A MAGNETIC CHARGING CONNECTION FOR A QUADCOPTER DRONE

AHMAD HARIZ BIN AZMI

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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AHMAD HARIZ BIN AZMI

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DECLARATION

I declare that this project report entitled "A magnetic charging connection for a quadcopter drone" is the result of my own work except as cited in the references

Signature : ....

Name : AHMAD HARIZ BIN AZMI

Date : 15 JULY 2021

APPROVAL

I hereby declare that I have read this project report. In my opinion, this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Honours.

Signature	:	....
Supervisor's Name	:	DR. SHAMSUL ANUAR BIN SHAMSUDIN
Date	:	15 JULY 2021

DEDICATION

I dedicate this work to my family and many friends. A special feeling of gratitude to my loving parents, Azmi Ahmad and Haswa Hashim, whose words of encouragement and push for tenacity ring in my ears. I also dedicate this dissertation to my many friends who have supported me throughout the process. I will always appreciate all they have done.

ABSTRACT

Drones, or Unmanned Aerial Vehicles (UAV), have become increasingly popular among enthusiasts and businesses alike. They are also utilized for surveillance in law enforcement, agricultural preservation in farming, monitoring of poaching of wild animals, and acquiring special effects in movies and sports videos. Despite its heavy weight and long charge time, the battery is used by many drones. The average life for drone battery is 20 minutes. This project involves designing the product development process and developing a Wireless Power Transfer (WPT) charging system for a quadcopter drone using magnetic resonant coupling. This project proposes a method for designing primary and secondary coils. The principal circuit in the charging station is made up of circular coils to counteract the negative impacts on the coupling factor caused by possible coil misalignment due to a bad landing. There are many benefits of the Wireless Power Transfer (WPT), such as simple design, low cost, and increased product life. A commercial drone, which is an E99 Pro drone, is used to test a WPT system demonstrator prototype. The electrical capabilities of the WPT are computed and measured at the end of the project. A simulation of the circuit has been tested using Simulink (MATLAB) to check component connection. The charging system produced a maximum output power of 4 W with less than 50% efficiency. An 850 mAh LiPo drone battery took about 2-3 hours to fully charge wirelessly. The transmitter and receiver coil wound has a total of 15 turns, and the diameter of the coil is 1mm. A magnetic enameled coil is used in this project. An 6-8 W series resonant wireless power transmission system was constructed in this project. With high efficiency of 65.3%, the WPT can charge the same drone battery in less than 1.5 hours. Finally, an automatic battery charging station is constructed.

ABSTRAK

*Dron, atau kenderaan udara tanpa pemandu, menjadi semakin popular di kalangan peminat dan perniagaan. Mereka juga digunakan untuk penguatkuasaan undang-undang, pemeliharaan pertanian, pemantauan perburuan binatang liar, dan memperoleh rakaman video dan gambar dalam acara sukan. Walaupun beratnya berat dan masa pengisian yang lama, bateri digunakan oleh banyak drone. Purata keseluruhan jangka hayat bateri drone adalah 20 minit. Projek ini melibatkan perancangan proses pengembangan produk dan mengoptimumkan sistem pengecasan "Wireless Power Transfer (WPT)" untuk dron quadcopter menggunakan kopling resonan magnetik. Prosedur untuk reka bentuk gegelung primer dan sekunder dicadangkan dalam projek ini. Litar utama di stesen darat terdiri dari gegelung bulat untuk mengatasi kesan negatif pada faktor gandingan yang disebabkan oleh kemungkinan penyelarasan gegelung akibat pendaratan yang buruk. Terdapat banyak kelebihan "Wireless Power Transfer (WPT)", seperti reka bentuk ringkas, kos rendah, dan peningkatan jangka hayat produk. drone komersial, yang merupakan dron E99 Pro, digunakan untuk menguji prototaip sistem WPT. Keupayaan elektrik WPT dihitung dan diukur pada akhir projek. Simulasi litar telah diuji menggunakan Simulink (*MATLAB*) untuk memeriksa sambungan komponen. Sistem pengecasan menghasilkan daya output maksimum 4 W dengan kecekapan kurang dari 50%. Bateri dron LiPo 850 mAh mengambil masa 2-3 jam untuk dicas sepenuhnya tanpa wayar. Gegelung pemancar dan penerima telah dililit sebanyak 15 putaran, dan diameter wayar gegelung adalah 1mm. Gegelung enamel magnetik digunakan dalam projek ini. Sistem penghantaran kuasa tanpa wayar resonan siri 6-8 W dibina dalam projek ini. Dengan kecekapan tinggi 65.3%, WPT dapat mengecas bateri drone yang sama dalam masa kurang dari 1.5 jam. Akhirnya, stesen pengecasan bateri automatik dibina.*

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LIST OF ABBREVIATIONS

UAV	Unmanned Aerial Vehicle
GPS	Global Positioning System
AC	Alternating Current
DC	Direct Current
PCB	Printed Circuit Board
WPT	Wireless Power Transmission
PC	Personal Computer

LIST OF SYMBOLS

D, d	-	Diameter
V	-	Volt
W	-	Watt
Ah	-	Ampere per Hour
C_b	-	Battery Capacity
F_t	-	Flight Time
A_d	-	Active Drain Current
D_b	-	Battery Discharge
W_t	-	Weight Of The Drone
B_{LT}	-	Battery Lifetime
D_s	-	Battery Discharge Safety

CHAPTER 1

INTRODUCTION

1.1 Background

Innovative improvement has affected social, financial, and individual lives, from business to global wars. These changes can be imagined by getting profited by these mechanical progressions. The unmanned aerial vehicle (UAV), otherwise called distantly worked as an aeroplane, is the best guide to envisioning the change. UAV's vehicle need not bother with any pilot installed and can be worked autonomously or distant pilot control (Gupta et al., 2019). The use of aerial vehicles for industrial applications goes back to the 19th century. In 1860, balloons were used to take pictures for remote sensing purposes (Moore, 1979). UAV can provide cloud-free and high-resolution images to serve commercial applications such as agriculture, mining, and monitoring.

Small Unmanned Aerial Vehicles (UAVs) guarantee critical execution and wellbeing enhancements to routine undertakings, such as investigation, observation, and policing. Notwithstanding, restricted battery power obliges the degree and self-rule of these errands as of now. In agriculture applications, UAV's can be utilizing to scanning yield area and atmosphere status and to broaden the correspondence scope of remote sensor networks in checking regions. However, when the UAV's scree crops, the atmosphere condition faces difficulties and restrictions, for example, power utilization, drone flight time, and correspondence separation, which are tended to in this investigation. Today, batteries are a severe issue for UAVs to travel significant distances. Half of the battery energy must be spared to make a trip back to the dispatch site for reviving, which is again tedious. Then, for the battery issue, surface contact energizes the user can handily apply the strategy.

Usually, these drones generally use high energy consumption when running on air, such as lithium batteries, to empower flight seasons of around 20-40 minutes (Lee et al., 2014). In any case, battery life is an issue looked at by drone frameworks. The first strategy comprises outfitting the UAV with a higher battery limit. However, this brings about an expanded load with a subsequent decrease in the payload. The second option is to make a base station where the batteries can be traded when the drone is landing. This arrangement permits the UAV to take off in a brief timeframe. However, it may be illogical because of these frameworks' cost and multifaceted nature with numerous mechanical components. The last option is to build base stations where the UAV area naturally energizes its battery. There are fundamentally two different ways to understand a charging station: the first depends on electrical contacts between the base station and the drone. The second solution arrangement depends on the wireless power transfer (WPT) innovation. The WPT can be used to indict drone batteries.

On the other hand, the WPT innovation allows an exceptionally effective and stable force transmission between the UAV and the ground base. The WPT innovation must ensure significant force move with high resistance to loop misalignment, with no guarantees frequently because of helpless landing exactness. A few past works depict the significant issues to energize drone batteries by WPT frameworks (T. Campi et al., 2016). Drones can be remotely charged utilizing the proposed charging framework. It also paying little mind to turn point among drones and remote charging stations, which can reduce their control of multifaceted nature for self-governing landing—the expanded by and considerable mission time.

1.2 Problem Statement

Nowadays, the drone system will face a battery life problem, especially in the air. The UAVs batteries only can be charged when it is on the land. Besides, the UAVs are only charging through their cable charger. For agriculture applications, most of the drone battery capacity is not enough. This problem is because the drone's coverage area to spread the fertilizer is too big and wide. Then, the drone battery decrease corresponds to its travel area—high current utilization requiring high-capacity batteries. Thus, the drone restricts long-lasting tasks, and the UAV flight time will continuously decrease.

1.3 Objective

The objectives of this project are as follow:

1. To understand the principle of Wireless Power Transfer (WPT).
2. To identify suitable wireless docking station.
3. To provide an analysis of the magnetic charging connection.

1.4 Scope of Project

The scopes of this project are:

1. To understand the working principle of WPT.

2. Wireless Power Transfer (WPT) is designed to transfer the magnetic fields between two resonant circuits.

3. Wireless charging component to be installed throughout the drone's body.

1.5 General Methodology

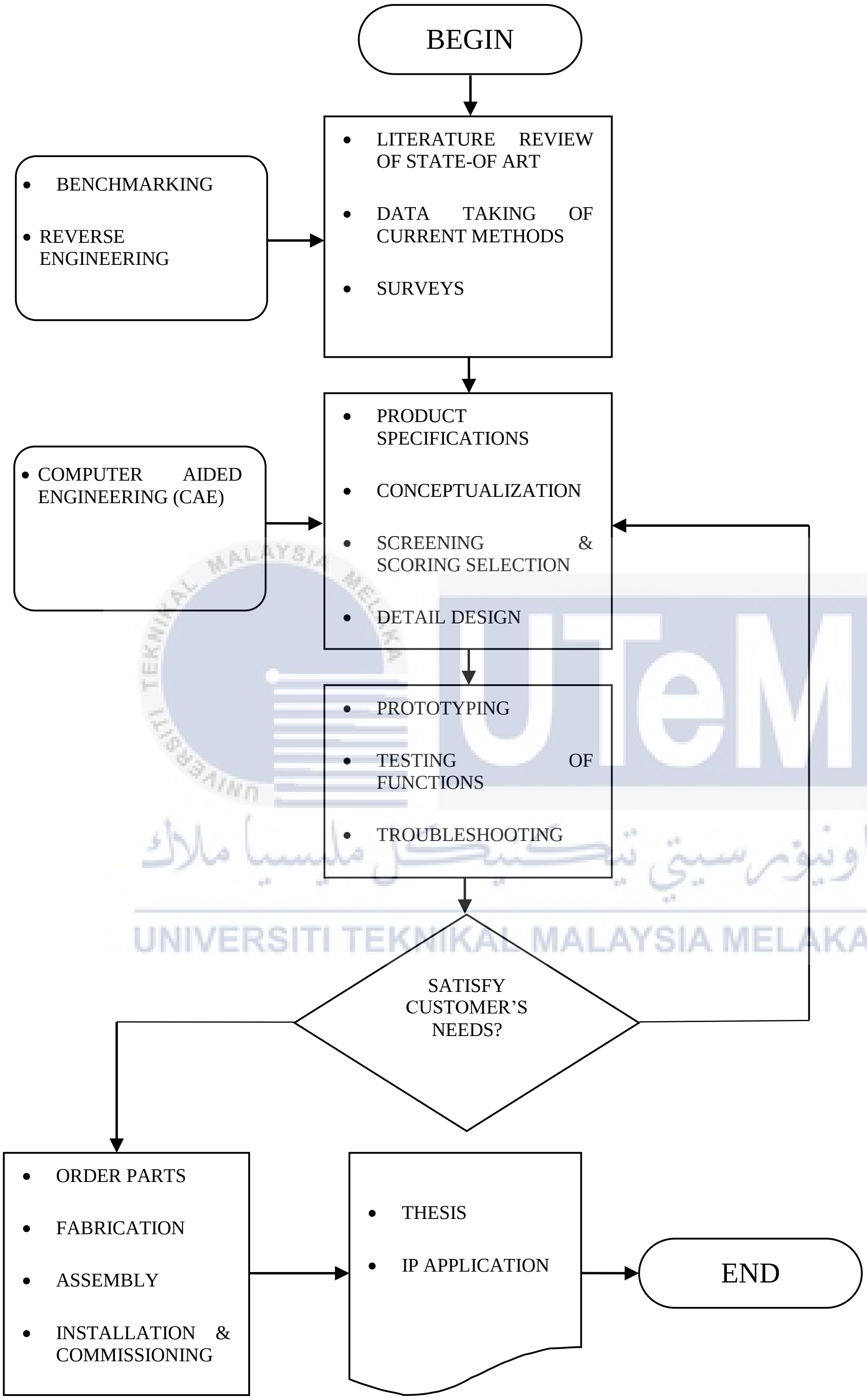

Figure 1.1: Flowchart of the methodology.

1.6 Project Outline

The project is divided into five main chapters, with a summary, references, and appendices at the conclusion.

Chapter 1 is about the problem statement, proposed solution, objective and project scope.

Chapter 2 present the overview and analysis of the literature. First, it contains past efforts on autonomous drone battery charging. After then, there will be a comparison of all of them, followed by a conclusion.

Chapter 3 shows the system design and component required for the system.

Chapter 4 discuss the experimental results after running the system, the wireless charger's efficiency, performance in various scenarios, and simulation test using Simulink (MATLAB).

Chapter 5 conclude the whole project and the proposed future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Historical Background

For a long time, drone advocates have referred to exactness horticulture - crop the board that utilizes GPS and huge information - as an approach to increase crop yield while solving water and food emergencies. Unfortunately, drones have not significantly improved horticultural practices at any rate.

Quite recently, there is an increase in the drone applications in agriculture and other developments. From the ability to picture, replicate, and dismember solitary leaves on a corn plant from 120 meters arbitrarily to getting information on the water-holding breaking point of soils to variable-rate water applications, cultivation is changing due to drones passing on agrarian information. Heartbreakingly, large numbers of the certifications made to farmers, drone expert associations fundamentally could not pass on. Recently, airspace regulators did not permit the airspace fearing they will become flight threats above horticultural territories. With open airspace to a specific flight height, the expert communities will, in like manner, have the alternative to use a drone to give better planting. Additionally, crop insurgency strategies give a more severe all-around, seeing how collects regularly progress in different bits of a given yield field. The entirety of drones' potential uses will be fleshed out by drone specialist co-ops and ranchers themselves in the coming years.

The insight will make cultivation more effective, and it can assist more modest tasks contending their all-around obeyed Big Agriculture contenders. A broadly referred to ramble a report delivered by the Association for Unmanned Vehicle Systems International predicts that business drones' authorization will make more than €70 billion in economic effect (for example, incomes, work creation) somewhere in the range of 2015 and 2025. Furthermore, that accuracy in agro-business will give the most excellent bit of that development. For the time being, here are five drone farming applications as of now. It is being actualized in the field.

2.2 System Configuration

The primary objective of a WPT system for a drone is to charge the battery consistently. The essential (or sending T_x) WPT coil is reasonably chosen from various autonomous planar loops set in a ground cushion station. Conversely, the optional (or getting R_x A planar loop is set on board in the drone. For the most part, drones are furnished with frameworks like top-notch cameras, infrared cameras, vicinity sensors, and so forth. These mechanical assemblies require a review territory that the WPT framework (fundamentally the optional coil) (see Figure 2.1). The WPT configuration's primary requirement concerns the shape and the size of the installed auxiliary loop that should be planned enough. Simultaneously, the WPT charging framework should be sensibly practical regarding electrical energy and moving force. Commonly, a drone battery includes 3 to 6 Li-Po cells that relate to a battery voltage between 11.1 V and 22.2 V, with a limit between 3 Ah and 10 Ah (*DJI - Official Website*, n.d.). This sort of battery can be revived in around 60 minutes. The quick charging method necessitates that much intensity should be sent to the drone.

Figure 2.1: Drone landing support.

Previous work set the locally available loop under the drone outline (Campi et al., 2018). Such an answer warrants the establishment of the coil without meddling with the payload. However, the air hole between the ground and the installed loop is significant (ordinarily considerably more than 100 mm). For this setup, it is essential to utilize huge coils and some ferrite to acquire elevated WPT proficient levels, prompting a critical expansion in the on-board segments' weight. In the proposed new arrangement, the accepting coil is put on the arrival slip diminishing the vertical air hole between the sending and the getting loops. This arrangement allows a considerable upgrade of the framework execution because of expanding the coil's coupling factor. Hence, it is conceivable to plan a tiny and lightweight optional coil keeping up high force transmission effectiveness. For the thought about landing slip, a tight rectangular state of the optional coil is chosen. Whether it is not the best answer for inductive coupling and energy move, this state of the optional loop fits the pallet very well and does not bargain the optimal design and the cameras' survey territory. Another bit of leeway is the auxiliary coil position, long from the drone outline where the electronic parts are found. This lessens the danger of electromagnetic obstruction on the drone's electronic system because of the time fluctuating attractive field produced by the coil flows.

2.3 Autonomous Battery Charging Using Conductive Power Transfer

The flight life of drones is very restricted, given the high force burned through from the battery. Giving an extra battery is certifiably impossible because adding more weight will bring about a similar issue. A potential arrangement was made in this undertaking by a group from the University of Connecticut (Marafie et al., 2019). The group utilized the conductive charging technique to charge the battery and assembled the UAV station to charge the drone automatically without requiring human obstruction. The group built a self-governing structure to explore the automated airborne vehicle to the charging area (Figure 2.2). It was subsequently charging the drone battery without human intervention (Campi et al., 2016).

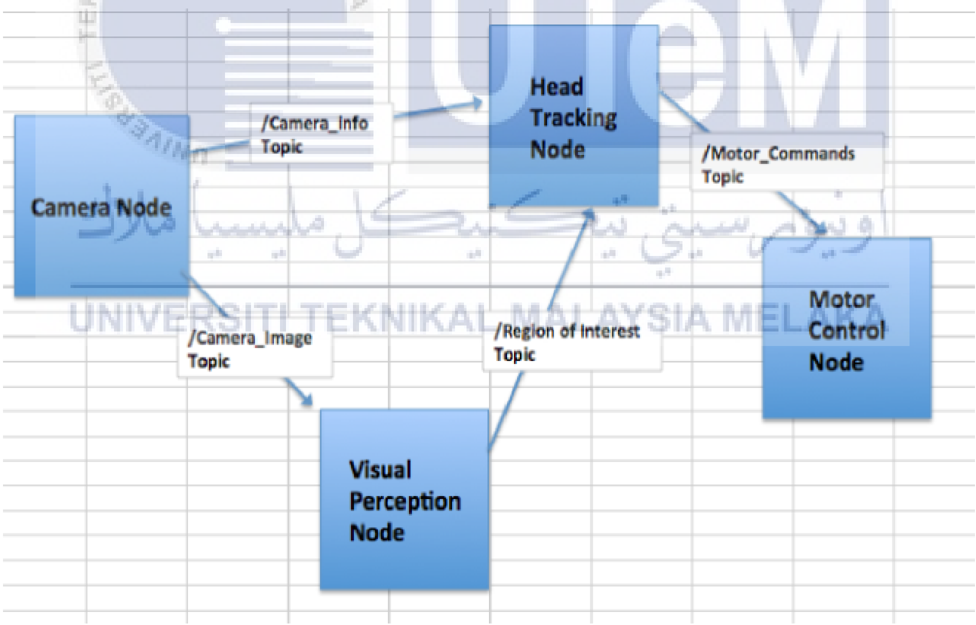

Figure 2.2: The Image tracking system (Design team of the University of Connecticut)

The University of Connecticut design group utilized an image tracking system to look through the charging station (Baietto et al., 2017). The design group accepted that it is the most reasonable alternative since it is intended to fly inside. Also, the group will