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Research on the Basic System for Dynamic Wireless Power Transfer Connected with Photovoltaic in the Off-Grid Environment

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In recent years, there has been a growing worldwide movement toward carbon neutrality. This requires that thermal power generation and gasoline-powered vehicles, which emit greenhouse gases, be replaced by power generation using renewable energy sources such as solar power generation and electric vehicles (EV). The problem with the expansion of solar power generation is that the duck curve phenomenon will become more severe. This phenomenon is caused by insufficient real electricity demand during the daytime. By supplying power while driving to vehicles that are running more during the day, the power demand can be increased and the duck curve phenomenon can be mitigated. The PV+DWPT system, which combines photovoltaic (PV) cells and dynamic wireless power transfer (DWPT), is useful. While there have been several studies combining PV and DWPT[6-12], there have been few studies of completely off-grid PV+DWPT systems. In an off-grid PV+DWPT system, the amount of electricity generated by PV and transmitted to the vehicle fluctuates. These power fluctuations cause the DC bus voltage between the PV system and the DWPT system to fluctuate significantly, which causes problems with the Maximum Power Point Tracking (MPPT) control of the PV system. The system proposed in this paper uses an Electric Double Layer Capacitor (EDLC) as a buffer to absorb power fluctuations and solve the problem. The proposed system was verified through experiments.

The overall view of the proposed system is shown in Fig. 1, and a schematic diagram is shown in Fig. 2. The power generated by the PV is MPPT-controlled by a DC/DC converter and output to the DC bus. MPPT control is a control that can automatically track the optimum voltage and current values that maximize output when solar cells are generating power. There are several methods for MPPT control, but this paper uses the most commonly used P&O (Perturbation and Observation) method. In a PV+DWPT system, the output power of PV fluctuates due to weather changes, and the transmitted power fluctuates due to vehicle traffic. The EDLC is connected to absorb these fluctuations. The inverter outputs a square wave at 85 kHz as specified in the SAE J2954 standard[13], and a Double-LCC circuit is used as a Wireless Power Transfer (WPT) compensation topology[14].

The electric double layer capacitor (EDLC) is a large capacitor that absorbs power fluctuations in the proposed system. In a PV+DWPT system, the output power of PV fluctuates due to weather changes, and the transmitted power fluctuates greatly due to vehicle traffic. Without a buffer to absorb these fluctuations, the DC bus voltage will fluctuate significantly. As a result, the output voltage of the DC/DC converter fluctuates significantly, and the MPPT control of the PV cannot keep up with the output voltage, and the PV cannot be maintained at its maximum output. In addition, the input voltage of the inverter fluctuates significantly, causing fluctuations in the transmission voltage and instability in the power received by the vehicle. To solve these problems, a buffer is needed to absorb power fluctuations. The buffer must be able to withstand intense charging and discharging, and be able to store and release power rapidly. EDLCs have little degradation due to charging and discharging, can be charged and discharged for hundreds of thousands to millions of cycles, and can be charged and discharged rapidly. Therefore, EDLCs are used in the proposed system in this paper because they satisfy the requirements for buffers.

Simulation and experiment confirmed the suppression of DC bus voltage fluctuation and showed stable system operation. Future studies will include a study of the optimal PV installation capacity and EDLC capacity for the amount of traffic on the road where the PV + DWPT system will be installed.

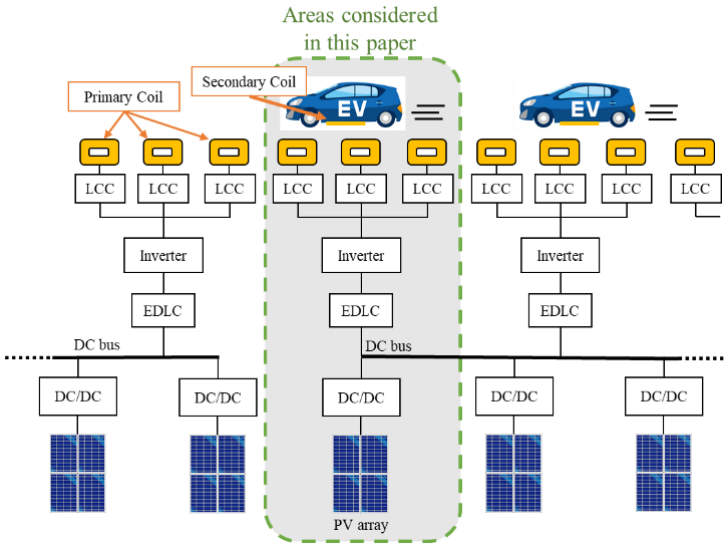

Fig.1 PV + DWPT system considered in this paper

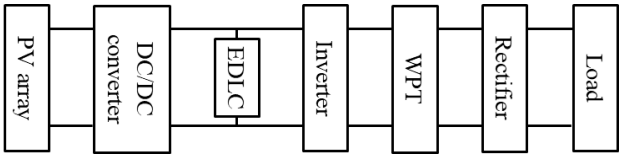

Fig.2 Schematic diagram of PV + DWPT (Off-Grid)