WIRELESS POWER TRANSMISSION TECHNOLOGIES FOR WSNS AND CHARGING OF MOBILE DEVICES

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Abstract

Wireless charging is the charging of devices not attached to the power source by any physical means. Wireless charging provides a hassle free to charge mobile devices on the go and with advancement in technology could eliminate the need for batteries in mobile devices. In this paper we delve into various modes of power transmission both radiative and non- radiative and its implementation in mobile devices and WSNs. The advantages of wireless charging and the shortcomings of its implementation with existing technologies are also discussed.

Keywords: *Wireless charging, Radiative and Non-Radiative, Wireless Power Transmission (WPT), Wireless Sensor Networks (WSN)*

Introduction

In the past few decades there has been a huge increase in the development and an even increase in the usage of electronic devices such as laptops, phones and even toothbrushes. Due to this surge a sudden surge in wireless charging technology has surfaced.

Wireless charging is the charging of devices through any media that does not need a physical tether attached to the device and a power source. Wireless power transfer based on magnetic resonance and magnetic coupling was pioneered by Nikola Tesla more than 100 years ago. Power transfer can be both radiative and non-radiative based on the transfer mechanism used. Radiative transfer works on electromagnetic waves that transmit data over any media such as air or vacuum from antenna over a large distance. Non-radiative transfer works on the principle of magnetic coupling resonance as. This was the mechanism Nikola Tesla implemented in his discovery.

[1] Nowadays this technology is developing and being implemented in many devices almost any mobile handheld gadget one can think of can benefit from the easy access of wireless charging from application of wireless power transfer. When one compares the traditional wired charging, wireless charging poses numerous advantages such as

- Easier access to charging on the go whenever and wherever one goes
- No problems of wire damages and need to purchase a new one
- One can implement the concepts of turbo charging through wireless means
- Wireless charging can provide on demand requirement thus eliminating the requirement of batteries in many cases.
- We can control the amount of power transferred which cannot be done through normal wired charging means Some of the shortcomings of wireless power transfer is the high cost requirements as a power transfer device needs to be installed and the mobile device requires some receivers which need to be installed separately, also these generate a lot of heat which need some additional coolers.

WPT Technologies Current and Past

Nikola Tesla first envisioned the idea of wireless power transfer back in the early 20th century and nearly achieved this when he sent an electrical signal across the Atlantic Ocean. Nikola Tesla built what is considered the worlds first power transmission setup the Wardenclyffe tower in Long island, New York. But due to the large scale electro-magnetic fields involved the method was highly inefficient. Since then with the advent of mobile devices the interest in wireless power transfer has grown again.

The current WPT technologies can be broadly classified into 2 groups the radiative power transfer methods like EM radiations and the non-radiative like inductive coupling and magnetic coupling.

EM Waves Radiation

E.M waves transmit energy from the transmitter antenna of the power source to the receiver antenna of the device in the form of EM waves. E.M waves can be either unidirectional or omni directional based on the direction of propagation of the waves. Omnidirectional waves are made by using a special type of antenna called an omnidirectional antenna where it has an axis and the radio waves are propagated outward radially in a symmetric fashion. Both unidirectional and omnidirectional waves are used for different means and suffer setbacks of their own. Omnidirectional waves are suitable for transferring information, but it cannot be used over a long distance as EM waves dissipate energy over distance and time and decay also for the safety purposes omnidirectional waves are used only in low power nodes as high frequency waves having higher energy can pose a health risk for people. Unidirectional waves can transmit high power radiation over a long distance but can work only if a clear line of sight (LOS) is established. Microwaves or laser beams are usually used. One such application of this mode of transmission is the control of the unmanned aircraft SHARP (Stationary High-Altitude Relay Platform) designed by Canada's communication research centre. The SHARP could fly in circles of up to 2km and could fly for months at a time. However unidirectional waves cannot be used for charging mobile devices or WSNs as a few criteria have to be met for it to work such as the LOS and complicated tracking mechanisms.

Inductive Coupling

Inductive coupling works on the phenomena of magnetic induction i.e. when an alternating current is passed through a primary coil it creates varying magnetic fields that induce an EMF in the terminals of the secondary coil. Inductive coupling mechanism is used widely in everyday products such as wireless charging pads for mobile phones however inductive effect between coils decreases as we move away from the coil. For even a small distance the effect reduces due to this the transmitter node and the receiver node have to be close to each other and in a particular alignment for power transfer to take place. Because of these limitations inductive coupling is not suitable for charging WSN over a long distance. Research in inductive coupling has led to development of different mechanisms such as magnetic resonant coupling.

Magnetic Resonant Coupling

Magnetic resonant coupling is based on the evanescent waves which transfer energy between two oscillating or resonating magnetic coils. An evanescent wave is an oscillating electro-magnetic field that does not propagate as electro-magnetic radiation, butthe energy is spatially concentrated near the source. This is obtained by having resonant magnetic coils operate at the same resonant frequency so that they are coupled by non-radiative magnetic resonance. Using this phenomenon high energy transfer can take place with minimal leakage due to dissipation. Magnetic resonant coupling can charge devices placed at slightly larger distances when compared to inductive coupling (in magnetic resonant coupling the receiving node and the transmitter node can be placed a few metres apart when compared to almost being in close contact in the case of inductive coupling) and more efficiently than omnidirectional EM waves and eliminates the LOS requirement for the unidirectional waves. Also, magnetic coupling resonance can be applied between one transmission resonator and many receiving resonators i.e. many receiving nodes can connect to a single source node in this mechanism. However, there are some shortcomings in this technique as well. Firstly, for the power transfer to work efficiently the nodes need to be aligned co-axially and when many numbers of nodes are connected to the source mutual inductance can take place between them and this can cause some interference.

Applications of WPT Technologies

Based on the range of the aforementioned techniques for wireless power transfer we can classify them as near field or far field charging.

Far field charging can be achieved through either omnidirectional EM waves or unidirectional EM waves. For unidirectional waves only one receiving node can be connected to the source node and a dedicated LOS has to be established first, but it can achieve high power transfer with good efficiency over a long distance even in the range of kilometres with little dissipation of energy. For example, as mentioned earlier the unmanned aircraft SHARP could be controlled and could even move in circle of diameter nearly 2km other unmanned aircrafts such as Raytheon Airborne Microwave platform (RAMP) and High=-Altitude electric motor Power Platform (HAPP) have also been developed using this technology. Microwave and laser beaming techniques used to transfer power in the range of kilowatt over long distance have been in development since the 1960's.[7]Omnidirectional EM waves can operate without a LOS and also and is less sensitive to the orientation if the two nodes, however it has a lesser range than the unidirectional waves and also has lower efficiency. Wireless charging for WSNs have become the most widely used applications for this technique. Experiments on using this technology for battery less devices have been conducted with positive results as in reports. Omnidirectional wave based sensors have also been used in Internet of Things (IoT) and Machine to Machine communication (M2M) systems.

Near Field Charging

Near field charging can achieved by applying inductive coupling or magnetic resonance coupling effects. Most existing WPT system are based on the inductive effect mainly because of its safe implementation and its easy setup and access. Inductive power transfer also allows the transfer of high power with comparatively higher efficiency than radio frequency EM waves. Due to these factors it is used widely in the automation industry. Its major applications are in induction generators, small scale and large robots, electric railway trains. It also sees a rapid development in the bio-medical sector for bio-medical implants.

Advantages and Disadvantages

The advantages of WPT are that it can provide a hassle-free way of charging mobile devices, because of this it saves time as the devices that require to be charged can be done so while they are in use. There is also less wastage of energy by dissipation due to internal resistances in the wires used for charging.

There a few disadvantages of wireless charging along with the advantages. The high cost of implementation is one of them. Network traffic in case of many nodes may cause interference during the charging process/ the rate of charging may not be as high as compared to tethered charging as there is not advancement in this field yet. Also, the radiations used for transfer may cause some effects to the human body

Findings

Many different technologies exist for transmission of power wirelessly. They are inductive coupling, EM waves and magnetic resonance coupling which can be used for near field and far-field charging depending on their need and range required. All of them have their own advantages and disadvantages and their own uses. However, with current technology it isn't completely possible to implement these technologies into all mobile devices so as to completely eliminate the need for batteries.

Conclusion

In this modern era, one does not have the time to always tether one's mobile device for charging all the time. The different technologies provide a promising way to make charging of devices easy and could even eliminate the need for batteries in the future.

In this paper the concept of WPT and its various techniques are presented. Also, the various advantages and disadvantages of it were also discussed. A comparative study of each technique and their advantages over each other and their shortcomings were also presented. The technology we currently posses is not sufficient for every gadget and more developments in current technology needs to be done for it to work on all gadgets.

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