

Development Environment for Embedded Systems

Using Linux PC as **host**

Using Raspberry Pi 2, 3, or 4 as **target**

Outline

- Development environment setup
- Installing Raspberry Pi OS on SD card
- Verify what is on SD card
- Boot Raspberry Pi with the installed SD card
- Booting Process
- System configuration tool: raspi-config
- WiFi setup
- OS update
- Firmware update

A Development Environment Setup

- RPi is a single board computer using ARM-based SoC



Host Computer

Serial link (USB-TTL)
Ethernet
JTAG



RPi

**ARM
SoC**

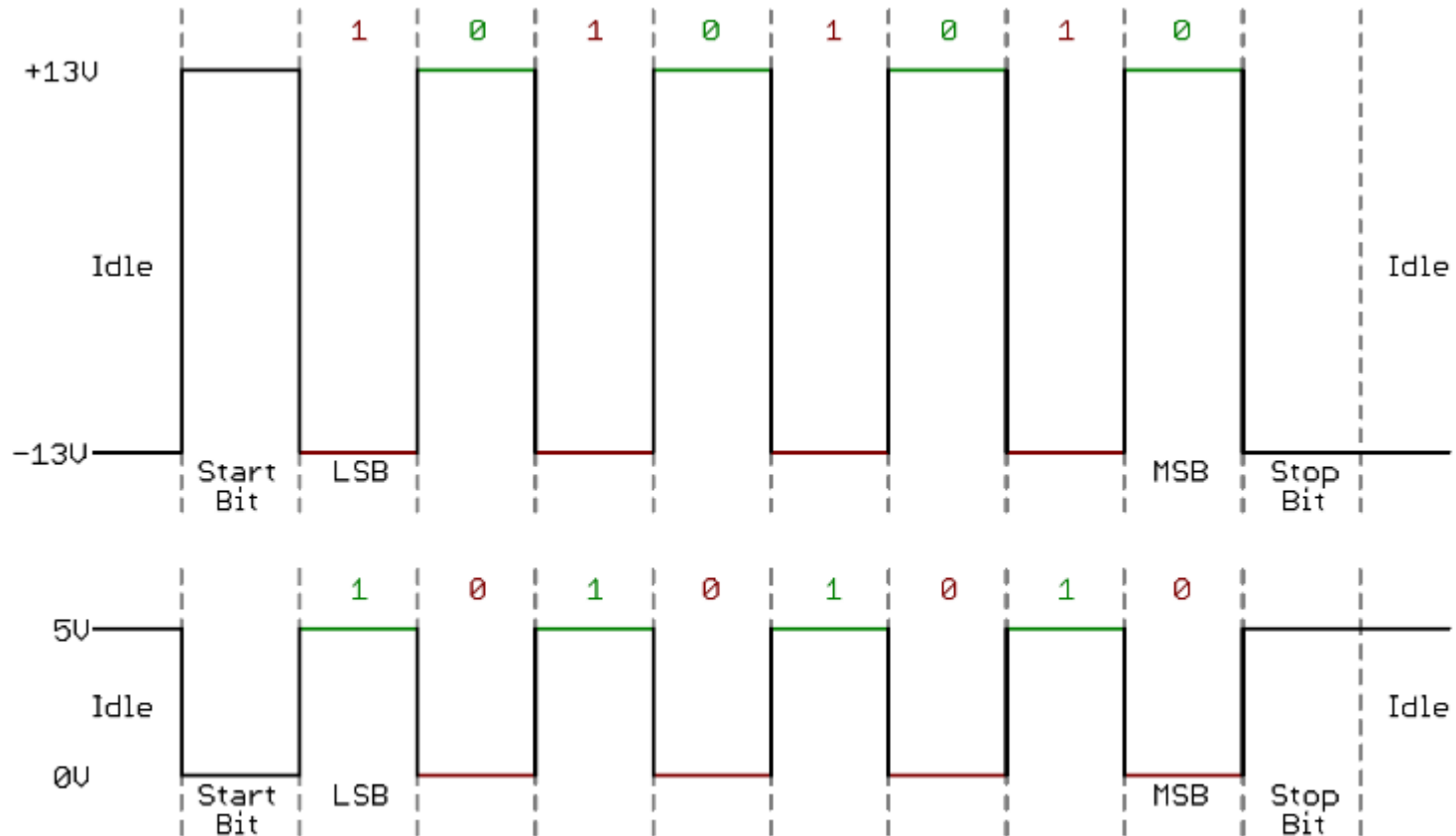
**Target System
(Embedded System)**

Note: USB-TTL is different to USB-RS232
in serial signal levels.

RS232 use negative logic.

Please see <https://www.sparkfun.com/tutorials/215>

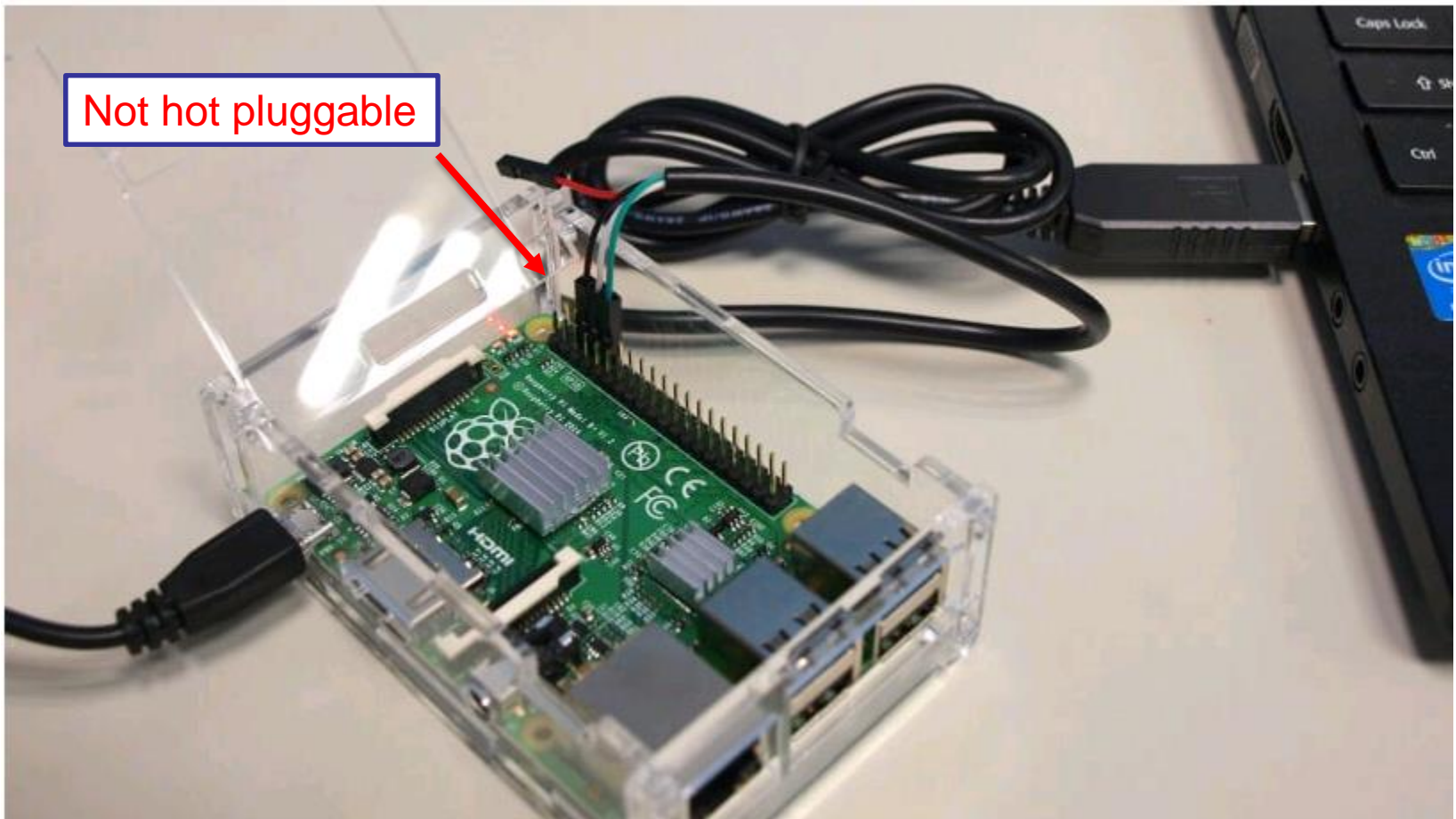
TTL vs. RS-232 signals



This timing diagram shows both a TTL (bottom) and RS-232 signal sending 0b01010101

USB to TTL cable

- Host: use minicom (console tool) and the USB-TTL cable to log in Raspberry Pi
- Target: check /boot/config.txt
- Note: **I/O expansion ports of RPi are not hot pluggable**



Installing Raspberry Pi OS on SD card

- Preparing a boot SD card for your Raspberry Pi
 - Using a development host computer: Windows/Linux/Mac
 - And a flashing tool, like Raspberry Pi Imager
- Download a Raspberry Pi OS image:
<https://www.raspberrypi.com/software/operating-systems/>

Here, we use a Linux PC as a development host computer.

We use the labels of (host) and (target) before commands to express the use scenarios.

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](#)

Raspberry Pi OS Lite

Release date: February 21st 2023

System: 64-bit

Kernel version: 5.15

Debian version: 11 (bullseye)

Size: 307MB

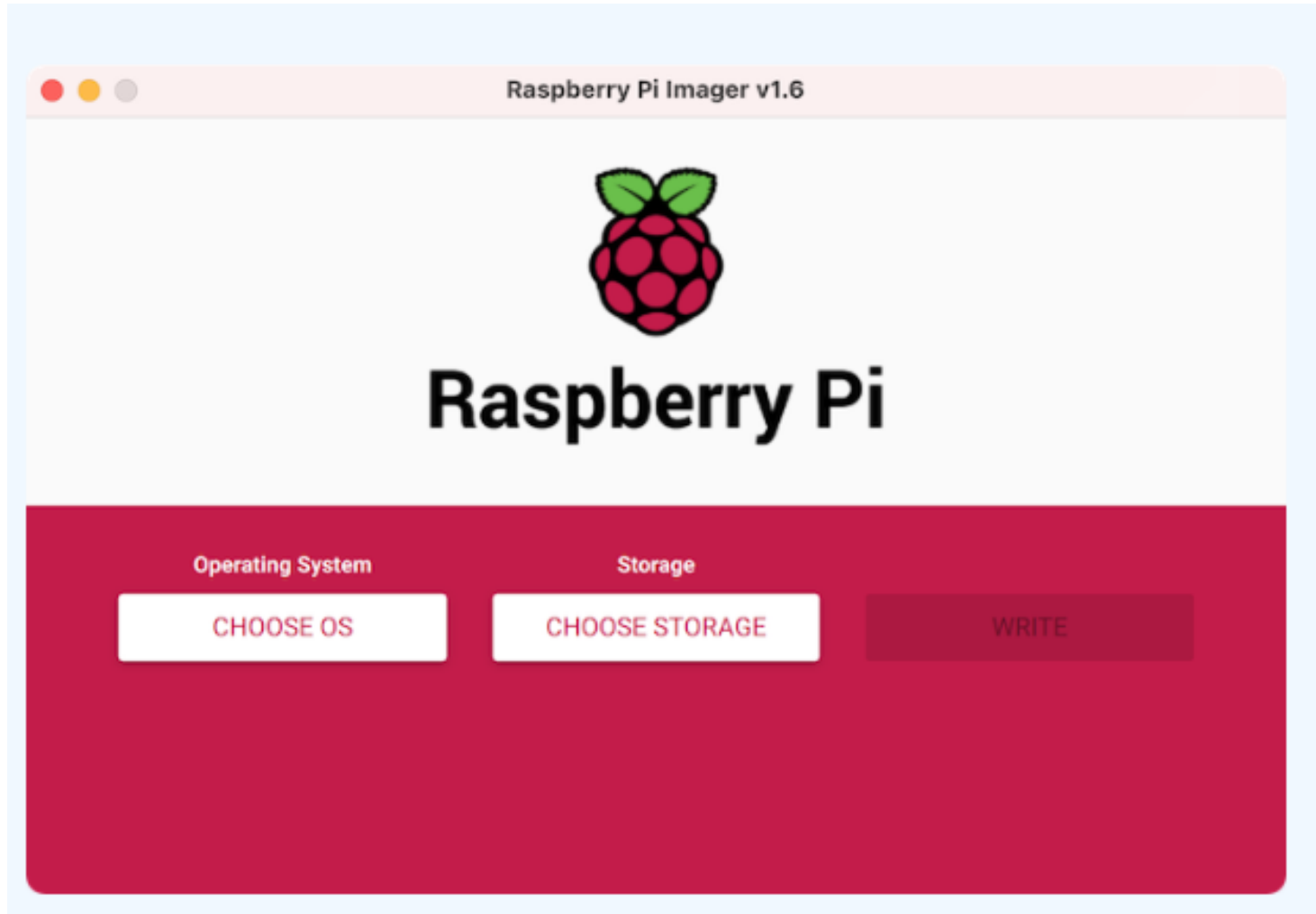
[Show SHA256 file integrity hash:](#)

[Release notes](#)

Steps of setup SD card

- Use a flashing tool to download an OS image to a micro SD card
 - Raspberry Pi Imager
 - Download a Raspberry Pi OS image and flash it to a micro SD card (> 16GB)
 - Raspberry Pi can now boot from the micro SD card.
 - Alternative use
 - Etcher
 - `dd` or `dcfldd` command in a Linux host

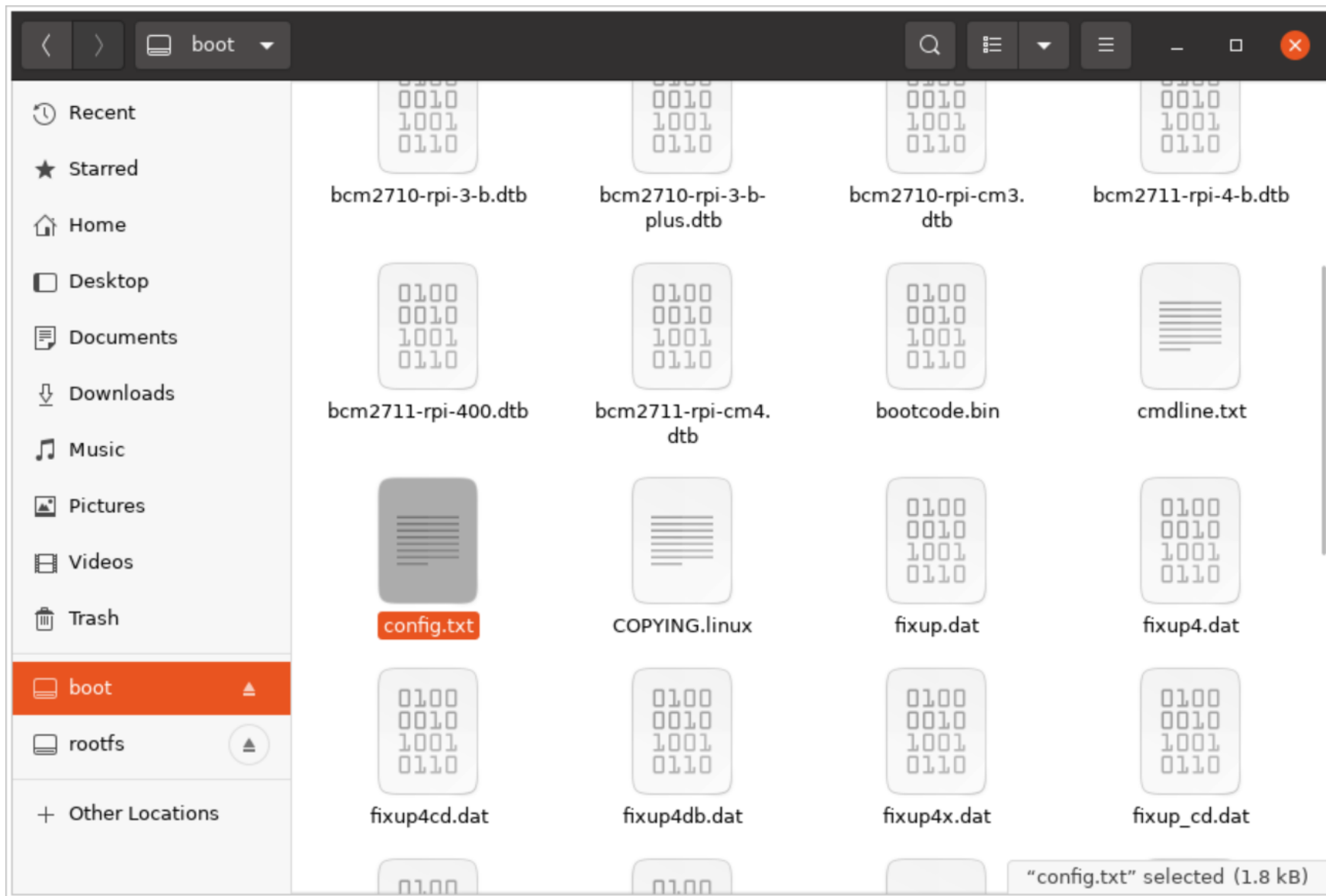
Use Raspberry Pi Imager



Raspberry Pi OS Image

- Include two partitions
 - 1: FAT filesystem, firmware, kernel, config, ...
 - 2: ext4 filesystem, Linux root filesystem
- Check the SD card after writing the OS into it
- Check config.txt at /boot of the SD
 - Has the following line to communicate with the development host with UART serial port

```
enable_uart=1
```



Verify what is on SD card

- (Host) `sudo fdisk -l /dev/sdb`
 - It should show at least two partitions, one is **boot** partition and another is the partition of a **root file system**.
1. Now the SD card should be bootable for your Raspberry pi
 2. Note: Some privileged commands should be preceded with `sudo`

Booting Process

- GPU: mount SD card, load `bootcode.bin`
- `bootcode.bin`: init cache, load `start.elf`
- `start.elf`: read `config.txt`, `cmdline.txt`, init RAM; Display boot message
- Load Linux Kernel, `kernel.img`, CPU take the control of the system

```
COPYING.linux
LICENCE.broadcom
LICENSE.oracle
bcm2708-rpi-b-plus.dtb
bcm2708-rpi-b.dtb
bcm2708-rpi-cm.dtb
bcm2709-rpi-2-b.dtb
bcm2710-rpi-3-b.dtb
bootcode.bin
cmdline.txt
config.txt
fixup.dat
fixup_cd.dat
fixup_db.dat
fixup_x.dat
issue.txt
kernel.img
kernel7.img
overlays
start.elf
start_cd.elf
start_db.elf
start_x.elf
```

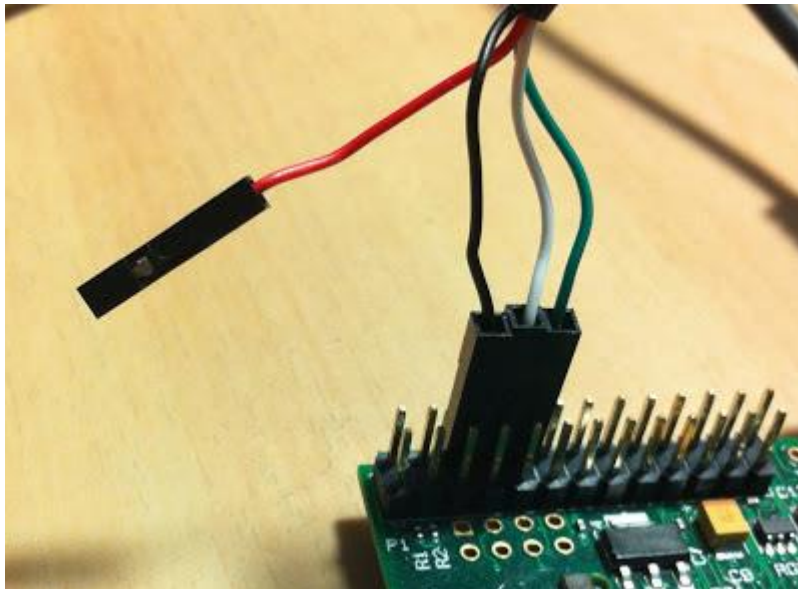
Use minicom in Linux host to connect to RPi

- Check config.txt at /boot of RPi
 - (target) `cat /boot/config.txt`
`enable_uart=1`
- Use `minicom` to connect **USB-TTL** serial console to Raspberry Pi to see boot and console messages

Alternative: Use Teraterm or MobaXterm in Windows host to connect to RPi

USB-TTL

- Connections to RPi



Raspberry Pi B 的 GPIO (PI)

R-Pi GPIO		left	
		bottom P1-01	top P1-02
3V3 Power			
R1: GPIO 0 (SDA) R2: GPIO 2 (SDA)			
R1: GPIO 1 (SCL) R2: GPIO 3 (SCL)			
GPIO 4 (GCLK0)			
Ground			
GPIO 17			
R1: GPIO 21 R2: GPIO 27			
GPIO 22			
3V3 Power			
GPIO 10 (MOSI)			
GPIO 9 (MISO)			
GPIO 11 (SCLK)			
Ground			

SV Power

SV Power

Ground

GPIO 14 (TXD)

GPIO 15 (RXD)

GPIO 18 (PCM_CLK)

Ground

GPIO 23

GPIO 24

Ground

GPIO 25

GPIO 8 (CE0)

GPIO 7 (CE1)

Black pin 6

White pin 8

Green pin 10

http://elinux.org/RPi_Low-level_peripherals

- Install minicom
(Host) `sudo apt install minicom lrzsz`

- First time run minicom)
(Host) `sudo minicom -s`

If use Windows, you can use **Tera Term** as the terminal app

- Please below for configuring minicom

- Save setting and re-run minicom
(Host) `sudo minicom`

- Or to enable line wrap
(Host) `sudo minicom -w`
(target) `stty cols xx rows yy`

Device name for USB-TTL cable at host, can be found using command **dmesg**

where your minicom window is of size xx by yy

```
sdwang@Vision: ~  
+-----+  
| A -   Serial Device       : /dev/ttyUSB0  
| B - Lockfile Location    : /var/lock  
| C -   Callin Program     :  
| D -   Callout Program    :  
| E -   Bps/Par/Bits       : 115200 8N1  
| F - Hardware Flow Control : No  
| G - Software Flow Control: No  
+-----+  
| Change which setting? █ |  
+-----+  
| Screen and keyboard |  
| Save setup as dfl   |  
| Save setup as..    |  
| Exit                |  
| Exit from Minicom   |  
+-----+
```


raspi-config

- `raspi-config` is a tool written by shell script, open source

(target) `sudo raspi-config`

```
##### Raspberry Pi Software Configuration Tool (raspi-config) #####
 1 System Options          Configure system settings
 2 Display Options        Configure display settings
 3 Interface Options       Configure connections to peripherals
 4 Performance Options     Configure performance settings
 5 Localisation Options    Configure language and regional settings
 6 Advanced Options        Configure advanced settings
 8 Update                  Update this tool to the latest version
 9 About raspi-config      Information about this configuration tool

                                <Select>                                <Finish>
```

3. Interfacing Options

Raspberry Pi Software Configuration Tool (raspi-config)

P1 Camera	Enable/disable connection to the Raspberry Pi Camera
P2 SSH	Enable/disable remote command line access using SSH
P3 VNC	Enable/disable graphical remote access using RealVNC
P4 SPI	Enable/disable automatic loading of SPI kernel module
P5 I2C	Enable/disable automatic loading of I2C kernel module
P6 Serial Port	Enable/disable shell messages on the serial connection
P7 1-Wire	Enable/disable one-wire interface
P8 Remote GPIO	Enable/disable remote access to GPIO pins

<Select>

<Back>

Setup wifi

- Using `raspi-config`

- System Options →
Wireless LAN

`set country`

`SSID`

`password`

Setup wifi using command line

- Open the wpa-supPLICANT configuration file in `nano` or `vi`:
- `(target)$ sudo nano /etc/wpa_supplicant/wpa_supplicant.conf`
 - Go to the bottom of the file and add the following:

```
network={
    ssid="testing"
    psk="testingPassword"
}
```

Or use `wpa_passphrase` to encode the PSK:

```
(target)$ wpa_passphrase "testing" | sudo tee -a
/etc/wpa_supplicant/wpa_supplicant.conf > /dev/null
```

After setup, reboot the RPi (or use commands: `sudo wpa_cli -i wlan0 reconfigure` and `sudo dhcpcd -n wlan0`)

Linux admin commands

- Admin commands prefix
(target) `sudo`
- Change password
(target) `passwd`
- Halt the CPU (check the led lights)
(target) `sudo halt`
- reboot
(target) `sudo reboot`

Update the Raspbian OS on RPi

- Raspbian OS is a Debian Linux distribution for RPi
 - 2016 version is Jessie (Kernel 4.4)
 - 2017 version is Stretch (Kernel 4.9)
 - 2018 version is Stretch (Kernel 4.14)
 - 2020 version is Buster (Kernel 5.4)
 - 2021 version is Buster (Kernel 5.10)
 - 2023 Version is Bullseye (Kernel 5.15)
- Update the Raspberry OS on RPi
 - (target) `sudo apt update`
 - (target) `sudo apt -y dist-upgrade`

Update the firmware

- It takes some time to update the firmware
- Firmware: some low-level hardware drivers that are not distributed along with Raspbian OS
 - (target) `sudo apt install rpi-update`
 - (target) `sudo rpi-update`
- To protect the data, make backup before update the firmware