Wireless Charging Techniques for New Energy Vehicles

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Abstract. Auto Wireless Billing is an easy and quick way to charge an electric or plug-in hybrid car. The car will be able to use wireless charging at any time, without having to connect to it. In extreme cold weather, the electric vehicles (EVs) will probably be buried in the snow and ice and will not be usable. But the wireless billing technique is able to satisfy the demand of all kinds of weather. Aside from recharging during idle mode, wireless charging also offers a potential for dynamic charging - enabling the car to be recharged as it travels. Once this technique is developed, it will be able to solve the problem of EV's running range. Therefore, it is possible to lower the load of EV, lower the cost of EV, and increase the quantity of EV. In this paper, various wireless charging technologies for EV are discussed and analyzed. Also, the optimization strategies will be given as future perspectives.

Keywords: Wireless charging, automotive, transformer, electric vehicles.

1. Introduction

With the rapid growth of cars, not only has made it easier for us to live, it has also helped to develop a lot of industries, speed up economic progress, and raise the chances of getting jobs and living standards. As one kind of transport vehicle, the car occupies the vital position in the modern society. Along with the auto society forming step by step, the auto ownership is increasing, but the fuel such as petroleum is being used continuously. By then, as more and more cars come into being, more and more toxic gases will be emitted. The final answer, however, is not to restrict the growth of car manufacturing, but to find a substitute for petroleum.

There are many ways to develop the new energy cars. In terms of technology developing level, it is necessary to push forward the development of electric vehicles (EVs). An EV is a car which is based on a car's onboard energy supply and is driven by an electrical motor, which satisfies all kinds of traffic and safety requirements. The EV does not have an internal-combustion engine and does not generate any exhaust. It helps to protect the environment and clean the atmosphere, which is called "zero-pollution". Studies on EVs have demonstrated that they are more efficient than petrol cars. Particularly in urban areas, where an EV is more efficient, it doesn't require much speed, so it's a good choice to drive in urban areas. Meanwhile, the use of EV can decrease the reliance on petroleum, make use of scarce fuel to achieve more significant goals, save energy and cut CO2 emissions. Furthermore, EV's charging time is often set at night, so that it can accurately offset the peak energy use, which helps to balance the load in the network and to cut costs [1,2].

The EV is composed of the electrical driver and the control system, the mechanism of the drive power transmission and the like, and the operation equipment for the completion of the specified mission. EV is the kernel of EV, which differs most from integrated circuit. The electric drive and control system consists of the drive electric machine, the electric source and the electric machine speed adjusting unit. The parts of the EV consist of the following parts: the source, the driver, the velocity, the transmission, the walking, the turning, the brake and the operating equipment.

But most of the current electric tramway is AC, which is 220 V in general. It will take about 8 hours for full charge, and the rate of charging is very low. Meanwhile, a great amount of charging piles will be required to take up a great deal of urban land. Due to the limitation of the quantity of charging vehicles, it is easy for the outside cable to be destroyed, so it will take up a lot of space for the building of the dedicated charger. So far, there have been three kinds of charging methods: Electromagnetic induction type, Magnetic resonance type, and Radio wave type.

Wireless power transfer (WPT) or the Wireless Energy Transfer. It can realize the noncontact power transfer by means of Electromagnetic induction type, electromagnetic resonance, radio wave type,microwave and laser. Based on the difference of power source distance between the two modes, there are short, medium and long distance transmission [3]. In this paper, various wireless charging technologies for EV are discussed and analyzed. Also, the optimization strategies will be given as future perspectives.

2. Charging Mode of Electric Vehicles

There are three kinds of charging methods for EVs: Cable, Wireless and Mobile [4,5]. Wireline billing is the preferred method, but wireless billing and cell phone billing are still under development.

2.1. Wired Charging

There are three types of cable charging: slow charging, rapid charging and switching. Slow charging, also called routine charging, means that a mobile charger fitted with a car is capable of being supplied from a home or a special charger. That's how we're going to do it now: Onboard Chargers and Wall Mounted Batteries for Houses. Usually, the charge current is approximately 16 32A, but it may be DC or two phase alternating or three phase alternating current. Therefore, it takes five to eight hours to charge according to the storage volume, as shown in Figure 1.

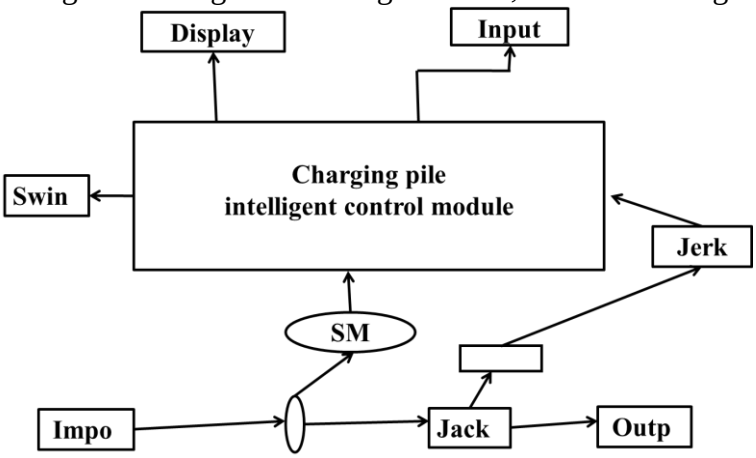

Figure 1. Schematic diagram of charging station [5].

Quick charging is quick, also called earth charging, as its name implies, can be a quick full charge mode, which can be charged by a non car charger with high electric power, and can be charged up to about 80 percent in a short period of time, which is also called "Emergency". Rapid charging is a Tesla Supercharger station. The current and voltage in quick charging method are usually between 150-400 A and 200-750 V, and the charge power exceeds 50 KW. Most of this model is direct current source, which makes it more powerful, and has a broad scope of variation in output current and voltage.

Quick replacement, also called mechanical charging, besides normal car directly charging, you can also take the alternative method to charge the battery. That is to say, if the battery is used up, it will be replaced by a full charge battery. There are three ways to change a battery from a vehicle: a purely manual, a semiautomatic or a robotic replacement.

2.2. Wired Charging

In this method, no power transmission is required, and the power is transmitted by electromagnetic induction, electrical field coupling, electromagnetic resonance and Radio wave type. With wireless charging, you will have to install an onboard inductive charger in your vehicle. The electrical component does not have a mechanical connection with the electrical component, but the electrical component and the power source are more precise. Due to technical maturity and fundamental

facilities constraints, electrical specialists think that it is impossible to use this technique on a large scale. Most of the current wireless charging techniques are based on electromagnetic interference (EMI) and electromagnetic resonance, but the Magnetic resonance type is more efficient, and the Electromagnetic induction type is weaker, so it is less effective for Electromagnetic induction type to communicate with the receiver, and more important is that it is not necessary for the transmitting coil and the receiver to be exactly aligned, which is inferior to EMI. In the future, there will be no limit to how far we can go. But in the future, it will be possible to use electricity from the road surface, or from the Electromagnetic induction type energy that the vehicle receives [6].

2.3. Mobile Billing

The best scenario for an EV battery would be to recharge it as it travels, known as Mobile Charging (MAC) [3,5]. That would mean that EV users don't have to look for a charger, park it, and take time to recharge it. The MAC system is located beneath a segment of the highway called a charging area without any extra room. It is possible to realize either the contact or the induction MAC system. As for the MAC system, it is possible to install the contact arc on the base of the vehicle, and to make contact with the charging member which is inserted into the pavement, to achieve a high transient electric current [7]. As the vehicle travels in a MAC region, it will be charged with a pulse mode. In the case of inductive MAC system, the on-vehicle contact arc is substituted with an inductive coil, and the charging component is substituted with a high current winding to produce a powerful magnetic field. Apparently, because of the mechanical loss and the location of the contact arc, the MAC does not attract much attention.

3. Wireless Power Transmission

3.1. Types of Wireless Energy Transfer

According to the different transmission mechanism, wireless power transmission technology can be divided into electromagnetic induction type, electromagnetic resonance type, electromagnetic radiation type, laser mode, electric field coupling type, etc., according to the distance between the electromagnetic field and the field source, it can be divided into near-field coupling type and far-field radiation type. Electromagnetic induction type, electromagnetic resonance type and electric field coupling type are near-field coupled radio energy transmission, while electromagnetic radiation type and laser mode are far-field radiation radio energy transmission [3].

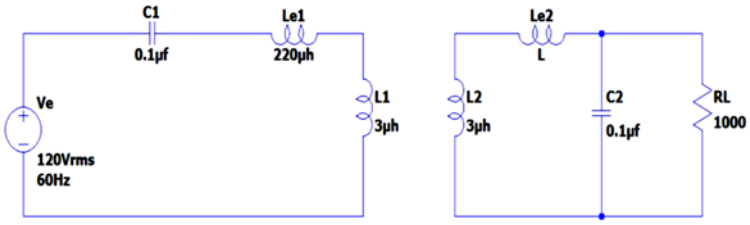

Figure 2. Electromagnetic resonance transmission method [6]

3.2. Benefits and Drawbacks of Wireless Power Transfer

Electromagnetic inductive and electro magnetic compatibility (EMC) techniques are based on the AC field produced in the transmission winding to connect the power to the receiver winding, thus achieving the wireless power transfer. Electromagnetic inductive coupling technique has been developed in a comparatively mature way, which has great transmitting power and high transfer efficiency in a short transfer range. Electromagnetic resonance is a kind of special kind of magnetic inductive coupling. It can realize high efficiency non - radiating power transfer by sending and receiving winding. It is a kind of middle distance wireless power transfer technique, as shown in Figure 2.

The electromagnetic radiation and the laser-based wireless power transfer technique adopt the far field radiation effect of the electromagnetic field to transfer the electricity in the free space. Electromagnetic radiation-type wireless energy transfer technique has many advantages such as long transmitting range, little atmosphere loss during transmitting, but big microwave scattering angle and low power density. Laser wireless power transfer technique is characterized by excellent direction and high power density, but its precision is low, so it is not mature yet, as shown in Figure 3.

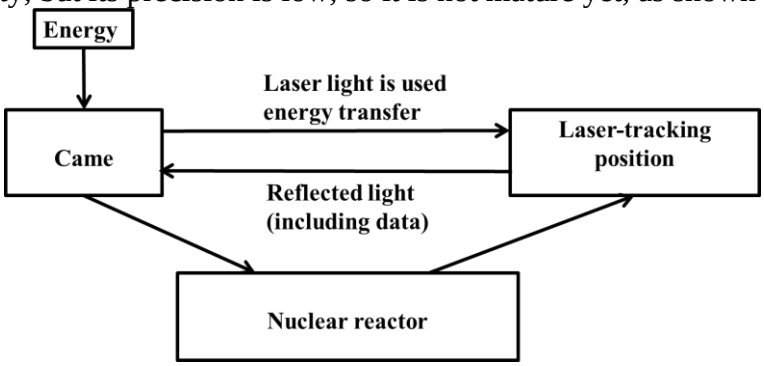

Figure 3. Laser based radio energy transmission method [6]

3.3. Receiving and sending equipment for EV wireless charging

First of all, 5 V direct current is converted to high frequency 800 KHz AC power by LC self excitation oscillator [8]. Then, the ATM16 micro-controller is used to control an isolated sub-circuit of a servo-motor. At this time, a normal closed connection of a relay is activated, and a capacitor is not charged. Push the button to resume transmission. Also, the time is 1 minute. The AC power is transferred via the transmission winding to the receiver winding, and is transferred by means of a magnetic coupling resonance (RF). The receiver winding and the receiver are subjected to resonance coupling [9], which transforms the electric energy to the magnetic field for transfer. The power transferred from the first to the second is fed to the super capacitor via the full-bridge rectifying link. Upon completion of the timing, the relay operates, and the transmission coil ceases to transfer power to the receiver coil. Simultaneously, the steering mechanism works so that the second loop is engaged, and the vehicle is instantly launched [10], as shown in Figure 4.

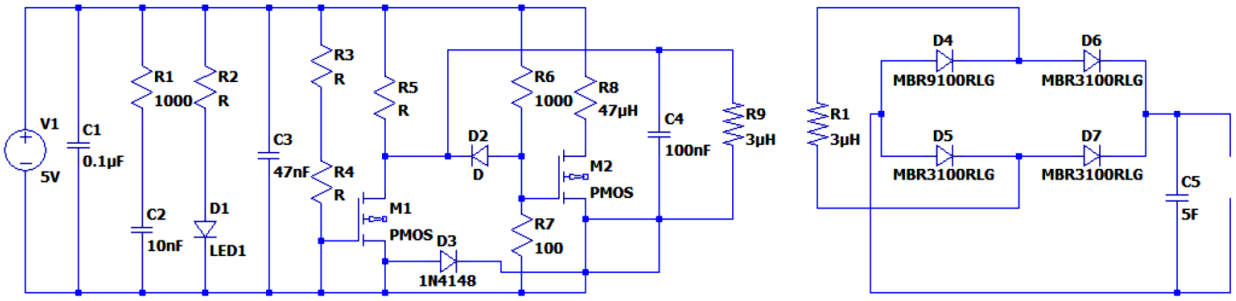

Figure 4. Circuit diagram of transmitting and receiving devices [10]

4. Potential Improvement

Along with the development of the study, there are still a lot of important issues to be resolved, for example, high performance, EMC and power transfer. Solving the above questions will be helpful to develop the technique of dynamic radio power [11].

The most difficult problem in wireless power transfer is the high efficiency and long range, while the scattering, absorbing and fading are the key problems in wireless power transfer. In the course of the transfer of energy in the free space, it is difficult to focus, the directional is bad, the energy is in the course of radio transfer, and the air is used as the coupling medium, so there is a big loss in the

magnetic field, particularly the microwave, which spreads in the space, and the energy is consumed quickly. Because of this, the radio power transfer rate is low, the total efficiency is bad, the high power transmission is hard, the high power long distance radio transmission is hard. In the case of wireless charging, the charging equipment and the charging equipment are connected by a magnetic field, which can lead to the loss of power transfer, low power transfer power, low transfer scope and so on. Wireless electricity transfer engineering is a big project, and it has resolved the two main issues in electricity generation and transmission. Moreover, for wireless billing, wireless billing devices have to pass the certification of related institutions. Therefore, we need to look for a more mature commercial mode in order to fill in the void. Moreover, it is very important for us to make some improvements in wireless billing techniques, and establish an international standard to make the transmitter-receiver equipment compatible with each other.

Simultaneously, biological security issues in wireless transport space must be guaranteed. Being exposed to electromagnetic environment for a long time will decrease their biology function, make them more likely to suffer from nerve, blood vessel and reproduction, and even influence their psychological and behavior.

In a radio network, it is possible to provide power to several vehicles at once through one power supply in a given area. Increase the flexibility of radio communication. Thus, when the radio billing network is operating, the multi-transmitter and the plurality of receivers need to be managed uniformly [12,13]. In order to satisfy the demand for charging startup, if it is not possible to detect the system's capability, then if it is not possible to do so, then if it is not possible to do so, then the high-priority device must be charged first-when a new device is connected to the network, as shown in Figure 5.

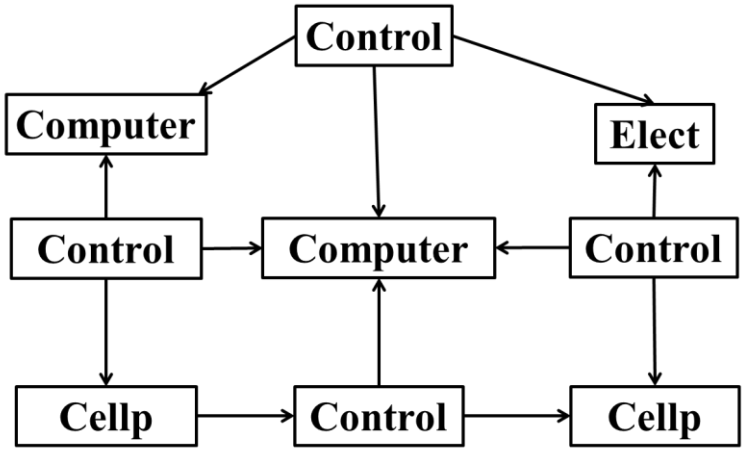

Figure 5. Electric energy transmission in wireless networks [12]

5. Conclusion

Although EV has many merits such as convenient and fast, it is at the developing and exploring phase, so much more needs to be done in practice. Moreover, based on the reality of the present lack of power, it is far from enough for EV to industrialize high power radio charging technique, but it is very important to do some initial research as a kind of flexible charging mode. Along with the development of Chinese Intelligent Grid, it will be widely used in EV's intelligent charging and replacement system. Therefore, it is possible to lower the load of EV, lower the cost of EV, and increase the quantity of EV. In this paper, various wireless charging technologies for EV are discussed and analyzed. Also, the optimization strategies will be given as future perspectives. In the case of multiple to one mode, the system must decide the amount of the charge target, and then rationally group it. Stop charging when there is an excessive amount of charging capacity in the system. In multi-mode operation, make sure that the electric supply is coordinated, the allocation of the billing facilities is reasonable, and the ability to make sure that the electricity is properly charged.

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