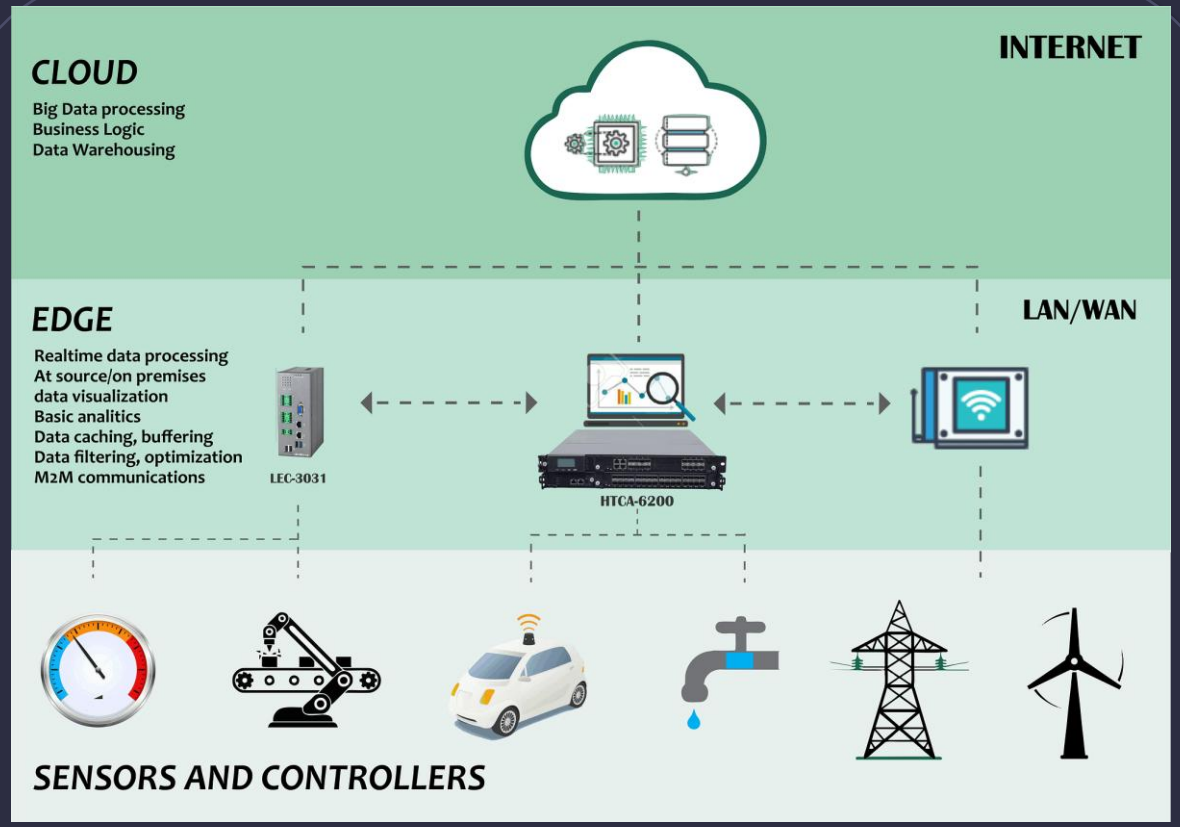
Internet of Things

System Design with Sensors
Linux Applications

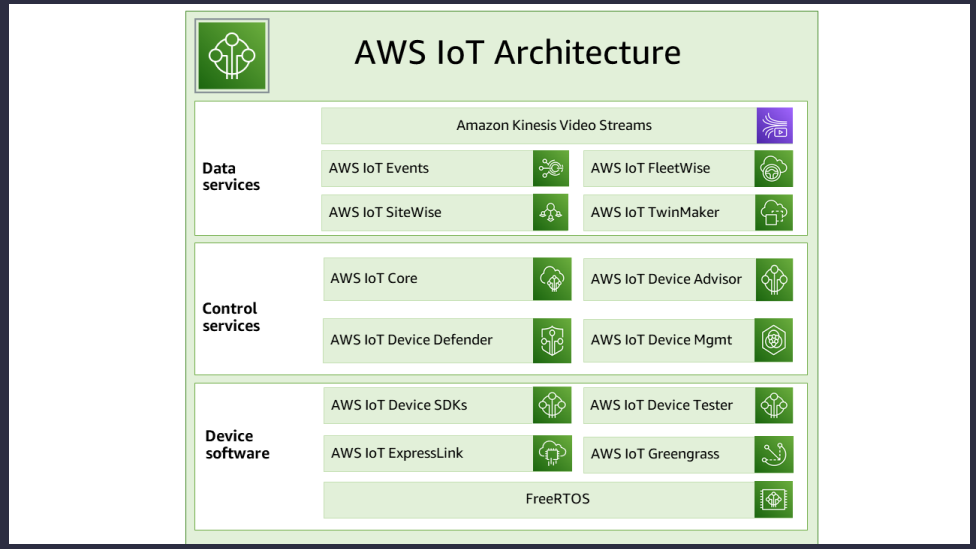
Fenerbahce University

How IoT Systems Work (End-to-End)

A practical mental model: device → network → edge/gateway → cloud → dashboard → actions



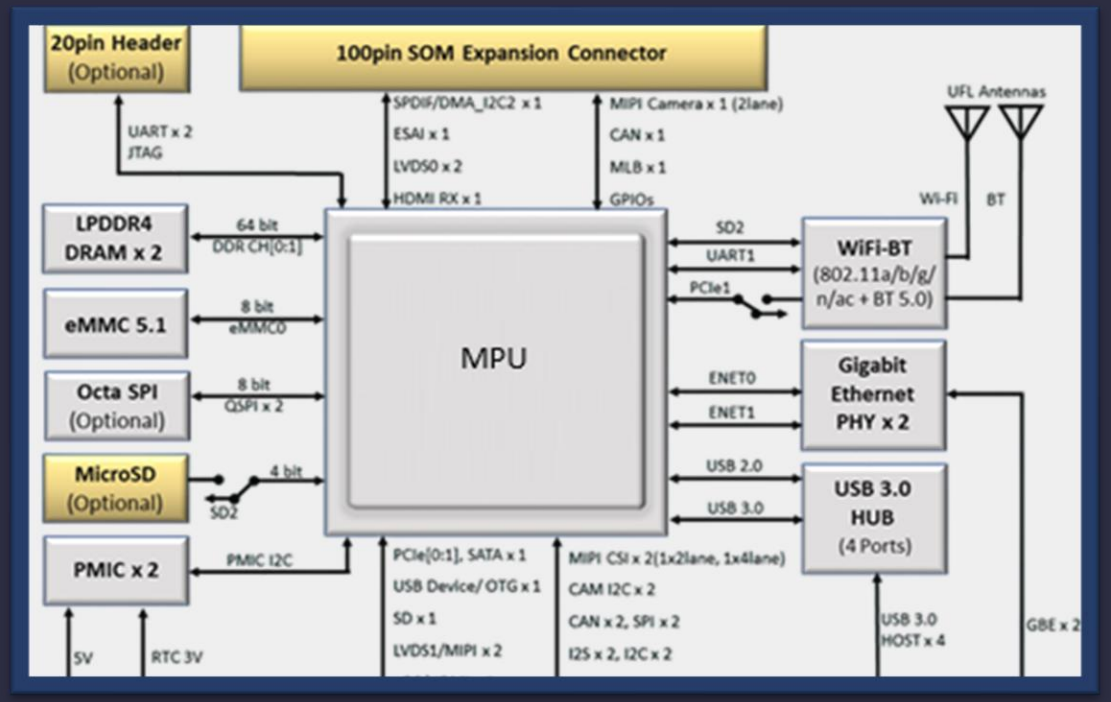
Edge–Fog–Cloud reference diagram



Example: AWS IoT “how it works” overview

System Design with Sensors III – Embedded Linux

- Microprocessor Unit
  - MPU (Microprocessor Unit)
    - Works with external RAM and storage, often used in embedded Linux systems.
    - More powerful than an MCU but not as strong as a CPU.
    - Handles higher-performance tasks requiring an OS.
    - Average Frequency: 500 MHz - 2.5 GHz
    - Average FLOPS: 1 GFLOPS - 10 GFLOPS

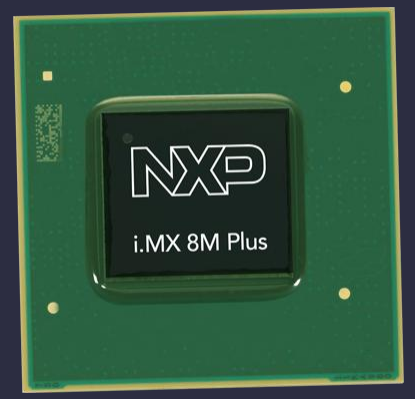


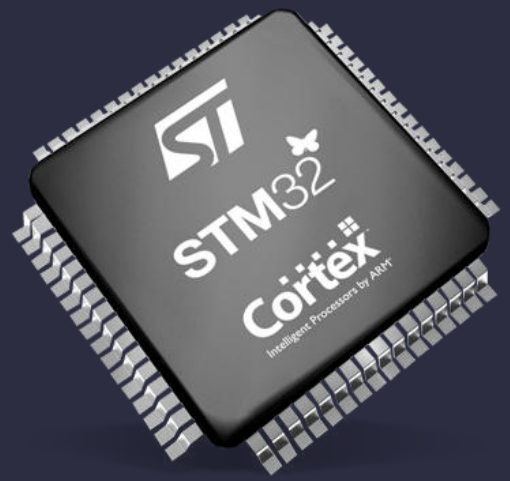
System Design with Sensors III – Embedded Linux

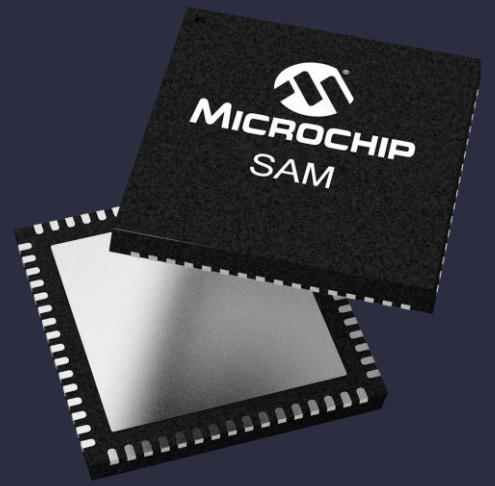
- Microprocessor Unit

  - MPU (Microprocessor Unit)

  - Vendors
    - NXP Semiconductors (i.MX)
    - Texas Instruments (Sitara)
    - ST Microelectronics (STM32)
    - Microchip Technology (SAM)





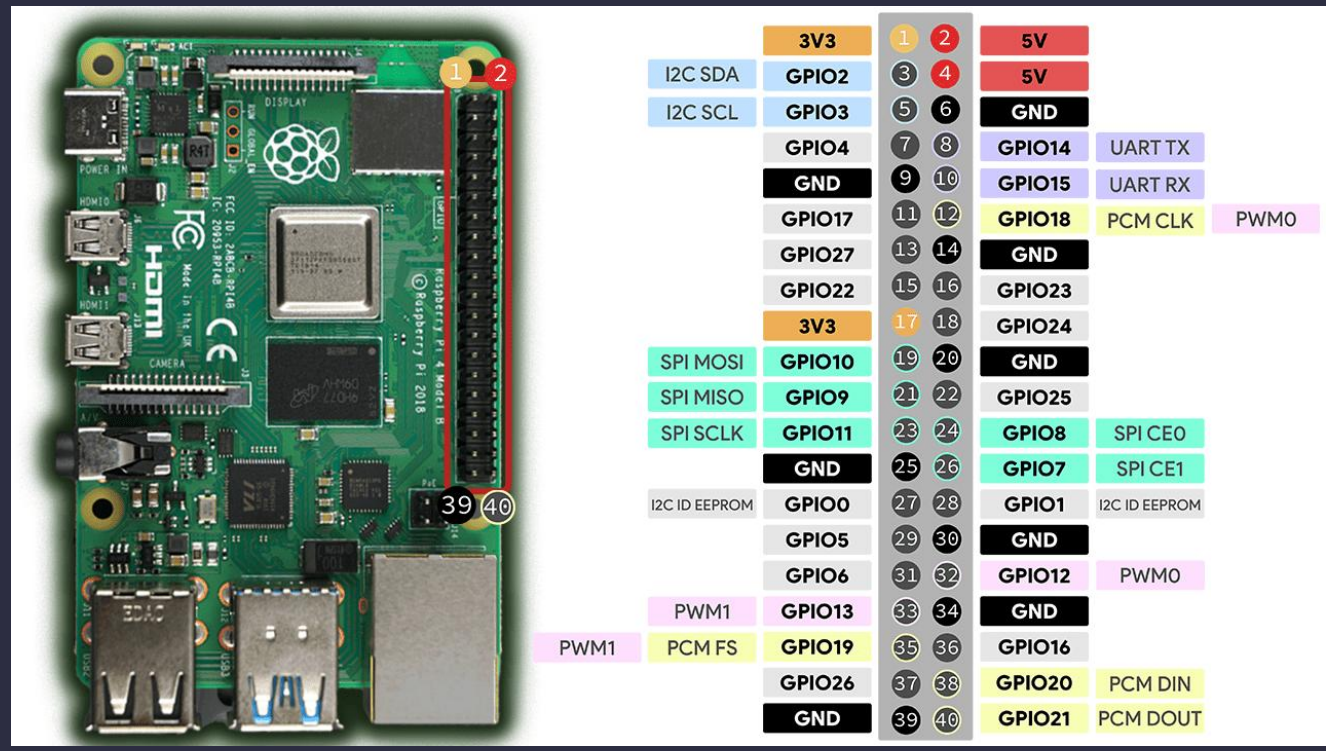


System Design with Sensors III – Embedded Linux

- Microprocessor Unit

  - MPU (Microprocessor Unit)

  - Development Board
  - Rasberry PI 3
    - HDMI
    - 4× USB 2.0
    - CSI (camera) port
    - DSI (display) port
    - 2.4/5GHz dual-band 802.11ac Wi-Fi (100Mb/s)
    - Bluetooth 4.2, Bluetooth Low Energy (BLE)
    - MicroSD card slot
    - Micro USB power



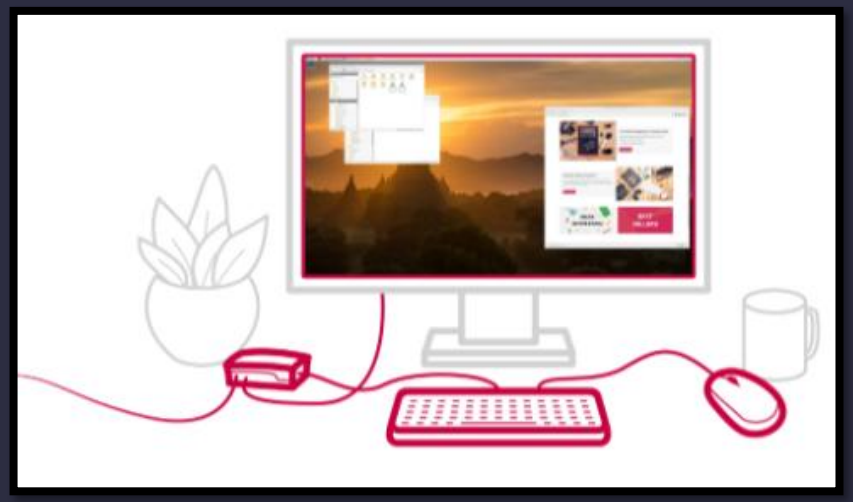
System Design with Sensors III – Embedded Linux

- Microprocessor Unit

  - Rasberry PI

  OS Options

  - Raspberry Pi OS (Raspbian)
  - Ubuntu
  - Fedora
  - Kali Linux
  - Others…



System Design with Sensors III – Embedded Linux

- Microprocessor Unit

  - Rasberry PI

  OS Options

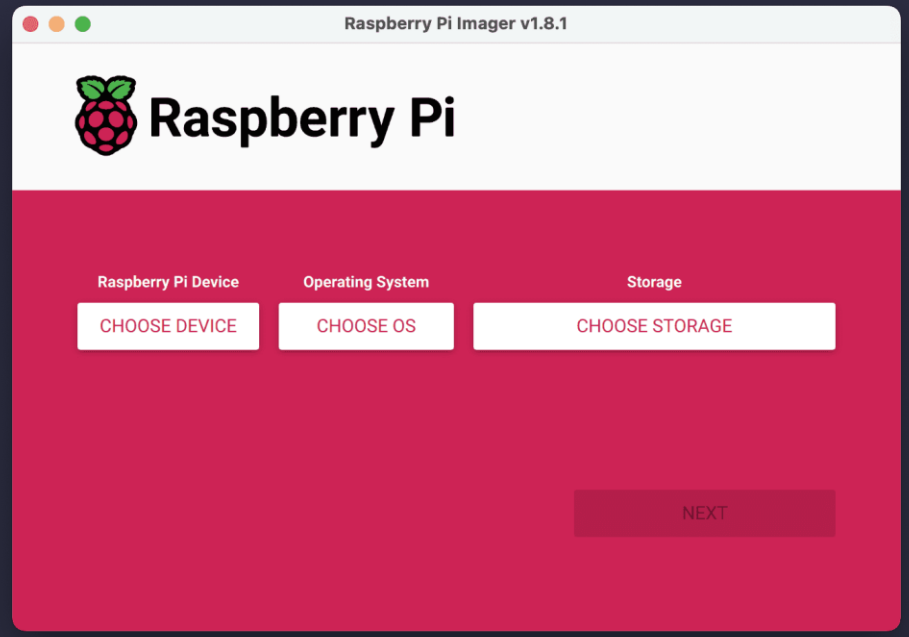
  - Raspberry Pi OS (Raspbian)

  Goto

  https://www.raspberrypi.com/software

  Download

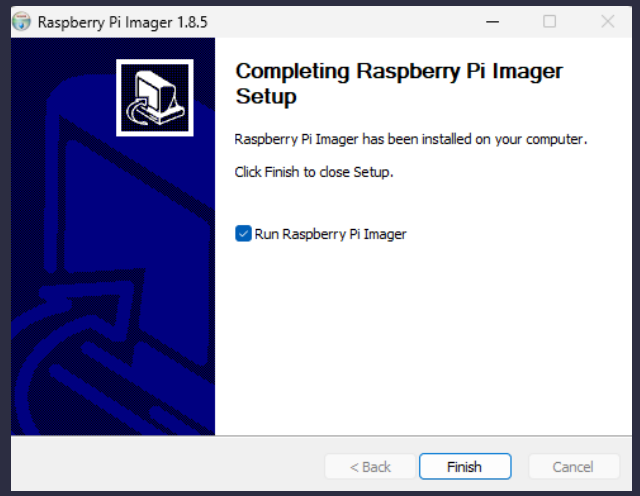
  Rasberry Pi Imager



System Design with Sensors III – Embedded Linux

- Microprocessor Unit
  - Rasberry PI

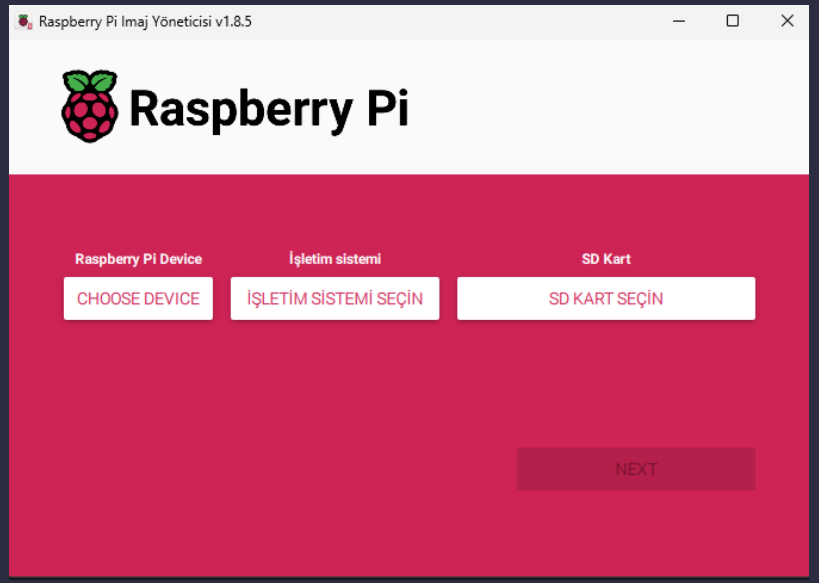
Install Rasberry PI Imager

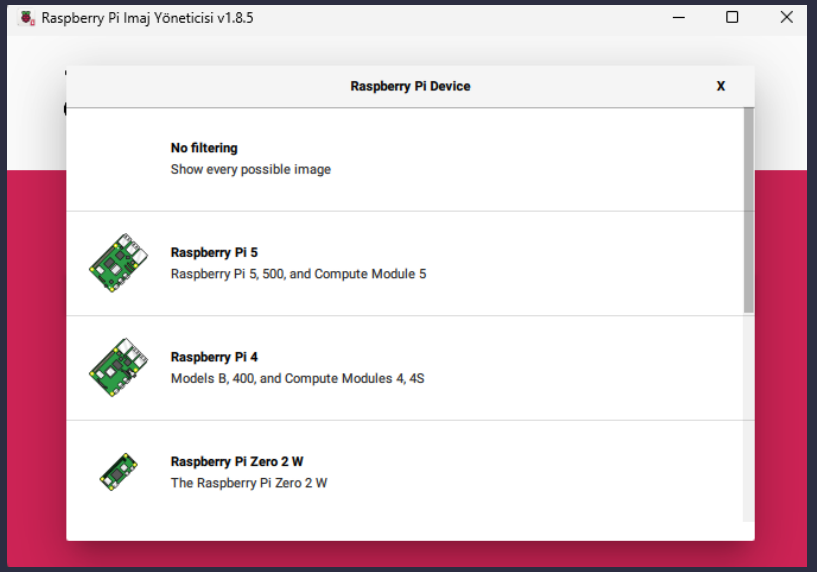


System Design with Sensors III – Embedded Linux

- Microprocessor Unit
  - Rasberry PI

Select Device

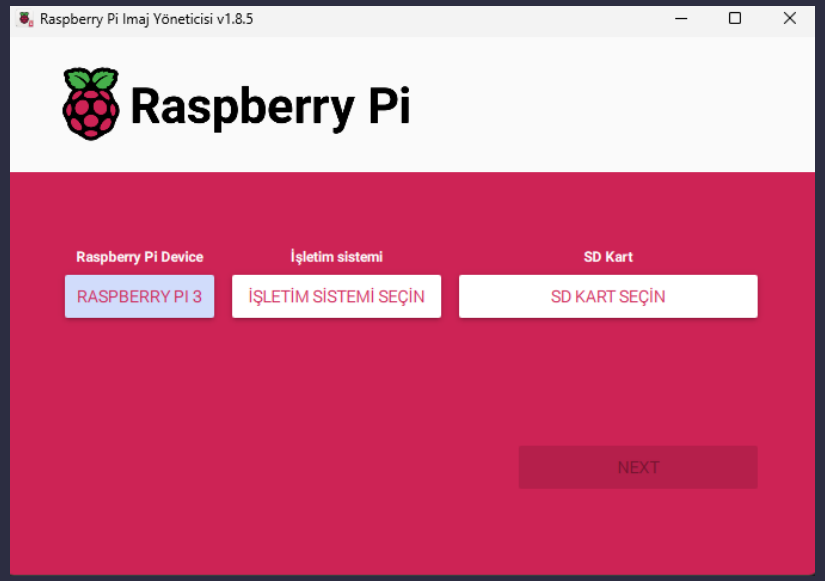


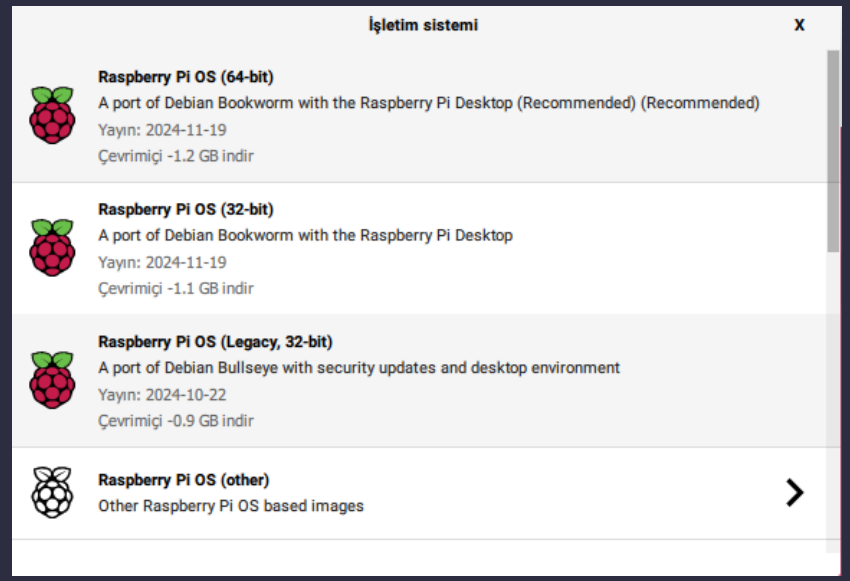


System Design with Sensors III – Embedded Linux

- Microprocessor Unit
  - Rasberry PI

Select OS

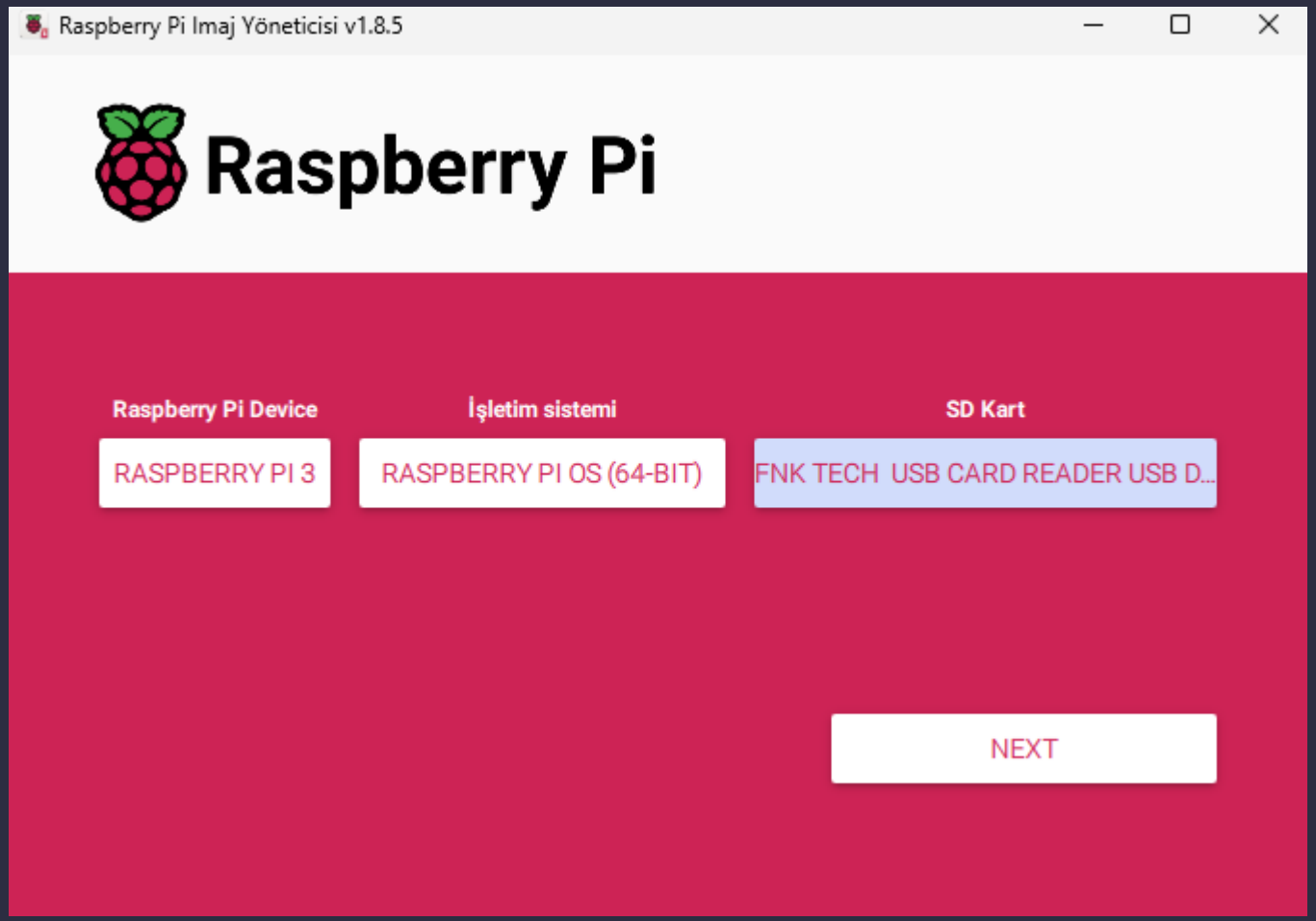




System Design with Sensors III – Embedded Linux

- Microprocessor Unit
  - Rasberry PI

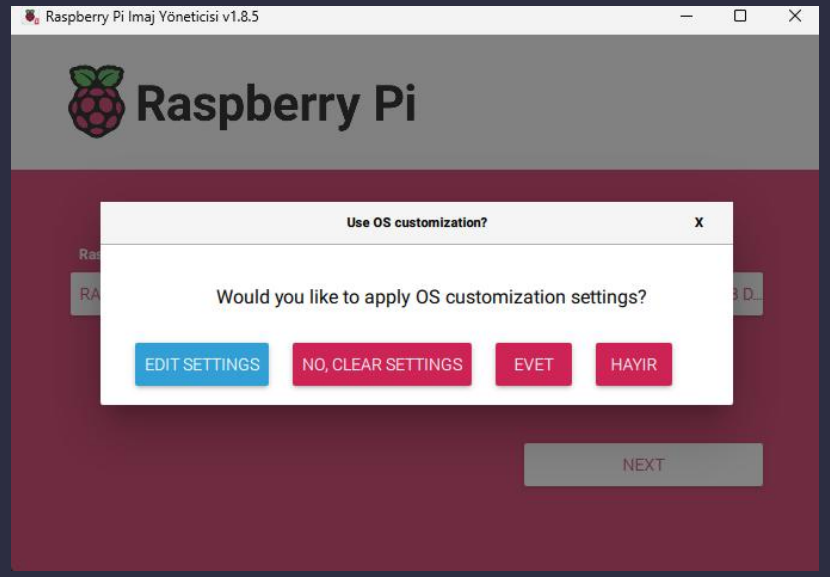
Select SD Card

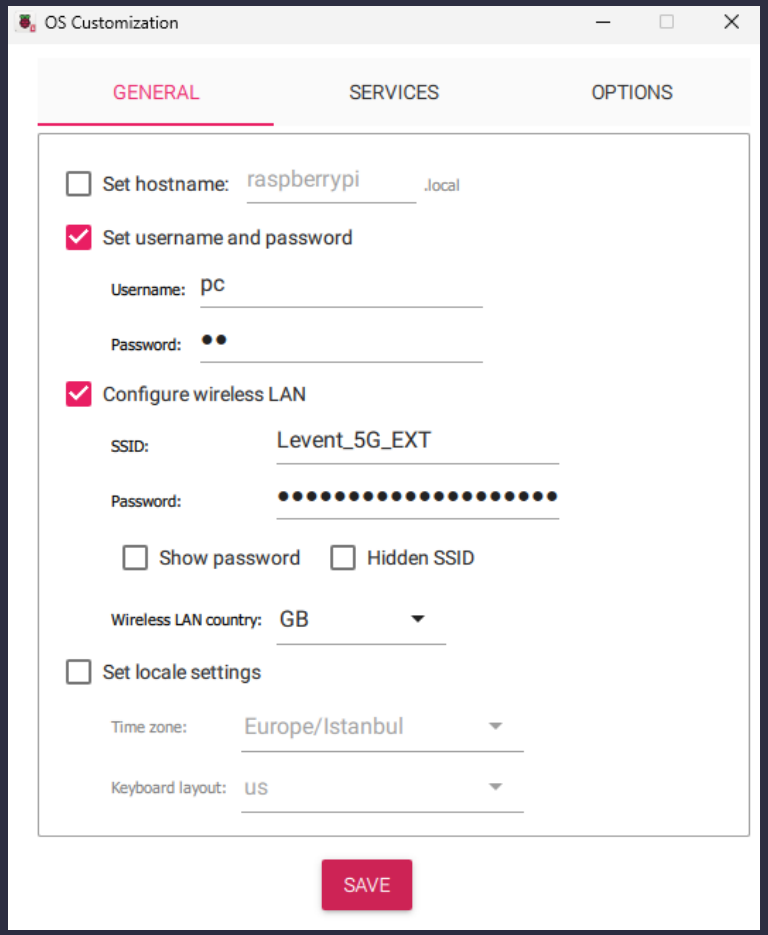


System Design with Sensors III – Embedded Linux

- Microprocessor Unit
  - Rasberry PI

Select SD Card

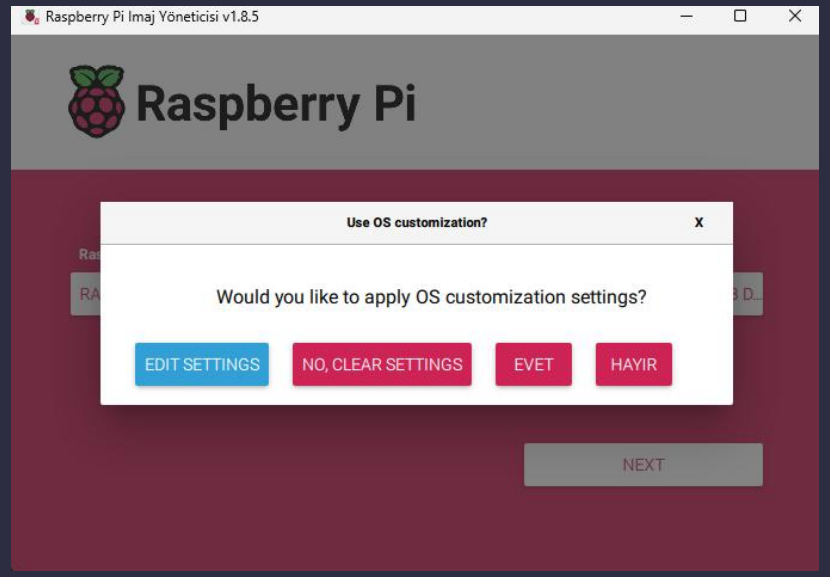


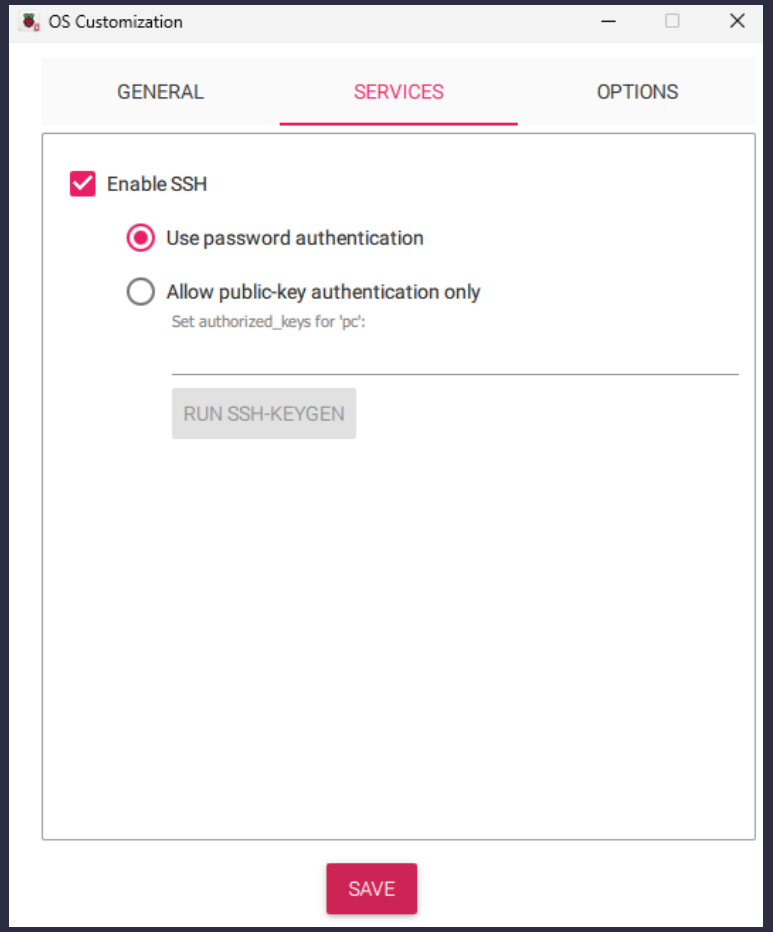


System Design with Sensors III – Embedded Linux

- Microprocessor Unit
  - Rasberry PI

Select SD Card

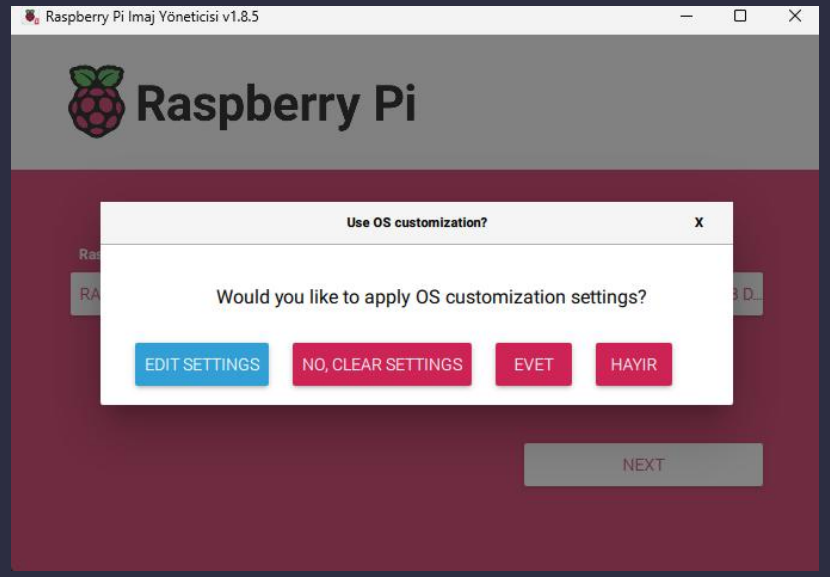


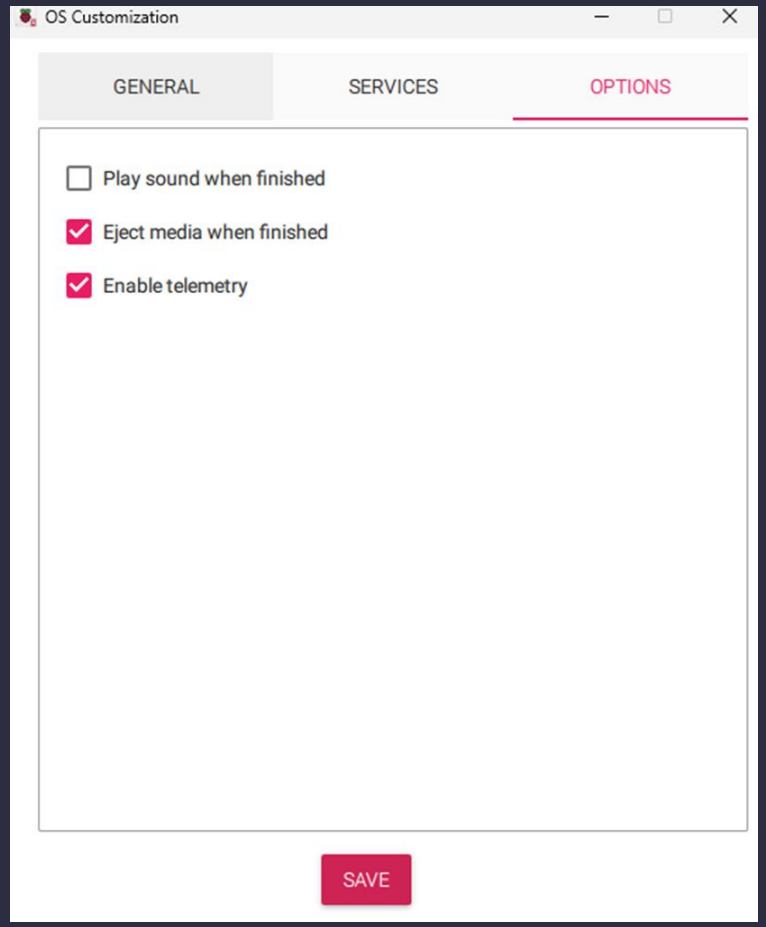


System Design with Sensors III – Embedded Linux

- Microprocessor Unit
  - Rasberry PI

Select SD Card



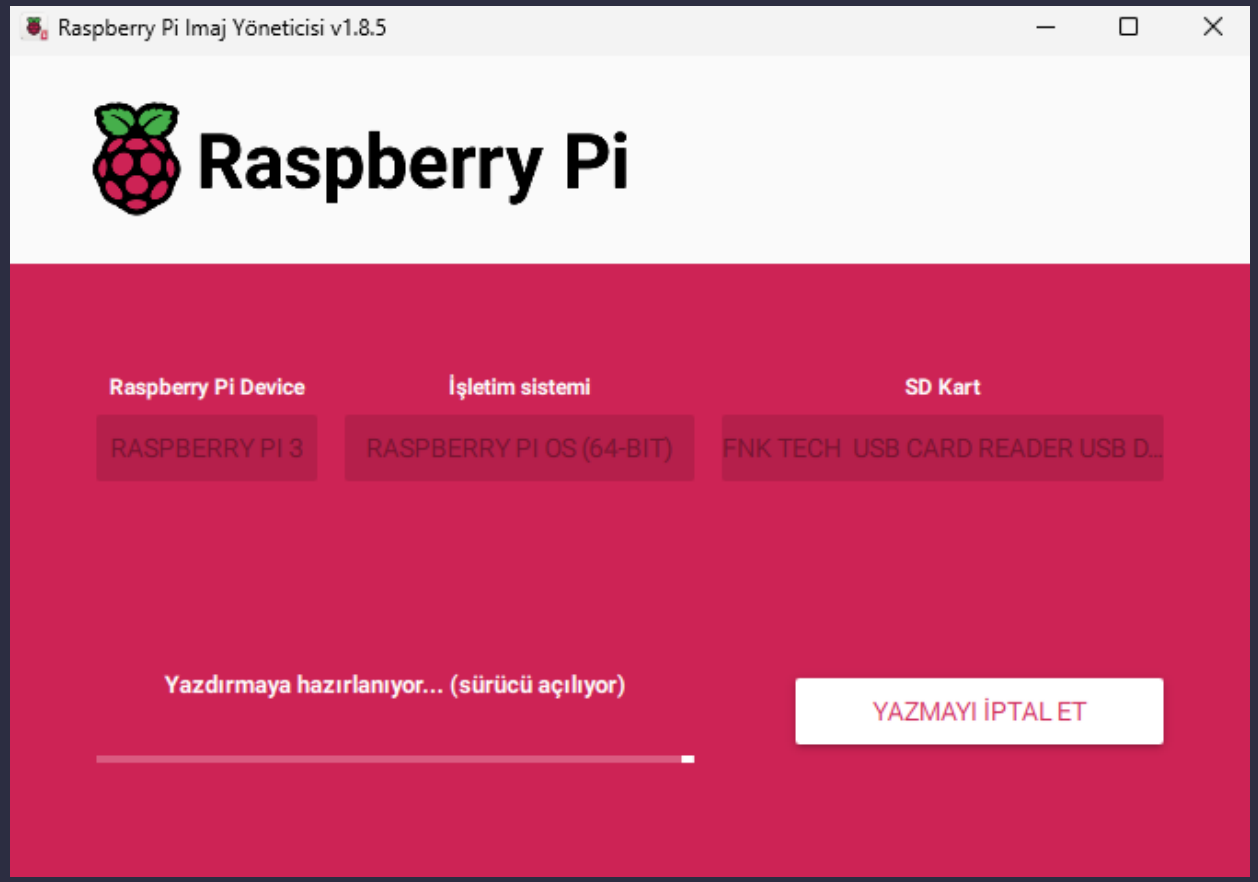


System Design with Sensors III – Embedded Linux

- Microprocessor Unit
  - Rasberry PI

Imager tool will

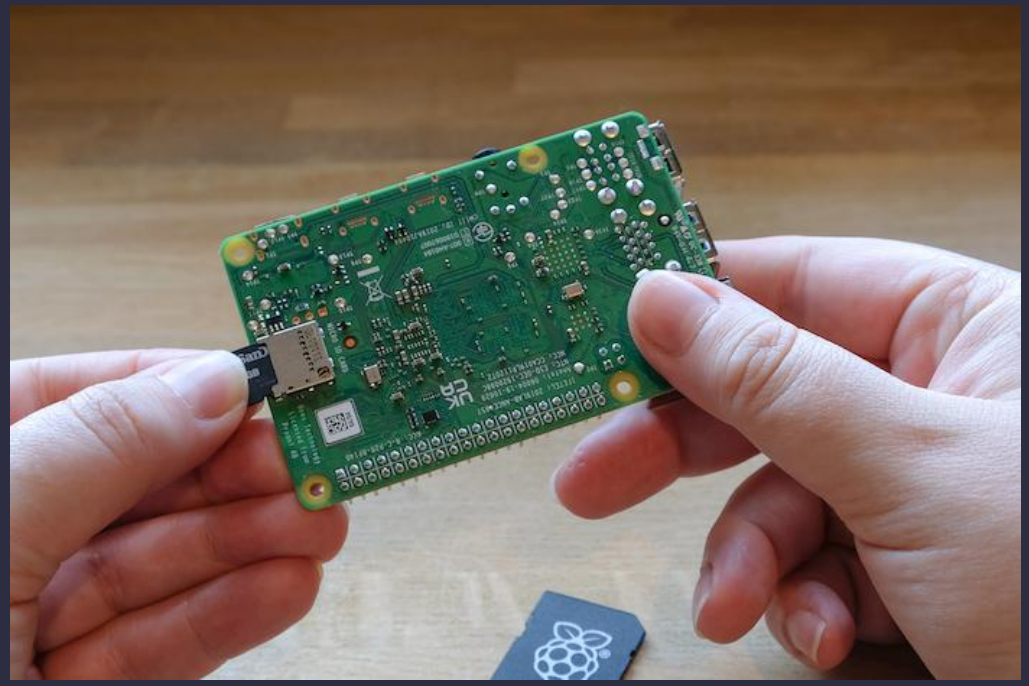
- Download Image
- Writes to SD Card



System Design with Sensors III – Embedded Linux

- Microprocessor Unit
  - Rasberry PI

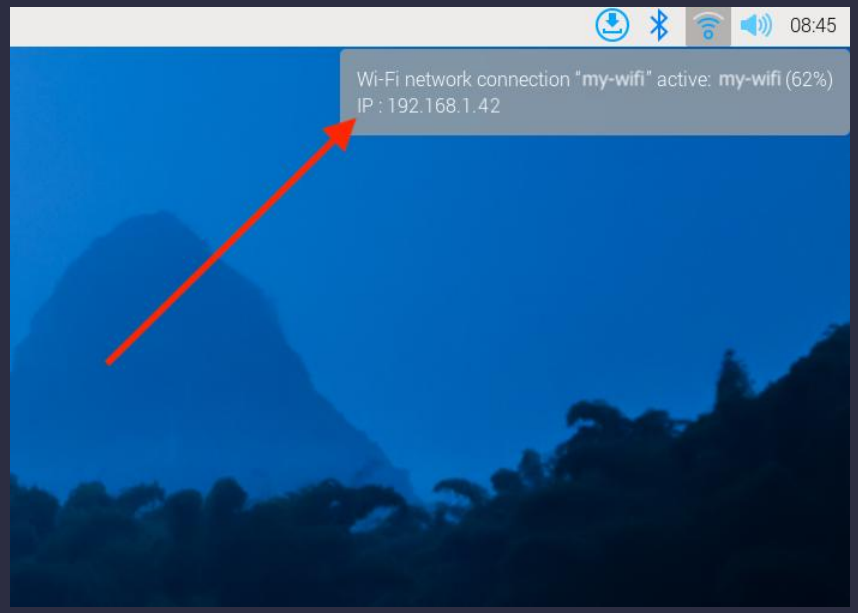
Insert SD Card to RPI



System Design with Sensors III – Embedded Linux

- Microprocessor Unit
  - Rasberry PI

Connect to Network

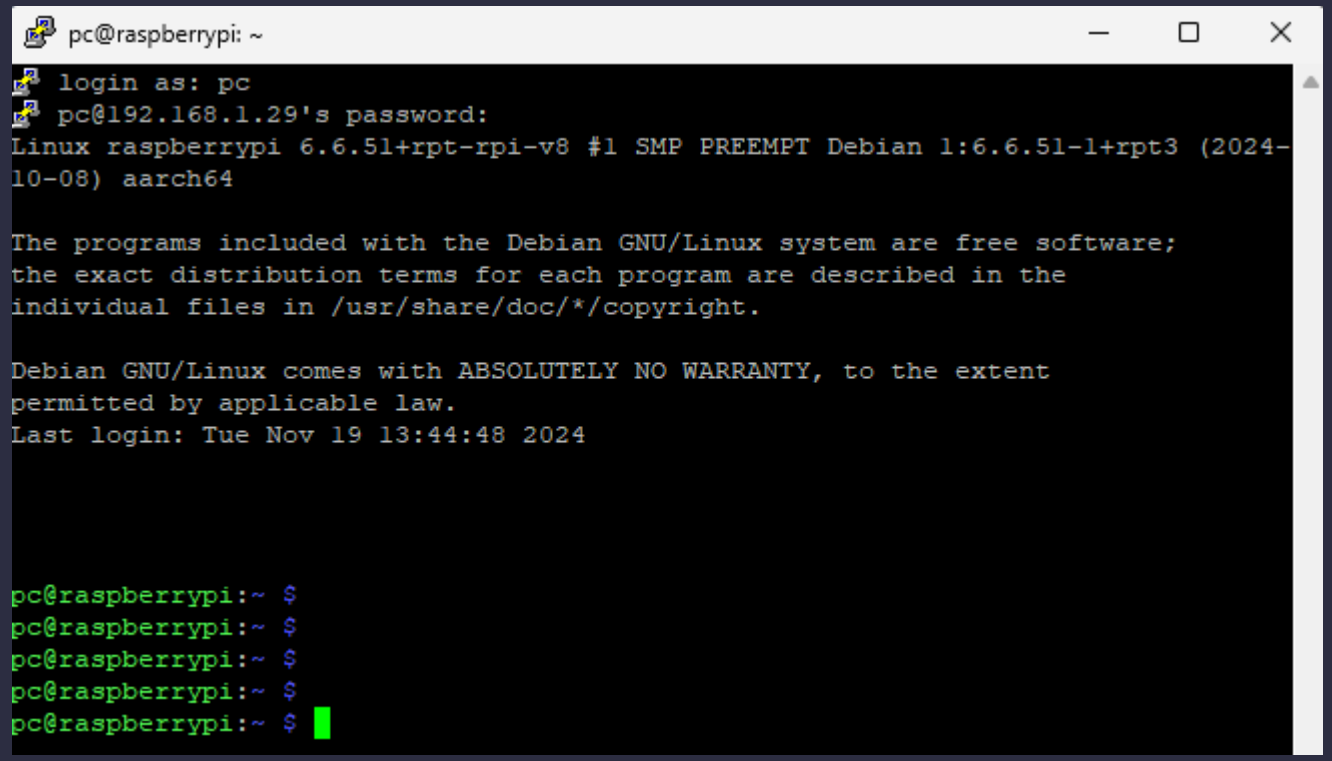


192.168.1.26	[yok]	[taranmadı]	[taranmadı]
192.168.1.27	[yok]	[taranmadı]	[taranmadı]
192.168.1.28	[yok]	[taranmadı]	[taranmadı]
192.168.1.29	150 ms	raspberrypi.bbrouter	[yok]
192.168.1.30	[yok]	[taranmadı]	[taranmadı]

System Design with Sensors III – Embedded Linux

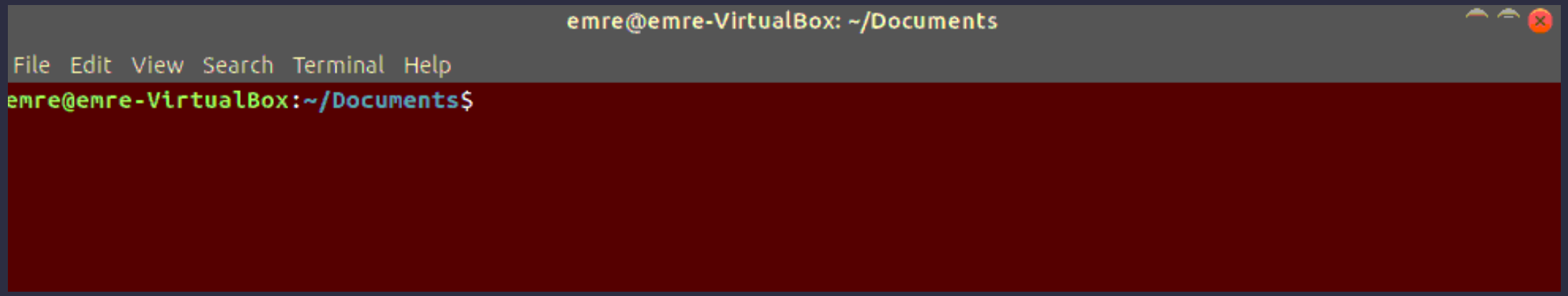
- Microprocessor Unit
  - Rasberry PI

Connect with Putty



Fundamental Linux Commands

If you are using a GUI based OS, you may type CNTRL + ALT + t
for opening terminal



Fundamental Linux Commands

pwd: Shows full path of working directory

```
emre@emre-VirtualBox:~/Downloads$ pwd
/home/emre/Downloads
```

Fundamental Linux Commands

ls: List files and directories under current working directory

```
emre@emre-VirtualBox:~/Downloads$ ls
petalinux-v2021.2-final-installer.run
pynq-supported-board-file-master.zip
Xilinx_Unified_2021.2_1021_0703_Lin64.bin
```

ls –al: List detailed files and directories under current working directory

```
emre@emre-VirtualBox:~/Downloads$ ls -al
total 2483188
drwxr-xr-x  2 emre emre       4096 Oca 22 16:42 .
drwxr-xr-x 41 emre emre       4096 Oca 22 16:34 ..
-rwxrw-r--  1 emre emre 2255897193 Ara 16 15:13 petalinux-v2021.2-final-installer.run
-rw-rw-r--  1 emre emre     812456 Ara 16 20:59 pynq-supported-board-file-master.zip
-rwxrw-r--  1 emre emre  286051682 Ara 16 15:09 Xilinx_Unified_2021.2_1021_0703_Lin64.bin
```

Fundamental Linux Commands

If you want more detail about command you can use

man "command"

```
emre@emre-VirtualBox:~/Downloads$ man ls
```

This will show detailed manual of command

```
LS(1)                                User Commands                                LS(1)

NAME
       ls - list directory contents

SYNOPSIS
       ls [OPTION]... [FILE]...

DESCRIPTION
       List  information about the FILEs (the current directory by default).  Sort entries alphabetically
       if none of -cftuvSUX nor --sort is specified.

       Mandatory arguments to long options are mandatory for short options too.

       -a, --all
              do not ignore entries starting with .

       -A, --almost-all
              do not list implied . and ..

       --author
              with -l, print the author of each file
```

Fundamental Linux Commands

cd: Changes working folder

```
emre@emre-VirtualBox:~/Downloads$ cd /home/emre/Desktop
emre@emre-VirtualBox:~/Desktop$ pwd
/home/emre/Desktop
emre@emre-VirtualBox:~/Desktop$
```

For going upper folder

```
emre@emre-VirtualBox:~/Desktop$ cd ..
emre@emre-VirtualBox:~$ pwd
/home/emre
emre@emre-VirtualBox:~$
```

Fundamental Linux Commands

mkdir: Creates folder

```
emre@emre-VirtualBox:~/Documents$ ls
emre@emre-VirtualBox:~/Documents$ mkdir test
emre@emre-VirtualBox:~/Documents$ ls
test
emre@emre-VirtualBox:~/Documents$ ls -al
total 12
drwxr-xr-x  3 emre emre 4096 Oca 22 17:03 .
drwxr-xr-x 41 emre emre 4096 Oca 22 17:02 ..
drwxrwxr-x  2 emre emre 4096 Oca 22 17:03 test
```

Fundamental Linux Commands

sudo: Super user command execution

sudo command …

Fundamental Linux Commands

- chmod: Change a file or folder authorizations

```
emre@emre-VirtualBox:~/Documents$ ls
test  testfile
emre@emre-VirtualBox:~/Documents$ ls -al
total 12
drwxr-xr-x  3 emre emre 4096 Oca 22 17:07 .
drwxr-xr-x 41 emre emre 4096 Oca 22 17:02 ..
drwxrwxr-x  2 emre emre 4096 Oca 22 17:03 test
-rw-rw-r--  1 emre emre    0 Oca 22 17:07 testfile
emre@emre-VirtualBox:~/Documents$ sudo chmod 777 testfile
[sudo] password for emre:
emre@emre-VirtualBox:~/Documents$ ls -al
total 12
drwxr-xr-x  3 emre emre 4096 Oca 22 17:07 .
drwxr-xr-x 41 emre emre 4096 Oca 22 17:02 ..
drwxrwxr-x  2 emre emre 4096 Oca 22 17:03 test
-rwxrwxrwx  1 emre emre    0 Oca 22 17:07 testfile
```

Fundamental Linux Commands

- chmod: Change a file or folder authorizations, authorize for execution

  chmod u+x petalinux-v202.X.X-final-installer.run

```
emre@emre-VirtualBox:~/Downloads$ sudo chmod u+x petalinux-v2021.2-final-install
er.run
emre@emre-VirtualBox:~/Downloads$ ls -al
total 2483188
drwxr-xr-x  2 emre emre       4096 Oca 22 16:42 .
drwxr-xr-x 41 emre emre       4096 Oca 22 16:34 ..
-rwxrw-r--  1 emre emre 2255897193 Ara 16 15:13 petalinux-v2021.2-final-installe
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.zip
-rwxrw-r--  1 emre emre  286051682 Ara 16 15:09 Xilinx_Unified_2021.2_1021_0703_
Lin64.bin
```

Fundamental Linux Commands

- rm: Remove a file

```
emre@emre-VirtualBox:~/Documents$ ls -al
total 12
drwxr-xr-x  3 emre emre 4096 Oca 22 17:07 .
drwxr-xr-x 41 emre emre 4096 Oca 22 17:02 ..
drwxrwxr-x  2 emre emre 4096 Oca 22 17:03 test
-rwxrwxrwx  1 emre emre    0 Oca 22 17:07 testfile
emre@emre-VirtualBox:~/Documents$ rm testfile
emre@emre-VirtualBox:~/Documents$ ls -al
total 12
drwxr-xr-x  3 emre emre 4096 Oca 22 17:09 .
drwxr-xr-x 41 emre emre 4096 Oca 22 17:02 ..
drwxrwxr-x  2 emre emre 4096 Oca 22 17:03 test
```

Fundamental Linux Commands

- rm -rf: Remove a folder

```
emre@emre-VirtualBox:~/Documents$ ls -al
total 12
drwxr-xr-x  3 emre emre 4096 Oca 22 17:09 .
drwxr-xr-x 41 emre emre 4096 Oca 22 17:02 ..
drwxrwxr-x  2 emre emre 4096 Oca 22 17:03 test
emre@emre-VirtualBox:~/Documents$ rm -rf test
emre@emre-VirtualBox:~/Documents$ ls -al
total 8
drwxr-xr-x  2 emre emre 4096 Oca 22 17:09 .
drwxr-xr-x 41 emre emre 4096 Oca 22 17:02 ..
```

Fundamental Linux Commands

- history: Shows previously entered commands

```
404  ls -al
405  sudo chmod 777 testfile
406  ls -al
407  rm testfile
408  ls -al
409  rm -rf test
410  ls -al
411  history
```

Fundamental Linux Commands

- touch: Creates empty file

```
emre@emre-VirtualBox:~/Documents$ ls -al
total 8
drwxr-xr-x  2 emre emre 4096 Oca 22 17:09 .
drwxr-xr-x 41 emre emre 4096 Oca 22 17:02 ..
emre@emre-VirtualBox:~/Documents$ touch testX
emre@emre-VirtualBox:~/Documents$ ls -al
total 8
drwxr-xr-x  2 emre emre 4096 Oca 22 17:19 .
drwxr-xr-x 41 emre emre 4096 Oca 22 17:02 ..
-rw-rw-r--  1 emre emre    0 Oca 22 17:19 testX
```

Fundamental Linux Commands

- exit: Closes current terminal

Fundamental Linux Commands

- To execute a executable file

./executableFile

- If this file is a shell script then you may call

sh script.sh

- Also you may use source command for execute a shell script

source script.sh

Difference ise sh creates new session and losts if this script sets environment variables

Fundamental Linux Commands

- export: to set a environmet variable:

export: variableName="test"

```
emre@emre-VirtualBox:~/Documents$ export testVar="deneme"
```

Fundamental Linux Commands

- echo: print variables:

echo $varName

```
emre@emre-VirtualBox:~/Documents$ echo $testVar
deneme
```

Fundamental Linux Commands

- ip a: lists current ethernet settings

```
emre@emre-VirtualBox:~/Documents$ ip a
1: lo: <LOOPBACK,UP,LOWER_UP> mtu 65536 qdisc noqueue state UNKNOWN group defaul
t qlen 1000
    link/loopback 00:00:00:00:00:00 brd 00:00:00:00:00:00
    inet 127.0.0.1/8 scope host lo
       valid_lft forever preferred_lft forever
    inet6 ::1/128 scope host
       valid_lft forever preferred_lft forever
2: enp0s3: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc fq_codel state UP gr
oup default qlen 1000
    link/ether 08:00:27:e4:f8:c4 brd ff:ff:ff:ff:ff:ff
    inet 10.0.2.15/24 brd 10.0.2.255 scope global dynamic noprefixroute enp0s3
       valid_lft 82776sec preferred_lft 82776sec
    inet6 fe80::62a0:5fee:8f60:af5/64 scope link noprefixroute
       valid_lft forever preferred_lft forever
```

Fundamental Linux Commands

- ping: Send a ethernet packet to remote host for checking alive test

```
emre@emre-VirtualBox:~/Documents$ ping 10.0.2.15
PING 10.0.2.15 (10.0.2.15) 56(84) bytes of data.
64 bytes from 10.0.2.15: icmp_seq=1 ttl=64 time=0.032 ms
64 bytes from 10.0.2.15: icmp_seq=2 ttl=64 time=0.024 ms
64 bytes from 10.0.2.15: icmp_seq=3 ttl=64 time=0.024 ms
```

Fundamental Linux Commands

- ps aux: List all process currently working

```
root     17335  0.0  0.0      0     0 ?        I    16:48   0:00 [kworker/2:2]
emre     17356  0.0  0.0  29908  4328 pts/0    T    16:55   0:00 man ls
emre     17366  0.0  0.0  18376   952 pts/0    T    16:55   0:00 pager
emre     17376  0.0  0.0  29908  4252 pts/0    T    16:57   0:00 man ls
emre     17386  0.0  0.0  18376  1040 pts/0    T    16:57   0:00 pager
emre     17416  0.1  0.5 680460 47400 pts/0    Sl+  17:02   0:03 gedit x.txt
emre     17426  0.0  0.1  35420  9812 pts/1    Ss   17:03   0:00 bash
root     17446  0.0  0.0      0     0 ?        I    17:05   0:00 [kworker/0:0-cg
root     17474  0.0  0.0      0     0 ?        I    17:09   0:00 [kworker/1:1-cg
root     17486  0.0  0.0      0     0 ?        I    17:14   0:00 [kworker/3:1-cg
root     17487  0.0  0.0      0     0 ?        R    17:14   0:00 [kworker/u12:3-
root     17506  0.0  0.0      0     0 ?        I    17:24   0:00 [kworker/u12:1-
root     18366  0.0  0.0      0     0 ?        I    17:34   0:00 [kworker/5:0-cg
emre     18394  0.0  0.0  45896  3764 pts/1    R+   17:37   0:00 ps aux
```

Fundamental Linux Commands

- top: List all process with their hardware (CPU, RAM) usage

```
top - 17:38:26 up  1:04,  1 user,  load average: 0,06, 0,09, 0,08
Tasks: 241 total,   1 running, 179 sleeping,   4 stopped,   0 zombie
%Cpu(s):  0,1 us,  0,1 sy,  0,0 ni, 99,8 id,  0,0 wa,  0,0 hi,  0,0 si,  0,0 st
KiB Mem :  8152360 total,  3158788 free,  1256060 used,  3737512 buff/cache
KiB Swap:  2097148 total,  2097148 free,        0 used.  6560028 avail Mem

  PID USER      PR  NI    VIRT    RES    SHR S  %CPU %MEM     TIME+ COMMAND
 1752 emre      20   0 4638500 327516 124028 S   0,7  4,0   1:14.47 gnome-shell
 2103 emre      20   0 5466992 235988  31348 S   0,7  2,9   0:42.63 java
 1472 emre      20   0 1387476 148328  74208 S   0,3  1,8   0:43.54 Xorg
 1665 emre      20   0  189740   2944   2588 S   0,3  0,0   0:13.43 VBoxClient
18397 emre      20   0   50440   4224   3568 R   0,3  0,1   0:00.01 top
    1 root      20   0  225664   9420   6672 S   0,0  0,1   0:05.26 systemd
    2 root      20   0       0      0      0 S   0,0  0,0   0:00.08 kthreadd
    3 root       0 -20       0      0      0 I   0,0  0,0   0:00.00 rcu_gp
    4 root       0 -20       0      0      0 I   0,0  0,0   0:00.00 rcu_par_gp
    6 root       0 -20       0      0      0 I   0,0  0,0   0:00.00 kworker/0:+
    7 root      20   0       0      0      0 I   0,0  0,0   0:00.94 kworker/u1+
    8 root       0 -20       0      0      0 I   0,0  0,0   0:00.00 mm_percpu_+
```

Fundamental Linux Commands

- ln: Creates a link

ln -s [Source_Directory_Path] [Symbolic_Link_Destination_Path]

```
emre@emre-VirtualBox:~/Documents$ ln -s testX /home/emre/Desktop/testLink
emre@emre-VirtualBox:~/Documents$ ls -al /home/emre/Desktop
total 28
drwxr-xr-x  2 emre emre 4096 Oca 22 17:44  .
drwxr-xr-x 41 emre emre 4096 Oca 22 17:02  ..
-rwxr--r--  1 emre emre  206 Ara 16 20:48 'Documentation Navigator.desktop'
lrwxrwxrwx  1 emre emre    5 Oca 22 17:44  testLink -> testX
-rw-rw-r--  1 emre emre    0 Oca 22 17:40  testX
-rwxr--r--  1 emre emre  212 Ara 16 20:47 'Vitis HLS 2021.2.desktop'
-rwxr--r--  1 emre emre  244 Ara 16 20:48 'Vitis Model Composer 2021.2.desktop'
-rwxr-xr-x  1 emre emre  194 Ara 16 20:47 'Vivado 2021.2.desktop'
-rwxr--r--  1 emre emre  200 Ara 16 20:47 'Xilinx Vitis 2021.2.desktop'
```

Fundamental Linux Commands

- kill: Kills specified process

kill processID

```
emre     17366  0.0  0.0  18376   952 pts/0    T    16:55   0:00 pager
emre     17376  0.0  0.0  29908  4252 pts/0    T    16:57   0:00 man ls
emre     17386  0.0  0.0  18376  1040 pts/0    T    16:57   0:00 pager
emre     17426  0.0  0.1  35420  9812 pts/1    Ss   17:03   0:00 bash
root     17474  0.0  0.0      0     0 ?        I    17:09   0:00 [kworker/1:1-cg
root     17486  0.0  0.0      0     0 ?        I    17:14   0:00 [kworker/3:1-cg
root     17487  0.0  0.0      0     0 ?        I    17:14   0:00 [kworker/u12:3+
root     17506  0.0  0.0      0     0 ?        I    17:24   0:00 [kworker/u12:1-
root     18366  0.0  0.0      0     0 ?        I    17:34   0:00 [kworker/5:0-cg
emre     18399  0.5  0.5 680340 46736 pts/0    Sl+  17:38   0:02 gedit x.txt
root     18412  0.0  0.0      0     0 ?        I    17:39   0:00 [kworker/0:2-cg
emre     18441  0.0  0.0  45896  3640 pts/1    R+   17:46   0:00 ps aux
emre@emre-VirtualBox:~/Documents$ kill 18399
```

kill -9 processID -> kill immediately the process

Fundamental Linux Commands

- shutdown -h now: Shutdowns the system

Fundamental Linux Commands

- df: List current filesystems sizes and area usages

```
emre@emre-VirtualBox:~/Documents$ df
Filesystem     1K-blocks      Used Available Use% Mounted on
udev             4051084         0   4051084   0% /dev
tmpfs             815236      1484    813752   1% /run
/dev/sda1      308585280 216447108  76393252  74% /
tmpfs            4076180         0   4076180   0% /dev/shm
tmpfs               5120         4      5116   1% /run/lock
tmpfs            4076180         0   4076180   0% /sys/fs/cgroup
```

- df –Bg: shows as gigabit

```
emre@emre-VirtualBox:~/Documents$ df -Bg
Filesystem     1G-blocks  Used Available Use% Mounted on
udev               4G    0G         4G   0% /dev
tmpfs              1G    1G         1G   1% /run
/dev/sda1        295G  207G        73G  74% /
tmpfs              4G    0G         4G   0% /dev/shm
tmpfs              1G    1G         1G   1% /run/lock
tmpfs              4G    0G         4G   0% /sys/fs/cgroup
```

Fundamental Linux Commands

- more: Shows file content

```
emre@emre-VirtualBox:~/Documents$ more testX
merhaba
```

Fundamental Linux Commands

- mv: Moving and renaming

```
emre@emre-VirtualBox:~/Documents$ ls
testX
emre@emre-VirtualBox:~/Documents$ mv testX testY
emre@emre-VirtualBox:~/Documents$ ls
testY
```

Fundamental Linux Commands

- Write or append a file

Write

```
emre@emre-VirtualBox:~/Documents$ echo merhaba > testY
emre@emre-VirtualBox:~/Documents$ more testY
merhaba
```

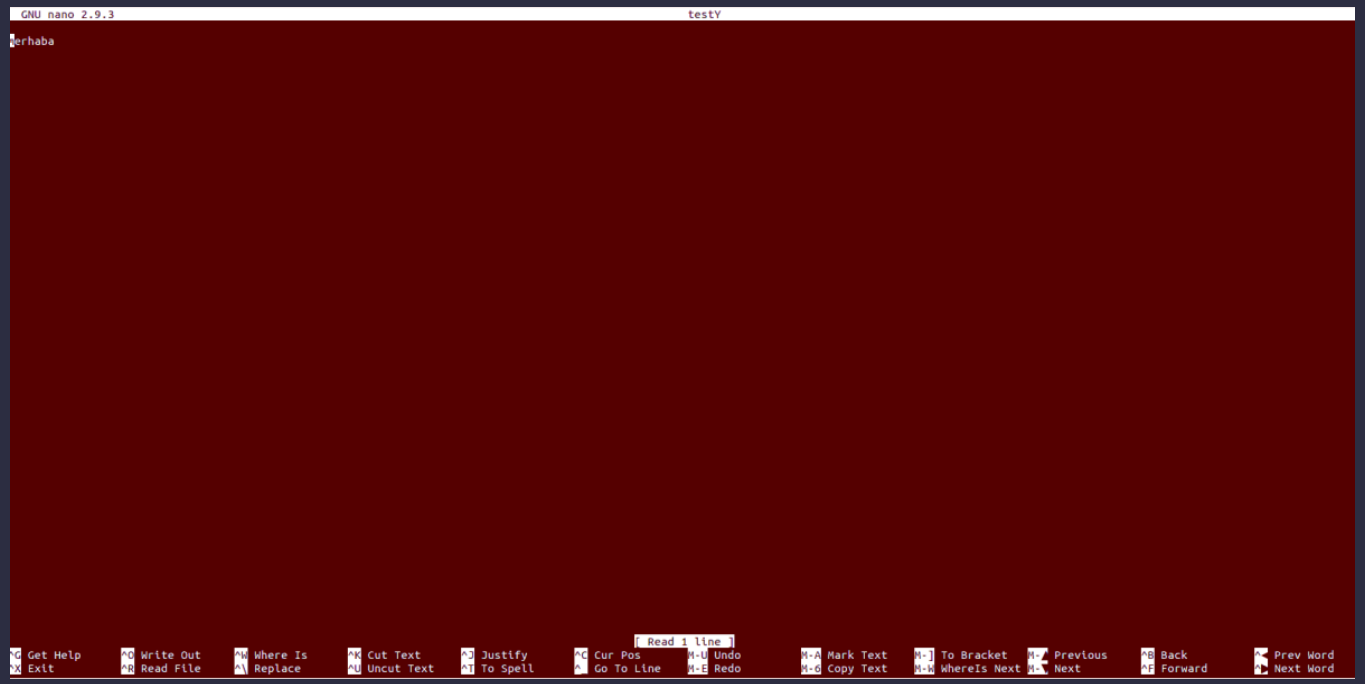
Append

```
emre@emre-VirtualBox:~/Documents$ echo Deneme >> testY
emre@emre-VirtualBox:~/Documents$ more testY
merhaba
Deneme
```

Fundamental Linux Commands

- nano: command line file editor tool

nano fileName



After complating changes press CTRL + X and type Y and enter

Fundamental Linux Commands

Advanced Package Tool or APT is a package management system used by Debian-based distributions.

Before installing a new package first, you need to update the APT package index:

- sudo apt-get update

The APT index is a database that holds records of available packages from the repositories enabled in your system:

- sudo apt-get upgrade

Installing packages is as simple as running:

- sudo apt-get install "package"

Fundamental Linux Commands

To remove a package

- sudo apt-get remove "package"

Fundamental Linux Commands

- To add new user to system

adduser username

- To change a user password

passwd username

- To remove a user

userdel username

Fundamental Linux Commands

- To create a group

groupadd newGroup

- To remove a group

groupdel newGroup

Fundamental Linux Commands

- Adding a user to group

usermod –a –G mygroup myuser

To grand sudo access a user:

usermod –a -G sudo myuser

Fundamental Linux Commands

- grep: filter specified keyword

```
emre@emre-VirtualBox:~/Documents$ ps aux | grep term
emre      2421  0.1  0.4 806360 39424 ?        Ssl  16:36   0:10 /usr/lib/gnome-terminal/gnome-terminal-server
emre     18513  0.0  0.0  22956  1072 pts/0    S+   18:10   0:00 grep --color=auto term
```

Fundamental Linux Commands

- chown: Changes file ownership

To give ownership a user:

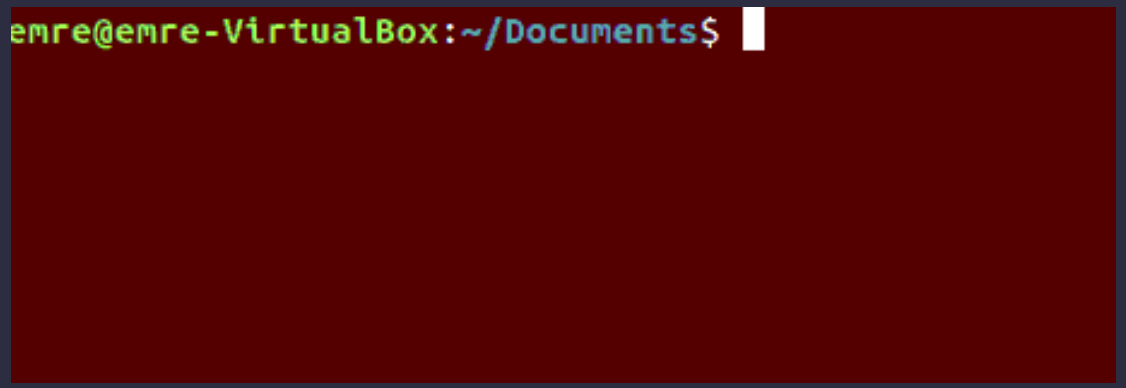
```
emre@emre-VirtualBox:~/Documents$ chown emre testY
```

To give ownership to group:

```
emre@emre-VirtualBox:~/Documents$ chown :sudo testY
```

Fundamental Linux Commands

- clear: Clears the terminal



Fundamental Linux Commands

- find: Search the specified file name

find searchStartPath –name fileName

```
emre@emre-VirtualBox:~/Documents$ find . -name testY
./testY
```

Fundamental Linux Commands

- tail: Prints file content starting from tail with given number of lines

tail –n fileName

```
emre@emre-VirtualBox:~/Documents$ tail -3 testY
askmdkamsd
ewokrokwe
mkfwkm
```

Original File

```
Merhaba
test
deneme
1234
adasd
htkrhoktr
mfskdfmk
askmdkamsd
ewokrokwe
mkfwkm
```

Fundamental Linux Commands

- head: Prints file content starting from head with given number of lines

head –n fileName

```
emre@emre-VirtualBox:~/Documents$ head -3 testY
Merhaba
test
deneme
```

Original File

```
Merhaba
test
deneme
1234
adasd
htkrhoktr
mfskdfmk
askmdkamsd
ewokrokwe
mkfwkm
```

Fundamental Linux Commands

- diff: compares given two files

diff file1 file2

```
emre@emre-VirtualBox:~/Documents$ diff testX testY
4,6c4,6
< 1234Y
< adaXsd
< htk124rhoktr
---
> 1234
> adasd
> htkrhoktr
```

testX

```
Merhaba
test
deneme
1234Y
adaXsd
htk124rhoktr
mfskdfmk
askmdkamsd
ewokrokwe
mkfwkm
```

testY

```
Merhaba
test
deneme
1234
adasd
htkrhoktr
mfskdfmk
askmdkamsd
ewokrokwe
mkfwkm
```

Fundamental Linux Commands

- Extract and compress TAR.GZ archives

Extract

tar -xf archive.tar.gz

Compress a folder

tar -czvf name-of-archive.tar.gz /path/to/directory-or-file

Fundamental Linux Commands

- date: prints current date

```
emre@emre-VirtualBox:~/Documents$ date
Cts Oca 22 18:49:53 +03 2022
```

Fundamental Linux – Bash Scripts

Bash Scripts

Bash is a command language interpreter. It is widely available on various operating systems and is a default command interpreter on most GNU/Linux systems.

To view current shell type:

echo $SHELL

```
emre@emre-VirtualBox:~/Documents$ echo $SHELL
/bin/bash
```

Fundamental Linux – Bash Scripts

Bash Scripts

Create a file named test.sh, helloworld

test.sh

```
#!/bin/bash

echo "Hello World"
```

```
emre@emre-VirtualBox:~/Documents$ sh test.sh
Hello World
```

or

```
emre@emre-VirtualBox:~/Documents$ chmod u+x test.sh
emre@emre-VirtualBox:~/Documents$ ./test.sh
Hello World
```

Fundamental Linux – Bash Scripts

Bash Scripts

Variables and printing

test.sh

```
greeting="Welcome"
user=$(whoami)
day=$(date +%A)

echo "$greeting back $user! Today is $day, which is the best day of the entire week!"
echo "Your Bash shell version is: $BASH_VERSION. Enjoy!"
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh
Welcome back emre! Today is Cumartesi, which is the best day of the entire week!
Your Bash shell version is: 4.4.20(1)-release. Enjoy!
```

Fundamental Linux – Bash Scripts

Bash Scripts

Read user input

test.sh

```
#!/bin/sh

echo "What is your name?"
read PERSON
echo "Hello, $PERSON"
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh
What is your name?
deneme
Hello, deneme
```

Fundamental Linux – Bash Scripts

Bash Scripts

int and string variables

test.sh

```
#!/bin/sh

year=2012
comp_name=jtp

echo $year
echo $comp_name
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh
2012
jtp
```

Fundamental Linux – Bash Scripts

Bash Scripts

echo variables

test.sh

```
#!/bin/sh

echo $HOME # Home Directory
echo $PWD # current working directory
echo $BASH # Bash shell name
echo $BASH_VERSION # Bash shell Version
echo $LOGNAME # Name of the Login User
echo $OSTYPE # Type of OS
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh
/home/emre
/home/emre/Documents
/bin/sh
4.4.20(1)-release
emre
linux-gnu
```

Fundamental Linux – Bash Scripts

Bash Scripts

Getting arguments

test.sh

```
#!/bin/sh

args=("$@")

echo ${args[0]} ${args[1]} ${args[2]} ${args[3]}
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh testa b c d
testa b c d
```

Fundamental Linux – Bash Scripts

Bash Scripts

Calling a command, example ls

test.sh

```
#!/bin/sh

lsResult=$(ls)

echo "My files are:" $lsResult
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh
My files are: test.sh
```

Fundamental Linux – Bash Scripts

Bash Scripts

Printing date

test.sh

```
#!/bin/bash

d=`date +%m-%d-%Y`

echo "Date in format MM-DD-YYYY"
echo $d #MM-DD-YYYY
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh
Date in format MM-DD-YYYY
01-22-2022
```

Fundamental Linux – Bash Scripts

Bash Scripts

Sleep

test.sh

```
#!/bin/bash

date +"%H:%M:%S"
echo "wait for 9 seconds"
sleep 9s
date +"%H:%M:%S"
echo "Task Completed"
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh
19:22:21
wait for 9 seconds
19:22:30
Task Completed
```

Fundamental Linux – Bash Scripts

Bash Scripts

There are 11 arithmetic operators supported by bash shell

Operator	Description	Examples
+	Addition, measures addition of numbers (operands)	$((10 + 3)), result=13
-	Substraction, measures subtraction of second operand from first	$((10 - 3)), result=7
*	Multiplication, measures the multiplication of operands.	$((10 * 3)), result=30
/	Division, measures the division of first operand by second operand and and return quotient.	$((10 / 3)), result=3
**	Exponentiation, measures the result of second operand raised to the power of first operand.	$((10 ** 3)), result=1000
%	Modulo, measures remainder when the first operand is divided by second operand.	$((10 % 3)), result=1

Fundamental Linux – Bash Scripts

Bash Scripts

There are 11 arithmetic operators supported by bash shell

Operator	Description	Examples
+=	Increment Variable by Constant- used to increment the value of first operand by the constant provided.	x=10 let "x += 3" echo $x result=13
-=	Decrement Variable by Constant- used to decrement the value of first operand by the constant provided.	x=10 let "x -= 3" echo $x result=7
*=	Multiply Variable by Constant- used to multiply the value of the first operand by the constant provided.	x=10 let "x *= 3" echo $x result=30
/=	Divide Variable by Constant- used to calculate the value of (variable / constant) and store the result back to variable.	x=10 let "10 /= 3" echo $x result=3
%=	Remainder of Dividing Variable by Constant- used to calculate the value of (variable % constant) and store the result back to variable.	x=10 let "10 %= 3" echo $x result=1

Fundamental Linux – Bash Scripts

Bash Scripts

Arithmetic operators

test.sh

```
#!/bin/sh

Num1=10
Num2=3
((Sum=Num1+Num2))
echo "Sum = $Sum"
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh
Sum = 13
```

Fundamental Linux – Bash Scripts

Bash Scripts

Arithmetic operators

test.sh

```
#!/bin/sh

x=8
y=2
echo "x=8, y=2"
echo "Addition of x & y"
echo $(( $x + $y ))
echo "Subtraction of x & y"
echo $(( $x - $y ))
echo "Multiplication of x & y"
echo $(( $x * $y ))
echo "Division of x by y"
echo $(( $x / $y ))
```

test.sh (cont)

```
echo "Exponentiation of x,y"
echo $(( $x ** $y ))
echo "Modular Division of x,y"
echo $(( $x % $y ))
echo "Incrementing x by 5, then x= "
(( x += 5 ))
echo $x
echo "Decrementing x by 5, then x= "
(( x -= 5 ))
echo $x
echo "Multiply of x by 5, then x="
(( x *= 5 ))
echo $x
echo "Dividing x by 5, x= "
(( x /= 5 ))
echo $x
echo "Remainder of Dividing x by 5, x="
(( x %= 5 ))
echo $x
```

```
x=8, y=2
Addition of x & y
10
Subtraction of x & y
6
Multiplication of x & y
16
Division of x by y
4
Exponentiation of x,y
64
Modular Division of x,y
0
Incrementing x by 5, then x=
13
Decrementing x by 5, then x=
8
Multiply of x by 5, then x=
40
Dividing x by 5, x=
8
Remainder of Dividing x by 5, x=
3
```

Fundamental Linux – Bash Scripts

Bash Scripts

if statements

test.sh

```
#!/bin/bash

read -p " Enter number : " number

if [ $number -gt 125 ]
then
echo "Value is greater than 125"
fi
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh
 Enter number : 130
Value is greater than 125
```

Fundamental Linux – Bash Scripts

Bash Scripts

if statements

test.sh

```
#!/bin/bash

# TRUE && TRUE
if [ 8 -gt 6 ] && [ 10 -eq 10 ];
then
echo "Conditions are true"
fi

# TRUE && FALSE
if [ "mylife" == "mylife" ] && [ 3 -gt 10 ];
then
echo "Conditions are false"
fi
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh
Conditions are true
```

Fundamental Linux – Bash Scripts

Bash Scripts

Nested if statements

test.sh

```
#!/bin/bash

if [ $1 -gt 50 ]
then
  echo "Number is greater than 50."

  if (( $1 % 2 == 0 ))
  then
    echo "and it is an even number."
  fi
fi
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh 52
Number is greater than 50.
and it is an even number.
```

Fundamental Linux – Bash Scripts

Bash Scripts

if else statements

test.sh

```
#!/bin/bash

#when the condition is true
if [ 10 -gt 3 ];
then
  echo "10 is greater than 3."
else
  echo "10 is not greater than 3."
fi

#when the condition is false
if [ 3 -gt 10 ];
then
  echo "3 is greater than 10."
else
  echo "3 is not greater than 10."
fi
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh
10 is greater than 3.
3 is not greater than 10.
```

Fundamental Linux – Bash Scripts

Bash Scripts

Elseif statements

test.sh

```
#!/bin/bash

read -p "Enter a number of quantity:" num

if [ $num -gt 100 ];
then
echo "Eligible for 10% discount"
elif [ $num -lt 100 ];
then
echo "Eligible for 5% discount"
else
echo "Lucky Draw Winner"
echo "Eligible to get the item for free"
fi
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh
Enter a number of quantity:100
Lucky Draw Winner
Eligible to get the item for free
```

Fundamental Linux – Bash Scripts

Bash Scripts

Case statements

test.sh

```
#!/bin/bash

echo "Which Operating System are you using?"
echo "Windows, Android, Chrome, Linux, Others?"
read -p "Type your OS Name:" OS

case $OS in
   Windows|windows)
      echo "That's common. You should try something new."
      echo
      ;;
   Android|android)
      echo "This is my favorite. It has lots of applications."
      echo
      ;; *)
      echo "Sounds interesting. I will try that."
      echo
      ;;
esac
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh
Which Operating System are you using?
Windows, Android, Chrome, Linux, Others?
Type your OS Name:wîndows
Sounds interesting. I will try that.
```

Fundamental Linux – Bash Scripts

Bash Scripts

For loops

test.sh

```
#!/bin/bash

for num in {1..10}
do
echo $num
done

echo "Series of numbers from 1 to 10."
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh
1
2
3
4
5
6
7
8
9
10
Series of numbers from 1 to 10.
```

Fundamental Linux – Bash Scripts

Bash Scripts

For loops

test.sh

```
#!/bin/bash

for num in {1..10..2}
do
echo $num
done
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh
1
3
5
7
9
```

Fundamental Linux – Bash Scripts

Bash Scripts

For loops

test.sh

```
#!/bin/bash

#For Loop to Read a Range with Decrement

for num in {10..0..3}
do
echo $num
done
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh
10
7
4
1
```

Fundamental Linux – Bash Scripts

Bash Scripts

For loops

test.sh

```
#!/bin/bash

for table in {2..100..2}
do
echo $table
if [ $table == 20 ]; then
break
fi
done
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh
2
4
6
8
10
12
14
16
18
20
```

Fundamental Linux – Bash Scripts

Bash Scripts

While

test.sh

```
#!/bin/bash
#While loop example in C style

i=1
while((i <= 10))
do
echo $i;
((i=i+1))
done
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh
1
2
3
4
5
6
7
8
9
10
```

Fundamental Linux – Bash Scripts

Bash Scripts

Functions

test.sh

```
#!/bin/bash

function denemeFnc {
    echo 'Merhaba'
}

denemeFnc

echo 'Test';
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh
Merhaba
Test
```

Fundamental Linux – Bash Scripts

Bash Scripts

Functions

test.sh

```
#!/bin/bash
function_arguments()
   {
   echo $1
   echo $2
   echo $3
   echo $4
   echo $5
   }

#Calling function_arguments
function_arguments
"Test""ABC""XTZ""XXX""Deneme."
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh
TestABCXTZXXXDeneme.
```

Fundamental Linux – Bash Scripts

Bash Scripts

File read

test.sh

```
#!/bin/bash

value=`cat deneme.txt`
echo "$value"
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh
Merhaba
Test
```

Fundamental Linux – Bash Scripts

Bash Scripts

File write

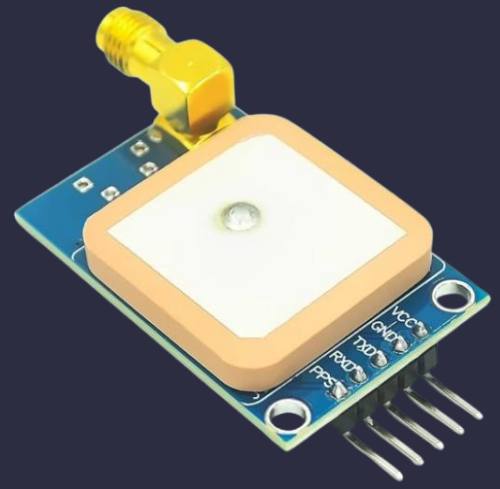
test.sh

```
#!/bin/bash
output=output_file.txt
ls > $output
```

```
emre@emre-VirtualBox:~/Documents$ ./test.sh
emre@emre-VirtualBox:~/Documents$ ls
deneme.txt  output_file.txt  test.sh
emre@emre-VirtualBox:~/Documents$ more output_file.txt
deneme.txt
output_file.txt
test.sh
```

System Design with Sensors III – Embedded Linux

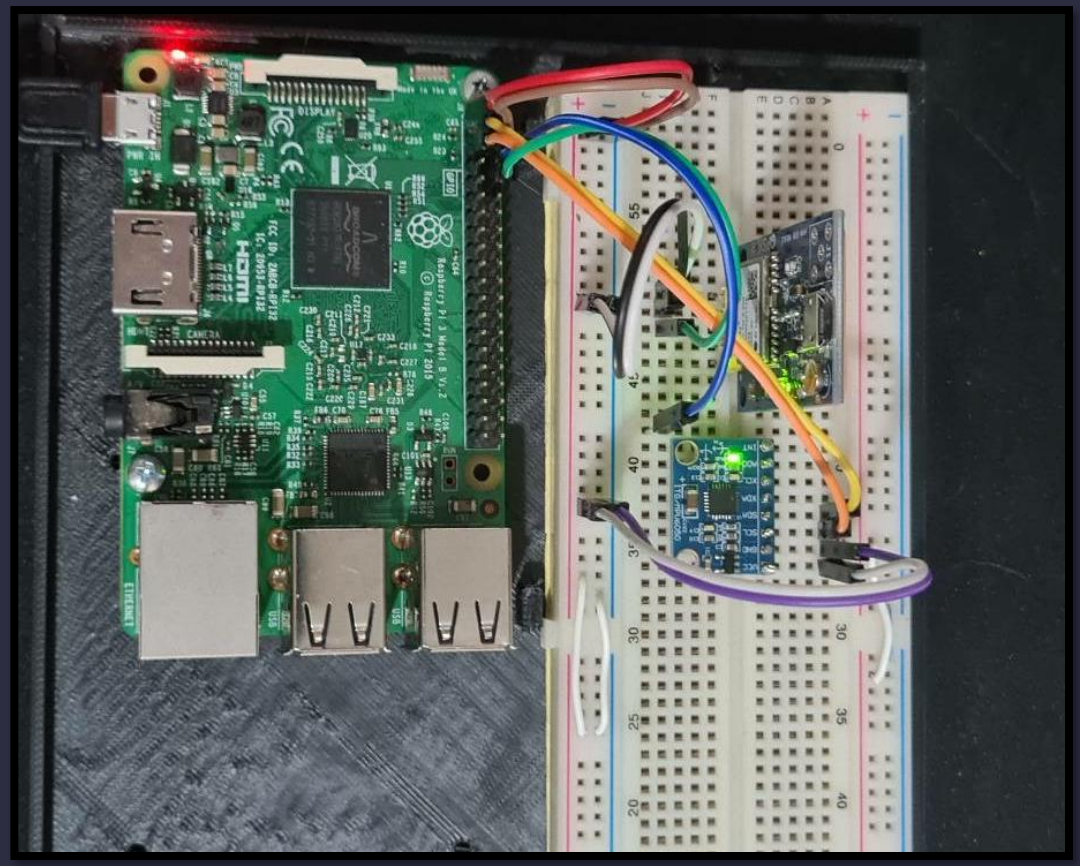
- Sensor Development Boards
  - Sensors
  - Use Case Hardwares
  - Gyroscope, MPU6050
  - GPS, NEO-7M



System Design with Sensors III – Embedded Linux

- Rasberry PI Sensor Applications

Connect MPU6050 to I2C-1



System Design with Sensors III – Embedded Linux

- Rasberry PI Sensor Applications

Devices

```
pc@raspberrypi:~ $ ls /dev
autofs           loop0          ram12   tty16  tty41  ttyprintk  vcsu3
block            loop1          ram13   tty17  tty42  uhid       vcsu4
btrfs-control    loop2          ram14   tty18  tty43  uinput     vcsu5
bus              loop3          ram15   tty19  tty44  urandom    vcsu6
cachefiles       loop4          ram2    tty2   tty45  v4l        vcsu7
cec0             loop5          ram3    tty20  tty46  vchiq      vga_arbiter
char             loop6          ram4    tty21  tty47  vcio       vhci
console          loop7          ram5    tty22  tty48  vc-mem     vhost-net
cpu_dma_latency  loop-control   ram6    tty23  tty49  vcs        vhost-vsock
cuse             mapper         ram7    tty24  tty5   vcs1       video10
disk             media0         ram8    tty25  tty50  vcs2       video11
dma_heap         media1         ram9    tty26  tty51  vcs3       video12
dri              media2         random  tty27  tty52  vcs4       video13
fd               mem            rfkill  tty28  tty53  vcs5       video14
full             mmcblk0        shm     tty29  tty54  vcs6       video15
fuse             mmcblk0p1      snd     tty3   tty55  vcs7       video16
gpiochip0        mmcblk0p2      stderr  tty30  tty56  vcsa       video18
gpiochip1        mqueue         stdin   tty31  tty57  vcsa1      video20
gpiochip2        net            stdout  tty32  tty58  vcsa2      video21
gpiochip4        null           tty     tty33  tty59  vcsa3      video22
gpiomem          port           tty0    tty34  tty6   vcsa4      video23
hwrng            ppp            tty1    tty35  tty60  vcsa5      video31
i2c-2            ptmx           tty10   tty36  tty61  vcsa6      watchdog
initctl          pts            tty11   tty37  tty62  vcsa7      watchdog0
input            ram0           tty12   tty38  tty63  vcsm-cma   zero
kmsg             ram1           tty13   tty39  tty7   vcsu
kvm              ram10          tty14   tty4   tty8   vcsu1
log              ram11          tty15   tty40  tty9   vcsu2
```

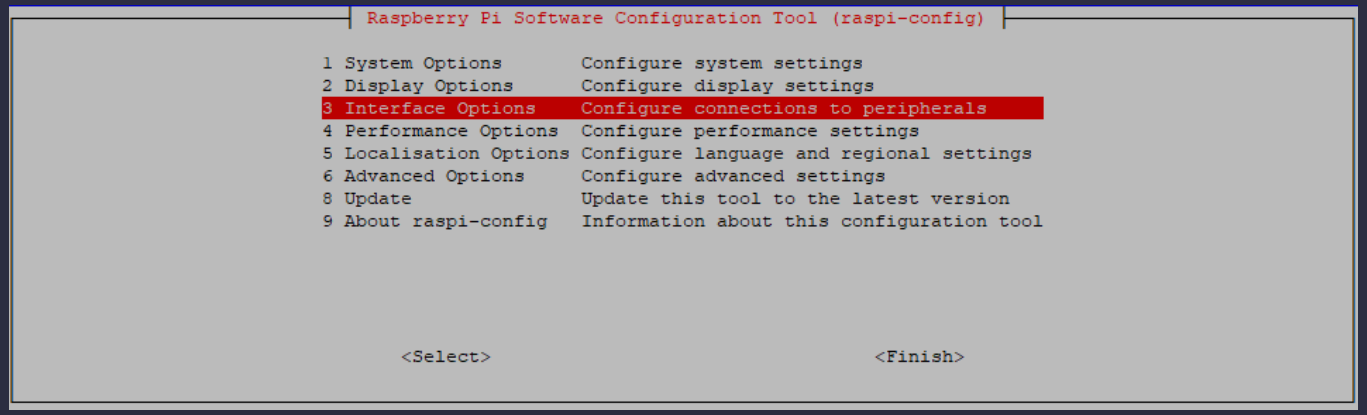
System Design with Sensors III – Embedded Linux

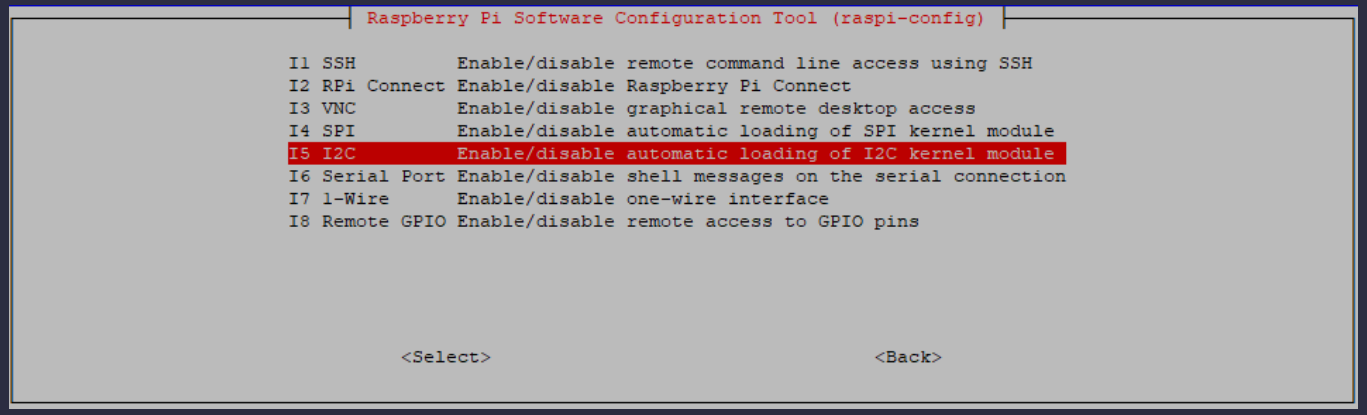
- Rasberry PI Sensor Applications

Enable I2C Devices

Execute

- raspi-config





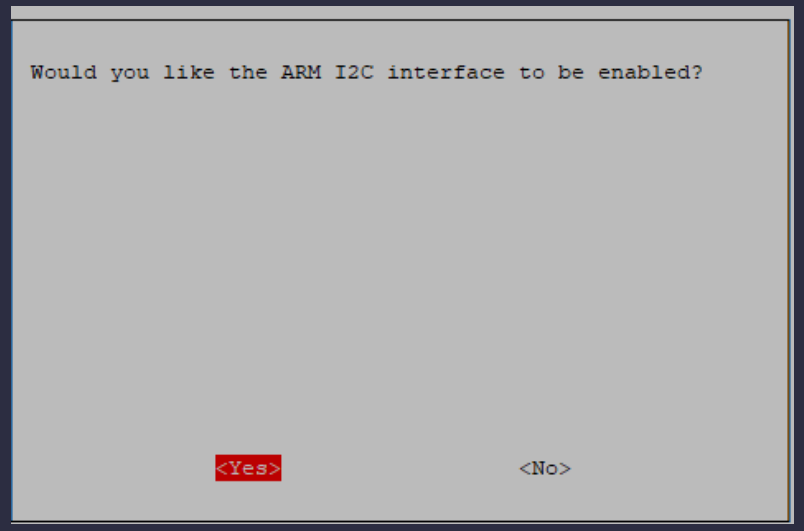
System Design with Sensors III – Embedded Linux

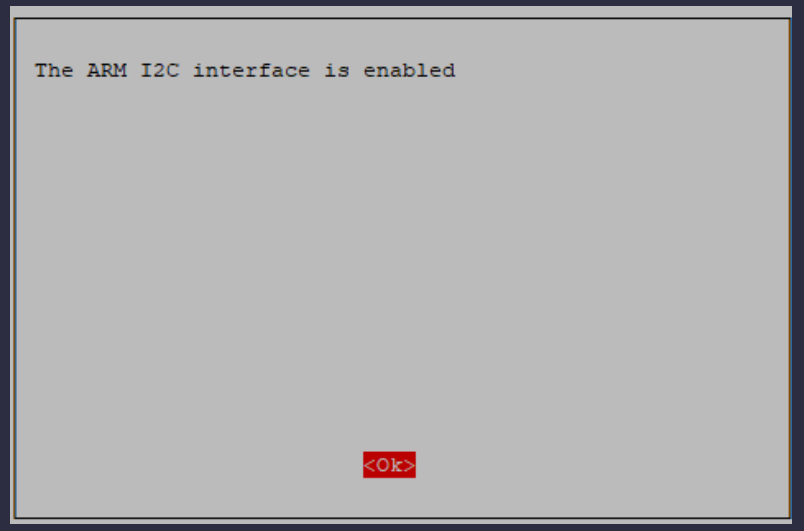
- Rasberry PI Sensor Applications

Enable I2C Devices

Execute

- raspi-config
- Reboot






```
pc@raspberrypi:~ $ ls /dev/i2c*
/dev/i2c-1  /dev/i2c-2
```

System Design with Sensors III – Embedded Linux

- Rasberry PI Sensor Applications

I2C Detect

```
pc@raspberrypi:~ $ i2c
i2cdetect           i2cget              i2c-stub-from-dump
i2cdump             i2cset              i2ctransfer
```

```
pc@raspberrypi:~ $ i2cdetect -y 1
     0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00:                         -- -- -- -- -- -- -- --
10: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
20: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
30: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
40: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
50: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
60: -- -- -- -- -- -- -- -- 68 -- -- -- -- -- -- --
70: -- -- -- -- -- -- -- --
```

Detected Sensor

System Design with Sensors III – Embedded Linux

- Rasberry PI Sensor Applications

MPU6050

Read WHO_AM_I Register

- sudo i2cget -y 1 0x68 0x75

```
pc@raspberrypi:~ $ sudo i2cget -y 1 0x68 0x75
0x68
```

System Design with Sensors III – Embedded Linux

- Rasberry PI Sensor Applications

MPU6050

Read PWR_MGMT_1 Register

- sudo i2cget -y 1 0x68 0x6B

```
pc@raspberrypi:~ $ sudo i2cget -y 1 0x68 0x6B
0x40
```

System Design with Sensors III – Embedded Linux

- Rasberry PI Sensor Applications

MPU6050

Read Yaw, Pitch, Roll

```c
#include <stdio.h>
#include <stdlib.h>
#include <stdint.h>
#include <fcntl.h>
#include <unistd.h>
#include <sys/ioctl.h>
#include <linux/i2c-dev.h>
#include <math.h>
#include <time.h>

#define MPU6050_ADDR 0x68
#define PWR_MGMT_1   0x6B
#define ACCEL_XOUT_H 0x3B
#define GYRO_XOUT_H  0x43

int main(void) {
    int file;
    const char *filename = "/dev/i2c-1";

    if ((file = open(filename, O_RDWR)) < 0) {
        perror("I2C bus açılamadı");
        exit(1);
    }

    if (ioctl(file, I2C_SLAVE, MPU6050_ADDR) < 0) {
        perror("MPU6050 ile iletişim kurulamadı");
        close(file);
        exit(1);
    }

    char buffer[2];
    buffer[0] = PWR_MGMT_1;
    buffer[1] = 0;
    if (write(file, buffer, 2) != 2) {
        perror("MPU6050 uyandırılamadı");
        close(file);
        exit(1);
    }

    struct timespec t_start, t_end;
    clock_gettime(CLOCK_MONOTONIC, &t_start);
    double yaw_angle = 0.0;  // Başlangıç yaw açısı
```

System Design with Sensors III – Embedded Linux

- Rasberry PI Sensor Applications

MPU6050

Read Yaw, Pitch, Roll

```
while (1) {
    clock_gettime(CLOCK_MONOTONIC, &t_end);
    double dt = (t_end.tv_sec - t_start.tv_sec) + (t_end.tv_nsec - t_start.tv_nsec) / 1e9;
    t_start = t_end;  // Bir sonraki döngü için zamanı güncelle

    char reg = ACCEL_XOUT_H;
    if (write(file, &reg, 1) != 1) {
        perror("Accelerometer register'ına yazılamadı");
        break;
    }
    char data[6];
    if (read(file, data, 6) != 6) {
        perror("Accelerometer verileri okunamadı");
        break;
    }

    int16_t acc_x = (data[0] << 8) | data[1];
    int16_t acc_y = (data[2] << 8) | data[3];
    int16_t acc_z = (data[4] << 8) | data[5];
    double ax = acc_x / 16384.0;
    double ay = acc_y / 16384.0;
    double az = acc_z / 16384.0;
    double roll  = atan2(ay, az) * 180.0 / M_PI;
    double pitch = atan2(-ax, sqrt(ay * ay + az * az)) * 180.0 / M_PI;

    reg = GYRO_XOUT_H;
    if (write(file, &reg, 1) != 1) {
        perror("Gyroscope register'ına yazılamadı");
        break;
    }
    char gyro_data[6];
    if (read(file, gyro_data, 6) != 6) {
        perror("Gyroscope verileri okunamadı");
        break;
    }
    int16_t gyro_x = (gyro_data[0] << 8) | gyro_data[1];
    int16_t gyro_y = (gyro_data[2] << 8) | gyro_data[3];
    int16_t gyro_z = (gyro_data[4] << 8) | gyro_data[5];
    double gx = gyro_x / 131.0;
    double gy = gyro_y / 131.0;
    double gz = gyro_z / 131.0;
    yaw_angle += gz * dt;
    printf("Roll: %6.2f°\tPitch: %6.2f°\tYaw: %6.2f°\n", roll, pitch, yaw_angle);
    usleep(50000);
}
close(file);
return 0;
}
```

System Design with Sensors III – Embedded Linux

- Rasberry PI Sensor Applications

MPU6050

Read Yaw, Pitch, Roll

Compile

- gcc -o main main.c -lm

```
pc@raspberrypi:~/mpu6050 $ ls
main  main.c
```

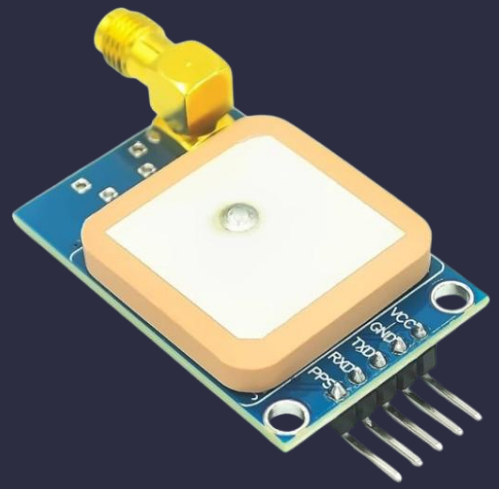
```
pc@raspberrypi:~/mpu6050 $ ./main
```

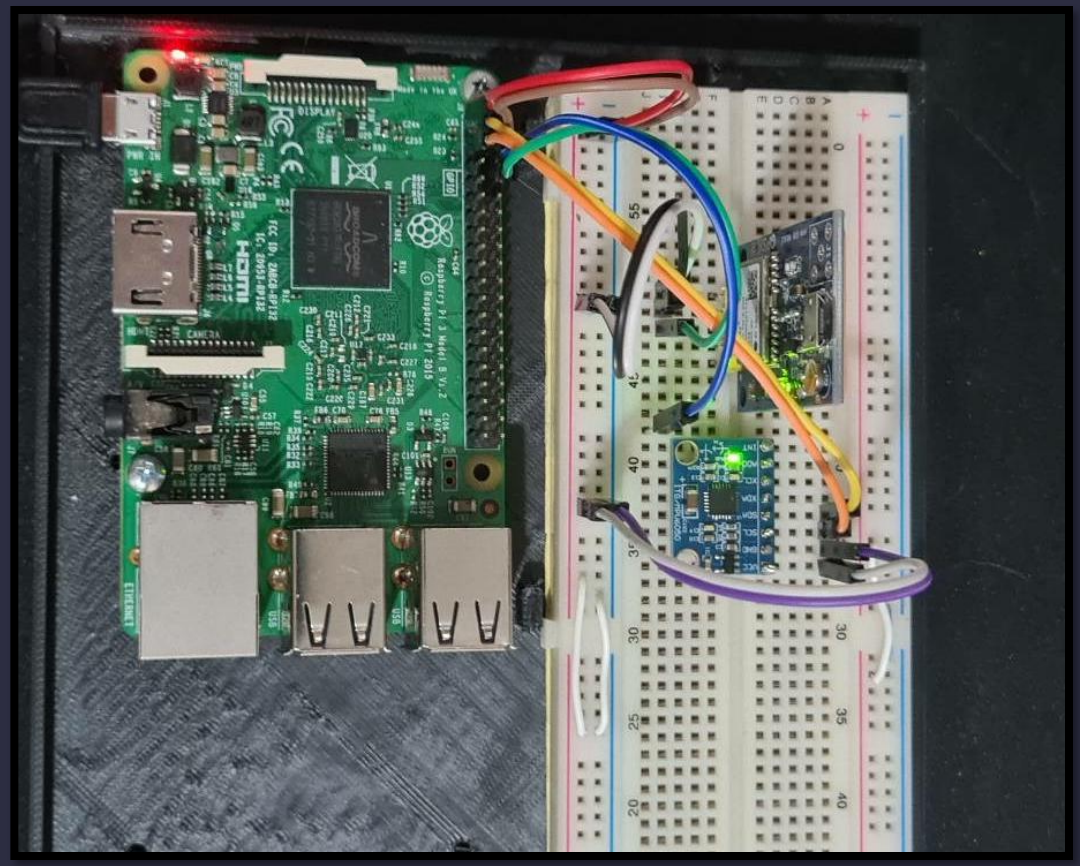
```
Roll:   3.32°   Pitch:  -4.63°  Yaw: -13.54°
Roll:   0.10°   Pitch:  -4.80°  Yaw: -13.61°
Roll:  -1.44°   Pitch:  -4.65°  Yaw: -13.68°
Roll:  -2.39°   Pitch:  -4.68°  Yaw: -13.74°
Roll:  -2.85°   Pitch:  -4.62°  Yaw: -13.81°
Roll:  -1.97°   Pitch:  -4.64°  Yaw: -13.89°
Roll:  -2.23°   Pitch:  -4.28°  Yaw: -13.95°
Roll:  -2.31°   Pitch:  -4.99°  Yaw: -14.02°
Roll:  -2.38°   Pitch:  -5.27°  Yaw: -14.07°
Roll:  -2.68°   Pitch:  -5.18°  Yaw: -14.14°
Roll:  -2.19°   Pitch:  -4.51°  Yaw: -14.22°
Roll:  -2.33°   Pitch:  -5.13°  Yaw: -14.27°
Roll:  -2.37°   Pitch:  -4.57°  Yaw: -14.33°
Roll:  -2.63°   Pitch:  -5.41°  Yaw: -14.39°
Roll:  -2.17°   Pitch:  -4.28°  Yaw: -14.47°
Roll:  -2.14°   Pitch:  -5.38°  Yaw: -14.54°
Roll:  -2.20°   Pitch:  -5.13°  Yaw: -14.61°
Roll:  -2.58°   Pitch:  -4.99°  Yaw: -14.67°
Roll:  -2.71°   Pitch:  -6.71°  Yaw: -14.74°
Roll:  -2.13°   Pitch:  -3.89°  Yaw: -14.80°
Roll:  -2.55°   Pitch:  -5.15°  Yaw: -14.85°
Roll:  -2.34°   Pitch:  -4.54°  Yaw: -14.91°
Roll:  -1.91°   Pitch:  -4.23°  Yaw: -14.97°
Roll:  -2.05°   Pitch:  -5.17°  Yaw: -15.03°
Roll:  -2.68°   Pitch:  -4.84°  Yaw: -15.10°
Roll:  -2.49°   Pitch:  -4.41°  Yaw: -15.16°
Roll:  -2.03°   Pitch:  -4.83°  Yaw: -15.23°
Roll:  -2.20°   Pitch:  -5.01°  Yaw: -15.30°
```

System Design with Sensors III – Embedded Linux

- Rasberry PI Sensor Applications

Connect GPS, NEO-7M to UART





System Design with Sensors III – Embedded Linux

- Rasberry PI Sensor Applications

Connect GPS, NEO-7M to UART

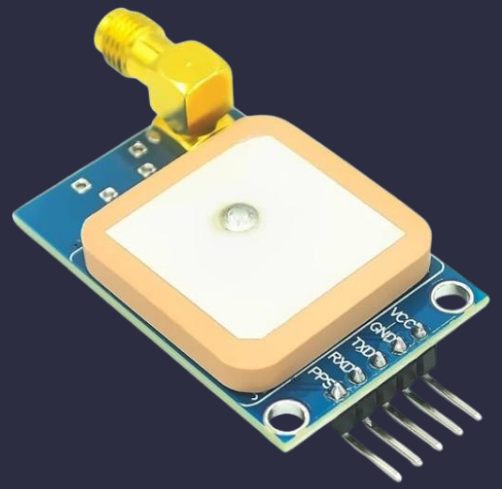
- Check serial0 device

```
pc@raspberrypi:~/gps $ ls /dev
autofs          cpu_dma_latency  gpiochip0  initctl     loop3         media1     null   ram11  ram5    shm      tty10  tty18  tty25  tty32  tty4   tty47  tty54  tty61    uhid        vcs1  vcsa1  vcsu   vga_arbiter  video14  video31
block           cuse             gpiochip1  input       loop4         media2     port   ram12  ram6    snd      tty11  tty19  tty26  tty33  tty40  tty48  tty55  tty62    uinput      vcs2  vcsa2  vcsu1  vhci         video15  watchdog
btrfs-control   disk             gpiochip2  kmsg        loop5         mem        ppp    ram13  ram7    stderr   tty12  tty2   tty27  tty34  tty41  tty49  tty56  tty63    urandom     vcs3  vcsa3  vcsu2  vhost-net    video16  watchdog0
bus             dma_heap         gpiochip4  kvm         loop6         mmcblk0    ptmx   ram14  ram8    stdin    tty13  tty20  tty28  tty35  tty42  tty5   tty57  tty7     v4l         vcs4  vcsa4  vcsu3  vhost-vsock  video18  zero
cachefiles      dri              gpiomem    log         loop7         mmcblk0p1  pts    ram15  ram9    stdout   tty14  tty21  tty29  tty36  tty43  tty50  tty58  tty8     vchiq       vcs5  vcsa5  vcsu4  video10      video20
cec0            fd               hwrng      loop0       loop-control  mmcblk0p2  ram0   ram2   random  tty      tty15  tty22  tty3   tty37  tty44  tty51  tty59  tty9     vcio        vcs6  vcsa6  vcsu5  video11      video21
char            full             i2c-1      loop1       mapper        mqueue     ram1   ram3   rfkill  tty0     tty16  tty23  tty30  tty38  tty45  tty52  tty6   ttyprintk   vc-mem      vcs7  vcsa7  vcsu6  video12      video22
console         fuse             i2c-2      loop2       media0        net        ram10  ram4   serial0 tty1     tty17  tty24  tty31  tty39  tty46  tty53  tty60  ttyS0    vcs         vcsa  vcsm-cma  vcsu7  video13      video23
```

System Design with Sensors III – Embedded Linux

- Rasberry PI Sensor Applications

GPS, NEO-7M

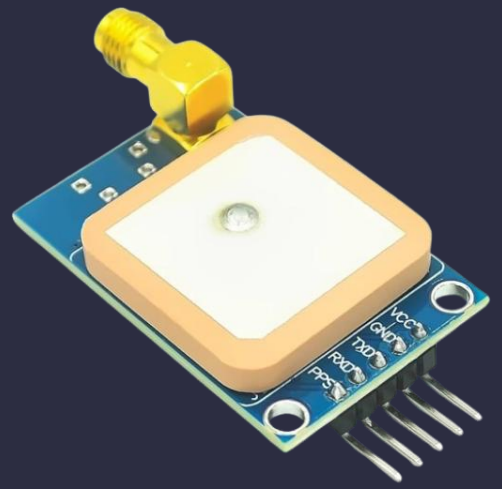



```c
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <fcntl.h>
#include <errno.h>
#include <string.h>
#include <termios.h>

int main(void) {
    const char *portname = "/dev/serial0";
    int serial_port = open(portname, O_RDWR | O_NOCTTY | O_NDELAY);
    if (serial_port < 0) {
        perror("Seri port açılamadı");
        return 1;
    }

    // Seri port ayarlarını yapılandırıyoruz.
    struct termios tty;
    if (tcgetattr(serial_port, &tty) != 0) {
        perror("tcgetattr hatası");
        close(serial_port);
        return 1;
    }
```

System Design with Sensors III – Embedded Linux

- Rasberry PI Sensor Applications

GPS, NEO-7M




```
    // Baud hızı, veri biti, dur biti ve parite ayarları (8N1)
    cfsetospeed(&tty, B9600);
    cfsetispeed(&tty, B9600);
    tty.c_cflag &= ~PARENB;        // Parite yok
    tty.c_cflag &= ~CSTOPB;        // 1 stop biti
    tty.c_cflag &= ~CSIZE;
    tty.c_cflag |= CS8;            // 8 bit veri
    tty.c_cflag &= ~CRTSCTS;       // Donanım akış kontrolü kapalı
    tty.c_cflag |= CREAD | CLOCAL; // Okumayı etkinleştir, modem kontrolü yok say

    // Yerel mod ayarları (ham mod)
    tty.c_lflag &= ~(ICANON | ECHO | ECHOE | ISIG);
    tty.c_iflag &= ~(IXON | IXOFF | IXANY);
    tty.c_oflag &= ~OPOST;

    // Zaman aşımı ve minimum bayt ayarı
    tty.c_cc[VMIN] = 0;
    tty.c_cc[VTIME] = 10; // 1 saniyeye kadar bekler

    if (tcsetattr(serial_port, TCSANOW, &tty) != 0) {
        perror("tcsetattr hatası");
        close(serial_port);
        return 1;
    }

    // Sürekli okuma döngüsü
    while (1) {
        char buf[256];
        memset(buf, 0, sizeof(buf));
        int n = read(serial_port, buf, sizeof(buf) - 1);
        if (n < 0) {
            perror("Okuma hatası");
            break;
        } else if (n > 0) {
            // Okunan veriyi konsola yazdır
            buf[n] = '\0';
            printf("Gelen veri (%d bayt): %s\n", n, buf);
        }
        // Kısa bir gecikme (100ms)
        usleep(100000);
    }

    close(serial_port);
    return 0;
}
```

System Design with Sensors III – Embedded Linux

- Rasberry PI Sensor Applications

GPS, NEO-7M

Compile

- gcc -o main main.c -lm

```
pc@raspberrypi:~/gps $ gcc -o main main.c -lm
```

```
pc@raspberrypi:~/gps $ ./main
```

```
$GPRMC,,V,,,,,,,,,N*53
$GPVTG,,,,,,,,,N*30
$GPGGA,,,,,,0,00,99.99,,,,,,*48
$GPGSA,A,1,,,,,,,,,,,,,99.99,99.99,99.99*30
$GPGSV,1,1,00*79
$GPGLL,,,,,,V,N*64
$GPRMC,,V,,,,,,,,,N*53
$GPVTG,,,,,,,,,N*30
$GPGGA,,,,,,0,00,99.99,,,,,,*48
$GPGSA,A,1,,,,,,,,,,,,,99.99,99.99,99.99*30
$GPGSV,1,1,00*79
$GPGLL,,,,,,V,N*64
$GPRMC,,V,,,,,,,,,N*53
$GPVTG,,,,,,,,,N*30
$GPGGA,,,,,,0,00,99.99,,,,,,*48
$GPGSA,A,1,,,,,,,,,,,,,99.99,99.99,99.99*30
```