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Brief Comparative Study On Wireless Power Transfer System for Implantable Biomedical Devices : A Review

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ABSTRACT

Wireless power is one of the new terms that define this century. In the age of mobility, the need for wireless power transfer (WPT) is growing fast. There are several approaches for transferring the electric power wirelessly. Wireless power transfer (WPT) via magnetic induction is an emerging technology that is a result of the significant advancements in power electronics. Mobile phones can now be charged wirelessly by placing them on a charging surface. Electric vehicles can charge their batteries while being parked over a certain charging spot and also used for charging biomedical devices. In this paper, different methodologies for WPT are investigated as well as advantages, disadvantages and possible applications for each one. A qualitative comparison between main methods has been achieved based on separation distance, transmitting power, cost, efficiency, and safety.

Keywords : Wireless power transfer, Inductive coupling WPT

I. INTRODUCTION

Wireless Power Transfer (WPT) makes it possible to supply power through an air gap, without the need for current-carrying wires. WPT can provide power from an AC source to compatible batteries or devices without physical connectors or wires. WPT can recharge mobile phones and tablets, drones, cars, even transportation equipment. It may even be possible to wirelessly transmit power gathered by solar-panel arrays in space.

WPT has been an exciting development in consumer electronics, replacing wired chargers. The 2017 Consumer Electronics Show will have many devices offering WPT.

The concept of transferring power without wires, however, has been around since the late 1890s. Nikola Tesla was able to light electric bulbs wirelessly at his Colorado Springs Lab using electrodynamics induction.

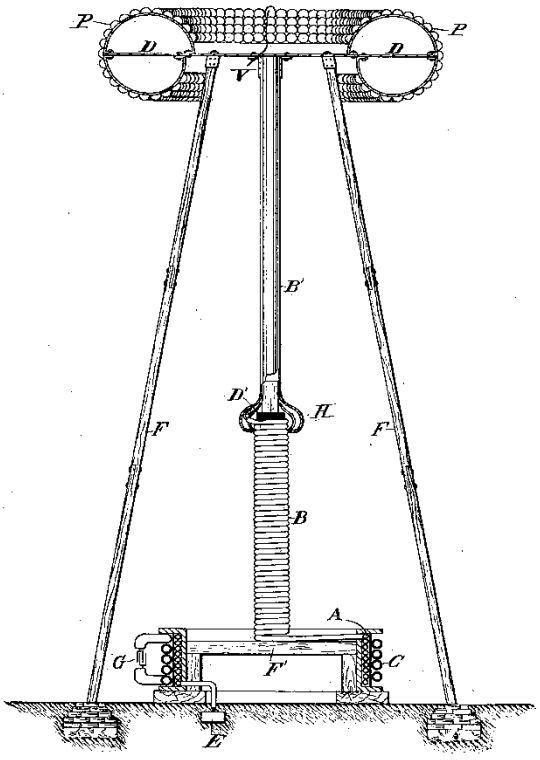

Fig 1. Wardenclyffe Tower Skecth

WPT uses fields created by charged particles to carry energy between transmitters and receivers over an air gap. The air gap is bridged by converting the energy into a form that can travel through the air. The energy is converted to an oscillating field, transmitted over the air, and then converted into usable electrical current by a receiver. Depending on the power and distance, energy can be effectively transferred via an electric field, a magnetic field, or electromagnetic (EM) waves such as radio waves, microwaves, or even light

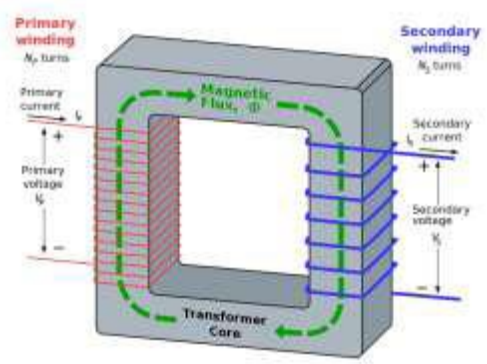

Fig. 2 Basic transformer circuit

II. WIRELESS POWER TRANSFER METHOD

The following table lists the various WPT technologies as well as the form of power transfer.

Technology	Energy Transfer	Enabling the Power Transfer
Inductive coupling	Magnetic fields	Coils of wire
Resonant inductive coupling	Magnetic fields	Resonant circuits
Capacitive coupling	Electric fields	Conductive coupling plates
Magnetodynamic coupling	Magnetic fields	Rotating permanent magnets
Microwave radiation	Microwaves	Phased arrays/dishes
Optical radiation	Light/ infrared/ ultraviolet	Lasers/photocells

A. Inductive Coupling WPT

The electrical transformer is the simplest application of wireless energy transfer between two coils. In mutual induction, the electrical power is transformed from DC into AC at the transmitter and field is created around the transmitter coil. The receiver coil cuts some of the magnetic field generated by the transmitter coil, and AC current is induced in it.

The received AC power is rectified and filtered to produce DC output. As the distance between the transmitter and the receiver coils increases, the receiver coil misses more lines of the magnetic field of the transmitter even in very short distance, so systems built on inductive coupling have low efficiency, so most of the transmitted power is wasted. This method can allow wireless power transfer in the range of millimeters and can reach at most few centimeters. One typical application for electromagnetic induction is electric toothbrush. Most electric toothbrushes use inductive coupling for recharging because daily exposure to water makes charging through an electric plug is unsafe. Wireless recharging allows completely sealed toothbrushes. This application represents one of advantages of wireless power transfer.

B. Magnetic Resonance Inductive Coupling

Resonant inductive coupling or electro-dynamic inductive effect is the solution for the main problems associated with non-resonant inductive wireless power transfer systems, specially the efficiency dependence on the power transmission distance .By using the resonance concept, power can be transferred between two coils separated by a distance of a few meters efficiently.

C. Wireless Power Transfer Using Microwaves

Microwave power transmission (MPT) is now the most efficient far-field technique which allows power transmission for several kilometers in range.This method includes microwave frequencies from 1GHz up to 1000GHz . In microwaves and optical power transmission systems, the reception area can be shaped. This can be achieved through high directivity antennas in microwaves case and laser beams in

optical systems case. This is why they can be used to transfer electric power wirelessly over long distances.

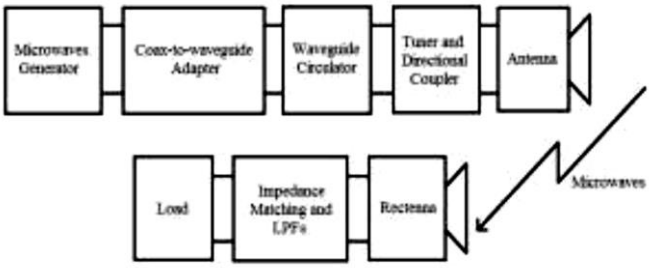

Fig. 3 Block diagram of microwaves power transfer system.

D. Power Transfer by Laser

Laser power beaming is mainly researched in military weapons development and space applications. When it comes to power transfer, this technology is used in relatively short distance application. This is because laser beams can harm humans and animals if they cut the laser beam path. For electric power transmission by laser, the electric current is first converted to high density laser (light) and at the receiver side, high efficiency photo voltaic cells are used to convert the received laser beam back into electricity. The overall laser power transmission system efficiency is about 50% which is quite low compared to the other wireless power transfer methods.

A comparison of different wireless power transfer Methods is shown in figure This comparison Highlights the strong and weak points for each Technique.

Magnetic Resonance Method	Microwaves Method	Lasers Method
It is economical as the equipment used is cheap and easily available	Relatively expensive as compared to other methods	Implies same economic conditions of mutual induction
Useful for implementation of the small distance applications	This method implies for long distance applications	Used for small distance but could be used for longer distances when high intensity beam is involved
It is safe from biological point of view.	Injurious for health because of high frequency rays (1GHz to 1000 GHz)	The laser method is also injurious to human health

Fig.4 Comparison of Different Methods of WPT

III.FEASIBILITY OF WPT

The use of WPT is feasible for the following Advantages.

A. Safety

- No electric shocks or short circuiting.
- Safe on humans and animals.
- Sealed power sources and devices allow more children protection.
- No corrosion can happen.

B. Durability

- No moving mechanical parts that require maintenance.
- Water proof and weather proof (for inductive coupling).
- Impervious to chemicals and dirt.
- Rugged and tough devices are possible.
- Low-profile, does not occupy much space
- No wires to be cut or worn.
- Consistent and secure connections.

C. Ease of use

- No need for electrical plugs.
- Data can be transmitted wirelessly at the same time of charging process.
- Auto charging, so one cannot forget to plug-in.
- A universal charger can be designed.
- Easier implanted devices charging.

D. Aesthetics

- Avoids unnecessary street clutter.
- Perceive historic city aesthetics.
- Maintain precious footpath area.

IV . CONCLUSION

Based on this study, we can say that the magnetic resonance WPT is the most promising technique for powering devices wirelessly with high efficiency over up to few meters. Being safe for humans and environment, magnetic resonance WPT can spread to be the standard charging method for most portable devices in the next few years. So, we recommend researchers to focus on this technology. Even though, microwave power transfer is trying to find its way to replace high power transmission lines. Due to health concerns, many researches should be done to find a safe solution that could enable using microwaves for long-distance high power transmission. Low power efficiencies and limited transfer range are the two main issues for IPT.

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