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Quasi - Dynamic Wireless PowerTransfer for Electric Vehicle Application

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ABSTRACT- Wireless power transfer (WPT) technology offers better operational flexibility, safety, and durability and some new opportunities compared to classical wired charging. Wireless power transfer applications include domestic appliances, rotating systems, mobile robots, and wearable devices. Although there exist some electric vehicles (EV) which utilizes wireless power transfer system they gained enormous attention. In the wireless power system, power is transferred from source to load without any physical connection. There are various advances in WPT one among themis Inductive coupling between two coils namely the transmitter and receiver coil. Transmitter coils are placed underneath the road, and receiver coils are introduced in the EV. An important aspect of designing an Inductive WPT is the compensation technique as it improves efficiency and aid with achieving soft switching of power electronics piecesof equipment. A steady-state model of a series- parallel (SP) compensated WPT system is designed to analyse the impacts like power transfer capabilityand the efficiency of the entire system due to changes in the mutual inductance and misalignments. The overall simulation of the systemis made in MATLAB/SIMULINK, and the performance of the system is verified by the simulation results.

KEYWORDS: Wireless Power Transfer, Electric vehicle (EV), Inductive Coupling, series-series compensation, Energy Efficiency, Simulation.

I.INTRODUCTION

The electric vehicle is an Ecologically sound trend worldwide. Wireless communication technology is moving forward day by day which leads to emerging wireless devices from toothbrushes to electronic vehicles. The advantages include the no hassle of carrying wires, easy charging, and smooth power transmission even in unfavourable situations. The idea behind it is Nicola Tesla's Wireless lighting bulbthat was used to receive electrical charge wirelessly. The standard technology of wireless EV battery charging is based on the Inductive Power Transfer (IPT) between two coupled coils, one is connected underneath and the other is at the vehicle. There are two types of IPT for Wireless charging: static IPT, when the vehicle is stationary, and nobody is inside it; dynamic or quasi dynamic IPT when the vehicle isbeing used. Obviously dynamic IPT is beneficialbecause the wired connection would be impossible during the motion. IPT works like a transformer witha large air gap around several meters, and its efficiency is much greater than Capacitive Power Transfer (CPT) which has a major drawback of low coupling capacitance between plates which requires frequency in the MHz range to reduce the reactance of the coupling capacitor.

In IPT main AC source supply which is of 50Hz is taken as input then we rectify this main AC source supply and get DC. Again, this rectified DC is converted into AC with a high-frequency AC inverter. AC Power supply through the primary coil causes the Alternating current which generates

Alternating flux, Alternating flux links with a secondary coil which intern induces the EMF in thesecondary coil. The induced EMF in the secondary coil is due to electromagnetic induction. That is why we called it Inductive power transfer. Two coils areseparated with an air gap so loosely coupled, there is no core that is connecting these two coils. The Induced EMF results in an Alternating current, thenusing a rectifier it is converted to DC. Required Power is up to a certain range in order to reach it weuse a Buck converter. (i.e., DC/DC) At last, it is given to the EV battery. Hence, a large magnetization current will pass through the track coil. In order to compensate this reactive current compensation network is used. Tuning of system plays prominent role for various motives like compensating primary inductance to enhance the power factor and Volt-Ampere rating of the primarysource. In series- series compensation, the voltage across the capacitance compensates the voltage drop of the primary equivalent reactance, making the

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required supply voltage to reduce.

II.LITERATURE SURVEY

1. Achmad Munir & Biru Tutur Ranum [1]: "Wireless Power charging System for Mobile Device Based on Magnetic Resonance Coupling". It is based on near field approach called magnetic resonance coupling. Energy is transferred between transmitter and receiver using Inductive coupling between two radiators. In transmitter circuit an op- am based Wein bridge oscillator is used to produce electrical energy of AC Signal at the operating frequency of 10MHz.

2.JinWook Kim, Hyeon-Chang Son, Do-Hyeon Kim, and Young-Jin Park: "Optimal Design of a Wireless Power Transfer System with Multiple Self-Resonators for an LED TV". This paper exhibited an ideal process based on mutual inductance calculation and circuital analysis for maximum power transfer efficiency in a wireless television system with multiple self-resonators (Tx, Rx & intermediate). Tx and Rx resonators are used for high mutual inductance and low conducting loss and are arranged in such a way that Tx and Rx should be perpendicular to the intermediate resonator.

3.Takehiro Imura, Hiroyuki Okabe and Yoichi Hori [3]: "Basic experimental study on helical antennas of wireless power transfer for Electric Vehicles by using magnetic resonant couplings": In this system, the viability of wireless power transfer with huge air gaps and greater efficiency by compact sized antennas that can be placed on the bottom of Electric vehicles. Here maximum efficiencies are not altered. Enormous air gaps are of weak couplings. But at resonance these weak couplings are magnetic resonance couplings which can transfer high power efficiency.

4.Yiming Zhang, Zhengming Zhao and Kainan Chen [4]: Entitled with "Frequency Decrease Analysis of Resonant Wireless Power Transfer". Two basic structures are investigated in this letter, and the transfer efficiency equations are obtained. The transfer quality factor and the load matching factor are two essential aspects that are investigated. The authors present and compare two strategies for lowering the resonance frequency. The conclusions are confirmed through theoretical calculations and experimental results.

5.Kai Song, Chunbo Zhu, K. Koh, D. Kobayashi, T. Imura, Y. Hori [5]: They have proposed system called "Wireless Power Transfer EV Powering using multi parallel segmented rails". In this systema single transformer, multiple self-contained radiofrequency transmitter devices are used to form magnetic flux between transmitter and receiver to achieve effective as well as stable power transfer. Deactivation of transmitter is done through switching when the vehicle is in motion and steer clear of human beings from vehicle surroundings.

6.Tianze Kan, Student Member, IEEE, Trong-Duy Nguyen, Jeff C. White, Rajesh K. Malhan, and Chris Mi [6]: The publication named "A new Integration Method for EV WCS using LCC Compensation Topology: Analysis and Design". It is an approach to attain efficient wireless charging technique by using LCC compensator. Coupling effects due to integration are minimized to a trivial level. A Three- dimensional finite element analysis (FEA) tool ANSYS MAXWELL is employed to enhance the amalgamated coils.

7.Xiaolin Mou [7]: The proposed paper is "Energy efficiency and adaptive design for WPT for Electric Vehicles". A novel collection of primary resonant coil design, which resolves the uneven alignment issue in magnetic resonant coupling wireless power transfer. Here 20% of power transfer efficiency is developed in simulation and between 30-90% in the experimental setup. It considers the case where only single transmitter coil is boosted. This design can reduce the receiver coil's radius and car's weight.

8.Mattia Forato [8]: "Transformed Power Levelling/ Energy Maximization in Dynamic WPT System". A single element series-series compensation network is introduced to charging the electric vehicles (EVs) during cruising. The survey depicts that the track coils and the pickup should have the same length then only reactance has a nearly equal value; otherwise, the compensation reactance expected to level the transmitted power doesn't guarantee the amplification of the transmitted energy.

III.PROPOSED SYSTEM

Electricity is delivered via an air gap between two magnetic coils in Quasi-Dynamic wireless charging of electric vehicles. Quasi-Dynamic charging is an approach to develop a WPT in vehicles during their stationary state as well as in motion state. Electricity is delivered through an air gap from one magnetic coil in the charger to a second magnetic coil installed to the car using inductive charging technology. A magnetic field is used to transfer power

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between wire coils in inductive coupling (electromagnetic induction). The coils of the transmitter and receiver combine to form a transformer. Ampere's law states that an alternating current via the transmitter coil produces an oscillating magnetic field. By Faraday'slaw of induction, the magnetic field generates an alternating EMF (voltage) in the receiving coil, resulting in an alternating current in the receiver. Theinduced alternating current can either drive the load directly or be rectified to direct current and then driven by a rectifier in the receiver.

Quasi-Dynamic wireless charging of electric vehiclesis done by emerging charging lanes on the road to transfer power to vehicle in both rest and moving position. But the model is not adequate in practical implantation because of the current roadways. So, before developing the suitable roads practically, the entire process is checked through simulation of the system in MATLAB. An important aspect of this model is to introduce series-series compensation in primary circuit to reduce transmission losses and getgreater efficiency.Block Diagram:

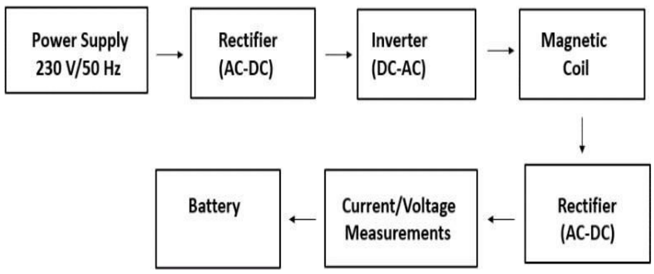

Figure 1: Block Diagram of the proposed system

As depicted in the block diagram, an IWPT system can be thought of as a loosely connected power transfer system that uses modern power conversion, control, and magnetic coupling techniques to achievewireless power transfer. It is made up of an AC/DC/AC resonant converter on the primary side that converts rectified AC power into high frequencyAC power.

The high-frequency AC power is then delivered to theprimary coil, which is magnetically connected to the secondary coil but is physically separated from it. The secondary side can then be moved (linearly or rotating), providing flexibility, mobility, and safety for the provided weights.

The induced high-frequency power is converted and managed on the secondary side by a secondary converter 8 Wireless Power Transfer - Fundamentals and Technologies to suit the load parameters' needs. In fact, the primary coil's time-varying magnetic fieldcreates an electromotive force in the secondary coil, which serves as the secondary power supply's voltagesource.

The induced voltage source is usually unsuitable for driving the load directly since the magnetic couplingof an IWPT system is normally quite loose compared to regular convertors. To adjust the output power according to the load requirements, a power conditioner with suitable circuit tuning and conversion is necessary.

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Flow Chart:

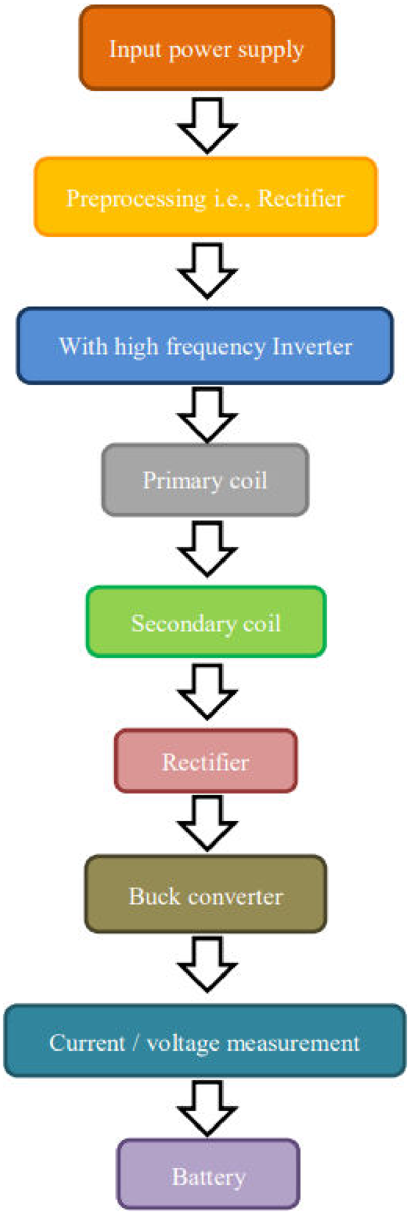

Figure 2: Flow chart

The main AC source supply is provided, which is 50Hz. Then we rectify this main AC source supply and get DC, and we will convert rectified DC into ACbut with a high frequency AC inverter. The primary coil is then passed through a high frequency AC supply, which intern causes the AC current to generate alternating flux. These alternating flux linksup with the secondary coil. This induced EMF in thesecondary coil is due to electromagnetic induction. That is why this wireless power transfer technology is called inductive power transfer (IPT).

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IV.RESULTS AND DISCUSSION

The entire model of the wireless power transfer system for Electric Vehicle Application. We can observe several scopes in Fig. 3. You can open the scope at any time by double-clicking the icon.

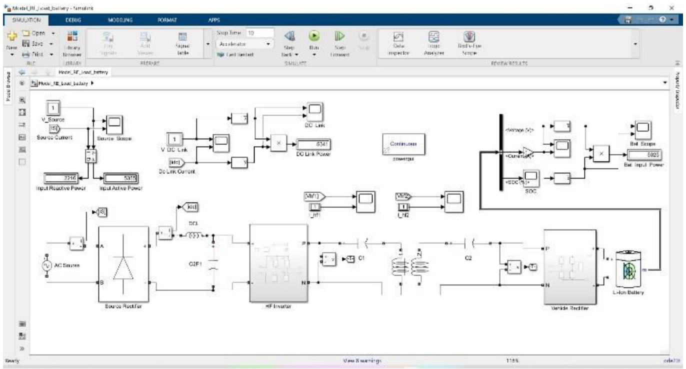

Figure 3: Model_RE_Load_battery.slx

In the absence of buck converter i.e., by removing inductor (DCL) and capacitor (CF1) we check output and compare it with buck converter simulation output

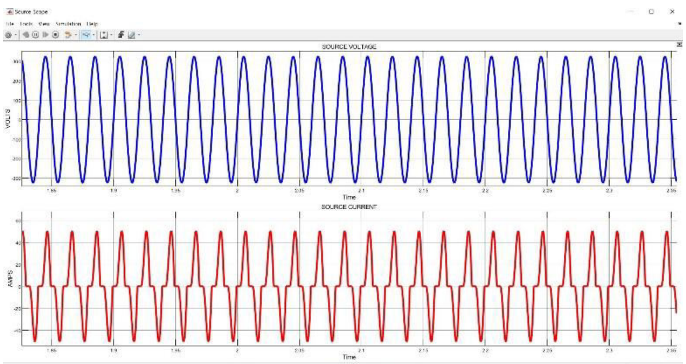

Figure 4: Source voltage and current (230V/50Hz)

Fig.4 shows the applied AC source which is get by computing active and reactive powers of a voltage-current pair at fundamental frequency. For the first cycle of simulation, the outputs are held constant to the powers computed for the Voltage initial input and Current initial input parameters.

After rectification a lift converter (additionally referred to as step-up converter) is used. It is one of the most effective kinds of switch-mode converters. As the call suggests, the converter takes an enter voltage and boosts it. In different words, it’s like a step-up transformer i.e., it step-up the extent of DC voltage (at the same time as transformer step up/ down the extent of AC voltage) from low to excessive at the same time as decreases the modern from excessive to low at the same time as the furnished strength is same.

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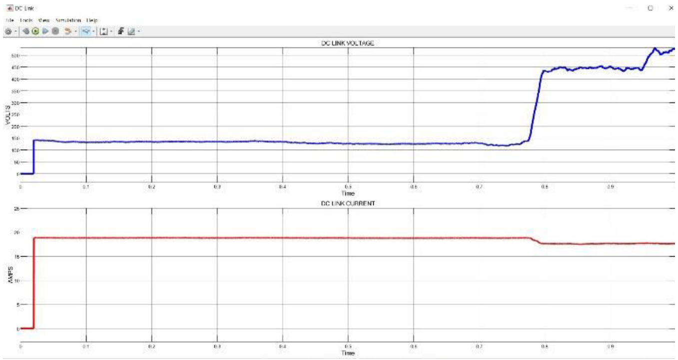

Figure 5: DC_Link voltage and DC_Link current (without buck converter)

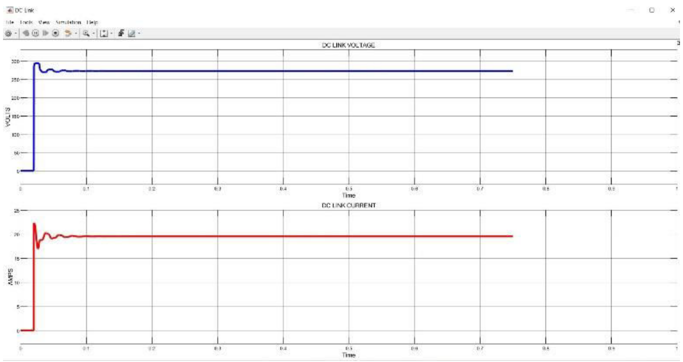

Figure 6: DC_Link voltage and DC_Link current (with buck converter)

From Fig.5 to Fig.6 DC_Link voltage and DC_Link current (with and without buck converter) outputs were shown. Roadside winding produces EMF(Electromotive force) due to change in frequency with a range of 3KHz to 30KHz when an High frequency inverter converts DC to AC and increase the frequency as per requirement.

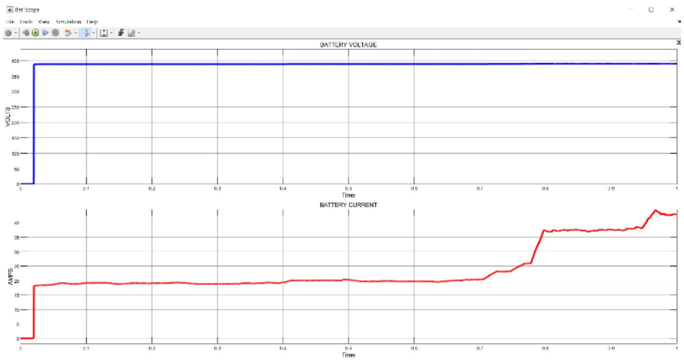

Figure 7: Battery voltage and current (without buck converter)

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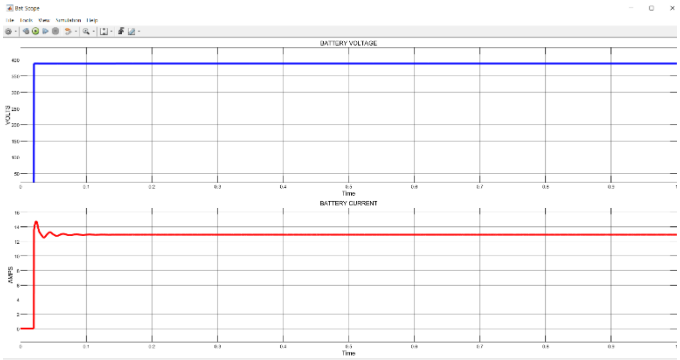

Figure 8: Battery voltage and current (with buck converter)

The output of the wireless power transfer for an electric vehicle is shown in Fig.7 to Fig.8 output i.e., Battery voltage and Battery current without buck converter and with buck converter. This output is shown for known the actual output of the WCS. After connecting the buck converter and load, a notable change occurs in the output signal.

Though the buck converter improves the quality of the output waveforms, it also causes a loss of energy. For this reason, the output waveforms with a buck converter have less amplitude than the output waveforms without the buck converter. Besides, the buck converter will increase the size and weight of the WCS. As the buck converter must be used inside the EV, it will increase the additional load on the EV. Moreover, the use of a buck converter requires a gate pulse, which includes additional arrangements to produce the gate pulse.

V.CONCLUSION

Several businesses support the "Go Green" initiative. They are opposed to regular gasoline-powered vehicles, which is why they are introducing electric vehicles. As a result, several other companies are interested in developing a wireless charging method to recharge them in an environmentally friendly manner. In this research, a Quasi-Dynamic WCS with inductive coupling has been constructed and simulated in the MATLAB/Simulink environment. The whole simulation technique for a WCS is detailed, and the system's response (output) is obtained in both loaded (with buck converter or load or both) and unloaded (without buck converter or load or both) conditions (without any buck converter and load, directly across the capacitor C2). The SS compensation topology is employed in this case. With and without a buck converter and load, the output waveforms are examined. When the output immediately across the capacitor C2 is zero (no load condition), it is substantially higher than when the capacitor is loaded. The output waveforms become smoother when a buck converter is used, which is important for battery charging.

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