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Microcontroller Based Control for On-Line Electric Vehicle with 2 Stage Inversion

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Abstract:
This paper develops the idea of control for power generation in electric vehicle. We represent a partitioned inverter circuit which is controlled by microcontroller programming. The circuit produces power which is transferred wirelessly in real time to electric vehicle by means of inductively coupled power transfer scheme. With this idea, highly efficient power can be transferred to batteries of electric vehicle, also providing rapid battery charging process. Another advantage is that this control circuit provides efficient power to vehicles on motion with control over loss in power transmission.

Keywords: Inverter Control, segments, On-line Electric Vehicle (OLEV), Wireless Power Transfer (WPT), Inductively Coupled Power Transfer (ICPT), IGBT.

I. INTRODUCTION

To minimize the greenhouse effect caused by emission of CO2, many automobile manufacturers are developing battery-powered automobiles that typically use rechargeable lithium polymer batteries. However, the future of these battery-powered electric cars is less than certain. The re-chargeable lithium batteries are heavy and expensive with a limited life. To overcome this, On-line Electric Vehicle has been developed for several years. OLEV draws its electric power from underground electric coils without using any mechanical contact. The maximum efficiency of power transmission over a distance of 17 cm is 72%. OLEV has a small battery, which enables the vehicle to travel on roads and its batteries are recharged whenever OLEV draws electric power from the underground coils and thus, does not require expensive separate charging stations. The infrastructure cost of installing and maintaining OLEV is less than those required for other versions of electric vehicles.

The most important part of OLEV system is the resonant inverter which is responsible to supply current to power track lines. Resonant inverters are electrical inverters based on resonant current oscillation. Power line track needs to be large enough to cover large area with a single inverter. This thus produces a cause of large line resistance and hence large amount of heat loss. To overcome this problem, we develop a partitioned inverter system. As OLEV inverter need not to be operated continuously to deliver power to track, but only when vehicle is on power supply track in motion or even when stopped.

Thus we develop an inverter with partitions which supplies power only when Electric vehicle arrives on power track lines. Mechanical switch partitioning has several limitations such as short durability, long segment switching time, and difficult switching control. By electrical partitioning we obtain a faster partitioned switching performance. It uses additional half wave bridge modules to drive more than 1 power lines. The inverter partitioned with 2 segments is shown in following figure

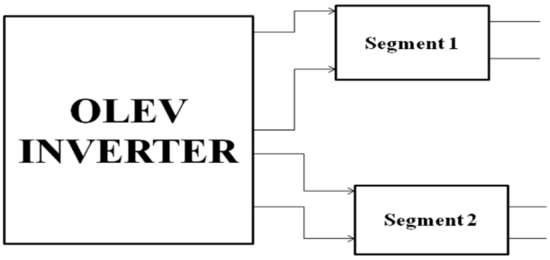


Figure.1. OLEV inverter with segments

II. CONFIGURATION OF THE PROPOSED OLEV INVERTER.

Construction-
The system consists of three phase full bridge SCR rectifier, a DC link capacitor, an SPWM controlled inverter using IGBT's with partitions to arms of Inverter. A high frequency transformer is connected to partition lines for electrical isolation. The 2 segments are power track lines. It is a voltage source type pulse width modulated inverter. 180 degree mode of operation for inverter is been considered as it provides higher efficiency, quite operation and low vibration than 120 degree mode.

Operation-
A 3 phase AC supply is provided to SCR Converter.SCR is used for converting input AC power to DC power. To maintain constant and controlled DC voltage as source to inverter, we use a DC capacitor bank. This DC voltage is then converted to AC current using inverter configuration. Inverter is controlled by Microcontroller programming. The sinusoidal pulse width modulation control technique is been used for this inverter. The SPWM method improves the efficiency and reduces the total harmonics distortion in the output voltage. In the SPWM control, the switches of the inverter are controlled by comparison of a sinusoidal modulating signal with triangular carrier signal. The sinusoidal modulating signal determines the desired fundamental frequency of the inverter output, while the triangular carrier signal decides the switching frequency of the inverter.

Transformer is used for electrical isolation between 2 segments via ground. The desired frequency output of this inverter configuration is 20 kHz. In that way we operate inverter as soft-switching mode in steady states. To supply current to first segment, we use first two half bridge networks of IGBT bridge configuration and others are kept off. Similarly to supply current to second segment, we use second and third half bridge networks of IGBT Inverter bridge configuration. Thus the half bridge network which is located at center is commonly used for both segments while partitioning. Thus H bridge network is formed.

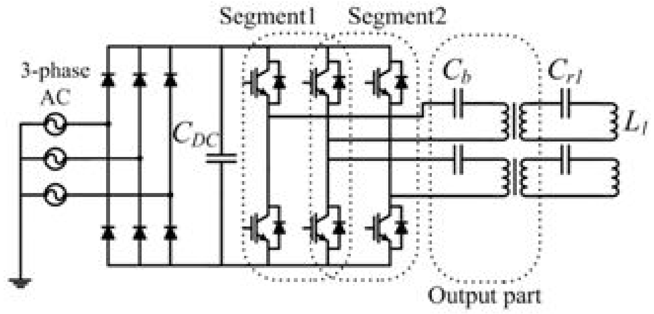


Figure.2. Proposed OLEV inverter.

The output current from inverter varies with load condition. Thus we should control output current unchanged for whatever amount of power is consumed from load, because we want uniform magnetic flux density which is medium of power transfer.

III.WIRELESS POWER TRANSFER BY INDUCTIVELY COUPLED POWER TRANSFER SCHEME (ICPT).

In the 1890's, a wireless power transfer (WPT) system was Demonstrated by Nikola Tesla using his demonstration on resonant transformers called Tesla coils. Various methods used in WPT mainly depend on the range between the transmitter and the receiver, operating frequency and the amount of transmitted power. There are two fields of WPT, Far Field WPT and Near Field WPT. The main differences between the two types of fields are illustrated in Table below

WPT	Near Field	Far Field
Range	Short-Mid	Long
Frequency	Kilo Hertz	Mega Hertz
Efficiency	High	Low

Transfer of power to electric vehicles employs near field wireless power transfer scheme which consists of Inductive power transfer scheme and capacitive power transfer scheme. Inductive Power Transfer scheme has more efficiency of power transfer as compared to that of capacitive power transfer scheme. Thus our system employs inductively coupled power transfer scheme. Generally, wireless power transfer systems for electric vehicles use 10-100 kHz frequency. In the OLEV system, the target power is 100 kW and the resonance frequency is 20 kHz. The basic circuit of the wireless power transfer system is shown in Fig. 4. This circuit is fundamentally the same as the circuit model of transformers. In the circuit, a larger mutual inductance M facilitates more effective power transfer. The mutual inductance M is determined by L1, L2 and the coupling coefficient k, as follows.

$M = k*(L1.L2)^{1/2}$……………….. (1)

Where k indicates the degree of coupling strength and is between 0 and 1.However, k of a wireless power transfer system for moving electric vehicles is very small due to the large air gap distance between the bottom of a vehicle and road, which is necessary for safe driving.

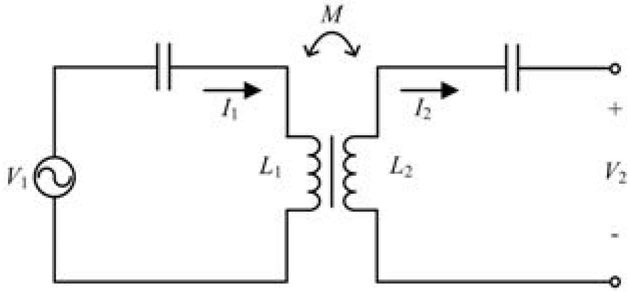


Figure.4. Basic circuit model of wireless power transfer system.

To compensate the reactive power and increase the power Efficiency, compensation capacitors are used in the OLEV system. These capacitors make the circuit resonate at the operating frequency and minimize the circuit impedance. There are four basic compensation topologies for primary and secondary sides: SS compensation, SP compensation, PP compensation, and PS compensation, where S denotes series compensation and P denotes parallel compensation. For a wireless power transfer system for moving vehicles, the use of SS compensation is recommended, because the required primary compensation capacitor depends on the mutual inductance M. To charge the moving vehicles, the system must be tolerant of unavoidable lateral displacement, which leads to a change of mutual inductance, and thus SS compensation is selected for the OLEV system.

IV. SIMULATION MODEL

We represent segment 1 between arms 1 and 3 and segment 2 is shown between arms 2 and 3. For our practical system we have considered output as a series R-L load for segment 1 and series R-L-C load for segment 2instead of power track lines of electric vehicles. We measured the current across load which is nothing but the output current across 2 segments and result is shown on waveforms obtained.

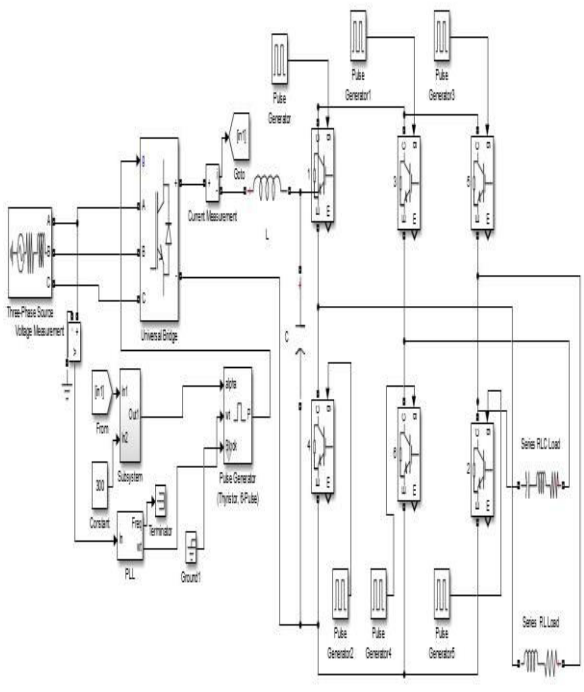
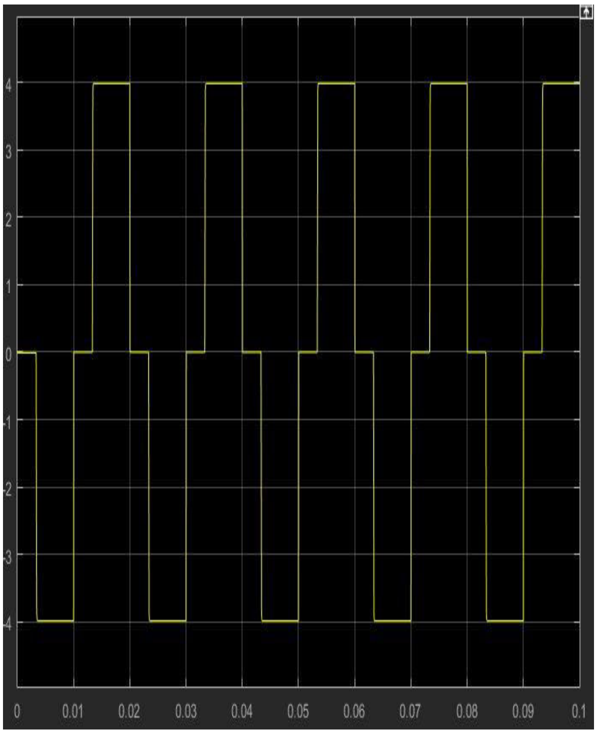


Figure.4. Converter-Inverter Bridge configuration.



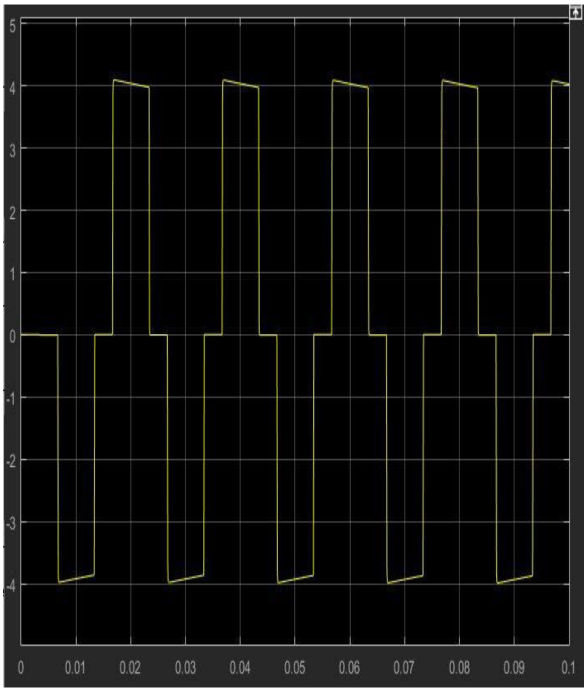


Figure.6. Output current(A) on Y-axis verses time t (sec) on X-axis

V. CONCLUSION

The bridge configuration has been simulated in MATLAB SIMULINK and the simulation results for output current have been obtained. It is seen that output current varies with time but the power remains same through the partitioning process. The circuit application for On-line Electricvehicle is been discussed in the paper. The scheme of wireless power transfer can also be extended for charging of mobile phones.

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