Wireless Charging Technology: A Review

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Abstract— Most of the electronic gadgets in use today are equipped with rechargeable batteries. The conventional charging method used is wired one and it requires a dedicated connection for which the user of the device has to carry a charger everywhere and every time. In the present times wireless charging is slowly gaining prominence. The recent trends in wireless charging techniques have turned to be a life saver for the portable, rechargeable electronic gadgets. This paper discusses the wireless charging technology, its implementation, applications and limitations.

Keywords: Wireless Charging

I. INTRODUCTION

Wireless power transmission or wireless charging is a technology which enables transfer of electrical energy without any physical link between transmitter and load. A wireless transmission device comprises of a transmitter device driven by a source. The transmitter generates a time-varying electromagnetic field. The electromagnetic field transmits power across space to a receiver. The receiver derives power from the field and supplies the same to the load.

Since wireless power transmission does not involve the use of any physical link it can eliminate the need for wires thus making the device highly portable, convenient and safe to use. This technology finds its applications in a wide range of fields ranging from charging electronic gadgets, medical devices like pacemakers to high power electric vehicles.

Wireless power techniques can be divided into two types: (i) Non-radiative (ii) Radiative as shown in Figure 1. Non- radiative techniques involve power transfer via inductive coupling or capacitive coupling. Radiative power transfer technique involves the use electromagnetic radiation via microwaves or laser beams. One of the important concerns associated with the wireless power transfer is to limit the exposure to people and living beings to harmful radiations.

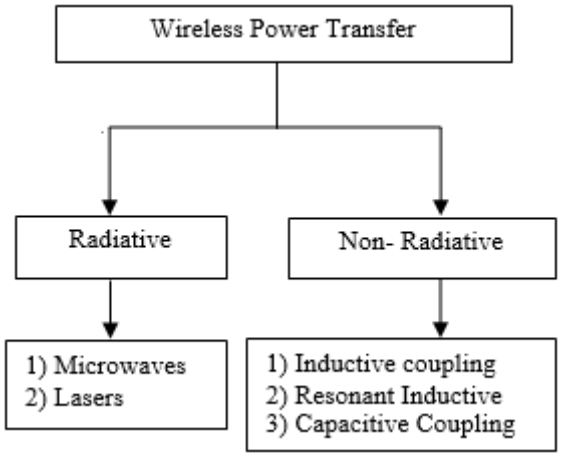

Fig. 1: Classification of Wireless Power Transfer

II. NON-RADIATIVE TECHNIQUES

Inductive and capacitive coupling can be used for short range power transfer. In inductive coupling magnetic field transfers power between coils of wire which are held in close proximity to each other. In capacitive coupling electric filed is used to transmit power between two electrodes forming a capacitor.

A. Inductive Coupling

Inductive coupling is the oldest and most popular wireless power transfer technique. It is used for charging electric tooth brushes, cardiac pace makers, insulin pumps and electric vehicles.

Inductive wireless power system consists of the transmitter and receiver coils. When an alternating current is passed through the transmitter coil it generates a magnetic field which links with the receiver coil and generates an alternating current in it. The alternating current may be used as it is or converted to direct current by means of a rectifier. This method yields high efficiency only when the coils are adjacent. Figure 1 illustrates Inductive coupling.

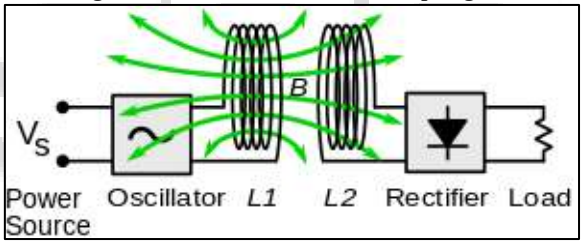

Fig. 1: Inductive Coupling

B. Resonant Inductive Coupling

In resonant inductive coupling power is transferred by magnetic fields between two resonant circuits: one at the transmitter and the other at the receiver. Both the resonant circuits are tuned to resonate at the same frequency. This method provides maximum coupling and power transfer. Figure 2 shows resonant inductive coupling.

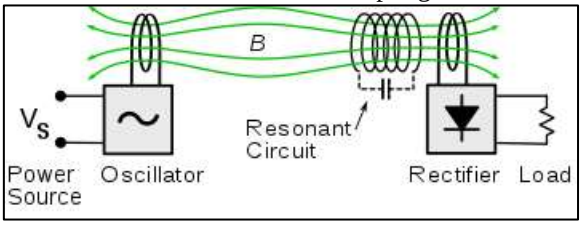

Fig. 2: Resonant Inductive Coupling

C. Capacitive Coupling

Capacitive coupling has been used only for few low power applications. Here energy is transferred by electric fields between electrodes. The transmitting and receiving electrodes form a capacitor with the space between them acting as a dielectric. An alternating voltage is applied to the transmitting plate which generates an electric field. This in turn induces

an alternating potential on the receiving plate which causes an alternating current to flow in the load circuit. The capacitive coupling technique is illustrated in Figure 3.

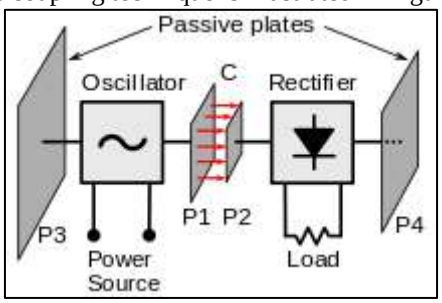

Fig. 3: Capacitive Coupling

III. RADIATIVE TECHNIQUES

Radiative techniques achieve longer ranges up to several kilometers. Antennas with high directivity or laser light can generate a beam of energy which can be made to match the receiving area. In fact visible light and microwaves are the forms of electromagnetic radiation best suited for energy transfer. Microwave power beaming is more efficient than lasers and is not affected much by atmospheric attenuation.

A. Microwaves

Microwaves are a form of electromagnetic radiation with frequencies ranging from 0.3GHz and 300GHz or in other words they have wavelengths ranging from as short as one millimeter to as long as one metre. The microwave frequencies offer greater benefits over low frequencies which can be listed as follows:

- Microwaves travel by line of sight and they can travel through snow, clouds and smoke.
- They offer higher bandwidth and directivity.

B. Lasers

The portion of the electromagnetic spectrum pertaining to visible light could be used to transfer power by converting electricity to laser beam which can be focused onto photovoltaic cells. Advantages of lasers include compact size, no radio-frequency interference with existing radio communication technologies. Drawbacks include:

- hazardous nature of laser
- Conversion efficiency between light and electricity is limited.
- Loss due to atmospheric absorption, scattering by clouds, fog, rain etc.

IV. COMPARISON OF WIRELESS POWER TRANSFER TECHNOLOGY

The wireless power transfer technique is one of the promising and practical technologies finding application in various fields. Table 1 gives a comparison of various wireless power transfer techniques.

Type	Frequency range	Devices used
Inductive Coupling	Hz-MHz	Coils
Resonant inductive coupling	kHz-GHz	Tuned coils, resonators
Capacitive coupling	kHz-MHz	electrodes
Microwaves	GHz	Parabolic Dishes, rectannas
Light waves	THz	Lasers, photocells

Table 1: Comparison of various wireless power transfer techniques.

Inductive coupling and capacitive coupling are suitable for short range applications while the microwaves and light waves are suitable for long range applications. Resonant inductive coupling provides better range than inductive coupling and capacitive coupling.

V. APPLICATIONS

Wireless power transmission is a trending technology which has a great potential in the near future. The various applications of inductive coupling technology include charging the battery of electric razors, electric tooth brush, induction stovetops and industrial heaters. Resonant inductive coupling could be used for charging portable devices, bio- medical implants, electric vehicles, buses and trains. Capacitive coupling could be used for charging portable devices, bio-medical implants. Microwaves and light waves could be used for charging wireless devices like mobile phones and powering drones.

VI. LIMITATIONS

Although wireless power transfer technology offers several advantages there are limitations too:

- It is necessary to limit the exposure to people and living beings to harmful radiations.
- Initial deployment cost is high.

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