Review on Development of Combined EV Charging System

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Abstract—The increasing adoption of electrical vehicles (EVs) worldwide demands a versatile and standardized charging infrastructure. However, the current charging ecosystem is fragmented, with multiple connector types- type 1, type 2, and type 3-each incompatible with others. This project focuses on developing a combined EV charging system with a universal socket that supports Type 1, Type 2, and Type 3 connectors. The goal is to simplify the EV charging process by creating a single charging station compatible with various electric vehicle standards. This system enhances convenience, reduces the need for multiple charging setups, and integrates smart features like load balancing and real-time monitoring.

Keywords: Electric vehicles, combined charging systems, AC charging, DC fast charging, smart grid, power electronics, interoperability, Universal Socket.

I. INTRODUCTION

The increasing adoption of electrical vehicles (EVs) worldwide demands a versatile and standardized charging infrastructure. However, the current charging ecosystem needs to be more cohesive, with multiple connector types- type 1, type 2, and type 3-each compatible with others. This project focuses on developing a combined EV charging system with a universal socket that supports Type 1, Type 2, and Type 3 connectors. The goal is to simplify the EV charging process by creating a single charging station compatible with various electric vehicle standards. This system enhances convenience, reduces the need for multiple charging setups, and integrates smart features like load balancing and real-time monitoring. This review paper explores the technological advancements within the development of the sort of mixed charging machine, studying the design considerations, challenges, and blessings of implementing a time-honored socket. The paper also examines how this solution can streamline EV charging infrastructure and contribute to the widespread adoption of electric vehicles. The paper also examines how this solution can streamline EV charging infrastructure and contribute to the widespread adoption of electric vehicles.

II. LITERATURE SURVEY

The class and topologies of electrical car chargers are examined, an overview of the current EV charging standards is furnished, the modern EV charging couplers is discussed, and the maximum extensively used batteries in ev packages are reviewed but restrained by using greatest operation at excessive temperature, danger of explosion constrained life of round six hundred cycles. [1].The observe examines the charging efficiency of stage 1 and level 2 electric vehicle deliver gadget (EVSE). Results show that Level 2 charging is 5.6% more efficient than Level 1, and even greater under low and high temperatures. The impact of these efficiency gains may be most significant at public charging stations, where charging times are shorter and climatic conditions are more variable. Future studies need to keep in mind DC rapid charging, and charging performance varies amongst vehicle fashions and at lower temperatures. Comparability of the charger and charging degree efficiency of stage 1, stage 2, and three[2].AC (Alternating Current) charging is easily accessible as it uses existing electrical grids and infrastructure but Charging times are longer, typically taking hours to fully charge a vehicle, especially for Level 1 charging[3].

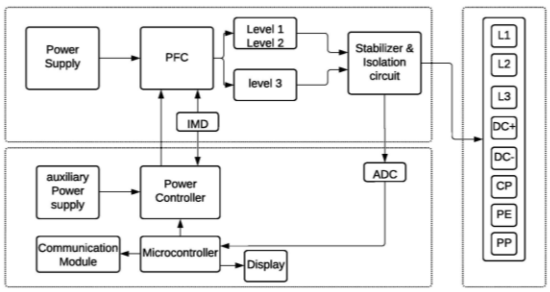
III. METHODOLOGY

1. System Design:

The methodology begins with designing the overall architecture of the Combined EV Charging System, integrating key components: Power Factor Control, Microprocessor, Power Controller, Stabilizer, Communication Module, and Socket.

2. Block Diagram Overview:

The block diagram illustrates the operational go with the flow and the interplay among special machine additives.



The entire system is divided into three sections. Section 1 comprises the contact power supply, Power Factor Correction (PFC), control level separator, rectifiers, stabilizer, and isolation circuit. To meet the high voltage and current demands of Electric Vehicles (EVs), a step-up transformer is employed to accommodate different charging levels.

Section 1: Power Supply and Control Circuitry

This section forms the backbone of the EV charging system, responsible for converting input power into a form suitable for different EV charging levels. Section 1 includes various components such as the contact power supply, Power Factor Correction (PFC) circuitry, control level separators, rectifiers, a stabilizer, and isolation circuits.

Power Supply and Voltage Adaptation: To support the varying charging requirements of different EVs, especially in high-voltage and high-current scenarios, a step-up transformer is utilized. This transformer plays a critical role in adjusting the power supply to match different EV charging levels (Levels 1, 2, and 3). It steps up the input voltage as needed, ensuring the system can cater to both fast-charging (DC) and slower AC charging modes.

The Power Factor Correction circuit is a technique used in EV charging systems to increase electrical power efficiency. PFC benefits both end-users and the electrical grid by meeting regulatory requirements and preventing premature breaker tripping. PFC reduces harmonics, while rectifiers eliminate unwanted harmonics from the input current and minimize harmonics in the rectifier output voltage and main DC link voltage.

Control Level Separation: For safety and efficiency, the system uses a relay-based circuit to separate the different levels of charging. Type 1 and Type 2 operate on AC power, while Type 3 provides DC power. This separation is crucial as the DC circuits in Level 3 charging operate at significantly higher voltages and power levels, requiring physical and electrical isolation from the AC circuits. The relays control when each circuit is active, ensuring there is no overlap between charging levels.

Rectifiers and Harmonic Reduction: Rectifiers convert alternating current (AC) to direct current (DC), which is required for Level 3 fast charging. However, rectifiers can generate unwanted harmonics in both the input current and the output voltage, which reduces the system's efficiency and could damage sensitive components. By implementing harmonic-reducing techniques, these disturbances are minimized, ensuring a smoother and more stable power supply for EV charging.

Stabilizer and Isolation Circuitry: Stabilizers and isolation circuits are necessary to ensure that the charging system operates reliably and safely. The stabilizer ensures that the output voltage remains consistent, regardless of fluctuations in the input power, which protects both the EV and the charger from damage due to power surges. The isolation circuit is equally important, as it prevents feedback from the high-voltage sections of the system to the lower-voltage control and communication circuits, maintaining system integrity and preventing malfunction or failure.

Section 2: Control and Monitoring

Section 2 focuses on the brains of the system—its control and monitoring circuits. The control system is responsible for managing power distribution and ensuring safe operation during charging. It includes a microcontroller, logic driver circuits, a user interface, and cloud-based communication.

Microcontroller: An Arduino Mega serves as the main microcontroller for this system. It is equipped with 16 analog input pins and 34 digital I/O pins, which makes it ideal for managing the various signals and sensors associated with the charging system. The microcontroller plays a crucial role in monitoring voltage and current levels, controlling relays, and interacting with the user interface. It also strategies real-time comments from the ev to regulate power stages and preserve secure charging conditions.

Logic Driver and Relay Control: The logic driver circuit, composed of logic gates and relays, is an intermediary between the microcontroller and the high-power components of the system. The microcontroller sends commands to the logic driver, which in turn controls the relays that manage power flow to different charging circuits. This ensures that the correct charging level is selected, whether it's AC or DC, and that power is safely disconnected once charging is complete.

An isolation monitoring device (IMD): to ensure certain the protection of the machine, an isolation tracking tool (IMD) is responsible. This device monitors the isolation between high-voltage and low-voltage circuits, preventing any accidental grounding or overlap. This is crucial in maintaining the integrity of the control circuits, which operate at lower voltages, and protect them from potential damage caused by high-voltage leaks from the main power supply.

User Interface and Cloud Connectivity: A user interface, featuring an LCD mounted on the front panel, allows users to monitor the charging process and view system status. This interface gives important information together with charge level, time remaining, and device fitness. In addition, the system is integrated with cloud-based communication, enabling remote monitoring and diagnostics. This feature is particularly useful for fleet management and maintenance teams, as it allows for real-time data analysis and proactive system servicing.

Section 3: Universal Charging Plug and Socket

This section is dedicated to the physical interface between the EV and the charger, focusing on designing a universal charging system that can accommodate different EV standards. The charger plug and socket are critical components of this system, allowing for compatibility with various vehicle types and charging levels.
1.)L1 and L2: These pins handle single-phase AC charging for Level 1.
2.)L1, L2, and L3: These pins are used for three-phase AC charging in Level 2, allowing for faster charging rates than single-phase.
3.)DC+ and DC-: These pins supply DC power for fast charging (Level 3), which bypasses the vehicle's onboard charger and delivers high-voltage direct current directly to the battery.
4.)Control Pilot (CP): The CP pin is responsible for communication between the EV and the EV Supply Equipment (EVSE). It presents data at the charging reputation and facilitates alter the strength float.
5.)Proximity Pin (PP): The PP detects the current capacity of the charging cable and ensures that the appropriate power is delivered, preventing overheating and overloading.
6.)Protective Earth (PE): The PE pin provides a safe grounding path, essential for protecting against electrical shock and ensuring compliance with safety standards.

Communication and Safety: The CP and PP pins play a vital role in ensuring the safe operation of the charging system. The CP pin not only manages power flow but also facilitates essential safety functions like verifying the connection between the EV and the charger. The PP pin prevents the vehicle from moving while charging, reducing the risk of accidents or damage to the plug and socket. The PE pin is equally important, as it provides an earth grounding connection to prevent any buildup of dangerous voltages that could lead to electric shock.

This breakdown highlights the technical aspects of the power supply, control, and universal plug design, emphasizing the advanced functionality and safety features critical for modern EV charging systems.

IV. LIMITATIONS

1. Complexity in Design and Implementation:
Developing a system that supports multiple charging standards and voltage levels (AC Level 1, Level 2, and DC Level 3) involves designing intricate circuitry and control systems. This complexity increases the chances of design errors, leading to potential reliability issues. The system must also ensure safety and efficiency while handling different power inputs, which makes the overall design more challenging and costly.

2. High Development and Manufacturing Costs:
The inclusion of advanced components such as transformers, Power Factor Correction (PFC) circuits, high-quality rectifiers, and robust safety mechanisms results in increased production costs. Additionally, integrating compatibility with multiple charging standards requires high-quality materials and extensive testing, driving up the overall expense of manufacturing the system, which could translate to higher costs for consumers.

3. Potential for Lower Efficiency:
While the combined system offers flexibility, managing both AC and DC charging within one platform can lead to inefficiencies. For instance, converting AC to DC for Level 3 fast charging introduces power losses, and balancing the power

supply across multiple charging standards may not be as efficient as dedicated single-standard chargers. The complex control systems may also introduce latency or reduced charging speed.

4. Compatibility Challenges with Future Standards:
While the universal socket is designed to accommodate current EV charging standards, new or evolving standards could render the system partially obsolete. For example, as EV technology advances, higher power levels or new connector types might emerge, requiring further modifications or upgrades to the charging system. Maintaining future compatibility would require ongoing investment in updates or new designs.

5. Increased Maintenance Requirements:
The more complex the system, the higher the likelihood of component failures, especially when managing both AC and DC power. Over time, the universal socket and internal components may wear out faster due to handling high power for DC fast charging. Furthermore, the system may require more frequent monitoring and maintenance, which could increase operational costs for charging station operators.

6. Safety Risks and Isolation Challenges:
The system must handle high-voltage DC charging, which poses safety risks such as electric shocks, short circuits, or fire hazards. Ensuring proper isolation between AC and DC circuits is critical to avoid potential risks. Despite safeguards, failures in isolation mechanisms, such as the relay system separating AC and DC charging, could lead to dangerous outcomes for both the vehicle and users.

7. Heat Management Issues:
A combined charging system that supports multiple levels of charging (especially high-voltage DC charging) generates significant heat during operation. Efficient heat dissipation systems must be in place to prevent overheating, but this adds complexity to the design. Inadequate heat management could lead to reduced lifespan of components, lower efficiency, or even system failure.

8. Grid Load Management Challenges
High-power DC fast charging, especially when integrated into a combined system, can place a significant load on the electrical grid. Managing this load requires sophisticated grid integration systems and real-time monitoring, which increases the complexity of the system. Failure to manage grid demand effectively could lead to grid instability or increased operational costs for utility providers.

V. FINDINGS

1. Enhanced Flexibility for EV Users:
A key finding is that a combined EV charging system with a universal socket provides enhanced flexibility for EV owners with support for multiple charging levels (AC Level 1, Level 2, and DC Level 3) and compatibility with a wide range of EV plug types (e.g., Type 1, Type 2, CHAdeMO), the system allows users to charge their vehicles at different speeds based on their immediate needs. This flexibility is especially beneficial in public charging stations where different EV models, each requiring different types of charging, converge. Users no longer need to worry about carrying multiple adapters or finding the right type of charger.

2. Increased Convenience through Universal Compatibility:
The universal socket design eliminates the need for separate charging stations for different EV standards. This convenience translates into greater accessibility for users across regions, as the charging system is compatible with most major global charging standards. EV owners can travel between regions or countries without worrying about compatibility issues at charging stations. This universality also simplifies the infrastructure setup for businesses or public institutions that wish to install charging stations, as they no longer need to provide multiple types of chargers.

3. Cost Efficiency in Infrastructure Deployment:
The combined EV charging system reduces the need for separate infrastructure for AC and DC charging, leading to cost savings in the deployment of charging stations. By consolidating the charging hardware into one system, businesses, municipalities, and other charging providers can reduce the space, materials, and labor required to set up charging points. This consolidation is particularly beneficial for urban areas where space is limited, and a compact, all-in-one solution can be more easily installed.

4. Efficient Power Management and Delivery:
The integration of advanced circuitry, such as Power Factor Correction (PFC), transformers, and rectifiers, ensures efficient power delivery to EVs. PFC helps to improve the system's energy efficiency by reducing

the phase difference between the voltage and current, minimizing energy waste. Rectifiers convert AC power to DC efficiently for Level 3 fast charging, while transformers step up or step down voltage levels as needed for different charging modes. These power management techniques reduce energy losses and contribute to more sustainable use of electrical resources, benefiting both users and the power grid.

5. Support for Multiple Charging Modes:
Another significant finding is the system's ability to seamlessly switch between AC and DC charging modes. This capability allows EVs that require slow or fast charging to utilize the same infrastructure without any disruptions. For example, users who need a quick top-up can access DC fast charging, while others who have more time can use AC Level 1 or Level 2 charging. This flexibility in charging speeds provides greater convenience to users based on their current charging needs and available time, enhancing the overall user experience.

6. Improved Safety Measures:
Safety is a paramount concern in high-power EV charging systems, and the combined EV charging system incorporates advanced safety features such as isolation circuits, stabilizers, and ground fault protection. These systems ensure that high-voltage circuits for fast DC charging are safely isolated from low-voltage AC circuits, preventing accidental damage or hazards. Additionally, the universal socket is designed with built-in mechanisms such as Control Pilot (CP) and Proximity Pilot (PP) pins, which facilitate communication between the vehicle and the charger, ensuring safe charging initiation and preventing charging if conditions are unsafe.

7. Ease of Maintenance and Monitoring:
The combined charging system includes cloud-based monitoring and diagnostics, allowing operators to remotely track system performance and detect issues in real time. This feature simplifies maintenance by enabling predictive maintenance measures, reducing downtime, and lowering operational costs. Charging station operators can monitor energy usage, identify potential failures, and schedule repairs or part replacements proactively. Additionally, users can benefit from app-based interfaces that allow them to monitor their vehicle's charging status, receive notifications, and even schedule charging times.

8. Future-Proof Design:
With the rapid evolution of EV technology, future-proofing the charging infrastructure is essential. The universal socket's adaptability to multiple charging standards means the system is less likely to become obsolete as new EV models emerge. Manufacturers can update the system's software to accommodate new charging protocols without needing to replace the entire hardware. This future-proofing ensures long-term value for charging station operators and businesses, protecting their investment against technological shifts in the EV industry.

9. Potential to Promote Widespread EV Adoption:
The introduction of a universal charging system is likely to accelerate the adoption of electric vehicles. One of the primary barriers to EV adoption has been the fragmented charging infrastructure, with different standards and incompatible chargers in various regions. By offering a standardized and versatile charging solution, the combined EV charging system reduces uncertainty and enhances consumer confidence in EV technology. This streamlined approach can help create a more unified global charging network, supporting the transition to electric vehicles and contributing to environmental sustainability goals.

These findings underscore the importance of a universal, efficient, and safe charging system to support the growing EV market. While challenges such as grid integration and development costs exist, the potential benefits of a combined EV charging system with a universal socket outweigh the limitations, making it a key component in future transportation infrastructure.

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