The Academic
International Journal of Multidisciplinary Research

An Online Peer Reviewed / Refereed Journal
Volume 4 | Issue 4 | April 2026
ISSN: 2583-973X (Online), SJIF IF: 5.6
Website: www.theacademic.in

A Study on Charging system and How Electric Vehicle Supply Equipment (EVSE) Works

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DOI : https://doi.org/10.5281/zenodo.20126372

ARTICLE DETAILS

Research Paper

Accepted: 25-04-2026

Published: 10-05-2026

Keywords:

EVSE, Electric Vehicle, Electric Vehicle Charging States of Charging, Levels of Charge

ABSTRACT

Electric Vehicle Supply Equipment (EVSE) serves as the primary gateway between the utility grid and an electric vehicle's (EV) battery, functioning as a critical component of modern transportation infrastructure. This research provides a technical evaluation of EV charging systems, focusing on how EVSE facilitates secure and efficient energy distribution. The paper categorizes charging hardware into Level 1, Level 2, and Level 3 (DC Fast Charging), examining their distinct technical specifications and deployment contexts. Key operational mechanisms—such as vehicle-to-grid communication, power management, and safety protocols for fault mitigation—are analyzed in depth. By synthesizing performance data, the study outlines the pillars of a robust user experience and discusses how scalable EVSE deployment accelerates the transition to global decarbonization.

I. Introduction

The global shift toward sustainable energy has positioned electric vehicles (EVs) as a primary solution for reducing transport-related carbon footprints. Consequently, the establishment of sophisticated Electric Vehicle Charging Systems (EVCS) is no longer optional but a foundational requirement. In urban environments, the proliferation of electric two-wheelers highlights the need for accessible, eco-friendly mobility solutions. Unlike conventional internal combustion engines, these vehicles rely entirely on electrochemical storage, making the reliability of charging infrastructure paramount. This paper offers a comprehensive guide for implementing these systems, ensuring they meet the demands of modern daily life.

i. Charging Classifications

Charging systems are generally distinguished by their voltage levels and current types:

- Level 1 AC: Utilizes a standard 120V AC supply.
- Level 2 AC: Operates on a 240V AC supply for faster replenishment.
- Level 3 DC: Known as "DC Fast Charging," bypassing the on-board charger to feed power directly to the battery.

ii. Connector Standards and Interface Geometry

To ensure interoperability, the industry utilizes standardized physical interfaces that vary by region and power requirements:

- Type 1 (SAE J1772): The standard for single- phase AC charging.
- Type 2 (IEC 62196): Common in international markets for multi-phase AC.
- CCS (Combined Charging System): Integrates AC and DC capabilities into a single port.
- CHAdeMO: A specialized protocol for high- speed DC charging.
- NACS (Tesla): A proprietary high-performance connector now widely adopted in North America

iii. Pin Assignment and Functionality:

The integrity of the charging process relies on specific pins within the connector:

- **Power Lines (L1, L2, L3, N):** Facilitate the transfer of AC power.
- **High-Speed DC (DC+, DC-):** Direct energy paths for fast charging.
- **Proximity Pilot (PP):** Confirms the physical engagement of the plug.
- **Control Pilot (CP):** The bidirectional communication channel for signaling and state management.

- **Protective Earth (PE):** Ensures safety via a dedicated grounding path.

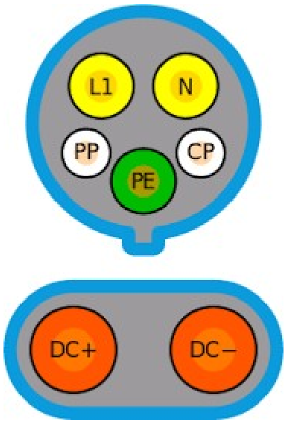


Figure 1.1 Pin Diagram

II. System Implementation and Architecture

i. Technical Framework

The infrastructure bridges the gap between the grid and the vehicle through a combination of On-Board and Off-Board components. Constant data exchange between the vehicle's Battery Management System (BMS) and the EVSE is required to maintain safety and efficiency. Block Diagram of the System

ii. Communication via Control Pilot (CP) The Control Pilot is the "brain" of the connection. It uses a 12V Pulse Width Modulation (PWM) signal to communicate. The vehicle modifies the resistance on this line, causing voltage drops that signal specific states to the EVSE:

a) **Safety Protocols**: The EVSE includes integrated protections such as ground fault detection, overcurrent safety, and circuit management.

b) **Vehicle Interaction**: A key feature of the EVSE is its ability to receive signals from the vehicle to start charging or identify technical errors.

c) **Energy Transfer**: Once all safety checks are passed, the EVSE activates the internal relays to allow power flow.

iii. Block Diagram

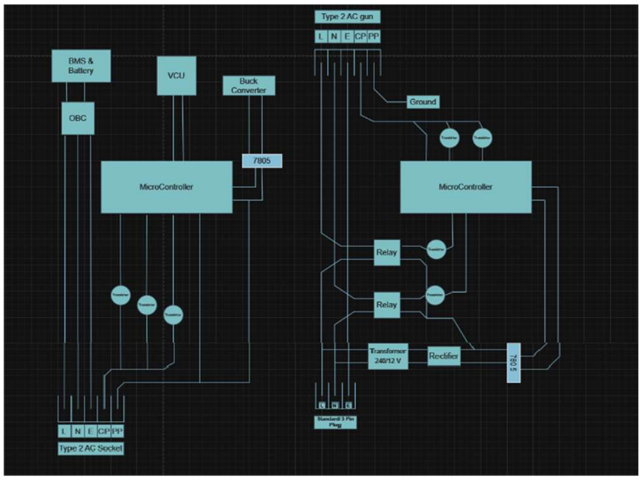
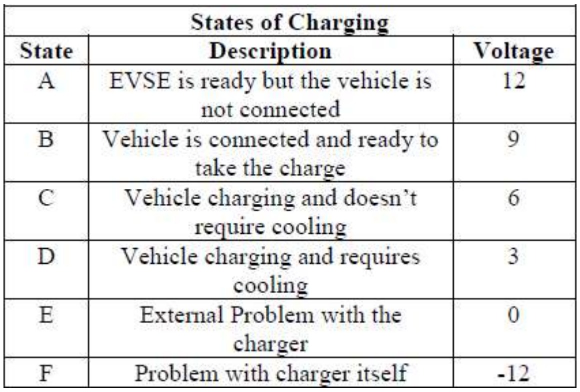


Figure 1.2 Block Diagram

iv. Operational Flow and Logic

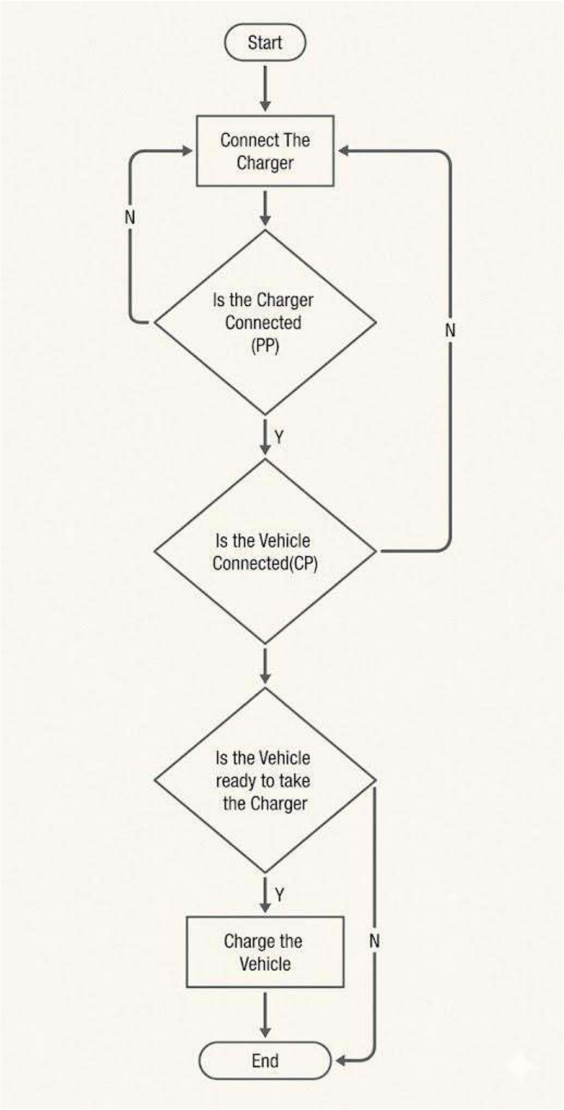
The system follows a strict logical sequence to ensure the vehicle is ready before power is transferred.

- **Connection Detection**: The process begins when the charger is physically plugged in.
- **Proximity Check (PP)**: The Proximity Pilot (PP) pin identifies that the connector is locked into the vehicle.
- **Control Pilot (CP) Verification**: The system checks if the vehicle is ready to receive a charge by monitoring the voltage on the CP pin.



States of Charging		
State	**Description**	**Voltage**
A	EVSE is ready but the vehicle is not connected	12
B	Vehicle is connected and ready to take the charge	9
C	Vehicle charging and doesn't require cooling	6
D	Vehicle charging and requires cooling	3
E	External Problem with the charger	0
F	Problem with charger itself	-12

Table 2.1 States of Charging



Flowchart

i. Current Regulation via PWM

To prevent overloading the vehicle's battery, the EVSE uses **Pulse Width Modulation (PWM)**. By adjusting the **Duty Cycle** of the signal, the charger tells the vehicle the maximum current it is allowed to draw.

$$\text{Duty cycle} = (T\_on)/T$$

For 6A-51A,

$$Amps = Duty\ cycle\ \times 0.6$$

$$Duty\ cycle = (Amps/0.6)\%$$

For 51A-80A,

$$Amps = (Duty\ cycle - 64) \times 2.5$$

$$Duty\ cycle = (Amps/2.5 + 64)\%$$

Amp	Duty Cycle	Amp	Duty Cycle
6A	10%	40A	66%
12A	20%	48A	80%
18A	30%	65A	90%
24A	40%	75A	94%
30A	50%	80A	96%

Table 2.2 Current vs Duty Cycle

ii. Simulation

The below simulation is done in Proteus to justify the logic, communication between charger and Electric Vehicle, and working of the charger. The relays are switching 230V AC, but the control circuit is working on 12V DC. The whole procedure explained in the above section works in this simulation; LEDs are kept for indication purpose.

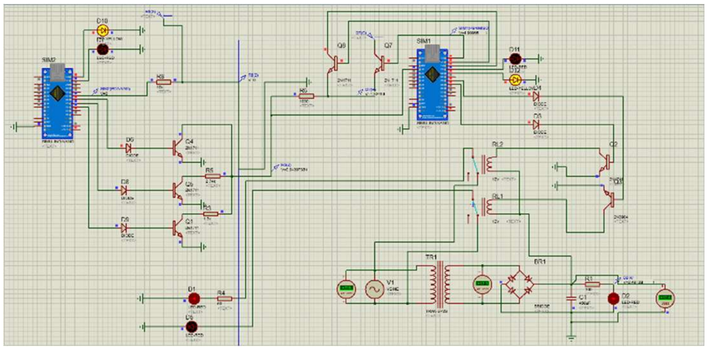


Figure 2.2 Simulation of the system

The above Simulation is only for demonstration purpose and not for actual charging, though actual circuit is similar and works on the same principle but it contains components which are according to the Automotive standards and other international standards. Here for demonstration the components which are used are chosen according to the current and voltage capacity which is essential for the circuit to run safely.

As shown in the figure and discussed in earlier section there is vehicle side, charger side (EVSE) and a battery. The above Circuit for demonstration is working on 12V DC. Both the Power and Control Voltage is 12V. So, instead of 230V AC here the battery is directly charged at 12V, as there is no On-Board Charger to convert AC to DC.

- **Power Distribution**: The equipment can deliver either AC (typically for residential use) or DC (for high-speed commercial stations).

Components used are:

Microcontroller – Arduino Nano

DC/DC Converter (12/5V) – LM2596

Current Sensor – ACS712

Relay – JQC-3FC

Transistor (BJT) – BC547

Connector – JST XH

Rechargeable Battery – 12V DC

LEDs, Different Values of Resistors

III. Conclusion

This study provided a detailed exploration into the fundamental architecture of electric vehicle charging systems, specifically focusing on the operational logic of Electric Vehicle Supply Equipment (EVSE). Our findings underscore that the continued advancement of EVSE technology is a vital prerequisite for the global transition to electric mobility, as it ensures a secure and optimized method for energy transfer between the grid and the vehicle. This research identified critical factors for future infrastructure, including standardized communication protocols and integration with renewable energy sources. It is clear that a widespread and dependable charging network is essential for mitigating "range anxiety" and encouraging consumer adoption. Furthermore, the trend toward universal standards for EVSE suggests a future of improved interoperability and reduced hardware costs across different vehicle manufacturers. Ultimately, the role of sophisticated charging equipment is central to a sustainable transportation ecosystem, and the technology must continue to evolve alongside the growing demands of the automotive industry.

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