

Study and Implementation of 10KW AC Electric Vehicle Charger

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ABSTRACT

The rapid growth of electric vehicles (EVs) has significantly increased the demand for efficient and reliable charging infrastructure, which plays a vital role in supporting sustainable transportation systems. This project focuses on the study and implementation of a 10 kW AC electric vehicle charger, categorized under Level-2 charging, which provides faster charging compared to low-power chargers while maintaining cost-effectiveness. The system is designed to deliver controlled and efficient power to EV batteries by utilizing a three-phase AC supply along with advanced power electronics and control circuits. It addresses key challenges in existing systems such as long charging times, high installation costs, and power quality issues by offering a balanced and practical solution. Keywords: Analysis, investigation, research.

I.INTRODUCTION

The rapid growth of electric vehicles (EVs) has increased the demand for efficient and reliable charging infrastructure. Electric vehicle chargers play a crucial role in supplying electrical energy to the vehicle battery. EV charging systems are mainly classified into AC charging. In AC charging, the electrical power from the grid is supplied to the vehicle's onboard charger, which converts AC power into DC power to charge the battery. The increasing demand for sustainable and eco-friendly transportation has led to the rapid adoption of electric vehicles (EVs) across the world. Unlike conventional vehicles that rely on fossil fuels, EVs operate using electrical energy stored in batteries, which helps in reducing greenhouse gas emissions and environmental pollution. However, the widespread use of EVs depends largely on the availability of efficient and reliable charging infrastructure. Electric vehicle charging systems are essential for transferring electrical energy from the power grid to the vehicle battery in a safe and controlled manner. EV charging systems are broadly classified into AC and DC charging types. In AC charging, the electrical energy supplied from the grid is in alternating current form, which is then converted into direct current by the onboard charger of the vehicle to charge the battery. AC chargers are further categorized into different levels based on their power rating and charging speed. A 10 kW AC charger falls under Level-2 charging, offering a balance between charging time, cost, and infrastructure requirements. It is widely used in residential complexes, commercial spaces, and public parking areas. The design and implementation of a 10 kW AC EV charger involve various electrical and electronic components such as power converters, protection circuits, control units, and communication systems.

II METHODOLOGY

Microcontroller-based control unit was interfaced with high-current relay modules to execute precise switching logic between the grid and the vehicle's onboard charger. Circuit was deployed, featuring MCBs, Surge Protection Devices (SPDs), and an Emergency Stop mechanism to safeguard the charger against electrical faults.

The engineering process began by defining a 10kW power threshold and selecting industrial-grade components capable of managing three-phase power distribution and localized thermal loads .To ensure authorized access, a multi-modal handshake protocol was implemented using RFID, QR code scanning, and OCPP-compliant mobile interfaces. A 4.3-inch industrial LCD was programmed to serve as a real-time diagnostic hub, displaying critical telemetry such as voltage, amperage, and energy consumption (kWh).The system was finalized by integrating 4G, Ethernet, and Wi-Fi modules to enable remote health monitoring, over-the-air updates, and smart load management via the cloud.

II.MODELING AND ANALYSIS

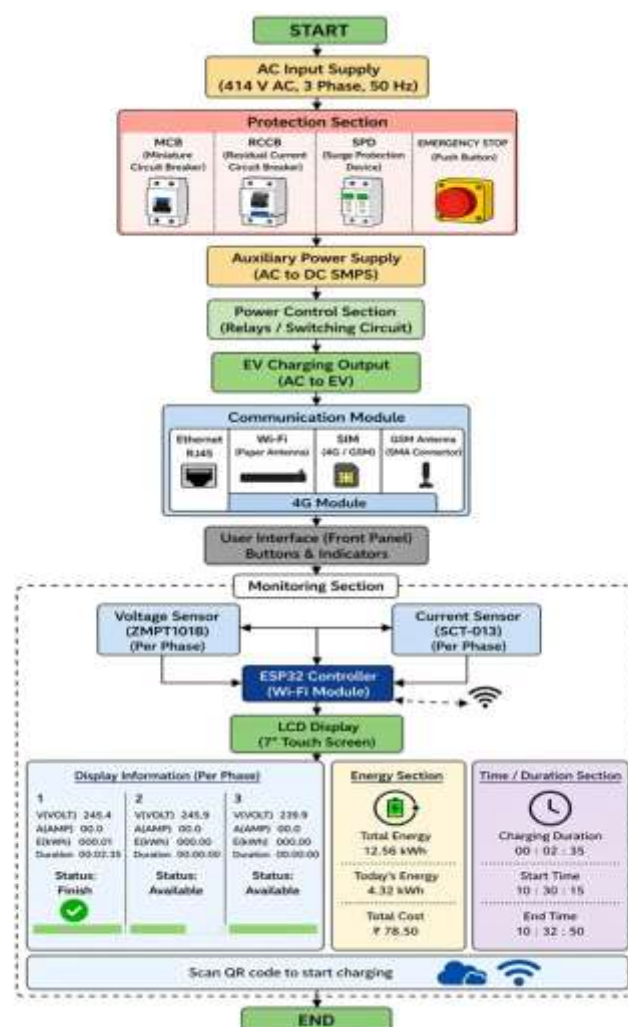




Figure 1: 3D view of model

Display System (HMI) The charger utilizes a 4.3-inch industrial-grade LCD which serves as the primary visual interface. It is programmed to provide real-time telemetry and operational transparency by displaying:

- Electrical Parameters:** Real-time Output AC Voltage and Amperage.
- Energy Metrics:** Precise consumption data in kWh and Total kWh.
- Billing Information:** Price per unit (based on MSME or institutional rates) and the total transaction amount.
- Diagnostics:** Specific error codes that identify system faults, ensuring safer maintenance compared to simple LED indicators.

2. Electrical Protection (MCB, SPD, & RCCB) The safety architecture is built around a multi-layered protection circuit to safeguard the charger, the vehicle, and the user:

- MCB (Miniature Circuit Breaker):** Provides essential protection against overcurrent and short circuits, physically disconnecting the circuit if the load exceeds safe limits.
- SPD (Surge Protection Device):** Protects the sensitive electronics (like the control unit and LCD) from high-voltage spikes caused by lightning or grid switching.
- RCCB (Residual Current Circuit Breaker):** Detects leakage currents to the ground, providing critical life-safety protection against electric shocks and preventing fire hazards.

3. Control System The "brain" of the charger is a microcontroller-based control unit that manages the entire charging lifecycle. It executes the core logic for:

- Switching Operations:** Coordinating high-current relay modules to safely engage or disengage power from the grid to the vehicle.
- Authentication Handshakes:** Processing inputs from RFID, QR codes, and mobile apps to authorize energy delivery.
- Thermal & Load Management:** Monitoring internal sensors to adjust power output or trigger a shutdown if operating temperatures exceed safe thresholds.

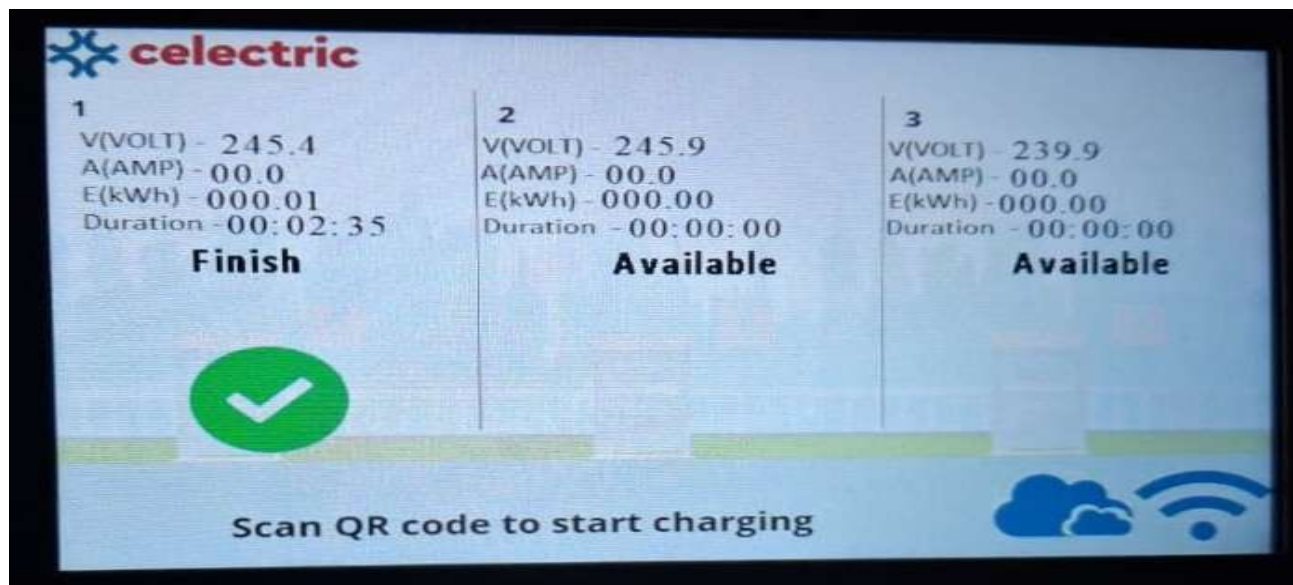
4. Battery Management & Smart Interface While the vehicle has its own internal BMS, your charger coordinates with it via the OCPP (Open Charge Point Protocol) interface. This system-level interaction ensures:

- Anomaly Detection:** Monitoring for thermal irregularities or ground faults during the charging process.
- Safety Interlocks:** Ensuring that power is only delivered when a secure physical and digital connection is confirmed, preventing

Analysis : The project utilizes a three-phase supply to manage a 10kW load. This is a strategic choice for commercial and semi-public environments as it ensures a balanced load across the grid, preventing phase imbalance and reducing energy wastage. The use of high-current relay modules for switching provides a reliable mechanical isolation between the control logic and the high-voltage output.

RESULTS AND DISCUSSION

The 4.3-inch industrial LCD provided real-time data with high precision. During active sessions, it accurately reported. In controlled fault simulations, the MCB and RCCB tripped within milliseconds of detecting overcurrent and earth leakage, respectively, ensuring zero damage to the charging controller or the vehicle interface. Unlike conventional chargers that use simple LED blink codes, the use of a detailed LCD display enhances user trust.



III.CONCLUSION

The project successfully demonstrates the design and implementation of a robust 10kW AC EV charging station that effectively bridges the gap between industrial safety standards and user-centric accessibility. By integrating a multi-layered electrical protection suite consisting of MCBs, SPDs, and RCCBs with an intelligent microcontroller-based control system, the station ensures high reliability and grid stability through balanced three-phase power distribution. The inclusion of a triple-mode authentication system and advanced connectivity options—including 4G, Ethernet, and Wi-Fi—transforms the hardware into a smart, manageable infrastructure asset capable of real-time monitoring and transparent billing via an industrial-grade LCD interface. Ultimately, this project establishes a scalable foundation for sustainable transportation infrastructure, proving that the integration of IoT-ready controls and renewable-based contactless charging theories can significantly mitigate range anxiety and promote the widespread adoption of electric vehicles.

V REFERENCES

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