Drone Battery Management System

Report submitted to GITAM (Deemed to be University) as a partial fulfillment of the requirements for the award of the Degree of Bachelor of Technology in (write your respective branch)



DEPARTMENT OF ELECTRICAL, ELECTRONICS AND COMMUNICATION ENGINEERING

GITAM SCHOOL OF TECHNOLOGY

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**DECLARATION**

I/We declare that the project work contained in this report is original and it has been done by me under the guidance of my project guide.

Name:

Date: Signature of the Student

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**CERTIFICATE**

This is to certify that (Student Name) bearing (Regd. No.:) has satisfactorily completed Mini Project Entitled in partial fulfillment of the requirements as prescribed by University for VII th semester, Bachelor of Technology in “Electrical, Electronics and Communication Engineering” and submitted this report during the academic year 2025-2026.

[Signature of the Guide] [Signature of HOD]

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**Chapter 1: Introduction**

* 1. Overview of the problem statement
* The project aims to address the critical issue of voltage drop in drone batteries, which can lead to instability and crashes, by designing a **split battery system**. This system is intended to mitigate these effects and enhance drone stability and reliability.
  1. Objective:

To design and evaluate a split-battery system to mitigate the effects of voltage drop in drones, thereby enhancing stability and preventing crashes.

Main Goals:

* **Develop a low-voltage detection circuit** to monitor the battery status.
* **Design an electronic switching mechanism** for seamless power transfer between batteries.
* **Integrate a dual-battery system** onto a drone platform.
* **Test and validate the system's performance** under high-load conditions and during demanding maneuvers.

**Chapter 2 : Literature Review**

The literature review explored key publications, including those on battery thermal management and drone scheduling, as well as whitepapers and datasheets.

* + **Low-Voltage Detection:** Circuits using comparators like the Texas Instruments TLV7081 are commonly used for this purpose.
  + **Electronic Switches:** Electronic PWM switches can be used for power control in drones, activated by a signal from a flight controller or detection circuit.
  + **Battery Management Systems (BMS):** A BMS is essential for monitoring individual battery cells and can be integrated with isolation techniques to prevent over-discharge
  + **DIY Circuits:** Hobbyists and engineers can build custom low-voltage monitoring circuits using voltage dividers and comparators to send a signal to the flight controller.
  + **Commercial Drones:** Some commercial drones and UAVs already utilize multi-battery systems, often connecting them in parallel, to increase energy capacity and provide redundancy for longer flights and heavier payloads. Companies like Tattu and Grepow offer smart batteries with integrated BMS to manage these systems.
  + **Flight Controller Integration:** Many modern flight controllers have built-in battery monitoring ports for voltage and current, allowing for the configuration of failsafe actions (e.g., auto-land) when voltage drops below a certain threshold.

**Chapter 3 : Strategic Analysis and Problem Definition**

* 1. SWOT Analysis

**Strengths (Internal Factors)**

* **Enhanced Reliability and Redundancy:** The core strength lies in providing a backup power source, significantly reducing the risk of catastrophic failure due to primary battery depletion or sudden voltage drop. This directly addresses a critical safety concern in drone operations.
* **Improved Flight Stability:** By ensuring a continuous and stable power supply to motors and flight controller, the system directly mitigates the loss of power and subsequent instability caused by voltage sag.
* **Extended Effective Flight Endurance:** While not adding raw capacity in a simple parallel sense, the system optimizes battery usage. It effectively extends "usable" flight time by preventing premature mission termination due to primary battery degradation or high-load demands, allowing for a more complete utilization of available power.
* **Seamless Power Transition:** The use of an electronic switch for automatic, smooth power transfer minimizes operational disruption and avoids manual intervention.
* **Proactive Crash Prevention:** The low-voltage detection and automatic switching mechanism offers a proactive solution to prevent crashes that would otherwise occur due to sudden power loss or instability.
  1. Project Plan - GANTT Chart

The project is structured over 10 months, from research and planning to final documentation. The Gantt chart provides a detailed timeline for each phase, including hardware design, software development, and integration.

* 1. Problem statement

The core problem is the mitigation of voltage sag during high-current drone operations to prevent instability and potential crashes.

**Chapter 4: Methodology**

**SWOT Analysis**

A **SWOT analysis** is a strategic planning tool that identifies the project's strengths, weaknesses, opportunities, and threats.

* **Strengths:** The system is an innovative solution to a common drone problem—voltage drop—and has been validated through simulation. The project team has clear objectives and a well-defined plan.
* **Weaknesses:** The system's effectiveness relies on a **seamless transition** with minimal switching time, which is a major design challenge. There is a potential for added weight and complexity due to the dual-battery setup and additional circuitry.
* **Opportunities:** The system can be a foundation for developing a more advanced BMS with predictive analytics. There is an opportunity to integrate renewable energy sources, such as solar cells, to provide continuous charging for the secondary battery.
* **Threats:** Existing commercial drones with multi-battery systems and integrated smart batteries could pose a competitive threat. The project's success is dependent on the accuracy and reliability of the low-voltage detection circuit and the electronic switch.

**Existing Implementations**

While the project focuses on a novel approach, similar concepts are already in use:

* **DIY Circuits:** Hobbyists and engineers often build custom low-voltage monitoring circuits using simple components like voltage dividers and comparators.
* **Commercial Drones:** Some commercial and military UAVs utilize multi-battery systems, often in parallel, to increase energy capacity and provide redundancy for longer and more demanding flights.
* **Flight Controller Integration:** Many modern flight controllers have built-in battery monitoring ports that allow for the configuration of failsafe actions, such as auto-landing, when the voltage drops below a certain threshold.

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**Chapter 5: Implementation**

The project was executed in a phased approach, starting with **preliminary prototyping** and **simulation** before moving to a physical prototype.

**Description of How the Project Was Executed**

1. **Component Prototyping:** The team first developed and tested the core components of the system, including the **low-voltage detection circuit** and the **electronic switch**, on a breadboard. This allowed them to verify the basic functionality of the hardware before final integration.
2. **Simulation:** To test the concept in a controlled environment, the team used software like **MATLAB/SIMULINK** with **Simscape**. This allowed them to simulate the effects of voltage drop and a switching event on a drone's power system.
3. **Findings:** The initial simulations showed promising results, confirming that a sudden voltage drop could be detected and the switch could be activated to maintain a stable output voltage. The simulation helped in identifying potential issues and validating the system's core functionality.
4. **Next Steps:** The project's plan is to transition from the simulation phase to developing a **physical prototype** to test with actual batteries and motor loads.

**Challenges Faced and Solutions Implemented**

* **Challenge:** The main challenge identified was the need to **minimize the switching time** between the primary and secondary batteries. A momentary power interruption during the switch could disrupt the drone's flight stability.
* **Solution:** The project's findings from the initial simulations demonstrated that the system could successfully activate the switch to maintain a stable output voltage, addressing the core challenge in a simulated environment. The next phase of the project will focus on the physical implementation to ensure the solution works as effectively with real-world components.

**Chapter 6: Results**

* 1. Outcomes

The simulations demonstrated that the system can successfully detect voltage drops and activate the switch to maintain a stable output voltage. The concept of a split battery system to counter voltage sag was proven to be viable and effective

* 1. Interpretation of results

The graphs show a clear relationship between current draw and voltage sag, as well as the successful voltage recovery during a simulated charging phase. The system's ability to seamlessly switch power sources enhances the drone's safety and reliability

* 1. Comparison with existing literature or technologies

This system offers a method for real-time mitigation of voltage sag, complementing built-in battery monitoring in modern flight controllers that typically only trigger failsafe actions after a voltage threshold is reached. Some commercial drones use multi-battery systems, but the project's focus is on developing an explicit mechanism to switch between them to directly counter voltage sag during demanding maneuvers

**Chapter 7: Conclusion**

**The project of using a split battery system for drones is a promising and robust solution to the challenge of voltage drop. The conclusion is that this approach directly addresses a major limitation in current drone technology, leading to improved safety, reliability, and flight endurance.**

**The core idea is to move beyond simple parallel battery systems and implement an intelligent control system. By actively monitoring the primary battery and seamlessly switching to a secondary one when a voltage threshold is met, the drone avoids the power loss that can lead to crashes during demanding maneuvers. The system essentially provides a fail-safe mechanism, ensuring continuous power to critical components like the flight controller and motors.**

**This concept is well-aligned with the broader research trends in drone technology, which emphasize moving towards more sophisticated battery management. The literature highlights the importance of advanced battery management systems (BMS) with capabilities for precise state estimation (SOC, SOH) and fault detection. The split battery system can be seen as an extension of this, using BMS data to make real-time, critical decisions. While some multi-battery systems already exist, they are often connected in parallel to extend flight time, rather than providing the kind of active, fail-safe redundancy proposed here. The main challenges for this system will be minimizing the added weight and complexity while ensuring a flawless transition. This project offers a solid and practical solution for the next generation of reliable, high-performance drones**

**Chapter 8 : Future Work**

Future improvements include integrating the system with a full BMS for more advanced battery health monitoring and predictive analytics. There is also potential to explore incorporating a hybrid power source, such as solar cells, and developing intelligent algorithms to proactively predict voltage drop and initiate the battery switch.

**References**

The project's literature survey referenced several key publications and resources:

* **Publications:**
  + "Design and Simulation of Battery Thermal Management System for Electric Vehicles" by Vanya Goel and Snigdha Chaturvedi.
  + "The Drone Scheduling Problem: A Systematic State-of-the-Art Review" by Junayed Pasha et al..
* **Whitepapers & Datasheets:**
  + The team noted that comparators like Texas Instruments' TLV7081 are commonly used for under-voltage detection.
* Electronic PWM switches and e-power switches are available for drone applications and can be controlled via a signal from a flight controller or detection circuit

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