Prospect of Dynamic Wireless Power Technology(WPT) for Electric Vehicles

Qingye Li [1, a], Luda Yu [2, b], Zhiyuan Jiao [2, c], Chao Ma [2, d]

[1]School of Transportation, Shandong University of Science and Technology, Qingdao266000, China.

[2]School of Mechanical and Electronic Engineering, Shandong University of Science and Technology, Qingdao266000, China.

[a]1265111284@qq.com, [b]441265440@qq.com, [c]1062036204@qq.com, [d]410235705@qq.com

Abstract

With the development of science and technology, people's awareness of environmental protection has improved. Electric vehicles are drawing public attention because of its zero-emission, non-pollution, energy saving and many other advantages. WPT for electric vehicles has attracted widespread attention due to its advantages such as safe operation, flexibility, and low maintenance costs. This paper reviews the application prospects of WPT for electric vehicles. Firstly, it briefly introduces the types and the basic principles of WPT. Then it compares the dynamic and static wireless charging technologies, and finally analyzes the technical principle of dynamic wireless charging system.

Keywords

Electric vehicle, wireless charging, technical principle.

1. Introduction

In recent years, with the deepening of global energy crisis, the depletion of fossil fuels, and the rapid development of new energy industries, developing energy-saving electric vehicles has reached a consensus. However, there are also many technical problems in the development of electric vehicles, such as battery technology, vehicle endurance, the construction of basic facilities such as charging piles, and maintenance costs. Among them, the construction of charging electric piles, charging safety, charging efficiency and other issues restrict the popularity of electric vehicles. The dynamic charging technology of electric vehicles has huge advantages in terms of safety, reliability, flexibility, and convenience compared with traditional plug-in charging systems and static wireless charging systems. The dynamic wireless charging technology can be used during the vehicle operation, which can not only greatly increase the cruising range of the vehicle, but also allow the vehicle to carry a relatively small number of battery packs and reduce the weight of the vehicle. This technology plays an active role in promoting the popularization and promotion of electric vehicles.

2. Types and principle of WPT

WPT technology converts electrical energy from the grid into energy that can be transmitted using wireless transmission, and then transfers the received energy into electricity at the receiving side to provide power to the load. The current WPT technology mainly includes the following four modes: microwave WPT, electromagnetic induction WPT, magnetic resonance WPT, and laser WPT.

2.1 Microwave WPT.

Microwave WPT is mainly composed of a microwave transmitting module and a microwave receiving module. Microwave-based WPT technology uses microwaves with a frequency of 300 MHz to 300 GHz as an energy carrier to realize wireless transmission of electromagnetic energy in a free space. Firstly, this technology converts electric energy into microwave form by a microwave source and transmits it by a microwave transmitting module. After being transmitted for a certain distance, the receiving terminal of the receiving module receives the microwave and then transmits

microwave signal through an internal rectifying circuit which converts alternating current(AC) into direct current(DC). This technology mainly uses the electromagnetic waves in the far field to transmit power, so the transmission distance can reach very far. However, the cost of this technology is also very high, and microwaves have also been questioned about the safety and health to the human.

2.2 Electromagnetic Inductive WPT.

The electromagnetic inductive WPT technology utilizes the principle of electromagnetic induction. Most forms adopt a detachable transformer structure with a core, and the energy is transmitted from the primary side to the secondary side by inductive coupling between primary coil and secondary coil. In order to achieve power transmission within a short distance, the technology has a high transmitting efficiency, and the structure is also relatively simple and the transmission power can reach several hundred kilowatts. But, the charging distance is limited to 10cm and the metal conductors may also generate heat.

2.3 Magnetic Resonance WPT.

Magnetic resonance WPT was first proposed by a group led by Marin Soljacic of MIT in 2007. He used transfer coil and receiver coil with diameter of 0.5m and he lit a 60W bulb 2m far away, and the efficiency was 40% -50% [1]. The magnetic resonance WPT technology also uses the principle of electromagnetic induction, and on this basis, the magnetic resonance of the coil is used to achieve the wireless transmission of medium-distance power. The difference between magnetic resonance technology and magnetic induction technology is that the coil works in a resonant manner. When the operating frequency of the primary side coincides with the resonant frequency of the secondary side, the secondary side coil can produce larger current to achieve long-distance transmission of power [2].

2.4 Laser WPT.

Laser type WPT also uses electromagnetic waves in the far field to transmit energy. It has a lot of advantages such as: good directive property, narrow spectrum, and high energy density [3]. However, this technology requires high accuracy for the transmitting antenna and the receiving antenna, and for this reason, it has high cost.

3. Advantages of Dynamic Wireless Charging for Electric Vehicles

The traditional charging method of electric vehicles is to use plug-and-socket charging methods, but this method has many shortcomings, such as easy to produce sparks, poor contact, and easy to be affected by the external environment, especially in severe weather. The static wireless charging method can overcome the above drawbacks, but static wireless charging and wired charging also have problems such as frequent charging times, short cruising range, a large number of vehicle-mounted batteries, and high operating and maintenance costs. Especially for large vehicles such as electric buses, the continuation of the journey is particularly critical. Therefore, the dynamic wireless charging technology of electric vehicles emerges. Vehicles can not only be charged in the running state, but also can be charged statically when the vehicle is stopped. This not only overcomes the shortcomings of wired charging but also enables the vehicle to carry less the battery pack, which reduces the quality of the vehicle and provides ideas for lightweight design of the vehicle.

4. The technical principle of dynamic wireless charging of electric vehicles

The wireless charging technology of the electric vehicle transmits the electric energy in the form of a high-frequency alternating magnetic field to the power receiving mechanism of the receiving end of the vehicle that operates in a certain range on the ground through the long-distance power rail buried in the ground, and then supplies power to the vehicle-mounted energy storage device, which makes electric vehicles can be equipped with a small number of battery packs and extends their running mileage. At the same time, the power supply mode becomes safer and more convenient. The main parameters of the dynamic wireless power supply technology include power transmission distance, power, efficiency, coupling mechanism side-shift adaptability, and electromagnetic compatibility. Therefore, the development of high-power, high-efficiency, strong side-shift adaptability, low

electromagnetic radiation, and moderate cost dynamic wireless power supply system have become major research hotspots at home and abroad.

5. Conclusion

In summary, the dynamic wireless charging technology for electric vehicles has the advantages of using convenient, high security and high degree of automation, and it also has a broad application prospect. This article first briefly introduces the types of WPT and the basic principles of wireless charging technology. Then it compares the dynamic and static wireless charging technology. Finally, it analyzes the technical principles of the dynamic wireless charging system. According to the research, the dynamic wireless charging technology of electric vehicles can effectively charge the car during driving, and greatly shorten the charging time and improve the vehicle's driving distance. It is expected to become an extremely important component of electric vehicles charging technology and has been widely used.

References

[1] Kurs, A., Karalis, A., Moffatt, R., et al. (2007) Wireless power transfer via strongly coupled magnetic resonances. Science, 317, 83-86.

[2] X. Dai, Y. Sun, C.S. Tang, et al. Radio transmission technology [M]. Beijing: Science Press, 2017: 17-18.

[3] C.B. Zhu, J.H. Jiang, K. Song. Research progress on key technologies for dynamic wireless charging in electric vehicles [J]. Automation of Electric Power System, 2017, 41(02): 60-65+72.