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Electric Vehicle Charging Station Types and Infrastructure

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A B S T R A C T

Electric vehicle charging refers to the process of supplying electrical energy to recharge the batteries of electric vehicles.

The implementation of electric vehicle charging involves the installation of charging infrastructure, which includes charging stations,

power management systems, and communication networks. The rapid growth of electric vehicles in recent years has led to an increased demand for

charging infrastructure, particularly in urban areas and along highways. The implementation of electric vehicle charging infrastructure requires careful planning and coordination among various stakeholders, including automakers, charging station manufacturers, utilities, and government agencies. The location of charging stations should be strategically planned to ensure that they are accessible and conveniently located for electric vehicle drivers. The power management system should be designed to balance the energy demand of the charging stations with the available power supply from the grid, to prevent overloading and blackouts.

Keywords: Electric Vehicle, Charging pads, Infrastructure.

1. Introduction

Electric vehicles are becoming increasingly popular as a way to reduce carbon emissions and promote sustainable transportation. However, one of the main challenges for EV owners is the need to regularly charge their vehicles, which can be inconvenient and time-consuming. Wireless electric vehicle charging (WEVC) is an emerging technology that promises to make charging EVs more convenient and efficient. Instead of plugging in their vehicles to a charging station, drivers need to park their EV over a wireless charging pad, and the charging process begins automatically. There are several types of wireless electric vehicle charging technologies available, each with its own advantages and disadvantages. These include inductive charging, conductive charging, resonant charging, and microwave charging. In this context, it's important to have a clear understanding of the various types of WEVC available, so that infrastructure planners and EV owners can make informed decisions about which technology to use for their charging needs. This could involve considering factors such as efficiency, cost, convenience, and safety. Overall, the development and deployment of WEVC technology has the potential to greatly improve the adoption and use of electric vehicles, by providing more convenient and efficient charging options for drivers.

1.1 Types of charging

There are several types of wireless electric vehicle (EV) charging technologies available, each with its own advantages and disadvantages. Here are a few examples:

Inductive charging: Inductive charging is most commonly used wireless charging technologies for EVs. It uses an electromagnetic field to transfer energy between two coils, one located in the charging pad on the ground and the other in the EV's chassis or frame. Inductive charging is easy to implement and requires minimal infrastructure, but it can be less efficient than other charging methods.

Conductive charging: This technology is similar to inductive charging but uses a physical connection between the charging pad and the EV's chassis. This is done using a conductive plate or cable. Conductive charging is generally faster and more efficient than inductive charging, but it requires more infrastructure and can be less convenient for drivers.

Resonant charging: Resonant charging uses a resonant magnetic field to transfer energy between the charging pad and the EV. This technology allows for greater distance between the charging pad and the EV, making it more convenient for drivers. Resonant charging can also be more efficient than inductive charging, but it requires more complex infrastructure.

Microwave charging: Microwave charging is a newer wireless charging technology that uses microwave radiation to transfer energy to the EV. This technology is still in the early stages of development and has not yet been widely adopted for commercial use. Microwave charging has the potential to be faster and more efficient than other charging methods, but it requires significant infrastructure and safety concerns related to radiation exposure must be addressed.

1.1.1 Inductive charging

Inductive charging which is also known as magnetic induction charging, is a type of wireless static electric vehicle charging technology.

It uses an electromagnetic field to transfer energy between a charging pad which is on the ground and the coil in the electric vehicles chassis/hood. This technology is based on the principle of electromagnetic induction. In an inductive charging system, the charging pad contains a coil of wire that is connected to a power source, typically an AC power supply. When an electric current flows through the coil, it creates a magnetic field around the pad. When the EV is parked over the charging pad, a second coil in the undercarriage of the vehicle, also known as a pickup coil, is positioned over the charging pad. As the two coils come into proximity, the magnetic field induces an electric current in the pickup coil, which can be used to charge the EV's battery.

Inductive charging is relatively easy to implement and requires minimal infrastructure, making it one of the most commonly used wireless charging technologies for EVs. The technology has been used in a variety of applications, including consumer electronics (such as electric toothbrushes), medical devices (such as implantable pacemakers), and industrial equipment (such as electric forklifts).

In the context of EV charging, inductive charging can provide a convenient and efficient alternative to traditional plug-in charging stations. For example, some public charging stations have installed inductive charging pads in the parking spots, allowing EV owners to simply park their vehicles over the pad and begin charging automatically.

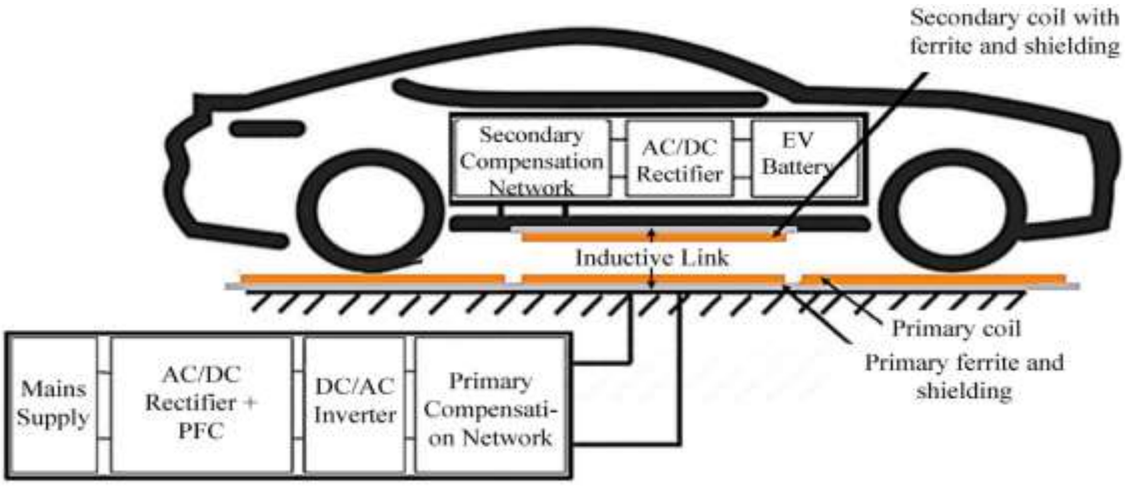

Fig 1. Inductive EV wireless charging system

The block diagram of a typical inductive EV wireless charging system is shown in Figure 1, following the standardized stationary wireless EV chargers model presented in the SAE J2954 Standard. This block diagram consists of several blocks that make up the wireless power transfer system. Starting from the primary side, electrical power from the mains supply is first rectified into a DC voltage to maximize its real power using an AC/DC rectifier and a power factor correction circuit (PFC). This DC signal is then input into a high-frequency inverter to be up-converted to the operating frequency of interest. Compensation networks are then required to help operate the inductive link in resonance conditions. On the secondary side, an AC–DC rectifier is utilized after the LCC compensation, in order to convert the coupled AC power to DC power that can charge the EV battery. Between the rectifier and the battery, a DC/DC converter may be used to aid in the output power control process.

The design of the complete LCC–LCC-compensated wireless charging system involves the following key stages:

Definition of the charging lane and EV specifications.

Setting the energy design objective as per (18) using estimated Econ Design and FEM simulations of the inductive link to maximize FoM and improve misalignment tolerance.

Circuit-level design and simulations of the DWPT system to achieve the power, efficiency and misalignment tolerance objectives.

Following the analysis presented an optimized DWPT system design maximizes the power transferred at different misalignment conditions while maintaining a satisfactory power transfer efficiency. For this work, the minimum allowed AC–AC power transfer efficiency was set to 90%.

The vehicle should be parked in a way that the two coils are aligned correctly to achieve maximum power transfer efficiency. Recent developments inIPT technology allow a certain degree of misalignments making it more feasible in practical implementations. The air gap between the two coils is another factor that affects the amount of power that could be transferred and the efficiency. The current state of technology allows up to 100 kW to be transferred with an air gap of 125 mm. This type of charging is suitable for home garages, shopping malls, and car parks, where the vehicle is being parked for sufficiently long time. The solution for road integration of the inductive system is The general design of the primary coils that will be embedded in the pavement. The coil block consists of a rectangular frame, supporting the copper cable inductive loops, the ferrite plates placed below the loops, and also the capacitors, located right next to the coils.

The ferrite is used to channelize the magnetic fields up towards the car. This frame has a hollow center, to reduce the quantity of materials, and facilitate embedding in pavement materials. The frame is filled with a dielectric resin, in order to protect the coils and capacitors, and ensure water tightness. The plastic materials selected for the coil block need to present good insulating properties, a good imperviousness, in case of rain and combined presence of cracks in the road, and also a good resistance to loading and to temperature (around 160 °C), to resist to the construction of the pavement.

1.1.2 Conductive Charging

Conductive charging, also known as plug-in charging, is a method of charging electric vehicles (EVs) that involves physically plugging the vehicle into an external power source. This is achieved through a charging cable that connects the EV to a charging station or a power outlet. Conductive charging is the most common form of charging for EVs, and it can be performed at home, at work, or in public charging stations. There are two types of conductive charging: AC (alternating current) charging and DC (direct current) charging. AC charging is the slowest form of charging, typically taking several hours to fully charge an EV battery. DC charging, on the other hand, is much faster and can charge an EV battery to 80% capacity in as little as 30 minutes.AC charging is commonly used for overnight charging at home or at work. It typically requires a charging cable with a standard Type 2 connector that plugs into the EV's charging port. AC charging stations can deliver power at different rates, ranging from 3.7 kW to 22 kW, depending on the station's power output and the EV's onboard charger. DC charging is commonly used in public charging stations along highways and major routes where drivers need to quickly charge their vehicles. DC charging requires a special charging station with a dedicated DC connector, such as the CHAdeMO or CCS (Combined Charging System) connector. These charging stations can deliver power at rates of up to 350 kW, allowing EVs to charge much faster than with AC charging. Examples of conductive charging systems include the Tesla Supercharger, which is a network of DC fast-charging stations that are exclusively available to Tesla drivers. The CCS connector is also widely used in Europe and North America, and many automakers, including Audi, BMW, Mercedes-Benz, and Volkswagen, have adopted the CCS standard for their EVs. In the following figure 2 the place and how much time required to charge a EV is shown.

Here are the steps involved in implementing conductive charging for electric vehicles along with some examples:

Site selection: The first step in implementing conductive charging for electric vehicles is to select suitable locations for charging stations. Charging stations should be conveniently located near areas with high electric vehicle traffic such as parking lots, shopping centers, and major highways.

Example: The city of Los Angeles has installed over 1,000 public charging stations across the city, including locations such as public libraries, parks, and recreation centers.

Charging station installation: Once the site has been selected, charging stations need to be installed. This involves the installation of charging units, charging cables, and supporting infrastructure such as electrical panels, transformers, and communication systems.

Example: The ChargePoint network is one of the largest charging networks in the world, with over 115,000 charging stations installed in more than 55 countries.

Power management system: A power management system is required to manage the energy demand of the charging stations and ensure that the power supply from the grid is not overloaded. This involves the use of smart charging technology that can regulate the charging rate of each vehicle based on the available power supply and the vehicle's battery capacity.

Example: Enel X, a global energy company, provides a range of smart charging solutions that can help utilities manage the energy demand of electric vehicle charging stations.

Communication networks: Communication networks are required to connect the charging stations to the internet and provide real-time information about the status of the charging station, availability, and pricing.

Example: The Greenlots network provides an open platform for managing electric vehicle charging infrastructure, including real-time monitoring and control of charging stations.

1.1.3Resonant Charging

Resonant charging can be used in vehicle charging stations to enable wireless charging of electric vehicles. This technology, also known as Wireless Power Transfer (WPT), allows for the transfer of electrical energy from the charging station to the electric vehicle without the need for cables or plugs. In a resonant charging system for electric vehicles, the charging station contains a resonant circuit that is tuned to a specific frequency. This resonant circuit generates an electromagnetic field that is used to transfer energy wirelessly to the electric vehicle.

The electric vehicle is equipped with a receiver coil that is also tuned to the same frequency as the charging station. This receiver coil is located on the underside of the vehicle and is used to capture the electromagnetic field generated by the charging station. The captured energy is then converted to electrical power, which is used to recharge the vehicle's battery.

When the distance between receiver and transmitter increases, the magnetic coupling between the coils decreases. Systems with a low coupling factor have to operate at the resonant frequency of the receiver. This mode is called "resonant". The following figure 3 will show the working of resonant charging.

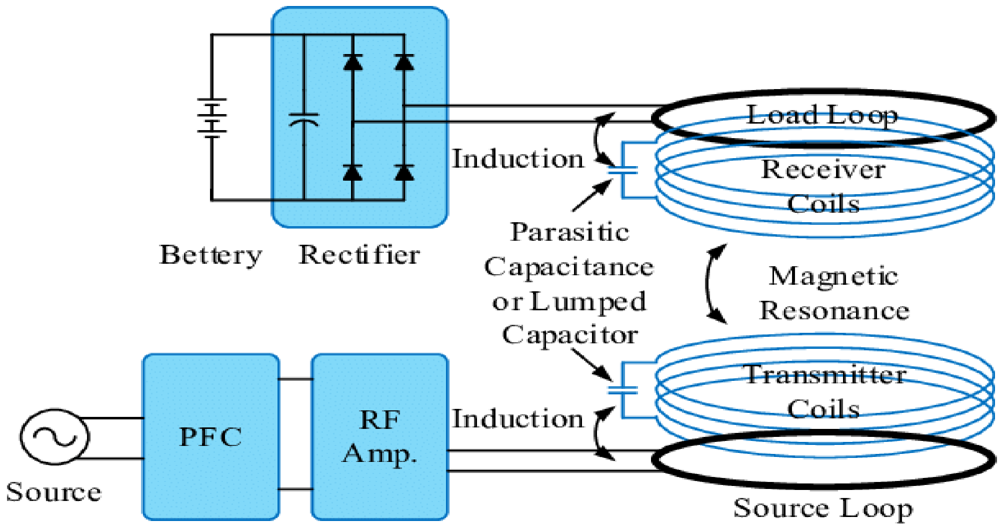

Fig 3. Resonant charging in EV

Resonant wireless charging offers significant user advantages that make it an enticing prospect for future technology.

Unlike inductive charging, resonant wireless power transfer does not require the transmitter and receiver to be physically touching,

instead permitting power transference within a flexible proximal distance from the transmitter. A resonant charge also allows for multiple devices of varying size and power requirements to be charged simultaneously. This flexibility and superior user convenience will prove increasingly

important as the number of wirelessly chargeable devices continues to expand.

1.1.4 Microwave charging

Microwave charging is a type of wireless power transfer (WPT) technology that uses microwaves to wirelessly transfer energy from a charging station to an electric vehicle. The process involves the use of a microwave generator in the charging station, which generates microwaves that are transmitted to the electric vehicle using an antenna. The electric vehicle is equipped with a receiver antenna that is designed to capture the microwave energy and convert it to electrical power, which is used to recharge the vehicle's battery. The receiver antenna is typically located on the underside of the vehicle, where it can be aligned with the charging station's transmitter antenna.

Microwave charging technology offers several potential benefits for electric vehicle charging, including:

1) Efficiency: Microwave charging technology can achieve high levels of efficiency, with minimal energy loss during the transfer process.

2) Flexibility: Unlike conductive charging, which requires physical contact between the charging station and the vehicle, microwave charging can be performed over a distance, allowing for greater flexibility in charging station placement and vehicle positioning.

3) Convenience: Microwave charging eliminates the need for cables or plugs, making it easier and more convenient to charge electric vehicles.

4)Safety: Microwave charging can be designed to be highly safe, with no exposed electrical conductors or high voltage connections.

One example of microwave charging technology is the Halo IPT system developed by Qualcomm. This system uses resonant magnetic coupling to transfer power wirelessly, and has been demonstrated in several electric vehicles, including the Halo Intercity EV and the London Taxi Company's TX5 electric taxi.

Another example is the WiTricity system, which uses magnetic resonance to transfer energy wirelessly between a charging pad on the ground and a receiver coil on the underside of the vehicle. WiTricity has partnered with several automotive manufacturers to develop wireless charging solutions for electric vehicles, including BMW, Toyota, and Nissan.

This technology is fairly new and imposes a lot of disadvantages like radiation exposure, efficiency issues and is still in development

Stage.

2. Applications for EV Charging

Electric vehicle charging has a wide range of applications, including:

Public charging: Public charging stations are located in public areas such as parking lots, shopping centers, and highway rest areas.

These charging stations are typically operated by charging network operators, and provide a convenient and accessible way for electric vehicle owners to recharge their vehicles while on the go.

Workplace charging: Workplace charging is becoming increasingly popular, as more employers recognize the benefits of offering charging facilities to their employees. Workplace charging stations can be installed in office buildings, parking lots, and other work-related areas, and can help promote electric vehicle use among employees.

Residential charging: Residential charging is the most common way for electric vehicle owners to recharge their vehicles. This involves installing a charging station at home, either using a standard electrical outlet or a dedicated charging unit. Residential charging provides a convenient and cost-effective way to recharge electric vehicles overnight.

Fleet charging: Fleet charging involves the use of charging infrastructure to recharge a fleet of electric vehicles, such as those used by delivery companies, taxi services, and other commercial operators. Fleet charging can help reduce operating costs and improve the environmental performance of these fleets.

Destination charging: Destination charging involves installing charging stations at hotels, resorts, and other tourist destinations. Destination charging can help attract electric vehicle owners to these locations, and provide a convenient and reliable way for them to recharge their vehicles while away from home.

3. Comparative

The results of this project performance on the wireless vehicle charging station are as follows:

Following practical investigation and theoretical analysis, the dependability and correctness of wireless charging were confirmed.\

Following figure 3 will give an representation of the applications of Electric Vehicle charging.

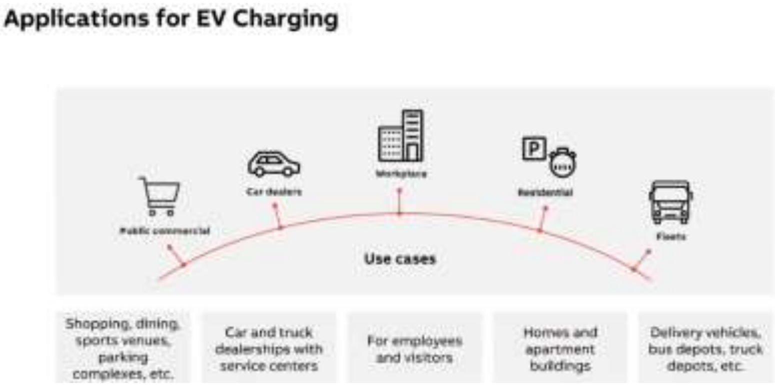

Fig 3. Applications for EV Charging.

4. Future scope

The global market for electric vehicles is growing rapidly, and wireless electric vehicle charging is expected to play an increasingly important role in the future. Here are some potential developments and advancements that could shape the future of wireless electric vehicle charging globally:

Standardization: Standardization is important to drive down costs and ensure compatibility between different systems. Efforts to establish global standards for wireless charging could help to accelerate its adoption. Improved efficiency: There will likely be continued efforts to improve the efficiency of wireless charging systems, reducing energy losses and minimizing the charging time required. Integration with smart grid technology: Wireless charging systems could be integrated with smart grid technology, allowing for more efficient use of renewable energy and reducing strain on the grid. Autonomous charging: As autonomous vehicles become more common, wireless charging could be integrated into the charging process, allowing vehicles to charge themselves without human intervention. Increased adoption of electric vehicles: As more electric vehicles are adopted globally, there will be a growing need for charging infrastructure. Wireless charging could offer a convenient and efficient solution, especially in urban areas. Collaboration between tech companies and automakers: Collaborations between tech companies and automakers could lead to innovative wireless charging solutions and accelerate the development and adoption of the technology.

References

https://www.researchgate.net/publication/334200391_A_Survey_on_Magnetic_Resonant_Coupling_Wireless_Power_Transfer_Technology_for_Electric_Vehicle_Charging

"Wireless charging technologies: fundamentals, standards, and network applications" by S. Ouyang et al. (2020)

Design and analysis of a wireless power transfer system for electric vehicles based on a class-E inverter" by X. Chen et al. (2019)

"A review of wireless power transfer for electric vehicles: pros and cons, key technologies, and challenges" by M. F. A. Rahman et al. (2018)

https://www.nrel.gov/docs/fy19osti/73772.pdf

https://www.mdpi.com/1996-1073/16/4/2057

https://www.sciencedirect.com/science/article/pii/S2666691X22000458

https://www.qualcomm.com/news/releases/2017/05/qualcomm-demonstrates-dynamic-electric-vehicle-charging

https://doi.org/10.1016/B978-0-12-811407-0.00038-6