Development of EV Charging Controller Utilizing Smart Outlet Principles

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1.Introduction

With the rapid increase in electric vehicle (EV) adoption, the demand for safe and efficient charging systems is growing, especially at destination charging locations such as hotels and apartments. In these places, remote monitoring and safe power control are essential for reducing energy waste and improving operational reliability.

Smart outlets have already demonstrated the effectiveness of IoT-based power monitoring and remote on/off control for electrical equipment. By applying these principles to EV charging systems, safety and energy management can be further improved. Therefore, this study focuses on the development of an EV charging control system based on smart outlet principles with real-time monitoring and remote operation. RS-485 communication with the EV charging controller is positioned as a future extension of the system.

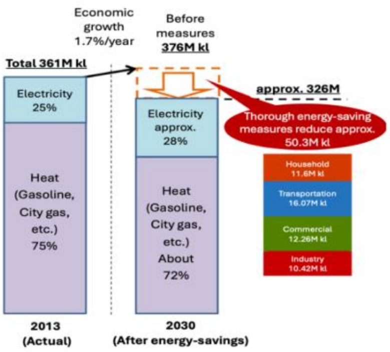

Figure 1. Final energy demand in the energy mix [1]

2. Objective

The objective of this study is to develop an EV charging control system based on smart outlet principles that can measure voltage, current, and power in real time, perform remote on/off control of a 200 V, 20 A EV charging circuit using an electromagnetic contactor, and transmit measurement data to the cloud for visualization and monitoring.

3. Contents of Research

3.1 From Smart Outlet to EV Control System

Previous studies developed 100 V smart outlets for general household use and 200 V smart outlets for EV charging applications. These systems enabled basic power monitoring and remote on/off control using IoT technology. This study builds upon those earlier works by improving the system design and extending its application toward EV charging environments.

In this research, the smart outlet principle is used to develop into an EV charging control system. The main function is a monitoring unit, while a 200 V electromagnetic contactor is used to safely switch the high-voltage EV charging load. This configuration maintains the advantages of smart outlet technology, such as real-time power monitoring and remote control, while supporting high-power EV charging.

3.2 System Concept and Operation

The proposed system applies smart outlet principles, such as power monitoring, remote switching, and IoT-based visualization, to an EV charging control system. Unlike a smart outlet, the system does not directly supply the charging current to the EV. Instead, the 200 V charging power is switched through an external electromagnetic contactor, while the control and monitoring are handled by a low-voltage control circuit. The ESP32 functions as the main controller, acquiring voltage, current, and power data from the measurement circuit and transmitting the data to the cloud via Wi-Fi for real-time monitoring. By separating the low-voltage control side and the high-voltage power side, the system ensures safe operation of the EV charging circuit.

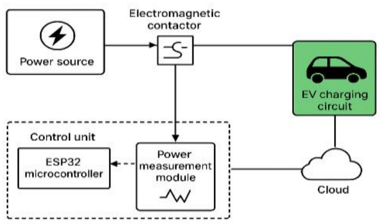

Figure 2. Concept Flow

3.4 Low-Voltage Control Board

Figure 3 shows the low-voltage control board. This board mainly consists of the **ESP32 microcontroller** and the **power supply circuit** that generates 5 V and 3.3 V for system operation. The ESP32 receives measurement data from the high-voltage board and transmits the data to the cloud via Wi-Fi for real-time monitoring.

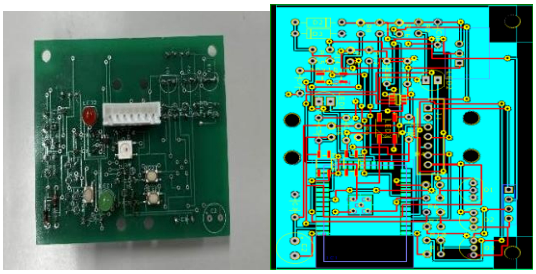

Figure 3. Schematic and developed Low-Voltage Board

3. 5 High-Voltage Power Board

Figure 4 shows the high-voltage power board for the 200 V, 30 A EV charging line. This board consists of the ACS758 current sensor, AC input/output terminals, and protection components. The ACS758 measures the charging current. The board is designed to operate with an external electromagnetic contactor for charging power switching. Electrical isolation between the low-voltage control board and the high-voltage power board ensures safe EV charging operation.

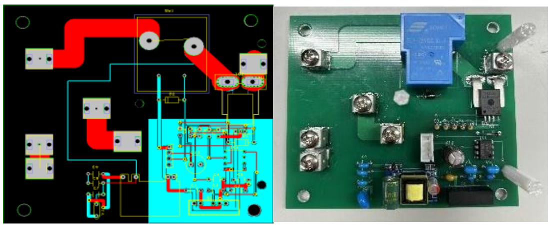

Figure 4. Schematic and developed High-Voltage Board

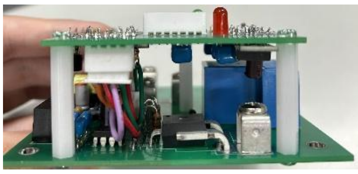

Figure 5. Overall Board

4. Conclusion and Future Works

This study developed a 200 V EV charging controller based on smart outlet concepts. The system can send the data to the cloud through Wi-Fi using the ESP32. Compared with the previous 200 V smart outlet system, the proposed 200 V controller is intended to replace the former 100 V control board ① in Figure 6, making it suitable for EV charging applications. The separation between the low-voltage control board and the high-voltage power board also helps improve safety during operation.

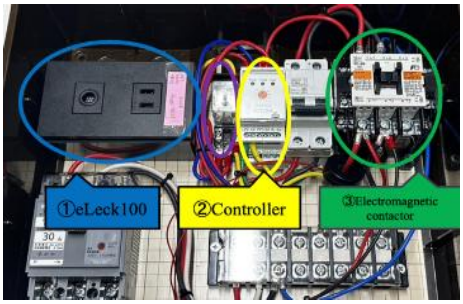

Figure 6. Hardware diagram of the previous smart outlet 200V for EV [2]

In the current system, the main focus is on power monitoring and cloud display. As the next step, RS-485 communication with the EV charger will be studied to allow the system to read the charging status and error information directly from the charger. With RS-485 communication, direct charger control and status detection will be possible, so the system might have less component needed for charging control.

References

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