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Energy Acquisition Through Wireless Power Transfer

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Abstract

Battery-powered devices face unprecedented technical problems due to limits such as low power density, expensive, and heaviness. Wireless power transfer (WPT) is a revolutionary energization pattern that provides a completely new way for electric-driven devices to acquire energy, reducing their reliance on batteries. This study provides a review of WPT approaches, focusing on their working mechanisms, technical obstacles and traditional applications. This study focuses on WPT systems and highlights current important research areas as well as potential development trends. This unique energy transmission system has important implications for the widespread use of renewable energy in our daily lives.

Keywords: capacitive power transfer (CPT), inductive power transfer (IPT), wireless power transfer (WPT), electric vehicles (EV)

1. Introduction

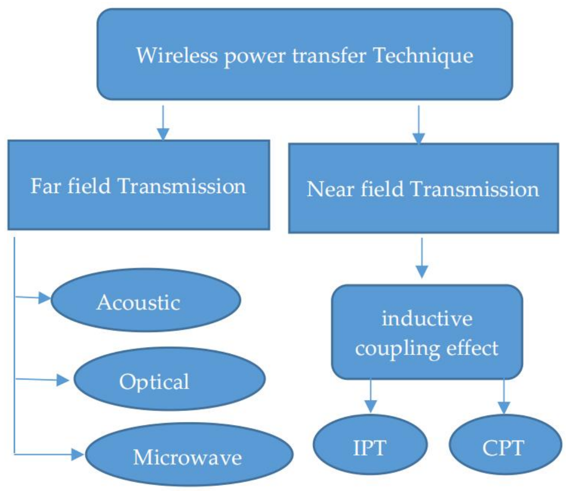
Old way of living is being upgraded by new technique which are revolutionary changing the life around us. WPT transfer energy in cord-less way. Power transfer through wires result in constant losses which cannot be removed. Flexibility of WPT technique is an ideal practical way for energizing portable applications (Rim, C. T., & Mi, C., 2017).

Battery-powered applications have short battery life and high cost. If we talk about EVs battery run time is less as claimed and in order to extend it extra batteries will solve but would increase cost. Waiting for new storage technology, charging method namely WPT technique may capture wireless electricity from the electromagnetic field in the air and charge their batteries cordlessly even while in motion, hence resolving the issue of limited battery life (Chau, K. T., 2015).

The following is the structure of this document. The functioning mechanisms of IPT and CCPT will be discussed in detail in Section II. Technical issues, such as efficiency, power, distance, misalignment, omnidirectional charging, and security, are discussed in Section III. WPT application in Section IV, including EVs Section V will draw conclusions and explore WPT systems' future potential.

2. Implementation Method

This system distributes electricity from the power source to the application through air as a replacement for of traditional wires.



The near-field method operates on inductive coupling effect, which is based on the inductive and capacitive mechanisms, this is the solely focus of this paper.

2.1 Inductive Power Transfer (IPT)

The primary loop L1 is energized by the power source. Figure 1 depicts a typical setup. IPT pickup, in its most basic form, consists of a coil of wire placed close to the track wires to catch magnetic flux around the track conductor. This coil generates a voltage (Covic, G. A., & Boys, J. T., 2013).

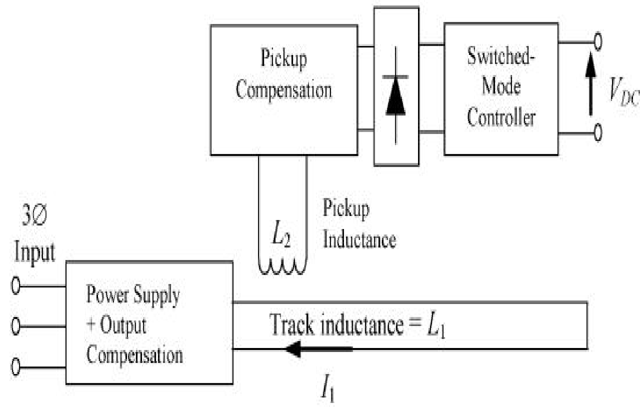


Figure 1. Circuit model of IPT systems (Covic, G. A., & Boys, J. T., 2013)

2.2 Capacitive Power Transfer (CPT)

Figure 2 depicts the CCPT systems' equivalent circuit, with power wirelessly delivered via the coupling electric field between plates (Theodoridis, M. P., 2012).

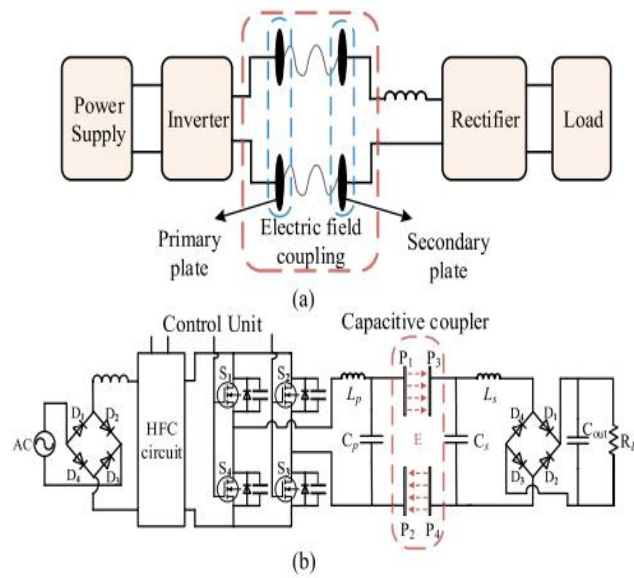


Figure 2. CCPT system

3. Near Field Technique Hurdles

(Zhang, Z., Pang, H., Georgiadis, A., & Cecati, C., 2018) In current years, the near-field WPT approach has undergone a rapid development period. Academic researchers and industrial engineers are increasingly focusing on enhancing energy transmission performance, with an emphasis on efficiency, capability, application, flexibility, security, and other factors.

The primary technical hurdles for nonradiative electromagnetic WPT systems will be discussed in this section.

A. Energy Efficiency

The most essential technical concern for WPT systems is optimal energy efficiency. Various efficiencies along the transmission line are shown in Figure 3 (Pinuela, M., Yates, D. C., Lucyszyn, S., & Mitcheson, P. D., 2012).

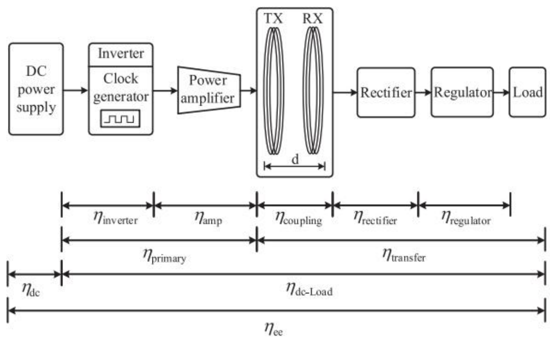


Figure 3. Efficiency of WPT systems

A number of works have been described in past research in order to boost efficiency, which may be grouped into coil design, circuit architecture, and power control.

- Coil Design
- Circuit Topology
- Power Control

B. Transmitted Power

C. Transmission Distance

D. Displacement Flexibility

- Coil Topology
- Compensation Network

E. Omnidirectional Charging

F. Security

4. Application

WPT techniques allow you to harvest energy through the air. Electric-driven gadgets provide exceptional energy access flexibility because they are not limited by the standard wire. Dynamic contactless charging is making its way into our daily lives. This section of the article will provide an overview of common WPT application such as EVs.

➔ For a system of low cost with high power for the resonant CCPT for continuous charging of EV;

(1) Small transmitter and receiver coils, narrow-width power rails are used and operating frequency of 20kHz delivers efficiency of 83% at an output power of 60 kW and which reduces current by 200A. battery size has been significantly reduced to 20 kWh (Mi, C. C., Buja, G., Choi, S. Y., & Rim, C. T., 2016).

(2) The efficiency is further improved to 88% by getting a high capacitive coupling through conformal bumper that decreases air gap between coils with confined field which reduces skin effect and voltage loss on semiconductor (Dai, J., & Ludois, D. C., 2015).

(3) Misalignment during charging lowers coupling coefficient (k) which decreases the power by half as volage on chassis is high which can be corrected by using chassis and ground of car in coupler structure design instead of 4 plates (Lu, F., Zhang, H., & Mi, C., 2017).

(4) Further reduction in chassis volage is achieved by Electric Field Resonance where inductor is inserted in compensation network which gave a high phase difference (Li, S., Liu, Z., Zhao, H., Zhu, L., Shuai, C., & Chen, Z., 2016).

(5) Capacitor in parallel with the CPT compensate for reactive power so unity pf and robust for misalignment and distance variations (Lu, F., Zhang, H., Hofmann, H., & Mi, C., 2015).

➔ For a system of low cost with high power for the resonant IPT for continuous and static charging of EV;

(1) For increasing k and minimizing skin and the proximity effect:

i: Multiple strands are wrapped around transmitting coils in both sides (Lu, F., Zhang, H., Hofmann, H., & Mi, C., 2015).

ii: DD coil, unipolar coil and aluminum shielding for coupled transformer structure (Lu, F., Zhang, H., Hofmann, H., & Mi, C., 2015).

iii: Ferrite bars of high quantity (Lu, F., Zhang, H., Hofmann, H., & Mi, C., 2015).

(2) IPT's primary and secondary coil misalignment was resolved by;

i: Alternate winding which gives evenly

distributed field (Zhang, Z., & Chau, K. T., 2015).

ii: Vertical-and-horizontal secondary coil removes ferrite block (Zhang, Z., & Chau, K. T., 2015).

(3) Unity-power-factor & zero-voltage-switching;

i: LCC with tuning method (Li, S., Li, W., Deng, J., Nguyen, T. D., & Mi, C. C., 2014)

ii: Adding coil make Resonant frequency also independent of coupling coefficient k and load conditions (Li, W., Zhao, H., Li, S., Deng, J., Kan, T., & Mi, C. C., 2014).

iii: It reduces the size hence high efficiency (Li, W., Zhao, H., Li, S., Deng, J., Kan, T., & Mi, C. C., 2014).

5. Conclusion

Problem regarding battery powered application were discussed. Rather than focusing and waiting for a breakthrough in energy storage, main focus is on charging system that can easily overcome battery issues. Two method of power transfer mechanism are present, but the short-term issue of charging portable batteries was discussed. Two WPT techniques were overviewed with emphasis on cost reduction, achieving higher efficiency, less coupling variation and minizine of skin and proximity effect associated with nearfield mechanism.

Area for concern in future will mainly focus on far field methods which object will achieve efficiency regarding mentioned parameters;

1) Transmission distance

2) Energy security

3) Bidirectional exchange (V2G)

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