Static and Dynamic Simulink model of Wireless Power Transfer methods for EV Applications

Lanka Komal Sai Manohar, Kotapati Subhash Reddy, Sk.Moulali, G.Swapna, K.V.Siva Reddy

Abstract*: Present day's remote power Transfer Systems are utilized mainly to move the limited quantity of power inside short ranges. In latest applications it is for the most part used to charge Smart Phones, Electric Toothbrushes Scanning RFID [Radio wave Frequency Identification labels are utilized to assemble information or read the data] Tags. In the fields medical, WPT frameworks are utilized to charge the Bio-gadgets like pacemakers with no contact and move the vitality in attractive medium. These all applications are low power gadgets. For high power applications like EV accusing is additionally conceivable of WPT Systems. From the previous barely any years, looks into on Electric vehicles are made increasingly concerned and it picked up ubiquity since it won't emanate any ozone depleting substances and it uses environmentally friendly power vitality. Indeed, even Electric vehicles are having numerous favorable circumstances there are a few issues ejected when it experiences with the clients. One of the primary drawbacks is charging framework. Since it is powerless against certain conditions like Weather, Vandalism and Electrocution. Thus, WPT frameworks are better partner for charging EVs. In this paper, unmistakable sorts of Wireless Power Transfer advancements has given and basic structure of shut and open circle WPT frameworks in tangle lab were given. Further, recognize highlights has been made in the middle of the tangle lab reproduction of both open and shut circle frameworks and distinctive link frameworks and remote power move frameworks.

***Index Terms*: *Wireless Power Transfer WPT, Design of Optimization, Electric Vehicles, coil shapes, Quality Factor and Coupling Coefficient..*

I. INTRODUCTION

In the Past decade, the electric vehicles had gained more popularity because of environmental concerns whereas the present conventional vehicles are polluting environment with the high carbon emission and other main setback is the higher fuel and maintenance costs. By using Plug in Electrical Vehicles there is some possibility to reduce the fuel and maintenance cost up to 70 %. But many consumers are not satisfied with the electrical vehicles because of the battery charging problems. The charging infrastructure is vulnerable to weather conditions, Vandalism and electrocution. The charging cables can represent as a trip hazard and due to the large amount of power being transferred.

Wireless Power Transfer Topologies are got more attention in past few years they can transfer the power without any contact, and it allows to charge the battery with user safety and convenience and eliminating the most of the problems faced by its counter parts.

II. CLASSIFICATION OF WPS SYSTEMS

In WPT Systems there are mainly classified into two types they are i) near-field ii) far-field. Out of these, non radiative is near field and it can exchange energy over within a short distance. In this type Inductive Power Transfer Systems is more popular. It is mainly used in Induction motors. It was first used by the famous scientist and inventor Nikola Tesla in the starting of the 20th century [1]. Even though it was used in the early 20's but major contribution was done in past 3 decades by researching on this area. It has been used in applications of small power such as wireless charging of smart phones [2],[3], electric tooth brushes, biomedical implants [3],[4] and scanning RFID tags which require small amount of power to scan the data [5]. In order to get more efficiency, coupled magnetic resonance is proposed. The range of power transfer is extended by resonance.it is coming under the category of near-field power transfer systems. The high-power application is Charging PEV's.

For Far-field or distant field technologies, they are capable to transfer the power for long [6]distances. Though it requires the Line of Sight transmission path and some complex tracking techniques to maintain the perfect alignment. It's mainly used in signal broadcasting and efficiency[7] will decline when it is used in the omni-directional transfer of power due to increase of air gap.

Capacitive WPT System is used to transfer energy by the alternative electric field. It has smaller Electro Magnetic Interference than the traditional electromagnetic field-based technologies. The electric flux needs to travel within the capacitive plates. The main problem of this system is having small coupling[8] capacitance and the air gap is very small. A costly dielectric material like BaTiO3 is used to increase its capacitance. These limitations are making this technology unfair for the charging of PHEV's. Attractive Gear Technology uses mechanical power as the vitality conveying medium and it has been applied in low control restorative[9] embeds, for example, cardio pace producers

Revised Manuscript Received on November 05, 2019.

***** Correspondence Author

Lanka Komal Sai Manohar *, B.Tech, Dept. of Electrical and Electronics Engineering, KLEF, Vaddeswaram, Guntur, INDIA.
Email: komalsai.manohar@gmail.com

Kotapati Subhash Reddy, B.Tech, Dept. of Electrical and Electronics Engineering, KLEF, Vaddeswaram, Guntur, INDIA.
Email:subhashreddy500@gmail.com

Sk.Moulali, B.Tech, Dept. of Electrical and Electronics Engineering, KLEF,Vaddeswaram,Guntur,INDIA.Email:itsmoulali212@kluniversity.in

G.Swapna, B.Tech, Dept. of Electrical and Electronics Engineering, KLEF, Vaddeswaram, Guntur, INDIA. Email:swapna@kluniversity.in

K.V.Siva Reddy, B.Tech, Dept. of Electrical and Electronics Engineering, KLEF, Vaddeswaram, Guntur, INDIA.
Email: sivareddy.v.k@kluniversity.in

In recent years research is going on in WPT systems and the most approached technology is near field Systems. With this system it is possible to get better efficiency on power transfer when the air gap is smaller within a few centimeters.

III. WPT SYSTEM FOR CHARGING OF PV's

Wireless Power Transmission is using several techniques to charge the Electrical vehicles based on charging time, average speed & power. There are two possible solutions to charge the EVs the first category of charging is static charging and the second one is charging on-route or dynamic charging.

STATIC CHARGING:
In static charging there are two different methods on charging time. Long duration of static charging time for several hours and other method is fast static charging time which is less than hour.

DYNAMIC CHARGING:
Charging scenario when EV is on-route there are two possible solutions are available

i. EV stops at short period of time at traffic signals and bus-stops etc. is called stationary charging. In this type of charging high power is transmitted and battery volume should in smaller in size.

ii. The second on-route charging is capable of movable charging. Special road lane is used at certain speed limitations to charge slow moving EV's. Battery capacity is lower and transmitting energy is depends upon the speed i.e., high speed results the low average energy transmission.

Review of Standard WPT System:-

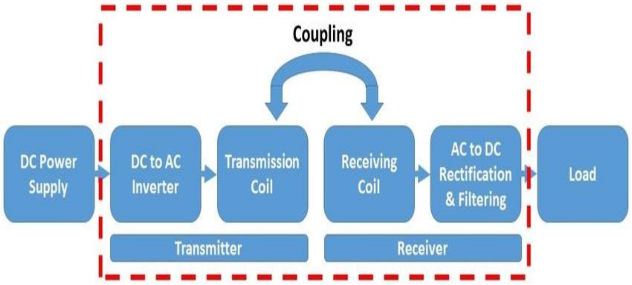

Fig 1: Block diagram of a WPT system

In wireless WPT system there are two main parts they are – i) the Transmitter and ii) the Receiver. The input power which is given to wpt system may given from AC or DC sources. For the event of AC source, the power input must be corrected or rectified. In rectification stage it contains a correction module for power factor. The rectification phase gives the precise power to the entire system. The subsequent phase is an inverter phase which contains of a full-bridge switching network which converts the DC waveform into square wave having high frequency. This frequency should be high so that it can transmit higher amount of power with maximum efficiency and low losses. During transmission stage. The frequency in both the receiver and transmitter sides is matched to improve the efficiency of transferred power. The amount of power that was received by the lift up coil is transformed into DC and then fed to the load or battery.

NOMENCLATURE			
L	Inductance	V_o	Output Voltage/Secondary Coil Voltage
N	Number of Turns of Coil	P	Power
D_{in}	Inner Coil Diameter	Q	Quality Factor
D_{out}	Outer Coil Diameter	K	Coupling Factor
W	Width of Conductor	R_o	Outer Radius of Coil
P	Pitch of Coil	R_i	Inner Radius of Coil
C	Capacitance	S_w	Conductor Diameter
f	Frequency	I_o	Output Current/Secondary Coil Current
M	Mutual Inductance		

Inductance:
The Self-inductanc of the coil can be designed by the wheeler approximations [6]. However, the formula is invalid if the coil has very smaller number of tuns and the pitch is low when compared to the coil diameter. The single layer helical coil inductance is given by

$$L = \frac{N^2(D_{out} - N(W+P))^2}{(16D_{out}) + 28N(W+P).} \times \frac{39.37}{10^6}$$

Capacitance:
The coil capacitance coil relies on the quantity of the turns and coil. The estimation of capacitance would hard or difficult to figure as the quantity of turns increments because of contiguous winding capacitance. As a rule, the coil capacitance can be calculated as

$$C = \frac{1}{(2\pi F)2L}$$

Mutual Inductance:
At the point when both coils are in mutual or shared inductance, the coupling coefficient (k), decides the quality of coupling between the two coils. The coupling coefficient can extend from zero(0) to one(1)

Where 1= superbly coupled
0= not coupled

Power.
The power transmitted to the second side or receiver is the output voltage and current product of the formulas obtained. It is given by,

$$P = \frac{\omega I I^2 M^2}{L_2}$$

The outrageous measure of intensity that can be scattered is for the most part subordinate in shared inductance that exist between the two curls and current at essential side. The transmitted power is reliant on the working recurrence or the coupling factor. The power is straightforwardly relative to the framework recurrence. A pay topology is utilized to expand the scope of intensity transmission. There are two sorts of pay topologies. They are pay capacitor in parallel or in arrangement with the exchange curls. Rules were set by the general public is to restrict the recurrence to 85 KHz via Automotive Engineers and International Electro-Technical Commission.

IV. COEFFICIENT OF COUPLING

The power transmitted is corresponding to the square of the mutual inductance involving the two coils. Mutual inductance is the main factor in the formula that cannot be amplified by making the electronic modifications. Hence, the plan has of the system must be such that it enhances the mutual inductance linking the two coils. The coupling between the two coils is related to the mutual inductance given by the formula.

$$K = \frac{M}{\sqrt{L1L2}}$$

Coupling relies on the separation among the coils which are in vertical axis. If there is any misalignment between the coils in the horizontal axis will also reduce the mutual inductance of the coils. Large variation in the coupling is isn't alluring in wpt systems as regular changes in current may harm the power electronic segments. In resonant power system, the coupling factor is in between the range of 0.1 to 0.4. This low coupling coefficient is because of the large leakage flux between the two coils because of the large distance. At times, it has also analyzed that a high value of coupling is not suitable for WPT systems [7]. By making the value of k large can in turn reduce the value of supply current and reduce the losses associated with it.

V. LEAKAGE FLUX

Leakage flux is what is going through air hole and has not been caught by the auxiliary loop. On the off chance that coupling between the two curls diminishes, the spillage motion increments. The best factors that lessens the coupling between the two curls are the vertical separation and misalignment of the loops. The spillage motion is identified with the coupling as pursues
Rules are set by the worldwide commission on Non-Ionizing Radiation Protection a limit of 27μT is the attractive field introduction limit for people.

VI. RESULTS AND ANALYIS

This section deals with the simulation results of the both open loop WPT system and closed loop WPT systems. Simulation is carried out in MATLAB 2016a Simulink software.

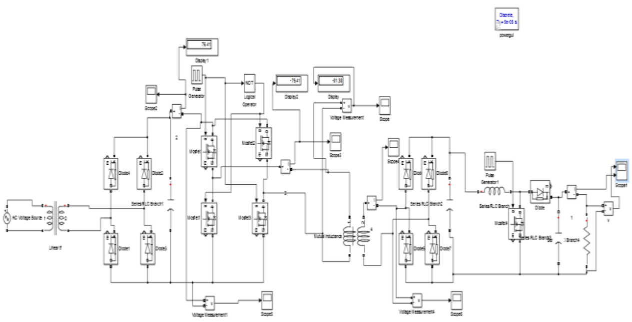

Fig.2: Open loop WPT system

AC input of 158v RMS is fed to the rectifier circuit and the filter capacitor produces an output of 99v is with a ripple voltage of about 3%. Fig 2 shows the output of the rectifier in the transmitter side.

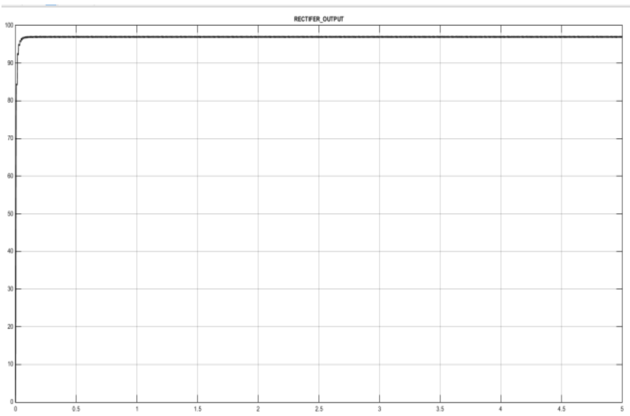

Fig. 3 : Output of the rectifier in transmitter side

Available output from this rectifier output is fed to the single-phase inverter in which the switches are operated in the frequency of 50 KHz using the pulse generator as shown in the circuit. The output of the inverter is ±85 volts that are nothing but the transmitter side voltage.

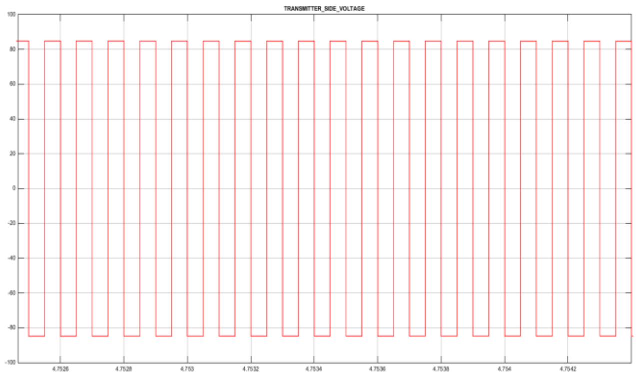

Fig 4: Transmitter side voltage

The output of the inverter is ±85 volts that are nothing but the transmitter side voltage. It is shown in the fig 3. The power transmission takes place to transmit the transmitter voltage to receivers side by mutual inductance.

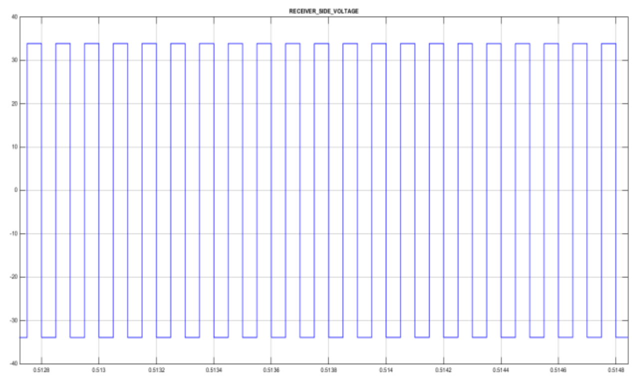

Fig 5 : Receiver side voltage

In fig 4 it shows the receiver side voltage and it is ±32 volts and the secondary coil is fed to the rectifier (Receiver side) and output of the rectifier is fed to boost converter. The final output of the static method is shown in given below figures.

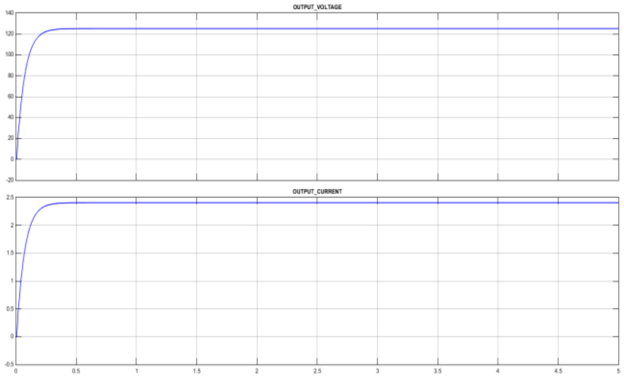

Fig 6: Output Voltage and Current

Further, the impact of input variation is observed in the simulation result to understand the significance of a controller. There are few issues that are observed in the open loop system. If input is increased the output values are also increasing. The input contribution to the chopper is thought to differ when the separation between the two coils are fluctuated and varied.

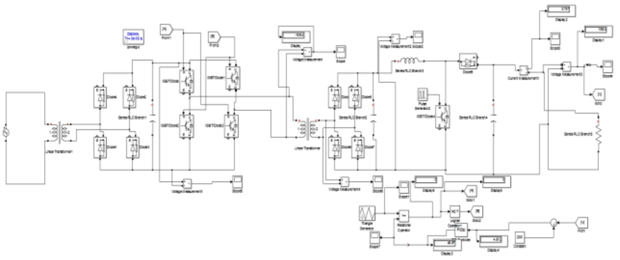

Fig 7 : Closed Loop WPT System

To conquer this issue a closed loop system is designed using P-I Controller feedback to the inverter switches as shown in figure 6. The auto tuning technique available in Simulink is used to acquire the controller pi parameters.

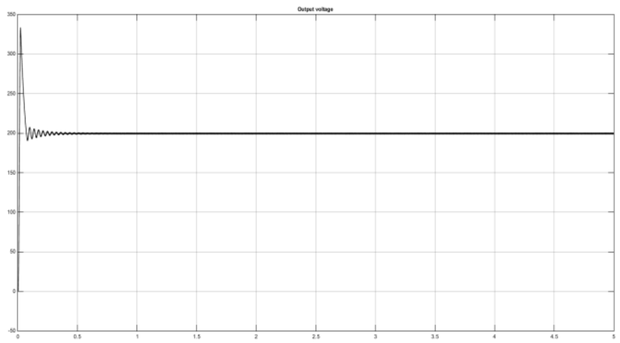

Fig 8 : Output Voltage of Closed Loop WPT System

It is observed that while using the controller, the output overshoots and settles to the constant voltage of about 200v and settling time is about 5ms.

VII. CONCLUSION

The main objective of this project is to transmit the power wirelessly without any contact within a short distance through magnetic medium. It is conceivable/ possible to operate some electric vehicles and other equipment etc.

In this paper we had simulated both open and closed loop systems and closed loop system is efficient charging system to transmit the desired output voltage. A closed loop system using Pi controller is feedback to transmitter side inverter switches and the distance between the coils is in between 10 to 20 cms. This project is going to implement in hardware design in future.

REFERENCES

1. Nikola Tesla, “Apparatus for transmitting electrical energy.,” US1119732 A, May 4, 1907
2. Sk. Moulali and K. Subbarao ”A Review on Recent Developments in Wireless Power Transfer” in IJCTA,2016, pp. 421-426.
3. Ravi teja.s,Moulali.sk, Nikhil.M and Venkata srinivas.B ‘A dual wireless power transfer-based battery charging system for electric vehicles’, IJEAT, Volume 8, Issue 4,April 2019,Pages 1211-1214.
4. J. C. Schuder, ‘Powering an artificial heart: birth of the inductively coupled-radio frequency system in 1960,Artificial Organs, volume.26,issue. 11, page.909-915, 2002.
5. J.C. Schuder, J.H. Gold, and H.E, Stephenson, ”An inductively coupled rf system for the transmission of 1kw of power through the skin,” IEEE Trans. On Biomedical Engineering, volume.18,no.4, page.265-273,1971.
6. C.Reinhold, P.Scholz, W.John, and U.Hilleringmann,”Efficient antenna design of inductive coupled RFID-systems with high power demand,” Journal of communications, volume.2, no. 6, page. 14-23, year-2007.
7. F. Grover, ‘Inductance calculations’, ser. Dover phoenix editions, Dover Publications, Incorporated, 2004.
8. H.L Li, A.P Hu, G. Covic, and C.S Tang, ”Optimal coupling condition of IPT system for achieving maximum power transfer,” Electronics letters, volume. 45, no.1,page. 76-77, January 2009.
9. Kumar, A., Guravareddy, Srikanth, M. “Automatic wireless mobile charger using arduino feedback”,IJITEE,2019.
10. Srinivasarao, B., Lalitha, S.V.N.L., Sreenivasarao, Y. “Selection of filter and reduction of ripple in the output of boost-converter for four bus micro grid system”,IJEAT,2019.

AUTHORS PROFILE

Komal Sai Manohar Lanka was born in Andhra Pradesh, India. He is pursuing B.Tech degree in EEE from KLEF, vaddeswaram, Guntur. He is interested to do research fields are electric drives, power electronics, electric machines, renewable-energy systems, and electrical and hybrid vehicles.

Kotapati Subhash was born in Andhra Pradesh, India. He is pursuing B.Tech degree in EEE from KLEF, vaddeswaram, Guntur. He is interested to do research in electric drives, power electronics and electrical and hybrid vehicles.

Sk. Moulali He is working as Assistant Professor in KLEF, Vaddeswaram, Guntur, Andhra Pradesh, India. He has received M. Tech degrees from Vignan University Guntur. He published 5 scopus and 10 international journal papers(non scopus). This author has overall 10 years teaching experience and guided more than 20 innovative projects as a part of his academic work. His research interests are power electronics, power electronics and drives, power systems.