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PROTOTYPING, SIMULATION AND IMPLEMENTATION OF WIRELESS POWER TRANSMISSION FOR EV CHARGING

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***Abstract*: The Inductive power transfer (IPT) method is used in this paper to simulate a wireless power transfer (WPT) system for electric vehicle (EV) charging applications. The proposed system is also designed to wirelessly transfer power from a charging pad on the ground to the EV's receiving pad without the use of physical conductors. To confirm the accuracy of the model, the simulation is carried out using MATLAB/Simulink.**

The IPT method uses a magnetic field to transfer power between two coils, known as the primary and secondary coils. The primary coil is embedded in the charging pad, and the secondary coil is integrated into the EV's receiving pad. The magnetic field generated by the primary coil induces a voltage in the secondary coil, which is then used to charge the EV's battery.

The simulation results show that the proposed WPT system using IPT is capable of transferring power wirelessly over a short distance with high efficiency. The system parameters, such as the number of turns, the distance between the coils, and the frequency of the power source, are found to have a significant impact on the efficiency of the system

A real prototype of the WPT system has been constructed. It is an Internet of Things-based collection system where a person can use RFID to pay the vehicle's charging fees. The system determines if the user has enough balance before deducting the charges and updating the balance. The network of physical things that employ sensors, software, and other technologies for the purpose of communicating and exchanging data with other equipment and systems is referred to as the "Internet of Things." There is no need for any human contact with this device. As a result of this initiative, we are now able to wirelessly charge our automobiles using inductive coupling and pay our charging fees using RFID tags. One of the technologies that could be a step in the right direction is IOT-based WPT system.

Keywords—Wireless power transmission(WPT), Electrical Vehicle(EV), Inductive power transfer, Simulation, Static charging

INTRODUCTION

The fast-growing technology of electric vehicles replaces fossil fuels by powering the battery to reduce air pollution. And it is charged via plug-in cables or wires. This plug-in wire system creates a mess or knotting when it has to charge several electric vehicles simultaneously. Here we found a lot of electric sockets at the charging port in the charging station. So, to replace this single technology of charging the electric vehicle simultaneously without the use of wires and not creating knots or mess in this process. We gave it a thought and came up with an idea. i.e. using inductive coupling, a simple, safer, and efficient way of transferring power wirelessly.

Wireless Power Transmission (WPT) is the efficient transmission of electric power from one point to another without using wire or any other substance. A WPT system mainly consists of an inverter, primary and secondary compensation networks, transmitter and receiver coils, a rectifier, and a load [14]. It is used in Inductive coupling for a short range where either an instantaneous amount or a continuous delivery of energy is needed but where conventional wires are unaffordable, inconvenient, expensive, hazardous, unwanted, or impossible. The power can be transmitted using Electromagnetic wave power transfer for high range, Resonant Induction power transfer for mid-range, and Inductive coupling power transfer for short range.

The basic function of compensation is to minimize the input apparent power or to minimize the VA rating of the power supply. On the secondary side, the compensation cancels the inductance of the secondary coil to maximize the transfer capability [1]

When the transmitting and receiving coil's internal resistance is small, LCC-S and LCC-LCC circuits can achieve constant voltage and current output. Secondly, the compensation strategy can stabilize the system output by changing the component parameters in the LCC network, when the transmission distance changes. [13]

When the primary side compensation inductance and parallel compensation capacitance are not in resonance, the system designed can provide a higher output power under the rated load and the same lateral misalignment [14]

A high-frequency inverter is used to convert low-frequency DC from rectifier to high-frequency AC, it is observed that the energy transfer efficiency depends on the operating frequency. It is seen that the energy transfer efficiency of resonance-based wireless energy transfer systems reaches the maximum (96%) at the resonant frequency. If the system is set at a frequency other than the resonance frequency, there is an abrupt drop in the energy transfer efficiency. Therefore, magnetic resonance wireless charging is seen to be an efficient method for charging electric vehicles [15].

In summary, this paper provides an overview of the Inductive Power Transfer method for EV charging applications, and its potential to revolutionize the method of charging our EVs.

Overall, IPT technology has several advantages over other wireless charging methods, including High efficiency, safety, convenience, flexibility, durability, and environmental impact. These advantages make it a promising option for the future of wireless EV charging technology.

METHODOLOGY

In WPT (wireless power transmission) system power is transferred from the primary coil to the secondary coil through electromagnetic induction. And it works on the principle of power transfer through magnetic resonance coupling at high frequency. WPT has two coils one on the transmitter side (charging site) and another on the receiver side(vehicle).

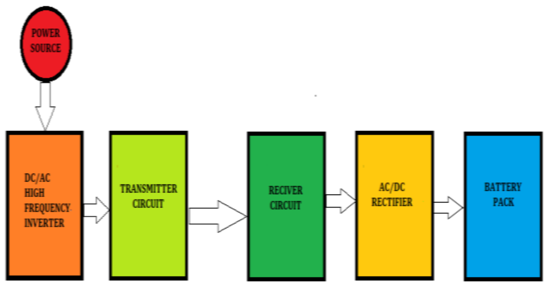

Fig. 1. Block diagram of WPT (wireless power transmission) System

A power source of 230V is supplied to a rectifier circuit. The rectifier circuit makes use of diodes with RC snubber circuits connected in parallel with each switch device. The output of the Rectifier is then connected to a High-frequency inverter. The inverter converts the DC from rectifier output to high-frequency AC. Here we are using a sampling frequency of 30KHz. This High-frequency AC is then fed to the transmitter circuit. Through Mutual Inductance between the coils of the Transmitter and Receiver circuits, AC power is transferred from the Transmitter circuit to the receiver circuit. Again the AC power received in the Receiver circuit is converted to DC by the rectifier and used for charging the Li-ion battery.

SIMULATION

The simulation is done using MATLAB/ Simulink. The batteries' initial SoC is set to 50%. AC Source voltage is set to 230 V. For Rectification Source Rectifier block is used, which makes use of Diode with RC Snubber circuit in parallel with each switch device. After each conversion the values are measured and the corresponding graphs are plotted. Conversion efficiency is around 65-70%.

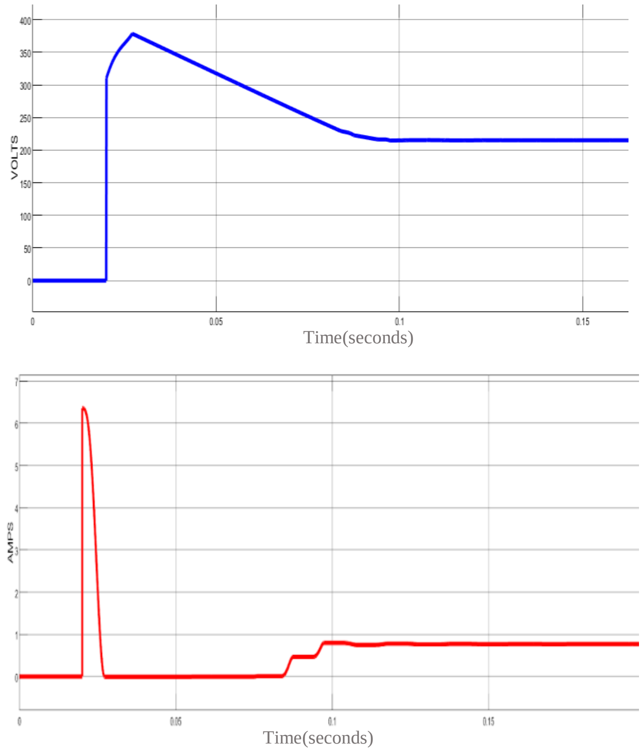

Fig. 2. Simulation result from a) dc-link voltage b) dc-link current

The above is the waveform of the voltage and current after source Rectification. We are using the readily available Source rectifier block with Diodes as the Power electronic device, in which Series RC snubber circuits are connected in parallel with each switch device.

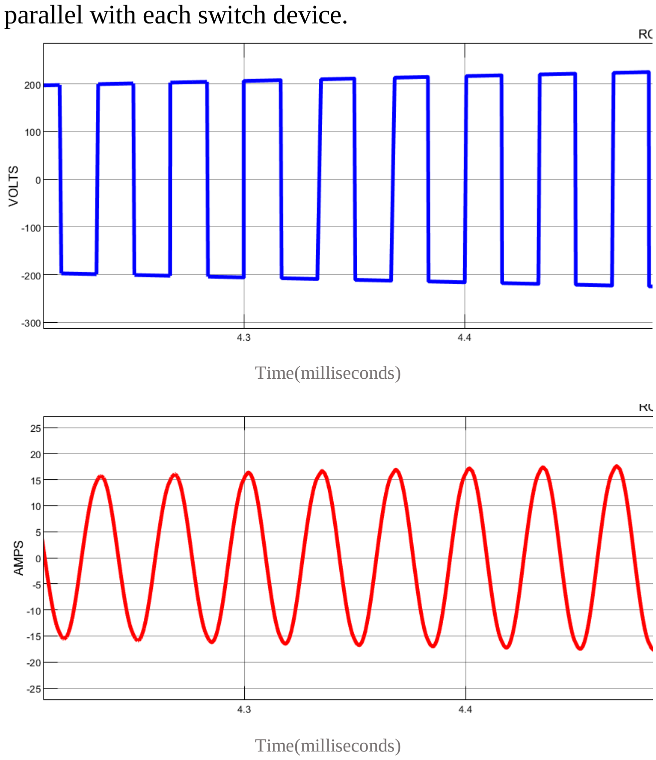

Fig. 3. Charging station, a) Voltage b) Current

The above diagram shows the voltage and current waveforms given to the transmitting coil. This is the output of the High-Frequency inverter.

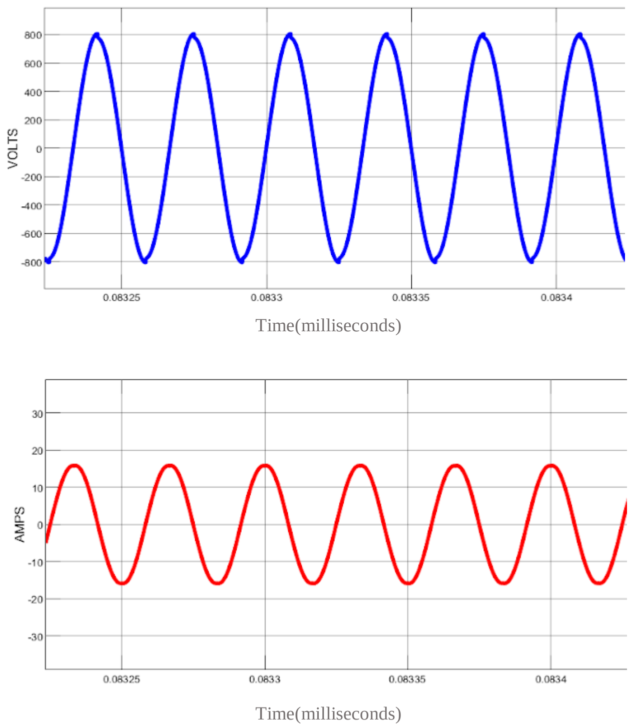

Fig. 4. Vehicle side winding a) Voltage b) Current

The above diagram shows the voltage and current waveforms received in the receiver coil. This is further rectified and used to charge the battery of the EV.

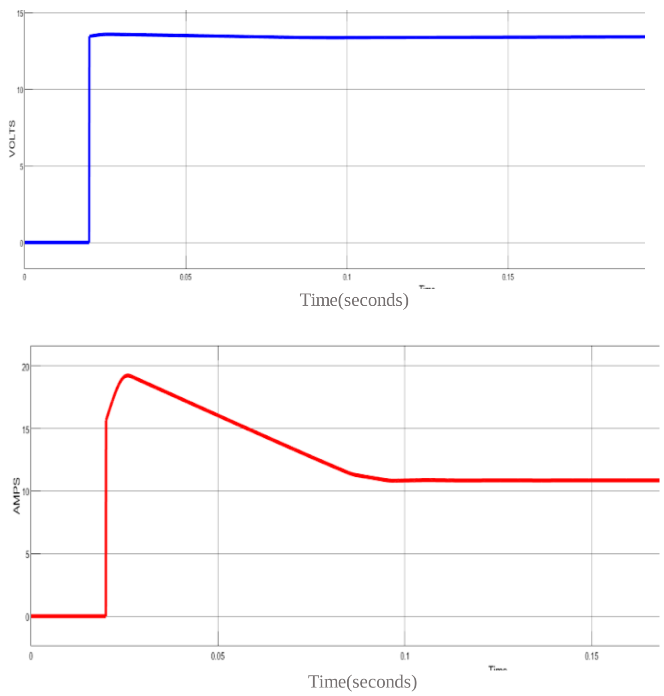

Fig. 5. Simulation result obtained at battery a) Voltage b) Current

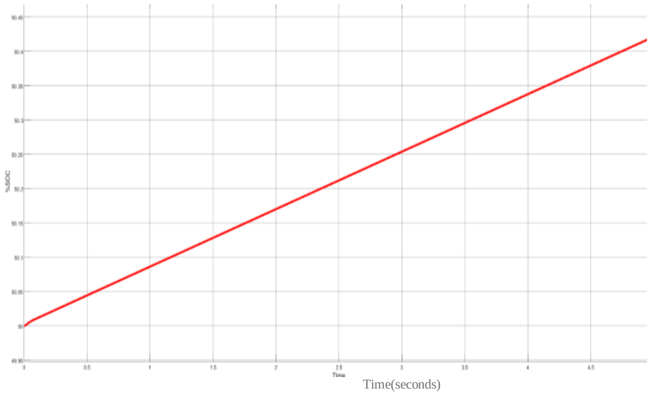

Fig. 6. Battery State of Charge

The above graph is the change in the State of charge of the battery when the circuit was simulated for 5 s. It is observed that the State of charge increased from the initially set 50% to 50.43%.

PROTOTYPE AND RESULT

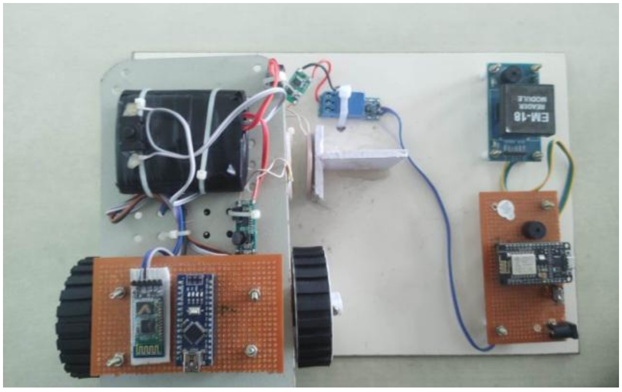

Fig. 7. Prototype image of the designed Wireless power transfer system

The working prototype is set up and prepared to transmit power wirelessly. According to the rules of electromagnetic induction established by Faraday, an electric car should now be aligned with the primary coil to get wireless charging. The working prototype is now turned on.

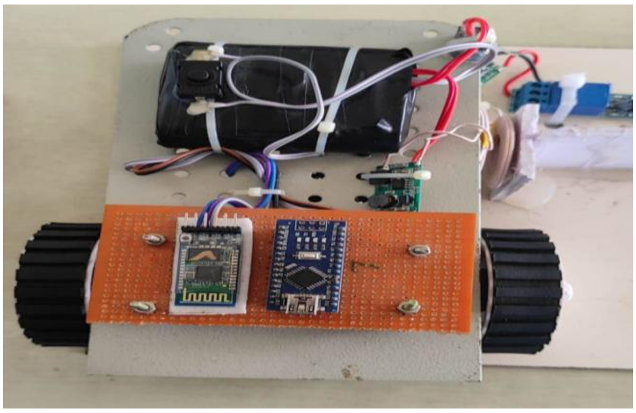

Fig. 8. The Assembly of the receiver circuit

The Wi-Fi module is linked to a hotspot connection with the following information: (SSID: "your SSID"), (Password: "your password") The designed RFID tags are read by an RFID reader, and the necessary information is then received via a cloud server ("http://iotcloud22.in/3B/).

Fig. 9. payment window for charging the vehicle

Information about the car name, kind, number, owner name, date and time of scanning, and paid details will be collected through the cloud server. If the vehicle is paid, the cloud server will charge it or deny it.

CONCLUSION

In conclusion, WPT system for EV charging is proposed with simulation results and Prototype. The simulation model is run for 100 s at initial SOC of 50% and it is observed that SOC is changed to 54.8% in 100 s. At transmitting side, conversion from AC to DC and DC to AC takes place and at the receiving side, conversion from AC to DC happens. After each conversion the values are measured and the corresponding graphs are plotted. Conversion efficiency is observed around 65-70%. A physical prototype for WPT EV charging station is shown, this system shows the efficiency and implementation of the charging station in future technology. This paper also covers future technology like payment through RFID tags and self-serviced entry and exit gate to maintain congestion at the station.

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