PERFORMANCE OF LITHIUM ... 'TRIC PROPULSION

AHMAD FATHI BIN MOHD ZAINUDDIN

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Faculty of Manufacturing Engineering
UNIVERSITI MALAYSIA PAHANG

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ABSTRACT

In recent years, most of the micro size UAVs are equipped with an electric propulsion system to reduce noise and thermal signatures. In some application the vehicle can be reused to perform subsequent mission due to endurance limitation and type of operation. In practice new battery system will be installed to reduce the risk of failures during operation. The present study is to determine the performance of Lithium Polymer battery. It shows that the new battery the internal resistance depending on manufacturer models and battery capacity.

ABSTRAK

Beberapa tahun kebelakangan ini, kebanyakan UAV bersaiz mikro dilengkapi dengan sistem pendorongan elektrik untuk mengurangkan bunyi dan tandatangan haba. Dalam beberapa aplikasi kenderaan itu boleh digunakan semula untuk melaksanakan misi berikutnya disebabkan had ketahanan dan jenis operasi. Dalam latihan sistem bateri baru akan dipasang untuk mengurangkan risiko kegagalan semasa operasi. Kajian ini adalah untuk menentukan prestasi Lithium Polimer bateri. Ia menunjukkan bahawa bateri baru rintangan dalaman bergantung pada model pengeluar dan kapasiti bateri.

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LIST OF ABBREVIATIONS

DC	Direct Current
UAV	Unmanned Aerial Vehicle
LiPo	Lithium Polymer
LCD	Liquid Crystal Display

CHAPTER 1

INTRODUCTION

1.1 Project Motivation

Propulsion is a means of creating force leading to movement. An electric propulsion system that is an electric power is used to move a mechanical power such engine or motor. The propulsion system is driven by DC brushless motor. The other components such as propeller and motor are important but the influence of the batteries on the electric propulsion system performance is usually far more significant.

1.2 Project Background

Most of today's unmanned aerial vehicles (UAVs) are used for reconnaissance and surveillance missions [1]. Considerable effort has been directed toward the development of small tactical UAVs, sometimes referred to as mini or micro UAVs [1]. These vehicles are applied as tactical surveillance tools, used by soldiers for "behind the hill" reconnaissance purposes. Most of these UAVs are equipped with electric motors that contribute to the simplicity of operation and significantly reduce their noise signature. The propulsion systems of these small UAVs such batteries, motor, and propeller account for as much as 60% of the vehicle weight [1]. Therefore, optimization of the propulsion systems is extremely crucial.

Hence, diagnosis of battery performance is necessary for an electric propulsion system. This can be achieved by monitoring the performance of the battery cells over the whole lifetime of the battery.

1.3 Problem Statement

The problem statement is to determine the performance parameter of the battery of Lithium Polymer Battery for flight assessment.

1.4 Objective of Project

The objectives of this study are divided into two that is:

i. General Objectives:

- Development of battery management system for electric propulsion for micro size UAV.

ii. Specific Objectives:

- To design battery monitoring device for electric propulsion
- To measure the internal resistance of Lithium Polymer battery

1.5 Scope of the Project

There are variable of LiPo batteries available through the manufacturer. This project will mainly focus on the 6 types of LiPo batteries. Variables that considered in this experiment are internal resistance, battery capacity as the function of battery mass and discharging rate between the batteries.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter it discusses about the research findings of literature reviews from past researches. This chapter will discuss about the model of LiPo batteries and other mechanism to build a voltage and current measurement device. This literature review will also evaluate the sources and some information will be used as references to analyze LiPo batteries on electric propulsion system.

2.2 Lithium Polymer Battery

The lithium polymer (LiPo), which offers a relatively high energy capacity along with low weight. Lithium-ion polymer batteries, polymer lithium ion or more commonly lithium polymer batteries are rechargeable batteries [2]. LiPo batteries are usually composed of several identical secondary cells in parallel to increase the discharge current capability, and are often available in series "packs" to increase the total available voltage [2].

This type technologically evolved from lithium-ion batteries [3]. The primary difference is that the lithium-salt electrolyte is not held in an organic solvent but in a solid polymer composite such as polyethylene oxide or polyacrylonitrile [3]. The advantages of Li-ion polymer over the lithium-ion design include potentially lower cost of manufacture, adaptability to a wide variety of packaging shapes, reliability, and ruggedness, with the disadvantage of holding less charge [3]. Lithium-ion polymer batteries started appearing in consumer electronics around 1995 [3]. Lithium-polymer differs from other battery systems in the type of electrolyte used [4]. The original polymer design dating back to the 1970s uses a solid (dry) polymer electrolyte that resembles a plastic-like film [4].

Figure 2.1: Lithium Polymer Battery

Figure 2.2 shows a block diagram to show how LiPo battery cells are wired. It should help explain what is meant by the "s" and "p" terms [5].

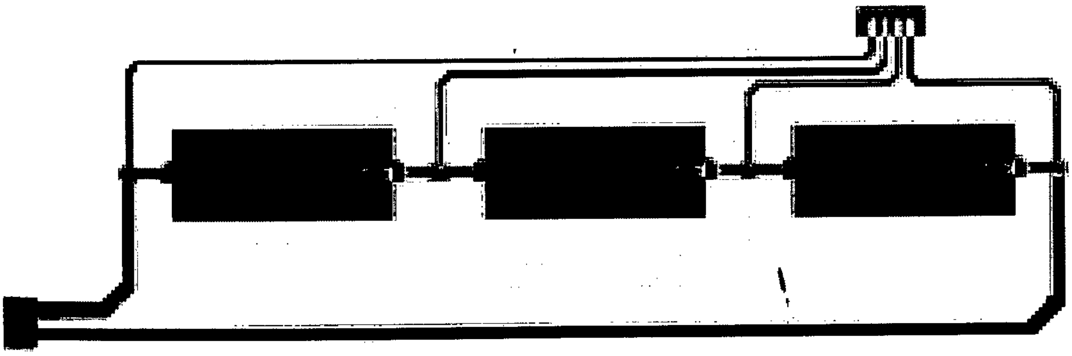

Figure 2.2: Block Diagram of LiPo Battery. [5]

2.3 Voltage or "S" rating

LiPo battery cells are rated at 3.7 volts per cell and 4.2 volts when fully charged [6]. Here is a list of LiPo RC battery pack voltages with cell counts most beginners will be using;

- 3.7 volt battery = 1 cell x 3.7 volts (1S)
- 7.4 volt battery = 2 cells x 3.7 volts (2S)
- 11.1 volt battery = 3 cells x 3.7 volts (3S)
- 14.8 volt battery = 4 cells x 3.7 volts (4S)
- 18.5 volt battery = 5 cells x 3.7 volts (5S)
- 22.2 volt battery = 6 cells x 3.7 volts (6S)

The number of parenthesis is a way of battery manufacturer indicates how a cell hooked in series "S" the battery pack contains [6].

2.4 Capacity or mAh rating

Discharge rate is simply how fast a battery can be discharged safely [7]. How fast a battery can discharge to its maximum current capacity depending on C rating. Current is generally rated in C's for the battery [6]. C is how long it takes to discharge the battery in fractions of an hour [6]. For instance 1 C discharges the battery in 1/1 hours or 1 hour. 2 C discharges the battery in ½ or half an hour [6].

Capacity indicates how much power the battery pack can hold and is indicated in milliamp hours (mAh) [8]. This is just a fancy way of saying how much load or drain (measured in milliamps) can be put on the battery for 1 hour at which time the battery will be fully discharged [8].

2.5 Internal Resistance

Internal resistance is one of the best ways to monitor your LiPo battery condition. As the battery gets older the internal resistance increases [7]. Most decent higher discharge rated LiPo cells will have roughly 2 to 6 milliohms (0.002 to 0.006 ohms) of internal resistance when brand new [7].

Internal resistance testing is a relatively simple way of measuring the health of your LiPo batteries [8]. The internal resistance is the electrical resistance that occurs inside the battery cells themselves as the battery creates electricity [8]. The higher the internal resistance the less current can flow from the battery to your ESC and motor [8].

2.6 Discharge Rate

Discharge rate is simply how fast a battery can be discharged safely [7]. This is probably the single most over rated and miss understood of all battery ratings. The faster the ions can flow from anode to cathode in a battery will indicate the discharge rate [7]. LiPo Battery packs will show the continuous C rating and some also indicating a burst rating as well. The burst rating indicates the battery discharge rate for short bursts of extended power [7].

CHAPTER 3

METHODOLOGY

3.1 Introduction

Methodology is one of the most important elements to be considered. It will describe about how the project will be conducted in step by step flow. This project flowchart consists planning from starting till the end of the project process. This part will explain briefly about how the LiPo batteries will be tested and how voltage and current sensor measurement have been built.

3.2 Project Flowchart

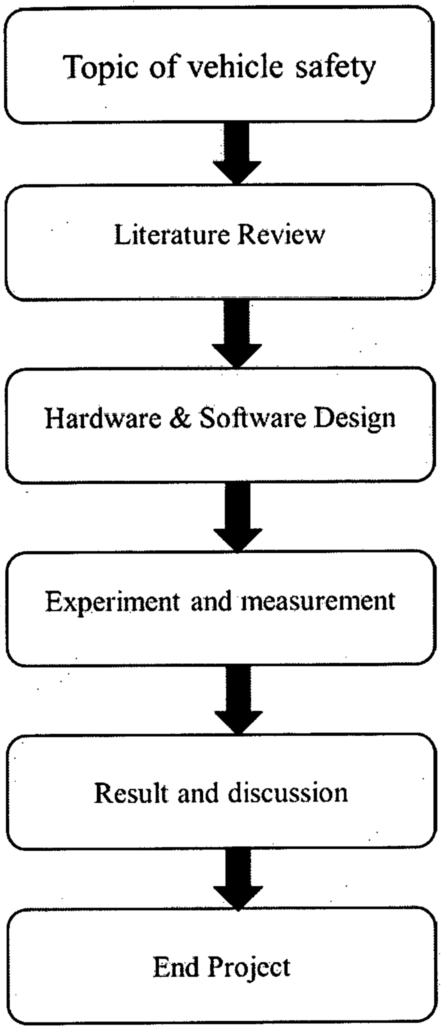

Figure 3.1: Project Flowchart

Project Flowchart in Figure 3.1 shows the process throughout the project. First is topic of vehicle safety which is the understanding of the project. From the understanding literature review is to get source for the research. After getting the information needed is to develop hardware and software design. From the development the experiment and measurement can be taken placed. Thus from the output, result is obtained and the result will be discuss.

3.3 Monitoring Device

This device system to monitoring the voltage of the LiPo battery in the electric propulsion system. It is to make sure the battery is in good condition such that to prevent failure in the system. There are few things that has to be consider for this device. Hence, the following aspect has to be taken.

3.3.1 Voltage divider

Voltage divider is a linear circuit that produces an output voltage, Voutput that is a fraction of its input voltage, Vinput. Voltage division refers to the partitioning of a voltage among the components of the divider [9].

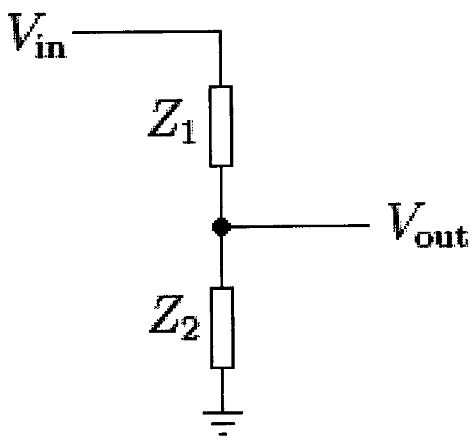

Figure 3.2: Voltage Divider

A voltage divider referenced to ground is created by connecting two electrical impedances in series, as shown in Figure 3.2. The input voltage is applied across the series impedances $Z_1$and $Z_2$and the output is the voltage across Z_2. Z_1 and Z_2 may be composed of any combination of elements such as resistors, inductors and capacitors.

The relationship between the input voltage, Vinput and the output voltage Voutput can be found :

$$V_{\text{out}} = \frac{Z_2}{Z_1 + Z_2} \cdot V_{\text{in}} \tag{1}$$

Proof:

$$V_{\text{in}} = I \cdot (Z_1 + Z_2) \tag{2}$$

$$V_{\text{out}} = I \cdot Z_2 \tag{3}$$

$$I = \frac{V_{\text{in}}}{Z_1 + Z_2} \tag{4}$$

Hence,

$$V_{\text{out}} = V_{\text{in}} \cdot \frac{Z_2}{Z_1 + Z_2} \tag{5}$$

3.3.2 Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the ATmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.

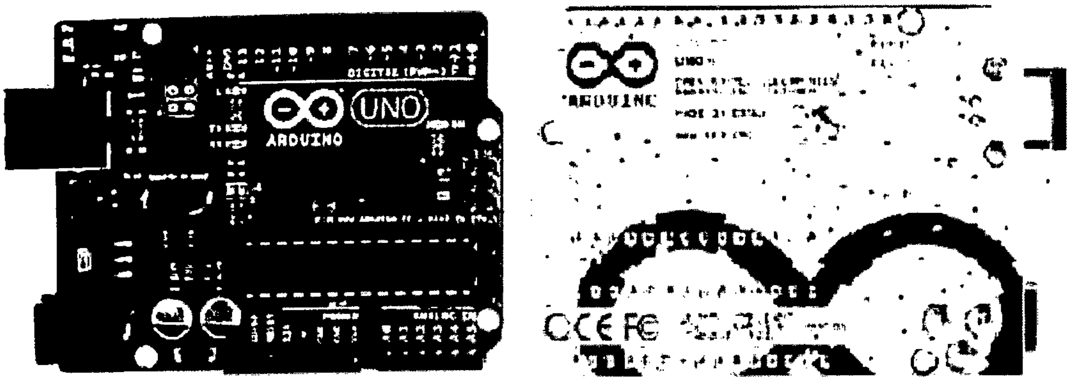

Figure 3.3: Front and Back view of Arduino Uno

Revision 2 of the Uno board has a resistor pulling the 8U2 HWB line to ground, making it easier to put into DFU mode. Revision 3 of the board has the following new features: 1.0 pinout: added SDA and SCL pins that are near to the AREF pin and two other new pins placed near to RESET pin, the IOREF that allow the shields to adapt to the voltage provided from the board. In future, shields will be compatible both with the board that use the AVR, which operate with 5V and with Arduino Due that operate with 3.3V. The second one is a not connected pin that is reserved for future purposes. Stronger RESET circuit. Atmega 16U2 replace the 8U2

"Uno" meas one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform; for a comparison with previous versions, see the index of Arduino boards.

3.3.3 Liquid Crystal Display

A liquid-crystal display (LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly.

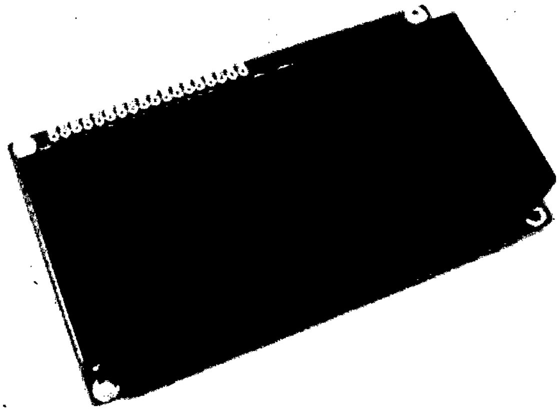

Figure 3.4: Liquid Crystal Display

To display the value of voltage, a LCD is connected to the Arduino. The connection between the LCD with arduino is shown in Figure 3.5.

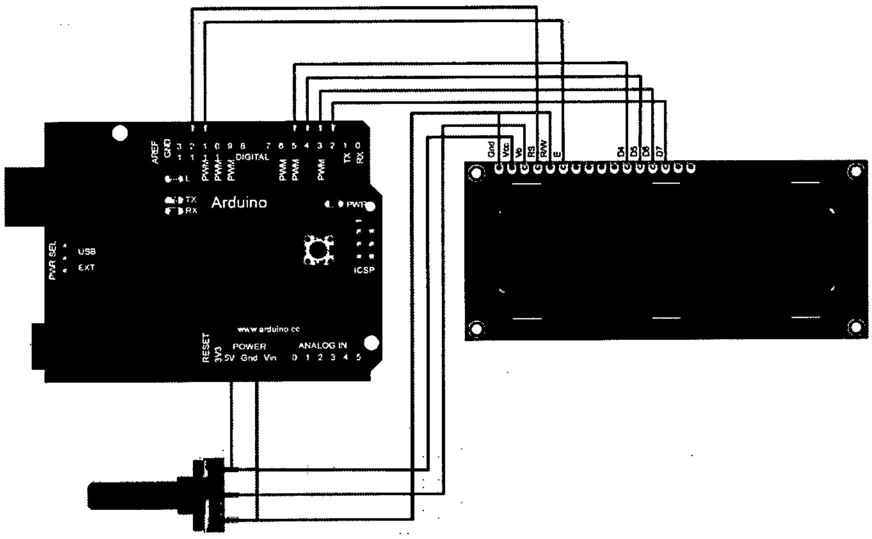

Figure 3.5: Connection between LCD and Arduino

3.4 Experimental Setup

This experiment is conduct a test on the LiPo battery to determine its internal resistance. The experiment is carry out as following.

3.4.1 LiPo Battery Model

There are about 6 different LiPo battery models that will be test throughout the experiment. Each batteries has different capacity, discharge rate and charging rate that from different manufactures. The figure show the LiPo battery models

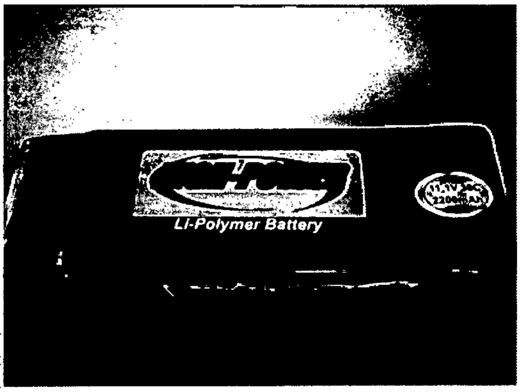

Figure 3.6: HighPower Model

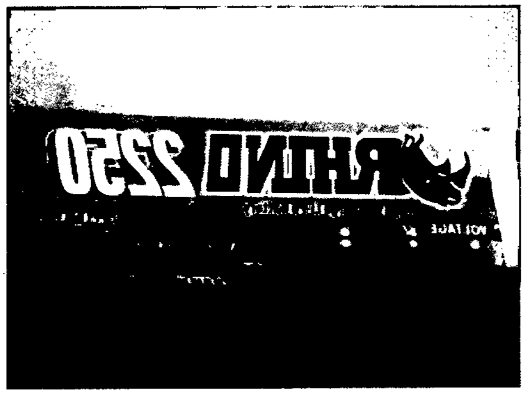

Figure 3.7: RHINO Model

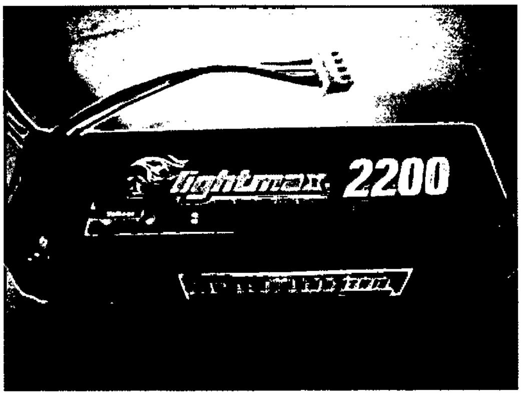

Figure 3.8: Flightmax Model

Figure 3.9: TeraHobby Model

Figure 3.10: Tipple Model

3.4.2 Battery Connector

These are a very popular connector type (also called "T" connectors) with a very loyal following, which unfortunately has driven the price up & made them one of the most expensive connectors around. They are rated for up to 50 amps of continuous load. This connector will be use in connection between battery and other components.

Figure 3.11: "T" connector

3.4.3 Internal Resistance Experiment

Older, abused, puffed, crashed, and lower quality batteries have a higher internal resistance and therefore cannot maintain voltage to your ESC and motor when you apply power. Because the battery itself creates current, you cannot simply hook up an ohmmeter and measure resistance. Instead you must measure the voltage, then apply a known electrical load (halogen light bulbs in this demonstration), re-measure the voltage and also measure the amperage. The internal resistance is the voltage drop divided by the amperage.

Measuring this occasionally will give you a good idea of the "health" of your battery packs. If you have a battery that doesn't give the "juice" or "oomph" like it used to, this is a good way to actually quantify the loss in power and determine whether the battery should be reassigned to bench work or the garbage.