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Research Article

Analysis of Wireless Power Transmission for Online Electric Vehicle with Effective Battery Management

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Abstract: Due to the consistent increase in energy efficiency issues, studies for improving the charging efficiency and energy density of batteries have been receiving attention in the electric vehicle transportation sector. This paper deals with a Modified On-Line Electric Vehicle (M-OLEV) system which utilizes the dc power system with a pair of battery for reducing loss as well as reducing the size of the required battery capacity. Intensive research on grid integration with (M-OLEV) has not been performed until recently and it is necessary to calculate the power flow analysis considering the unique characteristics of (M-OLEV) for the application of this new system in the transport sector. The dc M-OLEV power system is being investigated for reducing line losses and peak power thereby reducing the electric cost levied on the substation and also switches between batteries in case of discharge of power from the driving battery in order to maintain the vehicle. Verification processes are performed through simulation for various scenarios to examine the effectiveness of the proposed system in terms of power consumption, battery state of charge, peak power, and loss reduction.
Keywords: DC distribution system, Electric vehicles, Wireless Charging Vehicle, Modified On-Line Electric Vehicle, Battery Management

INTRODUCTION

The increase in the interest of energy conservation recently across industries implies to find reliable technical solutions in order to reduce the energy consumption. In the field of power systems, the concept of energy efficiency has gained a lot of attention in the past few years [1]. Active research is being performed to find solutions for increasing energy efficiency and encouraging the implementation of distributed sources of generation near the load centres for the purpose of power loss reduction and resolving environmental issues. For road transportation, the electric vehicles (EVs) have received attention since they can use energy sources other than petroleum thereby decreasing air pollution [2], [3]. However, the main drawback of EVs is that owing to the limited energy density of the batteries, larger requirements in battery size are required thereby resulting in higher costs.

To encourage the increase in the utilization of electric vehicles, it is required to install the infrastructure for charging the EVs where the bus stop and the parking lot could also be converted into another type of place to provide the required energy [4]. Various studies to establish this circumstance are required and among them, the increased efficiency and the reduction of the charging time are especially expected to be the main concerns [5]–[7].

By attention to this point, a study about wireless power transmission system for electric vehicle to charge the battery during low-speed driving without stopping the vehicle is underway [8], [9]. If vehicles can be recharged while driving, the rate of discharging will be greatly reduced and EV’s battery size will reduce accordingly. The various concepts of the wireless power transmission system have been already configured, considering the efficiency and stability problem as well as harmonics impact on the system [10], but little research has been performed on the effective integration with the power system. In this paper, a study is performed focusing on the effective operation of the online electric vehicle (OLEV) system which is an innovative project that utilizes wireless charging for supplying energy to the EVs. Fig 1 shows a OLEV inverter system concept .The OLEV system undergoing research utilizes a power inverter developed particularly for this system, where the 440-V, ac, three-phase, 60-Hz input is converted to dc which then is converted to generate a 20-kHz ultrahigh frequency voltage by using insulated-gate bipolar transistor (IGBT) devices .

The ac OLEV system, which is presently under the demonstration phase, is an ac supply system where the supplied ac power from the grid is converted into dc power by each inverter. Thus, the system has a large switching loss compared with other electrical transportation system such as the dc railway system. Also, since the entire charging system is located at the end of the electric power distribution system, there is a possibility of a loop occurrence when an electrical interconnected system is configured between each substation. Due to this issue, there is an efficiency problem in power supply and substation capacity calculation because only one substation system is responsible for power supply for several inverters. A large peak power can occur in the substation when there is simultaneous battery charging on the charging platforms since the system is radial and does not receive power from the other substations.

In the case of OLEVs, since the capacity of the battery is comparatively low, the system cannot be configured so the EV is not charged for a long interval, i.e., the distance between the charging sections cannot be too long. Furthermore, since the system has adopted the low-speed charging section, the resistance has a large deviation depending on the location of the EV within the charging section.

Furthermore, owing to several other issues, many charging inverters are required in the OLEV system and the system utilizing an ac source can result in the following problems.

1) First, large switching loss can occur as the system will need many power electronic devices.
2) Second, due to many power conversion processes, a lot of harmonics is generated and since the OLEV system is a high-frequency power transfer system, countermeasures to remove these harmonics should be developed.
3) Third, the substation supplies the power without support from other substations which results in high peak power and underutilization of the substation, i.e., the capacity set for the substation is unnecessarily high due to the peak power.

In the ac OLEV method, in order to minimize the losses occurring in the dc OLEV system, the dc distribution system is being proposed to enable electricity exchange between the substations similar to other dc-based transportation systems. The system configured is based on the given line information, the scheduling being performed which reflects the consumption power of the vehicle and the charging power of inverter for the efficient operation of the whole system. Through simulations, the operating condition of each section is verified and the state-of-charge (SOC) of the vehicle's battery is checked whether it is being maintained at an appropriate level. Also, the power flow analysis is performed to verify peak power reduction through the proposed system.

EXISTING OLEV SYSTEM

The OLEV system is comprised of sections without power supply unlike the railway system and consists of low-speed charging sections that enable the charging of the battery during operation unlike other electric vehicle. Although the system shows the mobility and energy consumption characteristics similar to the urban railway system, the inflow of regenerative energy does not occur because the battery power is consumed independently.

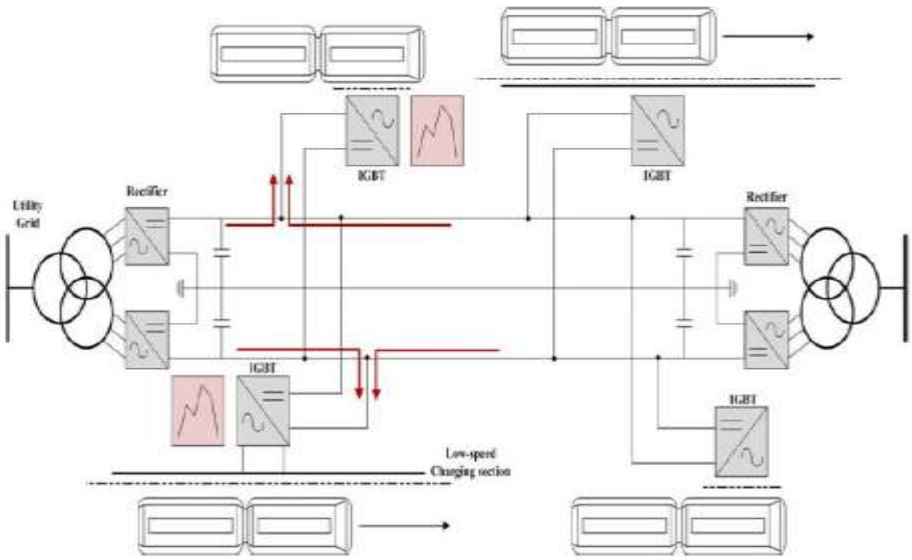

Fig-1: Concept of dc OLEV system

In addition, analysis of the power consumption pattern is more straightforward than other transportation systems due to the charging at a certain point. Unlike the railway system, where the power consumed by the trains can be supplied from adjacent substations or regenerative energy from adjacent trains, the power required for the vehicle charging in the OLEV system at the charging points is supplied from a single transformer owing to the radial characteristics of the distribution network. If these charging points are electrically connected, this would result in the formation of a loop, which would result in the false operation of the circuit breakers during a fault condition. This is because the protection schemes available in the system have been set according to the radial characteristics of the distribution system and a loop formation would result in the disruption of the existing protection coordination scheme. For that reason, one substation must supply power to several charging inverters, and the burden of power supply of substation increases instantaneously when the number of charging vehicles is more than one. Moreover, since the power supply is carried out by a single substation, a complexity problem of the scheduling process arises when considering several vehicles. Furthermore, since the power supply system is configured within the urban power grid, the system has to consider limitations in space for installation of the OLEV system components.

In case of batter failed or drained, at that time it fails to do the task, this is the main drawback of dc OLEV system. To overcome this issue, a pair of battery is used in the proposed system model with automatic switching and also without any compromising the existing system performance.

MODIFIED OLEV SYSTEM

The modified system works on the principle of wireless power transmission. The power is transmitted by means of electromagnetic waves in this system. The vehicle is operated in Battery mode.

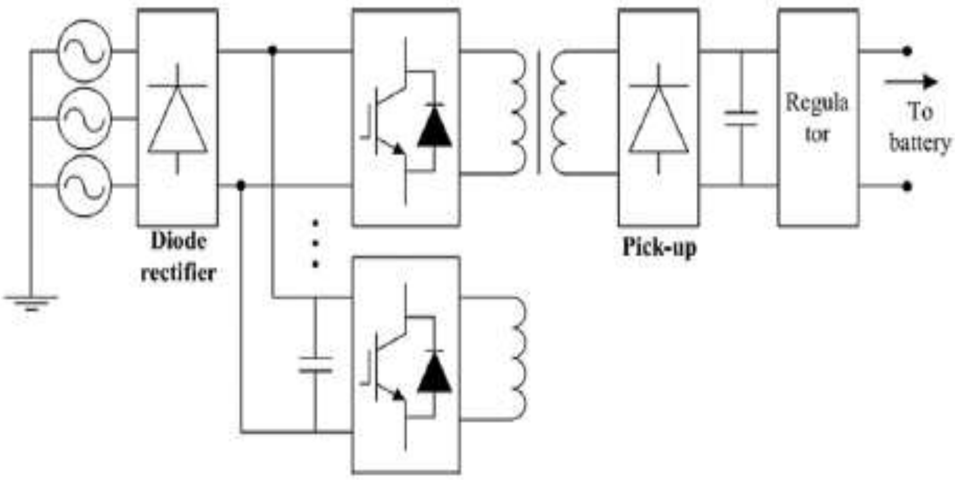

Fig. 2 Circuit Diagram

The battery is charged by the wireless electric power. The vehicle consists of a pair of battery, one is used for driving the vehicle, and other will be in charging state and vice versa. The energy transmitters are connected at the particular places at regular distances. Whenever the vehicle reaches near the transmitters, it gets the charge from the transmitter through electromagnetic waves and thus the battery in charge will be charged. When the driving battery is empty, automatically the battery is switched and the driving battery will switch to charge mode and the charging battery will become driving battery. The circuit diagram of the dc OLEV.

SIMULATION RESULTS

The simulation is done using matlab tool and the results are shown below-

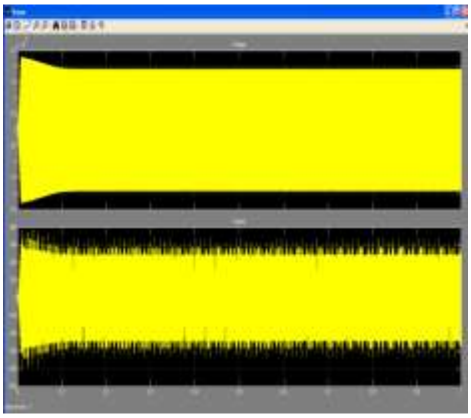

Fig-3: Input Current and Voltage

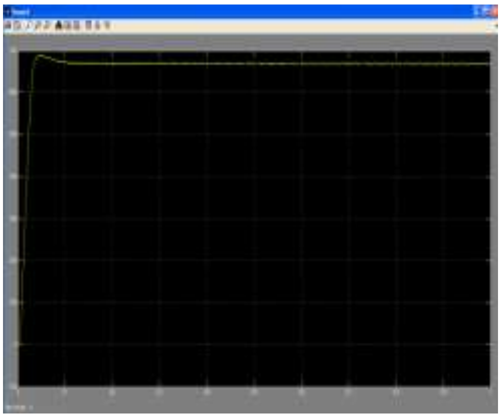

Fig-4: Output Voltage

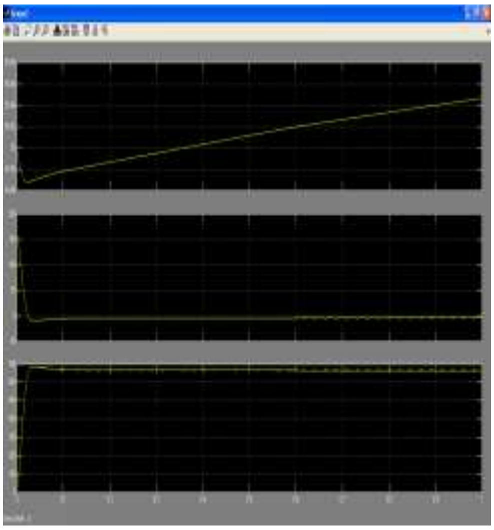

Fig-5: First Battery used for driving

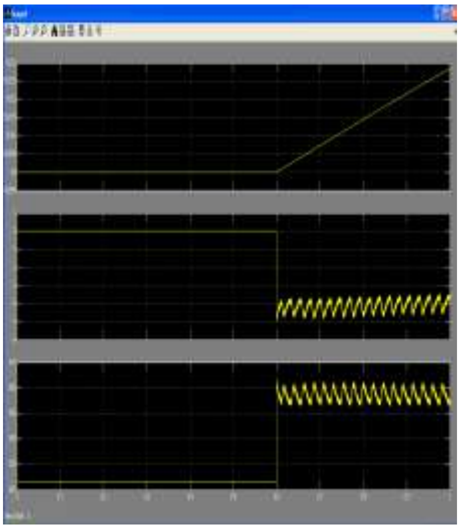

Fig-6: Second Battery in Carging mode

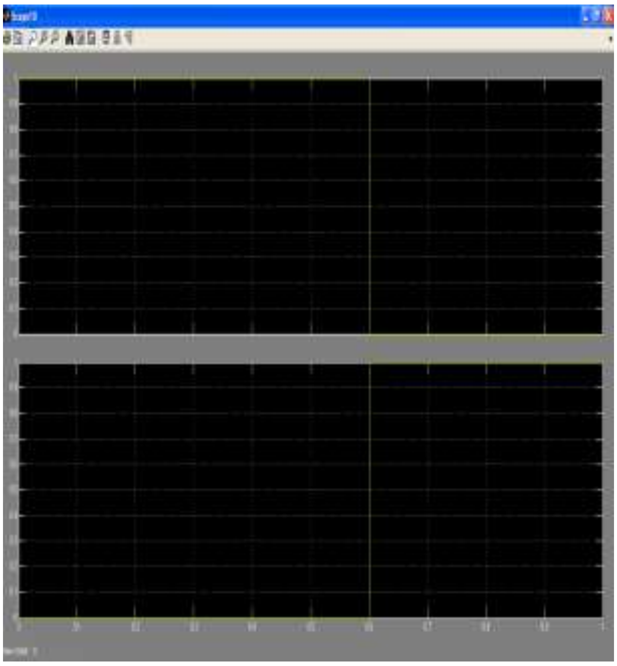

Fig-7: Switching of Batteries

Figure 3 shows the input given to the primary coil of the transformer and the output obtained from the secondary coil is shown in figure 4. Figure 5 shows first battery used for driving the vehicle. Figure 6 shows about the battery in charging mode. The switching of battery takes place when the charge level reaches the threshold point. For example, here we use 50% of charge level as threshold point. So whenever the battery reaches this threshold point switching takes place. The same process occurs in case of battery failure.

CONCLUSION

In this proposed system, a pair of battery is used so it overcomes the drawback of single battery system without compromising the performance of the original system. Even though it overcomes the drawback, the weight and cost of the vehicle may increases due to additional battery. So the future work includes the less weigh and low cost battery design.

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