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A REVIEW ON WIRELESS POWER TRANSFER (WPT) FOR ELECTRIC VEHICLE (EV) APPLICATIONS

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ABSTRACT

This paper provides the wireless power transfer (WPT) or contactless power transfer (CPT) for charging electric vehicles (EV). This technology is recent method in electrification for transportation, useful for the environment. This type of system mainly consists of two parts such as transmission unit and receiving unit, transmission unit send power or electricity and receiving unit received this power and charge the battery of electric vehicle (EV). WPT is applicable for mobile devices, household facilities, medical implants, and electric vehicles. This paper describes the existing systems and also discusses basic contactless power transfer (CPT).

KEYWORDS: WPT, CPDT, EV, electrification, transmission unit, receiving unit.

INTRODUCTION

Transportation required huge amount of fuel like diesel, petrol, electric power etc. hence the electric vehicle i.e. EV is emerging technology in the transportation field. The main advantage of electric vehicle (EV) is, it does not produce harmful gases like other fuel-based vehicles, and also these type of vehicle are depend upon the electrical charging where we can use the renewable energy resources like solar energy and wind energy, represent a great advantage. The main disadvantage of this system is that electricity storage technology i.e. battery, but battery provides unsatisfactory energy density, limited life time and high cost. In this type of system electric vehicles need continuous battery charging and hence battery can be connected to charging wire. This creates another disadvantage of this system i.e. the connection should be achieved manually. To overcome this disadvantage wirelessly transfers the power to the electric vehicles which is called contactless power transfer (CPT). Contactless power transfer (CPT) is nothing but the process in which electrical energy is transferred between two or more electrical devices without using wire connections. This CPT provides many advantages like maintenance-free operation, no sparking problems, complete electric isolation between primary and secondary conductors and ruggedness against dust and environmental conditions [1][2].

In an EV, the battery is not so easy to design because of the following requirements: high energy density, high power density, affordable cost, long cycle life time, good safety, and reliability, should be met simultaneously. Lithium-ion batteries are recognized as the most competitive solution to be used in electric vehicles [3]. Wireless power transfer (WPT) could overcome the inconvenience of EV charging. WPT allows power to transfer from a transmitter coil to a receiver coil over an air gap. WPT is based on the principle of magnetic resonance couplings and mainly composed of a high-frequency power inverter, transmitter coil and receiver coil [4].

BASIC CONTACTLESS POWER TRANSFER

Contactless power transfer (CPT) is also known as Wireless Power Transfer (WPT). As shown in the fig 1 contactless power transfer system consists of two parts; the transmitter side and the receiver side. In the transmitter side, the DC supply will be converted to AC through an inverter with a resonant circuit, and in the receiver side AC power will be converted to DC using a rectifier. This system does not only transfer power, it also transfers data between transmitter and receiver sides. Transfer of power from one side to another side is done through the inductive coupling. In this figure Single phase inverter (which produce a high frequency output, the inverter will be

controlled for square wave operation), Resonant circuits (Capacitors are inserted in both ends in order to cancel the effect of the high leakage inductances of the transmitter and receiver coils), and ZigBee for the communication system [2].

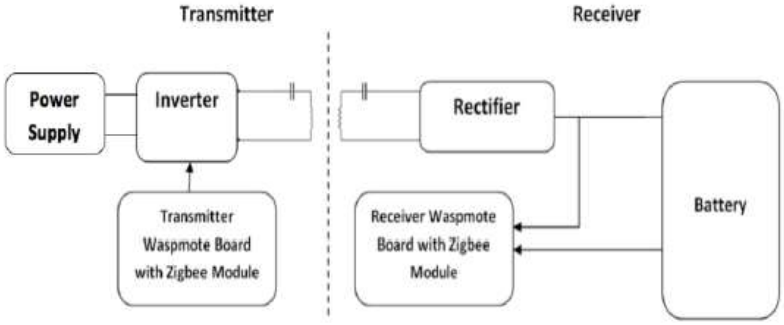

Fig. 1 CPT System [2].

EXISTING WORK

Siqi Li and Chunting Chris Mi [1] developed wireless power transfer (WPT) for electric vehicle (EV) applications. In this system FUNDAMENTAL THEORY regarding a typical wireless EV charging system, shown in the fig. 2. Fig. 2 shows that a wireless EV charger consists of two main parts namely transmission system and receiving system. Transmission system first converts ac power to a dc power source by an ac to dc converter with power factor correction, and then this dc power is converted to a high-frequency ac to drive the transmitting coil through a compensation network. Transmitting coil contains high-frequency current which generates an alternating magnetic field. This alternating magnetic field induces an ac voltage on the receiving coil and finally ac power is rectified to charge the battery. This EV charger contains three main parts; 1. Transmitting and receiving coils. 2. The compensation network and 3. The power electronics converters.

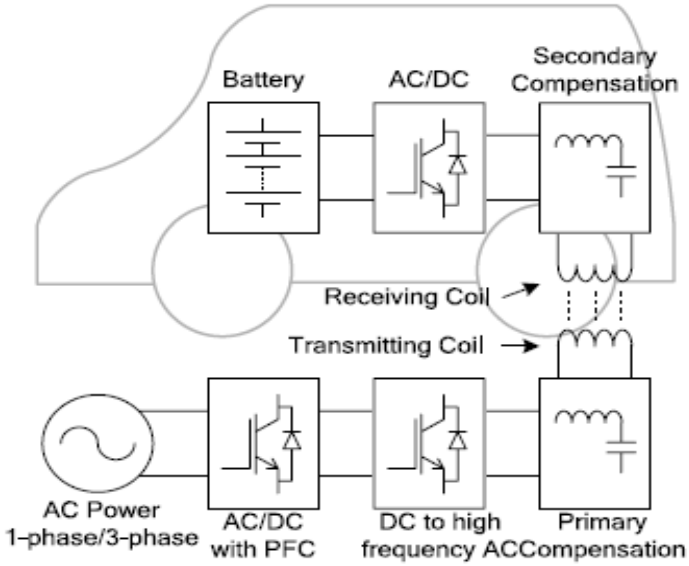

Fig. 2 Typical wireless EV charging system [1].

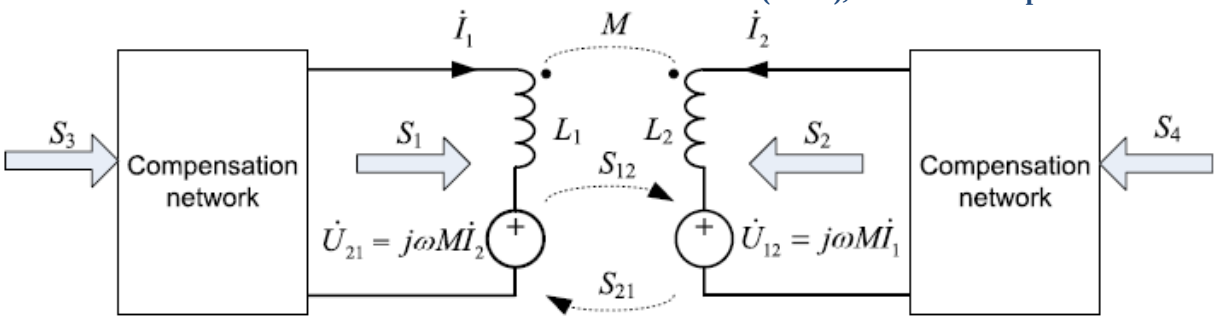

Fig. 3 General two-coil WPT system [1].

WPT principle is shown in the fig. 3. Where, L1: self-inductance of transmitting coil and L2: self-inductance of the receiving coil, I1 and I2 are the current in the two coils. U12: it is the voltage in the secondary coil that is induced by the current in the primary side coil. U21 is the voltage in the primary coil that is induced by the current in secondary side coil due to coupling, or mutual inductance between the primary and secondary coils. S1 and S2 are the apparent power goes into L1 and L2, respectively. S3 and S4 are the apparent power provided by the power converter. S12 and S21 represent the apparent power exchange between the two coils [1] .Therefore, the total reactive power goes into the two-coil system is:

$$Q = \omega\left(L_1 I_1^2 + L_2 I_2^2 + 2M I_1 I_2 \cos\varphi_{12}\right). \quad \text{.....1}$$

Sara Asheer et al. [2] developed contactless power and data transfer for electric vehicle applications. This CPT system consists of mainly of two parts, the transmitter and the receiver part as shown in fig 1. Figure 3 shows the block diagram of the proposed system. In the transmitter side, the DC supply will be converted to AC through an inverter with a resonant circuit, and in the receiver side AC power will be converted to DC using a rectifier. This system not only transfers power but also transfers data between transmitter and receiver sides. The data transmission system is the separate part of this system. ZigBee program is used for the data transmission system. This communication system is very useful, the transmitter will send a notification to the controller of the receiver asking to check the battery level and if the battery is low it will start charging otherwise it will stop charging. There are different scenarios are used for the charging scheme like Charge once parked (COP: system will send a message to check the battery levels, if the battery needed charging then it will transfer the power otherwise not), Charge based on request (CBR: car will be charged and stop charging depending on the request of the user so it is a controlled method), Charge based on request with delay (CBRD: the car will charged with delay so that the electric vehicle system to cool a little before charging.) and Charge with engine switched off (CEOFF: when the engine is OFF a message will be sent from the charger to check the battery levels and then to start charging if needed).

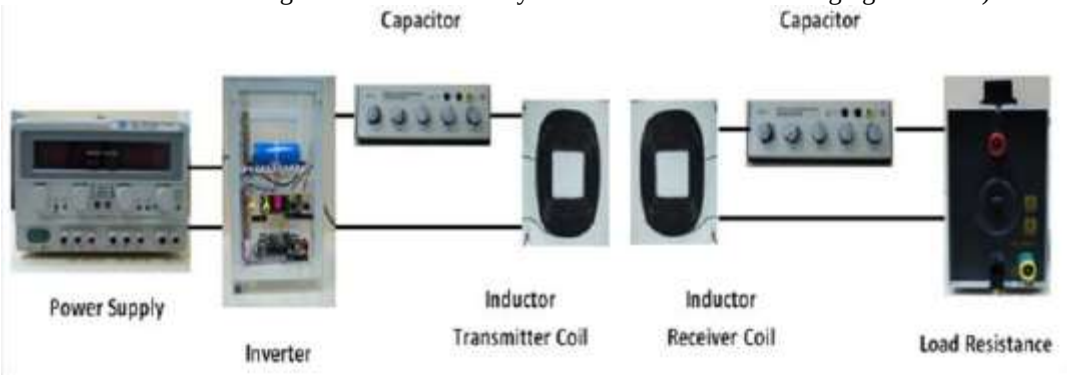

Fig. 4 System Block diagram [2].

CONCLUSION

The commercial market of electric vehicles (EVs) has begun to grow and requires high power charging devices or charging stations to recharge the vehicle within a short time. This paper provides the wireless power transfer (WPT) for charging electric vehicles (EV) systems. This paper describes the existing systems and also discusses basic contactless power transfer (CPT) system.

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