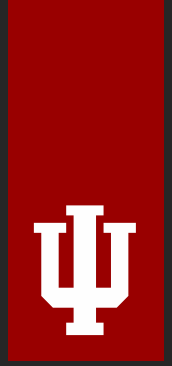


E210 Engineering Cyber-Physical Systems (Spring 2021)

Raspberry Pi/UART Introduction

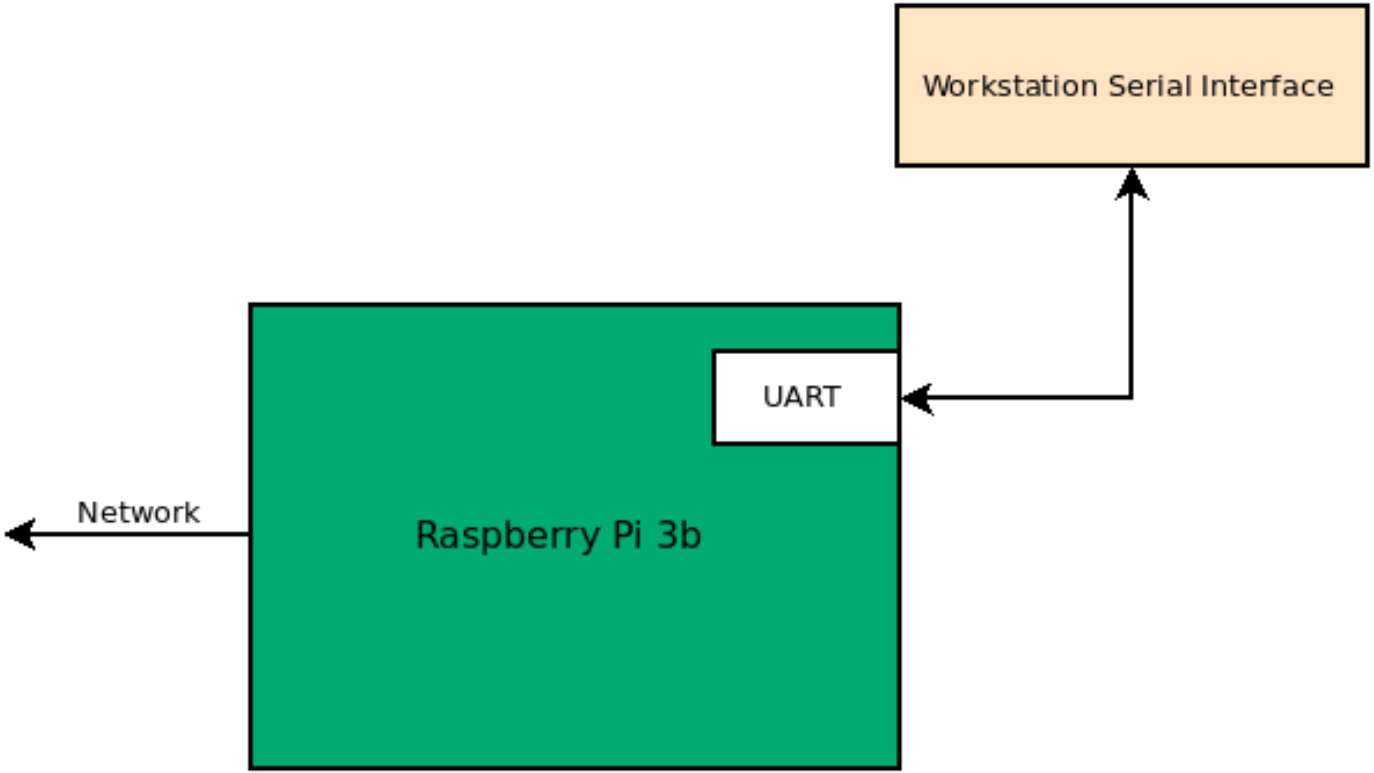
Bryce Himebaugh

Weekly Focus	Reading	Monday	Wed	Lab
Exam/CPS Introduction	Ref 1 Chapter 1	**3/8:** Exam 1	**3/10:** CPS Introduction	**Project 5 Raspberry PI Setup**
Raspberry Pi	Ref 2 Chapter 1-3	**3/15:** Pi Intro/UART Bus	**3/17:** Git/Github	
I2C Bus	Ref 3	**3/22:** I2C Bus	**3/24:** Wellness Day	**Project 6 I2C Pressure Sensor**
Python/Sensor	Ref 4, Ref 5	**3/29:** Classes/Modules	**3/31:** Pressure Sensor	
SPI	Ref 6	**4/5:** SPI Bus Overview	**4/7:** SPI HDL Design	**Project 7 SPI Connected I/O**
SPI	Ref 7 Chapter 1	**4/12:** SPI HDL Design	**4/14:** Sensor Memory	
Network Interface	Ref 7 Chapter 2	**4/19:** Ethernet Interface	**4/21:** MQTT	**Project 8 Network Interface**
MQTT/Flask	Ref 7 Chapter 14	**4/26:** Flask	**4/29:** Open Topic	

Final Exam Tues 5/4 10:10-12:10

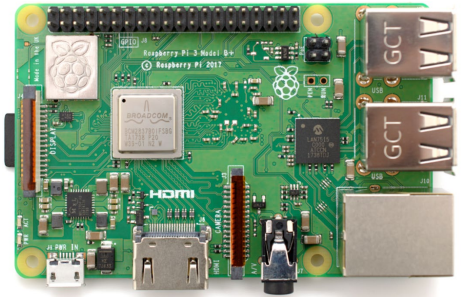
https://engr210.github.io/

Raspberry Pi/UART

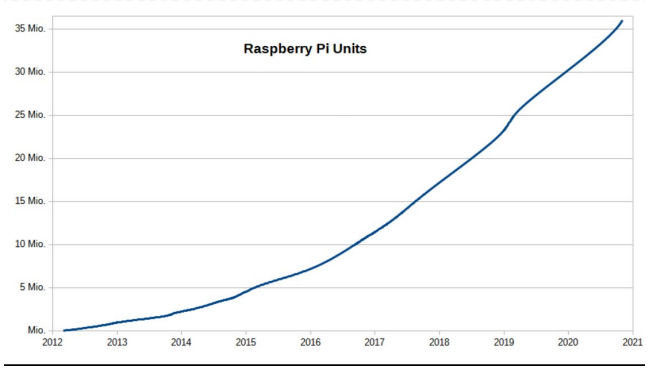


Raspberry Pi Overview

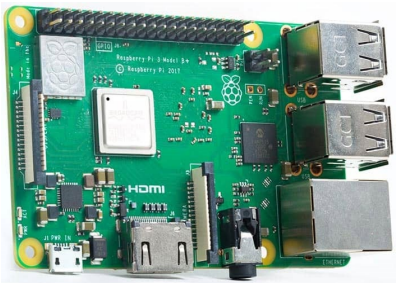
Raspberry Pi History



- Collaboration between University of Cambridge and Broadcom
- Released in 2012 to teach basic computer science in schools and developing countries.
- Managed by Raspberry Pi Foundation
- Original target application was robotics.
- 3B+ Costs $35, 4B Costs $75



Raspberry Pi Hardware

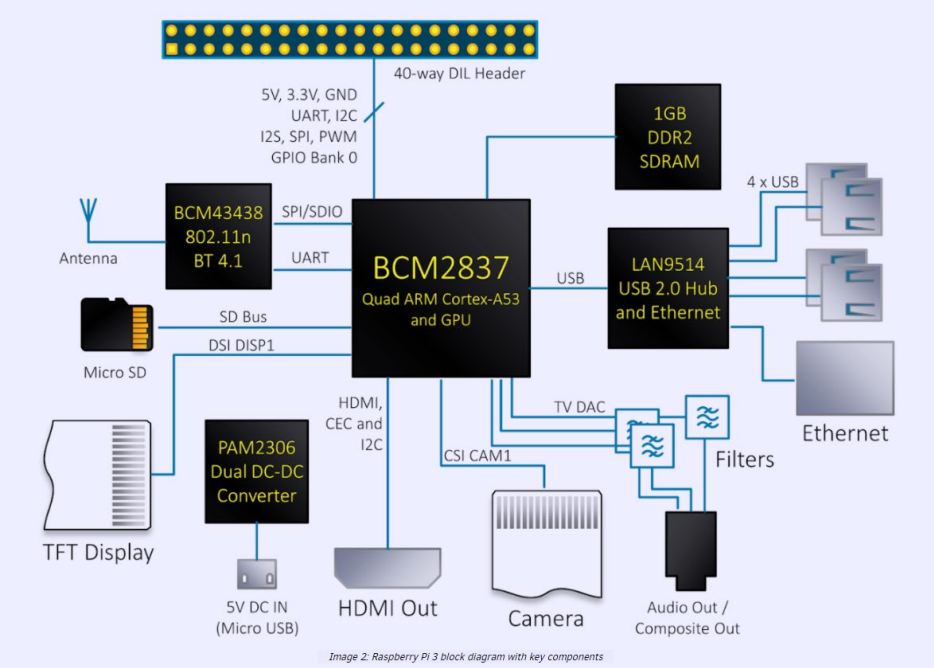


- Processor
  - Broadcom BCM2837B0 quad-core ARM A53
  - 64-bit 1.4Ghz
- GPU
  - Broadcom Videocore-IV
- 1GB LPDDR2 SDRAM
- Gigabit Ethernet, 2.4GHz and 5GHz 802.11b/g/n/ac Wi-Fi
- HDMI Video Output
- Audio Output
- 32GB SD Card Drive

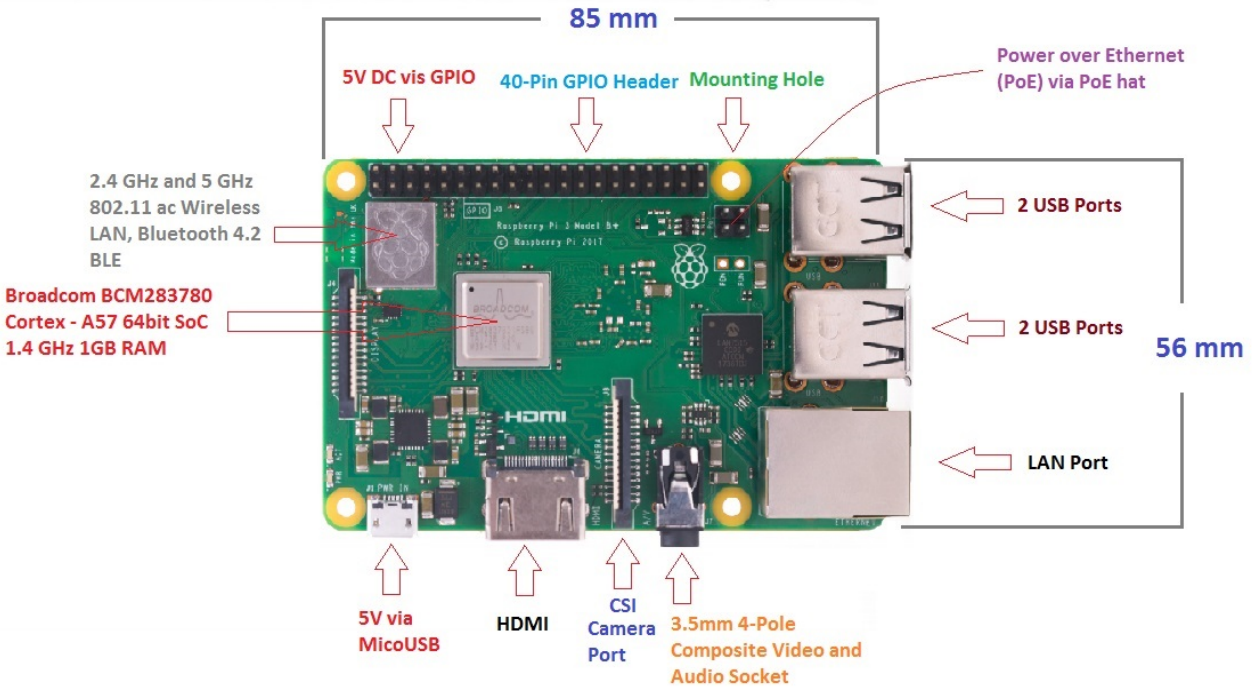
Raspberry Pi Software

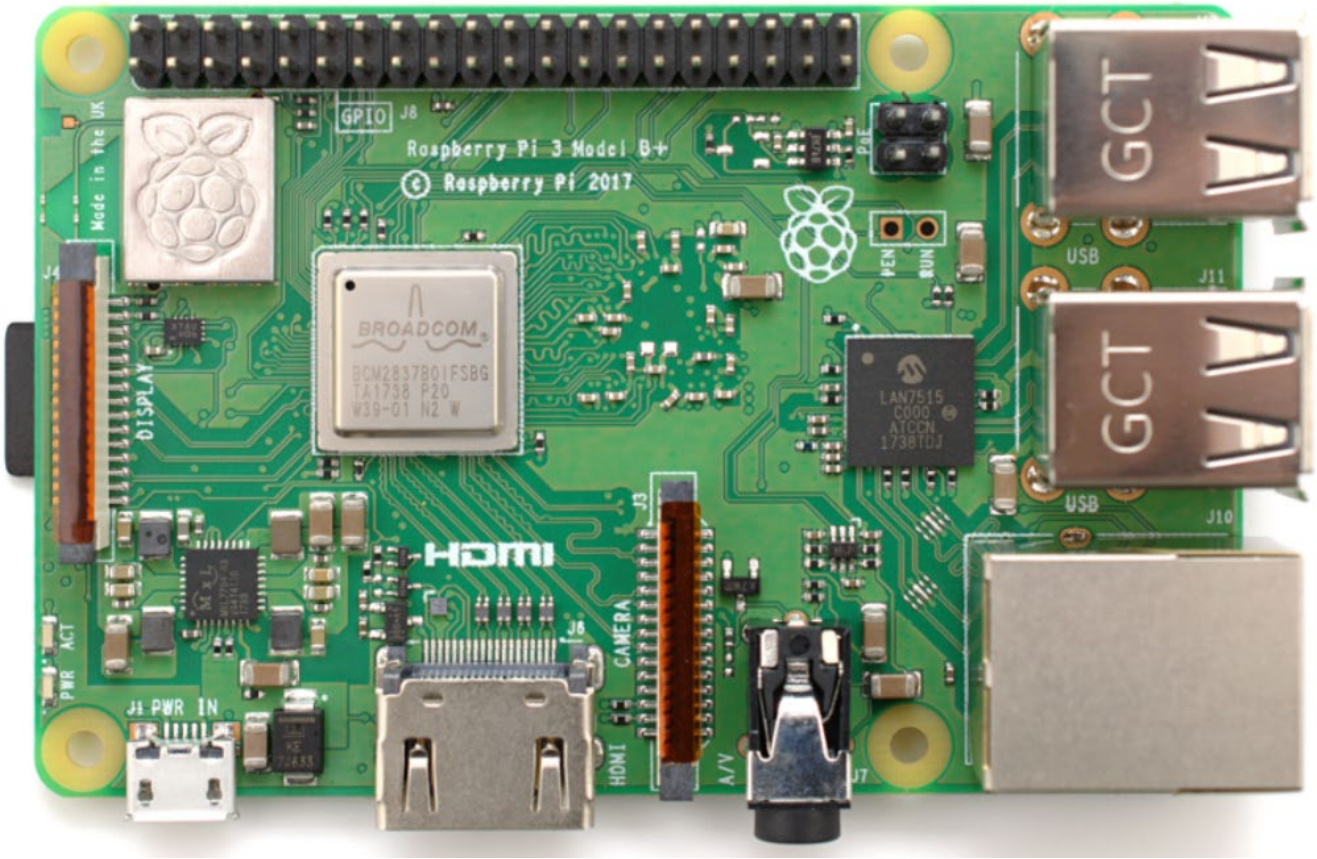
- Typically runs a variant of Linux
- Pi OS Linux
  - Formerly known as Raspian
  - Debian based
  - Created in 2012
  - Managed by the Raspberry Pi Foundation
  - Uses LXDE (lightweight X11 Desktop Environment) Desktop Environment by default
- Others
  - Ubuntu
  - LibreElec
  - RetroPie
  - TLXOS
- Possible to create “bare-metal” programs.
  - Documentation can be challenging

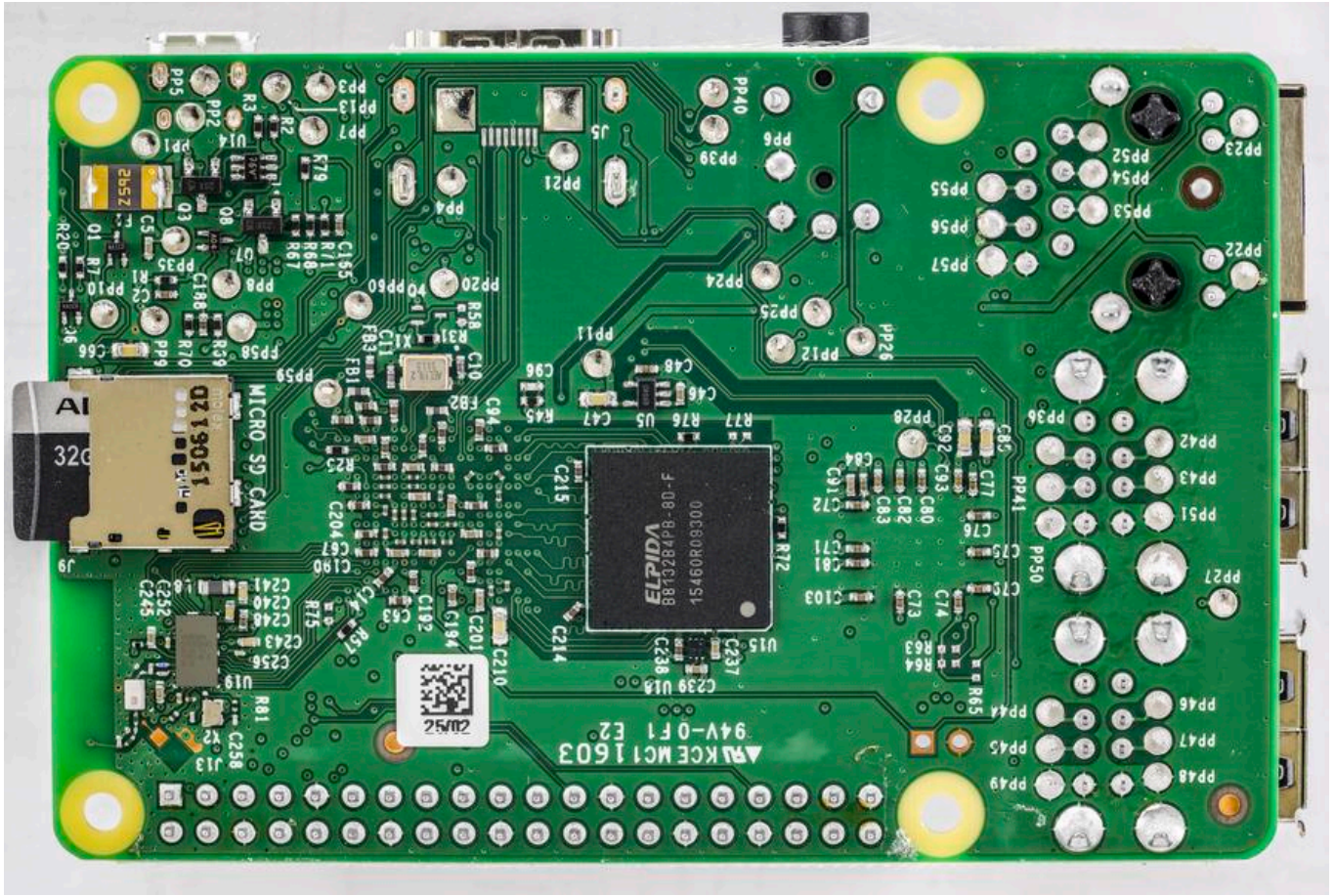
Raspberry Pi Block Diagram

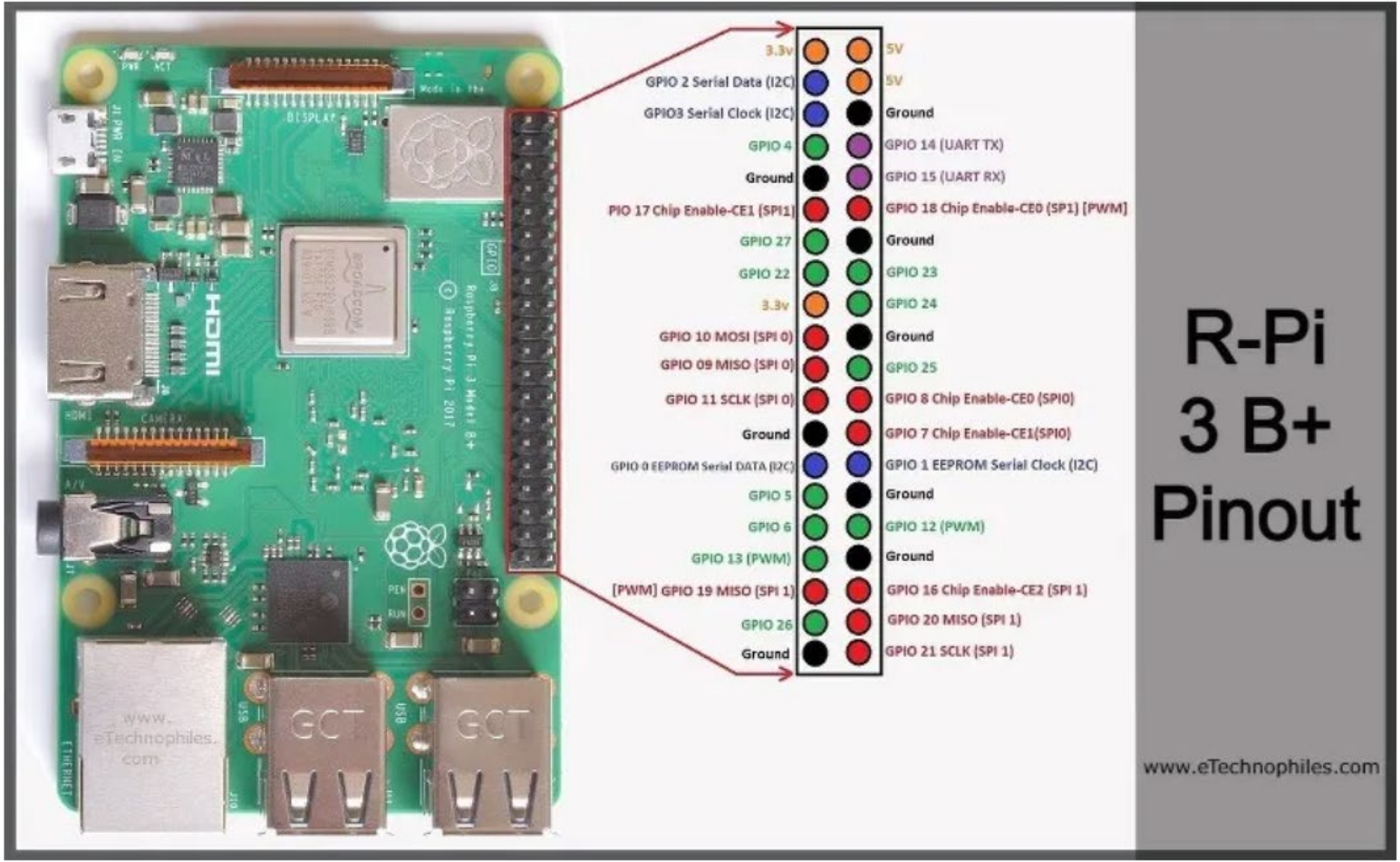


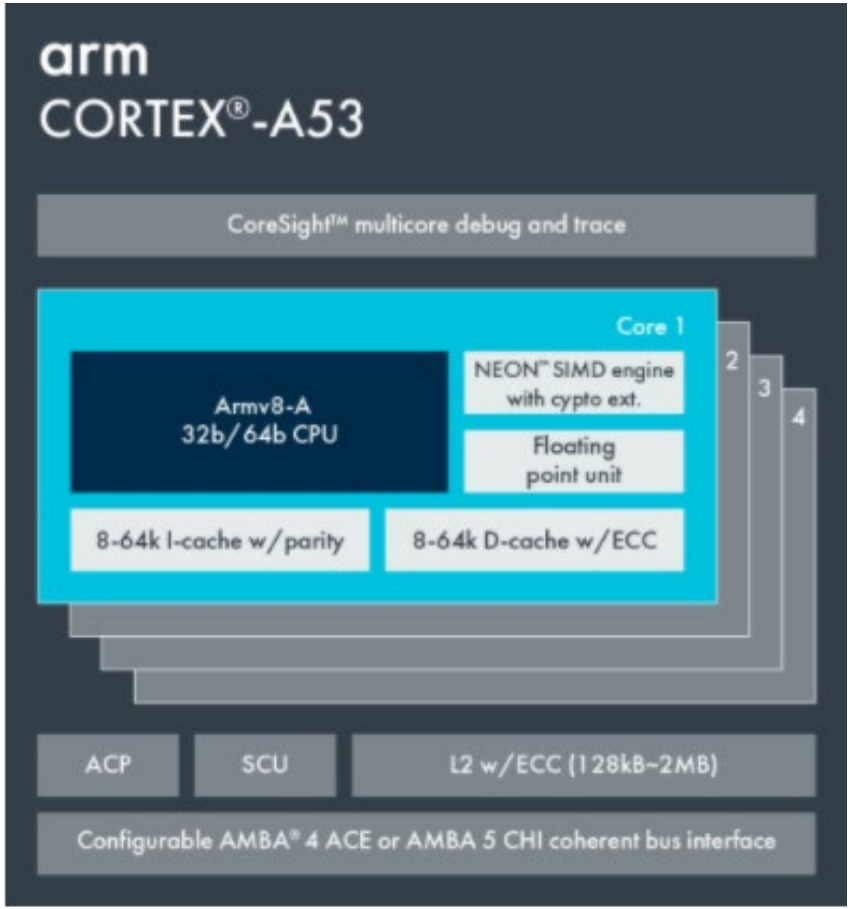
https://xdevs.com/article/rpi3_oc/

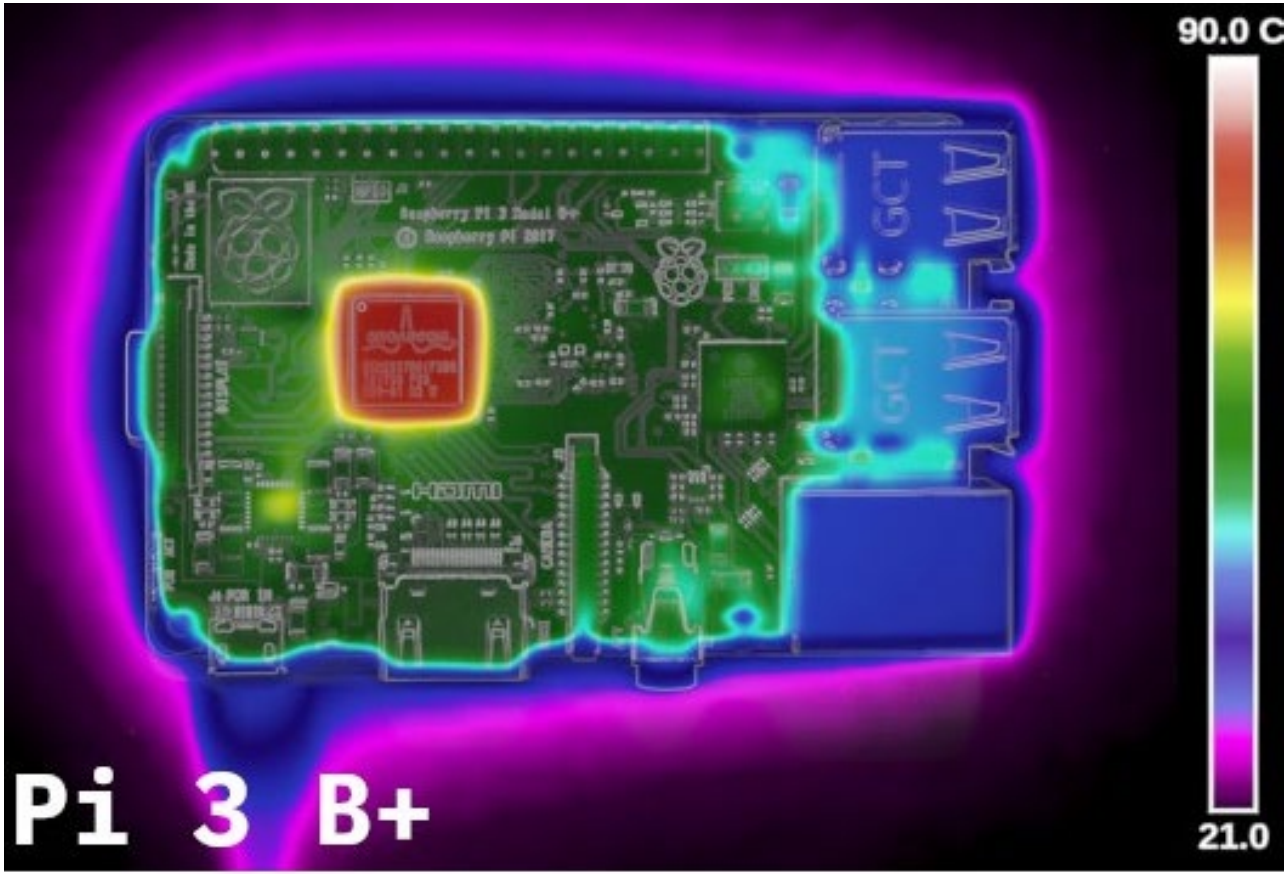

85 mm
5V DC vis GPIO
40-Pin GPIO Header
Mounting Hole
Power over Ethernet (PoE) via PoE hat
2.4 GHz and 5 GHz 802.11 ac Wireless LAN, Bluetooth 4.2 BLE
Broadcom BCM283780 Cortex - A57 64bit SoC 1.4 GHz 1GB RAM
2 USB Ports
2 USB Ports
56 mm
LAN Port
5V via MicoUSB
HDMI
CSI Camera Port
3.5mm 4-Pole Composite Video and Audio Socket
Introduction to Raspberry Pi 3 B+
www.TheEngineeringProjects.com

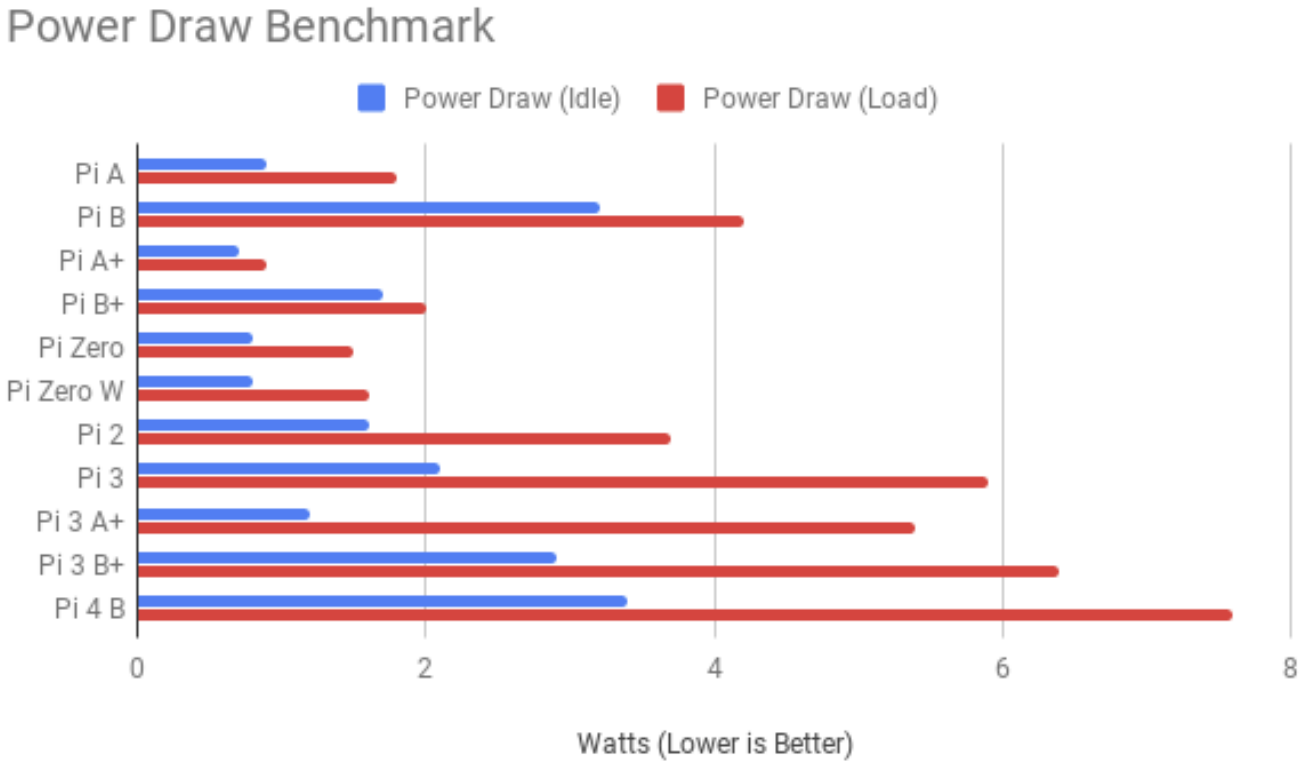

GPIO
Raspberry Pi 3 Model B+
© Raspberry Pi 2017
BROADCOM
BCM2837B0IFSBG
LAN7515
C000
ATCCN
1738TDJ
GCT
GCT
USB
USB
DISPLAY
HDMI
CAMERA
PWR IN
PWR
ACT
A/V
PEN
RUN
PoE


MICRO SD CARD
ELPIDA
B81328A4PB-8D-F
1546OR09300

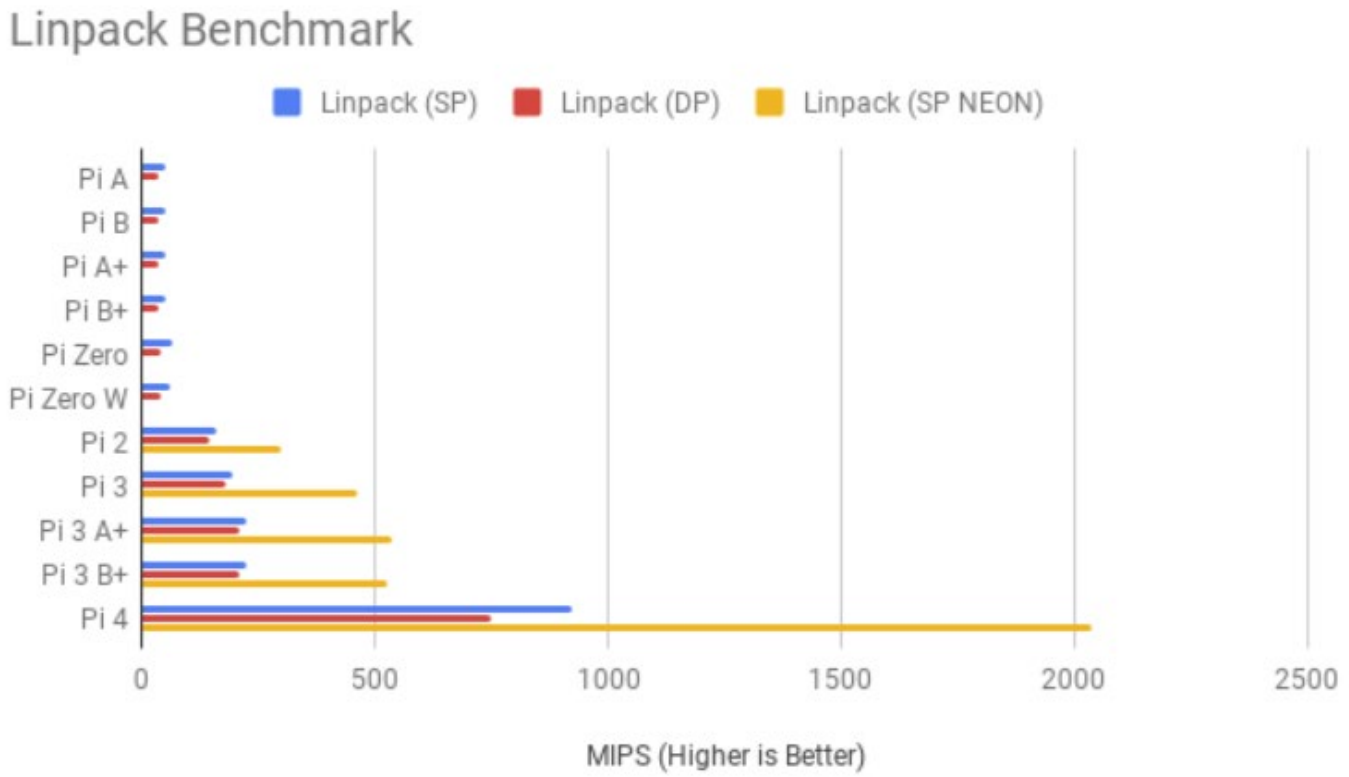

3.3v
5V
GPIO 2 Serial Data (I2C)
5V
GPIO3 Serial Clock (I2C)
Ground
GPIO 4
GPIO 14 (UART TX)
Ground
GPIO 15 (UART RX)
PIO 17 Chip Enable-CE1 (SPI1)
GPIO 18 Chip Enable-CE0 (SP1) [PWM]
GPIO 27
Ground
GPIO 22
GPIO 23
3.3v
GPIO 24
GPIO 10 MOSI (SPI 0)
Ground
GPIO 09 MISO (SPI 0)
GPIO 25
GPIO 11 SCLK (SPI 0)
GPIO 8 Chip Enable-CE0 (SPI0)
Ground
GPIO 7 Chip Enable-CE1(SPI0)
GPIO 0 EEPROM Serial DATA (I2C)
GPIO 1 EEPROM Serial Clock (I2C)
GPIO 5
Ground
GPIO 6
GPIO 12 (PWM)
GPIO 13 (PWM)
Ground
[PWM] GPIO 19 MISO (SPI 1)
GPIO 16 Chip Enable-CE2 (SPI 1)
GPIO 26
GPIO 20 MISO (SPI 1)
Ground
GPIO 21 SCLK (SPI 1)
R-Pi
3 B+
Pinout
www.eTechnophiles.com


arm
CORTEX®-A53
CoreSight™ multicore debug and trace
Core 1
2
3
4
Armv8-A
32b/64b CPU
NEON™ SIMD engine
with cypto ext.
Floating
point unit
8-64k I-cache w/parity
8-64k D-cache w/ECC
ACP
SCU
L2 w/ECC (128kB–2MB)
Configurable AMBA® 4 ACE or AMBA 5 CHI coherent bus interface

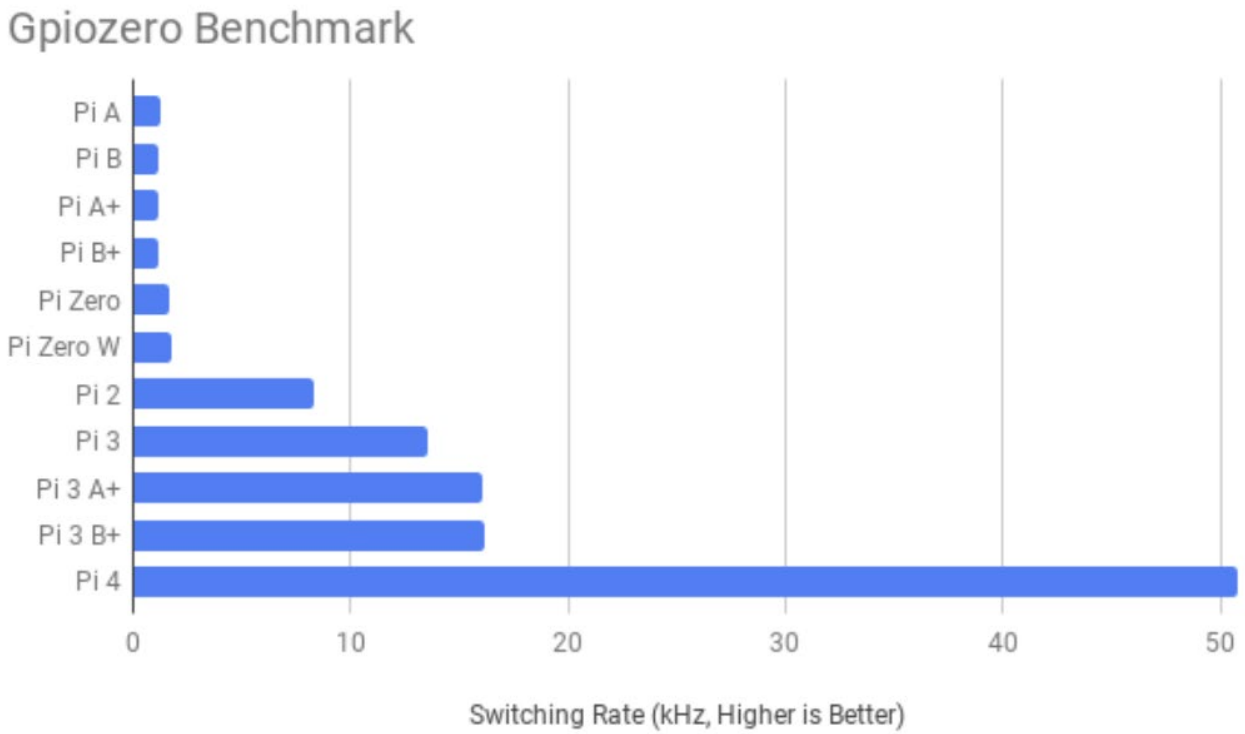

90.0 C
21.0
Pi 3 B+



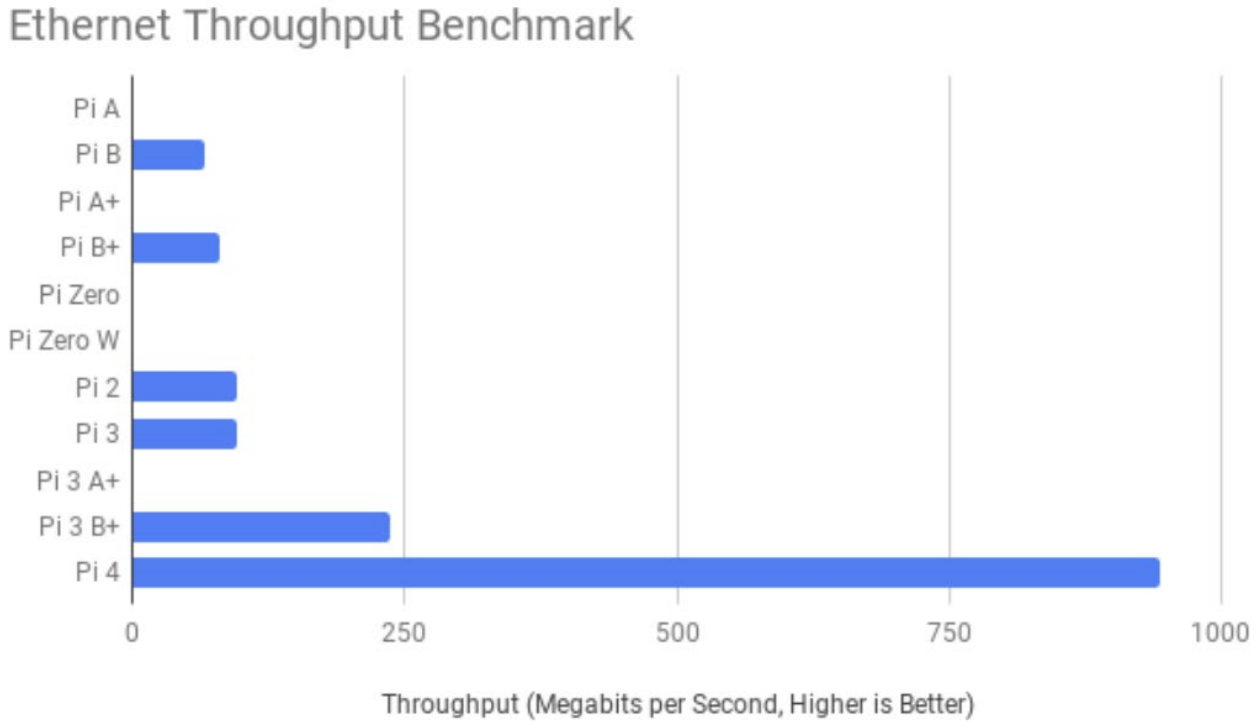
https://medium.com/@ghalfacree/benchmarking-the-raspberry-pi-4-73e5afbcd54b



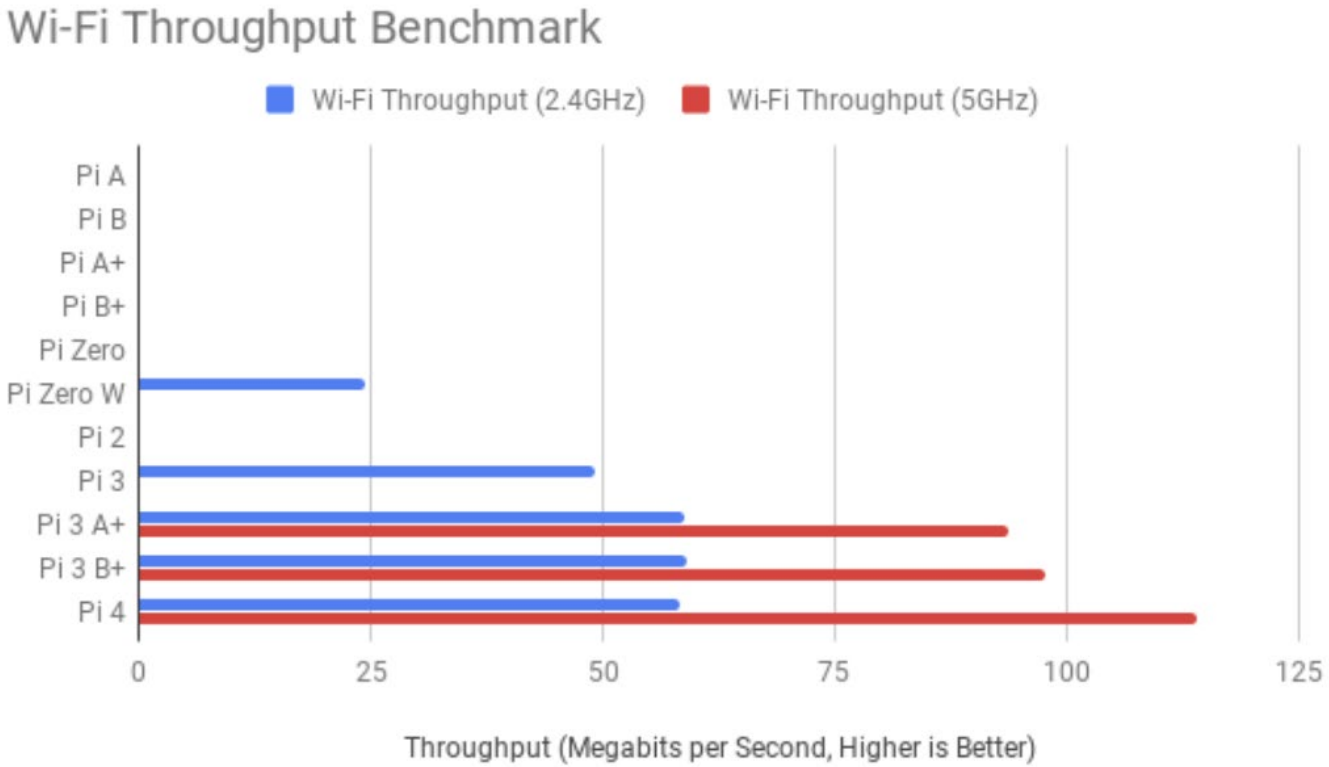
https://medium.com/@ghalfacree/benchmarking-the-raspberry-pi-4-73e5afbcd54b



https://medium.com/@ghalfacree/benchmarking-the-raspberry-pi-4-73e5afbcd54b



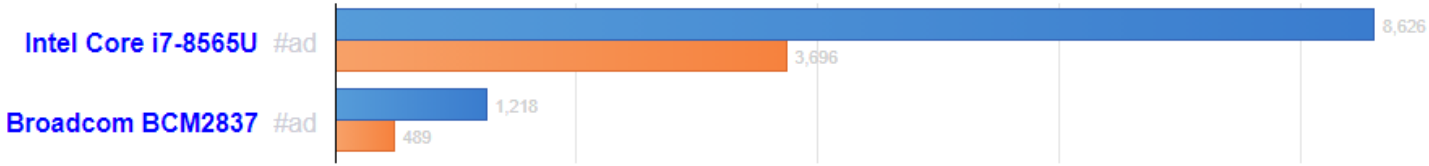
https://medium.com/@ghalfacree/benchmarking-the-raspberry-pi-4-73e5afbcd54b



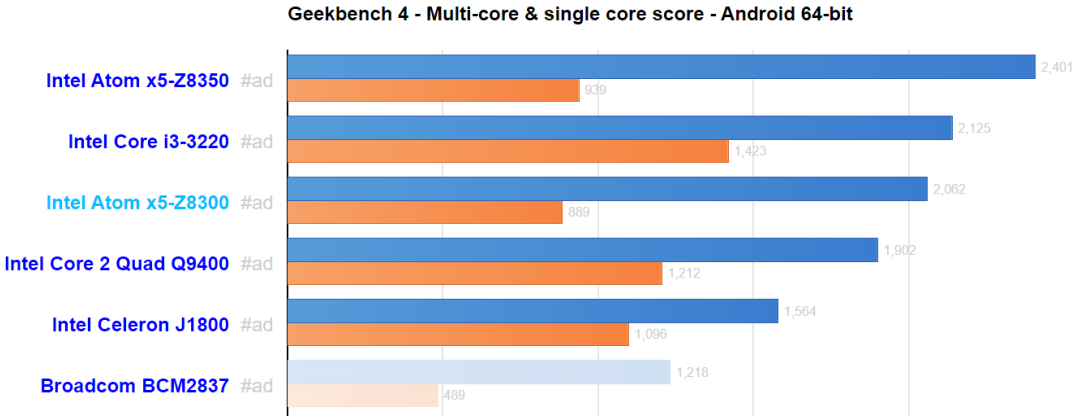
https://medium.com/@ghalfacree/benchmarking-the-raspberry-pi-4-73e5afbcd54b

On Android 64-bit:

Geekbench 4 - Multi-core & single core score - Android 64-bit



In single core, the difference is 656%. In multi-core, the differential gap is 608%.

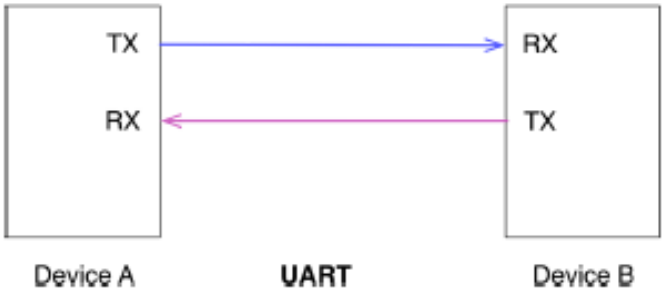


https://gadgetversus.com/processor/intel-core-i7-8565u-vs-broadcom-bcm2837/

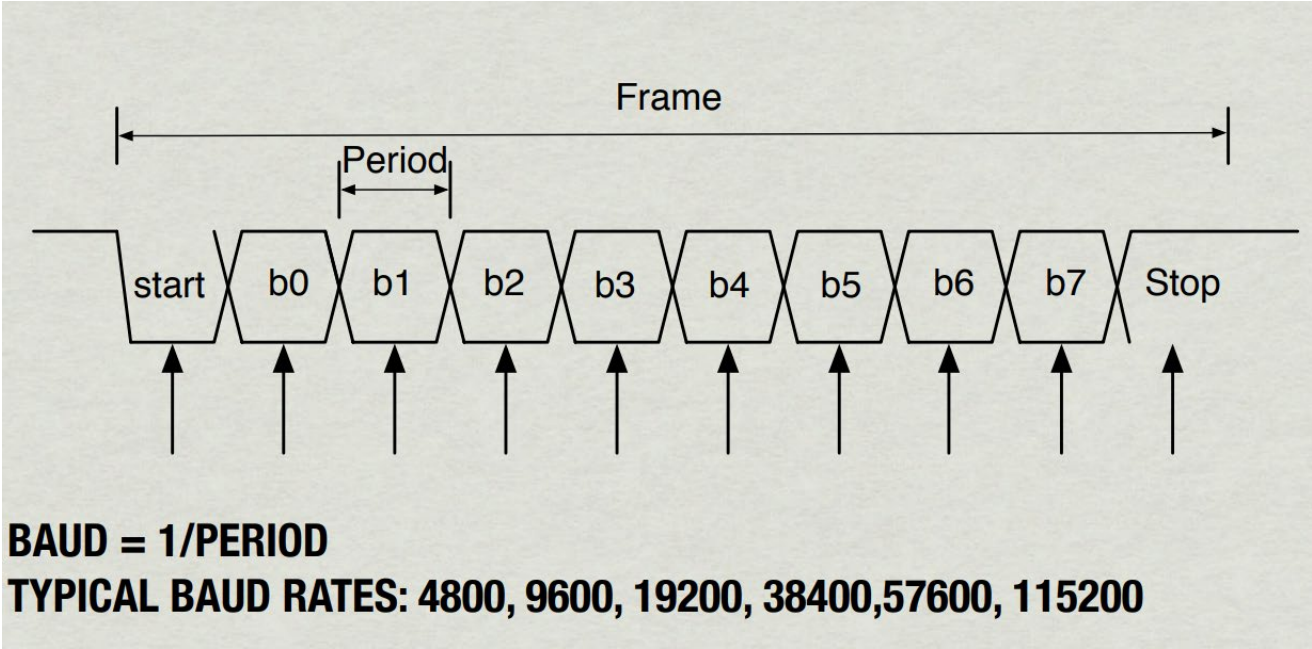
UART Overview

UART Overview

- Universal Asynchronous Receiver Transmitter
- Full-Duplex - Receive and Transmit Simultaneously
- Communication with systems using different clocks.



Waveform


Frame
Period
start
b0
b1
b2
b3
b4
b5
b6
b7
Stop
BAUD = 1/PERIOD
TYPICAL BAUD RATES: 4800, 9600, 19200, 38400,57600, 115200

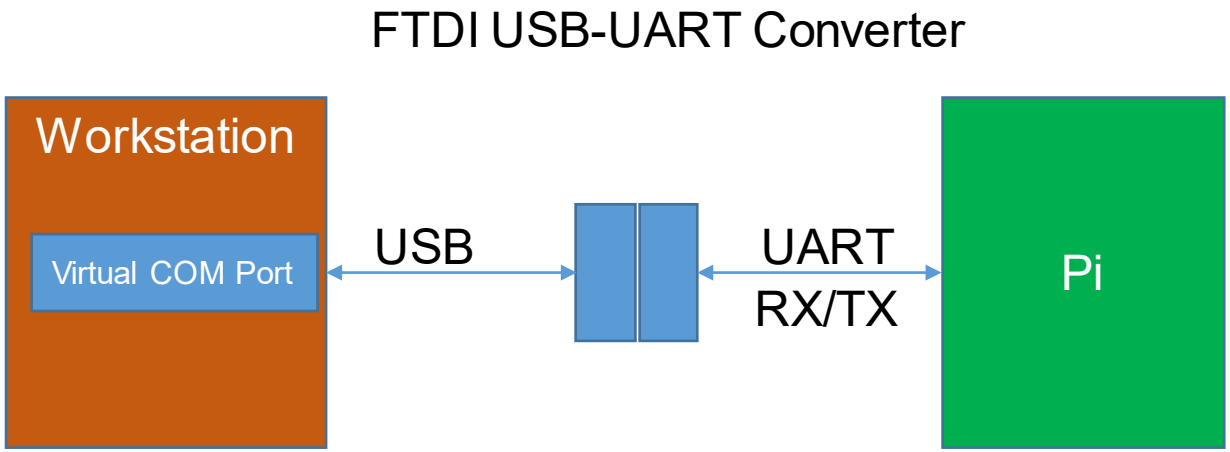
Pins

- TX (output): Transmit Data
- RX (input): Receive Data
- Flow Control
  - nCTS: Clear to Send - prevents STM32 from transmitting data when high.
  - nRTS: Ready to Send - indicates STM32 is ready to receive data when low

USB to Serial Converter

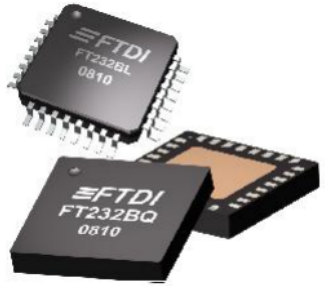
Serial Connection to PI

USB-to-Serial Adapter


FTDI USB-UART Converter
Workstation
Virtual COM Port
USB
UART
RX/TX
Pi

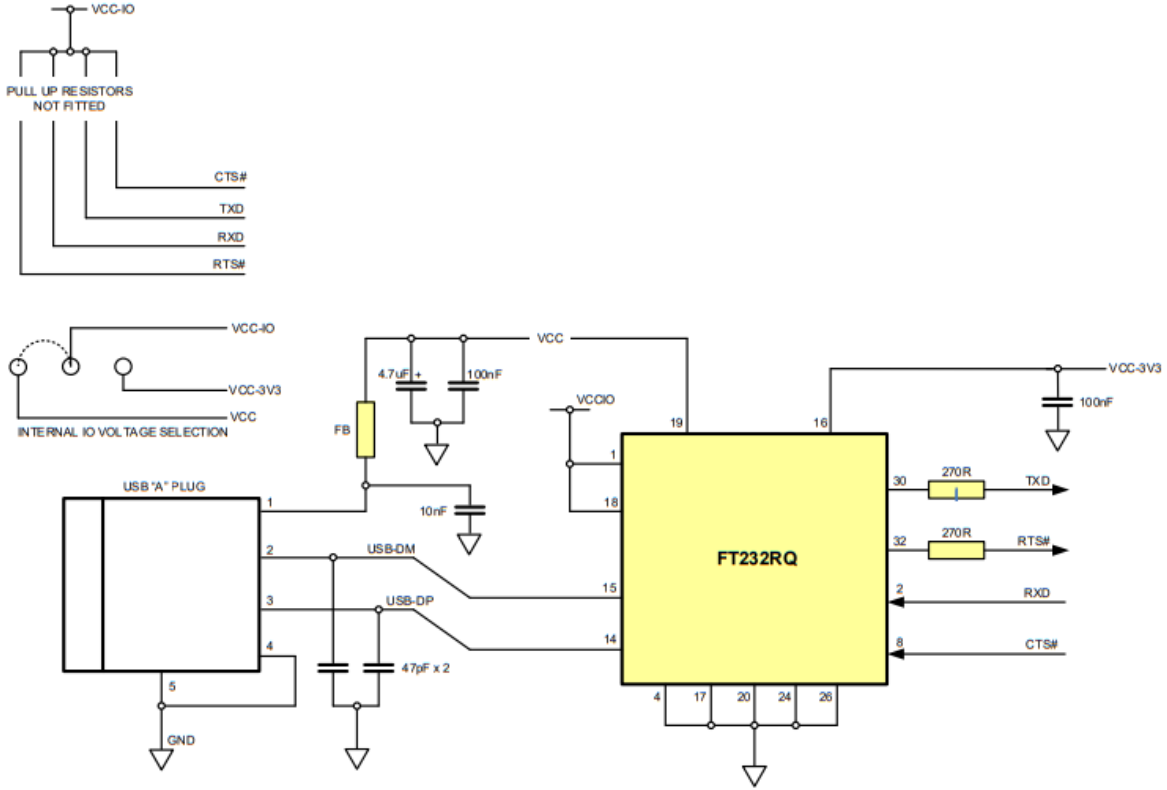
Future Technology Devices International Ltd.

FT232BL/BQ USB UART IC



The FT232B is a USB to serial UART interface with the following advanced features:

- Single Chip USB to Asynchronous Serial Data Transfer
- Full Handshaking & Modem Interface Signals
- UART I/F Supports 7 / 8 Bit Data, 1 / 2 Stop Bits and Odd/Even/Mark/Space/No Parity
- Data rate 300 => 3M Baud (TTL)
- Data rate 300 => 1M Baud (RS232)
- Data rate 300 => 3M Baud (RS422/RS485)
- 384 Byte Receive Buffer / 128 Byte Transmit Buffer for high data throughput
- Adjustable RX buffer timeout
- Fully Assisted Hardware or X-On / X-Off Handshaking In-built support for event characters and line break condition
- Auto Transmit Buffer control for RS485
- Support for USB Suspend / Resume through SLEEP# and RI# pins
- 4.35V to 5.25V single supply operation
- Support for high power USB Bus powered devices through PWREN# pin
- Integrated level converter on UART and control signals for interfacing to 5V and 3.3V logic
- Integrated 3.3V regulator for USB IO
- Integrated Power-On-Reset circuit
- Integrated 6MHz – 48Mhz clock multiplier PLL
- UHCI / OHCI / EHCI host controller compatible
- USB 1.1 and USB 2.0 compatible
- USB VID, PID, Serial Number and Product Description strings in external EEPROM
- EEPROM programmable on-board via USB
- Available as a compact lead free RoHS compliant 32-LD LQFP package (FT232BL) or 32-LD QFN package (FT232BQ).

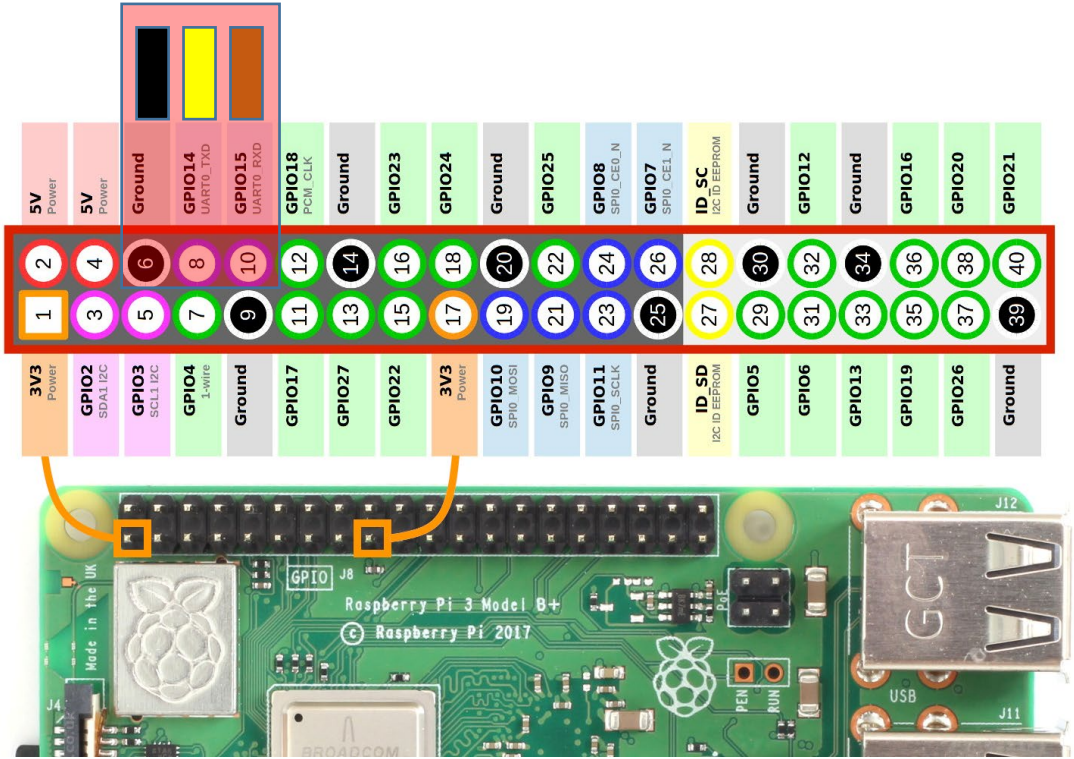

VCC-IO
PULL UP RESISTORS
NOT FITTED
CTS#
TXD
RXD
RTS#
VCC-IO
VCC-3V3
VCC
INTERNAL IO VOLTAGE SELECTION
VCC
4.7uF +
100nF
FB
10nF
VCCIO
19
16
VCC-3V3
100nF
USB "A" PLUG
1
2
3
4
5
USB-DM
USB-DP
47pF x 2
GND
18
15
14
FT232RQ
30
270R
TXD
32
270R
RTS#
2
RXD
8
CTS#
4
17
20
24
26

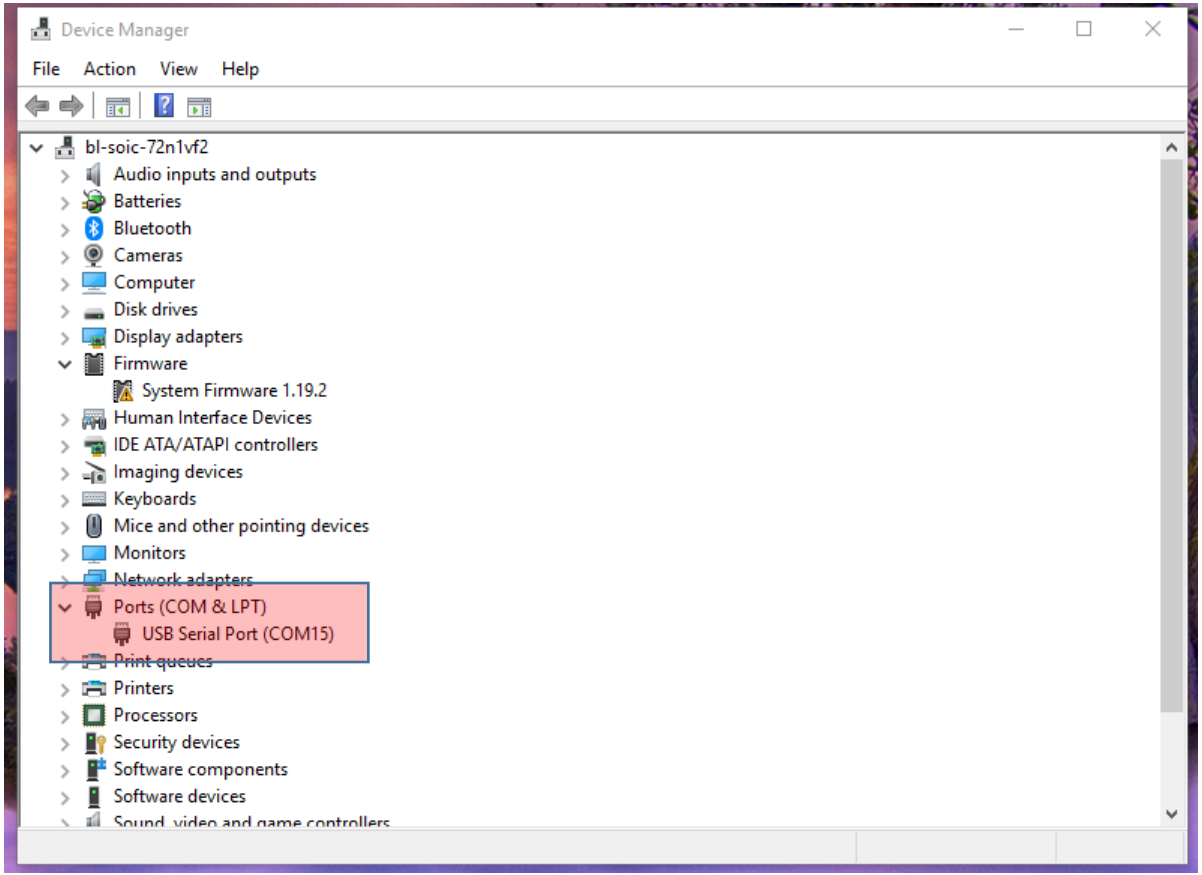
Connecting the Pi

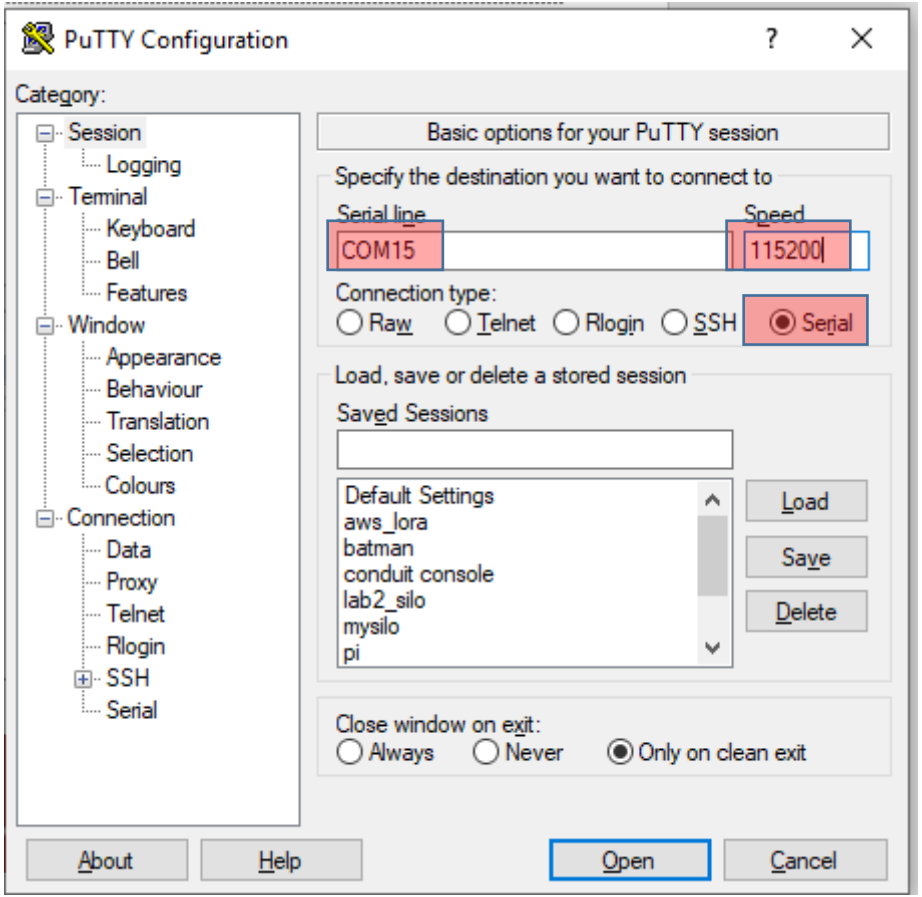
Connecting with Putty

- Connect USB cable
- Determine the COM port of FTDI cable
- Connect to COM port using Putty

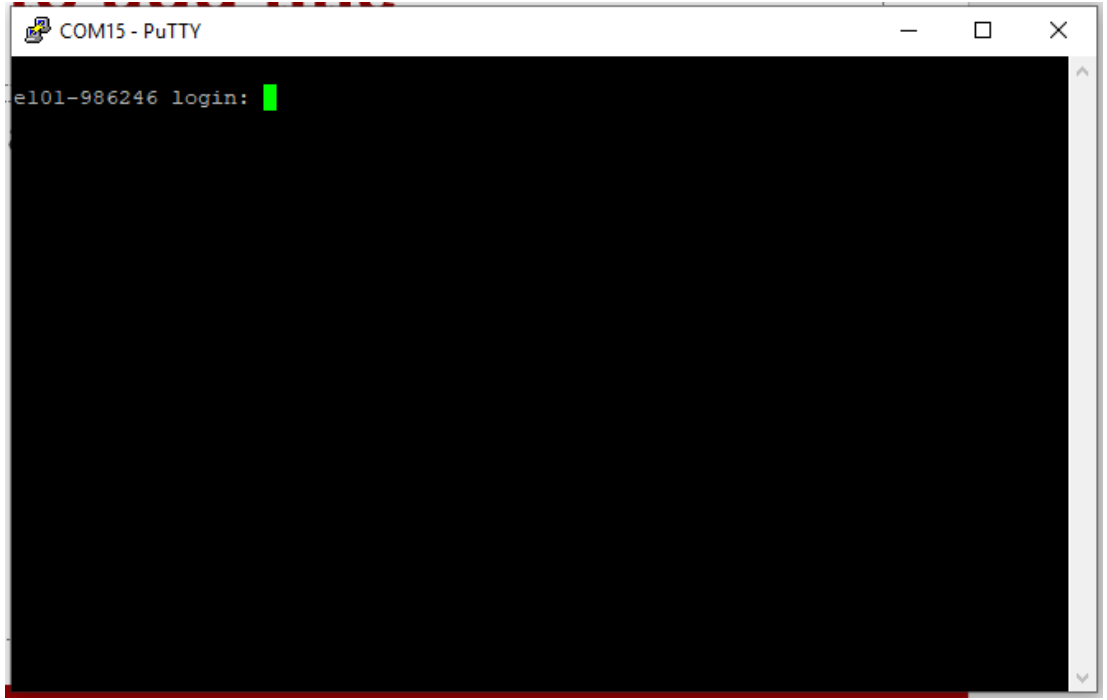
Console Connections




Device Manager
File
Action
View
Help
bl-soic-72n1vf2
Audio inputs and outputs
Batteries
Bluetooth
Cameras
Computer
Disk drives
Display adapters
Firmware
System Firmware 1.19.2
Human Interface Devices
IDE ATA/ATAPI controllers
Imaging devices
Keyboards
Mice and other pointing devices
Monitors
Network adapters
Ports (COM & LPT)
USB Serial Port (COM15)
Print queues
Printers
Processors
Security devices
Software components
Software devices

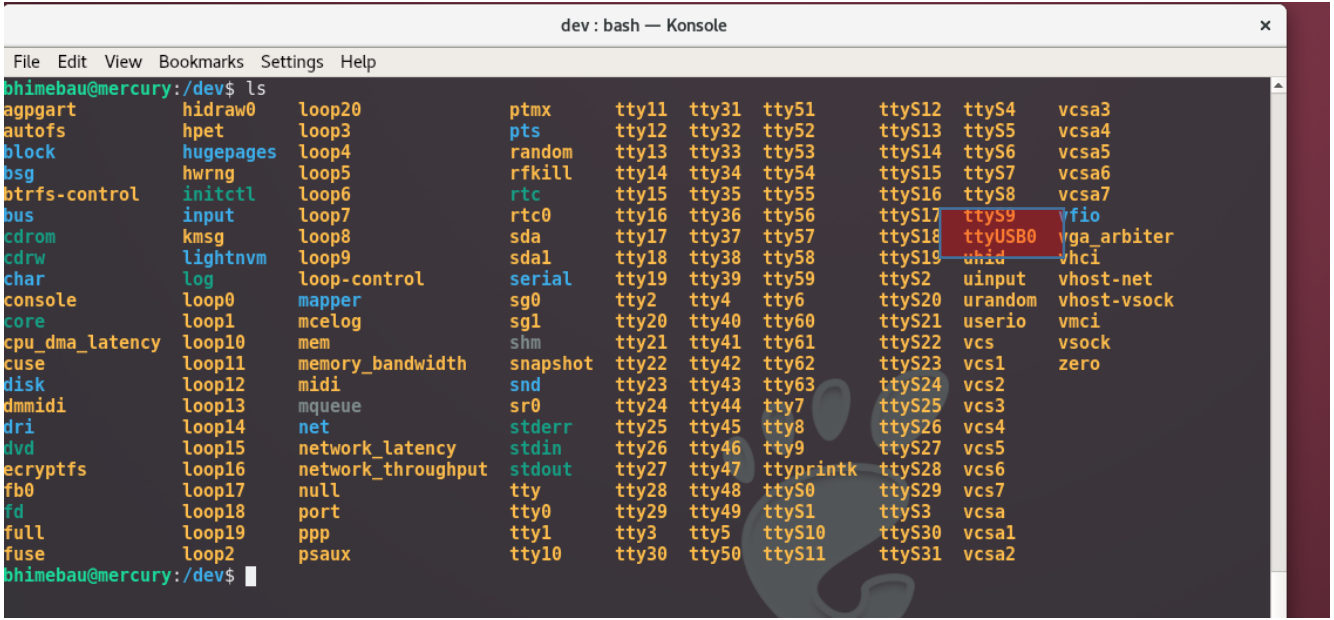

PuTTY Configuration
Category:
Session
Logging
Terminal
Keyboard
Bell
Features
Window
Appearance
Behaviour
Translation
Selection
Colours
Connection
Data
Proxy
Telnet
Rlogin
SSH
Serial
Basic options for your PuTTY session
Specify the destination you want to connect to
Serial line
Speed
COM15
115200
Connection type:
Raw
Telnet
Rlogin
SSH
Serial
Load, save or delete a stored session
Saved Sessions
Default Settings
aws_lora
batman
conduit console
lab2_silo
mysilo
pi
Load
Save
Delete
Close window on exit:
Always
Never
Only on clean exit
About
Help
Open
Cancel

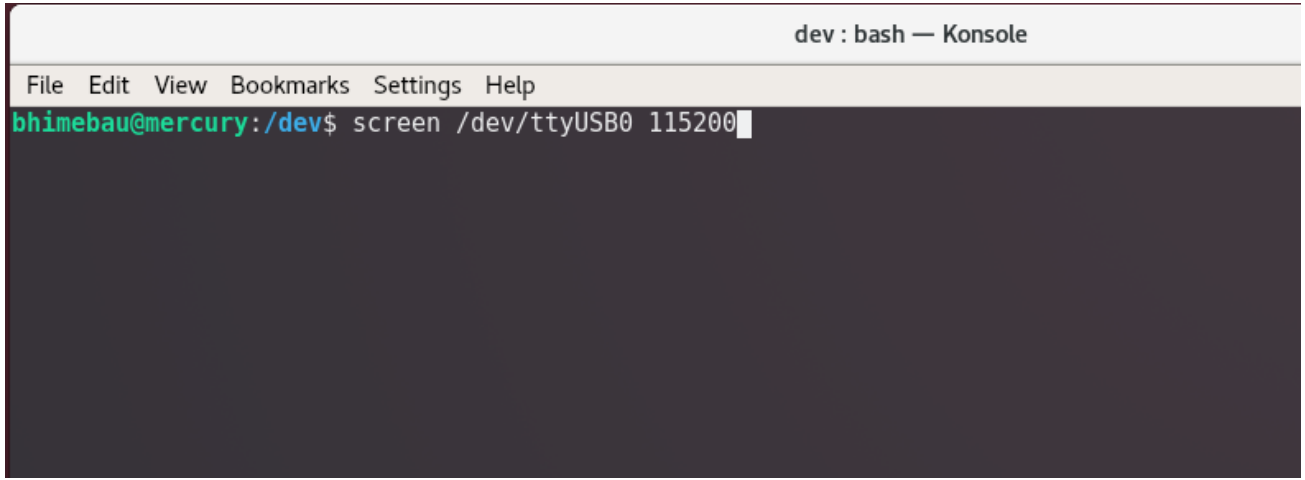
Might have to hit Enter a couple of times …
Username: pi
Password: e101class

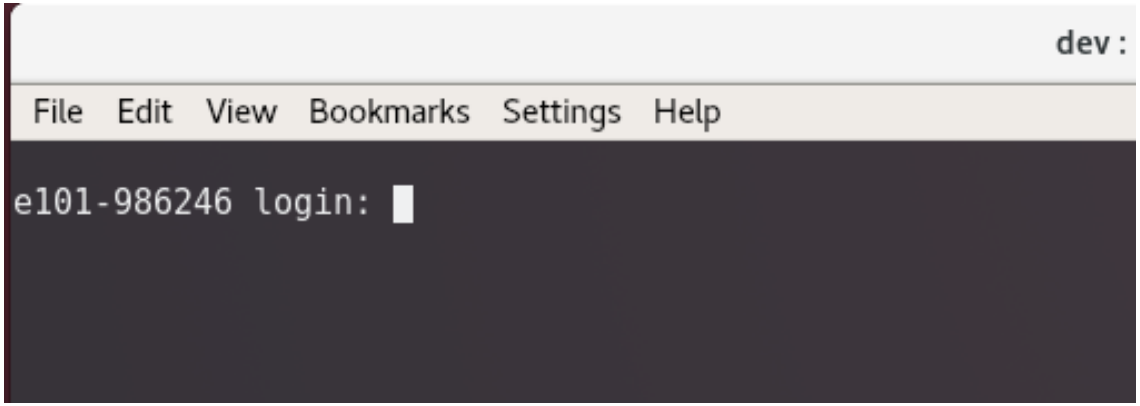


Connecting with Mac/Linux

- Connect the USB/Serial Cable
- Look in the /dev directory to find name of device.
  - Linux: ttyUSBx where x is an integer starting at 0
  - MacOS: cu.x where x is likely something like usbserial
- Connect to the device using screen
- https://pbxbook.com/other/mac-tty.html

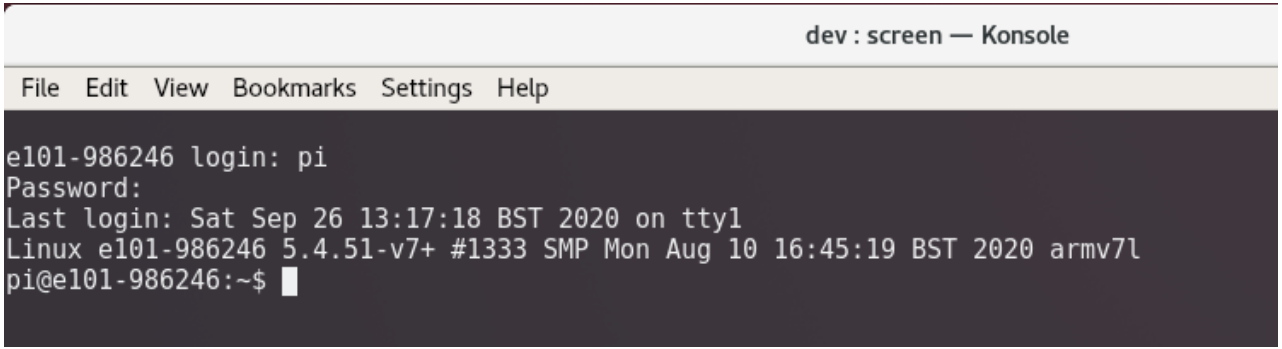

dev : bash — Konsole
File Edit View Bookmarks Settings Help
bhimebau@mercury:/dev$ ls
agpgart autofs block bsg btrfs-control bus cdrom cdrw char console core cpu_dma_latency cuse disk dmmidi dri dvd ecryptfs fb0 fd full fuse
hidraw0 hpet hugepages hwrng initctl input kmsg lightnvm log loop0 loop1 loop10 loop11 loop12 loop13 loop14 loop15 loop16 loop17 loop18 loop19 loop2
loop20 loop3 loop4 loop5 loop6 loop7 loop8 loop9 loop-control mapper mcelog mem memory_bandwidth midi mqueue net network_latency network_throughput null port ppp psaux
ptmx pts random rfkill rtc rtc0 sda sda1 serial sg0 sg1 shm snapshot snd sr0 stderr stdin stdout tty tty0 tty1 tty10
tty11 tty12 tty13 tty14 tty15 tty16 tty17 tty18 tty19 tty2 tty20 tty21 tty22 tty23 tty24 tty25 tty26 tty27 tty28 tty29 tty3
tty31 tty32 tty33 tty34 tty35 tty36 tty37 tty38 tty39 tty4 tty40 tty41 tty43 tty44 tty45 tty46 tty47 tty48 tty49 tty5
tty51 tty52 tty53 tty54 tty55 tty56 tty57 tty58 tty59 tty6 tty60 tty61 tty62 tty63 tty7 tty8 tty9 ttyprintk tty50
ttyS10 ttyS11 ttyS12 ttyS13 ttyS14 ttyS15 ttyS16 ttyS17 ttyS18 ttyS19 ttyS2 ttyS20 ttyS21 ttyS22 ttyS23 ttyS24 ttyS25 ttyS26 ttyS27 ttyS28 ttyS29 ttyS30 ttyS31
ttyS4 ttyS5 ttyS6 ttyS7 ttyS8 ttyS9 ttyUSB0 uhid uinput urandom userio vcs vcs1 vcs2 vcs3 vcs4 vcs5 vcs6 vcs7 vcsa vcsa1 vcsa2
vcsa3 vcsa4 vcsa5 vcsa6 vcsa7 vfio vga_arbiter vhci vhost-net vhost-vsock vmci vsock zero
bhimebau@mercury:/dev$


dev : bash — Konsole
File Edit View Bookmarks Settings Help
bhimebau@mercury:/dev$ screen /dev/ttyUSB0 115200


dev :
File Edit View Bookmarks Settings Help
e101-986246 login:

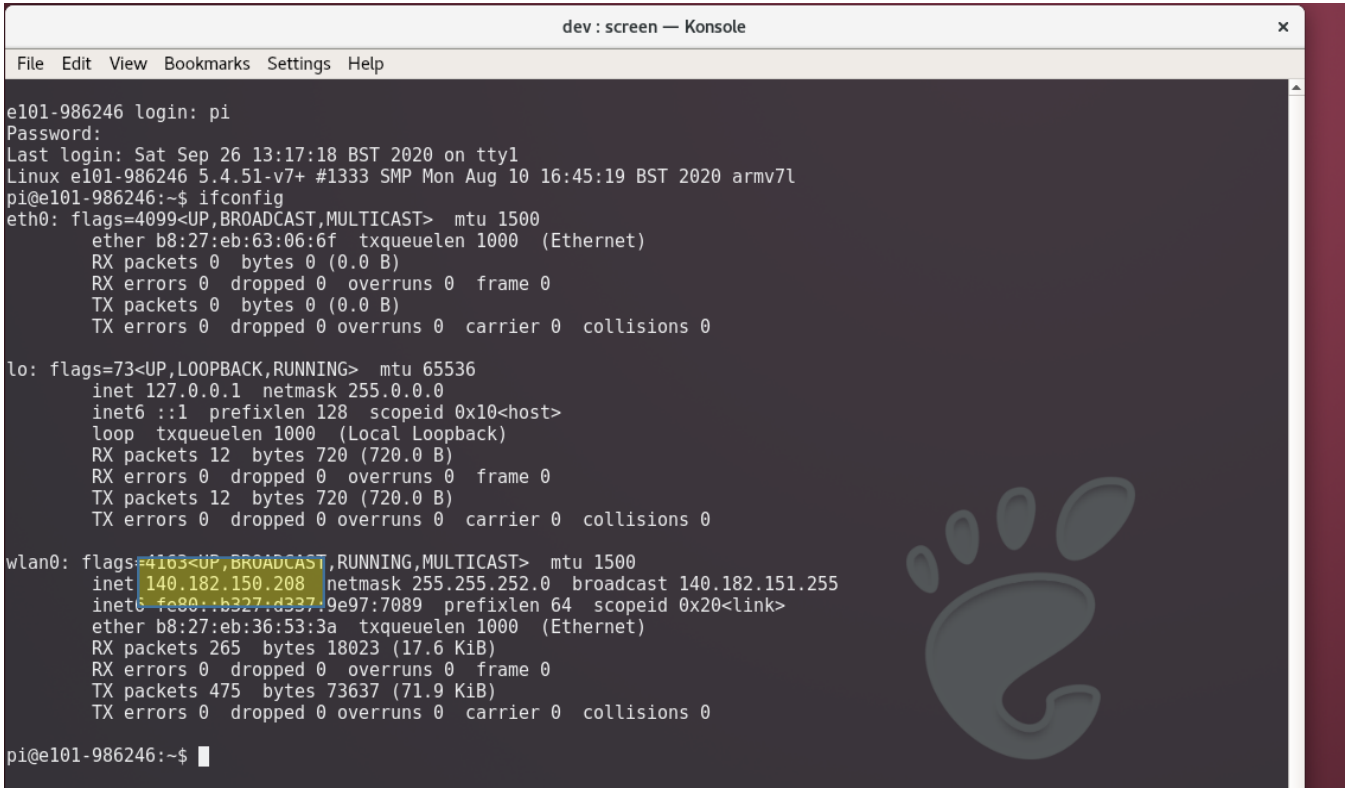
After logging into the machine:

- Username: pi
- Password: e101class

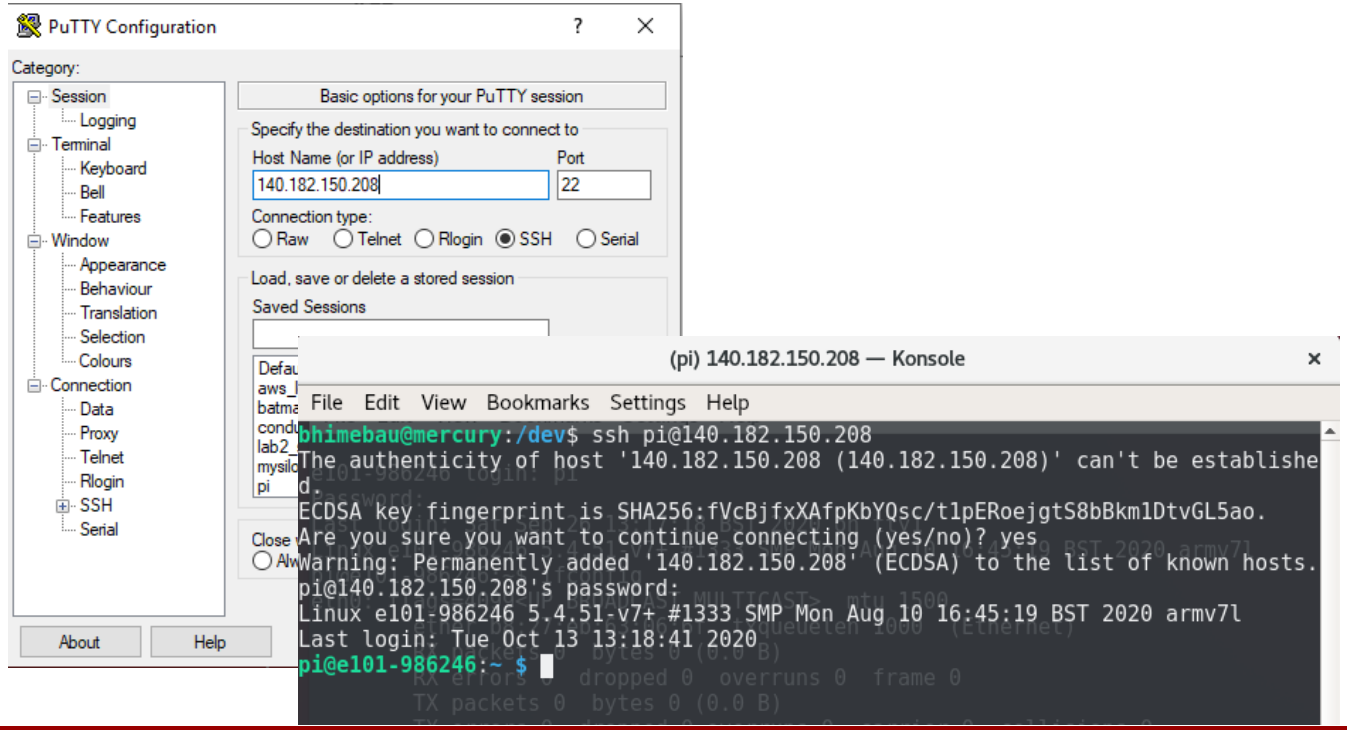


Determine IP Address

- If you are in Luddy, the PI will connect automatically to IU DeviceNet
- You should have an IP address that begins with 140.
- Use the command ifconfig to verify address of wlan0 interface

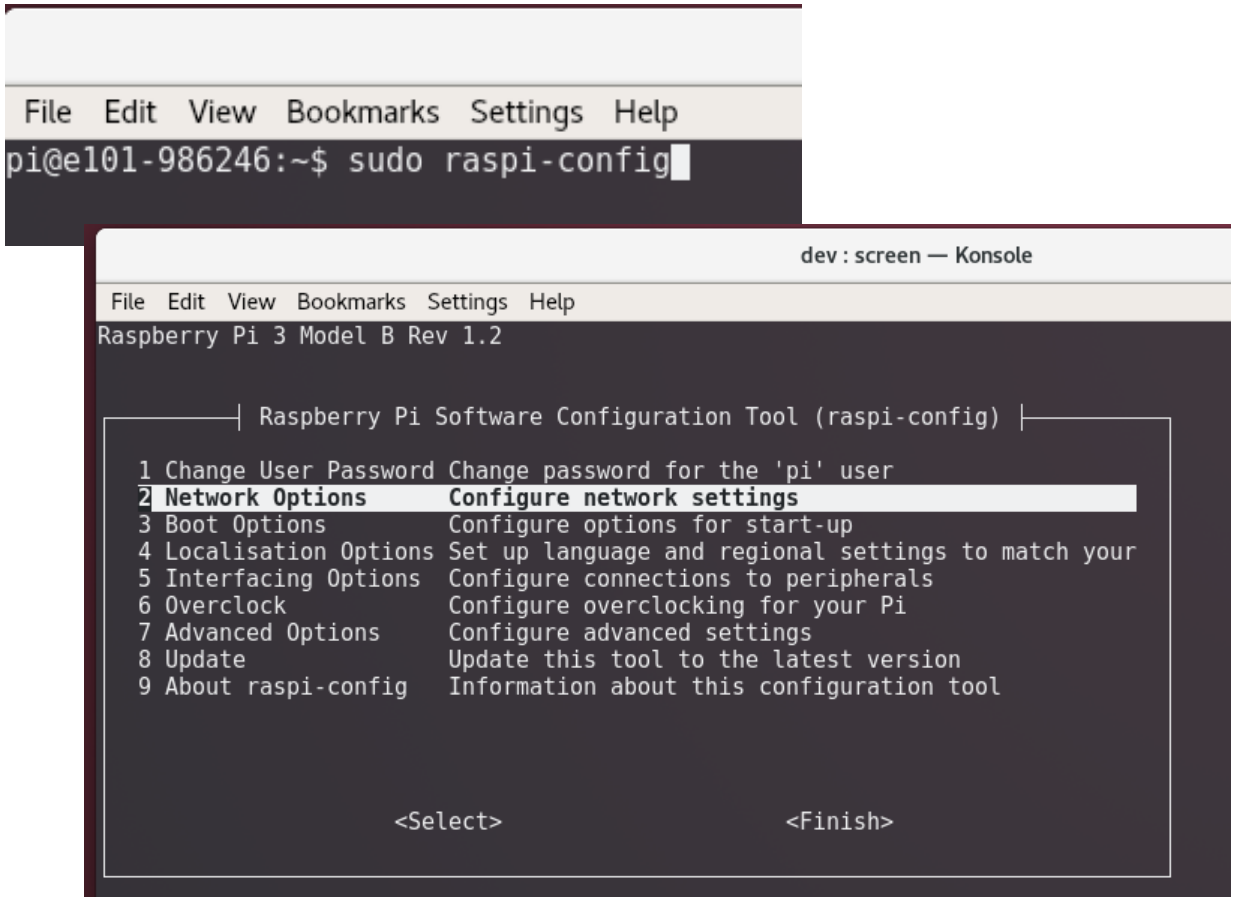

dev : screen — Konsole
File Edit View Bookmarks Settings Help
e101-986246 login: pi
Password:
Last login: Sat Sep 26 13:17:18 BST 2020 on tty1
Linux e101-986246 5.4.51-v7+ #1333 SMP Mon Aug 10 16:45:19 BST 2020 armv7l
pi@e101-986246:~$ ifconfig
eth0: flags=4099<UP,BROADCAST,MULTICAST> mtu 1500
ether b8:27:eb:63:06:6f txqueuelen 1000 (Ethernet)
RX packets 0 bytes 0 (0.0 B)
RX errors 0 dropped 0 overruns 0 frame 0
TX packets 0 bytes 0 (0.0 B)
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
lo: flags=73<UP,LOOPBACK,RUNNING> mtu 65536
inet 127.0.0.1 netmask 255.0.0.0
inet6 ::1 prefixlen 128 scopeid 0x10<host>
loop txqueuelen 1000 (Local Loopback)
RX packets 12 bytes 720 (720.0 B)
RX errors 0 dropped 0 overruns 0 frame 0
TX packets 12 bytes 720 (720.0 B)
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
wlan0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST> mtu 1500
inet 140.182.150.208 netmask 255.255.252.0 broadcast 140.182.151.255
inet6 fe80::b327:d337:9e97:7089 prefixlen 64 scopeid 0x20<link>
ether b8:27:eb:36:53:3a txqueuelen 1000 (Ethernet)
RX packets 265 bytes 18023 (17.6 KiB)
RX errors 0 dropped 0 overruns 0 frame 0
TX packets 475 bytes 73637 (71.9 KiB)
TX errors 0 dropped 0 overruns 0 carrier 0 collisions 0
pi@e101-986246:~$

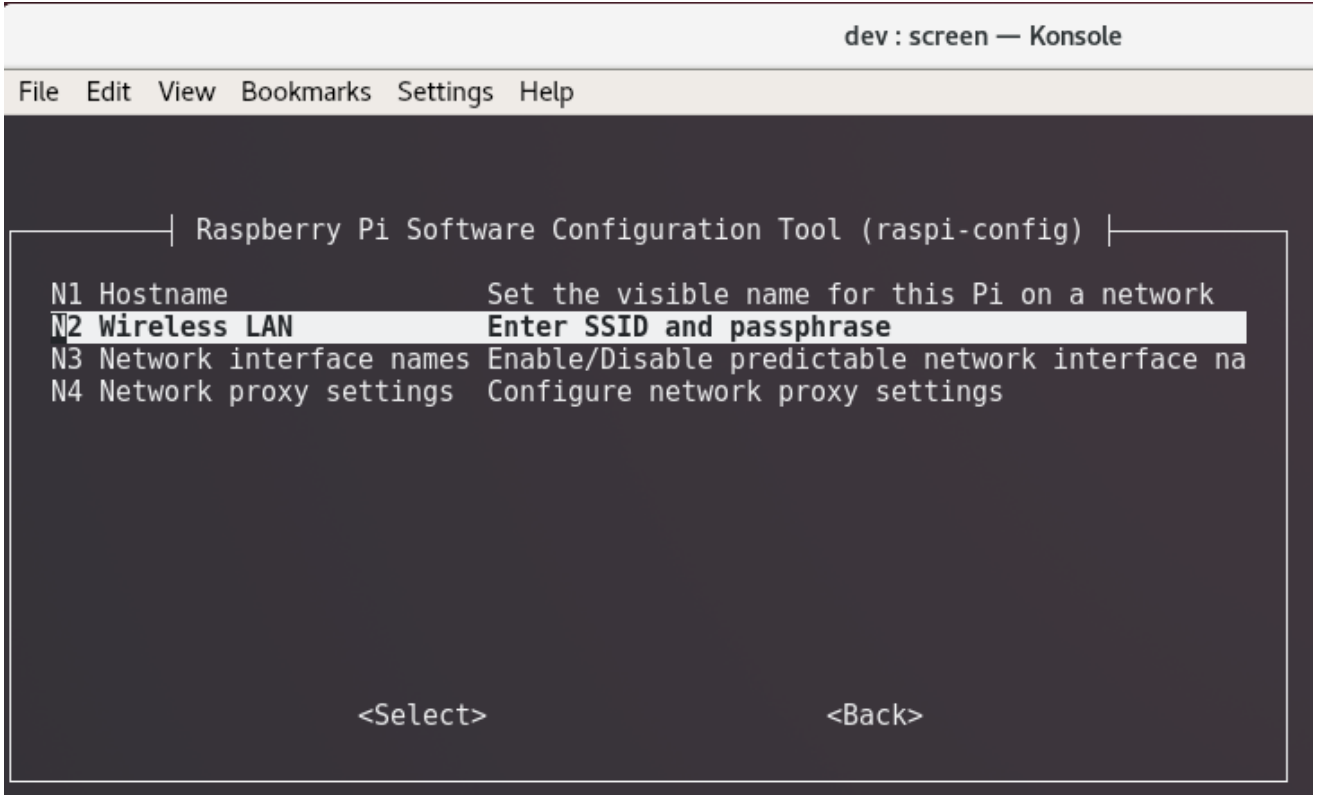
SSH to this IP Address

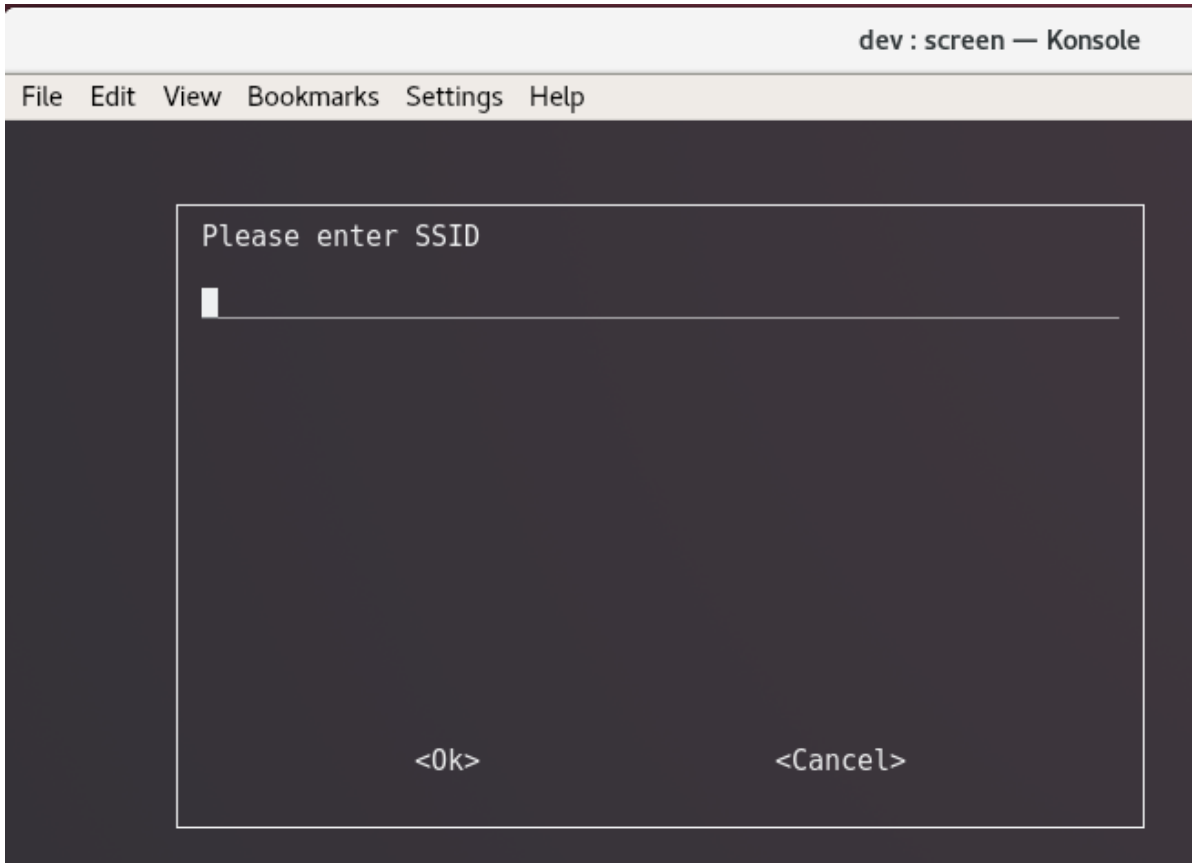


Not at Luddy …

- Use the raspi-config utility to add the name and password of your wireless access point.
- Run the command using sudo. For Example:
  - “sudo raspi-config”


File Edit View Bookmarks Settings Help
pi@e101-986246:~$ sudo raspi-config
dev : screen — Konsole
File Edit View Bookmarks Settings Help
Raspberry Pi 3 Model B Rev 1.2
Raspberry Pi Software Configuration Tool (raspi-config)
1 Change User Password Change password for the 'pi' user
2 Network Options Configure network settings
3 Boot Options Configure options for start-up
4 Localisation Options Set up language and regional settings to match your
5 Interfacing Options Configure connections to peripherals
6 Overclock Configure overclocking for your Pi
7 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>


dev : screen — Konsole
File Edit View Bookmarks Settings Help
Raspberry Pi Software Configuration Tool (raspi-config)
N1 Hostname Set the visible name for this Pi on a network
N2 Wireless LAN Enter SSID and passphrase
N3 Network interface names Enable/Disable predictable network interface na
N4 Network proxy settings Configure network proxy settings
<Select>
<Back>


dev : screen — Konsole
File Edit View Bookmarks Settings Help
Please enter SSID
<Ok>
<Cancel>