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Wireless Power Transfer Using Bidirectional Resonant Converter for Electric Vehicles

T.Sarath Kumar[1] | R.Senthil Kumar[2]

[1]PG Scholar, Department of EEE, Roever Engineering College, Perambalur, Tamilnadu, India.
[2]Assistant Professor, Department of EEE, Roever Engineering College, Perambalur, Tamilnadu, India.

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ABSTRACT

Wireless power transfer (WPT) using magnetic resonance is the technology which could set human free from the annoying wires. In this paper wireless power transfer with bidirectional dc to dc converter is proposed. Bidirectional dc to dc converter transfers the power in both directions it wirelessly charges the electric vehicle from utility and energizes the utility from the electric vehicle while the power supply is blackout. In fact, the WPT adopts the same basic theory which has already been developed for at least 30 years with the term inductive power transfer. WPT technology is developing rapidly in recent years. At kilowatts power level, the transfer distances from several millimetres to several hundred millimetres with a grid to load efficiency above 90%. The advances make the WPT very attractive to the electric vehicle (EV) charging applications in both stationary and dynamic charging scenarios. This paper reviewed the technologies in the WPT in EVs, the obstacles of charging time, range, and cost can be easily mitigated. Battery technology is no longer relevant in the mass market penetration of EVs.

Keywords *- Capacitive Circuit, Wireless Power Transfer, Power Electronics Surface Charging, Transportation.*

I. INTRODUCTION

Wireless power transfer (WPT) using magnetic resonance is the technology which could set human free from annoying wires. However, for electric vehicles (EVs), the high flexibility makes it not easy to get power in a similar way. Instead, a high power and large capacity battery pack is usually equipped as an energy storage unit to make an EV to operate for a satisfactory distance.

The problem for an electric vehicle is nothing else but the electricity storage technology, which requires a battery which is the bottleneck today due to its unsatisfactory energy density, limited life time and high cost. To overcome this, what the owners would most likely do is to find any possible opportunity to plug-in and charge the battery. The wireless power transfer (WPT) technology, which can eliminate all the charging energy to the EV, the charging becomes the easiest task.

The advances make the WPT very attractive to the electric vehicle (EV) charging applications in both stationary and dynamic charging scenarios. For a stationary WPT system, the drivers just need to park their car and leave. For a dynamic WPT system, which means the EV could be powered while driving; the EV is possible to run forever without a stop. Also, the battery capacity to EVs with wireless charging could be reduced to 20% or less compared to EVs with conductive charging.

II. HIGH FREQUENCY TRANSFORMER

High-frequency (HF) power transformer are used in switched-mode power supplies (SMPS) and insulated dc-to-dc converters to transfer as LF power transformers. However, HF power transformers are smaller, lighter, and cheaper than their LF counterparts, making them ideal in applications where minimal space, weight, and cost are at a premium.

III. CAPACITOR

A capacitor (formerly known as condenser) is a device for storing electric charge. The forms of practical capacitors vary widely, but all contain at least two conductors separated by a non-conductor. Capacitors used as parts of electrical systems, for example, consist of metal foils separated by a layer of insulating film. Capacitors are widely used in electronic circuits for blocking direct current while allowing alternating current to pass, in filter networks, for smoothing the output of power supplies, in the resonant circuits that tune radios to particular frequencies and many other purposes.

A capacitor is a passive electronic component consisting of a pair of conductors separated by a dielectric (insulator). When there is a potential difference (voltage) across the conductors, a static electric field develops in the dielectric that stores energy and produces a mechanical force between the conductors. An ideal capacitor is characterized by a single constant value, capacitance, measured in farads. This is the ratio of the electric charge on each conductor to the potential difference between them. The capacitance is greatest when there is a narrow separation between large areas of conductor.

Hence capacitor conductors are often called "plates", referring to an early means of construction. In practice the dielectric between the plates passes a small amount of leakage current and also has an electric field strength limit, resulting in a breakdown voltage, while the conductors and leads introduce an undesired inductance and resistance.

A. Analysis of the Modified LIC Topology

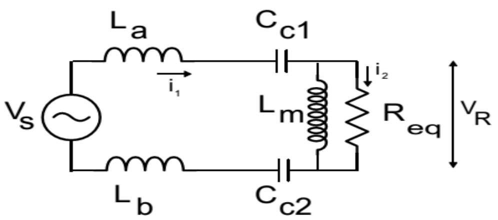

Fig1. FHA of the LLC Converter

The analysis of both the modified converters can be obtained from the first harmonic approximation technique which is used to deduce the resonant converters. Considering the use of a full bridge inverter the analysis of the system is given below , the equivalent circuit of the FHA is given in Figure 4. As the circuit are resonant in nature, the converters allow the passage of the fundamental to the output filtering out the higher order harmonics.

IV.INVERTER

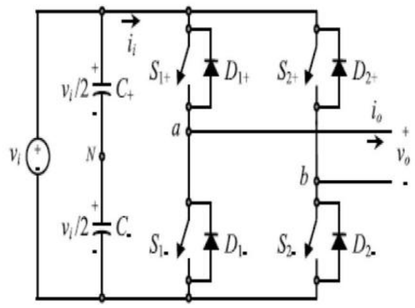

Fig.1.1 Circuit diagram of VSI

The word 'inverter' in the context of power-electronics denotes a class of power conversion (or power conditioning) circuits that operates from a dc voltage source or a dc current source and converts it into ac voltage or current.

The 'inverter' does reverse of what ac-to-dc 'converter' does. Even though input to an inverter circuit is a dc source, it is not uncommon to have this dc derived from an ac source such as utility ac supply.

The simplest dc voltage source for a VSI may be a battery bank, which may consist of several cells in series-parallel combination. Solar photovoltaic cells can be another dc voltage source. An ac voltage supply, after rectification into dc will also qualify as a dc voltage source. All voltage source inverters assume stiff voltage supply at the input.

For an ideal input (dc) supply, with no series impedance, the dc link capacitor does not have any role. However a practical voltage supply may have considerable amount of output impedance. The supply line impedance, if not bypassed by a sufficiently large dc link capacitor, may cause considerable voltage spike at the dc bus during inverter operation.

Pulse width modulation:

Output voltage from an inverter can also be adjusted by exercising a control within the inverter itself. The most efficient method of doing this is by pulse-width modulation control used within an inverter.

In this method, a fixed dc input voltage is given to the inverter and a controlled ac output voltage is obtained by adjusting the on and off periods of the inverter components. This is the most popular method of controlling the output voltage and this method is termed as Pulse-Width Modulation (PWM) Control.

V. EXISTING SYSTEM

The existing system consists of rectifier, DC to high frequency AC converter, magnetic coils coupled and a battery for storage.

A. BLOCKDIAGRAM:

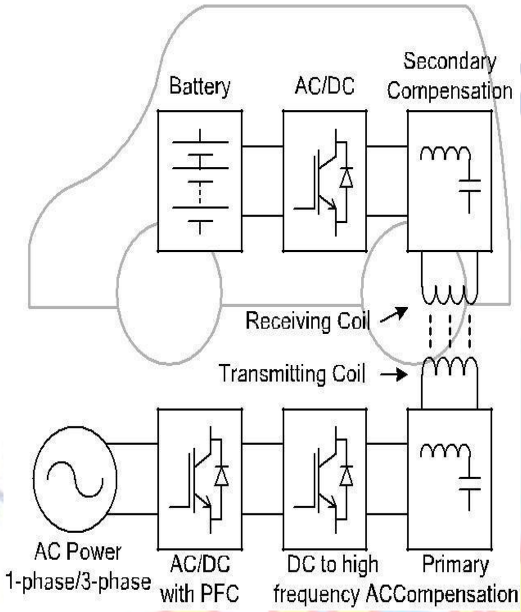

Fig.2.Existing block diagram

From the ac power source power flows in a unidirectional path to charge the battery present in the electric vehicle.

VI. PROPOSED SYSTEM

A. Proposed block diagram:

In the proposed system there are two modes of operation 1) energy is flowing from ac power to the battery via power converter. 2) energy is flowing from battery to ac power converters. Bidirectional converters acts as rectified and inverter depends on mode 1 and mode 2.

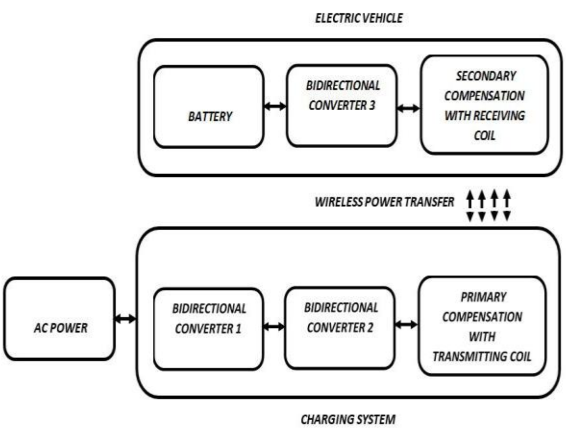

Fig.3.Proposed block diagram

B. Proposed circuit diagram:

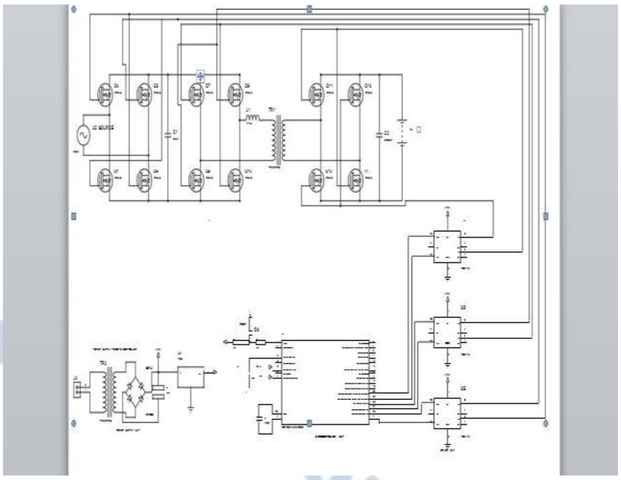

Fig.4. Circuit diagram of Bidirectional wireless power transfer for electric vehicle application

Bidirectional converter 1 acts as rectifier which converts ac power into dc. Bidirectional converter 2 acts as inverter which converts dc into ac. Capacitor and inductor provide primary compensation for ac then it is transmitted via transmitting coil to the secondary coil where compensation obtained using capacitor and inductor.

Bidirectional converter 3 acts as inverter which converts dc into ac. Capacitor and inductor provide secondary compensation for ac then it is transmitted via coil to the primary coil where compensation obtained using capacitor and inductor. Bidirectional converter 2 acts as rectifier which converts ac into dc. Then the dc is converted into ac using bidirectional converter 1 which acts as inverter.

VII. SYSTEM DESCRIPTION

Mode 1:

Bidirectional converter 1 acts as rectifier which converts ac power into dc. Bidirectional converter 2 acts as inverter which converts dc into ac. Capacitor and inductor provide primary compensation for ac then it is transmitted via transmitting coil to the secondary coil where compensation obtained using capacitor and inductor. Then the compensated ac is converted into dc using bidirectional converter 3 which acts as rectifier. Then the dc power energize the battery present in electric vehicle.

Mode 2:

The above circuit acts in mode 2 during power blackout. Bidirectional converter 3 acts as inverter which converts dc into ac. Capacitor and inductor provide secondary compensation for ac then it is transmitted via transmitting coil to the primary coil where compensation obtained using capacitor and inductor. Bidirectional converter 2 acts as rectifier which converts into dc. Then the dc is converted into ac using bidirectional converter 1 which acts as inverter. Then the ac power energize the utility grid.

VIII. RECTIFIER

A rectifier is an electrical device that converts alternating current(AC), which periodically reverse direction, to direct current (DC), which is in only one direction, a process known as rectification. Rectifiers have many uses including as components of power supplies and as detectors of radio signals.

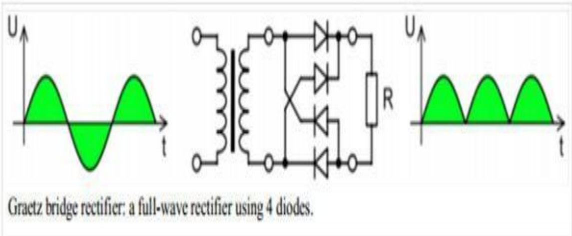

Fig.5 Full-wave rectification

IX. EXISTING SYSTEM CIRCUIT

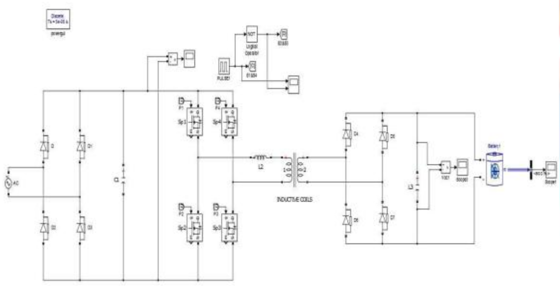

Fig.6.Existing circuit diagram

In this existing system circuit, inverter, high resonance transformer are used. A pulse signal is given for inverter operation. The input voltage is 230V and the output voltage transferred is 12V required for the battery. The simulation of the circuit is shown. The output dc voltage is simulated.

The power from the ac load system is transferred through a rectifier where the rectifier converts ac voltage to an equivalent dc voltage. This dc voltage is converted to ac voltage using inverter for high resonance. The high resonance voltage is fed to inductive coupling and ac voltage is achieved, which is again converted to dc voltage by rectifier and then fed to the battery. The output voltage achieved in the battery is 12V and gets on charging.

X.SIMULATION VERIFICATIONS

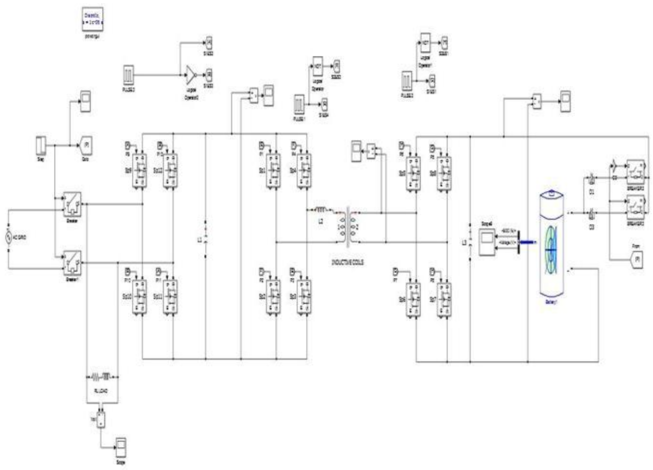

Fig.7.Simulation of propesed system

In this proposed system, the ac voltage is fed to the rectifier circuit. The rectifier is made of mosfet device since it is bidirectional. The output dc voltage is again fed to the invertor circuit for high resonance. The dc voltage is gain converted to ac voltage in the invertor operation. The output ac voltage is converted again to c and fed to battery. The battery gets charged and if in case of power failure the battery gets discharged.

A. *Output Simulation of Existing System:*

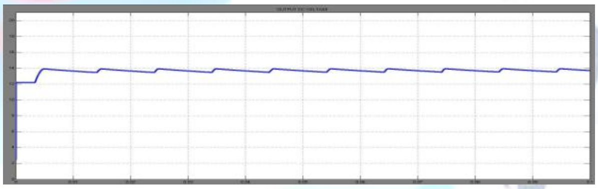

Fig.8.Output DC voltage waveform for existing system

B. *SOC an a Battery:*

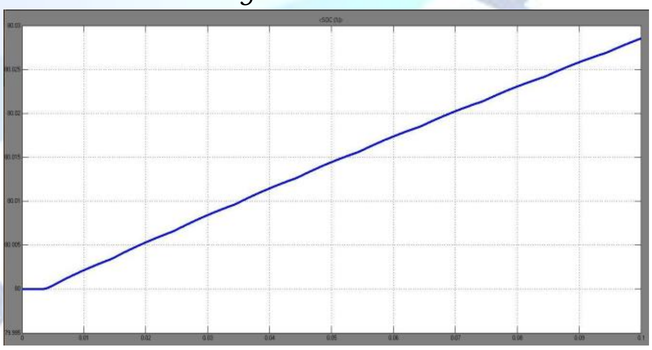

Fig.9.SOC in a battery

XI. SIMULATION FOR BIDIRECTIONAL CONVERTER ONE

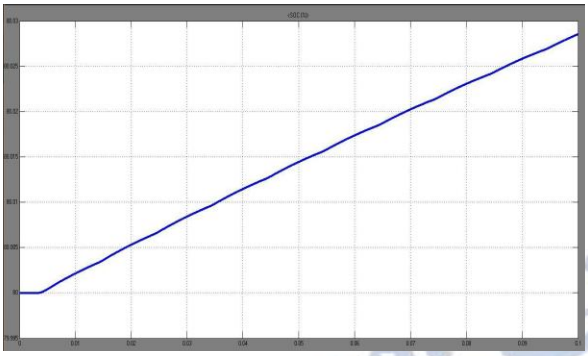

Fig 10.Bidirectional converter one

In this system, the output of the bidirectional converter 1 is shown. During the first mode, the ac load voltage is converted into the equivalent dc voltage.

XII. SIULATION FOR INPUT AC VOLTAGE

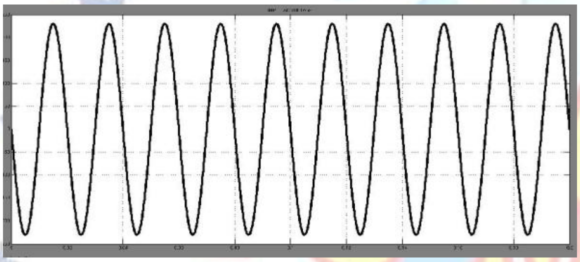

Fig 11.Input AC voltage waveform

This simulation determine about the input ac voltage waveform. The ac load is used as the input in the first mode of operation. The 230V voltage with frequency of 50Hz is given as the input.

XIII.SIMULATION FOR OUTPUT VOLTAGE

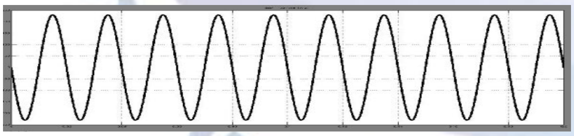

Fig 12.Output DC voltage for proposed system

In this simulation, the charge transferred is bidirectional. For step input T=0 to 0.1 system operates in mode 1 and for step input T=0 to 0.2, system operate in mode 2. Hence for a step pulse of T=0 to 0.1 the battery gets charged at 12 volt and then after the step pulse till T= 0.1 to 0.2 is completed the remaining function is of battery controlled.

XIV.OUTPUT OF BATTERY

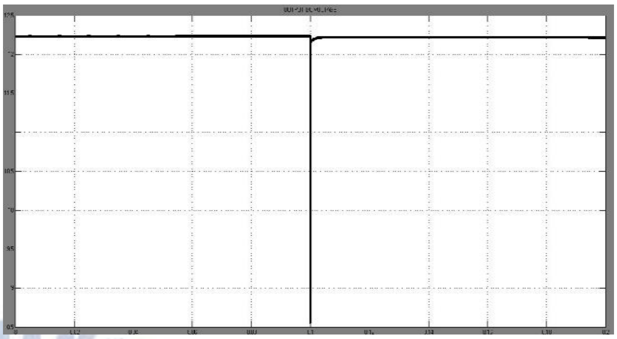

Fig13.output of battery

The output of the battery is shown with charging and discharging mode. The battery charging is done and then discharging operation takes place.

XV. CONCLUSION

Our paper explains how power can be transferred wirelessly. It clearly determines how power can be transmitted bidirectionally with ease of control. Although wireless power transmission is an existing one, it helps us to transfer power in bidirectional manner. It also avoid repels and produce high resonance frequency. The ac voltage 230V is directly converted to dc voltage without ant repels. Our paper is useful in the future world. The future world will be a more advanced one with this technology.

In our paper the problem of charging battery using charger is not needed. This type of technique is useful and a major advantage to many humans and requires less human power. In bidirectional system, power management is highly possible.

Bidirectional converters are more concentrating of reducing harmonics and can be used in many vehicle applications. Using this technology, small industries can also be charged in case of any failure.

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