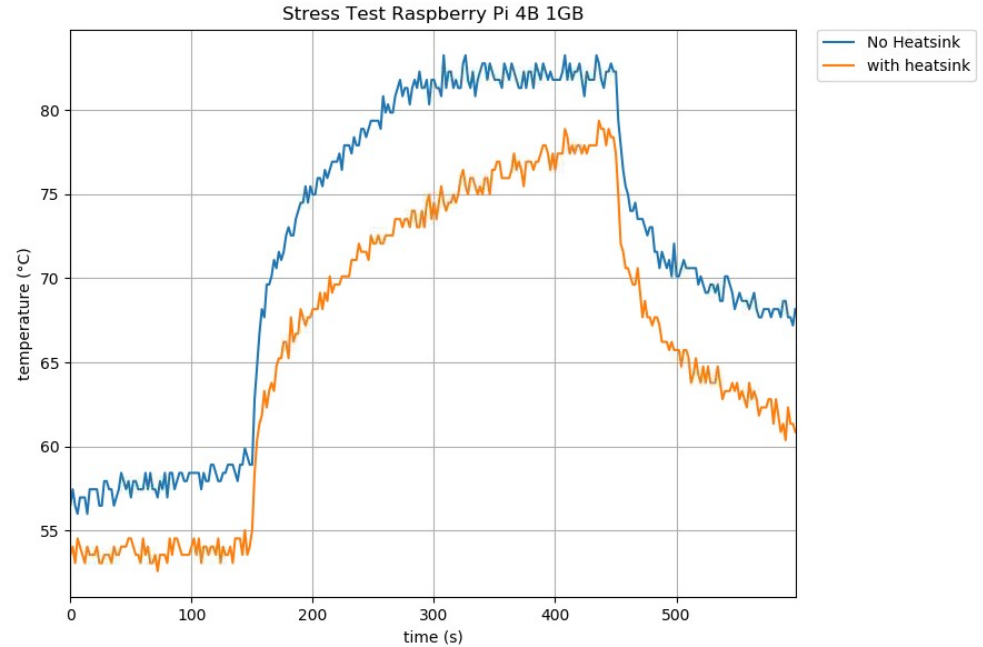
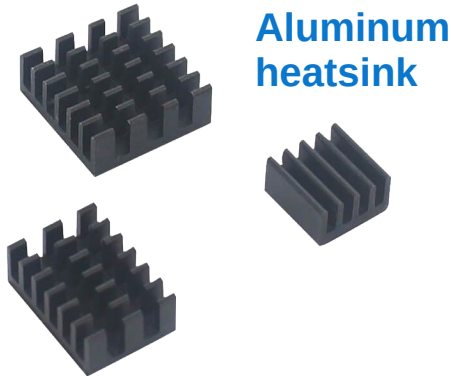
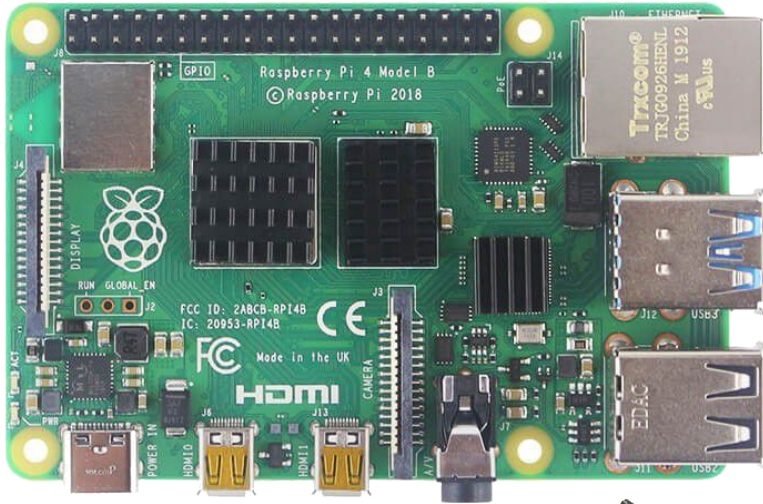
Raspberry Pi Official
Micro-HDMI to HDMI-A Cable



HDMI Video Capture USB Adapters



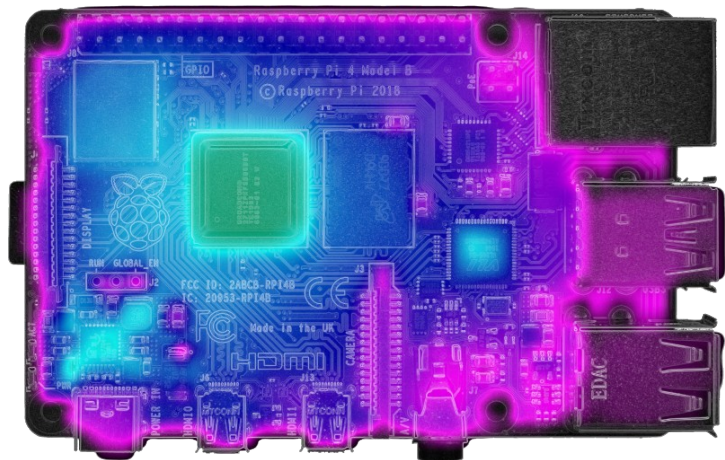
Raspberry Pi Accessories: Cooling



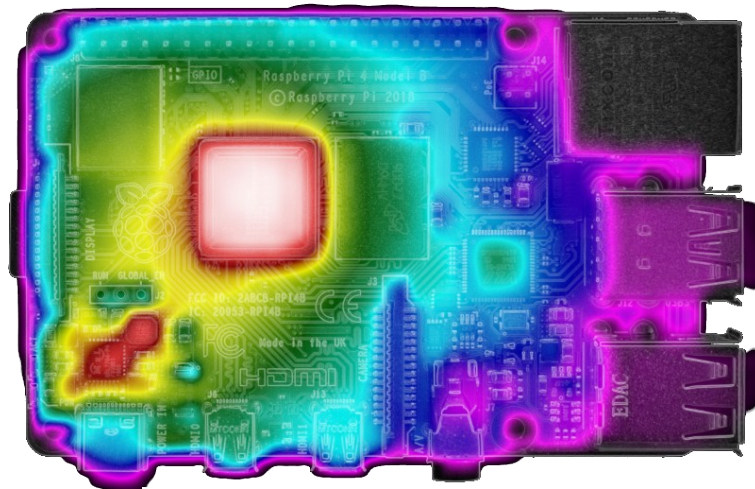
<https://th.cytron.io/p-raspberry-pi-4-heatsink-set-3pcs-black>

3V-5V 0.2A Cooling Fan
(DC Brushless Motor)

Raspberry Pi Thermal Testing



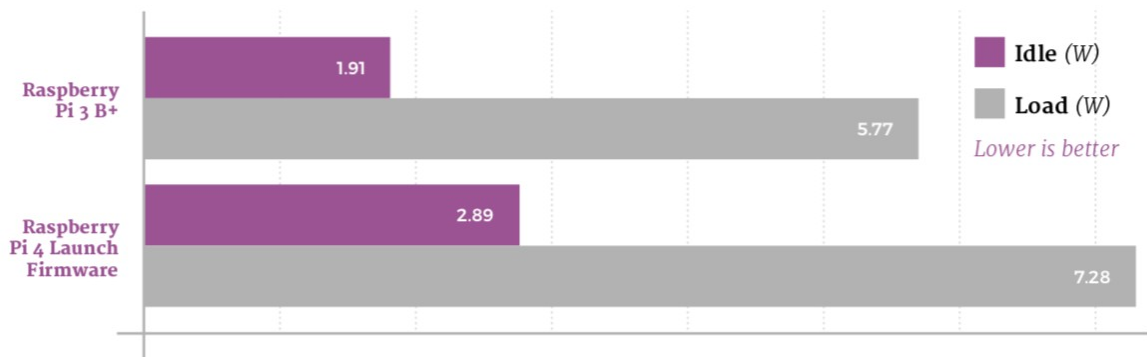
Thermal imaging: RPi 4 (Idle Load)



Thermal imaging: RPi 4 (Stress-Test Load)

75 °C

35 °C



Source: <https://www.raspberrypi.com/news/thermal-testing-raspberry-pi-4/>

RPi for Industrial Applications



Brainboxes BB-400
NeuronEdge Controller



Techbase's ModBerry M500

RPi for Industrial Applications



Kunbus RevolutionPi RevPi Connect

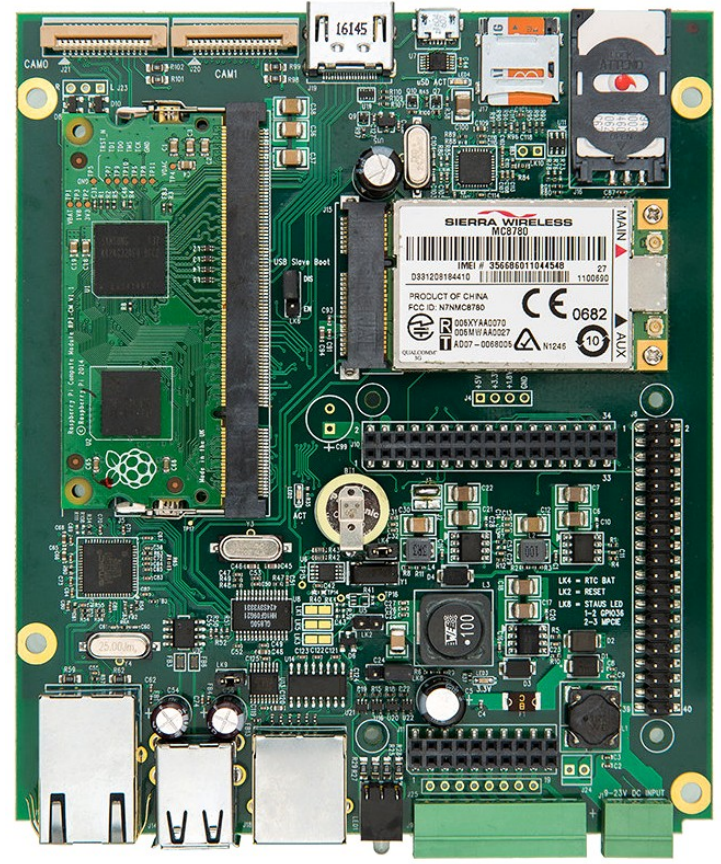


Unipi Neuron S103 and M103

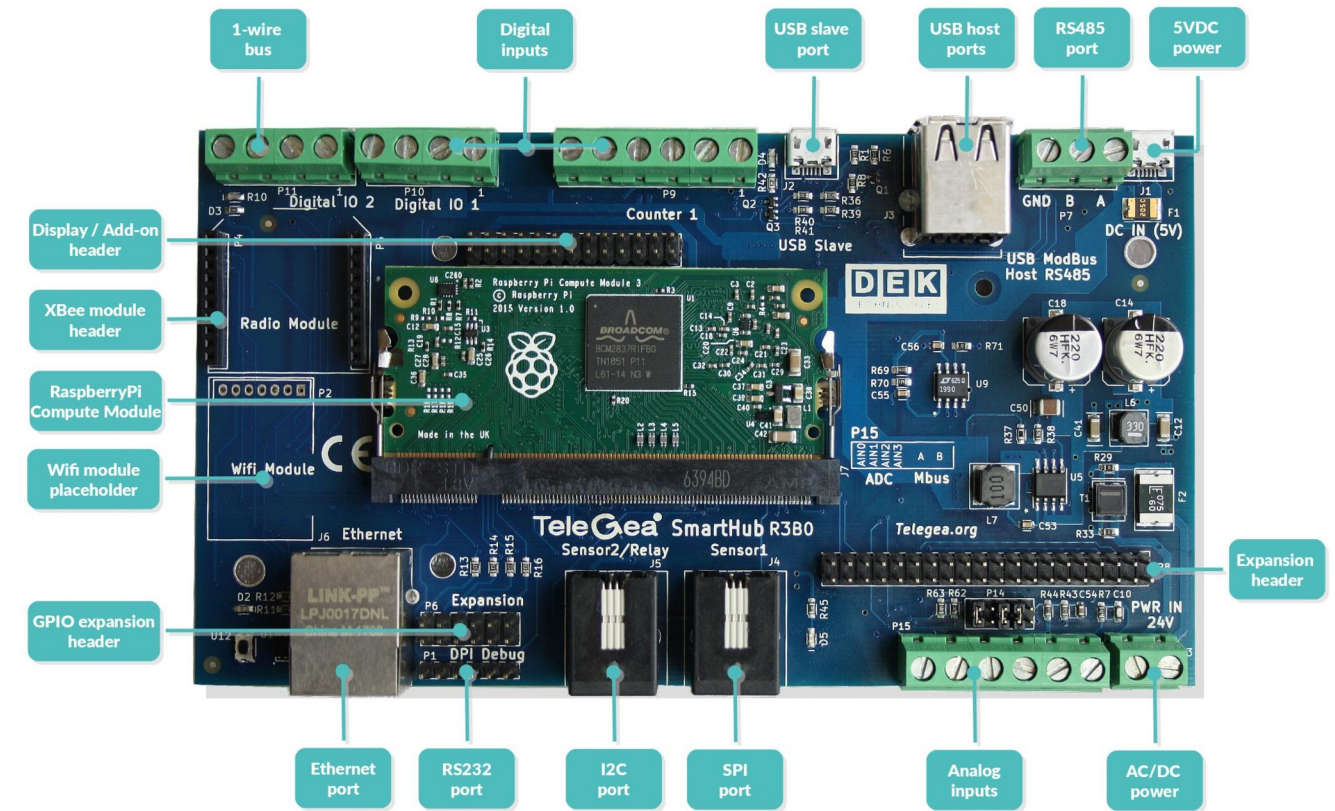
RPi for Industrial Applications



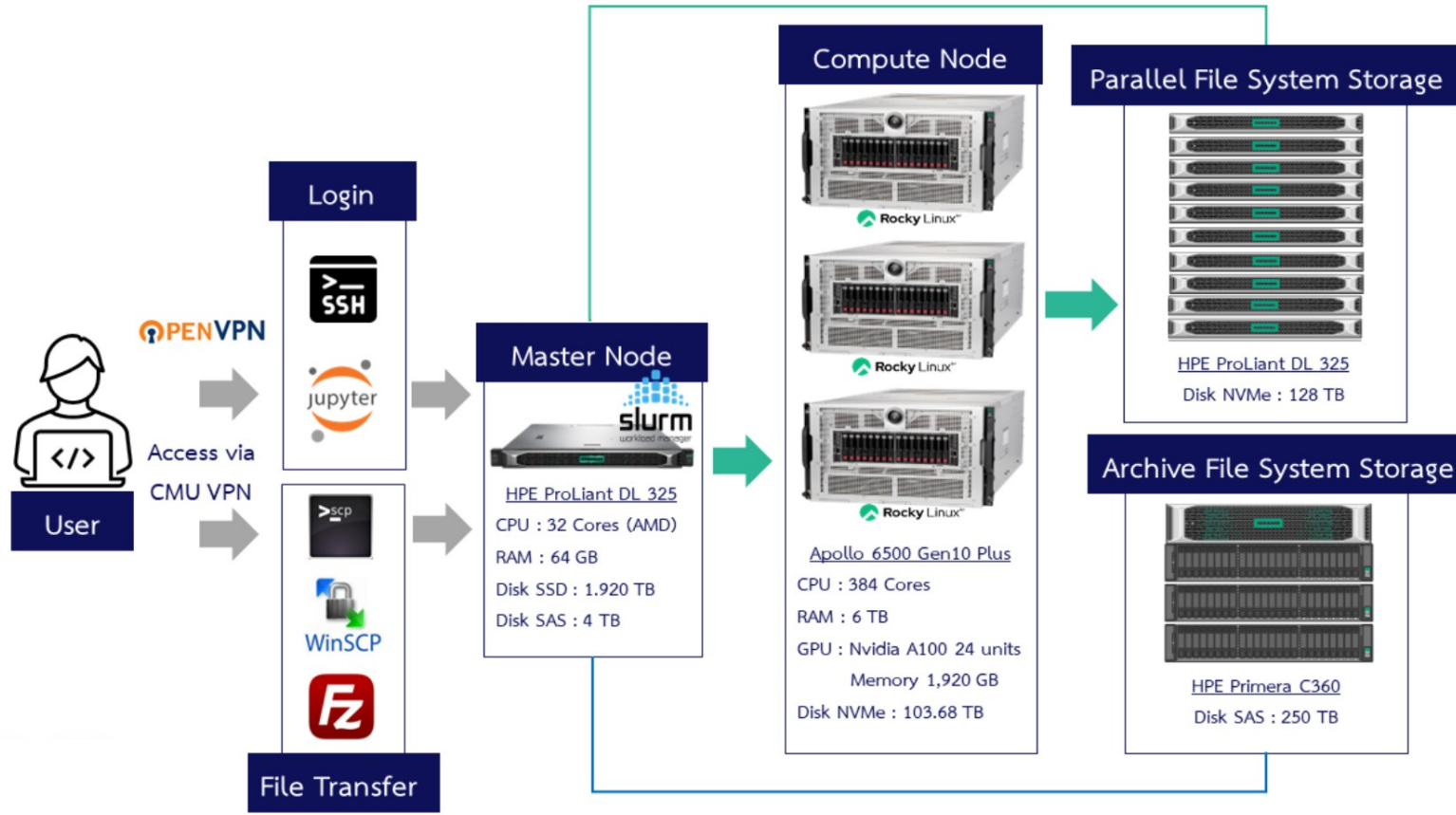
EmbeddedPi - MyPi Industrial IoT Edge Gateway



RPi for Industrial Applications



Telegea Smart Hub: an IoT gateway based on Raspberry Pi CM3



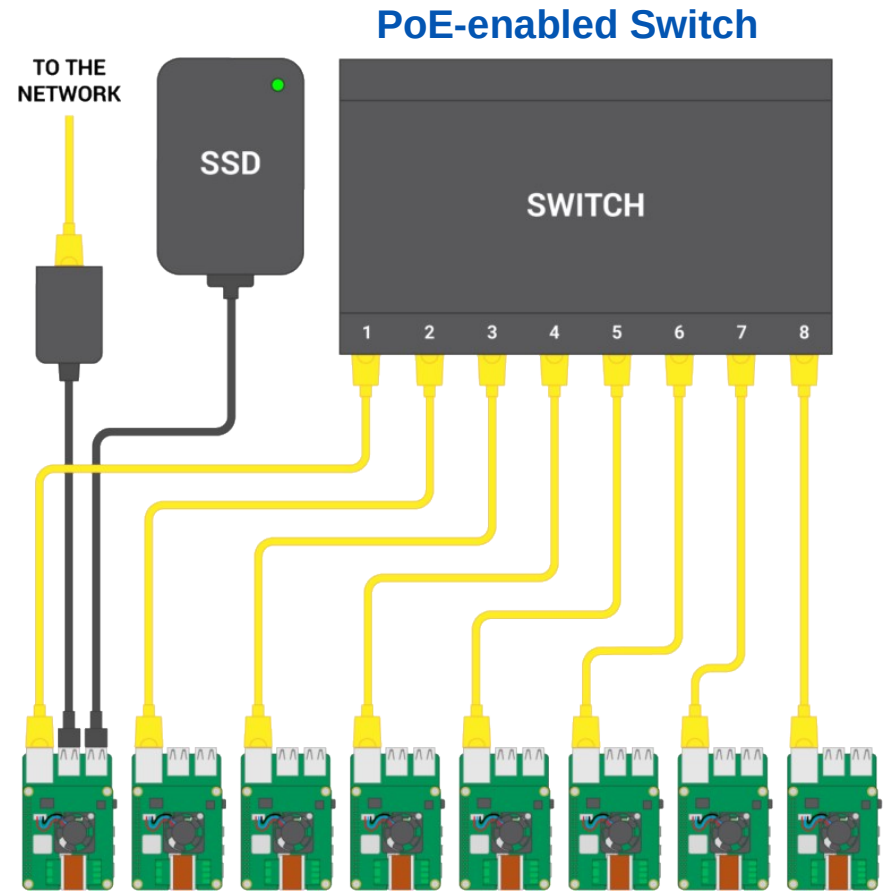
High-End Computer Cluster for High-Performance Computing

How to build a Raspberry Pi cluster

Shopping list

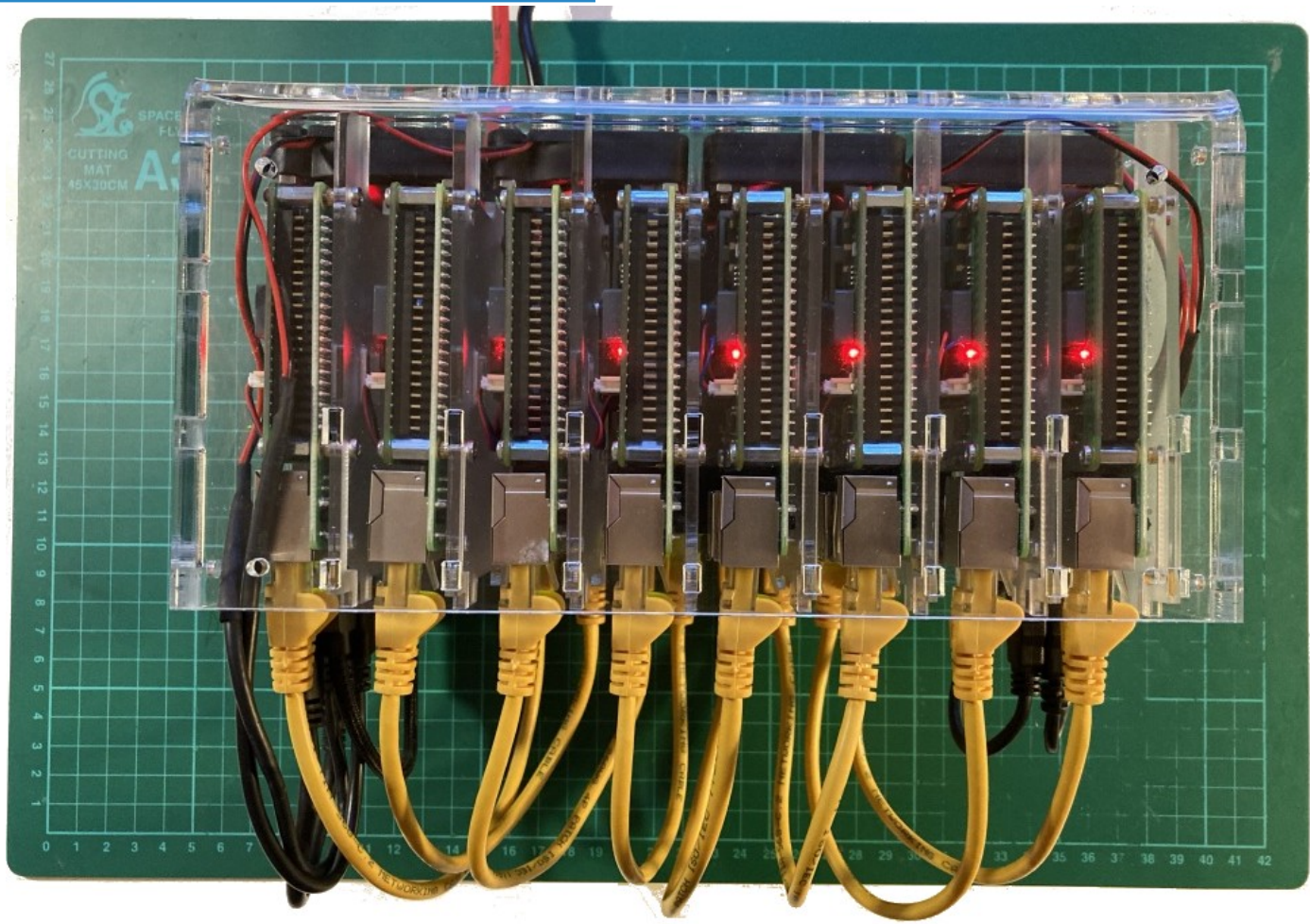
- 8 x Raspberry Pi 4
- 8 x Raspberry Pi PoE+ HAT
- 8-port Gigabit PoE-enabled switch
- USB 3 to Gigabit Ethernet adaptor
- USB 3 to SATA adaptor
- SSD SATA drive
- 8 x Ethernet cables
- 16 GB SD card
- Cluster case

- The Head node has a **USB 3.0 Ethernet dongle** and an **external SSD** mounted via a **USB3-to-SATA** connector.
- The Head node will boot from an **SD card** as normal, the other nodes (the “Compute” nodes) will be configured to **network boot**.
- All eight of Raspberry Pi boards will have a **Raspberry Pi PoE+ HAT** attached.



Source: <https://www.raspberrypi.com/tutorials/cluster-raspberry-pi-tutorial/>

How to build a Raspberry Pi cluster



Source: <https://www.raspberrypi.com/tutorials/cluster-raspberry-pi-tutorial/>

RPi Software Support

- Linux OS (Debian-based): Raspberry Pi OS
 - 32-bit vs. 64-bit versions
 - Desktop (GUI mode) vs. Server (Headless mode)
 - Ubuntu Desktop to Server for Raspberry Pi
 - Armbian for RPi 4
- Android OS
- Windows 10 IoT Core

<https://www.raspberrypi.com/software/operating-systems/>

<https://ubuntu.com/download/raspberry-pi>

<https://www.armbian.com/rpi4b/>

Raspberry Pi OS Images: 32-bit

Compatible with:

All Raspberry Pi models

Raspberry Pi OS with desktop

Release date: May 3rd 2023
System: 32-bit
Kernel version: 6.1
Debian version: 11 (bullseye)

Size: 872MB

Raspberry Pi OS Lite

Release date: May 3rd 2023
System: 32-bit
Kernel version: 6.1
Debian version: 11 (bullseye)

Size: 364MB

Raspberry Pi OS with desktop and recommended software

Release date: May 3rd 2023
System: 32-bit
Kernel version: 6.1
Debian version: 11 (bullseye)

Size: 2,701MB

Raspberry Pi OS Images: 64-bit

Raspberry Pi OS (64-bit)

Compatible with:

3B 3B+ 3A+ 4 400

CM3 CM3+ CM4

Zero 2 W

Raspberry Pi OS with desktop

Release date: May 3rd 2023

System: 64-bit

Kernel version: 6.1

Debian version: 11 (bullseye)

Size: 818MB

Raspberry Pi OS Lite

Release date: May 3rd 2023

System: 64-bit

Kernel version: 6.1

Debian version: 11 (bullseye)

Size: 308MB

OS Installation Steps

- Download and install **Raspberry Pi Imager**.
 - Alternative tool for MicroSD flashing: **Balena Etcher**
- Download an OS image (**64-bit**).
 - **RPi 3** or **RPi 4**: Raspberry Pi OS
 - **RPi 4**: Ubuntu Desktop or Server 22.04 LTS
 - **RPi 5**: Ubuntu Desktop or Server 24.04 LTS
- Use Raspberry Pi Imager to write an OS image to an microSD card (8GB or more) or USB-to-SSD storage.

<https://ubuntu.com/tutorials/how-to-install-ubuntu-on-your-raspberry-pi>

<https://ubuntu.com/tutorials/how-to-install-ubuntu-desktop-on-raspberry-pi-4>

Operating system images – Raspberry Pi

raspberrypi.com/software/operating-systems/

Raspberry Pi OS (64-bit)

Compatible with:

- 3B 3B+ 3A+ 4
- 400 CM3 CM3+
- CM4 Zero 2 W

Raspberry Pi OS with desktop

Release date: February 21st 2023
System: 64-bit
Kernel version: 5.15
Debian version: 11 (bullseye)
Size: 816MB
[Show SHA256 file integrity hash:](#)
[Release notes](#)

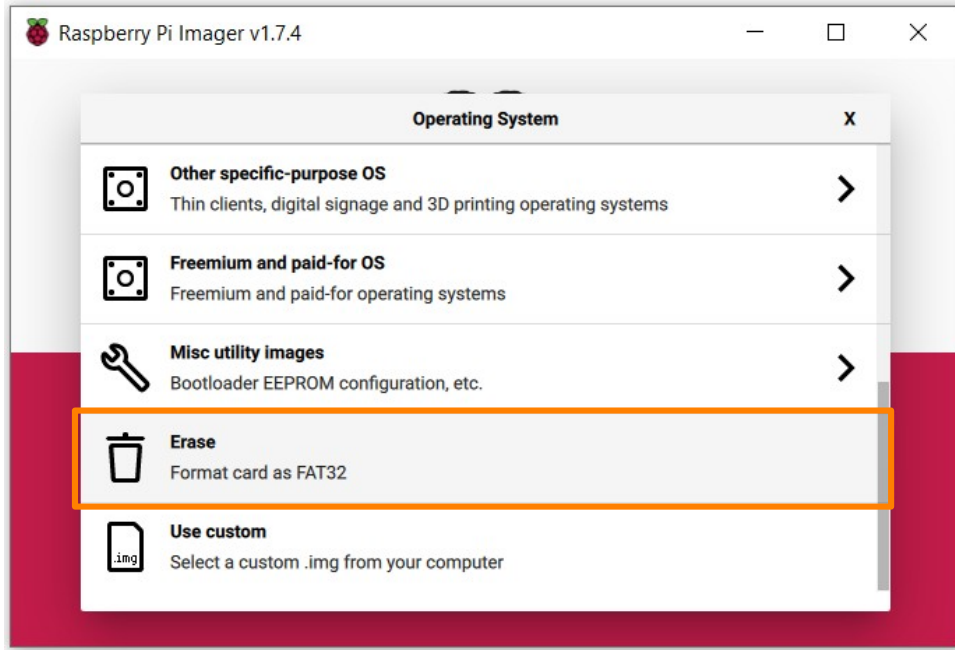
[Download](#)
[Download torrent](#)
[Archive](#)

Raspberry Pi OS Lite

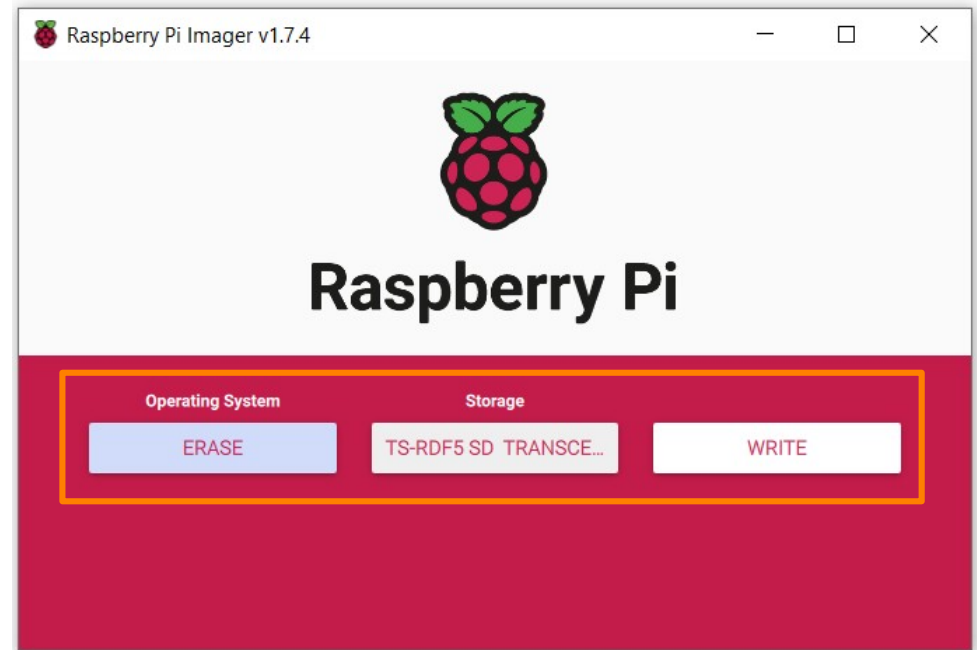
Release date: February 21st 2023
System: 64-bit
Kernel version: 5.15
Debian version: 11 (bullseye)
Size: 307MB
[Show SHA256 file integrity hash:](#)
[Release notes](#)

[Download](#)
[Download torrent](#)
[Archive](#)

Raspberry Pi OS Installation

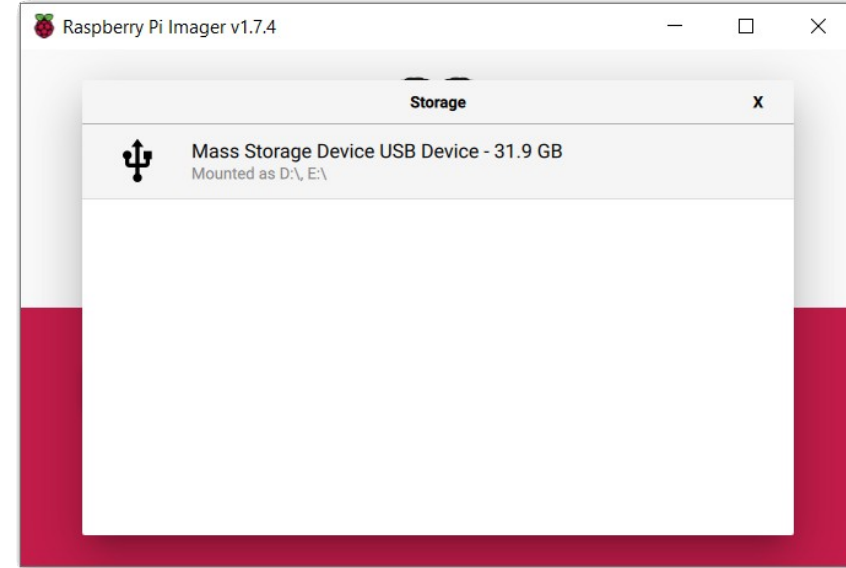
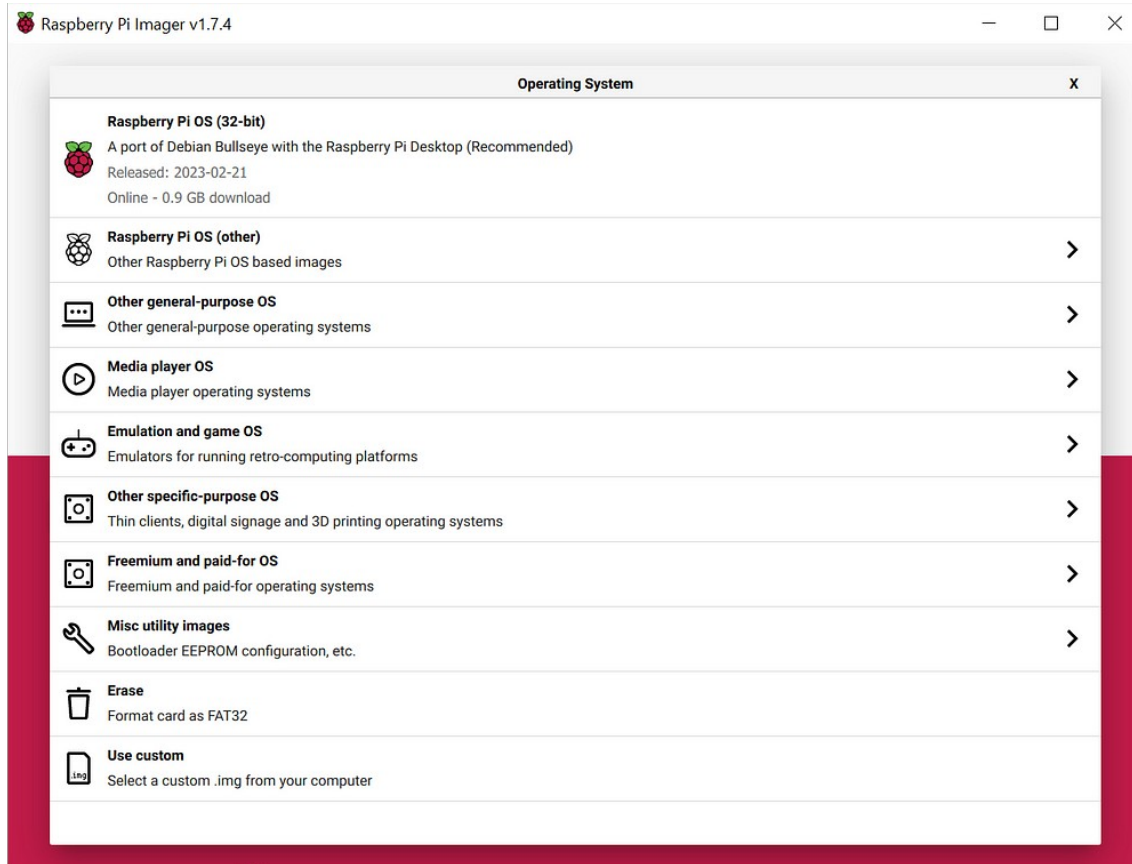


- Insert the microSD into the user's computer.
- Start Raspberry Pi Imager.
- Select "Erase" to format the microSD card.

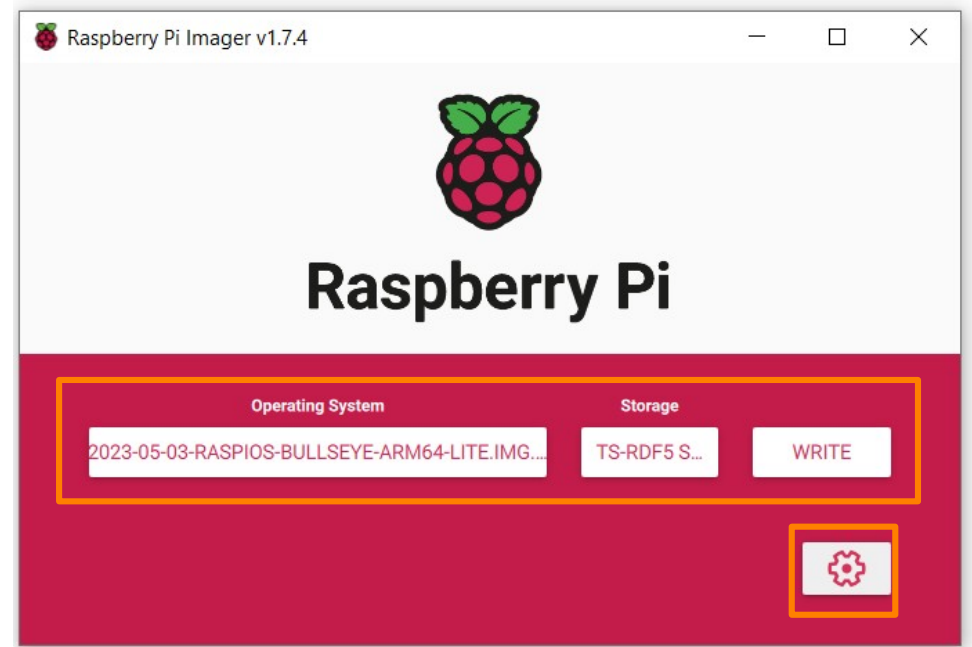
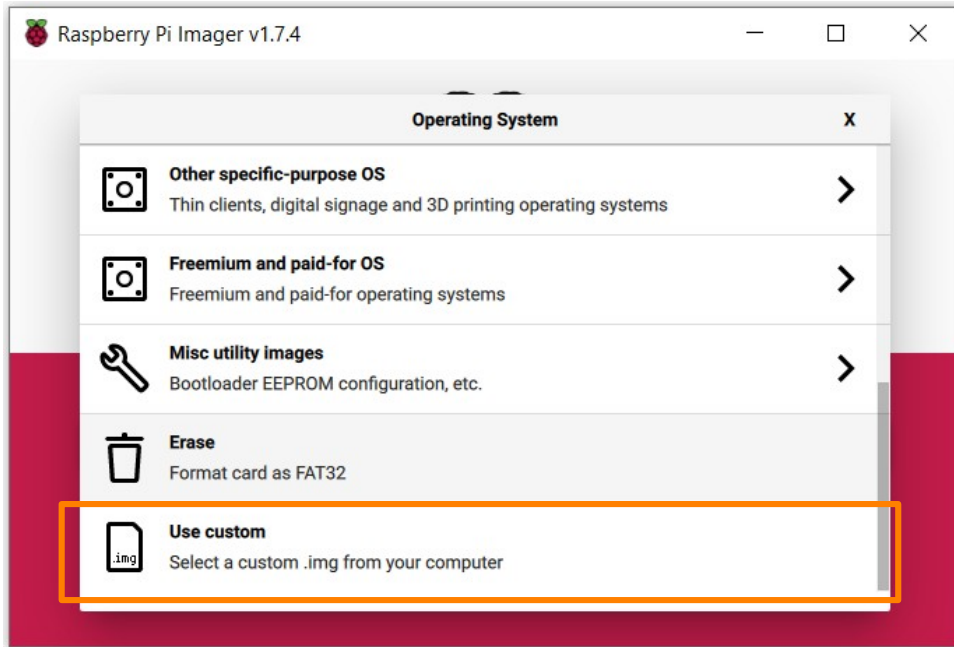


- Select the microSD storage.
- Press "WRITE" to format the microSD card.

Raspberry Pi OS Installation



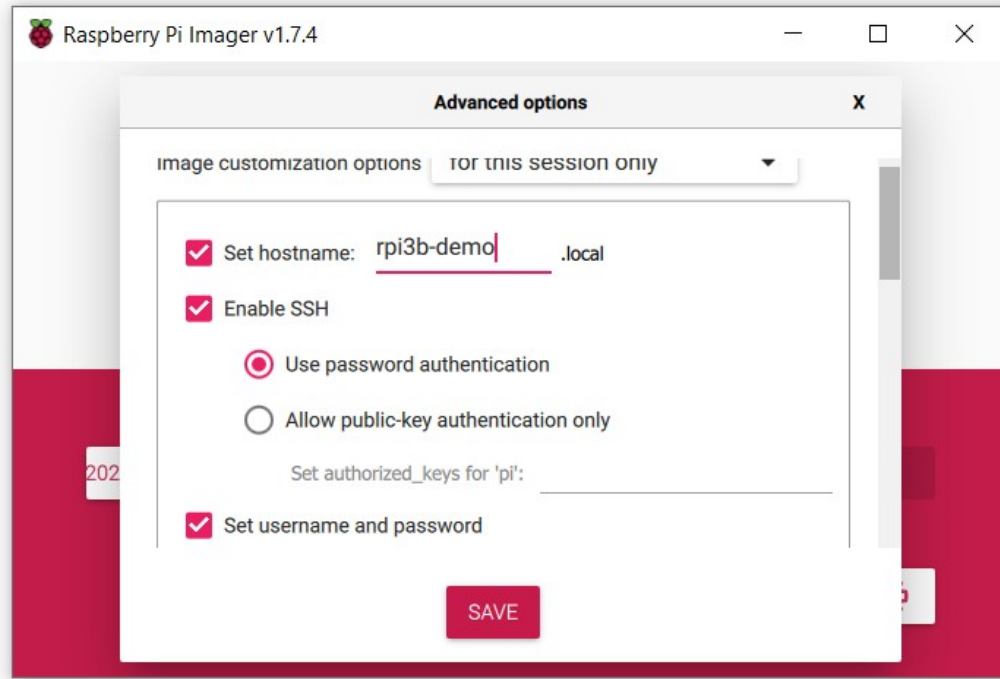
Raspberry Pi OS Installation



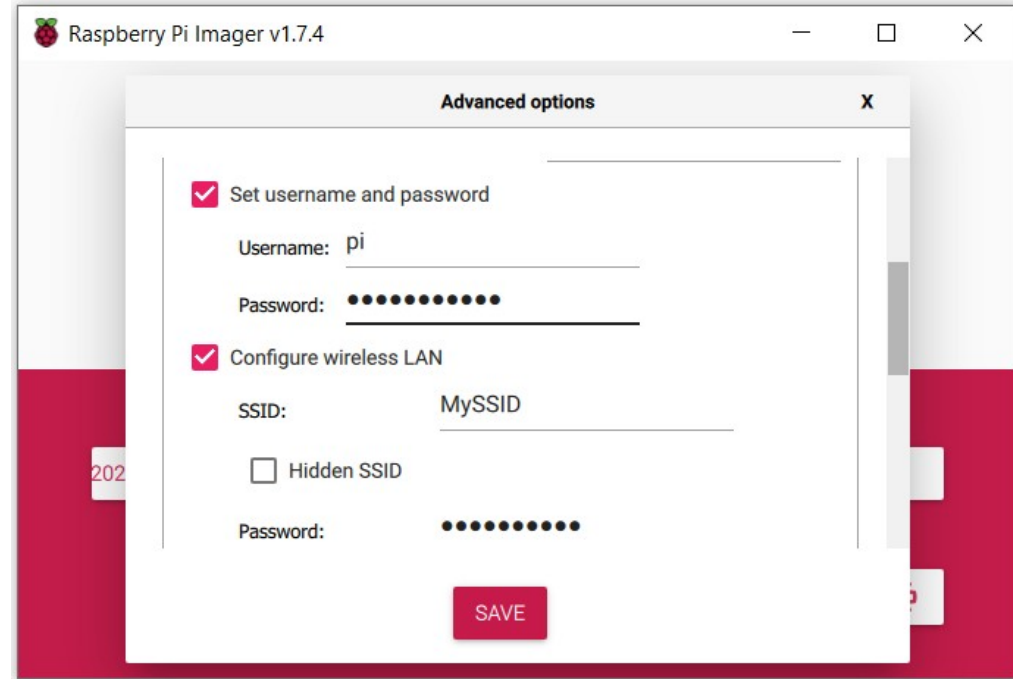
- Select “Use custom” for an OS.
- Select the downloaded image file (.img.xz).

- Select the target microSD storage drive.
- Configure the OS Installation Settings.
- Press “WRITE” to flash the image to the microSD card.

Raspberry Pi OS Installation

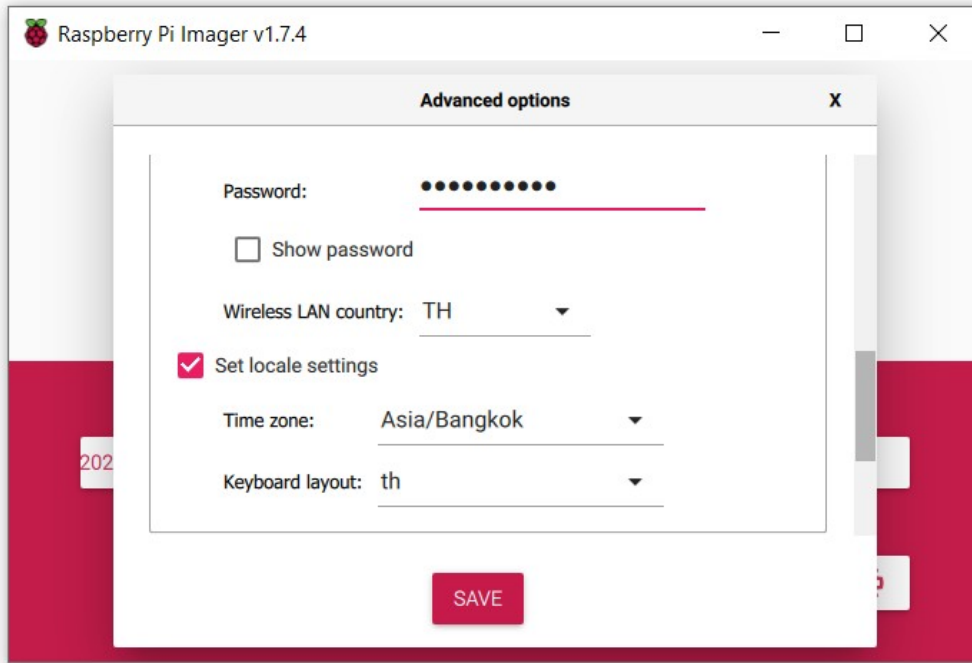


- Set the host name for the RPi.
- Enable the SSH service for remote access.



- Set the default username and password for login.
- Set WiFi SSID and password (optional).

Raspberry Pi OS Installation

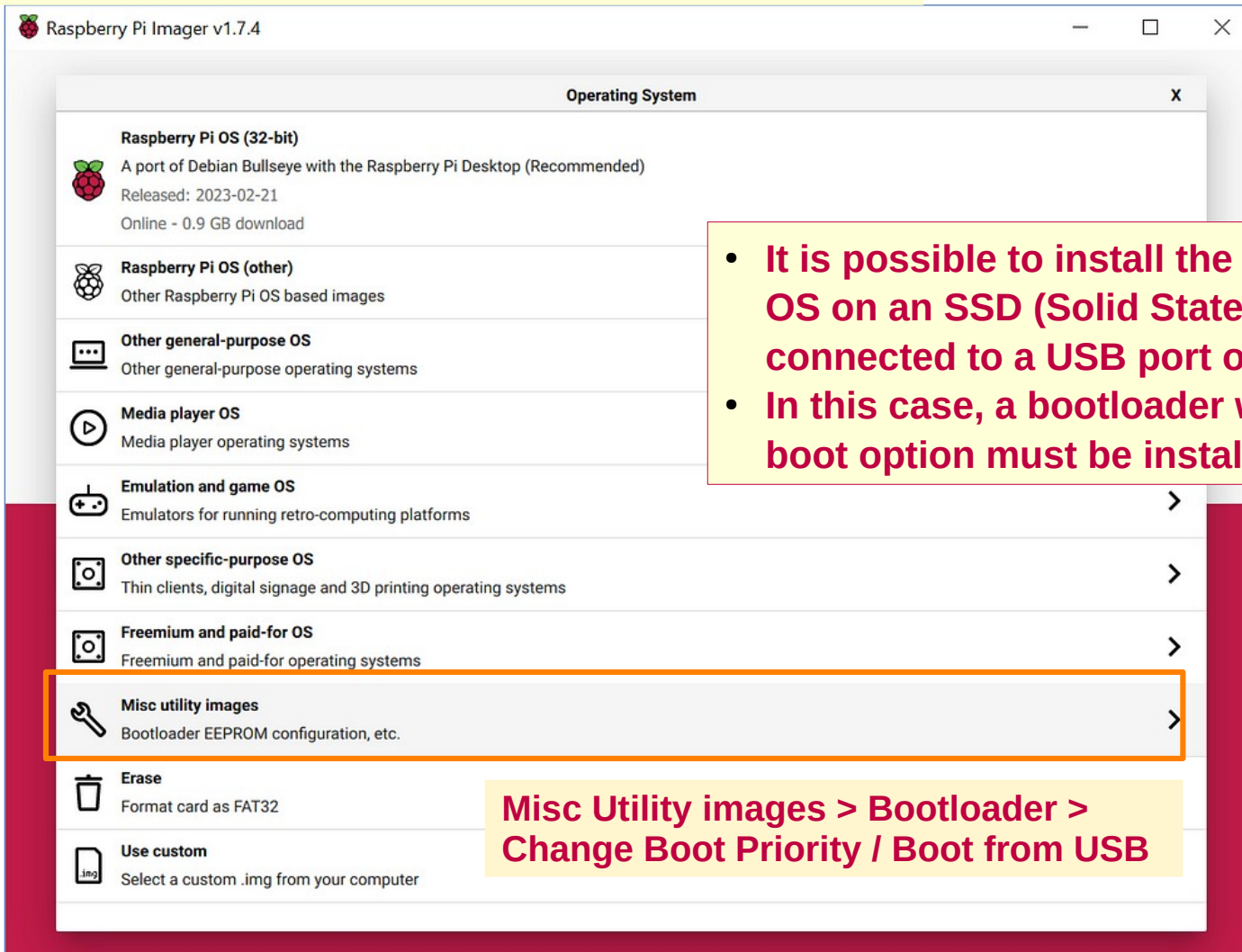


- Set locale settings (Asia/BKK) and Thai keyboard.



- Press the “WRITE” button to start the flashing process.

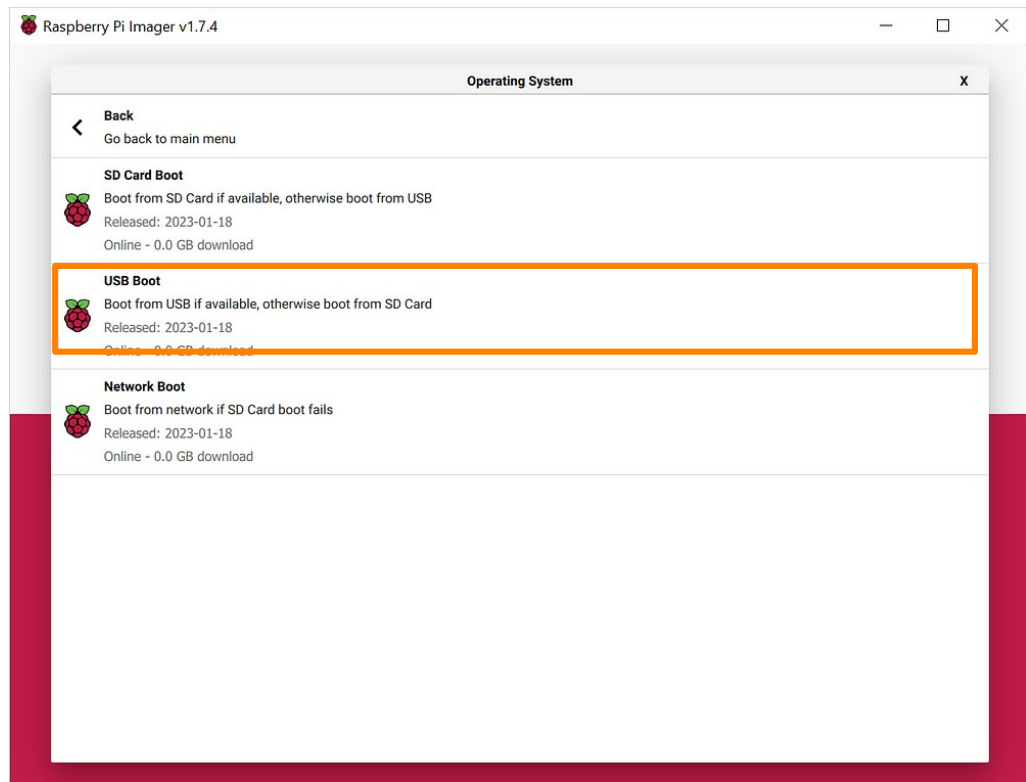
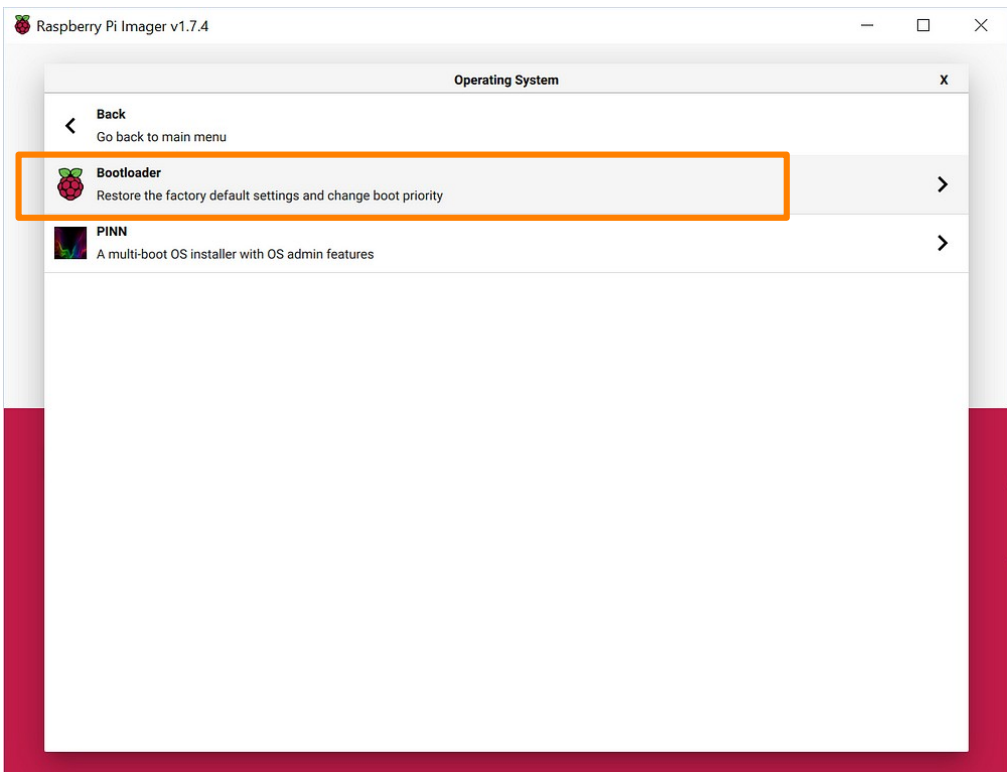
Write the bootloader with USB boot option to a microSD.



- It is possible to install the Raspberry Pi OS on an SSD (Solid State Drive) connected to a USB port on a RPi 4.
- In this case, a bootloader with USB boot option must be installed properly.

Misc Utility images > Bootloader > Change Boot Priority / Boot from USB

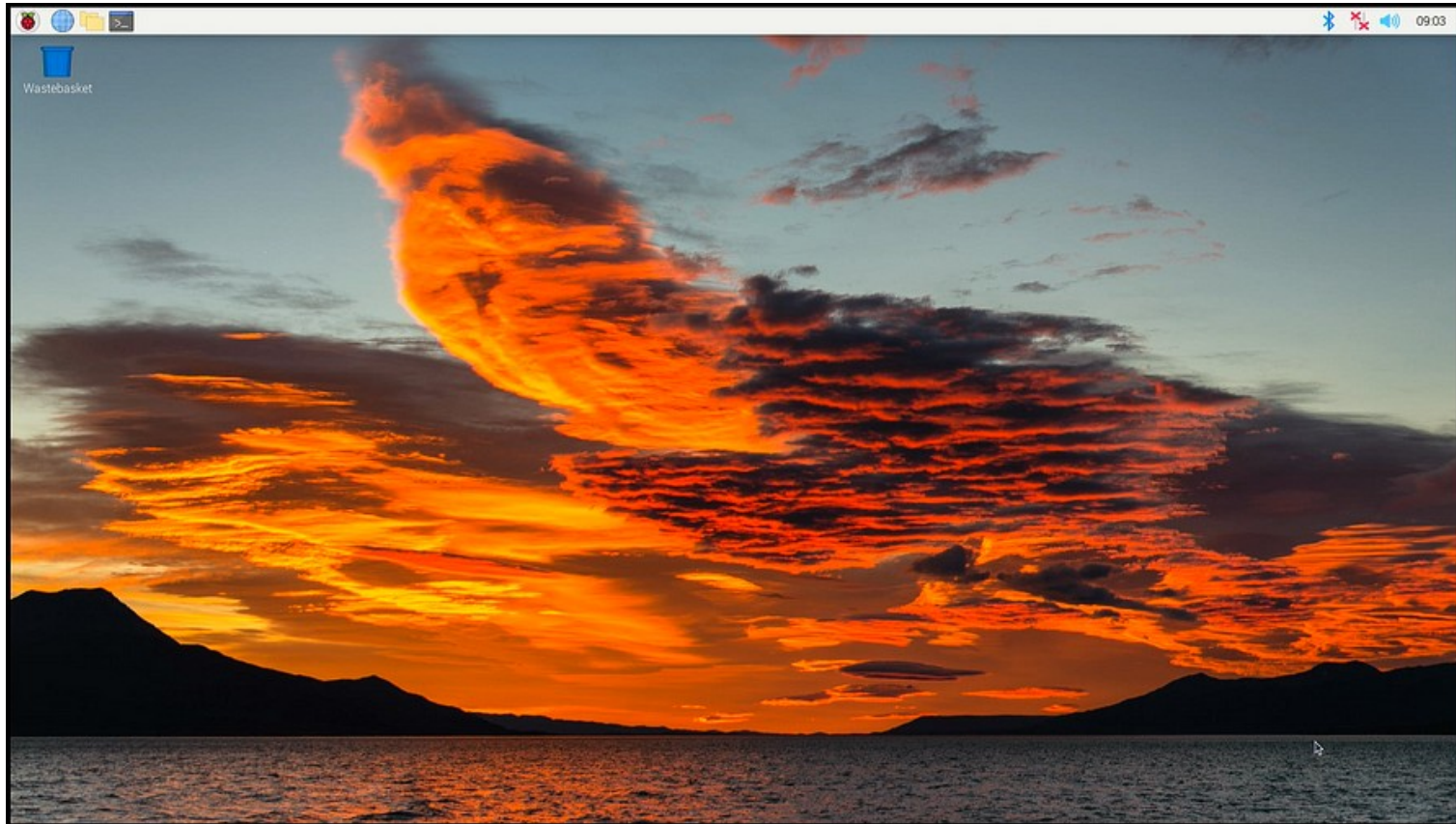
Write the bootloader with USB boot option to a microSD.



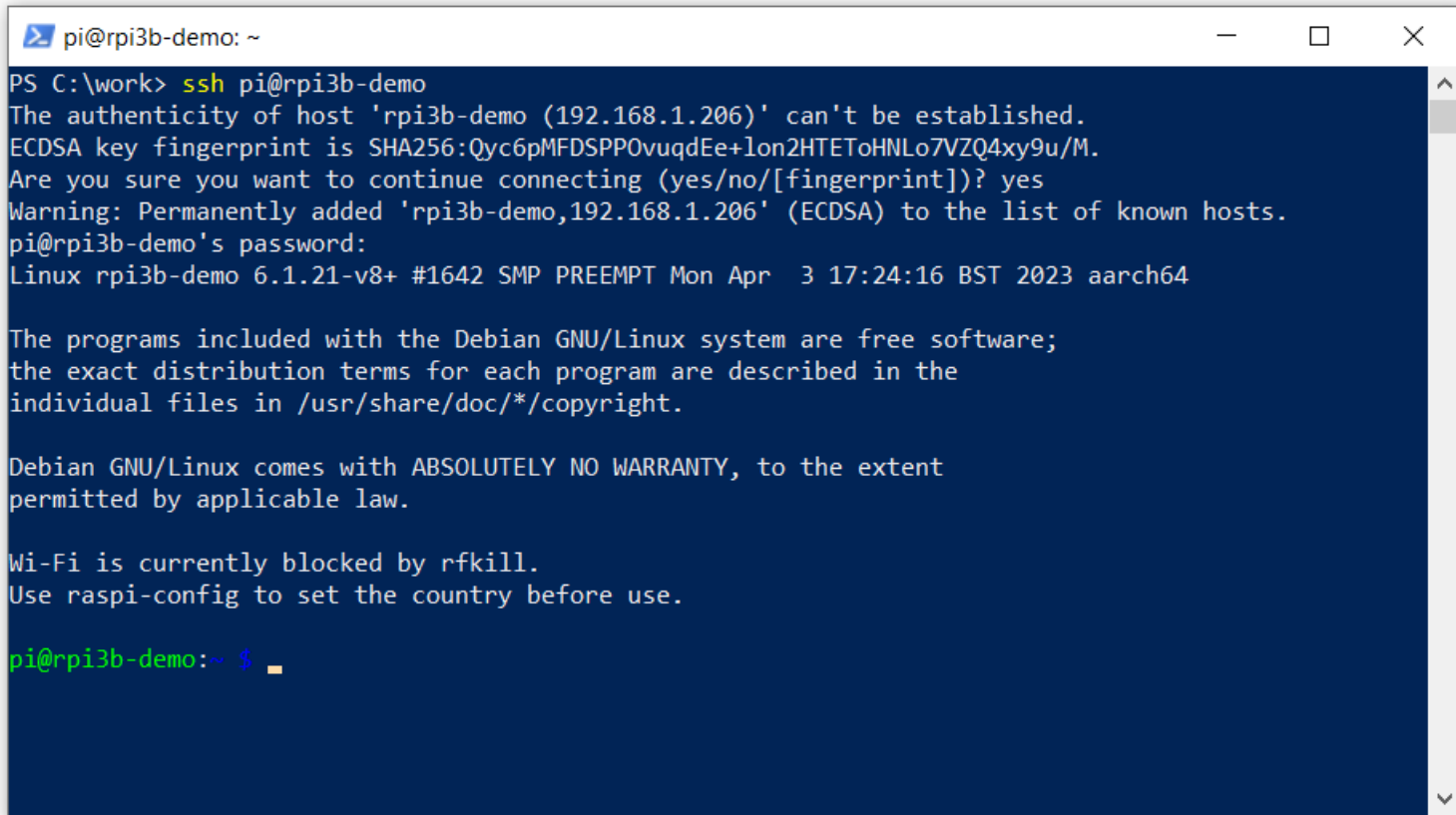
Write Raspberry Pi OS image to SSD via USB-Adapter



Raspberry Pi Desktop on Raspberry Pi 4 Model B (MicroSD Boot)



SSH Access To RPi

A terminal window titled 'pi@rpi3b-demo: ~' with standard window controls. The terminal shows a Windows command prompt session where 'ssh pi@rpi3b-demo' is executed. The output includes a warning about host authenticity, a confirmation to continue, a warning about adding the host to the known hosts list, a password prompt, and the Linux boot banner for 'rpi3b-demo'. It also displays the Debian GNU/Linux license notice and a message about Wi-Fi being blocked by rfkill.

```
pi@rpi3b-demo: ~
PS C:\work> ssh pi@rpi3b-demo
The authenticity of host 'rpi3b-demo (192.168.1.206)' can't be established.
ECDSA key fingerprint is SHA256:Qyc6pMFDSPP0vuqdEe+lon2HTEToHNL07VZQ4xy9u/M.
Are you sure you want to continue connecting (yes/no/[fingerprint])? yes
Warning: Permanently added 'rpi3b-demo,192.168.1.206' (ECDSA) to the list of known hosts.
pi@rpi3b-demo's password:
Linux rpi3b-demo 6.1.21-v8+ #1642 SMP PREEMPT Mon Apr  3 17:24:16 BST 2023 aarch64

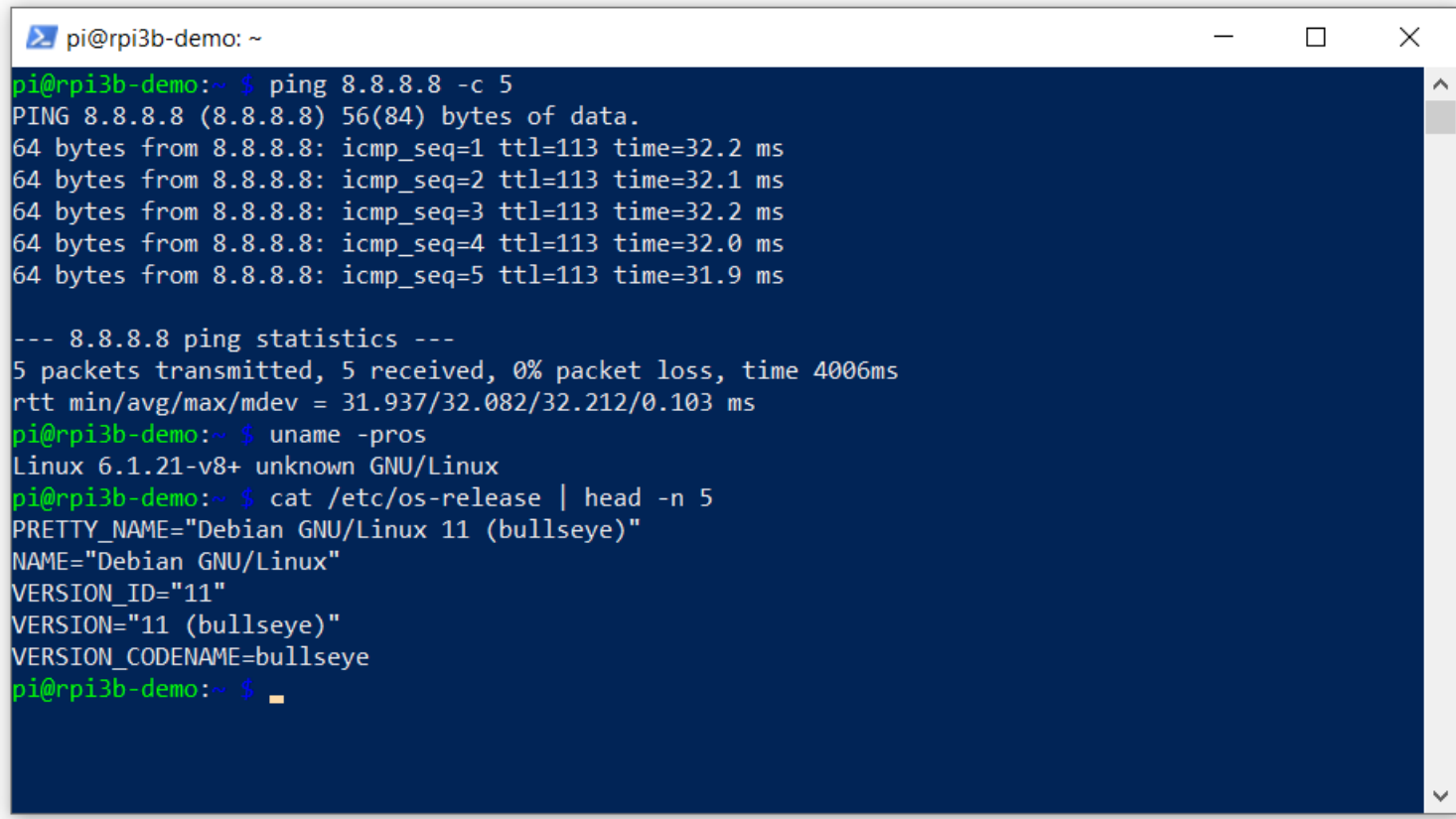
The programs included with the Debian GNU/Linux system are free software;
the exact distribution terms for each program are described in the
individual files in /usr/share/doc/*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent
permitted by applicable law.

Wi-Fi is currently blocked by rfkill.
Use raspi-config to set the country before use.

pi@rpi3b-demo:~ $ █
```

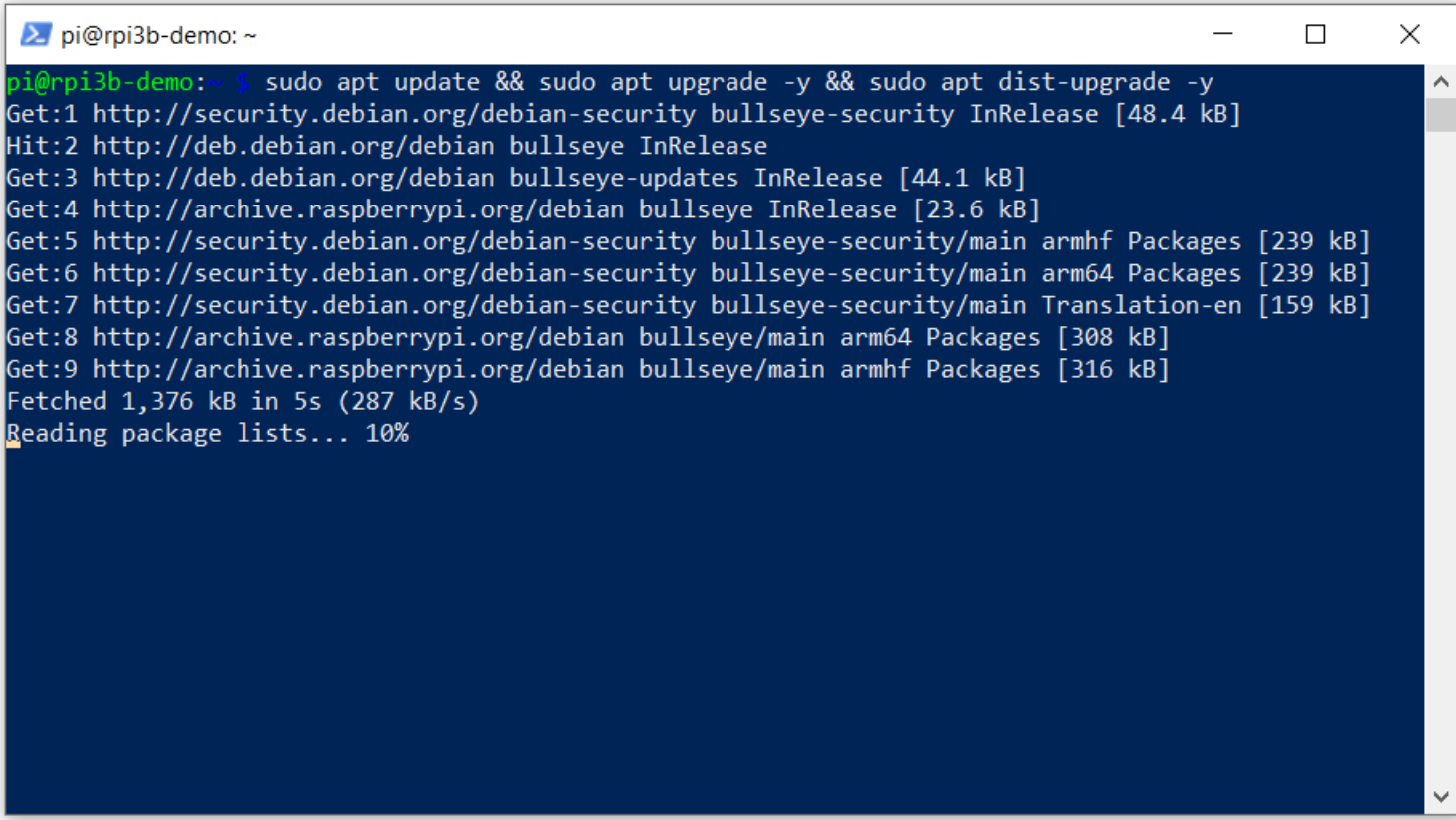
SSH Access To RPi



```
pi@rpi3b-demo: ~
pi@rpi3b-demo:~$ ping 8.8.8.8 -c 5
PING 8.8.8.8 (8.8.8.8) 56(84) bytes of data:
64 bytes from 8.8.8.8: icmp_seq=1 ttl=113 time=32.2 ms
64 bytes from 8.8.8.8: icmp_seq=2 ttl=113 time=32.1 ms
64 bytes from 8.8.8.8: icmp_seq=3 ttl=113 time=32.2 ms
64 bytes from 8.8.8.8: icmp_seq=4 ttl=113 time=32.0 ms
64 bytes from 8.8.8.8: icmp_seq=5 ttl=113 time=31.9 ms

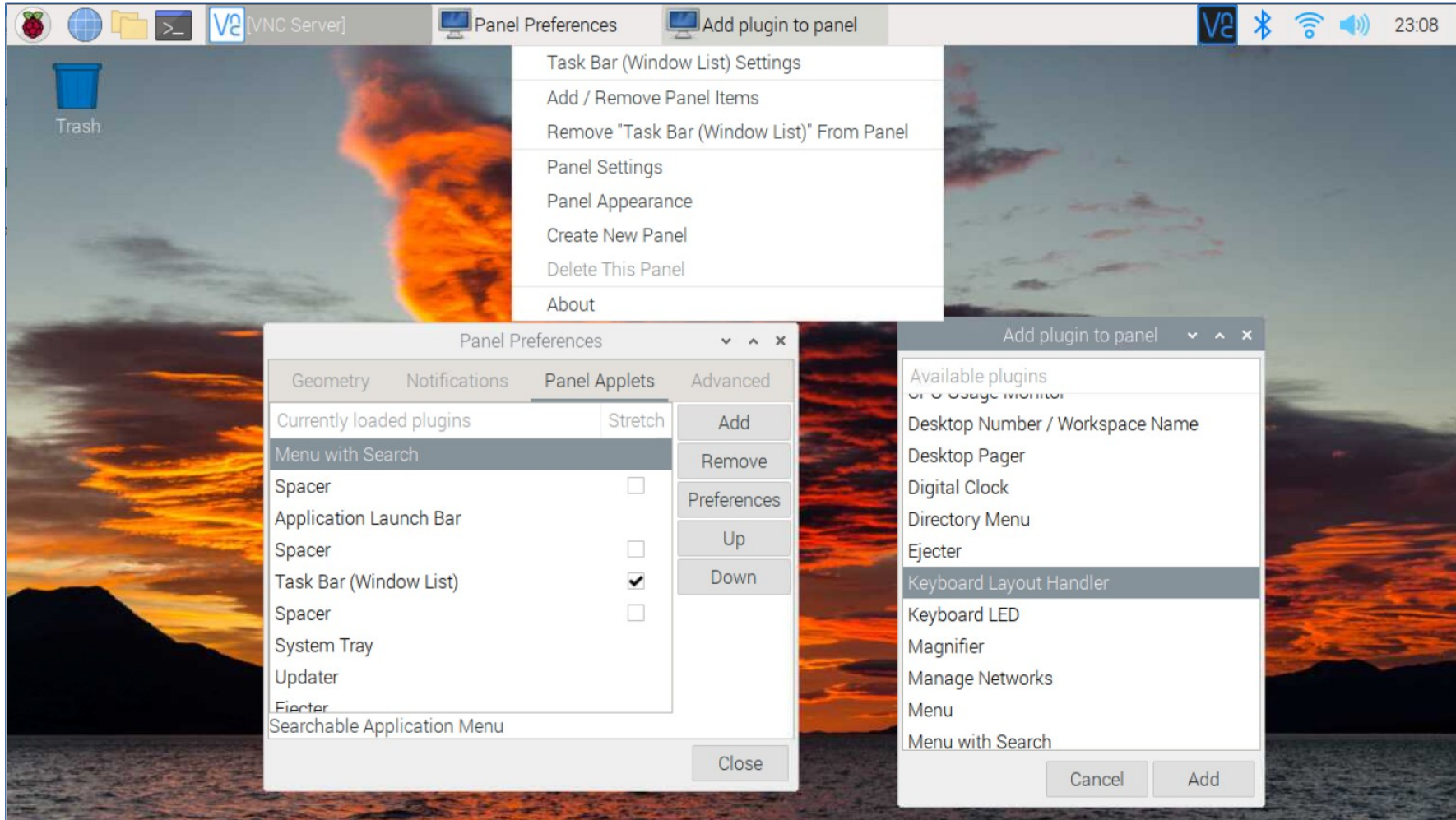
--- 8.8.8.8 ping statistics ---
5 packets transmitted, 5 received, 0% packet loss, time 4006ms
rtt min/avg/max/mdev = 31.937/32.082/32.212/0.103 ms
pi@rpi3b-demo:~$ uname -pro
Linux 6.1.21-v8+ unknown GNU/Linux
pi@rpi3b-demo:~$ cat /etc/os-release | head -n 5
PRETTY_NAME="Debian GNU/Linux 11 (bullseye)"
NAME="Debian GNU/Linux"
VERSION_ID="11"
VERSION="11 (bullseye)"
VERSION_CODENAME=bullseye
pi@rpi3b-demo:~$ █
```


Software Package Update

A terminal window titled "pi@rpi3b-demo: ~" with standard window controls. The terminal shows the execution of a command to update and upgrade software packages. The output displays the progress of fetching release files and package lists from various sources, including security.debian.org and archive.raspberrypi.org. The terminal text is as follows:

```
pi@rpi3b-demo:~ $ sudo apt update && sudo apt upgrade -y && sudo apt dist-upgrade -y
Get:1 http://security.debian.org/debian-security bullseye-security InRelease [48.4 kB]
Hit:2 http://deb.debian.org/debian bullseye InRelease
Get:3 http://deb.debian.org/debian bullseye-updates InRelease [44.1 kB]
Get:4 http://archive.raspberrypi.org/debian bullseye InRelease [23.6 kB]
Get:5 http://security.debian.org/debian-security bullseye-security/main armhf Packages [239 kB]
Get:6 http://security.debian.org/debian-security bullseye-security/main arm64 Packages [239 kB]
Get:7 http://security.debian.org/debian-security bullseye-security/main Translation-en [159 kB]
Get:8 http://archive.raspberrypi.org/debian bullseye/main arm64 Packages [308 kB]
Get:9 http://archive.raspberrypi.org/debian bullseye/main armhf Packages [316 kB]
Fetched 1,376 kB in 5s (287 kB/s)
Reading package lists... 10%
```

Add Keyboard Layout for TH / EN

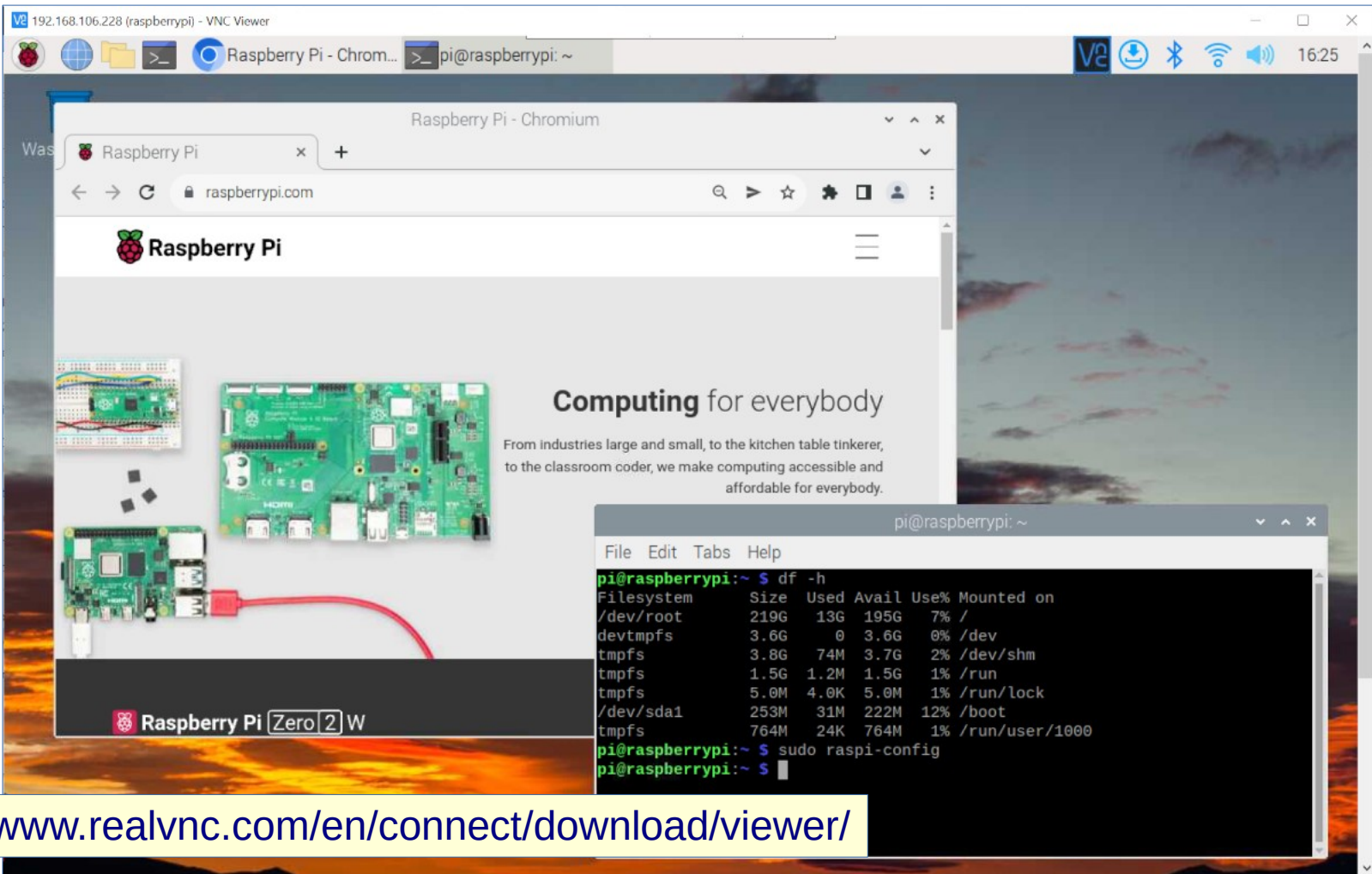


Raspberry Pi Configuration Tool

```
pi@raspberrypi: ~  
  
Raspberry Pi Software Configuration Tool (raspi-config)  
  
I1 Legacy Camera  Enable/disable legacy camera support  
I2 SSH           Enable/disable remote command line access using SSH  
I3 VNC           Enable/disable graphical remote access using RealVNC  
I4 SPI           Enable/disable automatic loading of SPI kernel module  
I5 I2C           Enable/disable automatic loading of I2C kernel module  
I6 Serial Port   Enable/disable shell messages on the serial connection  
I7 1-Wire        Enable/disable one-wire interface  
I8 Remote GPIO   Enable/disable remote access to GPIO pins  
  
Enable VNC Server on Raspberry Pi (Desktop)  
  
<select>          <Back>
```

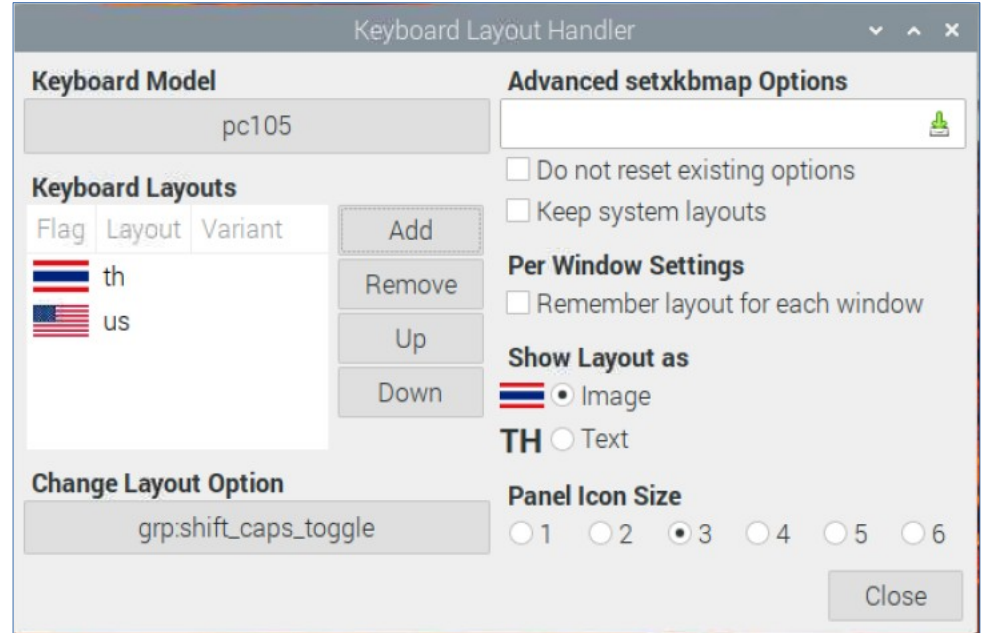
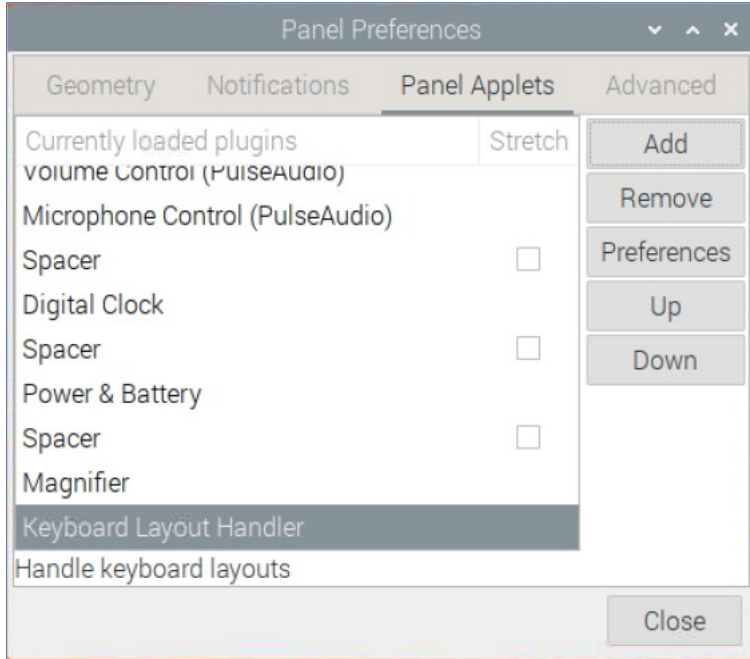
raspi-config is a configuration tool in Raspbian / Raspberry Pi OS, used to configure various settings on Raspberry Pi.

Remote Desktop with RealView VNC Viewer (VNC Client) on Windows



<https://www.realvnc.com/en/connect/download/viewer/>

Add Keyboard Layout for THAI / ENG



Using VS Code IDE on Raspbian OS Desktop / RPi 4

The image shows a screenshot of the Raspbian OS desktop environment. The top panel includes system icons for network, Bluetooth, Wi-Fi, and volume, along with the time 13:22 and the US flag. The desktop background is a scenic sunset over water. A terminal window is open in the background, showing the command prompt `pi@raspberrypi: ~`. The foreground is dominated by the Visual Studio Code interface, which is displaying the Python extension marketplace. The left sidebar shows a list of installed and popular extensions, including Python, Jupyter, Pylance, C/C++, Jupyter Key..., Vim, and GitLens. The main panel shows the details for the Python extension (v2023.4.1) by Microsoft, with an 'Install' button. A yellow text box is overlaid on the bottom right of the VS Code window, containing the terminal commands: `$ sudo apt install -y code` and `$ code --disable-gpu &`.

Using Arduino IDE on Raspbian OS Desktop / RPi 4

The screenshot displays the Arduino IDE 2.0.4 interface on a Raspbian OS desktop. The main window shows a sketch named 'esp32c3_demo-1.ino' with the following code:

```
4
5 void setup() {
6   Serial.begin(115200);
7   pinMode( LED_PIN, OUTPUT );
8 }
9
10 void loop() {
11   static int state = 0;
12   uint32_t now = millis();
13   if (now - ts >= 100 ) {
14     ts = now;
15     digitalWrite( LED_PIN, state ^= 1 );
16     Serial.printf( "LED state: %d\n", state );
17   }
18 }
```

The Output window at the bottom shows the compilation process:

```
Compiling sketch...
/home/pi/.arduino15/packages/esp32/tools/riscv32-esp-elf-gcc/esp-2021r2-patch5-8.4.0/bin/riscv32-esp-elf-g++ -DHAVE_CONFIG_H "-
Compiling libraries...
Compiling core...
Using precompiled core: /tmp/arduino/cores/3251888bce6ca60b458ab2f7a3368d18/core.a
Linking everything together...
/home/pi/.arduino15/packages/esp32/tools/riscv32-esp-elf-gcc/esp-2
```

The status bar at the bottom of the IDE indicates the current position: Ln 14, Col 14, ESP32C3 Dev Module on /dev/ttyACM0.

Arduino IDE Installation

```
# see: https://github.com/koendv/arduino-ide-raspberrypi/releases/
$ wget https://github.com/koendv/arduino-ide-raspberrypi/releases/download/
2.0.4/Linux_arm64_zip.zip
$ sudo apt install zlib1g-dev fuse libfuse-dev
$ unzip Linux_arm64_zip.zip
$ unzip arduino-ide_2.0.4_Linux_arm64.zip
$ sudo mv arduino-ide_2.0.4_Linux_arm64 /opt/
$ sudo chown -R pi:pi /opt/arduino-ide_2.0.4_Linux_arm64
$ sudo ln -s /opt/arduino-ide_2.0.4_Linux_arm64/arduino-ide
/usr/local/bin/arduino-ide
$ arduino-ide --disable-gpu > /dev/null 2>&1 &
```

Note:

- The latest version of the pre-built Arduino IDE for 64-bit RPi is v2.2.0 (Last access: 2024-07-05).
- An Appliance file is also available for download.