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# PROJECT PRESENTATION

## POLLUTANT ESTIMATION NEAR PHARMACEUTICAL INDUSTRIES

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- AIR POLLUTION NEAR PHARMA HUBS HARMS PUBLIC HEALTH.
- CONTINUOUS PLANT OPERATIONS CAUSE HIDDEN NIGHT EMISSIONS.
- LIMITED MONITORING MISSES OFF-PEAK POLLUTION.
- PROJECT TRACKS AND ANALYZES NIGHTTIME EMISSIONS.
- AIMS TO GUIDE CLEANER PRACTICES AND REGULATIONS.

# MOTIVATION

# INTRODUCTION

- THE PROJECT FOCUSES ON MONITORING EMISSIONS FROM PHARMACEUTICAL INDUSTRIAL CLUSTERS.
- PRIMARY POLLUTANTS MEASURED INCLUDE PM2.5, PM10, $CO_2$, NOX, AND VOCS (BENZENE, FORMALDEHYDE, XYLENE, ACETONE).
- SECONDARY POLLUTANTS SUCH AS OZONE, SULPHURIC ACID, NITRIC ACID, PAN, AND FINE PARTICULATES ARE ALSO ANALYZED.
- SUPPORTING PARAMETERS LIKE TEMPERATURE AND UV INTENSITY ARE RECORDED TO STUDY THEIR IMPACT ON POLLUTANT FORMATION.
- A BACKUP BATTERY AND SD STORAGE ENSURE CONTINUOUS DATA LOGGING DURING POWER INTERRUPTIONS.

# PARAMETERS

**1. ENVIRONMENTAL PARAMETERS**

THESE HELP IN UNDERSTANDING THE OVERALL ATMOSPHERIC CONDITIONS INFLUENCING THE POLLUTANT CONCENTRATION.

- TEMPERATURE (°C)
- HUMIDITY (RH)
- TIME OF DAY (DAY/NIGHT)

**2. POLLUTANT CONCENTRATION PARAMETERS**

THESE FORM THE CORE OUTPUT OF OUR PROJECT

- $NO_2$ (NITROGEN OXIDES)
- $CO_2$ (CARBON DIOXIDE)
- PM2.5
- PM10

# KEY REACTIONS

## OZONE FORMATION CHEMISTRY

### PRIMARY REACTIONS

$NO_2 + light \rightarrow NO + O$ (wavelength < 420 nm)

$O + O_2 + M \rightarrow O_3 + M$

$O_3 + NO \rightarrow NO_2 + O_2$

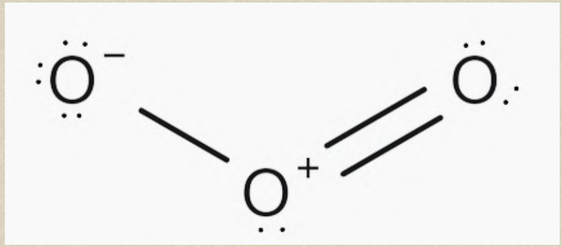
### VOC ENHANCED FORMATION

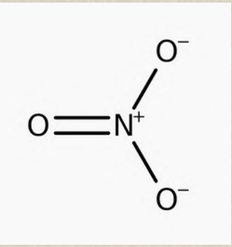
$RH + OH \rightarrow R\bullet + H_2O$

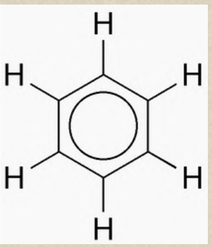
$R\bullet + O_2 \rightarrow RO_2\bullet$

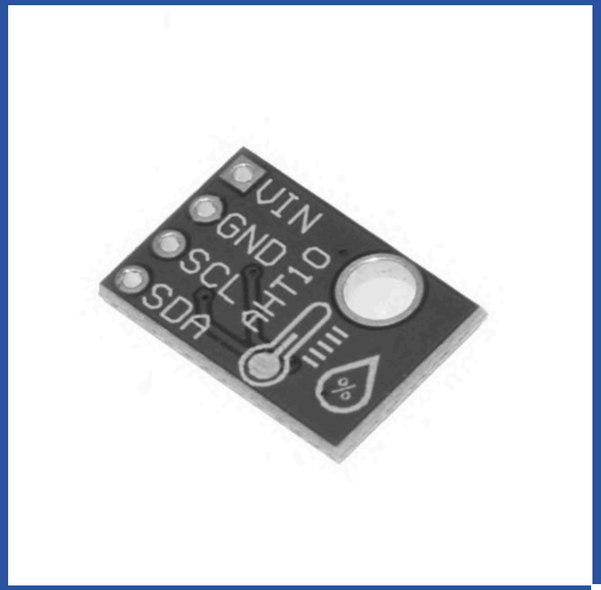
$RO_2\bullet + NO \rightarrow RO\bullet + NO_2$

NET RESULT: $NO \rightarrow NO_2$ WITHOUT CONSUMING $O_3$








# SENSORS

OUR PRIMARY GOAL IS TO MEASURE AND ANALYSE VARIOUS POLLUTANTS. HENCE WE ARE USING SEVERAL SENSORS TO RECOGNISE ANY PATTERNS OR TRENDS OBSERVED.

SENSORS USED :

- MICS-2714 - USED TO MEASURE NOX CONCENTRATION
- ACD10: USED TO MEASURE CO2
- AHT10: USED TO MEASURE TEMPERATURE
- SDS011 - USED TO MEASURE PM10 AND PM2.5 CONCENTRATION


# DESIGN EXPLANATION

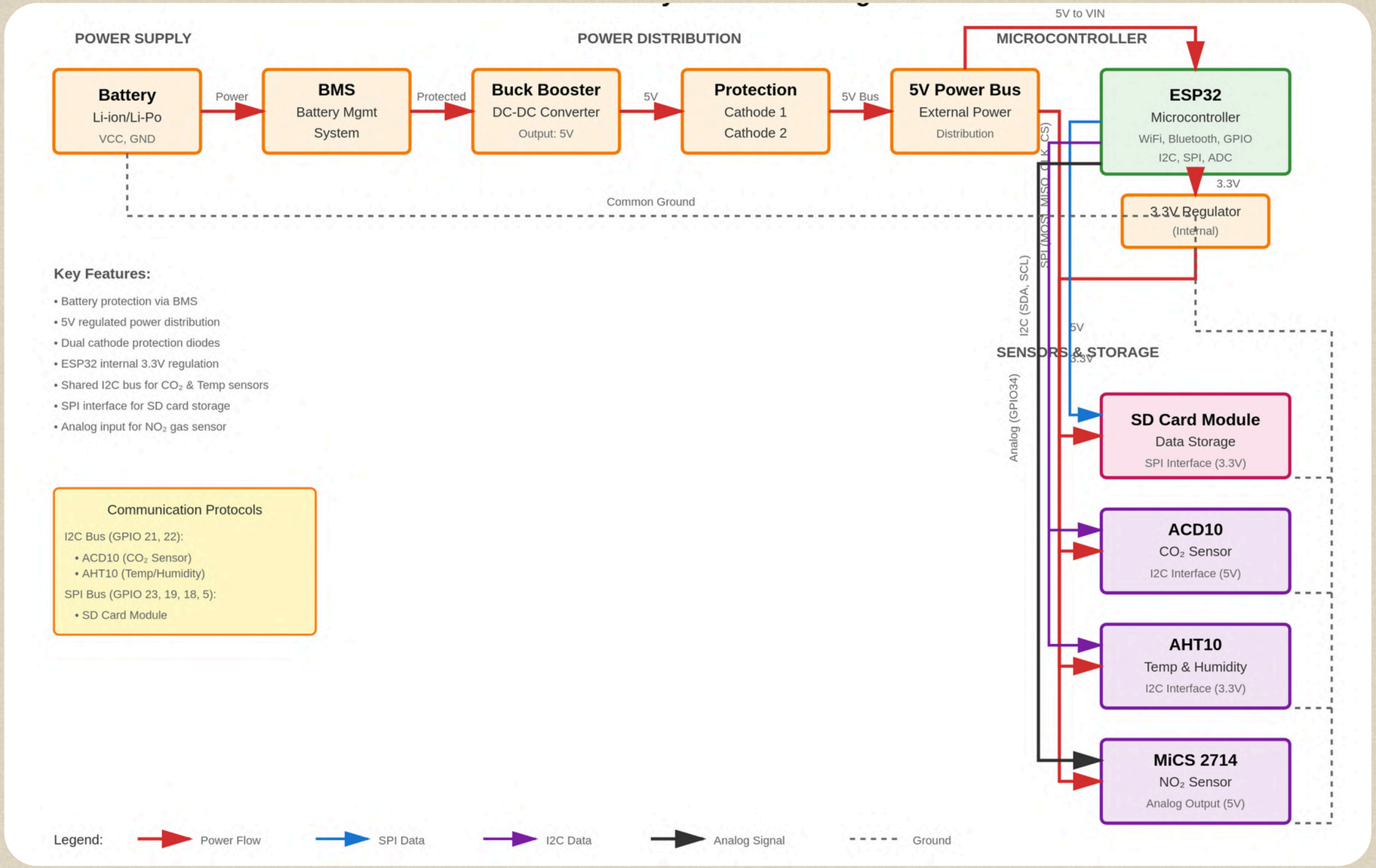
## REQUIREMENTS

- To track intensive emission hours - proportionate to CO2 concentration
- Measuring secondary pollutant - PM
- Measuring primary pollutant - precursor gases for ozone & secondary aerosol formation
- To track ambient parameters and identify patterns(if any)
- To power the circuit if external power is not available.
- To convert 3.7v received from battery to 5v.
- AC to DC converter
- To prevent data loss

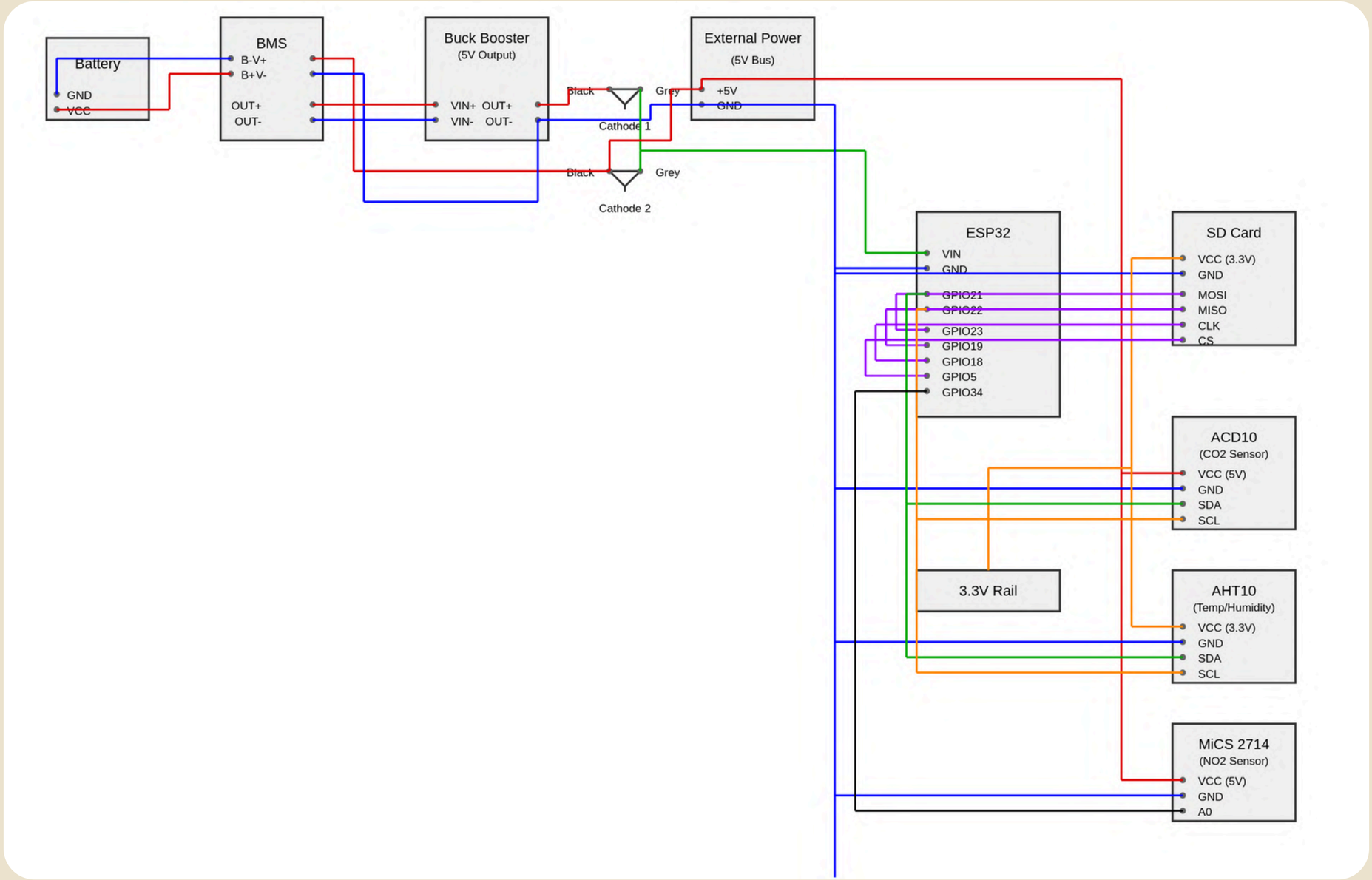
## COMPONENTS

- **ACD10 ($CO_2$)**
- **SDS011 (PM2.5, PM 10)**
- **MiCS-2714 (NO, $NO_2$, $H_2$)**
- **AHT10 (Temperature, Humidity)**
- **HW-107(BMS) and Battery**
- **Buck Booster**
- **HLK 5M05**
- **SD Card**

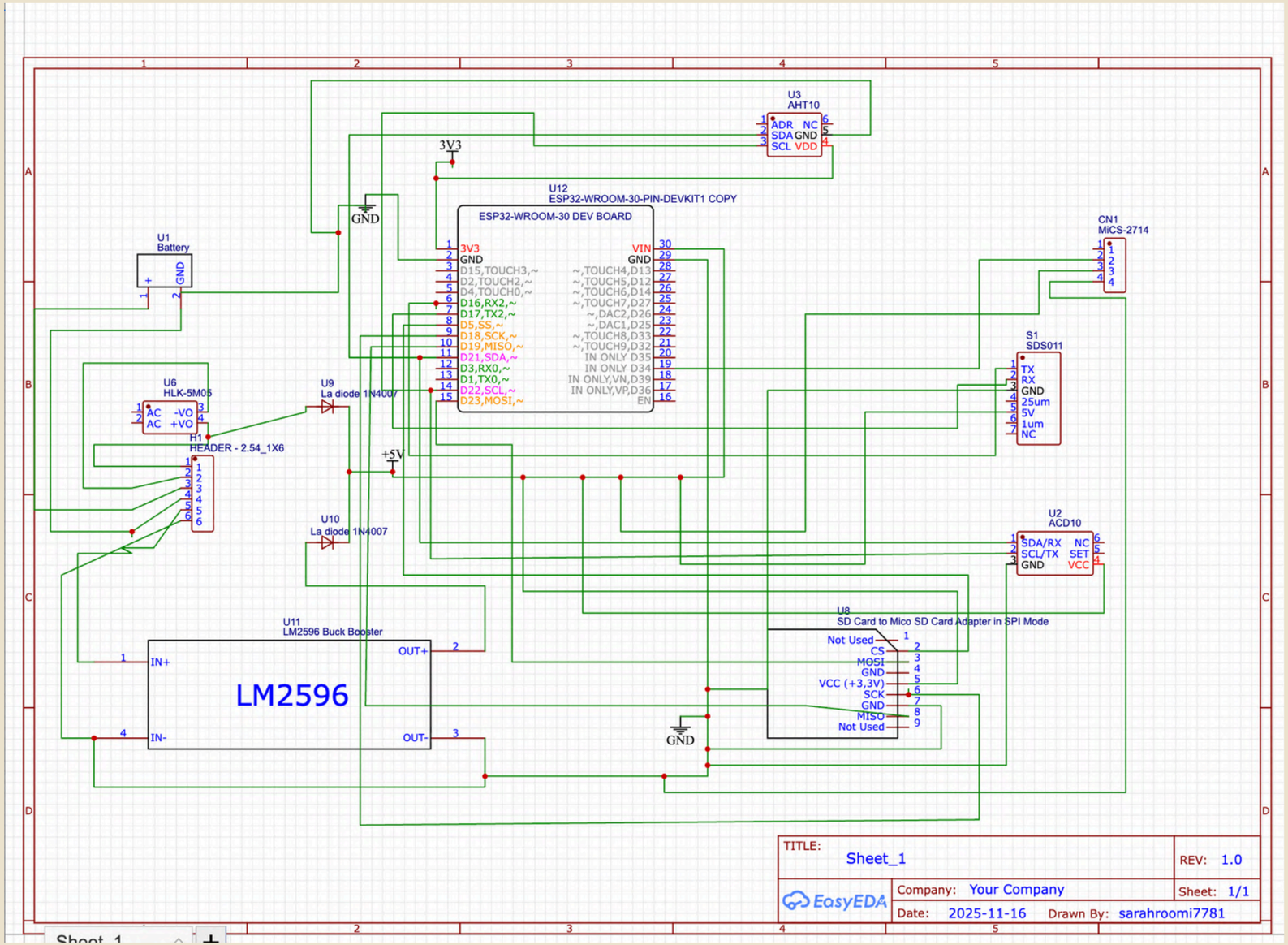
# BLOCK ARCHITECTURE



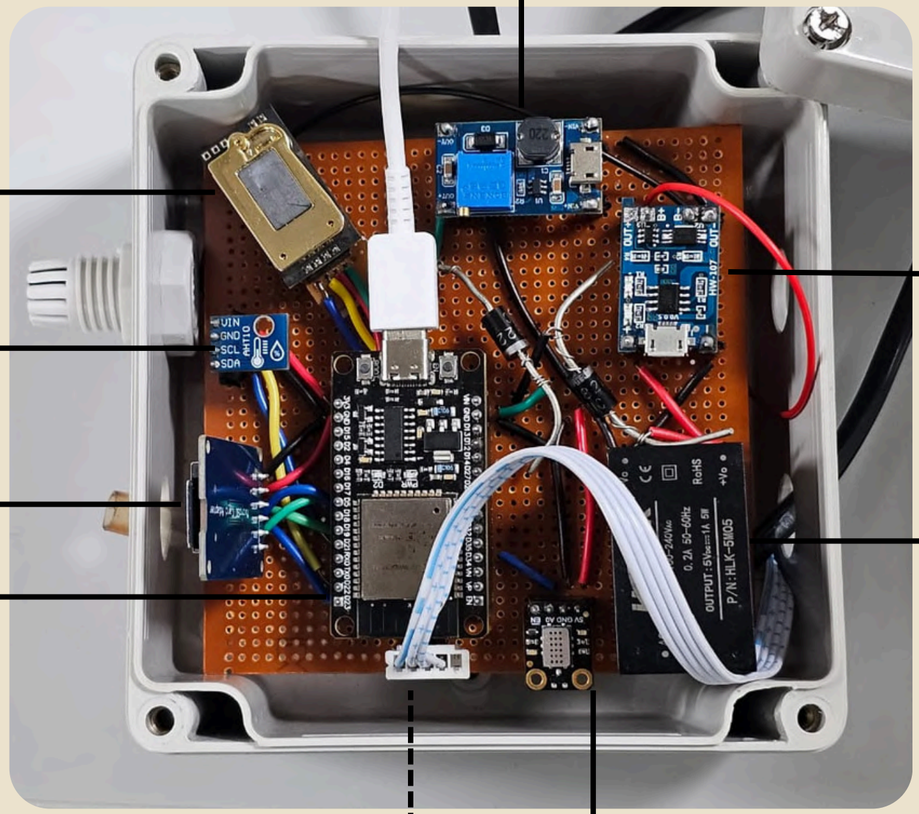
# CIRCUIT DIAGRAM



# PCB SCHEMATIC DIAGRAM



# FINAL NODE




BUCK BOOSTER

ACD10 (CO2 SENSOR)

BMS MODULE

AHT10 (TEMPERATURE SENSOR)

SD CARD

HLK-5M05
(AC TO DC CONVERTOR)

ESP 32

SDS011 (PM SENSOR)

MICS-2714(NOX SENSOR)

# NODE DEPLOYED!

## AIR – Quality Test Report:

### 1. Operating conditions:

| | |
|---|---|
| **Team Name** | Male and Females |
| **adapter** | 5V - 1A (SMPS) |
| **Enclosure** | Closed |
| **Wi-Fi Connectivity** | In Range |
| **IDE Version** | Arduino IDE 2.3.6 |

### 2. Test conditions:

| S. No | Test Case | Result Expected | Actual Result | Remarks |
|---|---|---|---|---|
| 1 | **Physical Checking** | • Connectivity Test (shorts & open)<br>• Keep all components in proper orientation test | Working and verified | |
| 2 | **Power Consumption** | ~5.0V | 5.5 V | |
| 3 | **Esp power Led Test** | Power LED should always be on. | Working | |
| 4 | **Wi-Fi connectivity test** | Signal strength RSSI in -60 dBm<br>MAC ID<br>IP address | Passed | |
| 5 | **SDS11 Sensor reading test** | PM-2.5<br>PM-10 | PM2.5 - ~59 ppm<br>PM10 - ~135 ppm | |
| 6 | **ATH10 Sensor reading test** | Temp,<br>Humidity | ~27.5C, ~58% | |
| 7 | **Functionality with timestamp from NTP server (ntp.pool.org)** | Epoch<br>UTC time | Working | |
| 8 | **Posting data to thingspeak test** | 201 | 201 code recieved | |
| 9 | **Sending data to SD card test** | | Working | |
| 10 | **Functionality with Wi-Fi Fluctuation**(1min,5 min) | | Connecting to wifi in both cases | |
| 11 | **Functionality with Power Fluctuation**(1min,5 min) | | Working in both cases | |

- These are the node quality tests that we performed before deployment to verify the perfect working of the node.
- All tests were performed and verified under the supervision of the TA.

# DATA COLLECTION AND DASHBOARD

- Node deployed on the roof of a 5-storey building in a pharmaceutical industry complex.
- Node is fully waterproof.
- The node is guarded by a shed above in case of rain.
- Data is being sent to the dashboard every 15 seconds via MQTT.
- Dashboard is deployed using Vercel.
- Link to the dashboard: Click Here
- Our dashboard has the following 3 features :
  - View Live Data (gets updated every 3 seconds)
  - Historical Mode (view data of a previous date)
  - Comparison Mode (compare data of two previous dates)

# Air Quality Monitoring Dashboard

Live Mode | **Historical Mode** | Compare Dates

Start Date & Time: 15/11/2025, 01:17 PM

End Date & Time: 16/11/2025, 01:17 PM

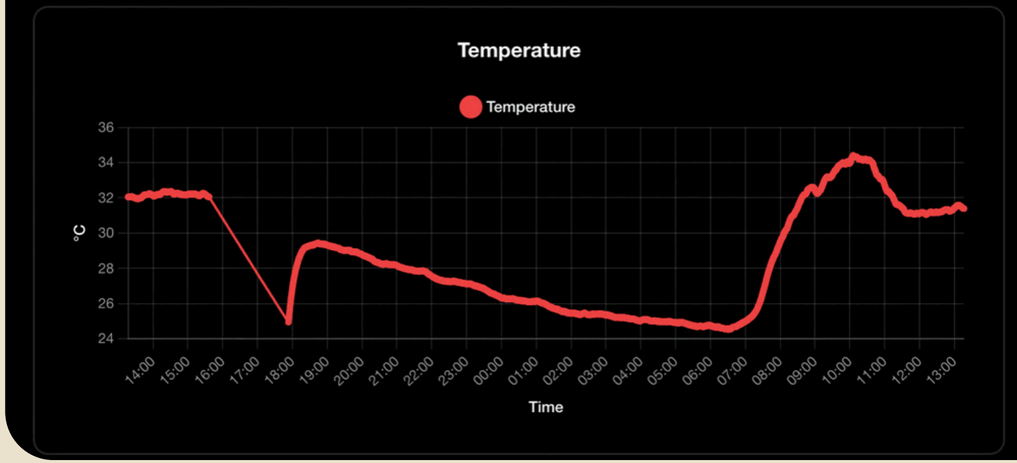
Load Data

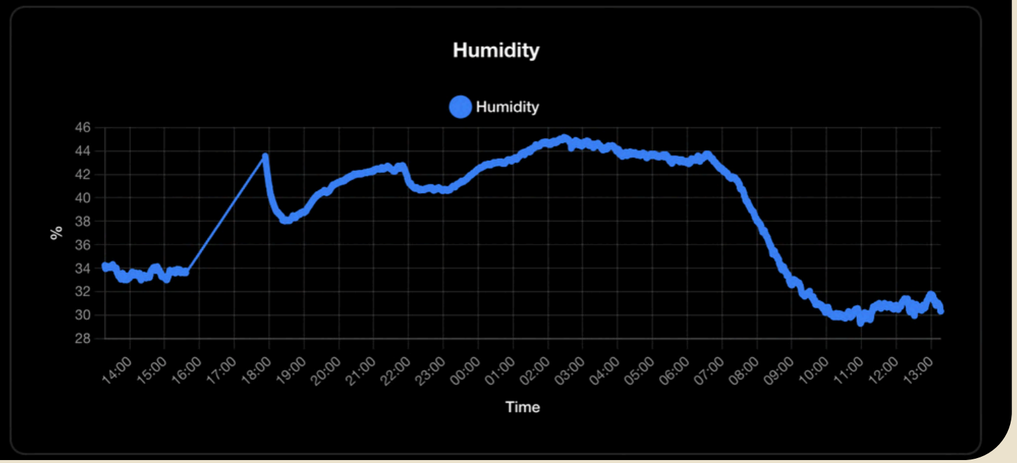
| TEMPERATURE | HUMIDITY | PM2.5 | PM10 | CO2 |
|---|---|---|---|---|
| 31.4 °C | 30.3 % | 31.3 µg/m³ | 51.8 µg/m³ | 536.0 ppm |

NO2

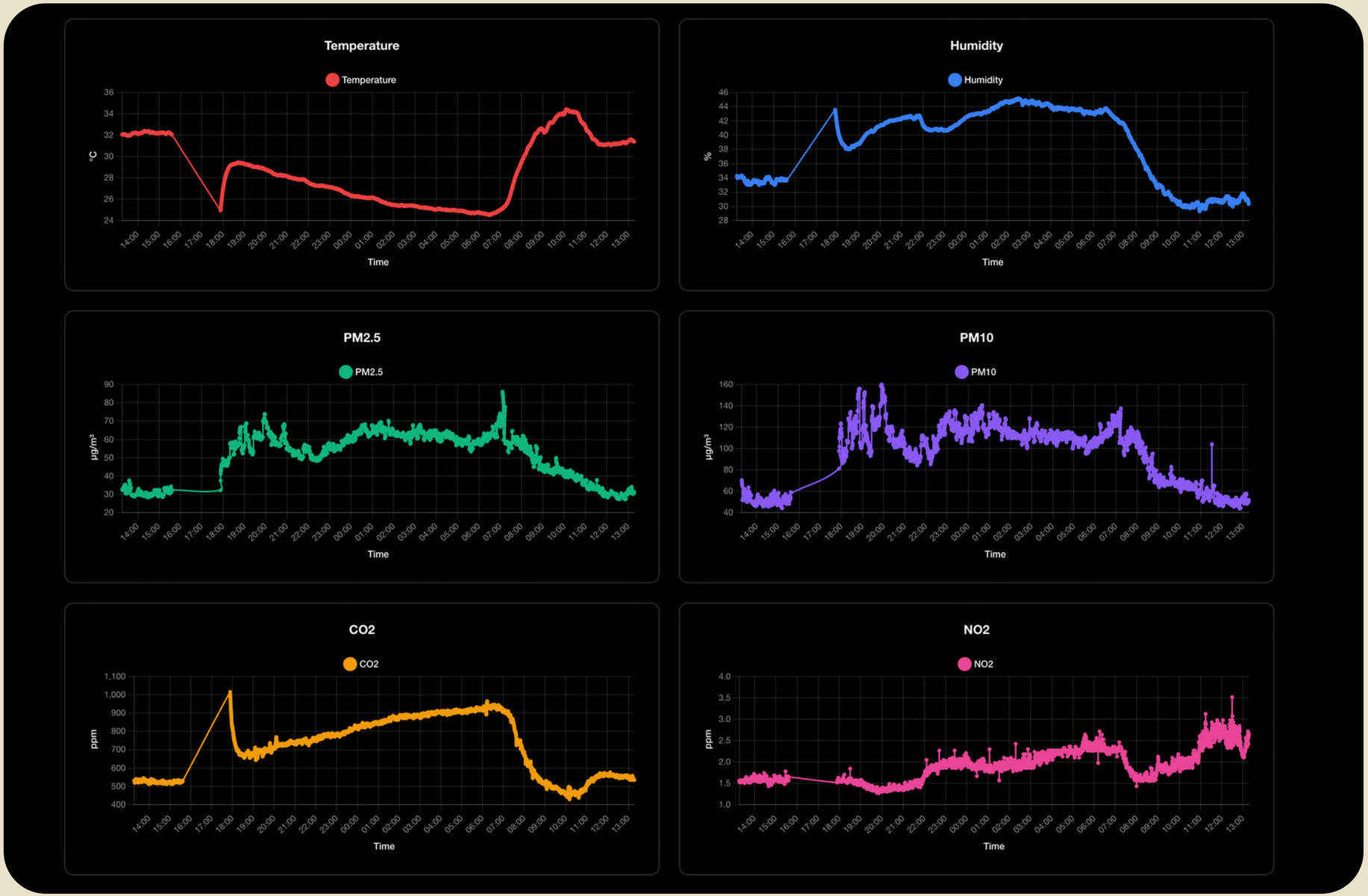
2.6 ppm

## Historical Trends

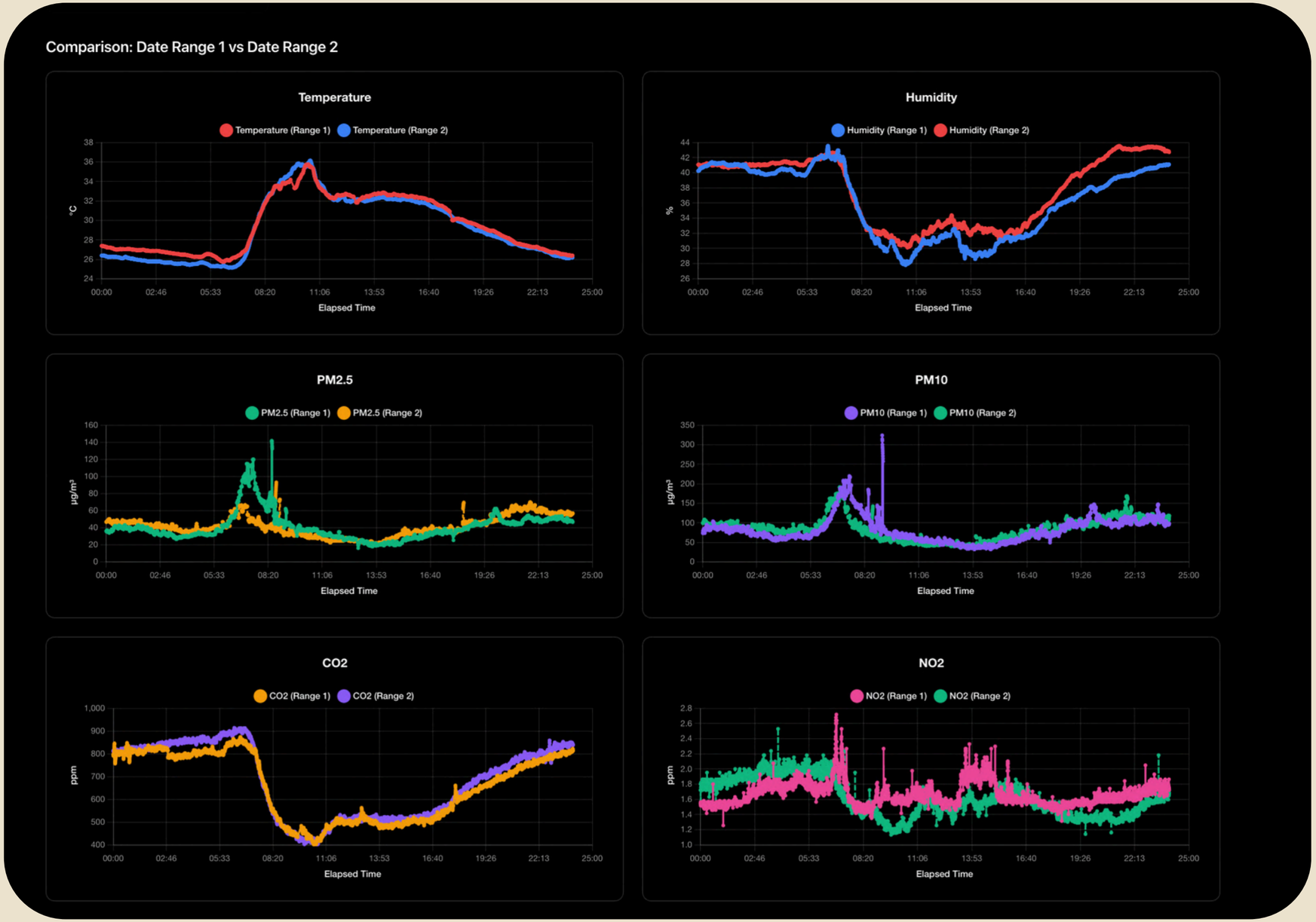


# HISTORICAL MODE FEATURE – PLOTS FOR 11/11/2025



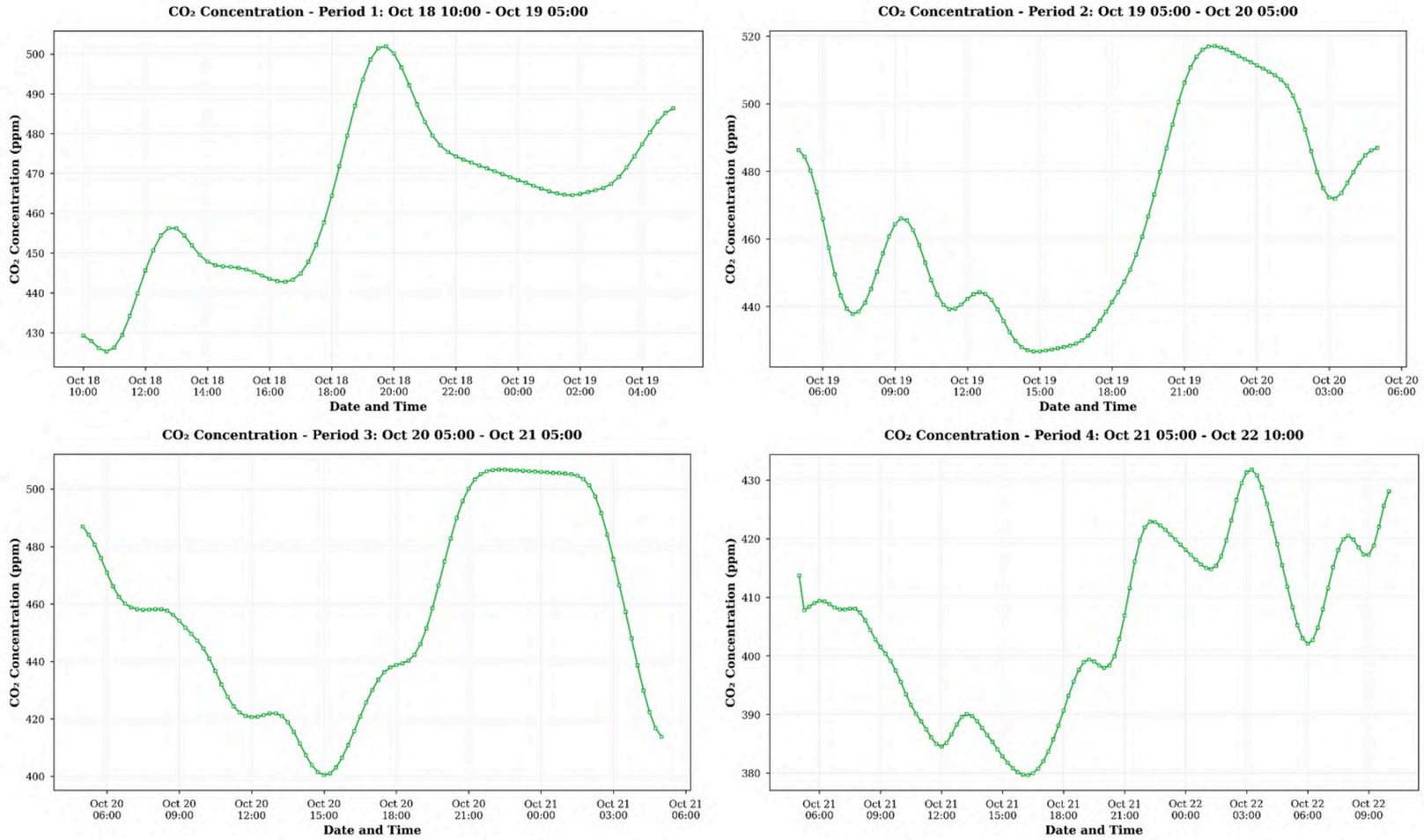
# COMPARISON MODE FEATURE – COMPARISON BETWEEN 13/11/25 AND 14/11/25



# DIWALI DATA PLOTS

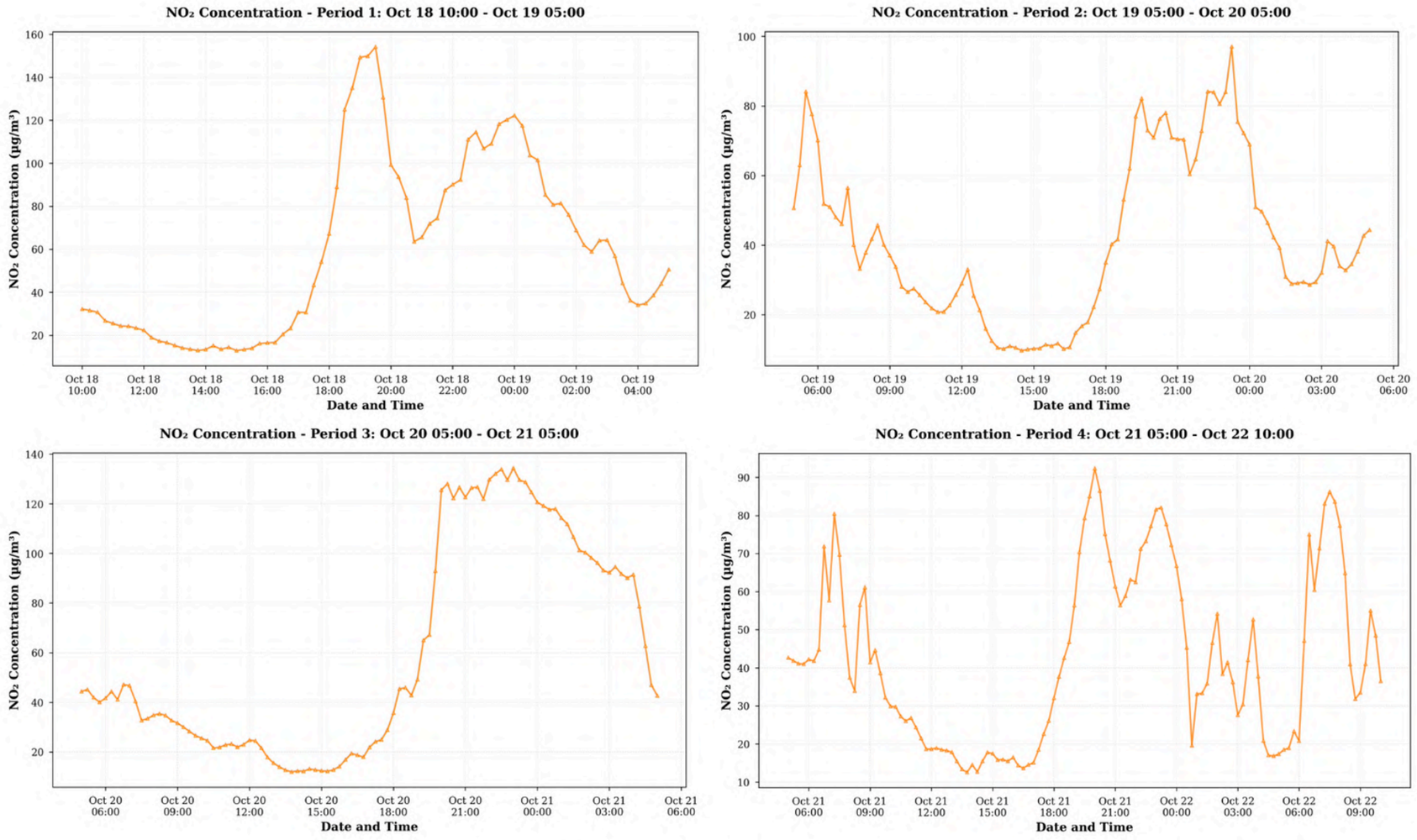
- The node was deployed from 18$^{th}$ to 22nd October (Diwali Time) in Gurugram in a residential area.
- This was done to do initial testing for the node and to get air quality data before, during and after diwali.
- For the detailed report containing the entire analysis and plots of the data, Click Here.
- Some of the plots of the data are on the following slides.

# $CO_2$ Trends Across All Periods



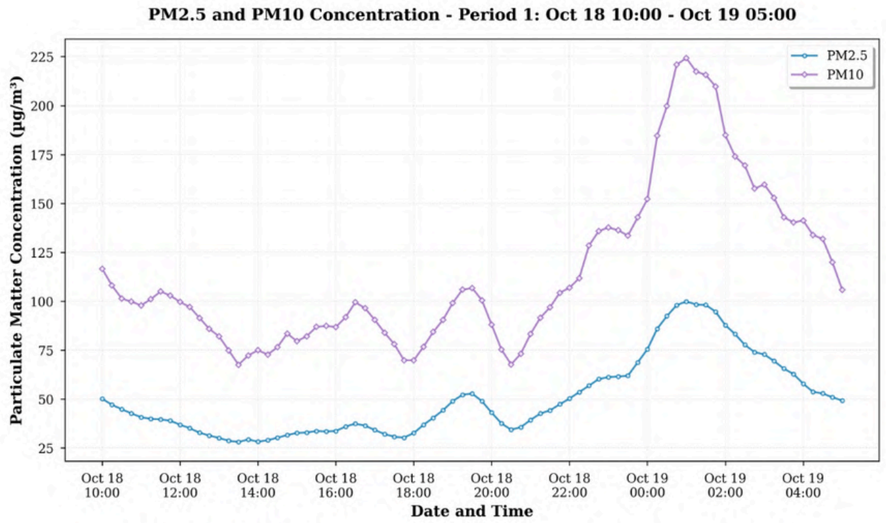

$CO_2$ concentration plots for Periods 1–4 (period1 = 18–19 Oct, period2 = 19–20 Oct, period3 = 20–21 Oct, period4 = 21–22 Oct).

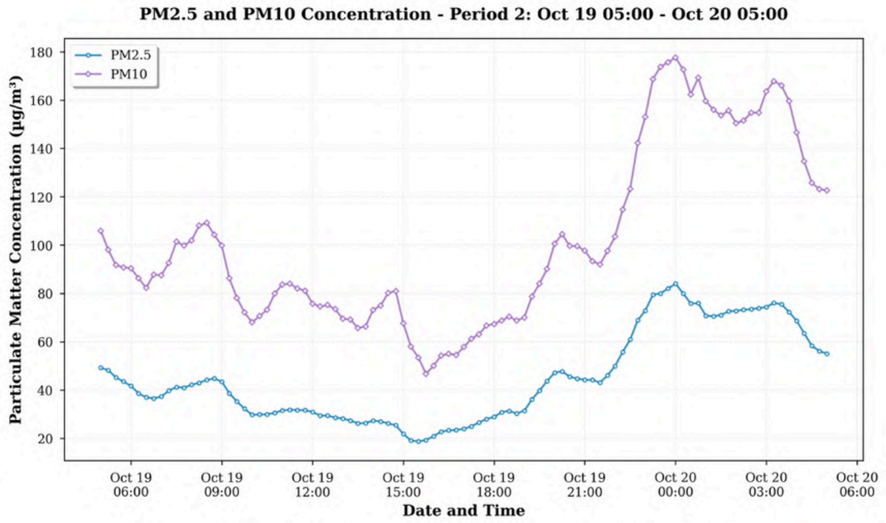
# $NO_2$ Trends Across All Periods

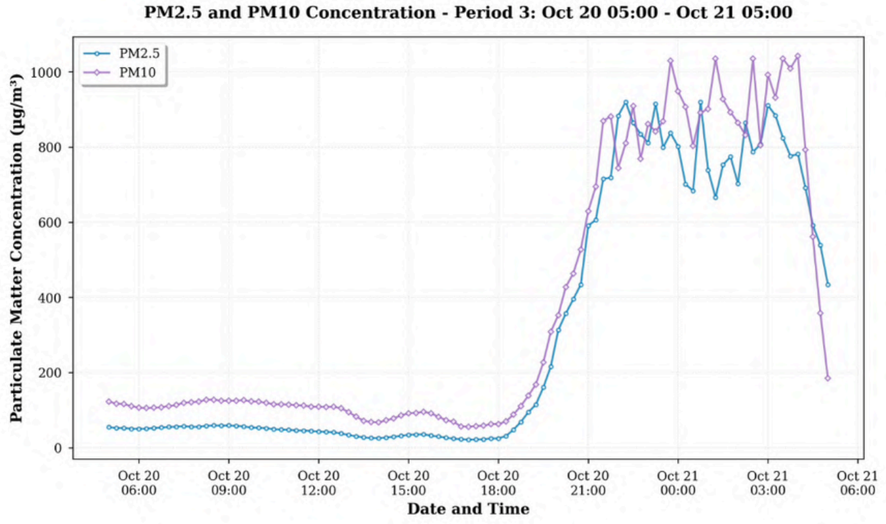


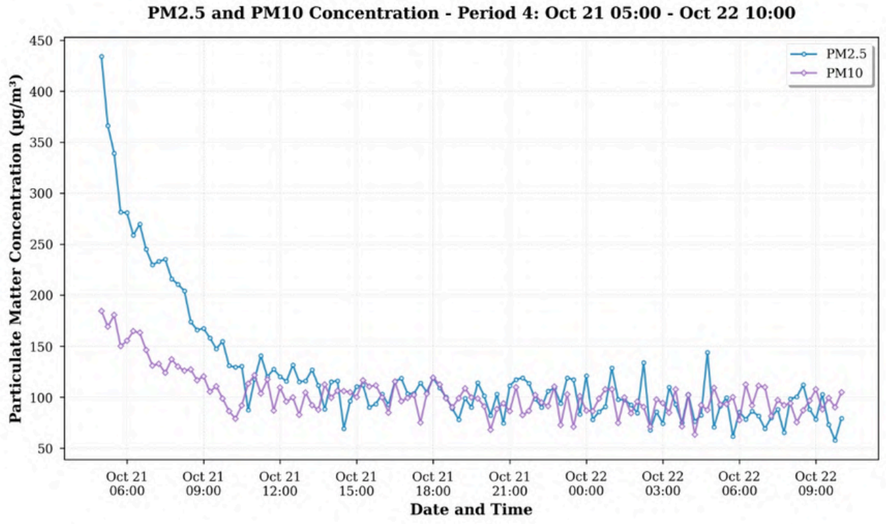

$NO_2$ concentration plots for Periods 1–4.

# PM Trends Across All Periods



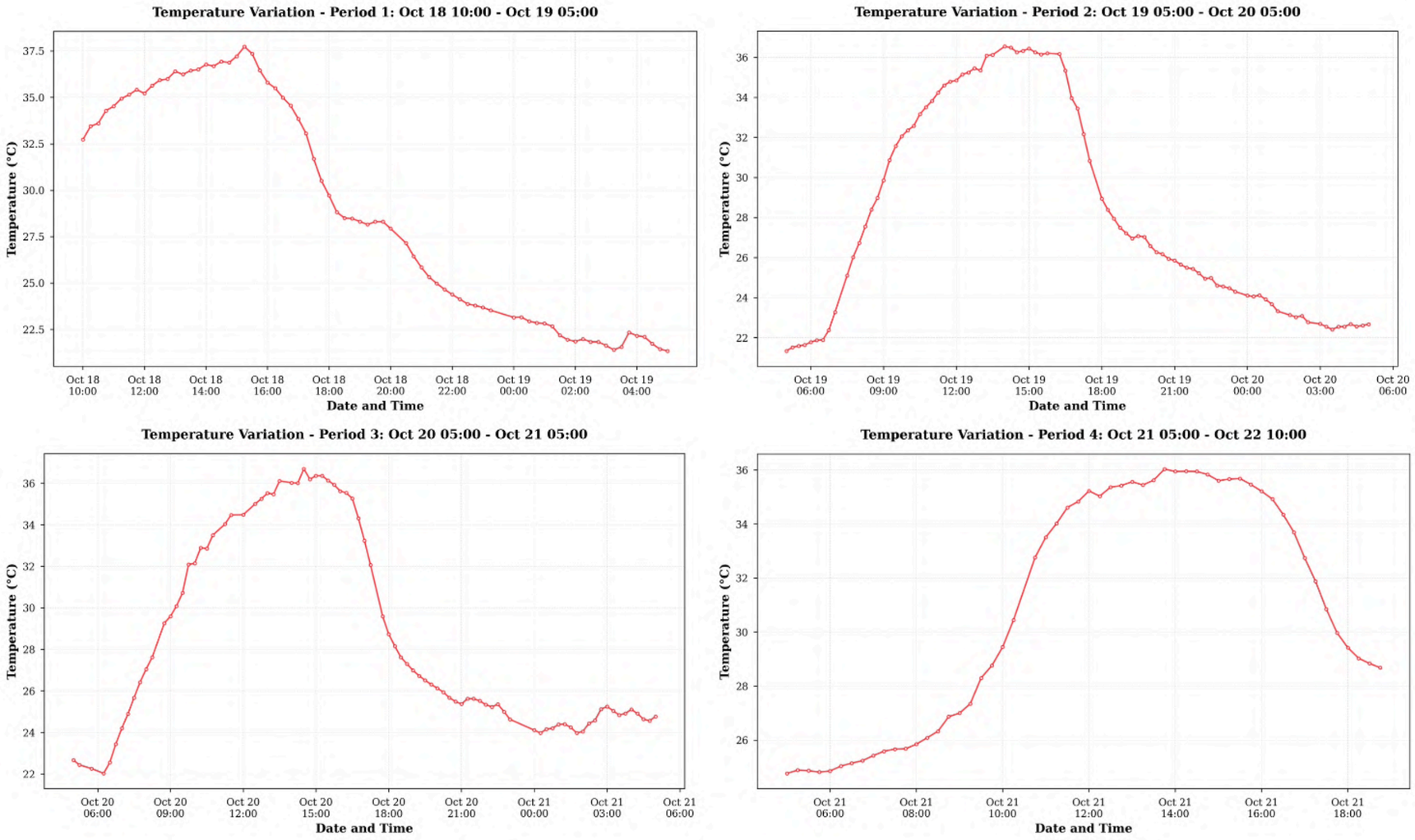




PM2.5/PM10 plots for Periods 1–4. Values are in $\mu g/m^3$.

# Temperature Trends Across All Periods




Temperature plots for Periods 1–4 (units: °C).

# CHALLENGES

- Integrating a rechargeable battery into the circuit, as it required using multiple components and understanding how those components work.
- Designing the PCB of the circuit using digital software like EasyEDA.
- Understanding how to analyse data and come up with conclusions.

# FUTURE PLANS

- Using a thermal camera sensor to figure out when emissions take place.
- Identifying any patterns in increase/decrease trend of gases-correlating with temperature and other ambient parameters.
- Trying to estimate PAN concentration and Ozone concentration with given sensors.

# RESEARCH INSPIRATIONS

- Secondary pollutants , RM Harrison
- Potential Estimation of Secondary Pollutant Formation of BVOC from Peltophorum pterocarpum in Urban Area
- Hyderabad’s pharmaceutical pollution crisis: Heavy metal and solvent contamination at factories in a major Indian drug manufacturing hub

# THANK YOU