An Overview of Wireless Power Transfer System in Power and Signal Transmission

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Abstract- Wireless power transmission has covered a wide range of subjects in many fields and also become a highly active research area for student, scientist and many other because of their potential to providing new technology to our daily lives. The wireless power transmission will have bright future because this technology used in the transmission of electrical energy from a power source to an electrical load across an air gap without any wires. this paper presents the existing technologies of wireless power transmission, the recent trend, the future and its application

I. INTRODUCTION

Wireless power transfer (WPT) technology becoming a reality has meant electrical power can be transferred over a range without physical contact. In recent times, the amount of energy required for many computing tasks is continuously decreasing, leading to low-power devices such as IoT devices, which in turn justifies the demand for wireless power transmission for uninterrupted operation. Thus, WPT has become a stable for applications in areas such as electric vehicles, unmanned aerial vehicles, biomedical implants, consumer electronics, and household appliances.

WPT is the answer to the issue presented by the short battery life and high initial cost of battery powered applications. The breakthrough of energy storage technology is unable to support the new generation of applications. Thus, WPT techniques have been increasingly investigated to overcome the technical bottlenecks of batteries. However, the design of WPT imposes numerous challenges. Considering WPT for low power applications such as bio-implantable systems, miniaturization and maximum efficiency of power transfer at low specific absorption rate (SAR) is the prime focus. However, in applications such as enhancing the operating lifetime of autonomous underwater vehicles (AUVs), smart WPT techniques are required to reduce the battery burden. In the case of simultaneous wireless data transmission and power transfer, the best use of the radio frequency spectrum is required (Houran et al, 2018).

To enhance the gain and efficiency WPT, the design of antennas and passive reflect array is a challenging task.

- Conventional Power System

One of the major problems in existing power system is the losses occurring in the transmission and allocation of energy to the end users. Because demand drastically increases daily, the power generation increases and also the power loss can be increased. The percentage of loss of power during transmission and distribution is approximated as 26% (Jawad, et al 2017)

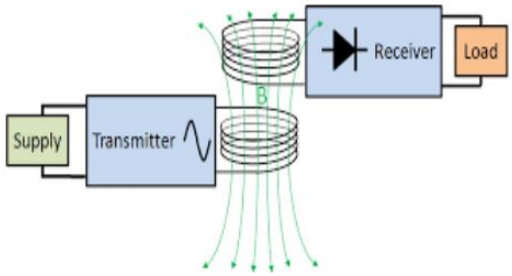

Figure 1: Block diagram of Wireless Power Transfer system

The primary reason for power loss during transmission and distribution may be the resistance of wires used for grid. The efficiency of power transmission may be improved to a particular level by employing high strength composite over head conductors and underground cables who use warm super conductor. But, the transmission is inefficient, however the efficiency can be improved with wireless transfer power transfer system model as presented in the block diagram in figure. 1

- Methods of Wireless Power Transmission

Transformer Coupling or Induction

Energy can be transfered between two coils, through magnetic fields, however in this technique, the distance between the coils should be too close. The principle of mutual induction between two coils can be used to the transfer electrical energy without using wires. The best demonstration of how mutual induction works would can be demonstrated with the transformer, where there is no physical contact between primary and the secondary coils (Zhu, et al 2015)

The transfer of energy develops due to electromagnetic coupling relating to the two coils as shown in figure 2

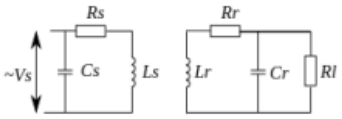

Fig 2: Transformer Coupling or Induction

Resonant Induction Coupling / Evanescent Wave Coupling Researchers at MIT have discovered an alternative way of wirelessly transferring power using non-radiative electromagnetic energy resonant tunnelling. Since electromagnetic waves would tunnel, they would not propagate through the air for being absorbed or wasted, and would not normally disrupt electronics or cause injuries like microwave or radio transmission. Researchers anticipate around 5 meters of range. According to them, an electro-magnetic wave in a very high angular waveguide is called as evanescent waves which carry no energy, when if a proper resonant waveguide is brought at the transmitter, then the tunnel is formed towards power drawing waveguide and this can be converted in DC using rectifier circuits. A prototype model is achieved with 5 meters of ranges using this method.

Radio/Microwave Energy Transfer

It is possible to achieve a long-range using this method. In this method, microwave is sent to the long distances which are received through rectenna. Rectenna extracts microwave energy back to electrical energy (Arai, 2018). The main problem with this particular strategy is how the diameter of antenna needs to be order of kilometer. Power transmission through radio waves as illustrated in figure 3, can be produced more directionally, allowing longer distance power beaming, with shorter wavelengths of electromagnetic radiation, typically in the microwave range, realizing Rectenna conversion efficiencies up to 95%.

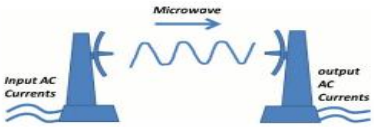

Fig 3: Radio/Microwave Energy Transfer

Moderate Distance Power Transmission

A competent method to transfer power between coils separated by a few meters is the fact that we are able to extend the length involving the coils with the help of resonance on the equation. An alternative way to understand resonance would be to think of it in terms of sound. An object's organic structure much like the configuration of a trumpet determines the frequency from which it naturally vibrates. This really is its resonant frequency.

Electrostatic Induction and Electro-dynamic Induction

Electrostatic Induction and Electro-dynamic Induction, generally known as capacitive coupling can be an electric field gradient or differential capacitance between two elevated electrodes over the conducting ground plane for wireless energy transmission, involving high frequency AC potential differences transmitted between two plates or nodes as illustrated in figure 4.

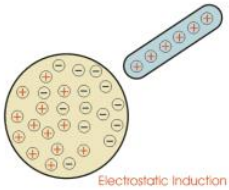

Fig 4 Electro static induction

The method is also referred to as resonant inductive coupling, the foremost problem in connection with non-resonant inductive coupling for wireless energy transfer is resolved through this method; specifically, the dependence of efficiency on transmission distance.

When resonant coupling is applied to the transmitter and receiver, the inductors are tuned to mutual frequency and the drive current is modified from the sinusoidal into a non-sinusoidal transient waveform (Shidujaman & Samani, 2014).

Pulse power transfer occurs over multiple cycles. This way significant power can be transmitted spanning a distance all the way to a number of times how big the transmitter

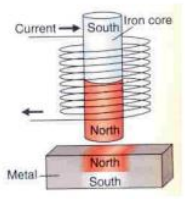

Fig 5 Electro dynamic induction

- Existing and Future Technologies in Wireless Power Transmission

In 1893, Tesla demonstrated the illumination of vacuum bulbs without the need for wires for power transmission in the World Columbian Exposition in Chicago. The Warden clyffe tower was designed and constructed by Tesla mainly for wireless transmission of electrical energy rather than telegraphy.

The Splash Power Recharging Mat and Edison Electric's Power desk both use coils to generate a magnetic field. Electronics use corresponding built-in or plug-in receivers to recharge while purchasing the mat. These receivers contain compatible coils as well as the circuitry necessary to deliver electricity to devices' batteries. A Splash power mat uses induction to recharge multiple devices simultaneously.

Canada's Communications Research Centre developed a small airplane that could elope power beamed in the Earth. The unmanned plane, referred to as Stationary High Altitude Relay Platform (SHARP), was created to be a communications relay.

Recently, most research and proposals use microwaves because of the frequency ranges of choice for transmission. Now an efficiency of 76% may be possible using current technology for microwave power transmission (Houran et al 2018). For greater transmission efficiency the waves have to be focused to ensure that each of the energy, transmitted from the source is focused on the wave collection device.

Advantages of Wireless Power Transmission

1. Wireless Power Transmission system would completely eliminates the previous high-tension power transmission line cables, towers and sub stations involving the generating station and consumers and facilitates the interconnection of electrical generation plants with a global scale.
2. The power could possibly be transmitted towards places and locations where the wired transmission is not feasible.
3. The level of transmission loss is negligible in the Wireless Power Transmission; therefore, the efficiency with this way is a lot higher than the wired transmission.
4. The power failure because of short and fault on cables could not exist from the transmission and power theft will be not possible in any respect.
5. Wireless power transmission system enables movement of User devices easily without connection loss in the wireless range.

Disadvantages of Wireless Power Transmission

1. High capital cost for practical implementation of wireless power transmission.
2. Another major disadvantage is the interference of the microwaves with the present wireless communication system.
3. The effect of microwave radiations at high doses is not suitable to human health.

- Areas of Applications of Wireless Power Transmission

Various applications of wireless power transmission have been famous for centuries. The most widely known example is the non-particulate radiation, for example radio waves, Energy supply to Moving targets which include fuel free airplanes, fuel free electric vehicles, moving robots and fuel free rockets. Another important area of application of WPT is in the wireless sensors and RF power adaptive rectifying circuits (PARC). However, generating power by placing satellites with giant solar arrays in Geosynchronous Earth Orbit and transmitting the power as microwaves on the earth called Solar Power Satellites (SPS) will be the largest application of WPT.

CONCLUSION

The concepts of wireless power transmission (WPT), its history, technological developments, merits, demerits and applications were discussed in this paper. By this, we are able to know the greater possibilities for transmitting power with negligible losses and simple transmission from a long time. It really is envisaged that wireless energy would be really accomplished using a advantage of easy implementation and less expensive i.e., tariff of transmission and distribution overhead would dwindle and moreover it is crucial the tariff of electrical power on the consumer would even be reduced when compared with existing systems.

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