



**POLITECNICO**  
**MILANO 1863**

SCUOLA DI INGEGNERIA INDUSTRIALE  
E DELL'INFORMAZIONE

# IoT Challenge #1, Wokwi and Power Consumption

INTERNET OF THINGS

Authors: **Kevin Zioldi - 10764177**

**Matteo Volgari - 10773593**

Professors: Alessandro Redondi, Antonio Boiano

Academic Year: 2024-2025

Version: 1.0

Release date: 20-3-2025



# Contents

<b>Contents</b>	<b>i</b>
<b>1 Code explanation</b>	<b>1</b>
<b>2 Energy consumption estimation</b>	<b>3</b>
2.1 Power consumption esitmatation . . . . .	3
2.1.1 Power consumption data plots . . . . .	3
2.1.2 Power consumption in deep sleep state . . . . .	6
2.1.3 Power consumption in idle state . . . . .	7
<b>3 Improvements</b>	<b>9</b>
<b>List of Figures</b>	<b>11</b>
<b>List of Tables</b>	<b>13</b>



# 1 | Code explanation



## 2 | Energy consumption estimation

### 2.1. Power consumption esitimation

In this section, there is a description of the power consumption of the ESP32 node in all states: deep sleep, idle, sensor reading, WiFi turned on and transmission.

In order to estimate power consumption based on the provided CSV files, we first plotted data using Python and Matplotlib library. Based on the plot, we computed the average power consumption in the analyzed working state.

#### 2.1.1. Power consumption data plots

In order to plot the data contained in the provided CSV files, we used the following algorithm.

```
import pandas as pd
import matplotlib.pyplot as plt
# read CSV file
df = pd.read_csv('deep_sleep.csv', parse_dates=['Timestamp'])
# plot data
plt.figure(figsize=(10, 6))
plt.plot(df['Timestamp'], df['Data'], linestyle='--', linewidth=2)
plt.xlabel('Time')
plt.ylabel('Power [mW]')
plt.title('Power consumption deep sleep')
plt.grid(True)
# save and shows
plt.savefig("power_consumption_deep_sleep.pdf", format="pdf",
            bbox_inches="tight")
plt.show()
```

#### Power consumption deep\_sleep.csv

The following plot represents the power consumption when the ESP32 is in deep sleep state (lowest power level), goes into idle mode (medium power level) and finally turns the

WiFi on (highest power level).

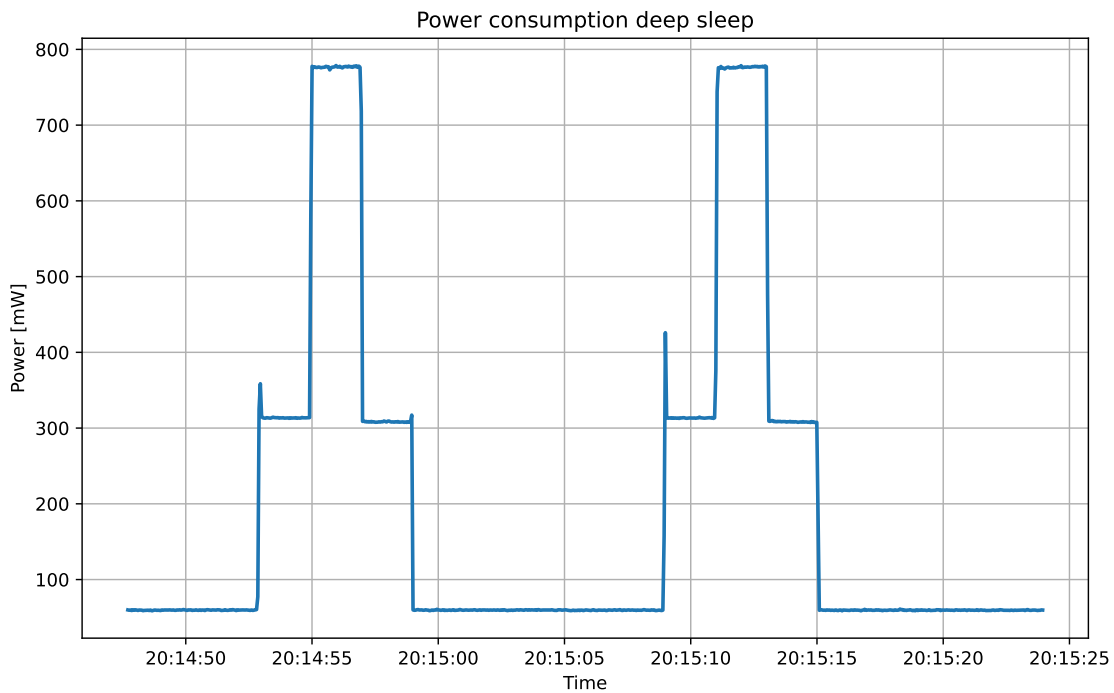


Figure 2.1: Power consumption deep sleep state

### Power consumption sensor\_read.csv

The following plot represents the power consumption when the ESP32 alternates the idle mode and sensor reading mode, in which it performs a measurement using the Ultrasonic Distance Sensor HC-SR04.



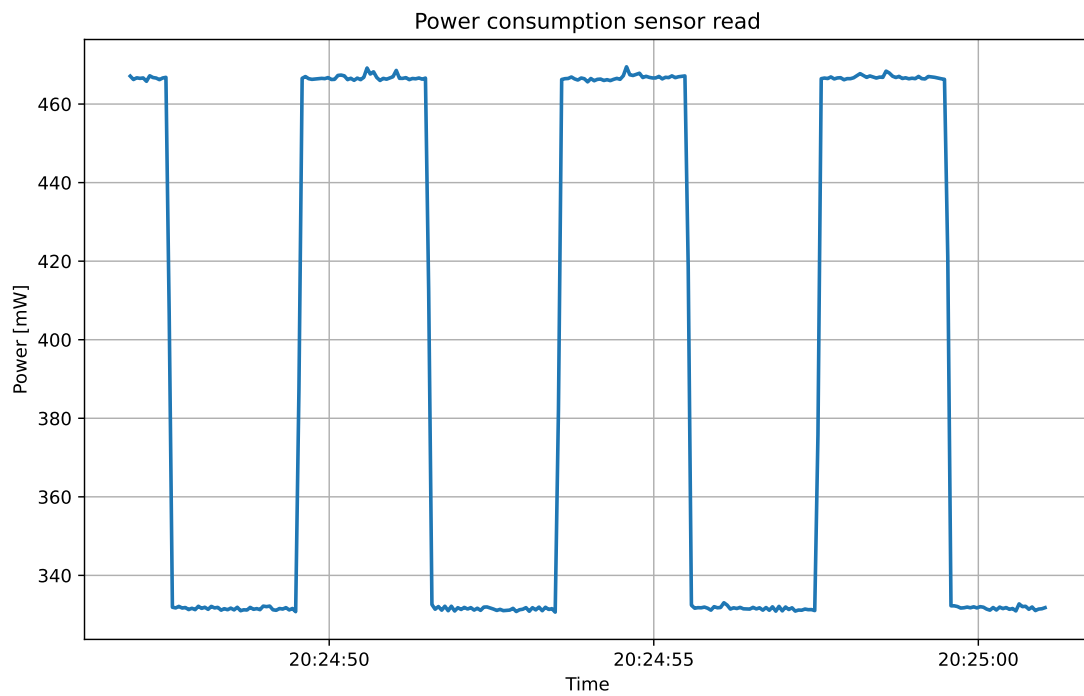


Figure 2.2: Power consumption deep sleep state

### Power consumption transmission\_power.csv

The following plot represents the power consumption when the ESP32 has the WiFi turned on and transmits data using ESP-NOW at 19.5 dBm and 2 dBm.

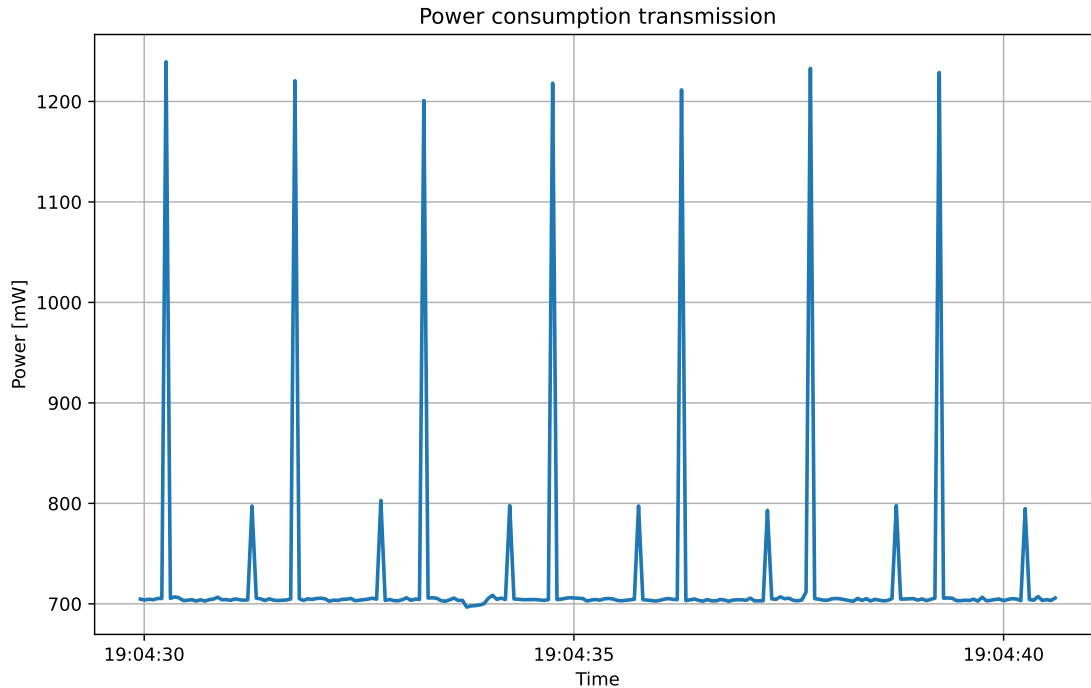


Figure 2.3: Power consumption deep sleep state

### 2.1.2. Numerical power consumption estimation

In order to find a numerical estimation of the power consumption in different states, we used some Python algorithms, using the library Pandas. Starting from the plot we selected the range of values regarding a particular state, discarding the others, and computed the average power consumption. For some states, the values of power can be found in multiple CSV files; in such cases, we merged different files in order to have a more accurate estimation.

In the following sections we also report two example of algorithms used to compute the average, both using a single dataset and multiple datasets.

#### Power consumption in deep sleep state

Data to estimate the deep sleep mode is contained in the dataset `deep_sleep.csv`. We filtered all values of power above 100mW, referring to other states as shown by the plot, and computed the average.

```
import pandas as pd
# read CSV file
dataset_deep_sleep = pd.read_csv("deep_sleep.csv", parse_dates=['
                                Timestamp'])
# filter data with power < 100mW, referring to deep sleep mode
```

```

deep_sleep_data = dataset_deep_sleep[dataset_deep_sleep["Data"] < 100]
# compute average
deep_sleep_avg_power = deep_sleep_data["Data"].mean()
# print average
print("Average power consumption deep sleep: ", deep_sleep_avg_power)

```

We obtained an average consumption in deep sleep of 59.66 mW.

## Power consumption in idle state

The power consumption in idle state can be extracted both by sensor\_read.csv and transmission\_power.csv. We used both datasets, merging all values and computing the average. We considered only values between 200 mW and 500 mW, that refer to idle mode.

```

import pandas as pd
# read CSV file
dataset_deep_sleep = pd.read_csv("deep_sleep.csv", parse_dates=['
                                Timestamp'])
dataset_sensor_reading = pd.read_csv("sensor_read.csv", parse_dates=['
                                Timestamp'])
# filter data with power between 200mW and 500mW, referring to idle mode
idle_data_deep_sleep = dataset_deep_sleep[(dataset_deep_sleep['Data'] >=
                                200) & (dataset_deep_sleep['Data']
                                <= 500)]
# filter data with power <= 400mW, referring to idle mode
idle_data_sensor_reading = dataset_sensor_reading[dataset_sensor_reading
                                ['Data'] <= 400]
# merge values
idle_merged = pd.concat([idle_data_deep_sleep, idle_data_sensor_reading]
                        , ignore_index=True)
# compute average
idle_avg_power = idle_merged['Data'].mean()
# print average
print("Average power consumption idle: ", idle_avg_power)

```

We obtained an average consumption in idle of 322.62 mW.

## Power consumption in measurement state

Data representing power consumption in measurement state is contained in the dataset sensor\_read.csv. We computed the average value considering values of power above 400 mW and obtained an average value of 465.18 mW. The algorithm is very similar to deep sleep mode, thus we don't report it.

## Power consumption in WiFi on state

We estimated the power consumption when the WiFi is turned on and the ESP32 is not transmitting based on `deep_sleep.csv` and `transmission_power.csv`, merging all value between 600 mW and 750 mW, as shown for the idle mode. The average power consumption when WiFi is turned on is 724.58 mW.

## Power consumption when transmitting at 2 dBm

Finally, we estimated the average power consumption when ESP32 is transmitting at 2 dBm, based on `transmission_power.csv`. We compute the average of values between 750 mW and 900 mW, obtaining an average value of 797.29 mW.

Power consumption estimation Deep sleep duration: 48 s Average Idle duration: 833.6985294117648 uS Average Measurement duration: 18647.79411764706 uS Average WiFi duration: 188640.86842105264 uS Average Sending duration: 59.6044776119403 uS

Battery size 18593 J

Average power consumption Average power consumption deep sleep: 59.66093555093555 mW Average power consumption idle: 322.62464743589743 mW Average power consumption measurement: 465.18097744360904 mW Average power consumption WiFi on: 724.5793571428571 mW Average power consumption transmission at 2dBm: 797.2942857142858 mW

## 3 | Improvements



## List of Figures

2.1	Power consumption deep sleep state . . . . .	4
2.2	Power consumption deep sleep state . . . . .	5
2.3	Power consumption deep sleep state . . . . .	6





## List of Tables