Simulation Model of Wireless Charging System For Electric Vehicle

Prof. Madhavi H. Nerkar[1] Mr. Sudarshan S. Jadhav[2], Mr. Shubham P. Suradkar[3], Mr.Balu J. Misal[4]

[1]Professor, Dept of Electrical Engineering

[2, 3, 4]Dept of Electrical Engineering

[1, 2, 3, 4]Dr. Vitthalrao Vikhe Patil Collage of Engineering, Ahmednagar, Maharashtra, India

Abstract- *Now a days, there is crises of air pollution arises around the world, contribution by automobile sector in pollution is considerable and the shortage of gasoline fuel will be arise in next few years because depletion of it with very fast rate. To reduce the pollution in some extent the automobile sector turn towards the use of electric vehicle as better option to conventional vehicle, which uses the electrical energy to drive the vehicle, which is one option to create pollution free environment and to minimize scarcity of petroleum products. Now the charging station is the main problem for Electric vehicle, especially it will create big problem in our India which is under the category of developing country .In this paper we are discussing about charging station of Electric vehicle and which is wireless battery charger .Here we are using new QDQ (Quad D quadrature)-QDQ coil design which increase the efficiency of power transfer at reasonable misalignment. This QDQ-QDQ structure use 2 sets of - 4 adjustment Q coils present inside 1 D coil. The coil design was made using JMEG FEM software to calculate inductive parameter and overall performance calculation was checked using MATLAB.*

Keywords- EV (Electric vehicle), QDQ (Quad D Quadrature),Wireless charging.

I. INTRODUCTION

Due to increasing greenhouse gas radiation, and scarcity of petroleum products for upcoming years makes vehicle manufactures to find out alternative solution like Electric vehicle, hydrogen car etc. The electric vehicle become famous from 21st century from 2010 to 2016 around 1 million electric vehicles including (cars, vans and trucks) was utilized by consumers. India will also going to be part in upcoming years. In this paper the power levels of battery charging and the infrastructure required for EVs are described[1].But charging station become major problem now a day especially for India which is under the category of developing country. So in this paper we are focusing mainly on charging station for electric vehicle it will be very much help full for India which is under the category of developing country.

As of now, three types of Charging Station are available for this Electric vehicle

TYPE 1: EV charging station –120v AC Plug
TYPE 2: charging Station -240v /280v AC Plug
TYPE 3: DC Fast charger

By considering the worry of electric car owners to find out suitable charging point, High cost and space consideration make us to move Type 4: wireless battery charger. This paper Discuss about wireless charging station for electric vehicle.

We are now in situation to rectify drawbacks that found in wireless battery charger. Even though many advantages present in this wireless battery charger there are some Disadvantages will also present

1) Charging time
2) Efficiency in performance
3) Misalignment between sender and receiver

In this paper we are using QDQ – QDQ coil structure with series-series compensation. As compare to many other Basic topologies of compensation methods like primary series-secondary series (SS), parallel-series (PS), primary series-secondary parallel (SP), parallel-parallel (PP) .The series-series compensation methods has proven to have higher efficiency so in this paper we are using LC (primary) – LC (secondary) for achieving higher efficiency. We have introduced new model of coil design QDQ – QDQ structure for reaching high Misalignment tolerance.

In wireless battery charge there is the chance of misalignment between charging coil (primary) and Pick -up coil (secondary). Due to misalignment in power transmission, the coupling coefficient produce between coils and design will reduce. So here we are in the situation to develop a coil design to withstand misalignment between both coils (Primary and secondary). Most of our current wireless charger are design as in circular, Oval and rectangular. From circular coil design we can achieve efficiency but it does not consider about misalignment .when misalignment acquire the output power get reduce. Then oval shape coil design was introduced but it is not helpful to transfer High power. Later DD pad design (2 rectangular coil joins together) was introduced. Its size is much larger than circular pad. But this pad design has good misalignment tolerance in X-Direction but poor in Y-Direction. So, we can't use this method for all direction alignment tolerance issue. In this paper we introduce new form of coil design QDQ (quad D quadrature)-QDQ (quad D quadrature) to perform misalignment tolerance in both X and Y direction.

The overall block diagram and circuit diagram for wireless battery charging station is shown in fig 1 and 2.

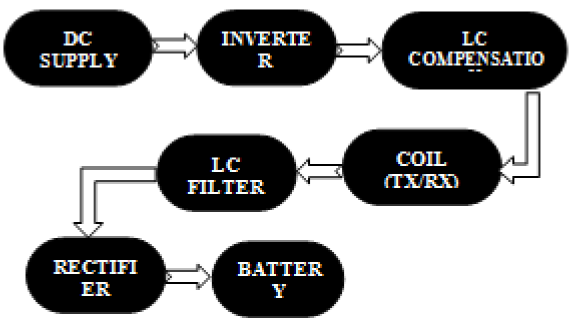

Fig.1 Block diagrams of wireless battery charger

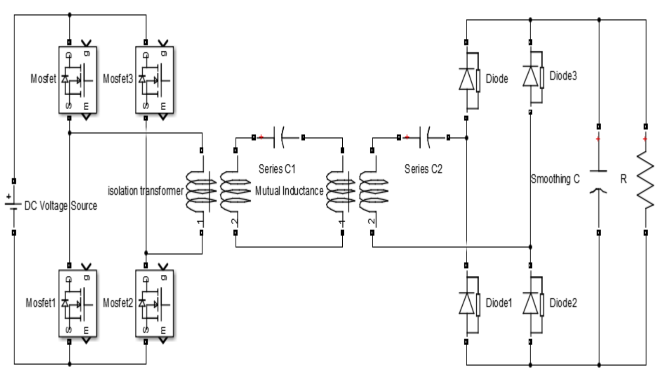

Fig 2. Circuit diagram of wireless battery Charger

The DC is converter into AC by using High Frequency (HF) inverter. The HF inverter Convert DC to High frequency AC whose frequency range is in KHz. High frequency transformer is used in order to transmit constant power across the wireless pads. The air gap between primary and secondary coil is 150mm. Here we are using LC compensation on SS (series-series) Topology which give higher efficiency as compare to other compensation method. Were Lf1, Cf1, are the compensation devices at primary side and Lf2, CF2 are the compensation devices at secondary side. AC output that fed from secondary coil is converted into DC by using rectifier. The DC output is used to store in battery.

II. PROPOSED COIL DESIGN

The New coil design is shown in fig 3. As shown in fig each coil has 2 square shaped coils joined together and 8 adjoining circular coil are surrounded by square coil which split in two half (4 for 1 side and remaining 4 for another square shaped coil) Both the coils, primary and secondary have same design & diameter. The energy transfer concerning the primary and secondary coils changes with respect to shape and position of the coil .The FEA tool is employed to design verification of the planned structure.

Thirdly, in order to discover out the influence of compensated coils with respect to position. An analysis software is employed to model the structure proposed. The circular coil diameter in 10cm and square coil diameter in 30 cm. The simulation results are shown fig.5, 6, and 7.

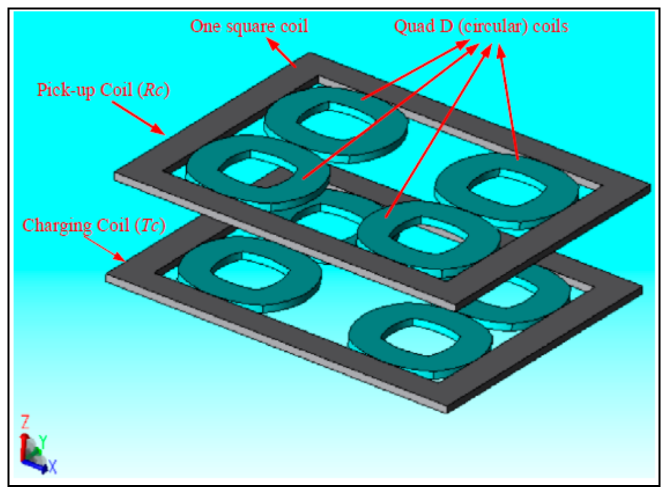

Fig.3 QDQ coil design

III. EQUIVALENT CIRCUIT FOR CALCULATIONS

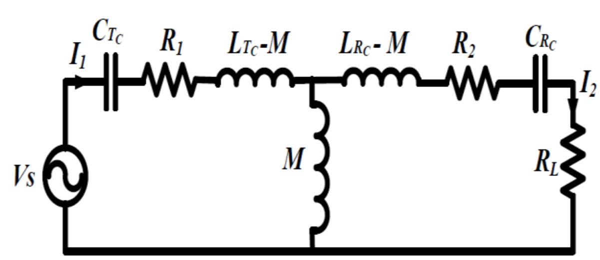

Fig.4 Circuit diagram of WPT system

$$n = \frac{P_{out}}{P_{in}}$$

Where,

The extent of coupling between charging coil & pick-up side coils is defined by coupling coefficient (K), is given by:

$$k = \frac{M}{\sqrt{L_{tc} + L_{rc}}}$$

The total impedance of the circuit for set parameters can be calculated as,

$$Z_{ss} = \left(R_1 + j\left(L_{tc\omega} - \frac{1}{C_{tc\omega}}\right)\right) + \left(\frac{\omega^2 M^2}{\left(R_2 + j\left(L_{tc\omega} - \frac{1}{C_{tc\omega}}\right)\right) + R_L}\right)$$

The amount of current used from the supply is given by:

$$I_1 = \frac{V_s}{Z_{ss}}$$

$$I_1 = \frac{V_s}{\left(R_1 + j\left(L_{tc\omega} - \frac{1}{C_{tc\omega}}\right)\right) + \left(\frac{\omega^2 M^2}{\left(R_2 + j\left(L_{tc\omega} - \frac{1}{C_{tc\omega}}\right)\right) + R_L}\right)}$$

The power input can be obtained as:

$$P_{in} = \frac{V_s^2}{\left(R_1 + \left(\frac{(2\pi f)^2 M^2}{R_2 + R_L}\right)\right)}$$

Likewise, the power output can be obtained as below:

$$P_{out} = \frac{V_s^2 (2\pi f)^2 M^2 R_L}{(R_1 R_2 + R_1 R_L + ((2\pi f)^2 M^2))^2}$$

IV. THE SIMULATION RESULTS

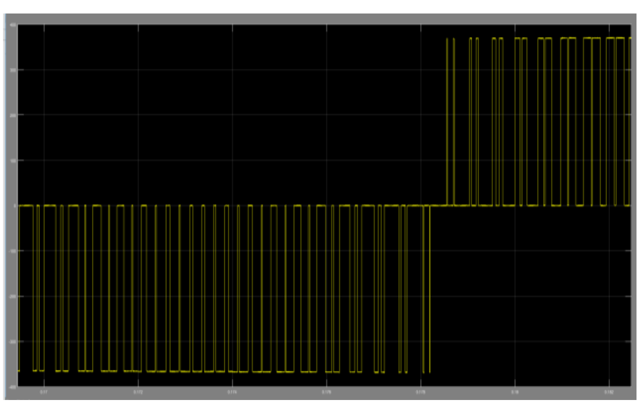

Fig.5 Inverter output

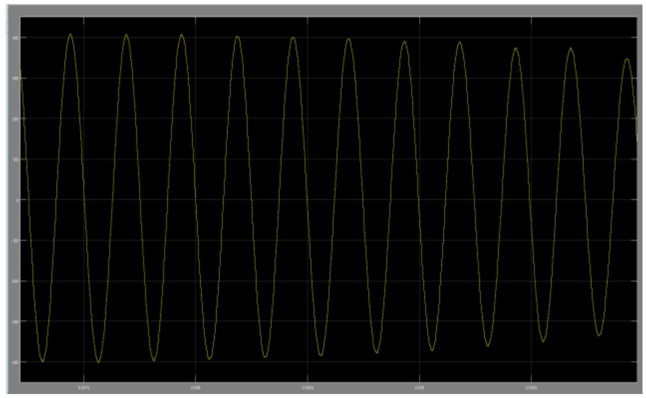

Fig.6 Recoil output

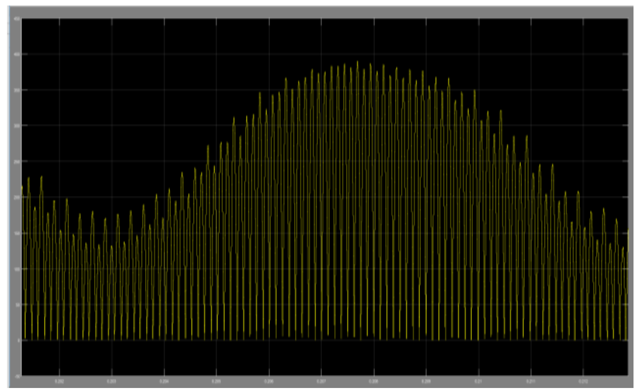

Fig.7 Rectifier output

V. CONCLUSION

This paper has dealt with Wireless Charging Systems for Electric Vehicle battery charging. An Inductive Power Transfer (IPT) system for an electrical vehicle charging has been designed and simulated. After the magnetic design of the IPT coils, the electric model of the coupling structure has been gained and acquired from a MATLAB simulation tool, in order to complete the design of the whole system. A series-series (SS) compensation topology has been chosen for the capacitive network that has been connected to the coupled coils. From the expected results of overall system efficiency will be 90%.

REFERENCES

[1] A Aswin and S Senthilmurugan “A survey on power levels of battery charging and infrastructure for plug-in electric and hybrid vehicles” 2018 IOP Conf. Ser.: Mater. Sci. Eng.402 012154.

[2] Junjun Deng, Member, IEEE,Weihan Li, Student Member, IEEE, Trong-Duy Nguyen, Siqi Li, Member, IEEE, and Chris Mi, Fellow, “Compact and Efficient Bipolar Coupler for Wireless Power Chargers: Design and Analysis” IEEE Trans. Power Electron., vol.30, no.11, Nov. 2015.

[3] S. Y. Choi, J. Huh, W. Y. Lee, and C. T. Rim, "Asymmetric coil sets for wireless stationary EV chargers with large lateral tolerance by dominant field analysis," IEEE Trans. Power Electron., vol. 29, no. 12, pp. 6406-6420, Dec. 2014.

[4] Budhia, M.; Covic, G.A.; Boys, J.T. Design and optimization of circular magnetic structures for lumped inductive power transfer systems. IEEE Trans. Power Electron. 2011, 26, 3096–3108.

[5] Kafeel Ahmed Kalwar, Saad Mekhilef, Mehdi Seyedmahmoudian and Ben Horan “Coil Design for High Misalignment Tolerant Inductive Power Transfer System for EV Charging” Energies 2016, 9, 937; doi:10.3390/en9110937

[6] Hunter H. Wu*, Member, IEEE, Aaron Gilchrist, Kylee D. Sealy, Member, IEEE, and Daniel Bronson “A High Efficiency 5 kW Inductive Charger for EVs Using Dual Side Control” IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS, VOL. 8, NO. 3, AUGUST 2012