Dynamic Induction Charging for EV

[1]Santhini C,[2] Kumaraguru G, [3]Manju Shree KNB, [4]Pavithra N, [5]Prem SV
[1]Assistant Professor/ECE ,[2,3,4,5]UG Student
Department of Electronics and Communication Engineering,
Velalar College of Engineering and Technology,
Thindal, Erode-638012, Tamil Nadu, India.

ABSTRACT–The introduction of electric vehicles has significantly impacted the automobile sector, offering a cost-efficient and sustainable solution for energy consumption while mitigating pollution. Transitioning from conventional to electric vehicles necessitates the establishment of an accessible and robust charging infrastructure network. This project proposes an innovative charging approach for electric vehicles, utilizing wireless power transfer through inductive power transfer technology based on electromagnetic induction principles. The system's implementation involves interfacing components such as transmission and receiving coils, along with power electronic devices forming the transmission and receiving circuit. In practical road implementation, specially designed roads with energized coils buried underneath are required. Electric vehicles typically have longer charging times compared to conventional vehicles, and this method aims to alleviate this constraint, envisioning a future where vehicles can charge without stopping or searching for resources. A prototype of the proposed charging method was developed to simulate and analyze battery charging rates and efficiency, providing insights into its effectiveness compared to existing solutions.

1.INTRODUCTION

In the past decade, the ongoing climatic conditions have spurred significant research and development in the field of electric vehicles. The escalating global warming concerns have prompted a heightened awareness among people, compelling them to consider the switch to electric vehicles. The substantial wait times at traditional charging stations have driven the exploration of on-road charging solutions during vehicle operation. While electric vehicles serve as a viable alternative, further advancements in their charging systems are imperative to establish them as the primary choice for transportation.

To achieve this goal, the development of dynamic charging systems is crucial. These systems boast enhanced reliability, user-friendliness, and time efficiency. Moreover, they enable reductions in battery size and improvements in overall range. Implementation of such charging systems extends beyond conventional charging stations and can be integrated into travel routes, traffic signals, and bus stations.

A recent survey conducted by the International Energy Agency forecasts a substantial growth in the adoption of electric vehicles, projecting an increase from 3 million to 25 million by the year 2030. This represents nearly a 41-fold increase from the current figures, driven by the rising demand for fossil fuel alternatives and escalating pollution concerns. Major internal combustion engine car manufacturers, including Ford and General Motors (GM), are gradually shifting their focus toward electric vehicles in response to this trend. The market and consumers are seeking more affordable personal transportation options, and governments are actively supporting electric vehicles through policy initiatives.

Considering these factors, it becomes evident that electric cars will soon become a ubiquitous sight on roads worldwide.

Fig 1 A practical example of wireless charging of lane in UK.

1.1 PLUG IN V-2G AND WIRELESS V-2G

The implementation of Plug-in Vehicle-to-Grid (V2G) technology for electric vehicles involves the utilization of a bi-directional charger, facilitating the seamless transition between the home and grid networks. The electric vehicle is charged through the AC socket, and to generate the necessary DC source, the AC power is converted into DC. The resulting DC current from the converter is then directed to the vehicle's battery through the Battery Management System (BMS) and other associated converters.

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Fig 1.1 Plug-In V2G

Fig 1.2 Wireless V2G

The fundamental operational principle of wireless charging closely resembles the functioning of a transformer. The wireless charging system comprises the transmitter and the receiver coils embedded with AC-DC and DC-AC converters. The AC mains from the grid undergoes conversion into high-frequency AC, which is then transmitted through the transmitter coil. This process generates an alternating magnetic field, cutting across the receiver coil and inducing the production of AC power output in the receiver coil.

An essential consideration for efficient wireless charging is the maintenance of resonant frequency between the transmitter and receiver coils. To uphold resonant frequencies, compensation networks are integrated on both sides of the system. The AC power at the receiver side undergoes rectification and filtration to yield stable DC, subsequently utilized for battery charging through the Battery Management System (BMS).

2. LITERATURE SURVEY

An electric vehicle is propelled by one or more electric or traction motors. It can draw electricity from an external power source using a collector system or be equipped with batteries, solar panels, fuel cells, or a generator fueled by various sources. The development of electric vehicles dates back to the mid-19th century when electricity emerged as a primary means of propulsion for motor vehicles, providing unprecedented levels of comfort and ease of use compared to gasoline automobiles of that era. Although internal combustion engines dominated automotive propulsion for nearly a century, electric propulsion remained prevalent in trains and smaller vehicles.

Commonly referred to as "electric vehicles," these cars have experienced a resurgence in the 21st century, driven by technological advancements, a greater focus on renewable energy, and the desire to reduce transportation's impact on climate change and environmental challenges. Electric cars, often recognized as a top 100 modern climate change solution, incorporate wireless charging technology. Lithium-ion batteries, abbreviated as Li-Ion or LIB, are typically employed in electric cars. These batteries offer superior energy densities, longer cycle lives, and higher power densities compared to many other types. However, challenges such as safety concerns, durability, and heat deterioration persist. To optimize performance and safety, it is essential to operate Li-ion batteries within acceptable voltage and temperature limits.

Reducing the overall cost of electric vehicles involves enhancing battery life, and one method is to operate specific portions of the battery cells at a time, alternating between them. In the past, certain electric vehicles, including those manufactured by General Motors, utilized nickel-metal hybrid battery cells, which faced challenges due to self-discharge in heat and patent ownership by Chevron. Presently, lithium-ion batteries have become the most prevalent choice in electric cars, despite their initial high cost. The continuous reduction in the cost of lithium-ion batteries contributes to the overall affordability of electric cars.

3. EXISTING SYSTEM

STATIC AND DYNAMIC WIRELESS CHARGING

Wireless charging system of an electric vehicle charges the vehicle by the electromagnetic field to transfer the energy. This methodology of charging the electric vehicle can be classified into the following two categories:

1. Static Wireless charging.
2. Dynamic Wireless charging.

3.1 STATIC WIRELESS CHARGING

In this wireless charging system type, vehicle batteries can autonomously charge while the vehicle is parked in a static mode. The transmitter, which houses the primary coil, is installed underground, accompanied by additional power converters and circuitry. A very high-frequency AC is transmitted from transmitter coil. The receiver coil, enclosed with the secondary coil, is mounted on the vehicle's underside to capture the AC. The received energy undergoes AC to DC conversion using a power converter and is then transferred to the battery bank. To enhance safety, the receiver coil is equipped with a battery management system (BMS) and power control, incorporating a wireless communication network for receiving feedback from the primary side.

This wireless charging concept is particularly well-suited for mass transit applications, applicable in parking areas at shopping malls, garages, and commercial buildings. Implementation of this system involves installing an automatic guidance system in the vehicle to assist the driver in aligning the vehicle directly above the primary charging pad. The transmitter at the charging station and the vehicle's receiver coil can exchange the data using an inductive link or through a short-range communication methods. This feature enables charging stations to adjust the charging procedure based on the battery condition and driver preferences. The duration of the electric vehicle charging depends on the charging pad size, power supply level, and the distance (air gap) between the transmitter and the receiver. The approximate distance between the transmitter and the receiver coil is 150-300mm.

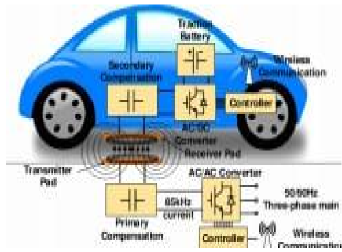

Fig 3.1 Typical structure of Static Wireless Electric Vehicle Charging System.

4. PROPOSED WORK

4.1 DYNAMIC WIRELESS CHARGING

In static wireless charging, it is imperative for the vehicle to have a sufficient charge before initiating the charging process. Consequently, larger batteries are necessary to ensure a continuous power supply to the vehicle. However, the use of larger batteries leads to system inefficiencies. The evolution of wireless charging has inspired researchers to explore dynamic wireless vehicle charging [13]. In the particular wireless charging system, the battery size is minimized, and the vehicles are charged while in motion. The transmitter is encapsulated within the primary charging pad installed beneath the concrete of the road along the pathway, emitting an high-frequency AC along with its corresponding circuitries. Concurrently, the receiver, equipped with a secondary coil, is positioned beneath the front of the vehicle. It incorporates a power converter and a battery management system that transforms high-frequency AC into DC, subsequently charging the battery bank.

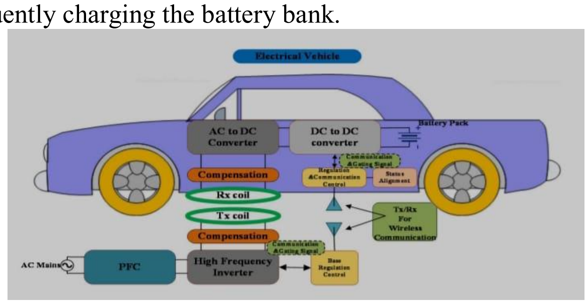

Fig 4. 1 An illustration of dynamic Wireless charging concept.

But the primary charging pad which is installed on the vehicle moving path, can be classified into two categories:

1. Lumped charging pad (Single coil design)
2. Segment charging pad (Multiple coil design)

4.1.1 LUMPED CHARGING PAD

In a lumped charging pad, a singular winding coil serves as the primary coil on the transmitter side. This method is primarily employed for static wireless charging, as any displacement can alter the mutual inductance between the primary and secondary coils, leading to deviations in magnetic flux. In dynamic charging scenarios, a control strategy becomes essential to rectify flux deflections.

The lumped charging approach involves fewer power converters and controllers. However, this reduction in components limits the power transfer capability.

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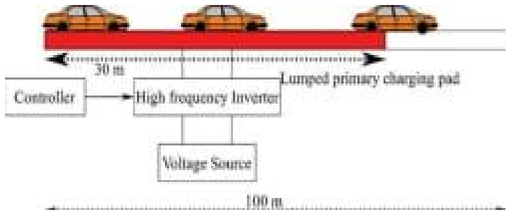

Fig 4.1.1 Block Diagram of Lumped Charging Pad.

4.1.2 SEGMENT CHARGING PAD

In the charging pad segment, the primary coil winding is partitioned into segments and strategically placed along the pavement for efficient power transfer. Each segment activates as the vehicle passes over it, ensuring that the remaining, non-energized segments remain in an off state, minimizing power loss. However, a drawback of this method is the utilization of individual inverters and controllers for each segment, leading to increased system complexity and manufacturing costs. As the vehicle traverse the pavement, there is a risk of misalignment between the transmitter and the receiving pads, impacting overall performance of the system. To address this issue, various control methods must be devised.

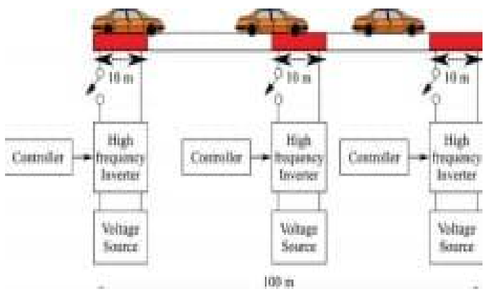

Fig 4.1.2 Block Diagram of Segment Charging Pad.

PERFORMANCE EVALUATION

We have achieved successful wireless charging of electric vehicles (EVs) using renewable energy grids. The experiment demonstrated a remarkable efficiency of 90% within a distance range of 125-175mm, utilizing a power output of 20KW. Notably, as the distance increases, there is a reduction in voltage. The experiment involved coils wound for several turns in both the primary and secondary components.

However, it is crucial to note that the alignment of the primary and secondary coils plays a pivotal role in the charging process. In cases where proper alignment is not maintained, there is an observable increase in the charging time for the vehicle's battery.

6. CONCLUSION

Wireless charging for electric vehicles holds the potential to revolutionize the automotive industry's road transportation. As electric vehicle technology advances, wireless charging techniques are anticipated to see significant growth in the next decade. The primary focus of this paper is to provide an overview of various wireless charging techniques, with inductive wireless transfer emerging as the most promising method. The paper also delves into the applications of both static and dynamic wireless charging, emphasizing the crucial role of the battery in electric vehicles.

Specifically, the size of the battery is influenced by wireless charging techniques, leading to a reduction in the overall cost of electric vehicles. This impact on battery size results in faster charging times for electric vehicle batteries, previously known to require a substantial amount of time to reach their rated capacity. However, the winning combination in wireless charging for electric vehicles lies in the simplicity, minimal driver intervention, and, most importantly, high power transfer efficiency.

As advancements continue, these key features consistently prove to be decisive factors, positioning wireless charging as a compelling solution for electric vehicles.

7. RESULT

Wireless charging for electric vehicles, particularly inductive wireless transfer, is poised to revolutionize road transportation by reducing battery size, cutting costs, and significantly improving charging times. This technology's simplicity, minimal driver intervention, and high power transfer efficiency make it a compelling and decisive solution for the evolving electric vehicle landscape.

8. FUTURE SCOPE

The future scope for wireless charging in electric vehicles appears promising, with ongoing advancements likely to enhance efficiency and convenience. Anticipated developments include further optimization of inductive wireless transfer methods, potentially leading to even faster charging times and increased power transfer efficiency. As technology progresses, the integration of wireless charging infrastructure into roads and parking spaces could become more widespread, bolstering the overall adoption of electric vehicles. Additionally, ongoing research may address potential challenges, such as standardization and compatibility issues, further solidifying wireless charging as a convenient and viable solution for the evolving electric vehicle landscape.

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