

**DESIGN AND DEVELOPMENT OF IoT QUADCOPTER USING  
MICROCONTROLLER**

**MUHAMMAD IMANUDDIN BIN AHAMAD**

**THIS REPORT IS SUBMITTED IN PARTIAL FULFILLMENT OF THE  
REQUIREMENT FOR THE AWARD OF THE DEGREE OF BACHELOR  
OF ELECTRONIC ENGINEERING (WIRELESS COMMUNICATION)**

**FACULTY OF ELECTRONIC ENGINEERING AND COMPUTER  
ENGINEERING**

**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**JUNE 2017**

## Borang Pengesahan Status Laporan PSM II



UNIVERSITI TEKNIKAL MALAYSIA MELAKA  
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN  
PROJEK SARJANA MUDA II

Tajuk Projek : DESIGN AND DEVELOPMENT OF IoT QUADCOPTER USING  
MICROCONTROLLER

Sesi Pengajian : 

1	6	/	1	7
---	---	---	---	---

Saya MUHAMMAD IMANUDDIN BIN AHAMAD  
(HURUF BESAR)

mengaku membenarkan Laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (  ) :

SULIT\*

\*(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)

TERHAD\*\*

\*\* (Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

TIDAK TERHAD

Disahkan oleh:

  
(TANDATANGAN PENULIS)

Tarikh: 2/6/2017

  
(COP DAN TANDATANGAN PENYELIA)

**DR. KHAIRUDDIN BIN OSMAN**

Pensyarah Kanan  
Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer  
Universiti Teknikal Malaysia (UTeM)

Hang Tuah Jaya  
Tarikh: .... 75100 Durian Tunggal, Melaka

“I hereby declare that the work in this project is my own except for summaries and quotations which have been duly acknowledge”

Signature: .....

Author: ... MUHAMMAD IMANUDDIN BIN AHAMAD

Date: .....

“I acknowledge that I have read this report and in my opinion this report is sufficiently in term of scope and quality for the award of Bachelor of Electronic Engineering (Wireless Communication) with Honours”

Signature: .....

Supervisor's Name: DR KHAIRUDDIN BIN OSMAN .....

Date: .....

*“So verily with the hardship there is relief, verily with the hardship there is relief “*

(Quran Ch 94:5-6)

Dedicated especially to my mother, Norul ‘In Binti Mokhtar, father Ahamad Bin Ali ,my siblings and my fellow friends who always be with me through these hardships and success.

## ACKNOWLEDGEMENT

First and foremost, I would like to express gratitude to Allah S.W.T, the most Gracious and most Merciful, for giving me all blessings and strength to complete this final year project on the time given. I also wish to express my sincere appreciation to my supervisor, Dr Khairuddin Bin Osman for his guidance, advices, ideas and support throughout the progress of this project.

My appreciation also goes to my family who has been supporting me all over these years, especially my father who help me a lot in financial supports to complete this project. I am very grateful for their encouragement and love that they had given to me.

Finally, I also would like to offer my special thanks to my colleagues in their continuous support and advices that helped me making this report a reality. Their views and tips are useful indeed.

## ABSTRACT

Quadcopter or widely known as ‘Drone’ is one of the emerging technologies nowadays. Controlling the quadcopter using RF transmitter sometimes offers threat to the user in terms of hacked controller. Hence, building this IoT quadcopter using Arduino Uno as the flight controller offers a least threat to be hacked. By building the flight controller using a simple and specific coding, all of the quadcopter users can design their own quadcopter freely with knowing the risk to be hack is low. With the additional features in this IoT quadcopter, an analysis of angular rate of the quadcopter can be obtain. User can easily monitor the angular rate of the quadcopter using the designed Blynk apps. This offers a great aid to all of the quadcopter’s researchers for their project studies



## ABSTRAK

Di masa kini, 'Quadcopter' atau lebih dikenali sebagai 'Drone' merupakan salah satu teknologi yang sedang membangun. 'Quadcopter' yang dikawal menggunakan pemancar RF kadang kala mendatangkan ancaman kepada pengguna dalam aspek alat kawalan digodam. Dengan menghasilkan 'IoT quadcopter' menggunakan 'Arduino Uno' sebagai pengawal penerbangan, risiko untuk digodam dapat dikurangkan. Dengan menghasilkan pengawal penerbangan menggunakan kod yang mudah dan spesifik, para pengguna dapat menghasilkan 'quadcopter' mengikut citarasa sendiri tanpa memikirkan risiko untuk pengawal penerbangan digodam. Analisis kadar sudut 'quadcopter' juga dapat dihasilkan dengan penambahan fungsi baru. Para pengguna dapat memerhatikan kadar sudut menggunakan aplikasi 'Blynk' yang direka. Hal ini membantu para penyelidik 'quadcopter' untuk kerja penyelidikan mereka.

## TABLE OF CONTENTS

CHAPTER	CONTENTS	PAGE
	<b>PROJECT TITLE</b>	<b>i</b>
	<b>PROJECT STATUS FORM</b>	<b>ii</b>
	<b>STUDENT’S DECLARATION</b>	<b>iii</b>
	<b>SUPERVISOR DECLARATION FORM</b>	<b>iv</b>
	<b>DEDICATION</b>	<b>v</b>
	<b>ACKNOWLEDGEMENT</b>	<b>vi</b>
	<b>ABSTRACT</b>	<b>vii</b>
	<b>ABSTRAK</b>	<b>viii</b>
	<b>TABLE OF CONTENTS</b>	<b>ix</b>
	<b>LIST OF FIGURES</b>	<b>xii</b>
	<b>LIST OF TABLES</b>	<b>xiv</b>
	<b>LIST OF ABBREVIATION</b>	<b>xv</b>
<b>1.</b>	<b>INTRODUCTION</b>	<b>1</b>
	1.1 Introduction	1
	1.2 Problem Statement	2
	1.3 Project Objectives	3
	1.4 Scope of The Project	2
	1.5 Thesis Outline	3

<b>2.</b>	<b>LITERATURE REVIEW</b>	<b>4</b>
2.1	Introduction	4
2.2	Multi-Rotor UAV	5
2.3	Flight Control of Quadcopter	5
2.4	Brushless DC Motor (BLDC)	7
2.4.1	Formulas to Calculate Static Thrust	8
2.4.2	Formula to Calculate Power	8
2.4.3	Formula to Calculate Flight Duration	8
2.5	Electronic Speed Controller (ESC)	9
2.6	Propeller	11
2.7	Lithium Polymer (LiPo) Battery	12
2.8	Inertial Measurement Unit (IMU)	14
2.9	Transmitter and Receiver	15
2.10	Arduino Uno as Flight Controller	16
2.11	Blynk as Medium for IoT Application	19
<b>3.</b>	<b>METHODOLOGY</b>	<b>21</b>
3.1	The Overall System Design	22
3.2	Methodology Process	23
3.2.1	Design Arduino as Flight Controller	25
3.2.1.1	Setup	25

3.2.1.2	Checking Receiver Input and MPU-6050	26
	Signal	
3.2.1.3	Vibration Test	29
3.2.1.4	Measuring Air Speed	31
3.2.2	Designing IoT Application via Blynk Platform	33
3.2.3	Combine Arduino Uno as the Flight Controller with IoT Application via Blynk Platform	37
<b>4.</b>	<b>RESULTS AND DISCUSSIONS</b>	<b>38</b>
4.1	Flow of the System	38
4.2	Circuit Design	39
<b>5.</b>	<b>CONCLUSION AND RECOMMENDATION</b>	<b>59</b>
5.1	Conclusion	59
5.2	Recommendation	59
	<b>REFERENCES</b>	<b>60</b>
	<b>APPENDICES A-B</b>	<b>63 - 91</b>

## LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
Figure 2.1	Block Diagram of The System	4
Figure 2.2	Quadcopter frame with propeller and rotor velocity configurations [17]	6
Figure 2.3	Basic movement of quadrotor [18]	6
Figure 2.4	BLDC Motor	7
Figure 2.5	Transfer of power through propulsion components [19]	10
Figure 2.6	HW 30A Electronic Speed Controller (ESC)	10
Figure 2.7	8x45 Propellers	11
Figure 2.8	10x45 Propellers	12
Figure 2.9	11.1 V LiPo Battery	13
Figure 2.10	Accelerometer	14
Figure 2.11	Gyroscope	14
Figure 2.12	MPU 6050 module	15
Figure 2.13	FLYSKY FS-i6 Transmitter and FS-IA6 Receiver	16
Figure 2.14	The Arduino UNO Board	17
Figure 2.15	Other Arduino Boards	18
Figure 2.16	Wifi Module (ESP8266)	20
Figure 2.17	Blynk Logo	20
Figure 3.1	The Overall Block Diagram of the IoT Quadcopter System	22
Figure 3.2	The Overall Process Methodology)	24
Figure 3.3	Process of Methodology of Setup	26
Figure 3.4	Checking Receiver Input and MPU-6050 Signal	28
Figure 3.5	Vibration Test	30
Figure 3.6	Measuring Air Speed	32
Figure 3.7	IoT Application	33
Figure 3.8	Blynk Installation	34
Figure 3.9	Email Log-In	35
Figure 3.10	Create New Project	36
Figure 3.11	Naming the Project	36
Figure 3.12	Hardware Selection	37
Figure 4.1	Flow of The System Process	38

Figure 4.2	Finalized IoT Quadcopter Circuit Design	39
Figure 4.3	Voltage Regulator Circuit	40
Figure 4.4	Top View of Prototype Before Combine Process	40
Figure 4.5	Top View of Prototype After Combine Process	41
Figure 4.6	Side View of Prototype After Combine Process	41
Figure 4.7	Error Setup Result	43
Figure 4.8	Final Setup Result	44
Figure 4.9	Error on Gyro Setup	44
Figure 4.10	Final Gyro Setup	45
Figure 4.11	Error Gyro Axes Configuration	45
Figure 4.12	Final Gyro Axes Configuration	46
Figure 4.13	EEPROM Saved	46
Figure 4.14	Receiver Signals	47
Figure 4.15	Movement for the Angle Check	47
Figure 4.16	Angle Check	48
Figure 4.17	Vibration Test Position	49
Figure 4.18	Test Motor 1	49
Figure 4.19	Test Motor 2	50
Figure 4.20	Test Motor 3	51
Figure 4.21	Test Motor 4	51
Figure 4.22	Test All Motor	52
Figure 4.23	Measuring Air Speed Using Anemometer	53
Figure 4.24	Graph Air Speed (m/s) vs Throttle Percentage on Transmitter (%) For 8x45 Propeller	54
Figure 4.25	Graph Air Speed (m/s) vs Throttle Percentage on Transmitter (%) for 10x45 Propeller	55
Figure 4.26	Coding Implementation	56
Figure 4.27	ESP8266 connect with Voltage Regulator Circuit	57
Figure 4.28	Configuration of “Display Settings” in Blynk apps	57

**LIST OF TABLES**

<b>TABLE NO.</b>	<b>TITLE</b>	<b>PAGE</b>
Table 4.1	Air Speed (m/s) vs Throttle Percentage on Transmitter (%) For 8x45 Propeller	54
Table 4.2	Air Speed (m/s) vs Throttle Percentage on Transmitter (%) for 10x45 Propeller	55

## LIST OF ABBREVIATION

UAV- Unmanned Aerial Vehicle

IoT- Internet of Things

RF- Radio Frequency

ESC- Electronic Speed Controller

LiPo- Lithium Polymer

IMU- Inertial Measurement Unit

BLDC- Brushless DC

DC- Direct Current

AC- Alternating Current

PPM- Pulse Position Modulation

PWM- Pulse Width Modulation

CW- Clock Wise

CCW-Counter Clock Wise



## CHAPTER 1

### INTRODUCTION

#### 1.1 Introduction

A quadcopter is an aerial vehicle with four rotors and famously known as “drone” at these day. The first designs made for manned flight was introduced in the beginning of the 20th century. Today, quadcopters are almost exclusively unmanned, small, electrical and used as hobby toys or within research. Over the last few years we have seen a massive growth in the manufacture and sales of remote control airborne vehicles known as Quadcopters. These Unmanned Aerial Vehicles have four arms and fixed pitch propellers which are set in an X or + configuration with X being the preferred configuration [18].

IoT (Internet of Things) can be defined in simple words as a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction [22]. Hence this IoT quadcopter enable the user to analysis the angular rate using the sensor that being used in the quadcopter. The microcontroller, Arduino Uno, that built as the quadcopter’s flight controller creates a new element in building the quadcopter which enable the user to create their own flight controller.

## 1.2 Problem Statement

Nowadays quadcopter or well known as “drone” technology is widely use RF transmitter to control the quadcopter itself. This type of controller give a threat to the user as it can be easily hacked by other parties. This IoT quadcopter which based on the Arduino Uno as the flight controller offer a less threat for being easily hacked by the third party. Next, most of the apps in the market did not have the ability to analysis the angular rate. Hence, through IoT application, angular rate of the quadcopter can be determined easily.

## 1.3 Project Objectives

The project objectives are follows:

- i. To create a flight controller using Arduino Uno microcontroller.
- ii. To analysis the angular rate through IoT application.

## 1.4 Project Scope

The project scopes are as follows:

- i. This project will need to design a quadcopter with a frame, brushless motors, propellers, ESC (electronic speed controller), Transmitter and Receiver and LiPo battery.
- ii. This main focus on this project is on building the flight controller using the Arduino Uno that connected with MPU 6050 module and Wifi module, ESP8266.
- iii. An analysis of angular rate of the quadcopter can be determined by the application of the IoT using the Blynk apps.

## **1.5 Thesis Outline**

This report consists of five chapters that described the project of Design and Development of IoT Quadcopter Using Microcontroller. In the first chapter, the objective and scope of this project and problem statement is discussed. While Chapter 2 will discuss more on theory and literature reviews that have been done, this includes a brief introduction to Arduino UNO, brushless motors, and further explanation about the standard in detail.

In Chapter 3, the discussion is about the methodology of the project, which includes the hardware and software implementation of the project. The result and discussion will be presented in Chapter 4. Last but not least, Chapter 5 discusses the conclusion of this project and future work that can be done.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Introduction

The project is needed to design and develop an IoT quadcopter using microcontroller. Four brushless motors with four propellers, four ESC, quadcopter frame, LiPo battery, receiver and transmitter will be used to build a quadcopter. This project also will be using a wifi module (ESP8266) to connect with the Arduino Uno that act as a flight controller. IMU (Inertial Measurement Unit) that consists gyroscope and accelerometer sensor also will be used in this project. This IMU will provide the analysis of the angular rate through the IoT application via the Blynk apps created.

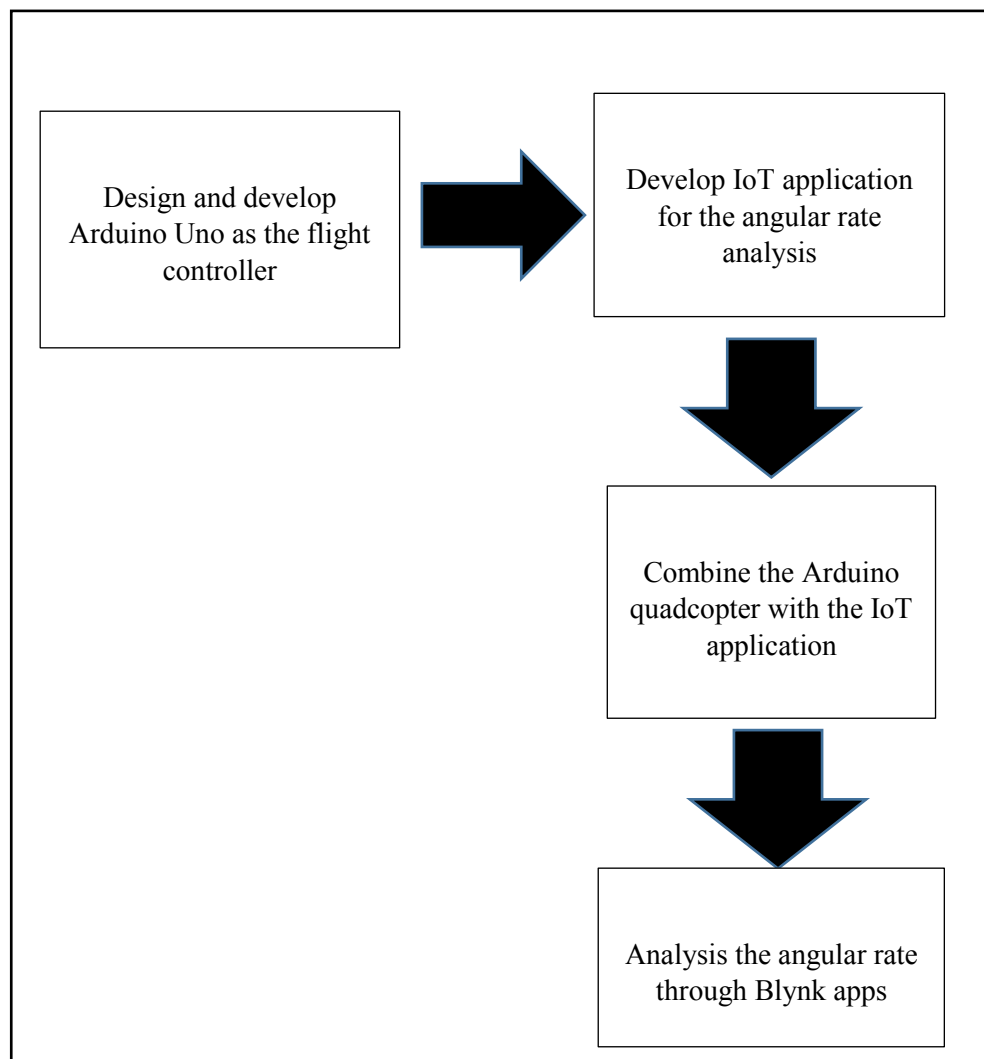


Figure 2.1: Block Diagram of The System

## **2.2 Multi-Rotor UAV**

Multi-rotor UAV utilizes differential thrust management of independent motor and propeller units to provide lift and directional control. The multi-rotor UAV which is also known as Multi-copter can be defined as variable flying multi-propeller platform. The variability is ensured by a puzzle construction which allows the designer to use any number of arms with propulsion drives. The large scale of small UAV applications has increased vastly with the past few years as an aid to provide the capabilities of more complex and expensive manned systems. These small UAVs are most suitable for jobs that too dirty, dangerous or dull for a human, thus, showing capabilities of market potential in the years to come. Among various types of UAVs, quadrotor platforms namely Quadcopter have been extensively used in Research and Development area to test algorithms and techniques due to their simplicity, ease of use and maintenance and low cost.

## **2.3 Flight Control of Quadcopter**

In contrast to a classical helicopter with main and tail rotor, a Quadcopter is propelled by four horizontal rotors directly attached to the airframe. The Quadcopter motion is controlled by the thrust generated by individual propellers regulated by the motor velocity [17].

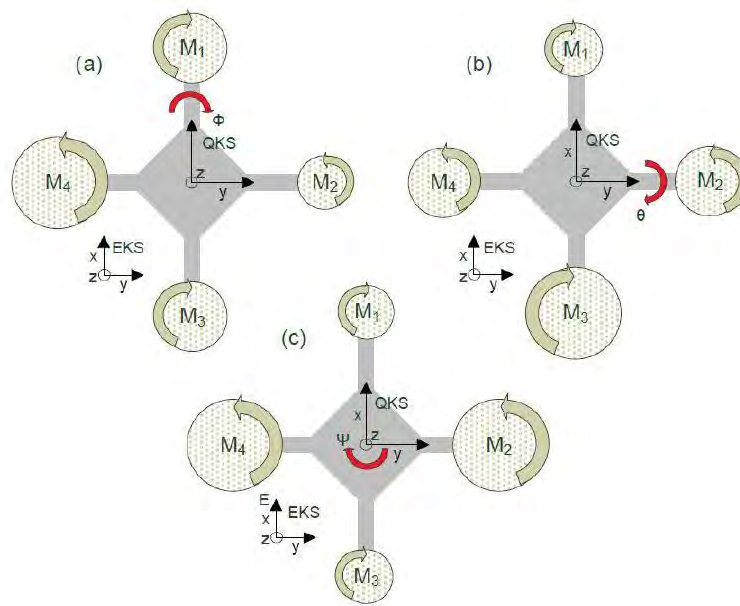


Figure 2.2: Quadcopter frame with propeller and rotor velocity configurations [17]

Figure 2.1 shows the Quadcopter body frame and the external frame, the location of propellers and combination of rotor velocities to independently generate roll (a), pitch (b) and yaw (c) motion. The Quadcopter six degrees of freedom are controlled by the four motors resulting in an under-actuated system. Figure 2.3 shows the basic movements of a quadrotor.

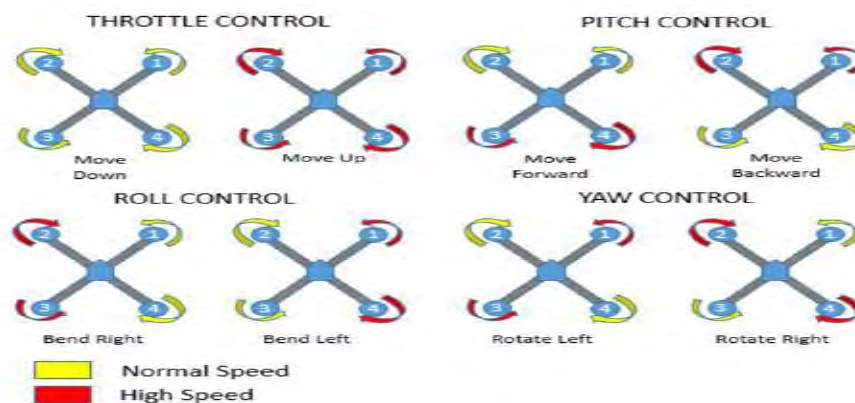


Figure 2.3: Basic movement of quadrotor [18]

## 2.4 Brushless DC Motor (BLDC)

Brushless DC Motor is also known as electronically commutated motors (ECMs). It is a synchronous motors that are powered by a DC electric source via an integrated inverter or switching power supply which produces an AC electric signal to drive the motor. Brushes used in shunt DC motors are not needed in brushless DC motors, therefore the maintenance costs are reduced. BLDC motors change the current direction by means of electronic commutation through switching electronics. The electronic commutation is done by the switch mode DC to AC converters by using Electronic Speed Controller (ESC) .For a safety margin and sufficient agility of a multi-rotor, demands a thrust weight ratio of about 2:1[19]. The suitable brushless DC motor, propellers and battery must be selected because it might cause the multi-rotor unable to lift or lift for a very short duration. The formulas in section 2.4.1, 2.4.2 and 2.4.3 are taken from The Electric Motor Handbook by Bob Boucher [16].

The advantages of using BLDC are is has better speed versus torques characteristics, high efficiency with noise less operation and very high speed range with longer life. The KV rating refers to how many RPM it turns per volt. The KV rating on a BLDC motor is equal to RPM applied to the motor and in this project, 1000KV rating will be used. The 1000KV will spin at 1000 RPM when 1 volt is applied.



Figure 2.4: BLDC Motor

### 2.4.1 Formulas to Calculate Static Thrust

$$F = m a \times 2 / N \quad (1)$$

Where, m = mass of multi-rotor

N = number of propellers providing the lift thrust

F = Static thrust required

$$F = 4.392399 \times 10^{-8} \cdot RPM \cdot d^{3.5} \sqrt{pitch} (4.2333 \times 10^{-4} \cdot RPM \cdot pitch - V_o)$$

Where, RPM = speed of motor in rev/min

d = diameter of propeller in inch

pitch = pitch of propeller in inch

$V_o$  = initial velocity of multi-rotor UAV

### 2.4.2 Formula to Calculate Power Drawn by Motor

$$P = K_p \cdot D^4 \cdot PITCH \cdot RPM^3 \quad (3)$$

Where, P = power drawn by brushless DC motor

$K_p$  = propeller constant

D = diameter of propeller in feet

PITCH = pitch of propeller in feet

RPM = RPM in thousands (RPM/1000)

### 2.4.3 Formula to Calculate Flight Duration

$$FD = 60 (BC) / I_{required} \quad (4)$$

Where, FD = flight duration in minutes

BC = battery capacity in mAH

$I_{required}$  = current drawn by motor