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Wireless Charging Control for Electric Vehicles

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Abstract: Wireless power transmission is a way to transmit power without a wire. Wireless power transmission helps connect areas where people do not have access to an adequate power source. Anyone can get clean and green wireless power. From now on, all devices will be connected to the power source wirelessly. Wireless charging for electric vehicles has been in development for several years before the widespread use of these vehicles. Today, wireless charging systems offer an efficient and flexible way to charge electric vehicles of several categories and different capacities from a common base source. Standardization work is well underway to ensure system compatibility between vehicles and locations. In this paper, we presented successful experimental experiments for wireless power transmission and the future scope of wireless power transmission in electric vehicles

Keywords: Wireless power transfer; Electric vehicle; Wireless charging; Environmental impact; Energy efficiency

I. INTRODUCTION

All over the world, electricity is sent from power stations to everywhere through cables. Wireless power transfer technology could potentially reduce or eliminate the need for wires and batteries. Wireless transmission helps power electrical devices where connecting wires is inconvenient, dangerous, or impossible. wireless power transmission technology reduces the use of wires made of copper and aluminum metal. The metals that make up electric wires will disappear in the future. Implementing wireless power transfer technology will reduce the use of electrical cables. In the future, we hope to develop wireless power transmission technology that can transmit power anywhere from a power plant without using cables. Self-driving vehicles are another compelling reason to adopt wireless charging. Wireless charging becomes more of a necessity than a convenience when a vehicle can drive itself to a charging station without the need for someone to plug it in. This paper provides an overview of the application of magnetic resonance-based wireless power transfer for charging electric vehicles. We provide an overview of the technology for this application, performance data from state-of-the-art systems, an overview of efforts to standardize the technology, and some challenges that remain for widespread adoption.

II. BATTERY STORAGE SYSTEM

In foreign countries, European and American are promoting the construction of electric vehicle charging facilities with direct or indirect preferential subsidy policies. By 2020, China is expected to construct more than 12,000 centralized charging and replacement power stations and more than 4.8 million decentralized charging piles to meet the charging demand of 5 million electric vehicles in China. It is self-evident that in the next few years, the global electric vehicles and supporting charging facilities will mushroom to usher in the golden age of their development. However, due to the aging of the charging line, the complexity of operation and the entanglement of the charging pile, the safety and user experience are greatly compromised in actual use.

Transition away from fossil fuel burning internal combustion engines has left somewhat of a gap between the high power demands of combustion engine applications and the power that battery technology is able to supply. Specifically in current electric vehicles, the size of the battery is frequently determined by the maximum power handling requirement, rather than the minimum range that vehicle must be capable of between charges, making this component of the vehicle the most expensive individual part. Furthermore, continued high power charging and discharging of batteries is known to reduce their life span from around a few thousand cycles, to only hundreds. Conversely, super capacitors are superb at high power handling, typically withstanding power loads up to 100times that of lithium based batteries, and importantly without damaging the unit or reducing its lifecycle, which is generally rated at a minimum of 500,000 cycles for existing commercial products.

III. NEED OF WIRELESS CHARGING SYSTEM

1) Charging process is simple and automatic.
2) It doesn't require any human input.
3) It is small in size and compact compared to a wired system.

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4) Compared to a wired system, it requires less space and can be installed underneath the surface.
5) As it does not have any contact, there are no exposed electric connections.
6) It can avoid electrocution risk typically arising from power cords.
7) Newer WPT designs are getting better in efficiency.

IV. WIRELESS POWER TRANSFER SYSTEM

Wireless power transfer (WPT), wireless power transmission, wireless energy transmission (WET), or electromagnetic power transfer is the transmission of electrical energy without wires as a physical link. In a wireless power transmission system, a transmitter device, driven by electric power from a power source, generates a time-varying electromagnetic field, which transmits power across space to a receiver device, which extracts power from the field and supplies it to an electrical load. The technology of wireless power transmission can eliminate the use of the wires and batteries, thus increasing the mobility, convenience, and safety of an electronic device for all users. Wireless power transfer is useful to power electrical devices where interconnecting wires are inconvenient, hazardous, or are not possible..

A. Advantages of Wireless power Transfer system

1) Charging process is simple and automatic;
2) It doesn't require any human input.
3) It is small in size and compact compared to a wired system.
4) Compared to a wired system, it requires less space and can be installed underneath the surface.
5) As it does not have any contact, there are no exposed electric connections.
6) It can avoid electrocution risk typically arising from power cords.
7) Newer WPT designs are getting better in efficiency.

V. PRINCIPLE OF OPERATION

A. Working Mechanism

Wireless EV charging is based on Inductive Power Transfer (IPT) technology, which transfers power between two coupled coils; a primary coil at a wireless charger is connected to the electrical grid, while a secondary coil is located at the EV such that there is a reasonably air gap between them.

In such near-field charging technique, a transmitting coil of the wireless charger produces a magnetic field that transfers energy via induction to a nearby receiving coil of the EV. Some fraction of the magnetic flux generated by the transmitting coil that penetrates the receiving coil contributes to the power transfer. And the transfer efficiency depends on the coupling between the coils and their quality factor.

Mainly, there are **two types** of IPT for the wireless charging:

1) Static IPT is deployed when the vehicle is spotted in a parking lot.
2) Dynamic or Quasi-dynamic IPTs are deployed when the vehicle is either on move or a brief stop at the traffic red light respectively.

It should be noted that as the wired charging would be impossible while the EVs are in the motion, thus the WPT would be the only solution for the dynamic or quasi-dynamic charging.

1) Stationary Charging

Wireless inductive EV charging transfers alternating current (AC) through a coil in the charging plate via a magnetic field to the car's inductive 'pick-up'.

A voltage converter in the car then turns the alternating current into direct current (DC) with, which in turn charges the battery pack.

A charging pad sits on the ground, connected to a wall-mounted power adapter. The car is parked over it. On the backside of the car there is a receiver when charger detects the receiver within range, it automatically starts charging**.**

2) Dynamically Charging

Similar to the Stationary charging system the EV's are charged through the resonant coil but, here the vehicle can be charged while moving on the road. A Charging lane will be provided alongside the roads where the people can move to charge their vehicles while driving.

Dynamically charging system cannot be provided through wired system and their by the WPTs is required to provide this method of charging.

Every electric bus has a wireless charging receiver. According to Figure Wireless chargers are embedded in the hard surface of a road or under the road surface at regular intervals. When the bus is stopped no need to plug in or no need to connect with wireless chargers. It will automatically have charged. It's a motion bus. These kinds of buses are already tested in the UK, Italy, the Netherlands, and South Korea.

B. *Coil design for dynamic charging systems*

Dynamic charging systems can help further reduce the size of the battery pack on a vehicle and offer the vehicle more convenience and flexibility. There are two kinds of coil structure used in dynamic charging systems for EVs. The major difference between the two coil structures is on the primary coil side: one uses the single-coil design (a long track loop that can still be considered as a coil because of its working principle) shown in Figure 4 (a) and the other employs the segmented-coil design shown in Figure 4 (b).

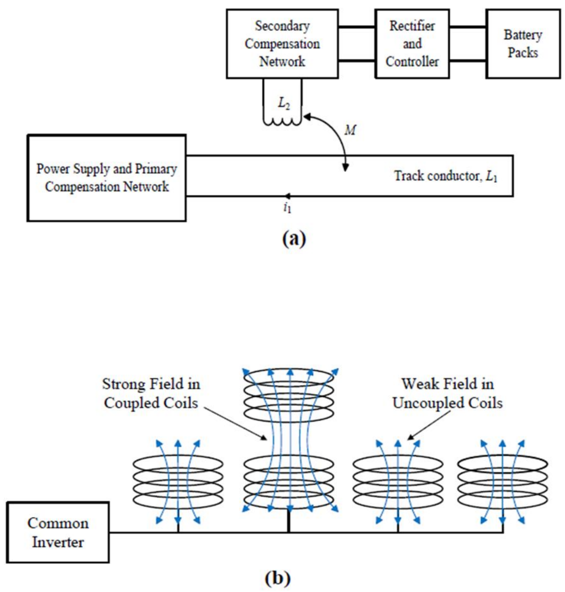

Figure 1. Typical coil configurations for dynamic charging systems with (a) single-coil design for primary coil and (b) segmented-coil design for primary coil. $L1$ = track conductor; $L2$ = receiver coils; M = mutual inductance between $L1$ and $L2$; $i1$ = the (excitation) current in the primary coil.

In a single-coil design for the primary coil, the drawback is that when the track conductor ($L1$) is not covered by the receiver coils ($L2$), it not only generates a redundant EMF, but also results in low efficiency of the whole system. To overcome this problem, researchers from Korea Advanced Institute of Science and Technology (KAIST) proposed a new cross-segmented power supply rail, in which two pairs of power cables were wound in I-type ferrites. By controlling the current direction in the power cables, they were able to power the rails on and off selectively. In addition, the power cables were wound in twisted pairs, which greatly reduced EMF issues. In order to further improve system performance, they introduced a new track rail wound in ultra slim S-type ferrite cores. The minimal amount of power cables and ferrite cores were employed, reducing the total construction cost. This design had better misalignment tolerance and lower EMF than the rail wound in the I-type cores. Researchers from North Carolina State University (NCSU) used a segmented-coil design for the primary coil and employed the reflected reactance from the secondary coil to self-increase the magnetic field strength in the coupled section between the transmitter and the receiver . As shown in Figure 1 (b), the magnetic field is strong in the coupled coils and weak in the uncoupled coils. This not only simplifies the control method, but also improves the system efficiency. However, speed-dependent pulsating power is common in this coil design, resulting from the moving vehicle passing over a sequence of coils that causes the alignment and straddling of magnetic fields. The power pulsation can shorten the battery service life and is detrimental to the power grid. Researchers from Oak Ridge National Laboratory (ORNL) had an innovative solution that utilized electrochemical capacitors to smooth power pulsation on both the grid side and vehicle side.

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They demonstrated that the active parallel combination of lithium-capacitor (LiC) energy storage and the grid supply resulted in very uniform power draw from the grid, where active parallel means that a high power, bidirectional controllable power flow, DC-DC converter interfaces the LiCs to the DC input of the high-frequency inverter. Furthermore, they installed passive parallel LiCs in vehicle and successfully smoothed the battery currents.

C. Types of EVWCS

Based on operating Techniques EVWCS can be classified into four types

1) Capacitive Wireless Charging System (CWCS)

Wireless transfer of energy between transmitter and receiver is accomplished by means of displacement current caused by the variation of electric field. Instead of magnets or coils as transmitter and receiver, coupling capacitors are used here for wireless transmission of power. The AC voltage first supplied to power factor correction circuit to improve efficiency and to maintain the voltage levels and to reduce the losses while transmitting the power. Then it is supplied to an H-bridge for the High-frequency AC voltage generation and this high frequency AC is applied to transmitting plate which causes the development of oscillating electric field that causes displacement current at receiver plate by means of electro static induction.

The AC Voltage at receiver side is converted to DC to feed the battery through BMS by rectifier and filter circuits. Frequency, voltage, size of coupling capacitors and air-gap between transmitter and receiver affects the amount of power transferred. It’s operating frequency is between 100 to 600 KHz.

2) Permanent Magnet Gear Wireless Charging System (PMWC)

Here transmitter and receiver each consist of armature winding and synchronized permanent magnets inside the winding. At transmitter side operation is similar to motor operation. When we apply the AC current to transmitter winding it induces mechanical torque on transmitter magnet causes it's rotation. Due to the magnetic interaction change in transmitter, PM field causes torque on receiver PM which results it's rotation in synchronous with transmitter magnet. Now change in receiver permanent magnetic field causes the AC current production in winding i.e, receiver acts as generator as mechanical power input to the receiver PM converted into electrical output at receiver winding. The coupling of rotating permanent magnets is referred as **magnetic gear**. The generated AC power at receiver side fed to the battery after rectifying and filtering through power converters.

3) Inductive Wireless Charging System (IWC)

The basic principle of IWC is Faraday's law of induction. Here wireless transmission of power is achieved by mutual induction of magnetic field between transmitter and receiver coil. When the main AC supply applied to the transmitter coil, it creates AC magnetic field that passes through receiver coil and this magnetic field moves electrons in receiver coil causes AC power output. This AC output is rectified and filtered to Charge the EV’s energy storage system. The amount of power transferred depends on frequency, mutual inductance and distance between transmitter and receiver coil. Operating frequency of IWC is between 19 to 50 KHz.

4) Resonant Inductive Wireless Charging System (RIWC)

Basically resonators having high Quality factor transmit energy at much higher rate, so by operating at resonance, even with weaker magnetic fields we can transmit the same amount of power as in IWC. The power can be transferred to long distances without wires. Max transfer of power over the air happens when the transmitter and receiver coils are tuned i.e., both coils resonant frequencies should be matched. So to get good resonant frequencies, additional compensation networks in the series and parallel combinations are added to the transmitter and receiver coils. This additional compensation networks along with improvement in resonant frequency also reduces the additional losses. Operating frequency of RIWC is between 10 to 150 KHz.

D. Challenges Faced by WEVCS

1) To install static and dynamic wireless charging stations on the roads, new infrastructure development is required as current arrangement are not suitable for the installations.
2) Need to maintain the EMC, EMI and frequencies as per standards for the human Health and safety concern.

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VI. IMPLEMENTATION ASPECTS

1) The key challenge in Wireless power transfer system development which will allow the devices to broaden their range of possible applications and may open the door to the use of purely wireless systems for vehicles and other devices.
2) Here this could be achieved when all the countries all over the world accept the Wireless power transfer system.
3) Starting by the implement of the wireless charging points for vehicles to dynamically charging lane to charge the vehicle while moving.
4) Electric buses are already tested in few countries like UK, Italy, Netherlands, and South Kore.

VII. FUTURE PLAN OF ACTION

In future we can use electric appliances by using electricity without wire. In the below, discussing some potential scope of using wireless power transfer technology.

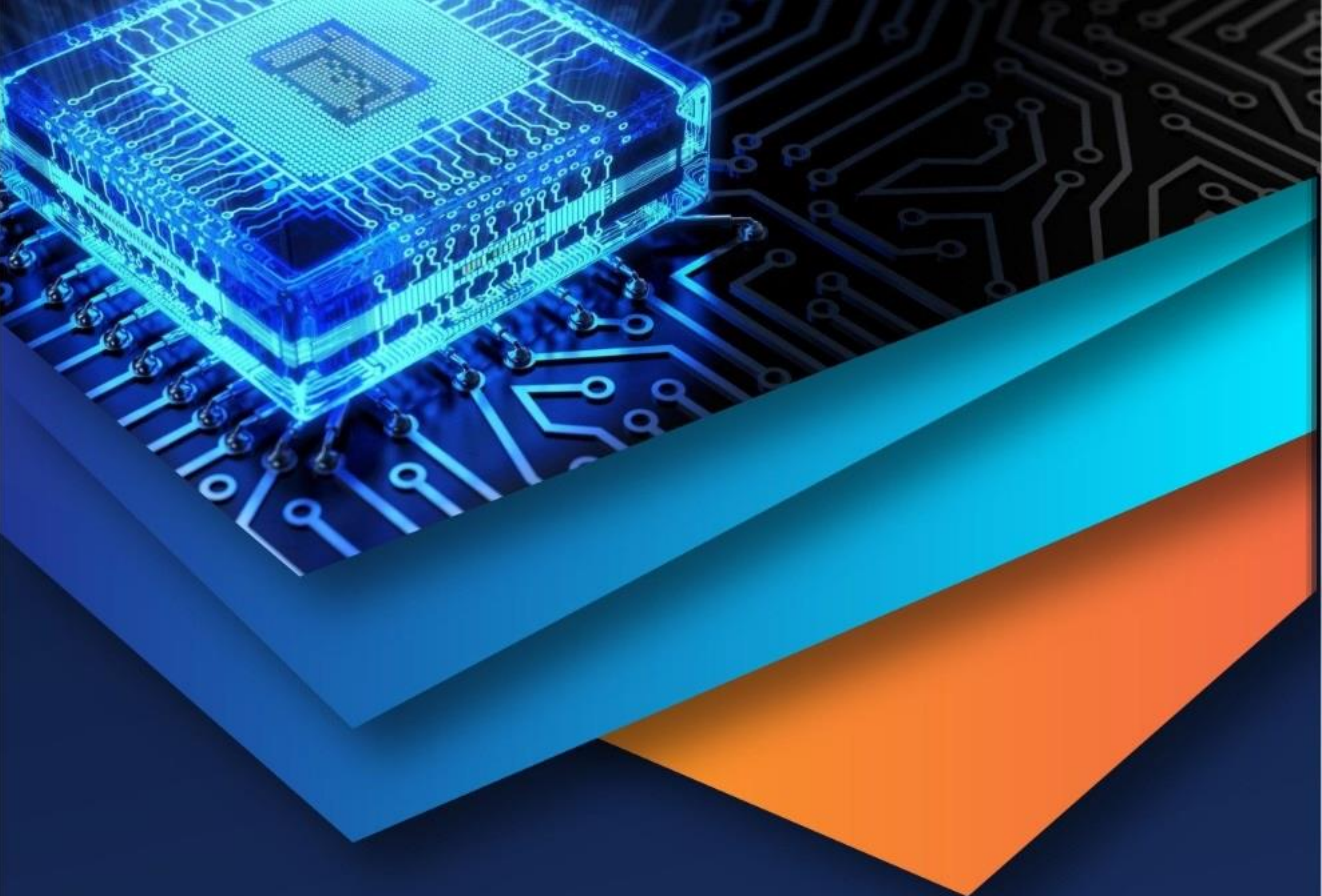
1) *Solar Power Satellite:* Satellite with solar panel is used to capture maximum amount of solar energy from the sun in the space.
2) *Wirelessly powered home appliances:* In future there will be a transmitting device inside home that will transmit power to all the home appliances.
3) *Wirelessly charging of electric vehicle on way*: In future there will be no need to stop and charge the electrical vehicles. On the way charging can be done.
4) Universal power source in emergency.
5) *Wireless Traction train*: In future train may get power wirelessly. There will be no need to connect the train with wire.

VIII. CONCLUSION

The electrification of transportation is underway and wireless charging is poised to play a significant role. Wireless charging systems provide a convenient hands-off method to charge electric vehicles at the same speed and efficiency as standard conductive AC chargers. A broad view of Wireless power transfer applications has been seen and wireless charging of Electric vehicles using WPTs technology and its types has been studied.

REFERENCES

[1] Morgan Stanley Research, "On The Charge", August 2017 [Online]. Available: https://www.docdroid.net/A5uNOPX/on-the-charge.pdf
[2] http://money.cnn.com/2017/09/11/autos/countries-banning-diesel-gascars/index.html
[3] https://www.reinventingparking.org/2013/02/cars-are-parked-95-oftime- lets-check.html
[4] "Wireless Power Transfer for Light-Duty Plug-In/Electric Vehicles and Alignment Methodology J2954_201711," available from SAE International,https://www.sae.org/standards/content/j2954_201711.
[5] "Future with Wireless Power Transfer Technology". From Journal of electrical and elect eng. 2018.
[6] Tesla N. Art of transmitting electrical energy through the natural mediums. U.S. Patent 787412; April 18, 1905.
[7] Tesla N. Apparatus for transmitting electrical energy. U.S. Patent 1119732; December 1, 1914.
[8] Zhang Y, Zhao Z, Chen K. Frequency-splitting analysis of four-coil resonant wireless power transfer. IEEE Trans Ind Appl 2014;50(4):2436-45.
[9] Zhang W, White JC, Abraham AM, Mi CC. Loosely coupled transformer structure and interoperability study for EV wireless charging systems. IEEE Trans Power Electron 2015;30(11):6356-67.
[10] Nguyen TD, Li S, Li W, Mi CC. Feasibility study on bipolar pads for efficient wireless power chargers. In: 2014 twenty-ninth annual IEEE applied power electronics conference and exposition (APEC), 16-20 March. IEEE; 2014. p. 1676-82.
[11] Onar OC, Miller JM, Campbell SL, Coomer C, White CP, Seiber LE. A novel wireless power transfer for in-motion EV/PHEV charging. In: 2013 twenty-eighth annual IEEE applied power electronics conference and exposition (APEC). IEEE; 2013. p. 3073-80.
[12] Choi SY, Gu BW, Jeong SY, Rim CT. Advances in wireless power transfer systems for roadwaypowered electric vehicles. IEEE J Emerg Sel Topics Power Electron 2015;3(1):18-36.
[13] Kurs A, Karalis A, Moffatt R, Joannopoulos JD, Fisher P, Soljačić M. Wireless power transfer via strongly coupled magnetic resonances. Science 2007;317(5834):83-6.
[14] Lukic S, Pantic Z. Cutting the cord: Static and dynamic inductive wireless charging of electric vehicles. IEEE Electrification Magazine: IEEE; 2013. p. 57-64.
[15] Bi Z, Song L, De Kleine R, Mi C, Keoleian GA. Plug-in vs. wireless charging: Life cycle energy and greenhouse gas emissions for an electric bus system. Appl Energy 2015;146:11–9.



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