

# Survey on A New Controller for Bi-Directional Wireless Power Transfer Systems

M.Tech. Scholar Manish Kumar, Assistant Professor Poonam Khatarkar

Department of Electronics & Communication Engineering,  
IES College of Technology Bhopal MP India.

**Abstract** - Wireless power transfer (WPT), which transmits power by an electromagnetic field across an intervening space, provides the prospect of new opportunities for electric vehicles (EVs) to enhance sustainable mobility. This review article evaluates WPT technology for EV applications from both technical and sustainability perspectives. The distinct research on, efficient WPT design for low power applications encompasses on designing proper coupling circuit by considering application constraint and addressing different issues in the resonant coupled circuit. This section analyzes the technical literature related to WPT links, capacitive power transfer, power transfer to multiple receivers, interference-free simultaneous power transfer, spatial misalignment mitigation technique and navigational force generation using magnetic circuits.

**Keywords**- Wireless power transfer, electric vehicles, Sustainability, Environmental impact; Energy efficiency.

## I. INTRODUCTION

Over the preceding decade, consumable electronic gadgets have become computationally more powerful and rapid lessening in size. These devices changed the human lifestyle and the way how human interact with the surrounding. We are almost relying on our electronic gadgets and machines which complete our work. Thousands of new products are coming to the market every year with new inventions and technology. As the increase in the number of electronic devices used by a person, the power supply to these devices to sustain for a long period becomes a major concern. Despite the fact the battery and power electronic interface have become effective over the period; it is much desirable to have charging facility as convenient as wireless internet. The WPT technology is gaining the momentum as a suitable alternative to for the wire free low power electronics.

Pioneering scientist Michael Faraday's invention of electromagnetic induction in 1831 surfaced the way for the development of wireless power transfer from source coil to load coil. By using this principle, the transformers were developed, which were the first device to transfer electrical energy without any physical contact [1]. Since the transformer requires strong coupling between the coils, it was mainly used for stepping up, stepping down current or voltage also in an isolation circuit. At the beginning of the 19th century, Hertz and Tesla proposed power transfer approach over longer distance [2]. Primarily Tesla's work was engrossed on resonance based WPT to improve the power transfer efficiency over distance. Improvements in the WPT were decelerated in the first of 20th century, due to the lack of well-developed

high-frequency oscillators [3]. Because efficient WPT requires channeling the electromagnetic waves into a narrow beam, which were impractical to produce at that time. In the 1960s, the progress in high-frequency microwave transmission link was used for different applications in solar energy beaming and space [4]. In the meantime, fully implantable biomedical devices such as pacemakers were conceptualized, and the requirement for WPT becomes ostensible [5]. However, the new microwave power link was not used in biomedical implants due to short range coverage between the receiver (Rx) and transmitter (Tx) and limitation on the power density exposure to tissue.

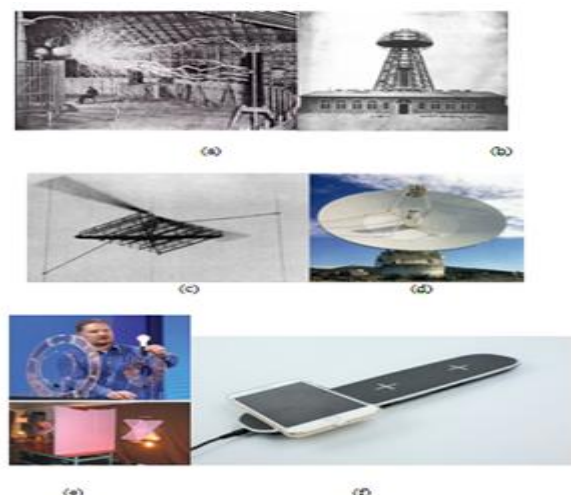


Fig.1. Initial Phase of WPT system [18] (a) Tesla Coil (b) Wardencliff Tower (c) Microwave Powered Airplane (d) JPL's Goldstone Facility (e) Witricity Demo (f) Qi-Charging pads.

## II. LITERATURE SURVEY

Yunyu Tang et al. obtained from a 1-kW prototype system show good agreement with simulated results, validating that the proposed controller can be used to regulate the power flow in BD-WPT systems.

Jun-Young Lee et al. a large air-gap bidirectional wireless power transfer charger for electric vehicle. It is controlled by pulse width modulation with a self-resonant frequency formed by self-inductance and resonant capacitor so that constant frequency operation can be accomplished under large air-gap without additional current chopper. The feasibility of the proposed method has been verified with a 6.6-kW prototype with air-gap of 12–20 cm.

Zicheng Bi et al. Wireless power transfer (WPT), which transmits power by an electromagnetic field across an intervening space, provides the prospect of new opportunities for electric vehicles (EVs) to enhance sustainable mobility.

Dr. Chokri MAHMOUDI et al. reviews state-of-art on electric vehicle concept giving description for each sub-category, and then details power management strategies and charging techniques highlighting main problems and solutions. Finally, power management structure and future research direction are also discussed.

Seung-Hwan Lee et al. A high-power online wireless power transfer system has been investigated intensively in recent years. However, no literature has focused on the design methodology of the high-power online wireless power transfer system with low flux density, high efficiency, and high control stability. This paper proposed a new design methodology for a 300-kW, over 96 % coil-to-coil efficiency, International Commission on Non-Ionizing Radiation Protection's safety regulation compatible online wireless power transfer system. Using finite-element analysis and experimental results, the proposed design methodology has been evaluated.

Sungwoo Lee et al. A large-signal dynamic model of the inductive power transfer system (IPTS) for the online electric vehicle (OLEV) is developed using the recently proposed Laplace phasor transform. With the help of this dynamic model, the effect of the output capacitor and load resistance variation on the transient response of the IPTS is analyzed. The maximum pickup current and output voltage for an abrupt in-rush of the OLEV are examined by both the proposed analysis and simulations, and verified by experiments with good agreement. Thus, it is found that the voltage and current ratings of the pickup remain relatively constant regardless of the load resistance.

### III. CLASSIFICATION OF WIRELESS POWER TRANSFER SYSTEM

The WPT schemes are classified into near field and far field power transfer or radiative and non-radiative power transfer as shown in Figure 2. The radiative power transfer is further divided into a directive and non-directive RF power transfer. Similarly, the non-radiative scheme is divided into the inductive coupling, inductive resonant coupling and capacitive coupling.

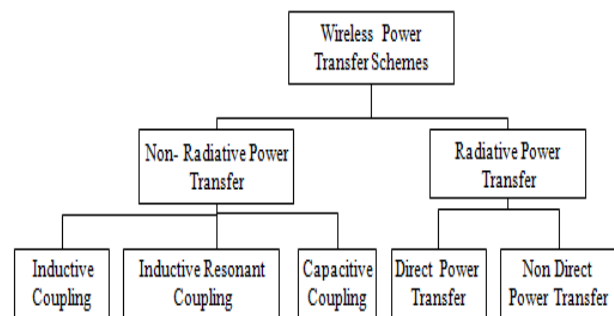


Fig.2. Wireless Power Transfer Schemes.

In the case of Capacitive coupled power transfer, the power transfer ratio depends on the coupling between the plates, which eventually depends on the area of the plates. However, in the case of low power applications restriction on the design size impose the major challenge to this method. Similarly, for the radiative- directive power transfer requires the exact direction of the receiver system.

Hence, to overcome these limitations the WPT systems are mostly investigated using inductive coupling, inductive resonance coupling and non-directive power transfer schemes. The inductive coupling and inductive resonance coupling works on the near-field coupling between the coil. The generated electromagnetic fields are decayed by the reciprocal of a cube of coupling distance. The non-radiative power transfer method operates on the far-field approach for the longer distance. However, the amount of power transfer is limited by this method because of safety constraints.

### IV. APPLICATIONS OF WIRELESS POWER TRANSFER SYSTEM

This section discusses briefly about the major applications of WPT system such as biomedical, wireless sensor nodes and electric vehicle.

- Biomedical Applications
- SAR and heat transfer of tissue
- Wireless Sensor Nodes
- Electric Vehicles

### V. CONCLUSION

Wireless power transfer (WPT) is gaining more attention in recent years as a means of transferring power without any physics contacts. In contrast to other techniques, WPT technology offers many benefits, such as high efficiency, galvanic isolation and high reliability especially in hostile environments. Currently, WPT is widely used in industry applications such as automated guided vehicles (AGVs), biomedical implants, people moving applications and electric vehicle (EV) charging.

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