CANSAT EDUCATION

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Space System Design and Testing Laboratory

Content of the Course

- What is a CanSat?
- CanSat Subsystems and components
- Arduin IDE
- Blink code test with ESP32
- How to use breadboard
- Pressure & altitude measurement
- Angular rates and acceleration measurement
- Magnetic field measurement
- Storing collected data on SD card
- Using buzzer
- Position accusation with GPS receiver.
- Receive data from CanSat to ground station.
- Using Camera
- Integrating the CanSat on a prototype board.
- Flight
- Reports (Mass Budget), Graphs(Temp, Press, Altitude, etc)

- Optional! Write your own ground station.

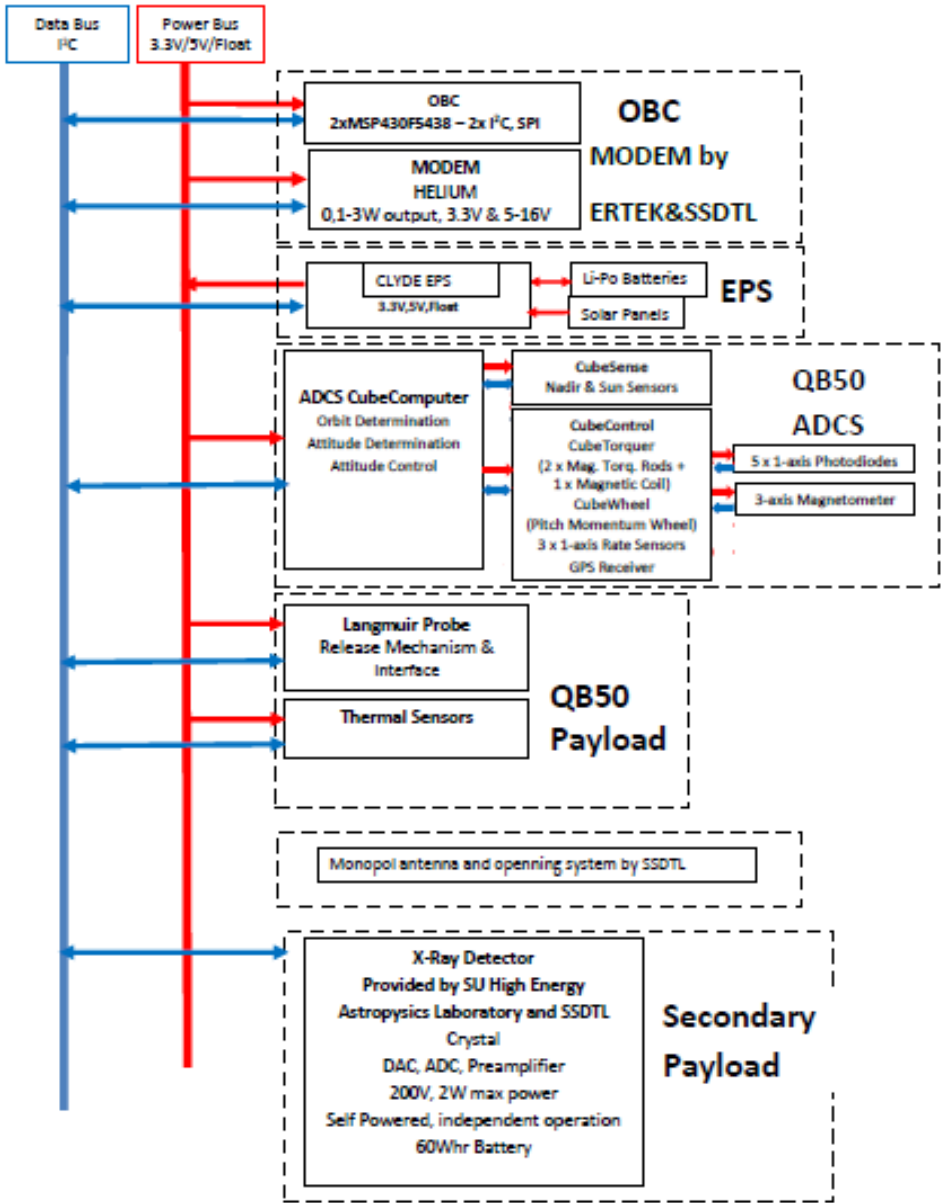
What is required for this course?

- At least 2 laptop for every team.
- Internet connection for all laptops

- Everyone should participate to handson work
- Work as a team
- Be careful with soldering iron

Wiring Diagram of an Example Satellite

Relationship between the subsystems

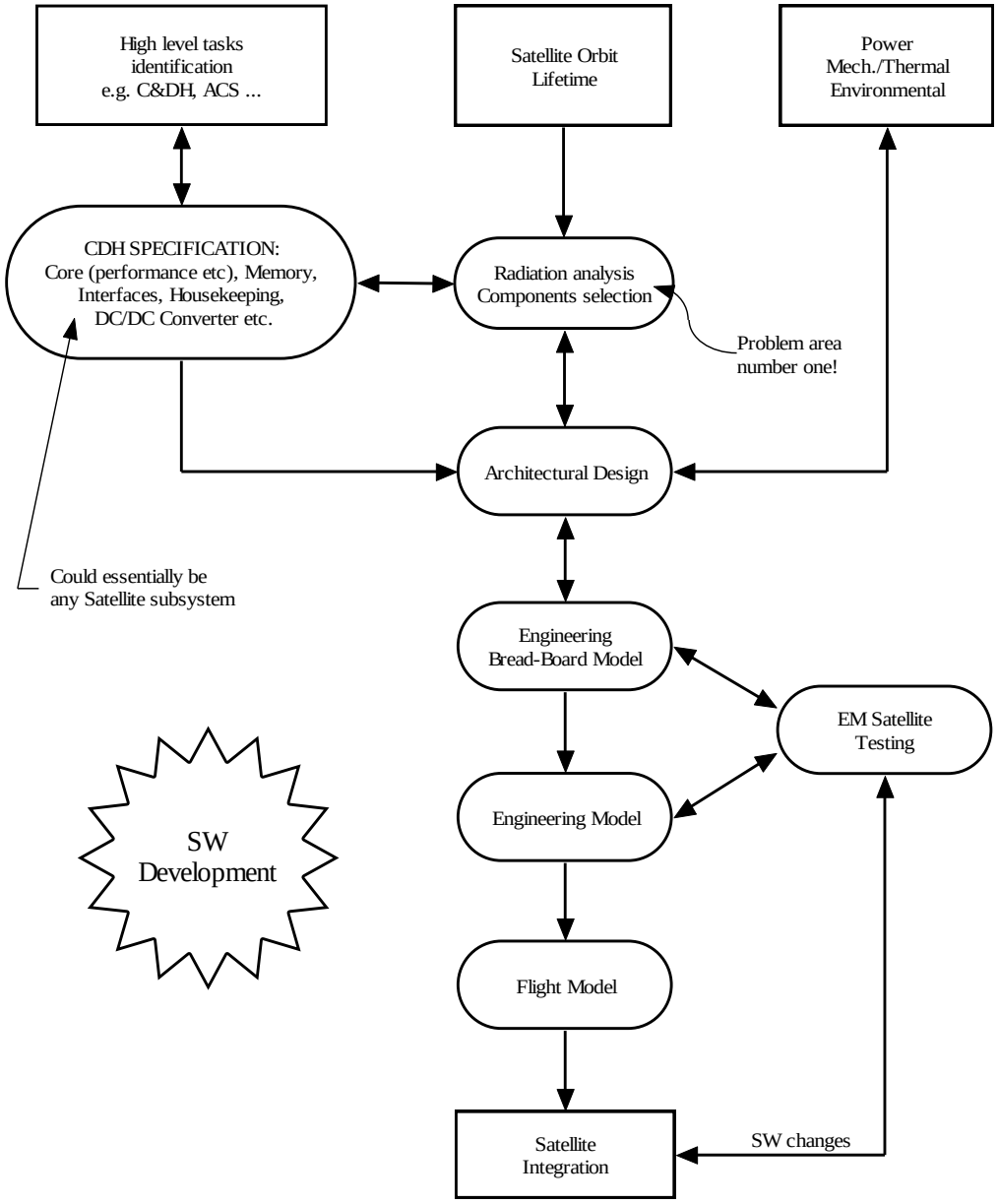


Architecture of On-Board Systems

Hardware Design Flow

HW design, step-by-step

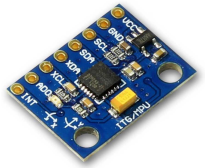
- Input
  - High level tasks
  - Radiation environment (given the orbit, lifetime and epoch)
  - Max power, mass, envelope etc.
  - External interface requirements
    - Power and data
- Output
  - Specification
  - Component selection
  - Architectural design
  - Detailed design



CANSAT Product Tree

ADCS

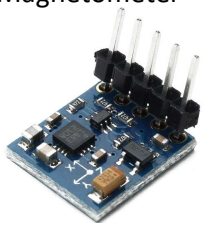
MPU 6050 (Acceleretometer, Angular Rate Sensor)



GY-NEO6MV2 GPS Module

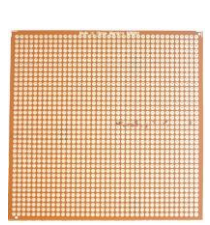
BMP 180 Barometer

HMC5883 (QMC) Magnetometer



STRUCTURE

Prototype Board and Connectors



Data Bus
I²C,SPI,USART

Power Bus
3.3V/**Battery**

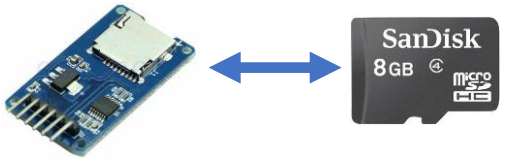
OBC-COM

ESP32 OBC-COM

- WiFi Module
- Embedded Antenna

Buzzer Board

SD Card Adapter & Storage Unit



EPS

9v Battery and Cable

Switch

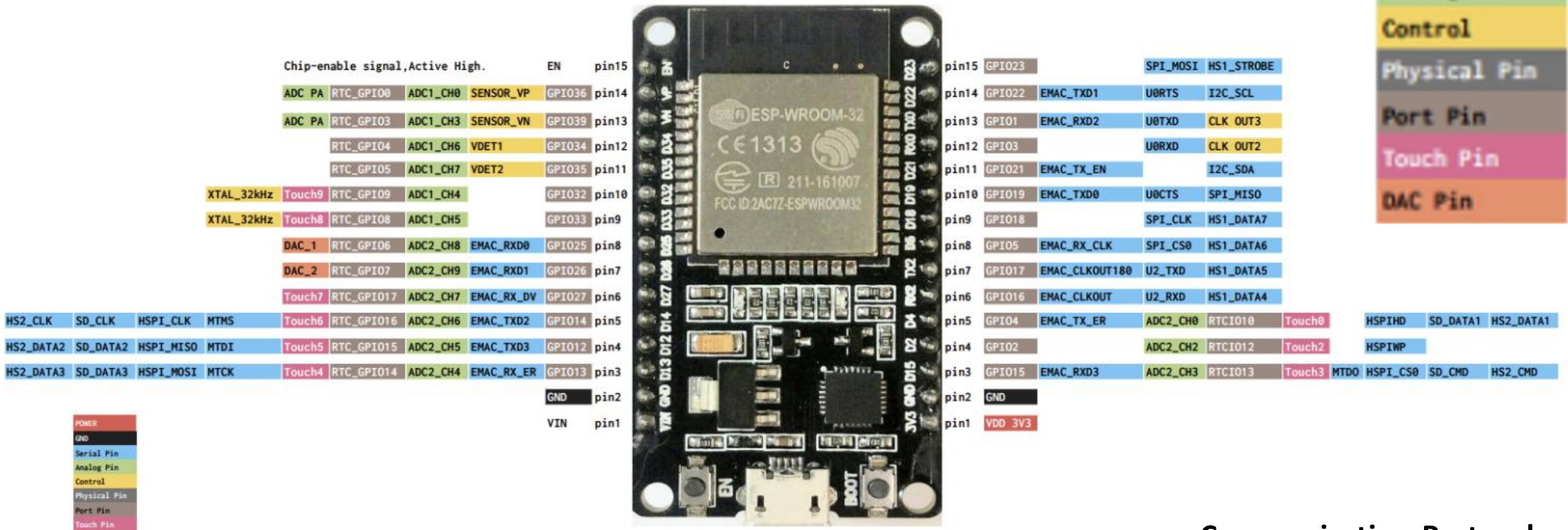
Payload

USB TTL Conv. & Camera Board

ESP32-WROOM-32

- Xtensa®32-bit LX6 microprocessor
- 240 MHz CPU Frequency
- 520 kB SRAM
- 4 MB Flash
- Operation temperature -40 ° C - 125 ° C
- 3.3V Logic
- ADC (16), SPI (2), I2C (1), UART (1), PWM (32), SDIO (50 Mhz)
- WiFi Transciever 802.11BGN HT40
- -98 dBm minimum sensitivity
- 150Mbps maximum transfer speed
- Wifi Range up to 500m
- Has embedded antenna
- Frequency Range 2.4Ghz to 2.5Ghz

ESP32-WROOM-32



Communication Protocols

- I2C
- SPI
- UART

ESP32 CAM Module

ESP32-CAM board specifications:

•Wireless Module- ESP32-S WiFi 802.11 b/g/n

•32Mbit SPI flash, 4MBit PSRAM

•External Storage – micro SD card slot up to 4GB

•Camera

- OV2640 sensor
- Image Format – JPEG(OV2640 support only), BMP, grayscale
- LED flash light

•Power Consumption

- Flash LED off – 180mA @ 5V
- Flash LED on to maximum brightness- 310mA @ 5V
- Deep-sleep – 6mA @ 5V min.
- Modem-sleep – 20mA @ 5V min.
- Light-sleep – 6.7mA @ 5V min.

•Dimensions – 40.5 x 27 x 4.5 mm

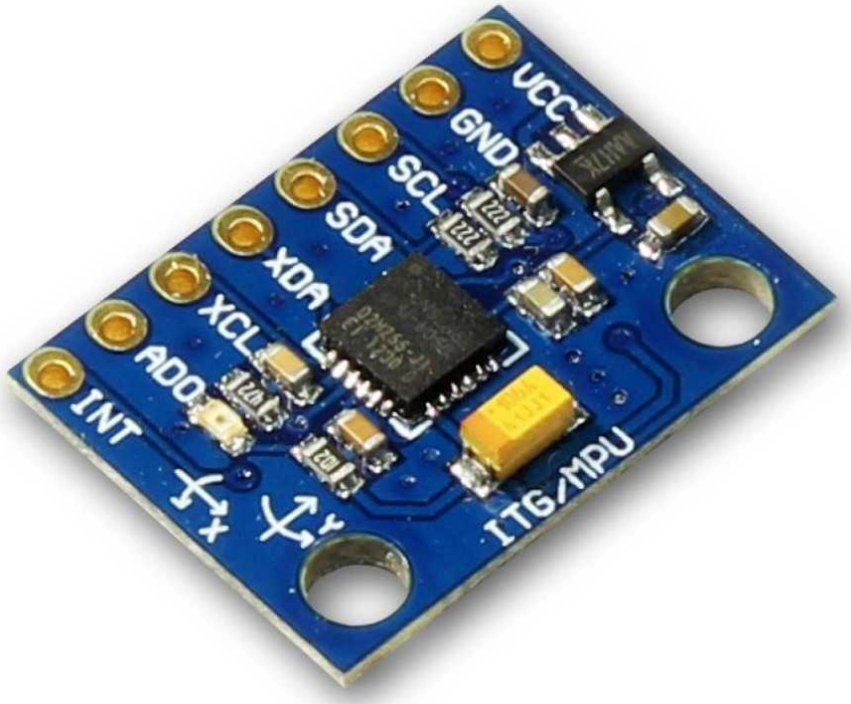
•Weight- 10 grams

•Temperature Range – Operating: -20 ℃ ~ 85 ℃; storage: -40 ℃ ~ 90 ℃ @ < 90%RH

BMP 180 Pressure Sensor

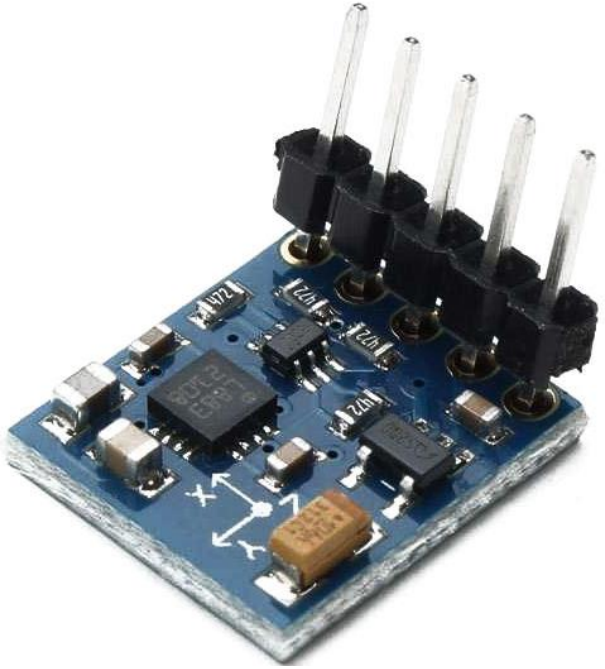
- Dimensions: 21mm x 18mm
- 1.8V - 3.6V Supply Bus
- Low Power Consumption- 1Hz'de 0.5uA
- I2C Interface
- Calibrated
- Pressure Scale: 300hPa - 1100hPa (+ 9000m - -500m)

MPU 6050 Accelerometer & Gyro



- MPU-6050 (3-axis Gyroscope+ 3-axis accelerometer)
- Power Input: 3.3V – 5V
- I2C protocol
- Measurement scale for angular rate: 250 500 1000 2000 ° / s
- Measurement scale for accelerometer: 2 4 8 16g

HMC5883L Magnetometer

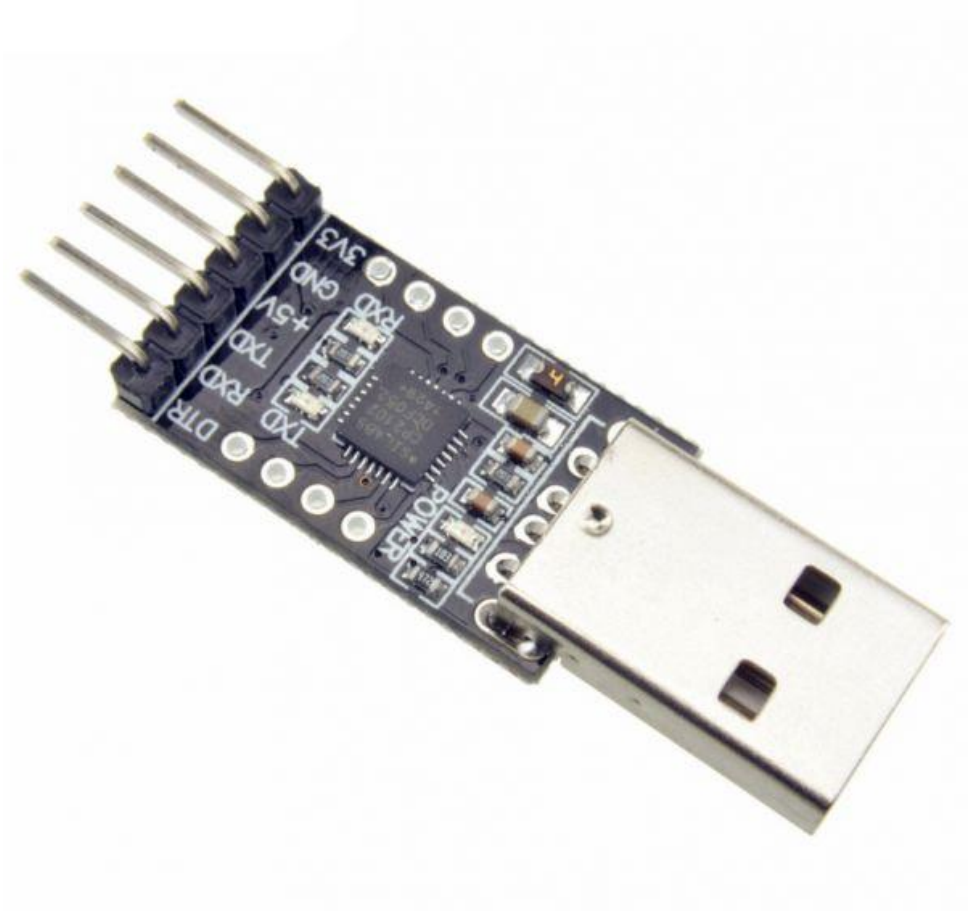


- Input Voltage: 3.3V -5V
- I2C protocol
- Measurement Scale: ±1,3-8 Gauss
- Board Dimensions: 14x13mm

https://pdf.direnc.net/upload/hmc5883l-3-axis-digital-compass-ic.pdf

https://drive.google.com/file/d/1qSMR_wpKw_oKWemaDlCTBbArQjQ5hMzj/view

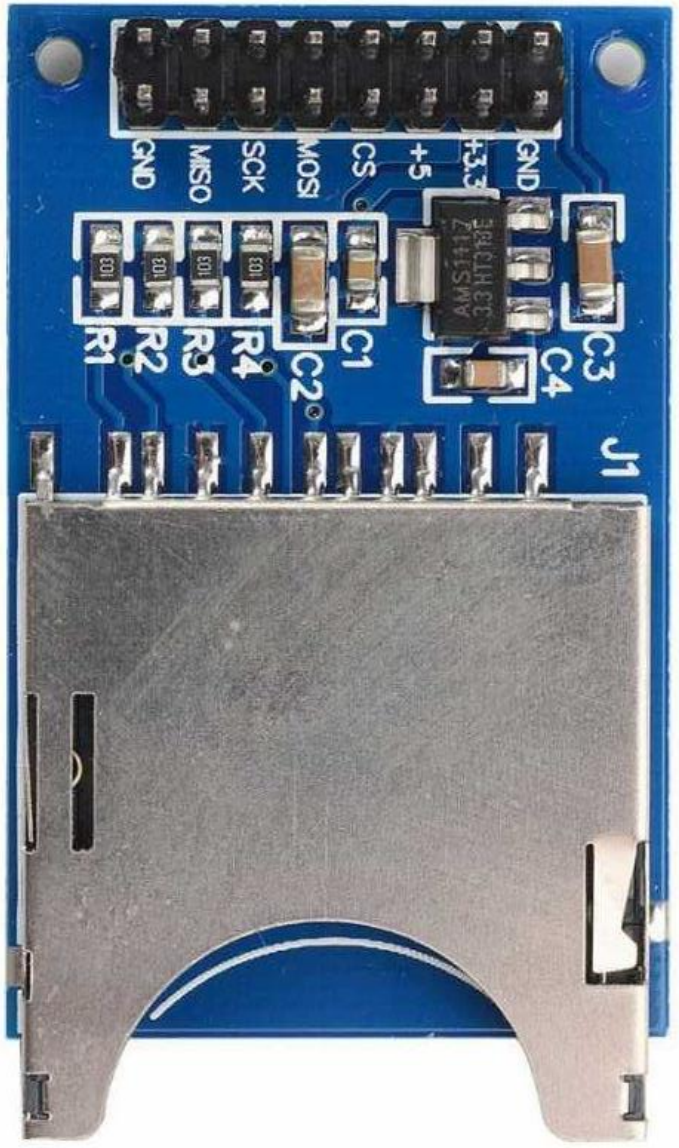
CP2102 Uart-USB Converter



- Used for uploading code to the ESP32 Camera Module
- USB TTL Converter
- Used for logic 3.3V and 5V

SD Card Adapter & SD Card

- Works with 5V
- Used to store collected sensor data



- 16-32 GB Storage

NEO-6M GPS Module

- Voltage: 3.3V
- Size: 36mm * 24mm
- interface: UART

Buzzer Board

- 3.3V – 5V operating voltage
- Makes noise when supplied with power.
- It is used for to find the CanSat after landing

9V BATTERY

- Voltage: 9V
- Supply power to CanSat during Flight.

Power Switch

- Used for cut the power from battery to CanSat.

Power and Data Cables

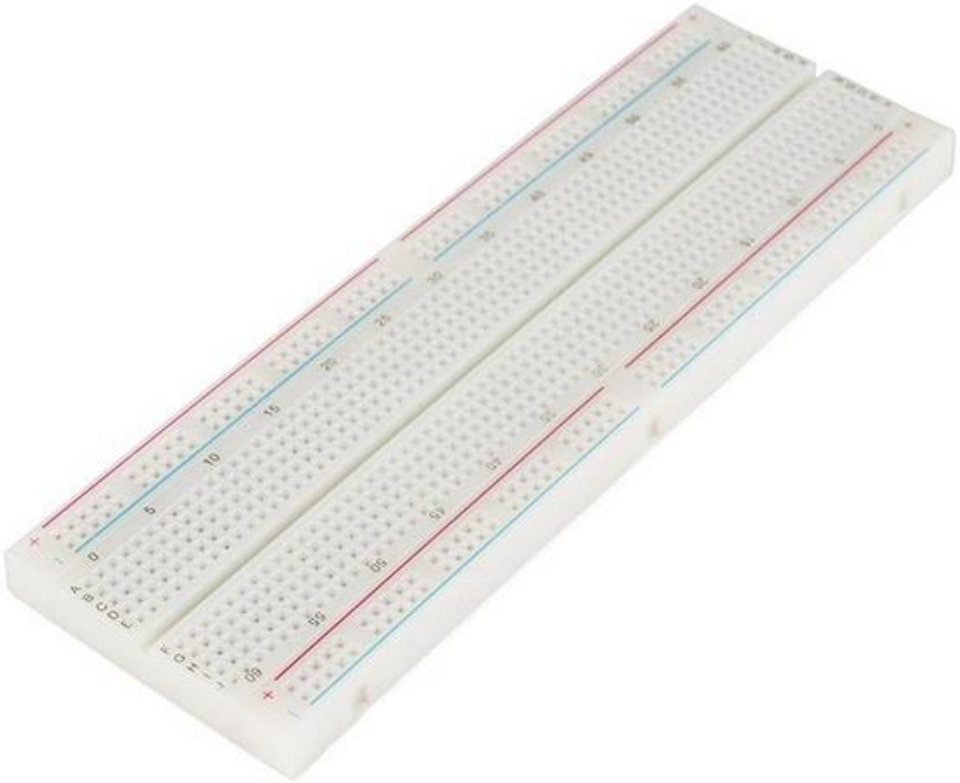
Cabling for prototype board.

Jumper cable will not be used for cabling.

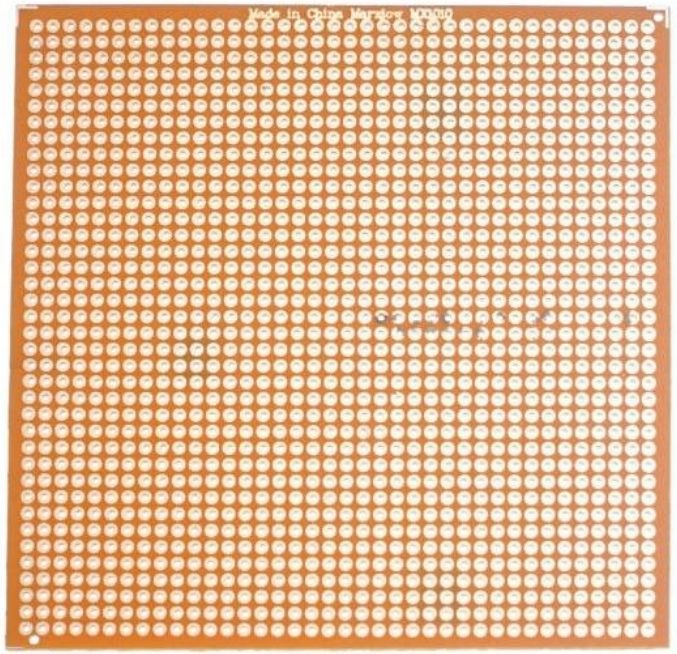
Soldering Wire + Soldering Iron

- Soldering wire for connecting components on Prototype Board with a soldering Iron.

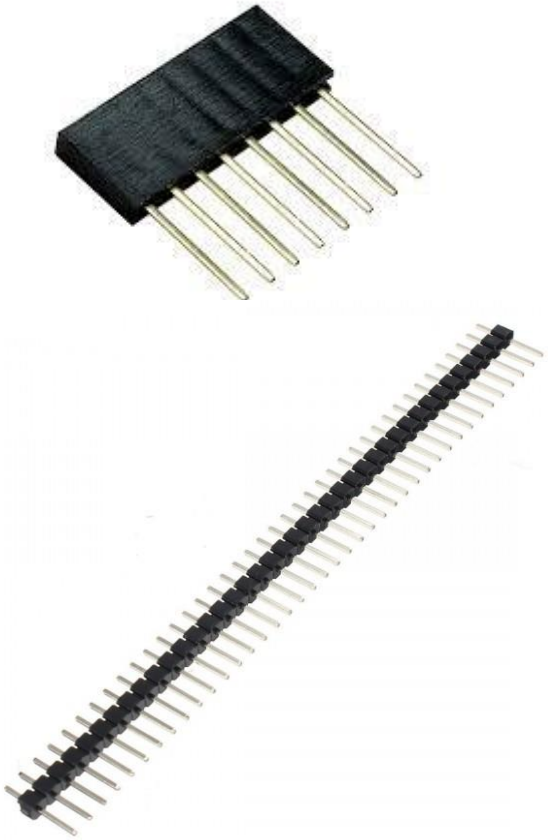
BreadBoard, Prototype Board, Connectors



BreadBoard



Prototype Board



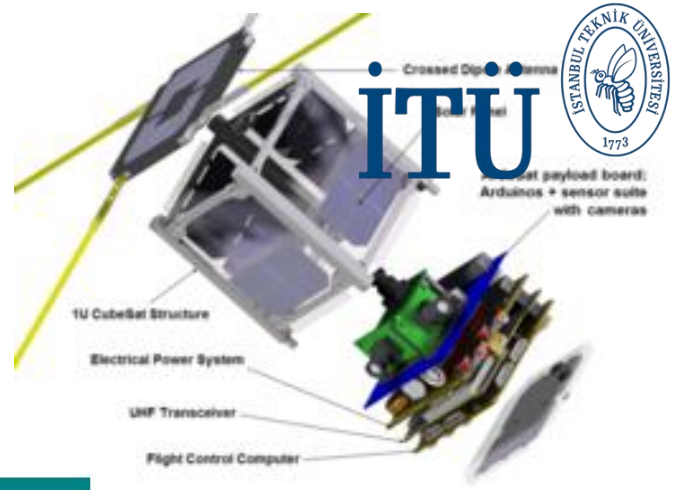
Connectors

Jumper Cable

- Jumper cables are used for connect the sensors and ESP32 on breadboard.

- We have these types;
  - Male-Male
  - Female-Male
  - Female-Female

Arduino IDE



Download the Arduino IDE

Arduino IDE 2.3.1

The new major release of the Arduino IDE is faster and even more powerful! In addition to a more modern editor and a more responsive interface it features autocompletion, code navigation, and even a live debugger.

For more details, please refer to the **Arduino IDE 2.0 documentation**.

Nightly builds with the latest bugfixes are available through the section below.

SOURCE CODE

The Arduino IDE 2.0 is open source and its source code is hosted on **GitHub**.

DOWNLOAD OPTIONS

Windows Win 10 and newer, 64 bits
Windows MSI installer
Windows ZIP file

Linux AppImage 64 bits (X86-64)
Linux ZIP file 64 bits (X86-64)

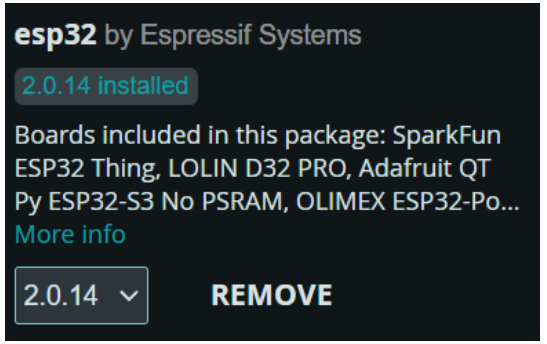
macOS Intel, 10.14: "Catalina" or newer, 64 bits
macOS Apple Silicon, 11: "Big Sur" or newer, 64 bits

Release Notes

- ArduSat

Arduino ESP32 Libraries

- Go to File/Preferences
- Paste the link to the Additional Boards Manager URLs:
- `https://raw.githubusercontent.com/espressif/arduino-esp32/gh-pages/package_esp32_index.json`
- Click OK
- Go to Board Manager (Tools/Board/Board Manager)
- Install "esp32 by Espressif Systems"

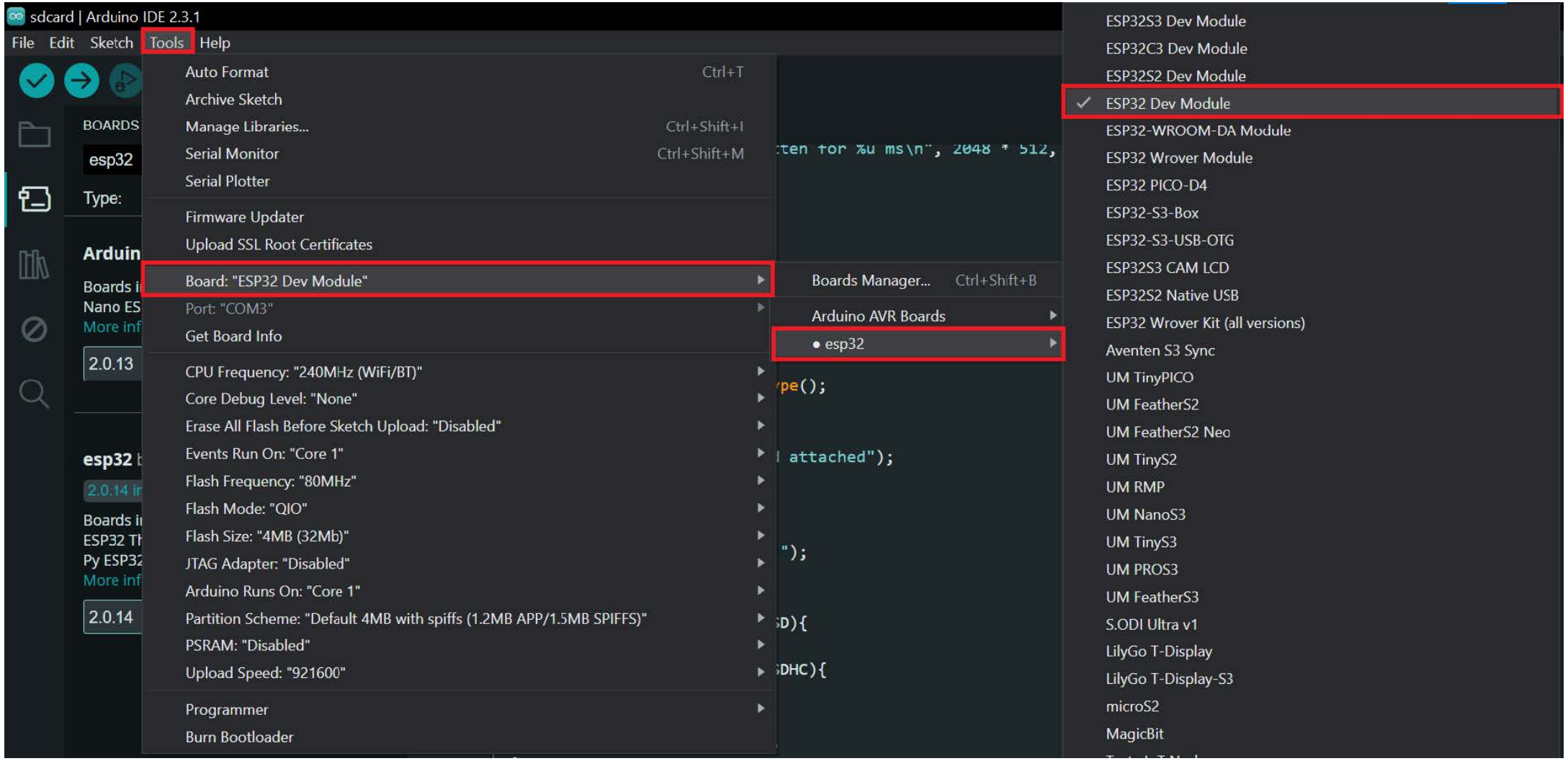


- beynek@itu.edu.tr

https://raw.githubusercontent.com/espressif/arduino-esp32/gh-pages/package_esp32_index.json

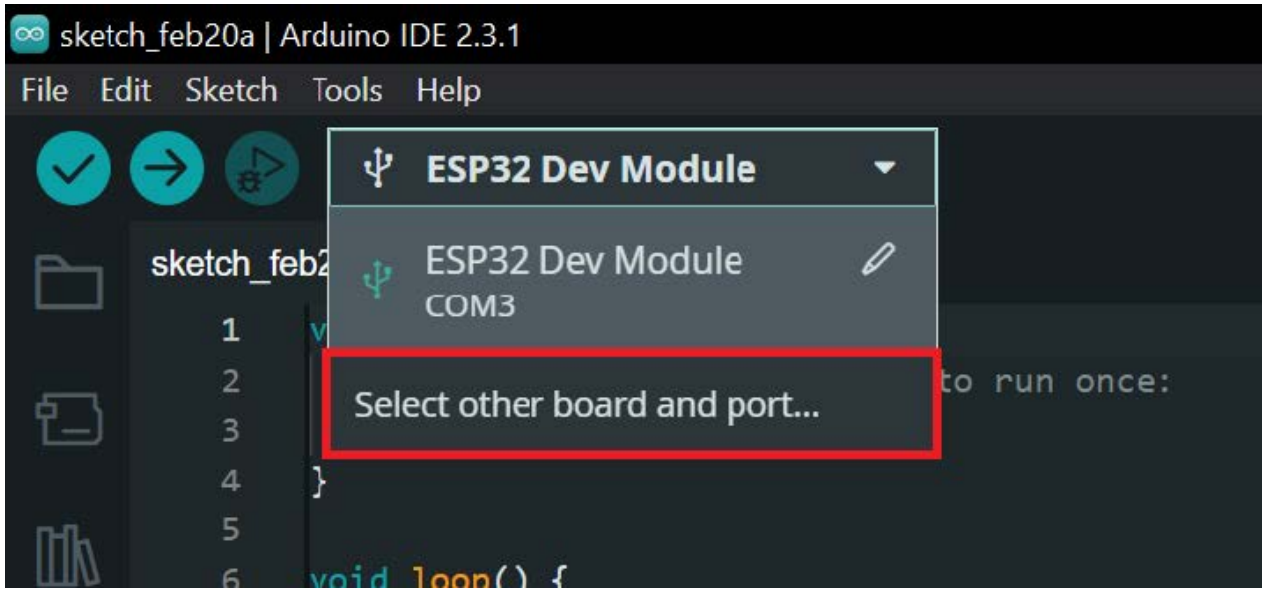
CHOOSE BOARD

- Your setttings should look like this.



CHOOSE PORT

- Choose the port that ESP32 is connected and choose ESP32 Dev Module for that port.

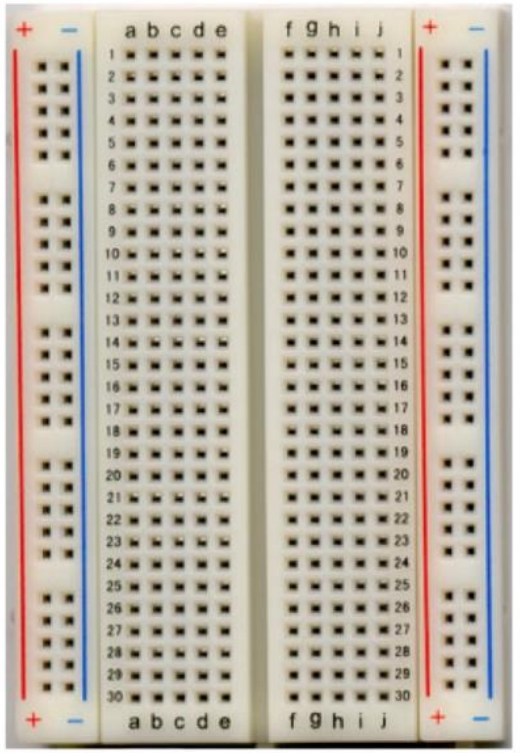


- If port cannot be seen, CP210x driver might be missing. You can download the driver from:
- https://www.silabs.com/developers/usb-to-uart-bridge-vcp-drivers?tab=downloads

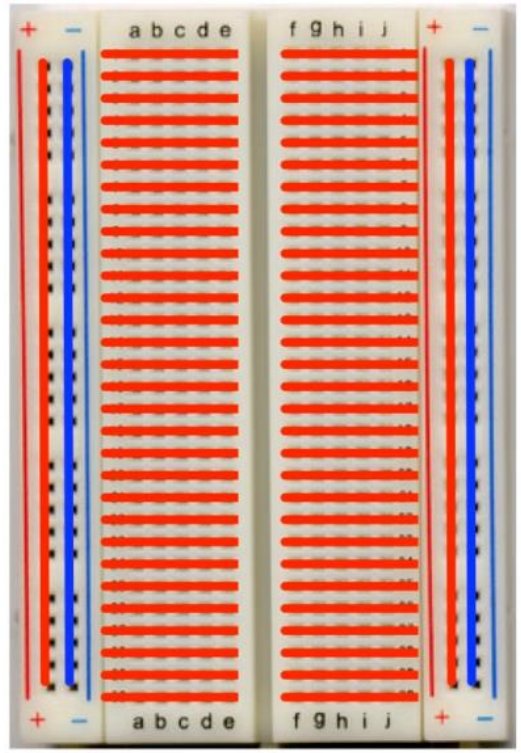
Breadboard

- Why Use BreadBoards ?
- An electronics breadboard (as opposed to the type on which sandwiches are made)is actually referring to a **solderless breadboard**.
- These are great units for making temporary circuits and prototyping, and they require absolutely no soldering. (Pluggable)

Breadboard (photo)



Breadboard (schematic)



BLINK CODE

- Upload: File/Examples/Basics/Blink
- Led is connected to pin D2

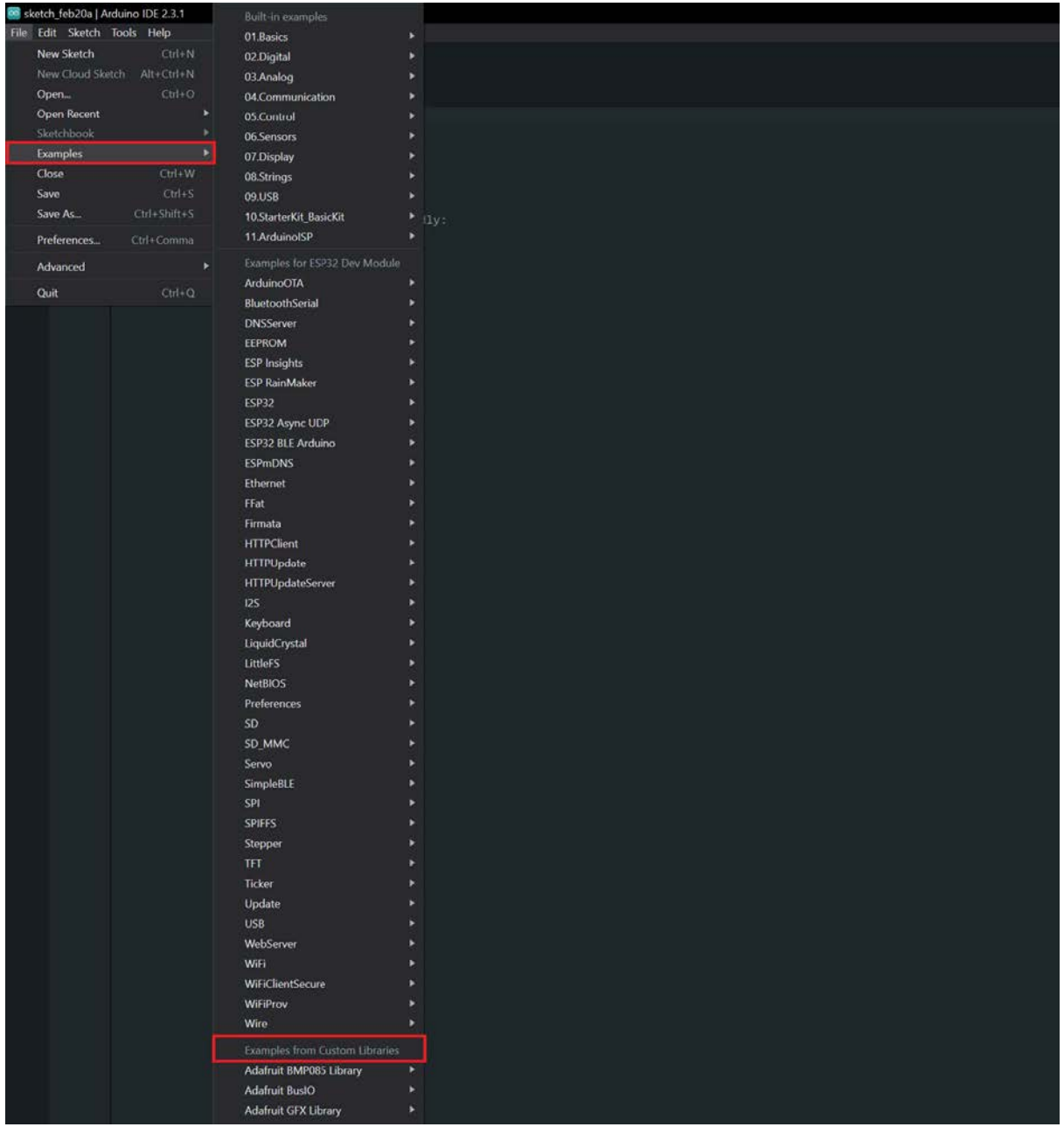
```
int LED_BUILTIN = 2;
// the setup function runs once when you press reset or power the board
void setup() {
  // initialize digital pin LED_BUILTIN as an output.
  pinMode(LED_BUILTIN, OUTPUT);
}

// the loop function runs over and over again forever
void loop() {
  digitalWrite(LED_BUILTIN, HIGH);   // turn the LED on (HIGH is the voltage level)
  delay(1000);                       // wait for a second
  digitalWrite(LED_BUILTIN, LOW);    // turn the LED off by making the voltage LOW
  delay(1000);                       // wait for a second
}
```

LIBRARIES

- Copy an Paste the libraries that we provided to the location below.

- C:\Users\”UserName”\Documents\Arduino\libraries

CHECK LIBRARIES



BMP 180

- Pressure
- Temperature
- Altitude (Seal Level)

Name	Date modified	Type
1.BLINK	14.07.2022 23:58	File folder
2.BMP	15.07.2022 00:10	File folder
3.BMP_MPU	15.07.2022 00:13	File folder
4.BMP_MPU_HMC	15.07.2022 00:17	File folder
5.BMP_MPU_HMC_SD	15.07.2022 00:45	File folder
6.BMP_MPU_HMC_SD_BUZ	15.07.2022 01:39	File folder
7.BMP_MPU_HMC_SD_BUZ_GPS	15.07.2022 02:00	File folder
8.BMP_MPU_HMC_SD_BUZ_GPS_COM	15.07.2022 02:54	File folder
9.BMP_MPU_HMC_SD_BUZ_GPS_COM_CAM	15.07.2022 00:20	File folder

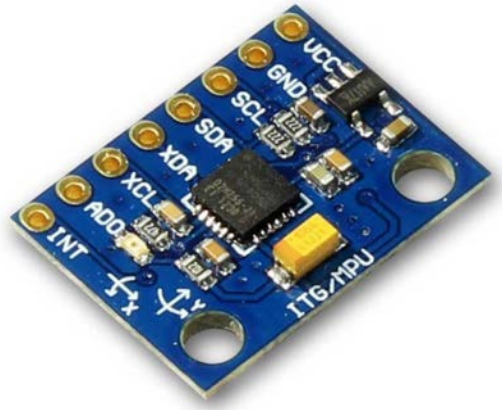
Pin Definition

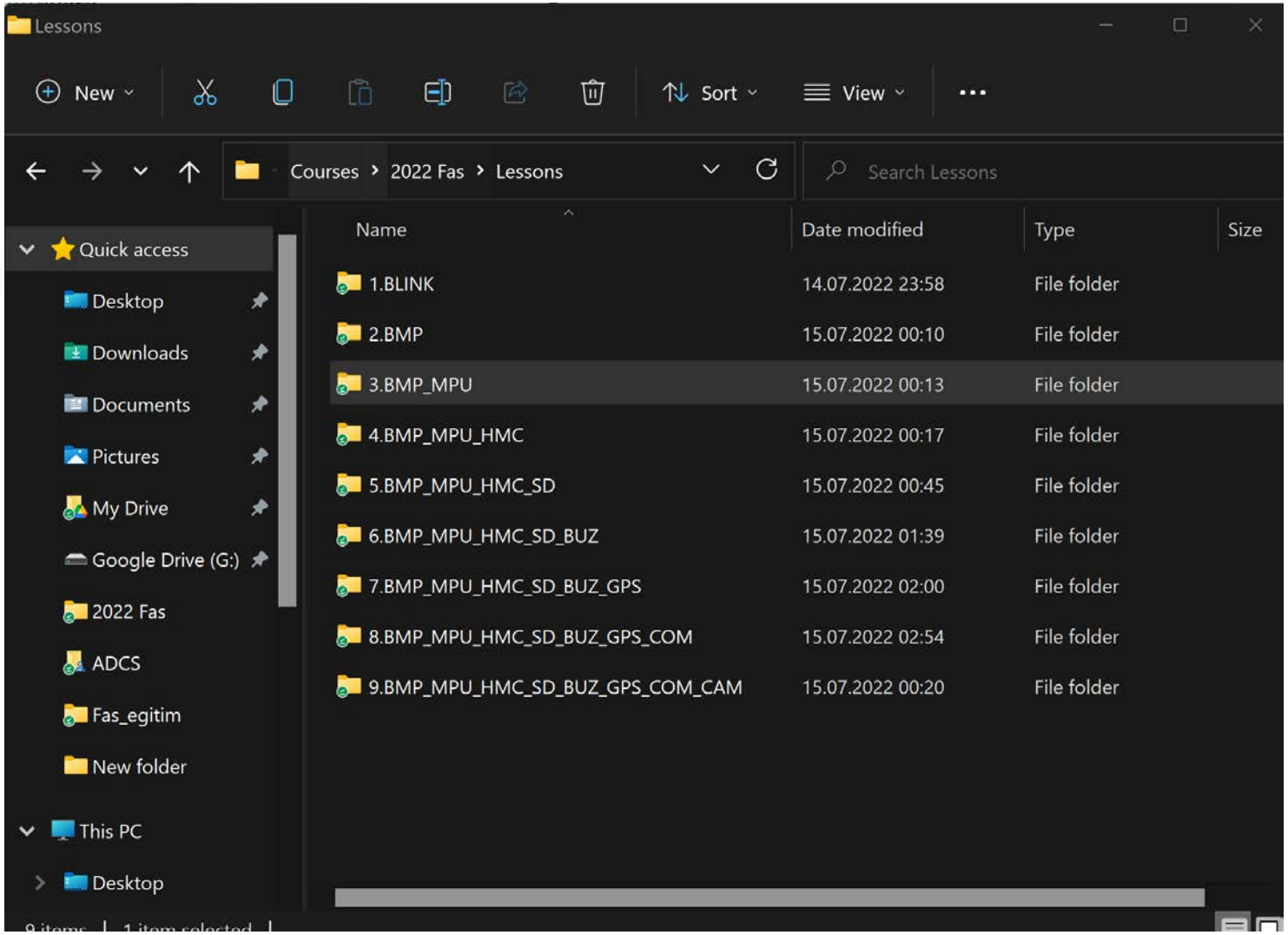
BMP180----------ESP32

GND----------->GND
3.3V---------->3.3V
SCL----------->D22
SDA----------->D21

MPU 6050

- Accelaration
- Angular Accelaration





MPU6050----------ESP32

GND---------->GND

3.3V---------->3.3V

SCL---------->D22

SDA---------->D21

HMC5883L

- Magnetic Field 3 Axis
- Magnetic North (Compass)

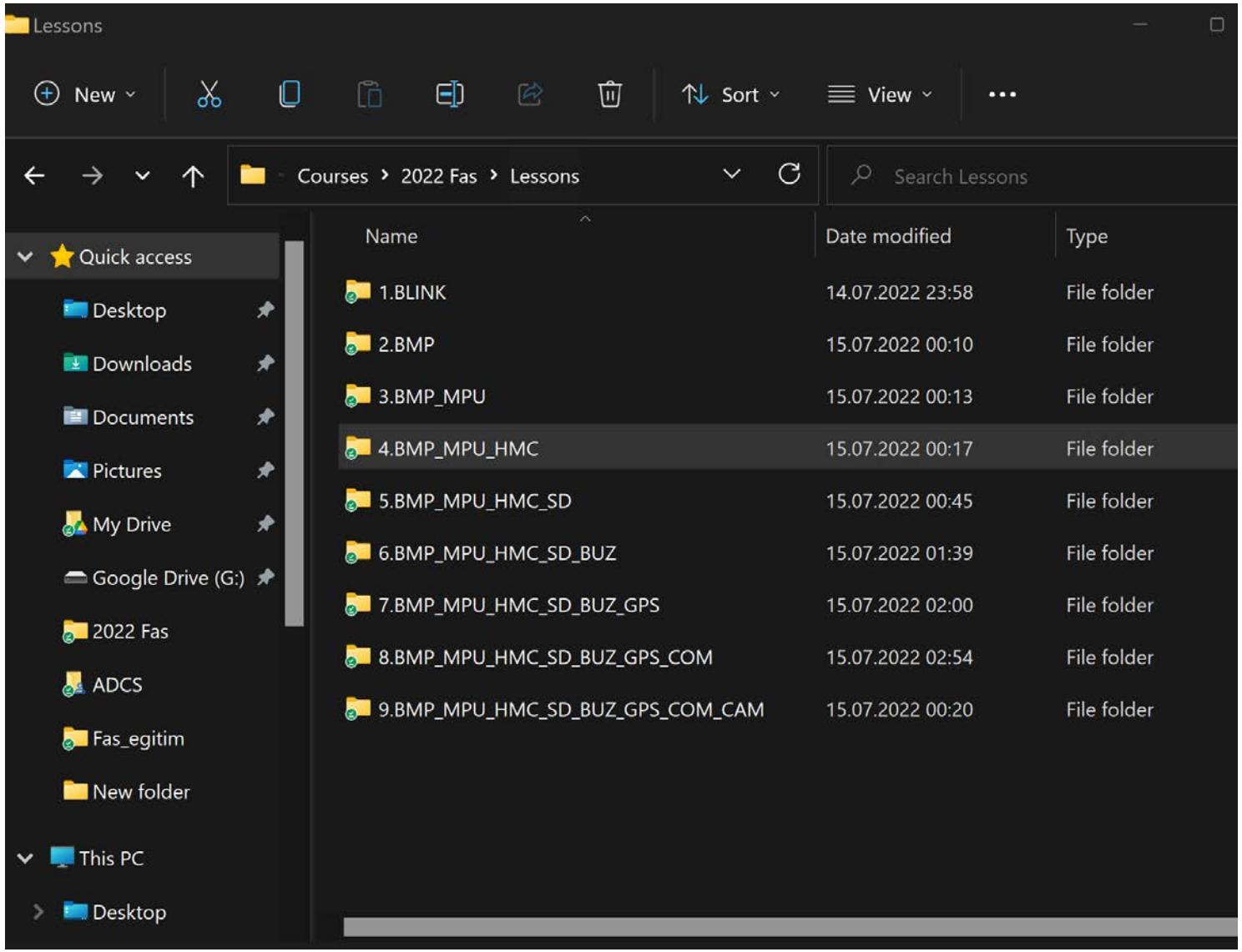
HMC5883L----------ESP32

GND---------->GND

3.3V---------->3.3V

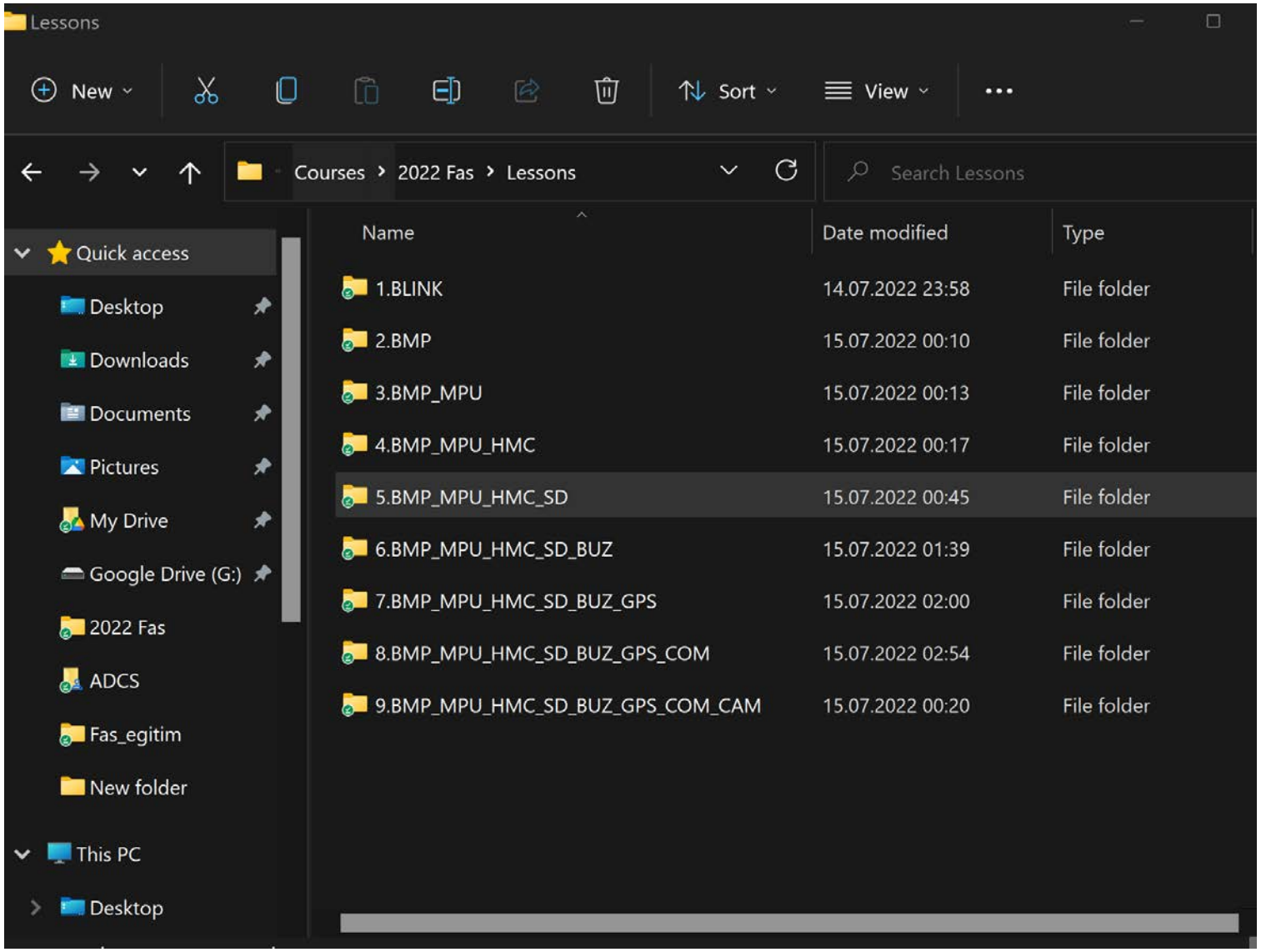
SCL---------->D22

SDA---------->D21



SD Card

- Store Sensor Data



SD Card----------ESP32

GND---------->GND

3.3V---------->3.3V

CS---------->D5

MOSI---------->D23

SCK---------->D18

MISO---------->D19

Buzzer

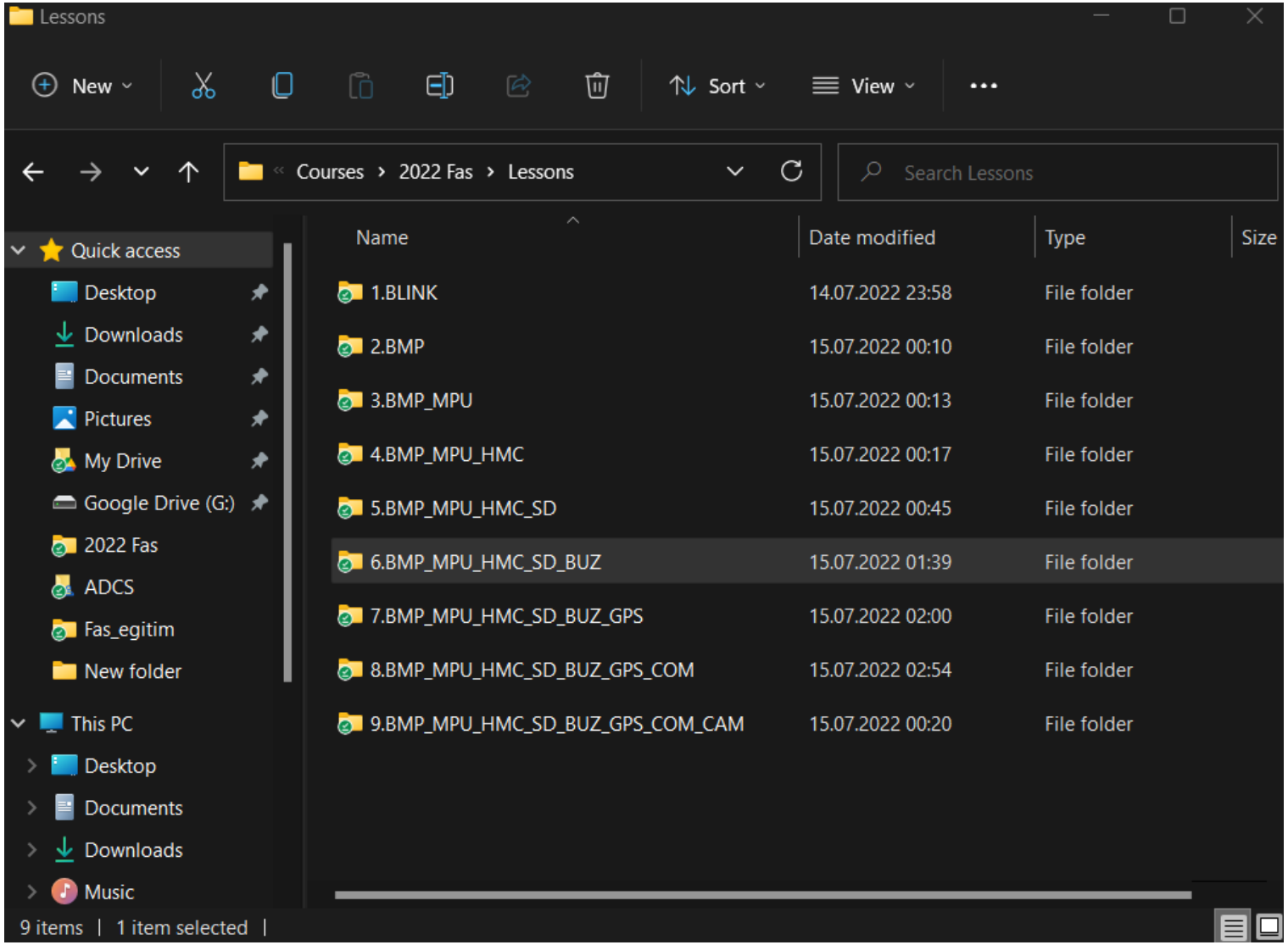
- Used for to ease to find the CanSat after landing.
- Beacons on satellite.

Buzzer----------ESP32

GND---------->GND

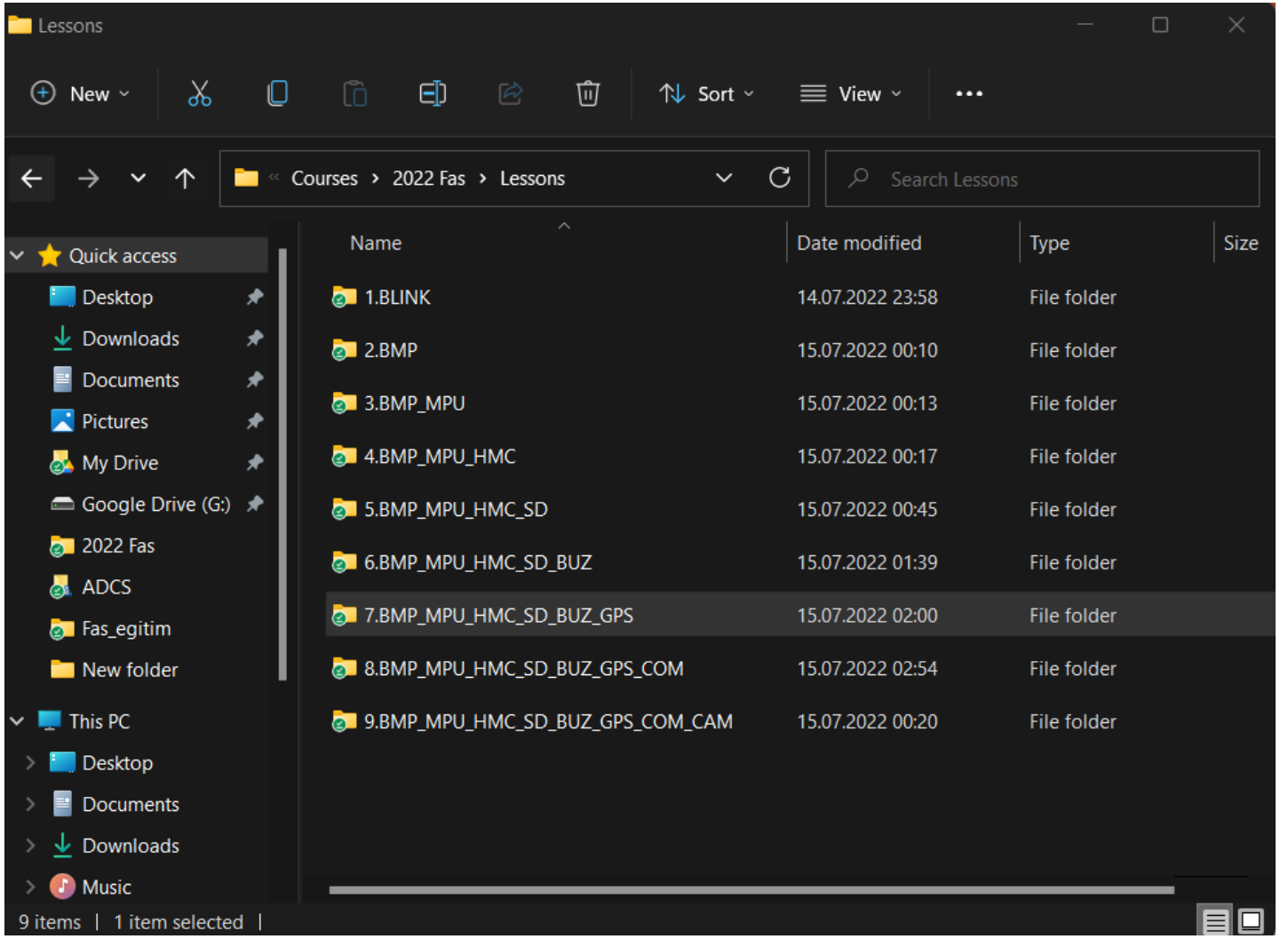
3.3V---------->3.3V

I/O---------->D4



GPS Module

- **When GPS Receiver fixed with GPS satellites the Green led begins to blink.**
- **It may take up to 10 minutes on clear sky.**
- **It has Embedded patch antenna.**



GPS----------ESP32

VCC----------→3.3V

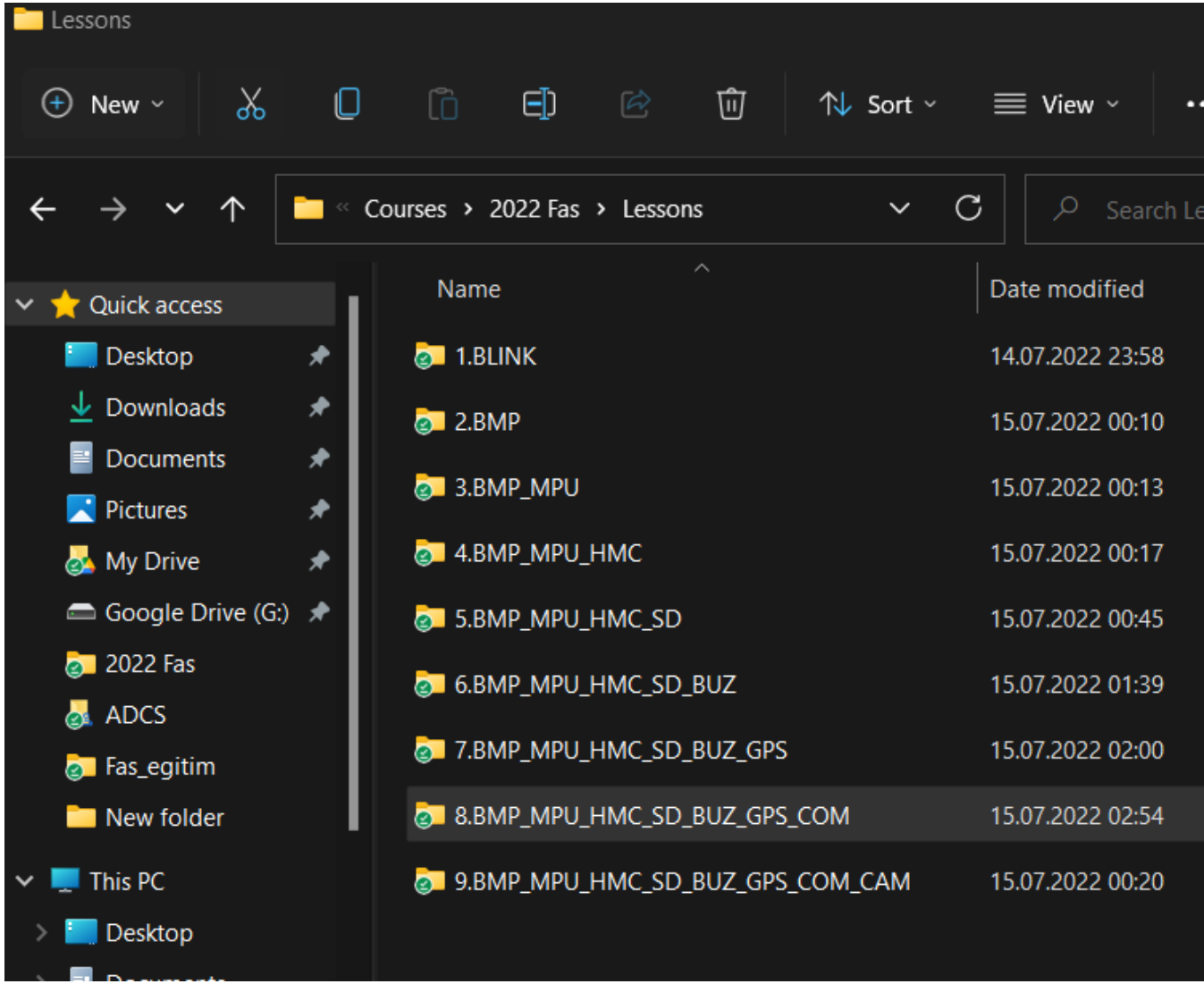
GND----------→GND

RX----------→ TX2

TX----------→ RX2

Ground Station

- **When CanSat deployed from multicopter, all sensor data will be received from our ground stations.**
- **Every Team has a different MAC address.**

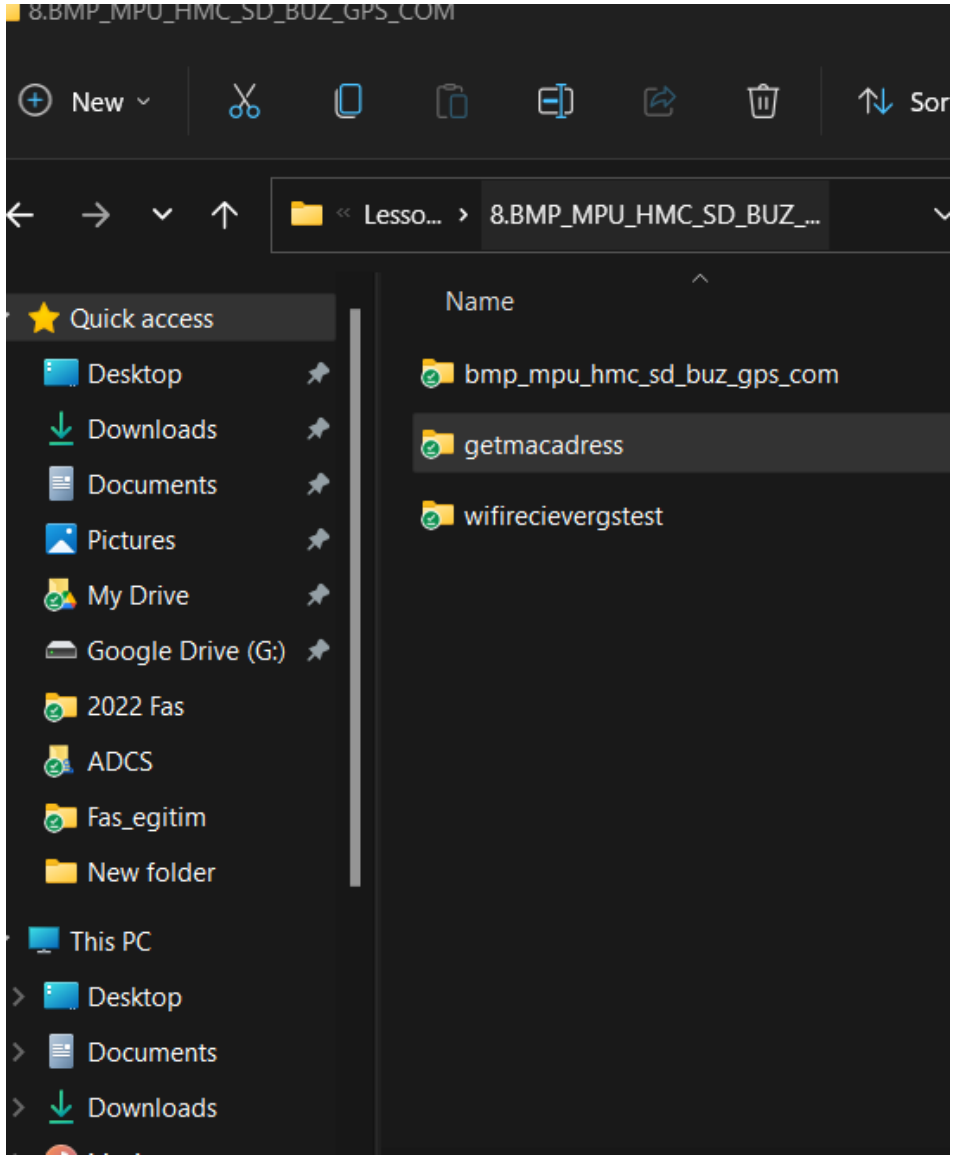


Ground Station Mac Address

- **A new ESP32 for Ground Station**

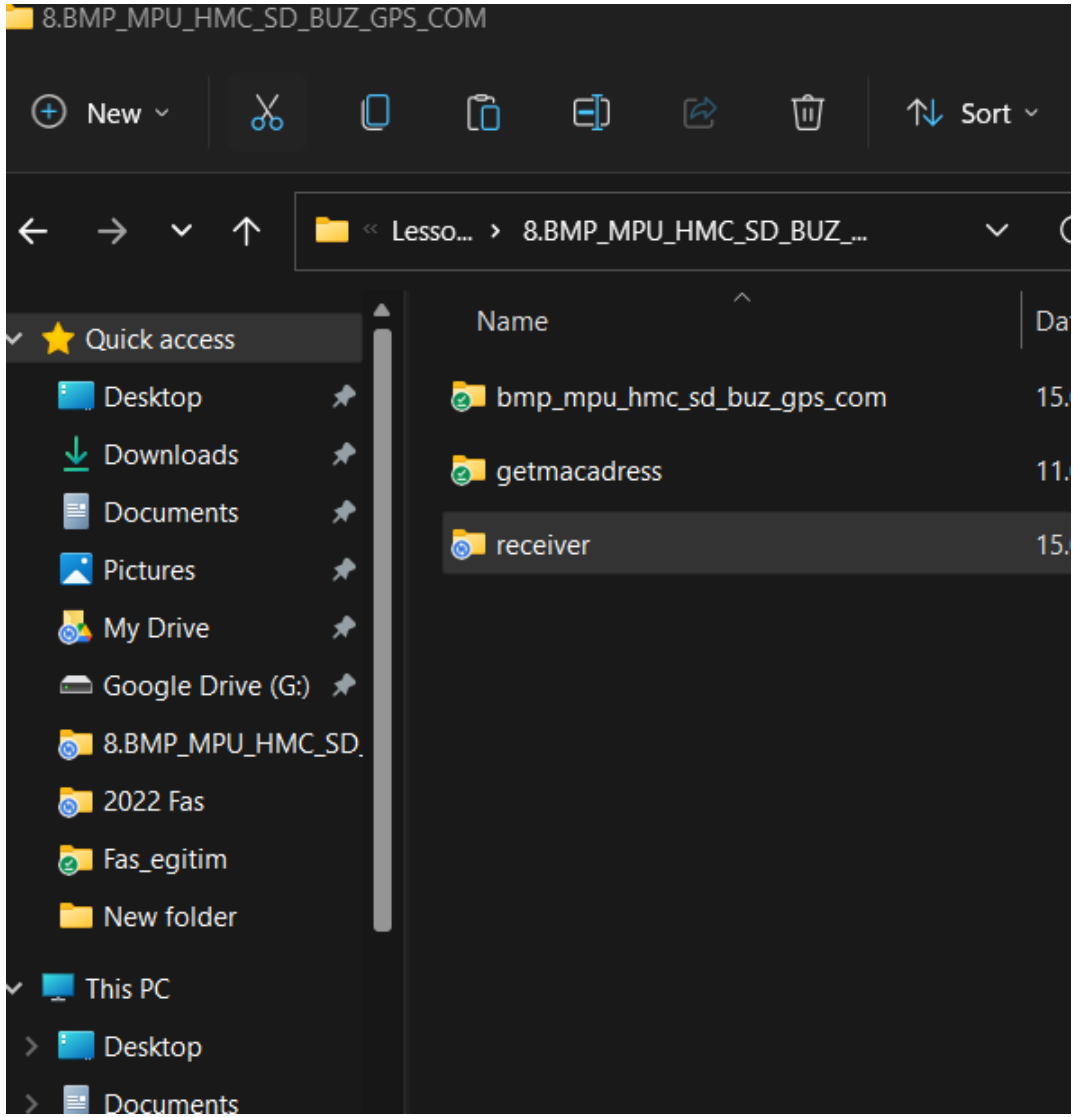
- **Connect ESP32 to Computer with another micro-USB cable.**
- **Choose the new COM port.**

- **Upload and Run the code “getmacadress”**
- **Open serial monitor to find your mac address. Save it for later.**



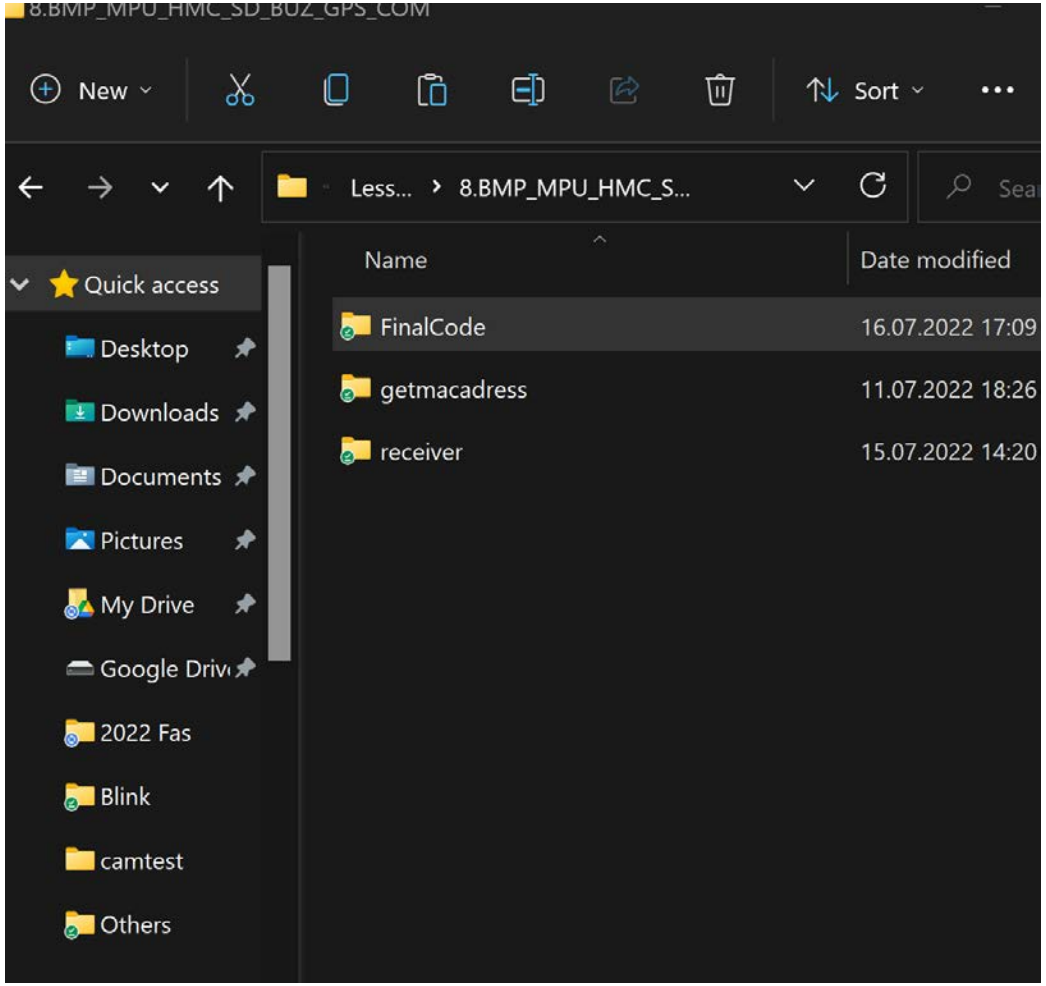
Ground Station Get Data

- Upload and run the “receiver” code.
- Ground Station is ready for receiving data.
- Open Serial Monitor.
- When data is received, it will ve displayed on Serial Monitor.
- Don’t forget to save your data from Serial Monitor and to SD Card.



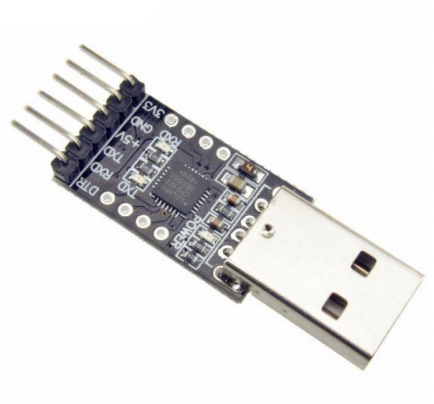
CanSat EPS32

- **After finishing the ground station,**
- **We have to upload the new code to our CanSat.**



ESP32 CAM

- **Make the connection shown below**
- **Connect FTDI to your computer**



<u>ESP32 CAM----------FTDI</u>

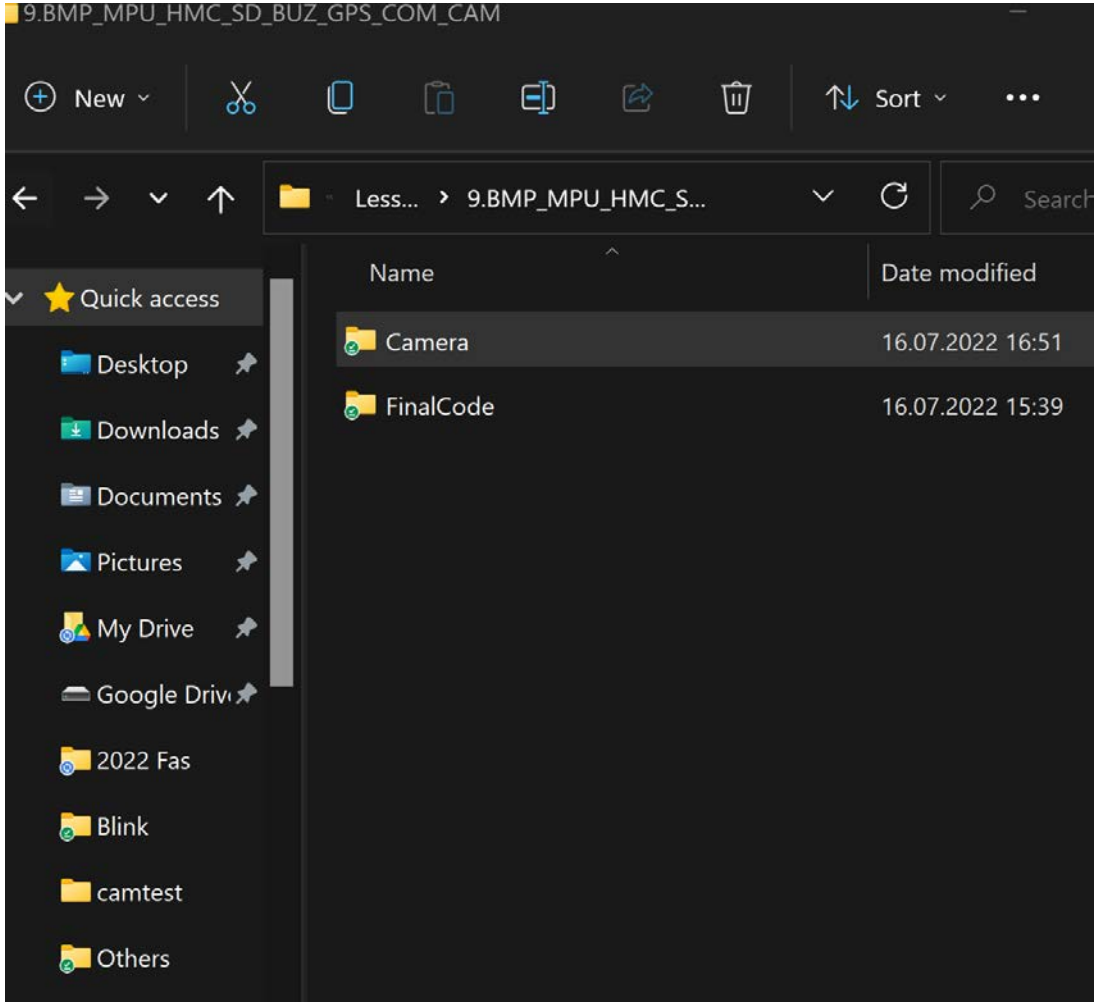
5V----------→5V

GND----------→GND

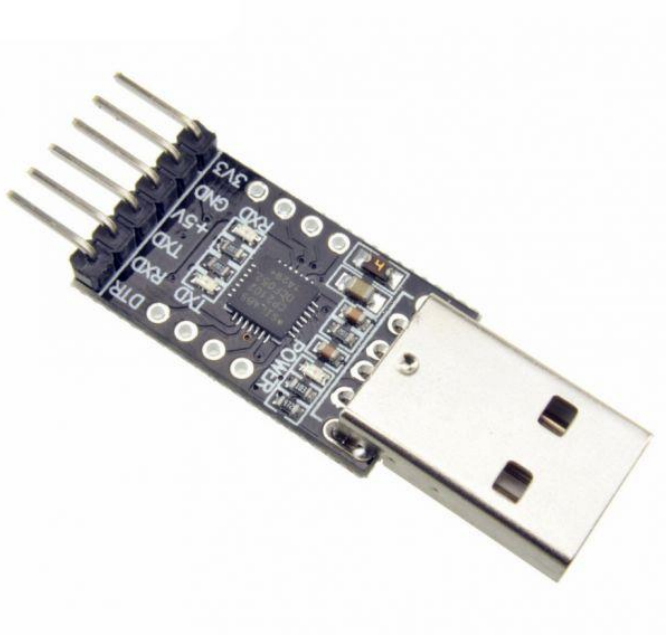
UOR----------→ TX

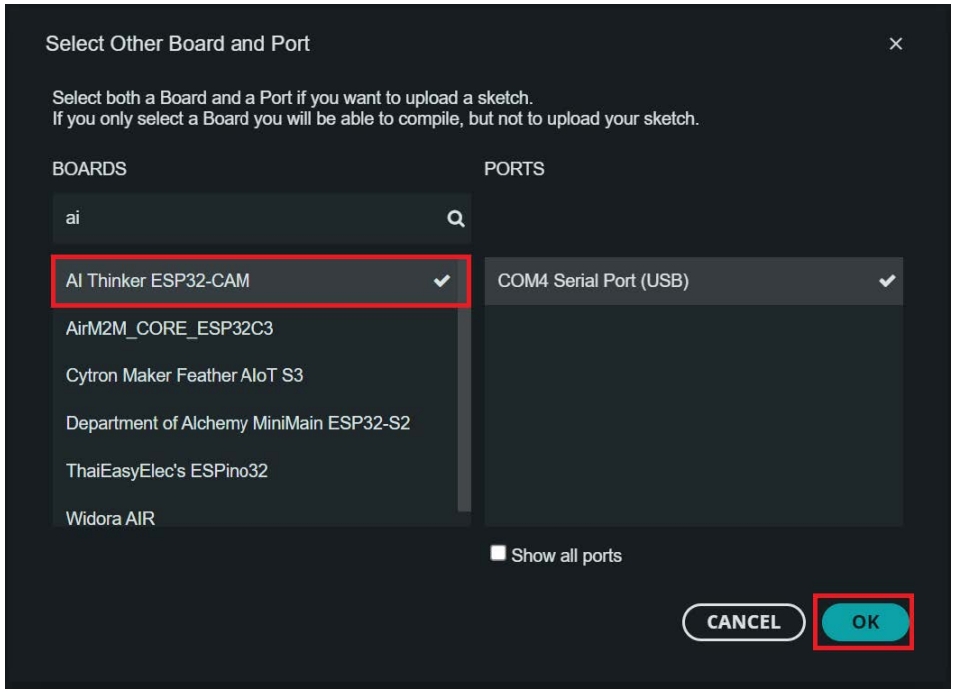
UOT----------→ RX

IO 0----------→ GND(on ESPCAM)



ESP32 CAM





- **Connect FTDI to your computer**
- **Choose the new COM port.**
- **We have to upload the new code “Camera”**

- **If you have problems while uploading the code, press reset button when “uploading” text seem on the Arduino Interface.**

Testing Camera

- Remove the IO0 – GND cable.
- Restart the camera with reset button.
- Take an image for every 1-5 seconds.

- We will take images during flight.

CanSat Connection Diagram

BMP180----------ESP32

GND---------->GND
3.3V---------->3.3V
SCL---------->D22
SDA---------->D21

MPU6050----------ESP32

GND---------->GND
3.3V---------->3.3V
SCL---------->D22
SDA---------->D21

HMC5883L----------ESP32

GND---------->GND
3.3V---------->3.3V
SCL---------->D22
SDA---------->D21

Buzzer----------ESP32

GND---------->GND
3.3V---------->3.3V
I/O---------->D4

BATTERY----------

9V(RED)---------->VIN(ESP32)
GND(BLACK)->SWITCH->GND(ESP32)

SD Card----------ESP32

GND---------->GND
3.3V---------->VIN
CS---------->D5
MOSI---------->D23
SCK---------->D18
MISO---------->D19

ESP32----------GPS

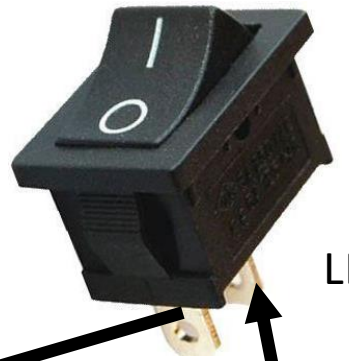
3.3V---------->VCC
GND---------->GND
RX2---------->TX
TX2---------->RX

BATTERY----------ESP32CAM

9V(RED)---------->5V (CAM)
GND(BLACK)->SWITCH->GND(CAM)

Battery Connections

- **You can use any leg of the switch, it works both ways.**
- **Battery should be connected to VIN pin on the ESP32 NOT 3.3V.**
- **When the Battery is connected to the ESP 32 you shouldn't connect usb cable to the ESP32.**



LEG 1

LEG 2

VIN

GND

Black Cable (GND)

Red Cable (9V)

BATTERY----------

9V(RED)----------→VIN(ESP32)

GND(BLACK)---→SWITCH---→GND(ESP32)

Design Constraints

- **Camera should look through sideways or of the CanSat or downwards.**
- **GPS antenna shouldn’t look through ground.**
- **All the components except power switch, should fit inside the the CanSat structure.**
- **Main SD Card and Camera Sd card shuld be reachable after assembly.**

MASS BUDGET

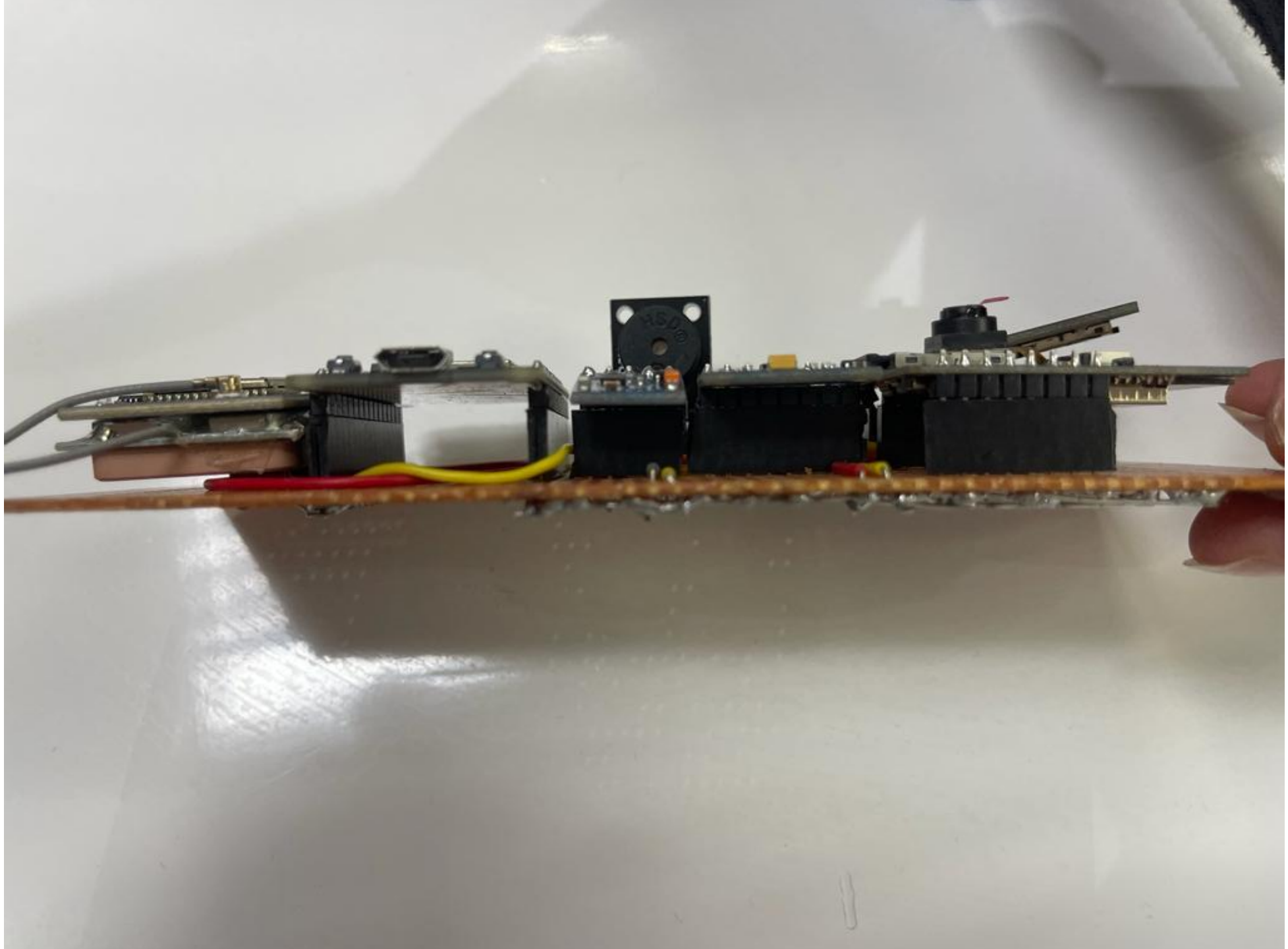
- **Find(or guess) the mass of the components and fill the table**
- **Check if your CanSat inside the mass limits.**

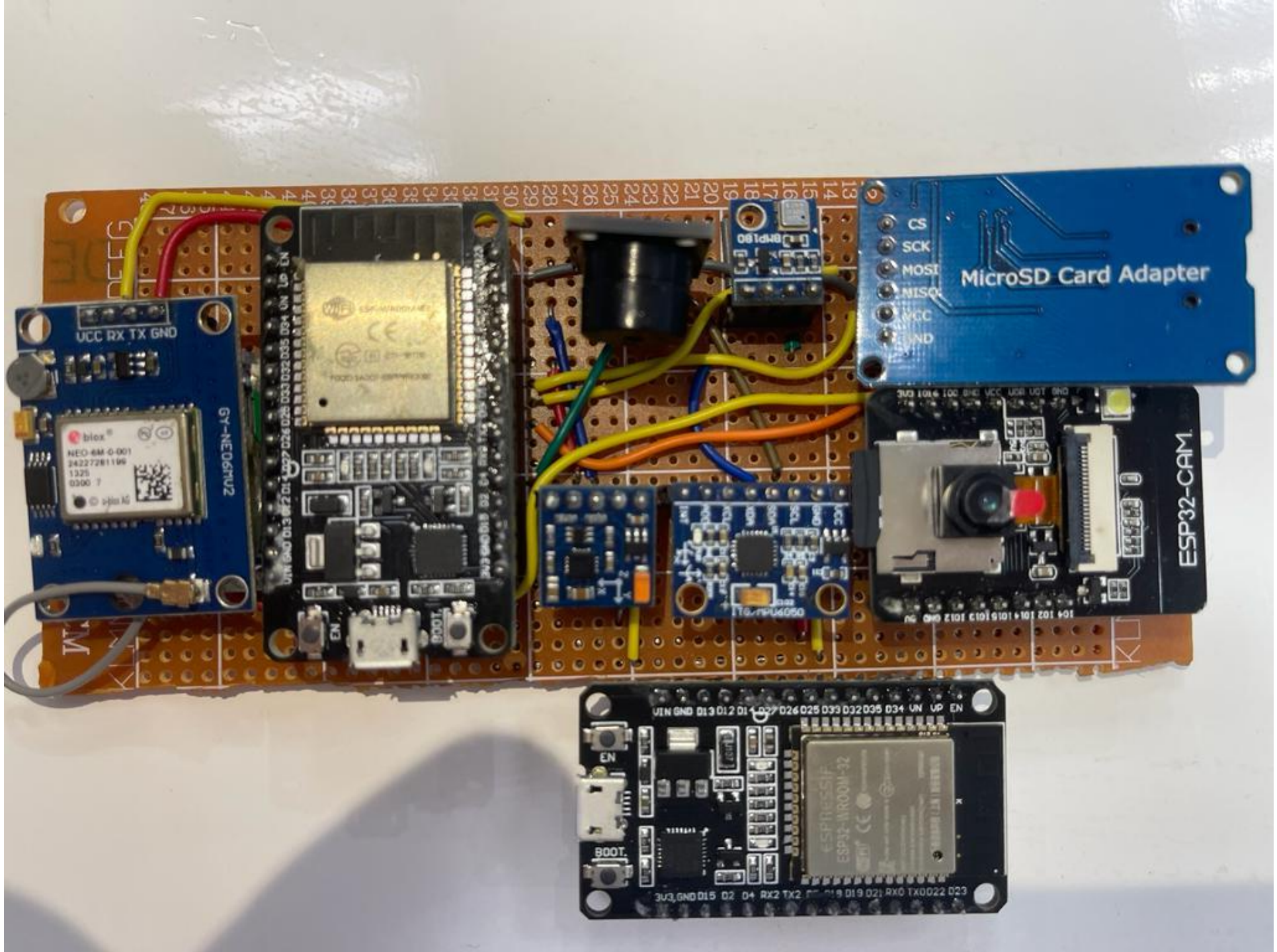
Component	Mass	Margin	Total Mass
ESP32			
BMP180			
MPU6050			
HMC5883			
GPS Board			
Buzzer			
SD Card Module			
SD Card			
Battery			
Cables			
Solder			
Prototype Board			
Structure			
Switch			
Others			

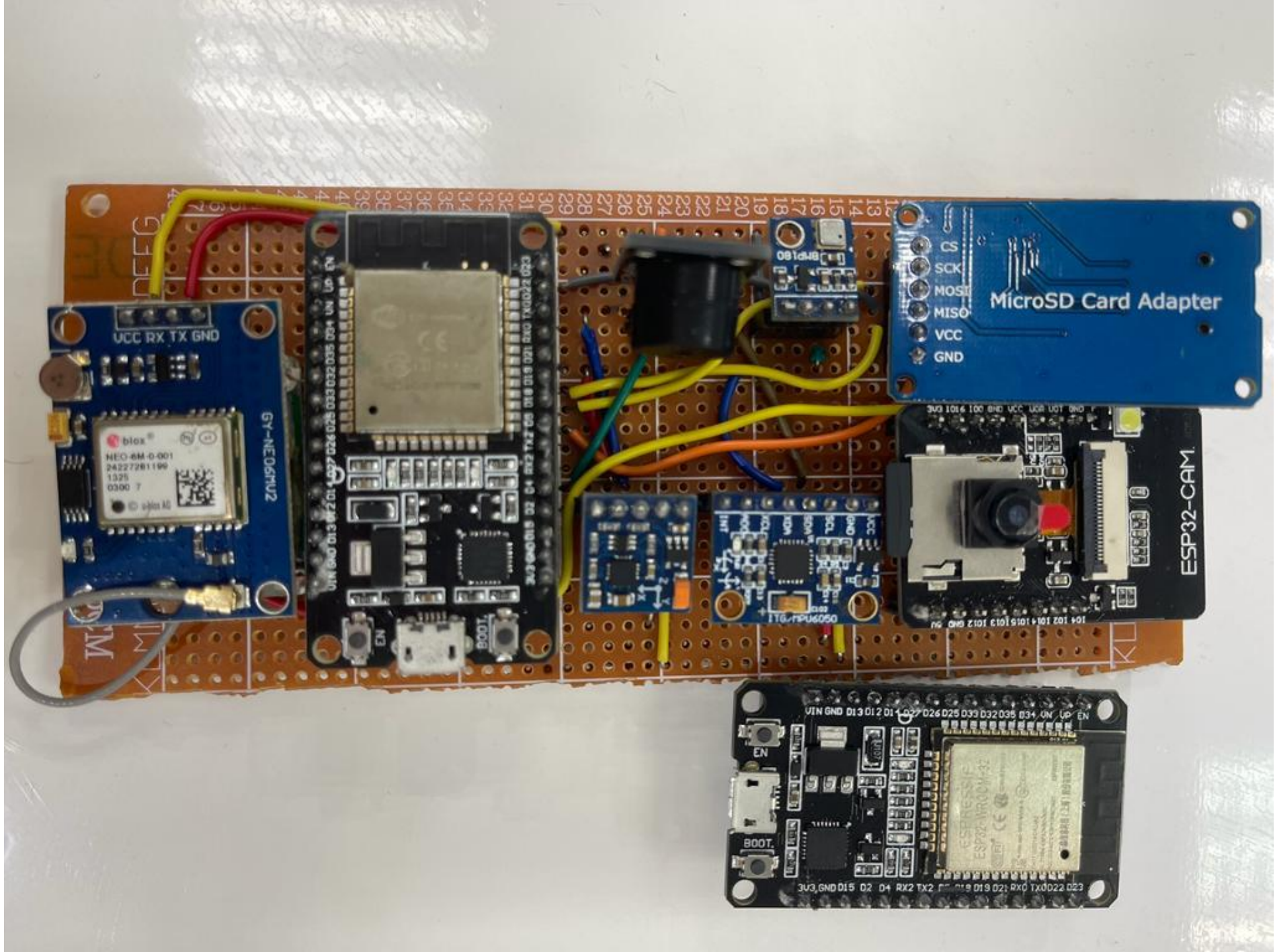
FLIGHT

- **Flush your sd cards.**
- **Be sure your battery have enough power.**

- **Show your Mass Budget**
- **Draw graphs for;**
  - **Temperature**
  - **Angular Rates**
  - **Accelerations**
  - **Magnetic fields**
  - **Altitude**
  - **Pressure**
- **Show the location of your CanSat with using latitude and longitude you get during the flight with any web based program.**




VCC RX TX GND
GY-NEO6MV2
NEO-6M-0-001
MicroSD Card Adapter
CS
SCK
MOSI
MISO
VCC
GND
ESP32-CAM
EN
BOOT
ESP32-WROOM-32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