WEATHER MONITORING DRONE (JNTUH)

BACHELOR OF TECHNOLOGY

In

ELECTRONICS AND COMMUNICATION ENGINEERING

MAJOR PROJECT REPORT

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Autonomous

(Kukatpally-Hyderabad-500085)

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CERTIFICATE BY THE SUPERVISOR

This is to certify that the project entitled

"WEATHER MONITORING DRONE (JNTUH)"

being submitted by

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In partial fulfilment of the requirements for the award of degree in Bachelors of Technology in Electronics and Communication Engineering at the Jawaharlal Nehru Technological University during the academic year 2022-23 is a Bonafide work carried out under my guidance and supervision. The results embodied in this major project report have not been submitted to any other University or institute for the award of any degree or diploma.

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CERTIFICATE BY THE HEAD OF THE DEPARTMENT

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DECLARATION OF THE CANDIDATES

We hereby declare that the major project report title **"WEATHER MONITORING DRONE (JNTUH)"** is a Bonafide record work done and submitted under the esteemed guidance of **Dr.A.Rajani**, Professor & Head ,Department of ECE, JNTUHUCESTH, in partial fulfilment of the requirements for Major project in Electronics and Communication Engineering at the Jawaharlal Nehru Technological University during the academic year 2022-23 is a Bonafide work carried out by us and the results kept in the major project have not been reproduced. The results have not been submitted in any other institute of university for the award of degree or diploma.

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ABSTRACT

The technique of applying science and technology to forecast the atmospheric conditions at a certain area and time is known as weather forecasting. By gathering information on the atmosphere's current condition and using a scientific understanding of atmospheric processes to forecast atmospheric advancement, meteorologists can better predict the weather. The benefits of weather forecasting are numerous are, it can acquire the real-time data so that people may prepare well and take action if there is a sudden storm or hurricane and also farmers can plan activities such as harvesting, fertilizing, and wind protection using weather forecasting in order to avoid dealing with yield losses.

Commercial weather stations can effectively collect weather data for a specified area. However, the amount of data that can be captured by their ground sensors is limited, making it impossible to gather accurate meteorological data in a local area like a micro-scale region. This occurs because even slight changes in altitude can have a significant impact on localized meteorological conditions. Existing weather models have difficulty in predicting with accuracy local weather phenomena such as fog, high fog, and thunderstorms, due to insufficient coverage of measurement data in the mid and lower levels of the atmosphere.

Weather monitoring systems using autonomous drones have become increasingly popular in recent years. These systems are used to collect data on various meteorological parameters, such as temperature, humidity, wind speed and direction, and precipitation. The data collected can be used to improve weather forecasting, as well as to track and predict severe weather events such as hurricanes and tornadoes.

One of the key components of a weather monitoring system using autonomous drones is the flight control system. This system uses a combination of GPS, inertial navigation, and other sensors to ensure that the drone stays on course and maintains a stable flight path. The flight control system also allows the drone to be programmed to follow a specific flight plan, which can be used to collect data from specific locations.

Another important component of a weather monitoring system using autonomous drones is the sensor suite. This includes a variety of instruments that are used to collect data on various meteorological parameters. Some of the most common sensors used in weather monitoring drones include temperature sensors, humidity sensors, wind sensors, and precipitation sensors. Overall, weather monitoring systems using autonomous drones have the potential to revolutionize the way we collect data on weather patterns and severe weather events. They offer a cost-effective and efficient way to collect data from remote and hard-to-reach locations, which can be used to improve weather forecasting and provide early warning of severe weather events.

CHAPTER – 1

INTRODUCTION

The systematic gathering, observation and analysis of atmospheric conditions and meteorological conditions for the purpose of comprehending and following weather trends is referred to as weather monitoring. Information about temperature, humidity, air pressure, wind speed and direction, precipitation, cloud cover and other atmospheric characteristics is gathered using a variety of equipment, technology and networks. To offer thorough coverage and collect data from various altitudes and geographic areas, these devices and systems are carefully positioned in diverse locations. There are many methods to monitor weather monitoring some of them are

a) Weather Stations: Weather stations are key components of weather monitoring systems and play a vital role in collecting data on various atmospheric parameters. These stations are designed to measure and record weather conditions at specific locations.

b) Weather balloons: Weather balloon also known as sounding balloon, is a balloon (specifically a type of high-altitude balloon) that carries instruments into the air to send back information on atmospheric pressure, temperature, humidity and wind speed by means of a small, expendable measuring device called a radiosonde.

c) Satellites: A weather satellite or meteorological satellite is a type of Earth observation satellite that is primarily used to monitor the weather and climate of the Earth. They can be polar orbiting or geostationary. They provide a global and comprehensive view of weather systems and atmospheric conditions, complementing ground-based observations.

d) Aircrafts: They provide a mobile and flexible platform for collecting atmospheric data, particularly in regions where ground-based monitoring is limited or hazardous weather conditions. Their ability to fly at different altitudes, cover large areas, and penetrate severe weather systems makes them valuable tools for weather monitoring, research, and improving forecasting capabilities.

e) Drones: Weather drone is a remotely piloted aircraft equipped with sensors to collect information about temperature, humidity, air pressure. It can be easily flown anywhere and get information at any particular point.

1.1. WEATHER AND ITS FACTORS

Weather refers to the short-term atmospheric conditions, including temperature, humidity, precipitation, wind speed and direction, cloud cover and atmospheric pressure at a specific location and time.

- **Temperature:** It is a critical factor in weather patterns. It is a measure of the average kinetic energy of air molecules in the atmosphere. Temperature variations are influenced by factors such as latitude, altitude, proximity to large bodies of water, cloud cover and air masses moving into the area.
- **Humidity:** It refers to the amount of moisture present in the air. It is influenced by factors such as evaporation from bodies of water, transpiration from plants, and the movement of air masses. High humidity levels can lead to the formation of clouds, fog, and precipitation, while low humidity levels can result in dry weather conditions.
- **Air Pressure:** It refers to the force exerted by the weight of the atmosphere on a unit area. Differences in air pressure result in the movement of air, leading to the formation of wind. High-pressure systems typically bring clear skies and stable weather conditions, while low-pressure systems are associated with cloud formation and precipitation.
- **Wind:** It is the horizontal movement of air caused by differences in air pressure. It is influenced by variations in temperature, air pressure gradients, the rotation of the Earth, and friction with the Earth's surface. Wind speed and direction play a crucial role in weather patterns, affecting factors such as temperature, cloud formation and storm development.
- **Topography:** The physical features of land, such as mountains, valleys and coastlines, can influence local weather conditions. Topography affects the flow of air masses, leading to variation in temperature, precipitation and wind patterns.

1.2. WHY USE DRONES TO MONITOR WEATHER

Weather drones are specially designed drones that are flown into the lowest layer of Earth's atmosphere, the boundary layer. They are equipped with sensors to gather information about temperature, humidity, pressure ultimately to help improve weather forecasting models.
Weather drones can be flown through the entire vertical layer of the boundary layer of the atmosphere, and collect crucial data on temperature, moisture and air pressure. Weather drones can collect this data in several ways

- By fixing the weather sensors directly onto the drone and fly it in the atmosphere.
- By dropping sensors called dropsondes, fitted with a parachute from a high altitude. The dropsondes descend through the vertical profile of the boundary layer, collecting data all the way down.

There are many advantages of using a drone in weather monitoring, some of which are

- Weather drones can be flown through the entire vertical layer of boundary level of atmosphere and collect crucial data on temperature, moisture, air pressure, wind speed and direction.
- Weather drones are maneuverable, can withstand sudden wind changes and are better equipped to collect vertical data.
- Measurements near buildings and structures in urban environments or offshore environments can also be taken using weather drones.

1.3. PROBLEM STATEMENT

The current methods of weather monitoring face limitations in spatial coverage, real-time data collection, and accessibility to remote or hazardous areas. Also, these methods can't take readings at a certain altitude, as the readings vary with altitude, they are not much accurate. In tornado prone regions, the current average early warning time is 16 minutes which leaves the residents with very less time for evacuation or taking cover.
Therefore, there is a need to address these challenges and find out the solutions to remove these limitations.

These problems have motivated us to take up this project of

"WEATHER MONITORING DRONE"

1.4. AIM AND OBJECTIVES

Our Aim is to build a drone equipped with sensors that can read barometric pressure, temperature, humidity, and also the altitude at which these readings are been taken. This drone is flown into the air using remote at a point where we want to read the meteorological parameters. These readings are then uploaded to the cloud using the Wi-Fi module through which we can monitor the weather parameters. The main objectives of this project are

- To build a system that can measure meteorological parameters at any altitude.
- To build a drone that can be taken anywhere and measure the required parameters.
- To instantly upload all the real time parameters data to the cloud.
- To remove the limitations of traditional weather forecasting.

CHAPTER-2

DRONE

2.1 HEXACOPTER DRONE

- Drones have emerged as versatile tools in various industries, including weather monitoring. Different types of drones offer unique advantages and capabilities, but the hexacopter drone stands out as a preferred choice for weather monitoring applications due to its specific attributes.

- One common type of drone used in weather monitoring is the quadcopter. As the name suggests, quadcopters are equipped with four rotors, providing stability and maneuverability. They are relatively compact and agile, making them suitable for navigating tight spaces and capturing high-resolution imagery. Quadcopters are often used for localized weather monitoring tasks, such as capturing data in urban areas or conducting close-range inspections of specific weather phenomena.

- Another type of drone commonly used in weather monitoring is the fixed-wing drone. These drones resemble small airplanes and are characterized by their ability to cover long distances and operate for extended periods. Fixed-wing drones are ideal for large-scale weather monitoring tasks, such as mapping and surveying vast agricultural areas or tracking weather patterns over expansive coastlines. They offer extended flight times and greater endurance compared to other drone types.

- However, when it comes to weather monitoring applications, the hexacopter drone provides distinct advantages over other drone types. The hexacopter, as the name suggests, features six rotors, which enhances stability and control. This increased stability is especially crucial in adverse weather conditions, such as strong winds, which can impact data collection accuracy. The hexacopter's ability to maintain steady flight in turbulent conditions makes it well-suited for capturing precise weather data.

2.1 HEXACOPTER

- The weather monitoring hexacopter drone is a remarkable technological innovation that combines the power of advanced aerial maneuverability with sophisticated data collection capabilities. Designed with precision and efficiency in mind, this hexacopter drone is equipped with cutting-edge features that make it an invaluable tool for weather monitoring and analysis.

- One of the standout features of this hexacopter drone is its impressive payload capacity of 3kg. This allows it to carry a variety of weather monitoring instruments, such as atmospheric sensors, humidity gauges, and temperature probes. With these instruments onboard, the drone is capable of collecting real-time data from various altitudes and locations, providing invaluable insights into weather patterns and atmospheric conditions.

- Powered by a high-performance lithium-polymer (LiPo) battery, the hexacopter drone boasts a flight time of 25 minutes. This extended flight duration enables it to cover significant distances and operate for extended periods, ensuring comprehensive weather monitoring and data collection. The drone's battery can be quickly recharged, allowing for minimal downtime between flights and ensuring maximum efficiency in capturing essential weather data.

- The range of the hexacopter drone extends up to 1 kilometer, giving it a wide coverage area for data collection. Whether it's monitoring weather conditions over vast agricultural fields, coastal areas, or urban environments, this drone can effortlessly navigate through challenging terrain and reach remote locations. The

extended range also allows for dynamic flight paths, enabling the drone to gather data from multiple areas within a single flight session.

- Constructed with lightweight and durable carbon fiber material, the hexacopter drone offers exceptional stability and maneuverability. The carbon fiber frame provides strength and rigidity while keeping the overall weight low, allowing for agile flight movements and precise control. This ensures that the drone can withstand various weather conditions, including strong winds, without compromising its data collection capabilities.

- Equipped with an HD camera, the hexacopter drone captures high-resolution imagery and videos of the monitored areas. This feature is especially useful for visual analysis and documentation of weather patterns and changes over time. Additionally, the HD camera can be utilized for remote visual inspections of critical infrastructure or natural disaster-affected areas, providing valuable situational awareness and aiding in disaster response efforts.

- Another essential feature of the hexacopter drone is its GPS functionality. The integrated GPS system ensures accurate positioning and navigation, enabling precise data geolocation. By combining the GPS data with the captured weather information, meteorologists and scientists can create detailed maps, analyze trends, and make more informed predictions about weather conditions and climate patterns.

- In conclusion, the weather monitoring hexacopter drone is a game-changing technology that revolutionizes the way we collect and analyze weather data. With its impressive payload capacity, extended flight time, wide range, LiPo battery, carbon fiber construction, HD camera, and GPS features, this drone offers unparalleled capabilities for weather monitoring and analysis. Its versatility and reliability make it an indispensable tool for meteorological research, disaster response, and various other applications where accurate and up-to-date weather information is crucial.

2.2 DRONE

2.2 DRONE COMPONENTS:

2.2.1. MULTI-ROTOR FLIGHT CONTROLLER:

2.3 FLIGHT CONTROLLER

- The DJI Naza M Lite Multi-Rotor Flight Controller is a feature-rich and highly capable control system designed for multi-rotor drones. Developed by DJI, a leading manufacturer in the drone industry, the Naza M Lite offers advanced flight control capabilities, stability, and ease of use.

- The Naza M Lite is equipped with a powerful control algorithm that ensures stable flight performance, allowing for precise maneuverability and control. It integrates a variety of sensors, including gyroscopes and accelerometers, to detect and analyze the drone's orientation, position, and movement in real-time. This enables the controller to make rapid adjustments to motor output and control signals, resulting in smooth and stable flight experiences.

- One of the standout features of the Naza M Lite is its GPS module. With GPS functionality, the controller provides accurate positioning, waypoint navigation, and return-to-home capabilities. The GPS module allows the drone to lock onto multiple satellites, which enhances the accuracy of position hold and altitude hold functions. This is especially valuable for tasks such as aerial photography, videography, and autonomous flight missions.

- The Naza M Lite offers multiple flight modes, catering to a range of flying preferences and applications. These modes include Attitude Mode, which provides stabilized flight with self-leveling capabilities, and Manual Mode, which offers full manual control for experienced pilots. Additionally, it features Intelligent Orientation Control (IOC), which enables the drone to maintain its course relative to the pilot's position, regardless of its actual heading. This simplifies control and enhances the user experience.

- To ensure safety and reliability, the Naza M Lite incorporates various built-in protection features. It includes a Motor Arm/Disarm system that prevents accidental motor activation during pre-flight checks or handling. The controller also has voltage and current sensors that monitor the power supply, alerting the user when battery levels are low or when the current draw exceeds safe limits. These safety features contribute to safer flight operations and help protect the drone from potential damage.

- Configuration and customization of the Naza M Lite are made simple through the DJI Assistant 2 software. The software provides a user-friendly interface where users can adjust flight parameters, perform firmware updates, and calibrate sensors. The intuitive interface makes it easy for pilots to optimize the performance of their drones and tailor settings to their specific requirements.

- Overall, the DJI Naza M Lite Multi-Rotor Flight Controller is a reliable and feature-packed control system that brings stability, precision, and advanced flight capabilities to multi-rotor drones. With its powerful control algorithm, GPS module, multiple flight modes, and user-friendly configuration software, the Naza M Lite empowers pilots to achieve smooth, stable flights and unlock the full potential of their drones for various applications, including aerial photography, videography, and recreational flying.

2.2.2. BRUSHLESS MOTORS:

2.4 Motor

- The A2212/15T 930kv Brushless Motor is a widely used and popular motor in the world of multi-rotor drones and other RC (Radio Control) applications. This motor is known for its reliability, efficiency, and versatility, making it suitable for a range of drone sizes and configurations.

- The A2212/15T 930kv motor features a brushless design, which offers several advantages over traditional brushed motors. Brushless motors are more efficient, have higher power-to-weight ratios, and require less maintenance due to the absence of brushes that can wear out over time. This makes the A2212/15T motor a reliable and long-lasting choice for drone enthusiasts and hobbyists.

- The "930kv" in the motor's name refers to its kV rating, which represents the motor's RPM (rotations per minute) per volt applied. In the case of the A2212/15T motor, it has a kV rating of 930, meaning that when one volt of power is supplied to the motor, it will rotate at approximately 930 RPM. This kV rating determines the motor's speed and is an important consideration when selecting the appropriate propeller size and battery voltage for the drone.

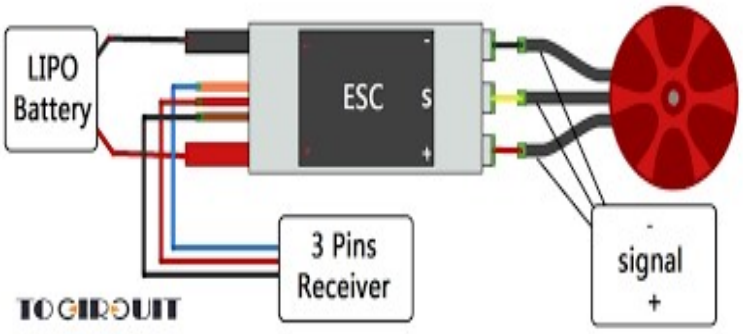
- The A2212/15T 930kv motor is typically used in medium-sized drones, ranging from 300mm to 600mm in diagonal motor-to-motor distance. It is commonly paired with propellers between 8 to 10 inches in diameter, depending on the specific application and desired performance characteristics. The motor is compatible with a wide range of ESCs (Electronic Speed Controllers) that control the speed and direction of the motor's rotation.

- In terms of power output, the A2212/15T 930kv motor can handle moderate loads and provide sufficient thrust for stable flight. It is well-suited for aerial photography and videography applications, as well as general recreational flying. However, for more demanding applications that require heavy payloads or aggressive maneuvers, higher-powered motors may be more suitable.

- The A2212/15T 930kv motor typically operates on a voltage range of 2S to 4S LiPo (Lithium Polymer) batteries, meaning it can handle 2 to 4 cells connected in series. It is important to choose an appropriate battery voltage to ensure optimal motor performance and longevity.

- Its efficient design, moderate power output, and compatibility with a range of propellers and battery configurations make it popular among drone enthusiasts for various applications. Whether you're building a drone for aerial photography, recreational flying, or experimentation, the A2212/15T 930kv motor provides a solid foundation for a reliable and enjoyable flying experience.

2.2.3. ELECTRONIC SPEED CONTROLLER (ESC):



2.5 ESC CIRCUIT DIAGRAM

- The Electronic Speed Controller (ESC) is a critical component in drone technology that plays a vital role in controlling the speed and direction of the motors. As an integral part of the drone's propulsion system, the ESC translates the signals from the flight controller and adjusts the power supply to the motors accordingly.

- The primary function of the ESC is to regulate the motor's rotational speed, ensuring precise control and responsiveness. It achieves this by modulating the power supplied to the motor based on the input signals received from the flight controller. The ESC takes these signals, interprets them, and converts them into appropriate power levels that drive the motors at the desired speed.

- ESC technology has evolved significantly, with modern ESCs offering a range of advanced features and capabilities. One crucial feature is the ability to provide a high refresh rate, which allows for faster and more accurate motor response. Higher refresh rates enable smoother and more precise control of the drone, resulting in improved flight performance and stability.

- Another vital feature of ESCs is their ability to support different types of motor configurations, such as brushed or brushless motors. While brushed motors are commonly found in entry-level drones, brushless motors offer numerous advantages, including higher efficiency, power, and reliability. ESCs designed for brushless motors are specifically tailored to optimize the performance of these motors, providing efficient and precise control.

- ESC firmware is also a critical aspect to consider. Firmware updates and customization options allow for fine-tuning of various parameters, such as motor timing, throttle response, and braking. These adjustments can optimize the performance of the motors, ensuring smoother operation and reducing motor noise.

- Furthermore, ESCs are equipped with various protection mechanisms to safeguard the motor and prevent damage in case of potential issues. Some common protection features include overheat protection, over-current protection, and low-voltage protection. These safety measures help prolong the lifespan of the motors and enhance the overall reliability of the drone.

- The size and weight of ESCs are crucial factors to consider when selecting the appropriate component for a drone. ESCs come in various form factors and power ratings to accommodate different drone sizes and power requirements. It is essential to choose an ESC that matches the motor's specifications and the overall power demands of the drone.

- The evolution of ESC technology has significantly contributed to the advancements in drone capabilities, enabling precise control, smooth maneuvers, and enhanced user experiences.

2.2.4. TS 832 VIDEO TRANSMITTER:

2.6 VIDEO TRANSMITTER

- The TS832 Transmitter is a powerful and reliable video transmitter widely used in the field of FPV (First Person View) drone racing and aerial photography. Designed for seamless video transmission, the TS832 offers a range of features and capabilities that enhance the FPV experience.

- One of the key features of the TS832 Transmitter is its robust transmission power. It operates on a frequency range of 5.8GHz, providing a strong and stable signal for transmitting video footage from the drone to the FPV goggles or receiver. With adjustable power settings, the TS832 allows pilots to optimize the transmission range based on their specific needs and flight conditions.

- The TS832 Transmitter supports multiple video input formats, including PAL and NTSC, offering compatibility with various camera systems. It also features multiple output channels, which can be selected to avoid interference from nearby transmitters and ensure clear and uninterrupted video transmission.

- The TS832 Transmitter incorporates advanced frequency synchronization technology, which minimizes signal interference and ensures a reliable and high-quality video feed. This technology helps prevent signal dropout and reduces video noise, providing a smoother and more immersive FPV experience for pilots.

- Another notable feature of the TS832 is its compact and lightweight design, making it easy to install and integrate into the drone's setup. The transmitter is equipped with standard SMA antenna connectors, allowing for compatibility with a wide range of antennas for enhanced signal reception and transmission.

- The TS832 Transmitter also includes built-in protection features to safeguard the device and ensure reliable operation. It incorporates temperature protection mechanisms, which monitor the operating temperature and automatically reduce power or shut down if the temperature exceeds safe limits. This protects the transmitter from overheating and extends its lifespan.

- Additionally, the TS832 Transmitter is often equipped with a cooling fan or heatsink to further dissipate heat generated during operation. This ensures optimal performance and stability, even during extended flight sessions or in demanding environmental conditions.

- The TS832 Transmitter is typically powered by a direct connection to the drone's battery or a dedicated power source. It is important to ensure that the power supply is compatible with the transmitter's voltage requirements to avoid damage and ensure reliable operation.

2.2.5. RECEIVER:

2.7 RECEIVER

- The 2.4GHz 6-Channel Receiver plays a crucial role in the world of drone technology, allowing for precise and reliable control over unmanned aerial vehicles (UAVs). As a key component of the drone's radio control system, this receiver enables seamless communication between the drone and its remote controller.

- Operating on the 2.4GHz frequency band, the 6-Channel Receiver offers several advantages for drone applications. The 2.4GHz frequency provides a wide bandwidth, allowing for robust and interference-free signal transmission. This

ensures stable and responsive control over the drone, even in environments with competing wireless signals.

- The 6-channel capability of the receiver is particularly valuable for drones, as it allows for versatile control over various aspects of the aircraft's flight. The six channels can be assigned to control functions such as throttle, pitch, roll, yaw, flight modes, and auxiliary features like camera control or landing gear deployment, depending on the specific drone model and configuration.

- One of the significant benefits of using the 2.4GHz frequency is the reduced susceptibility to signal interference. Compared to lower frequency bands, the 2.4GHz band experiences fewer interruptions from other wireless devices, ensuring a more reliable and consistent connection between the drone and the remote controller. This is crucial for maintaining control over the drone and preventing signal loss or interference that could result in accidents or crashes.

- The binding process between the 6-Channel Receiver and the remote controller is typically straightforward. Following the manufacturer's instructions, the receiver is bound to the remote controller, establishing a secure and exclusive communication link between the two devices. This ensures that the drone responds only to signals transmitted by its paired remote controller, enhancing control reliability and safety.

- The compact size and lightweight design of the 2.4GHz 6-Channel Receiver make it easy to integrate into drones of various sizes and configurations. It usually features multiple input/output ports, allowing for seamless connectivity to the drone's flight controller, ESCs (Electronic Speed Controllers), and other components.

- Safety features are often incorporated into the receiver to protect against voltage fluctuations or reverse polarity connections. These measures help safeguard the receiver and ensure safe operation of the drone.

2.2.6. GPS MODULE:

2.8 GPS MODULE

- The NAZA GPS module is a key component of the NAZA flight control system developed by DJI, a leading manufacturer of drones and aerial photography equipment. The GPS module enhances the capabilities of the NAZA flight controller by providing accurate positioning and navigation information for drones.

- The NAZA GPS module utilizes Global Positioning System (GPS) technology to determine the drone's precise location, altitude, and speed. This allows the flight controller to maintain stability, accurately calculate flight paths, and enable advanced features such as waypoint navigation and return-to-home functionality.

- With the NAZA GPS module, drones can accurately hold position and maintain a stable hover, even in windy conditions. The GPS data is continuously updated, enabling the flight controller to make real-time adjustments to ensure optimal stability and performance during flight.

- One of the key advantages of the NAZA GPS module is its ability to support waypoint navigation. By setting GPS coordinates as waypoints, drone pilots can plan and program complex flight paths for autonomous missions. This feature is particularly useful in aerial surveying, mapping, and cinematography, where precise control and repeatable flight paths are essential.

- The NAZA GPS module also enables return-to-home functionality, which automatically directs the drone to fly back to its takeoff point. This feature can be triggered manually by the pilot or automatically activated in cases of low battery, lost connection, or signal interference. The return-to-home function provides an added layer of safety and helps prevent the loss of the drone in unexpected situations.

- Another notable feature of the NAZA GPS module is its ability to support GPS-assisted stabilization. By combining GPS data with the drone's onboard sensors, such as accelerometers and gyroscopes, the flight controller can compensate for external factors like wind drift, ensuring smoother and more stable flight performance.

- The NAZA GPS module is typically designed for easy integration with the NAZA flight controller, allowing for simple installation and setup. It communicates with the flight controller through a serial interface, exchanging data and commands to enable precise positioning and navigation capabilities.

- It is important to note that the NAZA GPS module requires a clear line of sight to the GPS satellites for optimal performance. This means that flying in areas with obstructed views, such as dense urban environments or under dense tree cover, may affect the module's accuracy and reliability.

2.2.7. Li-Po BATTERIES:

2.9 BATTERIES

- A LiPo (Lithium Polymer) battery pack is a popular and widely used power source for a variety of electronic devices. Known for their high energy density, LiPo batteries offer a compact and lightweight solution for portable electronics. The term "LiPo" refers to the battery's construction, which utilizes a polymer electrolyte instead of a traditional liquid electrolyte.

- LiPo battery packs are valued for their high discharge rates, allowing them to deliver bursts of power when needed. This makes them suitable for applications that require quick and responsive performance, such as remote-controlled vehicles, drones, and high-performance gadgets.

- One of the key advantages of LiPo batteries is their ability to maintain a relatively constant voltage throughout their discharge cycle. This means that devices powered by LiPo batteries often operate at consistent performance levels until the battery is depleted.

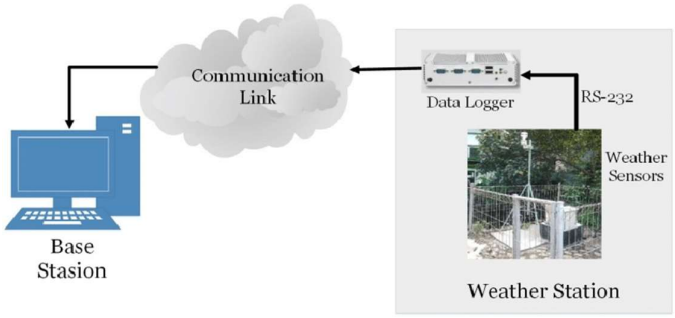
- It is important to note that LiPo batteries require special care and handling. They should be charged with a compatible charger specifically designed for LiPo batteries, and proper storage practices should be followed to ensure safety and maximize battery lifespan. Additionally, precautions should be taken to avoid overcharging, over-discharging, or damaging the battery through physical abuse.

CHAPTER – 3

WEATHER MONITORING SYSTEM

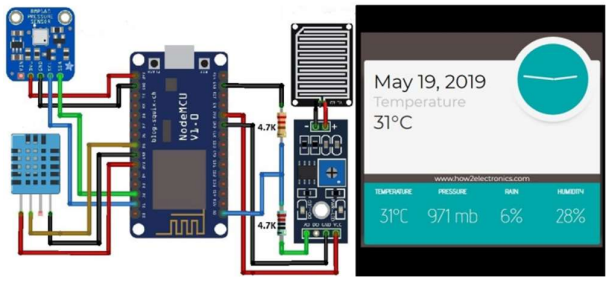
A weather monitoring system is a collection of sensors, equipment, and devices that measure and collect data on a variety of weather factors. Temperature, humidity, air pressure, wind speed and direction, rainfall, and sometimes other elements such as sun radiation or UV index are included. The device is installed in strategic areas to continuously monitor and record meteorological conditions.

In traditional weather monitoring systems, sensors are typically deployed at various locations to collect weather data. Wired connections connect these sensors to a central data collecting system. The gathered data is processed and stored by the data acquisition system. Users can examine and analyze weather data by accessing the system locally or remotely. These systems frequently rely on human data retrieval or on periodic visits to sensor locations to collect data.



3.1 WEATHER MONITOR STATION

IoT-based weather monitoring systems leverage wireless connectivity, cloud computing, and data analytics to enhance the capabilities of weather monitoring. Sensors deployed in the field communicate wirelessly with a central gateway device or directly to the internet. The sensor data is transmitted in real-time to an IoT platform or cloud-based service. Users can access the platform remotely through web or mobile applications to monitor, analyze, and visualize the weather data.



3.2 IOT BASED WEATHER MONITOR SYSTEM

3.1. IoT based Weather Monitoring System Over Traditional Stations

- Traditional weather monitoring stations are few in number and often concentrated in certain geographic areas. IoT-based solutions, on the other hand, can make use of a network of interconnected devices spread across a large geographic area to provide more widespread data coverage. This enables a more in-depth understanding of weather patterns and conditions.

- Traditional weather stations frequently have data collecting and distribution delays. IoT-based devices can collect and transmit data in real time, allowing for faster and more accurate weather updates. This real-time data is critical for making prompt decisions, such as forecasting severe weather events or optimizing agricultural practices.

- Weather monitoring systems based on IoT can be readily scaled up or down dependent on the needs. As needed, more sensors and devices can be placed in specific places to enable fine-grained monitoring and analysis. This scalability and flexibility improve the capacity to monitor meteorological conditions in remote or neglected places.

- Data from multiple sources, such as weather stations, satellites, and ground sensors, can be integrated into IoT-based systems, allowing for a full analysis of weather trends. Advanced analytics approaches, such as machine learning and data modelling, can be used to extract important insights from IoT-generated data and increase weather forecasting accuracy.

- Traditional weather monitoring systems are frequently costly to establish, maintain, and run. IoT-based systems can take use of inexpensive and quickly deployable IoT devices, considerably lowering infrastructure costs. Furthermore, cloud-based data storage and processing reduce the requirement for on-site data storage and maintenance.

- Individuals and groups can be involved in IoT-based weather monitoring systems by employing citizen science and crowdsourcing methodologies. This collaboration provides for a larger network of data contributors, improving data collection capabilities, and encouraging community participation in weather monitoring initiatives.

- The creation of early warning systems can be facilitated by real-time data from IoT-based weather monitoring devices, improving readiness and reaction to extreme weather occurrences.

- IoT sensors offer increased flexibility and mobility in weather monitoring since they may be installed in a variety of contexts, including distant or inhospitable areas.

- Advanced analytics and integration with other data sources are made possible by IoT-based systems, allowing for a more thorough investigation of weather patterns and forecasts.

- IoT systems can readily scaled up and expanded to cover a broader region, making it possible to monitor the weather in-depth across several sites.

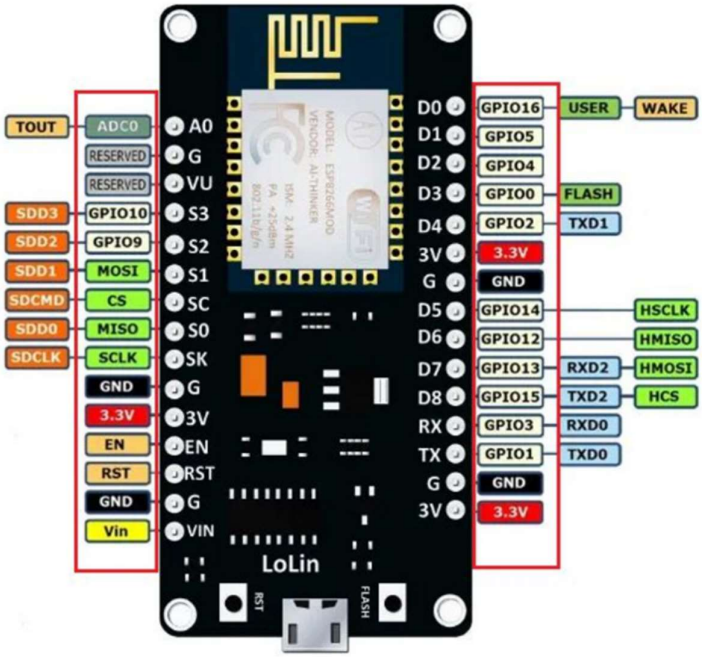
- The accessibility of IoT-based weather monitoring devices is what makes them convenient. It is tremendously useful for those on the go or for those who need weather information for certain activities or planning purposes because users can easily check weather data through their own devices from anywhere. Users can quickly obtain the information they need with a few taps on their smartphones or clicks on their PCs, whether they need to check the forecast before a weekend excursion, get ready for an outdoor event, or simply keep updated about daily weather changes.

- IoT-based solutions offer real-time weather information, enabling precise and current weather monitoring.

3.2. IMPLEMENTATION (HARDWARE REQUIREMENTS)

3.2.1. ESP8266 WI-FI MODULE

The ESP8266 is a Wi-Fi module developed by Espressif Systems, combining a microcontroller unit (MCU) with built-in Wi-Fi capabilities. It enables devices to connect to Wi-Fi networks, supports popular Wi-Fi standards, and can be programmed using different languages and frameworks like Arduino IDE and Micropython. Its low cost, small size, and versatility have made it popular for hobbyist projects and IoT applications, adding wireless connectivity to various devices and projects.



3.3 ESP8266

3.2.2. BOARD BREAKDOWN OF ESP8266

Here are the components that make up an ESP8266 Wi-Fi module and their functioning:

- **Microcontroller unit (MCU):** The microcontroller unit (MCU) integrated into the ESP8266 module is a key component that plays a crucial role in the module's functionality. It is typically based on the Xtensa LX106 architecture, which is a high-performance and low-power microcontroller architecture developed by Tensilica. The MCU is responsible for executing firmware, running applications, and controlling the overall operation of the ESP8266 module.

- **Memory:** The ESP8266 module is equipped with built-in memory that serves as storage for various purposes such as firmware, program code, and data. This memory is crucial for the module's operation and functionality. Typically, the module consists of two main types of memory: flash memory and RAM. Flash memory is non-volatile, meaning it retains data even when the power is disconnected. RAM is volatile, meaning it loses its data when the power is disconnected or the module is reset.

- **Wi-Fi Radio:** The ESP8266 module integrates a Wi-Fi radio that supports IEEE 802.11 b/g/n standards, enabling wireless communication. It operates on the 2.4 GHz frequency band and allows devices to connect to Wi-Fi networks, transmit

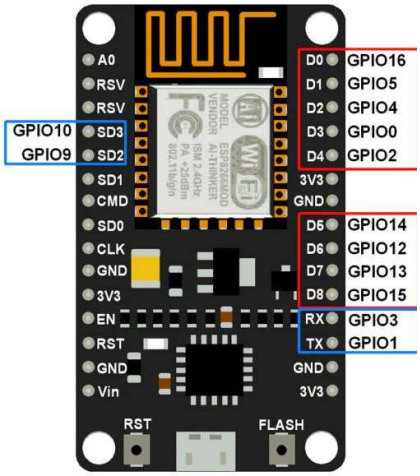
and receive data wirelessly. The module can establish connections with various Wi-Fi networks, utilize standard authentication methods, and achieve data transfer rates of up to 150 Mbps or more with the IEEE 802.11n standard. This functionality enables applications such as IoT communication, remote control, and data acquisition, making the ESP8266 module a versatile solution for wireless connectivity and data transmission.

- **GPIO Pins:**
  - GPIO0: This pin is a general-purpose I/O pin with a pull-up resistor. It is often used during the boot process for programming and firmware update purposes. It can also be used as a general-purpose I/O pin after the boot process.

  - GPIO1: This pin is a general-purpose I/O pin that is often used as a TX (transmit) pin for serial communication, such as UART or SPI interfaces. It can also function as a general-purpose I/O pin for other purposes.

  - GPIO2: This pin is a general-purpose I/O pin that is often used as an RX (receive) pin for serial communication, such as UART or SPI interfaces. It can also function as a general-purpose I/O pin for other purposes.

  - GPIO3 to GPIO15: This pin is a general-purpose I/O pin that can be used for various purposes, including general-purpose I/O, external interrupts, or other specific functions depending on the firmware and application requirements.



3.4 GPIO PINS

- **Analog to Digital Converter:** The ESP8266 module has an integrated Analog-to-Digital Converter (ADC) that converts analog signals from external sensors into digital values for processing by the microcontroller unit (MCU). This enables

the module to interface with various analog sensors and gather data such as temperature, light intensity, or humidity. The ADC enhances the module's versatility and allows the MCU to utilize analog data in different applications and decision-making processes.

- **Clock and Timing:** The ESP8266 module has an onboard clock source and timing circuits for precise timing and synchronization of operations. These components generate clock signals to regulate processes such as data transmission and sensor readings. Accurate timing ensures coordinated execution, adherence to protocols, and efficient resource utilization. These features enhance the module's reliability and performance in time-sensitive applications.

- **Serial Interface:** The ESP8266 module supports UART serial communication interfaces for seamless connectivity with other devices. UART enables programming, firmware updates, and debugging, while also facilitating data exchange with external devices. Its versatility and widespread adoption make UART an ideal choice for serial communication in the ESP8266 module, enhancing its interoperability and ease of use in various applications.

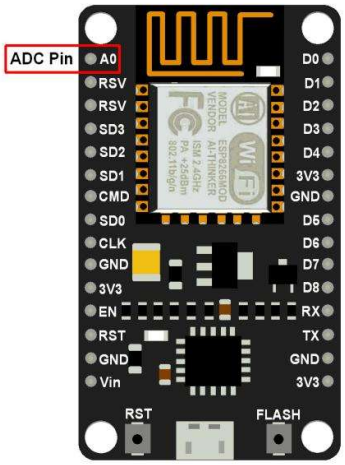
- **Power Management:** The ESP8266 module includes power management circuits for efficient power usage and voltage regulation. Some modules also provide options for low-power sleep modes to conserve energy.

- **Power Pins:** For supplying power to the module and connecting it to an external power source, the ESP8266 module includes power pins, such as VCC and GND.

- **Reset Pin:** There is a reset pin on the module that allows for resetting the module and initiating a restart of its operation.

- **Chip Enable (CH_PD) Pin:** The module utilizes this pin to enable or disable its functionality.

- **Analog Input Pins:** This module has only a single analog pin A0. This pin can be used to read analog voltage levels from external sensors or devices. The ADC present on the module allows the A0 pin to convert the analog voltage into a digital value that can be processed by the microcontroller.



3.5 ANALOG PIN

BME 280 MODULE

The BME280 sensor is an environmental sensor module that combines pressure, temperature, and humidity sensing capabilities. It provides accurate measurements of these parameters in a compact package, allowing for simultaneous sensing. It is commonly used in applications like weather monitoring and indoor climate control.

Working:

- The BME280 pressure sensor employs a piezoresistive sensing element. This element comprises a small membrane that flexes when subjected to alterations in atmospheric pressure. As the membrane flexes, the electrical resistance undergoes changes. These variations in resistance are subsequently detected and converted into digital pressure values. To guarantee precise pressure measurements, the sensor incorporates calibration coefficients that account for temperature fluctuations and other factors.

- The BME280 module's temperature sensor operates on the principle of a bandgap temperature sensor. It calculates the ambient temperature by measuring the voltage across a temperature-dependent diode. The sensor is carefully calibrated to deliver precise temperature readings and takes into account factors like self-heating and changes in ambient temperature during operation.

- The BME280 utilizes a capacitive sensing element for its humidity sensor. This element comprises a thin polymer film that absorbs or releases moisture based on the ambient humidity level. The alteration in moisture content leads to a change in capacitance, which is subsequently measured and converted into relative humidity values. To ensure accurate humidity measurements, the sensor

incorporates calibration coefficients that account for temperature variations and the non-linear characteristics of the sensing element.

- Typically, to retrieve data from the BME280 sensor, it is connected to a microcontroller or other devices using digital communication interfaces such as I2C or SPI. The sensor outputs raw sensor data, which can be processed and converted into meaningful measurements. The manufacturer provides formulas and calibration coefficients that are used to transform the raw data into accurate measurements.

- The BME280 sensor includes internal registers that serve configuration and control purposes. These registers enable the adjustment of measurement resolution, sampling rate, filtering options, and other settings according to the specific requirements of the application. By accessing these registers, users can customize the sensor's behavior to optimize its performance for their particular needs.

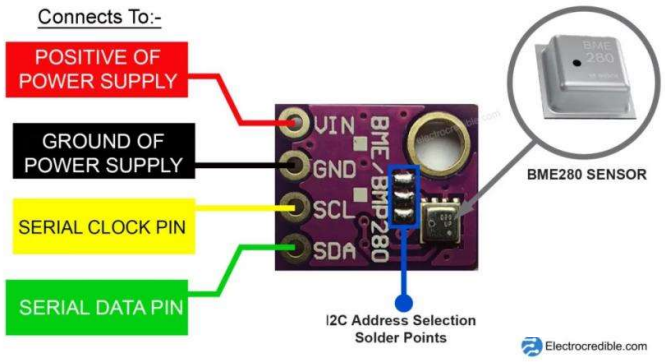
Pins:

- **Vcc:** The purpose of this pin is to provide power to the sensor, typically by connecting it to a regulated 3.3V power source.

- **GND:** For proper grounding of the sensor, it is crucial to connect this pin to the ground of the system.

- **SDA:** In I2C communication, the Serial Data Line (SDA) pin facilitates bi-directional data transfer. This pin is connected to the SDA pin of the microcontroller or the I2C bus. It serves as a communication channel for transmitting and receiving data between the BME280 sensor and the connected device.

- **SCL:** The Serial Clock Line (SCL) pin is utilized for synchronizing data transfer. This pin is connected to the SCL pin of the microcontroller or the I2C bus. It ensures that data is transferred at the correct timing and allows for synchronized communication between the BME280 sensor and the connected device.



3.6 BME280 PINOUT

3.3. THINGSPEAK – AN IOT PLATFORM

ThingSpeak is a platform created by MathWorks that focuses on the Internet of Things (IoT). Its purpose is to provide users with a customizable and user-friendly platform for gathering, analyzing, and visualizing data from various connected devices. By utilizing ThingSpeak, individuals can easily construct IoT applications and keep track of real-time information from sensors, actuators, and other IoT devices.

Working:

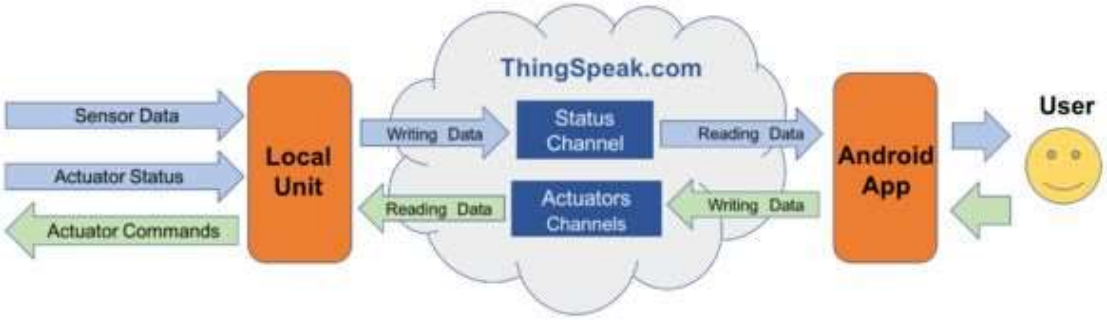
- With the use of its APIs and libraries, ThingSpeak enables devices to communicate with the platform via a variety of protocols, including HTTP, MQTT, and its proprietary TCP/IP-based TCP/ThingSpeak Communication Protocol.

- The platform uses channels, which serve as data repositories, to store the received data. Information can be stored in several fields for each channel, which makes it simple to organize and access data.

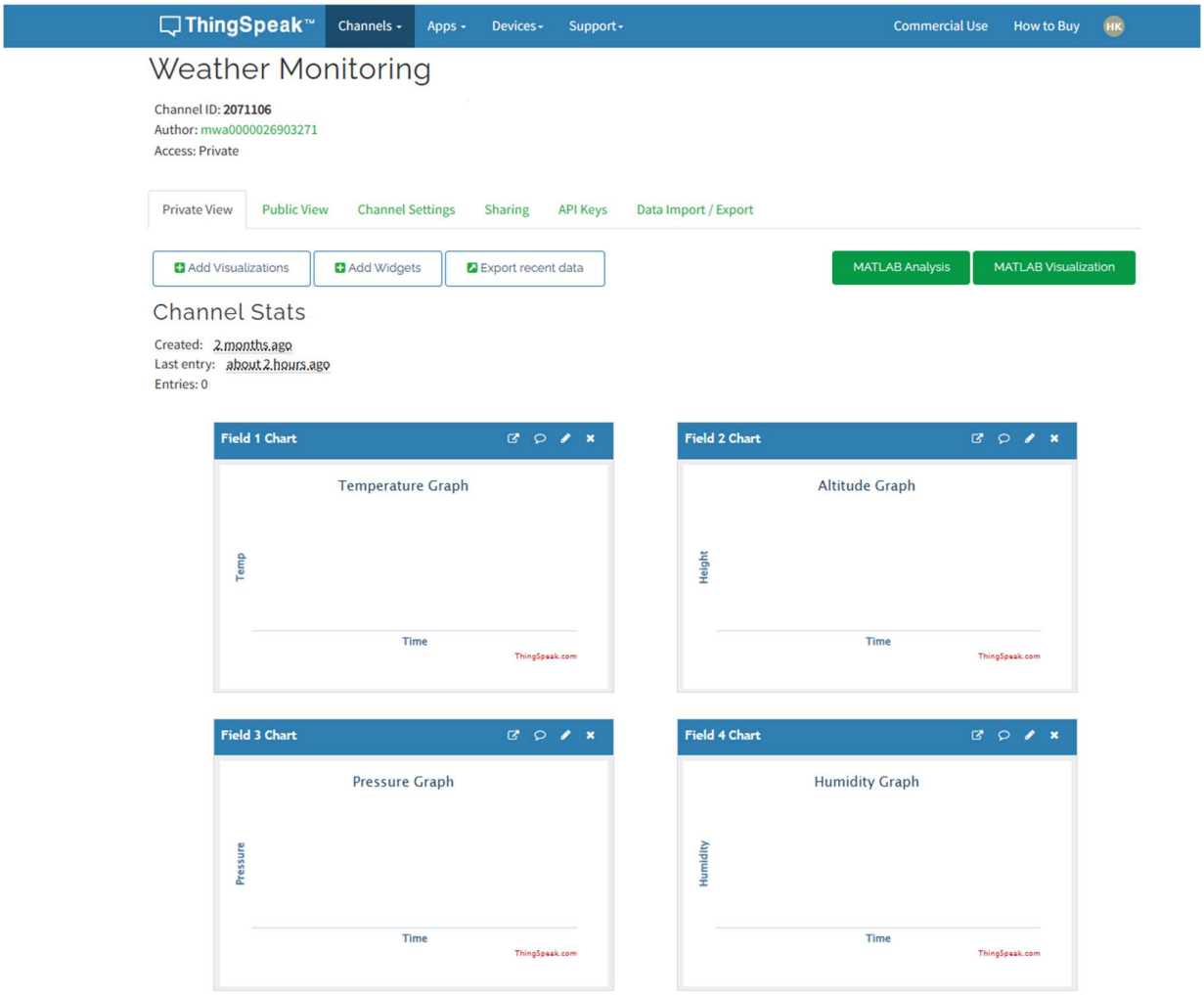
- Charts, gauges, maps, and other visualizations are available through ThingSpeak and can be customized. IoT data can be tracked and analyzed via interactive dashboards that users can develop.

- Applying MATLAB code to the gathered data is possible with ThingSpeak. As a result, users may carry out sophisticated data analysis, filtering, and calculations right inside the platform.

ThingSpeak provides an open API, allowing developers to extend the platform's functionality and integrate it with their own applications and services.



3.7 THINGSPEAK



3.8 THINGSPEAK PLATFORM

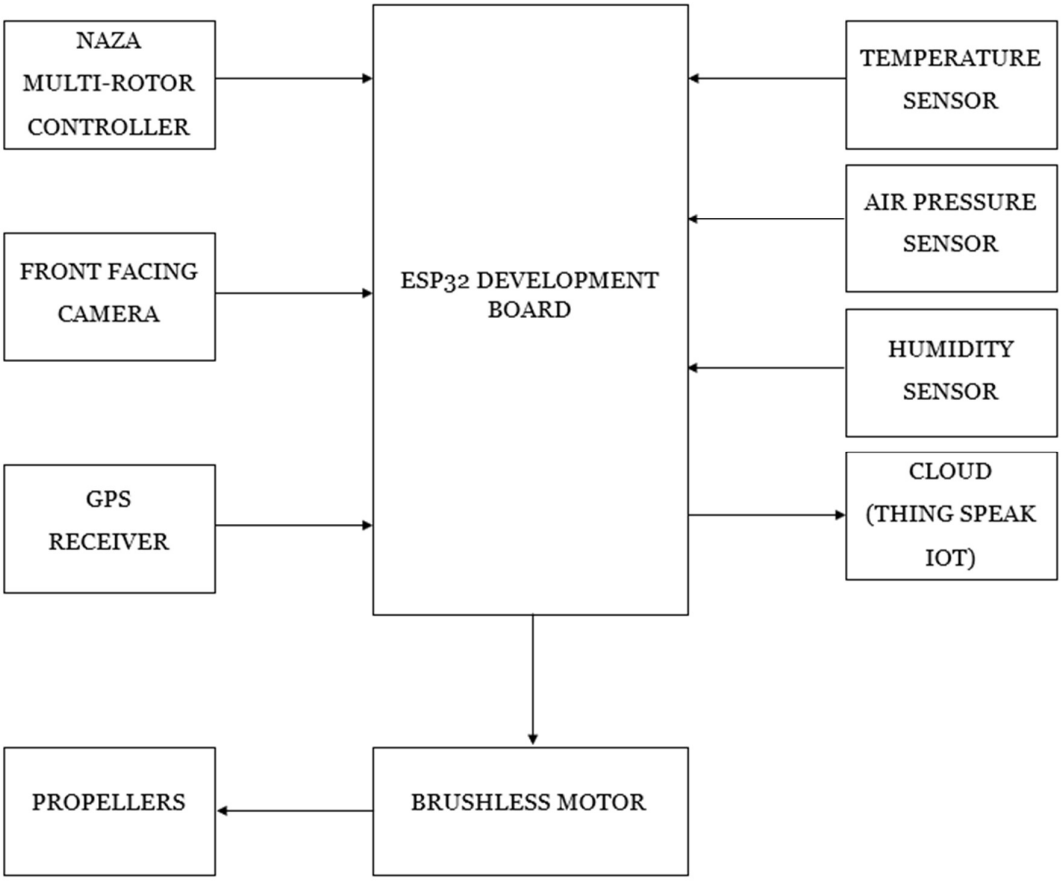
CHAPTER -4

ANALYSIS OF THIS PROJECT

4.1. CIRCUIT:

- The major aim of this project as discussed above is to monitor the weather using the BME280 sensor which integrates four different attributes of weather I.e., Temperature, Humidity, Pressure and Altitude.

- The Weather Monitoring Circuit is created by integrating the BME280 module with the ESP8266 Wi-Fi module. The circuit is controlled by the microcontroller unit of the Wi-Fi module which is programmed through Arduino IDE Platform.



4.1 BLOCK DIAGRAM

- The aim is not just limited to monitor weather using this circuit at one particular place, but instead to get a sequential value of the weather (with respect to these four attributes) by keeping the sensor in motion using a drone.

- The drone carries the sensor along with it to different locations of an area so that the sensor records the weather values at these locations to get an overall understanding of the weather in that area.

- The recorded values are then continuously uploaded to the cloud (ThingSpeak platform in this case) by gaining access to Wi-Fi (wi-fi module in the weather monitoring circuit) at different locations.

- These continuously recorded values are then analyzed in the ThingSpeak platform following the below procedure:

    - Navigate to the Channels area of ThingSpeak account and click "New Channel" to establish a new channel. Give the channel a name and add fields to reflect the various sensor readings you want to monitor (for example, temperature, pressure, and humidity). Other variables, such as field labels, privacy options, and data retention policy, can be customized.

    - API keys are generated once the channel has been created. These keys enable communication between the device and the ThingSpeak platform.

    - Use the ThingSpeak API in the microcontroller programme to deliver sensor data to the corresponding fields of the ThingSpeak channel. For authentication, the API keys got earlier must be supplied.

    - Navigate to the channel in ThingSpeak account. The incoming sensor data should be shown in the fields defined. The visualization can be personalized by selecting different chart styles, adding gauges, and incorporating other visual elements to represent the data.

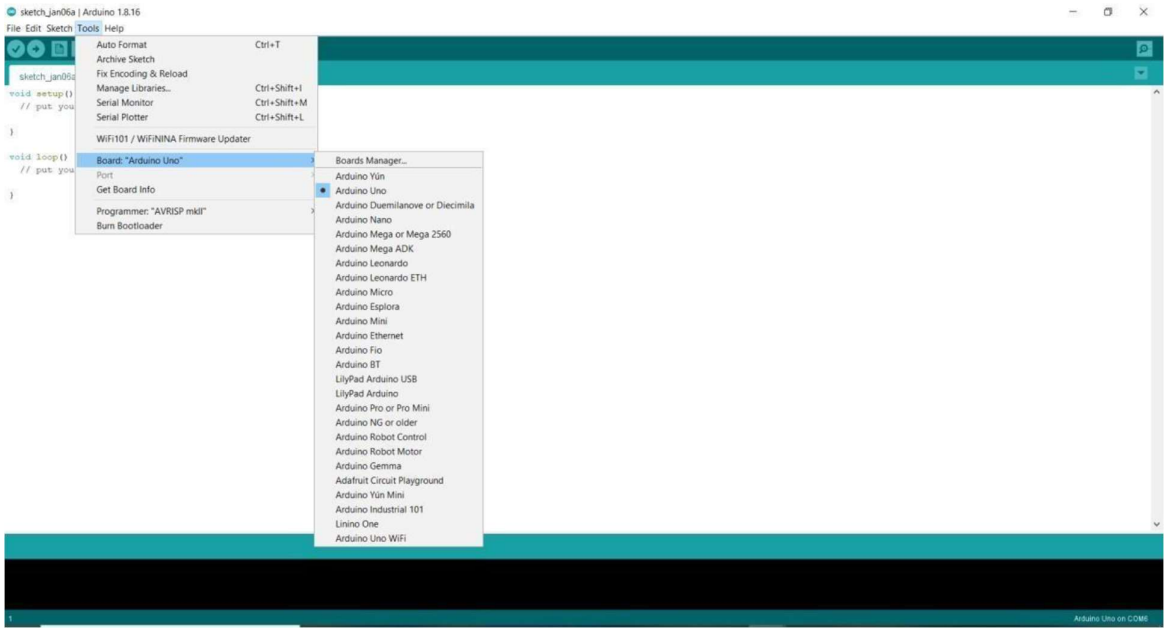
4.2. SOFTWARE REQUIREMENTS

Arduino 1.8.13 is open-source Arduino software (IDE) makes it an easy to write code and upload it on to the Arduino board. It runs on Windows, MAC OS X, and LINUX. This software can be used with any of the Arduino board

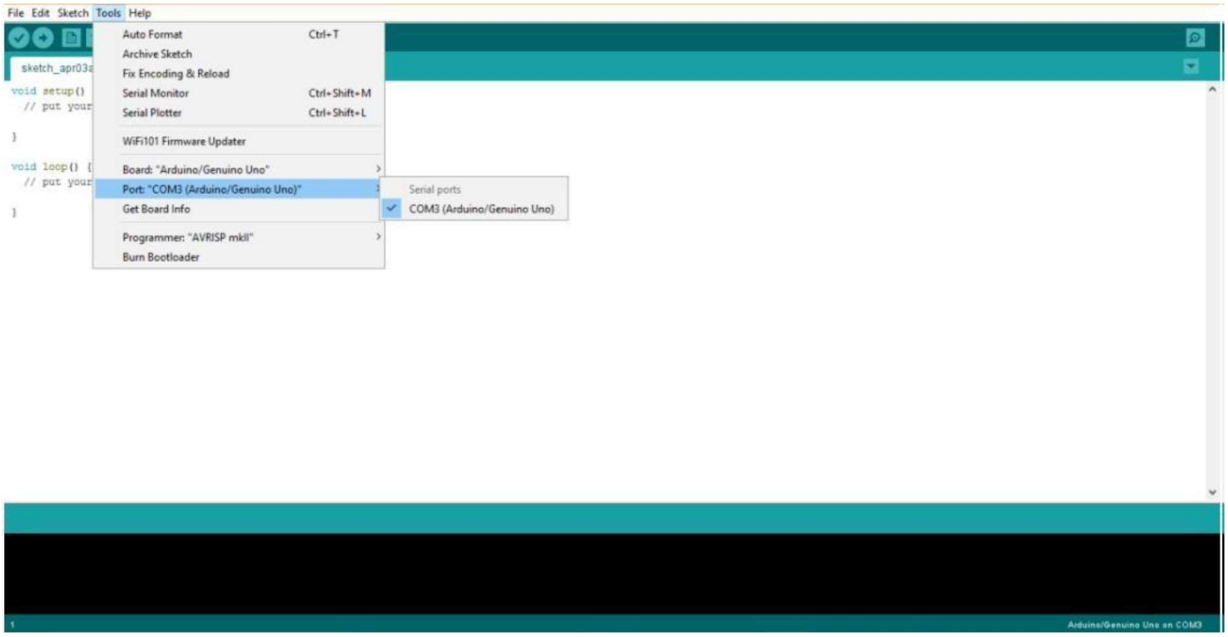
Before uploading the program to the Arduino 1.8.13 software, there are few steps:

1. Select the board we are working on, in the software.

Tools ⇨ Boards ⇨ Arduino



2.Selection of the serial port



In order to know which serial port is our device we need to disconnect the USB cable connected.

3.After the code is written, before uploading to the Arduino, it is compiled first in order to check the errors in the program.

4.3. CODE:

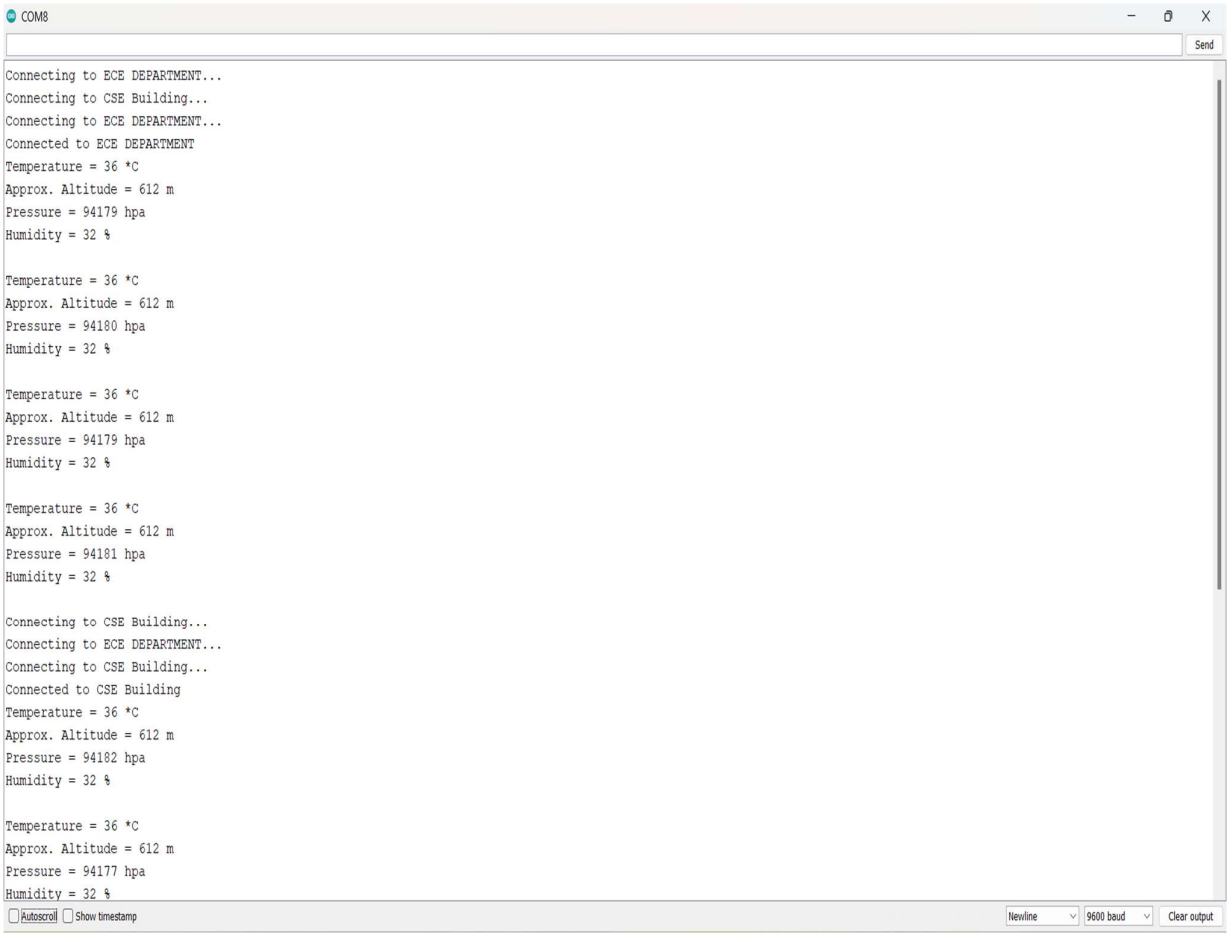
```
#include <ESP8266WiFi.h>
#include <WiFiClient.h>
#include <ThingSpeak.h>
#include <Wire.h>
#include <Adafruit_Sensor.h>
#include <Adafruit_BME280.h>

const char* ssid[] = {"CSE Building","IST Block","Manjeera Boys Hostel","ECE Block","Civil Block","Admin Block"};
const char* password[] = {"csejntuh","istjntuh","12345678","ecejntuh","civiljntuh","adminjntuh"};
int temp=0;
int alt=0;
int pres=0;
```

```
int hum=0;
int i=0;
WiFiClient client;
unsigned long myChannelNumber = 2071106;
const char * myWriteAPIKey = "N0A9TGHRA4CLNRY0";

#define SEALEVELPRESSURE_HPA (1013.25)

Adafruit_BME280 bme;

void setup() {
  Serial.begin(9600);
  delay(10);
  ThingSpeak.begin(client);
  bme.begin(0x76);
  Serial.println();
}
void loop() {
  while(WiFi.status() != WL_CONNECTED){
    WiFi.begin(ssid[i],password[i]);
    Serial.printf("Connecting to %s...\n", ssid[i]);
    delay(5000);
    if(WiFi.status() == WL_CONNECTED) Serial.printf("Connected to %s\n",ssid[i]);
    i++;
    if(i==6) i=0;
  }

  temp=bme.readTemperature();
  Serial.print("Temperature = ");
  Serial.print(temp);
  Serial.println(" *C");
  ThingSpeak.writeField(myChannelNumber, 1,temp, myWriteAPIKey);

  alt=bme.readAltitude(SEALEVELPRESSURE_HPA);
  Serial.print("Approx. Altitude = ");
  Serial.print(alt);
  Serial.println(" m");
  ThingSpeak.writeField(myChannelNumber, 2,alt, myWriteAPIKey);

  pres=bme.readPressure();
  Serial.print("Pressure = ");
  Serial.print(pres);
  Serial.println(" hpa");
```

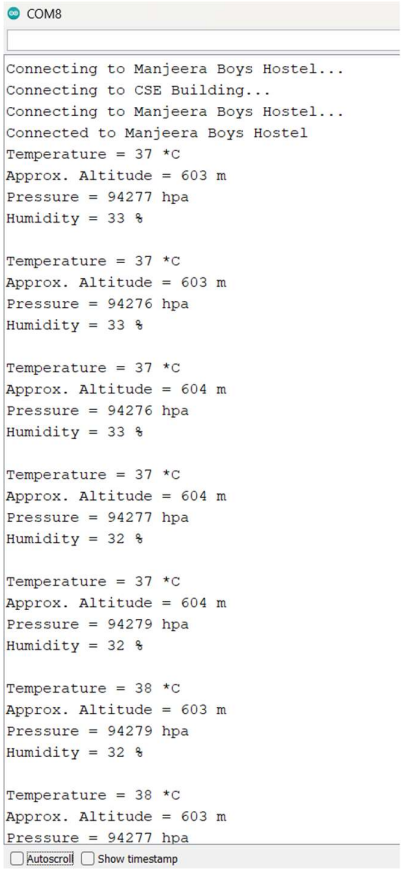
```
  ThingSpeak.writeField(myChannelNumber, 3,pres, myWriteAPIKey);

  hum=bme.readHumidity();
  Serial.print("Humidity = ");
  Serial.print(hum);
  Serial.println(" %");
  ThingSpeak.writeField(myChannelNumber, 4,hum, myWriteAPIKey);


  Serial.println();
  delay(500);
}
```

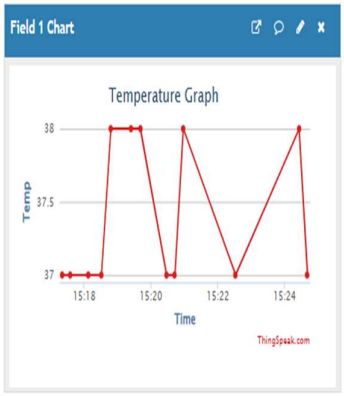
4.4. RESULTS:

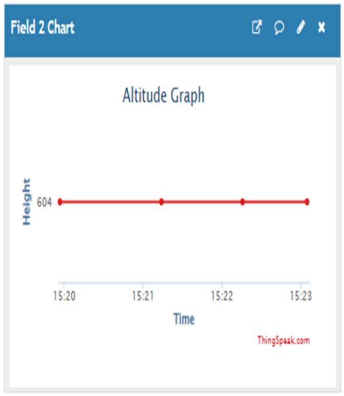
4.4.1. SAMPLE SERIAL MONITOR

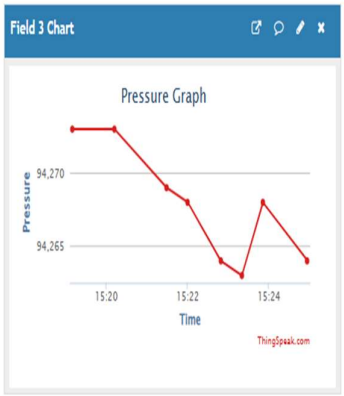


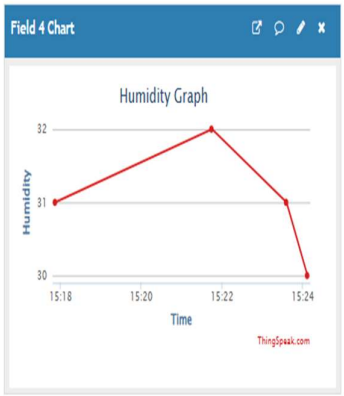
4.4.2 OBSERVATION-1: MANJEERA BOYS HOSTEL







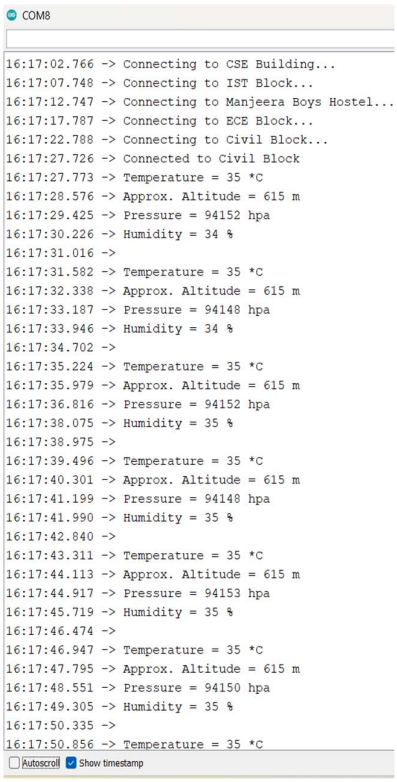


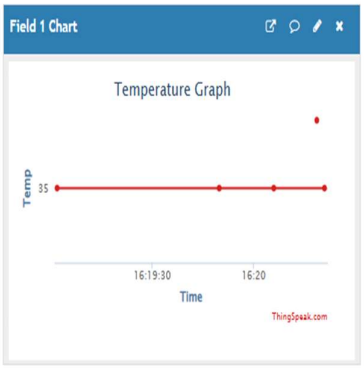


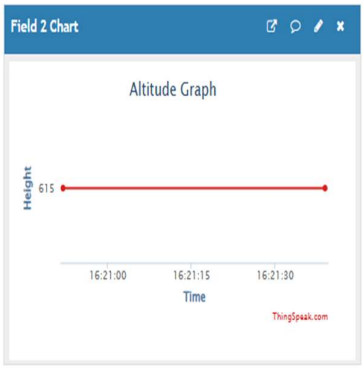
These are the output values taken at the manjeera boys hostel. The following are average values of weather parameter taken at 3:20pm.

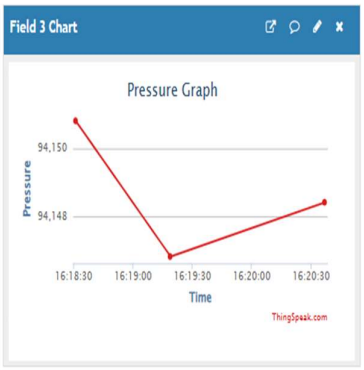
- Average Temperature: 37.5 degree Celsius
- Altitude: 604 meters
- Average Air Pressure: 94268 hPa
- Average Humidtity: 31%

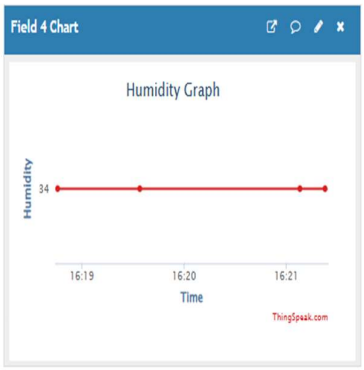
4.4.3. OBSERVATION-2: CIVIL BLOCK







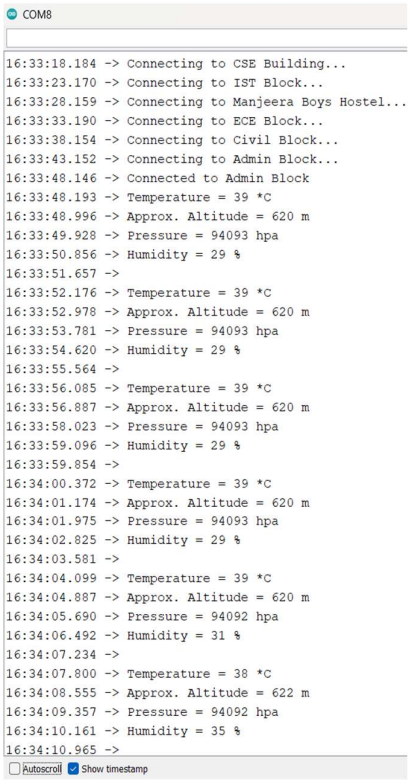


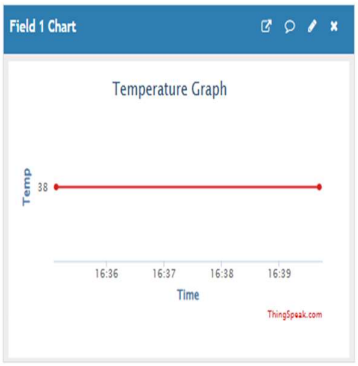


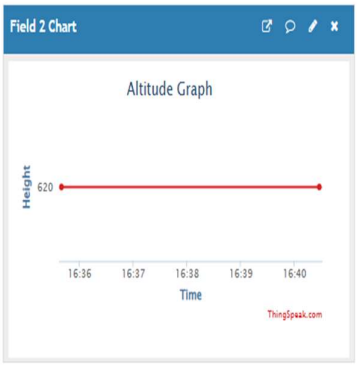
These are the output values taken at the Civil Block. The following are average values of weather parameter taken at 4:17pm.

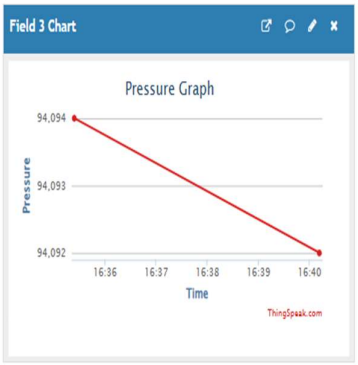
- Average Temperature: 35 degree Celsius
- Altitude: 615 meters
- Average Air Pressure: 94148 hPa
- Average Humidtity: 34%

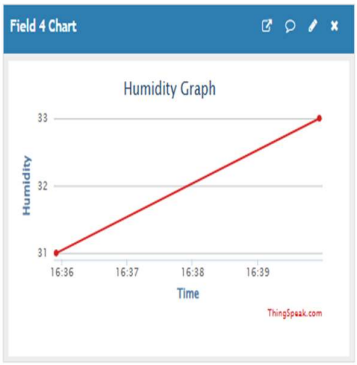
4.4.4. OBSERVATION-3: ADMIN BLOCK







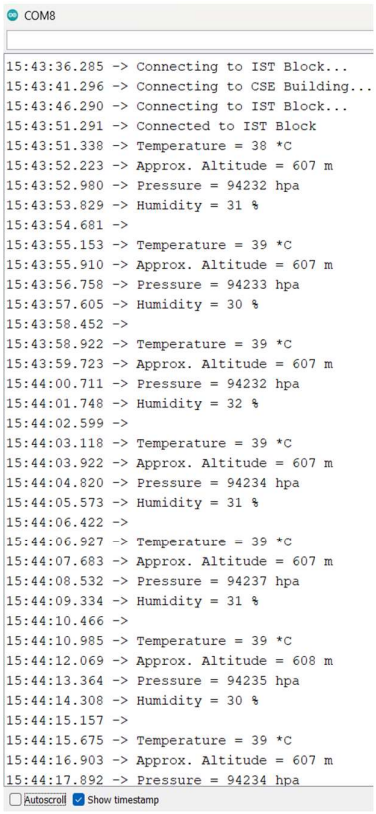


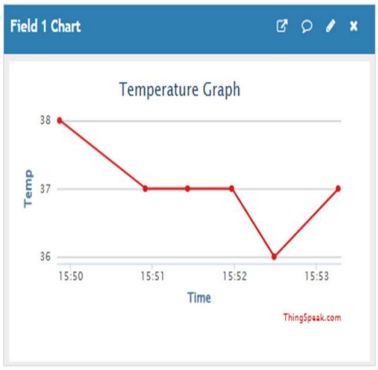


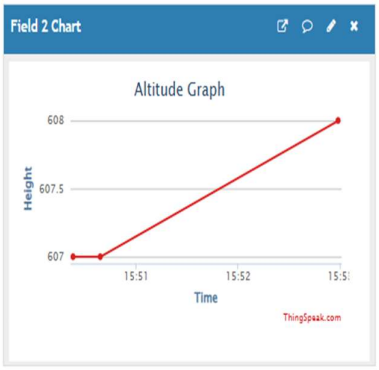
These are the output values taken at the Admin block. The following are average values of weather parameter taken at 4:33pm.

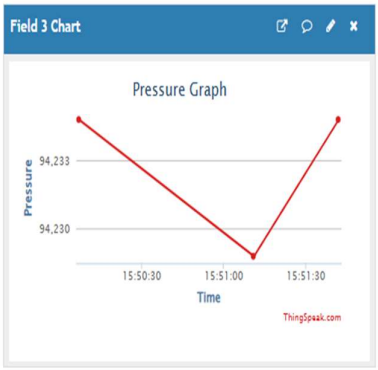
- Average Temperature: 38 degree Celsius
- Altitude: 620 meters
- Average Air Pressure: 94093 hPa
- Average Humidtity: 32%

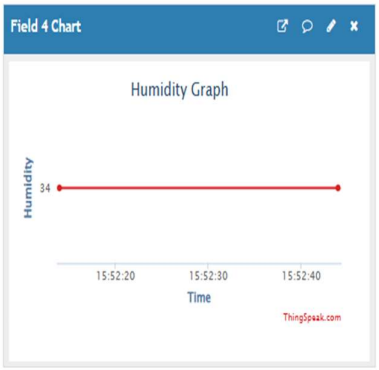
4.4.5. OBSERVATION-4: IST BLOCK







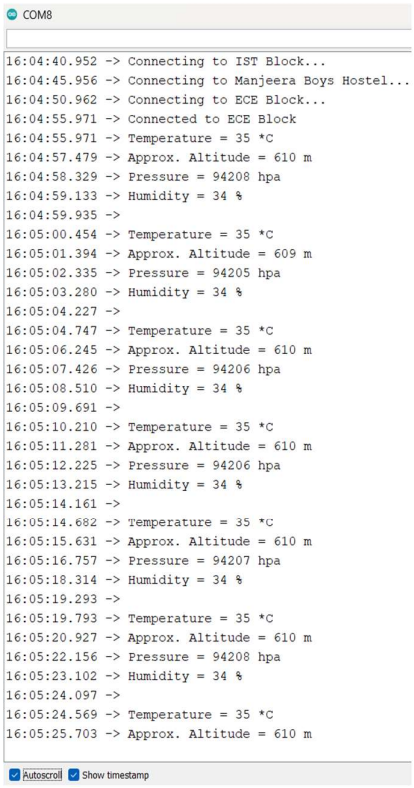


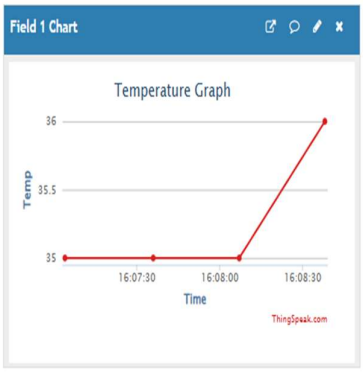


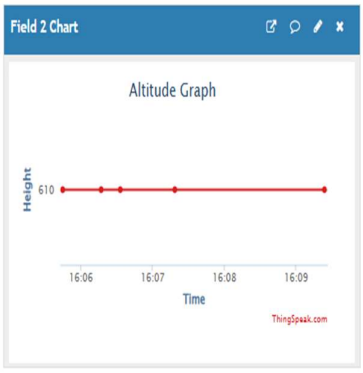
These are the output values taken at the IST block. The following are average values of weather parameter taken at 3:44pm.

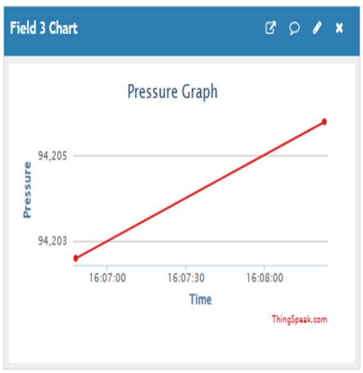
- Average Temperature: 37 degree Celsius
- Altitude: 607.5 meters
- Average Air Pressure: 94232 hPa
- Average Humidtity: 34%

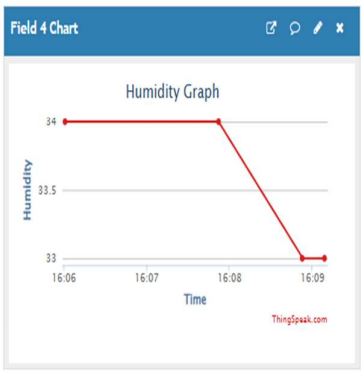
4.4.6. OBSERVATION-5: ECE BLOCK











These are the output values taken at the manjeera boys hostel. The following are average values of weather parameter taken at 4:05pm.

- Average Temperature: 35.2 degree Celsius
- Altitude: 610 meters
- Average Air Pressure: 94204 hPa
- Average Humidtity: 33.5%

4.5. COMPARISON OF RESULTS

Place	Temperature	Altitude	Air Pressure	Humidity
Manjeera Boys Hostel	37.5	604	94268	31
Civil Block	35	615	94148	34
Admin Block	38	620	94093	32
IST Block	37	607.5	94232	34
ECE Block	35.2	610	94204	33.4

Considering all the above buildings, the average weather parameters is as follows

- Average Temperature: 36.52 degree Celsius
- Average Altitude: 611 meters
- Average Air Pressure: 94189 hPa
- Average Humidity: 32.88%

CHAPTER – 5

CONCLUSION & FUTURE SCOPE

Drones that monitor the weather are predicted to make substantial advancements in sensor technology, flight capabilities, and data collection. Drone battery technology has advanced, enabling weather monitoring drones to fly for longer periods of time and cover wider territories. Drones will be able to capture continuous and real-time data over vast areas because to improved battery efficiency and capacity. The flight range of weather monitoring drones may also be extended through advances in propulsion and aerodynamics, enabling them to reach farther-flung or inaccessible sites. The capabilities of drones used for weather monitoring will change as smaller and more potent sensors become available. Drones will be able to gather more exact and thorough data as sensors for monitoring temperature, humidity, air pressure, wind speed, and other meteorological characteristics become smaller and more portable. A more complete understanding of weather conditions and their effects on the environment may be provided by the incorporation of new sensors, such as those for monitoring atmospheric composition or particulate matter, as a result of developments in sensor technology. The capabilities of weather monitoring drones will be improved by the integration of artificial intelligence (AI) and machine learning algorithms. Drones that use AI algorithms can instantly analyze massive volumes of data to find patterns, trends, and anomalies. This aids in precise data interpretation, accurate weather forecast, and early identification of severe weather events. Drones can also use machine learning algorithms to learn from previous weather patterns and gradually increase the accuracy of their forecasts.

The future of weather monitoring drones lies in autonomous operations and swarm technology. Advancements in autonomous navigation systems and obstacle avoidance algorithms will enable drones to operate independently, reducing the need for human intervention during data collection missions. Swarm technology, where multiple drones work together in a coordinated manner, can facilitate simultaneous data gathering from multiple locations, increasing coverage and efficiency. Swarm drones can collaborate to monitor large areas, exchange data in real-time, and adapt to changing weather conditions more effectively.

These developments in weather monitoring drones will not only increase the precision and timeliness of weather forecasts but also make it possible to collect more thorough and extensive data for a variety of uses, including disaster management and climate research. To facilitate the integration of cutting-edge drone technology into current weather monitoring systems, it is crucial to take into account the accompanying issues, such as legislative frameworks, privacy concerns, and the creation of a robust communication infrastructure.

5.1. APPLICATIONS

As technology advances and drones become more sophisticated, their ability to gather precise, real-time weather data will continue to expand, leading to further advancements and applications in the field of weather monitoring. There are numerous versatile and potential applications of weather monitoring drone as such:

- Drones used for weather monitoring are essential for gathering high-resolution, real-time data on temperature, humidity, wind speed, air pressure, and other meteorological factors for weather forecasting and research. By utilizing this data, weather forecasting models are enhanced, allowing for more precise and timely predictions of weather patterns, severe weather events, and weather conditions.

- Disaster management benefits greatly from the use of drones with weather monitoring capabilities. Natural calamities like hurricanes, storms, floods, or wildfires can have an impact assessed. Drones assist emergency response teams in making knowledgeable decisions, effectively allocating resources, and organising evacuation plans by delivering real-time information on weather conditions, water levels, fire spread, and damage assessment.

- Drones with weather monitoring sensors can keep an eye on the condition of important infrastructure like bridges, electricity lines, and pipelines. Drones assist in identifying maintenance requirements by evaluating weather-related stresses like corrosion or wind damage, which lowers the risk of failure and ensures the safety and integrity of infrastructure systems.

- Drones with weather monitoring capabilities can help with smart cities and urban planning by determining heat islands, assessing local microclimates, and reducing energy use. Drones assist in the construction of resilient, sustainable cities by gathering data on temperature, air quality, and other variables. This increases energy efficiency and improves the standard of living for urban residents.

- Weather monitoring drones help in climate research by gathering information for long-term weather pattern analysis, researching the effects of climate change, and keeping an eye on ecosystem health. They help in understanding the dynamics of

climate systems, the impacts of human activity on the environment, and the creation of policies for mitigation and adaptation.

- By keeping an eye on soil moisture, crop health, and weather conditions, weather monitoring drones help in precision agriculture. They can collect information on temperature, precipitation, and wind patterns, which can be used by farmers to optimize irrigation schedules, find illnesses or pests, and manage their farms more effectively as a whole. They support by monitoring environmental factors such as water and air quality.

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