



WIRELESS POWER TRANSFER FOR ELECTRICAL VEHICLE CHARGING USING HIGH-POWER THREE LEVEL DC-DC CONVERTER

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ABSTRACT

In This Paper various methods of non contacting Plug-In Electric Vehicle charging types are either under development or now deployed as flexible aftermarket options in the Light-Duty automotive market. Wireless power transfer (WPT) has been accepted term for wireless charging and it uses synonymously for inductive power transfer and magnetic resonance coupling. WPT technology is in its infancy stage; Standardization is lacking in especially on interoperability, centre frequency selection and magnetic fringe field suppression, and the methods employed for power flow regulation. We Proposes a new analysis concept for power flow in wireless power transfer in which the primary coil provides frequency selection and tuned in secondary, with its resemblance to an power transmission network having a reactive power voltage control, is studied as a transmission network. This project proposes a new analysis concept for power flow in WPT in which the primary provides frequency selection and tuned in the secondary, with its resemblance to a power transmission network having a reactive power voltage control, is defined as a transmission network. The active dc power balance management (APBM) is proposed to assist the central Neutral point clamped converter in balancing power so that the additional balancing circuit is eliminated; while the passive dc power balance management (PPBM), is proposed to eliminate the fluctuating neutral-point currents and to ensure the balanced operation of fast chargers.

KEY WORDS

Electrical vehicle charging, Three level DC-DC converter, inductive power transfer, wireless power transfer, DC Power balance Management

1.INTRODUCTION

IN recent years the field of wireless charging of PEVs has grown tremendously due to this point, at present several companies are offering commercial wireless chargers as secondary market of the

automotive industry, concerned with the manufacturing products for better way to integrate into light-duty passenger vehicles [1]. WPT can be viewed as sudden impact on society in PEV charging, because it fits to the paradigm of V2I, wirelessly. The most Benefits of WPT are well known as a safe, flexible, convenient, and autonomous means of passenger vehicle charging that has capability to completely displace today's conductive charging; WPT has a new innovative technology. There are no cables to trip over, no heavy plugs and cabling to wrestle with during harsh weather, and no concerns about inadvertent disconnection.

Wireless charging of EVs represents important role in the context of connected vehicle, wireless communications, by the existing standards and hardware for secure and private wireless communications. In the stationary charging technology the power transfer takes place in a residential garage, car port or public parking structure when the WPT-equipped vehicle is simply parked over a charging pad or embedded into the floor. Recharging the PEV is autonomous, and follows a state control method of algorithm to built the base WPT controller. The communication series consists of vehicle to infrastructure short-range messaging to recognize the charger location, operational and eventually, with the in-motion charging of EVs, the ultimate in independent vehicle operation; dynamic wireless charging.

Once the appropriate exchange of information is complete between the PEV and the WPT base unit (WPTB), the three level inverter provides excitation current to the tuned primary coil at a standardized centre frequency. Power is transferred across the nominal gap that is in the order of the PEV ground clearance. By the utility ac power and Active Front End rectifier via the three level converter, secondary power is rectified, filtered, and delivered to the energy storage system. Fig. 5 shows the functional blocks involved in the power transmission path. The utility AC power is



converted to the controllable dc voltage by the active front end rectifier comprising a Power factor correction stage. Adjustable DC voltage is applied to the high-power rails of a three level converter having selectable duty ratio. The three level inverter stage delivers excitation current to the series-tuned primary coil of sufficient magnitude to magnetize the air volume between it and capture coil or vehicle-mounted secondary. Voltage induced at the secondary is rectified, and delivered to the vehicle HV battery either directly from the wireless power transfer rectifier or indirectly via the vehicle on board charger. WPT applications standardization activities are related to interoperability, health and safety, communications, and field measurement of WPT. The available facilities of charging are the greatest concerns of consumers, which can be the main factors influencing their purchase of EVs [2], [3]. In order to allow the future widespread use of EVs, there is an urgent demand to develop the fast chargers to shorten charging time, If fast chargers reduce the EVs replenishing time within acceptable levels comparable to the usual refuelling of ICEVs, The common dc-bus architecture can be realized as the unipolar dc bus using two-level voltage source converters or bipolar dc bus using three-level neutral-point-clamped (NPC) converters. The three-level dc-dc converters have been applied in the power factor correction [4], renewable energy systems. The bipolar dc bus architecture has been previously represented in [5] using a NPC converter as the central grid-tied ac-dc converter. The bipolar dc bus offers more power capacity, more flexible ways for the loads to be connected to dc bus. Moreover the line-to-line voltage waveform of two level voltage source converter contains three voltage levels, whereas the NPC converter produces five voltage levels and the equivalent switching frequency of the Neutral point clamped converter is twice the device switching frequency, lead to the lower dv/dt, lower filtering requirement, and better current performance [6]–[10]. However, the configuration in [5] suffers from the imbalanced power between the positive dc bus, and the negative dc bus, for the reason that each dc bus is independent to each other and their loads differs most of the time. The imbalanced power can lead to fault grid-side currents and make the bipolar dc bus unbalanced. Unbalanced power leads to unbalanced voltage, resulting in the poor current performance and even damage to the equipment, therefore the occurrence of a dc power balance management mechanism is must. This paper proposes comprehensive dc power balance management in conjunction with an high-power three-level dc-dc converter based fast chargers for high-power charging stations with a bipolar dc bus. The proposed fast charger with the dc power balance management capability eliminates the need for an

additional balancing circuits and a high-frequency transformers, thereby improves the overall system efficiency. At the same time, since the dc power balance management task is partially achieved by the three-level dc-dc converters, the central Neutral point clamped converter has more freedom to accurately control the grid-side currents leads to higher power quality. To answer the unbalanced dc power problem among the positive dc bus and the negative dc bus, and the comprehensive dc power balance management is proposed. The active and passive dc power balance managements (APBM and PPBM) are investigated from the aspects of operating principles, balance limits and circulating currents. The efficient integration between APBM and PPBM is studied, and the overall control procedure for the fast charger is proposed. The performance of the proposed fast charger and control algorithms are demonstrated through simulation and experimental results

2. ELECTRICAL VEHICLES

An electric vehicle is an automobile that is driven by one or more electric motors, using electrical energy stored in rechargeable batteries or another in the energy storage device. Electric motors give electric cars instant torque, creating the strong and smooth acceleration. They are nearly three times as efficient as cars with an internal combustion engine. Electric cars are significantly quieter than conventional internal combustion engine automobiles. They do not emit tailpipe pollutants, which gives large reduction of local air pollution, and, can give a significant reduction in the greenhouse gas and other emissions. By introduction of wireless charging high benefits can be achieved with respect to user interaction, availability, reachability and automation compared to plug in charging. First of all, we would like to explain the physics of wireless charging. We need two electromagnets coils that are positioned in a certain distance to each other. The road-side electromagnet part is called primary coil and the vehicle-side electromagnet part is called secondary coil. If current is flowing through the primary coil, the magnetic field is created which will cause via the principle of Faraday Induction a flow of current in the secondary coil. The efficiency of an induction based energy transmit is going down quickly with increasing distance between the coils. But the efficiency can be significantly improved if the frequencies of the electromagnetic fields of primary and secondary coil can brought into the resonance, i.e. if the simulating frequency and the Eigen frequency are same. This method is denoted as inductive resonant energy transfer. In order to additional optimize the efficiency of the transmitted energy with accomplishment of the resonance frequency, parameters such as the coupling factor between the



coils depends up on coil geometry and coil inductivity and coil distance quality factors of the electromagnetic resonance circuits need to be considered and personalized accordingly.

Wireless charging systems follows the principle of inductive resonant energy transfer ,it can achieve the best energy transfer rates and efficiency rates with increased coil distances, reduced electromagnetic assumption risks and more compact geometrical proportions in the (lower) kHz frequency band.

The important components of a wireless charging system are:

- Utility interface
- Inverter rand controller(off-board)
- Coupled coils
- Power electronics(on-board)
- Communication interface between road-side and vehicle side radios

3.HIGH-POWER THREE-LEVEL DC-DC CONVERTER

Topology explanation

The structure of the projected converter for high-power fast chargers is presented in Fig.5. It consists of two parallel threelevel dc-dc converter units to handle the high charging current, and the input terminals p, z, n directly fit the bipolar dc bus of the central charging station Each unit is composed of four switching devices along with four freewheeling diodes, and two output inductors.. The converter structure is modular in nature because the parallel dc-dc converters contribute to common input filter capacitors C_{i1} , C_{i2} , and common output filter capacitor C_f , so the power capacity can be easily scaled up by connecting more number of dc-dc converters in parallel.

Modulation and Operating Principle

The modulation method and functioning principle of the proposed fast charger is presented in Fig. 5, for the case when the system is in under balanced power situation and the two converter units operate in the in-phase mode. Under this mode, the immediate power sharing of the proposed dc-dc converter is always equal, which is different from the interleaved converters [11], [12], [13], [14]. Two operating regions are presented to analyze the

4. EV battery charging technologies

Different Electric Vehicle battery charging methods have been developed in the mission to achieve high efficiency range, large power transfer and other attributes. The deployed methods have approached the different capabilities in conditions of power level, air gap and efficiency.

4.1. Microwave power transfer (MPT)

This technology enables the transmission of power and information by using radio waves whose wavelength range falls into the category of microwaves. The operation of microwave power transfer involves apparatus including a microwave generator, transmitting antenna and receiving antenna . The block diagram shows the mechanism of MPT. Initially, the power supplied from the 50 Hz grid is transformed into DC, which is fed into a microwave generator. There are resonating cavities in the microwave generator all the way through which the current passes and produces microwave electromagnetic radiation. The rectenna receives the microwave energy and convert it back to DC [4]. Although the MPT has the advantage of transferring power over longer distances.

4.2. Inductive power transfer (IPT)

The charging of plug-in electric vehicles has always a protection risk of the direct contact of metal-to-metal. To avoid this concern, the designs of electric vehicle charging systems were developed based up on inductive power transfer (IPT) [4]. The inductive power transfer works on electromagnetic induction phenomena to transmit power through an air cored transformer with closely spaced primary and secondary coils [2,4,14]. The coils seems to be associated physically to each other but are isolated electrically, as shown in Fig. 1. The charger is insert into the vehicle like fueling a conventional vehicle. The schematic diagram of IPT is shown in Fig.1. Inductive power transfer has been effectively implemented for EV battery charging. This method showed promising high power transfer with an smaller air gap, though, when the air gap between the primary and secondary coils is increased the concert decreases significantly due to leakage inductance [2]. Inductively coupled power transfer The inductive power transfer offers the low efficiency when the gap of air is increased between charging coils and also involves wired chargers, whereas the design for full wireless charging systems have been developed to overcome the deficiencies of IPT and make the charging system suitable for the users. The inductively coupled power transfer (ICPT) employs capacitors connected to both the primary and secondary coils

to reimburse the leakage flux due to the increased air gap, as shown in Fig. 1. Both the LC circuits work on resonance phenomena to enable effective energy transfer at resonant frequency [5]. The inductively coupled power transfer (ICPT) method is known worldwide for its high power transmit in many applications, mainly in electric vehicles [12]. It provides a rapid charging process, and optimized power transmission by frequency variation.

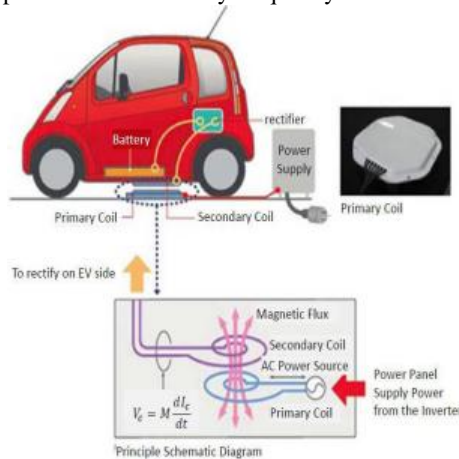


Fig.1 Schematic Diagram of Inductive Power Transfer System for EVs.

5.PASSIVE DC POWER BALANCE MANAGEMENT PRINCIPLE

Passive DC Power Balance Management Principle
Since all the three-level dc-dc converter based fast chargers have access to the neutral point of the central NPC converter, although the average capacitor voltages are equal under balanced operating conditions, the accumulated total neutral-point current fluctuation is drastic and leads to big voltage fluctuations at the dc-side capacitors, which is harmful to the safety and lifetime of capacitors [9]. In order to solve this problem, the passive power balance management (PPBM) is proposed. Under the PPBM mode, the proposed parallel three-level dc-dc converters feature a virtual disconnection to the neutral-point, working as the two-level converter connected to the total dc bus directly, hence minimizes the presence of the total neutral-point current and guarantees the balanced power operation of fast chargers. From the charging station point of view, if all the fast chargers are operating under the PPBM mode, there will be no unbalanced power between the dc buses, however, as the total neutral-point current is zero, it cannot balance the dc power actively, that is the reason why it is called PPBM.

6.WIRELESS POWER TRANSFER METHODS

Wireless power transfer technology used in Electrical vehicle such as inductive coupling and magnetic resonance coupling. These technology can be broadly categorized based on, transmission range, and power rating. Based up on the power transfer distance wireless energy transfer methods can be categorized into two types; near field and far field. Inductive coupling and magnetic resonance coupling based methods are regarded as near field). Inductively coupled near the field approaches can be used to transmit high power efficiently in very near range (up to several centimetres). WPT functional cascade and overall efficiency goals status, and to aid in alignment. Once the appropriate power exchange is complete between the PEV and the WPT base unit (WPTB) its three level inverter provides excitation current to the tuned part of primary coil at a standardized centre frequency. Power is transferred across a nominal gap that is on the order of the PEV ground clearance. Three level inverter secondary power is rectified, filtered, and delivered to the Energy storage system. Incremental frequency adjustment needed to accommodate gap variations in the coupler is done automatically in the wire less power transfer base unit controller power tracking algorithm. Power flow sensing, connections, and grid-side regulation complete the regulation loop through the radio channel. Fig. 1 shows the functional blocks involved in the power transmission path. An utility ac power is converted to controllable dc voltage by the Active front end comprising a Power factor correction stage. Adjustable dc voltage is applied to the high-power rails of a three level full-bridge inverter having selectable duty ratio. The three level inverter stage delivers excitation current to the series-tuned primary coil of sufficient magnitude to magnetize the air volume between it and the vehicle-mounted secondary, or capture coil. Voltage induce at the secondary is rectified, filtered, and delivered to the vehicle high voltage battery either directly from the wire less power transfer or indirectly via the vehicle on board charger

7.COMPREHENSIVE DC POWER BALANCE MANAGEMENT

Based on the proposed APBM and PPBM as discussed in the previous two sections, the comprehensive dc power balance management is formulated. When the imbalanced power between the dc buses is outside of the pre-defined controllable zone of the central NPC converter, the APBM is activated to assist it in balancing power so that additional balancing circuits can be eliminated; while when the imbalanced power is

within its balanced zone, the PPBM is chosen to ensure the balanced operation of fast chargers and minimize the fluctuant neutral point currents. Therefore, the transition between APBM and PPBM is proposed to be triggered by the power difference is chosen based on the balance limits of the central NPC converter [14] and the balance task sharing between it and the operating fast chargers. Christo Ananth et al.[7] presented a brief outline on Electronic Devices and Circuits which forms the basis of the project.

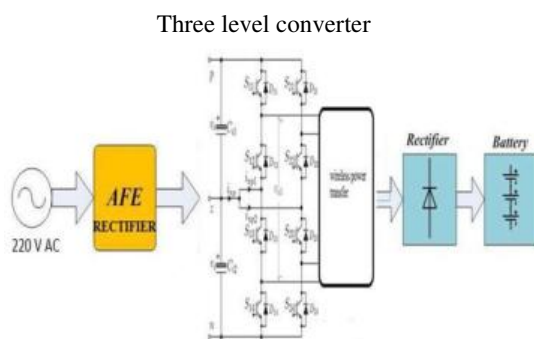


fig.4 Equivalent circuit of proposed diagram

Equivalent circuit consists of AC supply voltage of 220 volts is given to the Active Front End rectifier for the power factor correction and connected to the High power Three level DC-DC converter for high power transfer energy to the coupling coils and it was connected to the rectifier to convert AC power to DC power and driven to the HV battery for storage of energy

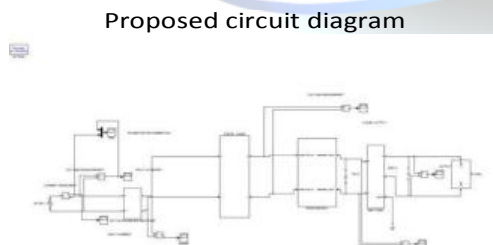


Fig.5 wire less fast charging using High level DC-DC converters

The proposed circuit diagram shows the functional blocks involved in the transmission path. Utility AC power is converted in to the controllable DC voltage by the Active Front End rectifier comprising a power factor correction stage. adjustable DC voltage is applied to the high power

magnitude to magnetize the volume of air between it and the vehicle mounted secondary. The three level dc-dc converter is connected between the active front end rectifier and coupling coils to handle the high charging current. The voltage induced in the secondary coil is rectified ,filtered and delivered to the vehicle high voltage battery.

Input supply wave form

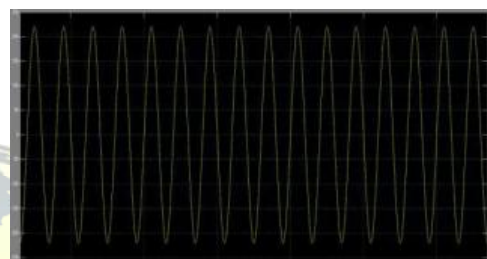


Fig.6 Input voltage supply of Ac 220v

Input supply voltage wave form of AC 220v is obtained by the MATLAB simulink. This was represented by x -axis and y-axis . It denotes the amplitude range of input supply voltage in the form of Sine wave form.

HIGH-POWER THREE-LEVEL DC-DC CONVERTER WAVE FORM

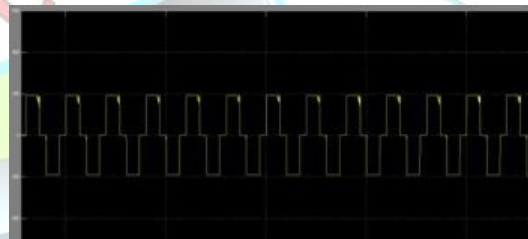


Fig.7Three level DC-DC converter voltage of 190v

The above figure denotes the efficiency obtained by the high power three level DC-DC converter by the MATLAB SIMULINK



DC OUTPUT LOAD

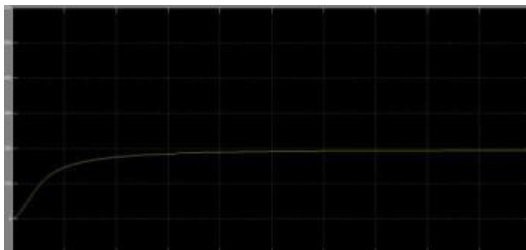


Fig.8 Obtained DC Output voltage of DC 190 volts

DC output load of 190 volts is an obtained final efficiency of high voltage battery system, obtained in matlab simulation results

9. ADVANTAGES OF WIRELESS POWER TRANSFER

- The main compensation of Wire less power are safe, flexible, convenient and autonomous means of passenger vehicle charging that hasoogd potential to completely displace today's conductive charging;
- Wire less power transfer is in advanced technology.
- There are no cables to trip over, no heavy plugs and wiring to struggle with during inclement weather, and no concerns about inadvertent disconnection.
- Reduce costs associated with maintaining direct connectors
- Greater convenience for the charging of everyday electronic devices
- Safe power transfer to applications that need to remain hygienic or hermetically preserved
- Electronics can be fully enclosed, reducing the risk of corrosion due to elements such as oxygen and water.
- Robust and efficient power delivery to

- Delivers reliable power transfer to mission in most critical systems, dirty and moving environments.

11.CONCLUSION

This paper express the most important factor of new analysis process for the computation of wireless charging technology. The main ideanted is, primary-side power regulation is selected and developed with the main intend to minimize vehicle on board complexity, size, and cost while ot keep possession of key scalability features considered necessary to meet future higher power wireless power transfer applications. The specific analysis method employed develops beyond the power electronic fundamentals used to determine the electric current flow from an ac source through the line inductance into the fixed dc voltage load, such as a battery, via a diode rectifier. Another unique method of regulation is a separate analysis of primary and secondary sides of the magnetic resonance coupler. For the secondary, the analysis of a utility network or a micro grid in which reactive power compensation is utilized for the voltage control, which in a wireless power transfer system, is the voltage appearing at the input of the full-wave rectifier. The primary side of the coupler on other hand is treated as the centre frequency selectivity stage needed to insure that a high mutual flux is developed, that in turn facilitates power transmission. The high-power three-level dc-dc converter based fast charger with comprehensive dc power balance management is proposed for high-power charging stations with a bipolar dc bus. The proposed fast charger has the dc power balance capability and enables the elimination of additional balancing circuits and high-frequency transformers, thus improves the overall system efficiency. It gives the central NPC converter more freedom to control grid-side currents, so enhances the power quality. Meanwhile, the use of parallel three-level dc-dc converters brings lower current stress and lower output current ripples, and the power capacity can be easily scaled up due to its modularity. Both the active power balance management (APBM) and the passive power balance management (PPBM) are proposed, their operating principles and the efficient cooperation between them are studied. The idea of dc power balance management center (PBMC) is introduced for the charging station, and the overall control diagram for fast chargers is developed. The active dc power balance management is proposed to assist the central NPC converter in balancing power

chargers themselves and eliminate the drastic fluctuant neutral-point currents so as to decrease the dc-side capacitors requirement. The power balance limits of APBM are explored for the PBMC to allocate the power balance tasks among the operating fast chargers and the central NPC converter. Meanwhile, the circulating currents of PPBM are also analyzed. Through the simulation and experimental results, it has been proved that the proposed fast charger performs very well in achieving the comprehensive dc power balance management in addition to the basic function of electric vehicle fast charging

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