XIA YUEJUN 25059117G Assignment1

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 are as follows: 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.

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.