Study on Automatic Charging Devices for Electric Vehicles in Vehicle to Grid

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Abstract—Vehicle to Grid (V2G) is a bi-directional power transmission technology that allows Electric Vehicles (EVs) to be connected to the grid to create a virtual Energy Storage System (ESS). However, in order to utilize the ESS of V2G technology, an EV Automatic Charging Device (ACD) with EV charging technology is essential[1]. An ACD is a device that automatically connects and disconnects the charging connector when the EV approaches a charging station, and is designed to eliminate the need for driver intervention to connect and disconnect the charging connector. ACDs are broadly categorized into wireless charging devices, Automatic Charging Device Underbody (ACDU), and Automatic Charging Device Sidebody (ACDS)[2]. In particular, for the detailed classification of ACDS, there is a pantograph that is not used in Korea, but is often used in Europe. In the case of wireless charging devices, two coils are used to charge the EV through power transmission through electromagnetic induction between the EV and the charging pad, and it is the only wireless charging method among ACD technologies. It has the advantage of providing power without using a wired connector, but it has the disadvantage of low efficiency if the two coils are misaligned, requiring careful parking by the user[3]. Recently, a mobile wireless charging device that combines a wireless charging device and an autonomous mobile robot is being developed to solve the problem of charging only in a fixed location, and this device is emerging as a solution to the misalignment of fixed wireless charging devices. In the case of ADCU, the charging unit devices are installed on the lower part of the EV and the upper part of the charging station floor, and when the EV approaches the charging station and parks, the connectors are automatically connected and disconnected, and the EV can be charged without user intervention. The charging unit devices installed at the top and bottom have a long radius of action, which has the advantage of not requiring detailed parking by the user compared to wireless charging devices. Recently, plugs are being developed that are installed in the body of the EV and the connector comes down from the body to connect to the charging unit using magnet technology, which is emerging as a solution to replace methods that require high technical skills such as robotic arms. ACDS can be categorized into fixed, rail, mobile and pantograph. A fixed ACDS is a device that automatically charges the EV from the side of the EV when it approaches a charging station by connecting the existing charging connector with a robot. Unlike fixed ADCS, rail-type ADCS has the advantage of being cost-effective because one robot arm can support multiple automatic charging stations, while the robot arm moves along the line of the car park along the rail and manipulates the existing charging connector to charge the EV. Both fixed and rail-based ADCS have the advantage of being easy to integrate into existing infrastructure, as they typically utilize existing chargers and do not require additional charging connectors. However, they also have the disadvantage of placing a large load on the arm, which limits their operation. Mobile ACDS is a method that uses autonomous robots. When a user calls for an EV to be charged, the robot determines its location based on a signal and drives autonomously to arrive at the requested EV. It then uses its own robotic arm to help charge the EV. Mobile ACDS is powered by the robot's charged battery, so it relies on the battery's capacity and requires additional technologies such as the robot arm's charging outlet recognition, collision avoidance, and communication positioning. In Europe, pantographs have been used as a power transfer method in public transport such as traditional electric locomotives and high-speed trains, and more recently for charging large capacity vehicles such as electric buses and trams. Pantographs are typically mounted on top of the EV to receive power, and are divided into pantograph up and pantograph down depending on where the connectors are mounted. Because pantographs charge large vehicles, they are installed in a higher position than other charging connectors to ensure safety, allowing them to charge large amounts of power. However, since pantographs are used to power large transport vehicles, they have the problem of not being able to be integrated into existing infrastructure. In conclusion, ACDs have various characteristics and constraints, and research and development are underway to compensate for them. Therefore, along with the expansion of charging station infrastructure using V2G technology, the automatic charging technologies of ACDs are expected to be further developed.

Keywords— Vehicle to Grid, Automatic Charging Device, Electric Vehicle

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