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Wireless Inductive Technology Based Power Transmission For Ev Charging

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Abstract- The need for Electric vehicle is increasing and the world is shifting to answer a of automation. With the increasing production of electric vehicles, the need for EV charging is also increasing. A lot of work is being put into easing the process of EV powering with a concentration on increased efficiency. The Electric vehicle Wireless Power transfer technique is one method which offers more flexibility and tolerance in comparison to the traditional plug in charging method. Wireless power transfer technology in contrast to conventional charging is fully automated, has higher power capability and capacity, safer as there is no human contact and most importantly has faster response and saves time. The coupling coil in the charger is the most important in a wireless magnetic resonance-based charging system. The power transferred from transformer to coil is a medium to high power conversion and transmission. While designing a charger of this type the losses have to be taken into account to improve efficiency of power transmission of the charging coupler. This paper presents a high power efficient wireless power charging method for EV based on WPT. Various types of charging coils are compared, analyzed and a conclusion describing the fastest and most efficient charging method is given.

Keywords: Vehicular communications, Electrical Vehicles, Wireless Charging, Fuel Efficient

I. INTRODUCTION

An electric vehicle uses one or more electric motors for momentum and propulsion; it replaces the internal combustion engine that generates power using a combination of fuel and gases. Electric vehicles are replacing current-generation automobiles due to the limited availability of resources and to reduce global warming. Electric cars are cheaper to run and maintain, they have advanced features like immediate torque, silent ride, and premium performance are also present. The charging time of an electric vehicle depends on the battery capacity and the charging power.

Now a day's plug –in charging has gained a lot of popularity but this will soon beer placed by high-power fast charging technology. High-power fast technology eliminates the need to queue in line for charging the EVs. The next generation lithium-ion batteries increase the range by providing 200-300 miles on a single charge.

The losses incurred due to transmission of power in wires is about 20-30%, WPT not only minimizes these losses but also provides a noiseless, cost efficient and convenient charging mechanism. WPT is based on inductive charging where the electricity is transferred via an air gap which is present between two magnetic coils.

The aim of this paper is to look into an effective way of charging EV vehicles and to reduce charging time and transmission losses. A superconductor is applied to the transmission and reception resonant coils to increase the efficiency, this efficiency can be measured by several variables like magnetic flux, the inductance of the resonant coil, shape of the coil, and the mutual inductance. In inductive wireless charging system, the charging coupler plays a major role; this transformer is medium to high- frequency. To improve on the power factor and to increase the transformer output voltage, resonance is used. We have also simulated the transmitter and receiver coil subsystems using MATLAB. We have integrated them into one and analyzed it.

II. AN OVERVIEW: WIRLESSCHARGING

A. Novelty

So far wireless charging technology has only been implemented in parking lots and charging stations, but the dynamic wireless charging technology demands more scope, so we are introducing “charging while driving”, this will not only reduce range anxiety, but also it mitigates the need to have heavy battery pack systems in electric-vehicles. This can be achieved by keeping in mind the energy transfer frequencies, the positioning of the coils for electromagnetic transfer of current and providing cooling technologies to avoid over-heating.

In this paper, we will be discussing few key components which are essential to understand so that we can achieve the next generation dynamic wireless charging technology.

B. High Efficiency Wireless Charging System Methods

The resonant frequency based wireless power transfer is one of the safest methods that ensures high power transmission with high efficiency, this system can even be implemented for a slightly distanced power transfer by matching the frequency of resonation of the coils. In urban areas, the secondary coil tends to be more in number to improve efficiency. One such example is a one to two power transmission where the primary coil is single while there are two secondary coils which increase high power and efficiency considering the loads. The resonant frequency is a combination of inductance and capacitances in a series parallel combination clubbed with band pass and band stops characteristics in the series-parallel combination. The efficiency is determined by how closely the coupled coil sarewrteach other. An important factor known as the Q-factor is one of the most important characteristics in determining the characteristicofresonanceofthewirelesschargingmethod.TheQ-factorhasadirect effect on the efficiency, as the Q-factor increases the resonance characteristic of the coil and efficiency increase proportionally. In order to have high Q-factors in the resonant coil, superconductors have to be implemented as they fall in the range of high Q-factor. The superconductors provide Q-factor in the magnitude of 100000 or 105 while giving minimal or zero resistance which is one of the standout features of the superconductor resonance based wireless power transmission.

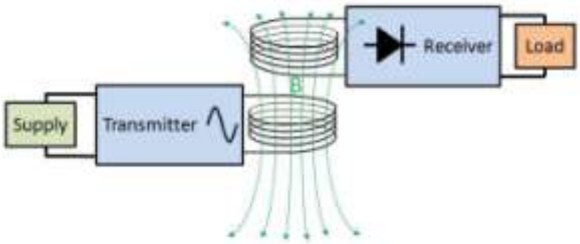

Figure 1. Power Transmission

$$Z = R + jX \quad (1)$$

$$Z = j\omega L + \frac{1}{j\omega L} \quad (2)$$

$$x = j(\omega L - \frac{1}{\omega C}) = 0 \quad (3)$$

$$j(\omega L - 1) = 2\prod \mathrm{fL} - \frac{1}{2\prod \mathrm{fC}} = 0 \quad (4)$$

$$Q = \frac{f}{\Delta f} = \frac{\omega L}{R} = \frac{2\Pi f L}{R} \quad (5)$$

The efficiency increases with increase in magnetic flux and not linkage flux alone. The magnetic flux increases with increase in inductance, current and the no. of turns in the coil. As seen previously, the linkage flux increased with the mutual induction which gave rise to increase in resonance. The magnetic flux gives rise to increased resonance if the value of inductance of transmission and receiver coil increases, in order for this to happen the radius of the coil must be increased which eventually increases the no. of turns. The shape of the coil is the deciding factor, in cases such as the sea Spiral coil must be chosen as it satisfies the criteria of larger radius and more number of turns and thereby increases the inductance and magnetic flux. If the criteria are met high mutual inductance and high coupling coefficient is obtained and this gives high efficiency along with high power transmission as show in figure1.

The impedance needs to be matched for an efficient flow of high power through the coils. The impedance matching can be realized addition of capacitance in either of the four combinations: series-series, series-parallel, parallel-parallel, parallel-series. The adding of capacitance is better than using soft switching technique. This helps in improving the output voltage and the compensation of the primary side is needed to reduce the volt-ampere rating of the inverter, whereas the secondary needs compensation to improve the rating of power of the secondary side for power transfer with a boosted voltage.

$$\Phi = \frac{\lambda}{N} = \frac{L}{N} \quad (6)$$

$$M = K\sqrt{L_1} = + L_2 \quad (7)$$

$$M = \frac{r^3}{\sqrt{(r^2 + d^2)3}} \quad (8)$$

The capacitance present on both the sides forms a resonant circuit along with the inductances of the coils. This method allows the reduction of losses such as copper losses and iron losses in the coupling circuit. This method also decreases switching losses and volt-ampere rating of power electronic components present in the inverter circuit.

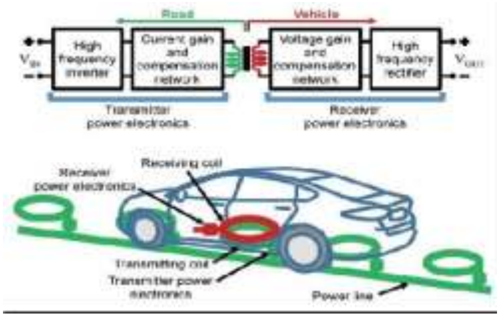

Figure 2. Power Electronics

C. Measuring efficiency in Wireless Charging Systems

Here, 3 power pads are analyzed and evaluated for power transfer efficiency using different vertical and horizontal arrangements in wireless charging systems.

The main function is to find out the power pad which is having the maximum performance. The pads which we are considering to evaluate the efficiency are: Circular pads, double D pads and a new pad which is named as double D circular (DDC) pad. Circular pads offer frequency which is around 90 kHz which ensures that highest efficiency is provided considering the horizontal and vertical arrangements. In DD power pads the flux path height is double compared to the circular pads. After all the analysis, DD pads have shown maximum efficiency and DDC pads have superior performance. The various misalignments have to be adjusted to get maximum efficiency, Figure 2.shows the Power Electronics.

Three scenarios have been simulated which are regular demand scenario, high demand scenario and extra demand scenario. Various important factors are considered such as price of electricity, the current state of the electricity grid, vehicle’s battery level and a suitable scenario where both cost and charging capability is satisfactory. To assess the performance, regular deem and scenarios were analyzed for EVs which presents a nominal battery level before starting the recharging process, in high demand scenarios, the EVs require a significant amount of energy to fully charge their batteries, in extra demand scenarios the vehicles reach the charging point with very low battery levels about 24.67%only.

The cost of electricity can be drastically reduced by improving the charging points where the chargers can adjust the charging process according to the battery level of the vehicle and also considering the time span available to charge the battery. The study is based on plug-in charging so the same parameters may not apply when considering wireless.

D. Wireless Control and Power Transmission System

The paper focuses on the wireless charging system which can find out the most efficient coil for transmission with the help of sensors. The WPT technology uses the charging system to activate the transmission coil when it's at rest and activates the sensors with the help of logical inputs to find the appropriate coil for transmission purpose and determining the position.

The system used for charging purposes helps to stabilize the voltage to the micro controller with a pad that includes pairs of charging coil sin three sets. Every coil is connected to a relay then to a microcontroller and mounted on a board which is primarily used for switching. When the car is at rest position there is an LED which is used for indicating the activeness by determining the parking angles of a car with respect to certain positions. According to the position determination of the car the micro controller activates the coil for the EV charging process. The key advantage that this kind of system is the smart charger that can offer an efficient alternative for response time by reducing it and making it minimal by improving the performance and reducing losses.

Wireless Power Transfer (WPT) is gaining more popularity as EV charging systems are thriving on improving over the years. This research introduces a concept where DC-AC power conversion of battery pack consists of modules which enable WPT. All the connections present are completely wireless which leads to the term which has been coined as Wirelessly Enabled and Distributed Battery Energy Storage (WEDES) are inserted into host slots as different modules. The whole unit generates power by combining and delivering current and voltage statistics. The driving range of this EV is dependent on the battery wrt its maximum capacity, so range anxiety can possibly be reduced, Figure3. Shows the Wedes Model

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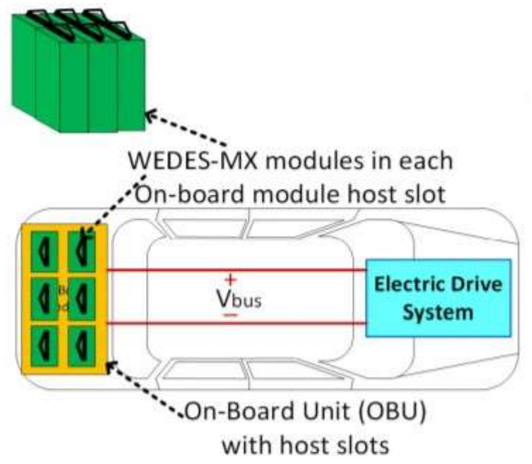

Figure 3. Wedes Model

E. Charging Power Control Method EV WPT system

Initially the electric vehicles were charged using grid electricity, now as the technological progress is happening day by day, wireless charging has become famous. But anew concept as been introduced to advance this system further by realizing the need for "charging while driving". This is known as dynamic wireless charging which is more efficient than static charging which exploits the space of the vehicle by determining the time and acts accordingly to recharge it. When the low charging efficiency arises, it provides dynamic charging method which considers the speed of the vehicle. Because large energy density is required and more charging efficiency its advisable to opt for wireless charging which can reduce ample losses and time and increase efficiency. The backdrop of wireless charging is that it emits harmful electromagnetic radiations. It can be achieved by coupling the primary and secondary coils with the help of different shielding plates. This type of shielding well outputs wrt magnetic and lessens the reduction of the coupling factor, but is also ensured that the efficiency of the shielding effect is not reduced.

III. COMPARISON WITH RECENT TRENDS

. • Better strategies for automatic, efficient, and scheduled electric vehicles' charging process, avoiding peak power demands is discussed [1].

• As much as wireless charging is gaining popularity, the difficulties arises with it , the primary factor being parking the electric vehicle where exactly the coils are present [2].

• Concept of a battery system or pack architecture that is divided into several battery modules that share the load power wirelessly and are controlled wirelessly [3]. The downside to this is the battery packs are large size, heavy weight and they need electrical & mechanical connections.

• It discusses the importance of spiral-type laminated superconducting resonance coil for increased efficiency [4]. But the cons are that it reduces fuel efficiency and mileage because of the cooling system.

• Importance of resonance in the wireless coupler which makes coupling coefficient and power rating important for a charging is discussed [5].But it may not be able to handle excessive load. It's expensive to make magnetic ferrite.

• Influence of speed on the EV power demand during driving & the effect on the direction of system parameter adjustment in the critical compensation state [6].But there is a problem of low charging efficiency caused by excessive driving speed.

• Method for reducing the shielding effect on the coupling factor in wireless power transfer system application. [7] Cons are the risk of exposure to significant levels of electromagnetic radiations.

• Three power pads are evaluated for power transfer efficiency in wireless charging systems with respect to various vertical and horizontal misalignments. [8] The various misalignments have to adjust to get maximum efficiency.

• Minimum input power operating point for a given output power is found out to evaluate a method for maximum energy efficiency tracking [9] The drawback is the presence of core losses and inverter losses.

• Very high efficiency of 95% is obtained, also producing 10kW output power. [10] A coupler is used for large gapped applications for wireless charging.

IV. STATE OFART

Generations and generations of people have depended on fossil fuels as their main source of energy for power generation and most importantly Combustion Vehicles. And the usage of these fuels has created a surge of CO_2 and thanks to this we are nearing the extinction of these fuels by 2050 utmost. Such scenarios need an alternative and that's how Electric Vehicles have paved their way into the automotive industry cutting off the need for fuel what so ever, Figure 4.shows the State of Art. The charging systems for an EV play an integral role in building a smart and efficient EV. The EV charging provides a solution for compact and reliable charging to meet the needs of the next level of smart mobility for the next generation. The rotating simulator was designed to depict the high-power transfer efficiency environment which can optimize fast charging as well as range anxiety. The simulation blocks has two subsections i.e., the transmitter section and the receiver section. The Wireless power transfer method contains different scenarios/methods of charging:

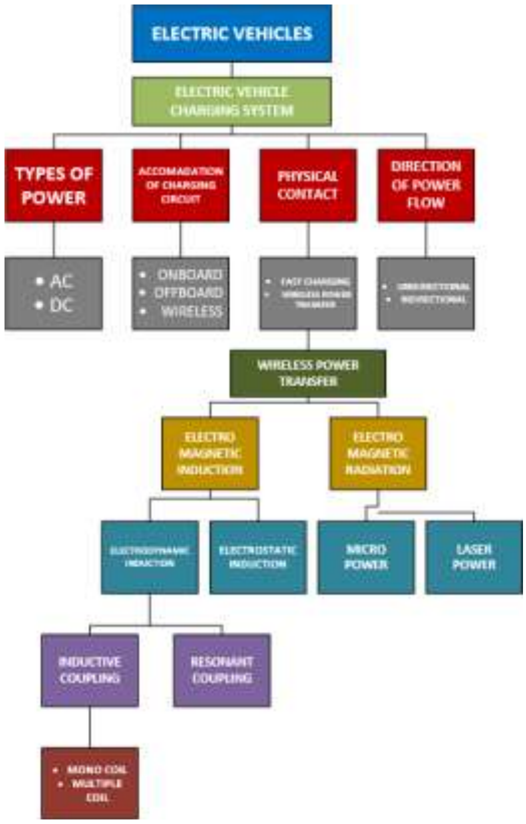

Figure 4. State of Art

LEVEL 1- This type of charging contains charging in households and can be used for charging ev at home with the help of power pads with 120 volts current

LEVEL 2- This type of charging contains 240-volt regenerative power to enhance the efficiency and opens new doors for fast charging with 3% increased efficiency.

DC FAST CHARGING- This type of charging contains conversion of DC to AC converters for increased frequency for fast charging along with efficiency and is used in many superchargers for energy storage in EV. The charge time is reduced drastically by this method.

The project is based on dc fast charging method which aims to increase charge efficiency along with reduced transmission losses. This method can take charging method to new heights with more than>40kW power which can deliver over 98kmof range in over 30-40 mins. Charging methods are also proposed- cheapest (keeping the time instant in the middle of the time period), cheapest starting (electricity is the cheap at the beginning), low cost (EVs start their recharges when the off-peak period begins)and last period (charging process will finish just before leaving the parking lot), Figure 5. Shows the Block diagram for wireless charging technology.

V. BLOCK DIAGRAM

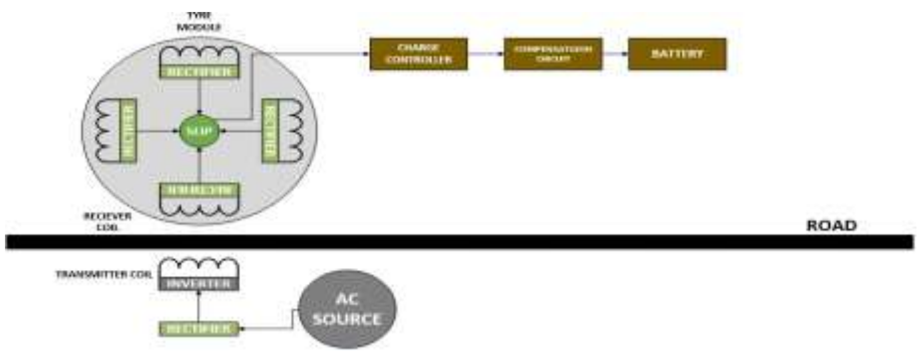

Figure 5. Block diagram for wireless charging technology

VI. CONCLUSION

In Conclusion, the purpose of this was to comprehend how we can maximize different infrastructures in Electric Vehicle Technology by maximizing Efficiency and improving the charging standards by fast charging process. Implementation on highway resting areas was inspected along with the charging facilities which can provide high performance with minimal losses. The supply of fast charging and discharging patterns can be observed with the help of the rotating simulator. The rotating simulator was designed to implement high power transfer with the help of 4 receiver coils to cut down the transmission losses. Existing charging algorithms have been explored along with the technical trends that can help understanding fast charging system and battery charges witching systems. The paper aim stop remote fast charging response, safety, range anxiety, silent ride, reduced transmission losses, cost reduction and high power transfer.

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