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Dynamic Wireless Charging for Electric Vehicles

AYUSH JHA[1], LALIT MISHRA[2], RIYANSH BHARADWAJ[3], PROF. SHRIPAD DESAI[4]
[1, 2, 3] *Student, Bharati Vidyapeeth (Deemed to be University) College of Engineering, Pune*
[4] *Assistant Professor, Bharati Vidyapeeth (Deemed to be University) College of Engineering, Pune*

Abstract- With the help of wireless power transfer the electric vehicles (EVs) can be charged without electric cables. The wireless charging can be categorized into two techniques: Stationary wireless charging (SWC) and dynamic wireless charging (DWC) systems. [1] Use of DWC is more than the static wireless charging (SWC) as it can counter the challenges that are related to heavy weight batteries and time-consuming charging process. There are but other issues that affect (DWC) those are - power transferring efficiency and range, lateral misalignment of the coils and the implementation cost. The issues like these can be countered by developing coil architectures and topologies and operating novel semiconductor switches at higher frequencies. This paper presents a dynamic wireless charging model for e-vehicles. It majorly focuses on the dynamic charging of e-vehicles and obtaining the optimal velocity at which the charging can be attained. A simulation model is carried out on the MATLAB/SIMULINK.

Indexed Terms- EV (E-Vehicle), (DWC) Dynamic Wireless Charging, (SWC) Static Wireless Charging, MATLAB/SIMULINK.

I. INTRODUCTION

In the modern times, when the world is looking towards the clean energy for the generation of power - e vehicles are also capturing the automobile market. However, there are certain limitations to the charging time and process involved for the e-vehicles. A thorough research has been done for breaking the limitations of processes and obtaining the optimal speed of the vehicle for the wireless dynamic charging (WDC) which is going to make the e-vehicle charging more efficient.

A few years before when the e-vehicles entered the automobile market for the first time the main problem that it carried always was the charging process. An e-vehicle had to be stopped and charged for hours before it can be charged and reach to its destination. The research has been done to counter this very problem that e-vehicle faced from starting. With the help of Dynamic wireless charging (DWC) a vehicle can be in a moving position at a specific speed and still be charged efficiently.

The e-vehicles were released in mid-19th century for the first time. During the initial days disposable batteries were used for the charging of EVs. The technology was simple for charging one had to replace the dead batteries and put a new one. Then as the time passed and technology advanced 'General Electric' came up with first charging stations which were called 'Electrant'. [1]-[3]

During the end of 20th century the world began to get more and more aware about the pollution and carbon footprint of the cars running on combustion fuel. It is when the cars companies started to manufacture and researching on e-vehicles for the new future.

Soon the companies started to make a plug in EV which is resulted in the growth of public charging infrastructure around the world. But, now it's time when we should be provided with a technology that allow us to save our hours that are lost during the charging of e-vehicle system.

In this paper we have discussed about the Dynamic wireless charging of e-vehicle systems. This research paper gives a brief about the parameters and the process involved in the process of dynamic wireless charging of e-vehicle with the help of mutual inductance.[4]

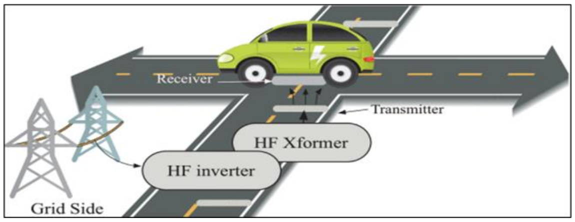

Fig 1 General Representation of Dynamic Wireless Charging Concept.

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II. PRESENT COMPREHENSIVE CHARGING METHOD'S FOR E-VEHICLE DYNAMIC CHARGING

1. Magnetic Type Charging
2. Capacitive Type Charging
3. Inductive Type Charging

Inductive Type Charging: -
Nikola tesla created the inductive power transfer in 1914 for the purpose of transferring electricity wirelessly. In the magnetic induction wireless power transmission, which has been long used in transformers the primary coil and magnetic coil are inductively coupled. When the distance in the air is superior to the diameter of the coil, the wireless power transmission efficiency decreases, and the coils are not aligned in the distance. The quality of inductors and coupling factor determine the efficiency of energy. In terms of efficiency the magnetic resonance method is outform. Smartphones are charged wirelessly with the help of this technology only. In the group of could this close coupled wireless power transfer can offer some flexibility in receiver coil in terms of the transmitter.[2][5]

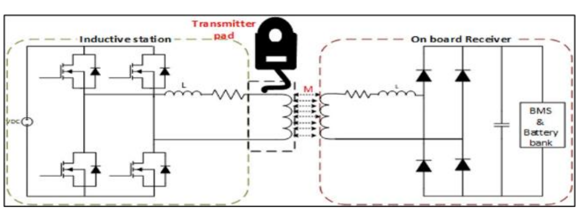

Fig 2:- General Representation of Charging System Circuit.

III. CHALLENGES AND HURDLES TO THE DEPLOYMENT OF WESVCS

Although though Wireless Electric Vehicle Charging System (WEVCS) offer more benefits than plug-in chargers, adoption is not yet achievable due to obstacles in the areas of health and safety, finances, power range restrictions, infrastructure development, and maintenance. In Sections 2.5 Health and safety concerns and 2.6 Health and safety standards, respectively, it is mentioned that the present development of the standards raises health and safety issues such EMC, fire, and electrical risks. The WEVCS's smaller power range compared to plug-in chargers is a significant barrier to its widespread adoption. The on-board AC Level 1 (1.4-1.9 kW) and 2 (3.3–20 kW) charging systems may charge a vehicle for a distance of up to 30 km per hour. A sophisticated network of wireless charging stations, both static and dynamic, must be installed on the highways to address these problems. Such a network necessitates the development of new infrastructure because it is incompatible with the existing configurations. Governmental organisations may need to make additional financial arrangements as a result, as WEVCS Level 1's beginning price (3.3 kW) is only a rough estimate. With a 200-kW charging power level, the cost of the dynamic WCS is expected to be Rs. 20 Cr. per km. For developing and disadvantaged nations, this is unaffordable. Therefore, a wide range of experimental with simulation scenario-based approaches are recommended to develop user-friendly international standards that may provide global consistency to successfully deploy WEVCS.[6][7]

IV. COMPONENTS

1. Pulse generator: It can be an electronic circuit and can also be a piece of electronic test equipment. The purpose of the pulse generator is to generate rectangular pulses. [8]
2. Gate turn - Off thyristor: A three terminal power semiconductor is referred to as a gate turn-off thyristor (GTO). GTOs are members of the four-layer thyristor family. Moreover, GTOs are part of a class of power semiconductor devices with complete control over on- and off-states via the control terminal (gate).

3. DC voltage source: The DC Voltage Source block is a representation of a perfect voltage source, capable of maintaining a specific voltage at its output independent of the source's current throughput. The Constant voltage parameter, which can be positive or negative, is used to determine the output voltage.
4. Diodes: By restricting the voltage, diodes protect circuits. They can also convert AC to DC. To maximise the performance of the diodes, semiconductors such as silicon and germanium are employed. Even though they both transfer electricity in the same direction, they do so in different ways. Diodes come in a variety of forms, and each form has a specific application.
5. Mutual inductance coil: The wireless charging is being done with help of mutual inductance. For the process of mutual inductance, we have installed mutual inductance coil.
6. Current measurement instrument: The term "ammeter" refers to a device used to measure electric current in amperes, either direct (DC) or alternating (AC). Because a shunt is connected in parallel with the metre and carries the majority of the current at high values, an ammeter can measure a wide range of current values.[4] An ammeter is represented by an inside-out circle with a capital A in circuit diagrams.
7. Scope: With relation to simulation time, the Scope block shows its input. The Scope block supports several axes (one for each port), each of which has an independent y-axis and a shared time range. You can change the amount of time and the range of input values displayed using the Scope.[7] The Scope window can be moved, resized, and its parameter values can be changed while the simulation is running.
8. Capacitors: A capacitor is a device that uses the accumulation of electric charges on two nearby surfaces that are electrically isolated from one another to store electrical energy in an electric field. It has two terminals and is a passive electrical component. Capacitance refers to a capacitor's effect.

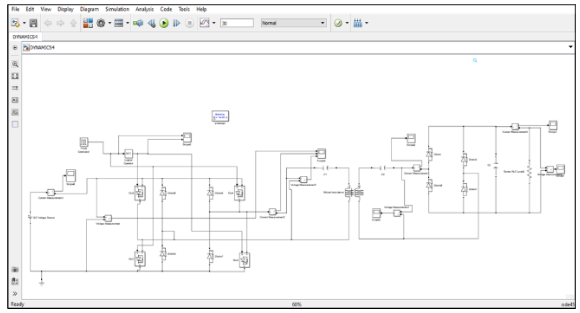

Fig 3: - Circuit Designed on MATLAB SIMULINK consisting of all the mentioned elements

V. METHODOLOGY

The inductive power transfer takes place between two coils that are magnetically connected. L1 and L2 are their self-inductances, while M is their mutual inductance. L1 and L2 stand in for the primary and secondary coils, respectively.[8][3] The electrical grid is connected to the primary side DC voltage source, and the load, which is the battery that needs to be charged, is on the secondary side DC section. As the coupled coils transfer power in AC, two intermediate stages—a DC-AC in the main side and an AC-DC in the secondary side—are required. If the system operates at resonance, a reactive network is required to improve the power factor and enhance power transfer efficiency due to the loosely linked nature of the coils.[9]

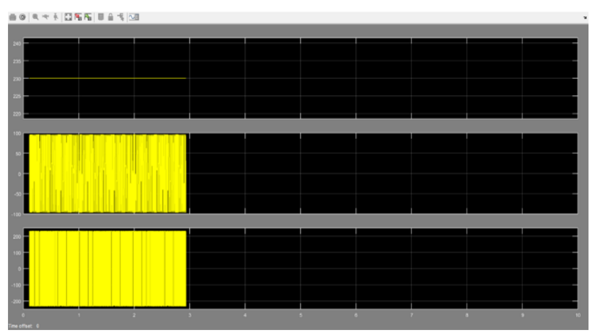

Fig 4:- Input Parameters with respect to time (on X Axis) on Primary Side of circuit represents a. 220V DC Supply (Upper most Column)
b. 100amp AC Current (Middle Column) & c. 220 V AC Supply (Lower Column)

In Fig.4 plot (a) shows the DC input supply given to the system. This supply to the system is now converted to AC by using power inverter created by using Gate Turn-off Thyristor and Diodes. The plot (b) shows the

AC Current after conversion whose value is around 100 amp and plot (c) represents AC Voltage whose value is 220volts.

Now the AC power is transferred to the secondary coil and the power transfer received by the secondary coil is now converted to DC by means of rectifier created by using Diodes. A pulsating DC is now received to the secondary coil side of the mutual inductor. Further this pulsating DC current generated is now used for charging of battery in the vehicle.

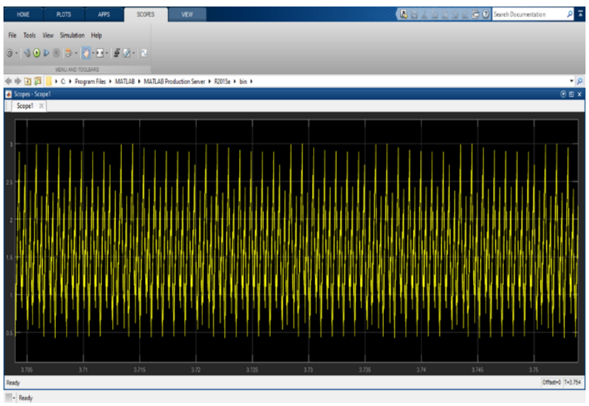

Fig 5: - The figure shows 3-amp Pulsating DC current with respect to time (to be obtained for Battery Charging.)

In Fig. 5 the plot represents the pulsating DC current obtained after successful conversion of AC power obtained via mutual inductance to the secondary coil to DC power. The value of this pulsating DC current varies between 0-3 amps.

CONCLUSION

In this research paper, we have described briefly our work on dynamic wireless charging of e - vehicles. We have shown our results in the form of graphs that were generated on the scope during the MATLAB/SIMULINK simulation. The circuit that designed on the MATLAB/SIMULINK has different electrical components for the desired purpose. The circuit works on the principle of mutual inductance. With the help of mutual inductance the wireless charging became possible in this project work. We were successful in generating pulsating DC for the purpose of charging the batteries at 3A and 12V. Through this simulation we could work on another charging approach of e-vehicle other than prevailing in the recent times.

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