IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
IJARSCT
Impact Factor: 7.53
Volume 4, Issue 3, April 2024

Solar Based Wireless Electric Vehicle Charging and Transmitting Extra Power to Electricity Mains

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Abstract: *The solar based Wireless Electric Vehicle Charging (WEVC) and Transmitting Extra power to Electricity Mains has several advantages over conventional energy transmission using wires and connectors, such as flexibility, convenience, safety, reliability and all-weather operation, etc. The development of this system will certainly promote the popularization and industrialization of EVs, and also an individual can earn by transmitting extra power to electricity mains. In this project we will be implementing a system for charging electric vehicles wirelessly by using the solar power. In order to design and implement we divide our project into two parts, in the first section we are trying to optimize the existing solar power system by transmitting extra power to electricity mains. In the second section we are designing the wireless power transmission system based on inductively coupled power transmission technology using the optimized solar power as input*

Keywords: WEVC

I. INTRODUCTION

In the last few decades, world has been facing the effects caused by the climate changes. This problem, commonly known as the global warming, has been pointed out as being caused by burning carbon, oil or derivatives. Worldwide, the production of electrical energy through carbon (coal) and the usage of petrol to power personal and public transportation is responsible for majority of carbon dioxide emission. In the Portuguese case the emissions caused by transportation sector rounds the 36% of the overall emissions.

With rising fuel costs, increasing concerns for global climate change and a growing demand for electricity, utilizing renewable energy sources such as solar power becomes a necessity rather than a luxury. One of the proposed solutions to reduce the emissions in the transportation sector was the replacement of internal combustion engines (ICE) by electrical engines [1]-[5]. Taking into account the referred concerns, this project addresses precisely the problem of charging an electric vehicle, the necessary support structure to do it and use of renewable energy sources for charging electric vehicles.

The non-existence of a standard solution to the charging system that will equip the future electric vehicles increases the importance of this issue. The solution proposed in this project is the adoption of an inductively coupled power transfer system (ICPT) to charge the batteries on board the electrical vehicle [6]-[7], for this we are using solar power as the source of energy. The total solar energy absorbed by Earth's atmosphere, oceans and landmasses is approximately 3,850,000 exajoules (EJ) per year but only a fraction of that is captured for electrical power production [8]. However to utilize this energy efficiently we have designed our project.

1.1. PROBLEM STATEMENT

Electric vehicles are not a new phenomenon and have been around since the beginning of automotive era in early 1900s [9] .However with the advent of internal combustion engine and cheap oil in the early 20th century, the EVs went out of mass production. The EVs also grew unpopular because of their very limited driving range. But the idea of an environment friendly, affordable and silent EV has not died and several attempts have been made by car manufacturers to come up with new technologies and make EV more affordable and popular. But glacial pace of advancements in battery technology has been a major setback in broad introduction of EVs on roads. Limited range, slow energy replenishment and cost have been major bottlenecks that limit the use of EVs on a large scale [10]. However, with the development of Li-ion batteries and fast charging infrastructure, and lower cost of production, EVs can become a realistic alternative to conventional vehicles.

Already there are several commercially available products that use conductive charging technology which are simple and reliable solutions. However, one major disadvantage of this is that connection will have to be made manually between the EV and the charging station. This is a source of inconvenience and may also cause safety risks in wet and damp conditions [13]. Another disadvantage of this is that easy automation cannot be achieved with this charging process. In solar vehicles we need to install the solar panel on the top of vehicle which is adding more weight and leads to ineffective utilization of solar power once the battery is completely charged. A solution to these problems is to use ICPT technology for charge replenishment of EVs.

If large numbers of Electric vehicles are connected to the electric grid randomly, peak load will be very high. The use of conventional thermal power plants will be economically expensive and environmentally unfriendly to sustain the electrified transportation. Intelligent scheduling and control of elements of energy systems have great potential for evolving a sustainable integrated electricity and transportation infrastructure. The maximum utilization of renewable energy sources using EVs for sustainable minimum cost and emission is very essential.

1.2. LITERATURE SURVEY

Several studies on Hybrid vehicles, solar vehicles and systems applied to electric vehicle battery charging and integration of electric vehicle with renewable energy sources have been carried out. Current status of electric vehicle industry, present charging technologies and problems associated with hybrid and solar vehicles has been explained in [1]-[5].

A control mechanism for renewable energy sources, problems associated with the efficiency, reliable delivery and use of electricity obtained from renewable resources and the integration of renewable sources is proposed in [5], it also addresses need for advanced control strategies to solve these issues effectively. The efficient utilization of renewable energy sources using electric vehicles at minimum cost and reduced emission is presented in [28], but methods used in this paper applies only for hybrid electric vehicles and solar vehicles.

A novel contactless inductive charging system with its circuit topology for electric vehicles is proposed, and the equivalent models for the primary and secondary circuits are built based on the theory of mutual induction [12]. However in our project we are going to design a system for charging EVs wirelessly, for this we use solar power as source and also design a technique for effective utilization of solar power by transmitting extra power to electricity mains. Most of the new electric vehicles require about the same electrical usage – about 200-250 kWh / month which is cheaper than the cost of fuel for vehicles [30], So by using an economical and environmental friendly solar energy as source we can charge our electrical vehicle [31].

1.3. SOLAR AND ICPT AS SOLUTION TECHNIQUES:

ICPT charging technology has the potential to bring about a positive change in mindset of people regarding EVs. EVs have traditionally been expensive, with limited driving range, inconvenient with respect to the charging process. However, with introduction of ICPT technology for charge replenishment, EVs can become an attractive option. ICPT charging has the advantage that it can make the charging process automated, convenient and safe for users and large scale introduction of ICPT charging infrastructure can help reduce the battery pack size and in turn make the EVs more efficient [11].

In this project we will be implementing a system for charging electric vehicles wirelessly by using the solar power. In order to design and implement we divided our project into two parts, in the first section we are trying to optimize the existing solar power. In the second section we are designing the wireless power transmission system based on inductively coupled power transmission technology using the optimized solar power as input.

As we know how the solar inverter or solar charger works, i.e solar energy falls on to the solar panels then it induces electricity and the energy is stored in a battery, later that energy is being utilized for charging electric vehicle wirelessly and running the home appliances. Now the condition is, if the battery which is used to store the charges gets charged earlier , then rest of the time when sun is available and solar panel which can generate the charges will not be utilized as the battery is fully charged. So to utilize this energy without wasting it in anyway we have designed this project.

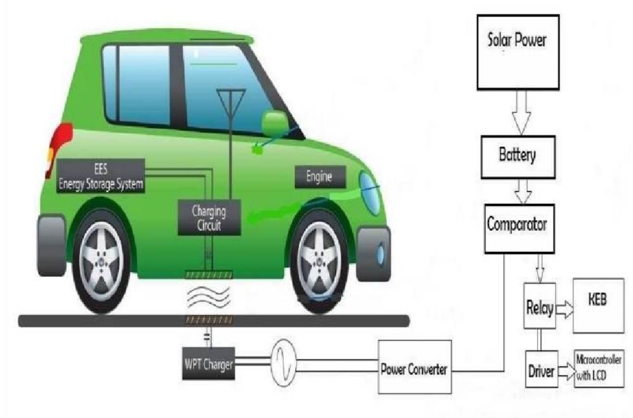

Figure 1.1 Fundamental Structure of the Solar based WEVC and Transmitting Extra Power to Mains.

When battery is fully charged then the next stage is to shift the charging point or the power line towards the grid or Electricity board so that wastage can be minimized and the power can be delivered to the Electricity Board (EB). In this section we will be monitoring the numbers of units we are transferring to the EB and the total amount we are going to earn from that.

Fig.1.1 shows the fundamental structure (Prototype) of WEVC system using solar power [8]. Power convertor takes power from the solar battery supply to generate a high frequency current in the primary energy emission unit (underground track or coil array), around which high frequency magnetic field is formed. In the pick-up unit, which is located in the high frequency magnetic field, high frequency current is induced and conditioned to produce stable supply to battery charging.

II. OVERVIEW OF ICPT

This concept of transferring energy without the need of using wires to connect the load to the source is based in the magnetic induction [12][17]. This technology have been considered a valid alternative to the classic charging system, by contact, due to the numerous advantages, some of them, very appellative to an electric vehicle charging system.

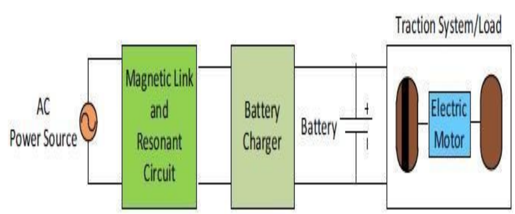

Figure 2.1: Main blocks of an ICPT vehicle charging system

The basic circuit of an ICPT vehicle charging system is constituted by four major blocks: a power source, a magnetic link, a resonant circuit and a battery charger (Fig. 2.1) [12]. The power source is responsible for the connection between the power grid and the magnetic link. It is usually composed by and rectifier followed by an inverter. With this topology, the frequency and current amplitude may be controlled allowing controlling the power flow of the system. The magnetic linkage is responsible for the transfer of the power between the power source and the battery charger and is composed by two coils that can have an iron core or be coreless. The resonant circuit is used to compensate the reactive part of total impedance increasing the power transfer efficiency.

The battery charger allows to control the charging process and to control the changing voltage to the levels accepted by each type of battery. It is also responsible by making the connection between the ICPT system and the battery set to be charged, which is on- board of the car.

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A simplified ICPT system diagram is presented in Fig. 3.2 The most important parts of an ICPT system, as it is well-known, are the magnetic linkage and the resonant circuit.

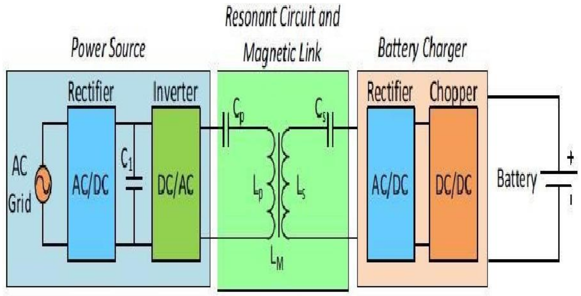

Figure 2.2: Simplified ICPT system diagram

2.1. ICPT THEORETICAL MODEL

The power transfer capability of an ICPT system depends directly on the coupling coefficient [13] which is given by

$$k = \frac{M}{\sqrt{L1L2}} \quad (1)$$

Where subscripts "1" and "2" stand for primary and secondary windings.

If SS compensation is selected, the primary capacitance is independent of either the magnetic coupling or the load [12]. The power transferred

from the primary to the secondary is given by

$$P_2 = \frac{\omega_0{}^2 M^2}{R_L} I_1{}^2 \quad (2)$$

Where "ω0" is the resonant frequency of the primary and secondary and is normally chosen [12].

$$\omega_0 = \frac{1}{\sqrt{L_1 C_1}} = \frac{1}{\sqrt{L_2 C_2}} \quad (3)$$

Equivalent Circuit Parameters:

To obtain the theoretical values of L1, L2 y M the following expressions must be used. L1 is given by:

$$L_1 = \frac{\mu_0}{\pi} N_1^2 \left[d \cdot ln \frac{2Ld}{R_1\left(d + \sqrt{L^2 + d^2}\right)} \right] + \frac{\mu_0}{\pi} N_1^2 \left[L \cdot ln \frac{2Ld}{R_1\left(L + \sqrt{L^2 + d^2}\right)} - 2(d + L - \sqrt{d^2 + L^2}) \right] + \frac{\mu_0}{4\pi} N_1^2 (L + d) \quad (4)$$

And L2 is given by

$$L_2 = \frac{\mu_0}{\pi} N_2^2 \left[d \cdot ln \frac{2ad}{R_2\left(d + \sqrt{a^2 + d^2}\right)} \right] + \frac{\mu_0}{\pi} N_2^2 \left[a \cdot ln \frac{2ad}{R_2\left(a + \sqrt{a^2 + d^2}\right)} - 2(d + a - \sqrt{d^2 + a^2}) \right] + \frac{\mu_0}{4\pi} N_2^2 (a + d) \quad (5)$$

Where R1 and R2 are the equivalent radius of the windings

$$R_1 = \sqrt{\frac{N_1 S_1}{\pi}} \; ; \; R_2 = \sqrt{\frac{N_2 S_2}{\pi}} \qquad (6)$$

And the mutual inductance coefficient M when the two coils have the same dimensions is given by

$$M = \frac{\mu_0}{\pi} N_1 N_2 \left[d\ln\left(\frac{d + (\sqrt{h^2+d^2})(\sqrt{h^2+a^2})}{d + h\sqrt{h^2+d^2+a^2}}\right) \right] + \frac{\mu_0}{\pi} N_1 N_2 \left[a\ln\left(\frac{a + (\sqrt{h^2+d^2})(\sqrt{h^2+a^2})}{a + h\sqrt{h^2+d^2+a^2}}\right) \right] + \frac{\mu_0}{\pi} N_1 N_2 \left[2(h - \sqrt{h^2+d^2} - \sqrt{h^2+a^2} + \sqrt{h^2+d^2+a^2}) \right] \qquad (7)$$

Considering a case where the primary track is longer than the secondary pick up, L >> a; the mutual inductance can be approximated by

$$M = \frac{\mu_0}{\pi} N_1 N_2 a \ln\left[\frac{\sqrt{h^2+d^2}}{h}\right] \qquad (8)$$

The resistive values of the windings can be calculated by

$$R_1 = \frac{1}{57} N_1 \frac{2(L+d)}{S_1}$$

$$R_2 = \frac{1}{57} N_2 \frac{2(a+d)}{S_2} \qquad (9)$$

Operational Frequency:

Working at secondary resonance frequency, the efficiency of the system is given by

$$\eta = \frac{R_L}{R_L + R_2} \frac{1}{1 + \frac{R_1(R_L + R_2)}{\omega_r M^2}} \qquad (10)$$

In order to achieve maximum efficiency

$$f_r >> \frac{\sqrt{R_1(R_L + R_2)}}{2\pi M} \qquad (11)$$

As can be seen in (12) the better the coupling between the two coils, the lower the design frequency.

Capacitors C 1 and C 2 must be selected at the secondary resonant frequency [26] in order to achieve maximum power transfer capability.

$$C_2 = \frac{1}{\omega_r L_2}$$

$$C_1 = \frac{1}{\omega_r L_1} \qquad (12)$$

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III. BLOCK DIAGRAM DESCRIPTION

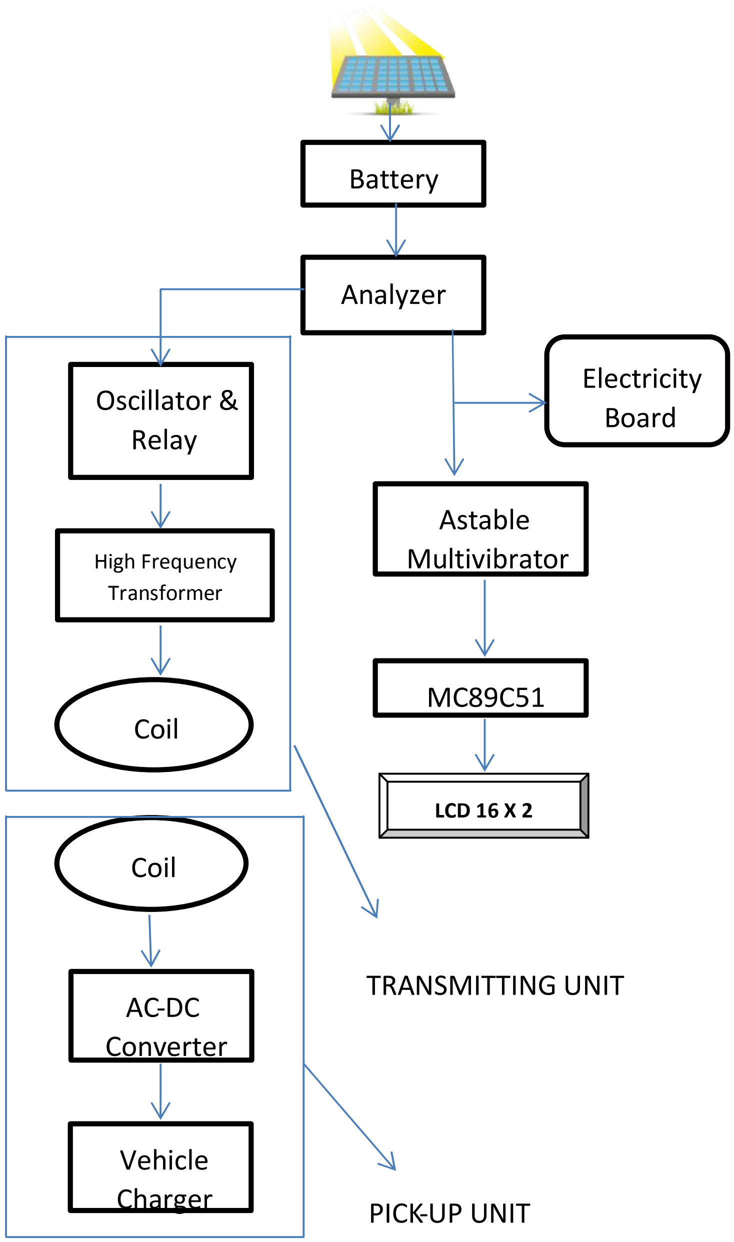

Figure3.1-Block diagram

3.1.WORKING OF THE PROJECT

The block diagram consists of two parts. First part is concerned with utilizing solar energy for home applications and giving the extra available energy back to the grid.

The Step-down transformer is used to step-down the 230V ac supply at primary to 12V peak to peak at secondary. The power supply unit converts the 12V ac at secondary to produce dual voltages

i.e +5V and + 12V. Operating voltage for opto coupler is 5V and it is 12V for Darlington pair

Solar panels are used to harness energy from sun and the energy is used to charge battery. In our experimental setup we use two batteries with different voltages i.e battery with voltage >7V is considered fully charged while battery with voltage <7v is considered as partially charged.

Comparator stage is used to decide whether to utilize the energy for home purpose or to give energy back to grid. Reference voltage of comparator is set to 7V and the other input to comparator is one of the two batteries. When partially charged battery is given as input to comparator, the upper opto-coupler & Darlington pair gets the control and relay is activated and the energy from solar is used for home. When fully charged battery is given as input to comparator, the lower opto-coupler & Darlington pair gets the control and relay is activated and the energy from solar is given back to grid. As we start to give energy back to grid, astableMultivibrator gets activated and generates square pulses as output. These pulses are used to determine the number of units we are giving back to grid and subsequently the total cost for the units transferred is noted. Microcontroller is programmed to count the no. of units being given back to grid and calculate the cost for it and a 16x2 LCD is used to display it.

The Second part deals with using the energy harnessed from solar to wirelessly charge a electric vehicle using the principle of "Inductive coupling". The electric vehicle wireless power supply technology mainly employs inductive coupling, magnetic resonance in the place of wires and connectors to transmit electric energy. Fig.3.1 shows the fundamental structure of solar based WEVC-ICPT system and transmitting extra power to electricity mains. Power convertor takes power from a conventional single-phase or three-phase power supply to generate a high frequency current in the primary energy emission unit (underground track or coil array), around which high frequency magnetic field is formed. In the pick-up unit, which is located in the high frequency magnetic field, high frequency current is induced and conditioned to produce stable supply to battery charging. At pick-up unit the ac voltage obtained by inductive coupling is given to rectifier stage to get DC voltage which is used for charging battery.

IV. PROGNOSIS

Over the course of project, a large number of domains were found that could be investigated particularly in relation to inductive power transfer and grid connected solar. Some of the problems that could be identified for future research are listed in the following paragraphs.

1. Dynamic Charging of EV

A dynamic charging system consists of a source coil embedded in the road, and a receiver system attached to the vehicle chassis. As a result of the vehicle movement, the receiver of a dynamic charging system moves laterally and longitudinally in a plane parallel to the source coil. The source coil designs can be categorized as single-coil designs, where the source coil is substantially larger than the receiver, or segmented coil designs where the source is made of multiple lumped coils that are com-measurable in size with the receiving coil [23][24].

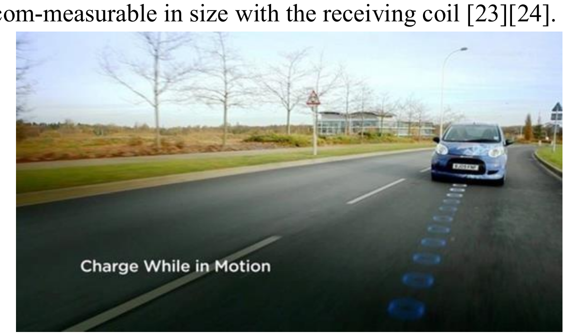

Figure 4.1- Charge while in motion

2. Segmented Coil Transmitter Design

The single-coil designs simplify system control, but they suffer from three key drawbacks. First, for high power applications, the elongated coil requires compensation capacitors to be distributed along the coil. Second, the field emitted in uncoupled sections of the coil needs to be contained. Third, the resulting coupling coefficient is fairly low, which results in low total efficiency [25].

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With a segmented transmitter coil design, the issues of field containment, large transmitter coil self-inductance and difficulties with coil impedance compensation can be addressed.

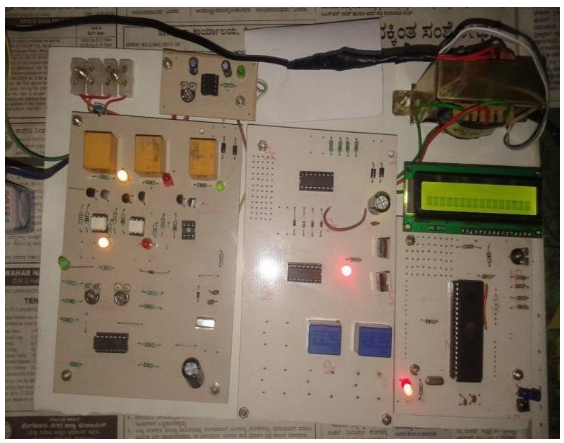
3. Charging Management

Development of a system in which electric vehicle is allowed to access dynamic charging system until it receive confirmation and permission message from the management system, at the same time, the battery type and charging power will be informed to it [23].

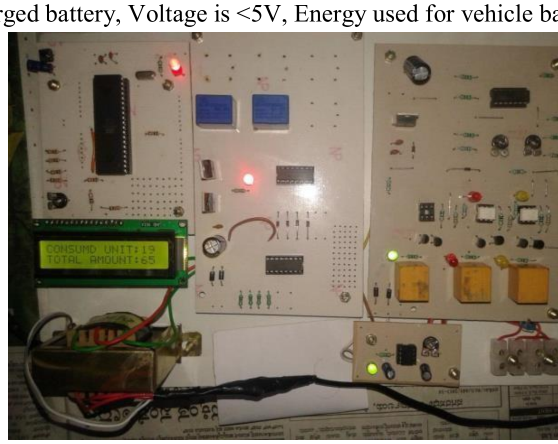
4. Contactless Power Bidirectional Push

In the system of electric vehicle and power grid, electric vehicle can not only be used as a load for getting energy from power grid, but also be used as a distributed energy-storing device, which can be charged at the off-peak period of power grid, and feeds back extra energy to power grid during peak demand period (V2G, Vehicle to Grid) [23].

V. EXPERIMENTAL RESULTS



Partially charged battery, Voltage is <5V, Energy used for vehicle battery charging



Connected Battery is Fully Charged (>5v), Energy will be Transferred to Electricity Board

Wireless Power Transfer Module

VI. CONCLUSION

WEVC system using solar power has several advantages over conventional power transfer. The limited fossil fuel availability throughout the world has allowed the electric vehicles to develop over the past decade and it will certainly be an important area of research.

In this project we have designed a model of Wireless Electric Vehicle Charging System based on ICPT for which we used solar energy as input source. We have designed the system in such a way that maximum utilization of solar power can be achieved by transmitting extra power to electricity board. This system proves that maximum efficiency can be achieved by transmitting power wirelessly.

There is also a clear economical benefit to wireless charging by using solar energy. It will encourage people to build their own solar power system which can be used for multiple purposes and by which they can earn money also. With wireless electric vehicle charging system the car owners need not take the effort to plug-in and charge the vehicle, instead they can simply park the car above the transmitting (embedded in road)unit of wireless charging system so that pickup unit can easily charge the battery of vehicle.

REFERENCES

[1]. Chan C. C., Alain Bouscayrol and Keyu Chen: Electric, Hybrid, and Fuel-Cell Vehicles:Architectures and Modeling, IEEE Transactions on Vehicular Technology, Vol. 59, No. 2, pp. 589-598, February 2010.

[2]. Chan C.C.: The state of the art of electric, hybrid, and fuel cell vehicles, Proceedings of the IEEE, 95(4), pp. 704 - 718, 2007.

[3]. Emadi A., Young Joo Lee, K Rajashekara: Power Electronics and Motor Drives in Electric, Hybrid Electric, and Plug-In Hybrid Electric Vehicles; IEEE Transactions on Industrial Electronics, Volume 55, Issue 6, pp. 2237-2245, June 2008.

[4]. Momoh O., Omoigui M.: An overview of hybrid electric vehicle technology", IEEE Vehicle Power and Propulsion Conference - VPPC '09, pp. 1286 – 1292, 2009.

[5]. Lixin Situ: Electric vehicle development: The past, present and future, 3rd International Conference on Power Electronics Systems and Applications – PESA 2009, pp. 1 - 3, 2009.

[6]. Wang C.-S., Stielau O., Covic G.: Design considerations for a contactless electric vehicle battery charger, IEEE Transactions on Industrial Electronics, Vol. 52, no. 5, pp. 1308 - 1314, 2005.

[7]. Keeling N.A., Boys J.T., Covic G.A.: A UnityPower-Factor IPT Pickup for High- Power Applications, IEEE Transactions on Industrial Electronics, 57(2), pp. 744 – 751 2010.

[8]. 2009 Annual World Solar PV Industry Report from MarketBuzz.

[9]. La JamaisContente. http://www.emobile.ch/pdf/2005/FactSheet_LaJamaisContente_FW.pdf

[10]. Ranjeet Singh1, Manoj Kumar Gaur2, Chandra Shekhar Malvi3, *A Study and Design Based Simulation of Hybrid Solar Car,* ISSN 2250-2459, ISO 9001:2008Certified Journal, Volume 3, Issue 1, January 2013

[11]. Swagat Chopra thesis, Contactless power transfer for electric vehicle charging applications, August 2011.

[12]. Chwei-SenWang, Stielau O.H., Covic G.A.: Design considerations for a contactless electric vehicle battery charger, IEEE Transactions on Industrial Electronics, 52(5), pp.1308 - 1314, 2005.

[13]. Pedder D.A.G., Brown A.D., Skinner J.A.: A contactless electrical energy transmission system, IEEE Transactions on Industrial Electronics, 46(1), pp. 23 - 30, 1999.

[14]. Chang-Gyun Kim, Dong-Hyun Seo, Jung-Sik You, Jong-Hu Park, Bo-Hyung Cho: Design of a contactless battery charger for cellular phone, Fifteenth Annual IEEE Applied Power Electronics Conference and Exposition- APEC 2000, Vol. 2, pp. 769 - 773, 2000.

[15]. Zhang Bingyi, Liu Hongbin, Zhao Yisong, Ying Yong, Feng Guihong: Contactless electrical energy transmission system using separable transformer, Proceedings of the Eighth International Conference on in Electrical Machines and Systems - ICEMS 2005, Vol. 3, pp. 1721 -1724, 2005.

[16]. Ayano H., Yamamoto K., Hino N., Yamato I.: Highly e-cient contactless electrical energy transmission system, IEEE 28th Annual Conference of the Industrial Electronics Society - IECON 02, Vol. 2, pp. 1364 - 1369, 2002.

[17]. Qingxin Yang, Jiangui Li, Haiyan Chen, Junhua Wang: Design and analysis of new detachable coreless transformer used for contact-less electrical energy transmission system, IEEE Vehicle Power and Propulsion Conference - VPPC '08, pp.1 - 4, 2008.

[18]. Arin Chakraverty, Design and Implementation of a Grid-Tie Inverter, M.S. Graduation Report, Case Western Reserve University, 2011

[19]. H.M. Abdar, *Student Member, IEEE*, A. Chakraverty, *Student Member*, IEEE, D.H. Moore, *Student Member, IEEE,* and J.M. Murray, *Student Member, IEEE,* K.A. Loparo, *Fellow, IEEE,* Design and Implementation a Specific Grid-Tie Inverter for an Agent-based Microgrid.

[20]. Juan Manuel Carrasco, et. al, '*Power-Electronic Systems for the Grid Integration of Renewable Energy Sources: A Survey*', IEEE Trans. On Industrial Electronics,Vol. 53, No. 4, 2006, pp. 1002- 1016.

[21]. Mervin Johns, Hanh-Phuc Le and Michael Seeman, Grid-Connected Solar Electronics, EE290N-3 – Contemporary Energy Issues, University of California at Berkeley.

[22]. J.L.Villa, A. Llombart, J.F.Sanz , J.Sallan, Development of an inductively coupled power transfer system (ICPT) for electric vehicles with a large airgap-2013

[23]. Yong Tian, Yue Sun, Yugang Su, Xin Dai, Zhihui Wang, Study on the Electric Vehicle Wireless Power Supply Technology and System Based on ICPT, *WorldElectric Vehicle Journal Vol. 4 - ISSN 2032-6653 - © 2010 WEVA*

[24]. Jaegue Shin, *Member, IEEE*, Seungyong Shin, *IEEE,* Design and Implementation of Shaped Magnetic-Resonance-Based Wireless Power Transfer System for Roadway- Powered Moving, Electric Vehicles, IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 61, NO. 3, MARCH 2014

[25]. P.Meyer, P. Germano, and Y. Perriard. Modeling of Inductive Contactless Energy Transfer Systems, THÈSE NO 5486 (2012) ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE PRÉSENTÉE le 25 septembre 2012

[26]. T. Bieler, M. Perrotter, V. Nguyen and Y. Perriard, "Contactless power and information transmission" Conf. Rec. IEEE-IAS Annual Meeting, vol. 1, pp. 83- 88, 2001.

[27]. MUHAMMAD H. RASHID, *POWER ELECTRONICS: CIRCUITS, DEVICES AND APPLICATIONS*, 3RD EDITION

[28]. Saber, A.Y. ; Electr. & the uter Eng. Dept. of Sci. & Technol., Rolla, MO, USA ; Venayagamoorthy, Efficient Utilization of Renewable Energy Sources byGridable Vehicles in Cyber-Physical Energy Systems G.K. Systems Journal,IEEE (Volume:4 , Issue: 3, sept 2010)

[29]. TarakSalmi, MounirBouzguenda, Adel Gastli, Ahmed Masmoudi, MATLAB/Simulink Based Modelling of Solar Photovoltaic Cell INTERNATIONAL JOURNAL of RENEWABLE ENERGY RESEARCH TarakSalmi et al., Vol.2, No.2, 2012

[30]. http://1bog.org/blog/charging-an-electric-carat-home-how-many-more-solarpanels- do-i-need/

[31]. Sedghisigarchi, K. ; Electr. &Comput. Eng. Dept., West Virginia Univ. Inst. of Technol., Montgomery, WV, USA, Residential solar systems: Technology, netmetering, and financial payback.