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LITERATURE SURVEY ON NEXT GEN WIRELESS CHARGING: ADVANCED TECHNOLOGY FOR EV POWER TRANSFER

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Abstract: Wireless charging is a type of charging method which uses an electromagnetic field to transfer energy through electromagnetic induction. Energy is transferred between devices (transmitter and receiver) through the process of mutual induction. Power from solar is given as input to transmitter inductive coil, the receiver inductive coil receives the power and converts it into electric current to charge the battery.

Solar panels convert solar energy into electricity. They use the concept of photoelectric effect, emission of electrons when light falls on solar panel. Solar panels are made up of silicon cells, silicon has an atomic number 14. When light falls on silicon cell, the outer most electrons of silicon i.e. two electrons are set into motion. This initiates the flow of electricity. Silicon has two different cell structures: monocrystalline and polycrystalline Monocrystalline solar panels are manufactured from one large silicon block and are made in silicon wafer formats. Polycrystalline solar cells are also silicon cells, which are produced by melting multiple silicon crystals together.

Wireless Power Transfer (WPT) utilizing attractive reverberation is the innovation which could set human free from the irritating wires. Indeed, the WPT embraces a similar essential hypothesis which has just been created for something like 30 years with the term inductive power exchange. Recently WPT innovation is growing rapidly at control level. The makes the WPT very useful to the electric vehicle (EV) charging applications in both stationary and dynamic charging situations. This project surveyed the advancements in the WPT to EV remote charging. By presenting WPT in EVs, charging system can be effectively relieved. Battery innovation is never again pertinent in the mass market entrance of EVs. It is trusted that specialists could be supported by the cutting-edge accomplishments, and push forward the further improvement of WPT just as the extension of EV.

I. INTRODUCTION

To travel from one place to other humans have been using vehicles for transportation. Internal combustion (IC) engines are used to drive it. As the vehicle population is increased there is a vast increase in the environmental pollution rate. In future days, the concept of pollution free transportation will be of focus. Due to increasing greenhouse gas radiation, and scarcity of petroleum products for upcoming year's efficient use of electric vehicles and recharging them portably becomes important. Electric vehicle does not need petroleum products as fuel and the level of pollution caused is negligible when compared to regular vehicle. Hence, electric vehicles and efficient recharging process becomes the major concern. Main concern with electrical vehicles is charging. Thus, the concept of wireless power transfer is proposed, where a vehicle can be charged portably. The reason for taking up this project is to make a model of wireless transfer of power for electric vehicle, which will enable dynamic charging in the electric vehicle, thereby increasing its range. The proposed concept in our project is to have emitter coils on roads where the traffic moves really slow like toll gates, traffic signals, roundabout, traffic congested areas etc. A receiving coil attached to the belly of the vehicle will receive power from the transmitting coil and charge the battery. Electric vehicle consists of an electric motor, and generally a rechargeable battery which powers the motor.

1.2 RATIONALITY BEHIND CHOOSING THE PROJECT

In destiny the fuel like coal, petrol, diesel will vanish because those are nonrenewable supply of electricity. The transportation device can have obstacles in future. Therefore, we go for electric vehicle for transportation purpose. Because of existing fuel vehicles greenhouse gases are increasing. Plug-in electric powered automobiles are environmental friendly transportation and decreased a few extents of greenhouse fuel. The use of EV is presently extended but there are a few batteries associated troubles together with slower charging fee, low electricity storage potential, length, and weight.

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It is needed to decrease battery related troubles and for the development of EVs. because of charging related issues many consumers do not have purchase EVs as precedence basis To lessen battery related issues, ozone harming substances and to settling the attractive control radiation issue the possibility of remote power transfer (WPT) is developed. Many charging stations are built up at the aspect of avenue, when you consider that the user's journey, similarly distance by means of recharging their electric powered car. This project will solve this all issues for charging reminder and other manual work for charging.

1.3 BACKGROUND

Personal vehicles have become an inevitable part of our life. But most of these vehicles use petrol or diesel as fuel and hence there is immense emission of greenhouse gases which causes global warming which has become a major issue these days. Electric Vehicles are a very promising hope to reduce emissions of harmful gases. Charging of electric vehicles through rechargeable battery which can only be charged when the vehicle is parked. Thus, the concept of wireless power transfer is proposed, where a vehicle can be charged portably.

The solar power is first stored in a battery then transferred through wireless medium by inductive coupling. There is a high thrust for renewable energy to mitigate the effect of global warming. The inductive power transfer has wide applications along with renewable energy. To demonstrate this solar based wireless power transfer system for home appliances has been developed. The advantage of this project is to increase the usage of renewable energy resources in order to reduce the CO emissions. And also the wireless power transfer system is a new way to transfer the power to the load rather than the conventional method of transferring power through livewires.

1.4 MOTIVATION

The "plug-in" EVs using wires for charging face many problems such as limited travel range, bulky heavyweight batteries, and a long charging duration. WCEVs are introduced to reduce the realized shortcomings of wire technology, leading to reduced costs and hazards. The WCEV system can be categorized as quasi-dynamic wireless charging (QWC), dynamic wireless charging (DWC), and static wireless charging (SWC). Many WCEV challenges were studied by researchers, such as battery capacity, wireless charging substation locations, and the required power electronic design, which can affect the cost and utilization of EVs.

II. LITERATURE REVIEW

The WC technology can be implemented using near-field or far-field methods. The magnetic field is capable of transmitting power over larger distances compared to the electric field, as it can penetrate objects. The WC near-field technology is commonly implemented through methods like inductive power transfer (IPT-WC), coupled magnetic resonance (CMR-WC), or permanent magnet coupling (PMC-WC) [1]. The integration of electric and magnetic fields, first described by Maxwell in 1864, has been enhanced over time by adjusting parameters such as air gap, frequency, and power transfer levels [2]. CMR-WC focuses on optimizing magnetic resonance coupling for maximum power transfer, improving the system power factor for applications like online EVs and dynamic wireless charging (DWC) setups. PMC-WC relies on utilizing permanent magnets as couplings or gears to achieve efficient power transfer, with about 81% efficiency at 150 kHz for a 15.0 cm gap [3]. However, this design may pose mechanical challenges such as increased vibration, noise, and alignment issues, especially in the context of EV charging. Overall, wireless charging technologies present both opportunities and challenges due to power transfer and EV charging. In QWC, battery electric buses (BEBs) can charge momentarily when they promptly stop due to traffic blocks. ABB Company could employ bus gained 400 kW charging after 15 s. QWC system has been introduced for vehicle-to-grid and grid-to-vehicle systems [4]. A comparative economic study was conducted between QWC, SWC, and DWC. It concluded that DWC capital and operating costs can be reduced by using QWC.

One major concern in EV adoption is the time taken for charging and the limited availability of charging services, which can lead to doubts about sufficient energy to reach destinations [5]. Efforts have been made to address this issue by focusing on reducing energy requirements for EVs; improving charging efficiency; enhancing battery capacity; and exploring alternative charging methods like battery swapping, static wireless charging (SWC), and DWC. SWC relies on the electromagnetic coupling between coils but still encounters challenges in charging time and service distribution [6]. In this authors have shown how power can be optimized in any communication system. Power optimization is providing optimum power to devices that is providing less power, where ever less power is required & more power where ever max power is required[7]. It has Been proposed. Other studies have explored the application of DWC with wireless power transfer (WPT) technology to reduce the size of EV batteries [8]. The implementation of DWC has led to cost minimization and the integration of electric and transportation networks, reducing the total travel costs.

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The original design of DWC involved creating a magnetic linkage with a 3 mm air clearance at a high frequency of up to 100 kHz, generating 8.3 kW power with 87% efficiency [9]. Recent advancements have allowed for an increase in the air gap to automate the charging process, with efforts focused on extending this distance up to meters using modern electronic devices to enhance power production and address the challenge of distant charging. WPT technologies are typically classified into three groups: inductive-based WPT (IWPT), magnetic (MRC)-based WPT, and electromagnetic radiation-based WPT. MRC-WPT offers advantages in terms of high safety levels and long transmission distances [10].

It can be concluded that for low or medium required WPT amounts, MRC is more suitable than the others. IWPT is the optimal choice for high-voltage WPT as it eliminates resonance [11]. A design for IWPT was proposed by positioning the primary winding of the power transformer in the ground on the same axis as the secondary winding in EVs, achieving efficiency levels ranging from 85% to 96%. Increasing the air gap diminishes power transfer efficiency. Conversely, when extreme power transfer capabilities are needed in WPT, the design of the air gap width should prevent overheating [12]. The degree of fine linkage primarily relies on the magnetic linkage coefficient, with a higher coefficient necessary for high power transfer. A power of 60 kW with efficiency reaching 80% could be transferred using 85 kHz through a 20 cm air gap and lateral tolerance of 24 cm. A power of 82 kW could be achieved for the very high-speed train with 83% efficiency with a 5 cm gap [13].

A wireless synchronization controller for vehicle parts was introduced to wireless charging EVs under stationary and semi-dynamic conditions, increasing the output power and efficiency [14]. A new dynamic two-way strategy to improve charging for dynamic EVs and fulfill their requirements using an improved mixed-integer linear program and numerical tests was proposed [15]. An integrated control strategy was proposed to overcome the mutual inductance instability that arises with dynamic EVs using an internal model-based regulator, and the results were confirmed by introducing a prototype model. The method exhibited less disruption and higher accuracy [16]. A superimposed dislocation coil (SDC) was suggested for dynamic and static WPT to guarantee a fixed coupling coefficient between the transmitting and receiving coils [17]. A new method was presented to evaluate the continuity of dynamic power transfer and its actual effects on the electric network [18]. An optimization technique was introduced to determine the optimal dynamic charging of EVs using a nonlinear integer programming model to minimize DWC requirements and cost considering stable charging resources in highways, the EV battery' nonlinear charging performance, and traffic capacity limits [19]. Another study proposed an optimized design of a DWC charging system integrated with distributed generator resources, which was incorporated with main networks and tested in a large road network in Sharjah, UAE [20]. A traffic assignment model was suggested using the DWC system considering user equilibrium and the probability of EV batteries running out. The suggested system used DWC system planning [21]. The cover-like coupling structure and the return-like coupling structure were designed to improve the DWC by reducing its cost and electromagnetic radiation in addition to increasing its efficiency using Ansoft software 2021 for simulation and analysis [22]. A comparative study was conducted between static and dynamic charging systems for EVs to analyze their operation, practicality, and applications [23]. Fixed output voltage for DWC was obtained by using a successful optimal control method considering the time-varying flux caused by mutual inductance as a result of EV motion [24]. A new methodology was suggested to control the switching of transmission lane segments depending on the location of the EV, which could be accurately detected. A new optimization technique was proposed, and a plan was prepared to locate the quasi-dynamic wireless charging (QWC) plants in the road lane to study and define the charging requirements of battery electric buses [25]. The optimization's main objectives are minimizing energy loss and fixed and variable costs, in addition to defining the optimal position of QWC, battery sizing, and length of power transmitters. A new method was developed to evaluate the number and distance of wireless charging segments required to permit the maximum number of EVs to pass and charge in a specific highway while they are running [26].

a. GAPS

In summary, the wireless charging of EVs has garnered significant attention as a promising technology to enhance the convenience and efficiency of EV charging. Several challenges impede the widespread adoption of wireless charging. High coupling frequencies can affect nearby electronic devices and require stringent shielding measures. In addition, the large size of transmitting coils (TCs) and receiving coils (RCs) can add considerable weight to the vehicle, affecting its efficiency and performance. High- frequency operations also generate heat, necessitating special cooling systems that increase the complexity and cost of the charging setup. Although the efficiency of TCs and RCs typically hovers around 80%, this figure often neglects the losses in the inverters and other associated components.

b. CONTRIBUTION

This paper aims to address the challenges in WPT for EVs by focusing on optimal coupling frequency and coil design to balance efficiency while minimizing EMI and heat generation. The authors propose a novel coil design and adaptive hardware to improve power transfer efficiency (PTE) in magnetic resonant coupling WPT and mitigate coil misalignment, a crucial roadblock in the acceptance of WPT for EVs.

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A methodology was introduced to arrange and design lanes and roadside facilities to operate EVs. The TC RC compensation circuit and high-frequency inverters/converters were optimized using the partial differential equation toolbox (pdetool) to achieve the highest WPT efficiency. In addition, the integration of wireless charging systems with smart grid technology was explored to optimize energy distribution and reduce peak load issues.

This paper proposes multi-segmented transmitters for the DWC of EVs integrated with adaptive renewable photovoltaic (PV) units along the EV road and a battery system with the utility main grid as backup. The required PV array capacity station battery size and inverters/converters were designed, ensuring maximum power point tracking (MPPT). A control methodology for the operation of PV units, station batteries, and the main grid was established. To validate the proposed system, it was applied to two scenarios: charging one running EV battery (EVB) at three different speeds and simultaneously charging two EVBs at the same speed over a 1 km stretch for 50 kW, achieving a total distance of 500 km. The results confirm the effectiveness of the proposed system demonstrating significant advancements in WPT for EVs. The contribution of the paper can be concluded as follows:

i. The development of a novel coil design and adaptive hardware for improved PTE and coil misalignment mitigation in WPT;
ii. The design of multi-segmented transmitters for DWC integrated with adaptive renewable PV units and a battery system;
iii. The introduction of a methodology for arranging and designing roadside lanes and running EV facilities;
iv. The optimization of the TC RC compensation circuits and high-frequency inverters/converters using pdetool;
v. The establishment of a control methodology for PV units station batteries and the main grid;
vi. The validation of the proposed system through practical application and analysis demonstrating its effectiveness in real-world scenarios.
vii. To validate the results, a wireless EV charging prototype using OPAL-RT 4510, OPAL-RT, Montreal, QC, Canada was created and integrated with the simulation MATLAB Simulink Software 2022 with WPT technology. The results confirmed the effectiveness of the proposed DWC system and could reliably transfer power to the moving EVs with high efficiency.

III. CONCLUSION

This manuscript presented a new technique for dynamically charging EVs running along a lane supplied mainly by adaptive renewable PV units supported by batteries and backed up by the main electric network. TCs and RCs were designed via multiple segments of magnetic resonant coupling distributed along the lane to obtain the best power transfer efficiency. The required PV array unit sizing, station battery sizing, EVB sizing, and the resonant frequency were designed. To verify the proposed strategy, it was applied to simultaneously charge EVs for 50 kW for a lane with 1 km as a sample and to satisfy a 500 km cutting distance at optimum EV operation. The best number of turns of TC and RC were 6.25 turns generated by pdetool with a 0.05 mm inner radius and 0.15 mm outer radius. The obtained best resonant frequency was 29.5 kHz with a reactance of 2200 ohms. The maximum WPT efficiency was achieved at the resonant frequency. The required PV unit was calculated as 56 cells; seven units were connected in series as one string, and eight strings were connected in parallel to produce 300 VDC. The station batteries were calculated as 12v 260AH each. The operation of the proposed system was tested using two cases: one with the EV running at three different speeds (45, 60, and 75 km/h) and the second by charging two EVs simultaneously running at 45 km/h. The behavior of roadside parameters was analyzed, which ensured the effectiveness of the proposed system. The EVB was charged with about 3.6% along a lane of 1 km with a car speed of 45 km/h. It should be noted that this can be increased by increasing lane distance and/or by increasing the TC and RC, which will be our future research challenge. Finally, experimental validation was employed and the integration of renewable energy sources ensured that the system operated sustainably, offering a scalable and cost-effective solution for future EV infrastructure. Future work will focus on extending the charging lane distance, improving coil arrangements, and enhancing system efficiency while reducing operational costs.

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