



## Unit 4: Charging System Design Technology For EV Applications

### Syllabus

Charging system design considerations, AC & DC Charging, Charging methods, On-board/Off-board chargers, Vehicle to charger communication system, OCPP familiarity cloud and device side, metrology, billing and authentication types, understand the computing needs in a charging system, Understand internal major block diagrams and subsystems of low and high power chargers. IEC61850 and 61851 familiarities, IEC61000, 60950/51, IEC62196 key highlights.

### Charging system design considerations

Electric vehicles (EV) can be charged in a variety of ways, depending on location and requirement. Accordingly, charging infrastructure for EVs is of different types and designed for different applications. Specifications and standards for EV chargers, also known as electric vehicle supply equipment (EVSE), vary from one country to another, based on available EV models in the market and the characteristics of the electricity grid. This chapter explains the technical concepts of electric vehicle charging infrastructure, and highlights the need for a contextual approach to local planning and implementation of EV charging networks.

Designing the charging system for electric vehicles (EVs) involves several important considerations to ensure efficient and safe charging. Here are some key design considerations.

1. **Charging Levels:** Determine the required charging levels based on the target market and user needs. The most common charging levels for EVs are:
  - a. Level 1: Uses a standard household outlet (120V AC) and provides a low charging rate. Suitable for overnight charging.
  - b. Level 2: Utilizes dedicated charging equipment with higher power capacity (240V AC) for faster charging. Commonly installed at homes, workplaces, and public charging stations.
  - c. Level 3 (DC Fast Charging): Provides high-power charging at public charging stations, allowing rapid charging within minutes.
2. **Charging Connectors:** Select appropriate charging connectors based on regional standards and vehicle compatibility. The two primary connector types are:
  - a. SAE J1772: Used in North America for Level 1 and Level 2 charging.
  - b. Combined Charging System (CCS): A global standard combining AC and DC charging, compatible with Level 1, Level 2, and Level 3 charging.
3. **Power Capacity:** Determine the required power capacity of the charging system based on the charging levels and expected demand. Consider factors such as the number of charging stations, anticipated charging time, and available electrical infrastructure capacity.
4. **Electrical Infrastructure:** Assess the existing electrical infrastructure and ensure it can handle the power requirements of the charging system. Upgrades may be necessary, including transformer capacity, circuit breaker ratings, and cabling.
5. **Charging Station Locations:** Strategically plan the locations of charging stations, considering accessibility, parking availability, and proximity to key areas (residential,



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Commercial, public spaces). Consider cooperation with local authorities, businesses, and utilities for installation and usage agreements.

6. **Smart Charging and Load Management:** Implement smart charging features to optimize charging efficiency and minimize strain on the electrical grid. Load management techniques can distribute charging loads based on grid conditions, time-of-use tariffs, and user preferences.
7. **Safety Considerations:** Ensure compliance with safety standards and regulations. Incorporate safety features such as ground fault protection, overcurrent protection, and monitoring systems to prevent electrical hazards and ensure user safety.
8. **Communication and Connectivity:** Enable communication capabilities between the charging system, vehicle, and network infrastructure. This facilitates features like user authentication, billing, remote monitoring, and smart grid integration.
9. **Scalability and Future-proofing:** Design the charging system to accommodate future expansion and technological advancements. Consider factors such as the potential growth of EV adoption, evolving standards, and emerging charging technologies.
10. **User Experience:** Focus on creating a user-friendly experience with clear instructions, intuitive interfaces, and reliable charging performance. Consider factors like user authentication, payment systems, real-time status updates, and user support channels.

### AC & DC Charging

When it comes to electric mobility, two types of electrical currents can be used to charge an electric vehicle (EV)—AC (alternating current) and DC (direct current). All home EV chargers and the majority of public charging stations use AC, while DC is used for fast charging.

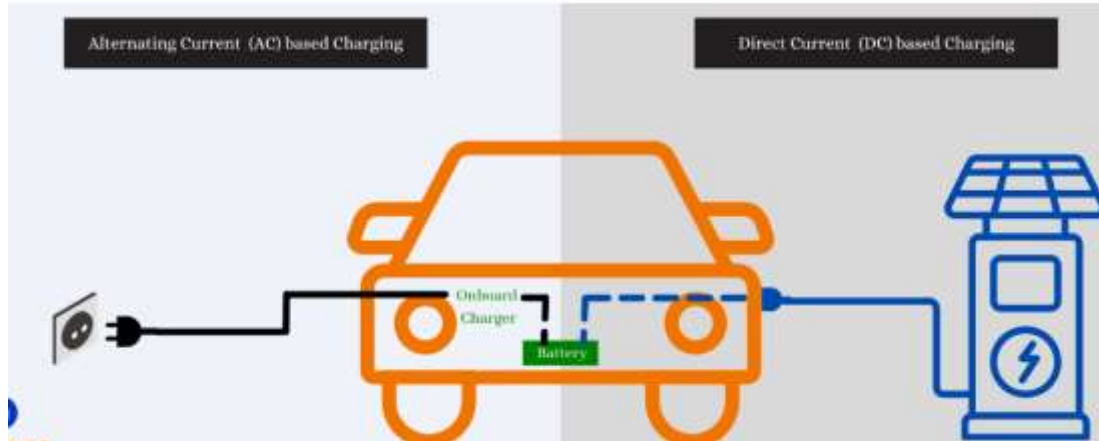
When we talk about charging an EV, the main difference between AC and DC charging (and the time it takes to do so) is where the conversion from AC to DC happens, i.e. in the vehicle or the charging station.

- The power that comes from the grid is always AC (alternating current).
- The energy stored in batteries is always DC (direct current).

Electric mobility is **more popular than ever**, and growing alongside it is the EV charging ecosystem. On paper, the concept is simple: instead of filling up a tank with fuel at the gas stations, EVs plug into a charging station to top up their batteries. In practice, however, not all chargers are created equal. EV charging stations come in many different shapes, sizes, and use cases. One of the main factors that differentiate them, however, is the type of current they use.



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### AC charging

In AC chargers, there is an inbuilt on-board charger. The input given is AC (Alternating current) power, this is converted into DC (Direct Current) power before feeding the battery. This is because the battery is compatible with DC power only. This is the most common mode of charging. They are most suitable at homes and for night charging. The charging speed is in the range 22kW-43kW per km/h.

AC chargers can be divided into two:

- Type 1 : They have a charging rate of 2.5kW to 3kW. Depending on the battery power the time required to charge varies from 1-6 hours.
- Type 2: They have a charging rate of 7.7 kw to 22 kw. Mainly used to charge batteries with higher power rates.

### Advantages

- Cost effective
- They are available easily
- Installation is simple
- Charges at a continuous rate

### Disadvantages

- They are slow in charging
- Limited power. Since the AC power depends on the capacity of on-board charger

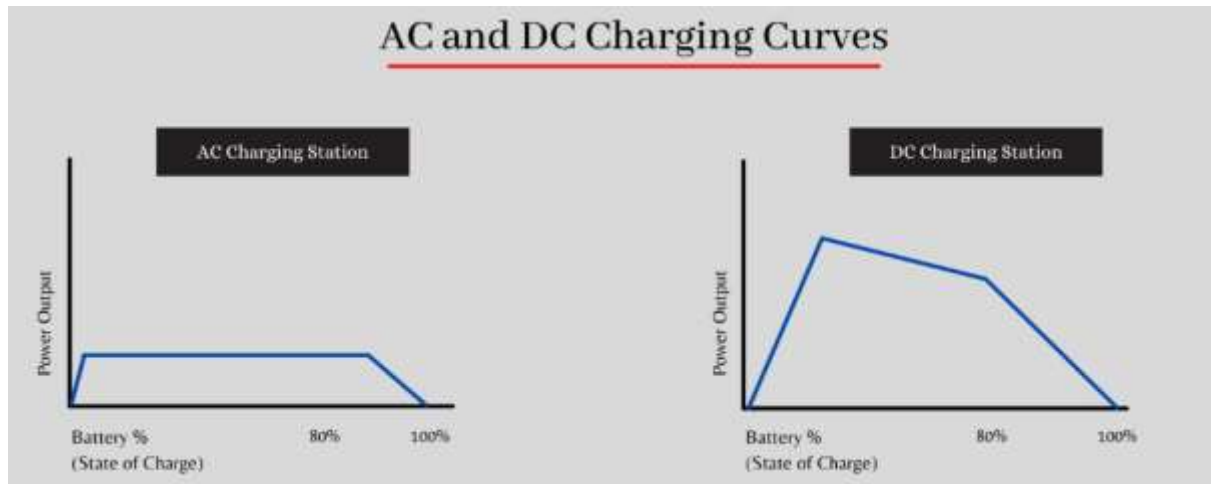
### DC Charging

In DC chargers, DC power is given directly to the battery bypassing the on-board charger. Here the DC charger itself has a converter that converts the AC supply to DC current before giving it to the battery. The charging speed is in the range 50-100kW per km/h. To be more precise, Dc chargers can supply the range of 100 km or more per hour of charging.

Mostly used in highways and charging stations. DC fast charging is essential for high mileage, high fleet and heavy vehicles. The charging curve is a degrading curve. In other words, the initial fast rate at which the battery accepts power decreases as it approaches its total capacity.



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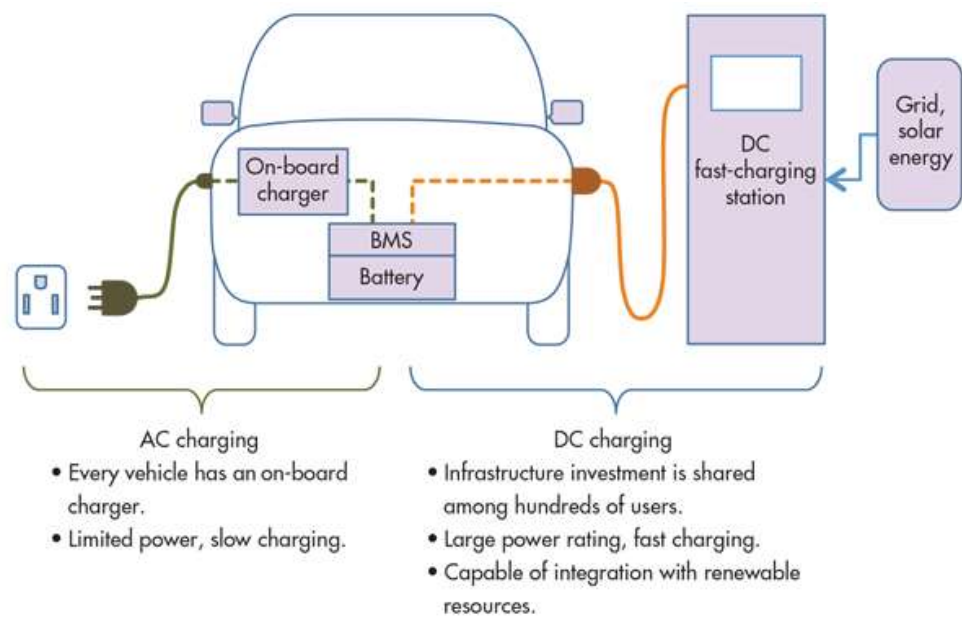
#### Advantages

- Charging speed is high
- Ability to charge more drivers in a day

#### Disadvantages

- They are expensive
- Complex components and needs large space
- Needs large power supply

DC chargers also accompany renewable sources of energy.





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### Indian Standard for DC charging

The IS-17017-Part-25, which is specifically for providing low DC power of less than 7kW for light EVs, was just finalised by the BIS (Bureau of Indian Standards). Communications will follow the IS-15118 series when the Combined Charging System (CCS) standard is implemented, which can support both AC and DC charging.

## Charging Methods

Electric vehicles (EVs) can be charged through various methods, depending on the available infrastructure and charging needs. Here are the primary charging methods for EVs:

**Residential Charging:** Level 1 Charging: It involves plugging the EV into a standard household outlet (120V AC). Level 1 charging is slow, typically providing a charging rate of 2-5 miles of range per hour. It is suitable for overnight charging or when higher charging speeds are not required. No additional charging equipment is needed, as the EV's onboard charger handles the conversion from AC to DC.

Level 2 Charging: This method uses a dedicated charging station with a higher voltage (240V AC). Level 2 charging provides faster charging rates, typically ranging from 10-30 miles of range per hour of charging. Level 2 chargers require professional installation and often involve a separate charging unit (EVSE or Electric Vehicle Supply Equipment) that communicates with the EV's on-board charger.

**Public Charging:** Public charging stations are available in various locations to enable EV charging on the go. They typically offer faster charging options, including Level 2 chargers and DC fast chargers. Public charging networks and apps help EV owners locate and access these stations, often requiring user authentication and payment.

**DC Fast Charging (DCFC):** DC fast charging, also known as Level 3 charging, provides the fastest charging rates for EVs. It delivers high-power DC electricity directly to the vehicle's battery, bypassing the on-board charger. DC fast chargers are commonly found along highways, at service stations, and in public areas, allowing for quick charging during long-distance travel. They can recharge an EV's battery to 80% or more in 30 minutes or less, depending on the charger's power output.

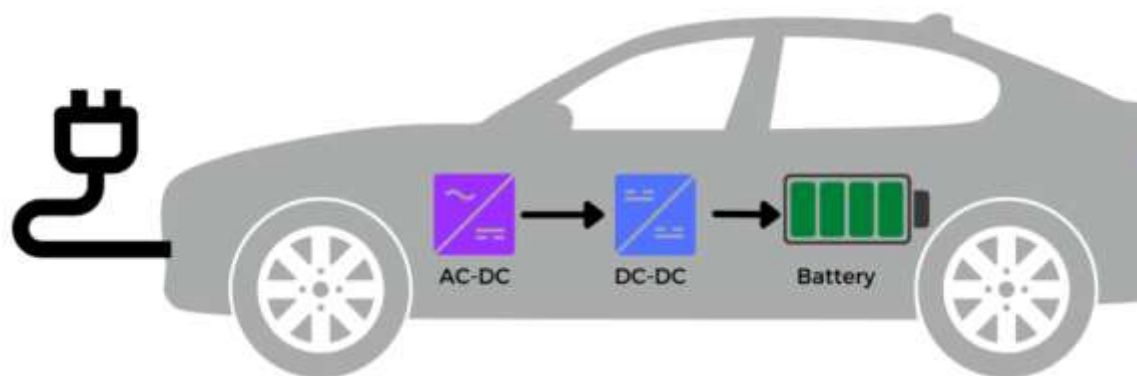
**High-Power Charging:** High-power charging is an emerging charging method that offers extremely fast charging times by utilizing extremely high-power outputs. These systems, such as ultra-fast DC chargers, can provide power outputs above 350 kW. High-power charging requires robust electrical infrastructure and is being deployed in select locations to support high-demand charging needs and reduce charging time.



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### On-board/Off-board chargers

**On-board charger (OBC)** is a device that convert ac power from any ac source into the practical dc form. It is usually mounted inside the vehicle and its main function is **power conversion**. Hence, on board chargers provides the advantage of charging the electric vehicle using the power outlet at our homes itself. In addition, it also eliminates the need for buying any extra equipment for power conversion.



The main function of an on-board charger, is to **manage the flow of current** from the grid to the traction battery. On board chargers (OBCs) helps in charging the electric vehicles from any source. Hence, electric vehicles do not have to depend on charging stations all the time.

Another function of OBC is that it **controls the level of current and voltage** at which the battery is charged. There are mainly two types of charging: constant voltage and constant current charging. Even though constant current charging provides high efficiency and high charging speed it can affect the lifespan of the battery. This is due to over-charging. In the case of constant voltage charging, there is a chance that a high amount of current can flow into the battery initially.

The above problem can be solved by charging the battery initially by constant current charging. Then after reaching a certain amplitude, the battery is charged using constant voltage charging. This charging strategy is the most important role of an EV on board charger.





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### On Board Charger in Different Charging Stations

EVSE	Charging level	AC Supply specification	Power rating	Time taken to charge a 24kWh battery pack (approx.)
<a href="#">AC charging station</a>	Level 1 – residential applications	Single Phase- 120/230 V and 12 to 16 A	1.44 kW to 1.92 kW	17 hrs
AC charging station	Level 2- Commercial applications	Split Phase – 208/240 V and 15 to 80 A	3.1 kW to 19.2 kW	8 hrs
<a href="#">DC charging station</a>	Level 3- Fast charging	Single Phase- 300/600 V and approx. 400 A	120 kW to 240 kW	30 min

The off-board charger, also known as Electric Vehicle Supply Equipment (EVSE), is the external charging equipment connected to the EV for charging. It provides the interface between the charging infrastructure and the EV's on-board charger. Off-board chargers are typically installed at charging stations in residential, commercial, and public areas.

**Power and Charging Speed:** Off-board chargers are usually capable of delivering higher power levels than on-board chargers. They can provide high-voltage charging, typically ranging from 50 kW to several hundred kilowatts, depending on the charger's capacity and the EV's capabilities. This results in faster charging times, reducing the time required to charge the vehicle.

**Charging Infrastructure:** Off-board chargers are commonly used in public charging stations, commercial charging networks, and fleet charging facilities. These charging stations are equipped with multiple chargers to accommodate multiple vehicles simultaneously.

**DC Fast Charging:** Off-board chargers often utilize direct current (DC) fast charging technology. DC fast charging bypasses the vehicle's onboard charger and delivers electricity directly to the vehicle's battery, allowing for more efficient and rapid charging. This technology is especially useful for long-distance travel or when quick charging is required.

**Public Charging Networks:** Off-board chargers are typically installed in public charging networks, providing convenient charging options for EV owners. These charging stations can be found in various locations such as parking lots, shopping centers, highway rest areas, and urban areas, making it easier for EV owners to charge their vehicles while away from home.

**Charging Station Management:** Off-board chargers are often connected to a central management system that monitors and controls the charging process. This management system can handle functions such as user authentication, billing, remote monitoring, and maintenance of the charging infrastructure. It helps ensure the efficient operation of charging stations and provides a seamless experience for EV users.

**Integration with Renewable Energy:** Off-board chargers can be integrated with renewable energy sources such as solar or wind power. By coupling the charging infrastructure with clean



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energy generation, it helps reduce the carbon footprint of electric vehicles and promotes sustainable transportation.

**Vehicle-to-Grid (V2G) Capabilities:** Some advanced off-board chargers support vehicle-to-grid functionality. This means that EVs can not only receive power from the charging station but also supply power back to the grid when needed. V2G technology enables bidirectional flow of electricity, allowing EVs to serve as mobile energy storage units and contribute to grid stability and energy management.

**Cost Considerations:** Off-board chargers are usually more expensive than onboard chargers due to their higher power capacity and advanced features. The cost of installation and electrical infrastructure upgrades, such as transformer capacity and wiring, can also add to the overall expense.



### Vehicle to Charger Communication

The vehicle-to-charger communication system enables communication and data exchange between an electric vehicle (EV) and a charging station. This communication is crucial for several reasons, including safety, authentication, charging control, and billing. Here's an overview of how the vehicle-to-charger communication system works:

**Communication Protocols:** To facilitate communication between the EV and the charging station, standardized communication protocols are used. Common protocols include:

**Charging Station Communication Controller (CSCC):** This protocol allows the vehicle and charging station to exchange control signals, status information, and authentication data. It enables the vehicle to request charging, receive status updates, and respond to charging control commands from the charging station.

**Open Charge Point Protocol (OCPP):** OCPP is an open communication protocol that enables interoperability between charging stations and central management systems. It allows for features like remote monitoring, firmware updates, and billing information exchange.

**ISO 15118:** ISO 15118 is a standard that facilitates communication between EVs and charging infrastructure, specifically for plug-in electric vehicles (PEVs). It defines a bi-directional communication protocol for control signals, authentication, and billing information.





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**Authentication:** The vehicle-to-charger communication system enables authentication processes to ensure that only authorized EVs can access and use the charging station. This can involve the exchange of authentication certificates, digital signatures, or secure communication channels to validate the EV's identity and authorize the charging session.

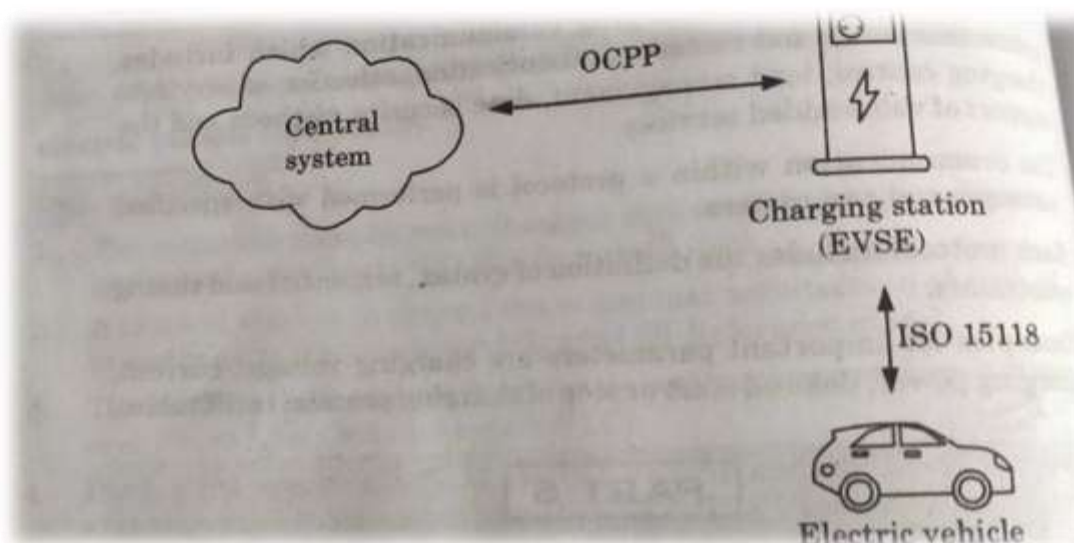
**Charging Control:** Communication between the EV and the charging station allows for charging control and coordination. The EV can send requests to the charging station, specifying the desired charging power or the charging schedule. The charging station can respond by adjusting the charging parameters accordingly, such as the charging power or current.

**Status and Safety Information:** The communication system enables the exchange of real-time status information between the EV and the charging station. This includes data such as battery state of charge, charging progress, and any error or fault notifications. It helps ensure safe and efficient charging operations by monitoring the charging process and responding to any anomalies or safety concerns.

**Billing and Payment:** The vehicle-to-charger communication system enables the exchange of billing and payment information. It allows the charging station to track the energy consumption and duration of the charging session, which can be used for billing the EV owner or a third-party payment provider.

### OCPP familiarity

OCPP, which stands for Open Charge Point Protocol, is a communication protocol that enables communication between charging stations (also known as charge points) and central management systems (CMS) or charging station management systems (CSMS). OCPP is an open standard, allowing interoperability between different charging infrastructure providers and charging station manufacturers.





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1. OCPP is an open-source communication protocol regulated by Open Charge Alliance
2. It has become a de-facto standard enabling transparent common between EV chargers and the backend charging station management system (CSMS).
3. It is a license-free and vendor-agnostic protocol to exchange vital charging information between chargers and the hack-end system
4. Use of these standards invites no cost or licensing barriers for adoption .
5. The most common way to connect a charge point with a central cloud system for EV charging is to connect an Open Charge Point Protocol (OCPP) to the internet.
6. The OCPP infrastructure consists of any number of Charging Stations, each referring to any physical system where an electric vehicle charge itself. can
7. These stations are managed by a single Charging Station Management System (CSMS), which also has the information for authorising users for using the Charging Stations under its management. The Charging Station itself may have multiple units of Electric Vehicle.
8. Supply Equipment (EVSE), where each EVSE can have multiple Connectors, though only one Connector can be active at any one point in time.
9. OCPP is not a single protocol, but itself consists of a number of sub- protocols, each implementing one of its use cases.
10. Before OCPP, switching to a different charging software or selecting new charger equipment was difficult due to closed systems working on proprietary communication protocols.

When it comes to OCPP, there are two primary sides involved: the cloud side and the device side. Let's explore each side's familiarity with OCPP.



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**Cloud Side:** The cloud side refers to the central management system (CMS) or charging station management system (CSMS) responsible for managing and monitoring the charging stations. This side typically handles tasks such as user authentication, billing, remote monitoring, and data analysis. Familiarity with OCPP on the cloud side includes:

**OCPP Server Implementation:** Familiarity with implementing an OCPP server that communicates with charging stations, receives their status updates, handles charging transactions, and manages their configurations.

**Protocol Compatibility:** Understanding the different OCPP versions (e.g., OCPP 1.6, OCPP 2.0) and their capabilities to ensure compatibility with various charging stations supporting different protocol versions.

**Security Considerations:** Being familiar with security aspects like authentication, encryption, and data privacy to ensure secure communication between the cloud and the charging stations.

**Data Analysis and Reporting:** Utilizing the data received from charging stations to generate reports, perform analytics, and gain insights into charging station usage, energy consumption, and other relevant metrics.

**Device Side:** The device side refers to the charging stations or charge points themselves. This side of OCPP implementation involves the firmware and software running on the charging stations to facilitate communication with the central management system. Familiarity with OCPP on the device side includes:

**OCPP Client Implementation:** Understanding and implementing an OCPP client on the charging station to establish communication with the cloud-side system.

**Protocol Compliance:** Ensuring that the charging station's OCPP implementation adheres to the protocol specifications, supports the required messages, and handles the associated data exchange correctly.

**State and Transaction Handling:** Managing the charging station's state transitions, handling charging sessions, metering, and transaction-related operations based on the OCPP protocol.

**Device Integration:** Integrating the charging station's hardware, power management systems, and metering capabilities with the OCPP client software for seamless interaction with the central management system.

Overall, familiarity with OCPP on both the cloud side and the device side is essential for effective implementation and interoperability of charging infrastructure systems.

In the context of OCPP (Open Charge Point Protocol), metrology and billing are crucial aspects related to the measurement of energy consumption during charging sessions and the generation of invoices or bills for the charging services. Let's explore each concept in more detail:



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**Metrology in OCPP:** Metrology in OCPP focuses on accurate measurement and reporting of energy consumption during charging sessions. It ensures that the charging stations provide reliable and standardized energy metering. Here are key points related to metrology in OCPP:

**Energy Measurement:** Charging stations equipped with energy meters measure the amount of energy consumed by electric vehicles (EVs) during charging. The OCPP protocol supports reporting the energy usage in units such as kilowatt-hours (kWh).

**Metering Accuracy:** Metrology standards and regulations define the accuracy requirements for energy meters used in charging stations. OCPP-compliant charging stations should adhere to these standards to ensure accurate energy measurements.

**Meter Readings and Reporting:** The charging stations periodically send meter readings to the central management system (CMS) or charging station management system (CSMS) through OCPP messages. These readings include information such as energy consumption, start and end times of charging sessions, and charging profiles.

**Calibration and Certification:** Charging station energy meters may require calibration and certification to maintain their accuracy over time. Compliance with metrology regulations and standards is necessary to ensure accurate and reliable measurements.

**Billing in OCPP:** Billing in OCPP involves the generation of invoices or bills based on the charging sessions and energy consumption of EVs. It enables proper monetization of charging services and supports various billing models. Here's what you need to know about billing in OCPP:

**Tariff Structures:** Charging infrastructure providers can define tariff structures that determine the cost of charging. Tariff structures can vary based on factors such as time of charging, energy consumption, power levels, or membership plans.

**Billing Data Collection:** The charging stations capture relevant data during charging sessions, such as energy consumed, charging duration, tariff information, and user identification. This data is used for billing calculations.

**Billing Calculation:** Using the collected data, the CMS or CSMS calculates the cost of charging according to the defined tariff structures. The billing system applies the appropriate rates and factors, considering variables like time, energy, and other billing parameters.

**Invoice Generation:** Once the billing calculations are complete, the system generates invoices or bills for the charging services. Invoices typically include information such as charging session details, energy consumed, applicable tariffs, taxes, and user identification.

**Billing Reports:** Charging infrastructure providers or EV owners can access billing reports, which provide a breakdown of charging costs, consumption patterns, and other billing-related information.



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Billing in OCPP can be integrated with backend systems, payment gateways, and user management platforms to facilitate seamless invoicing and payment processes.

By ensuring accurate metrology and implementing effective billing mechanisms in OCPP, charging infrastructure providers can accurately measure energy consumption, monetize charging services, and provide transparent billing information to EV owners or service providers.



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### Computing needs in a charging system

A charging system for electric vehicles typically involves various computing needs to facilitate efficient and safe charging. Here are some of the computing aspects involved:

- 1. Charging Infrastructure Management:** Computing systems are used to manage and control the charging infrastructure. This includes monitoring the availability and status of charging stations, managing user access and authentication, and handling payment transactions.
- 2. Charging Station Communication:** Charging stations often require communication capabilities to interact with the electric vehicle and the central management system. This communication can be wired (such as Ethernet) or wireless (such as Wi-Fi, cellular, or RFID) and enables data exchange related to charging status, power requirements, and diagnostics.
- 3. Power Management and Optimization:** Computing systems play a vital role in managing power distribution and optimization within the charging infrastructure. They analyze factors like grid load, charging demand, energy costs, and vehicle requirements to allocate power effectively, balance loads, and optimize charging schedules.
- 4. User Interfaces:** Charging systems typically include user interfaces for electric vehicle owners to interact with the charging station. These interfaces can be in the form of touchscreen displays, mobile applications, or web portals. Computing systems enable user authentication, display charging status, provide payment options, and offer control over charging parameters.
- 5. Data Analytics and Monitoring:** Computing systems collect and analyze data from charging stations and electric vehicles to monitor performance, detect faults, and optimize charging operations. This data may include charging session details, energy consumption, battery health, and other relevant metrics. Advanced analytics can be used to identify patterns, predict maintenance needs, and optimize charging infrastructure usage.
- 6. Cybersecurity:** As with any connected system, cybersecurity is crucial for charging systems. Computing systems implement various security measures like encryption, authentication protocols, intrusion detection, and secure communication channels to protect against unauthorized access, data breaches, and cyber threats.
- 7. Integration with Smart Grids:** Charging systems can be integrated with smart grid technologies to support demand response programs, time-of-use pricing, and grid stability. Computing systems enable bidirectional communication with the grid infrastructure to optimize charging based on renewable energy availability, load balancing, and grid capacity.



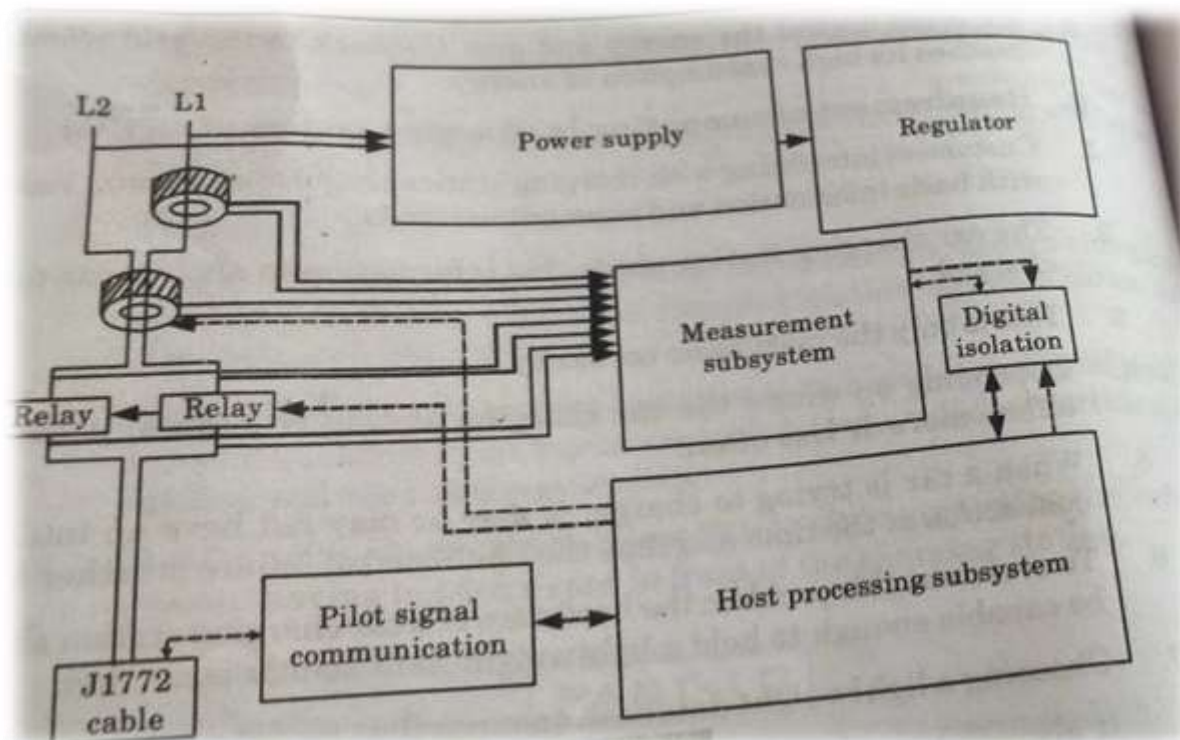


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Overall, computing systems are essential for managing and optimizing electric vehicle charging systems, providing a seamless charging experience, and ensuring efficient and secure operation of the infrastructure.

### Block Diagram and Subsystem of Low Power Charger

The Low Power Charger simply supplies AC Power to the on board charger in an EV which takes care of charging process .It Provide the right amount of power from the grid as required by the battery Pack through Pilot wire .



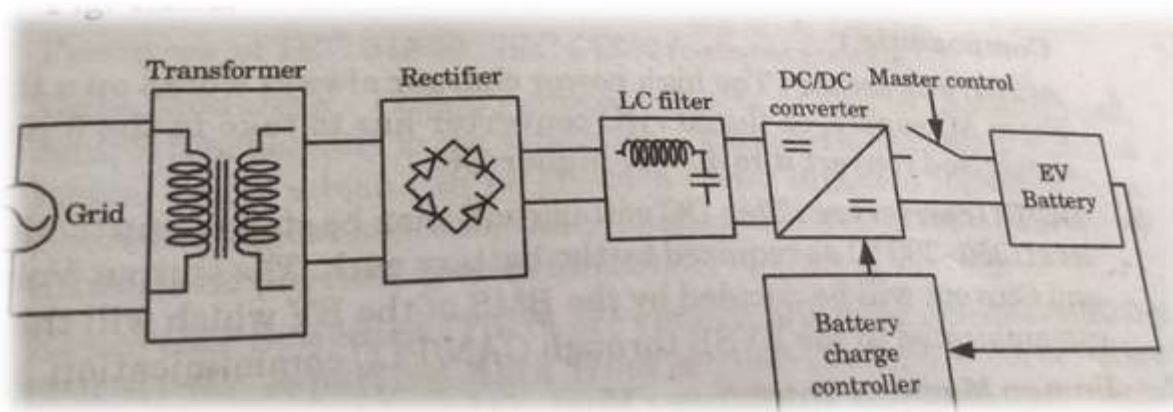
- 1. AC Power Line:** Low power chargers normally use the SAP-J1772 standard plug connectors. The AC Power Line (L1 and L2) connected to the J1772 connector through a relay. This relay will close to begin the charging process and open when charging is completed.
- 2. Pilot Signal Communication:** The pilot signal communication is used to detect battery status and the host processing system decides how much power should be supplied to the on-board charger.
- 3. Power Supply:** The power supply unit consists of an AC/DC converter which takes in the AC power from the grid and converts it to DC 15V using a switching circuit.
- 4. Regulator:** The 15V from the power supply is then provided to the regulator which consists of a DC/DC converter. It uses three different Buck regulators to regulate 12V, 5V and 3.3V which is used to power the sensors, displays and controllers in the charger unit.



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5. **Measurement System:** The measurement system consists of V/I Sense circuits which is used to measure the AC current and AC voltage.
6. **Digital Isolation:** Since the measurement subsystem deals with AC voltage and current it is digitally isolated from the Host Processing Subsystem.
7. **Host Processing Subsystem:** It consists of the main microcontroller which receives the information from pilot communication and based on the information it triggers the relay. It also monitors the current and voltage using the values provided by measurement subsystem and takes corrective actions whenever required.

#### Subsystem of Low Power Charging



1. The EV battery is charged by the battery charging subsystem for improved performance and better control.
2. The charging circuit draws power from the utility grid and supplies the stable power for charging the EV battery.
3. The power conditioning unit includes step-up transformer 230-340 V, rectifier, and filter unit along with a boost converter.
4. AC charging unit provides 320 V (nominal DC voltage to EV battery) and provides 15 A pulse current for charging the battery.

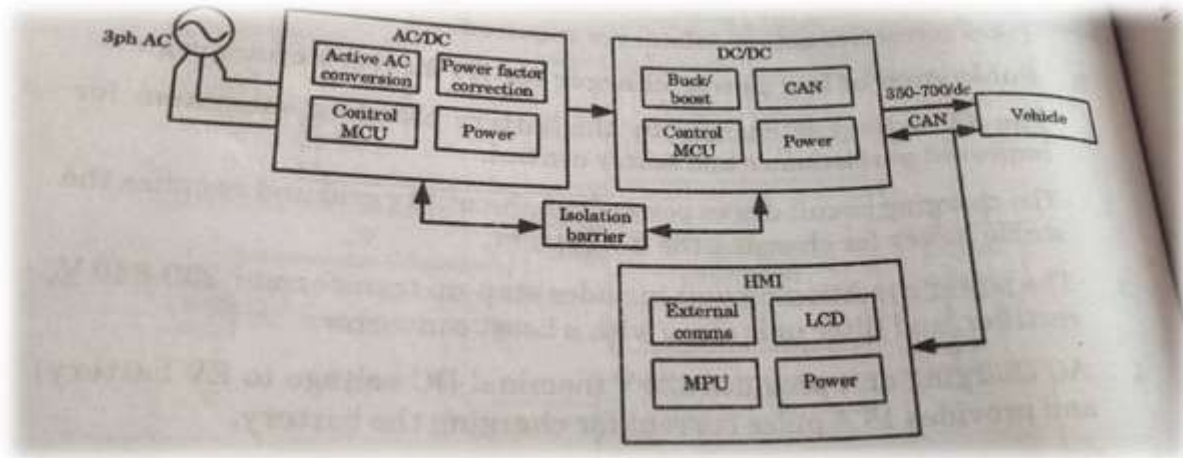
#### Block Diagram and Subsystem of High Power Charger

1. The high power chargers are more complex than the low power charger since the DC/DC conversion for the battery pack has to be done by the EVSE itself.
2. Since a DC EVSE bypasses the on-board charger it should know all vital parameters of the battery pack to charge it safely.
3. Hence a CAN or PLC (Power Line Communication) should be established between an EVSE and the BMS of the EV.
4. A high power charger (Level 3 charger) normally uses the CHAdeMO charger socket.



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5. These chargers can deliver up to 200A directly to the battery pack to charge the EV in less than 30 minutes.



1. AC Power Input: This subsystem is responsible for converting the AC power supply from the grid to a suitable form for the charger's operation. It typically includes an AC-DC converter that rectifies and filters the incoming AC power.
2. Power Factor Correction (PFC): The PFC subsystem improves the power factor of the charger by adjusting the input current waveform to be in phase with the input voltage. This ensures efficient power transfer and reduces harmonic distortion on the grid.
3. DC-DC Converter: The DC-DC converter subsystem converts the rectified AC power to the required DC voltage level for charging the electric vehicle's battery pack. It includes a high-frequency switching converter that regulates the voltage and current output based on the charging requirements.
4. Charging Control Unit: The charging control unit manages the overall charging process. It consists of a microcontroller or digital signal processor (DSP) that monitors and controls various parameters such as charging voltage, current, and charging mode (e.g., constant current or constant voltage).
5. Communication Interface: The charger may have a communication interface, such as CAN (Controller Area Network) or Ethernet, to communicate with the electric vehicle's onboard control system. This interface allows exchanging data related to charging status, battery information, and control signals.
6. Battery Management System (BMS) Interface: The charger may also include an interface to connect with the electric vehicle's Battery Management System (BMS). This interface enables communication and coordination between the charger and the BMS for safe and efficient charging, including monitoring battery temperature, voltage, and state of charge.



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### IEC 61850

IEC 61850 is an international standard for communication protocols used in electrical substations and power systems. It defines a set of communication services and data models that facilitate interoperability and efficient exchange of information between various intelligent electronic devices (IEDs) within a substation.

Key features and components of IEC 61850 include:

- 1. Communication Services:** IEC 61850 specifies communication services for real-time monitoring, control, protection, and automation in power systems. These services include reporting of measured values, control commands, event notification, file transfer, time synchronization, and more.
- 2. Data Models:** The standard defines a standardized data model for representing various elements and functions within a substation. It uses a logical node concept, where each logical node represents a specific function or data type. The data model provides a common language for IEDs to exchange information and ensures interoperability between different manufacturers' devices.
- 3. Substation Configuration Language (SCL):** SCL is an XML-based language defined by IEC 61850 for configuring and describing the communication interfaces and data models of devices within a substation. SCL files contain information about substation topologies, communication parameters, data mapping, and device capabilities.
- 4. Ethernet-Based Communication:** IEC 61850 primarily relies on Ethernet-based communication networks, such as TCP/IP and UDP/IP, for data exchange between IEDs. It utilizes protocols like MMS (Manufacturing Message Specification) and GOOSE (Generic Object-Oriented Substation Event) for high-speed, reliable, and deterministic communication.
- 5. Sampled Values (SV) and Generic Object-Oriented Substation Event (GOOSE):** IEC 61850 introduces SV and GOOSE mechanisms to enable high-speed transmission of sampled analog values and digital signals between devices. SV allows the transmission of real-time measurements, while GOOSE facilitates fast event-based communication for tripping and control purposes.
- 6. Interoperability and Standardized Testing:** IEC 61850 promotes interoperability by specifying standard testing procedures and certification requirements. Compliance testing ensures that devices from different manufacturers adhere to the standard and can communicate effectively with each other.
- 7. Use Cases:** IEC 61850 is widely used in various applications within power systems, including substation automation, protection and control, intelligent electronic devices (IEDs), distribution automation, and renewable energy integration. It enables advanced functionalities like centralized monitoring, automation, and improved fault detection and analysis.



Unit 4: Charging System Design Technology For EV Applications  
**IEC 61851**

IEC 61851 is a different international standard that specifically addresses electric vehicle (EV) charging systems. It defines the communication and performance requirements for EV charging equipment and is widely used to ensure compatibility and interoperability between charging stations and electric vehicles.

Key aspects of IEC 61851 include:

- 1. Charging Modes:** IEC 61851 defines different charging modes for EVs, including Mode 1, Mode 2, Mode 3, and Mode 4. Each mode specifies the characteristics of the charging infrastructure, such as the presence of protective devices, control pilot signals, and maximum charging currents.
- 2. Communication Protocols:** The standard specifies communication protocols between the EV and charging station, including the control pilot signal for charging initiation, proximity detection for safety, and communication of charging status and power limits. It ensures that EVs can communicate with charging stations from different manufacturers using standardized protocols.
- 3. Charging Connector Types:** IEC 61851 defines charging connector types, such as Type 1 (SAE J1772) for North America and Type 2 (Mennekes) for Europe. These connector types determine the physical interface and pin configurations for power and communication exchange between the charging station and the EV.
- 4. Safety Requirements:** Safety is a crucial aspect of IEC 61851. The standard outlines safety measures related to electrical shock protection, temperature monitoring, fault detection, and emergency shut-off procedures to ensure the safety of users and equipment during the charging process.
- 5. Charging Parameters:** IEC 61851 specifies various charging parameters, such as voltage, current, power limits, and time limits for different charging modes. It ensures that charging stations and EVs adhere to these parameters, promoting compatibility and safe charging.
- 6. Interoperability and Compliance:** IEC 61851 promotes interoperability by defining standard compliance requirements for charging stations and EVs. Compliance testing ensures that charging equipment meets the standard's specifications, allowing for seamless interaction between different charging systems.
- 7. EV Communication Controller (EVCC):** The EVCC is an important component defined by IEC 61851, responsible for managing communication between the EV and the charging station. It interprets control pilot signals, handles communication protocols, and enables coordination between the EV and charging infrastructure.





Unit 4: Charging System Design Technology For EV Applications  
IEC 61000

IEC 61000 is a series of international standards developed by the International Electrotechnical Commission (IEC) that addresses electromagnetic compatibility (EMC) in electrical and electronic systems. These standards define the requirements and test methods to mitigate and control electromagnetic disturbances and ensure the proper functioning of equipment in various environments.

Key aspects of IEC 61000 include:

- 1. Electromagnetic Compatibility (EMC):** IEC 61000 standards are designed to ensure EMC, which is the ability of electrical and electronic equipment to operate without interference in the presence of electromagnetic disturbances. The standards aim to minimize the emission of unwanted electromagnetic energy and enhance immunity to external electromagnetic disturbances.
- 2. Emission Standards:** IEC 61000 specifies limits for the electromagnetic emissions generated by electrical and electronic equipment. These standards define the maximum permissible levels of conducted and radiated emissions across a range of frequency bands to prevent interference with other devices.
- 3. Immunity Standards:** The standards also establish criteria for immunity, which is the ability of equipment to withstand electromagnetic disturbances without malfunctioning. Immunity standards specify the required level of immunity to different types of disturbances, including electrostatic discharge, fast transients, power frequency magnetic fields, conducted disturbances, and more.
- 4. Testing and Measurement Methods:** IEC 61000 provides standardized test procedures and measurement methods to evaluate the EMC characteristics of equipment. These tests help determine compliance with emission and immunity requirements and enable comparison of results across different devices.
- 5. Application-Specific Standards:** Within the IEC 61000 series, various subcategories of standards address specific applications and sectors. For example, IEC 61000-4-2 focuses on electrostatic discharge (ESD) immunity, while IEC 61000-4-4 addresses electrical fast transient (EFT) immunity. These application-specific standards provide detailed requirements and test methods tailored to specific scenarios.
- 6. Compliance and Certification:** Compliance with IEC 61000 standards is often required for electrical and electronic equipment to be sold and used in many countries. Compliance testing and certification help ensure that devices meet the necessary EMC requirements, minimizing the risk of interference and maintaining overall system reliability.





## Unit 4: Charging System Design Technology For EV Applications

7. Harmonization with International Standards: IEC 61000 is closely aligned with other international EMC standards, such as the European Union's EMC Directive and the Federal Communications Commission (FCC) regulations in the United States. This harmonization promotes global consistency and facilitates the international trade of compliant equipment.

### IEC 60950/51

IEC 60950 and IEC 60951 are international safety standards developed by the International Electrotechnical Commission (IEC) for information technology equipment (ITE) and audio/video, information, and communication technology equipment (AV/ICT), respectively. These standards define safety requirements and guidelines to ensure the protection of users and operators of such equipment.

1. **IEC 60950:** This standard, also known as "Information Technology Equipment - Safety," applies to a wide range of ITE, including computers, servers, routers, switches, printers, and other similar equipment. It addresses potential hazards related to electrical, mechanical, thermal, and fire risks that could arise during normal use or foreseeable abnormal conditions. Compliance with IEC 60950 ensures that ITE meets the necessary safety requirements, reducing the risk of electrical shock, fire, and other potential hazards.
2. **IEC 60951:** This standard, titled "Safety of Information Technology Equipment Including Electrical Business Equipment," specifically applies to AV/ICT equipment, such as audio/video equipment, telecommunication equipment, and office equipment like photocopiers and fax machines. IEC 60951 covers similar safety aspects as IEC 60950, considering the specific characteristics and risks associated with AV/ICT equipment.

Key aspects of IEC 60950 and IEC 60951 include:

- a. **Electrical Safety:** The standards outline requirements for electrical safety, including insulation, grounding, protection against electric shock, and limits on accessible parts and energy sources. They specify testing methods and criteria for compliance with these safety requirements.
- b. **Mechanical Safety:** IEC 60950 and IEC 60951 address mechanical hazards, such as moving parts, sharp edges, and potential impact or crushing risks. They define requirements for proper equipment construction, protection against hazardous mechanical conditions, and guidelines for safe handling and installation.
- c. **Thermal Safety:** The standards cover aspects related to thermal safety, such as preventing equipment from overheating, ensuring proper ventilation, and setting temperature limits to avoid excessive heat generation that could lead to fire or equipment malfunction.



### Unit 4: Charging System Design Technology For EV Applications

d. Fire Safety: IEC 60950 and IEC 60951 include provisions for fire safety, specifying requirements for fire resistance, flammability of materials, and prevention of ignition sources. They address potential fire risks and establish guidelines for the safe design and use of equipment.

e. Compliance Testing and Certification: Compliance with IEC 60950 and IEC 60951 is typically evaluated through testing conducted by authorized testing laboratories. Manufacturers seek certification to demonstrate that their equipment meets the safety requirements defined by these standards. Certification marks, such as the CB Scheme (Certification Body Scheme), are commonly used to indicate compliance.

By adhering to the safety requirements of IEC 60950 or IEC 60951, manufacturers can ensure that their information technology and AV/ICT equipment is designed, constructed, and operated with due consideration for user safety. These standards contribute to the overall protection of users, prevention of accidents, and the safe and reliable use of the equipment in various environments.

## IEC62196

1. IEC 62196 is a series of international standards that requirements and tests for plugs, socket-outlets, vehicle con and vehicle inlets for conductive charging of electric vehicles,
2. Socket-outlets, vehicle connectors and vehicle inlets According to this series of standards are used in EV supply equipment.
3. Plugs most plugs, socket-outlets, vehicle connectors and vehicle according to this series of standards provide additional contact that support specific functions that are relevant for charging of electric vehicles.

The following parts of IEC 62196 series have been published

**IEC 62196-1:** General requirements.

**IEC 62196-2:** Dimensional compatibility and interchang requirements for AC pin and contact-tube accessories.

**IEC 62196-3:** Dimensional compatibility and interchangeability requirements for DC and AC/DC pin and contact-tube vehicle couple

**IEC TS 62196-3-1:** Vehicle connector, vehicle inlet and cable assembly intended to be used with a thermal management system for DC

**IEC TS 62196-4:** Dimensional compatibility and interchangeability requirements for DC pin and contact-tube accessories for class II or class III applications

**IEC 62196-6:** Dimensional compatibility and interchangeability. requirements for DC pin and contact-tube vehicle couplers for DC EV supply equipment where protection relies on electrical separation

**IEC TS 62196-7:** Vehicle adapter.