



INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Psg Polysat: Design And Optimization Of Model Based Engineering Nano Satellite

Mr.A.Kathiresan ,Mr.N.Ravi ,R.Prabanjan ,S.Vaibhav,V.Jeya Shanmuga Pandian

Lecturer,Lecturer,Student,Student,Student

DIPLOMA IN INFORMTIONT ECHNOLOGY

PSG POLYTECHNIC COLLEGE, COIMBATORE,INDIA

ABSTRACT:

This project report details the design and optimization of PSG POLYSAT, a nano-satellite system developed for Earth observation and environmental monitoring. The satellite integrates solar power, an ESP32 microcontroller, and a range of environmental sensors (DHT11, BMP, MQ-135) to collect and transmit data in real-time. The adoption of Model-Based Systems Engineering (MBSE) principles ensures modularity, cost-effectiveness, and scalability for future missions. This approach significantly reduces development time, enhances flexibility, and supports mission-specific modifications.

The system was extensively tested for functionality, environmental stability, and communication reliability, demonstrating its potential as a scalable and cost-effective solution for various scientific applications.

I. INTRODUCTION

Nano-satellites, like CubeSats, offer cost-effective and compact solutions for Earth observation and research, making space technology accessible to diverse organizations. PSG POLYSAT is a modular nano-satellite designed for environmental monitoring, equipped with IoT-enabled sensors and solar-powered systems to collect real-time data on temperature, humidity, pressure, and air quality.

This project addresses the high costs and complexity of traditional satellites, providing an affordable, scalable solution to promote innovation and accessibility in space exploration.

II. OVERVIEW AND ISSUES SOLVED

The advent of nano-satellites, particularly CubeSats, has revolutionized space exploration by offering compact, cost-effective platforms for Earth observation, communication, and research. PSG POLYSAT, a modular nano-satellite, is designed for environmental monitoring, integrating IoT-enabled sensors, solar energy systems, and real-time communication. This project aims to provide critical data on temperature, humidity, air quality, and atmospheric pressure, contributing to climate research and addressing the limitations of traditional satellite systems.

1. Modular Architecture: Develop a highly modular design to simplify upgrades and enable adaptability for diverse mission requirements.

2. Energy Optimization: Harness solar energy through efficient photovoltaic panels and store power using robust lithium-ion batteries to ensure uninterrupted operation during eclipse periods.

3. Environmental Data Collection: Utilize sensors such as DHT11 (temperature and humidity), BMP (pressure), and MQ-135 (air quality) to gather real-time environmental data.

4. IoT Integration: Employ IoT platforms, such as the Blynk app, for seamless remote monitoring and data management.

5. Cost-Effectiveness: Demonstrate the feasibility of a low-cost satellite system using off-the-shelf components and open-source technologies, promoting accessibility for educational and research institutions.

III. PROBLEM DEFINITION

The increasing demand for efficient and affordable environmental monitoring has highlighted the limitations of traditional satellite systems, which are often expensive, complex, and inaccessible to smaller institutions. These systems also lack modularity, making them unsuitable for rapid upgrades or mission-specific customization.

To address these challenges, there is a need for a cost-effective, scalable, and modular nano-satellite that can collect real-time environmental data, operate efficiently under varying orbital conditions, and provide seamless communication with ground stations. Such a solution must also be robust enough to withstand the harsh conditions of space while remaining accessible to educational and research organizations.

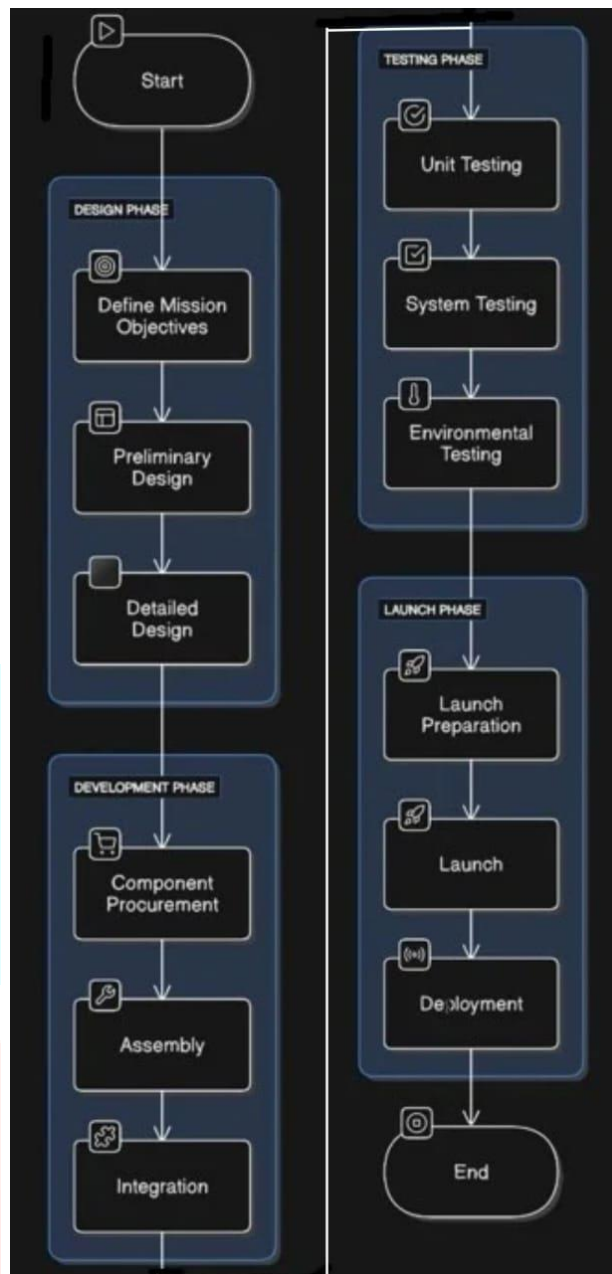
IV. PROPOSED SYSTEM

PSG POLYSAT is a modular and cost-effective nano-satellite designed to address the challenges of traditional satellite systems. It incorporates advanced technologies and a flexible architecture to enable real-time environmental monitoring and seamless data transmission.

Key Features of the Proposed System:

- 1. Modular Design:**
 - Easy upgrades and scalability for diverse missions.
- 2. Energy Efficiency:**
 - Solar panels and lithium-ion batteries ensure continuous operation.
- 3. Real-Time Monitoring:**
 - IoT-enabled sensors (DHT11, BMP, MQ-135) collect and transmit environmental data.
- 4. Cost-Effectiveness:**
 - Uses off-the-shelf components and open-source software to reduce costs.
- 5. Reliability:**
 - Thermal and attitude control systems ensure robust performance under harsh conditions.

4.1 Project Workflow



Working of nano sat

V. LITERATURE SURVEY

The development of PSG POLYSAT is informed by advancements in nano-satellite technologies and the application of Model-Based Systems Engineering (MBSE). Research highlights the increasing role of CubeSats in environmental monitoring, with studies emphasizing their cost-effectiveness and versatility. Taylor (2020) explores the success of nano-satellites in Earth observation missions like Planet Labs' Dove satellites, showcasing their potential for climate studies and disaster management. Garcia (2019) focuses on overcoming challenges related to size, power, and communication in CubeSats, while Mohan (2018) highlights their modular design as a breakthrough in making space missions accessible to universities and research institutions.

Advances in MBSE are discussed by Thompson (2023), who illustrates its integration with artificial intelligence and big data analytics to enhance satellite design and operation. Chen (2022) emphasizes the role of digital twin technology in simulating satellite performance for predictive maintenance and risk assessment. These studies underscore the importance of scalability, modularity, and efficiency in modern satellite systems, providing a strong foundation for the design and implementation of PSG POLYSAT.

VI. TECHNOLOGIES AND TOOLS

6.1 Environmental Monitoring

PSG POLYSAT's primary function is to perform real-time environmental monitoring. It is equipped with advanced sensors, including the DHT11 for measuring temperature and humidity, the BMP sensor for atmospheric pressure and altitude, and the MQ-135 sensor for detecting pollutants like CO₂ and NO_x. These sensors continuously collect data, which is processed onboard and transmitted to ground stations. This real-time monitoring provides valuable insights into climate patterns, air quality, and environmental changes, making the satellite a crucial tool for scientific research and environmental studies.

6.2 Data Collection and Transmission

The satellite gathers data using its onboard sensors and processes it through an ESP32 microcontroller. The processed data is then transmitted to ground stations via a robust communication system, enabling researchers to analyze the information in real time. This continuous data flow supports studies in meteorology, environmental science, and pollution monitoring.

6.3 Remote Monitoring and Control

Through the Blynk IoT platform, the satellite can be remotely monitored and controlled by operators on Earth. This capability allows researchers to make real-time adjustments to the satellite's operations, ensuring efficient performance and adaptability to mission requirements.

6.4 Attitude Control and Stability

Maintaining proper orientation in orbit is essential for the satellite's functionality. The Attitude Control System (ACS) uses reaction wheels and magnetorquers to stabilize and adjust the satellite's position. This ensures that solar panels face the Sun for optimal energy capture, communication antennas align with ground stations, and sensors point in the right direction for accurate data collection.

VII. SYSTEM ANALYSIS

PSG POLYSAT's system analysis evaluates its hardware, software, and operational efficiency. The satellite uses an ESP32 microcontroller, sensors (DHT11, BMP, MQ-135), solar panels, and lithium-ion batteries integrated into a lightweight modular structure. Its software, programmed via Arduino IDE and monitored through the Blynk IoT platform, enables real-time data acquisition and control.

The communication system ensures reliable data transfer via Wi-Fi and Bluetooth, while the power management system optimizes energy harvesting and distribution, ensuring continuous operation during eclipse periods. Thermal control mechanisms protect components from extreme temperatures. The modular design allows for scalability, ensuring adaptability for future missions.

VIII. SYSTEM DESIGN

The design of PSG POLYSAT is centered around modularity, scalability, and efficiency, ensuring it meets the operational requirements for environmental monitoring and data collection in space. The system is divided into several interconnected subsystems, each responsible for a specific function, working together to achieve the mission's objectives.

8.1 Architecture Design

The architecture of PSG POLYSAT is designed to ensure seamless integration and interaction between its subsystems while maintaining modularity, scalability, and efficiency. The architecture comprises interconnected modules that work collaboratively to perform core functions, such as environmental monitoring, data acquisition, communication, and power management.

8.2 Specifications:

8.2.1 Hardware Specifications

- **Microcontroller:** ESP32
- **Sensors:** DHT11, BMP sensor, MQ-135
- **Power System:** Solar Panels, Lithium Ion Battery,
- **Structure:** 3D Printed (10cm * 10cm * 10cm)

8.2.2 Software Specifications

- **Arduino IDE:** For programming and debugging.
- **Blynk IoT Platform:** Real-time monitoring and control.
- **Sensor Libraries:** Integrates DHT11, BMP, and MQ-135 sensors.
- **Onboard Processing:** Reduces transmission load.
- **Wi-Fi & Bluetooth:** Reliable data transfer.
- **Power Management:** Optimizes energy usage.
- **Automation:** Handles data collection and diagnostics.

8.3 Module Design

- **Sensor Module**
Collects temperature, pressure, and air quality data.
- **Communication Module**
Ensures real-time data transfer via ESP32.
- **Structural Module**

Compact, lightweight 10x10x10 cm CubeSat design.

- **Power Module**

Manages energy with solar panels, batteries, and a power unit.

IX. IMPLEMENTATION & TESTING

The implementation of PSG POLYSAT involved integrating all hardware and software components into a functional satellite system. The ESP32 microcontroller was programmed using Arduino IDE, and sensors were interfaced to collect environmental data. The Blynk IoT platform was set up for real-time monitoring and control. Power systems, including solar panels and batteries, were connected to ensure efficient energy management. The satellite structure was assembled using lightweight materials, with components arranged for optimal performance.

TESTING

Testing was conducted in several phases:

1. Unit Testing

Each subsystem was tested individually to ensure proper functionality. Sensors like DHT11, BMP, and MQ-135 were verified for accuracy in measuring temperature, pressure, and air quality. The power system, including solar panels and batteries, was tested for energy generation, storage, and distribution, while the ESP32 microcontroller's Wi-Fi and Bluetooth capabilities were checked for stable communication.

2. Integration Testing

Once individual modules were validated, they were integrated to test their interaction and compatibility. Sensor data was processed by the ESP32 and transmitted to the ground station via Wi-Fi, ensuring smooth communication between hardware and software components.

3. Environmental Testing

The satellite was subjected to simulated space-like conditions to test its durability and reliability. It was exposed to extreme temperatures to validate the effectiveness of thermal management systems like heat sinks and insulation. Power system performance was tested during simulated eclipse periods to ensure uninterrupted energy supply.

4. Communication Testing

Real-time data transmission and control were tested using the Blynk IoT platform. The satellite's ability to send sensor data and respond to commands from the ground station was verified over varying distances, ensuring reliable communication.

X. FUTURE ENHANCEMENT

Future improvements for PSG POLYSAT include adding advanced sensors like high-resolution cameras and spectrometers for imaging and spectral analysis, as well as integrating AI for autonomous decision-making and data prioritization. Communication can be enhanced with long-range technologies like LoRa, while more efficient solar panels and higher-capacity batteries will improve energy systems. Incorporating a mini propulsion system will enable orbital adjustments for greater flexibility, and expanding onboard storage and processing will allow for more complex data analysis. A network of satellites can improve global coverage, and the platform can be adapted for educational purposes, allowing students and researchers to explore satellite

operations and data analysis. These upgrades will significantly enhance the satellite's performance, adaptability, and impact.

XI. PROJECT OUTPUT

```
DHTxx test!
Temperature = 25.4 *C
Pressure = 101325 Pa
Altitude = 150.0 meters
Pressure at sea level (calculated) = 101325 Pa
Real altitude = 150.0 meters

Air Quality: 35 PPM

Humidity: 60.0% Temperature: 25.4°C 77.7°F Heat index: 26.0°C 78.8°F
```

Sample Output

REFERENCES

1. Twiggs, R. J., "The Origin of CubeSat," *Acta Astronautica*, Vol. 25, No. 12, 2010.
2. Swartwout, M., "The First One Hundred CubeSats: A Statistical Look," *Journal of Small Satellites*, Vol. 2, No. 2, 2013.
3. Puig-Suari, J., Turner, C., and Ahlgren, W., "Development of the Standard CubeSat Deployer and a CubeSat Class PicoSatellite," *Proceedings of the IEEE Aerospace Conference*, Vol. 1, 2001.
4. S. W. Janson, D. W. Barnhart, "The History and Future of PicoSatellites," *Journal of Small Satellites*, Vol. 3, No. 1, 2014.
5. Fortescue, P. W., Stark, J., and Swinerd, G., *Spacecraft Systems Engineering*, 4th ed., Wiley, 2011.
6. Bouwmeester, J., and Guo, J., "Survey of Worldwide Pico- and Nanosatellite Missions, Distributions and Subsystem Technology," *Acta Astronautica*, Vol. 67, 2010.