HARDWARE DESIGN OF THE AUTONOMOUS HELICOPTER FOR STABILIZATION CONTROL

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Dedicated to my family, specially to my beloved mother, father and sisters, my lectures and lastly my friends.

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ABSTRACT

This thesis presents the practical design approach on the stabilization of autonomous helicopter. The common problem of the helicopter is unstable. The helicopter will keep on rotating along the Y axis from clockwise to anticlockwise and vice versa as it lift and hover. Therefore, an approach comes out to solve its stability problem is to introduce the integration of an accelerometer into the helicopter's circuit.

A control board which is powered by microcontroller PIC16F877A is used to control the behavior of the helicopter autonomously. The control board will be attached to the bottom of the helicopter with connection to the top rotor, bottom rotor and tail rotor motor. The wire is keep as shorter as possible to avoid any mechanical trap during rotation of helicopter rotor.

The PIC16F877A is programmed to test the helicopter movements in two stages that is test the helicopter with and without the integration of accelerometer. For testing with integration of accelerometer, the helicopter will react accordingly to the different accelerometer values in X and Y axis. Therefore, the particular accelerometer values need to be set in the microcontroller programming so that the helicopter will performs the basic movements that is hover, forward, backward, turn left and turn right respectively. For testing without integration of accelerometer, the helicopter also do the basic movements as mention above but without referring the accelerometer values. The coding in the microcontroller is preset with the movements. Each stage of movement is differentiated with the delay of 5 seconds. The experimental results are consists of ±2% of errors from the expected results. If the error percentage is within the range, then the objective of the project is achieved.

ABSTRAK

Kajian ini membentangkan pendekatan projek reka cipta yang praktikal tentang Stabilisasi helikopter secara autonomi. Masalah umum helicopter adalah tidak stabil. Helikopter itu akan terus berputar sepanjang paksi Y dari arah ikut jam ke arah melawan jam dan sebaliknya semasa mengapungkan dirinya. Oleh sebab itu, satu pendekatan dikaji untuk menyelesaikan masalah kestabilan dengan mengintegrasikan accelerometer ke rangkaian helikopter.

Satu papan kawalan dipasang dengan micropengawal PIC16F877A digunakan untuk mengawal perilaku helikopter secara autonomi. Papan kawalan itu akan dilekatkan pada bahagian bawah helikopter dengan sambungan dawai ke motor rotor atas, rotor bawah dan rotor ekor. Dawai mesti dikemaskan sependek yang mungkin untuk mengelakkan dawai diperangkap semasa pusingan rotor helikopter.

PIC16F877A diprogramkan untuk menguji pergerakan-pergerakan helikopter dalam dua peringkat iaitu menguji helikopter dengan dan tanpa integrasi accelerometer. Untuk pemeriksaan dengan integrasi accelerometer, helikopter akan bertindak balas mengikuti nilai-nilai accelerometer yang berbeza dalam paksi X dan paksi Y. Antarannya, nilai-nilai accelerometer tertentu akan dimasukkan dalam pengaturcaraan mikropengawal supaya kehendak helikopter menjalankan pergerakan-pergerakan asas yang terapung, ke hadapan, ke belakang, belok ke kiri dan belok kanan dengan masing-masing. Untuk pemeriksaan tanpa integrasi accelerometer, helikopter turut melakukan pergerakan-pergerakan asas seperti disebut di atas dengan tanpa merujuk nilai-nilai accelerometer. Keputusan eksperimen mempunyai ± 2% kesalahan ralat daripada keputusan yang dikirakan. Jika peratusan ralat adalah dalam julat kesalahan ralat, maka boleh dikatakan objektif kajian telah dicapaikan.

TABLE OF CONTENT

LIST OF TABLE

LIST OF FIGURE

LIST OF ABBREVIATIONS

CPU	-	Central Processing Unit
DC	-	Direct Current
ERC	-	Electronic Design Rule
USB	-	Universal Serial Bus
mAH	-	milliampere-hour
GND	-	Ground
LED	-	Light Emitting Diode
LiPo	-	Lithium Polymer
MCLR	-	Mode to clear
NiCd	-	Nickel Cadmium
NiMH	-	Nickel Metal Hydride
PIC	-	Programmable Interface Controller
DIP	-	Dual in-line Package
PWM	-	Pulse-Width-Modulation
RISC	-	Reduced Instruction Set Computer

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

Chapter one states the objectives of hardware design of the autonomous helicopter for stabilization control. A roughly background in this research field will be introduced. Next, scopes of thesis listed in this chapter will layout the related topic. Problem statement will clarify problem faced in this field. Lastly, organization of thesis describes the structure of all five chapters.

1.0 Introduction

Helicopter is classified as rotorcraft to differentiate them from fixed-wing aircraft such as airplane because the helicopter uses one or more horizontal rotors to lift up. The rotor which rotates around a mast consists of two or more rotor blades. The main advantage of a helicopter is it can easily take off and land without a runway with the rotor which provides lift without the needing to move forward. Therefore, it often used in congested or isolated areas as fixed-wing aircraft cannot take off or land. Besides, the lift from the rotor allows it to hover in one area more efficiently than other types of vertical takeoff and landing aircraft besides accomplish tasks that fixed-wing aircraft cannot perform [1]. RC helicopter can be regarded as a model to an actual helicopter as they have similarities in system architecture. However, RC helicopter is not stable when it lifts up as the original design is unbalanced and asymmetric in weight. Therefore, some improvements must carry on

the current hardware design to ensure the helicopter is balance and stable. A stable RC helicopter is relatively important in some applications such as collecting data on the terrain conditions. Without a stabilizing system applied in the helicopter, the data collecting and transferring process will be simply impeded by some environment factors such as wind. Therefore, some action need to be taken to obtain some finding based on monitoring and controlling the stability of RC helicopter.

1.1 Problem Statement

Conventional Radio-Controlled (RC) helicopter is usually designed with a main rotor with two blades attached to it as shown in Figure 1.1. Such RC helicopter is hard to control due to its design is a simplified design of the original helicopter. The design is not as sophisticated and robust as original helicopter design. Besides, it is hard to control and unstable when it move forward or backward, turn left or right and even make a hovering in an area. Therefore, it needs a wider space for it to hover on an area. Furthermore, it is also easily distorted by environmental factors such as wind due to the unstable and asymmetry weight design. The helicopter will not able to hover in one place when the wind is strong. Therefore, an autonomous helicopter with stabilization system is the best alternative to solve it.

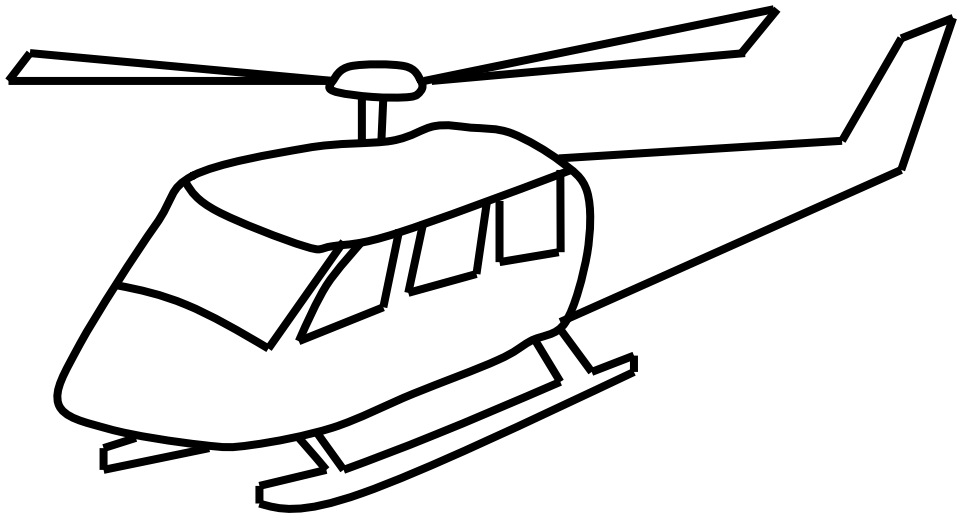

Figure 1.1: Single Rotor Helicopter with Two Blades

1.2 Objectives

The main purpose of this project is to design the hardware of the autonomous helicopter for stabilization control. Therefore, the objectives as below should be achieved.

i. To study the hardware design of the conventional helicopter by identifying the helicopter's parts functionality in contributing a helicopter system
ii. To design the helicopter to react autonomously by implementing the functional program in C programming language into the microcontroller, PIC16F877A which as the core of the autonomous system.
iii. To improve the control and stability of the helicopter by redesign the hardware parts in symmetric weight condition with integrated stability sensor
iv. To analyze the stability sensor data by the microcontroller and provide the proper feedback to the rotor movement

1.3 Scope of Work

The scopes of works in this project are:

i. Design the helicopter based on coaxial helicopter model which is a double rotor with each rotor attached to 2 blades
ii. PIC16F877A as the microcontroller is programmed in C language environment to control the behavior of helicopter
iii. The stability sensors, accelerometer plays an important role in providing the helicopter's stability condition to the microcontroller for further and thus control its rotor movement in order to achieve stable state

1.4 Brief Explanation of Methodology

First of all, this project is started by discussing about the helicopter concepts and ideas and its importance of the project with supervisor. Then, a lot of research is carried on by referring various sources such as reference book, journals, datasheet for the literature review stage. Follow on is the suitable helicopter components will be identified and selected for this project. On next stage, the Proteus software will be used to create and simulate the virtual circuit of the main core of the helicopter. After that, the hardware of the helicopter will be assembled according to the design set previously. The, the helicopter system will be test to evaluate it's functionally to identify if the system fulfill the project's requirements and specifications. If the project meet the requirements, then it is a success project and if fail to meet the requirements, an immediate troubleshooting action will be carried on to identify the problems and solve it.

1.5 Importance of Project

At the end of the project, the helicopter with coaxial design will be more stable and capable than the conventional helicopter designs. It will far more stable when it encounters some unexpected external disturbance such as environmental factor that is wind.

Besides, the helicopter can react autonomous with relate to the current stability state of the helicopter through real-time feedback from accelerometer which is also known as a stability sensor. The microcontroller, PIC16F877A which is programmed in C language environment is plays an important role in analyzing the data gets from the stability sensors and recalculate the output voltage for the rotor movement to enable the helicopter reach the stability state.

Furthermore, the helicopter also able to hover in an area constantly compared to the conventional helicopter. Therefore, it only needs a narrow space for it to hover and land in an area. In addition, the helicopter flying time also extended due to more

robust rechargeable battery source is used. It is a great improvement compared to the previous design and this project solely for educational purpose.

1.6 Report Structure

Chapter one will bring out introduction of hardware design of the autonomous helicopter for stabilization control. First part of thesis will bring out clear cut of objective, scope, problem statement of the thesis. Basic introduction and historical background will layout on first pages of chapter one.

Next chapter will explain detail in literature review. Works done by preview researchers in this area will bring out and discussed here. Overviews of helicopter components and the hardware needed will be presented in this chapter.

Chapter three is related with the flow chart diagram of the project methodology. Besides, it also includes the hardware design methodology flow chart and system block diagram.

Chapter four consists of the result including result get through experiments. There are total three experiments carried on to test the components' performance and functionality.

Chapter five is related to validation of data. The value of result from chapter four will be taken for 30 times to validate the results.

Finally, in chapter six is conclude the works. Future recommendations also explained in this chapter.

CHAPTER II

LITERATURE REVIEW

This chapter consists of literature review on theoretical concepts applied in this project. The chapter introduces helicopter project background, helicopter rotors concepts, stability sensor, microcontroller PIC16F877A and power source.

2.0 Project Background

A helicopter is defined as an aircraft where the lift is generated by rotating blades. Autonomous Helicopter means that the helicopter able to fly on its own no man control its decision making in movement and actions and is purely based on the programming set in its Central Processing Unit (CPU). It can perform the basic movement of helicopter that is forward, backward, turn left and turn right autonomously based on pre-programmed microcontroller command.

2.1 Hardware Components

This section will list out and explain all the hardware components used in helicopter. There are a lot of components involved in constructing the circuit that are microcontroller PIC16F877A, motor driver L293B, appropriate resistor and capacitor