

# Advanced Wireless Power Transfer System

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**Abstract** - In present era, every human needs a system that transfer power in a very efficient way. Wireless power transfer is one of those system that become a highly active research area in past few years. Wireless power system transfer the power without using of wires and increase the efficiency by decreasing power loss. In this paper, different methods are discussed for wireless power transfer. In addition, a qualitative comparison between methods on the basis of separation distance, power transmitting capacity, cost, efficiency and safety is discussed. Furthermore, we also discuss about recent technology on wireless power transfer such as Qi, A4WP, and PMA technology. Furthermore there are plenty of application of WPT such as in medical science, solar power satellites (SPS) e.t.c.

**Key Words:** Wireless power transfer, induction coupling, resonance coupling, microwave, SPS

## 1. INTRODUCTION

The Transfer of electrical power in reliable and efficient way is always challenging for the designers and engineers. Presently all electrical power from the generating stations to the distribution station is transferred by the uses of wires and underground cables. One of the major issues in these types of systems is the losses due to resistance of the material. Generally the percentage of loss of power during the transmission and distribution is 26% [1].

In modern technology the use of portable device has increased such as mobile robots and electric vehicle. Mobility is the main concern of these equipment i.e. they are not connected to the main source of power.

All these problems are the main motivation for researchers. Nikola Tesla was the first who introduce the concept of wireless power transfer [2]. But this technology from the time of Tesla is underdeveloped due to lack of funding and technology. But research from past few years has always going on and recent development has been observed in the field.

Wireless power transfer can be achieved by several methods (discussed later). Here we discussed few methods such as induction coupling, resonating coupling, LASER technology for electrical power transfer.

## 2. LITERATURE REVIEW

- After the immense research in electromagnetic field by many pioneers and development of electromagnetic induction law by Michael Faraday which gives the basis of wireless power transfer.
- In 1891 Nikola Tesla was the first pioneer who started working on wireless power transfer system in his "experimental station" at Colorado, by using Tesla coils [3].
- Tesla want to develop a wireless power system that is capable of transmitting power over long distances. He proposed many such systems.
- Nikola Tesla successfully lighted a small incandescent lamp by means of a resonant circuit grounded on one end. The lamp is lighted by the current induced in the coil.
- Wardencllyffe tower was also designed by Tesla for Trans-Atlantic wireless telephone and also for demonstrating wireless electrical power transmission [5].
- In 2008 the wireless power consortium was established to connect all manufactures its Qi inductive power standard enable wireless power charging and powering of portable devices of capacity up to 5W with separation distance 4cm [4].
- In recent years the research on microwave and LASER wireless power transmission system such as solar power satellite has increased.
- Energy harvesting also called power harvesting which is the conversion of ambient energy from environment to electric power which mainly used to power mini watts wireless electronic devices. The ambient energy is produce from stray electric or magnetic field or radio waves.



Fig.1: Wardencllyffe Tower [11]

### 3. WIRELESS POWER TRANSFER METHOD

#### 3.1 INDUCTIVE COUPLING

This type of WPT is simply based on inductive coupling between two coils. This is a type of near field technique measuring with appliance near the source. It is generally based on the principle of mutual induction, where two coils are placed vicinity to each other and there is no physical connection between these two coils. The simplest example is transformer where the transfer of energy takes place due to electromagnetic coupling. Each of these coils connected without wires and it has been an important and popular technology to transfer power without wires because of its simplicity and reliability. Based on this technology there are various application device has been already made including electric brush and charging pad for cell phones or laptop. But this kind of method also have some limitation i.e. the range can be very less upto few cm and separation distance is very less than the coil diameter.

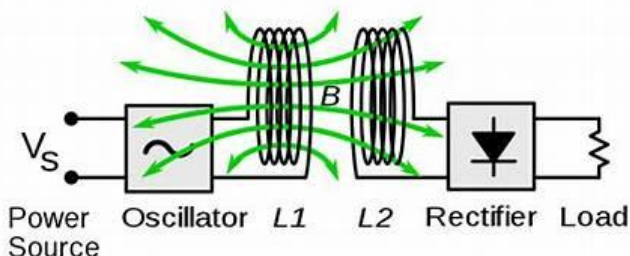


Fig.2: inductive coupling[12]

#### 3.2 MAGNETIC RESONANCE COUPLING WPT

This is also one of the important method for transferring power based on near field technique. It generally overcome the disadvantage of upto some extent which arise in non-

resonant inductive coupling. This type of coupling used the concept of resonance. At resonance we know that natural frequency and excitation frequency are same. This leads to the maximum amplitude, that means a maximum amount of energy is transferred between two coils. Here the receiver and transmitter coils are tuned to be at same resonant frequency. This allow us to transfer significant amount of power by increasing distance between coils [7]. These type of system are used for building mid range power transfer. Mid range can be specified by distance upto 10 times the diameter of the transmitting coil. Magnetic resonance coupling have several advantage such as efficiency increases with decrease in the radiation and power loss and range can be increase upto some meter and it is directional. The mainly disadvantage is that selection of resonance frequency which tunes with the natural frequency and it cannot be used for long range application.

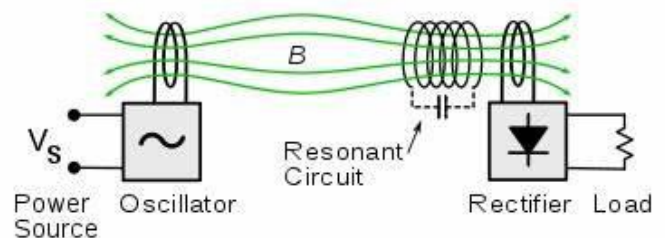


Fig.3: Magnetic resonance coupling[13]

#### 3.3 MICROWAVE WPT

This is one of the type of far-field technique of WPT which have range upto KM, with power transfer upto MW. This method uses microwave frequency ranging from 1GHZ to 1000GHZ generated from the microwave generator. First the microwave is generated by microwave generator which pass through the coax-waveguide adapter to the waveguide circulator. Then a tuner and directional coupler are used to separate wave according to their propagation direction. Then they are transmitted through antenna. At the receiver terminal, a receiver antenna receives which pass through a low pass filter to finally produce DC power. Based on microwave WPT system the present application is solar power satellite [8]. Advantages of microwave WPT are that it is used for several KM range with transferring high amount of power. Disadvantage are generally that the radiation effect to human beings from the microwave electromagnetic radiation

#### 3.4 LASER WPT

This is also one of the types of far- field technique, where the power is transmitted through LASER beams. For power transmission firstly the electrical energy is converted to high LASER beams and at receiving side, these LASER beams are converted to electricity by using photo voltaic cells. This type of WPT has several disadvantage i.e. why it is not used for electrical power transmission because LASER beams can easily harms human being if they cut LASER beam path. Therefore these are generally used for military weapon development and space research[9].

**FUNCTIONAL BLOCK DIAGRAM OF WIRELESS POWER TRANSMISSION SYSTEM**

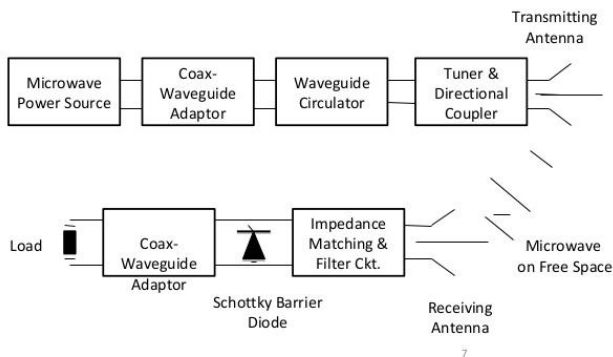


Fig.4: Functional block diagram of WPT[14]

**4. COMPARISON BETWEEN WPT METHODS**

WPT METHODS	SEPERATION DISTANCE	POWER	EFFICIENCY
Inductive coupling	Few mm	Few watts	Low
Magnetic resonance coupling	Few meter	Few Kilo Watts	High
Microwave WPT	Upto 100KM	Upto 100 MW	High
LASER	Few meter but with high intensity	Upto 100 MW	Low

**5. ADVANTAGES AND DISADVANTAGES**

**5.1 ADVANTAGE**

- It gives the human comfort as there is no chording or wiring problem, so mobility is easier.
- There is no problem of power failure and extensive heating.
- Cost of overall system decreases due to no uses of wires.
- Overall efficiency increases due to decrease in the power loss.
- It offers no corrosion as there is no exposure to the atmosphere which is Ecofriendly[10].

- It offers ranges of power levels and separation distance between coils.
- It offers convenient, reliability, high efficiency, low cost at the same time.

**5.2 DISADVANTAGE**

- WPT methods uses the electromagnetic radiation for power transfer and the main effect of electromagnetic wave is its biological impact which harms human beings and animal.
- Biological impact of inductive coupling and resonance coupling is far less than compared to microwave power transmission technique
- There is also a limitation of separation distance and power capacity.
- Interference of microwave with other communication system.
- Initial cost is very high for implementing WPT system

**6. APPLICATION OF WPT**

**6.1 MEDICAL DEVICES**

The most important application of WPT is in medical science. As we know medical device uses very small amount of power. Some medical device are LAVAD heart assist pumps, pacemaker and infusion pumps. These device one implemented in human body. Now for replacement of battery there is a need of surgery after a particular period. With using the WPT technology, the power can sufficiency supplied to medical device without harming human body.

**6.2 ELECTRICAL VEHICLES**

Electrical vehicles are the new technology which uses electrical energy for their operation. The main concern about the electrical vehicles is that their mobility i.e. they are not directly connected to the source of power by wires. With using this technology, it enables the reliable and efficient power transmission to electrical vehicles without using of wires. WPT also marketed the electrical vehicles which attract the consumers to buy it and decrease the load on diesel and petrol vehicles.

**6.3 SOLAR POWER SATELLITE (SPS)**

The most important application of WPT system is solar power satellite that uses the microwave for energy transferring. Satellites are generally equipped with solar power transmitter and receiver antenna. Solar panel converted the generated electricity into high power microwave beams and directed towards the ground station receiver antenna. The major problem with this system is it biological effect of microwave radiation on human and animals, if they are distracted from their path. The receiving zone of SPS is much larger for getting a small amount of

power. For achieving 750MW power with power intensity of  $1\text{mw}/\text{cm}^2$ , we have to take a area with 10KM diameter so that radiation level is in safe zone.

## 7. CONCLUSIONS

So far, we have discussed all aspects of wireless power transmission system and we can conclude that it is an important research area for electrical engineers that has large scope in future in domain of power generation and transmission. Based on the study, we also conclude that from all method magnetic resonance coupling is the most efficient compare to other in all aspects. Microwave WPT gives us to increase the range up to KM and power transferring capacity upto MW, but it cannot safe for humans and animals due to its biological impact. Researchers have to find a safe solution for microwave WPT so that it cannot harm humans. WPT gives the comfort, convenience, safety, reliability, low cost, high efficiency simultaneously which make it one of the best research areas in electrical engineering.

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