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An Overview of Wireless Power Transmission (WPT)

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Abstract: it is imperative to note that in our daily life electricity is an essential factor as it contributes largely to the success of activities; this has led to a greater demand for electricity transmission which happens to be the most essential component of any control system. It also has its setback as there is always a fraction of loss during transmission and as such it is important to have an efficient transmission of power; this has given rise to the wireless power transfer system. Regardless of the technological concerns, wireless power transfer system in its capacity will expunge the use of wires or cables by providing individuals the option of re-charging the dead batteries of devices effortlessly in the same manner as using a wireless communicator. A concise report and evaluation on the several methods of wireless power transmission is shown and discusses the advantages and disadvantages as well as the analysis and comparison of each method.

Keywords- components; Wireless power transmission; Magnetic resonant; Radio frequency radiation; Inductive coupling

1. Introduction

Wireless Power was introduced a long time ago by notable and pious researchers such as Nikola Tesla, Michael Faraday, Guglielmo Marconi, and Christian Orsted. Today it is one of the promising emerging technologies with potentialities and expected improvement in suitability and liberty for buyers around the world [1]. WPT technology has a wide range of application in electrical power supply and charging the battery. It enhances and improves the flexibility of how home and office appliances can be used. Classical examples of where wireless power transmission (WPT) application can be used are as follows:

- Electricity power supply and cordless battery charging can be accomplished [2].
- Devices like TV set, Refrigerators, Air conditioners and Projector can be displayed anywhere without the need for a power cable.
- In outdoor applications such as electric automobiles, medical human body implant devices, power transmission between cohesive circuits and microwave energy transferral for solar energy satellite [3].

WPT technology is expected to dominate numerous upcoming applications in the future and revolutionised business, and as such is perceived and regarded as one of the leading and the most impacted emerging technology [1], [6].

2. Methods of Wireless Power Transmission

Various methods are used in the transmission of power from a transmitting source to a load. However, we shall take a critical survey of three wireless power transmission methods, namely; magnetic resonance, radio frequency radiation and inductive coupling.

2.1. Magnetic Resonance

Magnetic Resonance [2], [4], commonly known as Inductive Resonant coupling or physical appliances of Magnetic resonance is somehow or closely associated with that of electromagnetic induction. The transmission and receiving coils are intensely coupled, which makes the coils resonate robustly, making the power transmission array grow – stronger [3]. Mutual induction principle states that in a different continuous current passing through a coil which forms a magnetic field in the planetary within the primary coil, different magnetic field interrelates and generates secondary coil by induction [5].

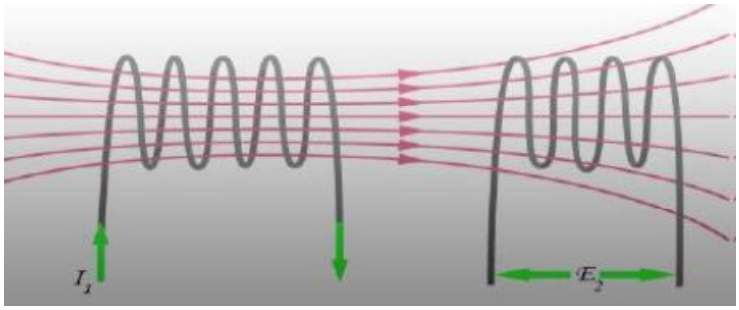

Figure 1: Mutual Inductive Principle [5].

This is magnetic resonance in the middle of two coils functioning at an equal resonance frequency rate. The resonant frequency is the maximum frequency produced by amplitude of waves and can be attained by changing different parameters distressing the amount of voltage gain generated via coils [5].

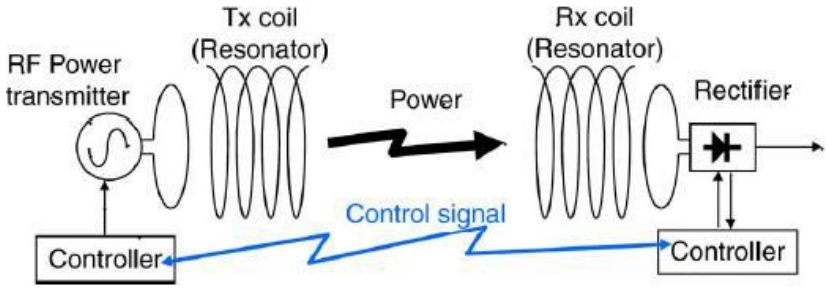

Figure 2: Configuration of magnetic resonant [3].

The objective of this technique is that two distinct resonators with equal resonant frequency can interchange power proficiently, even though the coupling influence is feeble among objects with dissimilar resonant frequencies. Magnetic Resonant coupling can transmit higher power within a short range. A research conducted by Marin Soljacic and team at MIT reveals how a 60

Watt bulb is powered without physical contact (wirelessly) within a range of 2m, with an efficiency of 40% and a resonant frequency of 10MHz. Later a repeated experiment was conducted at Intel with an increase of 75% efficiency, but this time within a range of 1m [6]. Resonant power transmission is one of the exceptions and broadly used technique of magnetic power transmission, with a wide range of applications, partial by the similar limitations of magnetic field productions and efficiency [7]. Its application includes, but not limited to inductive mobile phone chargers and medical implants [8].

2.1.1. Advantages of Magnetic Resonance

1. Convenient use of devices and eliminating the need for power cable or plug and replacement of batteries, thus resulting to more desired customers.

2. Increase the reliability of the devices by getting rid of cords or connectors and component that make system weaker.

3. Devices promote a hygienic environment because it reduces disposable batteries. Using network power is less expensive rather than developing, shipping, and consuming batteries.

4. Devices are harmless by eradicating the sparkling danger connected with electrode interconnections, and thus making the waterproof and detonation proof by removing the connector heads and wires passing through rooftops, walls or any other barrier.

5. Multiple Devices can be centrally powered and controlled by single resonator source, thereby reducing maintenance cost [9].

2.1.2. Disadvantages of Magnetic Resonance

1) Magnetic Resonance devices are very expensive to afford and implement, unlike the other techniques such as RF.

2) Extremely difficulty in implementation and maintenance of great quality [6].
3) Large percentages of users have the impression that they are no longer safe with magnetic resonance, because of efficient energy exchange within a short range distance [9].
4) MR devices are very sensitive to motion, thereby making it complex to be used in some places where movement is needed to carry out some operation, for example, medically it cannot be applied to the patient without their consent [4].

2.2. Radio Frequency Radiation

Radio frequency (RF) radiation is one of the methods used in wireless power transmission. Generally, radio frequency transmits electromagnetic signals with the main purpose of sending and receiving information from both far and near distances with the aid of special devices. The

power transmitted using this technique contains a very low efficiency, which makes the method not suitable to supply enough electrical energy to charge the devices [4], [10].

The process of transmission of data begins with the aid of a transmitter which sends out the alternating current (AC) in the form of electrical energy signal, this is achieved by means of a transporting medium connected to an external antenna [11].

A coaxial cable serves as a good conductor and is capable of conveying a reasonable amount of electrical signal from the transmitter to the antenna. Electromagnetic waves sent from the antenna are picked up by another antenna connected to base stations containing receivers configured to accept such signals; Radio frequency works with different ranges of frequencies which are normally used to transmit and receive signals from one station to another [4],[10],[11].

The figure below shows an example of two based stations sending and receiving data using the radio frequency transmission of wireless power.

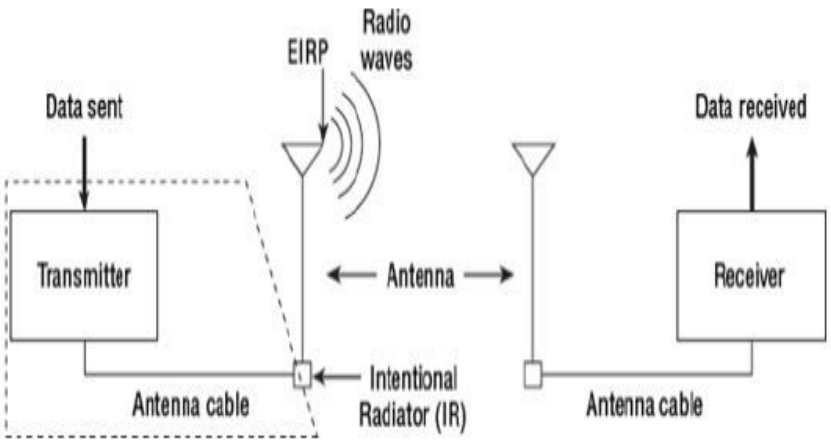

Figure 3: An illustration of Radio frequency transmission [11].

2.2.1. Advantages of Radio Frequency (RF)

1) This method of transmission has the capacity to cover and travel a very wide range of distance making data communication possible [4].

2) Radio frequencies carry very low electrical energy which makes it virtually harmless to humans [10].

3) The waves transmitted have the capacity to penetrate through walls. The electromagnetic wave transmission does not require a definite path to travel [11].

4) The technology uses a wireless form of transmission which makes it very cheap compared to using wires [10].

2.2.2. Disadvantages of Radio Frequency (RF)

1) The efficiency of the power produced during transmission is very low which makes it impossible to charge an electrical load [4].

2) Base stations are required for both transmission and receiving of electromagnetic waves and as such can lead to serious health concerns if located close to residential areas [12].

5) The transmission technique only supports data communication because of the low power efficiency, which is all lost in space during transmission [12].

2.3. Inductive Coupling

This technique of wireless power basically deals with the transmission of magnetic field generated by a transmitter to an electrical load at another end. The method uses the process of "inductive magnetic coupling at low frequency (LF) and high frequency band" [13]. It covers a very short distance when transmitting and also has a high efficiency of power [4]. Electrical appliances can be charged with the use of this method because of the high level efficiency of power produced. The concept of inductive coupling involves the use of coils in the transmitting and receiving devices and this works as a transformer that steps down the high voltage to the reasonable amount capable of powering a load [13].

The power transmitted is converted by the transmitting coil to suit the various appliances and the receiving end. A gap exists between the two coils at the transmitter and the receiver which serves as a medium to regulate the available voltage supplied [13]. Below in Figure 4 is an illustrative diagram showing the inductive coupling transmission method.

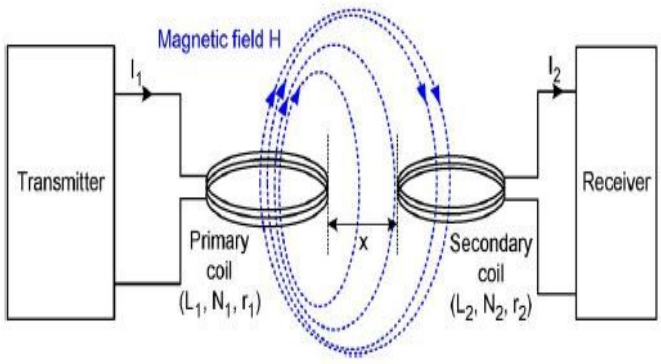

Figure 4: Simple inductive coupling transmission diagram [13].

2.3.1. Advantages of Inductive Coupling

1) The technique also transmits power in a low frequency mode, which increases its level of efficiency [4]
2) Power transmitted when using this method can be used to change electrical load.
3) Unlike other methods that transmit signals through electromagnetic waves and is hazardous to human health, inductive coupling makes use of magnetic field which coiuld be harmless [4], [12].

2.3.2. Disadvantages of Inductive Coupling

The major disadvantage of the inductive coupling technique is that it can only transmit power within a very short range [4].

3. Comparison of Different Methods

In this paper, it is observed that two different resonators with related resonant frequency can switch power capably whereas the coupling effect is weaker among entities with dissimilar resonant frequencies [4]. The inductive coupling has a high, strong, and effective transmission point. It can transfer power within a short range (centimetres) when compared to resonant coupling and radio frequency [4], [14]. The radio frequency shows a low efficiency in human wellbeing as it could lead to health issues as a result of the electromagnetic waves, but the inductive and resonant coupling is not detrimental to the health as it makes use of magnetic field [15].

Magnetic Resonance devices are very expensive to afford and implement, unlike the other techniques such as Radio frequency, etc. In fundamental nature, one can say that the wireless power transfer irrespective of the method(s) chosen as each method comes with its own advantages and disadvantages but it is expected to dominate future applications [1], [6].

4. Conclusion

A novel approach of WPT has been discussed in this research paper, their impact, applications and how people perceive and predict the development of future technologies. Different WPT techniques and applications are expected to be improved on and further researches should be carried out. However, there are concerns over guidelines, regularity bands, security, human body protection, and regulation. Researchers, Vendors and engineers contributed corporately and immensely to the development of working WPT technology, which is a step forward to the innovation and emerging technology and has promising potentialities to achieve more in the future.

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