A NEW DESIGN OF SELF CHARGING UNMANNED AERIAL VEHICLE (UAV) SYSTEM USING INDUCTIVE APPROACH FOR PRECISION AGRICULTURE

JUSTIN CHUA CHIA YANG

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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PROFESOR MADYA DR. MOHD SHAKIR BIN MD SAAT
Profesor Madya
Fakulti Kejuruteraan Elektronik dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya
76100 Durian Tunggal, Melaka

Alamat Tetap: Lot 29, Jln Bunga Raya Utama, Tmn Bumiko, 98000 Miri, Sarawak

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DEDICATION

To My Beloved Father and Mother

ABSTRACT

Wireless Power Transfer (WPT) is a power transfer technology with no physical link in between transmitter and receiver. With the benefit of non-contact concept, WPT has been commonly used in many devices, and UAV is one of them. Generally, there are two classes of WPT which are near-field and far field-wireless power transfer. Among these, Inductive Power Transfer (IPT) from near field WPT has been design in this project to improve the charging system of UAV, because IPT can generate higher efficiency and able to transmit power in rough condition compare to Capacitive Power Transfer (CPT). This technique enables wireless power conveys from a charging tower to UAV. Hence, the UAV able to conserve the time for flying back to the user just for charging issue. To be more details, Class E inverter circuit has been constructed to convert the 12V direct current (DC) to alternating current (AC) with 1MHz of operating frequency and 50% of duty cycle. Solar panel has been proposed as the power supply for Class E inverter circuit, because the UAV is working at the outdoor environment which is under the sun and solar is renewable resources which does not cause pollution to our mother earth. Next, impedance matching circuit has been constructed to maximize the power transfer to the load in order to increase the overall efficiency of the wireless charging system. The prototype of the UAV

wireless charging system in precision of agriculture has been successfully developed with a 12 cm x 12cm width per length of transmitting and receiving coil. Analysis between transmitting coil and receiving coil such as distance apart and misalignment distance was carry out during the experimental session. With the features of 3cm apart and perfectly aligned between transmitter coil and receiver, the output power for the prototype is obtained with value 23.32W and the input power is 24.36W. An optimum ZVS waveform has been obtained with the efficiency up to 95.73%.

ABSTRAK

Pemindahan Kuasa Tanpa Wayar (WPT) adalah teknologi pemindahan kuasa tanpa pautan fizikal di antara pemancar dan penerima. Dengan manfaat konsep bukan hubungan, WPT telah biasa digunakan dalam banyak peranti, dan UAV adalah salah satu daripada mereka. Umumnya, terdapat dua kelas WPT yang hampir-lapangan dan pemindahan kuasa tanpa wayar medan jauh. Di antara ini, Pemindahan Kuasa Induktif (IPT) dari WPT berhampiran telah direka bentuk dalam projek ini untuk meningkatkan sistem pengecasan UAV, kerana IPT boleh menjana kecekapan yang lebih tinggi dan dapat menghantar kuasa dalam keadaan kasar berbanding dengan Pemindahan Kuasa Kapasitif (CPT). Teknik ini membolehkan kuasa tanpa wayar menyampaikan dari menara pengecasan ke UAV. Oleh itu, UAV dapat menjimatkan masa untuk terbang kembali kepada pengguna hanya untuk masalah pengisian. Untuk maklumat lanjut, litar Inverter Kelas E telah dibina untuk menukar arus langsung 12V (DC) kepada arus selari (AC) dengan frekuensi operasi 1MHz dan 50% daripada kitaran tugas. Panel solar telah dicadangkan sebagai bekalan kuasa untuk litar penyongsang Kelas E, kerana UAV bekerja di persekitaran luar yang berada di bawah matahari dan solar adalah sumber yang boleh diperbaharui yang tidak menyebabkan pencemaran ke bumi ibu kita. Selanjutnya, litar pencocokan impedans telah dibina untuk memaksimumkan

pemindahan kuasa kepada beban untuk meningkatkan kecekapan keseluruhan sistem pengecasan tanpa wayar. Prototaip sistem pengisian tanpa wayar UAV dalam ketepatan pertanian telah berjaya dibangunkan dengan lebar 12 cm x 12cm per panjang pemancar dan penerimaan gegelung. Analisis antara gegelung pemancaran dan gegelung penerima seperti jarak jarak jauh dan jarak misalignment dijalankan semasa sesi eksperimen. Dengan ciri-ciri 3cm dan sejajar dengan sempurna antara gegelung pemancar dan penerima, kuasa output untuk prototaip diperoleh dengan nilai 23.32W dan kuasa masukan adalah 24.36W. Satu bentuk gelombang ZVS optimum diperolehi dan kecekapan sistem pengecasan tanpa wayar mencapai 95.73%.

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LIST OF SYMBOLS AND ABBREVIATIONS

WPT	:	Wireless Power Transfer
APT	:	Acoustic Power Transfer
IPT	:	Inductive Power Transfer
CPT	:	Capacitive Power Transfer
Tx	:	Transmitter
Rx	:	Receiver
DC	:	Direct Current
AC	:	Alternating Current
MOSFET	:	Metal Oxide Semiconductor Field Effect Transistor
ZVS	:	Zero Voltage Switching

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

In this chapter, the introduction of the project will be briefed and discussed. The subtopic and information for this chapter including the project background, problem statement, objectives, and scope of work.

1.1 Project Background

Wireless power transfer (WPT) is the transmission of energy without any physical link between the device and power source. Without the interconnecting of wires or cables, WPT accomplished energy transmission by creating an electromagnetic field, electric field or magnetic field between the device and the power source [1]. By using WPT technology, the charging system of electrical devices is innovating and improving with low risk of electric shock, ease of installation as the requirement of adaptor plug-in and out is the refrain, or short circuit and damaged of cables would never exist. Figure 1-1 shows the basic structure of the WPT idea. The transmitter part of the WPT charging system begins with the direct current (DC) supply, then the DC flow through the class E inverter to convert DC to alternating current (AC). After that, AC energized the transmitting coil, causing the coil to produce induce current and generate an electromagnetic field. The electromagnetic field is then propagated from the transmitter coil to the receiver coil. At the receiver part, an inverse process from the transmitter part happens. As the AC flow through a rectifier circuit to convert to DC to meet the requirement of the load parameter.

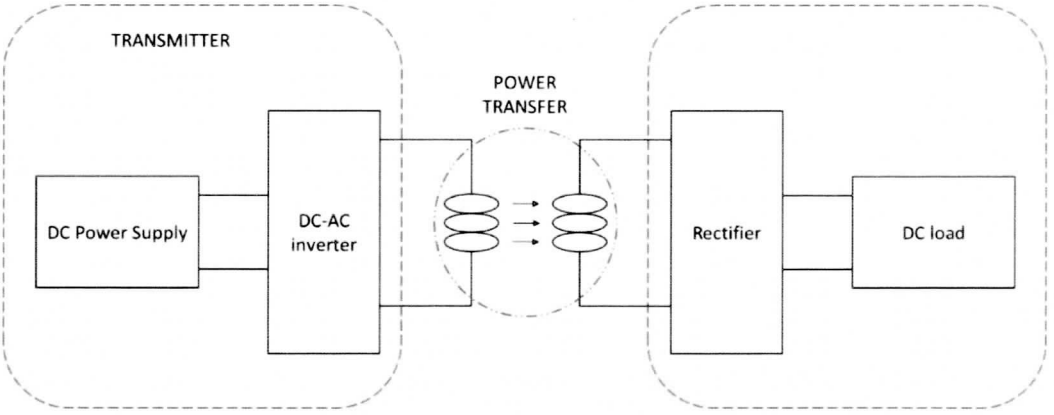

Figure 1-1 : Block diagram for Wireless Power Transfer

As shown in Figure 1-2, WPT can be classified into two categories according to the radiation distance, which is far-field WPT and near-field WPT. Far-field WPT achieved a further range of transmission compared to near-field WPT, often multiple kilometer ranges, where the distance is greater than the diameter of the device. Near-field WPT has a shorter transmission range between transmitter and receiver compare to far-field WPT. The range of the near-field WPT only within a few times the diameter of the antenna device [2][3]. Microwave and lasers are the most common forms of electromagnetic radiation which use for the far-field WPT. In a comparison between these two methods for the project use, microwave power beaming is more efficient compared to lasers, because microwave has better performance of energy transfer to atmospheric attenuation caused by water vapor and dust [4].

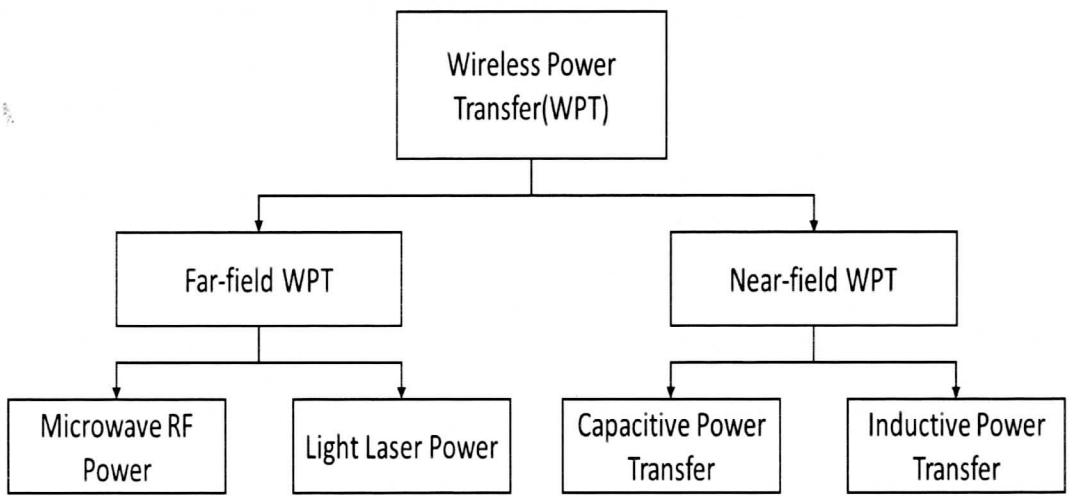

Figure 1-2 : Categories of the WPT

For near-field WPT, Capacitive Power Transform (CPT) also named as electrostatic induction is the transmission of the electric field in between two electrodes. The electrodes are realized by metal plates and act as the transmitter and

receiver. Normally, at least four plates are needed for the CPT system to form a capacitive coupler with the intervening space as the dielectric. Two plates will be placed at the primary side act as a transmitter and another two plates will be located at the secondary side act as a receiver to provide a complete power flow loop [1].

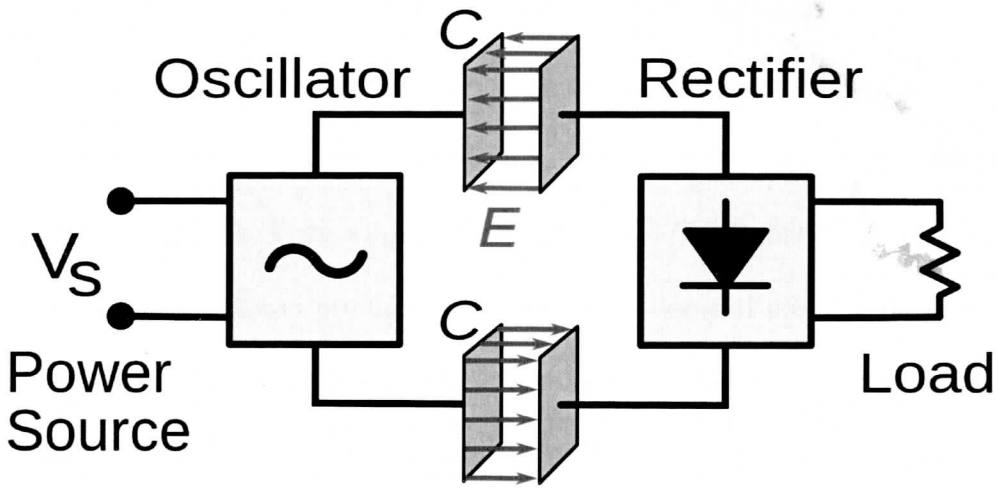

Figure 1-3 : Working Principle of the CPT system

Inductive power transfer (IPT) is the transmission of power in between two coils through a magnetic field. AC moves through the primary coil which acts as a transmitter, a circular magnetic field creates around the coil by Ampere's law [5]. Wire bending in the form of a coil amplifies the magnetic field and the more loops the coil makes, the larger the field creates. Then, the magnetic field transmits to the secondary coil which acts as a receiver, where the coil induces an alternating electromagnetic field (EMF) by following Faraday's law of induction, which alters the EMF to AC in the receiver [6]. The induced AC may either be powering up the device directly, or the AC will go through a rectifier to transform back into DC to fulfill the requirement of the load. IPT is widely used in current commercial product, because of high efficiency,

low cost, and still able to function at the extreme condition of the environment as IPT will not be affected by water or dust.

Nowadays, people are discovering all sorts of ingenious ways to improve efficiency and maximize profit using Unmanned Aerial Vehicle (UAV) technology. In term of the agriculture industry, the use of UAV can be roughly boiled down into four roles. First of all, crop scanning with compact multispectral imaging sensors provides clearer data for a deeper understanding of crop health, thereby to increase crop production and monitor crop growth. Then, Global Position Satellite (GPS) map creation through onboard cameras, which can provide a much precision view of the plant field to the farmer [7]. Hence, farmers are allowing for more efficient decision making about where the crops should be planted. Next, heavy payload transportation also one of the segment that UAV is interesting in agriculture use. UAV is used to carry heavy items such as water tank, pesticides, and fertilizer around the farm field, through this function of UAV the profit of the farm can be increased as the manpower used for watering and fertilizing can be reduced. Finally, livestock monitoring with a thermal-imaging camera-equipped drone can reveal many issues, for example, pest and fungal infestation, and wild animals in need [8][9].

However, the main issue using UAV in agriculture is the limitation of its battery ability that leads the UAV unable to fly at a long time. Large-scale estate might be difficult to use UAV due to this limitation. This limitation can be solved by applying battery charging towers with WPT technology around the farming field. When the UAV is in the low battery condition, the user can control the UAV to the nearest charging tower to recharge the battery and no manpower is in need to plug in wire or cable as the WPT technology is applied. The battery charging tower is located outdoor and could be far away from the living area. Thus, a solar panel which can transform