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On Road Wireless Battery Charger for Electric Vehicles with Continuous Power Supply

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***Abstract*—This paper aims to develop a reliable and secure charging method for electric vehicles[1] using Wireless power transfer. Recent fossil fuel shortages and global warming related problems have caused a substantial shift from internal combus- tion engine vehicles towards Electric vehicles (EV's). This paper explores the thorough review of battery charging infrastructure from wired connection to on-road wireless charging for an EV[2]. The initial part of the paper deals with the wired charging and its power electronics infrastructure. The later portion deals with the wireless charging where both static and On-Road types are discussed. Furthermore , various aspects of wireless power transfer are also discussed. The Market scenario and future growth prospects are reviewed and presented in last section of the paper . The second main objective of this project is to provide uninterrupted power supply to a load, by selecting the supply from any source out of 4 such as mains, generator , and inverter and solar automatically in the absence of any of the source. The demand for electricity is increasing every day and frequent power cuts is causing many problems in various areas like industries, hospitals and houses. An alternative arrangement for power source is a a necessity . This paper uses four switches to demonstrate the respective failure of that power supply . When any of the switches is pressed it shows the absence of that particular source ,switches are connected to micro-controller as input signals .A micro-controller of 8051 family is used. The output of micro-controller is given to the relay driver IC ,which switches appropriate relay to maintain uninterrupted supply to the load. The output shall be observed using a lamp drawing power supply from mains initially .On failure of the mains supply actuated by pressing the appropriate switch the load gets supply from the next available source, say an inverter .If the inverter also fails it switches over to the next available source and so on. The current status, as to which source supplies the load is all so displayed on an LCD . As it is not feasible to provide all 4 different sources of supply ,one source with alternate switches are provided to get the same function. The paper can be further enhanced by using other sources like wind power also and the n taking into consideration for using the best possible power whose tariff remains lowest at that moment .**

Index Terms*—Unidirectional Battery Charger (UBC), Bidi- rectional Battery Charger(BBC), Electric Vehicle Supply Equipment(EVSE), Wireless Power Transfer(WPT), Vehicle to Grid(V2G),On Road Wireless Power Transfer(ORWPT),electric vehicle supply equipment(EVSE),Conventional vehicle(CV).

I. INTRODUCTION

The increase in price of oil and environmental issues has resulted in growing interest in clean vehicle technologies such as EV and Fuel cell EV . As a result, electric vehicles(EV) are becoming a more attractive solution than conventional vehicles(CV). EVs are powered by electric batteries, which need to be recharged with electricity from the grid. It is clear that the EVs constitute a clear link between the electricity and the transport sectors. Moreover, the EVs can provide a good solution to reduce the environmental impacts of transportation and energy dependency because they have low energy con- sumption and zero emissions . Generally, two types of battery chargers are used: onboard and on-board battery chargers with unidirectional and bi-directional power flow[3].

Most of the battery chargers take a power from the utility grid, for this reason they often termed as unidirectional battery chargers(UBCs) . Unidirectional charging reduces the inter- connection issues and battery degradation. On the other hand, some battery chargers work in both directions and these are called bidirectional battery chargers(BBCs) .These chargers support stabilization of power with proper power conversion. On-board chargers can be used to charge from the utility outlet at the workplace or household plug or shopping malls during the day time. Onboard charging is like a gas station used for conventional vehicles and thus its purpose is to charge fast. Compared to onboard charging, equipment is less for on-board charging. Charging of an electric vehicle can be performed by either wired(conductive)charging or wireless(inductive) charg- ing[3] . Wired charging uses metal contact between electric vehicle supply equipment(EVSE) and the charging inlet of the vehicle. Even though wired charging is popular, problems with messy wires and safety concerns in wet environment are major drawbacks of this system. These problems can be overcome by fig 2 bidirectional battery charger the battery of the vehicle without wires and this technology is termed as wireless power transfer(WPT). Wireless charging has been attracting more attention because of their advantages compared to the wired counterpart such as no exposed wires, ease of charging, and fearless transmission of power in adverse environmental conditions . Now a days, the concept of vehicle- to-grid(V2G) has gained interest due to its ability of to supply stored energy to the grid . It absorbs energy from the grid to charge the battery during peak electricity production and delivers to grid when there is a peak electrical demand. EVs with BBCs are able to implement V2G concept as bidirectional power flow capabilities of their battery chargers. So, BBCs can work in two operating modes, namely recharge mode when they absorb energy and generation

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mode when they deliver energy to grid. In recent years, interest in wireless charging technology is growing for EV charging applications .

It consists of two main stages, namely the transmitter and the receiver, each of them having a coil coupled to the other one with an air gap between them. By Faradays law of magnetic induction energy will transfer from the transmitter to receiver. Misalignment of coils, long charging times and degradation of the battery are major issues. The difficulties in static wireless charging can be overcome by on-road charging and charge the battery while in vehicle is moving which saves the charging time and degradation problems . On-road EV charging is an emerging technology where one can charge their EV batteries while vehicle is on move .Apart from their advantages such as less battery requirements, they suffer a problem of misalignment and further leads to synchronization failures . Various loading conditions, frequency mismatch, misalignment and component tolerance are the main causes for the synchronization failure. This paper is organized as follows: Section 2 considers the EV charging infrastructure and section 3 Power supply infrastructures. Section 4 considers and discusses wireless charging of EVs in static position and On-Road wireless charging of and EVs. Section 5 discusses Simulation studies ,evaluation and the future scope and market scenario of battery chargers and section 6 concludes the paper.

II. TYPES OF BATTERY CHARGERS

There are mainly two types of battery chargers. Bidirectional and Unidirectional chargers. The unidirectional charger cannot allow power flow in reverse direction, because of uncontrolled diode rectifiers. If converters in all stages are kept bidirectional converters i.e. fully controlled, then the complete charger arrangement becomes bidirectional. In the first stage, instead of a diode rectifier, a fully controlled rectifier is then used as it can perform bidirectional flow as well as the function of power factor correction. In the same way in the secondary side of transformer if full controlled converter is utilized instead of the diode bridge, the dc chopper can be eliminated.

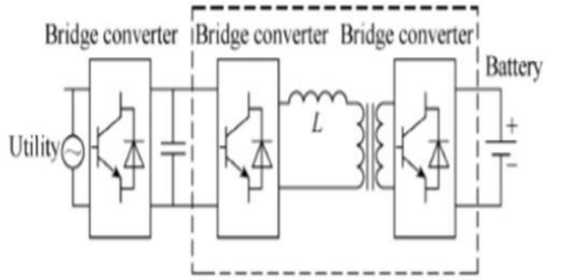

Fig. 1. Unidirectional battery charger.

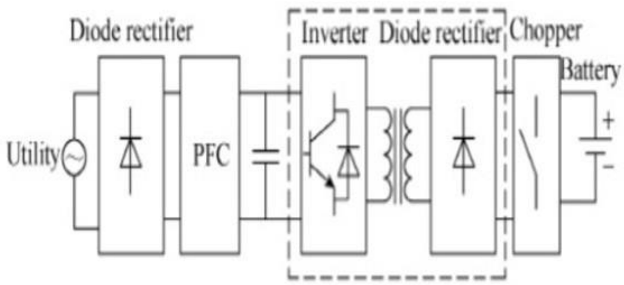

Fig. 2. Bidirectional battery charger.

III. TYPES OF TRACKS

In general, On Road Wireless Power Transfer(ORWPT) track can be categorized into two types; elongated track and segmented track[4].Elongated track consists of a substantially long transmitter track connected to a power source. The single transmitter track can be few meters to several tens of me- ters long. However, this type of design suffers from several drawbacks. Firstly, the electromagnetic field emitted within the uncoupled region has to be suppressed to eliminate harmful exposure. Secondly, the compensation capacitor has to be distributed along the track to compensate large inductance. This brings additional constraints in construction. Thirdly, coupling coefficient is low because of the smaller transmitter region covered by the receiver resulting lower efficiency.

Segmented track has multiple coils connected to high fre- quency power sources as shown in figure 4 Segmented track eliminates issues raised by single transmitter track such as field exposure and requirement for distributed compensation while lowering coupling issues[6]. However, it introduces the design challenges such as synchronization between track and pickup. In addition, separation between transmitter coils needs

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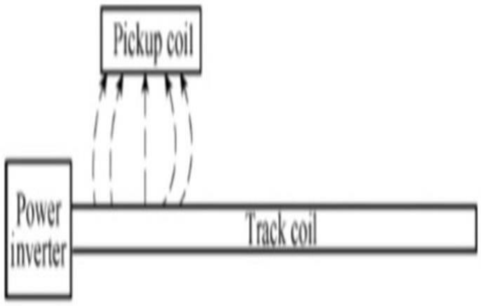

Fig. 3. Elongated track.

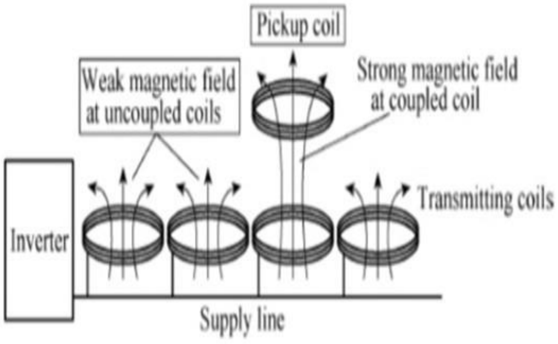

Fig. 4. segmented track.

to be carefully optimized by placement of the segmented coils on track. However, coils cannot be kept too close to each other due to two reasons. Firstly, negative mutual inductance between adjacent transmitter coils is significant generating negative current stress. Secondly, design cost will be increased with many transmitters in a given length of the track. On the other hand, designing the Power supply such as High Frequency Input(HFI) for each segmented track is not a feasible solution[7]. In addition, integrating the control of overall mechanism with synchronization poses major design challenges.

IV. SOURCES OF POWER

The block diagram for the Auto power supply control from four different sources is as shown in figure[5]. Relay is provided for the security of the system .The microcontroller prioritizes the sources and automatically switches the sources in case one source fails The shifting of sources when one source fails to operate, in turn ensures continuous power supply. Solar energy from the panels can be used during the day time and in case one supply fails or cannot be used no more, then

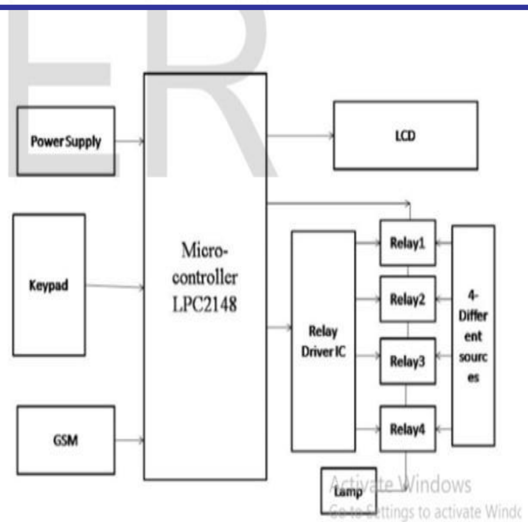

Fig. 5. Automated power control from 4 different sources.

the other supply can be automatically used .It can be shifted from inverted to main or to wind turbine energy according to priority the microcontroller as needed to ensure the continuous power supply .

Initially we have given high input signal to the microcon- troller, so as a result the controller generates a low output to activate the first relay driver which will result in the relay being energized and the lamp glows. While the push button for solar is pressed that represents failure of solar supply as a result the supply is provided from the next source and the microcontroller receive high input and generates low output to activate the second relay driver which will result in the second relay being energized and the lamp glows. When we press the inverter button, it indicates the inverter or fails to operate and the supply comes from the next source and the next source will supply high input to the controller and which will provide low signal to the third relay and the lamp switches ON and when we press the third push button the supply will chose next source now the fourth source will provide input to the microcontroller and controller activates the fourth relay and the load will get the supply and the lamp continues to glow. When all the relays are off leaving no supply to the lamp ,the lamp is switched off. One 16 x 2 lines LCD is used to display the condition of the supply sources and the load on real time basis.

V. SIMULATION STUDIES

The simulation circuit was processed in Mat lab Ra16 soft- ware. The circuit was made by necessary components and pulse given by pulse generators .The output waveforms were generated and analyzed for various components of the circuit as required for the wireless power transfer in the project. The input waveform for the voltage and current is given at V=200v.

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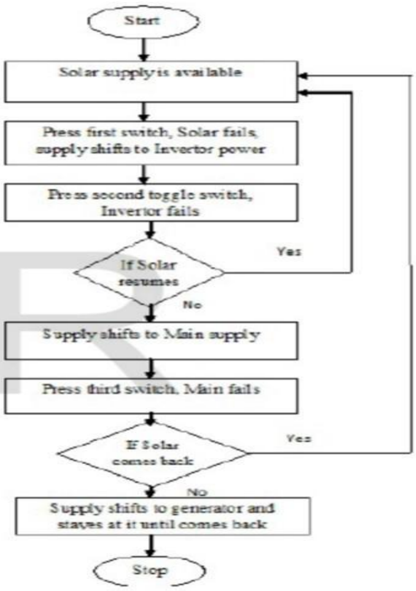
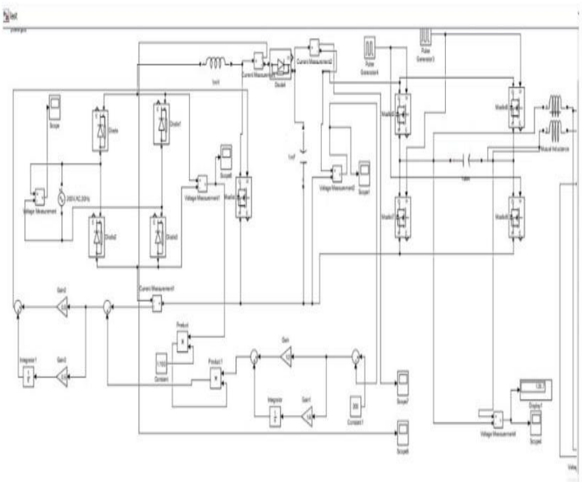


Fig. 6. Flowchart operations.



The input voltage waveform is rectified and its output is represented in figure 8.

Power factor correction is done so as to improve the power factor of the circuit. It is required for improving the efficiency of the system. The output current waveforms before and after power factor correction is represented in figures 10 and 11. And the power factor corrected output voltage waveform of simulation circuit is shown in figure 12.

Output from the Inverter is shown in figure 13. An output Voltage of 129.7 . The inverter is of High frequency type. Output from the Mutual inductance coil receiver side is shown in figure 14. Mutual inductance coil is used for the Wireless power transfer.

Rectifier output voltage waveform is represented in figure
15. Battery output voltage and current waveforms obtained after simulation is shown as figure 16.

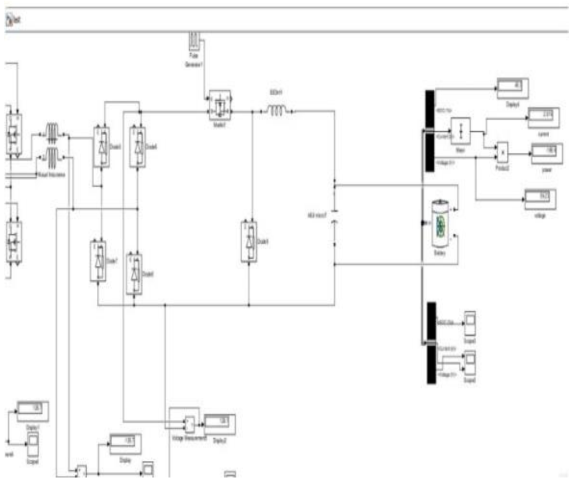


Fig. 7. Simulation circuit diagram

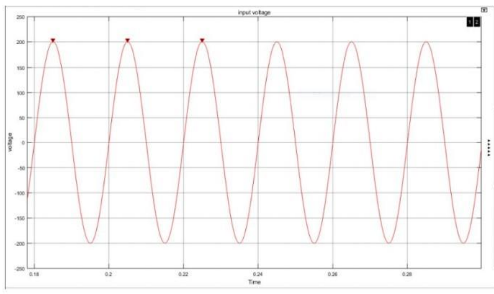


Fig. 8. input waveform

VI. Conclusion

This paper reviewed the battery-charging infrastructure for the Electric Vehicle and the charging and power infrastructure for the wired charging. The different aspects such as coil coupling and Power electronics infrastructure of Static and ORWPT charging were discussed. Finally, Market scenario and future prospective growth opportunities were detailed. Recent reviews of WPT technologies and their transportation applications are optimistic about their prospects for deploy- ment and growth. A promising strategy for competing WPT

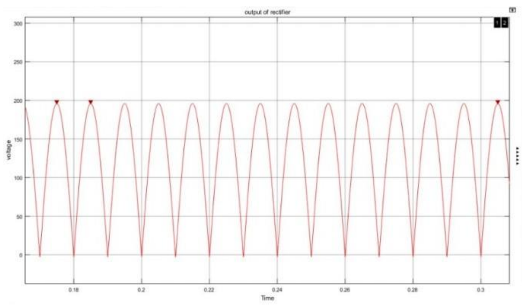


Fig. 9. input rectifier output

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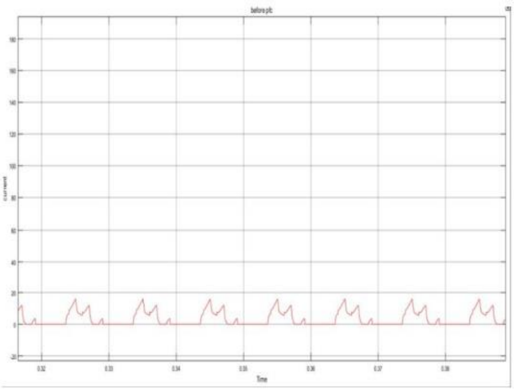

Fig. 10. Output current before Power Factor Correction.

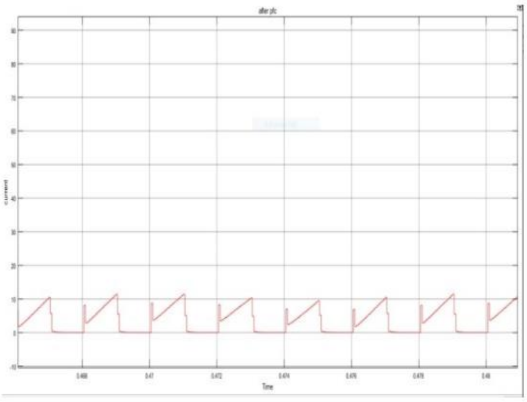

Fig. 11. Output current after Power Factor Correction.

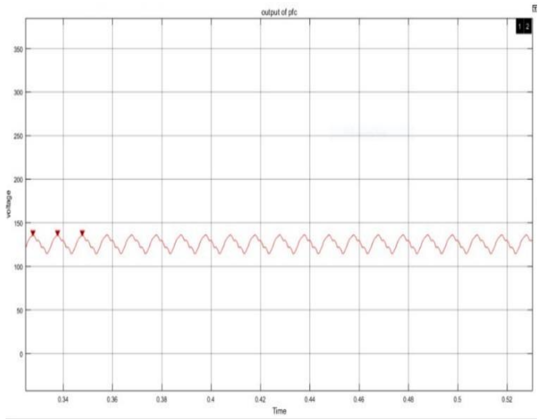

Fig. 12. Power factor corrected output voltage waveform.

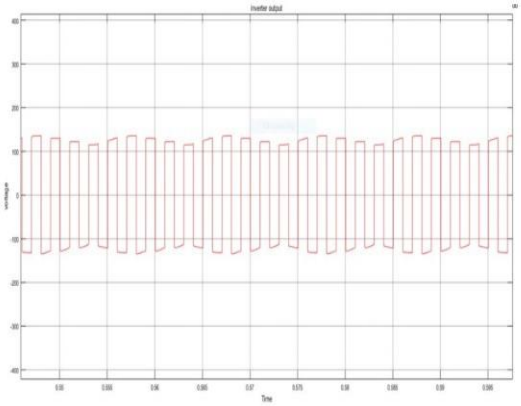

Fig. 13. Output voltage waveform from an inverter circuit.

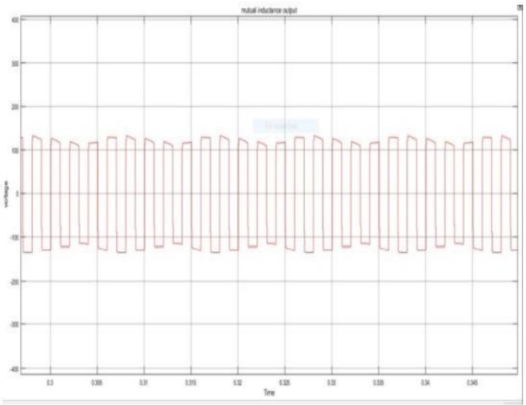

Fig. 14. Output voltage from mutual inductance coil receiver side.

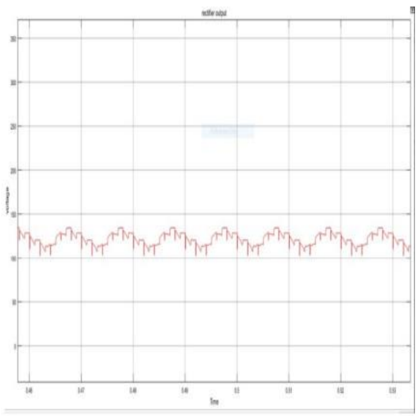

Fig. 15. Rectifier Output voltage waveform.

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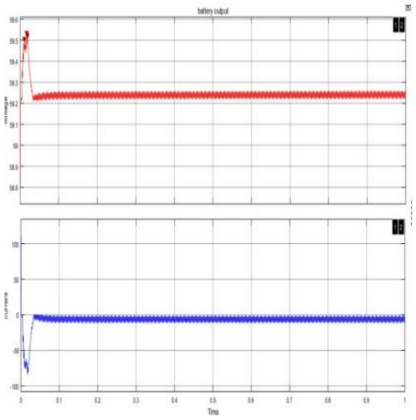

Fig. 16. The Battery output waveforms.

technology providers is to enter into partnerships with bus or LRV manufacturers in order to demonstrate in service operations, their commercial reliability, cost-effectiveness, and market niche viability. From this WPT review of emerging and existing transit applications in the U.S. and world-wide, it is evident that there are multiple candidate WPT technologies for transit applications in various stages of technology maturity: from development to prototype test/evaluation, to some in- service deployment. Progress in WPT products standardization and the harmonization of international WPT standards will broaden market access to competing EVSE and on-board products for electric light duty and heavy-duty vehicle appli- cations, including public bus and rail transit as a market niche. WPT developers and technology providers claim multiple core benefits for EV owners and electric transit operators and users that are yet to be proven in an operational environment, in- cluding convenient choice of fast (On-Road) or slow (in station or depot), battery recharging with one infrastructure system; automatic trigger of charging high power transfer potentially in all weather, without corrosion or exposed terminals; no loose cords or potential for electrocution or tripping; no adverse human safety or health impacts (as long as emissions of and exposures to magnetic and electric fields and radiation comply with applicable guidelines, standards and regulations).

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