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Battery Management System (BMS) Planning on Quadcopter Flying Electric Vehicle

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ABSTRACT

Electric Vehicle Flying (KLT) quadcopter is an emerging technology that has great potential for various applications. The battery is one of the important components in the quadcopter KLT, and the battery management system (BMS) plays an important role in maintaining the performance, safety, and service life of the battery. This study aims to design, determine the wiring design and test the performance of the BMS on a quadcopter flying electric vehicle. Methods: This study is to design a battery management system (BMS) for a flying electric vehicle and then test it to see its effect on the performance of the electric motor and the safety of the battery Results: Based on testing when the battery management system is on standby, it shows that the battery is in good condition and has sufficient capacity. The battery voltage is within the normal range, the battery current is not flowing, the battery power is unused, the average cell voltage is normal, and the remaining battery capacity is almost full. The Jikong BMS is functioning properly and the battery is in good condition. Conclusion: The planning of the battery management system (BMS) on the quadcopter flying electric vehicle was successfully made with adjustments to the Battery LifePo4 used.

Keywords: Electric flying vehicle, Quadcopter, Battery, Battery Management System

1. INTRODUCTION

As human activity and population increase, the demand for transportation also increases. This causes air and noise pollution. Therefore, people need vehicles that have the advantages of producing no exhaust emissions, no noise pollution, clean, and easy to maintain.

The emergence of flying electric vehicles, especially quadcopters, requires the development of advanced battery management systems (BMS) to ensure safety, reliability and efficiency. BMS plays an important role in monitoring and managing battery charging and discharging, thereby improving the performance and lifetime of batteries used in air vehicles. Recent studies have laid the foundation for BMS planning in quadcopter applications, highlighting various strategies and technologies.

One of the main considerations in a BMS for quadcopters is accurate monitoring of battery parameters such as voltage, current and temperature. Smith et al. discusses the application of voltage and current sensors that provide real-time data that is important for the stability of flight control systems [1], [2]. In addition, the integration of temperature sensors to reduce the risk of thermal runaway in lithium-ion batteries has been studied extensively [3].

Another important aspect is the development of algorithms for state-of-charge (SoC) and state-of-health (SoH) estimation. Johnson and Lee presented an adaptive algorithm that improves the accuracy of SoC estimation under various environmental conditions [4]. Likewise, the work of Fernandez et al. introduced a model-based approach for SoH prediction, which significantly improved safety protocols during flight operations [5].

The BMS architecture in a quadcopter also includes considerations for fault detection and management. The diagnostic framework that identifies potential faults in the battery before they affect vehicle performance [6]. This research on redundancy management that enables continuous operation even when individual battery cells fail [7].

Communication protocols in BMS have also been an intensive area of research. The integration of wireless communication standards, such as Bluetooth and Zigbee, facilitates real-time data transmission between the BMS and the pilot control panel [8]. This technology ensures that critical battery information is available, which is critical for safe quadcopter operation.

Power management strategies are critical to maximizing flight time and battery life. The explored various energy optimization techniques that adjust power output based on flight mode and battery condition [9]. This dynamic management helps conserve battery power during less intensive phases of flight.

Finally, the impact of PASI on the environment is increasingly being considered. Green and Harris highlight the importance of designing PASI that not only improves performance but also complies with environmental standards [10]. This includes developing systems that can efficiently handle end-of-life batteries and encourage recycling[11].

The evolution of BMS for quadcopters is driven by advances in sensor technology, diagnostic frameworks, communications protocols, and power management strategies. As this field matures, future research will likely delve deeper into integrating artificial intelligence to further improve the predictive capabilities of BMS, which could revolutionize the safety and efficiency of quadcopter operations.

The excessive transportation activity causes significant economic losses [12]. This is due to high fuel costs and vehicle operating costs. In addition, traffic congestion also causes economic losses and time costs. Pollution generated by vehicles also causes environmental harm. It can negatively affect public health and the environment.

At present, flying electric vehicles are still in the development and research stage. There are several aspects that have a significant influence on the development of flying electric vehicles. Such as battery capacity. The energy capacity that can be stored by the battery is still a major issue. It requires batteries that are lightweight, but capable of storing enough energy to enable efficient flight and long endurance.

Over the past few years, the popularity of electric cars (EVs) has been increasing. Battery management systems (BMS) are critical to the long-term viability and smooth operation of electric vehicles. Daily management of an electric vehicle's battery can help it operate better.

BMS (Battery Management System) system design. BMS has three functions, namely computation, monitoring, and protection. State Of Charge (SOC) measurement accuracy has an important aspect in the design of the Battery Management System. Precise SOC measurements can prevent the battery from overcharge and undercharge conditions. The protection system on the BMS will be active when the battery is in a non-ideal condition so that the battery is not easily damaged and can reduce the decrease in life time.

Battery management system is an electronic system that functions to regulate, monitor and maintain the battery from a condition that can cause damage to the battery. battery management system (BMS) must immediately detect what disturbances occur in the battery.

The installation of BMS aims to protect the battery so that the battery life becomes more durable and long-lasting [13]. In general, BMS has two main functions, namely controlling and monitoring energy.

The functionality of the battery management system is determined by the complexity of the electronic components. The BMS microcontroller measures cell voltage and cell current in real time and switches MOSFETs based on this. The BMS uses only one bus for charge and discharge. First, the charge/discharge FETs are turned off, so no current flows [14].

The Jikong BMS is a reliable and versatile BMS that can be used with various types of lithium batteries. It has many features that help protect the battery, extend its life, and improve its performance [15]. Jikong BMS is a complete and powerful Battery Management System (BMS) for lithium batteries. Jikong BMS is a complete BMS with many features that make it ideal for various lithium battery applications. This BMS is safe and easy to use.

In cases found, the battery is easily damaged and has a short life time. Damage to the battery is caused by non-ideal use and the battery is not equipped with a protection and monitoring system, so that the battery continues to operate even in conditions of over-voltage, over-current and over-heat when charging and charging experiencing under-voltage when discharging [16].

The battery in the quadcopter serves as the main power source, so the battery selection should be adjusted to the needs of the quadcopter and the components installed in it. Maximizing flight duration is the goal of calculation and design to get the best results when the quadcopter is flowing. LiPo (Lithium Polymer) batteries are the most commonly used battery type for quadcopters [17].

In this research using Lithium Iron Phosphate (LiFePO4) battery type. LiFePO4 batteries are a type of secondary battery, this battery is one type with lithium ion batteries, this type of battery has a cell voltage of 3.3v / cell with an energy density of 220Wh / L. This battery has a reactive and thermodynamically stable. This battery has stable reactivity and thermodynamics. This battery also has a long life cycle, high energy density, and high working voltage. LiFePO4 can also charge with high efficiency and the loss of charge in the discharge process is very small, as well as fast charging when compared to other types of batteries, the capacity of Lihtium Iron Phosphate (LiFePO4) batteries is greater than other types of batteries . The BLDC motor (Brushless DC Motor) is a type of 3-phase synchronous electric motor that uses permanent magnets in its rotor. The term "brushless" refers to the absence of mechanical brushes for current commutation as in conventional DC motors. BLDC motors use power electronics to control the current to the stator coils.

The electrically driven motor uses the push and pull of a permanent magnet. With a stator made of iron wrapped around copper, the rotor magnetic poles can change according to the polarity of the current [18]. BLDC motors have several advantages over DC motors. The elimination of motor brushes enables high efficiency, quiet operation, compact design, reliability, and low maintenance costs. The speed and responsiveness of BLDC motors are additional advantages.

2. RESEARCH SIGNIFICANCE

Research on BMS for quadcopters has enormous significance, both in terms of technology development, solutions to unique challenges, positive impact on industry and society, and scientific development. With continuous research, we can expect more rapid progress in the field of electric flying vehicles. This research aims to design and develop an optimal Battery Management System (BMS) for quadcopter electric flying vehicles. By considering the unique characteristics of quadcopter batteries, this research is expected to improve battery performance, safety, and lifespan, thus contributing to the development of the UAV industry in Indonesia.

3. RESEARCH METHODS

This research uses a descriptive method by designing a Battery Management System (BMS) for flying electric vehicles and then testing it to see its effect on electric motor performance and battery safety. This research was conducted at the Mechanical Engineering Building of Malang State Polytechnic. The research to design a battery management system (BMS) on the market to the innovate lifepo4 3.2V 60Ah battery. This research includes making wiring diagrams of electrical components, implementing control systems, stabilizing vehicles and designing battery management systems (BMS) to LifePO4 batteries.

Fig. 1. Battery management system

The BMS model in the Fig 1. above is the Jikong BMS with a battery voltage of 3.7 Volts, battery capacity of 10Ah-300 Ah, maximum current of 100 A, peak current for 10 seconds of 300 A, operating temperature of -20°C to 60°C (-4°F to 140°F).

3.1 Material

Fig. 2. Battery

Fig. 2 show the battery is used as a power source to supply the ESC. The battery uses LifePo4 3.2V 60Ah shown in the figure, with a series of 20 series to get a total voltage of 64V and a capacity of 60Ah.

Fig. 3. Multimeter

Fig. 3 show a multimeter is used to measure voltage, current, and resistance on the battery and BMS components. These measurements are important to ensure that the BMS is functioning correctly and to diagnose problems if they occur. A digital multimeter is an ideal choice for BMS installation.

Fig. 4. Cable

Fig. 3 show cables are used to connect one component to another. This plan uses AWG 10, 12, and 18 cables with a maximum temperature of 200^{O}C.

Fig. 5. *Charger battery*

Fig. 5 show the battery charger has the main function of charging a 60V lead-acid battery. This battery charger has several features designed to ensure charging safety and efficiency, as well as a charging indicator that shows the battery's charging status.

3.2 Experiment Procedure

The circuit planning using a text manual. The text manual is a source of data that helps design the battery circuit as needed. Proper battery circuit planning is essential to ensure the performance, safety and reliability of the system using it. Connecting the battery management system (BMS) to the LiFePO4 battery involves several important steps to ensure and functioning connection.

Fig. 6. Design BMS

Fig. 7. Battery tool assembly

Fig 6 and 7 shows the battery management system (BMS) consists of several electronic components that work together to monitor and control battery performance. In the design of the battery using the main components of the BMS tool circuit in the form of sensors, microcontrollers used to calculate battery parameters, actuators to control battery operations, communications such as inventers and charge controllers to provide information about battery status and control the operation of the system, software to control the operation of the BMS.

4. Results and Discussion

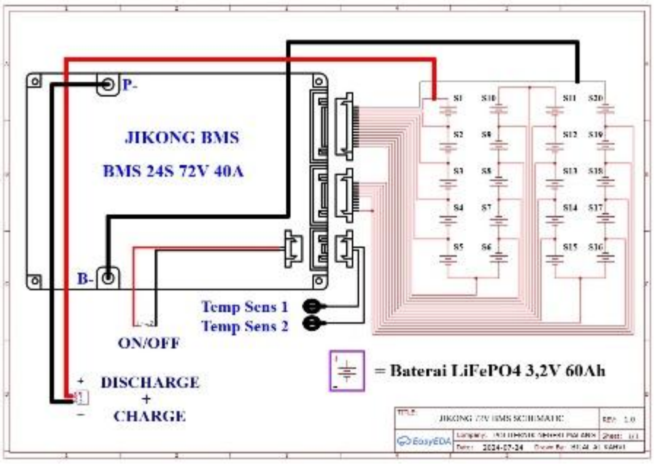

Fig. 8. BMS wiring design on battery

The schematic diagram in the figure above shows the connection design between the JIKONG 72V Battery Management System (BMS) and the 3.2V 60Ah LiFePO4 battery. The BMS is an important component in the battery system, serving to monitor and control the condition of each battery cell in the battery pack, as well as protect the battery from overcharge, overdischarge, and excessive temperature conditions.

The connections of the schematic diagram design P- and B- are the negative terminals of the BMS and the battery pack is connected directly. S1 to S24 represent Each S1 to S24 label represents the connection to each battery cell. The BMS will monitor the voltage of each cell through these connections. Temp Sens 1 and Temp Sens 2 are temperature sensors used to monitor the battery temperature. This temperature information is important to prevent overheating. ON/OFF is the main switch to enable or disable the system. discharge and charge terminals to connect the load (discharge) and charger (charge). This diagram shows the basic configuration of a battery system that uses a JIKONG 72V BMS to manage 24 LiFePO4 battery cells. The BMS will ensure that the battery operates safely and efficiently.

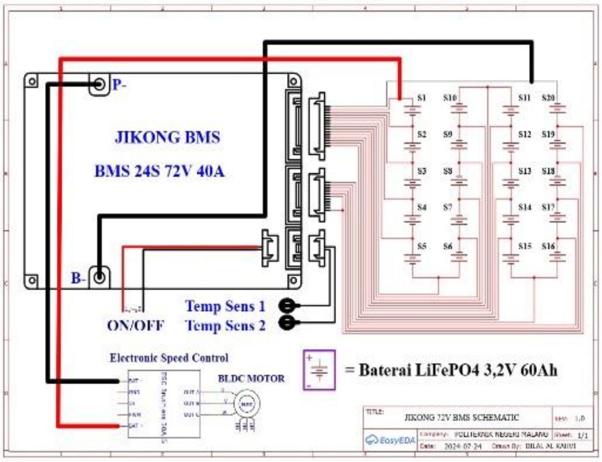

Fig. 9. Design wiring management system to BLDC

Fig. 9 shows how a JIKONG 72V Battery Management System (BMS) is connected to a BLDC (Brushless Direct Current) motor through an Electronic Speed Controller

(ESC). The BMS serves to manage and protect the battery, while the ESC serves to control the speed and torque of the BLDC motor.

The power flow explanation in the figure above shows the battery going to the BMS which means the battery provides power to the BMS. The BMS monitors the voltage of each cell and controls the charge and discharge of the battery. Furthermore, the BMS goes to the ESC, namely the BMS provides a regulated DC voltage to the ESC. The ESC goes to the BLDC motor so that the ESC converts the DC voltage into a three-phase AC voltage to drive the BLDC motor. The PWM from the ESC regulates the rotation speed of the motor. This wiring design shows a simple system consisting of a battery, BMS, ESC, and BLDC motor. The BMS plays an important role in managing the battery and ensuring the system works safely and efficiently. The ESC controls the speed of the BLDC motor based on inputs from the user or other control systems.

Fig. 10. Test results when Battery Management System is on Standby

Fig. 10 shows the display of the Jikong BMS battery monitor when it is in standby mode. In accordance with the Fig. when charging is off, discharging is off, and balancing is off, it shows that the battery is not being charged, discharged or balanced at the time of shooting. The battery is in good condition when it has sufficient capacity, the battery voltage is within the normal range, the battery current does not flow, the battery power is not used, the average cell voltage is normal, and the remaining battery capacity is almost full.

The Fig. 10 shows that the Jikong BMS is functioning properly. The cycle count and cycle capacity indicate that the battery has not been used. The temperatures of the MOS, battery 1, and battery 2 are within the normal range. The special charging status indicates that the battery is not connected to an external charger. Emergency time indicates that the battery still has enough power to operate in an emergency. The number of detail logs indicates the amount of data that has been recorded by the BMS. Sleep entry time indicates the time since the BMS entered standby mode. Cell voltage difference indicates the voltage difference between the lowest and highest battery cell. Balancing current indicates the current used to balance the battery cell voltage. Cell count not equal to setting indicates that the number of battery cells detected by the BMS is not equal to the actual number of cells.

5. CONCLUSIONS

Battery Management System (BMS) designed to manage 3.2V 60Ah LiFePO4 batteries in a system with a total voltage of 72V and a maximum current of 40A. The planning of a battery management system (BMS) on a quadcopter flying electric vehicle was successfully made with adjustments to the LifePo4 battery used. Testing when the battery management system is on standby shows that the battery is in good condition and has sufficient capacity. The battery voltage is within the normal range, the battery current does not flow, the battery power is not used, the average cell voltage is normal, and the remaining battery capacity is almost full.

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7. AUTHOR CONTRIBUTIONS

Conception and design: Mochammad Bilal Al Kahvi,
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Data acquisition: Mochammad Bilal Al Kahvi
Analysis and interpretation of data: Sugeng Hadi Susilo
Writing publication: Mochammad Bilal Al Kahvi
Approval of final publication: Sugeng Hadi Susilo
Resources: Mochammad Bilal Al Kahvi
Supervision: Sugeng Hadi Susilo

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