

Charging the Future: Wireless Power for Electric Vehicles

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Abstract:

The better results of electric vehicles as compared to fuel vehicles is continuously leading to a growth in demand of EVs. Better quality in driving, less noise, more efficiency, less running cost and smooth operation of EVs is dominating all the drawbacks users were facing in fuel vehicles. EVs increasing adoption leads to a step towards reducing the greenhouse gases and environmental effects of traditional internal combustion engine vehicles.

One of the most important aspects of EV that caught many eyes in recent years is wireless charging. This paper provides a descriptive look into the working of wireless charging in EV. Later it will also be discussed how wireless charging will affect environment and living life positively as well as negatively along with a comparison on which is better charging method for EVs (wired or wireless) according to the present generation's needs.

This abstract serves as a brief introduction of wireless charging and its future aspects on the industry of EVs.

Keywords:

Wireless charging systems; Fossil fuels; Vandalism; Resonant electromagnetic induction; Inductive coupling; Static EV charging; Dynamic EV charging; High frequency converters.

Introduction:

The EV runs on a hybrid mode i.e., it can be fueled by fossil fuels as well as can use electricity from a battery as its source. The first electric vehicle was made in 1870s, however it was not until recent years that EVs started to rise in the market[1]. Due to better results of EVs as compared to traditional IC engine vehicles, whether it is zero emission, low running cost, reduced fuel cost, quiet and smooth operation, advanced technology and improved air quality, EVs have rose as a better option than fossil fuel vehicles. And thus subsequently, demand of EVs is increasing day by day.

As it is an electric vehicle, no doubt it would need a charging system. Although the wired charging is efficient and cheaper but the fact that wireless charging provides much better results can't be ignored. Wired charging comes with the issue of limited mobility as it requires physical connection to charging stations, high charging time, cable management, parking space accessibility, risk of damage, potential theft or vandalism, etc.

On the other hand, wireless charging has many advantages than wired charging including convenient as it eliminates the need for physical plugging, safety, durability, weather resistance, minimal human interventions, reduced maintenance and most importantly fast charging. Unfortunately, wireless charging is not as much available to the world as the EVs are. Plugless is the only company offering wireless charging for many of the EVs on the road today. The Plugless system covers nearly half the North American EV market and makes a wireless charging available today for more than a quarter million EV drivers in the US alone[2]. In the upcoming years the global wireless EV charging systems market is projected to exceed \$825 million by 2027. Thus, the wireless charging of EV will be available in more countries and hence it is important to have an introductory discussion about the wireless charging of EVs.

Working:

Resonant electromagnetic induction (also known as inductive charging) is used as the principle for charging EVs wirelessly. Just like the smart phones have a magnetic coil inside them that receives electricity from the charging pad's magnetic coil, similarly with a magnetic coil inside the charger that sends current to the magnetic coil on the car's underside, wireless charging in EVs works in the same way as wireless charging in smart phones. The complete procedure for wireless charging of EV takes place in the following manner:-

1. The wireless charging system contains a **Charging Pad** which is installed on a wall or in the ground and is connected to a power supply.
2. Another equipment is the **Receiving Pad** which contains a coil of wire and electronics and is mainly located on the underside of the EV.
3. When the EV is being parked over the wireless charging pad which is connected to an electrical power source generates an AC current field or **Electromagnetic Field**.
4. Now due to **Inductive Coupling** the AC current is induced in the coil (within the receiving pad on the vehicle) by the alternating magnetic field created by the charging pad.
5. The electronics withing the receiving pad of vehicle convert induced AC current into **DC current**. The DC power is used to charge the EV's battery.
6. The charging process is managed by the **Onboard Charger** of the vehicle.
7. Tasks like status update, ensuring safety and managing the charging process are done by the **Communication Protocols** that allow the charging pad and the vehicle to communicate are often included in the wireless charging systems of EVs.

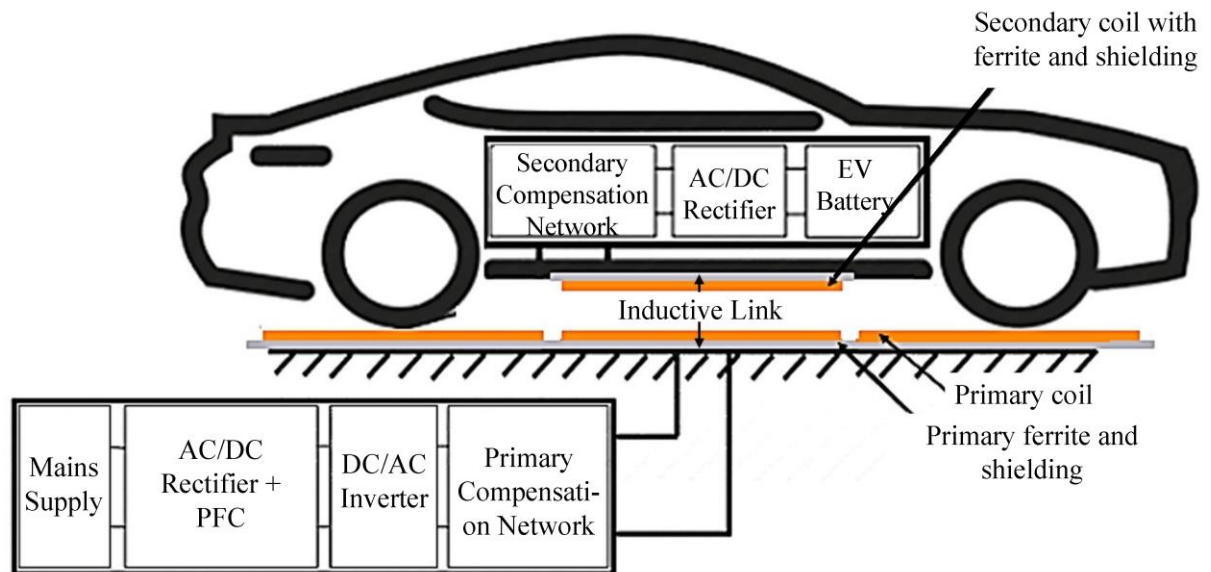


Fig: Design of a wireless EV charging system

Options for wireless charging an EV:

There are two options to charge an EV wirelessly:

- A. **Static EV charging:** In this type of charging the EV is not moving while charging. The EV is parked over installed wireless charging coil in the designated space either at home or office charging station.
- B. **Dynamic EV Charging:** In this type of charging the EV is not stationary while charging rather it is indeed moving and getting charged. However, it is recommended to operate this type of charging smoothly at 65mph, exceeding this speed limit might be dangerous. Obviously, this technology will be very costly and is long from getting to countries world-wide. The automaker Stellantis is already working on a solution to build wireless charging for EVs into certain roadways. In September 2021, the state of Michigan announced a partnership with Electreon to create the first wireless EV charging road in the U.S., a one-mile stretch in Detroit that will be available to the public when completed [4].

Benefits of wireless charging of EVs over wired charging:

1. **More convenience:** Wireless charging offers more convenience, it eliminates the need to physically plug and unplug a charging cable. Wireless charging is even more convenient when static charging and when dynamic charging becomes a reality the convenience will be unimaginable.
2. **No Need of Wires:** It is definitely the most important benefit of wireless EV charging. There is no risk of hazards due to wires and EV owners simply don't need to carry heavy charging cables.
3. **Saves Time:** Well wireless charging is indeed not faster than regular wired EV charging, it saves somewhat a little time by not having the driver to come out and plug in the charging and once dynamic charging becomes available, the amount of time saved on charging would again be unimaginable.

4. *Low Accident Risk:* Wired charging can be hazardous to the vehicle and its owner as over time cables can become damaged particularly in extreme heat and cold areas. Replacing damaged cables with new ones will be much costlier than having no need of wires at all.
5. *Durability and less maintenance:* Having fewer mobile parts in wireless charging than wired charging, wireless charging systems are usually designed to be more durable and hence they require less maintenance requirement.
6. *Flexibility:* It offers more flexibility in designing charging infrastructures including road embedded charging that can be deployed in various locations and configurations.
7. *Standardization:* Since industry standards for wireless charging are emerging, making it easier for various EV models to use the same charging infrastructure.

Cons of wireless charging of EVs:

1. *Efficiency:* There are more energy losses during wireless transfer of electricity, making it less efficient than traditional wired charging methods.
2. *Cost:* The wireless charging infrastructure comes with a high installation and maintenance cost which can abrupt the spread of wireless charging technology in future.
3. *Limited Range and Alignment Requirements:* Precise alignment between the charging pad and the vehicle's receiving pad is required to efficiently charge an EV wirelessly which can be challenging, especially for autonomous vehicles.
4. *Initial Investment:* A higher upfront costs when installing wireless charging systems may be faced by businesses and individuals, particularly in retrofitting existing infrastructure.
5. *Heat Generation:* The longevity of the battery and other components can be affected by wireless charging during charging process.
6. *Interference and Regulations:* Electromagnetic interference and regulatory considerations can be challenges for wireless charging deployment.
7. *Lower Charging Power:* In some cases, wireless charging may not provide the same high power levels as fast-charging stations, which can be a concern for EV owners looking for quick refueling.

Effect of Wireless Charging on Environment and Living Beings:

Positive Impacts:

1. *Noise Reduction:* Wireless charging systems are quieter than traditional refueling and wired charging methods resulting in reduction to noise pollution.
2. *Clean Energy Integration:* Wireless charging can be designed to prioritize charging during periods when renewable energy sources, like solar or wind, are abundant, reducing the carbon footprint of charging.
3. *Reduced Emissions:* By spreading the wireless charging more throughout the world, adoption of EVs can be increased which will result in reduction of greenhouse gases and air pollution as compared to IC engine vehicles.

Negative Impacts:

1. *Energy Efficiency:* Since the wireless transfer of electricity causes more losses as compared to wired charging, wireless charging is less energy-efficient than wired charging.
2. *Resource Use:* The manufacturing and disposal of wireless charging components may have environmental impacts related to resource extraction and waste disposal.

3. *Heat Generation*: The longevity of the battery and other vehicle components can be reduced by the heat generated from wireless charging during the charging process.
4. *Electromagnetic Fields*: The electromagnetic fields generated by wireless charging systems can raise concerns about potential health effects on living beings.

Comparison: Which charging is better according to present needs

Both wired and wireless charging options for EVs have their advantages and disadvantages. The choice between them depends on various factors, and what's considered "better" can vary based on individual preferences, use cases, and available technology.

Wired charging is more efficient, is cost effective, has higher charging rates and is widely available whereas wireless charging is more convenient, safe, has reduced wear and tear, is aesthetic. According to present time, where wireless charging is not available in almost every country and will be much costlier whenever it will be introduced to the global market, it can be said that wired charging is more economical and better option for most of the average EV user. Wireless charging technology is continuing to improve in terms of efficiency, charging speeds and cost effectiveness, making it more attractive. However, the decision completely depends on one's specific needs, charging habits and the available infrastructure in the area.

Below is a comparison between the wired and wireless charging of EVs in tabular format [5].

	Wired	Wireless
Authentication	<ul style="list-style-type: none"> • Reduced risk of unauthorized interference • User needs to input details to establish EV communication with the charging point 	<ul style="list-style-type: none"> • Requires small range to prevent snooping and unauthorized interference • Direct connection to EV is not required
EV to charging point	<ul style="list-style-type: none"> • Can be used for proximity detection (detecting the presence of the charging connector in order to prevent movement of the EV whilst connected to the charging point) • No problems regarding connection loss 	<ul style="list-style-type: none"> • Loss of connection during charging results in no control signal • Open to snooping or interference
Charging point to to DSO or supplier/aggregator	<ul style="list-style-type: none"> • May require installation of cables, implying high investment costs 	<ul style="list-style-type: none"> • Less installation required • Can use a mesh network to increase robustness

Major Players in the EV Wireless Charging Industry: The major current players in the wireless charging of EVs industry are not much but some of the major names include – Continental AG, Daihen Corporation, Delachaux Group, Electreon Inc., ELIX Wireless, HEVO Inc., InductEV, Mojo Mobility Inc., WAVE Inc., and WiTricity Corporation. These companies are continuously working and trying to improve the future of wireless charging in EVs as well as improving other features of EVs.

Conclusion:

In conclusion, this review paper given a brief overview of wireless charging for EVs. It is clear that wireless charging has made significant strides in past few years, providing many advantages, like convenience, reduced wear and tear and improved safety. Along with the improving technology, the efficiency and charging speeds of wireless systems are likely to improve.

On the other hand, it is important to consider that challenges remain, especially in terms of energy efficiency and infrastructure deployment. While wireless charging is undoubtedly more convenient, it is consequently less energy efficient than traditional plug-in charging. The cost of installation and running wireless infrastructure is also a barrier to widespread adoption.

As the global transition to electric mobility continues to gain momentum, while wireless charging may not completely replace wired charging, the role of wireless charging in shaping tomorrow's infrastructure can't be understand, as it serves as a valuable addition, especially in application where convenience and aesthetic play a significant role.

Further research and development are essential to address the remaining challenges and ensure that wireless charging systems become more energy efficient, cost effective and readily available. With these improvements, wireless charging has the potential to play a vital role in shaping a sustainable and convenient future for electric vehicle charging.

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