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无线电动汽车能源网络的核心原理是**无线电能传输（WPT）**。它利用电磁场在地面充电板与车载接收线圈之间传递能量。wireless electric vehicle 是指利用无线充电技术的电动车辆，其核心在于无线充电在电动车辆上的应用。

无线充电系统的工作原理在主流上基本均依赖于线圈绕组的电磁感应。传输端需要通过AC/DC,DC/AC将电网的交流电转变为高频率交流电（HFAC），并利用初级线圈产生频率在20-100千赫兹范围内的交变磁场。当配备次级线圈的电动汽车停在该发射器上方或经过时，变化的磁场在接收线圈中感应出电流，然后通过DC/AC转换为直流电经电池管理系统（BMS）控制下为电池充电。其中最先进的实现使用谐振感应 (RIPT)，其中发射和接收线圈都调谐到相同的谐振频率。这种方法显著提高了效率。并且其引入补偿网络，补偿网络采用串串能令谐振频率能与接收端负载和补偿无关，同时保证了功率因素。

除了这种方法（谐振感应）以外，也能通过电容和永磁同步电机进行无线电力传输，电容式的缺点是对于过大极板间距其效率就相对低，而永磁同步电机的无线电力传输的方式会在高频时主次级电机会失去同步。

同时轮内电机在无线充电系统中与主回路的气隙间距距离更短，因而有更高的传输效率。

无线充电的优点：解决了电车充电站设置难的问题，

安全性改善显著。由于充电没有暴露的电气接触，电击、电缆损坏和天气相关故障的风险几乎被消除。

嵌入式道路线圈可以在行驶时为车辆充电，可能减在不提升电池容量的情况下能延长续航里程。为V2G系统打下基础，将车辆成为移动储能和分配节点可以促进车辆之间的能源交易，进一步更可以最大化利用电能以及保证电力系统稳定性。

其缺点主要在于：开发，维护，建造的巨大成本。动态无线充电站的建造这代表了巨大的公共基础设施投资需求。除了是动态充电设施的部署，无线充电系统在多变工况的充电效率的保持也要求更多的研发投入。另外电磁兼容性(EMC)和健康担忧持续存在A。大功率无线系统产生的电磁场必须严格符合对人类和电子设备暴露限制。适当的屏蔽和场控制为系统设计增加了复杂性和成本。BMS的控制也需要优化升级以保证安全性和使用寿命。

最后是无线充电系统标准仍不完善。不同制造商可能采用不同标准如不同的额定频率，电压。

Wireless electric vehicle energy networks are based on the principle of **wireless power transfer (WPT), with its core application being the implementation of wireless power transfer in electric vehicles and grid.** WPT often uses electromagnetic fields to transmit energy between a charging pad on the ground and a receiver coil installed in the vehicle.

**The operating principle of mainstream wireless charging systems relies on electromagnetic induction through coil windings. The transmitter side converts AC power from the grid to high-frequency AC (HFAC) through AC/DC and DC/AC conversion stages, utilizing a primary coil to generate an alternating magnetic field within the frequency range of 20-100 kHz. When an electric vehicle equipped with a secondary coil is positioned above or passes through the transmitter, the varying magnetic field induces current in the receiving coil. This current is then converted to DC power through AC/DC conversion and charges the battery under battery management system (BMS) control. The most advanced implementations employ resonant inductive power transfer (RIPT), where both transmitting and receiving coils are tuned to the same resonant frequency. This approach significantly enhances efficiency. Additionally, compensation networks are incorporated, with series-series compensation topology ensuring that the resonant frequency remains independent of the receiver-side load and compensation parameters while maintaining unity power factor.**

In addition to this method (resonant induction), wireless power transmission can also be achieved through capacitive coupling and permanent magnet(PM) synchronous motors. The disadvantage of the capacitive approach is that its efficiency becomes relatively low when the distance between the plates is excessive. For PM synchronous motor-based wireless power transmission, the primary motors and secondary generator may lose synchronization at high frequencies.

Meanwhile, in-wheel motors in wireless charging systems have shorter air gap distances from the main circuit, resulting in higher transmission efficiency.

**Advantages of wireless charging include: Resolution of electric vehicle charging infrastructure deployment challenges; significant safety improvements due to the elimination of exposed electrical contacts, virtually eliminating risks of electric shock, cable damage, and weather-related failures; embedded roadway coils enabling in-motion vehicle charging, potentially extending driving range without increasing battery capacity; establishment of foundation for vehicle-to-grid (V2G) systems, transforming vehicles into mobile energy storage and distribution nodes to facilitate inter-vehicle energy trading and maximize energy utilization while ensuring power system stability[1].**

**The main disadvantages include: substantial development, maintenance, and construction costs, with dynamic wireless charging infrastructure representing enormous public infrastructure investment requirements; beyond dynamic charging facility deployment, maintaining charging efficiency of wireless systems under varying operating conditions demands additional R&D investment; persistent electromagnetic compatibility (EMC) and health concerns, as electromagnetic fields generated by high-power wireless systems must strictly comply with exposure limits for humans and electronic devices, with proper shielding and field control adding complexity and cost to system design; BMS control systems requiring optimization and upgrades to ensure safety and battery life.**

**Finally, wireless charging system standards remain incomplete, with different manufacturers potentially adopting varying standards such as different rated frequencies and voltages.**

1. W. Liu, K. T. Chau, C. C. T. Chow and C. Jiang, "Design and Analysis of Wireless Electric Vehicle Energy Network," 2022 IEEE Transportation Electrification Conference and Expo, Asia-Pacific (ITEC Asia-Pacific), Haining, China, 2022, pp. 1-6, doi: 10.1109/ITECAsia-Pacific56316.2022.9941965.