DESIGN OF FULL BRIDGE THREE LEVEL LLC RESONANT CONVERTER FOR WIRELESS BATTERY CHARGING WITH PULSE WIDTH MODULATION TECHNIQUE

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Abstract - *This project focuses on design and implementation of wireless charging of lithium ion (or) lead acid battery for electrical vehicles using full bridge three level LLC resonant converter. The proposed converter reduces the switching and electromagnetic interference losses of the components and especially used for soft switching. It operates according to the pulse width modulation technique in which each duty voltage level is identified by the "master duty". Thus the cost effective LLC resonant battery charger to reduce the fuel consumption and to make wireless charging of battery in e-vehicles is successfully implemented with the verification of experimental results with theoretical results as obtained in matlab Simulink.*

Keywords: Battery charger; Electrical vehicles (EV); LLC; Pulse width modulation; Wireless charging.

I. INTRODUCTION

All around the world there is an adverse increase in usage of vehicles day to day which leads to more amount of consumption of fossil fuels. Fossil fuels like petrol, diesel cause air and noise pollution to the environment. In order to decrease the fossil fuel consumption-vehicles acts as a feasible solution .E-vehicles has a battery which is rechargeable via an ac outlet. The major difficulty in charging such a battery is to achieve a high density of power which needs optimum efficiency.

The proposed architecture consist of dc-ac converter, resonant tank, induction coils, diode rectifier and a 12-24V rechargeable battery. The dc-ac converter charges the battery with the required current and isolates the power supply from the battery pack. The converter incorporates the profit of LLC converter with conversion technique in three levels.

The proposed system provides a cost effective mechanism to charge the battery in E-vehicles wirelessly using full bridge three level LLC resonant converter (Fig.1.) thereby reduces the consumption of fossil fuels.

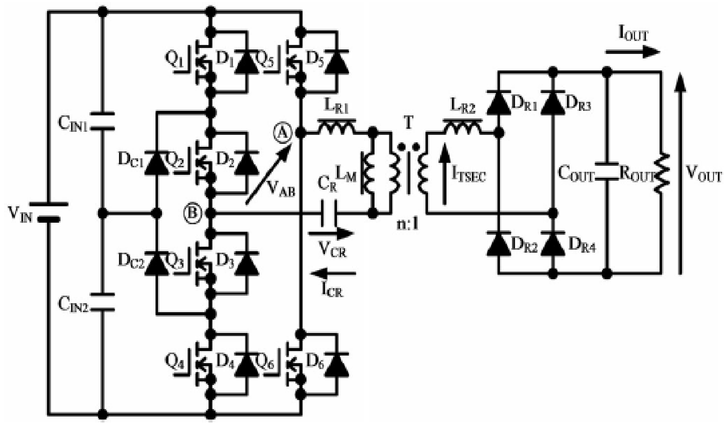

Figure 1 Full bridge three level LLC resonant converter

II. METHODOLOGY

Pulse Width Modulation technique is used to control the duty cycle of power semiconducting switches used in the LLC resonant converter. Mosfet transistor is used as the power semiconducting switch for high commutation and for greater efficiency even at low operating voltage. The LLC converter has the advantage of soft switching but it is not easy to design and analyse such a converter Thus, first harmonic analysis (FHA) is used to get the design procedure for LLC converter.

The DC supply is fed to a DC-AC converter in which the switch S1 and S3 & S2 and S4 are grouped together. The turning ON and OFF of the switches are due at 50% duty cycle of fixed frequency with 180^{o} out of conduction mode. The converted ac supply is passed to the primary inductive coil which in turns induces the magnetic field in the secondary coil with air core as the medium. Thus, the wireless power transfer is successfully achieved and the transferred ac power is rectified using diode rectifier and the output dc produced is used to charge the battery.

The block diagram of wireless battery charging system is shown in Fig.2.

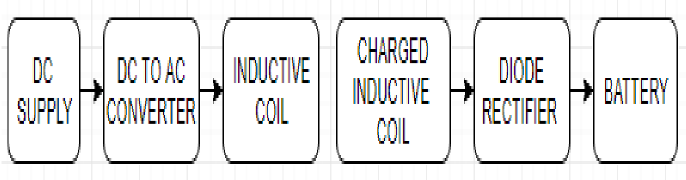

Figure 2 Block diagram of wireless battery charging system

A.OPERATING PRINCIPLE

Fig.3. shows the modulation technique of LLC converter. The voltage (V_{AB}) is the input voltage of the LLC resonant tank whereas the low level V_{AB} generates less energy. Therefore V_{AB} needs to be controlled to regulate the output power.

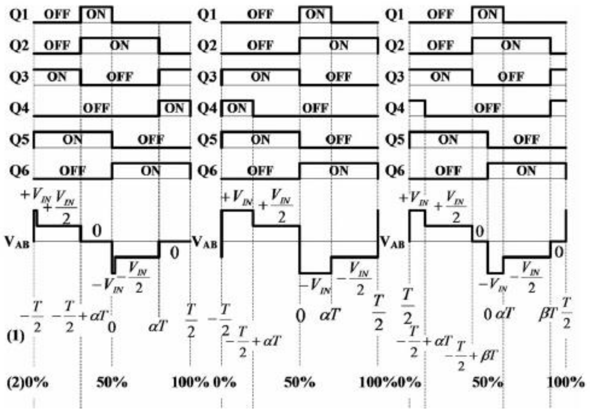

Figure 3 Three level gate pulse of LLC converter

B. MODULATION METHOD

The LLC resonant converter works similar to that of conventional LC resonant converter. The only difference is that LLC resonant requires less magnetizing inductance. The value of resonant frequency will shift to higher value as the load becomes heavier. LLC resonant converter has network of capacitor and two inductor which forms the resonant tank. When the current is passed in the resonant tank the transfer of energy to the load takes place. LLC resonant provides smooth switching with the help of operation of ZCS and ZVS (Zero current source and Zero voltage source).When the turned OFF thyristors are turned ON ZVS is produced in the primary side of the rectifier in which the output voltage is generated. When the inductive current is generated at the resonant tank ZVS occurs and when the resonant tank is capacitive ZCS occurs. The charging of Li battery consist of two main stages namely a constant-current (CC) charging stage and a constant-voltage (CV) charging stage .Fig.4 represents the DC characteristics of LLC resonant converter.

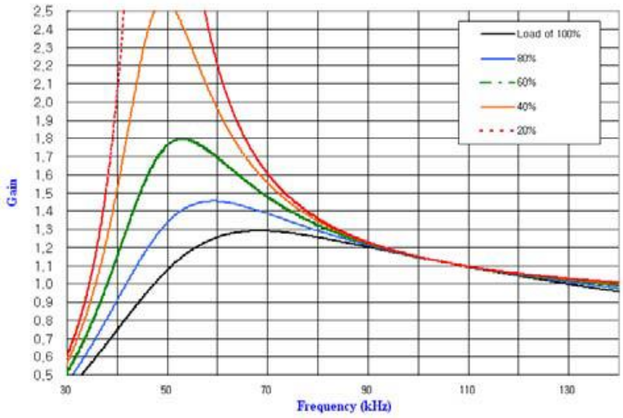

Figure 4. DC characteristic of LLC resonant converter.

C. EXPERIMENTAL RESULTS

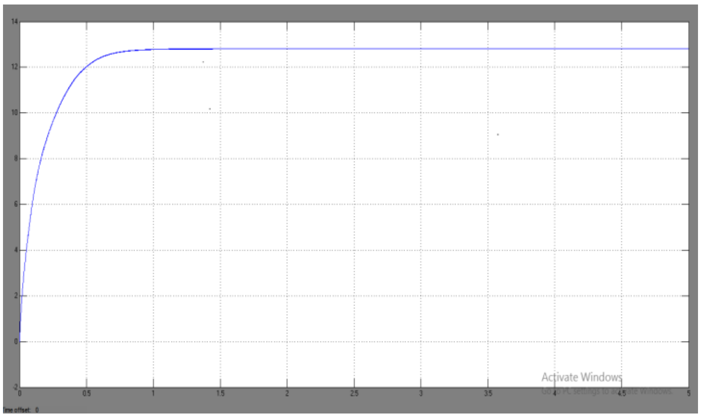

Figure . Simulation result of output voltage

The simulation output of the designed prototype is shown in Fig 5.When a 12V, 1A input is given to the converter (dc-ac), a constant 13V, 1A is obtained to charge the 12v battery. With the prototype designed high power rating LLC converter can also be implemented. 3-6KW battery is used for cars and 30-200KW battery is used for buses and trucks in real time. The prototype model is shown in Fig 6.

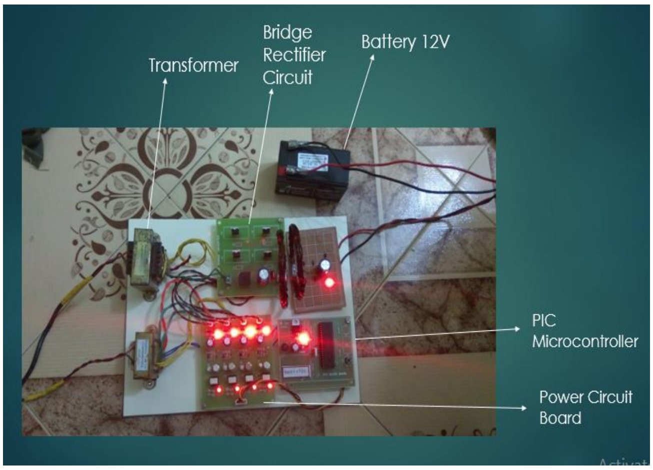

Figure 6.Hardware Component

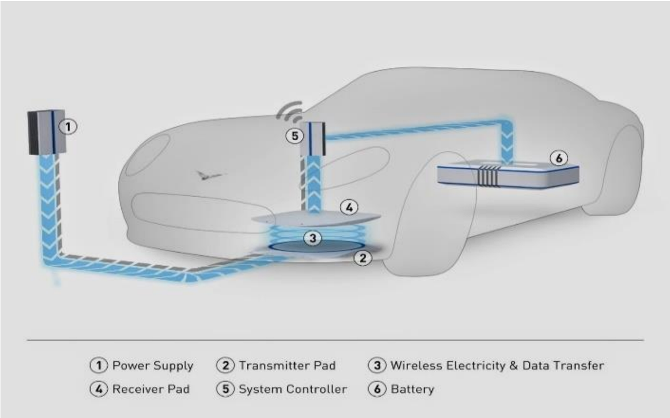

Figure 7. Real time operation of wireless battery charging of vehicles

III. DISCUSSION

By using full bridge three level LLC resonant converter, high efficiency of 98.2% is obtained. Faster wireless charging is achieved by using air core as a medium in the inductive coil. The real time operation of wireless battery charging of vehicles is shown in Fig 7.The proposed system can be implemented as a future technology of wireless battery charging by pulse width modulation as shown in Fig 8.A DC supply is given to the parking station. Charging station has a transmitter coil and the receiver coil is implemented in the car.

Whenever the battery of the car wants to be charged wireless charging can be done in the charging station. Charging station can be implemented in car/bike parking lot.

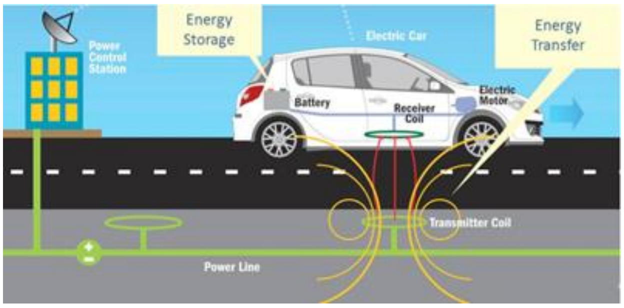

Figure 8 .Future technology of wireless power transfer through coils

IV. CONCLUSION

The three level full bridge LLC resonant converter is successfully proposed which has the main advantage of wide output voltage variation and battery output power control. The method of Modulation can be modified by charging the relationship between master duty cycle and turn off period of each gate pulse.

V. ACKNOWLEDGEMENT

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