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Development of Battery Monitoring System for Drone Using Raspberry Pi

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Abstract: Malaysians currently face the same problem when controlling their drones, primarily with battery management. The battery's lifespan is crucial, and a dead stick situation in which the battery is totally depleted during flight can be disastrous. Therefore, this project aims to improve the battery estimation performance using the Battery Monitoring System (BMS) by monitoring the condition of the battery in real time. On the drone, a voltage sensor is attached, which gives the readings of the drone's battery. Also, there is a Raspberry Pi attached as mediation for monitoring the battery in real time. These readings are sent from the drone to a base station using a server-client concept. A Wi-Fi module, namely the Blynk application, has been used for this. This system evaluates and displays the battery voltage, current, and time for the considered model battery. For monitoring purposes, analogue to digital ADC converters is used. The battery information and the obtained results explaining the main characteristics of the system are presented via graphs, and some experimental results are given via the LCD screen. The presented result shows that the hovering height of the drone affects the output voltage and the time of the battery lifespan.

Keywords: ADC converter; Battery; Battery Monitoring System; Drone; Microcontroller; Raspberry Pi.

1. INTRODUCTION

A drone is an unmanned aerial vehicle (UAV) or unmanned aircraft system (UAS). Drones are most commonly utilised in the military. Weather monitoring, firefighting, search and rescue, surveillance, and traffic monitoring are all examples of applications. Drones have gained popularity in recent years for a variety of business applications. The drone's flight time is anticipated to be 30 minutes within a 10-mile radius. As a result, domestic UAV use, rather than military use, has a bright future in a variety of disciplines [1].

A drone is a flying robot that can be commanded remotely via radio waves or that can fly autonomously thanks to software-controlled flight plans in its embedded systems. Drone's system contains an onboard flight control system based on processing units that handles critical activities such GNC algorithms, in-flight data gathering and analysis, communication with the ground station, and mission planning in a drone platform. A propulsion system consists of power sources, a speed controller, converters, an energy management system, a motor, and a propeller. In addition, the drone needs sensors to maintain autonomous flying and payload, as well as mission-specific equipment such as actuators, cameras, and radar [2].

People in Malaysia are currently experiencing the same difficulty operating drones. One of the most serious concerns with drones is battery management. The battery lifespan is important to flight time, and a dead stick circumstance, in which the battery is totally depleted during flight, can be devastating [3]. They are unaware of the battery usage and believe that the power drawn by the motor is equal to the power drawn by the battery. As a result, omitting the real battery performance study could lead to an incorrect estimate of the drone's true flight time.

Related work, Koko Friansa et al,. 2017, suggested a battery monitoring system based on internet of things (IoT) to monitor the operational and performance of batteries in a smart microgrid system. A battery pack, PV system, Intelligent Electronic Device (IED) hybrid inverter, grid connection, and power load are all part of this smart microgrid. The battery monitoring system information is displayed on a Human Machine Interface (HMI) using the ExtJS / HTML5 framework and may be accessed via desktop or mobile devices as part of the battery management system (BMS)[4]. Amit Adhikaree et al., 2017, suggested a novel cloud-based battery condition monitoring platform for large-scale lithium-ion (Li-ion) battery systems. This system utilizes Internet-of- Things (IoT) devices and cloud components. The IoT components including data acquisition and wireless communication components are implemented in battery modules and also include a cloud storage, analytics tools, and visualization[5].

Mohd Helmy Abd Wahab et al., 2018, suggested an application of Internet-of-things (IoT) in monitoring the performance of electric vehicle battery. This system consisted with two major parts; monitoring device and user interface[6]. Md.Shahriar Al Moshin et al., 2021, suggested a wether monitoring IoT drone. This system using a drone to receives instructions via the remote controller and processes the data with the Arduino microcontroller and transmit data to the cloud server automatically, and transmit data to the mobile network via message or transmit the data to an Android cell phone or PC. The drone will collect data of temperature, humidity, gas(carbon monoxide, methane, ozone/ O3 gas, SO2, NO2 and LPG), take pictures from that place with the sensor DHT11,MiCS-2610 O3 Sensor,Gas sensor MQ-9, SO2-AF, DGS-NO2 and send those data via Wi-Fi to the cloud database with the help of node MCU ESP8266 or send via sim module[7].

The analysis of the literature detect that there is no standard method for designing a battery monitoring device for drone, and all the methods listed differ in terms of the type of microcontroller and the type of sensors used to simulate the functional circuit, and differ in the methods of connecting to the internet. In these systems, some defects have been found in terms of the type of microcontroller used where certain controllers do not have built-in Wi-Fi and the large number of sensors used raises the cost of the designed system.

The motivation for this research is to provide a battery monitoring system (BMS) for drones that deal with the fluctuating power demands of numerous elements of drone operation while optimising battery utilisation. The BMS will track battery voltage, current, and maybe predict additional data to help manage battery performance. The BMS can also protect the battery during charging, protecting it from overcurrent and overvoltage situations. As a result, this study aims to monitor battery estimation performance utilizing the BMS by monitoring the battery's condition in real time.

2. PROPOSED SYSTEM

The main objective of the proposed system is to provide a drone battery monitoring system that can estimate battery state and performance. The Mini Pro Arduino microcontroller is connected to a voltage and current sensor, which serves as the controller's analogue input signal. The sensor will analyse the contents of a web page that is being used as a display depending on the voltage and current sensor output. Data can be streamed online to a web server using the Raspberry Pi for real-time monitoring.

3. METHODOLOGY

In this study, a battery monitoring system were developed using hardware component, Arduino and Raspberry Pi software. Raspberry pi is used as Wi-Fi interface with cloud server while the Atmega168 is used as microcontroller unit which acts as an ADC converter of the system. This system is focused to transmit the data to web server for real time data display. The system operated when the drone system in a standby mode for flight, the sensor gets activated. As the sensor get activated it will detect the voltage and current flow of the drone's battery. Once the detection process of the sensors is achieved it will display the value of voltage and current through web server page. The analysis result we got from the sensor; we will be able to monitor the drainage of the battery for each hovering range for drone versus the time taken for 15 minutes. The system's block diagram is shown in Fig. 1.

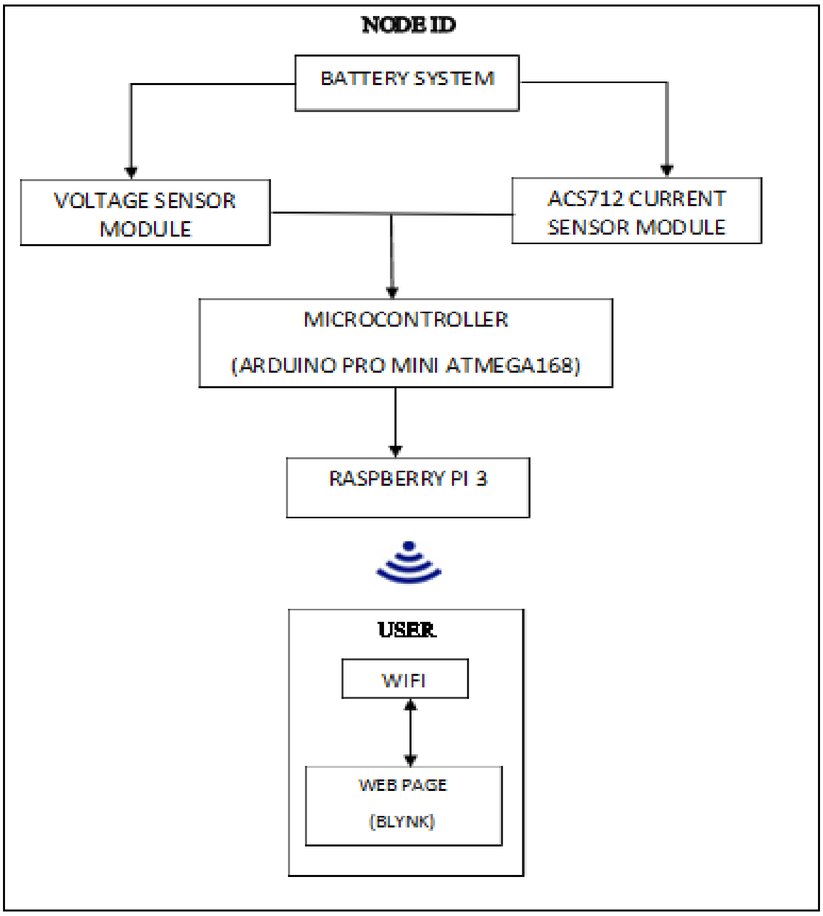

Fig. 1 Block diagram of battery monitoring system

3.1 Voltage sensor module

This voltage sensor module is a basic module that uses a potential divider to lower any input voltage by a factor of five. In that scenario, it allowed a microcontroller's analogue input pin to monitor voltages greater than it was capable of perceiving. Voltages up to 5V were used by any microcontroller analogue input pin, but the voltage sensor module's capability allowed it to measure voltages up to 25V. Two header blocks are integrated in the voltage sensor module. The connector with the screws is attached to the power supply whose voltage needs to be measured, while the other is used to interface microcontrollers. The voltage sensor module contains 5 pins, 2 on the front and 3 on the rear. The analogue input pin on the Arduino could handle voltages of up to 5V. The voltage circuit consists of a voltage divider circuit with two resistors, R1 being 30K and R2 being 7.5K. Connect the VCC and GND of the voltage source whose voltage is to be measured to the screw terminals of the voltage sensor when connecting it with a microcontroller. Connect the voltage sensor's S and -(GND) pins to the microcontroller's Analog pin and GND, respectively.

3.1 ACS712 Current sensor module

The ACS712 Current Sensor can be used to measure and calculate the amount of current provided to the conductor without compromising the system's performance. The essential role of this sensor is to measure and calculate the amount of current provided to the conductor without impacting the system's performance. The ACS712 Current Sensor is a fully integrated linear sensor IC based on the Hall effect. The ACS712 IC is typically used as a linear current sensor to measure AC and DC currents This sensor has an output voltage of Vcc x 0.5 = 2.5 with an input current of 0A and a 5V Vcc power source. Aside from that, there are three types based on the comprehensible current range: 5A, 20A, and 30A, with output sensitivity of 185mV/A, 100mV/A, and 66mV/A, respectively, that can be used for our application. This current sensor's output is analogue. As a result, we may test the output voltage directly with a voltmeter or via a microcontroller's Analog Read pin or ADC pin.

3.2 Microcontroller

The Arduino Pro Mini is a microcontroller board based on the ATmega168. It contains 14 digital input/output pins, including 6 PWM output pins, 6 analogue inputs, an on-board resonator, a reset button, and mounting holes for pin headers. To supply USB power and connectivity to the board, a 6-pin header can be linked to an FTDI cable. For semi-permanent installation displays, the Arduino Pro Mini is designed. The board is shipped without pre-installed headers, allowing for the use of a variety of connections or direct wire soldering. The Arduino Mini is compatible with the pin layout. The use of Arduino is due to the fact that all connections with other modules are made by connecting wire rather than soldering. The boot loader is used to programme the entire programme for the Atmega328P microcontroller. It processes the request after receiving input from several predetermined devices.

3.3 Raspberry Pi

The Raspberry Pi 3 is a small computer that connects to a monitor and works with a regular keyboard and mouse. It's a capable gadget for learning how to programme in languages and exploring computing. It is also an open-source platform from which we may obtain a variety of data associated by customising the system to meet personal needs after using Arduino. The Raspberry Pi 3 has a quad-core 64-bit Broadcom BCM2837 ARM Cortex-A53 SoC CPU with a clock speed of 1.2 GHz, making it around 50% faster than the Pi 2. As a result, the new Raspberry Pi 3 may be used for both office and web browsing. The addition of a Wi-Fi chip and Bluetooth Low Energy is certainly the most significant advancement in this third version. It not only saves space, but it also makes extra USB ports available for connecting other devices.

The Raspberry Pi 3 is a PI series developer board. It can be considered of it as a single-board computer that can run any operating system. The board not only offers a lot of functionality, but it also has a fast processor, making it ideal for complex applications. The PI board was created with the Internet of Things in mind (IoT). We may now download and install application programmes that we need for our use, just like we do for our PC, thanks to technological advancements. After that, we may concentrate on building the appropriate software and having the PI run it.

3.4 Drone Bug12 EIS

A popular type of UAV is the drone. The lift and torque are controlled by adjusting the spin limit RPM of four rotors. Its compact size and quick manoeuvrability allow the user to make intricate moves as part of their flying routine. However, accurate angle management of the drone is essential to carry out such manoeuvres. The Bugs 12EIS drone was the ideal choice for this project as a viable drone. The remote control operates at 2.4 - 2.4835 GHz and can cover around 120 metres with average obstacles. The 3400mAh LiPo battery has a capability of 10-15 minutes of hovering. It simply requires roughly 240 minutes of charging. The drone has the ability to apply a height hold mode, which allows it to fly smoothly at the height selected by the player.

4. PROJECT IMPLEMENTATION

4.1 Hardware

Connecting the electrical circuit of the system is shown in Fig. 2. Arduino IDE is a program used to generate the system's main code and download the required libraries. IDE stands for "Integrated Development Environment" and is an official program developed by Arduino.cc, which is used primarily to edit, compile and upload code to the board. This software is open source and readily accessible. This environment supporting C and C ++ languages.

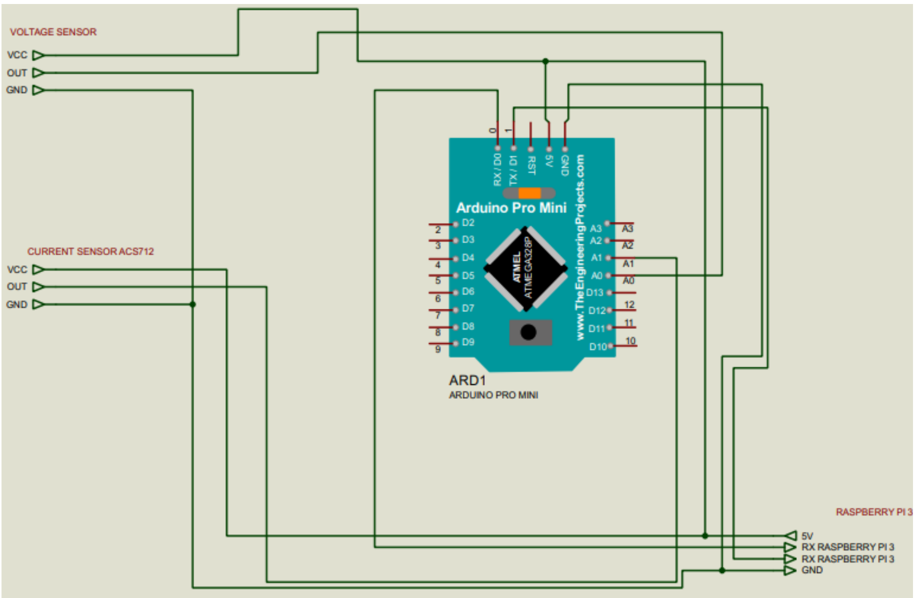

Fig. 2 Flowchart of the battery monitoring system

4.2 Software

Fig. 3 shows the flow chart of the system. The process begins with when the drone in a standby mode for take-off operation, the system turns on as well. The voltage sensor module and ACS712 current sensor module will detect the presence output voltage and current of the drone's battery. The voltage sensor module's value and the ACS712 current sensor module's value are converted into analogue signals and sent to the microcontroller. The Arduino Pro Mini Atmega168 microcontroller converts analogue to digital signals. The digital signal's output value will be sent to the Raspberry Pi 3 module, which will communicate the data to a Web server. Then it will be linked to Web-page of the Blynk application. The voltage and current meter were set up by the rate of battery drainage and the time taken for drone's hovering is directly proportional the load output of the drone's usage. As the drone's load usage increases, the rate of drone's battery drainage increases while the time taken for drone's hovering will decrease.

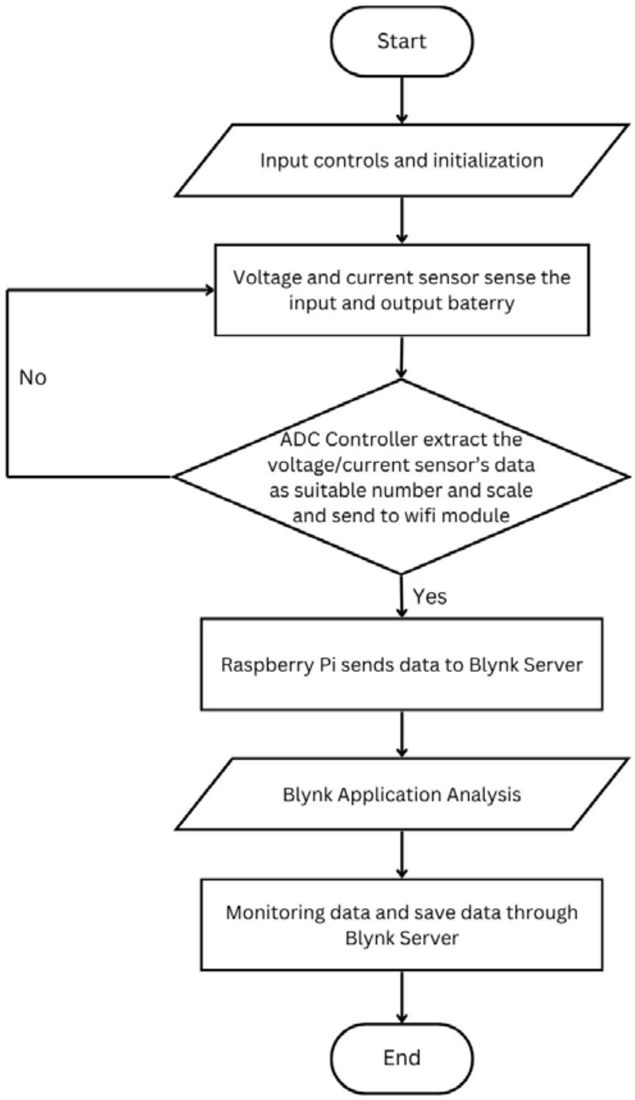

Fig. 3 Flowchart of the battery monitoring system

5. RESULT AND DISCUSSION

The voltage and current of the drone's battery were recorded. This experiment was conducted in a community hall with a close proximity and no wind. This test was conducted with drone's hovering height range for low, medium, and highest levels. While each hovering height range was given only 15 minutes maximum of time. The result for all level were compared and based on the graph of differences of voltage output for low, medium and high hovering altitude level as shown in Fig. 4. Clearly stated that the maximum time taken for the depletion of the drone's battery depend on the level of the drone's hovering heights. Fig. 5 shows the result of a real time data displays.

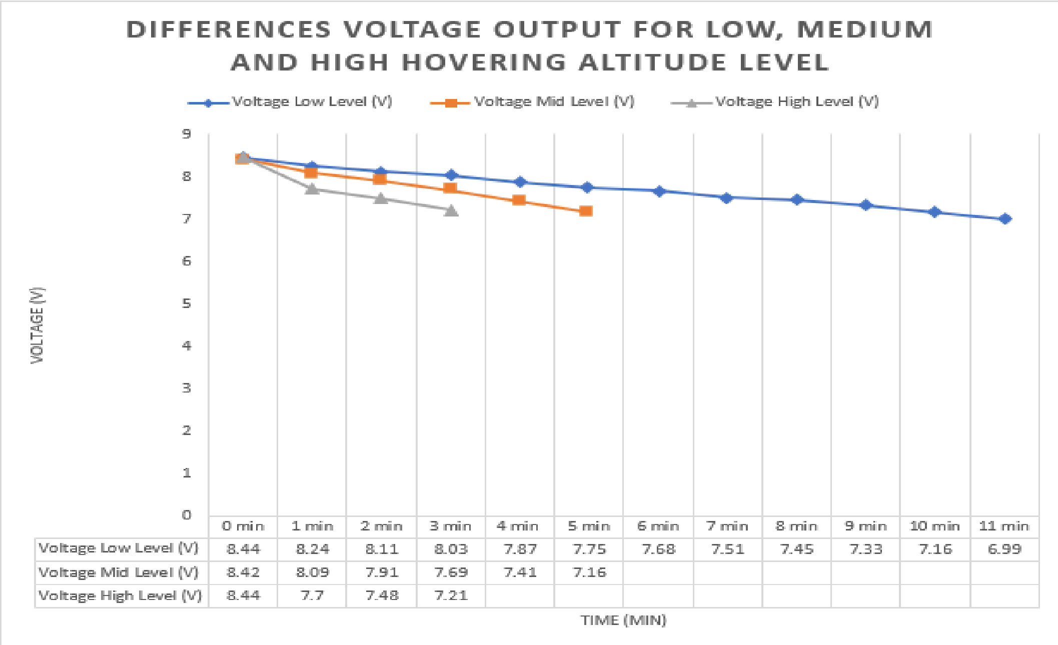

Fig. 4 Differences of voltage output

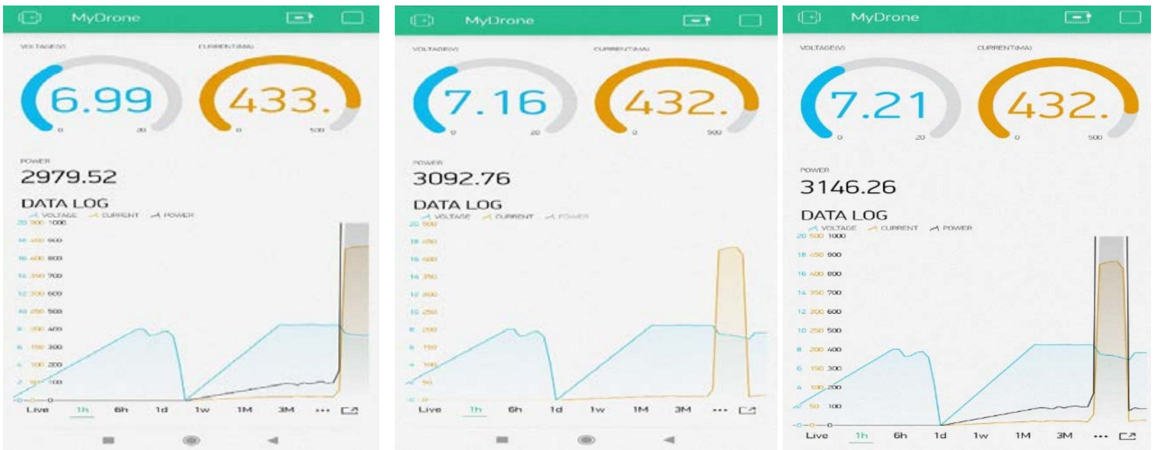

Fig. 5 Result of Real Time Display.

6. CONCLUSION

This project aims to develop a battery monitoring system for drone in order to improve the accuracy in drone's battery operational principle. With this project design and development of a battery monitoring system using Raspberry pi for drones to ensure the battery performance degradation can be monitored online while the drone is in control activity managed to overcome the problem of a wrong estimation of battery flight performance. The experimental assessment of this system revealed that the hovering height of the drone influences the output voltage and the time utilisation of the battery lifespan at three distinct height levels. The main influence is due to additional weight of this system that being attached to the drone that effecting the flight performance of the drone. Furthermore, hovering the drone in a windy environment will impact the output voltage due to drone hovering stability. This system was selected as a medium to continuously monitor other important battery parameters while dealing with the varying power demands of the many aspects of the drone's operation and optimising the battery's usage.

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