IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

IJARSCT

Impact Factor: 6.252

Volume 2, Issue 8, May 2022

Wireless Charging System

Ajay Dhamale[1], Anand Hajare[2], Nitin Chormule[3], Sandesh Gore[4]

Department of Mechanical Engineering

ISBM College of Engineering, Pune, Maharashtra, India[1,2,3,4]

Abstract: *In order to reduce pressure on fossil fuel and reduce environmental pollution, the use of electric vehicles (EV) is rapidly increasing, instead of combustion engine vehicles. The main concern issue of the EV customers is being addressed through various charging methods. The key difficulty in implementation of EV is arrangement of charging infrastructure. The wireless charging system (WCS) is a favourite option in the growing EV market. In this paper, a WCS for charging electric vehicles is developed via inductively coupled power transfer technology. The performance of the system is verified by the simulation results. Plug-in electric vehicles (PEVs) are growing in popularity in developed countries in an attempt to overcome the problems of pollution, depleting natural oil and fossil fuel reserves and rising petrol costs. In addition, automotive industries are facing increasing community pressure and governmental regulations to reduce emissions and adopt cleaner, more sustainable technologies such as PEVs. However, accepting this new technology depends primarily on the economic aspects for individuals and the development of adequate PEV technologies. The reliability and dependability of the new vehicles (PEVs) are considered the main public concerns due to range anxiety. The limited driving range of PEVs makes public charging a requirement for long-distance trips, and therefore, the availability of convenient and fast charging infrastructure is a crucial factor in bolstering the adoption of PEVs. The goal of the work presented in this thesis was to address the challenges associated with implementing electric vehicle fast charging stations (FCSs) in distribution system.*

Keywords: Electric Vehicle, Battery, MATLAB, Simulation, Charger, Wireless, etc.

I. INTRODUCTION

The transition towards electric mobility offers India not only an occasion to ameliorate effectiveness and transfigure the transport sector but also addresses several issues that the country is presently scuffling with. The enterprises regarding energy security and rising current account deficiency (CAD) on account of rising reactionary energy significances can be addressed with the uptake of electric mobility. India is a power fat country and is presently witnessing lower factory cargo factors due to lower capacity application. As per the conservative estimates, demand from electric vehicles (EV) could greatly ameliorate the application factor of underutilized power shops, as charging pattern of EV druggies is considered to coincide with power demand during thenon-peak hours in the country. Also, India has a clear intention of multiplying its generation from renewable energy (Shaft) sources which are innately intermittent.

Several reports suggest that EVs can round the intermittent nature of power generated from Shaft by absorbing power at out- peak hours. The batteries in EVs can act as ancillary services for the proliferation of distributed generation coffers (DER). Piecemeal from supporting Shaft generation, EVs with doable vehicle to grid technology can act as a dynamic storehouse media and can enhance the grid adaptability through ancillary request. This can reduce the burden of bankroll to produce static energy storehouse systems, especially in distribution networks, to support proliferation of grid connected roof top solar and DERs. The new ecosystem offers India the openings to come a leader in domestic manufacturing and job creation as electric mobility is still in incipient stages in numerous advanced requests around the globe.

DOI: 10.48175/IJARSCT-4508

Further, transition to electric mobility can really help India achieve its global commitments of reducing carbon footmark and hothouse gas (GHG) emigrations. Still, to accelerate the relinquishment of electric mobility in India, a lot of medication needs to be done so that the request grows in a tone-sustainable manner with minimum civil support and interventions.

The study undertaken by BEE involved a consortium of consultants led by Ernst & Young LLP to conduct a study encompassing the technical and commercial aspects of sustainable operations of EV charging infrastructure by taking a cue from business models that are prevalent globally, technological interventions as well as technical and testing standards. It also includes assessments on the degree of federal support required and the role distribution utilities play in facilitating the growth in advanced markets such as United States (the US), Germany, Finland, China and Japan. The study further dives into development and assessment of commercial viability of business models for EV charging infrastructure. Moreover, assessment of readiness of the industry was undertaken by conducting a consultation with several stakeholders to identify the challenges and barriers in embracing the transition to the era of electric mobility. An analysis on the impact of transition to electric mobility on distribution infrastructure of Delhi, Lucknow and Nagpur was assessed using statistical models followed by a development of a city-agnostic implementation model.

An IPT system is inherently less efficient in terms of power transfer efficiency if compared to a conventional wire-based system. Indeed, due the magnetic coupling between the coils, there is an unavoidable minimum leakage magnetic field, leading to an energy loss. Furthermore, some technical aspects need to be taken into account in the practical implementation of an IPT system: for example, in order to obtain the maximum coupling, the misalignment between the coils must be as small as possible. As far as safety is concerned, even if the IPT allows to reduce the electrocution risk, some care is required regarding the magnetic field exposure. In addition to design-related issues, other important considerations should be made, such as costs, infrastructural implications, standardization and customer reception.

The different present exploration workshop haven't studied the case of the two- receiver system rightly nor delved its energetic yield. For illustration, some questions should be answered, similar as if a two- receiver system is developed, is it possible to have a binary energy model? Is it possible to extend the battery life cycle? and is it possible to extend the vehicle's autonomy? These questions haven't yet been answered rightly, and indeed the results presented weren't justified in the literature. This is why this paper has been drafted. This paper deals with the possibility of using two receiver coils and compares this approach to the traditional approach, grounded on only one receiver coil. This study is grounded on a new fine representation of the wireless power transmission system. In the new proposed model, the effectiveness of the recharge tool was delved given all the parameters mentioned before, where resistance, inductance, pitch angle, coil confines, the distance between the coils, and the receiver coil relegation speed were delved. This new model helps to find the necessary information on the right number of wireless coils to completely charge the vehicle if it's on a rechargeable road.

II. PROBLEM STATEMENT

IPT is seen as a key enabling technology to increase the adoption of electric vehicles. Through different applications of IPT there is great potential to displace petroleum currently used in transportation. So, to eliminate dependency on petroleum products an alternative way needs to be proposed.

Wired Charging Station

Different types of EVSE provide different speeds of charging. Level 1 charging stations use a 120 volt (V), alternating-current (AC) plug and require a dedicated circuit, offering about 5 miles of range for every hour of charging. Level 2 stations charge through a 240V, AC plug and require home charging or public charging equipment to be installed. Level 2 stations provide 10 to 20 miles of range for every hour of charging. Level 2 chargers are the most common and charge at approximately the same rate as a home system.

IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

Impact Factor: 6.252

Volume 2, Issue 8, May 2022

Figure 1: Wired EV Charging

Applications of Wireless Charging System

The wireless solution represents an ever-growing method of battery charging in several applications. The lack of wires is desirable whenever the power cable is inconvenient or even impossible to use. Wireless battery charging can be employed in different applications, ranging from the ultra-low power levels of the wireless sensors to the ultra-high-power levels of the Railway Applications and passing through the following examples: electrical toothbrush, mobile phone, laptop, television, electric bicycle, electric car, and electric bus.

The wireless battery charging for low-power devices ranges from ultra-low power applications, such as wireless sensors or implantable devices, to consumer electronic devices, such as smartphones or notebooks. The ultra-low power devices range from µW to mW power levels, whereas the power levels of the consumer electronic devices range from some W (e.g., mobile phones) to tens of W (e.g., laptops).

1. **Consumer Electronic Devices and Household Appliances**

   The following range of power levels is represented by the electronic consumer devices, such as mobile phones and notebooks. For these applications, the power level ranges from some W to tens of W. The wireless battery charging for mobile phones is fully commercialized and standardized [19]. This wireless charging is based on the Inductive Power Transfer (IPT) between two coupled coils: one of them is placed inside a pad and connected to the electrical grid, the other one is placed inside the device and connected to the electric battery. By positioning the mobile device upon the pad, the charging operation automatically starts through magnetic induction. A standard has been created by Wireless Power Consortium (WPC) to build a common platform that helps the compatibility between wireless charging stations and mobile devices. More than 200 companies have joined WPC [10]. One of the most attractive benefits brought by wireless battery charging for consumer electronics is the opportunity to simultaneously charge different devices on the same pad.

Figure 2: Multiple Wireless Charging Pad

2. Wireless charging for Electric Cars

If compared to the consumer electronic devices, the electric vehicles (EV) charging occurs at notably higher power levels, ranging from a few hundreds of W (as in the case of the E-car) to several tens of kW (as in the case of the electric buses). The Wireless Electric Vehicle Charging (WEVC) is still far from a full commercialization and standardization. Nevertheless, being implemented through Inductive Power Transfer (IPT) between two coupled coils, it provides benefits in terms of safety and comfort to all the users.

The EVs can be recharged or supplied by IPT exploiting mainly three alternative options [05]: static wireless charging, quasi-dynamic or dynamic wireless charging. The static IPT consists of the EV charging whenever the vehicle is stationary and nobody stays inside it, e.g. in the case of a parked car. In the quasi-dynamic IPT, the recharge occurs when the electric vehicle is stationary but someone is inside it, e.g. in the case of a cab at the traffic light intersections or a bus at the stop. The dynamic IPT consists in supplying the vehicle during its motion, e.g. in the case of a car running on a highway or of a moving train.

Figure 3: EV Charging Station

EVs, Connectors and Charging Power Levels

A selection of available EVs and their charging powers are provided in Table 1.1, sorted by charging power3 . A few important facts are clear from the table: All EVs have an onboard charger, meaning they can charge from a regular AC outlet. Most EVs have a relatively low charge level of around 3.3kW or 6.6kW, and at these rates, single-phase charging is always used. Many vehicles rely on an off-board charging mechanism to support higher charge levels, especially those that have a low AC charge level. This is often offered by DC charging or in the case of the Fluence ZE, battery swap4. However, it is also evident that some manufacturers use faster AC chargers, including Tesla, BMW, Volvo and Renault.

Tesla uses three-phase chargers in Europe. They use single-phase chargers rated for 20kW in US, since three-phase service is not typically found in residential locations in the US. The BMW Mini-E was developed with a powertrain from the American supplier AC Propulsion, who also uses a single-phase onboard charger rated for 19kW (240V/80A). Volvo uses powertrains from the Swiss manufacturer Brusa, who develops three-phase onboard chargers rated for 22kW (3x32A at 230V). Renault has developed their own high power onboard charger known as Chameleon. referring to the fact that it charges at many power levels ranging from 3kW to 43kW (3x63A at 230V).

Table 1: Some EVs, their range and charge options

	AC charger (Phases/kW)	Energy storage (kWh)	Approximate range (km)	Off-board charge option
Renault Zoe	3/43	22	210 (NEDC)	No
Volvo C30 Electric	3/22	24	150 (NEDC)	No
Tesla Model S	1|3/22	85	480 (Tesla)	Yes (Tesla)
BMW Mini-E	1/19	35	160 (BMW)	No
Nissan Leaf 2013	1/6.6	24	135 (EPA)	Yes (CHAdeMO)
Ford Focus Electric	1/6.6	23	122 (EPA)	No
Think City 2011	1/3.6	24	160 (Think)	No
Renault Fluence ZE	1/3.6	22	185 (NEDC)	Yes (Bat Swap)
Chevy Spark EV	1/3.3	21	132 (EPA)	Yes (Combo)
Mitsubishi i-MiEV	1/3.3	16	100 (EPA)	Yes (CHAdeMO)
Chevy Volt (hybrid)	1/3.3	16	60 (EPA)	No

IPT System Design

typical schematic of an Inductive Power Transfer system is shown. The DC-DC stage is highlighted in following figure. For battery charging applications, the electrical power flows from the DC-link to the battery.

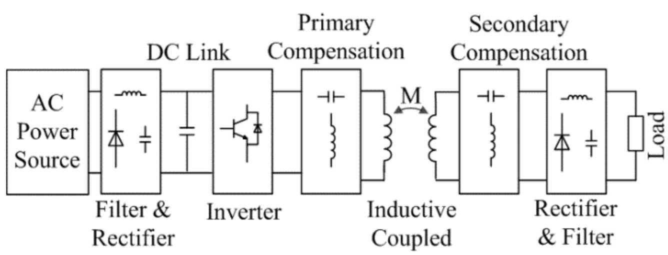

Figure 4: Functional Model of Proposed System

The inductive power transfer occurs between two magnetically coupled coils. Their self-inductances are L1 and L2; the mutual inductance is M. L1 and L2 correspond respectively to the primary and the secondary coil. The primary-side DC voltage source is connected to the electrical grid; the secondary-side DC section is the load representing the battery to be charged. Since the power transfer between the coupled coils is in AC, two intermediate stages are needed: a DC-AC in the primary side and an AC-DC in the secondary side. Since the coils are loosely coupled, a reactive network is needed in order to maximize the power transfer efficiency and to optimize the power factor, if the system works at the resonance. This reactive network is named compensation circuit and includes two capacitors, one for each side. In the example of the figure, both the compensation capacitors C1 and C2 are connected in series with the primary and the secondary coils. Following are the main parts of the IPT system.

Coil Simulation

Different structures of inductive coupling are investigated in terms of system efficiency and tolerance to misalignments. The goal is to find the best solution in compliance with an E-bike wireless battery charging system. The investigated solutions consist of two flat winding coils; each of them features a copper wire, with a 3 mm diameter section. The pitch between two consecutive turns is 3.5 mm. The proposed structures imply two identical coils, thus minimizing the total leakage flux and well-fitting the case of a bi-directional power transfer. No ferromagnetic material is used in order to lighten the weight of the structure, taking into account the E-bike application.

As for the previously proposed structure, one coil is supposed to be placed upon a wheel of the bicycle; the other one is supposed to be placed on the support holding up this wheel during the parking time. The equivalent electric model concerning each investigated option is gained after several magnetic field simulations. The software COMSOL Multiphysics has been used as modeling and simulation tool working in a 3D geometry [30]. Different distances and misalignments between the primary and the secondary coil have been taken into account to obtain thorough models in terms of self-inductances and mutual inductance. The first option to be considered consists of two circular coils. This solution is applied on the actually assembled prototype of E-bike wireless charger. Each coil consists of a flat helix winding, featuring 9 turns and a 15 cm outer diameter.

As for the next considered options, the coils lie on the x-y plane, whereas the distance between them belongs to the z axis. The other investigated solutions are based on the DD shape [98]: each coil is made of two square parts, the so-called “D”, which are connected in series. The result is that there is a continuous magnetic flux loop inside the structure including the two DD coils. This should create a structure inherently tolerant to misalignments between the two coils. The longest dimension is kept under 30 cm in order to well fit the size of a bicycle wheel. Fig. II.7 shows the 3D model of the DD option. The whole winding coil consists of two “D-shaped” parts.

Each “D” is a flat square winding made of 9 turns. In compliance with the size of a bicycle wheel, for the proposed option three different sizes are tested. Keeping the shape and the proportions of the whole structure for each coil, the length of the shortest side belonging to the smallest square (labeled “s” in the figure) is modified according to the following three values: 4 cm, 5 cm, 6 cm. The corresponding values of the longest size, that is the side along the y axis, are the following ones: 21 cm, 23 cm, 25 cm. For each proposed option, the magnetic field simulations are carried out considering different distances and misalignments between the two coils. The air gap between the coil’s ranges from 1 cm to 3 cm on the z axis, whereas the misalignment on the x-y plane ranges from 0 to 2 cm for each of the two axes.

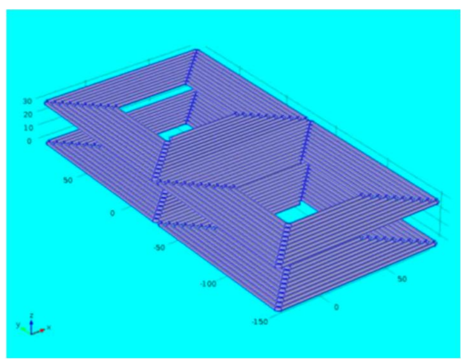

Figure 5: 3D Simulation of Coils

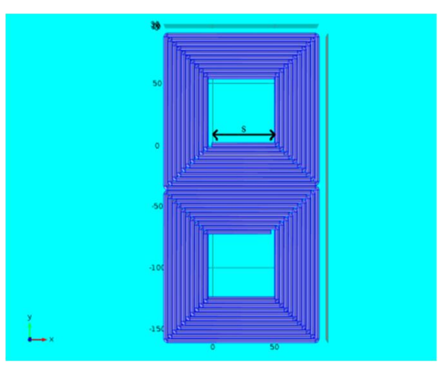

Figure 6: X-Y plane of Coils

III. MATLAB MODEL AND SIMULATION RESULTS

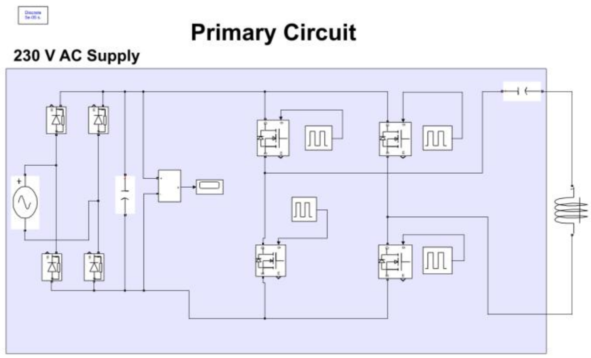

Figure 7: MATLAB Model of Wireless Charger

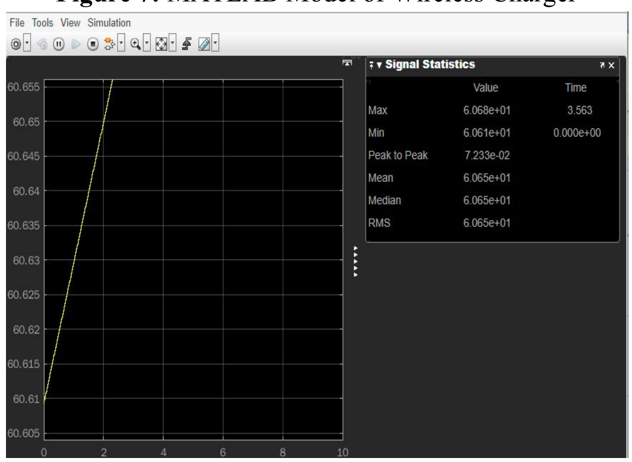

Figure 8: SOC Simulation Results

Since the determination of the SOC of a battery is a complex task depending on the battery type and on the application in which the battery is used, much development and research work has been done in recent years to improve SOC estimation accuracy. Accurate SOC estimation is one of the main tasks of battery management systems, which will help improve the system performance and reliability, and will also lengthen the lifetime of the battery. In fact, precise SOC estimation of the battery can avoid unpredicted system interruption and prevent the batteries from being over charged and over discharged, which may cause permanent damage to the internal structure of batteries. However, since battery discharge and charge involve complex chemical and physical processes, it is not obvious to estimate the SOC accurately under various operation conditions.

The general approach for measuring SOC is to measure very accurately both the coulombs and current flowing in and out of the cell stack under all operating conditions, and the individual cell voltages of each cell in the stack. This data is then employed with previously loaded cell pack data for the exact cells being monitored to develop an accurate SOC estimate. The additional data required for such a calculation includes the cell temperature, whether the cell is charging or discharging when the measurements were made, the cell age, and other relevant cell data obtained from the cell manufacturer. Sometimes it is possible to get characterization data from the manufacturer of how their Li-ion cells perform under various operating conditions.

Once an SOC has been determined, it is up to the system to keep the SOC updated during subsequent operation, essentially counting the coulombs that flow in and out of the cells. The accuracy of this approach can be derailed by not knowing the initial SOC to an accurate enough state and by other factors, such as self discharge of the cells and leakage effects.

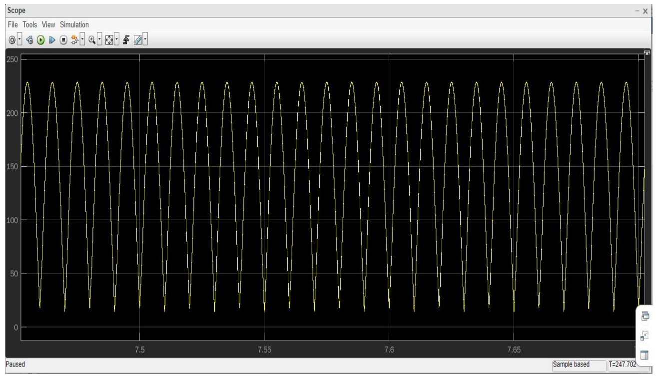

Figure 9: Output Voltage of Primary Circuit

IV. CONCLUSION

This paper presents a basic representation of the IPT Technique for stationary applications with current researched technology. In addition, a variety of core and ferrite shapes of coils have been demonstrated, which have been utilized in current wireless charging pad design. Health and safety issues have been raised and current developments in international standards are tabled for IPT. State-of-the-art stationary- and dynamic-PITS have been studied and tabled, with current research and development from a variety of public and private organizations. Finally, upcoming future technologies are investigated and simulated with the utilization of MATLAB Overall, the latest developments in the area of IPT are included in this project. The successful simulation results shows that the IPT system is capable of charging the EV batteries wirelessly. The objective of the project can be fulfilled using this technique.

REFERENCES

[1] T. Fujita, T. Yasuda, and H. Akagi, “A dynamic wireless power transfer system applicable to a stationary system,” IEEE Trans. Ind. App., vol. 53, no. 4, pp. 3748-3757, Aug. 2017.

[2] T. Kan, T. D. Nguyen, and J. C. White, R. K. Malhan, and C. Mi, “A new integrated method for an electric vehicle wireless charging system using LCC compensation topology: analysis and design,” IEEE Trans. Power Electron., vol. 32, no. 2, pp. 1638-1650, Feb. 2017.

[3] S. Wang, J. Chen, Z. Hu, and M. Lui, “Study on series-parallel mixed resonance model of wireless transfer via magnetic resonance coupling,” in Progress in Electromagnetic Research Symposium (PIERS), pp. 2941-2945, Aug. 2016.

[4] M. R. Amin, and R. B. Roy, “Design and simulation of wireless stationary charging for hybrid electric vehicle using inductive power pad in parking garage,” in 8th International Conference on Software, Knowledge, Information Management and Applications (SKIMA), Dec. 2014.

[5] O. Knecht, and J. W. Kolar, “Comperative evaluation of IPT resonant circuit topologies for wireless power supplies of implantable mechanical circulatory support systems,” in Applied Power Electronics Conference and Exposition (APEC), pp. 3271-3278, Mar. 2017.

[6] F. Zhao, G. Wei, C. Zhu, and K. Song, “Design and optimization of asymmetric solenoid type magnetic coupler in wireless charging system for electric vehicles,” in IEEE PELS Workshop on Emerging Technologies: Wireless Power Transfer (WoW), pp. 157-162, Apr. 2017.

[7] S. D. Barman, A. W. Reza, N. Kumar, M. E. Karim, and A. B. Munir, “Wireless powering by magnetic resonant coupling: recent trends in wireless power transfer system and its applications,” Renew. Sustain. Energy Reviews, vol. 51, pp. 1525-1552, Nov. 2015.

[8] Y. P. Su, X. Liu, and S. Y. R. Hui, “Mutual inductance calculation of movable planar coil on parallel surfaces,” IEEE Trans. Power Electron., vol. 24, no. 4, pp. 1115-1124, April, 2009.

[9] International Commission on Non-Ionizing Radiation Protection, 'Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz–100 kHz),' Health Phys., vol. 99, no. 6, pp. 818–836, 2010.
[10] C.-Y. Huang, J. T. Boys, G. A. Covic, and M. Budhia, "Practical considerations for designing IPT system for EV battery charging," in Vehicle Power and Propulsion Conference, 2009. VPPC '09. IEEE, 2009, pp. 402–407.
[11] Pellitteri, V. Boscaino, A. O. Di Tommaso, F. Genduso, and R. Miceli, "Ebike battery charging: Methods and circuits," in Clean Electrical Power (ICCEP), 2013 International Conference on, 2013, pp. 107–114.
[12] F. Pellitteri, V. Boscaino, A. O. Di Tommaso, R. Miceli, and G. Capponi, "Inductive Power Transfer for 100W battery charging," in Industrial Electronics Society, IECON 2013 - 39th Annual Conference of the IEEE, 2013, pp. 894–899.
[13] F. Pellitteri, V. Boscaino, A. O. Di Tommaso, R. Miceli, and G. Capponi, "Wireless battery charging: E-bike application," in Renewable Energy Research and Applications (ICRERA), 2013 International Conference on, 2013, pp. 247–251.
[14] X. Liu and S. Y. Hui, "Optimal Design of a Hybrid Winding Structure for Planar Contactless Battery Charging Platform," in Industry Applications Conference, 2006. 41st IAS Annual Meeting. Conference Record of the 2006 IEEE, 2006, vol. 5, pp. 2568–2575.
[15] F. Pellitteri, V. Boscaino, A. O. Di Tommaso, R. Miceli, and G. Capponi, "Experimental test on a Contactless Power Transfer system," in Ecological Vehicles and Renewable Energies (EVER), 2014 Ninth International Conference on, 2014, pp. 1–6.
[16] Software 'MATLAB Simulink'– Release 2012a, 2012, by MathWorks
[17] Fairchild Semiconductor. 'FAN7390 Datasheet', https://www.fairchildsemi.com/datasheets/FA/FAN7390.pdf

DOI: 10.48175/IJARSCT-4508