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WIRELESS POWER TRANSFER

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Abstract

This paper depicts an original idea to remove the hazardous usage of electrical wires which involve lot of confusion in particularly organizing them and it also involves lot of wear, aging and produced electric spark etc, also transferring power in some areas like high mountains and several ocean region may be difficult, wireless power transfer can play a major role in such areas .Therefore, wireless power transfer technology has made people to look towards it also increasing the developments in the field .So this paper introduces the applications of Wireless Power transfer anywhere in the world also we look into the current developments and the basic problems faced.

Introduction

As years pass by, we are moving towards a future with more consumption and an increasing population which will lead to increasing demand of electricity, which non-renewable sources are soon (30-40 years) going to be completely exhausted and we will be then requiring an alternate source of energy production, and so renewable sources are being used in the form of alternate source. Although power from different sources is currently being used but the methods of transferring power can be more efficient rather using the hefty amounts of wires, tangling around the house for every electronic working device, for these reasons, scientists have tried to develop methods of wireless power transfer that could cut this mess or lead to clean sources of electricity. Researchers have developed several techniques for moving electricity over long distances without the use of wires. Some exist in theories, prototypes, but others are already being used. This paper provides the techniques used for wireless power transfer.

History of WPT [1]

The end of 19th century: Nikola Tesla's wireless power transfer experiment between two coils and lit a light bulb.

1960s: In 1975, the first Microwave Power Transfer experiment was launched in Venus's laboratory. The radio frequency 2.388GHz of 450kW can be transmitted to a distance of 1.6km, and its wireless transmission efficiency is8.1%.

2007: Professor Marin Sorgasik of MIT proposed magnetic coupled resonant radio transmission
[2] and achieved some experimental results.

Theory

According to the energy transfer mechanism [3], WPT can be categorized into two types, namely: Far field and Near field WPT system [4].

Far Field WPT

Far-field wireless power transfer which is also called electromagnetic radiation WPT [3], adopts electromagnetic waves like radio frequency signals as a medium to deliver energy in a form of radiation [5]. This is then transferred by the electric field of an electromagnetic wave, which is radiative [5].

This technique aims at higher power transfer to the load. Far-field Wireless Power Transfer includes microwave power transfer, Laser Power Transfer, and Solar Power Transfer [4].

1) **Microwave Power Transfer (MPT):** Microwave Power Transfer (MPT), which is based on electromagnetic radiation, utilizes the far-field radiation effect of the electromagnetic field to transfer power in free space. [6]. This technology transfers high power from the source to the receiving end or mobile devices with two places being in line of sight. With the help of geosynchronous receiving and transmitting satellites, this technology enables the objects to acquire power from the source or base with using the magnetron. MPT provides the efficiency in energy conversion but it is slightly difficult to focus the beam in a small region. Besides, this technology could pass through the atmosphere easily. The first step of power transmission is initiated with converting electrical energy to be microwaves energy and then microwaves energy will be captured with using rectifying antenna. In this technology, Alternating Current (AC) cannot be directly converted to microwaves energy. Therefore, AC needs to be converted to Direct Current (DC) first and then DC is converted to microwaves by using magnetron. Transmitted waves are received at the rectifying antenna and then rectify microwaves into electricity with a good efficiency. It will give DC as the output. In the final step, DC will be converted back to AC [7] [8-13].

2) **Laser power transfer (LPT):** This technology is different with respect to MPT, LPT transmits power under visible or near-infrared frequency, it enables concentration of power at a small area utilizing mirror to a long distance. The receiver of laser powering uses specialized photovoltaic cells to convert the received laser light into electricity [14]. LPT has an advantage of energy concentration. However, laser radiation could be hazardous [17] and it requires Line of Sight (LOS) link as well as accurate pointing towards the receiver which could be challenging as seen in practical sense [15]. It also requires complicated tracking mechanisms and a large spectrum of devices, being an expensive method. Compared to microwave WPT, LPT gets attenuated when it propagates through the atmosphere hindering its practical applications [16]. The practical application of this technology has been used to apply to a rover to explore the presence of ice in the bottom of craters of the moon where no sunlight is available. [18] [19].

3) **Solar Powered Satellite:** It is the largest application of WPT and it makes use of satellites with giant solar panels and placing them in Geosynchronous Earth Orbit. These satellites play an important role in generating and transmitting power as microwaves to the earth [20].

Near Field WPT

Near-field WPT techniques are measuring with appliance near from the power source. It can be

classified into three categories, which are inductive coupling, magnetic resonant coupling and capacitive power transfer.

1) **Inductive Coupling WPT:** The Inductive coupled WPT is the most used method for wirelessly charging low powered devices so far [21]. It transfers power from one coil to another and has been used to power RFID tags, medical implants [6], in the fields of sensors, wirelessly charging electronic devices. The operating frequency of inductive coupling is in the khz range and is typically used within a few millimetres to a few centimetres (20 cm) from the targeted load [6] and its power varies between watt and kilowatt based on transmission efficiency [6]. The advantages of the inductive coupling WPT system include ease of implementation, convenient operation [22]. It is non-radiative and due to its low transmission frequency, it is considered safe for humans [3, 6]. However, a limitation of inductive charging or coupling is that it performs well in short distances, increasing distance adversely drops the performance.
2) **Magnetic Resonant Coupling:** It follows the same basic principle as of Inductive Coupling. This technology was developed by Kurs et al., which enable to make the interactions between two different objects very strongly because of the combination of inductive coupling and resonance [23]. In addition, energy will be shifting back and forth between magnetic field surrounding the coil and electric field around the capacitor. To the classical mechanical resonance, the effect of magnetic resonance is analogous, under which a string when tuned to a certain tone it can be excited to vibration by a faraway sound generator if there is a match between their resonance frequencies. In this technology, energy can be transferred efficiently from a source coil to a receiver coil with little loss of energy to alternating current in a primary coil (connected to a source) generates a varying magnetic field that induces a voltage across the terminals of a secondary coil at the receiver. An electrical transformer is a good example off-resonant object. There are several advantages of this technology, the non- radiative nature of the system presents no threat to the environment as compared to microwave and laser.

   Magnetically Coupled Resonance WPT has higher transfer power and efficiency and is considered to be one of the most potent techniques for mid-range WPT applications at present.

3) **Capacitive Power Transfer:** It involves the transmission of energy between electrodes such as metal plates. A charged retaining capacitor is formed by receiver and transmitter electrodes. The transmitter creates an alternating voltage on the transmitting plate, from which the oscillating electric field via electrostatic induction induces on the receiver plate, an alternating potential, which turns into alternating current flow in the load circuit. [24]. Though CPT is cheaper than Inductive coupling and magnetic resonant coupling, however, CPT requires close contact between the two metal surfaces. Hence, it is limited by range requirements to a great extent

   [6] The major drawback with CPT systems is that electric fields do not share the safety characteristics of

magnetic fields, since their relative field strength is much greater, posing a harm to both humans and electronic devices [6, 25]. Also, the achievable amount of coupling capacitance is dependent on the available area of the device.

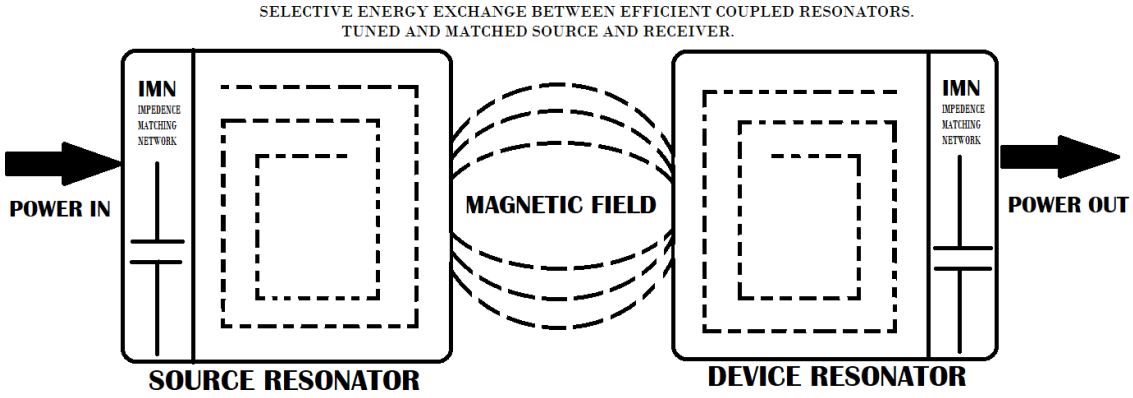
However, it is difficult to create sufficient power density required for charging normal portable electronic devices and this poses a design challenge[26].

wireless power in 1899, today, commercially there is little more than electric toothbrushes and charger mats available, and in both technologies, the toothbrush, phone, and other small devices need to be extremely close to their chargers. However, an MIT team of researchers led by Marin Soljacic invented in 2005 a method of wireless energy transmission for household use that is practical at much greater distances. WiTricity Corp. was founded in 2007 to commercialize the new technology for wireless electricity.

Advancement in the field

WiTricity Corporation:

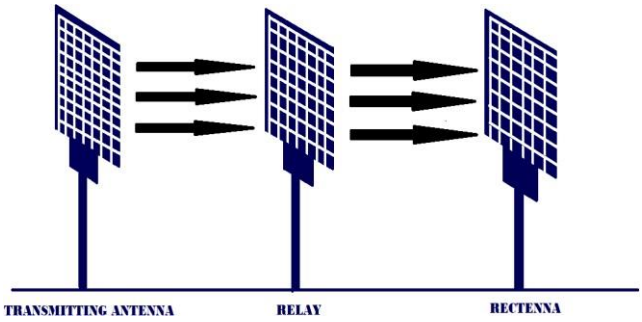
While Tesla was the first person to demonstrate the practical possibilities of



carry kilowatts of electricity wirelessly over very large distances.

EMROD (AUCKLAND, NEWZEALAND):

Emrod, explained how Emrod's wireless system works by converting electricity into microwave energy, which is then shaped into a collimated beam and sent directly through the air from a transmitting antenna to a receiving one. When reaching the receiving antenna, the microwave energy is converted back into electricity for consumers' use. According to the company, this technology can be upgraded to



Alliance for Wireless Power (A4WP): Technology A4WP is a next-generation of wireless power transfer enabling the efficient transfer of power to electronic devices. This is based on reference power transmitting and receiving resonators without the use of interconnecting wires [28]. This technology allows multiple devices to be charged with differing power requirements from a single transmitter at any one time. Because this technology uses a larger electromagnetic field rather than the small inductor coils, therefore it enables devices to be charged without having to line-up precisely with the coil. A further advantage of A4WP is allowing charger to be embedded in the objects where the magnetic fields can still emit the energy from the objects [27] [29].

Applications

Electric Vehicles: Rechargeable hybrid and battery electric vehicles can be directly powered with wireless charging systems. With using this technology, it enables the reliable and efficient of power transmission to electric vehicles without the use of wires. So it is expected that wireless charging will vastly improve the charging experience for EV owners, making such vehicles even more attractive to the vehicle customers.

LED Lightning: Nowadays, use of wireless power transfer in LED lights, we can directly charge our devices using wireless electricity so it can eliminate the need for batteries in under-cabinet task lighting. Moreover, it can also help architectural lighting designers to create products that seemingly float in mid-air with no power cord.[30].

Implantable medical device: The power demand of implantable medical devices is very small. Through wireless power transfer technology, it can greatly improve its operation time in vivo, improve the accuracy of diagnosis and treatment, reduce the rate of misdiagnosis, and achieve permanent operation in vivo, so as to improve patient comfort. Such as cardiac pacemaker, gastrointestinal endoscopy [31] and so on [32-35].

Industrial application: Many fields and devices in the industry cannot use the wired power supply, such as underwater and chemical environment. Wireless power transfer can overcome these shortcomings and drive the development of technology. Such as underwater detector, pipeline detection robot and so on.

Advantages:

- No fuel transportation problem.
- Produces no waste or greenhousegases.
- Lower maintenance.
- Maximum utilization of energy.

Disadvantages:

- Efficiency cannot 100% due to several loss factors.
- Longer exposure of electromagnetic radiation causes several diseases in living beings.
- Expensive compare to the current wired technology, for example a wired charger etc.
- Improper weather can sometimes interfere or distort the transmission.

CONCLUSION

The concept of wireless power transfer although with some disadvantages can be a beneficial and efficient method for transmitting power. This concept offers greater possibilities for transmitting power with negligible losses and ease of transmission than any invention or

discovery made till now. In the next few years, the field will be vastly explored and will be in practical use reaching to the consumers even more. Despite the extensive work in the field by researchers, WPT's full potential has not been realized up till now in term of transfer power and distance, frequency and coils dimensions as the current designed transmitter and receiver coils are too large and expensive to be integrated into the consumer devices and cannot be said to be portable as the coil would occupy space in the working area. So, it requires a continuation of research in the field for more improvements to be of suitable and promising applications.

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