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Wireless Power Transfer for Unmanned Aerial Vehicle (UAV) Charging

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Abstract – Wireless power transfer technology is one of the new emerging technologies for research. This paper presents an overview of wireless power transfer (WPT) technology for the application of unmanned aerial vehicle charging. They are available in different size with wide range capabilities. The major drawback of UAV is limited battery capacity. Increasing the battery system is not a permanent solution because of their limiting weight factor. Hence UAV charging wirelessly with a resonant inductive power transfer. Which is done through wireless power transfer.

***Key Words*: Wireless Power transfer, Unmanned aerial Vehicle, Wireless, Battery, Power, Flux.**

1.INTRODUCTION

Wireless power transfer (WPT) is used for the transforming electric power from one point to another through vacuum or atmosphere without requiring wiring infrastructure or any substance. This idea is not new Nikola Tesla firstly proposed the concept of WPT in the early of 20th century. His experiment was not successful even though he attempted to demonstrate its feasibility.

The most common wireless power transfer technologies are Inductive coupling, Resonant Inductive Coupling, Air Ionization these technique is used for near field power transfer and Wireless power transfer(WPT), Microwave power transfer(MPT), LASER power transfer(LPT) is used for far field power transfer.

The wireless power transfer must satisfy three conditions:
a) High Efficiency
b) Large air gap
c) High Power

1.1 Basic Theory

Inductive or magnetic coupling works on the principle of electromagnetism. Inductive or magnetic coupling works by creating an alternating magnetic field (flux) in a transmitting coil and converting that flux into an electric current in the receiving coil. Depending on the distance between the transmitting and receiving coils. Fig1 shows tightly coupled coil in which coil distance (z) is much smaller than coil diameter (D) so that all magnetic flux generated by the transmitter coil penetrates the receiver coil and contributes to the power transmission.

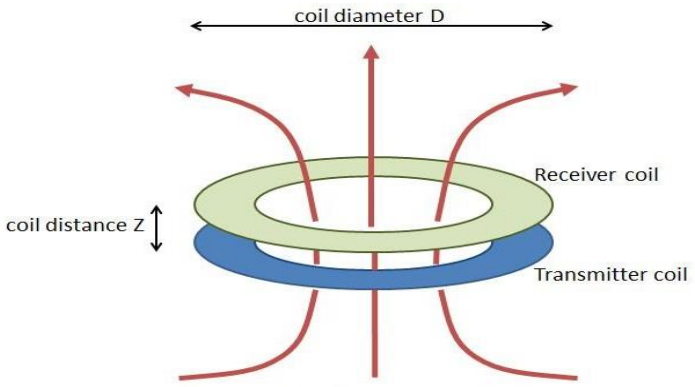

Fig -1: Tight Coupled Coil

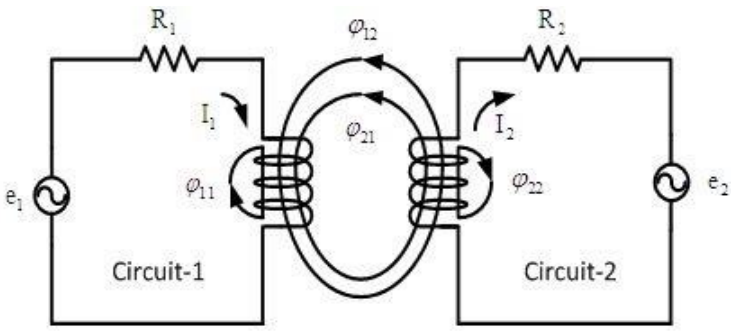

Fig -2: Magnetic Coupling with four components of fluxes

The circuit used for the power transfer system in this paper contains a resistor R1 in series with the coil on the primary side inductor ϕ11 and resistor R2 in series with the coil secondary coil inductor ϕ22 on the secondary side. The output power of secondary coil is defined as:

$$Pout = \frac{e1^2\ \omega^2 M^2 R_L}{R1(R2+R1)+\omega^2+M^2}$$

Here e1 is input voltage, M is mutual InductanceR1, R2 parasitic resistances (loss resistances in the inductors). RL is load resistance. Thus the overall efficiency of the system depends only on the transmission frequency, mutual inductance, coil's parasitic resistances and load resistance.

2.METHODOLOGY

In this paper, wireless power transfer using resonant inductive coupling is used which depends on electrical characteristic of source and load, Transmitting coil and receiving coil must be tuned to resonant at same frequency. This can be achieved through three steps: (i) the electrical circuits; (ii) the coil geometries; and (iii) optimization of the coil geometry and circuit components.

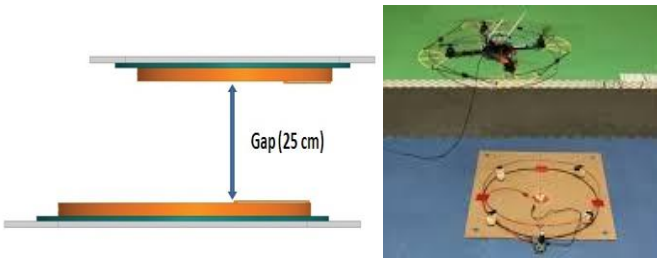

Fig -3: Variables considered to create efficiency map

The optimization is carried out in two steps. In the first step, we optimize the coil geometry to maximize the magnetic coupling between the coils. In the second step, we optimize the circuit parameters of the wireless power transfer system to maximize the efficiency and power transfer.

3.GENERAL PRINCIPLE OF DESIGN

General principle of operation is designed using resonance inductive coupling. Which is ensuring that the power transfer is as efficient as possible and the transfer within the near field also versatility and optimization the battery charging.

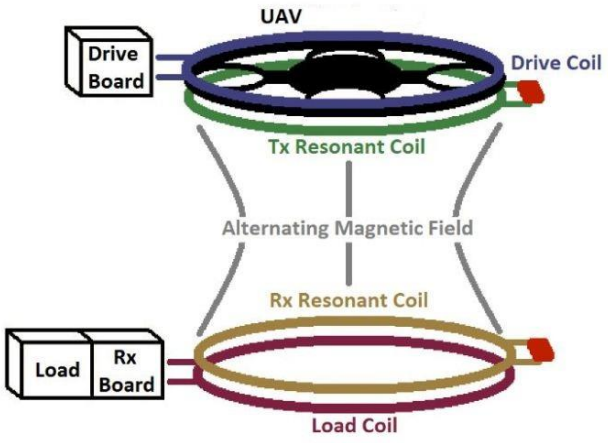

Fig -4: Resonant coupling for wireless power transfer

The circuit is divided into two sections.

1. Transmitting Resonant Circuit
2. Receiving Resonant Circuit

Transmitting Resonant Circuit: The transmitter resonant circuit comprised of the Battery, power amplifier, matching circuit, drive board and the copper laminated coils.

Receiving Resonant Circuit: The receiving resonant circuit consist of rectifier DC-DC receiving resonating coil, receiving board, load as shown in fig 4.

Fig -5: UAV charging through WPT

Transmitter and receiver coils are the air core inductor coils which are used to transfer the power over a specified distance through mutual induction. The inductive coupling is specified for some fixed distance. This distance depends upon magnetic field of the coil received by a air core receiver coil. Greater the magnetic field greater the distance over which the power is transferred.

4. SYSTEM EFFICIENCY

The total system efficiency of the wireless power transfer application depends on the output power loss. Which is measured through the ratio of receiver output power to the transmitter input power. Using a high grade transmitting resonance coil and receiving resonance coil. Efficiency of WPT normally lies between 70 to 80%.

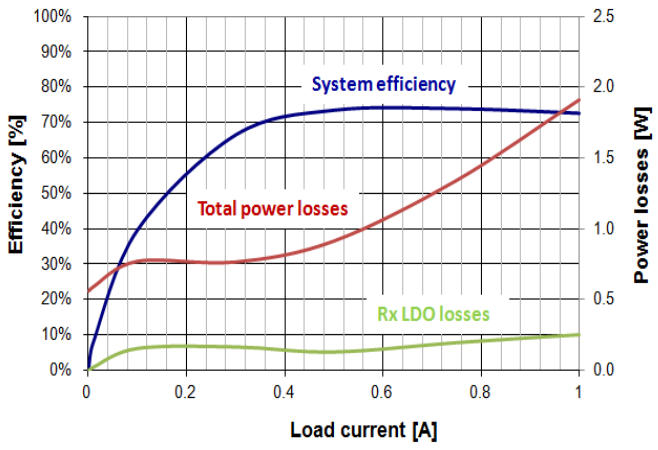

Chart -1: System efficiency and power loss

5. APPLICATION

There are several applications of wireless power transfer are apparent and obvious. Firstly, WPT could eliminate wire cord charging systems such as plugging in a mobile phone or laptop or other home appliances via power cord to charge the battery, wireless power can be harnessed and implemented in a home appliances such that a laptop and phone charge continuously and wirelessly without the need for plugging anything in. Higher level applications include charging of unmanned aerial vehicle (UAV). UAVs enable organizations across multiple industries to decrease costs while improving frequent tasks, such as investigation, monitoring, data collection, and various other day-to-day activities. Today, most UAVs having battery limiting capacity of 15-40 minutes. Due to which UAVs return to a fixed location for battery replacement. WPT technology can be improve battery charging in the field.

Fig -6: UAV charging pad for mobile charging

UAV Charging pad can

- Transfer 35W to UAV with 71% transmitter RF to DC battery efficiency.
- Charging UAVs with a maximum gap between UAV and charging pad is 25cm.
- Fully charge a 7.4V/450mAh battery in less than 9 min. while hovering.
- Charge multiple UAVs with a single charging pad.

WPT can help users to overcome many challenges

1. Increase total time in air
2. Reduce human intraction
3. Other Benifit

1.Increase total time in air: Due to limited battery life UAVs unable to complete task in effective manner such as uncomplete investigation, monitoring or incomplete data collection. Wireless charging pad can be placed near the investigation area so that increase the total time in air for complete investigation. It also reduce multiple UAVs for carrying a single task.

2.Reduce human intraction: UAV can be charged by simply landing on or hovering near charging pads. There is no battery swap or need to connect a wire cord to power supply, Hence charging via charging pad reduce human intraction.

3.Other benefit: For WPT we uses resonance inductive coupling. Which will not demagnetize the permanent magnet used in UAV.

Applications of UAVs include

1. Private security & Surveillance
2. Inspections
3. Delivery and Distributions
4. Monitoring in harsh environment

1.Private security & Surveillance: The charging pad can be fixed at different locations for UAVs charging during surveillance so that mission time will increase. Charging pad can be fixed at rooftop or other location so that UAVs stay a long duration to gather the data.

2.Inspections: Continuous inspection performed through wireless charging because without any interruption in it's mission UAVs need not to return a fixed point for charging .Inspection can also performed at the time of charging.

3. Delivery and Distribution: Wireless charging pad can be established on rooftop of the vehicles and allows UAVs to complete a daily distribution/delivery schedule without operator intervention to swap batteries, or plug in each UAVs, Which leads to increase the number of deliveries per UAVs.

4. Monitoring in harsh environment: UAVs are increasingly deploy to conduct monitoring in harsh environment where human can't reach. UAV can be completely sealed, since batteries do not require replacement and exposed charging contacts are not necessary.

6. CONCLUSION

Wireless power transfer without wires is not a theory, it is now a reality. The electrical power can be transmitted without wires to one point to other point with a distance. In this device we have transmitted power up to 25cm of air gap without any help of wires. We have noticed that the harmonics of the current in the transmission coil leads the power loss in the form of magnetic energy. Due to the presence of harmonics in current, at the time of conversion of electrical energy into magnetic energy, some unwanted magnetic flux generated. If we will manage to remove or reduce this harmonics we will be able to link maximum flux from primary to secondary resonant coil.

NOMENCLATURE USED

WPT-Wireless Power Transfer
LDO-Low Dropout Regulator
UAV-Unmanned Aerial Vehicle

REFERENCES

[1] N. Tesla, "Apparatus for transmission of electrical energy," U.S. Patent 649,621, dated May 15, 1900.
[2] BrownWC.The history of power transmission by radio waves.IEEE Trans Microw Theory Tech 1984; 32(9):1230–42.
[3] Micro-Robot for Endoscope Based on Wireless Power Transfer" Proceedings of the 2007 IEEE International Conference on Mechatronics and Automation August 5 - 8,2007, Harbin, China.
[4] Garnica J, Chinga R A, Jenshan L.Wireless power transmission: from far field to near field. Proc IEEE2013;101:1321–31.
[5] G. A. Covic and J. T. Boys, "Inductive power transfer," Proc. IEEE, vol. 101, no. 6, pp. 1–14, Jun. 2013
[6] J. Hirai, K. Tae-Woong, and A. Kawamura, "Study on intelligent battery charging using inductive transmission of power and information," IEEE Trans. Power Electron., vol. 15, no. 2, pp. 335–345, Mar. 2000.
[7] Harouni. A Dual Circularly Polarized 2.45-GHz Rectenna for Wireless Power Transmission, Antennas and Wireless Propagation Letters, IEEE, Vol. 10, 2011.
[8] A. Kurs, A. Karalis, R. Moffatt, J. D. Joannopoulos, P. Fisher,and M. Solja˘ci´c, "Wireless power transfer via strongly coupledmagnetic resonances," Science, vol. 317, no. 5834, pp. 83–86,2007.

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