# Continuously Safe Wireless Charging for Electric Vehicles

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**Abstract**

Wireless charging technology has emerged as a promising solution for improving the convenience and efficiency of electric vehicle (EV) charging. This literature review examines the current state of the art in sustainable and safe wireless charging technology for electric vehicles. It provides insight into technological advances, safety considerations, and challenges associated with implementing wireless charging technology, safety considerations, and challenges associated with implementing wireless charging systems. Through a comprehensive examination of existing research and innovations, this review aims to provide insights into the future of wireless charging for electric vehicles.

**Keywords:** electric vehicles; wireless charging technology; inductive charging; charging safety

## 1.Introduction.

Transportation electrification is an important part of the global effort to reduce greenhouse gas emissions and combat climate change. Electric vehicles (EVs) are a green and environmentally friendly way of traveling and have been widely welcomed. However, one of the major challenges hindering the widespread adoption of EVs is the need for efficient and convenient charging infrastructure.

Traditional plug-in charging methods have limitations in terms of user convenience and scalability. As a result, wireless charging technology has been explored as a potential solution. Wireless charging (often referred to as inductive charging) offers several advantages over traditional plug-in charging. It eliminates the need for a physical connector, simplifies the charging process, and blends seamlessly into the urban landscape.

Despite the promising future, wireless charging of electric vehicles still faces a number of technical, safety and regulatory challenges. The focus of this literature review is to examine the current state of the art of continuous safe wireless charging for electric vehicles. Continuous safety is a key aspect of any charging system that ensures that the vehicle and charging infrastructure remain safe throughout the charging process.

## 2 Wireless charging technologies for electric vehicles

### 2.1 Induction charging

Compared with traditional wired charging piles, inductive charging piles come into being under some individual or extremely harsh environmental conditions, such as rainy days and snowy days. The contactless charging method does not need to rely on the physical medium for power transmission, and the requirements for the site are greatly reduced, so the economic cost is reduced compared with wired charging. Not only that, this for the charging site flexibility of the qualities of the car owner can also be based on the demand to choose the nearest site, saving time costs, adapted to the new energy development trend that is humanized and intelligent [1].

Wireless charging technology is mainly divided into electromagnetic resonance type (ERPT), radio wave type (MPT), electromagnetic induction type (ICPT), electric field coupling type (ECPT), magnetic coupling resonance type (RCPT), these five basic methods. These technologies are suitable for short, medium and long distances. In this the magnetic coupled resonant technology is more adaptable, in 2007, MIT proposed the use of magnetic coupling resonance for wireless power transmission [2] WPT technology is highly similar to ICPT technology, they both use magnetic field to transmit power, which can be illustrated by the principle of electromagnetic induction. The significant difference can be seen in the frequency difference, the former with the frequency can be based on the distance, generally fixed and low (a few hundred kHz); while the latter according to the transmission distance change, generally higher up to (generally less than 100kHz ~ MHz) [3].

### 2.2 Dynamic wireless charging

Dynamic wireless charging technology removes the distance barrier and enables charging on the move, which generally exists in a specific roadway, and real-time charging takes place when the car enters the dynamic wireless charging channel. Therefore, in a way, dynamic wireless charging has the benefit of no distance limitation and reduced cost of charging devices. And, magnetic coupling technology is most common in the construction of dynamic wireless charging roads [4].

# 3 Safety Considerations

## 3.1 Electromagnetic field exposure

Electromagnetic field exposure has a certain degree of impact on human health, such as the nervous system, cardiovascular system, endocrine system, immune system, reproductive system, and other parts of the health system, and the most significant impact is reflected in the impact on human skin [5]. In vitro tests have shown that DNA double-strand breaks in human lens epithelial cells increase with prolonged exposure to a 0.4 mT mid-frequency magnetic field [6].

3.2 Foreign Object Detection

With the distance and energy efficiency of radio transmission increased, foreign object detection is a major important aspect of the examination of safety detection, the detection of foreign objects around the vehicle and the owner's safety is a strong guarantee, the algorithm uses a mathematical regression analysis of the method of contacting the parameters obtained in the system power analysis approximation. According to the surface of the test data, the method can be used for the detection of foreign objects and detection of radio transmissions [7].

Here are some details on how FOD is implemented in wireless EV charging systems:

**1. Basic Principle:**

The FOD system utilizes a combination of sensors and algorithms to detect the presence of foreign objects on the charging pad. These sensors can be optical, capacitive, inductive, or ultrasonic sensors, among others. The system continuously monitors the charging pad and surrounding area to recognize any foreign objects.

**2. Sensors**

Capacitive Sensors: These sensors can detect the presence of conductive objects (such as metal tools or wires) by measuring changes in capacitance. When the object is placed on or near the charging pad, it changes the electromagnetic field and capacitance, which triggers a warning or shutdown.

Inductive Sensors: Inductive sensors utilize electromagnetic induction to detect metal objects. Any change in the electromagnetic field due to the presence of a foreign object is recorded by the sensor.

Optical Sensors: Optical sensors use a camera or infrared sensor to visually detect foreign objects on the charging pad. They are often used in combination with other sensors for redundancy.

**3. Algorithms:**

FOD systems rely on complex algorithms to process data from sensors and make determinations about the presence of foreign objects. These algorithms can be based on machine learning, pattern recognition, or predefined criteria. They take into account various factors such as the size, shape and conductivity of the detected object to distinguish between foreign objects and legitimate charging devices.

The distance detection algorithm for wireless charging of cell phones is studied in literature [8], which mainly uses machine learning based MLP and SVR to study the collected data. The feature data collected at different distances are analyzed by machine learning, and the distance detection algorithm is modeled using MLP and SVR by using the actual distance as the label Y,and finally selecting the appropriate feature data as X. The distance detection algorithm is based on the MLP and SVR.

This paper [9] is an innovative proposal for a complete metal foreign object and alignment detection program.

A complete set of metal foreign object and alignment detection program is proposed in this paper, in which metal detection is divided into three stages: pre-detection, alignment detection and post-detection. Pre-inspection refers to the metal inspection before the equipment to be charged enters the charging area; post-inspection refers to the equipment to be charged.

The post-test is the metal test in the normal charging stage of the device to be charged. Alignment testing is performed between the time the device to be charged is positioned and the start of formal charging.

# 4. technological advances:

## 4.1 High power wireless charging

In the electric vehicle wireless power transfer (WPT) circuit, there exists a zero reactance frequency (ZRF) that is, from the input side of the circuit, the reactance of the whole circuit is zero, and the phase difference of the primary side current is zero at this frequency, at which time the whole system can realize high power under high efficiency transmission [10].

## 4.2 Smart charging and grid integration

The modular multilevel converter (MMC) provides a feasible solution for realizing large-scale EV and smart grid integration. Taking a medium-sized community charging station as a scenario, an MMC system with a power of 480kW is optimally designed, and simulation analysis is carried out in Matrix Laboratory/Simulink environment to verify the reasonableness and necessity of the optimized design of the integrated system parameters, which provides a certain reference for the design and operation of the MMC-EVIS[11].

## 5.Future direction and conclusion:

Under the further improvement and advancement of magnetic coupling resonance type technology, the wireless charging equipment for electric vehicles continues to be developed, the use of new generation batteries to extend the range of electric vehicles, the development of faster and safer means of charging as well as the provision of faster and more convenient charging devices, and the integration with the grid system is a key step in the future development of new energy electric vehicles[12] to produce a more reliable power supply and monitoring system. The advantages of EVs will be magnified, and once the charging efficiency is comparable to the refueling efficiency, EVs will be considered as an alternative to conventional fuel vehicles.

The purpose of this literature review is to provide a comprehensive overview of the current state of sustainable and safe wireless charging for electric vehicles, revealing future opportunities and challenges. While promoting technological advancements, it is important to address safety issues that can be used to create a sustainable and convenient charging infrastructure to support the widespread adoption of electric vehicles.

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