Design of Resonant Wireless Charging Device for Public Electric Bicycle

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Abstract: As a starting point for the difficulty of charging public electric bicycles, this paper proposed a convenient and efficient charging device design concept, namely the design of resonant wireless charging device applied to public electric bicycles. Firstly, the main wireless charging technology on the market is introduced. Secondly, the design of the resonant wireless charging device is analysed including the charging principle, main circuit design and its advantages. The device supply power in centimeters or meters, even if there are obstacles in the charging range, energy can be efficiently transmitted, and it can be applied to the public electric bicycle parking hall, which can effectively solve the problem of difficult charging.

1. Introduction

In the age of household appliances, smart human beings to cable transmission as the main way, so that electrical energy is widely used in every aspect of life. In recent years, as a public transportation tool with high efficiency, convenient use and low price, public e-bike has been increasingly popular with people. Figure 1 shows an exhibition of public e-bike. However, the new convenience will also bring new problems, the emergence of public electric bicycles has brought their own charging difficult problem. Such as inadequate charging facilities,

FIG. 1 Public electric bicycle

The charging device is not easy to carry and other problems, but more in the past through the cable transmission of electrical energy charging equipment because of the disorderly pull wire caused accidents. Based on these problems, this paper proposes a wireless and efficient resonant wireless charging device for public e-bike. Based on the difference of power transmission principle and transmission path, there are three main transmission modes of radio energy in the research circle of power transmission up to now [1]: one is resonant coupling mode, and the other two are electromagnetic induction coupling mode and microwave radiation mode. In addition, there are other
emerging power transmission methods such as electric field coupling, ultrasonic wave and laser, but they are still in the initial stage of research.

1.1. Electromagnetic induction coupled wireless charging technology
Electromagnetic induction coupled wireless charging technology [2] is proposed based on the theory of induced current generated by changing magnetic field. The principle of electromagnetic induction coupled power transmission is shown in figure 2. It works like a transformer. In the radio energy transmission system based on the electromagnetic induction coupling theory, the coupling between the coil at the transmitting end and the coil at the receiving end requires a high degree of directivity, and is almost not coupled when it is relatively vertical. What's more important is that it restricts the distance and can only supply power within a short distance.

![Electromagnetic induction mode](image)

**FIG. 2** Schematic diagram of electromagnetic induction coupled power transmission

1.2. Microwave radiation wireless charging technology
As shown in figure 3, the system first converts the electric energy into Microwave form, transmits it through the antenna at a long distance, and then transmits it through free space. Finally, it receives the signal from the receiving end and converts it into direct current through rectifying circuit to supply Power to the load. However, although the use of microwave power transmission can achieve a relatively long distance power transmission, but the transmission power is small, and the microwave energy transmission system is generally used in special occasions, such as microwave aircraft, satellite solar power station.
1.3. Resonant wireless charging technology

Resonant wireless charging technology [4] is established mainly on the basis of the non-radiation near-field resonance strong coupling theory, which is also the wireless charging technology of public electric bicycles to be introduced in this paper. Its basic principle is to use two objects with the same frequency as the medium to achieve efficient energy exchange. Compared with inductive coupling, it can realize more efficient power transmission over longer distance. In addition, the resonant radio energy transmission system can provide wireless power to two or more devices simultaneously.

2. Principle of resonant wireless charging for public electric bicycles

The so-called Wireless charging, as its name implies, is a kind of application of Wireless Power Transfer (WPT), also known as Contactless Power Transmission (CP). It refers to the technology that can store electric energy without the help of metal wires and other physical connections, so as to use the electric field, magnetic field and other space invisible medium as the transmission way, at the beginning of the electric energy output, the end of the electrical energy receiving and storage. Resonant wireless charging technology is a kind of technology based on electromagnetic wave induction theory and other related ac induction theory. As shown in figure 4, the charging device is mainly composed of the power supply, inverter circuit, resonant circuit, rectifying and filtering circuit, booster circuit and load that provide direct current to the whole system.

![FIG. 4 Theoretical composition of resonant wireless charging device](image)

The power supply section is used to provide direct current to the entire public electric bicycle charging system. Inverter circuit adopts high frequency inverter principle to convert direct current into alternating current. The resonant circuit is composed of primary side resonance and secondary side resonance. The primary side resonance circuit receives the alternating current converted by the inverter and then transmits the electric energy to the secondary side resonance circuit through the magnetic coupling of the resonant circuit. The rectifying and filtering circuit converts the alternating current from the resonant circuit into direct current after rectifying and filtering. Finally, the booster circuit is used to convert it into a voltage that can meet the needs of the load. The booster circuit used in this system is Boost chopper. Boost circuit converts the input direct current into another kind of direct...
current by controlling the switching device. In this design, as the impedance matching and power regulator of load, its conversion efficiency is high, and the output is controllable, which can fully meet the requirements of wireless charging system. The load of this design system is the public electric bicycle.

3. **Core design of resonant wireless charging device**

In the system design of radio energy transmission device, its composition is mainly based on three problems.

3.1. **Design of inverter circuit**

The inverter circuit is the basis to ensure the smooth transmission of electric energy. The higher the inverter frequency, the higher the power transmission efficiency. As for this system, it is inevitable that the interference signal should be as small as possible. The harmonic of bridge inverter circuit is very small, and the inverter frequency is high, which meets the requirements of the design system. If the load is resonant, the current can be kept in the same phase with the voltage to achieve zero voltage and zero current switching, which can reduce the switching loss to the minimum. As is shown in figure 5, is the schematic diagram of bridge inverter circuit.

![FIG. 5 Schematic diagram of bridge inverter circuit](image)

3.2. **Resonant circuit design**

Resonant circuit is the core of resonant wireless charging device for public electric bicycle. Wireless charging system can effectively complete the transmission of electric energy within a certain distance. The key lies in whether the resonant topology circuit can be truly close to full resonance. In this system, LC series resonance is adopted to realize the coupling of primary and secondary energy. The series resonance of the primary side circuit can bear the electromotive force generated by the coil, reduce the damage to the switching devices in the inverter circuit, and improve the power factor of the primary side resonance circuit. The auxiliary side circuit adopts series resonance, and the voltage of the load will not change with the change of the load, which will lay a foundation for the stability of the system output.

3.3. **The design of rectifying filter circuit**

The function of rectifying filter circuit is to convert alternating current into pulsating direct current. Considering the rectifying efficiency and effect of the system, as well as the maximum reverse peak voltage assumed by the diode in this circuit, the principle of bridge rectifying circuit is shown in figure 6.
There is still a small amount of ac ripple in the dc obtained through rectification, so it cannot be directly supplied to the load. Therefore, this system adopts the function of filter capacitor to filter out the useless ac ripple through charging and discharging.

4. Advantages of resonant wireless charging
In terms of the current development situation of public electric bicycles, wireless charging technology is at the forefront of power supply technology and is worth studying. In this paper, resonant wireless charging device has many advantages: firstly, in terms of its energy transmission form, there is no physical connection between the power supply end and the load, which is very convenient compared with the use of bulky cables in traditional charging technology. In terms of its safety, resonant wireless charging device can be made into a completely closed structure, even in a humid environment, do not have to worry about the leakage of electricity often occurred in the wired charging equipment. Since the principle of resonant wireless charging is based on the strong coupling between two objects with the same frequency, the same coupling device can be used for the equipment to be supplied with similar power, which can save space to a great extent.

5. Conclusion
Nowadays, with the popularization of electronic products in every aspect of human life, with the continuous development of science and technology, people's requirements are getting higher and higher. In terms of efficiency and convenience, resonant wireless charging devices of public electric bicycles are at the forefront of wireless energy transmission. Resonant wireless charging technology not only has the advantage of providing power to multiple devices at the same time, but also can meet the requirement of long distance energy transmission. In terms of its development prospects and application prospects, the public e-bike is very popular today. Because the wired charging equipment itself has a lot of defects, such as cable equipment occupies a lot of space, low safety performance. For resonant wireless charging device, it has good sealing performance and high safety performance. In such a comparison, the development prospects and application prospects of wireless charging devices are indeed very broad. Of course, in today's rapid development, users will have higher and higher requirements on wireless charging equipment, so the research on resonant wireless charging device of public e-bike is still on the way.

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