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"Weather Imaging Cube Sat With Telemetry Transmission"

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Abstract

The Weather Imaging CubeSat with Telemetry Transmission project aims to develop a CubeSat -based system capable of collecting crucial environmental data from space, including temperature, infrared (IR) signals, and satellite orientation using a magnetometer. This data is transmitted to Earth via Wi-Fi using an ESP_01 module and displayed on Things peak as waveforms. Additionally, a mobile phone configured in IP camera mode will provide live footage from space, which can be viewed on a PC.

Keywords:

Real-Time Object Detection, Deep Learning, Video Analysis, Computer Vision, Model Optimization.

1.INTRODUCTION

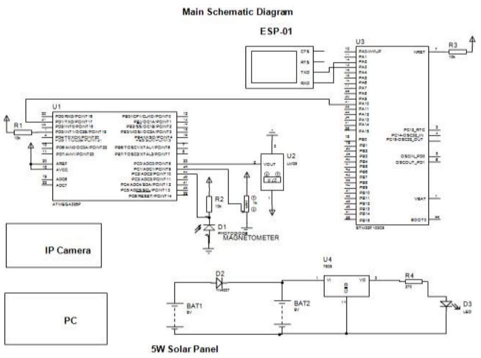
The project focuses on creating a Cube Sat-based satellite system designed to monitor and transmit critical weather-related information from space. This information will include temperature reading, IR sensor data for solar storm monitoring, and satellite orientation using a magnetometer. The Weather Imaging Cube Sat with Telemetry Transmission project Aims to develop a CubeSat based system capable of collecting crucial environmental data from space, including temperature, infrared (IR) signals, and satellite orientation using a magnetometer. This data is transmitted to Earth via Wi-Fi using an ESP-01 module and displayed on Thing Speak asWaveforms. Additionally, a mobile phone configured in IP camera mode will provide live footage from space, which can be viewed on a PC. Satellite is launched inorbit for a variety of purposes including communication, GPS, Weather imaging and similar applications. Weather imaging satellite are used to transmit data about weather parameters that can be used for prediction and forecasting systems The system makes use of an STM32 controller along with a solar panel, battery for power supply, a magnetometer, infrared sensor, a camera and 2.4 GHZ RF transmitter to develop the satellite. We here develop a basic CubeSat design without an ACDS stabilizer system with more focus towards weather data gathering and transmission part. The CUBE SAT body is a cubicle shaped frame made of 4 sides. The 4 parts are merged to develop a cube with mounting holes for the controller, sensors, circuits board, solar panels and battery. The solar panels are used to generate energy that is store in battery using charge controller and charging circuitry. The battery charging and auto cut-off is managed by circuitry to avoid overcharging and maintain battery health. The magnetometer is used to check orientation of the CubeSat. The sensor transmits orientation data to controller. The temperature sensor is used to measure the orbital temperature. Infrared sensor is mounted on top to help measure the infrared radiation from the sun and detect solar waves/blasts. The camera is mounted at the bottom of the CubeSat for capturing the live footage of the earth from above. This footage along with sensor data is transmitted by the controller through a 2.4 GHZ RF transmitter module with a high gain antenna for max distance transmission. The sensor data is also displayed on an LCD Display for reference. The transmitted data is now received by a receiving station on the ground. The ground station circuit consists of an LCD display andfootage display. The 2.4 GHZ receiver is used to receive the signals from CubeSat and display all the data for data for further processing -

2.RELATED WORKS

Since 2000, more than 100 universities and several emerging notations have been planning launch CubeSats into space for different purposes .7
Most missions are based on the deployment of a single CubeSat. [The 3U CubeSat belonging to the radiometer assessment using vertically aligned nano tubes (RAVAN) mission 16 was deployed in 2016 to measure the Earth's radiation imbalance in order to predict course of climate change over the next century. Some missions are based on the deployment of more CubeSats in order to perform complex tasks where the required number of sensors and the amount of data to be processed and sent to the earth are more relevant. The orbiting low-frequency antennas for radio astronomy (OLFAR) 17 is a distributed system composed of a swarm of 50 CubeSats orbiting around the Earth's Moon. Three are the major tasks dependingon the satellite position 18 sensor Module Integration the CubeSat is equipped with a sensor module consisting of temperature, magnetic compass (HMC5883), & IR sensor The sensor Module is connected to an ATmega328 controller, which reads data from the sensor and processes it. The communication subsystem of CubeSat consists of a microcontroller manages communication tasks and interfaces with the sensor module. The ESP 01 module provides Wi-Fi connectivity for transmits data to Thing Speak. The Atmega328 controller collects sensor data

from the temperature, magnetic compass and IR sensors. Data from the sensors is processed and formatted into packets suitable for transmission. The ESP01 module is configured to the connect to the CubeSats Wi-Fi network. Network credentials are securely stored on the ESP01 module to enable automatic connection upon start-up. The STM32the ESP01 module. Sensor data packets sent to Thing Speaks API endpoint over the Wi-Fi network. Each type of sensor data (temperature, magnetic compass, IR signals) is sent to a separate channel on Thing speak. Thing Speak receive the sensor data packets sent by the CubeSat. The data packets are processed and stored in corresponding channels created on ThingSpeak. ThingSpeak provides visualization tools to display the received data in real-time.

4. CIRCUIT DIAGRAM



3.PROPOSED METHOD

System Design and Components Selection Define the requirements and objectives of CubeSat project. Select appropriate components including solar panel battery, microcontroller (STM32 and Atmega328), sensors (LM35, IR sensor, magnetic compass), and communication modules (ESP01). Design the power distribution system to efficiently manage power generated by the solar panel and stored in the battery.

Hardware Implementation set up the hardware components according to the system design. connect the solar panel to the battery for charging. Ensure proper power regulation to provide stable 5V supply to the STM32 and Atmega328 from the battery connect the sensor (LM35, IR sensor, magnetic compass) to the Atmga328 for data acquisition.

Firmware Development for Atmega328 write firmware for the Atmega328 Microcontroller to read sensor data. Implement algorithm to process raw sensor data ad convert it into meaningful units (e.g., temperature in Celsius from the LM35). Develop a protocol for transmitting processed sensor data to the STM32 microcontroller.

Integration and Testing Integrate the hardware and firmware components into the CubeSat structure. Test the functionality of individual components and their interactions. Conduct environmental testing to ensure the system operates reliably under simulated space conditions (e.g. Vacuum, temperature extremes).Perform functional testing to verify data acquisition,processing and transmission capabilities.

Data Analysis and Visualization Analyze the data received from data using graphs, charts, share findings with relevant stakeholders and contribute to scientific knowledge or mission objectives.

Mission Evaluation and Future Work Evaluate the success of the CubeSat mission based on the achievement of predefined objectives. Identify areas for improvements and future enhancements to the CubeSat system. Documents lessons learned and best practices for future CubeSat Projects. By following these steps, you can systematically develop and deploy your CubeSat project, leveraging solarpower, sensor data acquisition, and wireless communications capabilities to achieve your mission objectives. Remember to collaborate with a multidisciplinary team and adhere to relevant regulations and safety guidelines throughout theproject lifecycle.

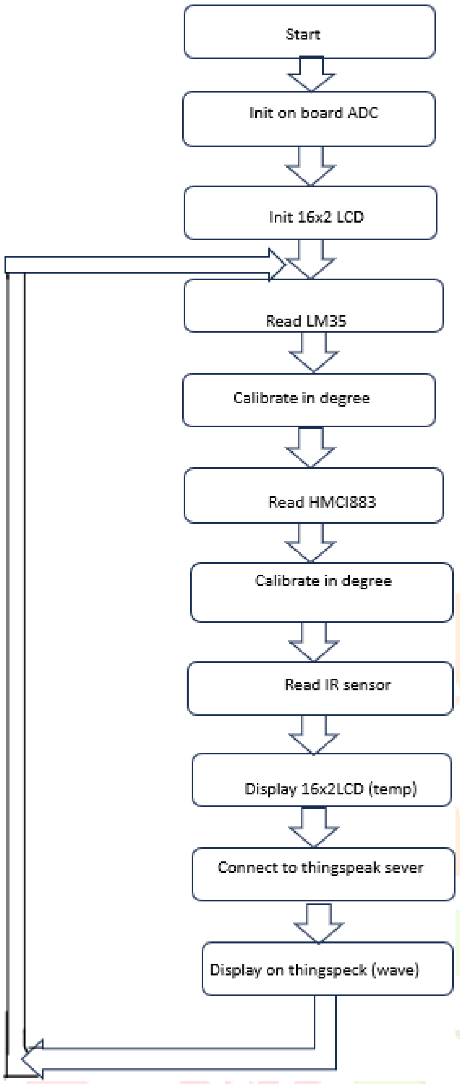
[1] Introduction to Communication System Overview: The communication system plays a crucial role in facilitating data transmission and exchange between the CubeSat and ground stations. It enables the CubeSat to send telemetry data collected from onboard sensors and receive commands from ground control.

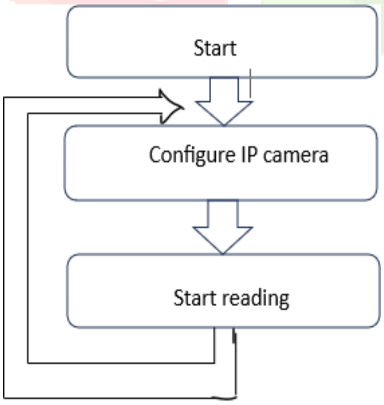
[2] Communication Architecture Description: The communication architecture of the CubeSat consists of two main components: the onboard STM32 microcontroller and the ESP01 module. The STM32 microcontroller serves as the central processing unit responsible for managing communication tasks, while the ESP01 module acts as the communication tasks, while the ESP01 module acts communication interface between the CubeSat and ground stations. The 16x2 LCD display provides visual feedback to the user and displays important information such as system status and received commands.

[3] STM32Microcontroller Role: The STM32 microcontroller serves as the brain of the communication system, handling tasks such as data processing, protocol implementation, and interface control. Features: The STM32 microcontroller offersa wide range of the features suitable for communication application, including UART SPI, and I2C interfaces for connecting with peripheral device, as well as built-in timers and interrupt controllers for precise timing and event handling.

[4] ESP01 Module Functionality: The ESP01 module is a Wi-Fi module based on the ESP8266 chipset, which enables wireless communication between the CubeSat and ground station usingTCP/IP protocol. Protocol The ESP01 module implements a custom communication protocol over Wi-Fi, allowing The directional date transmission between the CubeSat andground. .

5.FLOW CHART





[5] 16x2 LCD Display Purpose: The 16x2 LCD display serves as the primary user interface for the CubeSat, providing visual feedback and displayed important information such as a system status, sensor readings, and received commands. Displayed Information the LCD display can show real-time telemetry data from onboard sensors, system health indicators, and diagnostics message to aid in troubleshooting and system monitoring.

[6] Data Transmission Protocol Protocol Overview: The data transmission protocol used by the CubeSat is based on the TCP/IP protocol suite, which enables reliable communication over Wi-Fi networks. Error Handling: The protocol incorporates errors detection and correction mechanisms such as checksum and acknowledgements to ensure data integrity and reliability during transmission.

[7] Power Management

System Description: The power management system of the CubeSat includes a 5W solar panel for harvesting solar energy and a 6V battery for energy storage. The solar panel charges the battery during daylight hours, while the battery provides power to allonboard system including the communication subsystem

Power Distribution: Power from the battery is distributed to the STM32 microcontroller, ESP01 module and 16x2 LCD display through ugh a power distribution networks, ensuring stable and uninterrupted operation of the communication system.

[8] Sensor Module Integration

Role of Sensor Module – The sensor module onboard the CubeSat consists of temperature, HM5883, and IR Sensor, which collect environmental data such as temperature variations, magnetic field strength, and infrared radiation levels. Data Processing: The STM32 microcontroller reads data from the sensor module, processes it, and packages it into telemetry packets for transmission to ground stations via the ESP01 module.

[9] Testing and Validation

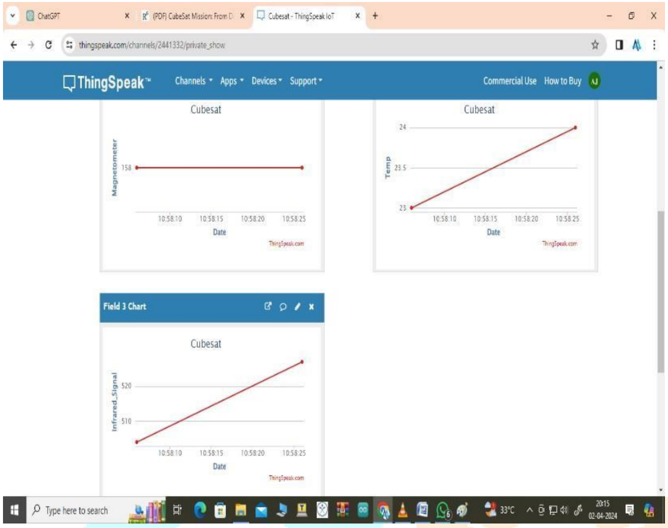
Testing procedures: The communication system undergoes rigorous testing procedures to validate its functionality, reliability, and performance under various operating conditions. Results: Testing results demonstrate the successful integration and operation of the communication subsystem, including reliable data transmission, error handling capabilities, and compatibility with ground station infrastructure.

[10] Performance analysis Analysis of testing result confirms The Performance and reliability of Communication system in meeting mission objective and requirement's reliability the communication system demonstrate high reliability and robustness in transmitting telemetry data and receiving command from ground control ensuring effectivecommunication throughout the mission duration.

[11] Lessons Learned and Future Improvements Lessons Learned: Lessons learned during the development and testing of the communication system include the importance of through testing, the need for redundancy in critical subsystem , and the impact of environmental factors on system performance .Future Enhancements: Future enhancements to the communication system may include the integration of additional sensors for expanded telemetry capabilities, optimization of power managements algorithms for improved energy efficiency , and implementation of advanced communication protocol for enhanced reliability and data trough put.

6. Appendices

This expanded documentation provided detailed information about each aspect of the communication system in your cubsat project



7.RESULTS AND DISCUSSION

Temperature Readings

Result The temperature sensor onboard the CubeSat recorded temperature readings throughout the mission duration. Discussion: The temperature data, as shown in the ThingSpeak waveform below, indicates variations in temperature over time. This fluctuation may be attributed to changes in the CubeSat's environment, such as exposure to sunlight or transitions between different orbits.

Magnetic Compass Data

Result The HMC5883 magnetic compass sensor captured data on the magnetic field strength and direction relative to the CubeSat's orientation. Discussion The magnetic compass data, depicted in the ThingSpeak waveform, provides insights into the CubeSat's orientation in space. Variations in the magnetic field strength and direction may be influenced by factor such as orbital maneuvers, interactions with Earth's magnetic field, or nearby magnetic sources.

IR Signal Readings

Result The IR sensor detected infrared radiation levels in the CubeSat's vicinity. Discussion The IR signal readings, illustrated in the ThingSpeak waveform, reflected the presence of infrared radiation sources encountered during the mission. These sources could include celestial bodies, other spacecraft, or thermal emissions from onboard components.

Overall, Mission Performance

Result The successful transmission and visualization of sensor data on ThingSpeak demonstrate the effective operation of the CubeSat's communication system. Discussion The reliable communication between the CubeSat ThingSpeak enabled real-time monitoring and analysis of environmental parameter. The availability o sensor data on ThingSpeak facilitated scientific research, mission planning, and decision-making processes

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Future Considerations Discussion Moving forward, enhancements to the CubeSat's communication system could include the integration of additional sensors for expanded telemetrycapabilities, optimization of power management algorithms for improved energy efficiency, and implementation of advanced communication protocols for enhanced reliability and data throughput.

8.CONCLUSION The communication system plays a critical role in the success of the CubeSat mission by enabling data transmission and exchange Between the spacecraft and ground control using ESP01, STM32 and ThingSpeak server. Parameters like temperature, magnetic compass, is signal graph will be plotted on ThingSpeak with data and time Effective communication is essential for monitoring the health and status of the CubeSat, collecting scientific data, and executing mission objectives, highlighting the significance of a robust and reliable communication subsystem

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