

**STABILITY CONTROL FOR QUADCOPTER WITH AN AUTONOMOUS
FLIGHT SYSTEM**

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA
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PROJEK SARJANA MUDA II

Tajuk Projek : STABILITY CONTROL FOR QUADCOPTER WITH AN
AUTONOMOUS FLIGHT SYSTEM

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I'm dedicated this to my family, especially my mother who always supported me.
Also to those who are always on my side which is my brother and sisters, my
nephews, lectures and all my friends.

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ABSTRACT

The final year project is a compulsory subject for engineering students towards completing the Bachelor Degree program. The final year project is determine to examine students what have they learned in four years at university, thus relates the theoretical and technical knowledge with the application in the final year project. Throughout the final year project, students were expected to successfully enhancing their skills in technical, communication, management time, creativity as well as able to give personal ideas or opinions.

Unmanned Aerial Vehicles (UAV) are becoming more and more popular in a multitude of fields, including but not restricted to military applications, corporate and academic research as well as personal hobbies. Many of these projects are constrained by high costs (military), or limited practical use (hobbies). The main goal of this project is to create lightweight flyer that can maintain a steady altitude in flight, fly in accordance to a pre-set flight path, has a simple interface for controlling, and has the capability to carry a payload. The quadcopter is to be used by any user capable of responsibly using the flyer. Therefore, a design and controller based on a beginner-level pilot's skills are essential to the project. To accomplish this, the quadcopter will use various technologies, including an Arduino microcontroller interfaced with an array of sensors, infrared sensors; communicate with radio frequency.

This report covers the design, analysis, manufacturing and testing of an autonomous quadcopter. A control system was designed and implemented through the use of an onboard microprocessor and inertial measurement system. The goal of

the helicopter was to maintain a hover at a user-defined altitude while minimizing lateral drift. In addition to achieving autonomous flight, the helicopter attained a 10% weight reduction from an earlier quadcopter design and which led to an increased flight time.

As an overview, this report consists of three chapters. Chapter 1 is an introduction about quadcopter. Chapter 2 is a literature review on quadcopter. Followed by chapter 3, consists of the details of the methodology.

ABSTRAK

Projek tahun akhir merupakan mata pelajaran wajib bagi pelajar kejuruteraan untuk melengkapkan program Ijazah Sarjana Muda. Projek tahun akhir menentukan dan memastikan pelajar apa yang telah mereka pelajari dalam tempoh empat tahun di universiti, sekali gus mengaitkan pengetahuan teori dan teknikal dengan permohonan dalam projek tahun akhir. Sepanjang projek tahun akhir, pelajar dijangka berjaya meningkatkan kemahiran mereka dalam bidang teknikal, komunikasi, pengurusan masa, kreativiti, serta mampu untuk memberi idea atau pendapat peribadi.

Kenderaan Udara Kawalan Jauh (UAV) telah menjadi lebih dan lebih popular dalam pelbagai bidang, termasuk tetapi tidak terhad kepada aplikasi tentera, penyelidikan korporat dan akademik serta hobi peribadi. Banyak projek-projek ini dikekang oleh kos yang tinggi (tentera), atau penggunaan terhad praktikal (hobi). Matlamat utama projek ini adalah untuk mewujudkan flyer ringan yang boleh mengekalkan ketinggian dalam penerbangan yang stabil, terbang mengikut laluan penerbangan pra-set, mempunyai antara muka yang mudah untuk mengawal, dan mempunyai keupayaan untuk membawa muatan yang. Quadcopter adalah untuk digunakan oleh mana-mana pengguna mampu bertanggungjawab menggunakan flyer. Oleh itu, reka bentuk dan pengawal yang berdasarkan kemahiran juruterbang baru-tahap ini adalah penting untuk projek itu. Untuk mencapai ini, quadcopter akan menggunakan pelbagai teknologi, termasuk mikropengawal Arduino diantaramukakan dengan pelbagai sensor, sensor inframerah; berkomunikasi dengan frekuensi radio.

Laporan ini adalah meliputi reka bentuk, analisis, pembuatan dan menguji quadcopter berautonomi. Satu sistem kawalan telah direkabentuk dan dilaksanakan melalui penggunaan mikropemproses atas kapal dan sistem pengukuran inersia. Matlamat helikopter adalah untuk mengekalkan 1 hover pada ketinggian yang digunakan jelas manakala meminimumkan hanyut sisi. Di samping itu untuk mencapai penerbangan autonomi, helikopter mencapai berat pengurangan sebanyak 10% daripada reka bentuk quadcopter awal dan yang membawa kepada masa penerbangan meningkat.

Sebagai gambaran keseluruhan, laporan ini terdiri daripada tiga bab. Bab 1 pengenalan tentang quadcopter. Bab 2 adalah kajian literatur quadcopter. Diikuti oleh bab 3, terdiri daripada butir-butir metodologi.

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LIST OF AMBREVIATIVES

A/D	-	Analog to Digital
DC	-	Direct Current
EEPROM	-	Electrically Erasable Programmable Read-Only Memory
Emf	-	Electromotive Force
GND	-	Ground
I/O	-	Input/Output
I2C	-	Inter-Integrated Circuit
IC	-	Integrated Circuit
ICSP	-	In Circuit Serial Programming
IR	-	Infrared Radiation
LED	-	Light Emitting Diode
NC	-	Normally Close
NO	-	Normally Open
PWM	-	Pulse Width Modulation
SPI	-	Serial Peripheral Interface

CHAPTER 1

INTRODUCTION

This project is to create an unmanned aerial vehicle (UAV) with the ability to wirelessly relay real-time information to a base station and simultaneously receive instructions directing a quad-rotor to its next task. The quad-rotor design UAV will be able fly to a location that been control by ground station, then patrol a predefined perimeter and wirelessly alert a base station with a camera. The UAV will also be able to maintain a hover at a used-defined altitude and avoid obstacle. The quad-rotor will consist of four motors attached to electronic motor controller in order to communicate with the microprocessor, with which will can control the speed of each individual motor. By controlling the speed of each motor we are able to generate upwards and downward acceleration of the UAV. Then we generate algorithms using an onboard accelerometer to measure the pan, and tilt of the UAV which the microprocessor would read and then appropriately control each motor to perform the given task. Using a four motor quad-rotor design we are able to change directions, elevation, and tilt by simply manipulating how much voltage goes into the motors

while the UAV is in the air. We will also be able to integrate a whole array of sensors into our UAV that will guide it away from obstacles, some of which include ultrasonic sensors and infrared sensor that detect where the ground is, and also ultrasonic sensors that can see objects and guide our UAV on a different path. This UAV will implement the use of a wireless module in order to communicate with a base station. We will be able to see real time flight by attached a camera and managed to see the whole activity. The goal of this project is to make this UAV hover and managed to fly with stabilize and collision avoidance.

1.1 Problem Statement

The control system of conventional helicopter is complex as compared to the proposed Quadcopter control system. In the proposed design every rotor plays a role in direction control and balance of the Quadcopter as well as lift, unlike the traditional single rotor helicopter designs in which each rotor has a specific task - lift or directional control - but never both [1].

Today there are alternatives to remote-sensing with airplanes or helicopters. Small autonomous flying vehicles can monitor the environment. A light-weighted, affordable version of a drone is for example a quadcopter, a vehicle similar to a helicopter but equipped with four upright oriented rotors of equal size. Quadcopters offer the same flight capabilities as usual helicopters and are therefore capable of vertical takeoff and landing. At the same time, because all flight maneuvers are achieved just by individual controlling of the four rotor speeds, quadcopters don't need any mechanic components [4].

Quadcopters were very hard to realize or at least very hard to control. The quadcopter is inherently unstable; therefore simultaneous individual control of each of the four motors is necessary to achieve a stable flight attitude [3]. This is a complex problem, which could only be solved using recent progresses in the fields of control engineering and microcontroller technologies [1]. The control of quadcopter

during autonomous flights relies on knowledge of variables like position, velocity and orientation, which to make this stable in the air we must use suitable sensors [3].

The main goal of this project is to create lightweight flyer that can maintain a steady altitude in flight, fly in accordance to a pre-set flight path, has a simple interface for controlling, and has the capability to carry a payload. The quad-copter is to be used by any user capable of responsibly using the flyer. Therefore, a design and controller based on a beginner-level pilot's skills are essential to the project.

1.2 Objective

The objective of this project is radically modifies the design of a conventional helicopter. Besides that, this project will create the talent of student to apply their knowledge in this final year project. The objectives and goals of this project are:

- To understanding the behaviors of quadcopter hover and are able to control by ground station.
- To getting the quadcopter in the air in stable flight.
- To learned the controlling the quadcopter with the flight system.
- To learned implementing gyroscope and accelerometer in the quadcopter.

1.3 Scope of the Project

This project will focus on hardware and software for this quadcopter. In this project, I will design it with a frame of quadcopter which can support to hover and suitable aerodynamic specification. I have to find main part of this quadcopter which

is motor, propeller, electronic speed controller (ESC), the flight controller, transmitter and receiver and battery. The flight controllers have four component which is arduino (atmega), stabilizer, accelerometer and logic converter. These main components that I am using in this project which are include:

- Make quadcopter hover and be able to control by ground station (Remote Control).
- Involves getting the quad-copter in the air in stable flight.
- Make quadcopter an autonomous.(Laptop as a ground station)
- Integrate software for the flight system; the processors will implement a high-level language to process commands and for fast debugging.

1.4 Motivation of the Work

The proposed project radically modifies the design of a conventional helicopter. The following benefits highlight why there is need to change the design;

1. To Simplify the Control Mechanism
2. To Lift More Payload
3. Stability
4. Safety Critical Operation

1.5 Project Methodology

In this part, I have cover five main things to finish my project which are description of methodology, hardware design, hardware simulation, hardware development and hardware testing. The below will be the main topic and sub topics that will be further elaborated in the project.

1.5.1 Description of Methodology

- Literature review
- Study about quadcopter
- Study about basic operation motor
- Study about electronic speed controller
- Study about aerodynamic
- Study about modeling of quadcopter
- Study about algorithm in flight control
- Study about stabilize sensor

1.5.2 Hardware Design

- List all the particular components and tools for the project
- Design a frame
- Design the minimum weight of the frame
- Design the overall operation of the quadcopter
- Design the diagram of the project components connection in flight control