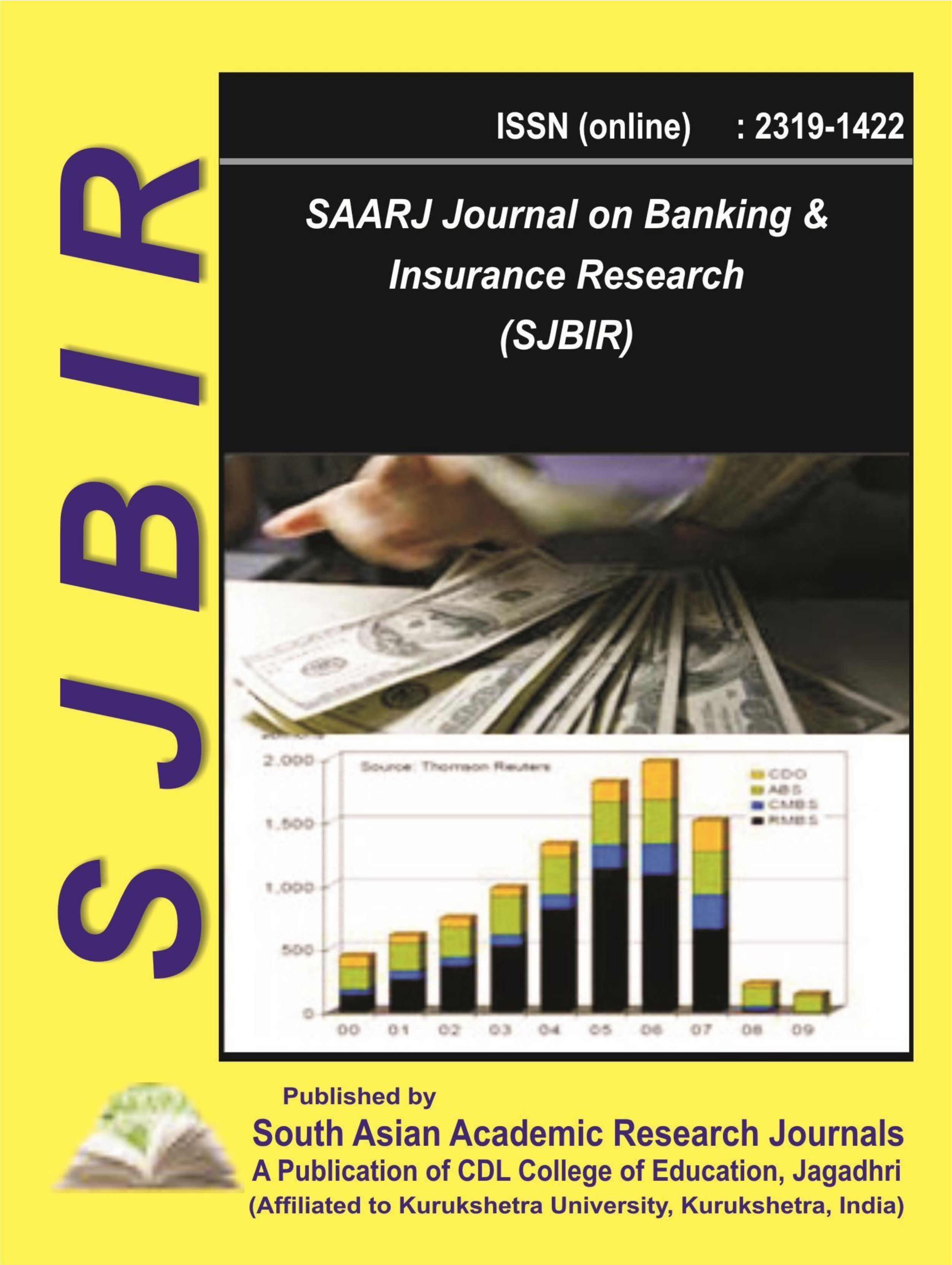

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## SPECIAL ISSUE ON

# “EV CHARGING STATION"

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# AN ASSESSMENT OF EV CHARGING STATION

**Dr. Rajiv Singh***

*Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-rajivranjansingh@presidencyuniversity.in

## ABSTRACT:

*Electric cars are a relatively new technology that is competing for a promotion on the market. It offers several benefits, including less greenhouse gas emissions, fuel savings, and simplicity of use. Concerns regarding the grid's ability to provide quality electricity have been raised by the rise of electric cars on the road. The fundamental points about power balancing are covered in this essay, along with how an electric car charge affects the voltage, current, and overall harmonic alteration. To gather data on voltage, current, active and reactive power for various charging profiles and battery state of charge, an experimental charging station prototype for Types 2 and 3 is employed. This chapter discuss charging station installing challenges, future progress of EV, charging infrastructure in details.*

**KEYWORDS:** *Charging Station, Dc Power, Electric Vehicle, Electric Car, Ev Charging.*

## INTRODUCTION

A charging station, sometimes referred to as a charge point or an EVSE (electric vehicle supply equipment) is a piece of equipment that provides electrical power for charging plug-in electric vehicles, such as plug-in hybrids and electric trucks, automobiles, and buses[1].DC charging stations and AC charging stations are the two primary categories. Since alternating current (AC) is the predominant kind of energy transmitted from the power grid, batteries can only be charged using direct current (DC) electricity. Because of this, the majority of electric cars are equipped with an "onboard charger", also known as an integrated AC-to-DC converter. This onboard charger receives AC electricity from the grid at an AC charging station, which it uses to generate DC power to charge the battery[2]. By integrating the converter into the charging station rather than the car to get around size and weight limits, DC chargers enable greater power charging which necessitates considerably bigger AC-to-DC converters. The car is then given straight DC power from the station, bypassing the onboard converter. The majority of versions of completely electric cars can use both AC and DC power.

Connectors that adhere to a number of international standards are offered by charging stations. In order to be able to charge a range of automobiles that use conflicting standards, DC charging stations often include numerous ports[3].Street-side or in retail shopping malls, governmental buildings, and other parking lots are the traditional locations for public charging stations. Residences, businesses, and hotels are often where one may find private charging outlets[4].

Electric automobiles, neighborhood electric cars, and plug-in hybrids may all be recharged at an electric vehicle charging station, which is a piece of technology. While some charging stations are simpler, others include more sophisticated features like smart metering, cellular capabilities, and network access.Electric utility providers or private organizations offer charging stations in public parking lots or at retail shopping areas under the name electric vehicle supply equipment (EVSE). These stations provide unique connections that adhere to the various requirements for electric charging connectors.

The cost to use an EVSE might be flat-rate monthly or annual, per-kWh, or hourly. Charging stations are often supported by the local government and might be free.The charging speeds offered by various EVSE variants vary. With a dedicated circuit and a socket that operates on 120 volts of alternating current (AC), level 1 charging stations provide around 5 miles of range for every hour of charging. Level 2 stations need the installation of home charging or public charging equipment and charge using a 240V, AC outlet. For every hour of charging at a level 2 station, 10 to 20 miles of range are provided. The most popular chargers, Level 2 chargers, charge about at the same pace as a residential system[5].

DC fast chargers are another name for level 3 chargers. A 480V direct-current (DC) socket is used for Level 3. Bypassing the onboard charger, they use a unique charging connector to provide DC power directly to the battery. While DC Fast Chargers can extend a vehicle's range by up to 40 miles for every 10 minutes of charging, not all cars can use them. Furthermore, a few specialized charging stations, like the Tesla Supercharger, are built for substantially faster charging.There is an increasing need for equipment that facilitates quicker charging at higher voltages and currents than are presently provided by residential ESVE as the need for more readily available charging stations increases. Around the world, there are more and more electric vehicle networks that provide a network of publicly accessible charging stations for recharging EVs. To build these networks, governments, manufacturers, and suppliers of charging infrastructure have reached agreements.

## DISCUSSION

### Power and voltage

In order to establish standards in the United States, the Electric Power Research Institute established the National Electric Transportation Infrastructure Working Council (IWC) in 1991. This council's initial work resulted in the definition of three charging levels in the 1999 National Electric Code (NEC) Handbook[6].A conventional NEMA 5-20R 3-prong electrical outlet with grounding was used to connect Level 1 charging equipment to the grid under the 1999 NEC. A ground-fault circuit interrupter was needed to be placed within 12 in (300 mm) of the plug. A breaker with a rating of 20 A was required for charging equipment with a continuous current rating of 16 amperes ("amps" or "A"). This is because the supply circuit needed protection at 125% of the maximum rated current[7].

According to NEC-1999, level 2 charging equipment has to be permanently connected and secured in a fixed site. Additionally, it needed grounding, ground-fault protection, an interlock to stop vehicle starts while charging, and a safety breakaway for the cable and connection. To safeguard the branch circuit, a 40 A breaker (125% of the continuous maximum supply current) was needed. Many early EVs preferred that owners and operators install Level 2 charging equipment, which was linked to the EV either by an inductive paddle (Magne Charge) or a conductive connection (Avcon). This was done for ease and faster charging.In order to provide the car with DC power, Level 3 charging equipment converted the input AC power to DC using an off-vehicle rectifier. The 1999 NEC guide expected that Level 3 charging devices will need utilities upgrading their transformers and distribution networks[8].

### Future progress

For big commercial vehicles greater power charging will be provided through an expansion of the CCS DC fast-charging standard for electric cars and light trucks. The new standard was first known as High Power Charging (HPC) for Commercial Vehicles (HPCCV), then renamed Megawatt Charging System (MCS), when the Charging Interface Initiative task force was established in March 2018. The estimated operating range for MCS is 200-1500 V and 0-3000 A, with a maximum theoretical power of 4.5 megawatts (MW). According to the proposal, MCS charge ports must work with current CCS and HPC chargers. In February 2019, the task force published aggregated standards that stipulated 3000 A continuous rating and maximum limitations of 1000 V DC (or, alternatively, 1500 V DC). The National Renewable Energy Laboratory (NREL) will test a connection design that was chosen in May 2019 in September 2020. The test examined the coupling and thermal performance of seven vehicle inlets and eleven charger connections, with participation from thirteen manufacturers. The MCS connection version 3.2 was released in December 2021, including the final connector specifications and standards[9].

On April 21, 2021, Daimler Trucks North America unveiled the "Electric Island," the first heavy-duty truck charging station, across the street from company headquarters in Portland, Oregon, with assistance from Portland General Electric. Eight cars may be charged at once at the station, and tractor-trailer-sized charging bays are available. In addition, whenever they become available, the design will support >1 MW chargers. In Bakersfield, California, a new business called WattEV revealed plans to construct a 40-stall truck stop/charging station in May 2021. At full capacity, it would provide a combined 25 MW of charging power, with some of it coming from an on-site solar array and battery storage.

### Chargers for electric vehicles

All automobiles contain batteries, although the majority of them are merely a little 12.6-volt battery needed to start the engine. A lithium-ion battery used in an electric vehicle is distinct and often considerably bigger, with a capacity of up to 100 kilowatt-hours. To operate to their maximum potential, these batteries must be plugged in continuously for a lengthy period of time. An electric automobile can be plugged into a typical 120-volt wall socket, but it may take up to a day for it to fully charge. Electric vehicle charging stations, sometimes referred to as electric vehicle supply equipment (EVSE), are created specifically to charge EVs more quickly than you can with a regular wall socket[10].

### Charging Station

The size of your car's battery and the kind of EV charger you choose will both affect how long it takes to charge an electric vehicle. While DC fast charging is accessible at select public venues, Level 2 chargers are the most common kind found in homes and public spaces.A 240-volt Level 2 charger can charge a Nissan LEAF or a Tesla Model 3 quicker than a wall outletin around eight hours. With up to 480 volts of electricity and charging speeds of less than an hour, DC fast charging stations are even more potent. Tesla boasts that at Supercharger stations, you may add 200 miles of range in only 15 minutes.

### Cost of Charging an Electric Vehicle at a Station

An EV's typical charging fee is said to be between $30 and $40. Assuming the charging station levies a fee of between 40 and 70 cents per kilowatt-hour. However, the precise quantity may vary depending on where you live and the sort of charging station you use. You may anticipate that rapid charging will cost a bit extra since DC fast chargers typically charge more per kilowatt-hour.On the opposite end of the scale, some companies provide free office charging, while other retail establishments allow you to charge your device for nothing while you shop in their parking lot.Additionally, charging networks like EVgo and Electrify America have different pricing. For instance, EVgo rewards EV drivers who sign up for a monthly subscription with cheaper per-kWh rates and no session fees.

## While Driving, Electric Vehicles Charge

Regenerative braking is a unique feature of electric vehicles that helps them save energy while you're driving. In a gas-powered vehicle, slowing down or using the brakes effectively "wastes" the energy that the engine has just created. You might claim that EVs do charge a little amount when they're on the road because regenerative braking recycles that kinetic energy and utilise it to replenish the battery. However, the more truthful response is that they don't. Although it is more effective, regenerative braking doesn't replenish the battery with any more energy. Your electric vehicle (EV) will still need to be plugged into a charging outlet; otherwise, it will ultimately run out of power.

## Electric Vehicle Parked Without Charging

Are you planning a lengthy trip and wondering whether you may leave your electric vehicle parked in its customary spot? The majority of the time, your automobile will be alright. When not in use, an electric vehicle battery may maintain its charge for several months. Having said that, you shouldn't keep your vehicle running on a full charge or running on nothing for extended periods of time. Long-term battery degradation may result from either circumstance.Your best strategy is to charge your vehicle to around 80% and, if it has one, switch it to power saving mode or deep sleep mode. Also, avoid leaving your automobile in a heated enclosed garage or in the sun for more than 100 degrees. The battery may be harmed by extreme temperatures.

## Do Electric Vehicles Lose Power in Cold Climates

For electric cars, excessive heat is undoubtedly harmful, but what about extreme cold? In cold temperatures, electric vehicles might lose 12–41% of their range. However, Blink Charging notes that both petrol and electric vehicles "struggle in cold weather," so it's more probable that your car is just consuming more energy throughout the winter.Before unplugging your EV from your home charger, keep it parked in a garage and put on the heating to maximise its range throughout the winter. By doing this, you won't need to drain your battery pack to make your automobile pleasant.

## Renewable Energy Is Used by EV Charging Stations

Even while an EV is more energy-efficient than a petrol vehicle, this does not imply that you are using renewable energy. The fuel that the power grid uses to generate electricity, such as oil, coal, or natural gas, is used to power charging stations.You must look for charging stations that are powered by wind or solar if you want to be sure that your automobile is powered by green energy. Alternately, you may enrol in a green energy plan with your electricity company to use renewable energy to run your home charging station.

### Reduce EV Charging Costs by Using Just Energy

For EV drivers, Just Energy provides time-of-use savings and green energy programmes. You may pick a green energy plan to completely offset your energy consumption, or you can charge your electric car during off-peak hours to earn reduced power costs.

### Various Electric Vehicle Charging Methods

### Level-1 EV Charging (120 Volts)

Most electric cars come with a control box and a power cable that can be used to charge level-1 electric vehicles at 120 volts. Level-1 charging may be done at home and is quite practical. Level-1 EV chargers are plug-and-play devices that need no installation. The charging time for a 60-kWh car on level 1 chargers is its lone disadvantage; it takes around 16–18 hours.

### Level-2 electric car charging

Electric vehicle supply equipment (EVSE) and electrical wiring equipped to handle higher voltage electricity must be installed before equipment, which supports currents up to 240V AC, may be used. A battery's capacity and charging rate determine how long it will take to charge. A 60-kWh car can be fully charged in 7 to 8 hours using a 7 kW EV charger, which is substantially quicker than Level-1 chargers. Level-2 chargers may be utilised in residential or commercial settings such houses and flats, small offices, hotels, and retail establishments.

### Level-3 EV Charging (480 Volts)

Also known as DC rapid charging, level-3 EV charging allows for the 80% charging of eligible cars in as little as 30 minutes. High voltage AC electricity is transformed into DC power by level 3 chargers for direct storage in EV batteries. Public charging stations are the main application for DC rapid charging. Comparing these systems to level 1 and level 2 EV chargers, they are extremely pricey. An electric car may be recharged using DC (level-3) charging in 20 to 30 minutes. Commercial usage for DC (level-3) EV chargers may be found in fleets of cars and public transportation systems that need quick charging and can handle a large number of vehicles at once, such as electric buses.

### Understanding the EV Charging Station Components

An electric vehicle charger, the power grid, a facility meter, an energy controller, a software platform, a network operations centre, and other pertinent parts make up the EV charging station.The battery, the power conversion system, and the software make up the three primary components of the power storage system at the electric vehicle charging station. Let's go through these in more detail.

### Battery:

Lithium-ion batteries make up the majority of the batteries at EV charging stations. These batteries are made up of cells, packs, and battery management systems (BMS), which regulate how the batteries are charged and discharged.

### Power Conversion System

To keep the battery at a certain temperature, the power conversion system for the EV charging station includes an inverter, its housing, and thermal management (HVAC) for batteries.

## Software

Electric vehicle charging software is a crucial component of the infrastructure for EV charging. It aids with the management of EV charging stations and their users for charge point operators and e-mobility service providers. The management of EV chargers at charging stations is facilitated by EV charging software (web- or mobile-based). The EV charging software has several important capabilities, including the ability to connect and monitor the charger, identify faults automatically, show live metre data, accept payments, track expenses, manage users, and more.

## EV Charging at Various Settings

Providers of EV solutions aim to serve all types of clients with cutting-edge products that are smarter, more dependable, more accessible, and emission-free. The most recent EV charging options have a small footprint, premium AC wall boxes, reliable connection for DC fast charging, and distinct on-demand EV charging options for EV fleets. The following are a few examples of corporate use cases for electric vehicle charging solutions.

## Residential Charging

EV charging solution providers provide EV chargers that are simple to install for private residences, housing cooperatives, and residential structures. The right safety elements for both humans and electric cars are nicely incorporated into home chargers. These chargers are flexible enough to be used as wall-mounted or portable chargers and are small and light. They also include AC input cables and DC output cables connected. With a conversion efficiency of over 95%, these chargers reduce the overall cost of ownership for battery-powered automobiles.

## Public Charging

Public charging stations employ AC Type 2 chargers that are appropriate for a variety of settings, including offices, shops, malls, lodging facilities, and public commercial charging. These systems are dependable and long-lasting, and they are controllable by centralised management software. Publicly accessible EV charging stations provide simple plug-and-play equipment and charge all type 2 compliant cars. Through the software connected to these chargers, the administrator may remotely monitor the apps and energy bills while using RFID tags for user verification.

## Fleet Charging

To cover all vehicle types and charging requirements, EV Fleet charging systems requires a DC charger. Modern hardware and application software are included with these quick DC chargers. Additionally, they enable easy payment platform connection and provide over-the-air firmware and software upgrade capabilities. These DC chargers can support EVs with 30KW to 300KW of power.

## EV Charging in the Future

Vehicle to grid (V2G) or bidirectional chargers are steps in the direction of using renewable energy sources, such as solar and wind, in the infrastructure for charging electric vehicles. On the other side, wireless charging of electric cars is also making a splash in the automotive industry as a way to ease range anxiety among EV owners and make utilising EV chargers simpler. The industry is anticipating providing e-mobility solutions that are not limited to autos and developing skills to energise our roads, industrial fleets, enterprises, communities, and utilities now that the infrastructure for electric vehicles is in place.

## Constructing infrastructure for electric vehicle charging

Access to charging stations is necessary for fleets and consumers that are thinking about purchasing electric cars (EVs), which include PHEVs and all-electric vehicles. The majority of drivers start by charging at home or at a fleet facility. By providing more flexible charging options at frequently frequented areas, charging stations at businesses and public venues may assist increase market adoption. Through PEV preparation planning, which includes case studies of current accomplishments, community leaders may learn more. Additionally, the EVI-Pro Lite tool may be used to calculate the amount and kind of charging infrastructure required to enable regional EV adoption by state, city, or metropolitan area, as well as to calculate how EV charging will affect power consumption.

A wide-ranging network of stations is needed for both consumers and fleets to be able to charge the increasing number of EVs in use. Users may look for both public and private charging stations using the Alternative Fueling Station Locator. Quarterly updates on developments in electric car charging stations illustrate the expansion of both public and private charging and evaluate the present infrastructure for charging in the US. Use the Submit New Station form to propose new charging locations for the Station Locator. By choosing "Report a change" on the station information page, you may provide suggestions for changes to current charging stations.

Learn more about the planning and financing for state electrification, as well as details on the Bipartisan Infrastructure Law. Consult the Get Equipped magazine by Plug in America and the Go Electric Drive of the Electric Drive Transportation Association for details on the models of charging infrastructure that are now in use. Both of these sources also include details on charging networks and service providers.

## Charging Infrastructure

### With this hierarchy for charging stations

Location, EVSE port, and connection, the charging infrastructure sector has converged on a single standard known as the Open Charge Point Interface (OCPI) protocol. The following charging infrastructure definitions are used by the station locator and the alternative fuels data center.

### Station Location

An area containing one or more EVSE ports at the same address is referred to as a station location. Parking lots in shopping centers or garages are two examples.

### EVSE Port

Even though it may have numerous connections, an EVSE port only supplies electricity to charge one car at a time. Sometimes referred to as a charging post, this structure contains the EVSE ports and may have one or more of them.

### Connector

To charge a car, a connector is connected into the car. One EVSE port may support a variety of connections and connector types (such as CHAdeMO and CCS), but only one car may charge at once. Some people refer to connectors as plugs.

## CONCLUSION

In this book chapter we discuss about the EV charging station. An electric vehicle (EV) charging station is a piece of infrastructure that connects an EV to an energy supply so that it may refuel electric vehicles, neighborhood EVs, and plug-in hybrids. The government has taken the lead in promoting the next generation of environmentally friendly automobiles in industrialized nations. The EV industry has attracted both big and small businesses as well as traditional automakers to the industrial realm as new business prospects. The public has high expectations for EVs as a result of the deployment of several pilot projects and EV-related events.

## BIBLIOGRAPHY:

[1] A. Paraskevas, D. Aletras, A. Chrysopoulos, A. Marinopoulos, and D. I. Doukas, "Optimal Management for EV Charging Stations: A Win–Win Strategy for Different Stakeholders Using Constrained Deep Q-Learning," *Energies*, 2021, doi: 10.3390/en15072323.

[2] V. Suresh, P. Janik, and D. Kaczorowska, "Energy savings approach to optimal location of ev charging stations in microgrids," *Renew. Energy Power Qual. J.*, 2021, doi: 10.24084/repqj19.207.

[3] M. F. Shaaban, S. Mohamed, M. Ismail, K. A. Qaraqe, and E. Serpedin, "Joint planning of smart EV charging stations and dgs in eco-friendly remote hybrid microgrids," *IEEE Trans. Smart Grid*, 2019, doi: 10.1109/TSG.2019.2891900.

[4] F. Salek, S. Resalati, D. Morrey, P. Henshall, and A. Azizi, "Technical Energy Assessment and Sizing of a Second Life Battery Energy Storage System for a Residential Building Equipped with EV Charging Station," *Appl. Sci.*, 2021, doi: 10.3390/app122111103.

[5] Z. Zhao and C. K. M. Lee, "Dynamic Pricing for EV Charging Stations: A Deep Reinforcement Learning Approach," *IEEE Trans. Transp. Electrif.*, 2021, doi: 10.1109/TTE.2021.3139674.

[6] S. Zhou *et al.*, "Planning and real-time pricing of EV charging stations considering social welfare and profitability balance," *CSEE J. Power Energy Syst.*, 2021, doi: 10.17775/CSEEJPES.2020.02340.

[7] W. Li, L. Yang, Z. Wen, J. Chen, and X. Wu, "On the Optimization Strategy of EV Charging Station Localization and Charging Piles Density," *Wirel. Commun. Mob. Comput.*, 2021, doi: 10.1155/2021/6675841.

[8] M. Boucetta, N. U. I. Hossain, R. Jaradat, C. Keating, S. Tazzit, and M. Nagahi, "The architecture design of electrical vehicle infrastructure using viable system model approach," *Systems*, 2021, doi: 10.3390/systems9010019.

[10] D. Wang, F. Locment, and M. Sechilariu, "Modelling, simulation, and management strategy of an electric vehicle charging station based on a DC microgrid," *Appl. Sci.*, 2020, doi: 10.3390/app10062053.

# CLASSIFICATION OF ELECTRIC VEHICLE COMPONENTS

**Ms. Renuka Bhagwat***

*Assistant Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-renuka@presidencyuniversity.in

## ABSTRACT:

*Electric cars are often utilized for pollution-free transportation. However, it has been noticed that their range is much less than that of vehicles driven by traditional fuels, and they do a poor job of recovering kinetic energy from their motion. There are a wide variety of losses in power converters that lead to an increase in battery energy consumption. We must enhance the performance of every component used in electric cars, such as the electric motor, power converter, and energy storage device like a battery or ultra-capacitor, in order to increase the distance that they can drive and the amount of regenerative energy that they can capture. The amount of energy lost in the power train during the process of converting electrical energy to mechanical energy and vice versa should be kept to a minimum. This can only be done by utilizing a converter with a high efficiency, such as an interleaved boost converter. This chapter explores the segmentation of the EV parts, market dominance by Asia-Pacific.*

**KEYWORDS:** *Electric Car, Electric Vehicle, Hybrid Electric Vehicles, Components.*

## INTRODUCTION

The market for electric vehicle parts and components is divided into segments based on vehicle type (passenger cars and commercial trucks), propulsion type (battery electric cars, plug-in hybrid cars, fuel cell electric cars, and hybrid electric cars), component type (battery packs, DC-DC converters, controllers & inverters, motors, on-board chargers, and others), and geography (North America, Europe, Asia-Pacific, and the rest of the world). For the aforementioned categories, the study provides market size and forecast in Value (in USD billion)[1].The function and components of an electric automobile or vehicle depend on the kind of car. At least four different kinds of electric vehicles are now available for purchase and use on the global market. Inverters (DC-DC converters), traction batteries, traction motors, on-board chargers, and controllers are only a few of the frequent major components or pieces or aspects of electric cars that will be covered in this article along with their functions. How an electric vehicle operates is determined by the many sorts of electric car components[2].

### Segmentation of the EV Parts & Components Industry

The motor, battery, onboard charger, power electronics, and the Electric Power Control Unit (EPCU) are just a few of the electric power components found in electric vehicles. All are required for the transformation of the electrical energy from the battery into the kinetic force that moves the EV ahead[3].The market for electric vehicle parts and components is divided into segments based on vehicle type (passenger cars and commercial trucks), propulsion type (battery electric cars, plug-in hybrid cars, fuel cell electric cars, and hybrid electric cars), component type (battery packs, DC-

DC converters, controllers & inverters, motors, on-board chargers, and others), and geography.

### Market trends for EV components and parts

According to our research analysts, the following are the key market trends influencing the EV Parts & Components Market.

### Increasing Investments in Electric Vehicles Driving the Market

Electric vehicles have become an integral part of the automotive industry, and it represents a pathway towards achieving energy efficiency, along with reduced emission of pollutants and other greenhouse gases. The increasing environmental concerns, coupled with favorable government initiatives, are the major factors driving this growth[4]. The annual sales volume of electric passenger cars is projected to cross the 5 million marks by the end of 2025, and it is expected to account for 15% of the overall vehicle sales by the end of 2025. However, logistics and e-commerce are also investing heavily to increase their electric vehicle fleets. For example, will invest more than 1 billion euros (USD 974.8 million) in electric vans, trucks, and low-emission package hubs across Europe over the next five years, accelerating its drive to achieve net-zero carbon.

Several manufacturers have raised the bar to go beyond the previous announcements related to EVs with an outlook beyond 2025. More than ten of the largest OEMs have declared electrification targets for 2030 and beyond. Significantly, several OEMs aim to reorganize their product lines to produce solely electric cars.Mercedes-Benz is in the midst of revamping its strategy, to enhance earnings by concentrating on higher-priced luxury automobiles. As part of its ambition to become all-electric by 2030, the company wants to update its product line and remove lower-cost versions[5].Volkswagen is expecting to invest USD 36 billion on electrified vehicles across its mass-market brands by 2024. According to the firm, by 2025, at least 25% of its worldwide sales will be electric cars[6].

One of the top automakers in Asia is Mahindra & Mahindra (M&M). The business intends to introduce new electric automobiles. The only electric model offered by the firm at the moment is the severity.Volvo said that starting in 2030, it would solely offer electric vehicles. Beginning in 2030, Ford will solely offer electric vehicles in Europe. After 2035, General Motors intends to sell entirely electric automobiles. By 2030, Volkswagen wants to sell 50% of electric cars in China and the US and 70% of them in Europe. Stellates wants to sell 35% of electric cars in the US and 70% of them in Europe.

### Market Dominance by Asia-Pacific

During the forecast period, the demand for electric cars is anticipated to increase due to the government's increased focus on promoting the use of electric vehicles and the availability of government incentives for buying them. Several governments from Europe, North America, and Asia-Pacific have made public announcements about their intentions to phase out gasoline-powered automobiles during the next ten years. Additionally, this will help electric car sales increase throughout the course of the predicted year[7].Due to the tendency of nations like China and Japan towards innovation, technology, and the creation of high-tech electric cars, the Asia-Pacific region is predicted to expand more quickly than Europe and North America. Additionally, the ASEAN nations are working on sizable initiatives related to electric transportation.

The electric car sector is dominated by China. Furthermore, China's government promotes the use of electric cars. By 2040, the whole nation will be using electric vehicles for all transportation. The demand for parts and components for electric vehicles is predicted to increase due to the fact that China has one of the biggest electric passenger car markets in the world. This market has been developing quickly over the last few years and is anticipated to continue rising throughout the forecast period.The electric car ecosystem in Japan is among the finest in the world. The nation is moving towards the production of electric cars thanks to efforts by automakers like Nissan and Toyota. The fact that there are several competitors in the market for hybrid and electric vehicles may be used to measure market growth. In Japan, the market for hybrid and electric cars is anticipated to grow due to these favorable characteristics.

Numerous plans have been developed by the Indian government to lessen pollution in the nation. For instance, the government has been accelerating the adoption of green cars in the country via the FAME and FAME II programs, which provide incentives to consumers and appealing opportunities for investors and manufacturers to build up EV factories. Additionally, to make electric vehicles accessible in India, automakers there are taking steps and spending money on R&D practices.

## LITERATURE REVIEW

Fei Chauet al. discussed that the major parts of electric vehicles (EVs) are the battery, power electronics, and electric motor [1]. EVs, their failure might lead to a serious system collapse or perhaps put lives at danger. This document provides a succinct overview of the defect diagnosis for the electric motor, power electronics, and battery in EVs. The most often utilised detection metrics for EVs are current and voltage. In addition to these, temperature, vibration, power, sounds, and torque are also used in accordance with various detecting methodologies. It demonstrates that the battery's diagnostic system, or battery management system, has already been pretty well-developed in EVs. A few research have been conducted exclusively for EVs, despite the fact that several literatures have presented different defect detection techniques for electric motor and power electronics separately.

Tobias Goldmannet al. discussed that due to the inclusion of new parts and materials into the recycling of vehicles, electromobility presents significant hurdles. The three main parts of (hybrid) electric vehiclestraction batteries, electric motors, and power electronicsare the subject of this research, which examines recent advancements in their recycling. Aspects that are technical and ecological are discussed [2]. All parts include metals that the EU (European Union) considers important, such as rare earth elements, cobalt, antimony, and palladium, in addition to base metals. Since electromobility is a recent concept, no industrial-scale recycling pathways for these parts have been devised. Small return flows and a wide range of vehicle ideas and components make the implementation challenging. In addition, throughout the next decades, radical changes in design and material composition might be anticipated. There is a lot of study focus on battery recycling because of the risks and heavy weights.

Gavin Sommerville et al. discussed that in order to reach global goals for lowering greenhouse gas emissions, to enhance the quality of the air in metropolitan areas, and to satisfy customer demand for electric cars, the market for them must expand quickly[3]. At the end of their useful lives, however, an increasing number of electric cars pose a significant waste management burden for recyclers. However, given that manufacturers need to have access to crucial elements and vital materials for important components in the production of electric cars, discarded batteries may also provide an opportunity. Recycled lithium-ion batteries from electric vehicles might offer a useful secondary supply of resources. Here, we describe and assess the various methods currently used to recycle and reuse lithium-ion batteries for electric vehicles and indicate areas for future development.

Haining Zhanget al. discussed that the sustainable growth of the building and transportation sectors impacts the future of human civilisation since they are the top and second greatest emitters of greenhouse gases (GHG) [8]. The properties of prefabricated components compared to raw materials, as well as electricity transportation, are not taken into account by the existing carbon emission calculation standard. This investigation examined the features of battery electric vehicles (BEV) in terms of carbon emissions, with an emphasis on the transportation of prefabricated components. The genuine carbon emissions performance of component transportation under various external conditions was achieved by real-world experimental investigation. Several variables were chosen as compensation coefficients for multiple linear regression after the variables were first initially screened using correlation analysis. The three parameters of load ratio, average speed, and atmospheric temperature were shown to be quantitatively related to the carbon emissions factor, and the R2 value of the fitting formula reached 0.7079(AC off). According to the, BEVs may cut GHG emissions by 36.18%–54.69%. Additionally, support the manufactured building sector's low-carbon innovation.

Leonardo Gomes, Fernandes Silva, et al. explored that research possibilities are made possible by the development of novel, lightweight, and efficient technologies for electric vehicles (EV). Alternative Al-Si alloy development is one of these fronts. Alloys that are more conductive while yet being robust enough should be developed in response to the present needs for enhanced EV autonomy. The current study effort assesses the inclusion of Ag (0.1 and 2.0 contents) in the high silicon Al-10 wt.% Si alloy within this scenario. The average content of cast alloys often used in EV components is what causes this Si concentration. A number of samples with various dendritic scales crystallised. After that, their tensile characteristics, electrical conductivity, and microstructures were assessed. It is shown that samples of the alloy consisting of 10% Al, 10% Si, and 0.1% Ag allow for tensile qualities of 160 MPa of strength, 12% ductility, and 34% IACS of electrical conductivity. These qualities suggest that adding Ag to new EV alloys is a promising idea [4].

Chitsaz, et al. explored that to reduce emissions and the effects of global warming, series hybrid electric vehicles are the middle technology between gasoline-powered cars and fully electric ones. Using experimental data and an artificial neural network, the current research examines the component size of a series hybrid electric car, which includes a high voltage battery, a combustion engine, and an electric motor. Despite earlier research, a solid artificial neural network model is produced using the experimental data. The artificial neural network is trained with around 3000 data series. The findings show that the high voltage battery's 1.44 kWh capacity is adequate for all driving circumstances. This battery's size may solve many of the vehicle's cost and packaging problems. For a combustion engine, three distinct operating points6.7, 12.2 and 22 kWare suggested in the optimal efficiency zone for urban, accelerated and highway driving, respectively[9].

Krishna Singhet al. explored that fuel-efficient vehicle development has been greatly accelerated by the growing usage of fossil fuels and the significant environmental harm. Since emerging from their incipient stage, hybrid electric vehicles (HEVs) have shown to be a potential answer to the planet Earth's significant existential issue. HEVs not only provide improved fuel efficiency and reduced emissions in compliance with environmental laws, but they also lessen the impact of increasing gasoline costs on customers. HEVs combine the electrical and internal combustion engine propulsion systems. The energy storage system, motor, bidirectional converter, and maximum power point trackers (MPPT, in the case of solar-powered HEVs) are the essential parts of HEVs. These parts and the architecture have a big role in how well HEVs function. This paper provides a thorough analysis of the key HEV components, including their architectures, benefits and drawbacks, the selection of a bidirectional converter for high efficiency, the use of an ultracapacitor in combination with a battery to prolong battery life, and the function of traction motors and their suitability for various applications. It has been extensively debated that photovoltaic cells may be used in HEVs. This study also discusses several MPPT methods utilised for solar-powered HEVs and their applicability[5].

Jürgen Fleischeret al. explored that battery electric car sales have increased over the last year, according to statistics. These vehicles need a dependable disassembly at the end of their useful lives for recycling or remanufacturing. On the one hand, those cars' drivetrain parts, which have significant materials in them and are thus primarily useful for recycling or remanufacturing. However, there are significant difficulties in automating the disassembly of certain components, particularly electric motors and Li-ion battery systems. For the disassembly system, the great number of variations and the unknown specifications and conditions of the components provide particular challenges. For the dismantling of these items, conventional automated disassembly techniques provide little flexibility and adaptability.This work methodically develops two robot-based flexible disassembly techniques for auxiliary electric motors and Li-ion battery modules. The obstacles and needs unique to each product are examined and recognised. The use of a morphological box as a technique allows for the capturing of the current state of the art for flexible disassembly systems. Kinematic, Tools, Workpiece fixation, and Safety system are the four recognised subsystems. The findings are used to build and discuss in-depth proposals for disassembly systems for both Li-ion battery modules and supplemental electric motors. Particularly, the design and operation of these systems are discussed. After that, the techniques are evaluated, their shortcomings are noted, and any room for improvement is discussed[6].

Fatima et al. discussed that future transportation must include electric vehicles (EVs), which will increase fuel efficiency and help reduce pollution. In order to meet the rising expectations for better performance, safety, and less environmental effect, EVs are becoming a more integral part of transportation. Therefore, an early problem diagnostic system is crucial for improving the effectiveness and lowering the maintenance costs of these vehicles. This makes it possible to identify the health of the vehicle before it deteriorates, making it easier to take preventive action and preventing unexpected component failure. This study offers a thorough analysis of the most recent Condition Monitoring (CM) and Fault Diagnosis (FD) techniques for different electric vehicle components, keeping in mind the need for more research. To encourage more focused research efforts based on the most pressing demands, the difficulties and recommendations for future work on developing technologies in an electric vehicle are also covered.

## DISCUSSION

### Motors and energy

The majority of big electric transportation systems are powered by fixed electrical sources that are wired directly to the cars. Regenerative braking, which uses the motors as generators to convert the motion of a train, typically, into electrical power and then feed it back into the lines, is made possible by electric traction. This technique is especially helpful for operations in hilly terrain since descending vehicles may provide a significant amount of the electricity needed for ascending ones.

Only if the system is big enough to use the electricity produced by falling cars will this regenerative system be functional.

An electric rotary motor produces motion in the aforementioned systems. It is nonetheless feasible to "unroll" the motor so that it may run right up against a unique matching track. These linear motors are used in maglev trains, which levitate magnetically above the tracks. This prevents the train or track from experiencing mechanical wear and tear and almost eliminates rolling resistance of the vehicle. Linear motors make switching and bending of the tracks difficult in addition to the high-performance control systems required, which has limited their use to high-speed point-to-point services up until now.

### Vehicle battery pack

An electric vehicle battery (EVB) is another name for a traction battery pack. It fuels an electric vehicle's electric motors. The battery functions as a method for storing electricity. DC current is used to store energy. With more kW in the battery, the range will increase. The battery's design affects its lifespan and functionality. A traction battery pack is predicted to last 200,000 kilometers.

### DC-DC Converter

A steady voltage is delivered by the traction battery pack. But the criteria for various vehicle components vary. The battery's output power is dispersed to the desired level by the DC-DC converter. Additionally, it supplies the power needed to charge the backup battery.

### A motorized device

The major part of an electric vehicle is the electric traction motor. Electrical energy is transformed into kinetic energy by the motor. The wheels are turned by this energy. The key feature that sets an electric car apart from a normal vehicle is its electric motor. The regenerative braking system of an electric motor is a crucial component. By transforming the vehicle's kinetic energy into another form and storing it for later use, this system slows it down. DC motors and AC motors are the two main categories of motors.

### Power Inverter

It transforms the batteries' DC electricity into AC power. Furthermore, it transforms the AC current produced by regenerative braking into a DC current. Additionally, the batteries are recharged via this. The 5. Charge Port's speed may be altered by the inverter.The electric car is connected to an external source via the charging connector. The battery pack is being charged. Sometimes the vehicle's front or back are where the charging port is positioned.

### Aboard power supply

The charging port's AC supply is changed into a DC supply using the onboard charger. Located and fitted within the vehicle is the onboard charger. It keeps track of several battery properties and regulates the amount of electricity that flows into the battery pack.

### Commanding

An electric car's operation is controlled by the power electronics controller. It controls how electrical energy is transferred from batteries to electric motors. The driver's chosen pedal controls both the vehicle's speed and the frequency of voltage variations sent to the motor. Additionally, it manages the torque generated.

### Backup batteries

In electric automobiles, the accessories' electrical power comes from auxiliary batteries. The auxiliary batteries will keep the automobile charged even if the primary battery fails. It prevents the voltage drop brought on by an engine start from having an impact on the electrical system.

### Thermostat (cooling system)

The thermal management system is in charge of preserving an operational temperature for an electric vehicle's primary parts, including an electric motor, controller, etc. To achieve optimal performance, it works even when charging. It makes use of forced air cooling, liquid cooling, and thermoelectric cooling.

### Communication

Through a gearbox, it is utilized to transmit the mechanical power from the electric motor to the wheels. Electric vehicles have the benefit of not requiring multi-speed gearboxes. To prevent power loss, the transmission efficiency has to be good.

## CONCLUSION

The rising levels of greenhouse gases in the atmosphere, the development of the electric car market in recent years is not only warmly welcomed but also critically important. The largest barrier to the wide-scale adoption of electric-powered transportation is cost, since petrol and the cars that run on it are easily accessible, practical, and less expensive. India's economy, now ranked 10th in the world, is expanding. The percentage of people who possess a vehicle is also among the highest in India. According to a survey by ICE, up to 34% of the cars and trucks on the road today are electric. With a market potential of $1 billion for manufacturers, India is its route to become an EV market.

## BIBLIOGRAPHY:

[1] F. Lin, K. T. Chau, C. C. Chan, and C. Liu, “Fault Diagnosis of Power Components in Electric Vehicles,” *J. Asian Electr. Veh.*, 2013, doi: 10.4130/jaev.11.1659.

[2] T. Elwert *et al.*, “Current developments and challenges in the recycling of key components of (Hybrid) electric vehicles,” *Recycling*. 2016. doi: 10.3390/recycling1010025.

[3] G. Harper *et al.*, “Recycling lithium-ion batteries from electric vehicles,” *Nature*. 2019. doi: 10.1038/s41586-019-1682-5.

[4] L. F. Gomes, B. L. Silva, P. S. da Silva, A. Garcia, and J. E. Spinelli, “Ag-containing aluminum-silicon alloys as an alternative for as-cast components of electric vehicles,” *Mater. Res. Express*, 2021, doi: 10.1088/2053-1591/abdabe.

[5] K. V. Singh, H. O. Bansal, and D. Singh, “A comprehensive review on hybrid electric vehicles: architectures and components,” *Journal of Modern Transportation*. 2019. doi: 10.1007/s40534-019-0184-3.

[6] J. Fleischer, E. Gerlitz, S. Rieß, S. Coutandin, and J. Hofmann, “Concepts and Requirements for Flexible Disassembly Systems for Drive Train Components of Electric Vehicles,” in *Procedia CIRP*, 2021. doi: 10.1016/j.procir.2021.01.154.

[7] P. I. Shyamkumar, S. Singh, A. Srivastava, and M. Visaria, “Numerical Investigation of Thermal Performance of Key Components of Electric Vehicles Using Nucleate Boiling,” *J. Therm.*

*Sci. Eng. Appl.*, 2021, doi: 10.1115/1.4050666.

[8] Z. Gao *et al.*, “Evaluation of electric vehicle component performance over eco-driving cycles,” *Energy*, 2019, doi: 10.1016/j.energy.2019.02.017.

[9] F. Un-Noor, S. Padmanaban, L. Mihet-Popa, M. N. Mollah, and E. Hossain, “A comprehensive study of key electric vehicle (EV) components, technologies, challenges, impacts, and future direction of development,” *Energies*. 2017. doi: 10.3390/en10081217.

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# EV CLASSIFICATION AND THEIR ELECTRIFICATION LEVEL

**Dr. Sreenivasappa Bhupasandra***
*Associate Professor,
Department of Electronics & Communication (Communication System Engineering),
Presidency University, Bangalore, INDIA
Email Id-sreenivasappabv@presidencyuniversity.in

## ABSTRACT:

*The electric vehicles (EV) as a potential means of reducing the greenhouse impact is significant. The plug-in hybrid electric vehicle (PHEV) offers comparable driving range and fuel efficiency to the internal combustion engine vehicle (ICEV) thanks to advancements in power electrics, energy storage, and support. The efficiency of the PHEV might be greatly increased by using optimal control techniques or by using the idea of an energy management system (EMS). The different sorts of EVs' operational procedures will be detailed in this review study. We'll also talk about battery and super capacitor technologies as potential ways to boost PHEVs' energy capacity. In this book chapter we discuss the HEVs, or hybrid electric vehicles, A PHEV, or plug-in hybrid electric vehicle,work on vehicle electrification. The problems with electrifying vehicles, charging device all this topic cover in this book chapter.*

**KEYWORDS:** *Combustion Engine, Charging Station, Driving Range, Electric Vehicle, Hybrid Electric, Internal Combustion.*

## INTRODUCTION

Electric cars (EVs) were first introduced in 2010, but the Indian market has seen enough hype about them already. The administration has chosen to encourage the idea of electric mobility, which was first proposed by the late Prime Minister Man Mohan Singh. An incentive programme of INR 95 crore that sought to reward EV makers for each sold unit was authorised by the Ministry of New and Renewable Energy (MNRE). Since then, the federal government has undertaken a number of commendable steps to raise awareness of EVs and the advantages they provide, therefore assisting the Indian people in quickly embracing this invention.

Unlike a traditional car, which has a combustible engine and is powered by a mixture of gasoline and gases, an electric car is propelled by an electric motor that has a rechargeable battery. Because EV batteries have a limited amount of energy storage, they must be recharged from an electrical power source after being discharged. These developments aim to transform the auto industry, particularly in terms of reducing the environmental risks and growing carbon footprint of internal combustion engines (ICEs) that are present across the world[1]–[3].

Pollution reduction, the creation of new intelligent transportation systems, and the ultimate depletion of fossil fuel supplies will be the key forces behind the electrification of vehicles. In contrast to an electric motor's efficiency of 85% to 90%, traditional petrol cars only operate at a 17% to 21% efficiency level. In a typical car, there is an internal combustion engine (ICE), together with mechanical, pneumatic, and hydraulic power transmission systems. In comparison to an electrical system, these mechanical, pneumatic, and hydraulic systems are big, heavy, and inefficient.

Capabilities allow electrical systems to be optimised and regulated for performance, making them the most efficient of all the systems. Therefore, a 100% electric vehicle (EV) will provide great efficiency and no polluting emissions, hence lowering the total carbon footprint and resulting in appealing designs.Access to charging stations is required for consumers and fleets that are contemplating electric cars (EVs), which include PHEVs and all-electric vehicles. For the vast majority of drivers, this begins with charging at home or at facilities used by fleets. By providing more flexible charging options at frequently frequented areas, charging stations at businesses and public venues may assist increase market adoption. By using case studies of continuing accomplishments, community leaders may learn more via PEV preparation planning. The EVI-Pro Lite tool is also available to assess the amount and kind of charging infrastructure required to enable regional EV adoption by state or city/urban area and to analyse how EV charging will affect energy consumption.

A strong station network is necessary for both consumers and fleets to be able to charge the increasing number of EVs in use. Searching for both public and private charging stations is possible using the Alternative Fueling Station Locator. Quarterly updates on developments in electric car charging stations illustrate the expansion of both public and private charging and evaluate the country's charging infrastructure as it is now. By using the Submit New Station form, you may suggest new charging stations to be included to the Station Locator. On the station information page, click "Report a change" to provide suggestions for improvements to current charging stations.

Find out more about state electrification planning and financing, as well as details on the Bipartisan Infrastructure Law. The Go Electric Drive website of the Electric Drive Transportation Association and the Get Equipped guide published by Plug in America, which also includes details on charging networks and service providers, are good resources for information on the various charging infrastructure options that are presently on the market.Asia, Europe, and North America all see an increase in electric car ownership. With California driving the charge with 49% of national sales, the United States has sold over 1.2 million plug-in electric vehicles as of today. In San Jose, 7% in San Francisco, and 5% in Los Angeles, EVs made up 13% of the vehicles sold in 2017. In certain local markets, EVs are becoming more commonplace, but for the most part, people are still unfamiliar with electrification and the many kinds of electric cars that are now available.Battery electric cars, plug-in hybrid electric vehicles, and hybrid electric vehicles are the three main categories of electric vehicles. While all three types of electric cars rely on electricity to move, there are distinctions between them in terms of how they function, as well as in terms of their individual powertrains and electric range.

### HEVs, or hybrid electric vehicles

Although the technology has been available for decades, hybrid electric vehicles are commonly referred to as "hybrids," and the term "hybrid" was first used in 1997 when Toyota unveiled the Prius. Due to its Prius battery, the Toyota Prius has since become the most popular hybrid electric vehicle in the world. The Kia Optima Hybrid, Ford Fusion Hybrid, Kia Niro, Hyundai Ioniq HEV, and several more hybrid vehicles are available on the market right now.A traditional internal combustion engine and an electric propulsion system are combined in hybrid electric cars. The electric motor aids the internal combustion engine, which normally has a petrol or petrol engine, with its primary function being to improve fuel efficiency.

Hybrids utilise their internal combustion engines and regenerative braking systems to replenish their motor vehicle batteries since they lack the ability to plug in and recharge from the grid. Most hybrid vehicles can't go forward solely on battery power; instead, they always need to be powered by an internal combustion engine. Some hybrids, however, can only move the car a short distance at moderate speeds before the combustion engine must kick in to help.When compared to comparable conventional automobiles, hybrid electric vehicles offer higher fuel efficiency and a lower total cost of ownership, although they often cost more up front. For instance, a traditional gas-powered sedan like the Nissan Altima, Mazda6, and Volkswagen Passat TDI receive less economy than the Toyota Prius, which can get up to 54 mpg in urban areas and 50 mpg on the highway.

**A PHEV, or plug-in hybrid electric vehicle**

A plug-in hybrid electric car has bigger batteries and can be plugged in to charge them, which is the main difference between it and a standard hybrid electric vehicle. Because PHEVs must do more labour, they often feature bigger electric motors. PHEV shows in figure 1. Plug-in electric vehicles may operate for a while without the help of a combustion engine since they have bigger vehicle batteries. Some plug-in electric vehicles, such the Ford C-Max hybrid, the Honda clarity PHEV, and the Chrysler Pacifica Hybrid, can travel 30 to 50 miles on battery power alone, while the BMW i3 REx plug-in hybrid can go 126 miles on battery alone before the internal combustion engine has to start.

If buyers need or desire more range, plug-in hybrids might be a great option. A plug-in hybrid provides the option of being able to rapidly fill up with petrol when charging facilities may not be accessible for individuals who often need to travel extremely long distances. On days when they don't go over the vehicle's all-electric range, owners of plug-in hybrids may travel totally on electricity while still having access to the combustion engine when necessary[4]–[6].

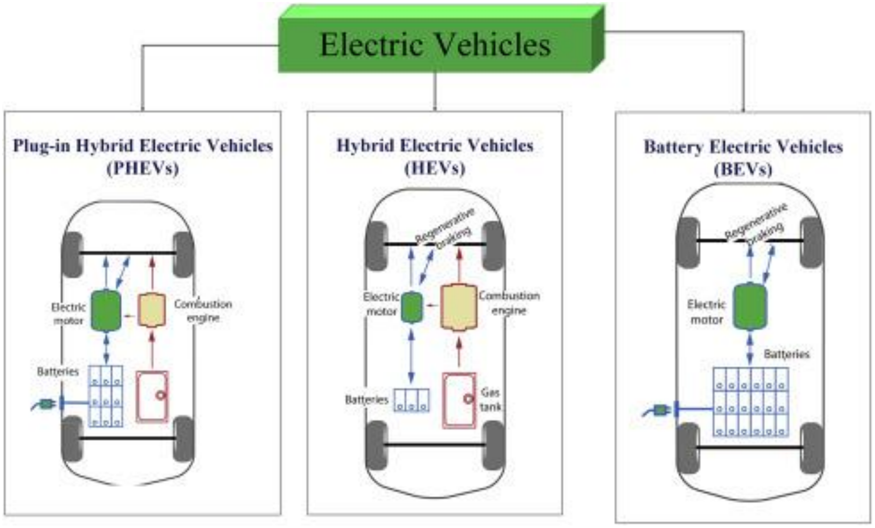

**Figure 1 Plug in hybrid electric vehicle** [ScienceDirect].

Although owners of plug-in hybrids will want to keep their batteries charged as often as possible to benefit from the savings that using electricity affords, they are not needed to do so in order to use the car. In the absence of a power outlet, plug-in hybrids behave like regular hybrid electric vehicles. Therefore, there won't be a problem if the owner, for whatever reason, forgets to plug the car in one day or travels to a place without access to power. When compared to electric power, gas-powered combustion engines often cost more to run.

## DISCUSSION

The Toyota Prius Prime, the Ford Fusion Energi, and the Honda Clarity PHEV are three of the greatest plug-in hybrid electric vehicles on the market in the United States right now. As you can see, a JuiceBox Pro 40 240V smart charger can greatly speed up the battery charging process, giving you more time to enjoy driving on electricity and less time at the petrol station.Battery Electric Vehicle (BEV) Battery electric cars, often known as BEVs or electric automobiles, are becoming more and more popular. BEVs have a full-electric powertrain and are totally battery-powered, in contrast to HEVs and PHEVs.

In fact, one of the benefits of battery electric cars is how simple they are. Battery electric vehicles need extremely minimal maintenance since they have so few moving components. There is no need for tune-ups or oil changes, and the money saved by forgoing these maintenance costs may pile up over the course of the vehicle's lifespan. However, you must be cautious of the battery life of your electric vehicle.The ability to swiftly recharge battery electric cars is much more crucial than it is for plug-in hybrid models since they are entirely dependent on the quantity of power stored in their batteries. So that you may get the most out of your BEV, it's important to choose a home charging solution that can completely recharge your BEV as rapidly as possible.

A 120-volt level 1 charger, which may take a very long time to recharge the car, is standard equipment for the majority of battery electric vehicles. Compared to HEVs or PHEVs, battery electric cars have substantially bigger batteries, which explains this. View the graph below to learn about the battery capacity, driving range, and charging times of four of the most well-known battery electric cars on the market right now.

### MHEVs (mildly hybrid electric cars) and FCEVs (fuel cell electric vehicles)

Two further types of electric cars that are available in Australia are mild-hybrid electric vehicles (MHEV) and fuel cell electric vehicles (FCEV). An integrated starter generator (ISG), also known as a 48-volt starting motor, is used as an additional ICE in mild hybrid electric vehicles. Since the ISG only helps the ICE but cannot accelerate the car on its own, there is still debate about whether MHEV can be referred to as a "true EV".While fuel cell electric cars (FCEV) and battery electric vehicles (BEV) both exclusively utilise electrical energy to move, their methods for storing energy are significantly different. FCEVs generate their own electrical charge by a chemical process, often utilising hydrogen, in contrast to BEVs, which store electrical energy obtained from a charger. Due to the fact that FCEVs may be filled with hydrogen, they are not dependent on the grid for 'charging'.

### Vehicle Electrification

The replacement of a petrol drive with an electric engine is the core and primary goal of vehicle electrification. With the aid of a power electronics converter, the traction battery pack drives the electric motor in an electric powertrain using the energy that is stored inside it. A regenerative braking system transfers the electric energy back to the battery when braking or when the vehicle's speed is lowered. The converter's architecture and control method will change depending on the kind of electric motor employed. The following are the numerous kinds of electric motors often seen in electric vehicles:

1. A BLDC motor (brushless DC motor). used in the majority of lightweight two- and three-wheeled EVs, such as electric bikes and scooters
2. PMSMs, or permanent magnet synchronous motors. High-performance electric bikes, electric automobiles, and electric buses are built using this technology by numerous EV manufacturers.
3. ACIM, an AC induction motor. used by the production of electric vehicles with two and four wheels
4. IPMMs, or inside permanent magnet motors. used by some manufacturers to create high-performance electric two-wheel bikes
5. PMSRMs, or permanent magnet switched reluctance motors. used in EVs with four wheels

There are three charging levels for electric vehicles (EVs): Level 1, Level 2, and Level 3. In order to charge the automobile at Level 1, it must be plugged into a 120-volt AC wall socket. An automobile has to be charged for 17 hours on average. Level 2 charging involves plugging the car into a 240-volt outlet at home or an outside charging station. Takes between 3.5 and 7 hours. Level 3 incorporates a 480-volt system-based standalone DC fast-charging equipment. Although charge times are quicker, these charging systems are not designed for placement in homes. As with bringing a car to a petrol station, users must instead take the vehicle to an independent charging station.

### Problems with Electrifying Vehicles

Limited driving range, high pricing, battery problems, lengthy charging times, and a lack of suitable charging infrastructure are all concerns that BEVs must contend with. There are problems with numerous power semiconductors and other devices due to the electrification of vehicles. Short driving distance and battery problems. The success of car electrification depends on the subject of charging. The main technological difficulty is that customers demand a driving range of at least 700 km (435 miles), yet the energy density of lithium-ion batteries can only give a restricted driving range of 400 to 500 km (249 to 311 miles). A battery pack's size and bulk are additional design constraints. A vehicle with more battery cells will have higher mass. In addition to requiring more energy to move, heavier vehicles also have difficulty managing, accelerating, and braking. It is more difficult to produce excellent outcomes on certain performance criteria as bulk increases. All BEV batteries also lose efficiency over time. Most automakers guarantee that EV batteries won't deteriorate below a specific point for eight years or more. Therefore, a battery replacement in an EV may be required while the driver is the vehicle's owner[7]–[10].

Poor charging infrastructure and a long charging time. EVs could be able to compete with ICE-powered cars if infrastructure and charging convenience are combined in the appropriate way. Long-distance travel is the main problem since there aren't always charging outlets accessible. Massive expenditures are required to install additional fast-charging stations. However, daily recharging at home, work, or in open or public parking places (retail spaces, rest areas along highways, etc.) would eliminate the need for vehicles to make fill-up stops in the future. In principle, charging comfort would greatly increase the adoption of PHEVs by encouraging their operation in electric mode as much as feasible in urban areas and reducing range anxiety during longer excursions when the existence of (and access to) sufficient charging facilities is uncertain.

Modern EVs need and depend on power conversion technologies. An AC induction motor is powered by a DC-AC inverter system, which converts DC from the battery. In charging systems, a power factor corrector (PFC), an AC-DC converter, and a DC-DC converter are combined. Other DC-DC converters in a vehicle power auxiliary electrical system. In order to increase system efficiency and reduce energy losses, power converter systems employ power semiconductor switches such power MOSFETs and the insulated-gate bipolar transistor (IGBT). Power semiconductors based on silicon are the most common varieties. However, silicon power MOSFETs can only operate at a voltage of up to 250 volts. IGBTs are powerhouses because they can operate with voltages ranging from 400 to 1600 volts.

However, owing to its subpar switching capability, IGBTs are seldom employed in high-frequency operation (>30 kHz). In frequencies greater than 200 kHz, power MOSFETs with improved switching capability are employed. Wide-bandgap electronics like those found in SiC and GaN must be employed to get around these restrictions. Due to the large energy bandgap, wide-bandgap devices may function at high voltages (> 1200 volts) and high frequencies (> 200 kHz). Additionally, they have a high thermal conductivity and minimal on-state resistance while operating. In EVs, this results in an efficiency increase of 2%, which is significant. The device and thermal management system (heat sink) are smaller because they have a better power density and thermal conductivity for a given power rating. The size of the passive components decreases as the operating frequency increases. In EVs, size and weight are crucial factors. Additionally, SiC diodes may be suggested for the PFC to increase charger efficiency and minimise component size. Wide-bandgap devices cost a lot of money, however, and not many companies make them for sale. Due to the high cost of wide-band gap devices, few EV manufacturers choose to use them.

## Charging Devices

The pace at which the batteries are charged determines what kind of charging equipment is used for EVs. The kind of battery, the amount of energy it can contain, the charging level, the charger's power output, and the electrical service parameters all affect how long it takes to charge a battery. Depending on these variables, the charging time might vary from less than 20 minutes to 20 hours or more. Numerous considerations, including as networking, payment options, and operation and maintenance, should be taken into account when selecting equipment for a particular application.

## CONCLUSION

This chapter discuss the many types of EVs, the technology used, the advantages over internal combustion engine vehicles, the growth in sales over the last few years, as well as various charging techniques and prospective future advancements. The main research roadblocks and options were also discussed. This kind of technology might give EVs a longer range, which would entice customers and drivers to adopt them. Higher capacity batteries will stimulate the use of the fastest, strongest charging procedures as well as more educated wireless charging technologies. The creation of a unique link that can be utilised everywhere may also aid in the adoption of electric automobiles.

## BIBLIOGRAPHY:

[1] W. Tang, P. Wu, Y. Zhang, and X. Cao, “Analysis on the Current Situation and Development Trend of China’s Electrification Level and Electric Energy Substitution under the Background of Carbon Neutral,” in *IOP Conference Series: Earth and Environmental Science*, 2021. doi: 10.1088/1755-1315/661/1/012019.

[2] Y. Wang, J. Wang, and T. Deng, “Analysis and Forecast of Energy Electrification Level in

Jilin Province of China," in *Proceedings - 2021 International Conference on E-Commerce and E-Management, ICECEM 2021*, 2021. doi: 10.1109/ICECEM54757.2021.00063.

[3] T. XianDong, H. ZhaoGuang, S. BaoGuo, and X. MinJie, "Study on the mid-long term electrification level of China," *Energy Procedia*, 2012, doi: 10.1016/j.egypro.2011.12.1114.

[4] X. Yue *et al.*, "Least cost energy system pathways towards 100% renewable energy in Ireland by 2050," *Energy*, 2020, doi: 10.1016/j.energy.2020.118264.

[5] F. Padovani, N. Sommerfeldt, F. Longobardi, and J. M. Pearce, "Decarbonizing rural residential buildings in cold climates: A techno-economic analysis of heating electrification," *Energy Build.*, 2021, doi: 10.1016/j.enbuild.2021.111284.

[6] F. Trocker, O. Teichert, M. Gallet, A. Ongel, and M. Lienkamp, "City-scale assessment of stationary energy storage supporting end-station fast charging for different bus-fleet electrification levels," *J. Energy Storage*, 2020, doi: 10.1016/j.est.2020.101794.

[7] L. Lozano and E. B. Taboada, "The power of electricity: How effective is it in promoting sustainable development in rural off-grid islands in the philippines?," *Energies*, 2021, doi: 10.3390/en14092705.

[8] C. Wang and X. Liu, "Analysis on the development path and potential of electrification level in the field of transportation in China," in *IOP Conference Series: Earth and Environmental Science*, 2019. doi: 10.1088/1755-1315/267/4/042150.

[9] K. Xiang, W. Cai, S. Zhang, and J. Chen, "Optimization Algorithm and Application of Electrification Level Considering the Development of Energy Storage," in *Proceedings - 2021 International Conference on Power System Technology: Carbon Neutrality and New Type of Power System, POWERCON 2021*, 2021. doi: 10.1109/POWERCON53785.2021.9697778.

[10] G. Conway, A. Joshi, F. Leach, A. García, and P. K. Senecal, "A review of current and future powertrain technologies and trends in 2020," *Transportation Engineering*. 2021. doi: 10.1016/j.treng.2021.100080.

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# ELECTRICAL VEHICLE TECHNOLOGY AND CHARGING EQUIPMENT

**Dr. Shilpa Mehta***

*Professor,
Department of Electronics & Communication (Communication System Engineering),
Presidency University, Bangalore, INDIA
Email Id-shilpamehta@presidencyuniversity.in

## ABSTRACT:

*Electric vehicle (EV) charging systems come in a wide variety and are used in a variety of real-world settings. In terms of converter topologies, power levels, power flow orientations, and charging management systems, this study provides an overview of the current and prospective EV charging technologies. A summary of the primary charging techniques is also provided, with a focus on highlighting a quick and efficient approach for charging lithium-ion batteries with regard to extending cell cycle life and maintaining high charging efficiency. Following a presentation of the key elements of charging technologies and strategies this chapter estimates the ideal size of the charging systems using a genetic algorithm and, based on a careful analysis, values potential future trends in this area.*

**KEYWORDS:** *Charging Station, Charging Infrastructure, EV Charging, Electric Car, Electric Vehicle, And Power Transfer.*

## INTRODUCTION

Access to charging stations is necessary for fleets and consumers that are thinking about purchasing electric cars (EVs), which include PHEVs and all-electric vehicles. The majority of drivers start by charging at home or at a fleet facility. By providing more flexible charging options at frequently frequented areas, charging stations at businesses and public venues may assist increase market adoption. Through PEV preparation planning, which includes case studies of current accomplishments, community leaders may learn more. Additionally, the tool may be used to calculate the amount and kind of charging infrastructure required to enable regional EV adoption by state, city, or metropolitan area, as well as to calculate how EV charging will affect power consumption.

A wide-ranging network of stations is needed for both consumers and fleets to be able to charge the increasing number of EVs in use. Users may look for both public and private charging stations using the Alternative Fuelling Station Locator. Quarterly updates on developments in electric car charging stations illustrate the expansion of both public and private charging and evaluate the present infrastructure for charging in the US. Use the Submit New Station form to propose new charging locations for the Station Locator. By choosing "Report a change" on the station information page, you may provide suggestions for changes to current charging stations.

Learn more about the planning and financing for state electrification, as well as details on the Bipartisan Infrastructure Law. Consult the Get Equipped magazine by Plug in America and the of Electric Drive Transportation Association for details on the models of charging infrastructure that are now in use. Both of these sources also include details on charging networks and service providers.The battery pack of your electric vehicle may be charged in a variety of ways. It might be a bit intimidating at first to have to choose between slow and rapid charging techniques and multiple connection kinds. But it's really simpler than it seems at first! We'll provide you all the essential information you want in this brief tutorial.

It really boils down to two decisions: where you choose to charge and how quickly you choose to charge. The charging speed will vary depending on the specific EV you possess, the battery size, and the kind of charging station you are utilising. These factors are interrelated.One reason for the fast-expanding sales of electric cars is the growing relief from range anxiety. Bloembergen estimated that by 2040, there will be 400 million passenger EVs on the road two years before. According to the most current estimate, that number has been increased to 700 million. This expansion is also being fuelled by increasing investments in EV charging infrastructure, cheaper EV pricing, ongoing improvements to vehicle range, and the steady stream of new EV models.The EV charging market is still evolving and bringing in new capital. While some in-progress technologies will materialise over the next several years, others are already progressively enhancing the EV charging experience.

## LITERATURE REVIEW

MorsyChaves-Ávilaet al. explored that due to falling EV costs, government incentives and subsidies, the need for energy independence, and environmental concerns, the adoption of electric cars (EVs) is rising steadily and quickly in many nations. In the next years, EVs are anticipated to rule the market for personal vehicles. These EVs utilise the electrical grid to recharge their batteries and might have serious consequences if not handled carefully. On the other hand, if they are effectively managed, they may provide the power grid significant advantages and generate income for EV owners. The article's major contribution is an examination of the possible detrimental effects of EV charging on electric power networks, mostly owing to uncontrolled charging, and how such effects might be diminished and even turned into positive effects via regulated charging and discharging. We discuss how uncontrolled EV charging affects peak demand growth, voltage deviance from permitted ranges, phase imbalance brought on by single-phase chargers, harmonic distortion, overloading of power system components, and a rise in power losses[1].

Alberto Panzaet al. discussed that in conjunction with the larger energy transformation taking place across the economy, industrial enterprises are moving towards the electrification of equipment and processes. Particularly, the energy efficiency of intralogistics operations and, the reduction of environmental pollution, have become competitive factors and are now a real research and development target. A wireless power transfer is a contactless electrical energy transmission technology that relies on the magnetic coupling between coils that can be installed under the ground and a coil mounted under the vehicle floor. It is a great way to reduce the demand for batteries because it minimises the amount of time that the vehicle is not in use while being recharged. In this study, a system is defined to find the best locations for static and dynamic wireless charging devices across the warehouse. First, a mathematical model of the warehouse is suggested to represent the forklift-performed transfers and storage/retrieval activities[2].

Yanhe Xu et al. discussed that the charging habits of these resources have in significant load increases on the grid due to the growing usage of electric vehicles (EVs), which has caused a number of issues including higher peak valley load differential and line flow violation. A crucial technology that may be used to monitor the multi-source load data information in the power grid and facilitate the high-proportion access of electric cars is non-intrusive load monitoring, or NILM.

The frequent and complex switching events of electrical equipment at this stage, however, preclude the straightforward use of typical NILM techniques, which are intended to detect the functioning of home appliances. In order to assist the high-proportion injection of distributed energy resources, a NILM algorithm that can be used to monitor the charging behaviour of electric cars at the substation level is suggested in this study. The suggested method makes use of a multi-kernel convolutional neural network (multi-kernel CNN) architecture and a deep learning framework[3].

ÁngelaRönnberg et al. discussed that the proliferation of devices that generate distortion between 2 and 150 kHz has led to (SH) in low-voltage (LV) and medium-voltage (MV) grids. There aren't any suggested procedures at the moment to evaluate how SH affects the electrical system. When SH spreads across the LV and MV grids, it interferes with the components of power distribution and end-user equipment, causing things like light flicker, deterioration of capacitors and cable terminations, loud noise, and a disruption in EV charging. There is an increasing demand for recommendations that make it easier to diagnose issues associated to SH since these instances occur increasingly often. Different interferences are caused by various SH distortion characteristics. The rules for evaluating the effect of SH based on interference morphology are introduced in this article. Simple techniques and procedures that are directly connected to the properties of the SH distortion are used to accomplish the assessment[4].

S. Nagarajanet al.[5], discussed that wireless or wired chargers may be used to charge electric vehicles. In the wired method of charging, there is a metal contact between the equipment that supplies power to electric vehicles and the vehicle's charging inlet. Electric cars that use wireless charging have no physical contact between the vehicle's charging port and the supply equipment. Lossless energy sharing is difficult to achieve since there is no physical touch between the electric car and the charging apparatus. When an electric car is not parked correctly in relation to the charging apparatus, energy is lost throughout the charging process. This project uses image processing to automatically position the wireless charging equipment.The near-field wireless power transfer technique provides the foundation for wireless charging of electric vehicles. There are two different kinds of near-field wireless power transfer systems: inductive charging and capacitive charging. In inductive charging, a magnetic field is created between the conducting coils, while in capacitive charging, energy is transferred between the conducting plates via an electric field coupling.

Fernando V. et al. [6]explored that utilizing a grid-connected photovoltaic (PV) source in residential units (RUs) enables energy bill reduction and uninterrupted supply. However, the widespread injection of excess PV energy might clog the electrical network (EN), particularly in the feeders, endangering the security and dependability of the system. This paper suggests a mixed-integer linear programming (MILP) model for the smart management of energy in an RU with the assistance of a hybrid PV scheme (HPVS) to allay this worry. The suggested strategy intends to reduce the expenses associated with energy consumption via the best scheduling of home appliance use, including the charging of electric vehicle (EV) batteries. The suggested HPVS effectively utilises a PV array, a storage battery (SB), and the energy supplied by EN to satisfy the RU's consumption requirements. Regarding the performance of each technology, operational restrictions and technological bounds are taken into account.

Mohammad[7]discussed that Bangladesh is just now beginning to see the effects of this technology as electric cars usher in a new age in the automotive and technological industries. It is incredibly effective and aims to modernise Bangladesh's fuel-free transportation systems while conserving our natural resources. This essay discusses a wireless charging method for solar- and electric-powered cars. The goal of this project is to design and put into practise a system that will improve wireless power transfer performance and decrease the need for wires by using a Tesla coil as a transmitter to create high frequency, high voltage, and low alternating current to produce high density flux for electric power transfer. Resonant magnetic induction, a kind of inductive coupling in which the conveyed flux may be caught by an inductive coil at the receiver that is connected to the main coil, is used to transmit power wirelessly by creating a magnetic field.

V. Keerthika et al. [8]explored that emerging as a future technology in both the electricity and transportation industries is the electric vehicle (EV). In terms of economic and environmental situations, there are greater advantages. The charging station, which lessens the impact of greenhouse gases and environmental pollutants, is the most crucial element in electric vehicles. The Electric Vehicle Supply Equipment (EVSE) is another name for an electric charging station. It is made up of both high and low power. If we build an on-road charging with the help of solar panels it will be very useful to charge at any point in time, and with the help of connected batteries we can drive in off-road. The high power is terminated at a fraction of second charging that can be implemented in the electric vehicle rather than the low power. The solar-powered force is transferred via a remote force shift mechanism from the photovoltaic (PV) cell to the battery powering the electric car. Sun-oriented boards are thought to build an independent force station, reducing its need on conventional energy resources. The sun-oriented boards use the light energy that the sun produces to generate electrical energy.

Shubham U Makode et al. [9], investigated the biggest disadvantage of today's bikes and vehicles is that they contribute significantly to the development of the economy while simultaneously producing pollution in the environment due to the burning of gasoline. This contributes to increased global warming and constrained fuel storage. Eco-friendly technology is increasingly required for travel. The e-bike (electric bicycle) is only one example of environmentally friendly technology, but it has several drawbacks. To address these drawbacks, I have developed and designed a self-power producing electrical bike. This design solves every e-bike disadvantage. A self-power generating electrical bike is nothing more than a bike that can be propelled without the need of external energy by producing its own power using a set of tools. This sort of bike does not need any external energy, such as petrol or external battery charging. This is charged internally and has no impact on how the electrical bike generates electricity.

### Terminology for Charging Infrastructure

With this hierarchy for charging stations: location, EVSE port, and connection, the charging infrastructure sector has converged on a single standard known as the Open Charge Point Interface (OCPI) protocol.The following charging infrastructure definitions are used by the Station Locator and the Alternative Fuels

### Station Location:

An area containing one or more EVSE ports at the same address is referred to as a station location. Parking lots in shopping centres or garages are two examples.

### EVSE Port

Even though it may have numerous connections, an EVSE port only supplies electricity to charge one car at a time. Sometimes referred to as a charging post, this structure contains the EVSE ports and may have one or more of them.

### Connector

To charge a car, a connector is connected into the car. One EVSE port may support a variety of connections and connector types but only one car may charge at once. Some people refer to connectors as plugs.

### Charging Devices

The pace at which the batteries are charged determines what kind of charging equipment is used for EVs. The kind of battery, the amount of energy it can contain, the charging level, the charger's power output, and the electrical service parameters all affect how long it takes to charge a battery. Depending on these variables, the charging time might vary from less than 20 minutes to 20 hours or more. Numerous considerations, including as networking, payment options, and operation and maintenance, should be taken into account when selecting equipment for a particular application.

### EV Smart Charging

Smart EV charging meets the energy demands of drivers and local grids while providing EVs with energy that is dependable, safe, green, and affordable. It is reliant on highly developed back-end software that gathers data from EVs, networked chargers, and the grid. The information is utilised to combine storage and renewable energy sources, optimise EV charging, and reduce grid impact. Site-level energy requirements are taken into consideration for structures and fleets. In order to dynamically distribute the cheapest energy when and where it is required without sacrificing either local energy demands or EV charging, sophisticated algorithms balance all these factors. EV smart charging is shown in figure 1.

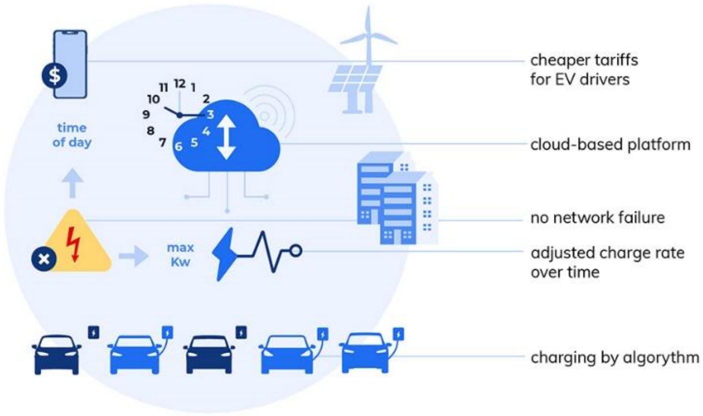

**Figure 1EV Smart Charging [GreenFlux].**

### EV Charging Management with Self-Healing Algorithms

In order to offer a smooth charging experience, EV drivers are pressing EV charge station operators and e-mobility service providers to manage charger availability and stability better. Up to 80% of the operational problems caused by software-related problems that prevent drivers from using EV chargers may be resolved by self-healing algorithms included into an EV charging management platform. The charging experience for EV owners is optimised through real-time problem identification and automatic self-repair.

### Technology for EV Batteries

Without discussing EV batteries, no blog on the latest developments in EV technology would be complete. The search for a lithium-ion battery substitute that is less expensive, charges more quickly, lasts longer, and is not dependent on rare minerals is still ongoing. Improved incremental performance is promised by new chemistries like sodium-ion. Solid state batteries and novel form factors like blades are being investigated by innovators searching for substantial advantages. That significant change in technology is what the sector needs.

### Big Truck Megawatt Charging System

Currently available ultra-fast charging options, such as 250kW and, shortly, 350-500kW DC fast chargers, allow for the swift refuelling of passenger cars, light-duty trucks, and vans. Depending on the vehicle, charging for five minutes may offer 60 miles of additional driving range or take 20 to 30 minutes to reach 80% charge.Much more power is required for medium- and heavy-duty vehicles. The international EV standards non-profit, after four years of development for heavy-duty cars, Char has developed a fast-charging connection based on the Megawatt Charging System requirements. Trucks may increase their range by around 200 miles during a half-hour charging session since it is built for DC charging at up to 3,750kW. Thus, the required 500-mile range for a single run is almost reached by electric trucks.

### Intelligent Battery Management

EV batteries are made up of tens of thousands of cells that are arranged into modules and combined to function as a single battery. Smart battery management technology may extend the life of a battery when enough cells have degraded to the point that it can no longer be used to power electric cars. Multiple EV batteries may be "racked and stacked" to function as a single, enormous battery that can be utilised for on-site energy storage using the grid or renewable energy sources. This is made feasible by technology that integrates software, sensors, and hardware to optimise charging, account for malfunctioning cells, and interact with smart EV charging and energy management software. In this manner, renewable energy may be harvested when circumstances are favourable, stored, and added back to the community grid or the infrastructure for EV charging. Quicker, cheaper, smarter, and greener. Whether it's charging and energy management, batteries, or the actual cars themselves, that is what consumers and corporate customers are seeking for in EV technological advancements. We may be certain that inventors are hard at work given the rising number of EV industry patent applications.

### Future progress

For big commercial vehicles greater power charging will be provided through an expansion of the CCS DC fast-charging standard for electric cars and light trucks. The new standard was first known as High Power Charging (HPC) for Commercial Vehicles (HPCCV), then renamed Megawatt Charging System (MCS), when the Charging Interface Initiativetask force was established in March 2018. The estimated operating range for MCS is 200-1500 V and 0-3000 A, with a maximum theoretical power of 4.5 megawatts (MW). According to the proposal, MCS charge ports must work with current CCS and HPC chargers. In February 2019, the task force published aggregated standards that stipulated 3000 A continuous rating and maximum limitations of 1000 V DC.

A connection design was chosen, and testing took place in September 2020 at the National Renewable Energy Laboratory (NREL). The test examined the temperature and coupling capabilities of seven vehicle inlets and eleven charger connections, with participation from thirteen manufacturers. The MCS connection version 3.2 was released in December 2021, including the final connector specifications and standards.

On April 21, 2021, Daimler Trucks North America unveiled the "Electric Island," the first heavy-duty truck charging station, across the street from company headquarters in Portland, Oregon, with assistance from Portland General Electric. Eight cars may be charged at once at the station, and tractor-trailer-sized charging bays are available. In addition, whenever they become available, the design will support >1 MW chargers. In Bakersfield, California, a new business called Watt EV revealed plans to construct a 40-stall truck stop/charging station in May 2021. At full capacity, it would provide a combined 25 MW of charging power, with some of it coming from an on-site solar array and battery storage.

## CONCLUSION

The main finding is that electric vehicles are unquestionably superior to petrol or diesel vehicles in terms of reducing climate change and improving air quality. In contrast to some popular scepticism and uncertainty over the environmental advantages of electric vehicles, the science is becoming more obvious. The battery and electric motor are the sole sources of power for this vehicle; there is no internal combustion engine. BEVs solely utilise EVSEs to charge; they don't use petrol. Of all vehicle kinds, a BEV has the biggest battery. Additionally, it has the lowest emissions from the tailpipe and is the most energy-efficient. Instead of utilising fossil fuels like petrol or diesel, electric cars charge their batteries with electricity. Due to their greater efficiency and the lower cost of power, charging an electric car is more affordable than purchasing petrol or diesel to meet your transportation needs.

## BIBLIOGRAPHY:

[1] M. Nour, J. P. Chaves-Ávila, G. Magdy, and Á. Sánchez-Miralles, “Review of positive and negative impacts of electric vehicles charging on electric power systems,” *Energies*. 2020. doi: 10.3390/en13184675.

[2] A. Faveto, L. Panza, G. Bruno, V. Cirimele, S. S. Furio, and F. Lombardi, “Efficient management of industrial electric vehicles by means of static and dynamic wireless power transfer systems,” *Int. J. Adv. Manuf. Technol.*, 2021, doi: 10.1007/s00170-022-10216-0.

[3] Y. Yin, B. Xu, Y. Zhong, T. Bao, and P. Wang, “A Non-Intrusive Load Monitoring Model for Electric Vehicles Based on Multi-Kernel Conventional Neural Network,” *World Electr. Veh. J.*, 2020, doi: 10.3390/wevj14020051.

[4] Á. Espín-Delgado, S. Rönnberg, S. Sudha Letha, and M. Bollen, “Diagnosis of supraharmonics-related problems based on the effects on electrical equipment,” *Electr. Power Syst. Res.*, 2021, doi: 10.1016/j.epsr.2021.107179.

[5] S. Divyapriya and M. Nagarajan, “Smart alignment of wireless charger system of electric vehicle using image processing,” *Int. J. Adv. Sci. Technol.*, 2020.

[6] F. V. Cerna, “A hybrid PV scheme as support to relieve congestion in the domestic supply network,” *Int. J. Electr. Power Energy Syst.*, 2021, doi: 10.1016/j.ijepes.2021.107413.

[7] M. Etemadrezaei, “Wireless Power Transfer Seminar,” *Power Electron. Handb.*, 2018.

[8] V. Kandasamy, K. Keerthika, and M. Mathankumar, “Solar based wireless on road charging

station for electric vehicles," 2021. doi: 10.1016/j.matpr.2021.01.102.

[9] S. U. Tayde, N. W. Makode, and U. M. Laybar, "SELF POWER GENERATING ELECTRICAL BICYCLE," *Int. Res. J. Eng. Technol.*, 2017.

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# EXPLORING THE CHARGERS USED FOR ELECTRIC VEHICLES

**Mrs. Kamireddi Sunandana***

*Assistant Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-sunandanak@presidencyuniversity.in

## ABSTRACT:

*This chapter explores the chargers used for electric vehicles. There has been presented and examined a closed-loop digital controller architecture based on a DSP execution. This work proposes to provide a better control machine for a Li-ion battery charger arranged on a real-time test platform. A well-known power pole studying and a DSP development for using the converter make up the test platform. The control strategy is based on a closed-loop current controller and pulse width modulation block in a digital control system, as well as real-time state of charge estimate technology for Li-ion batteries. To express the whole control system in Simulink, however, block diagrams and automatically generated code that is aimed at the DSP processor are utilised. In this book chapter we discuss about the Block diagram of an EV charger, process of charging an EV Battery, working EV charger, voltage regulation, protection against overheating, general factors etc.*

**KEYWORDS:** *Battery Charging, Voltage, Charging Process, EV Charger, Electric Vehicle.*

## INTRODUCTION

In principle, charging a battery is straightforward i.e., just provide a voltage across the terminals to start the charging process. Things get challenging when rapid charging, safe charging, or maximum battery life are priorities. The charging of nickel-metal-hydride (NiMH), nickel-cadmium (NiCd), lithium-ion, and lead acid (PbA) batteries will all be covered in this article in different ways[1].NiMH, NiCd, and Li-ion batteries are the three most prevalent types found in electronic gadgets. The C rate must be taken into account while establishing the charging settings for certain batteries. "C" stands for the battery's capacity after one hour of discharge. A battery with a 1,000mAh capacity, for instance, might be charged at 0.33C, which would need a charge current of around 0.33mA over the course of three hours to attain full charge[2]. The cut-off voltage, often known as the minimum permissible voltage, is used to calculate these batteries' capacity. This voltage often characterises the battery's "empty" condition. There is still charge at that point, but pulling it out runs the danger of destroying the battery[3].

When choosing a charging method for PbA batteries, the ampere-hour (Ah) rating is often a crucial factor. The battery's Ah rating is determined with a complete discharge; cut-off voltage is not taken into account, therefore thus may not represent the actual usable capacity[4].Electric cars (EVs) are becoming more and more popular in India. A study projects that the Indian EV market would grow by 29 million units by 2027, with a CAGR of 21.1%, up from 3 million units in 2019. As a consequence, there will be a rise in the need for smart EV chargers and AC/DC chargers[5].

We need an intelligent battery management or charging system in order to charge the batteries effectively and assure their long life. Based on their low-cost ASSP flash microcontroller (MCU) HT45F5Q-X for charging EV batteries, Holtek has developed intelligent Electric Vehicle Battery Charging Solutions to realise such EV charging stations.Three EV charger designs with specifications of 48V/4A, 48V/12A, and 48V/15A are now available for quick product development. These designs are suited for the Indian market. Both lithium-ion and lead-acid battery types may be supported by this semiconductor-based smart charging technology[6].

**Block diagram of an EV charger**

The Electric Vehicle Battery Charging Solution Block Diagram is This EV charger circuit's operational amplifiers (OPAs) and digital-to-analog converters (DACs) are incorporated right into the battery charger ASSP flash MCU HT45F5Q-X, which is essential for battery charging[7].Designers may choose a suitable MCU from the HT45F5Q-X family based on the needs of their applications. Below is a quick explanation of the functions and characteristics of the EV charger solution for the 48V/12A standard. The HT45F5Q-2 MCU is used in this EV charger design to accomplish the battery charging control function[8].

A battery charging module included into the MCU allows for closed-loop charging management with consistent voltage and current for speedy battery charging. MCU HT45F5Q-2's internal block diagram.OPAs and DACs are included into the HT45F5Q-2's battery charging module since they are necessary for the charging procedure. The design eliminates the need for extra parts such shunt regulators, OPAs, and DACs, which are often employed in traditional battery charging circuits. As a consequence, the peripheral circuit requires less space on the PCB and is simpler and more compact. EV battery charger shown in figure 1.

The AC voltage used to power the EV charger ranges from 170V to 300V. Due to its high-power and high-efficiency features, the half-bridge LLC resonant converter design is used by the EV charger to provide DC power for the batteries charging.The design includes an electromagnetic interference (EMI) filter to filter out high-frequency noise from the input power source and a rectifier circuit to convert input AC voltage to high-voltage DC output. The MOSFETs of the half-bridge LLC converter may be driven by a pulse-width modulation (PWM) controller IC like the UC3525.

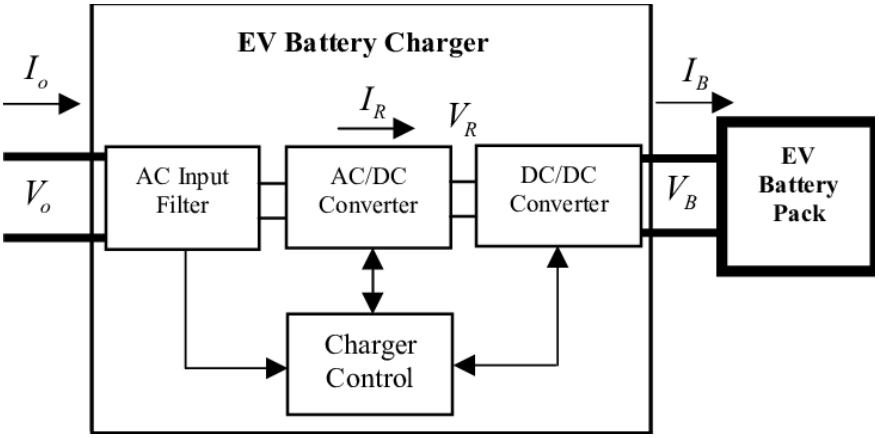

**Figure 1 EV battery charger** [Research Gate].

### Working EV Charger

The MCU HT45F5Q-2 monitors the battery charging procedure. It provides feedback to the PWM controller IC while monitoring the battery voltage and charging current levels. The PWM controller modifies the duty cycle of its PWM signal in response to feedback, driving the MOSFET circuit in order to provide variable output voltage and current for charging the battery.A photo-coupler is used to separate HT45F5Q-2 from the remainder of the circuit (i.e., the high-voltage components) for increased protection. LED battery-level indicators are provided so that you can see how the battery is charging.

### Process of Charging an EV Battery

If the battery voltage is too low when connected for charging, low charging current (i.e., trickle charge (TC)) will be set initially, and the charging process will commence. This graph shows the change in charging voltage and current throughout the charging process. Constant voltage (CV) and constant current (CC) are applied for charging and continues until the battery is completely charged after the battery voltage reaches a pre-defined level (Vu). When the voltage hits VOFF, the battery is regarded as having reached full charge. The final voltage (FV) is established when the charging current reaches.

### Voltage regulation

The battery's initial voltage when it is connected for charging is used to determine the charging voltage. The charging voltage adjusts in accordance with the charging process, and the ultimate voltage is determined after the battery is completely charged. The 48V/12A battery charger's charging-voltage decision levels are described below.If the battery voltage is below 36 volts, charge it at a rate of 0.6 amps with the voltage set at FV(56 volts), at a rate of 0.6 amps with CV(58 volts), and at a rate of 12.0 amps with a battery voltage over 40 volts. Voltage Setting, Charging CV (58V) the voltage is set to FV (56V) when completely charged. The charging current will be reset to CC (12.0A) if the battery voltage is less than FV. (b) Current Control

The battery voltage determines the charging current. An initial trickle-charge current would be set for charging the battery if the battery voltage was too low. A continuous current is delivered for charging the battery once its voltage reaches a specified point and continues until the battery is completely charged. The following is a list of the charging-current decision levels for the 48V/12A battery charger.

1. Recharging Current 1.2A, Identify Charging End
2. When the recharging current is more than 0.2 A, start the charging

### Protection against Overheating

A fan controls the heat while a negative temperature coefficient (NTC) thermistor measures the temperature. The fan is automatically turned on when the temperature rises to remove the heat; it is turned off when the temperature falls below the lower threshold. Additionally, the fan operates in two modes: on when the charging current is high, and off when it is low. The charging current will be lowered to 50% of the charging current and will be routinely checked when the NTC temperature exceeds 110°C.

### LED Charging Status Indicators

1. TC charge, slowly flashing red light (0.3 seconds on, 0.3 seconds off)

2. Red light flashes swiftly (0.1 seconds on, 0.1 seconds off), CC, CV charge

1. The green light is on while the battery is not charging, and the red and green lights are bright when the battery is charging for more than eight hours. Charge Period

The voltage lowers to FV, the current decreases to TC, and the charger periodically checks the battery voltage when the charging time (length varies on battery capacity) is surpassed.

**Circuit diagram for an EV charger**

Higher-wattage designs may also be created using the ASSP flash MCU HT45F5Q-2. It is very practical for EV charger designs since it provides a programmable option for setting parameter thresholds. To aid designers and shorten time to market, Holtek offers technical materials including block diagrams, application circuits, PCB files, source code, etc. [Circuit diagram for an EV charger show in figure 2].

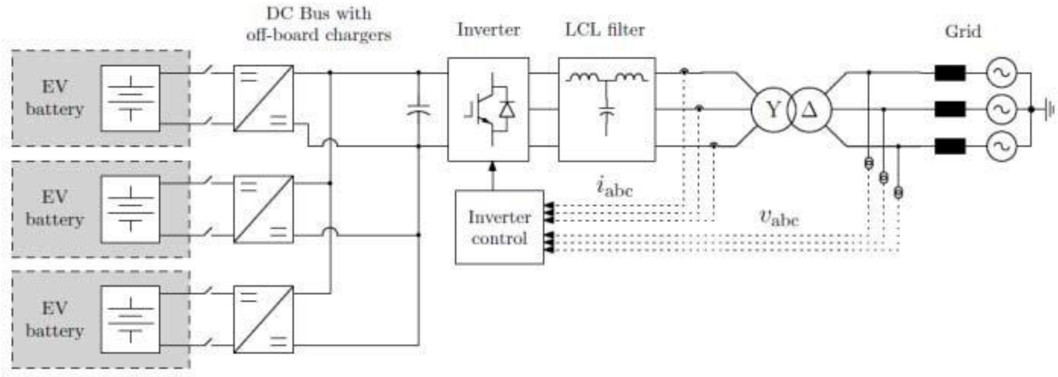

**Figure 2Circuit diagram for an EV charger [**Research Gate**].**

**Fast charging**

A battery may be charged by providing a DC current. The current generates electrical charge that is stored in the battery via an electrochemical process. The transportation of electrical charge per unit of time is referred to as current. As a consequence, the quantity of DC 1 current provided and the length of time passed both affect how much energy is given throughout the charging process. From a generator to the customer, electrical energy is delivered in AC amounts. Such energy has to be transformed into DC amounts. This is the battery charger's main function. One fundamental issue with electric vehicles (EVs) is that they are not currently a particularly feasible substitute for vehicles powered by combustion engines. Recharging an electric vehicle (EV) always takes longer than recharging a car with an internal combustion engine (ICE), which may be done in a few minutes. An electric vehicle (EV) may be charged in one to two hours.

This kind of charging is known as rapid charging. Fast charging is the only practicable way to charge an EV in order to provide a practical replacement for the ICE. However, a very big charger is needed to deliver 75 kW. It is installed outside of the vehicle and utilised at a "charging station" since it could not be contained within the automobile. Two prototypes of such a chargerone in Malmo and the other in Stockholmare in operation in Sweden. It is known as the DUAL battery charger. Using 375 V batteries and a current of 2 CIOA, or 75 kW of electricity, it can charge a bus. An EV owner may anticipate a much longer driving range thanks to rapid charging than they would with a regular charger for the same amount of time. This may be two, three, or even four times as much. The IEA's Per Karson and Martin Burrup have created a distinctive offboard charger. It runs at 10 kW, and a picture of it shows how the department's prior learningacquired by working on this projectwas very helpful when building the onboard charger for this project.

Grid-related effects Fast chargers decreased the grid's quality of electricity. With off board chargers, which often consume more power, the battery charger's effect on the grid is most noticeable. In the case of the design of this specific charger, which will be configured as an on-board charger, the issue is not very significant.The user of an EV needs just connect the car to charge; they are unconcerned with the outcome.

The electricity company is accountable for it ‘When utilising an on-board charger, the current taken from the grid may be roughly described as sinusoidal. Power electronics' non-linear properties lead to distorted or non-sinusoidal currents on the power grid. Voltage distortion resulting from self-impedance in cables and transformers is another effect of this distortion. Eventually, this causes harm to sensitive electrical equipment, such as computers, as well as the possibility of malfunction. Naturally, this has devastating ramifications. Other battery chargers that rely on standard diode rectifiers increase the grid currents' low order harmonic content. The transmission network and the distribution network, which together create a tree-like structure, are the two steps of the power grid's distribution process. The former can transport a lot of electricity with little losses and first delivers power to many places. The latter, on the other hand, distributes electricity among these several areas. It is possible to see distortion and voltage dips of how this distribution takes place. Additionally, resonance between the conductors and capacitor banks or loads may cause distortion in the current (and subsequently the voltage).

### Certain design issues

It's critical to reduce an EV's weight as much as possible since it has a significant impact on performance. Although employing a single-phase AC supply for all charging would be the lightest design, using the three-phase grid was thought to provide benefits that outweighed the "weight issue." Since inductors are heavy, one method of lowering weight is to try to minimise the size of the inductors. The acceleration, ability to climb hills, speed, and range of an electric vehicle are all impacted by its weight. Each time, the performance suffers. But it's also critical to make sure there is strong stability. The weight distribution is also a crucial factor. This is something to keep in mind, but it's not directly related to this project since the limits are mostly set by the vehicle's design. Additionally, it makes sense to utilise as little voltage as feasible. For instance, it will be better to utilise the lowest voltage feasible even when the nominal DC-link voltage has not been established in the early phases of design[9].

### Recharging electrical gadget batteries

NiMH and NiCd batteries have a nominal voltage of around 1.2 V/cell, and they should typically be charged up to 1.5 to 1.6 V per cell. There are many ways to tell when to cease charging NiMH and NiCd batteries, including delta temperature (dT/dt), temperature thresholds, peak voltage detection, negative delta voltage, and basic timers. One or more of these may be bundled in a single charger for more important applications[10].The constant current regulator (CCR) battery charging circuit depicted below employs peak voltage sensing. For NiMH and NiCd batteries, charging to around 97% of full capacity requires a peak voltage detection point of 1.5 V/cell.

### General factors for Li-ion charging

The CCR battery charger seen above might be used to charge a Li-ion battery with the proper care.

Li-ion batteries are often charged to 4.2 V/cell at 0.5C or less to capacity around 1C, perhaps with a slower charging rate after that. Keeping the increase in temperature to under 5°C is a difficulty. A catastrophic occurrence, such as a fire, might from a greater temperature while charging. And the last phases of charging are usually when a Li-ion battery's temperature increases the greatest. By not including a second, lower-rate charge stage, this CCR controller makes an effort to get rid of that possible issue. Eliminating the second charge step prolongs battery life while also maintaining the battery's safety. However, by skipping the second step of charging, the battery may only be charged up to 0.85C, or 85% of its full capacity.A Li-ion battery can only be charged to a maximum of 0.7C if the charge is stopped once the voltage reaches 4.2 V/cell, unless it is charged extremely slowly (typically 0.15 C or even less). Some batteries may not even get to 0.4C. Li batteries may be charged at less than 4.2 V/cell, however it is not advised. Li batteries will charge but not fully charge at low voltages, unlike other battery chemistries. Lower voltage charging has the benefit of significantly increasing cycle life at the expense of considerably lower capacity.

Multi-stage solutions are required for optimum performance, even if simple constant current battery charging circuits may provide cheap cost and somewhat sluggish charging. Trickle charging is not allowed for Li-ion batteries; the charging process must be stopped. Li-ion battery overcharging may harm the cell and perhaps plate out lithium metal, which is dangerous.The more effective method of charging Li batteries. The procedure begins with trickle charging if the battery is totally or almost fully discharged, followed by a somewhat quicker pre-charge. Depending on the exact battery being charged, after a certain charge level is achieved, rapid charging takes place using a constant current technique until a crucial battery voltage, typically about 4.2 V/cell, is reached. Constant voltage charging is then used to finish the operation. After then, the battery is not given any voltage and the charging process is stopped.

## DC with a low voltage

Initially an Intent endeavour, narrow voltage DC (NVDC) was created to improve system efficiency by reducing the voltage range of the system load in laptop and tablet computers. This is done by switching out the standard battery charger with a system charger that includes a buck converter. This makes it possible to optimise dc/dc (buck) converters and gets rid of the power-path switch, which reduces dissipation, board space, and cost.An example of an NVDC implementation is shown in the image below. The buck converter is used to link the system to the adaptor. When the battery is being charged and when the battery is used to complement the adapter to provide system power, NVDC functions as a buck converter.

## Charging using hybrid power

When the system load exceeds the adapter's rating, both NVDC and HPB allow the adapter and battery to cooperate to provide the system power. The system bus receives a reverse-boost of battery energy from HPB. In the image above, the NVDC setup simultaneously activates QBAT to allow the battery to support the adapter and provide system power.In an HPB arrangement, the adapter powers the system and charges the battery while the buck converter continues to function normally. The buck converter operates in reverse when the adapter power is insufficient, allowing the battery to provide extra power. A standard adaptor may be used to implement HPB.Battery charger controller adjustments are needed to implement HPB. In contrast to a standard battery charger, HPB enables the battery to provide more power when required. The charging system's lesser efficiency under light loads is a drawback.

### Lead-acid battery charging in three stages

Several charging phases are also necessary for lead acid batteries to operate at their best. However, this is a far easier technique than the lithium batteries mentioned above. Although there are PbA battery chargers with two to five charging stages, three-stage chargersalso known as three-phase or three-step chargersare the most popular. There are three stages: trickle, bulk, and absorption.Regardless of the names given to the three phases, the battery should be completely charged in a short amount of time, have a long lifespan, and remain fully charged for as long as the charger is attached.Lead-acid battery charging in three stages show in figure 3.

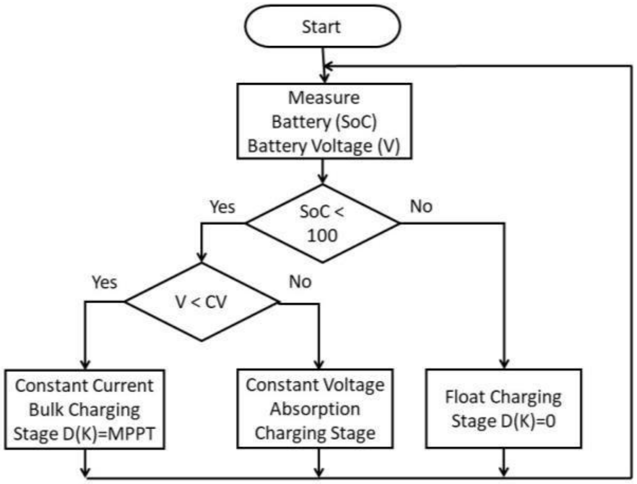

**Figure 3 Lead-acid battery charging in three stages [**ResearchGate**].**

If a continuous current of roughly 25% of the battery's ampere-hour (Ah) capacity is delivered, the battery will attain about 80% of full charge during the bulk stage. The bulk charge rate must be as low as 10% of the Ah rating in order to meet this 25% requirement, which might vary from manufacturer to manufacturer. Almost often, a quicker charging rate during the bulk stage than 25% of the Ah rating will in a shorter battery life.

## CONCLUSION

This chapter discuss the basic charging block diagram. The fast charging is available in the market but the drawback of the fast charging to down battery fast. To increase the technology, there are few obstacles to producing and operating electric vehicles. A shared, electrified, and connected mobility future may help India save 37% of its projected carbon emissions and 64% of its predicted passenger road-based mobility-related energy consumption by 2030.The battery may be charged as quickly as possible using a smart charger while maintaining a temperature of under 100° F. While this may be useful, it may also shorten the lifespan of certain batteries, therefore it is best to abide by the manufacturer's instructions.

## BIBLIOGRAPHY:

[1] A. Hassoune, M. Khafallah, A. Mesbahi, A. Nouaiti, and T. Bouragba, "Experimental implementation of a smart battery charger for electric vehicles charging station," *Int. J. Power Electron. Drive Syst.*, 2020, doi: 10.11591/ijpeds.v11.i4.pp1689-1699.

[2] X. Yang, Z. Jia, D. Wang, B. Nie, X. Zhao, and Y. Su, “An integrated equalization charger for series-connected energy storage cells,” *Int. J. Circuit Theory Appl.*, 2021, doi: 10.1002/cta.3276.

[3] H. Li, X. Zhang, J. Peng, J. He, Z. Huang, and J. Wang, “Cooperative CC-CV Charging of Supercapacitors Using Multicharger Systems,” *IEEE Trans. Ind. Electron.*, 2020, doi: 10.1109/TIE.2019.2962485.

[4] X. Zhang, J. Lei, H. Li, H. Liao, and J. Peng, “Cooperative control for multi-module charging systems of ultracapacitors,” *Energies*, 2020, doi: 10.3390/en13195218.

[5] E. Ayoub and N. Karami, “Review on the charging techniques of a Li-Ion battery,” 2015. doi: 10.1109/TAEECE.2015.7113599.

[6] Hassoune A, Khafallah M, Mesbahi A, and Bouragba T, “Experimental Analysis of Control in Electric Vehicle Charging Station Based Grid Tied Photovoltaic- Battery System,” *World Acad. Sci. Eng. Technol. Int. J. Electr. Comput. Eng.*, 2019.

[7] Panasonic, “Overcharge / Overdischarge / Overcurrent Safety Circuits Overcharge / Overdischarge / Overcurrent Safety Circuits - Continued,” *Panasonic webpage*, 2012.

[8] K. H. Koh, C. A. Vaithilingam, and R. A. Gamboa, “Viability assessment of Taylor’s University as a PV-grid charging station for electric vehicles,” 2020. doi: 10.1063/5.0001581.

[9] J. Schulman, P. Mobley, J. Wolfe, R. Davis, and I. Arcos, “An Implantable Bionic Network of Injectable Neural Prosthetic Devices: The Future Platform for Functional Electrical Stimulation and Sensing to Restore Movement and Sensation,” in *Biomedical Engineering Fundamentals*, 2014. doi: 10.1201/b15482-63.

[10] S. Dan Grigorescu, C. Cepisca, and V. Cimpoeru, “Virtual instrumentation based laboratory for batteries testing,” 2013. doi: 10.1109/ATEE.2013.6563538.

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# DIFFERENCE BETWEEN SLOW CHARGING AND FAST CHARGING

**Dr. Rajiv Singh***

*Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-rajivranjansingh@presidencyuniversity.in

## ABSTRACT:

*This chapter explores key difference between slow charging and fast charging which is major challenges in electric vehicles (EVs). Overall, there are two basic ways to charge EVs: slowly and quickly. Slow charging is more frequently utilized at home or at the office because it takes many hours to fully charge the battery. Fast charging stations are often found at motorway service areas or places adjacent to major roadways and can recharge an EV battery up to 80% in less than an hour. The situation and the demands of the driver determine the charging technique. Direct current (DC) energy can be used to power the battery to fast charge an EV. Find a fast-charging station, check the battery level, connect the charger, start the charging procedure, keep an eye on the charging procedure and then unplug the charger to quickly charge an electric vehicle. When the EV needs a quick charge, especially for lengthy trips, fast charging can save time.*

**KEYWORDS:** *Combined Charging, Charging Station, Dc Charging, Electric Cars, Fast Charger, Load Balancing.*

## INTRODUCTION

The battery pack of your electric vehicle may be charged in a variety of ways. It might be a bit intimidating at first to have to choose between slow and rapid charging techniques and multiple connection kinds. But it's really simpler than it seems at first. We'll provide you all the essential information you want in this brief tutorial[1].It really boils down to two decisions: where you choose to charge and how quickly you choose to charge. The charging speed will vary depending on the specific EV you possess, the battery size, and the kind of charging station you are utilizing. These factors are interrelated[2].

### Charging speed

We'll describe the various charging speeds, where you could generally find them, how long it typically takes to charge an EV using each method, and which we think is ideal.

### Slowly charging EVs

A slow charger powers your EV using AC (Alternating Current) from the national grid, and it normally runs between 2.3kW and 2.5kW. The slow chargers often take the shape of 3-pin plug EV chargers and charge from standard wall outlets.According on the kind of battery you have, utilising a 3-pin plug charger might take up to or even more than 18 hours to fully charge your EV, making it the slowest method. Let's use the Renault Zoe as an example. It will take around 17 hours to completely charge your EV using a 3-pin plug charger with a power output of less than 3kW.Slow chargers are most often seen in households or, in rare instances, workplaces where businesses have not yet made the investment in a dedicated EV charging station.

Although, it is a less expensive method of charging since you do not need to buy a specialised home EV charging station or pay to use a quick charger, we believe the drawbacks appear to outweigh the benefits. One of the biggest drawbacks of 3-pin plug chargers is that they can actually pose a fire risk because overloading a domestic socket near its 3kW capacity puts stress on your circuit, the cables, and the socket and could lead to serious issues like overheating and, in the worst case, fires[3].A slow charging will work just fine if you are staying with family members who don't have a dedicated EV charger and there aren't many nearby public chargers. Therefore, we advise having a backup 3-pin plug charger on hand for situations like these[4].

### Quick EV charging

Fast chargers are the most prevalent kind of EV charger in the UK, with a typical rating of 7kW or, more precisely, 7.4kW. Dedicated home chargers for EVs or public charging stations may be found in locations like supermarkets and parking lots. Like slow chargers, fast chargers utilise AC (alternating current from the national grid) to power your EV (EVs have built-in converters inside, changing it into DC inside the vehicle). All electric cars need charging with DC current (direct current), and fast chargers use this AC to power your EV.

For instance, 22kW fast chargers are also available in certain public locations, and you may have them installed at your house. However, you need a three-phase electrical supply, which may be expensive and time-consuming to convert, in order to install a 22kW EV charger in a home. The quickest charging is 22kW, however most UK residences typically utilise single-phase power.When compared to slow chargers, fast chargers charge your electric car three times faster, and if you're lucky, a 22kW fast charger will charge it ten times faster. Using the Renault Zoe as an example, charging with a 7kW fast charger should take roughly 7 hours, while charging with a 22kW charger should take around 2.3 hours. However, using a 7kW fast charger should typically take 4-6 hours to fully charge your EV.

A dedicated home charging port is a fast charger that you may purchase that offers a number of advantages. Convenience is one among them, along with safer and less expensive charging[5].One of the main benefits of public fast chargers is that many of them are free to use, particularly in grocery stores and shopping centres. It won't be very enjoyable after a long day at work to have to travel particularly to one you know or drive around looking for one. There can be limitations on the amount of time that charging is free, and you might not be able to completely charge your EV in that period[6].

## DISCUSSION

### Public versus at-home charging

You may either utilise public charging stations or charge your EV at home using your household mains electrical supply. Your options for charging kinds (and speeds) will be impacted by this.

### Charging at home

Currently, 80% of all EV charging takes place at home. the majority of the time while users sleep, allowing them to awaken the following morning to a fully charged battery that nearly usually gives more than enough EV range for the majority of people's everyday travel requirements[6].Using Trickle Charge with your household current or AC Household Charge with a wall box installed are the two types of home charging that are available. The main variations are as follows:

**Control Charge**

Offers charging using the stock (three-prong) 220V socket that comes with your electric vehicle. The other end is simply put into your EV; it doesn't need any extra equipment to be installed. It can offer 13 to 16 km of range each hour of charging. It charges your EV at a rate of around 65 miles per hour (overnight) or 200 km per hour. Trickle Charge should only be used in extreme circumstances when your battery is running low and you are unable to go to a public station or use an AC wall box at home. This is because to the possibility that using home electricity can in issues with energy bills and electrical loads, therefore use this charge solution with care and talk to your power provider before using it for the first time. To ensure optimal dependability and peace of mind while utilising trickle charge, it is advised to purchase an ICCB (In Cable Control Box) cable[7].

Ac household charging with wall box provides charging through a 230V outlet, allowing charging 3 to 4 times faster than Trickle Charge - depending on the acceptance rate of your particular model and the charger o Useful especially if you have time to top up your electric vehicle overnight: it takes about 6 hours to fully charge a 40-kWh battery car o Requires the installation of a dedicated EV charging wall.

**Centralised charging**

These stations, which are more accessible due to the network's continued expansion and are often found across metropolitan centres in particular, enable you to recharge your battery while you're on the move if you need to go further. Public charging stations provide DC Fast Charging or AC Charging with a wall box in most circumstances.And compared to charging at home, both solutions are faster. Depending on the wattage of the charging station and your EV's ability to absorb AC Chargers, public charging may be 3 to 10 times quicker than AC household charging. All DC charging devices are referred to as fast chargers. It can charge an electric car from 20% to 80% of its capacity in around 40 minutes thanks to its use of Combo DC (CCS for Combined Charging System), which offers charging power over 50kW at voltages above 450V and currents up to 125A. Minimising the use of DC Charge will assist to extend the life of high-voltage batteries[8].

**Explained: AC verses DC charging**

Electric automobiles need DC (Direct Current) to charge their battery pack rather than AC (Alternating Current), which is what the national grid provides.The electric vehicle's onboard charger receives electricity from an AC charger, which it converts to DC so the battery may be charged. The onboard charging device's size is limited by available space. The quantity of power they can provide to the battery is rather modest because of this constrained volume. Therefore, charging often takes longer[9].A DC fast charger bypasses the on-board charger and powers the EV's battery directly. The DC charger has no size or price restrictions since it is not a part of the vehicle. Meaning that charging is usually done considerably more quickly.

The IEC 62196 Type 2 connection, which the EU has designated as standard, is used to charge electric cars, mostly in Europe. A single size was chosen because the maximum possible power will be transmitted to the car via two additional communication pins and by a straightforward resistor coding within the cable. The size selection was based on the widely used red IEC 60309 three phase plugs with five pins, which come in different diameters according to maximum current (the most common are 16 A and 32 A). The internal on-board charger in the vehicle must restrict the current appropriately.

The connector is shaped like a circle with a flat top edge; the original design specification called for an output electric power of 3–50 kW for charging battery electric vehicles using single-phase (230V) or three-phase (400V) alternating current (AC), with a typical maximum of 32 A 7.2 kW using single-phase AC and 22 kW using three-phase AC in everyday use. The plugs contain holes on the sides that enable the vehicle and the charger to automatically lock the plug to eliminate unintentional charging interruptions or cable theft[10].In the form that Tesla changed it for its European Supercharger network (up to Version 2), it may generate 150 kW of direct current (DC) through two pins per channel, with the needed mode being selected via a switch inside a Tesla Model S or X vehicle. Tesla has standardised the CCS2 connection in Europe with the introduction of the V3 superchargers in 2019.

## System for Combined Charging

Electric car charging is done according to the combined charging system (CCS) standard. It can provide electricity at up to 350 kilowatts using Combo 1 or Combo 2 connections. The two extra direct current (DC) contacts on these two connections, which enable high-power DC rapid charging, are expansions of the IEC 62196 Type 1 and Type 2 connectors.Depending on the location, the Combined Charging System permits AC charging with either a Type 1 or Type 2 plug. The electric car, charging stations, charging couplers, charging communication, and many charging-related features, including load balancing and charge authorisation, are all included in this charging ecosystem.If an electric vehicle or electric vehicle supply equipment (EVSE) supports AC or DC charging in accordance with the specifications set by the CCS, then it is CCS-capable. BMW, Daimler, FCA, Ford, Jaguar, General Motors, Group PSA, Honda, Hyundai, Kia, Mazda, MG, Polestar, Renault, Rivian, Tesla, Mahindra, Tata Motors, and Volkswagen Group are among the automakers who support CCS.

## Powerful communication

The charging communication is the same all across the world, unlike the connection and inlet, which are location-specific. Generally speaking, there are two distinct styles of communication[11]. In accordance with IEC 61851-1, basic signalling (BS) is carried out using a pulse-width modulation (PWM) signal that is sent via the control pilot (CP) contact. When a connector is plugged in, before contacts are made live (or energised), and when an electric car and charging station are both ready for charging, these safety-related functions are communicated. The PWM signal is the only one that allows for AC charging. The on-board charger is in this instance informed of the maximum current available at the charging station by the duty cycle of the PWM (A pulse width of 5% indicates that HLC must be utilised).High-level communication (HLC), also known as Power Line Communication or PLC, is a method of transferring more complicated information by modulating a high-frequency signal across the CP contact. It may be used, for example, to provide "plug and charge" or load balancing services or for DC charging. The DIN SPEC 70121 and the ISO/IEC 15118-series standards serve as the foundation for high-level communication.

## Balanced loading

CCS distinguishes between two load balancing techniques.Reactive load balancing enables immediate switching of the energy flow from EVSE to EV to a predetermined limit.Scheduled load balancing helps reactive load balancing as well as arranging the energy flow from EVSE to EV with various power restrictions and cost indications over time, for example. For instance, a smart grid may utilise it to optimise energy distribution.

**Automobile coupler**

The vehicle coupler is made up of the vehicle intake, which is found within the vehicle, and the vehicle connector, which is attached at the end of a flexible cable. The Type 1 coupler, the North American standard, and the Type 2 coupler, the European standard, as detailed in IEC 62196-2, served as the foundation for the CCS couplers. Creating a vehicle inlet that is compatible with both the current AC car connections and extra DC contacts was one of the difficulties of the Combined Charging System. This has been done for Type 1 and Type 2 by adding two more DC connections to the intake below the current AC and communication contacts. Combo 1 and Combo 2, the ensuing novel combinations, are well-known.Combo 1 and Combo 2 use different implementations for the DC vehicle connection. While the Type 1 section of the connection stays the same and the AC contacts (L1 & N) are left unutilized in Combo 1, the connector is extended by two DC contacts. There are just three connections left on the Type 2 section of the connector for Combo 2, two communication contacts and a protective earth. This is because the AC contacts (L1, L2, L3, & N) have been totally removed from the connector. To enable non-CCS AC charging, the car inlet may keep its AC connections.

**Powerful charging**

Due to the fact that vehicle couplers for DC charging only provide DC charging with currents up to 200 a, they are insufficient to meet the demands of the foreseeable future's charging infrastructure. a subsequent version of the standard is compatible with currents up to 500 A. To compensate for these high currents, cables must either have huge cross-sections, which makes them heavy and stiff, or they must be cooled if thinner cables are needed. Additionally, increased heat dissipation is of contact resistance. The standard outlines the specifications for high-power DC couplers, including temperature monitoring, cooling, and silver plating of contacts, to address these technological challenges. Equipment is being tested, and Charing is looking at electric truck versions that are above 2 MW.The CHAdeMO Association, founded by the Tokyo Electric Power Company and five major Japanese manufacturers, created the fast-changing technology for battery-electric cars in 2010. The organization's translation of the phrase is "charge for moving". The name is an acronym for "Charge de move".

It competes with China's GB/T charging standard, Tesla's proprietary connection used by its Supercharger network outside of Europe, and the Combined Charging System (CCS), which has been mandated for electric cars sold in the European Union since 2014. In Japan, CHAdeMO is still widely used as of 2022, however it is relatively uncommon for new automobiles sold in North America or Europe to have this feature. First-generation CHAdeMO connections add roughly 120 kilometres (75 miles) of range in a half-hour by delivering up to 62.5 kW by 500 V, 125 A direct current using a specialised electrical connector. It has been included into numerous international standards for car charging.The second-generation standard permits direct currents of up to 400 kW at 1 kV. The third-generation standard, dubbed "Chaoji" in working form, is being jointly developed by the CHAdeMO Association and the China Electricity Council (CEC) and is intended to provide 900 kW.

**Charger GBT**

The market for electric car chargers is also expanding quickly. The major competitor in the market for electric car chargers, which is contested by several nations, is the electric vehicle charging standard. There are currently three main groups of charging standards for new energy vehicles: Type1 (American standard), Type2 (European standard), which uses the SAE J1772 standard led by the international society of automotive engineers (SAE), and GBT, Chinese standard as well as CHAdeMO (Japanese standard), which were both first introduced in 2010 by the Japan Electric Vehicle Association and the Japan Electric Vehicle Charging Association. Charger GBT show in figure 1.

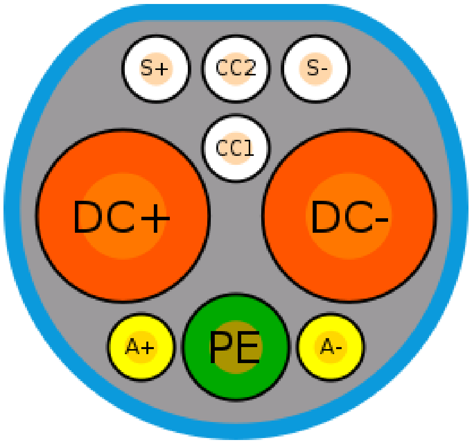

**Figure 1 GB/T charge standard**

## Standard GB/T

The National Energy Administration, the Ministry of Industry and Information Technology, the Ministry of Science and Technology, and the Standardisation Administration of the Chinese General Administration of Quality Supervision, Inspection and Quarantine issued five newly revised national standards for charging interfaces and communication protocols for electric vehicles on December 28, 2015, in Beijing. The new requirements were effective on January 1, 2016. The basic requirements, AC and DC, and the communication between the charger and BMS are the three sections of the GB/T standard.

## Security

The features of the charging interface temperature monitoring, electronic lock, insulation monitoring, discharge circuit, and other functions are increased by the GB/T standards. They further extend the security protection measures for the vehicle interface of DC charging and expressly prohibit the use of risky charging modes. The safety of electric cars and users when charging is assured thanks to the measures made to prevent incidents like people electric shock, equipment combustion, and other mishaps.

## Compatibility

The original standard is compatible with the style and structure of AC-DC charging interface. The new and old plugs and sockets may work together, and the electronic locking mechanism introduced to the DC charging interface has no effect on the electrical connection between the new and old goods. The GB/T standard adjusts the size of several contacts and mechanical locks. For new power supply equipment and electric cars to perform the fundamental charging function, users merely need to upgrade their communication protocol version.

## CONCLUSION

In this book chapter we discuss about thedifference between slow charging and fast charging. The most popular charging methods in the EV future will probably be Level I and II slow charging because to its ease and cheap power. However, Level III rapid charging offers a way to reduce "range anxiety" in the driver of a passenger electric vehicle (EV) and is probably going to be required for many different fleet kinds, notably taxis. A fast charger can provide an electric vehicle (EV) with enough power in one ten-minute charge cycle to go 100 miles. By reducing vehicle downtime, this fast-charging capabilities may allow the EV industry to expand quickly.

## BIBLIOGRAPHY:

[1] S. Huang *et al.*, “In Situ Measurement of Lithium-Ion Cell Internal Temperatures during Extreme Fast Charging,” *J. Electrochem. Soc.*, 2019, doi: 10.1149/2.0441914jes.

[2] I. D. Campbell, M. Marzook, M. Marinescu, and G. J. Offer, “How Observable Is Lithium Plating? Differential Voltage Analysis to Identify and Quantify Lithium Plating Following Fast Charging of Cold Lithium-Ion Batteries,” *J. Electrochem. Soc.*, 2019, doi: 10.1149/2.0821904jes.

[3] N. Andrenacci, F. Karagulian, and A. Genovese, “Modelling charge profiles of electric vehicles based on charges data,” *Open Res. Eur.*, 2021, doi: 10.12688/openreseurope.14354.3.

[4] Y. Ligen, H. Vrubel, and H. H. Girault, “Mobility from renewable electricity: Infrastructure comparison for battery and hydrogen fuel cell vehicles,” *World Electr. Veh. J.*, 2018, doi: 10.3390/wevj9010003.

[5] N. Kelly, A. Samuel, and J. Hand, “Testing integrated electric vehicle charging and domestic heating strategies for future UK housing,” *Energy Build.*, 2015, doi: 10.1016/j.enbuild.2015.07.044.

[6] R. Lugolole, A. Mawire, K. A. Lentswe, D. Okello, and K. Nyeinga, “Thermal performance comparison of three sensible heat thermal energy storage systems during charging cycles,” *Sustain. Energy Technol. Assessments*, 2018, doi: 10.1016/j.seta.2018.09.002.

[7] N. Andrenacci, F. Karagulian, and A. Genovese, “Modelling charge profiles of electric vehicles based on charges data,” *Open Res. Eur.*, 2021, doi: 10.12688/openreseurope.14354.1.

[8] L. Teo, V. R. Subramanian, and D. T. Schwartz, “Dynamic Electrochemical Impedance Spectroscopy of Lithium-ion Batteries: Revealing Underlying Physics through Efficient Joint Time-Frequency Modeling,” *J. Electrochem. Soc.*, 2021, doi: 10.1149/1945-7111/abda04.

[9] Q. Zhou *et al.*, “Effect of current rate on energy deposition of electrical wire explosion in air,” *IEEE Trans. Plasma Sci.*, 2014, doi: 10.1109/TPS.2014.2360873.

[10] B. P. Chandra *et al.*, “Transient behaviour of the mechanoluminescence induced by impulsive deformation of fluorescent and phosphorescent crystals,” *J. Lumin.*, 2008, doi: 10.1016/j.jlumin.2008.07.003.

# EXPLORING VARIOUS ON-BOARD CHARGER SPECIFICATION

**Ms.Renuka Bhagwat***

*Assistant Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-renuka@presidencyuniversity.in

## ABSTRACT:

*This chapter's major goal is to show the design of an on-board charger that can be used to recharge a car battery for plug-in technology. This charger has the ability to regulate the load's voltage and current levels and keep them there. The grid's 50 Hz electrical values are converted into dc quantities using a first converter. A second converter offers galvanic isolation while also adjusting the levels to the battery's specifications. A power factor corrector is used to achieve the first converter's control. Correct voltage and current levels may be supplied to the battery thanks to the management of the second converter. This approach is one of the most effective ways to provide an electronic supply with little harmonic grid effects. It explains why the components and the structure were chosen. In this article, the effectiveness of the on-board charger, loading costs, and required loading times are examined.*

**KEYWORDS:** *Ac Charging, Constant Current, Constant Voltage, Charging Station, Electric Vehicle, Power Battery.*

## INTRODUCTION

In electric vehicles (EVs), an on-board charger (OBC) is a power electronics component that transforms AC power from external sources, such household outlets, to DC electricity to charge the battery pack. To decide the appropriate current/power and charging standard to use, the OBC connects with the vehicle controller and charging station. Globally, there are many different charging standards, including regional rules for China, Europe, and North America. Based on information from the vehicle controller or EV supply equipment (EVSE) controller, the OBC may automatically adapt to the appropriate regional requirements.

As it can also convert DC power from the high-voltage battery pack to AC power to support AC loads (V2L), grid power (V2G), and even other EVs, the on-board charger also plays a crucial role in bidirectional charging modes.When purchasing a car, factors like comfort, safety, and dependability are quite essential, but with electric vehicles, the amount of time it takes to charge is also very crucial. While filling up a traditional car just takes a few minutes, charging an electric vehicle's battery takes much longer.Both AC and DC may be used to charge EVs Today, the majority of EVs come with an on-board charger (OBC) that transforms the AC input from the grid to DC and charges the battery. An on-board charger's main responsibility is to control the power flow from the grid to the battery.

### When using an AC charger

Inside the EV, electrical current is converted to DC. Every EV has an integrated charger that may change the current before delivering it to the battery.

### AC adapters

Allow the AC to DC conversion of current outside of the vehicle. The EV receives DC directly, eliminating the need for on-board conversion.

### On-board charger prepares

Most importantly, the on-board charger's Voltage or Current Control Mode lets you manage the current and voltage at which the battery needs to be charged, extending the battery's life.Both the constant current and constant voltage charging options provided by the charger are simple to use. Additionally, each of them has benefits and drawbacks. Constant current charging has a high efficiency and charging speed, but there is a chance that the battery could eventually get overcharged, shortening its lifetime. In the event of constant voltage charging, there is a chance that excessive current may flow into the battery right away, overheating it and reducing its lifetime once again.In order to preserve speed and efficiency, the charger makes sure that the battery is first charged with a constant current. Once the voltage at the battery's two ends reaches a particular amplitude, it switches to constant voltage charging. The most crucial mechanism of the on-board charger is referred to as the charging method.

## LITERATURE REVIEW

Xiangwu Wang et al. verify the effectiveness of an off-board charger, a power battery simulation system for electric vehicles that simulates various power battery packs has been developed. In order to simulate the charging response, the enhanced lightweight charging load is paired with the improved power battery model, and the online estimate of the state of charge as well as the electromotive force of the battery model are utilised to alter the charging load parameters in real time. The classic battery model now includes an acceleration coefficient to increase test effectiveness, and online settings for the battery's type, specification, temperature, and voltage may be made in accordance with test requirements. The use of a mobile test vehicle's DC converter cascaded power battery pack to create a lightweight charging load with constant voltage, constant current, constant power, and constant resistance that can be continuously adjusted within the rated range is proposed as an improved charging load scheme. As a consequence, the charging load's size and weight are decreased, and the off-board charger's autonomous test is made possible. The numerous experimental findings serve to verify the suggested battery simulation system's performances[1].

ShenliZouet al. simulate and optimise an integrated transformer for on-board chargers in electric cars, this study suggests a methodical methodology. The suggested strategy involves a thorough transformer loss model, an electromagnetic description of leakage inductance that is precise, and an optimisation procedure. The multi-objective optimisation utilising genetic algorithm is introduced to optimise the design-space parameters, such as winding specifications and core candidatures, as well as the performance-space variables, such as volume, weight, and losses. In terms of theoretical studies, finite-element analyses, and actual performance, four sets of integrated transformers are best constructed and contrasted. The integrated transformers are used and tested on a 3.3-kW on-board charger prototype as confirmation to the proof-of-concept. It has been shown that the observed losses and the theoretical calculation line up. In contrast to other viable alternatives, the peak efficiency of the CLLC stage with the best transformer choice is 98.2%, resulting in efficiency increase and temperature improvement[2].

Stefan Ditze et al. explored that the off-board portable 11 kW charger for electric cars is suggested in this study. A three-phase power factor correction (PFC) in VIENNA topology is selected for the ac/dc stage. In terms of design, winding, and core material, the loss and volume of the PFC inductance are determined across a broad range of parameters. For the galvanically separated dc/dc stage, a three-phase LLC resonant converter with a 1 MHz operating frequency is used. To reduce volume, weight, and losses, a parametrizable loss model of the high-frequency transformer and the resonance inductor is created. The inductive components are optimised in terms of winding specification, magnetic material, and core shape with the aid of an automated algorithm employing these loss models, and measurements and finite element analysis are used to confirm this. SiC devices with 900 V are utilised for the ac/dc stage, while SiC devices with 1200 V are used on the main and secondary sides of the dc/dc stage. To alter the charging profile and run the LLC resonant converter at its most effective setting close to the series resonance frequency, a variable dc-link voltage is used[3].

Nayak et al. explored that in this work, integration of wireless EV charging stations with on-board renewable solar PV is investigated. Without the need for additional land for solar plant construction, the grid will be less stressed thanks to the integration of on-board solar PV electricity with EV charger power. The two power sources are combined via a dual-input buck-boost converter (DIBBC), which also charges the electric vehicle battery. The controller for the three switches of the DIBBC is designed using the small-signal model of the converter. The integrated solar PV system's simulation model and wireless power transfer (WPT) technology are made to charge a 120V/165Ah battery at 130V. The suggested EV battery charging system's hardware prototype is built for 1.5kW in order to validate the simulation's findings. The WPT system is designed for coils with a circular spiral form and series-series compensation for an 85 kHz resonance frequency. A solar simulator that has been configured to run with the same parameters as in the simulation takes the place of solar PV. Results and analysis of the 130V charging voltage DIBBC-based charger demonstrated increased efficiency of up to 92% when DIBBC is receiving power from both sources. Higher source voltages and smaller power supply differences from the two sources improve the efficiency of the proposed charging system. Higher voltage sources are thus advantageous for raising the integrated charging system's efficiency. The discussion of loss analysis in the converter's key components continues[4].

VarunKuppala et al. compares the hardware and software outcomes of the creation of an on-board charger for electric vehicles utilising cc and cv modes.We developed a level-1 charger that is affordable and portable since electric car charging in homes and businesses is still in its infancy in India. As a result, portable chargers are more expensive and charging at stations is not always feasible. The primary goal of the Development of the Electric Vehicle On-Board Charger is to create a level-1 electric vehicle charger that is affordable and more dependable using IEC60309 and IEC62196 connectors that are compliant with Bharat EV specifications. A software model in MATLAB with simulation results will be completed. In this assignment, we learned about level 1 chargers and EVSEs. Arduino was used to create a hardware prototype for a 7.4V Li-ion battery, and the CC and CV modes were employed for quick charging. Therefore, a prototype working model and the functioning and regarding the components will be implemented in this project[5].

ShipraKumari et al. explored on-board battery charger for plug-in electric vehicles (PHEVs) is created using the Brayton-Moser passivity-based control (BM-PBC) technique. This electric vehicle (EV) charger's key attributes are better power quality, smaller filters, less voltage stress across switches, and quick dynamic response. The Brayton-Moser formulation is used in this study to create a dynamic model of the three-level (TL) boost power factor correction (PFC) converter. After that, a virtual resistor is added in series with the input inductor to create the Brayton-Moser based control mechanism. Additionally, the suggested controller's stability study is done utilising an energy balancing technique. A PI controller is combined with the aforementioned controller to enhance dynamic performance and decrease steady state error. As a result, the TL boost PFC converter is developed with the controller consisting of BM-PBC and the PI controller as a battery charger, and its performances are examined in different operating modes with the aid of MATLAB/Simulink. Additionally, by tracking source current total harmonic distortion (THD) under various operating circumstances, the power quality of chargers is evaluated[6].

Sandy Atanalian in [7], offers a comparison and classification of battery chargers for electric vehicles in a number of different categories. The research focuses on fast charging stations, which are off-board chargers. More specifically, it focuses on bidirectional AC/DC converters, which are a crucial component of the fast-charging station. The grid's needs and criteria must be met via AC/DC converters, which interact with the grid and DC/DC converters. Additionally, this research addresses the drawbacks of traditional two-level AC/DC converters and emphasises the need of switching to multilayer converters.

## On-Board Charger

Various signal conditioning techniques, integrated high voltage isolation AC-DC converters, AC rectifiers, dual bridgeless power factor correction (PFC), gate drivers, error amplifiers, and numerous other power electronic parts make up the on-board charger in electric vehicles. The OBC must be as light as possible since it is permanently placed, which will lessen its effect on the vehicle's range. The original OBCs only have 3.7 kW of charging power for e-cars. As a result, some electric vehicle batteries required eight hours to fully recharge.

Technology advancements produced improved on board charging systems that deliver 6.6 to 22 kW. These enabled quick charging for automobiles using AC charging systems. Over 98% of OBCs will be 6-11 kW models rather than 3-5 kW ones in the next few years. The primary forces underlying this transformation are improvements to the charging infrastructure. Some OBCs are being created with the capacity to transmit electricity in both directions, from the grid to the car and from the vehicle to the grid.An on-board charger is one of the most crucial components of an electric car. It offers tremendous freedom to charge an EV battery using an AC power supply anywhere, anytime, although being significantly slower than the DC fast chargers.

## DISCUSSION

Both Mahindra and Tata have introduced electric vehicles in India. These vehicles include on board AC chargers that have a maximum output of 3 kW and very tiny batteries (11–15 kWh). The on-board chargers in global EVs have greater ratings between 7- and 20-kW AC.Two-wheelers use relatively tiny (2–3 kWh) batteries that are often detachable to allow for home and workplace charging from a regular wall outlet. The on-board AC charger for electric two-wheelers is only capable of providing a charging rate in the range of 1-3 kW and requires a standard three-pin 15-amp connection.

## Facilitating quicker AC charging

While minimising battery deterioration, OBC innovations may assist EV manufacturers in meeting customer demand for quicker charging. Constant current and constant voltage charging are the two charging options offered by AC chargers. Constant voltage, often known as trickle charge, is slower but offers greater control and can charge the car to its full capacity. [8][9]Constant current charges the battery more quickly but cannot fully charge the vehicle. The OBC starts the charging cycle with constant current and changes to constant voltage towards the end to maximise speed.

Single-phase and three-phase on board chargers are the two most common varieties. Standard single-phase OBCs have a capacity of 7.2 kW to 11 kW, whereas three-phase OBCs have a capacity of 22 kW. The vehicle's charging time is significantly influenced by the OBC's capacity.DC fast charging, which completely avoids the OBC and delivers direct power to the battery, is the quickest charging option accessible to customers. The capacity of typical DC charging stations ranges from 50 kW to 300 kW, which is more than six times that of single-phase on-board chargers. However, as AC charging is less harsh on batteries, users may maximise the benefits of AC charging while minimising battery deterioration by using three-phase OBCs' higher capacity.

## Systemic Response

A number of safety features are built into an on-board charger to safeguard the user and provide the functional safety needed for automotive applications, such as cutting power if the load exceeds operating limits and separating internal components from external hardware to reduce the risk of an electrical failure. Given that the OBC serves as a high-speed gateway for data to transit between the vehicle and the grid when the EVSE controller is installed, ensuring a cyber-secure connection is also crucial[10].From the inlet to the battery, Aptiva offers high-voltage products. One of these products is a three-phase on-board charger that complies with a number of automotive-grade data and charging standards, including the V2G standard, the Home Plug standard, and the ISO 26262 functional safety standard.Internationally, there are many levels of EV charging.

1. The nominal supply voltage and maximum current for Level 1 AC charging are 120 V and 20 A, respectively. They have a power output of up to 2.4 kW and are typically utilised in domestic settings. They include an integrated single-phase charger. It is a plug-in technology that is less costly since it doesn't need to be installed. Due to the low charging power, the charging period is lengthy, ranging from 8 to 12 hours, and is best suited for domestic applications.

2. Level 2 AC charging offers a nominal current of up to 80 A and a nominal voltage of 240 V. It features a 19.2 kW maximum power output and an inbuilt charger. In comparison to level 1 AC charging, it involves installation work and is thus more costly. It is often implemented in public parking lots, workplaces, shopping centres, etc.

3. Level 3 charging, sometimes referred to as DC fast charging, uses an off-board, three-phase charger that bypasses the on-board charger and delivers DC power straight to the battery.There are on-board chargers.On-board chargers may be categorised based on the number of phases they can utilise (one, two, or three), as well as their output. On-board chargers typically provide power in the range of 3.7 kW to 22 kW. The charger's price and, by extension, the cost of the whole electric vehicle are determined by these two factors.

## Charge port on board

The power of the typical AVID charger is either 7.3 kW with a single phase or 22 kW with three phases. The charger may also choose whether it can utilise three phases or just one. The charging time will solely rely on the battery capacity when linked to a home AC station, which will likewise have an output of 22 kW.When connected to a single phase, this on-board charger can take electricity between 110 and 260 volts (or 360 and 440 volts when utilising three phases). The output voltage that is sent towards the battery is between 450 and 850 V.

**Charging only during night**

Operators that use this technique overnight charge their fleets at the hub or depot where they are parked. This method makes the assumption that E-Trucks only work one shift per day, remain inactive at night, and typically have batteries big enough to cover the daily needed range. With today's infrastructure and technology, overnight-only charging is feasible and could be the most economical charging option.Given the lengthy rest periods, fleets may utilise cheaper, slower Level 2 chargers at the hub or depot, limiting their upfront capital costs. Additionally, with overnight charging, trucks would charge at night when power is less costly. Alternately, the fleet operator might lease the charging equipment from a third-party supplier of charging infrastructure, a move that would minimise capital-expenditure outlays but probably result in somewhat higher total costs.

**Midnight and route-specific charging**

In this scenario, drivers charge E-Trucks throughout the day at fast chargers and overnight at the depot. Private rest areas, destination warehouses, open-air shopping centres, public charging stations, and truck rest areas are all potential places for midroute chargers. When the battery pack is not big enough to sustain the whole day needed range, even when completely charged, an overnight-and-midroute charging plan makes sense.Because operators may use smaller battery packs in their cars and hence need fewer depot chargers, this charging option lowers the needed capital expenditures at the depot for both fleet operators and charge-point operators.The requirement to assure availability and the increased expense for building out or using midroute infrastructure are the key factors behind this method. Operators' capital expenses will rise if they choose to construct dedicated midroute stops. The cost of a kilowatt-hour used will also be higher for operators that utilise public charging stations in the middle of a route than it is at hubs. Charging stations must be accessible and functional when required for fleets that choose to utilise public networks, or else on-time performance may suffer.

**Charge solely during transit**

Fleet operators will only use public or private midroute charging if they choose a midroute-only charging option. This concept lowers the amount of money needed to build the necessary infrastructure, but it is only practical in areas where there are public charging stations along the desired route or if energy prices are low enough to support switching to exclusive midroute charging. This technique, like other pricing strategies, has a number of shortcomings. For instance, if chargers are not accessible, a fleet's total idle time may rise.Fleet operators with limited daily mileage or lengthy gaps between cycles, such as car-on-demand providers with free-floating fleets, are most suited to use midroute-only charging. Even with such enablers in place, we anticipate that in order to guarantee charging access and prevent interference with fleet performance, fleet operators would need to negotiate specific agreements with charge-point operators.

**Battery replacement**

In this approach, eTruck drivers may switch out depleted batteries for fully charged ones either at the hub or depot site or in-between stops at designated swapping points. Time is the key benefit of this charging method. Instead of waiting for a cable charger to finish charging an on-board battery, swapping stations will contain a supply of previously charged batteries that can be placed quickly.This methodology may be speedier, but the expenditures involved might be high. Operators will need to build up a centre for charging and storing the battery packs, keep several batteries in each vehicle, and maybe engage workers to do the changing. Costs can increase further if a fleet operator uses two distinct vehicle types with two different battery-pack combinations. Nevertheless, there are certain situations when switching batteries makes sense, such as when travelling through isolated regions without a public charging infrastructure. When charging turnaround times are tight or a fleet owner only employs one brand of vehicle, battery changing can also be the best option. Battery changing has not yet been made commercially available by any operators.

### Catenary charging in the air

The eTruck itself either has a tiny battery or doesn't have one with this option. It travels along a predetermined path while using an above catenary, which is a line or wire that directly powers moving vehicles. This approach enables the fleet manager to reduce costly eTruck battery-related charges. Savings may be significant given that batteries often account for between 40 and 60 percent of these cars' total capital costs.The costly capital investments necessary to create the overhead power grid and the need for fixed routes that are always in place are two significant drawbacks of catenary charging. This approach is usually not financially viable since so few routes are now equipped with it. Catenary charging may be appropriate outside of places where the infrastructure is already in place for extremely brief fixed transfers involving high payloads, such as in mining applications.

## CONCLUSION

The strength of the weakest connection always dictates how quickly an electric vehicle charges. There is a trend towards more potent on-board chargers. Current research is primarily focused on reducing the size and weight of chargers while keeping their high energy density, high charging efficiency, and efficient heat dissipation. After significant study, the PFC phase of the charger, which is the first phase, currently has a 98% efficiency. The second phase's DC-DC converter's design and performance, thus have the biggest an impact on the overall efficiency. Additionally, electric cars have their own powertrains that can convert AC current into DC.

## BIBLIOGRAPHY:

[1] X. Yan, L. Wang, Z. Chai, S. Zhao, Z. Liu, and X. Sun, “Electric vehicle battery simulation system for mobile field test of off-board charger,” *Energies*, 2019, doi: 10.3390/en12153025.

[2] S. Zou, J. Lu, A. Mallik, and A. Khaligh, “Modeling and optimization of an integrated transformer for electric vehicle on-board charger applications,” *IEEE Trans. Transp. Electrif.*, 2018, doi: 10.1109/TTE.2018.2804328.

[3] S. Ditze *et al.*, “A High-Efficiency High-Power-Density SiC-Based Portable Charger for Electric Vehicles,” *Electron.*, 2021, doi: 10.3390/electronics11121818.

[4] K. Kamalapathi, P. S. R. Nayak, and V. K. Tyagi, “Analysis of dual input buck-boost converter for solar PV integration with wireless electric vehicle charger,” *Distrib. Gener. Altern. Energy J.*, 2021, doi: 10.13052/dgaej2156-3306.3714.

[5] L. V. Chowdary, M. K. Kuppala, and A. Pandian, “Development of electric vehicle on-board charger using cc & cv modes and hardware implementation,” *J. Adv. Res. Dyn. Control Syst.*, 2020, doi: 10.5373/JARDCS/V12I2/S20201221.

[6] K. Shipra, "Brayton-Moser Passivity Based Controller for Electric Vehicle Battery Charger," *CPSS Trans. Power Electron. Appl.*, 2021, doi: 10.24295/cpsstpea.2021.00004.

[7] S. Atanalian, K. Al-Haddad, R. Zgheib, and H. Y. Kanaan, "A Review on Electric Vehicles Battery Chargers and AC/DC Converters for Fast Charging Stations," 2021. doi: 10.1109/IMCET53404.2021.9665577.

[8] M. Jawahar, V. Jayasankar, K. Karthik Kumar, and S. Edward Rajan, "Efficiency enhancement of solar PV powered micro-integrated high frequency isolated vehicle battery charging converter," *Int. J. Power Electron. Drive Syst.*, 2019, doi: 10.11591/ijpeds.v10.i2.pp953-960.

[9] IEEE, *IEEE 2030.1.1 Standard Technical Specifications of a DC Quick Charger for Use with Electric Vehicles*. 2016.

[10] V. L. Tran, D. D. Tran, V. T. Doan, K. Y. Kim, and W. Choi, "A novel hybrid converter with wide range of soft-switching and no circulating current for on-board chargers of electric vehicles," *J. Electr. Eng. Technol.*, 2018, doi: 10.5370/JEET.2018.13.1.143.

# AN ANALYSIS OF OFF BOARD CHARGER SPECIFICATION

**Dr. Sreenivasappa Bhupasandra***
*Associate Professor,
Department of Electronics & Communication (Communication System Engineering),
Presidency University, Bangalore, INDIA
Email Id-sreenivasappabv@presidencyuniversity.in

## ABSTRACT:

*The common usage of electric vehicles (EVs) may allay worries about climate change and the scarcity of fossil fuels. The lack of charging stations, which only have high-charge batteries and high-energy charging infrastructure, is one of the biggest barriers to the adoption of EVs. In this study, a novel transformer-less architecture for boost DC-DC converters is developed. This topology has a better power density and reduced switch stress, making it a promising choice for high-power fast-charging battery chargers for EVs. In-depth analyses of the proposed converter's two working modes, discontinuous current mode (DCM) and continuous current mode (CCM), are presented in this study. Critical inductances and design factors are also computed for the proposed converter. Finally, hardware-in-loop (HiL) simulation-based real-time verifications are conducted to evaluate the accuracy of the suggested theoretical notions.*

**KEYWORDS:** *Charging System, Charging Infrastructure, Dc Converter, Electric Vehicle, Off-Board Charging, Power Density.*

## INTRODUCTION

The need for effective and quick charging stations is growing in response to the rising popularity of electric cars. The best way to reduce charging time is to use DC off-board chargers. The size of the battery has the most impact on how long it takes to charge, however many cars can use standard DC fast chargers to reach 80% of their capacity in under an hour.Drivers no longer need to plug in overnight for a full charge since the shorter charging time allows them to recharge throughout the day or during a brief stop. In order to keep up, DC chargers have been increasing their outputs; some of them can currently provide up to 350 kW.PI offers the customised, isolated SCALE-driver Gate Driver IC Family based on the unique Flux Link galvanic isolation technology, as well as SCALE-2 Plug-and-Play Gate Drivers, for the DC off-board charging application. In order to operate Si IGBT and Sic MOSFET appropriately, PI gate driver solutions provide a perfect companion chip, significantly increasing system efficiency and providing excellent design freedom and equipment dependability.

The most pressing issues confronting governments are the environment, air pollution, the decline of fossil fuel use, and the associated costs. Some of these issues can be resolved by the usage of EVs. Through the use of vehicle-to-grid (V2G) technology, these cars may sometimes be able to pump power into the grid and therefore play a crucial part in decommissioning. The issues faced by EVs include battery chargers, the cable between the vehicles and the charger, feeder, material type and cost, connection, transformer, ground surface quality, and peak voltage management. On-board and off-board charging solutions for electric vehicles may be separated into two categories. Electric automobiles are equipped with on-board systems, which are further split into AC level 1 and AC level 2 subcategories. The benefits of this category include not needing to construct a charging station, being able to connect directly to the distribution power supply, and affordability.

The drawbacks of this sort of charging system, however, include the need to install a battery charging system in every vehicle, an increase in the cost of automobile manufacture, limited power, and a lengthy battery charging period. Charging stations are used to recharge EVs in off-board systems. In other words, everything an EV needs to charge, save the battery, is only present at the charging station. Compared to on-board vehicles, the cost of making electric vehicles is lower. On the other hand, compared to on-board systems, the power density and efficiency are increased, and the charging time is greatly decreased. Both AC-connected and DC-connected versions of this kind of electric car charging equipment, also known as a DC fast charger (level 3), are available. In AC-connected systems, a transformer provides power from the grid, and an AC/DC converter and a DC/DC converter for each output port convert other equipment to run on an AC bus.

Extremely rapid charging stations and grid-facing AC/DC converters are the two subcategories of AC-connected systems. DC-connected systems need a transformer and an AC/DC converter to provide the necessary energy for the DC-bus. DC/DC converters in these systems allow for the connection of EVs. In both systems, there may be certain uses for energy storage devices and renewable energy sources. While AC-connected systems have more uncomplicated protection and more widely used measurement equipment, DC-connected systems often have higher efficiency, simpler control, and fewer conversion steps. Isolated and non-isolated DC-connected systems are installed in different ways. It is possible to utilise non-isolated converters if the isolation of the charging system is given by the transformers placed before the AC/DC converter.

Although most unidirectional non-isolated converters are more efficient and have simpler control systems than bidirectional non-isolated boost converters, study has been sparked by the unidirectional converters' straightforward layout. Depending on the battery voltage, a unidirectional boost converter may be a useful and simple option for EV charging applications. The current flowing through the switches and the size of the inductor for minimal current ripple serve to restrict the converter's power. The capacity of this kind of converter has been improved by the introduction of several ways.

The switched-capacitor (SC) approach is one of the key methods for this kind of converter. For this approach, the SC technique offers sufficient voltage increases, high density, and improved efficiency. However, its application has been limited by the strains on semiconductors. One of the additional strategies provided is the interleaving technique. To provide more favourable circumstances on the output side, numerous converters might be placed in series-parallel relationship to one another. A three-phase interleaved boost DC-DC converter is presented in. It has the benefits of a straightforward construction, practical performance, and great power density.

The suggested converter in was expanded to six phase legs in describes the design of a three-phase interleaved boost converter operating in discontinuous current mode (DCM), where the tiny inductor size enables reversible inductor current and zero-voltage switching situations. Partial power principles were used to an interleaved boost converter in DCM in and low voltage rates for switches and lower losses were also presented. This structure's disadvantage is the need for a significant amount of hardware equipment and inner DC-bus balancing. Another well-liked approach for non-isolated boost converters is the voltage-lift technique.Using the energy storage capacity of the inductor and capacitor, the voltage is raised gradually in this method. The most significant flaw in this method is the loss of semiconductor components.

This research proposes a novel architecture for an EV charger that uses a non-isolated boost DC-DC converter. First, a thorough analysis of the converter's topology is conducted. The critical inductances are then computed in order to establish the device's working conditions, particularly when designing for DCM operation as described.The design considerations for selecting better switches are then carried out, and a comparison of relevant literature is offered. The theoretical principles are validated using Actual exams. A few closing comments are then made.

## LITERATURE REVIEW

Wang, et al. verify the effectiveness of an off-board charger, a power battery simulation system for electric vehicles that simulates various power battery packs has been developed. In order to simulate the charging response, the enhanced lightweight charging load is paired with the improved power battery model, and the online estimate of the state of charge as well as the electromotive force of the battery model are utilised to alter the charging load parameters in real time [1]. The classic battery model now includes an Acceleration coefficient to increase test effectiveness, and online settings for the battery's type, specification, temperature, and voltage may be made in Accordance with test requirements. The use of a mobile test vehicle's DC converter cascaded power battery pack to create a lightweight charging load with constant voltage, constant current, constant power, and constant resistance that can be continuously adjusted within the rated range is proposed as an improved charging load scheme. As a consequence, the charging load's size and weight are decreased, and the off-board charger's autonomous test is made possible. The numerous experimental findings serve to verify the suggested battery simulation system's performances.

Ehrlich et al. discussed off-board portable 11 kW charger for electric cars is suggested in this study. A three-phase power factor correction (PFC) in VIENNA topology is selected for the AC/DC stage. In terms of design, winding, and core material, the loss and volume of the PFC inductance are determined ACross a broad range of parameters [2]. For the galvanically separated DC/DC stage, a three-phase LLC resonant converter with a 1 MHz operating frequency is used. To reduce volume, weight, and losses, a parametrizable loss model of the high-frequency transformer and the resonance inductor is created. The inductive components are optimised in terms of winding specification, magnetic material, and core shape with the aid of an automated algorithm employing these loss models, and measurements and finite element analysis are used to confirm this. SiC devices with 900 V are utilised for the AC/DC stage, while Sic devices with 1200 V are used on the main and secondary sides of the DC/DC stage. To alter the charging profile and run the LLC resonant converter at its most effective setting close to the series resonance frequency, a variable DC-link voltage is used. A prototype portable air-cooled off-board charger with mechanical integration that has 11 kW, three-phase 400 VAC input, and 620–850 VDC output is created and put to the test. The prototype has a 2.3 kW/litter (37.7 W/in3) power density, a 96% peak efficiency, and a 95.8% efficiency Across the specified battery voltage range.

Al-Haddad et al. offers a comparison and classification of battery chargers for electric vehicles in a number of different categories. The research focuses on fast charging stations, which are off-board chargers. More specifically, it focuses on bidirectional AC/DC converters, which are a crucial component of the fast charging station [3]. The grid's needs and criteria must be met via AC/DC converters, which interact with the grid and DC/DC converters. Additionally, this research addresses the drawbacks of traditional two-level AC/DC converters and emphasises the need of switching to multilayer converters.

Reis et al. outlines a novel method for testing Nan satellite components within sounding rockets.

The process enables all stages of the rocket flight, including rocket liftoff, for the subsystems to preserve their telemetry data. In order to confirm their design and integration process, the subsystems of the FloripaSat (1U CubeSat) engineering model have been tested on board a VSB-30 rocket [4]. The electrical link between the rocket electronics and the Nan satellite subsystems has been suggested to be a specialised embedded system. On the ground station, a mechanism for processing telemetry data was also put in place. In addition to other features, the test technique verifies the definition of data frames, communication protocol specifications, and hardware integration specifications. Electrical Power Subsystem (EPS), Telemetry, Tracking and Command (TT&C), and On-Board Data Handling (OBDH) are the three FloripaSat subsystems that have undergone testing. The battery monitoring, inertial measurement unit, temperature readings, radio transceiver, and beacon operations of nan satellites have all been examined.

Sang et al. discussed that to manage battery packs and communicate with other systems that need information about charging status, the Battery Management System (BMS) is offered. It created and constructed a simulated BMS system that can connect with an off-board charger for electric vehicles (EVs) using the SAE J1939 protocol [5]. Based on related electrical data such battery type, charging method, nominal voltage, etc., the system could create several battery models. It was used in the protocol conformity testing to see if the off-board charger design complied with protocol requirements. The findings demonstrate that the method is effective and dependable and significantly increases the off-board charger's development and testing efficiency.

Joseph, et al. discussed that currently available hybrid electric vehicles (HEV) overcome the range restrictions of electric vehicles (EV) while still adhering to strict pollution standards[6]. The majority of commercial HEVs are built with a minimum six-hour stop-and-go interval to allow for regular maintenance and continuous battery charge. The rise of HEVs has made a small, inexpensive, and effective battery charger a necessity. Here, an effort has been made to create an offline charger and satisfy the aforementioned specifications for the installation of HEVs in three-wheeled vehicles. This is a portable off-board charger appropriate for lead ACid batteries, which are widely used in India to install HEVs. The 350W charger uses a digital controller and high frequency isolated power hardware to handle the constant current (CC), taper current (TC), constant voltage (CV), and equalising charging needs for lead Acid batteries. This offline charger, which charges a 60V, 60AH battery using a 25 kHz MOSFET-based soft switching full bridge converter with gating from a DSP & CPLD-based digital controller, was developed in Accordance with the requirements of Automotive India Standards (AIS), which are adhered to by the Automotive Research Association of India (ARAI).

## DISCUSSION

### Electric or hybrid car

Modular design allows for the creation of systems with a broad variety of I/O voltages and 1 to 3-phase AC power supplies. The on-board charger (OBC), a technology integrated into the automobile, uses the AC grid to replenish the high voltage battery while it is parked. By boosting the battery capacity and the energy efficiency of the electric components, plug-in hybrid (PHEV) and battery electric (BEV) cars are able to go further on a single charge. Since higher voltages facilitate quicker charging periods and permit lighter cabling within the car, the employed battery voltage classes tend to become standardised at around 450 V with a tendency towards higher voltages. As module-based solutions are being replaced by discrete high voltage components due to price pressure, these components are commonly employed for OBC (on-board charger) applications. The popularity of rapid charging has an effect on the power range required of OBC topologies as well; thus, new designs go towards 11 kW or even 22 kW. This evolution is a major force behind the use of three-phase systems, together with the need for high efficiency and power density at low system cost. Currently, power flows from the grid to the batteries are mainly unidirectional, but there are also bidirectional use cases, such as power flows from the battery to a load or from the battery to the grid.

### Off-board chargers

Off-board chargers, which provide a DC to the vehicle battery, must exchange information with the car in order to provide the right voltage and current to the battery. This is especially true with public charging stations' non-dedicated chargers, which should be able to power cars with various battery voltages and chemistries.This data link's communication protocol was supposed to follow part 24 of IEC 61851. The European prestandard ENV 50275-2-4, which the IEC standard would replace, was moved to Technical Specification 50457-2 in 2006, despite the fact that the IEC never published the document.

The proposed protocol is mostly based on ISO 14229 and ISO 14230, which establish the requirements for road vehicle diagnostics. These deal with specifications for serial data link-layer-based diagnostic systems, which enable testers to command diagnostic operations within and on top of vehicle electronic control units.The protocols were customised for the chosen application, and when the off-board charger completes its setup phase, the vehicle's charge management unit manages the off-board charger's charging cycle. In contrast to the ISO 14230 standard communication, where the responsibilities of the server and client are constant during the whole session, their roles are clearly reversed after the start up step.

### Systems for Off-Board Charging

Incoming AC power is transformed into the DC power required to charge the battery system via an off-board charging mechanism. "Off-board" charging systems are those that are not built into the Actual vehicle (such as public charging stations for cars). The off-board charger's capacity to fast recharge the vehicle is one of its key performance features. For instance, some contemporary fast chargers can recharge a 250-mile range in under 30 minutes[7]–[10].

### System Charging using SiC

The selection of a power semiconductor is a key consideration in contemporary charging system designs. Engineers have found that Silicon Carbide (SiC) enables these charging systems both on-board and off-board, to complete their tasks with less heat generation and reduced energy losses, while also requiring less physical space, in contrast to older technologies that make extensive use of Silicon (Si). These more compact, lighter Sic charging systems provide a greater driving range in less time and at a lower cost, making them economical and environmentally beneficial.

### Automotive Systems using Sic

For EV/HEV devices, extreme temperatures, vibrational loads, and shock loadings are to be anticipated. The Automotive Electronics Council certifies certain electronics, including Sic devices, as automotive AEC-Q101 approved because automotive electronic systems must be particularly robust and dependable. This indicates, in the words of the AEC, that "a device is capable of passing the specified stress tests and thus can be expected to give a certain level of quality and reliability in the application".

**Charge rates**

As demonstrated in Table 1, the charging power at different charge sites may vary by orders of magnitude, which affects how long it takes to charge a car. The fastest quick charging stations may charge at up to 350 kW, but a typical domestic outlet may only be able to charge at 1.2 kW. Based on speed, charging infrastructure may be roughly divided into three categories: Direct current (DC) rapid charging (also known as Level 3), Level 1, and Level 2 are all charging levels.

**Individual Charging**

Recharging the batteries of privately owned vehicles at home. The majority of home/domestic metering AC involves billing. The 230V/15A single phase plug, which can produce a maximum of up to 2.5KW of power, is often used with the home private chargers. The on-board charger of the car receives AC current from the EVSE, which the on-board charger then converts to DC so the battery may be charged.

**Public Fee-Riding**

Electricity use must be invoiced and money must be collected for charging beyond the home's boundaries. These chargers' power consumption may sometimes need to be regulated.Through the charge port, DC current is immediately sent to the battery of the electric vehicle. Typically, 50 KW or more, FC chargers may provide 100 or more km of range per hour of charging. The quick chargers are often used to top up vehicle energy rather than completely charge them. These are crucial for taxi services and businesses with an electric vehicle fleet.

**Choices for Charging EVs**

To encourage the use of EVs, it is vital to provide adaptable charging infrastructure for various car segments. The most important enabler in the whole EV value chain is the infrastructure for charging. Faster adoption of electric car technology throughout the nation will be made possible by the investigation of various charging models in Accordance with local circumstances. According to widely Accepted projections, by the year 2020, 15% of all automobiles in the nation will be electric vehicles. Therefore, it will be considered that the Metropolitan and "Tier I" cities have a greater percentage share of EVslet's say 20% for nowwhile assuming percentage composition of all planned capacities' in public facilities of car holding capacity.All urban planning guidelines must, therefore, align their recommendations for charging infrastructure with the aforementioned proportion.

**Certain design issues**

It's critical to reduce an EV's weight as much as possible since it has a significant impact on performance. Although employing a single-phase AC supply for all charging would be the lightest design, using the three-phase grid was thought to provide benefits that outweighed the "weight issue." Since inductors are heavy, one method of lowering weight is to try to minimize the size of the inductors. The Acceleration, ability to climb hills, speed, and range of an electric vehicle are all impacted by its weight. Each time, the performance suffers. But it's also critical to make sure there is strong stability. The weight distribution is also a crucial factor. This is something to keep in mind, but it's not directly related to this project since the limits are mostly set by the vehicle's design. Additionally, it makes sense to utilize as little voltage as feasible. For instance, it will be better to utilize the lowest voltage feasible even when the nominal DC-link voltage has not been established in the early phases of design.

## CONCLUSION

In this book chapter we discuss about the off-board charger specification. Long-term changes in the EV charging station market are problematic to anticipate for a variety of factors, including the lack of standards and continual improvements. The last part of this study shows potential GA-based predicting and estimation. According to the research, an electric vehicle's battery should have a capacity of around 60 kWh, the on-board charger should be rated at 14 kW, and the off-board fast charger should be rated at 170 kW. In order to drastically decrease the weight and volume of chargers, wide band gap silicon carbide (SiC) devices are projected to replace silicon switching components.

## BIBLIOGRAPHY:

[1] X. Yan, L. Wang, Z. Chai, S. Zhao, Z. Liu, and X. Sun, "Electric vehicle battery simulation system for mobile field test of off-board charger," *Energies*, 2019, doi: 10.3390/en12153025.

[2] S. Ditze *et al.*, "A High-Efficiency High-Power-Density SiC-Based Portable Charger for Electric Vehicles," *Electron.*, 2021, doi: 10.3390/electronics11121818.

[3] S. Atanalian, K. Al-Haddad, R. Zgheib, and H. Y. Kanaan, "A Review on Electric Vehicles Battery Chargers and AC/DC Converters for Fast Charging Stations," in *2021 IEEE 3rd International Multidisciplinary Conference on Engineering Technology, IMCET 2021*, 2021. doi: 10.1109/IMCET53404.2021.9665577.

[4] L. K. Slongo *et al.*, "Pre-flight qualification test procedure for nanosatellites using sounding rockets," *Acta Astronaut.*, 2019, doi: 10.1016/j.actaastro.2019.01.035.

[5] X. Li, L. Sang, J. Ye, and X. Zhang, "A simulated system of battery management system based on SAE j1939 protocol," in *Advanced Materials Research*, 2013. doi: 10.4028/www.scientific.net/AMR.608-609.1001.

[6] V. Chandrasekar, S. C. Joseph, R. V. Chacko, and Z. V. Lakaparampil, "Design and implementation of a digital automatic high frequency battery charger for HEV application," in *2012 IEEE International Electric Vehicle Conference, IEVC 2012*, 2012. doi: 10.1109/IEVC.2012.6183260.

[7] SAE International, "Communication Between Plug-In Vehicles and Off-Board DC Chargers J2847/2_201504," *https://www.sae.org/standards/content/j2847/2_201504*, 2015.

[8] J. H. Lee *et al.*, "Design and implementation of a control system for the interleaved boost PFC converter in on-board battery chargers," *Trans. Korean Inst. Electr. Eng.*, 2016, doi: 10.5370/KIEE.2016.65.5.843.

[9] R. A. Scholer *et al.*, "Communication requirements for plug-in electric vehicles," in *SAE 2011 World Congress and Exhibition*, 2011. doi: 10.4271/2011-01-0866.

[10] R. A. Scholer, A. Maitra, E. Ornelas, M. Bourton, and J. Salazar, "Communication between plug-in vehicles and the utility grid," in *SAE Technical Papers*, 2010. doi: 10.4271/2010-01-0837.

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# COMMUNICATION BETWEEN AC CHARGER AND EV

**Dr.Shilpa Mehta***

*Professor,
Department of Electronics & Communication (Communication System Engineering),
Presidency University, Bangalore, INDIA
Email Id-shilpamehta@presidencyuniversity.in

## ABSTRACT:

*The most popular words and standards in the EV charging field are described in this chapter. It provides a summary of the various EV charging kinds, EV charging levels, EV charging modes, EV charging connector types, and associated communication protocols. All EV followers and young engineers beginning a new career in the EV market may find this material to be helpful the purpose of this document's content is to spread general information and encourage e-mobility. It shouldn't be seen as a technical standard or a regulatory necessity. The regulations and standards in the realm of e-mobility are subject to periodic updates. For your growth, please refer to the most recent applicable rules. Manufacturer names and brands that are shown in the numbers are not being used for advertising or marketing. In this book chapter we discuss the protocol communication or OCPP,OCPP use charging stations, Characterization of Signal Level Attenuation (SLAC), public protocol, OSCP, OCPI etc.*

**KEYWORDS:** *Ac Charging, Charging Station, Dc Charging, Electrical Car, Open Charge.*

## INTRODUCTION

A significant portion of the transportation industry is anticipated to be replaced by electric vehicles (EVs), such as battery electric cars or plug-in hybrid electric vehicles. As a consequence, there is a rising need for Charging Stations, commonly referred to as Electric Vehicle Supply Equipment (EVSE). Different EV models should be able to charge with the help of an EVSE. Furthermore, various EVs may demand different charging conditions in terms of power, duration, AC/DC charging, etc. A number of standards have been developed to govern the requirements for the EV-EVSE interface and the charging process.

One of the first standards created to govern the EV-EVSE interface is DIN 70121. It was lacking certain features, nevertheless, such Transport Layer Security. Later, further standards were created based on DIN 70121, such as ISO 15118 and SAE standards, to control the criteria for secure charging in an EV-EVSE interface. While ISO 15118 is the accepted standard in Europe, SAE standards are more popular in North America. The Power-Line Communication (PLC) physical layer has been accepted by both SAE J2847-2 and ISO 15118-2 for communications between EV and EVSE, although there are some discrepancies in the data link levels of these two protocols[1]–[3].

The EV must have an integrated rectifier for AC charging. When using AC charging, an EV and EVSE communicate with each other through a PWM signal sent over the Control Pilot signal. However, there are certain advantages to DC charging versus AC charging. The integrated rectifier is no longer required for DC charging. In addition, compared to AC charging, substantially more electrical power may be delivered in a single DC charging session, shortening the duration of the charging session. However, a more sophisticated communication protocol than PWM communication is required owing to the intricacy of a DC charging session and billing requirements.

The EV-EVSE interface's Pilot and Proximity signals call for a common handshaking protocol. In order to start or stop the flow of electric energy to the EV, digital communication may also occur between the EV and EVSE. The PLC protocol described in the Home Plug Green PHY standards is used for this communication through the Control Pilot signal. PLC is necessary for DC charging but is optional for AC charging. The Home Plug Green PHY specification for PLC has been approved by SAE and ISO 15118, and both organizations have created a number of standards to control the digital communication in an EV-EVSE interface. These standards are supported by and compatible with Home Plug Green PHY requirements by Dana's Open ECU M560 and M580 controllers. The Qualcomm Power line Communication (PLC) chipset, which supports digital communication between the EV and EVSE through the Control Pilot signal, is installed in the M560 and M580 in order to accomplish this purpose. Additionally, the Open ECU development tool chain provides a library of supporting Simulink blocks based on SAE J2847-2 and ISO 15118-2 to handle PLC communication in the Simulink environment.

The Open ECU M560 and M580 are ECUs designed for sophisticated hybrid and electric vehicle applications, including battery management systems or supervisory controllers. The onboard charger controller normally manages the EVSE interface during AC charging. However, the car does not need to be equipped with an onboard charger (rectifier) for DC charging. Another ECU in the car, such the supervisory controller, is tasked with controlling the EVSE interface and the charging session. According to SAE and ISO 15118 standards, M560 and M580 are intended to be compliant with DC charging needs.

Once an EV is linked to the EVSE, an association protocol designates that EVSE to the EV, in accordance with Home Plug Green PHY PEV-EVS. The SLAC Association on Pilot signal manages this operation in accordance with SAE J2931-4 (or ISO 15118) and Green PHY PEV-EVS. The platform (base) software of Open ECU M560/M580 manages the SLAC protocol for SAE J2931-4. But in order to comply with ISO 15118, the SLAC protocol must be implemented in application software utilizing the Simulink blocks made available by the Open ECU platform software.

The most popular protocol for initiating communication and setting charging session settings for the EV-EVSE interface is currently SAE J1772 in North America, whereas ISO 15118 is the leading standard in Europe. Following the association of an EVSE with an EV via the SLAC protocol, both standards need certain consecutive steps to be carried out using PLC connection in order to configure the charging settings and manage the energy flow to the EV.

**Protocol communication or OCPP**

Open Charge Point Protocol is referred to as OCPP. This protocol is totally free and independent of the tools used. The server software and the electric car chargers can communicate thanks to OCPP. It communicates with the server by sending start/stop data, charging session status, and firmware update notifications.This information should ideally be delivered without the use of any extra hardware, such as converters or cable extensions for EV charging. An electric vehicle's wireless induction charging operates on a similar data exchange premise.

### OCPP use charging stations

Any network may be used with any charging station using OCPP. Owners of public charging stations will find it to be more important than finest NEMA 14-50 residential EV chargers. Before the introduction of this protocol, owners of electric charging networks had to entirely replace their equipment whenever it became necessary to switch the network provider.

### OCPP 1.6 and 2.0.1 protocols

The protocol that is most often used is OCPP version 1.6. It offers intelligent charging, allows power level limitations to be set, and allows time limits to be set for certain stations. It offers up-to-date data on how well the charging stations are working. Additionally, it controls billing status, handles payments, and quickly finds errors.Additionally offered for stations that utilise the OCPP protocol is load balancing. It enables the charging stations and other electrical devices to share the available power in an equitable manner. Thus, during rush hour, the grid is not overwhelmed. By the way, using the EV charging time calculator to estimate waiting times and costs is simple if you know the grid power.All of the features mentioned above and many more may be found in OCPP version 2.0.1. For instance, greater security, Plug and Charge capabilities, and improved transaction processing.

The owner of the electric vehicle is recognised by the station.The procedure of charging an electric vehicle is made easier with Plug and Charge. Owners of cars may now present an RFID tag using a mobile app instead of using a credit card. Simply plugging their automobile onto the charging station is all that is required. The charger and the automobile are where all access and billing transactions take place. No details about the electric vehicle or its owner are disclosed to other parties. The ISO 15118 standard, which enables the electric vehicle to be automatically recognised and authorised on behalf of the owner, ensures the security of this procedure. Tesla charging stations follow the same guiding idea. Even the usage of a J1772 to Tesla adaptor has no impact on how the electric vehicle is recognised while charging.With the OCPP protocol, you can be confident that your chargers have the greatest control system and that your equipment will be up to date for many years to come. The OCPP is less common in the United States than it is in Europe, despite a centre that was formed in 2013 with the goal of harmonising electric transportation. Its American name is the Centre for Electric Vehicle and Smart Grid Interoperability.

### Procedures for exchanging data

You may switch hardware and software providers using the Open Point of Presence Protocol (OCPP) without losing the specification. It is as simple as switching out your iPhone's SIM card. The purpose of OCPP is to provide a framework for electric vehicle charging that is genuinely interoperable, adaptable, and simple to use for both electric car drivers and system operators. Customers may include charging stations from several manufacturers into a common internal IT infrastructure using OCPP. Additionally, they are free to choose the best server IT service provider as well as the best charging station vendor(s). The Open Charge Alliance created the OCPP, which has grown to be a widely recognised agreement and a genuine standard for more than 50 nations and over 10,000 charging stations. The OCPP is open and free of licence fees or constraints, which makes it simple to access in contrast to restricted matching agreements. OCPP consistency is becoming into a "absolute necessity" for speculators thanks to assistance from several charging station suppliers and significant platform providers[4]–[6].

Another sort of agreement, known as OSCP (Open Smart Charging Protocol), has been created by the Open Charge Alliance. The charging station operator may get a 24-hour prediction of local capacity through this contract. Within the permitted limit, the service provider will modify the charging profiles for electric cars. This is a communication protocol between the energy management system of the property owner and the charging station management system.

### Infrastructure for charging

The electric car, the charging station, and the charging station management system (CSMS) often make up the charging infrastructure. An electric car may be charged within a physical building known as a charging station. There must be at least one electric vehicle supply equipment (EVSE) at the charging station. The EVSE is part of the controlled charging station that may at any moment transmit viability to an electric car and is thought to run independently. The battery may be charged at the proper pace to maintain the SOH of the battery thanks to communication between the EVSE and the battery management system (BMS) of the electric car. Power Line Communication (PLC) or controller area network, which are both extensively utilised by Indian automakers, might be the physical layer of this compliance. The connection requirements for electric cars vary per nation.

### Load station's setup

The OCPP 2.0 initialization function block should be used to carry out the loading, configuring, and reset of the load station functions. The functions that enable the CSO to manage the load stations, check certificates, and get the configuration information for these load stations via the system are all described in this functional block. It also has a feature for changing the loading system's setup. Cold Load Station, Cold Load Station- Standby, Cold Load Station- Reject, Standby Standalone Load Station, Configure Variables, and Accept Variables are the function blocks. "Reset - without current transaction" and "Reset with current transaction" are the use cases for the fundamental execution of OCPP 2.0. Use cases for transactions are required.

### Options for authorization

The OCPP 2.0 authorisation function block includes this function. The processing of Authorize Request messages, various forms of user authorisation (online or offline), and the authorisation Cache function are all included in this feature block. The charging station must confirm that the user is the one who started the charge or that he is a part of the same group and therefore qualified to stop the charging when a user wishes to unplug an EV from the charging station. The authorised charging station must notify the CSMS that charging has been halted. There are 16 use cases for this function block, one of which must be used for the fundamental application: the RFID, start button, or PIN identification of the driver of an electric car.

### Mechanism for transactions

The OCPP 2.0 Transaction Function Block, which lists the operations connected to OCPP transactions, contains this function. Only one active transaction may be in progress at any one moment on the EVSE, and transactions can be started or stopped at the loading station. This function block has 15 potential applications. Transaction start is when the cable is initially attached, according to the transaction start parameter. Initial transaction ID at transaction start beginning of transaction - when no ID is obtained, parameter for transaction suspension, Using ID Token, transactions are suspended locally. When the charging station is down, transactions are suspended. If the cable is cut on the EV side, the transaction will be halted. If the cable is cut during the transaction, the transaction will be stopped locally using the ID Token, and the transaction will be stopped if the charging station is offline. The core technologies must notify to CSMS any transactions that are offline and any communications pertaining to a transaction that CSMS has rejected.

### Availability

The availability feature block in OCPP 2.0 is referred to by this feature. It demonstrates how the charging station notifies the CSMS of the present availability to start a new exchange. It is critical for the CSO to be aware of whether the charging station is open to charge EVs and to advise EV drivers of this availability. CSMS must receive updates from charging stations on their status and EVSE adjustments.If EV drivers run into issues when charging, this transaction status is quite helpful. The CSO may modify the availability at the precise time when the charging station is required in order to avoid restarting the exchange. As soon as the charging station acknowledges the authorised person, the authorised person can make a particular notice and notify the CSMS of the failure. For instance, the requirement for maintenance prevents the usage of the charging station, and the CSO may alter the availability of at least one EVSE. As an example, suppose the client calls to report a malfunctioning EVSE.

## DISCUSSION

When charging issues arise for electric car owners, this transaction status is quite helpful. Once the authorised person has been identified by the charging station, he or she may send a particular notice and notify the CSMS of the fault; the CSMS can then adjust the charging station's availability at the appropriate moment to prevent having to initiate another exchange. For instance, if a charging station requires maintenance, it may not be necessary to use it. The CSO could also alter the availability of at least one EVSE. For instance, the CSO may prevent an EV rider from using an EVSE at a charging station if a customer phones to report that it is faulty. Similarly, it is evident that outlets and charging stations might be made accessible once again if the CSMS directs.

### Transmission of transaction-related counter

The measuring function block of OCPP 2.0 has this function. The function described allows the charging station to regularly deliver counter values (perhaps in synchrony with the clock). Depending on the objective, a variety of transaction-related measurement data may be captured and communicated in various ways. The transfer of transaction-related counter values is one of three use cases for this function block and a MUST use case for the execution of the OCPP 2.0 basic protocol[7]–[9].

### Characterization of Signal Level Attenuation (SLAC)

A broadcast message is first sent by the car, and any EVSE that received it (cross-talk) calculates the signal strength and transmits it back to the vehicle. Then, by measuring attenuation, SLAC confirms that the vehicle and EVSE are physically linked; the EVSE with the strongest received signal is considered to be the proper EVSE. The unique identifying characteristic that must be present in all future messages of the same SLAC session is agreed upon by the vehicle and charging station. The fundamental software elements of AUTOSAR support the SLAC protocol.Power Line connectivity (PLC) uses IP-based protocols for EVSE and EV connectivity. This is accomplished using PLC technology and a specific physical connection (CP, PE). The data stream is modulated onto the PWM signal in this system. In the world of consumer goods, it is better known as home plug AV and IP-overpower line. A Transmission Control Protocol/Internet Protocol (TCP/IP) stack is utilised for communication in the vehicle's charge control module.

**Public protocols**

In the electric vehicle (EV) business, protocols are a collection of rules and principles that guarantee efficient communication and data sharing between different organisations. These are useful tools for encouraging the use of electric vehicles, lowering operating costs, and creating scalable, future-proof infrastructure. They also provide broad interchange with industry stakeholder systems.

**OCPP**

The Open Charge Point Protocol (OCPP) is a universally accepted standard for back-end systems of charge station operators to communicate with charging stations. With the use of this protocol, information may be exchanged between EVs and the power grid as well as data related to charging.

**OSCP**

An open communication protocol between a charge station management system and an energy management system is called OSCP (Open Smart Charging Protocol). This protocol provides a 24-hour prediction of an energy grid's usable capacity.The Open Charge Alliance (OCA), a global group of leaders in EV infrastructure that promotes open standards in EV charging infrastructure, is responsible for maintaining both OCPP and OSCP.

**OCPI**

An open protocol called OCPI (Open Charge Point Interface) is used for communications between service providers and operators of charging stations. Simply explained, this protocol makes it easier for EV drivers to automatically roam between different EV charging networks. This interface enables cars to charge on many networks, supporting the accessibility and cost of charging infrastructure for EV owners. In addition to taking into consideration real-time invoicing and mobile access to charge stations, the protocol gives precise information about charge station location, accessibility, and price.

**Equipment for charging electric vehicles (EVSE)**

Electric Vehicle Supply Equipment (EVSE) is the aggregate name for the components that make up an electric vehicle charging station. The more often used phrase only refers to the charging stations. ECS, which stands for electric charging station, is another name for it that some people use.A battery pack may be found in an electric vehicle (EV) or a plug-in electric vehicle (PEV) and is charged using the grid by an EVSE, which is developed and constructed for this purpose. These EVSE's power, connection, and protocol will differ depending on their design, which we'll cover in this post.

**Charging stations and On-Board Chargers**

Understanding what is inside the EV and to which component the charger will be linked is crucial before using charging stations. The majority of EVs on the market now include an On-Board charger (OBC), and the manufacturer also includes a charge. When the client reaches home, he or she may use these chargers in addition to the on-board charger to charge the EV from the power outlet in their home. But since these chargers are so basic and lack sophisticated capabilities, it often takes 8 hours to fully charge an average EV.

### EVSE (EV Charging Station Equipment) Types

The two main categories of charging stations are AC charging stations and DC charging stations. As the name suggests, an AC charging station delivers grid-supplied AC power to the EV, which is subsequently charged using the on-board charger after being converted to DC. These chargers, which are used in both residential and business settings, are also known as Level 1 and Level 2 Chargers. The benefit of an AC charging station is that the on-board charger will manage the voltage and current as necessary for the EV, therefore communication with the EV is not necessary. Its low output power lengthens the charging period, which is a drawback. In the image below, a typical AC charging setup is seen. As we can see, the EVSE supplies the OBC with AC straight from the grid, which the OBC then converts to DC and uses to charge the battery through the BMS. The Pilot wire is used to determine the OBC's necessary input current based on the kind of charger connected to the EV.

### The EVSE's pilot wire communication (AC charger)

The needed input current, or charging rate, for AC chargers is really chosen by the EV itself. Not The amount of input charging current needed by all EVs is the same, hence the AC Charger must interact with the EV to find out this information and engage in a handshake before the charging process can start. This communication is known as the Pilot wire communication.The J1772 cable, which has two connections on the charger other than power lines, is often used with AC chargers. Through +/-12V PWM signals, these two signal lines enable communication between the charger and the EV. By default, the signal pins on the EVSE output +12V; however, when connected to an EV, this voltage is decreased to 9V due to a load resistor built into the EV; this informs the EVSE that the connector has been inserted into an EV. The EVSE will then transmit a PWM signal with a magnitude of 12V and a duty cycle value equal to the maximum current it is capable of delivering. When the PWM voltage is reduced to 6V and the load resistance is changed, the charging process starts if the EV is alright with that amount of current.

### Level 3 chargers at EVSE DC Charging Stations

Since the DC/DC conversion for the battery pack must be completed by the EVSE itself, level three charging stations are more complicated than level 1 and level 2. In order to securely charge the battery pack because a DC EVSE bypasses the on-board charger, a CAN or PLC (Power Line Communication) should be created between the EVSE and the BMS of the vehicle. Other connections, such the J1772 Combined Charging Connector and Tesla Connector, are also being adapted by other manufacturers. These chargers can supply up to 200A straight to your battery pack to charge the EV in less than 30 minutes. Level 3 chargers typically utilise the CHAdeMO charger socket.

### Improvements to EVSE

A small number of individuals have argued that electric vehicles (EVs) are not entirely green if they are fuelled by electricity produced by non-renewable power plants like coal, nuclear, etc. It's a good thing that solar-powered EVSEs are starting to gain traction. EVs cannot be powered directly by solar energy due to the size, efficiency, and weight of solar panels. On the other side, an EVSE may use a solar panel to generate electricity instead of the grid. The drawbacks include a high initial cost and low efficiency since solar energy must first be stored in batteries before being transmitted once again to electric vehicles (EVs). Additionally, solar panels' efficiency is quite low (the highest recorded value is 44.5%), and new technology is still needed to make them an economical upgrade.

The Vehicle to Grid (V2G) system is a further noteworthy development. In such case, a home's appliances may be powered by an EV's battery pack. The massive battery packs used in today's EVs, which may be up to 100 kWh or more, make them portable powerhouses. Therefore, the electricity from these battery packs may be delivered to the grid during times of high demand with the appropriate converter. Then, to recharge again, these EVs may be driven to solar-powered charging stations, creating an entirely green eco system[10].

### Establishing a charging station for electric vehicles in India

We have already seen a significant increase in the number of EVSE setups in India's main cities as EVs become more and more popular there. These are the typical issues with installing an EVSE in India, where laws are still being standardised.

### Low Charge Rate for Indian EVs

Due to their inability to enable rapid charging, Indian EVs are currently unable to use Level 3 or Super chargers. The C rating of a battery determines how quickly it can charge, and most Indian EVs currently have relatively low C ratings, therefore a Level 2 charger is not necessary. Due to this, demand for public EVSE will decline.

### Problem with power resale

By law, you are not permitted to sell electricity directly. Selling power is only permitted via the DISCOM. The charging stations, however, might be seen as a future expectation due to pressure from ISGF.

### Weak Distribution Transformers

The majority of DTs in India are already loaded to capacity. An EVSE will need a lot of electricity from the grid, which is a serious issue. Therefore, it is necessary to replace the whole DT in that region with ones with better ratings. This will become a significant issue when more EVSE start to appear in the city. You may get more information on establishing an EV charging station in India by reading this ISGF whitepaper.

## CONCLUSION

Li-ion batteries have a wide range of charging capacity are available, which may make the design and management of the charger more or less complex. The straightest forward charging technique is the normal one since it doesn't need model information to charge the battery. They may also be implemented using relatively simple circuits, which keeps the cost of the charger to a minimal. However, the electrochemical model-based charging techniques are more accurate since they account for the internal dynamics of the battery as well as the battery's ageing and other limitations.

## BIBLIOGRAPHY:

[1] S. Kumar, A. Usman, and B. S. Rajpurohit, “Battery charging topology, infrastructure, and standards for electric vehicle applications: A comprehensive review,” *IET Energy Systems Integration*. 2021. doi: 10.1049/esi2.12038.

[2] V. Monteiro, J. C. Ferreira, A. A. Nogueiras Melendez, C. Couto, and J. L. Afonso, “Experimental Validation of a Novel Architecture Based on a Dual-Stage Converter for Off-Board Fast Battery Chargers of Electric Vehicles,” *IEEE Trans. Veh. Technol.*, 2018, doi: 10.1109/TVT.2017.2755545.

[3] U. R. Prasanna, A. K. Singh, and K. Rajashekara, “Novel Bidirectional Single-phase Single-Stage Isolated AC-DC Converter with PFC for Charging of Electric Vehicles,” *IEEE Trans. Transp. Electrif.*, 2017, doi: 10.1109/TTE.2017.2691327.

[4] S. Wang *et al.*, “Multifunction capability of SiC bidirectional portable chargers for electric vehicles,” *IEEE J. Emerg. Sel. Top. Power Electron.*, 2021, doi: 10.1109/JESTPE.2021.3052841.

[5] D. M. Chandwadkar, A. G. Maniyar, and S. P. Ugale, “Design of 2kw DC charger for two wheelers,” *Int. J. Innov. Technol. Explor. Eng.*, 2019, doi: 10.35940/ijitee.I8960.0881019.

[6] I. Marková, M. Oravec, L. Makovickáosvaldová, E. Sventeková, and D. Jurč, “Magnetic fields of devices during electric vehicle charging: A slovak case study,” *Symmetry (Basel).*, 2021, doi: 10.3390/sym13111979.

[7] S. S. Williamson, A. K. Rathore, and F. Musavi, “Industrial Electronics for Electric Transportation: Current State-of-the-Art and Future Challenges,” *IEEE Trans. Ind. Electron.*, 2015, doi: 10.1109/TIE.2015.2409052.

[8] K. M. Tan, V. K. Ramachandaramurthy, J. Y. Yong, and M. Tariq, “Experimental verification of a flexible vehicle-to-grid charger for power grid load variance reduction,” *Energy*, 2021, doi: 10.1016/j.energy.2021.120560.

[9] R. H. Ashique, Z. Salam, M. J. Bin Abdul Aziz, and A. R. Bhatti, “Integrated photovoltaic-grid dc fast charging system for electric vehicle: A review of the architecture and control,” *Renewable and Sustainable Energy Reviews*. 2017. doi: 10.1016/j.rser.2016.11.245.

[10] S. Pirouzi *et al.*, “Power Conditioning of Distribution Networks via Single-Phase Electric Vehicles Equipped,” *IEEE Syst. J.*, 2019, doi: 10.1109/JSYST.2019.2896408.

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# DIMENSION SELECTION OF CHARGER CONNECTOR CABLE

**Mrs.Kamireddi Sunandana***

*Assistant Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-sunandanak@presidencyuniversity.in

## ABSTRACT:

*A charging connection included inside a charging cable may be connected to a vehicle inlet. The charging connector has a lock button to secure it to the charging inlet; a limit switch that can be switched between two states, the first of which connects the control pilot wire and ground wire to each other and the second of which connects the cable connection signal wire and ground wire to each other; and a lighting device that can be driven in accordance with the operation of the limit switch. In this book chapter we discuss about the longer cable and shorter cable, EV charging cord be extended, The best cable for EV charging, element of cable production, rated power/phase are discussed in details.*

**KEYWORDS:** *Cable Type, Charging Cable, Ev Charging, Electrical Vehicle.*

## INTRODUCTION

The most important component of an electric car is a charging connection. Every new electric vehicle often comes with two different charging cords. These cables come in useful at public charging stations; one is designed particularly for a three-pin socket. If the maker of your car does not somehow provide both cables, you may want to think about getting the one that is missing on your own. Unfortunately, the majority of individuals have no real information about this kind of cable.There is no denying the superiority of electric automobiles. However, making the transition from conventional fossil fuel-powered automobiles to electric ones is a significant step. To choose the best EV charging cable for your electric vehicle, you must first be aware of the many varieties available. Additionally, bear in mind that not just any cable may be used at the different electric car charging stations. When searching for a charging cable for your car, keep these three essential aspects in mind[1].

When you purchase an EV, you are switching from gasoline to electricity, but there are other considerations, such as charging the vehicle. What kind of wire, for instance, is required for an EV charger these little nuances matter much, particularly when it comes to where to put chargers in the driveway or garage but don't worry This article covers all the essential information on EV charger cable lengths, including the advantages and disadvantages of longer and shorter choices. The fuel for your electric vehicle is provided by the charger, which is connected to the automobile via a wire. Three components make up an EV cable a socket for plugging into an EV charger, a wire, and a connection for your automobile. When choosing the finest EV home charger for your garage, the cable length is a crucial factor.

### Charger connection

You must first think about where you'll connect an EV charger in before choosing the optimal cable size. Charging stations and universal wall outlets are two distinct kinds of charging cords. Your best option is a Type 2 charger for the house if you don't have access to a charging station (often located on residential streets, supermarkets, and shopping malls). In both the UK and Europe, it serves as the industry standard for EV charging plugs.

### A plug-in station

Anyone utilising a charging station to charge their automobile on the street should think about how far their car is from the station. The cable shouldn't be too lengthy on a public roadway since it might be dangerous. However, it must still be long enough for you to safely drive from your vehicle to the charging station.

### Cable size do I need for an EV charger

The majority of EV cable lengths range from four to 10 metres. No matter where the charger is, distances must be able to stretch from your automobile to it. A 7.5-meter cable is often seen to be the ideal length since it is neither too long nor too short. Storage should also be taken into account since a longer connection needs more room[2].

### Long cables

Flexible EV charging is made possible with a lengthy cable. It makes no difference where the car is parked or if the charging port is facing the charger. Longer charging cables are better for driveways and might be useful if you need to extend the charger for access[3].

### Shorter cables

Shorter wires are easier to handle and take up less room than longer ones. A shorter cable should work perfectly for EV owners who overnight park in tiny garages with close proximity between the wall socket and the vehicle socket. Shorter charging wires also reduce safety risks since there is less chance of someone falling over the loose cables.

### Cable length impact on charging efficiency

According to certain ideas, a cable's length might impact how quickly a device charges: the longer the connection, the longer it takes to charge. However, this isn't really the case. More resistance exists between longer and shorter cables. However, the length of a contemporary EV charging cable won't affect charging times, at least not in a way that makes a difference that can be felt. But there might be some variations in terms of gauge and quality. As long as the cable is of high quality, the charging time decreases with wire thickness. This is due to the fact that a wire with a larger gauge has less resistance and allows the current to pass through it temporarily. As a consequence, charging time is reduced.

### EV charging cord extended

Maybe you have purchased an EV charging cable but then realised you need a longer one to satisfy your requirements. A new cable might be pricey, so it makes sense if you don't want to spend extra money on one. Fortunately, you can use a second charging cable to extend your present EV cord. Because extension cords come in a variety of lengths and characteristics, you may choose the one that best suits your requirements. All EV cables, including three-pin and tethered cables, are extensible[4].

### Tethered vs untethered differences

You may be debating between a tethered and an untethered charger in addition to the length. The most common chargers are those that are tethered to the power box so you may charge your car and wind it up afterward. To prevent damage, you must constantly wound the cable up and store it.You'll need to attach your own cord to an untethered charger. Untethered wires are a basic characteristic of most EVs. When using an untethered cable, you must plug it in at both ends and attach it to the wall box each time. The majority of untethered chargers have longer length options than tethered ones[5].

## Best Cable for EV Charging

When it comes to charging wires, there is no universal size. The appropriate size is determined by your unique electrical setup and the on-board charger capacity of your car. Most electric cars' voltage requirements fall within the range of 32 amps with a 240-volt charger's capability.It would be advisable to agree on a 32-ampere cable if your vehicle's requirements fall within this range. In most cases, a 4 mm EV charging cable can handle 32 amperes over a short distance of around 10 metres. A 6 mm cable, on the other hand, is ideal for long distances since it compensates for the voltage loss over a great distance.When selecting the proper cable size, it's crucial to take the kind of charger you use into account as well. According to the operational voltage requirements of the charger, EV charging cable types may be divided into two groups. An overview of each of these categories is provided below;

## Level 1 Using AC Power

You can connect into a typical wall charging port and use 120 volts with this form of charging. The majority of North America enjoys it. According to experts on electric vehicles, each hour the car is plugged in may increase the vehicle's travel range by three to eight kilometres.

## Level 2 AC Charging

Depending on the charging outlet and kind of vehicle, this cable's operating rate ranges from 7 to 19 kilowatts. If you travel more than sixty kilometres each day, you should think about purchasing it. It uses 240 volts, or twice as much power as a level 1 charging panel. Depending on the kind of automobile and the charging station, an hour of charging might add 16 to 97 km.An additional level 2 portable cable is available, and it can function with both 120- and 240-volt systems. These cables are becoming more common in contemporary electric automobiles. Due to its growing popularity, the majority of EV charging cable producers provide this dual-functional cable. It basically comes with several "plaits" that make it easier to use in various sorts of outlets[6].

## Do EV Charging Cables Cost

You may have noticed that an EV charging cable is rather pricey if you own an electric vehicle. There are several varieties of charging cords available. Despite the fact that their costs vary, it is reasonable to assume that they are expensive, particularly when compared to the cost of electrical wire. Most individuals often ponder why charging cords cost more than other accessories[7].Well, copper is a material that is often used in manufacturing. It is reasonable to presume that the cables' high cost is due to the growing cost of copper. All charging cables, including EV charging cable type 1, are pricey for other reasons as well. These cable types' high price is of many things. Here are some common elements that drive up the price of charging cables.

## Element of Cable Production

When it comes to a car charging cable, the manufacture and testing procedures are quite intricate. Any business wishing to create the greatest EV charging cable must invest much in the manufacturing and testing processes. The expense of shaping different metallic resources needed for the cable testing step is borne by a reliable manufacturer[7]. Additionally, since electronic cars are a relatively recent development, producers must invest more money in the marketing phase. The costliest choice is the level 2 portable charging cable, which is now the most common cable type. This is largely because it has a number of extra features that were rather expensive to include[8].

Several particular design elements are used in the manufacturing process.Various EV charging cable kinds exist, each with a unique construction style. Manufacturers of charging cables must adhere to a number of design requirements, unlike those for electrical cables. Manufacturers must make sure the cables adhere to several electrical amps criteria in addition to the design work. In essence, a lot of resources are needed to make the ideal charging cable.To ensure safety, manufacturers must invest more.It costs a lot of money to develop and manufacture an EV charging cable that complies with all safety regulations. Throughout the production process, there are a number of factors that we must take into account. The following are a few of the most crucial elements that go towards the overall safety of the cable Despite copper's high cost, we choose it as the conductive material since it ensures maximum conductivity.

### Monitoring box

This device enables you to track and gauge the cable's current flow. We also use a smart cable design to prevent your house from catching on fire of the high voltage the cable carries.

### Universal EV Charging Cable

Are you thinking about switching to an electric car from a fossil-fuelled one because they are so fundamentally different from traditional automobiles, electric vehicles are becoming more and more popular but also present many obstacles if you have one, you've probably observed that it doesn't have an engine additionally, the method of filling it is entirely different. You must consider the EV charging cable specification and how well it matches your car model if you own an electric vehicle. Every owner of an electric car has sometimes struggled with the issue of charging wires being universal. Several electric automobiles are available on the market right now.

## DISCUSSION

The most well-known manufacturers of electric automobiles include, to mention a few, Audi, BMW, Tesla, Nissan, and Hyundai. These companies manufacture several automobile models that use various connection types. It is realistic to assume that EV charging cables are not available everywhere. For instance, a cable with a type 2 connection or CCS is required if your car is an Audi E-torn. Renault Zoe owners are restricted to using only type 2 EV charging cables. Having said that, type 2 cables work with the majority of modern electronic car models.

### Prevent Theft of the EV Charging Cable

Have you ever heard someone say that your charging cord cannot be stolen. My dear friends, it is a misconception that charging wires are theft-proof. The majority of EV charging cable makers are aware of the possibility of theft of this very pricey wire. They included a locking system that engages each time the charger is plugged into the car. Unfortunately, these locking systems are not always impenetrable. Recent research suggests that cable robbers mostly employ visceral force to cut the wire[9].

You must first realise that there are a number of factors that might lead someone to steal your EV charging cord. It's a great option for some folks to be paid quickly. This kind of cable has a sizable secondary market, in part because new ones are so pricey. Secure your cable as much as you can to prevent unforeseen costs in the event of theft. Well, there are a few different methods to safeguard your cable. Here are a few things to think about:

### Utilise a lock

There have been padlocks for many years. More significantly, they are incredibly affordable and effective. The majority of electric cars feature a loop where you may lock your cord with a padlock. You may wrap the wire through one of the wheel spokes if your automobile lacks a specific loop. Once you've done that, use the spoke as a loop to secure the padlock over the cable[10].Use the boot of your car as a locking mechanism.If you are using the longest EV charging cable available, this strategy will work best. Simply trap your cable through the locking mechanism of the boot to secure it. Your cable may be too short. You might think about purchasing a heavy-duty EV charging cable extension from reputable suppliers like ZW cables.

### Set up your vehicle on the cable

This is a risky choice since the car's weight might break the cable. Parking on the cable, though, is a good technique to secure it if you have no other choice. The cable must be laid out on the ground so that the automobile may roll over it. In order to reduce strain that might harm the cable, you must allow adequate slack[10].

### The Best EV Charging Cable Type

When selecting an EV charging cable, there is no room for mistake because of how costly they are. At first, you must choose the appropriate kind for your car. In general, there are three important factors to take into account while choosing the best cable. The cable connection types, power/phase ratings, and cable length are the important factors. Let's examine each of them in more detail.

### Plugs for EV Charging Cables

There are various prevalent connection types for charging cables. By just looking at it, you can quickly determine which one is right for your automobile. The majority of electric car models also have a manual that explains which connection is best for your car. Type 1, type 2, CCS, and CHAdeMO connectors are the two most used types. Fast chargers are compatible with Type 1 and Type 2 variations. Rapid chargers are intended for CCS and CHAdeMO. The majority of vintage electric car models use an EV charging cable type 1. A type 2 EV charging cable is used by modern electric car models. However, to utilise this cable type, you need a wall box that consumes between 7 and 22 kilowatts.

### Rated Power/Phase

It is essential to choose a charging cable with a voltage rating that can quickly charge the battery in your car. Charger cables often come in 16-ampere and 32-ampere versions. Even if the on-board battery in your car only has a 16-ampere rating, it is still a good idea to get a 32 ampere. In general, a 16-amp cable is less thick than a 32-amp cable. You can distinguish between the two kinds of cables with this.

Select the best EV charging cable quality available.Not every EV charging cord is the same. Cables of various grade levels vary significantly in a number of ways. Higher-quality cables are more resilient, constructed with superior materials, and protected against stresses associated with regular usage.Additionally, high-quality cables are better adapted to harsh environments. Many cable owners have probably experienced that as the temperature lowers, the cable is rigid and difficult to handle. The design of higher-end cables keeps them flexible even in extreme cold, making them simpler to use and store.Another typical issue that may eventually lead to corrosion and a bad connection is water getting on the terminals and into the vehicle intake. Choosing a cable with a cap that doesn't gather water and dirt while the cable is in use may assist to alleviate this problem. High-end cables often have a stronger grip and a more ergonomic design. Usability is something to take into account for something you could use every day.

### Select recyclable

Even the most resilient charging cable eventually has to be replaced. Every component should then be completely recycled. Unfortunately, the majority of EV charging cable plugs use a technique called potting, which involves coating the inside of the plug with a plastic, rubber, or resin compound, to protect them from water and impacts. It is virtually hard to subsequently separate and recycle the constituent parts because of these chemicals. Fortunately, there are recyclable materials that may be totally recycled after use and cables that are created without potting.

### Pick the appropriate accessories.

An EV charging wire may be challenging to store and move properly without a bracket, strap or bag. The ability to coil and hang the wire up at home will help you keep it out of the way and safeguard it from water, dirt, and being accidentally driven over. A bag that may be fastened in the trunk of the vehicle aids in keeping the cable tucked away and immobile while the vehicle is being driven.

### Electricity insulation

Low voltage cables, which often range in voltage from 0 to 60 V, and high voltage cables, which typically range in voltage from 60 V and up to 600, 800, or as high as 1500 V in the e-mobility industry, may generally be classified into two voltage groups.Safety is the main justification for this discrepancy. Although the lethality of any wire or cable may be exacerbated by variables like the person's health, the amount of current flowing through the conductor, or whether it is a DC connection rather than an AC supply, anything more than 60 V is often regarded as being fatal when it comes in touch with humans.

To make this risk visible to the owner of the vehicle, technicians, and safety responders at collision scenes, standards mandate that the exterior jackets of high-voltage wires be dyed in distinctive orange.A vehicle's designer may decide to use stronger insulation to shield occupants and nearby components from electrical supply at ever-higher voltages. Although it may raise material costs and make the cable heavier and stiffer, making it harder to route through a vehicle, this can consistently result in improved electrical performance.Insulation levels are provided by various materials. The needed temperature rating is one of the primary criteria by which they may be distinguished. Additionally common are silicone rubber jackets, which for EVs are normally rated to 180 C, but they may be designed to function at greater temperatures. Depending on the application, EPDM (ethylene propylene diene monomer) rubbers used in EV and HEV cables may be designed to work at temperatures as high as 150 C.

### Shielding

Vehicle integrators must also take into account the impact on the surrounding systems as cable voltages rise. The electromagnetic "noise" produced by high-voltage cables, for example, may pose a special danger to electric and hybrid cars employing high-power electric motors with pulse width modulation (PWM) systems since the wiring can function as an antenna and spread that noise throughout the vehicle.

The signals governing the on-board motors for traction and other mechanical systems may be interfered with by this EMI. Shielding is necessary for safety reasons as cars grow "smarter" and have an increasing number of sensors, computer processors, RF systems, and connections placed throughout their designs.Thus, cables for electric and hybrid cars may be made in a variety of ways, from relatively basic single-insulator designs to ones with several levels of insulation, a braid or shield incorporated to cut down on EM emissions, and a jacket covering that. While decreasing mechanical flexibility, this dramatically increases cable complexity and thickness, which poses new questions about the cost, routing, packing, and usability within the vehicle.

However, inadvertent EMI or the generation of electrical arcs are not permitted while operating with high voltages in delicate parts of a vehicle since they would be detrimental to essential system operations. However, not all sections of the car need EMI shielding. In an early "leg" of the powertrain, for instance, wires carrying reliable DC power from the batteries may not need shielding.However, as said, PWM-enabled electric motors produce a lot of EMI, necessitating the use of shielded connections. That holds true for any gadget with variable frequency and inductive feedback. High-voltage cables must also be insulated if they are situated close to crucial safety circuits for components like proximity sensors to avoid the corruption of such safety data. Furthermore, an autonomous vehicle that uses GNSS signals for location updates must maintain the security of its cables and satellite receivers. By utilising a braid, for instance, the protection's precise nature might be altered. This is constructed by wrapping the insulating layer in a weave of metal strands.

Tin and copper are often used as braid materials because of their ability to resist corrosion, while aluminium is also gaining popularity because of how lightweight it is when compared to other metals. However, due to its tendency to oxidise readily in air, making it difficult to create connections with it, working with aluminium may be difficult and expensive.

**Cables with low voltage**

The old 12 and 24 V designs are rapidly being replaced with 48 V systems in automotive electronics for systems like radio, air conditioning, sensors, and so forth. Even while that amount of power is far less than the voltages connected to batteries and traction motors, it still raises a lot of concerns when the vehicle's design specifications tighten.

For instance, a 48 V system requires far more care to ensure safety, arc resistance, and corrosion resistance than a 12 V system. Despite the fact that 48 V is considered to be "low voltage" when compared to battery cables, for instance, a 48 V DC connection is nevertheless potent enough to result in catastrophic damage.In comparison, a 12-48 V cable may be constructed with less costly components and designs without compromising safety, electromagnetic interference, or other factors. For instance, using an off-center cable is not advisable in high-voltage applications because the noise and heat emissions may be unevenly distributed and the insulation may be subjected to higher electrical strain on one side than the other. However, this is less of an issue with a low-voltage connection, and an off-center cable may still be utilised.

In contrast, flaws in the insulation, such as an uneven distribution of a component or particle or a mechanical defect, are unlikely to cause an issue in a low-voltage cable. However, considering the higher hazards involved, such flaws are very undesirable in high-voltage cables.Due to the 12-48 V cables' lower amounts of power, heat, and EM emissions, it is also possible to utilise less expensive insulating materials, such as PVC or other thermoplastics, with less danger of melting and conductor exposure. The use of thermosets would result in wires that are disproportionately thick and challenging to route compared to the insulation needs of such wires.

Thinner cables are being used for higher frequency connections, such as those for sophisticated sensors used in safety, autonomy, or performance monitoring applications. Vehicles are being built to employ wires no smaller than 48-50 AWG (0.03160-0.02504 mm), as operation frequencies exceed 1 MHz.Such sizes demand high-precision equipment and tension control, making their reliable production quite difficult. Additionally, they can withstand just grammars of force before snapping.Losses might also occur on a single wire running at extremely high operating frequencies. The conductor's resistance rises with frequency due to the skin effect, which makes AC density tend to be higher close to the conductor's surface. This decreases the wire's effective cross-section, which results in those losses.

**Adapter cables**

Wire is helpful for charging applications as well since it lowers losses when utilising both DC and AC at high frequencies. UL and NEC standards specify charging cable types and offer some flexibility in the choice of conductor and insulation.For instance, type EV charging cables have a 600 V rating, two or more thermoset-insulated conductors of 18 AWG (1.024 mm) or 240 mm2, and one or more insulated grounding conductors. Similar to type EV cables, type EVE and EVT cables employ PVC in place of thermoset insulation in the former and thermoplastic elastomer in the latter.

The usage of type EVJ cables, which include two to six 18-12 AWG (1.024–2.053 mm) thermoset-insulated conductors and one or more insulated grounding wires, is required by NEC and UL regulations for 300 V charging cables. The types EVJE and EVJT are identical to type EVJ, however type EVJT is insulated with PVC whereas the other two types employ thermoplastic elastomer insulations and jackets.Additionally, the standards define the nominal insulating thickness. The material thickness for types EV, EVE, and EVT may vary from 0.76 to 2.41 mm, with the degree of insulation increasing as the conductors' diameter and volume increase. The walls of all 300 V kinds are officially defined to be 0.76 mm thick. All of these charging cables are required by the regulations to have oil-resistant outer jackets, be useable in damp conditions, and have an optional Nylon insulation and shielding if requested.

When choosing or specifying a cable, designers of car charging stations should take user friendliness into account in addition to standards compliance. Flexibility is not addressed by the standard; thus, some people may find it difficult to handle and put in the charger cable into their car, which might result in small damage to the vehicle or harm to the user. The cables are forwarded to UL for testing before they can be approved. In addition to features of electrical performance and chemical resistance, this will examine areas like crush resistance (for instance, if a car runs over the charging wire) and other types of mechanical performance.

## CONCLUSION

One of the most important aspects of any electrical system's design is choosing the right power cable and cable types, as well as the conductor sizes needed for certain applications. It is often carried out with the least amount of work and with the least amount of consideration for all relevant effective cable sizing model for building electrical services. The resulting calamity is that poor selection and size may quickly increase a facility's installed cost while simultaneously reducing the dependability of the whole system. This essay focuses on a few factors that should always be taken into account when choosing a cable. The appropriate design tool is then recommended in order to assist the selection process without using oversimplifications in calculations.

## Bibliography:

[1] D. Rempel, C. Cullen, M. M. Bryan, and G. V. Cezar, “Reliability of Open Public Electric Vehicle Direct Current Fast Chargers,” *SSRN Electron. J.*, 2021, doi: 10.2139/ssrn.4077554.

[2] T. Nakanishi, H. Zaitsu, T. Kikuta, S. Tsuda, H. Nii, and S. Kodama, “CHAdeMO-conformity high-power charger connector assembly for over 100 kW-class EV charge,” *SEI Tech. Rev.*, 2019.

[3] S. Pratiksha *et al.*, “Design and Development of Solar Mobile Charger with MPPT,” 2019.

[4] Sairaj Gumul, Piyusha Jujgar, Arati Vijapure, Pooja Rao, and Prof. P. S. Mehtre, “Wireless Charger for Electric Vehicles,” *Int. J. Adv. Res. Sci. Commun. Technol.*, 2021, doi: 10.48175/ijarsct-7537.

[5] L. Mandache, A. Marinescu, and I. Dumbrava, “Novel Design Approach of Wireless Chargers for Electric Vehicles,” 2018. doi: 10.1109/EPEPEMC.2018.8521999.

[6] B. Warner, O. Augé, and A. Moglestue, “Taking charge: Flash charging is just the ticket for clean transportation,” *ABB Rev.*, 2013.

[7] K. Kerk, C. Sivathasan, C. Lim, D. Sim, and T. Tan, “Device Malfunction in Long Term Mechanical Circulatory Support Devices - A Single Centre Experience,” *J. Hear. Lung Transplant.*, 2014, doi: 10.1016/j.healun.2014.01.683.

[8] T. Kalogiannis, D. I. Stroe, J. Nyborg, K. Nørregaard, A. E. Christensen, and E. Schaltz, “Incremental Capacity Analysis of a Lithium-Ion Battery Pack for Different Charging Rates,” *ECS Meet. Abstr.*, 2017, doi: 10.1149/ma2017-01/5/439.

[9] R. Glocker, “Using Liquid Cooling to minimize temperature impact in High Power Charging (HPC) Systems,” 2017.

[10] L. Jiang, W. Meng, Y. Wang, C. Su, and J. Li, “Exploring energy consumption of juice filming charging attack on smartphones: A pilot study,” 2017. doi: 10.1007/978-3-319-64701-2_15.

# LOAD ANALYSIS OF DISTRIBUTED TRANSFORMER

**Dr. Rajiv Singh***
*Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-rajivranjansingh@presidencyuniversity.in

## ABSTRACT:

*This chapter discusses load analysis of distributed transformer. Transformer loading analysis is the process of examining the health and loading patterns of each transformer within the service area. Various tools and software can be used to perform this analysis. Estimating the load is done using probabilistic daily load curves and their likelihood of occurring. The peak-day load factor, which is calculated as the peak kVA for the season divided by the average kVA and then given as a percentage, is used to describe the load shape. This is a crucial factor to take into account while analysing transformer loading. In this book chapter we discuss the size of transformer, transformer types, considering the design of transformers, standard of energy efficiency etc.*

**KEYWORDS:** *Conversion Chain, Distribution Transformer, Phase Transformer, Single Phase Transformer.*

## INTRODUCTION

One of the key elements when considering power distribution is a transformer. It has a considerable influence on the electrical system's functioning, whether there are no disruptions or there are. Therefore, clever engineers make sure that transformers are properly chosen, precisely scaled for a particular purpose, and capable of supplying enough power to the electric loads in accordance with certain requirements and laws. By guaranteeing low power loss, a transformer aids in the scalability, flexibility, and cost-effectiveness of power systems. You may learn how to choose and size a transformer from this page.In this instance, the most recent edition of the code, which was released in 2017, will be utilised to regulate the transformers. Transformers are essential parts of a wide range of industrial, commercial, and household electrical systems. The working voltage may be "stepped" up or down thanks to them. Through the use of the magnetic field generated passively by the current carrying windings, transformers may "step" voltage up or down.

The most fundamental form two copper loops of varying sizes, placed one within the other without making contact, may serve as an example of this idea. The terminals of the other loop experience an induced voltage if one of these loops has current flowing through it. The second loop's voltage and current are proportionate to those of the first loop's voltage and current. A range of working voltages may be produced by varying the number of loops or windings.Copper or aluminium are used to make transformer windings. The most popular choice is aluminium since it is less costly and has comparable electrical properties to copper. Despite being physically bigger than copper, aluminium is lighter than copper.

In the industry, power rating sizes for power distribution transformers are standardised. Three-phase delta primary to wye secondary step-down type transformers are the most popular use in a commercial building. 480-to-120/208-volt wye transformer sizes typically range from 15, 30, 45, 75, 112.5, 225, 300, and 500 kilovolt-amperes.Additionally, single-phase 277- or 480-volt transformers in the 5, 7.5, 10, 15, 25, 37.5, 50, 75, and 100 kilovolt-ampere range are available. This is not an exhaustive list, but it does show the breadth and diversity of products that are commercially accessible.

In general, three-phase transformers are the most often chosen and used by electrical designers. Single-phase transformers are often employed for specialised voltages or applications. An item of equipment that expressly needs 240 volts single-phase but whose service voltage is 120/208 volts wye three-phase may be an example. It is typical to merely offer a single-phase transformer for the equipment in a specific scenario like this since it won't be serving many different loads. When a three-phase utility is utilized with a single-phase transformer for general distribution, phase imbalances may result. Otherwise, a single-phase transformer might be useful if a property is serviced by single-phase and a transformer is utilized. Every transformer must have a nameplate with the details listed in NEC 450.11(A). Name of the manufacturer, rated kilovolt-amperes, frequency, primary, and secondary voltages, impedance of transformers 25 kilovolt-amperes or larger, necessary clearances for transformers with ventilating openings, quantity and type of insulating liquid where used, temperature class for the insulation system for dry-type transformers are all included in this data.

## LITERATURE REVIEW

Heleno et al. discussed the widespread use of distributed energy resources will lead to issues with voltage, congestion, and reverse power flows in the distribution networks. In order to assist distribution system operators developing medium voltage distribution networks with high penetration of distributed energy resources behind the metre, this article suggests a unique optimisation model [1]. With the goals of reducing network technical issues and investment and operating costs, the optimisation model specifies the ideal mix, positioning, and size of on-load tap charger transformers and energy storage devices. By using a restricted second-order cone programming model and the big-M approach, the suggested optimisation model relaxes the non-convex formulation of the optimum power flow and precisely linearizes the non-linear model of the on-load tap changer transformer. The findings show how these two adjustments lessen the computing overhead of the optimisation and enable it to be applicable to real-scale distribution grids. The numerical outcomes further demonstrate that combining the optimisation of energy storage systems with on-load tap changer transformers resulted in a more cost-effective and adaptable planning approach than doing so separately for each technology.

Martin et al. created a DC solid state transformer (DC SST) module, two modular multilevel converters (MMC) operating with phase-shifted square wave modulation (PS-SWM) must be connected [2]. This article suggests a method for identifying the medium frequency transformer's inherent power losses. For HVDC to MVDC conversion for DC grid applications as well as for the integration of renewable and dispersed energy resources into the DC grid, cascaded MMC module-based DC SST architecture is a fantastic option. Reduced cell capacitor size and lower overall semiconductor device ratings are possible when operating with PS-SWM. In contrast to other known square-wave modulation types, this modulation creates a special quasi-square waveform at the SST internal medium frequency (MF) AC interface. This results in a transformer flux density that is similarly unique, leading to a transformer core loss that is difficult to detect since it cannot be anticipated by current techniques. This paper proposes a mechanism to forecast the loss of the MF transformer exposed to PS-SWM in an effort to present a practical and optimizable MF transformer design approach.

Li et al. discussed that in numerous 2D vision challengestransformer has shown promising performance. However, since point clouds are a lengthy series of data that are irregularly distributed in 3D space, computing the self-attention on large-scale point cloud data is difficult. Existing approaches often conduct convolutional self-attention on a discretized representation or calculate self-attention locally by grouping the points into clusters of the same size to address this problem. The latter often has restricted attention fields, while the former causes stochastic point dropout. In this research, we present a new set-to-set translation-based voxel-based architecture called Voxel Set Transformer (VoxSeT) for 3D object detection from point clouds. The foundation of VoxSeT is a voxel-based set attention (VSA) module, which models features in a hidden space created by a collection of latent codes and decreases the self-attention in each voxel by two cross-attentions. VoxSeT can handle voxelized point clusters of any size and process them in parallel with linear complexity thanks to the VSA module.

Selmi et al. explored that the architectures of photovoltaic (PV) conversion chains and their current state of the art are the focus of this article. To categorise these chains, two key criteria are taken into account. These two factorsgalvanic isolation and stage countare often found in close proximity to the DC-AC converter (inverter) at the end of the PV conversion chain[3]. In order to differentiate between transformer-based and transformer-less conversion chains, this study provides a thorough overview of the many inverter topologies that may be included into PV conversion chains. The study indicates that transformer-based inverters, which have a long history of success as a component of solar energy systems and are still commonly employed today, are particularly successful for residential applications due to their higher efficiency, smaller size, and lower cost. Transformer-free chains are criticised for having a few issues and drawbacks, nevertheless. Furthermore, the re-examination of the current solar PV conversion chains, their architectures, and potentially new conversion chains suitable for all distributed generation including electric cars and storage devices are required by solar energy storage devices, wireless charging systems in stations, and along highways.

Zhang et al. discussed that the effective charging of many EVs is one of the problems that the growing electric vehicle (EV) industry is grappling with. In order to lower charging costs, guarantee a high battery state of charge (SoC), and prevent transformer overload, this article examines the coordinated charging of several EVs. To achieve this, we first construct the EV coordinated charging issue as a Markov Decision Process (MDP) with the numerous goals listed above, and we then suggest a multi-agent deep reinforcement learning (DRL)-based solution. The suggested method implements the distributed calculation of global information (namely the energy price, the transformer load, and the overall cost of charging many EVs) using a unique interaction model, namely the communication neural network (CommNet) model. In addition, the suggested solution just requires the transformer load, unlike the majority of previous studies that impose precise limits on the size, location, or architecture of the distribution network. Additionally, since the proposed method employs long and short-term memory (LSTM) for price prediction, it is flexible enough to handle a variety of uncertain pricing mechanisms.

Yang Liet al. discussed that in large distributed systems, big-batch training is essential for accelerating deep neural network training. Large-batch training is challenging, however, since it results in a generalisation gap. Simple optimisation often results in accuracy loss on the test set [4]. A cutting-edge deep learning model called BERT draws on deep bidirectional transformers for language interpretation. When we increase the batch size (for example, beyond 8192), previous large-batch training methods do not work well for BERT. It takes a lot of time to complete BERT pre-training as well (around three days on 16 TPUv3 chips). We suggest the LAMB optimizer as a solution to this issue since it enables us to increase the batch size to 6553 without compromising accuracy. LAMB is a universal optimizer that performs well for both small and big batch sizes and just requires learning rate modification. Pre-training for the standard BERT-Large model requires one million iterations, but LAMB with batch size 65536/32768 only requires 8599 iterations. We are able to complete the BERT training in 76 minutes by pushing the batch size to the TPUv3 pod's memory limit.

Eka et al. explored that the voltage drops and power loss in the electrical conducting medium must be considered in the distribution of electric power. This essay will examine the usage of copper cables, copper busducts, and aluminium busducts as electrical conducting medium in a 27-story high-rise building's electrical system. Two 3000 kVA distribution transformers are located in the basement level and are powered by a medium voltage PLN 20 kV with output voltages of 400 V and 4330 A, respectively. The energy is further delivered to the Low Voltage Main Panel (PUTR), namely PUTR-1 for the Low Zone (Floor 01 – 13) and PUTR-2 for the High Zone (Floor 14 – 25) [5]. The maximum current allowed per floor in the low zone region is 153 A, but it is 166 A in the high zone. A cable size of 10 x 300 mm2 or a busduct size of 5000 A was chosen from the Transformer to PUTR based on the field circumstances and the maximum current allocation, and a cable of 70 mm2 or a busduct size of 2000 A was chosen from PUTR to each level. The copper busduct has the lowest calculated power loss, which results in the highest efficiency score.

Deng et al. suggest that publicly shared gradients in the training process may disclose the private training data (gradient leakage) to a third party, even if distributed learning has rapidly attracted attention in terms of properly using local devices for data privacy improvement [6]. However, the gradient leaking mechanism of the Transformer-based language models has not yet been subjected to a thorough investigation. We construct the gradient attack issue on the Transformer-based language models in this study as a first effort, and we provide a gradient attack technique, TAG, to retrieve the local training data. Test results on Transformer, TinyBERT4, TinyBERT6, BERTBASE, and BERTLARGE using the GLUE benchmark demonstrate that, when recovering private training data, TAG performs well on more weight distributions than DLG (Zhu et al., 2019) and outperforms earlier methods by 1.5 Recover Rate and 2.5 ROUGE-2 without the need for ground truth label. By exploiting gradients on the CoLA dataset, TAG can extract up to 88.9% of tokens and up to 0.93 cosine similarity in token embeddings from private training data. TAG is also more effective than earlier methods on bigger models, smaller dictionaries, and shorter inputs.

## DISCUSSION

### Size of transformers

Finding the load that will be served either at the branch circuit, feeder, or service level is the first step in sizing a transformer. Using NEC Article 220, estimate or calculate the demand load, and then apply any necessary demand factors are the first steps in this process. Demand considerations will lower the predicted load to establish the proper transformer size based on the kinds of loads serviced.The base load or starting point for sizing the transformer is represented by this computed design load. Depending on the kind of project, you will need to take a few factors into account after you have established the base load when estimating the transformer's ultimate size. Future adaptability, accessible physical area, pricing, and project kind are a few of these factors to take into account.One of the most important factors in choosing the right size for a property is its potential capacity or growth. This is crucial since both large and undersized transformers run at reduced efficiency and have the potential to gradually harm equipment. It is essential to comprehend how the facility will be used by the owner. In certain cases, the property is not expected to grow, therefore the owners may not need space for more equipment or loads in the future.

## Transformer types

Once a transformer's size has been established, take into account the uses and different kinds of loads it will handle. There are a few transformer types with the following features that are often used in commercial design Transformers of the dry kind utilize outside air to cool the core and windings. These transformers are often less costly in terms of materials and installation expenses while being bigger than liquid-filled transformers.The two dry-type transformers that are most often used are enclosed and ventilated. No ventilated or enclosed sections that are suitable for wash-down regions and corrosive, combustible, or other hazardous circumstances are totally sealed with surface cooling. Ventilated dry-type transformers are bigger in size, employ different insulating materials, have an enclosure for the windings, and have air vents built into them. These features provide both workers and equipment with physical safety.

Transformers with liquid insulation employ the liquid to cool the cores and serve as an insulator. The most often utilized liquids are mineral oil and bio-based oils. Better cooling is possible with liquid-insulated transformers, which results in a smaller transformer than with a dry kind.These transformers must periodically have their oil analysed, although maintenance is thought to be less expensive. In the event of a spill, bio-based oils are less combustible and beneficial to the environment. Liquids having a fire point of at least 300°C are thought to be less combustible. Utility transformers that are located on an outside pad are often filled with mineral oil and are regarded as flammable. Indoor installations for transformers under 35 kilovolts can just need a few things, such an automated sprinkler system or a liquid containment space without any combustibles kept there.The specifications for indoor and outdoor installations of these liquid-insulated kinds are covered by NEC 450.23. Additionally, under NEC 450.24, a transformer vault must be constructed inside for non-flammable fluid-insulated transformers that employ a non-flammable dielectric fluid. When used inside, oil-insulated transformers must be placed in a transformer vault in accordance with NEC 450.26.

## Unique applications

For harmonic, nonlinear loads like computer/servers with switch-mode power supply, gambling slot machines, LED lights, motors, or variable frequency drives, K-rated and harmonic mitigating transformers are often utilized. Harmonic difficulties caused by nonlinear loads may be solved with HMTs.On the other hand, K-rated transformers enable a more resilient system to endure the harmonics rather than mitigating them. Transformer failure from harmonics is brought on by excessive and/or continuous overheating of the coils, which accelerates the deterioration of the insulation on the coils. Electrical systems with too many harmonics may deform the sinusoidal wave, which can lead to electronic component failure.

K-rated transformers are designed to withstand the stresses and strains of nonlinear loads depending on the level, which is the main distinction between them and HMTs. The physical design of HMTs prevents disruptive currents from travelling electrically upstream of the transformer by reducing or mitigating harmonic currents from downstream devices.Switch mode power supply now power the majority of electronic devices. SMSPs use rectifiers and capacitors to transform sinusoidal alternating current to constant direct current, causing the original AC sinusoidal wave to change. Since the wave has changed, it is now a nonlinear load with strange harmonics, which may damage the transformer by raising the current in the windings and producing too much heat in the transformer coils. These strange harmonics, especially the third harmonic, which adds to the neutral conductor's effects, are suppressed or diminished by HMTs.

### Considering the design of transformers

The transformer's actual placement must be taken into account. The surroundings or building type where the transformer is installed, as well as any nearby occupants or rooms, should be taken into account.For instance, spill containment sections that are normally more expensive are needed when an oil-insulated transformer is put inside. NEC Article 450.26 specifically states that a vault room is necessary for oil-insulated transformers unless one of six exceptions is fulfilled. Using a transformer vault has benefits and drawbacks that might vary based on a variety of factors, but they should be considered since they call for more care and can be expensive. Utility companies often employed oil-insulated transformers, even though they were exempt from the NEC's strict building design rules.

Additionally, take into account the transformer's actual placement inside the structure as well as the region it will be used to distribute electricity to. Due to voltage loss, a 277/480 volt-delta transformer is better suited for longer lines on medium-sized structures. Use a higher voltage to deliver electricity as necessary rather than designing bigger feeders for longer lines.At the branch circuit level, a 120/208 volt-wye is typical for non-industrial uses, but the lower voltage makes it inadequate for long-distance distribution. Power is transported throughout the site via medium-voltage properties, where the voltage-to-ground is 1,000 volts or greater.

### Noise

Depending on the kind of occupancy in the building, noise should also be taken into account. The customer or tenants may hear an unpleasant hum due to the transformer's continuous oscillations. For instance, in a hotel tower occupation, sound-proofing or acoustical treatment may be required in the transformer rooms on the top floors, where the guestrooms are situated, to reduce noise from the electrical area.If the transformers are located at grade level or on the roof at a position that provides sufficient separation from the transformers and guests, then room treatment may be unnecessary. Offering vibration-isolation cushions that lower the loudness to a level the customer is comfortable with might be another option. It may be necessary to enlist the aid of an acoustical engineer or consultant to help with this noise reduction.

Construction of the space must adhere to NEC Article 450 Part II regulations. According to NEC 450.21(A), dry-type transformers placed inside must have at least 12 inches of space between them and flammable materials if their rating is less than 112.5 kilovolt-amperes. According to NEC 250.21(B), the room must have a fire-resistant structure of at least one hour for dry-type transformers greater than 112.5 kilovolt-amperes.There is, however, one rule that often applies: they do not have to be situated in one-hour rated rooms if they have Class 155 or above and are entirely enclosed with the exception of ventilation apertures. One of these transformers is therefore the room it is in doesn't need to have a one-hour fire-resistant rating.

### Standards for energy efficiency

The determines the dry-type distribution transformers' energy efficiency. As a result, from January 1, 2017, complying transformers are marked with the DOE-2016 designation. Using 35% of the nameplate-rated load, efficiencies vary from 97.0% to 98.9% depending on the transformer's capacity and number of phases. Many authorities with jurisdiction want transformers that are specifically stated to fulfil these standards in addition to the DOE's label requirement for commercially available transformers.Not all projects will adhere to the process as it is laid out here, but some may extend to take more factors into account. Due to the unique nature of each property, no two projects will ever be the same. Design engineers are in charge of selecting the best options and working with their clients to meet their goals.

### Operating Periodicity

A transformer requires a certain frequency to function. The transformer frequency is directly proportional to the magnetic current, rated current, and kVA. As a result, the transformer has to run at its rated frequency. The operating frequency of the load and the input power source should always be equivalent to the transformer's rated frequency.

### Connector Windings

The winding connection does not need to be considered for single-phase transformers, but it is an important factor for three-phase transformers. The winding configurations for a few different three-phase transformer connections[7], [8].

### (50-2500kv) distribution transformer

The specifications of the network dictate the distribution transformers' defining characteristics. To get the rated power SrT, the effective power must be multiplied by the power factor cos. Distribution networks like the value uk=6%.No-load losses and short circuit losses make up transformer losses. The iron core's ongoing reversal of magnetization is what causes the no-load losses, which are essentially constant and irrespective of loading. Osmic losses in the windings and leakage field losses make up the short circuit losses. They are inversely proportional to the loading's square[9], [10].

## CONCLUSION

The transformer is a crucial component of the distribution system. This might experience various issues that could result in aberrant operation and a shorter lifespan. Harmonic distortion is the cause of one of the disturbances. Excessive harmonic distortion may have negative consequences, including temperature increases and increased power losses that lower efficiency. It may not be possible to prevent the growing application of nonlinear loads, thus their impacts should be carefully examined. The evaluations of Total Harmonic Distortion (THD), power losses, and efficiency are necessary for the transformer handling nonlinear load. It is confirmed that the transformer supplying a three-phase rectifier with nonlinear load has greater THD on voltage and current, higher power loss, and worse efficiency.

## BIBLIOGRAPHY:

[1] J. Iria, M. Heleno, and G. Candoso, “Optimal sizing and placement of energy storage systems and on-load tap changer transformers in distribution networks,” *Appl. Energy*, 2019, doi: 10.1016/j.apenergy.2019.04.120.

[2] R. Agarwal, S. Martin, and H. Li., “Influence of Phase-Shifted Square Wave Modulation on Medium Frequency Transformer in a MMC Based SST,” *IEEE Access*, 2020, doi: 10.1109/ACCESS.2020.3042935.

[3] M. Bouzguenda and T. Selmi, “Review of dc-ac converters for photovoltaic conversion chains,” *International Journal of Power Electronics and Drive Systems*. 2021. doi: 10.11591/ijpeds.v12.i2.pp886-901.

[4] Y. You, J. Li, J. Hseu, X. Song, J. Demmel, and C.-J. Hsieh, “Reducing BERT Pre-Training Time from 3 Days to 76 Minutes,” *arXiv*, 2019.

[5] A. Eka, P. Lestari, P. Oetomo, F. T. Industri, and J. Selatan, “Analisis Pemilihan Penghantar Tenaga Listrik Paling Effisien Pada Gedung Bertingkat,” *Progr. Stud. Tek. Elektro - ISTN Sinusoida*, 2021.

[6] J. Deng *et al.*, “TAG: Gradient Attack on Transformer-based Language Models,” in *Findings of the Association for Computational Linguistics, Findings of ACL: EMNLP 2021*, 2021. doi: 10.18653/v1/2021.findings-emnlp.305.

[7] A. Mammoli, M. Robinson, V. Ayon, M. Martínez-Ramón, C. fei Chen, and J. M. Abreu, “A behavior-centered framework for real-time control and load-shedding using aggregated residential energy resources in distribution microgrids,” *Energy Build.*, 2019, doi: 10.1016/j.enbuild.2019.06.021.

[8] A. Awasthi, S. Bagawade, and P. K. Jain, “Analysis of a Hybrid Variable-Frequency-Duty-Cycle-Modulated Low-QLLC Resonant Converter for Improving the Light-Load Efficiency for a Wide Input Voltage Range,” *IEEE Trans. Power Electron.*, 2021, doi: 10.1109/TPEL.2020.3046560.

[9] I. Daminov, A. Prokhorov, R. Caire, and M. C. Alvarez-Herault, “Assessment of dynamic transformer rating, considering current and temperature limitations,” *Int. J. Electr. Power Energy Syst.*, 2021, doi: 10.1016/j.ijepes.2021.106886.

[10] W. Bukhsh, C. Edmunds, and K. Bell, “OATS: Optimisation and Analysis Toolbox for Power Systems,” *IEEE Trans. Power Syst.*, 2020, doi: 10.1109/TPWRS.2020.2986081.

# AN EVALUATION OF VOLTAGE DROP IN CABLE

**Ms.Renuka Bhagwat***

*Assistant Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, India
Email Id-renuka@presidencyuniversity.in

## ABSTRACT:

*This study presents a brand-new ground power unit cable voltage drop compensating technique. By monitoring the current amounts at the source, the method can forecast and correct the voltage drop in an output cable. A sophisticated cable model that incorporates self- and mutual impedance factors underlies the forecast. The voltage loss is predicted by the model for both symmetrical and unbalanced loads. An automated identification approach is developed to identify the cable model characteristics. On a 90 kVA, 400 Hz ground power unit with a 100 m output cable, the idea is tested at full size. Both symmetrical and asymmetrical cables, as well as balanced and unbalanced loads, significantly increase performance.*

**KEYWORDS:** *Voltage Drop, Cable, Electric Current, Electrical Wires.*

## INTRODUCTION

Every wire, regardless of size or length, has some dc resistance; when current flows through this resistance, voltage drops. The length of the cable directly affects the reactance and resistance of the cable. As a result, VD is a major problem in areas with lots of cable connections, such as large buildings or farms. In single phase, line to line electrical circuits, this approach is often used to size conductors correctly. A voltage drop calculator may be used to calculate this.Current flow across electrical wires is continuously impeded by impedance, often known as inherent resistance. The voltage loss, shown by the symbol VD in volts, that results from what is known as cable "impedance" and happens over all or part of a circuit an electrical cable is a collection of one or more wires that are bundled together or run side by side to transport electric current.

One or more electrical cables and the connectors they come with may be combined to form a cable assembly; this isn't necessarily required to link two devices, but it is possible (for example, to be soldered onto a printed circuit board with a connector affixed to the housing). Cable assemblies may also resemble a cable tree or cable harness to connect several terminals together. In the context of electrical wiring, the word "cable" originally referred to underwater telegraph cables that were armored with iron or steel wires. Early attempts to deploy subsea cables without protection failed because of their fragility. The production of the armoring began in distinct facilities from those that made the cable cores in the middle of the 19th century. These companies are experts in making the wire rope used in nautical cables. As a consequence, the finished protected cores were given the name cables. Later, regardless of whether it was armored, the word was used to describe any grouping of electrical wireseven just oneencased in an outer sheath. In place of copper conductors in the outer sheath, the term is currently used to describe telecommunications cables[1]–[3].

Motors may run hotter than usual, heaters may heat inefficiently, and heaters may eventually burn out if there is too much VD in the cable cross sectional area. Lights may also flicker or burn inefficiently as a result. The size (cross section) of your conductors must be increased in order to reduce the voltage drop (VD) in a circuit; this is done in order to reduce the total resistance of the cable length. It is crucial to compute VD and find the right voltage wire size that would lower VD to acceptable levels while staying cost-effective since bigger copper or aluminum cable diameters inherently increase cost.Voltage loss (VD) brought on by current passing through a resistance. The VD increases directly as resistance increases. Connect a voltmeter between the measurement point and the VD to verify the VD. In both DC and AC resistive circuits, the voltage supplied to the circuit should be equal to the sum of all voltage drops across all series-connected loads.

To function at its optimum, each load device has to receive its rated voltage. The gadget won't function properly if there is insufficient voltage. At all times, be sure the voltage you want to measure is within the voltmeter's functioning range. If the voltage is unknown, this might be challenging. If so, be sure to always choose the highest range. Damage might occur if you try to measure a voltage that the voltmeter is not equipped to manage. You could sometimes be asked for the voltage between a specific location in the circuit and ground or another recognized reference point. To achieve this, first connect the circuit's common or ground using the voltmeter's black common test probe. The red test probe will then be attached to the location in the circuit where the measurement will be performed.

You need to correctly know the cable type's resistance in order to compute the VD for a certain cable size, length, and current. However, it provides a less complicated approach that might be applied.Charges accumulate at one end of an electric wire or device due to its resistance, causing a voltage drop. Due to the device's resistance, charges go through it more slowly, changing the voltage between its two locations. For instance, if a device has a voltage of 20 volts at point A (where charges enter the device) and a voltage of 16 volts at point B (where charges exit the device), the voltage is reduced from 20 volts to 16 volts. The voltage fell by 4 volts in this instance.

All electrical wires have resistance, thus it's important to keep this in mind while figuring out what the voltage drop is. By resisting electric current, an electric element may alter the voltage and relative charges on both sides. To produce a greater voltage, the element's resistance has to be raised.Electric wires are a part of every electric circuit. A wire's resistance (R) is controlled by its length (L), cross-sectional area (A), and material resistivity constant, according to the equation R = L A. The resistance of the wire is inversely related to its cross-sectional area but directly proportionate to its length. The cross-sectional area of the wire and its diameter, often known as wire gauge, are linked. in case anything goes wrong. If the circuit needed more voltage dips, an electrician would use wider gauge wires.

### Voltage drops in the circuit

Consider a voltage drop circuit that consists of a series connection of a battery, a resistor, and a light bulb. Throughout the whole circuit, the electric current from the power source (battery) is constant. The difference in the number of charges between the two ends determines the voltage drop across the bulb. In this circuit, there are two voltage dips, the first happens across the bulb, and the second is caused by the resistor.

Voltage drop estimates are necessary while designing a building's or a home's electrical wiring system. Electricians create electrical circuits to guarantee that electricity is available at every switch box and outlet in every room. Each linked home device, including the HVAC system and refrigerator, is built to draw power in order to operate effectively with a supply of typically constant voltage. To put it another way, the voltage in the home's circuit dips when the motor of the refrigerator begins, but the HVAC soon makes up for it due to the continuous supply.

Consider a scenario in which there are 5,000 homes affected by a power outage, each of which includes 5,000 refrigerators, HVAC units, and other electric appliances that will all turn on simultaneously when the power is restored. A voltage drop might occur at each home if the power supply can't simultaneously adjust to the high demand and react to it.This energy from the power source is required for an appliance like an HVAC unit to work since they are built to utilize a particular amount of energy per hour. An appliance with an electric motor may have problems starting if the voltage goes too low, which might result in a burned-out or damaged circuit on the circuit board of the appliance.

## LITERATURE REVIEW

Zhang et al. discussed that when a power source travels through long distance connections to a load system, a voltage drop often happens. It is vital to enable remote detection and control of the load-side voltage and boost to the needed voltage in order to make up for such voltage decreases. The resistance and inductance measurements for distant cables using a unique impedance detection technique are reported in this paper. For the voltage drop and delayed response brought on by cable intrinsic impedance, a digital-analog hybrid control technique based on the impedance detection method is provided. The suggested technology is more appealing and promising for engineering applications since it conducts detection and compensation at the source of the cable and can be included into power source devices without adding additional load to the load system. Finally, a prototype is constructed for experimental validation, and a methodical and straightforward comparison is made with the currently used voltage-drop compensation techniques. According to experimental and comparison findings, long-distance cables' issues with voltage drop and delayed response have been resolved, and precise and quick control of the distant voltage has been accomplished.

Shibata et al. discussed that through the use of a transmission test, the impact of mineral-insulated (MI) cable materials on their electrical properties in high-temperature circumstances was investigated with the aim of stabilising the potential distribution over the cable length. Aluminium oxide (Al2O3) and magnesium oxide (MgO), the insulating components of the MI cable, were shown to cause a voltage drop along the cable. The potential leakage that was discovered at the terminal end was evaluated using a finite element method (FEM)-based analysis. For the MI cable made of Al2O3 and MgO materials, the voltage drop yields from the transmission test and the analysis were in excellent agreement, indicating that the FEM analysis was able to accurately reproduce the magnitude relationship of the experimental data. The same FEM analysis was performed to reduce the voltage loss, and the core wires' diameter (d) and spacing (l) were adjusted. By dividing the variation in d by the variation in the insulating material (D), the potential distribution in the MI cable generated a minimal voltage drop equal to a ratio of d/D of 0.35. A minimal voltage loss was l/D of 0.5 when l was variable.

Rizvi et al. explored those costs of production, transmission, emissions, and a set cost of distribution depending on the time of day and main source are all factors in the current models used to determine the price of electricity. The authors contend that as rapid charging for EVs becomes more prevalent, networks will experience more overloading and voltage dips at the low voltage level. To achieve this, the authors suggest a unique approach that makes use of a centralised, double-sided optimised algorithm to promote reactive power injection to reduce voltage dips and active power injection to reduce cable loading. This approach enables peer-to-peer power supply, which is encouraged by price considerations. It also encourages higher islanding in the network, which enhances grid resilience and enables the best EV charging and discharging, as well as local optimization-based solutions to network overloading. Instantaneous electricity is the transactional commodity for both stationary consumers and generators (houses) and mobile consumers and generators (EVs), and then rewarded peer-to-peer transactions are documented in a centralised blockchain. Even with a low EV penetration level (5% of available transportation), the mathematical model and the impact of such a decentralised network show the potential for decongestion of 5–10% in terms of a reduction in voltage drops and cable loading by using existing resources as V2G and voltage stability resources.

Oshurbekov et al. discussed that the effectiveness of traditional direct-on-line electric motor-driven fluid equipment, such as pumps and fans, is increased by the introduction of Line-Start Permanent Magnet Synchronous Motors (LSPMSM). These motors are more efficient than induction motors and lack an excitation winding in contrast to conventional synchronous motors that do. However, initiating mechanisms with a large moment of inertia is challenging for LSPMSMs. Reduced supply network voltage and a voltage loss on the cable might make this issue worse. This article looks at the transients that occur when a line-start permanent magnet synchronous motor starts up an industrial centrifugal pump. The simulation findings shown that the synchronisation is delayed by 10% when the voltage on the motor terminals is lowered. In a steady state, using the cable also results in a drop in voltage at the motor terminals, but the time synchronisation delay is more substantial and causes a commensurate drop in supply voltage. The given simulation example demonstrates that, even with a lower supply voltage, the pumping unit can be started by the line-start permanent magnet synchronous motor without any issues. The findings of this study may be used when choosing an electric motor to power a centrifugal pump and advocate a greater adoption of energy-efficient electric motors.

Vladislav et al. explored that voltage dips and higher current loading of cable lines in the distribution grid happen when electrical energy is taken by electric cars from charging stations during the charging process. The voltages at grid points might drop below the acceptable level if the electrical grid is undersized or if several electric cars are charging at once without a controlled charging mechanism. This causes the voltage quality of a specific grid to decline. Active power losses caused by increasing cable current loading shorten and lengthen the cables' useful lives. The use of simulating electric cars while charging using power load model in physical diagram applied into alternative simulation software is described in the study. The load model for charging stations that was established is used to analyse cable line capacity and to solve voltage problems in the distribution grid. There are few points on the grid, and there are few charging stations installed. When charging stations are operated at random throughout the workday without a regulated system, voltage levels are resolved. The household typical daily loads diagrams are used for different loads[4]–[6].

SajjadHaideret al. in, discussed that finding measures to offset the impact of rising electric vehicle (EV) uptake on the current power transmission infrastructure is crucial. Although purchasing new equipment is the simplest course of action, optimising the sites where EVs may charge has the potential to significantly reduce overloading in terms of voltage dips and line loading. A heuristic optimisation strategy is put out to study this, with the goal of optimising EV charging sites inside a feeder while reducing nodal voltage dips, cable loading, and total cable losses. The optimisation strategy is contrasted with conventional unoptimized Monte Carlo analysis findings. The findings indicate a peak line loading decrease of up to 10% at a common benchmark voltage of 0.4 kV. According to further findings, the voltage that may be used at various nodes has increased by 1.5 V on average and up to 7 V in the worst scenario. For a future simulation, optimisation for a decrease in transmission losses reveals no gains. These optimisation techniques might make it possible to implement spatial pricing across multiple nodes in a low voltage network, allowing electricity prices for EVs to be set independently of existing temporal pricing models and reflecting the unique effects of EV charging at various nodes across the network.

Abdelaziz et al. in, explored that the power cables graphical user interface (PCGUI) is a useful computer-based design programme for a power cable network that is shown in this research. With open-source code and a straightforward user interface, this programme is primarily for academic teaching, consulting electrical designers, primary engineers, and technical workers. As a low/medium-voltage cable selection programme, PCGUI will be a crucial component of any electrical system's design, including many complicated analytical techniques based on several worldwide standards. A novel approach for analysing and determining the optimal cable design is provided by a MATLAB PCGUI programme, which uses a large variety of MATLAB script files and data that are suited for various elements and situations. The kind of insulation, temperature factor, grouping factor, acceptable voltage loss, cable lifespan costs, etc. are some of these parameters and criteria. With the least amount of work and the fewest human input processes, PCGUI offers a quick and affordable design with very high precision. The whole economic cable design, the standard rating and type of circuit breakers, the real cable current loading, the actual voltage drop, and the principal and most economical cable cross-section area "CSA" based on the cost analysis are all included in the findings after the programme has run.

Zhang et al. provided a detailed description of a digital control strategy based on precise sampling and cable voltage drop compensation to increase the primary-side controlled flyback converter's accuracy of the constant output voltage. The output diode and cable voltage drops were examined first since these were the two main variables affecting output voltage accuracy. Then, a precise sampling technique that can remove the output diode's voltage loss was suggested. The correction of cable voltage drop was also created, using digital resistance capacitance (RC) filtering and output current estimation. Finally, the suggested system was validated by software simulation and prototype test results.

## DISCUSSION

Electrical potential (voltage), which pushes electrical current through the wire, must triumph over some amount of opposing pressure created by the wire in order for electrical current to flow through the wire. The voltage drop indicates how much electrical potential (voltage) is lost as a result of the wire's opposing pressure. Impedance is the opposing pressure in an alternating current. Reactancethe response of an electric field that has built up to a change in currentand resistance combine to form the two-dimensional vector known as impedance. Resistance is the opposing force that a direct current faces.A high voltage drop in a circuit may cause heaters to heat inefficiently, lights to flicker or burn dimly, motors to run hotter than usual before eventually ceasing to function. Under fully loaded conditions, it is advised that the voltage loss should be less than 5%. This may be done by utilizing the right wire and using caution while using extension cables and other similar equipment.

Voltage drops may be caused by four different fundamental factors.First and foremost is the kind of material utilized to produce the wire. The metals with the greatest electrical conductivity are silver, copper, gold, and aluminum. Copper and aluminum are the two materials used to make wire the most often since they are less expensive than silver and gold. For a given length and wire size, copper will have a smaller voltage drop than aluminum due to its superior conductor.Voltage loss is also significantly influenced by the size of the cable. Larger diameter wire sizes will have a lower voltage drop when compared to smaller diameter wire sizes of the same length. Every 6-gauge decrease in American wire gauge twice the diameter of the wire, and every 3-gauge reduction doubles the cross-sectional area. A 50-gauge metric wire would have a diameter of 5 mm since the gauge on the Metric Gauge scale is 10 times the millimeter diameter.

Wire length is a key additional element in voltage loss. For the same wire size, shorter cables experience less voltage loss than longer ones. Throughout very lengthy sections of wire or cable, voltage loss worsens. Problems might arise when extending wire to an outbuilding, a well pump, etc., however often this won't impact home circuits.The degree of voltage drop may also be influenced by the quantity of current flowing through a wire; as more current runs through a wire, the voltage drop increases. The word capacity, which stands for ampere capacity, is frequently used to refer to current carrying ability. Capacity is the greatest number of electrons that can be pushed simultaneously.

The capacity of a wire is dependent on a number of variables. Naturally, the raw materials used to make the wire are the main limiting element. The capacity of an alternating current wire may be impacted by the alternation rate. Amplitude may also be impacted by the temperature at which the wire is being utilized.The heat generated during assembly of the bundles of cables, which are often utilized, affects the voltage drop and capacity. This necessitates that particular standard for cable bundling be adhered to.Two main concepts guide the choice of cables. The cable must, first and foremost, be able to withstand the current load being delivered to it without overheating. It must be able to function in the hottest and coldest environments possible over its working life. The earthing must also be strong enough to (i) keep people's exposure to voltage at a safe level and (ii) provide the fault current enough time to blow the fuse.

Impedance, which refers to the constant resistance to current flow, exists in wires that transport current. The loss of all or part of the voltage across a circuit as a result of impedance is known as voltage drop. A garden hose is a typical example used to demonstrate voltage, current, and voltage loss. Voltage may be likened to the pressure of the water running through the hose. Current moves in a manner akin to water flowing through a hose. Similar to how the kind and size of an electrical wire affect its resistance, the type and size of a hose influences its inherent resistance.

A high voltage drop in a circuit may cause heaters to heat inefficiently, lights to flicker or burn dimly, motors to run hotter than usual before eventually ceasing to function. Because there is less voltage to drive the current, the load must work harder in this scenario. According to the National Electrical Code, there cannot be a voltage drop of more than 3% of the circuit voltage for electricity, heating, or lighting from the breaker box to the furthest outlet. Choosing the appropriate wire size is required for this, and it is discussed in greater depth under "Voltage Drop Tables[7]–[10]."

### Effects of Voltage Drop

Voltage Drop is the element that affects the amount of voltage loss between the source voltage and the load voltage.

1. Reduced electric current flow is another effect of a voltage decrease.

2. Voltage drop results in a loss of electrical energy or power in the circuit.
3. Voltage drop may step down both AC and DC voltage.
4. Voltage loss reduces the circuit's effectiveness.
5. Examples and applications Power Loss

Rheostats work according to the voltage drop hypothesis. It steps down the voltage by reducing it.The voltage drop principle is also used by an old or conventional electrical fan regulator. It can change both the voltage across the ceiling fan coil and the current flow by modifying the voltage drop in its variable resistor.The principle of voltage drop also applies to a transformer-free power supply with a series capacitor, however in this instance the voltage drop is caused by capacitive reactance rather than resistance.

## CONCLUSION

In electrical and electronic systems, calculating voltage drop is crucial since it quantifies how much voltage is lost in the conductor as opposed to being given to the load. This conductor voltage drop effectively represents a loss of energy. Calculating voltage loss for lengthy chord assemblies (more than 50 feet) is crucial owing to possible safety hazards. Equipment power outages, the possibility of cables and cords being damaged, and safety concerns.

## BIBLIOGRAPHY:

[1] N. Hirota, H. Shibata, T. Takeuchi, N. Otsuka, and K. Tsuchiya, "Voltage drop analysis and leakage suppression design for mineral-insulated cables," *J. Nucl. Sci. Technol.*, 2020, doi: 10.1080/00223131.2020.1782280.

[2] S. Haider and P. Schegner, "Heuristic optimization of overloading due to electric vehicles in a low voltage grid," *Energies*, 2020, doi: 10.3390/en13226069.

[3] V. Síťař, T. Vysloužil, L. Raková, and T. Hruška, "The Power Load Model for Electric Vehicle Charging Modelling and its Utilisation for Voltage Level Studies and Cables Ampacity in Distribution Grid," *Manuf. Technol.*, 2021, doi: 10.21062/mft.2021.015.

[4] M. H. Chou, C. L. Su, Y. C. Lee, H. M. Chin, G. Parise, and P. Chavdarian, "Voltage-drop calculations and power cable designs for harbor electrical distribution systems with high voltage shore connection," *IEEE Trans. Ind. Appl.*, 2017, doi: 10.1109/TIA.2016.2646658.

[5] N. I. Ahmad, Z. Ali, M. Z. A. A. Kadir, M. Osman, N. H. Zaini, and M. H. Roslan, "Impacts of lightning-induced overvoltage on a hybrid solar PV–battery energy storage system," *Appl. Sci.*, 2021, doi: 10.3390/app11083633.

[6] S. Xu, X. Zhang, C. Wang, and W. Sun, "High precision constant voltage digital control scheme for primary-side controlled flyback converter," *IET Power Electron.*, 2016, doi: 10.1049/iet-pel.2015.0771.

[7] B. G. Bhang *et al.*, "Transmission Loss from Voltage Drop in a DC Cable for a Floating Photovoltaic System in a Reservoir," *New Renew. Energy*, 2020, doi: 10.7849/ksnre.2020.2062.

[8] M. I. Sani, S. Siregar, M. M. Kurnia, and D. Hasbialloh, "An electrical power control system for explorer-class remotely operated underwater vehicle (ROV)," *Telkomnika (Telecommunication Comput. Electron. Control.*, 2019, doi: 10.12928/TELKOMNIKA.V17I2.11757.

[9] A. Desai, V. Pandya, I. Mukhopadhyay, and A. Ray, “Temperature Effects on DC Cable Voltage Drop in Utility Scale Rooftop Solar PV Plant Based on Empirical Model,” in *Conference Record of the IEEE Photovoltaic Specialists Conference*, 2020. doi: 10.1109/PVSC45281.2020.9300709.

[10] R. T. Jurnal, “ANALISIS DROP TEGANGAN PADA JARINGAN TEGANGAN MENENGAH DENGAN MENGGUNAKAN SIMULASI PROGRAM ETAP,” *Energi & Kelistrikan*, 2019, doi: 10.33322/energi.v10i1.321.

# EXPLORING SELECTION AND SIZING OF HT EQUIPMENT

**Dr.Sreenivasappa Bhupasandra***

*Associate Professor,
Department of Electronics & Communication (Communication System Engineering),
Presidency University, Bangalore, INDIA
Email Id-sreenivasappabv@presidencyuniversity.in

## ABSTRACT:

*Overhead wires are regularly used extensively in the electrical power distribution and transmission system for urban and rural areas. Underdeveloped and emerging nations did not benefit from the underground system. The major cause of it was the much greater capital expenditure required for subterranean cabling compared to above bare wires. But because to market rivalry and technological innovation, metropolitan regions can afford it. Compared to overhead lines, this method demands greater preparation and expertise for installation, jointing, and termination. The power distribution system up to 33 KV is used with the paper that is being presented. In this book chapter we discuss about the settlement of cables***,** *cable configuration, cable engineering, conductor, and insulation, and exterior finish, voltage control rated of short circuit etc.*

**KEYWORDS:** *Cable Sizing, Carrying Capacity, Fatigue Design, Geothermal Wells, Non-Contact*.

## INTRODUCTION

An assemblage of one or more wires that are bunched together or run side by side to convey electric current is known as an electrical cable. In order to carry electrical signals or power from one device to another, electrical cables are used to link two or more devices. As electrical engineers, we are all familiar with cable jargon, construction details, etc. However, a general approach to cable sizing is covered in this article.Whether it's during Installation and Commissioning or functioning state, is a crucial metric for the industry. It is a crucial factor in safety, cost savings, and the elimination of unintended losses. A cable that is too small might catch fire during motor operation, endangering people's lives, damaging equipment, infrastructure, and costing money to rebuild[1].

An enormous conductor, however, would result in excessive costs for the long-distance cables as well as the cable termination components used with them, such as lugs, glands, jointing kits (in case any problems arise in the future), and oversized cable trays. In comparison to corresponding lesser size cable, the cost of labor for laying bigger size cable will likewise be higher. It's crucial to calculate the correct cable size for our motor while taking into account all of these critical factors.

To comprehend issues with cable systems, knowledge of cable architecture, properties, and ratings is crucial. However, more information is needed to effectively choose a cable system and ensure its good functioning. This information might include things like service parameters, the kind of load handled, methods of operation and maintenance, and similar things.The most effective cable for the application must be chosen, the installation must be done correctly, and the system must get the necessary maintenance. The discussion in this technical paper is centered on the appropriate cable selection and application for power utilization[2].

**Settlement of cables**

Depending on the distribution system and the load serviced, cables may be utilized circumstances, installation teams, and maintenance staff. By using the inappropriate pulling tensions during installation, cable insulation is often degraded or destroyed.The number of conduit bends and the space between manholes should be kept to a minimum in conduit system designs, which should also include pulling tension specifications.The inspection team should make sure that throughout installations, the installation staff do not go beyond these limits. Maintaining the proper bending radius is also crucial in order to prevent unneeded stress spots. Once a proper installation has been accomplished, periodic inspection, testing, and maintenance should be performed on a regular basis to monitor the cable system's ongoing maintenance and progressive degradation.In a particular distribution system, a variety of cable systems are available for transmitting electrical energy. Local circumstances, current corporate policy, or prior experience may have an impact on the choice of a certain system.

## LITERATURE REVIEW

Sahuet al. deals with effect of proper selection of materials in electrical apparatus. When ferromagnetic materials are subjected to heavy electromagnetic flux applications, the flux creates phenomena like eddy current or Foucault currents in them according to Faraday’s Law. There are numerous instances in power plants where high current application does show this behaviour like stator core bolts in HT motors, support rings in stator overhang, fitting bolts in EHV CTs etc. Improper selection of them in places of their non-applicability can cause premature failure and complete breakdown of electrical equipment. In order to overcome or foresee these types of situations, advanced condition monitoring techniques like-Thermography Analysis and tabulating all the collected data to create a trend of the readings to make a better comparison can help significantly in reduction of breakdown[3].

Dhamiet al. discussed that accelerometers, used as vibration pickups in machine health monitoring systems, need physical connection to the machine tool through cables, complicating physical systems. A non-contact laser-based vibration sensor has been developed and used for bearing health monitoring in this article. The vibration data have been acquired under speed and load variation. Hilbert transform (HT) has been applied for denoising the vibration signal. An extraction of condition monitoring indicators from both raw and envelope signals has been made, and the dimensionality of these extracted indicators was deducted with principal component analysis (PCA). Sequential floating forward selection (SFFS) method has been implemented for ranking the selected indicators in order of significance for reduction in the input vector size and for finalizing the most optimal indicator set. Finally, the selected indicators are passed to k-nearest neighbor (kNN) and weighted kNN (WkNN) for diagnosing the bearing defects. The comparative analysis of the effectiveness of kNN and WkNN has been executed. It is evident from the experimental results that the vibration signals obtained from developed non-contact sensor compare adequately with the accelerometer data obtained under similar conditions. The performance of WkNN has been found to be slower compared to kNN. The proposed fault detection methodology compares very well with the other reported methods in the literature. The non-contact fault detection methodology has an enormous potential for automatic recognition of defects in the machine, which can provide early signals to avoid catastrophic failure and unplanned equipment shutdowns[4].

Zhou et al. discussed that gears and rolling bearings are important components of mechanical equipment, and their conditions are strongly associated with the safe operation of equipment.

However, the diagnosis of slight fault of rolling bearing in gearbox often fails due to the interference of background noise and discrete frequency components. It is not conducive to long-term stable operation of equipment. In this paper, a local cepstral editing procedure (LCEP), which combines the local cepstrum (LC) theory with cepstral editing procedure (CEP), is proposed. The LC theory is adjusted so that the time-domain signal can be reconstructed. For the crucial problem of analysing frequency band selection, the selection criterion is given in the detection of slight gearbox bearing fault. The adjusted local cepstrum can extract the interference components in the complex vibration signal, and the interference components can be recognized and suppressed. The proposed method is used as signal preprocessing method, then Hilbert transfer (HT) and envelope analysis are carried out for the reconstructed signal to extract bearing fault characteristic components. The vibration signal model of gearbox is established and the proposed method is employed to analyse the simulated signal and the experimental signal[5].

Chenet al. explored thatpower has gained much attention as a promising contributor to the energy transition for its ability to provide a reliable, environmentally friendly source of heat and baseload power[6]. However, drilling high-temperature (HT) reservoirs presents significant technical and economic challenges, including thermally induced damage to bits and downhole (DH) tools, increasing drilling time and cost [7]. This paper introduces drilling heat maps for proactive temperature management in geothermal wells during well planning and real-time drilling operations phases to avoid thermally induced drilling problems.This study uses a transient hydraulic model integrated with a thermal model to predict the bottomhole circulating temperature (BHCT) while drilling geothermal wells. The model is used to generate a large volume (1,000s) of case scenarios to explore the impact of various cooling and other heat management strategies on the BHCT in the Utah FORGE field, used here as an example, covering a wide range of drilling parameters. Results are captured, visualized, and analysed in convenient heat maps, illustrating the advantages of using such heat maps in geothermal well construction and real-time operations.Model validation with FORGE 16A(78)-32 well data and a west Texas case scenario shows good agreement between the modelling results and experimental data, with a mean absolute percentage error (MAPE) of less than 4%. There is a clear logarithmic relationship between the drilling flow rate and BHCT at a constant mud inlet temperature and a linear relationship between the mud inlet temperature and BHCT at a constant drilling flow rate. Pronounced variation of BHCT in geothermal wells is observed with mud type, mud weight, and mud viscosity. In addition, insulated drill pipe (IDP) technology is found to significantly reduce BHCT (14–44% on average for FORGE scenarios) compared to conventional drill pipe (CDP), particularly in wells with extended measured depth (MD) where other heat management technologies and strategies become less effective.

T. Cowen in [8], attempted to demonstrate the technical requirements and performance of a microscopical assay using a densitometric application of image analysis to measure immunohistochemical stain intensity. Not surprisingly, the techniques required were more demanding than those used for the quantification of field and object parameters in the nervous system. The following areas of methodology have been shown to be important: (1) use of buffers free of metallic ions for tissue processing, (2) selection and titration of first and second layer antibodies, (3) reduction and control of fading of fluorescence, (4) selection of microscopical and imaging equipment to give accurate, sensitive and uniform representations of low-light biological images, and (5) use of appropriate image analysis algorithms in order to generate binary images that match the spatial and intensity distributions of immunostaining. Incorporation of these techniques into our assay system gave sensitive measurements of the time-scale of uptake of 5-

hydroxytryptamine (5-HT) into sympathetic nerve terminals. The microscopical assay appears to have advantages over alternative approaches used for studies of neurotransmitter dynamics, particularly in small, heterogenous tissue samples.

Harish Patelet al. explored that recent experiences with manufacturers, operators, rig contractors, and industry committees will be shared to provide a broad, high-level overview of a design concept that is new to many segments of our industry[9]. The paper is intended to initiate further discussions while providing insights for the future design of high-pressure, high-temperature (HP/HT) equipment. Current gaps in equipment codes and design standards along with a fundamental shift in design methods have created unique challenges with a need for modification. Guidance documents available to the designers and manufacturers of HP/HT equipment are limited with respect to prescriptive requirements, and more work is required. This paper addresses the application of the American Society of Mechanical Engineers (ASME) codes and standards, (or a functional equivalent,) for HP/HT oil field equipment in proposed subsea environments that include exposure to harsh fluids. It will also discuss what is required to adequately evaluate fatigue design concepts. Further dialogue is needed to appropriately address the concerns of regulators, manufacturers, and operators regarding the optimum method to achieve a safe fatigue-sensitive designs. The United States Bureau of Safety and Environmental Enforcement (BSEE) requirements for fatigue-sensitive applications require a detailed verification and validation of equipment designs, materials selection, and the manufacturing process. Criticality of key components in an HP/HT system and their impact on fatigue design and safety margins for fatigue design will be discussed. In addition, suitability of using engineering codes written for pressure vessels for the design of HP/HT well control equipment will be deliberated.

## DISCUSSION

The kind of cable structure required for a given installation is a factor in the selection and use of cable. Conductors, cable configuration, insulation, and final coating are all components of cable manufacturing.

### Conductor

The craftsmanship, surroundings, and upkeep of conductor materials like copper and aluminum should be taken into account. With respect to these variables, the specifications for aluminum conductors are more stringent than those for copper conductors.

### Cable configuration

One conductor or three conductors may be combined to create a cable. Both kinds of arrangements have their benefits and drawbacks. Single conductors make multiple-cable circuits possible and are simpler to install and splice.As opposed to three-conductor wire, they have a larger reactance. High shield currents are carried by shielded single conductors, thus it's important to take precautions to keep the cable from overheating.

### Insulation and exterior finish

The kind of installation, ambient operating temperature, service circumstances, type of load served, and other related factors are often taken into consideration while choosing cable insulation and finish coating. Unusual circumstances, such caustic air, high ambient temperature, insect and rodent danger, the presence of oil and solvents, the presence of ozone, and severe cold, may be present in many installations. When two or more of these peculiar circumstances are present in a given application, choosing the right cables becomes much more challenging.

### Use of cables

The cable's insulation has to be strong enough to resist the voltage strains that arise from both typical and unusual operation circumstances. Therefore, the appropriate phase-to-phase voltage and the general system category, which are divided into 100%, 133%, or 173% insulation levels, should be taken into consideration when choosing the cable insulation.When the system is equipped with relay protection, which typically clears ground faults within a minute, cables in this category may be used. The grounded systems are the common name for this group.

When the system is equipped with relay protection, which typically eliminates ground faults within one hour, cables in this category may be used. Common names for this group include low resistance grounded systems and ungrounded systems.

Where the time required to de-energize the ground fault is indeterminate, cables in this category may be used. For ungrounded and resonant grounded systems, this level is recommended.The cable's required current carrying capability is determined by the load it supports. The following formula may be used to determine the current carrying capacity in situations where cables may be load cycled: Ieq is for equivalent current carrying capacity; t stands for the time period of constant current; I stand for constant current; T stands for the overall duty cycle; and E stands for cable voltage. The conductor size for thermal withstand should be chosen based on similar current carrying capability.

### Sized cables

The following criteria are used to determine the cable size:

1. The carrying capacity as of today

2. Voltage control

3. Rating for short circuits

Before choosing a cable size, consider these variables! Voltage regulation and short circuit rating parameters are often ignored. Due to this error, there may be a risk to people, equipment, and the cable itself.

### The carrying capacity as of today

A cable's thermal heating determines its current carrying capability. The NEC has tables available that show the current capacity for different cable sizes. The ICEA offers the most recent ratings for different insulation kinds and installation scenarios.The cable's current rating is based on a certain spacing that allows for thermal dissipation. Derating of the cable is necessary if this space is smaller where the cable is to be put.

### Voltage control

Voltage control is often not an issue with electrical power systems that have been properly built. To guarantee proper load voltage, voltage dips during very lengthy runs at low voltage should be examined. Checks on steady-state voltage control and beginning should both be done for spinning loads.Based on the circuit opening time for a short circuit scenario, the cable size chosen should be tested for its capacity to tolerate short circuits. To put it another way, the cable should continue to function without suffering any heat damage until the switching device, such as a circuit breaker or fuse, can fix the problem.When choosing and using cables at medium voltage, whether the cable should be insulated or not is a key factor. The following discussion explains the circumstances under which shielded cable should be chosen and used.

The following factors need to be taken into account while using shielded cable:

1. Insulation system type

2. Whether or not the system neutral is grounded.

3. The system's safety and dependability criteria

The electric field in power systems without a shield or metallic covering is partially in the atmosphere and partially inside the insulating system. Surface discharges will occur and ionize the air particles if the electric field is strong, as is the case with high and medium voltage. Ozone may degrade certain insulations and finish coatings as a result of air ionization.In multi-circuit systems, the external electric field may be strong enough to endanger workers on a single wire. If non-shielded cable is utilized, there may be significant safety risks while handling portable cables, cable assemblies, or exposed overhead cable installations

## CONCLUSION

For the system's reliability, uniformity, and safety, proper cable size is crucial. Money is wasted on big cables, while short circuits or fires may result from undersized cables. When the current surpasses the cable's capacity, a very tiny cable will heat up and get destroyed. Therefore, it is necessary to choose a cable size that will allow it to resist both the potential short circuit current and the full load current. Three key criteria are used to determine the cable size: the carrying capacity, voltage control, rating for short circuits.

## BIBLIOGRAPHY:

[1] M. Desquilbet, D. S. Bullock, and F. M. D'Arcangelo, "A discussion of the market and policy failures associated with the adoption of herbicide-tolerant crops," *Int. J. Agric. Sustain.*, 2019, doi: 10.1080/14735903.2019.1655191.

[2] J. Thuriot-Roukos, M. Bennis, E. Heuson, P. Roussel, F. Dumeignil, and S. Paul, "Design of a multi-well plate for high-throughput characterization of heterogeneous catalysts by XRD, FT-IR, Raman and XRF spectroscopies," *RSC Adv.*, 2018, doi: 10.1039/C8RA08216B.

[3] M. Mandal and I. Sahu, "Selection and fitting of metals in electrical apparatus," *Water Energy Int.*, 2016.

[4] D. Goyal, S. S. Dhami, and B. S. Pabla, "Vibration Response-Based Intelligent Non-Contact Fault Diagnosis of Bearings," *J. Nondestruct. Eval. Diagnostics Progn. Eng. Syst.*, 2021, doi: 10.1115/1.4049371.

[5] X. Zhang, R. Zhou, Q. Guo, and W. Zhang, "Local Cepstral Editing Procedure with Applications to Slight Gearbox Bearing Fault Feature Extraction," *Hsi-An Chiao Tung Ta Hsueh/Journal Xi'an Jiaotong Univ.*, 2019, doi: 10.7652/xjtuxb201912001.

[6] ANON, "Offshore drilling technology. Proceedings of a conference, Aberdeen, November 1995." 1995.

[7] M. S. Khaled, D. Chen, P. Ashok, and E. van Oort, "Drilling Heat Maps for Active

Temperature Management in Geothermal Wells," *SPE J.*, 2020, doi: 10.2118/210306-pa.

[8] T. Cowen and C. Thrasivoulou, "A microscopical assay using a densitometric application of image analysis to quantify neurotransmitter dynamics," *J. Neurosci. Methods*, 1992, doi: 10.1016/0165-0270(92)90048-I.

[9] H. Patel, J. Ji, S. Meruva, and J. Lin, "Adequate fatigue design for HPHT," 2017. doi: 10.4043/27524-ms.

# SELECTIONS AND SIZING OF HT CABLE AND LT CABLE

**Dr. Shilpa Mehta***

*Professor,
Department of Electronics & Communication (Communication System Engineering),
Presidency University, Bangalore, INDIA
Email Id-shilpamehta@presidencyuniversity.in

## ABSTRACT:

*Cables support the transmission and distribution networks used in modern power systems. Although short circuit faults occur more often in underground cables than in above-ground transmission lines, due to the thermal and dynamic stress they generate, short circuit faults must still exceed resistance criteria. The High-Power Laboratory has routinely tested for short circuits on the LT and HT cables. This page provides a summary of the experiments that were done. There are different type of the cable LT and HT cable according to the current capacity. In this book chapter we discuss conductor of the cable, number of cores, selection criteria of cable, cables for medium voltage power, continuous current rating, short circuit current, voltage of electric wire etc.*

**KEYWORDS:** *Cable Sizing, Current Rating, Continuous Current, Ht Cable, Voltage Cable.*

## INTRODUCTION

Electricity is the primary cause of fires in 50% of urban, suburban, and suburban settings. Accident more than anything else lesser wire Yes, because of its poor quality, such incidents happen more often. Short circuits and electrical overloads are often to blame for fires. Electricity is responsible for almost half of fires in industries or regions near manufacturers. Additionally, this electricity is to blame for 60 to 70 percent of fires in the nation. The market offers a wide variety of wire kinds. However, it is of a lower quality. Additionally, a lack of knowledge about cable selection leads to a lot of issues.

For your high voltage line, it's crucial to understand HT cable selection rather than merely LT cable selection. Perhaps you're wondering how you can properly understand how to choose HT cables.A collection of many wires bundled together to carry an electric current is known as an electric cable. As they assist in moving electricity from one place to another, they are the most crucial component of the whole power transmission system. The cable is available in a variety of forms, diameters, and voltage ranges.

Cables may be categorized as either low voltage or high voltage cables. Both high tension (HT) and low tension (LT) cables are other names for them. Additional Rating: LT cables are rated between 660 and 1100 volts. HT cables are defined as having a voltage rating of more than 3300 V (33kV).

### Armoring

Armoring describes a cable's protective coating. Some LT cables are not armored; however, armor is found in both the round and flat cables. LT and HT cables, in contrast to other cables, include an insulating layer to shield the cable from any mechanical or environmental effects. Insulation for LT cables is made of materials like cross-linked polyethylene (XLPE) or polyvinyl chloride (PVC). The majority of HT cables include XLPE insulation.

**Conductors**

Copper or aluminum conductors are used in LT and HT cables. Aluminum is less expensive than copper. The cost of cables tends to move along with the market price of copper.

**Number of Cores**

LT cables have up to 61 cores (LT Control cables), ranging from 1 core to 2 cores. Stranded copper or aluminum conductor cores make up HT cable. They have one core or three.

**Application**

There are many uses for LT and HT wires. LT cables may be utilized in 1.1 kV range-related businesses including electricity distribution, power plants, trains, etc. While power transmission and distribution with a range higher than 1.1 kV uses HT cables.

## LITERATURE REVIEW

Rajkumar et al. explored that modern electricity distribution and transmission systems rely heavily on cables. Although short circuit faults are more frequent in overhead transmission lines than in subterranean cables, they nevertheless must be tolerated due to the thermal and dynamic stress they cause[1]. Short circuit testing on LT and HT cables have been periodically performed by High Power Laboratory. A summary of the experiments conducted is provided in this publication.

Er. Parveen Kumar Goyal explored that overhead lines are often used extensively in both the urban and rural electrical power transmission and distribution systems. Underdeveloped and emerging nations did not benefit from the underground system. The major cause of it was the much greater capital expenditure required for subterranean cabling compared to above bare wires. But because to market rivalry and technological innovation, metropolitan regions can afford it. Compared to overhead lines, this method demands greater preparation and expertise for installation, jointing, and termination. The power distribution system up to 33 KV is used with the paper that is being presented[2].

Mahmood et al. discussed that the nature of the load has changed significantly in recent years, and several pieces of electrical equipment, including as mercury lamps, transformers, motors, and switchgears, are functioning naturally at low power factors. Because of this, power supply authorities must provide a lot more current than is necessary. Our system's high current level has to be decreased, and efforts should be made to increase its ability to handle energy while incurring the fewest costs possible. This covers a variety of methods, including enhancing power factor, altering conductor size, swapping cables for conductors, etc. The major goal of this project is to provide a technique and set of guidelines for distribution engineers that will demonstrate how the system's capacity may be preserved by minimising energy losses without adding more capacity. Any specific HT/LT system is evaluated using a generalised computer programme, which then suggests capacitor banks at various places and varied conductor diameters in various system components.As a consequence, the system's stability and energy handling capability are increased at the lowest possible cost[3].

Loganathan et al. discussed that the most general phrase used to describe an electrical transmission network in a GIS system is "electrical utility network". The network begins at the source and finishes at the washbasin. The source is where electricity is generated, and the washbasin is where it is used upthis might be in a modest residence or factory. The energy that is transferred via this electric utility network starts at the source, is dispersed through the grid, is sent to the ends by way of feeders, switches, and transformers, and is then linked by cables. The total technical and commercial loss incurred throughout this procedure cost our nation 700 billion Rupees, or around 25% of the total. Finding the loss pocket is the first step in reducing the loss. The purpose of GIS is to pinpoint loss pockets by geographically mapping the entities, executing the whole process in real time, and sharing the data across all verticals. This paper's goal is to provide recommendations for the most efficient ways to use GIS for planning, analysis, load forecasting, and asset management for power distribution systems[4].

Junaid, et al. explored that due to their electrical nature, personal computers (PCs) require non-sinusoidal current. This non-sinusoidal current significantly distorts voltage as it travels through the line's or cable's resistance. This distorted voltage, which occurs at the LT/HT sides of the distribution transformer in a parallel connection scheme, has a substantial impact on the operation of equipment that is only intended to function at sinusoidal voltage and current. Using the programme Electrical Transient Analyzer Programme (ET AP), the whole distribution network of Rachna College of Engineering & Technology (RCET), Pakistan, has been simulated in this research article. In an experiment carried out for this purpose at the RCET Research Lab, the oscilloscope was used to capture the current waveform pulled by a PC together with its spectrum. This single PC model is added to ETAP's harmonic library to simulate the RCET distribution network. In this study paper, the effects of harmonics produced by PCs on distribution transformers have been thoroughly analysed. Additionally, a mathematical & graphical analysis of the trend of Total Harmonic Distortion (THD) with variation in various kinds of loads has been done[5].

## DISCUSSION

### Cables for Medium Voltage Power

In the market, a range of cables in different sizes are offered. However, you need an electrical cable size calculator to determine which size is best for your application. It aids in your understanding of the ideal fit size for your needs. It is computed using British and IEC standards. The power factor used to calculate the KW is 0.8. Calculator for Cable Sizing for 230V and 415V Voltage Drop.Divide the voltage flowing through the cable by the desired current to get the cable size. For instance, divide 150 by 30 if your wire has a voltage current of 150 volts and your aim is 30. You now have the necessary target resistance of 5. An electrical cable size calculator is useful for doing huge calculations.

Typically, 1.5mm or 1mm wires are utilized while looking for wiring for domestic lighting in your house. The majority of the time, 1 mm electrical cable sizing is sufficient. Only use 1.5 when the cable length is long and you need to deal with supply and demand changes as well as voltage drops.When choosing a cable, the electrical cable sizing chart aids in more informed decision-making. The size of cable needed for your application may be determined using these charts. For instance, if a small-sized cable is utilized, the excessive current flow may cause it to melt. Thus, a cable sizing chart is useful for estimating size and diameter. The greater the resistance to energy flow, the smaller the diameter.

The voltage rating for medium voltage cables ranges from 1KV to 100 VK. They contain intricate connections that must be correctly cut. If they are not cut correctly, they might explode and harm people or property. The rise in demand for a level of voltage led to the introduction of the idea of MY Cable Sizing. The categorization evolved along with the growth in demand. Extra low and high classes are also available today.The power cable size calculator assists in evaluating the size of the cable needed to prevent any accidents as cables with varying levels of electrical resistance are used in various applications.We provide you with the most straightforward method to determine the size that is acceptable for your application since the formula for calculating electrical cable size is tiresome and complex. The British Standard for the Current Carrying Capacity of Single Core Armored XLPE Insulated Copper Cable, Bs7671 Cable Sizing, is used to compute size.Any electrical network's nerve center are its electrical wires. In each electrification project, cables make up a significant portion of the capital outlay. They are also the most susceptible to failures. The majority of cable failures might be attributable to poor choice. The purpose of this essay is to discuss the subject of choosing electrical power cables properly.

### Voltage Rating

This is the system's rated voltage for the cable to be placed and utilized in. It's also crucial to understand how to earth a system. The cable's rated voltage is often stated as a dual rating, such as 6.6kV (UE)/11kV (E).The designation "UE" denotes the cable's suitability for usage at the given voltage in an uncovered or ineffectively earthed system. The letter "E" indicates that the cable may be used in a fully earthed system at the given voltage. Therefore, a cable with a rated voltage of 6.6kV (UE)/11kV (E) may be utilized in systems that are 6.6kV unearthed, 6.6kV non-effectively earthed, or 11kV firmly earthed.

### Conductor type

Copper or aluminum are the two most often utilized conductor types in cables. As is well known, the continuous current rating, the short time current rating, and the cost per unit length of a Copper cable are much greater than those of an Aluminum cable for the same voltage rating, type, insulation, cross sectional area, and method of installation[6]–[8].

### Insulation material

The majority of cables in use today are either insulated with PVC or with XLPE. Evidently, the continuous current rating, the short time current rating, and the cost per unit length of an XLPE insulated cable are significantly higher than those of a PVC insulated cable for the same conductor material, voltage rating, type, insulation, cross sectional area, and method of installation.Armored or unarmored cables unarmed cables are used in above-ground and interior installations such as cable trays, ditches made of pre-cast concrete, etc. Any subterranean cable installation must use armored cables.The armor may be a wire or a strip composed of aluminum or galvanized iron. Frequently, this armor is only linked to the plant's earthling system at one end, usually the transmitting end.

### Continuous Current Rating

Various cable manufacturer catalogues provide the continuous current ratings of cables with copper and aluminum conductors. However, it should be remembered that these catalogues only provide continuous current ratings under certain, predetermined laying circumstances. In reality, obtaining or maintaining these normative criteria is impossible. To determine the practical continuous current rating, a few rating parameters are therefore utilized.

1. Rating factor for fluctuation in ambient temperature
2. Rating factor for variation in ground temperature or duct temperature

3. Group Rating Factor - Vertical Spacing
4. Group Rating Factor - Horizontal Spacing Rating factor for variance in soil thermal resistance

The cable manufacturers' catalogues also provide all of these rating variables for a variety of circumstances.Cables are made up of reactance and resistance, which causes voltage drop. And hence a voltage drop will from the current passing through such an impedance. The loads linked by the cable shouldn't be impacted by this dip.The catalogues of the cable manufacturers include the actual voltage dips in cables for different kinds of cables in V/km/A. The code of practice for the installation and maintenance of power lines up to and including 33 kV rating is also included in Indian Standard IS 1255.Calculating the acceleration state voltage drop during the startup of heavy loads is just as important as calculating the steady-state voltage drop.Additionally, it must be assured that the voltage drop in the acceleration state at the load terminals is no greater than 15% and the voltage drop in the steady state at the load terminals is no greater than 10%.

### Cable HT

Wire or cable refers to an electrical conductor composed of fibre, copper, or aluminium. The power of power passes via whatever current or energy runs through. One of the crucial methods of data transfer is cable. Cable is used to carry or convey all electrical energy, electrical, and electronic information. HT cables are defined as having a voltage rating of more than 3300 V (33kV).

### RM of Cable

The term "RM" denotes a round conductor in the context of an electric cable or wire. I hope you realise that RM stands for "stranded round conductors" and that the image and list of these conductors are below. You must be familiar with rm = stranded round conductors in order to calculate cable size, determine cable size, and determine cable size.HT cable size may be determined in a variety of ways. Certain claim that just by perusing the catalogue of a cable maker, one can see that certain people's selection procedures are so intricate that they often become superfluous. But proper power cable sizing is essential for construction as it guarantees that the cable will: continuously operate at higher loads without interruption Withstand the highest possible short-circuit currents flowing through the cable Provide a suitable voltage to the load and avoid excessive voltage drops

### Inner sheath

Laid up cables have a high-grade PVC inner sheath that serves as a bed for steel wire or strip armouring. Filler cords are offered when necessary to keep the circularity of cable laying up. The inner sheath of Havel's cables is made of polymers, which are softer than the insulation or outer sheath, consistent with the cables' temperature ratings, and which have no detrimental effects on the other cable components. Applying the inner sheath may be done via wrapping or extrusion. Despite being tightly adhered to the laid-up cores of Havel’s Cables, the inner sheath may be removed easily without harming the insulation.

### Armouring

Armouring offers mechanical protection to the cable. Havel’s single core cables are armoured with wire or strips made of aluminium or an alloy of aluminium, preventing magnetic hysteresis losses on air conditioning systems. Galvanised steel wire and/or strips are included with multicore cables. Wherever cables must run vertically and are susceptible to pressures, galvanised wire armouring is supplied for Havells cables. Steel wire and tinned copper wires are used to armour the Havells Mining cables, increasing the conductivity of the armour to over 75% of the primary conductor of the cable.

**Current Carrying Capacity of Cables**

A cable system's amp city, or ability to remove heat from the cable and disperse it in the soil and environment around it, is a measure of the system's ability to carry current. The harm that excessive operating temperatures might cause to the insulation determines the maximum operating temperature for cables. There are three types of standardised ampacity ratings: transient (or emergency) state, steady state, and short circuit state. The ampacity of cables is calculated using both numerical and analytical approaches. The numerical method is mostly based on the technique of finite differences of finite elements. The circular form of the cables makes the finite elements method more appropriate for cable amplitude. The analytical technique is used as the foundation for standards by the two main international standards organisations, the IEEE and the IEC. With the exception of the air in the conduit in the duct banks or buried duct installations, conduction is the primary method of heat transmission in an underground cable system. In the research's motivation, the various Ampacity Rating circumstances are taken into account.

**Transient state**

The transmission lines' excessive voltage spikes have deteriorated the insulators. When XLPE insulated cables are used for subterranean wiring, this is particularly noticeable. Cable failure ultimately occurs from this. However, in order to ensure that this failure does not occur, it is necessary to calculate the insulator breakdown due to temperature increase in order to estimate the over-voltage ratings of such cables. To determine the over-current rating, the increase in core temperature and the length of the over-current period should be known; this relies on their thermal conditions[5].

**Short circuit current**

In an electrical network from the unintentional connection of one or more phase conductors, either together or with the ground, according to Jean-Pierre in Nexus publication. There are two different kinds of short circuit currents: Three-phase symmetrical short circuits in which the three phases' currents are in balance with one another. Therefore, these currents exclusively flow through the conductor (cores) of the cable. The cause of a zero-sequence short circuit is an asymmetrical, or unbalanced, current system. Zero sequence currents return via conductors that are electrically parallel to the ground or the ground itself. Ground conductors, or metallic screens linked to the ground at the line termination or the ground itself, make up the majority of these conductors.

**Voltage of electric wires**

Low voltage cables (up to 750 V) may be used for a number of purposes and have coatings made of both thermoplastic and thermoset materials. They are created and constructed in accordance with unified specifications.

**Low voltage cables**

Also known as 0,6/1 kV (up to 1,000 V) The cables in this part are utilised in a variety of sectors (general industry, public installations, infrastructures, etc.) for industrial power installations. They are created in accordance with UNE, IEC, BS, and UL international standards[9], [10].

### Medium voltage cables

Medium voltage cables with a range of 1 kV to 36 kV they are used to transfer power from transformer stations to electrical substations.

### High voltage cables

High voltage Cables for start at 36 kV they are used to move power between electrical substations and producing units.

## CONCLUSION

To avoid any interaction between other items or living things and a high voltage conductor, high voltage power cable systems are used. Additionally, its leakage current has to be properly managed and observed. Whether they be LT or HT lines, overhead lines are drawn using various kinds and sizes of aluminium conductors. All Aluminium Conductors (AAC) hard drawn 1350 aluminium alloy is used to make one or more strands of this sort of conductor. They are ideal for any weather because of their great soil insulating resistance. Additionally, LT aerial bunched cables are more adaptable. It implies there won't be any disruptions since they operate simultaneously with the present overhead bare conductor system.

## BIBLIOGRAPHY:

[1] V. Sreeram, M. Rajkumar, S. S. Reddy, T. Gurudev, and . M., "Short Circuit Testing of Cables: HPL Experience," *Power Res. - A J. CPRI*, 2020, doi: 10.33686/pr.v18i1.1094.

[2] Er. Parveen Kumar Goyal, "Installation, Testing and Jointing of LT and HT Power Cables up to 33 KV," *IISTE*, 2014.

[3] S. A. Qureshi and F. Mahmood, "Evaluation by Implementation of Distribution System Planning for Energy Loss Reduction," *Pakistan J. Eng. Appl. Sci.*, 2009.

[4] S. Mathankumar and P. Loganathan, "GIS Based Electrical System Planning and Network Analysis," *World Eng. Appl. Sci. J.*, 2015.

[5] R. A. Jabbar, M. Junaid, M. A. Masood, and K. S. Akhtar, "Impacts of harmonics caused by personal computers on distribution transformers," in *2009 3rd International Conference on Electrical Engineering, ICEE 2009*, 2009. doi: 10.1109/ICEE.2009.5173191.

[6] J. Zhu *et al.*, "Experimental investigation of a high temperature superconducting pancake consisted of the REBCO composite cable for superconducting magnetic energy storage system," *IEEE Trans. Appl. Supercond.*, 2019, doi: 10.1109/TASC.2019.2897574.

[7] E. W. Collings, M. D. Sumption, R. M. Scanlan, D. R. Dietderich, and L. R. Motowidlo, "Low coupling loss core-strengthened Bi:2212/Ag rutherford cables," *IEEE Trans. Appl. Supercond.*, 1999, doi: 10.1109/77.783405.

[8] M. D. Sumption *et al.*, "AC loss in cored, stabrite-coated, superconducting cables in response to external compaction and variation of core thickness and width," *Cryogenics (Guildf).*, 2001, doi: 10.1016/S0011-2275(01)00153-9.

[9] C. Almeras *et al.*, "[Double J stent removal's cost estimate using a re-sterilizable fibroscope in a French private structure].," *Prog. en Urol. J. l'Association Fr. d'urologie la Soc. Fr. d'urologie*, 2017.

[10] S. L. Welles, D. Shepro, and H. B. Hechtman, “Vasoactive amines modulate actin cables (stress fibers) and surface area in cultured bovine endothelium,” *J. Cell. Physiol.*, 1985, doi: 10.1002/jcp.1041230307.

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# ROLE OF COMPACT SUBSTATION IN POWER SYSTEM

**Mrs.Kamireddi Sunandana***

*Assistant Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-sunandanak@presidencyuniversity.in

## ABSTRACT:

*This chapter explores the key role of compact substation in power system. An electrical generating, transmission, and distribution system includes a substation. Substations conduct a number of additional crucial tasks in addition to converting voltage from high to low or vice versa. In order to make it simple to supply homes and businesses in the region via lower voltage distribution lines, a substation converts high voltage power from the transmission system to lower voltage electricity. Electricity may travel at various voltage levels via many substations between the producing plant and the customer. Compact substations are often outdoor substations enclosed in metal, where each piece of electrical equipment is placed closely together to reduce the overall size of the substation's footprint. They are frequently utilized in sectors including mining, oil and gas, renewable energy, and industrial plants since they are made to be simple to transport, install, and maintain.*

**KEYWORDS:** *Compact Substation, Low Voltage, Power Distribution, Transformer.*

## INTRODUCTION

One type of compact complete set of distribution equipment is the prefabricated compact substation, which is designed by combining medium voltage switchgear, low voltage switchgear, distribution transformer, energy metering devices, and reactive power compensation devices into one or more boxes in accordance with a specific wiring scheme. It is appropriate for three-phase AC systems for line and distribution of electrical energy with rated voltages of 11KV or 33KV.Prefabricated compact substations with voltage ratings between 11 kV and 33 kV were often employed in all three phases of the power distribution system due to their benefit of being small in size. Due to its compact size and IP55 protection level, it might be mounted outside.

Prefabricated compact substations are appropriate for residential areas, urban public utilities, and construction power supplies, among other applications. Users may choose compact transformers based on various load levels and use scenarios.If there are no particular requirements, our clients often choose an oil-filled transformer in the prefabricated compact substation since it is less expensive than a dry type transformer. The distribution transformer's capacity ranges from 100 KVA to 1250 KVA, with a limit of 1 600 KVA.

The prefabricated compact substation shell part uses the most recent domestic leading technology; the shell typically uses galvanized steel plate, while the frame makes use of standard container materials and manufacturing techniques, has a strong antiseptic performance, and offers a 20-year rust-free guarantee. The ability of the equipment to operate normally in difficult settings between -40°C and +40°C is unaffected by the natural climatic environment and external contamination.Due to ageing equipment and rising demand, the majority of businesses worldwide are looking for solutions to replace substations or improve their capacity. However, it cannot be disputed that updating transmission infrastructure is a difficult and expensive task. the electricity sector is searching for more affordable options, and a tiny substation is one such option.

### Miniature Substation

Well, a compact substation may be defined as a collection of electrical devices that are mounted on a platform or trailer. A small substation is integrated and carefully tested in a manufacturing setting to verify that it is capable of completely energizing upon delivery to the appropriate location. A small substation has more benefits than a traditional substation, including quicker construction times, less need for space, and more safety.

## LITERATURE REVIEW

Yin et al. explored a technique of enhancing the discharge distance of the silicon rubber encased wire is presented in response to discharge caused by foreign matter hanging in the wire in the protected dead zone in the 3/2 wiring mode of the 500 kV conventional substation. Based on the reality that the field insulation is directly impacted by the distance between the equipment, the current transformer (CT) addition scheme's limits are examined. The dead zone solution of compact 3/2 wiring mode silicone rubber sheathing is proposed through material selection, high thermal conductivity performance analysis, resistance leakage tracking performance analysis, thickness selection, installation process control, and electric field simulation analysis. The test findings, which give a theoretical foundation and real-world experience on how to prevent dead zones, confirm its viability[1].

In [2], researchers discussed that three-phase AC systems from 1 kV to 800 kV, offers recommendations for electrical operating and safety clearances and insulation levels in air-insulated electric supply substations, discusses insulation coordination practises, offers design guidelines for the selection and coordination of the insulation levels within the station as they relate to substation clearances, and discusses how decreased clearances in high-voltage ac substations will allow for co-location.

Binxian Luet al. in [3], explored that high voltage rated substations are very concerned about very fast transient overvoltage (VFTO) caused by operational disconnect in gas insulated substations. This approach is considered as accurate since it allows for the integration of various influencing elements, such as structural parameters and charge distribution, into analysis of 3-D electromagnetic finite element method (FEM). The electromagnetic FEM approach was used to analyse VFTOs, taking into account not only the structure of the conductors and contacts but also the initial non-uniformity of the electric field surrounding the conductors. According to the findings of the simulation, the VFTOs produced by the field-based model are bigger than those produced by the electromagnetic transient programme (EMTP), and they also occur sooner in time even if their diameter to length ratio is lower. Between the field-based model and the circuit-based model, simulation was compared. The essential considerations for using a field-based model were discussed. Analysis techniques have a considerable impact on the size of simulated VFTOs for greater diameter to length ratios in compact GIS. This field-based analytic technique will be utilised to model the arcing channel, determine the corresponding source line impedance in GIS, and conduct phase-selection research to decrease VFTO.

E. Dullni et al. in[4], explored that in the case of an internal arc occur-ring in switchgear assemblies (IEC 62271-200) or in pre-fabricated substations (IEC 62271-202), many international standards address the safety of workers. Switchgear assemblies may have various design characteristics with differing likelihood of fault incidence, despite similar testing and parameters, which the manufacturer may analyse using risk assessment. The issue of whether an internal arc test, for instance, is necessary not just for the high voltage portion of a substation, but also for the low voltage portion, may also come up in standard writing. This problem is important as pre-fabricated substations expand into new uses in utility and industrial networks, where the power flow may be bidirectional, as in tiny substations regulating solar power plants, for instance. In addition to the manufacturer, who is in charge of making safe items, it is the user's responsibility to evaluate and lower the danger of an internal arc occurrence.

Heinrich Kohl et al. in [5], explored that in light of the significant upfront expenditures associated with substation design, rationalisation is given primary emphasis. The system structure, the actual substation design, and the choice of contemporary primary distribution switchgear with universal applicability all play significant roles in this regard. The application of this trend and its potential futures are shown by the BELG system in Northern Bavaria.

Hongmei Liet al. explored that with the advantages of being highly dependable, environmentally friendly, and maintenance-free, VCB has a sizable market capacity in China and other nations around the globe. At the same time, 220kV power substations and industrial consumers with significant loads often utilise small 40.5kV air insulated switchgear with VCB. In 40.5kV air insulated metal enclosed switchgear, various failures will eventually arise, and practical operation over many years has shown. Statistics indicate that inadequate insulation performance is to blame for the majority of faults and failures. In this work, the root cause that leads to insulation fault and failure was explored by simulation and electrical test based on the various appearances of fault and failure that happened in the operating field of switchgear. Numerous causes may in various faults and failure modes, according to a detailed investigation of fault and failure. The following are some major causes that may be determined, field environment, switchgear maintenance, selection of insulation part and material, design of insulation part, manufacturing processing of insulation part, assembly processing of component used in air insulated switchgear. In this article, FEA simulation and electrical testing were used to enhance the insulation performance of air-insulated metal enclosed switchgear. The test show that simulation is a beneficial technique to improve the quality of insulation components[6].

Aditya et al. explored that when fossil fuels are becoming more limited, the development of gas motor cycles greatly improved fuel economy. The system control for automobile technologies has improved throughout time. The fuel safety and valve system control were designed and put into place in the preceding final project. For the Wisanggeni motor cycle, a new renewable technology was designed and implemented in the form of an automated gas level indicator, auto lock and charging system. Using an MPX5700DP sensor, this device indicates the amount of LPG gas. When the gas motorcycle becomes too hot, this system also serves as safety. The technology will immediately stop the gas supply, which will turn off the motor cycle. Last but not least, this system has a charging station for smartphones. This motorbike underwent some experimental testing during the manufacturing process, including the choice of the sensors to be used, data collection from the MPX5700DP sensor, EOT, and the development of the circuit regulator for automatically maintaining or terminating a voltage at a specific level when using the charging system[7].

## DISCUSSION

### Significant Benefits of Compact Substation

Compact substations are often favored over traditional substations because they are full solutions that can be simply configured to meet the needs of the client[8].

### Lower Total Costs

These units are pre-assembled in comparison to a traditional substation, which helps to save expenses. So, there is a decrease in the price of shipping several components, field wiring, and on-site testing. They are carefully designed so that they accelerate installation and significantly shorten building time. Additionally, they shortened the testing procedure on-site, which saved money and time.

### A Miniscule Trace

Compact substations are designed to take up the least amount of area possible. And unlike with traditional substations, fitting them in various configurations is not difficult. The covered equipment makes it simple to transport them to the required position and eliminates the need for extra electrical clearances.

### Removed environmental risks

A normal substation must be dug up, which affects the natural drainage; this is not the case with a compact substation. The device is contained in a tamper-proof metal container, which eliminates a number of environmental risks including exposed grounding conductors and fences.

### Comfort and Safety

Equipment relocation is not a problem with a small substation, nor is it necessary to demolish or rebuild a conventional station. This unit's mobility and small size make it very convenient. The equipment is completely enclosed, with built-in oil containment, covered grounded conductors, and has very few exposed components, among other safety measures. In general, it offers a safe atmosphere for everyone around.Given that the bulk of current substations won't endure for very long, it's time to choose a solution that offers more advantages. Future-proof substations are compact ones. After all, maintaining outdated technology with expensive maintenance or replacement is pointless. Contact us and our specialists can help you if you have any inquiries about compact substations.

### Communal Substations

In addition to the fact that public substations are essentially outdoor-only substations, this sort of substation is owned by the firm that distributes power. Their primary responsibility is to provide consumers with electricity through single-phase or three-phase alternating current, or simply A.C. The two different kinds of power supplies, which may be either 230V or 400V, likewise use this as their normal voltage. Then it is separated into urban and rural substations, each of which may have only one transformer.

### Individual Substations

Private substations, on the other hand, are sometimes referred to as terminal type substations, such as substations where the MV line terminates at the substation's installation site. Additionally, since they are also controlled by the owner, they may generate both civil and industrial users from the shared MV grid.Additionally, the user must provide the distributing firm with access to a designated area where the equipment is kept and for which the corporation is accountable. Private substations, like other transformers, may have a variety of design options that the customer can select. However, prefabricated substations are often used in modern times.

### Work of Compact Substations

Switching plays a crucial role in the operation of small substation transformers because it allows you to shut off a feeding circuit when a load is required to safeguard the producing plants.Additionally, switching high voltages may be risky; thus, arc-reducing circuit breakers like oil and air breakers are excellent for use.High voltages may be used to step up and step down the voltage for power distribution and transmission across large distances. This implies that the current may be low, which in minimal transmission losses.

This indicates that either the voltage has to be increased or decreased since the current offered is insufficient for typical customer usage.Transformer banks of three 500kV autotransformers each are often installed. Because of this, the small substation transformer is particularly practical in terms of space. However, jeopardize its strength the quick answer is no in this case. In some circumstances, tiny substation transformers may be just as powerful as standard substation transformers.

### Reduced Losses

Because the demands for the short-circuit strengths are so high, the voltage level requirements for tiny substations are simply on another level. Every single transformer must be able to sustain a particular amount of short-circuit load.However, this indicates that autotransformers for subterranean substations can withstand an impedance of around 22%. In essence, this indicates that the transformer in the unit substation will continue to function normally even if it is subjected to loads that are 22 percent greater than typical. Unquestionably, there is a high impedance that presents difficulties for the management of stray losses, and this is completely supported by a 3D magnetic model that protects its structural design, particularly as the tank and clamping frame size grows.

### Requirements for a small substation transformer

The equipment of the compact substation transformers may be enclosed in an interior area now that we have attained the small substation components. This indicates that even in both scenarios, the installation of the compact substation transformer will adhere to both the local P.P.C. and the international safety regulations. Additionally, each facility must have particular demands and criteria that must be taken into account for each client.

Fuse and circuit breakers are typical safety devices for tiny substation transformers. In addition, they have high voltage bus bars, lightning arresters, load shedding, maintenance, and a lot more. There could be a metering device, low voltage bus bar, low voltage circuit breaker, and many more for unique needs. This is dependent upon the client's preferences.Depending on the manufacturer and the intended use, a tiny substation transformer may have different specs. Compact substations are often created to be cost-efficient, adaptable, and space-saving solutions for power distribution and control. The following are some typical features of a compact substation transformer:

### Voltage

Depending on the needs of the power distribution network, compact substations may be constructed to operate at a variety of voltage levels, such as 11kV, 33kV, or 66kV.

**Power Rating**

Depending on the load requirement, a small substation transformer's power rating may vary from a few kVA to several MVA.

**Configuration**

Depending on the application, a small substation transformer may be set up with different transformers, switchgear, protective devices, and control systems.

**Size**

Depending on its power rating, design, and installation area, a small substation transformer's size might change.Fuse, relay, and circuit breakers are just a few of the protective mechanisms that compact substations may be fitted with in order to avoid overloading, short circuits, and other failures. Compact substations are designed to distribute electricity safely and reliably.

**Efficiency**

To minimize power consumption and save operating costs, compact substations are constructed with minimal losses and high-efficiency transformers.

**Environmental considerations**

Compact substations are made with minimum environmental effect, low emissions, and low noise levels in mind.Benefits of a small substation transformer are given as follows. Compared to conventional substation transformers, a small substation transformer has a number of benefits.

**Space-saving design**

Compact substation transformers are made with a taking up less room than conventional substation transformers, making them perfect for usage in locations with limited space. They may be deployed in places where conventional transformers cannot, like as crowded cities or rural regions[9].

**Simple Installation**

since compact substation transformers are preassembled and tested. They may be swiftly placed with little impact on the neighbourhood.

**High safety standards**

Compact substation transformers are designed to fulfil strict safety requirements. To safeguard the transformer and guarantee safe operation, they include safety measures such protection against short circuits, overloads, and overvoltage[10].

**Reliability**

Compact substation transformers are designed with a long service life and high levels of reliability in mind. Before they leave the factory, they undergo rigorous testing and are built using top-notch materials.

**Flexibility**

Compact substation transformers may be modified to suit particular needs. They may be made to function at a variety of voltages and frequencies, and they can be customised to fit certain environmental requirements.

### Transformer for a small substation's size

Depending on the particular design and application requirements, the size of a small substation transformer might change. These transformers typically have dimensions that range from a few metres in length and breadth to bigger units, and they are designed to be more compact and smaller than conventional substations. A small substation transformer's size will vary according on the voltage and power rating, the requirements for the individual application, and the installation area. Compact substations are appropriate for usage in urban areas and other places with limited space since they are built to save space and need less land for installation. Overall, the precise specifications of the application in which a small substation transformer will be utilised will decide its size.

### Small secondary substation

A prefabricated substation called a compact secondary substation is made to fit in small spaces or other situations where a conventional substation is impractical. It is a self-contained unit that combines several elements into a single enclosure, including switchgear, transformers, protection and control equipment, and auxiliary systems. The transformer is often situated on top of the enclosure, and the substation is set up on a plinth.Compact secondary substations are often utilised in metropolitan areas, businesses, residences, and other places where space is at a premium and there is a great need for dependable and efficient power delivery. They may be put inside or outdoors and are designed to offer electrical power distribution and protection.A small secondary substation's cost-effectiveness as opposed to constructing a conventional substation is one of its benefits. They are also simple to move, set up, and commission, which cuts down on the time and expense of installation and commissioning. Additionally, in order to guarantee the security of both people and machinery, these substations are built to adhere to international standards for dependability, performance, and safety.

## CONCLUSION

Substations are the locations in the electrical grid where distribution feeders and transmission lines are joined by circuit breakers or switches, bus bars, and transformers. The substation needs to be placed away from overfilled areas. Transmission substations are constantly sought after outside of urban areas. In order to provide low voltage (LV) systems with energy from medium voltage (MV) systems, low voltage switchboards, distribution transformers, connectors, and auxiliary equipment are all included in a compact secondary substation (CSS), which is an assembly that has undergone type testing and arc testing. The substation's benefit a small substation has more benefits than a traditional substation, including quicker construction times, less need for space, and more safety.

## BIBLIOGRAPHY:

[1] J. Li, Z. Yin, S. Zhao, Y. Meng, J. Zhao, and P. Feng, “Silicon Rubber Sheathing Solution For Dead Zone of 3/2 Wiring Protection,” *Gaoya Dianqi/High Volt. Appar.*, 2021, doi: 10.13296/j.100-1609.hva.2021.12.029.

[2] Committee Ieee Society, *IEEE Guide for Recommended Electrical Clearances and Insulation Levels in Air-Insulated Electrical Power Substations*. 2006.

[3] B. Lu, Y. Shi, X. Lin, and X. Bian, “3D full maxwell research for effect of initial

electromagnetic field on very fast transient overvoltage in GIS," *IEEE Trans. Dielectr. Electr. Insul.*, 2016, doi: 10.1109/TDEI.2016.005390.

[4] E. Dullni, E. Hansen, and A. Müller, "Risk assessment of internal fault in compact substations under the aspect of new network topologies," 2014.

[5] H. Kohl, G. Henning, and R. Prohl, "EXPERIENCE GAINED WITH SIEMENS COMPACT SWITCHPANELS IN SECONDARY DISTRIBUTION SUBSTATIONS.," *Siemens Rev*, 1974.

[6] H. Li, D. Tan, and Y. Liu, "Application condition of 40.5kV air insulated metal enclosed switchgear with VCB in China," 2012. doi: 10.1109/CICED.2012.6508653.

[7] B. A. K. BABTYO, "Rancang Bangun Sistem Otomasi Gas Level Indicator, Auto Lock Dan Charging System Pada Sepeda Motor Gas Lpg (Wisanggeni)," *Tugas Akhir Inst. Teknol. Sepuluh Sept.*, 2016.

[8] A. A. Khairunisa and R. H. Yustrianthe, "KAJIAN EMPIRIS FAKTOR-FAKTOR YANG MEMENGARUHI KUALITAS," *J. Ilm. Wahana Akunt.*, 2015.

[9] G. W. Utomo and B. Prabawani, "Pengaruh Brand Ambassador Dan Citra Merk Terhadap Keputusan Pembelian Sepeda Motor Suzuki Type Nex," *Jur. Adm. Bisnis Fak. Ilmu Sos. Dan Ilmu Polit. Univ. Diponegoro*, 2017.

[10] V. Sharma and Y. Medury, "Impact of e-recrutment on Human Resources Supply Chain Management: An empirical investigation of service industry in Indian context," 2010.

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# PREPARATION OF EV CHARGER SINGLE LINE DIAGRAM

**Dr. Rajiv Singh***

*Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-rajivranjansingh@presidencyuniversity.in

## ABSTRACT:

*Electric vehicles (EVs) are becoming more and more popular due to a variety of factors, including falling prices and growing environmental and climate awareness. In terms of battery technical trends, charging methods, new research issues, and untapped opportunities, this report assesses the advancements of EVs. More specifically, a study of the worldwide EV market's situation right now and its potential is carried out. This chapter includes a thorough study of the power ratingincreasing accessibility, electric connection type, selection of microcontrollerand other essential components of EVs. Also included suggestions for power control and battery energy management as well as the many standards that are available for EV charging. We conclude our study by describing our predictions for the near future of this topic as well as the open research questions for both the academic and industry sectors.*

**KEYWORDS:** *Charging Infrastructure, Electric Vehicle, High Power, Charging Station.*

## INTRODUCTION

The fundamental component of an EV charging infrastructure is electric vehicle supply equipment (EVSE). The EVSE uses a connected connection and a control system to securely charge EVs by drawing power from the local power grid. A control system for an EVSE may perform a number of tasks, including user identification, charging authorization, information recording, and exchange for network management, as well as data privacy and security.For all charging needs, it is advised to utilize EVSEs having at least fundamental control and management features. The most popular charging technique is conductive charging, often known as plug-in (wired) charging. The amount of EVSE needed for conductive charging depends on a number of variables, including the kind of vehicle, the battery capacity, the charging techniques, and the power ratings.

In India, light electric vehicles (LEVs), which include two-wheelers (scooters, motorcycles) and three-wheelers (passenger and freight), are anticipated to be the primary force behind transport electrification during the next ten years. The two important vehicle sectors that are being electrified include autos and light commercial vehicles (LCVs), in addition to these. There will also be a lot more electric buses, although these are beyond the purview of this manual.The parameters of EV batteries affect the charging needs for EVs since electricity must be delivered to the battery at the proper voltage and current levels to enable charging. Various EV segments have varying average EV battery capacities and voltages. Low-voltage batteries power E-2Ws and E-3Ws. Low voltage batteries are also used to power the initial generation of e-cars. Nevertheless, even if they persist in certain use cases like taxis, they will probably be phased away in the future. The forthcoming e-car models of the second generation of e-cars are powered by high-voltage batteries. Depending on their ability to carry a load, electric LCVs will be made up of both low-voltage and high-voltage vehicles.

Direct current (DC) must be supplied to the battery pack in order for an EV to charge. A converter is needed to deliver DC power to the battery since electrical distribution networks only offer alternating current (AC) power. AC or DC conductive charging is both possible. In the case of an AC EVSE, the onboard charger of the EV receives the AC power and converts it to DC. Bypassing the onboard charger, a DC EVSE externally transforms the electricity and delivers DC power straight to the battery. The four charging modes for AC and DC charging are further divided into AC charging (Modes 1-3) and DC charging (Mode 4). An electric vehicle (EV) may be connected to a regular socket outlet using a cable and plug in either mode 1 or mode 2. It is not advised to utilize mode 1, commonly known as dumb charging, since it prevents communication between the EV and EVSE. The portable cable used in Mode 2 is designed for home charging and contains built-in safety and control features. The upgraded control systems of modes 3 and 4, which provide a separate charger device to power the EV, are utilized for commercial or public charging.

### Power Ratings

Based on charging needs, EVSEs have varying power ratings or levels, which in turn affect the input power requirements for charging infrastructure. Classifies EV charging according to power level; low power charging is limited to 22kW, while high power charging is limited to 200kW. While EVSEs with power ratings up to 500kW are readily accessible across the world, they are mostly relevant to big trucks and buses. For e-2W, e-3W, and e-car charging, standard AC power is sufficient. Due to the high incidence of LEVs and the usage of low-voltage batteries in e-cars, normal power DC charging is unique to India. For LEVs and vehicles with single phase on-board chargers, single-phase AC chargers with a maximum power rating of 7kW are sufficient. For electric vehicles with bigger onboard chargers, three-phase AC chargers with a power rating of up to 22kW are necessary. The conventional electricity distribution network may offer input power supply for regular power charging. High-power DC charging of 50kW is utilized for high-voltage e-cars with battery capacity between 30 and 80 kWh. The market offers DC chargers with power outputs between 25kW and 60kW. However, more powerful DC chargers will soon be accessible. High-power DC charging, however, requires less time.

### Increasing Accessibility

Accessibility may be interpreted as the simplicity with which one can locate and get to public charging stations from any place. This comprises places with little predicted demand for charging but still in need of some basic infrastructure. Planning the network and choosing the best locations are important for increasing EV charging accessibility. The average distance that EV customers must travel to obtain public charging is decreased when there are more dispersed charging sites in a given location. Additionally, charging locations' visibility, their ease of entrance and egress, and their closeness to busy roadways may all affect how accessible they are.

### Utilize To the Fullest

To guarantee maximum utilization, public charging infrastructure should be placed where there is a need for charging. The need for public charging at a particular area will rely on a number of factors, such as the population and employment densities, parking accessibility, traffic volumes, and the existence of tourist attractions, transit stations, and other commercial businesses and other centers of interest. It also depends on if there are any other private or public charging stations nearby.

### Electrical Connection

The required sanctioned load determines the type of connection, such as single-phase LT, three-phase LT, or high-tension (HT), which has an impact on the tariffs, the time, and cost to obtain a connection, and the requirement for ancillary upstream infrastructure like Distribution Transformers (DTs). An HT connection requires the applicant to build up supplementary electrical equipment, incurs more installation and monthly demand fees, and takes longer to energies. States have vastly different sanctioned load limitations for LT and HT connections.

### Power Supply from Current Network

Commissioning an EV charging connection may be more expensive and time-consuming depending on the regulations controlling the delivery of electricity from the current network. It is simpler and more cost-effective to connect to an existing network (without the need for expansion) than it is to extend the distribution system. In addition to taking time, network expansion may also require the applicant to contribute financially.

### System augmentation is required for new connections.

When the capacity utilization of the closest feeder is anticipated to surpass the permissible level (often 70%) upon award of a new connection, such as a charging infrastructure link, a system upgrade is suggested. The distribution network may be expanded, although doing so can be costly and time-consuming. With lower sanctioned loads and fewer charging ports at each location, a dispersed public charging network may minimize the time and expenses involved with obtaining power connections for EV charging. It may also in higher capital and operating expenses and serve as a deterrent to installing EV charging stations when more charging outlets are necessary or mandated by building bylaws or other governmental regulations. The supply code has to be modified by SERCs and DISCOMs to provide a cost-effective and dependable energy supply for charging infrastructure. EV charging is a new kind of consumer need that is unique from current consumer categories.

### Captive Renewable Energy

Production has the option of using captive electricity production to partially or entirely satisfy the energy needs for EV charging. The viability of this choice must, however, be evaluated on a case-by-case basis. Solar photovoltaic (PV) or solar-wind hybrid systems are often used to provide captive electricity for EV charging, with stationary energy storage providing a stable power source. A crucial factor in determining viability is the surface area available for installing the generating system as well as the site's solar insolation and wind profile. A typical installation space for a 1 kWp solar PV system is 10 sq m. To make the most of the available space, the system may be built as a roof over the charging facility, or it can be installed, if necessary, on the host establishment's roof.

### Net Metering

Power generated on-site using renewable energy may be subtracted from the overall amount of power used during a billing period thanks to net metering or net billing. A "presumes" is a person or entity who uses energy from the grid and has the ability to provide power to the grid, thus this lowers their electricity cost. At the conclusion of the billing cycle, the presumes may choose to pay the DISCOM for any excess units or pay the difference in units. The rules allowing customers to participate by installing renewable energy generating equipment on their properties have been specified in several states' Net Metering Regulations, which have been made public. DISCOMs should encourage CPOs and host businesses to use the rules for net metering. Additionally, SERCs may provide incentives to EV owners who charge their vehicles using captive renewable energy sources.

## LITERATURE REVIEW

Jahnes et al. in [1], discussed that for the battery system of electric vehicles (EVs), a non-isolated DC charger is suggested. The innovative charging mechanism, which does not need a large transformer, may decrease leakage current. To stabilise the common-mode voltage and subsequently lower the leakage current, a zero-sequence voltage control approach is devised. A DC-DC converter for battery side control and a DC-AC converter for grid interface and common-mode voltage management are both included in the proposed fast charger's two energy conversion stages. For improved grid interface performance, the LCL filter system's settings are analysed and optimised. Grid service functionalities are designed to offer grid-voltage/frequency compensations for the EV charger. Low leakage current ($ 20 mA) is used to generate high power (22 kW) and high efficiency (>$99%). The suggested EV charging system is validated via the use of experiments.

Panda et al. in, explored that in order to charge EV batteries and enhance grid power quality at the same time, this paper offers an effective control method for a multifunctional grid-connected solar photovoltaic (PV) powered EV charger. In order to enhance the output voltage quality, a multilayer architecture is used for the grid-facing converter. The basic EV current and grid voltage needed to produce pure sinusoidal reference current and synchronising voltage template, respectively, are precisely estimated by the ANF. In comparison to a phase-locked loop and second-order generalised integrator under non-ideal grid voltage settings, the ANF-based voltage template estimator accurately predicts in-phase and in-quadrature synchronising voltage templates. To maximise PV production, the charger is designed to function in both grid-connected operation (GCO) and standalone operation (SO). In GCO, the charger supports the grid's reactive power and compensates for grid current harmonics. Additionally, in an emergency, it provides backup power for the household load. To enable a seamless transition from SO to GCO and vice versa, the charger control method also contains a grid synchronisation mechanism based on phase error reduction. The efficiency of the suggested control algorithm is verified in a laboratory prototype for an off-board EV charger with a 12.6 kVA output. The acquired findings attest to the charger's compliance.

Hosseini et al. in, suggests a bidirectional battery charger for electric vehicle (EV) operations from the grid to the car and from the vehicle to the grid. The suggested converter's dc stage has a quadratic buck-boost voltage gain ratio, which enables it to be used as a home EV charger by connecting the battery pack unit of EVs to both dc and ac grids. High levels of utilisation factors (UF) for both directions are attained, together with high voltage gain ratios, low voltage and current stresses on switches. The continuous output current of the suggested converter makes it feasible to implement the pseudo-dc-link approach for connecting to an ac grid while maintaining continuous input current and common electrical ground at the dc-dc stage. As a consequence, the suggested charger operates more effectively and coolly since the switching power loss in the dc-ac step of the EV charger is decreased. In-depth analysis is done on the working concept, steady-state properties, such as the current, voltage stress, and UF of the switches, and comparison with other cutting-edge dc-dc bidirectional converters. Finally, a 500-W laboratory prototype of the suggested EV charger is put into use to confirm the theoretical accomplishments. The EV charger displays the capacity to regulate both ac and dc, and it achieves a peak efficiency of 97.8% when operating in the forward direction and 97.5% when operating in the reverse direction.

Elrais et al. explored that research and development of power electronic converters are required in order to provide high power, affordable, and dependable charging solutions for the EV battery due to the widespread acceptance and anticipated expansion of electric cars (EVs). This study provides a thorough analysis of EV off-board chargers that use AC-DC and DC-DC power stages to transfer power from the power network to the EV battery. Off-board chargers must be used for dc fast and ultra-quick charging even if there are two kinds of EV chargers: on-board and off-board chargers. This will greatly decrease the volume and weight of EVs. Here, we review the state-of-the-art topologies and control strategies of both ac-dc and dc-dc power stages for off-board chargers with an emphasis on technical specifics, current research, and difficulties. Also displayed are the majority of the most contemporary multiport EV chargers that integrate solar power, energy storage, electric vehicles, and the grid. Furthermore, a comparison of the topologies and control strategies of ac-dc rectifiers, dc-dc converters, and multiport converters has been made in terms of architecture, power and voltage levels, efficiency, bidirectionality, control variables, advantages, and disadvantages that can serve as a roadmap for future research directions in EV charging solutions.

Morris et al. in [2], suggests a design for a single-phase bidirectional electric vehicle (EV) charger that can function in each of the four P-Q plane quadrants. Based on the actual answers of a bidirectional charger prototype for various P-Q demands, the steady-state and step responses of the proposed model are utilised to verify it. The model is effective for time-domain simulations that call for representations of a variety of EV chargers, such as EV integration studies in low-voltage (LV) distribution networks. A real-world case study examining the supply of vehicle-to-grid (V2G) for active and reactive power in an LV home distribution network is provided to illustrate and evaluate the suggested smart charger and model. These findings highlight the benefits of the charging model that is now being used to create V2G distribution network strategies.

AnjeetVermaet al. in [3], explored that the installation of a grid-connected domestic electric vehicle (EV) charger that can serve the needs of an EV, household loads, and the grid is given in this article. With the help of a PV array, the charger is equipped to run independently while supplying uninterruptible power and charging to home loads. However, the grid-connected mode of operation is offered if there is no PV array or inadequate PV array production. Additionally, the charger is supported by synchronisation and smooth mode switching management, enabling automated grid connection and disconnection without interfering with EV charging or residential supplies. The charger may also transmit active/reactive power from a car to the grid and from a vehicle to a residence to sustain local loads when an island is present. In order to achieve unity power factor functioning and a total harmonic distortion of the grid current within 5%, the charger is additionally regulated to function as an active power filter. Additionally, a sliding mode control is employed to regulate the dc-link voltage as part of an energy management approach based on dc-link voltage regulation. The sinusoidal reference grid current is produced using a second-order generalised integrator frequency-locked loop with dc offset rejection for successful operation under distorted voltage conditions.

## DISCUSSION

Although they have been around for more than a century, electric cars have only lately seen significant commercial success. Efficiency gains in battery technology today have boosted demand for electric cars that can compete with conventional internal combustion vehicles, and market forces have increased adoption rates. A very high-power item must now be regularly plugged into and unplugged from a residential energy supply for many car owners. A vast network of petrol stations is particularly advantageous for traditional worldwide combustion cars since it allows for quick energy supply and range expansion. Electric cars still have sluggish energy delivery rates, which necessitate keeping them immobile for a lengthy time to recharge, despite advances in technology. The drawbacks of the petrol station concept are further highlighted by the energy supply systems for electric cars that are sluggish.

The low battery charge currents used to prevent damage (an issue that is continually being addressed) and the limited energy capacity of the nearby grid connection are the causes of the sluggish charging pace. The addition of a high-power connection may raise concerns about dependability and safety. Public charging stations have access to considerably greater current connections found in business buildings, but in order to be useful, these facilities must be able to charge all types of electric vehicles (EVs) on the road. Electric car Service Equipment (EVSE), which regulates the power flow into an electric car, helps to minimise such issues. The J1772 SAE standard for AC electrical connections to a vehicle has been accepted by several automakers. International localizations use the same specs but with different form factors. The AC-DC converter for the battery charge system is built inside the car in the current standard design of EV charging systems, necessitating just AC power. Some cars are equipped with external DC-DC and charge circuits; however, this setup is not covered by this design.

## Microcontroller Selection

The MSP430TM series of microcontrollers (MCUs) from Texas Instruments (TI) includes a variety of devices that may be utilised to meet the needs of an EVSE. Due to its built-in delta sigma () converters, which may be used to incorporate power metrology, the MSP430F6736 microcontroller has been specially selected for this application. A potent 16-bit RISC CPU, 16-bit registers, and constant generators are further aspects of the gadget that let it run programmes as efficiently as possible. A successive approximation register (SAR) analogy-to-digital converter (ADC) to read the response of the vehicle on the pilot wire, an interruptible general-purpose input/output (GPIO) pin for quick responses to GFCI events, several universal serial communication interface (USCI) modules, and a highly accurate timer module are all features of the MSP430F6736. These MCUs also provide a straightforward, code-compatible route to devices with condensed flash, RAM, and feature sets for designs that simply need a portion of these functionalities.

## Charging Infrastructure Terminology

With this hierarchy for charging stations: location, EVSE port, and connection, the charging infrastructure sector has converged on a single standard known as the Open Charge Point Interface (OCPI) protocol. The following definitions of charging infrastructure are used by the Alternative Fuels Data Centre and the Station Locator.

## Station Location

A station location is a place having one or more EVSE ports at the same address. Parking lots in shopping centres or garages are two examples.

## EVSE Port

Even though it may have numerous connections, an EVSE port only supplies electricity to charge one car at a time. Sometimes referred to as a charging post, this structure contains the EVSE ports and may have one or more of them.

### Connector

To charge a car, a connector is connected into the car. One EVSE port may support a variety of connections and connector types (such as CHAdeMO and CCS), but only one car may charge at once. Some people refer to connectors as plugs.

### Charging Devices

The pace at which the batteries are charged determines what kind of charging equipment is used for EVs. The kind of battery, the amount of energy it can contain, the charging level, the charger's power output, and the electrical service parameters all affect how long it takes to charge a battery. Depending on these variables, the charging time might vary from less than 20 minutes to 20 hours or more. Numerous considerations, including as networking, payment options, and operation and maintenance, should be taken into account when selecting equipment for a particular application.

### Lithium-ion batteries for automobiles

Electric cars and a variety of portable gadgets employ lithium-ion (Li-ion) batteries, a kind of rechargeable battery. Compared to normal lead-acid or nickel-cadmium rechargeable batteries, they offer a greater energy density. The size of the battery pack as a whole may be decreased by battery makers.The lightest of all metals is lithium. However, lithium-ion (Li-ion) batteries only have ions and not lithium metal. Ions are atoms or molecules having an electric charge brought on by the loss or gain of one or more electrons. In addition to being safer than many alternatives, lithium-ion batteries must also have safety precautions in place to safeguard customers in the unusual case of a battery failure. To preserve the batteries during frequent, fast charging sessions that take place quickly, manufacturers, for example, include charging protections in electric cars.

### Quick charging

A battery may be charged by providing a DC current. The current generates electrical charge that is stored in the battery via an electrochemical process. The transportation of electrical charge per unit of time is referred to as current. As a consequence, the quantity of DC 1 current provided and the length of time passed both affect how much energy is given throughout the charging process. From a generator to the customer, electrical energy is delivered in AC amounts. As a result, such energy has to be transformed into DC amounts. This is the battery charger's main function. One fundamental issue with electric vehicles (EVs) is that they are not currently a particularly feasible substitute for vehicles powered by combustion engines[4].

Recharging an electric vehicle (EV) always takes longer than recharging a car with an internal combustion engine (ICE), which may be done in a few minutes. An electric vehicle (EV) may be charged in one to two hours. This kind of charging is known as rapid charging. Fast charging is the only practicable way to charge an EV in order to provide a practical replacement for the ICE. However, a very big charger is needed to deliver 75 kW. As a result, it is installed outside of the vehicle and utilized at a charging station since it could not be contained within the automobile. Two prototypes of such a charger one in Malmo and the other in Stockholm are in operation in Sweden. It is known as the DUAL battery charger. Using 375 V batteries and a current of 2 CIOA, or 75 kW of electricity, it can charge a bus. An EV owner may anticipate a much longer driving range thanks to rapid charging than they would with a regular charger for the same amount of time. This may be two, three, or even four times as much[5].

### Design Issues

It's critical to reduce an EV's weight as much as possible since it has a significant impact on performance. Although employing a single-phase AC supply for all charging would be the lightest design, using the three-phase grid was thought to provide benefits that outweighed the "weight issue." Since inductors are heavy, one method of lowering weight is to try to minimize the size of the inductors. The acceleration, ability to climb hills, speed, and range of an electric vehicle are all impacted by its weight. Each time, the performance suffers. But it's also critical to make sure there is strong stability. The weight distribution is also a crucial factor. This is something to keep in mind, but it's not directly related to this project since the limits are mostly set by the vehicle's design. Additionally, it makes sense to utilize as little voltage as feasible. For instance, it will be better to utilize the lowest voltage feasible even when the nominal DC-link voltage has not been established in the early phases of design[6].

### Capacitance in DC links and semiconductors

The author was not in charge of the semiconductors or the capacitance of the DC connection. Instead, department staff members defined them from the beginning of the design process. Using intelligent approximation, for instance, the value of the DC-link capacitor, denoted as Cd in decided. It would be necessary to study the current spectrum to more precisely compute this capacitance value[7]–[10].

## CONCLUSION

A single line diagram can be created once the electrical needs of the EV charger have been established. The electrical connections between the EV charger and the electrical system, as well as any protection devices that will be employed, should be shown on the single line diagram. Making sure the single line diagram complies with local laws and regulations is crucial. This includes adhering to all applicable laws and regulations, including electrical and construction rules. Reviewing and approving the single line diagram is the last step. To guarantee that the installation is secure and complies with all relevant standards and regulations, this should be carried out by a qualified electrical engineer or electrician. Overall, drawing out a single line diagram for an EV charger is a crucial part of installing an EV charging station. It guarantees that the installation is secure, complies with local laws and ordinances, and satisfies the EV charger's electrical specifications.

## Bibliography:

[1] L. Zhou, M. Jahnes, M. Eull, W. Wang, and M. Preindl, "Control Design of a 99% Efficiency Transformerless EV Charger Providing Standardized Grid Services," *IEEE Trans. Power Electron.*, 2020, doi: 10.1109/TPEL.2021.3124987.

[2] M. Restrepo, J. Morris, M. Kazerani, and C. A. Cañizares, "Modeling and testing of a bidirectional smart charger for distribution system EV integration," *IEEE Trans. Smart Grid*, 2018, doi: 10.1109/TSG.2016.2547178.

[3] A. Verma, B. Singh, A. Chandra, and K. Al-Haddad, "An Implementation of Solar PV Array Based Multifunctional EV Charger," *IEEE Trans. Ind. Appl.*, 2020, doi:

10.1109/TIA.2020.2984742.

[4] M. R. Khalid, I. A. Khan, S. Hameed, M. S. J. Asghar, and J. S. Ro, “A Comprehensive Review on Structural Topologies, Power Levels, Energy Storage Systems, and Standards for Electric Vehicle Charging Stations and Their Impacts on Grid,” *IEEE Access*. 2021. doi: 10.1109/ACCESS.2021.3112189.

[5] S. Weckx and J. Driesen, “Load Balancing with EV Chargers and PV Inverters in Unbalanced Distribution Grids,” *IEEE Trans. Sustain. Energy*, 2015, doi: 10.1109/TSTE.2015.2402834.

[6] S. Taghizadeh, M. J. Hossain, N. Poursafar, J. Lu, and G. Konstantinou, “A Multifunctional Single-Phase EV On-Board Charger with a New V2V Charging Assistance Capability,” *IEEE Access*, 2020, doi: 10.1109/ACCESS.2020.3004931.

[7] A. K. Seth and M. Singh, “Resonant controller of single-stage off-board EV charger in G2V and V2G modes,” *IET Power Electron.*, 2020, doi: 10.1049/iet-pel.2019.1111.

[8] J. Nájera, H. Mendonça, R. M. De Castro, and J. R. Arribas, “Strategies comparison for voltage unbalance mitigation in LV distribution networks using EV chargers,” *Electron.*, 2019, doi: 10.3390/electronics8030289.

[9] H. Wang, X. Jia, J. Li, X. Guo, B. Wang, and X. Wang, “New single-stage EV charger for V2H applications,” in *2016 IEEE 8th International Power Electronics and Motion Control Conference, IPEMC-ECCE Asia 2016*, 2016. doi: 10.1109/IPEMC.2016.7512724.

[10] D. Patil and V. Agarwal, “Compact Onboard Single-Phase EV Battery Charger with Novel Low-Frequency Ripple Compensator and Optimum Filter Design,” *IEEE Trans. Veh. Technol.*, 2016, doi: 10.1109/TVT.2015.2424927.

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# EXPLORING THE DESIGN CHALLENGES OF EV CHARGER

**Ms.Renuka Bhagwat***

*Assistant Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-renuka@presidencyuniversity.in

## ABSTRACT:

*This chapter discloses the design challenges of EV charger. Moreover, this chapterprovides suggestions and idea for an intelligent process-based system that will create and oversee the charging procedures for electric vehicles (EVs). Due to the limitations of the electrical power distribution network and the lack of smart metering technology, charging of electric vehicles should be done in a balanced manner, taking into account past experience, meteorological data gathered via data mining, and simulation approaches. A mobile application was also developed to help the EV driver with these responsibilities by easing information sharing and improving user mobility. The proposed smart electric vehicle charging system connects renewable energy sources and electric vehicles to smart grids (SG) using vehicle-to-grid (V2G) technology. This book chapter also explores about the charging at home, installation fees for EV chargers, the power panel etc.*

**KEYWORDS:** *Charging Station, Design Challenges, Ev Charger, Electric Vehicle.*

## INTRODUCTION

EVs suddenly appear to be present everywhere. Prior to the EV boom, it wasn't unusual to spend days without seeing an EV, but today EV sightings are more frequent than ever. Many individuals wonder if they should purchase an EV in light of the current EV boom[1].The good news is that purchasing an EV is straightforward, particularly when it comes to charging, something many people are wary about. Many individuals still have questions about how to charge an electric vehicle (EV) at home as well as how to speed up the process and do it more quickly[2].Electric motors in electric cars are powered by electricity. Unlike automobiles that run on petrol, electric cars can be charged at home, so you never have to worry about pit breaks for refuelling (particularly if you travel locally). The lithium-ion battery pack of an electric vehicle (EV) enables the vehicle to store energy, which is then used to power the electric motor. Nowadays, it's easy to charge an electric car. In essence, you are taking electricity from your home's grid and sending it via a wire to your car. Obviously, depending on the kind of plug you're using, charging periods vary. But the beautiful news is that EVs come with a simple 120V charging connection that you can plug into your regular household outlets and start charging right away.

### Charging at home

Depending on your requirements, you could need to modify your house or you might be able to charge your vehicle using the included 120-volt wire without doing anything more. Why not use the wire that EV manufacturers currently provide before making changes to your house. An L1 (level 1) charger is the name for the included 120V charging adaptor. This converter can recharge your car at a pace of around five miles of range per hour of charging utilising the ordinary 120V infrastructure in your house[3].

Although it may not seem like much, leaving your vehicle to charge overnight may restore roughly 50 miles of range. You truly don't need an L2 charger if you travel fewer than 50 miles per day, which is fantastic news. Using the L1 charger overnight guarantees you can safeguard your battery over the long term since charging a lithium-ion battery to 100% continuously isn't the greatest for its battery life[4].Furthermore, the convenience of having a charging system for your automobile that you can just plug into a regular outlet to start charging it cannot be emphasised. Absolutely plug and play. The ability to arrange when your car starts charging with the majority of EVs is also a great benefit since you can plan for it to start charging during the times when your local grid has the lowest rates.

### Fast charging

On the other hand, an L2 (level 2) home charger installation is the solution if you need to charge your car more quickly because of a longer daily journey. As an illustration of how quickly your car may be charged with the L2 system, Enel X Way claims that its Juice Box charging stations can provide anywhere between 12 and 60 miles of driving range per hour. The L2 technology actually requires 240V electricity. If you're fortunate, you may be able to charge your electric vehicle for free using L2 chargers that are available for public use[5].This is far quicker than the standard L1 charger, even at the lowest end of the range, and can fully charge your car in the same amount of time that an L1 charger couldn't. However, installing an L2 charger and charging station in your house requires more work, therefore it's advised that you speak with a local electrical expert who can assess your property and decide the proper installation steps.

You probably already have practically everything you need if your garage has a 240V outlet (the same kind of outlet your washing machine plugs into). Nevertheless, it is still advised that you consult an expert, who can determine if it is secure for you to install the L2 charger and power it using the electrical system in your house. An electrician will need to adjust your electrical system and add a 240V outlet if you don't already have one so the charging station can hook into it. Alternatively, to being connected into a 240V socket, certain charging stations may be hardwired into your home's electrical system. If you install these hardwired stations outdoors, you may be required to do so.

L2 chargers are not required, but many individuals choose to install them nevertheless for their own piece of mind. Even if you don't use it much, it's still a useful function to have. Preparing for a lengthy road trip is the perfect situation for one of these L2 chargers. Simply charge your car overnight to have a fully charged battery when you need it. After you leave the house, you may plan your route using a charging software like Charge Point and decide where you want to stop for charging stops[6].

### L2 Chargers Will Prevail in Residential EV Charging

The difficulty of installing an L2 charger in your house will gradually disappear as more and more EVs are sold. In a few years, electric cars will be the norm for mobility, and most new houses will be built with them in mind.It is conceivable that the majority of newly constructed houses will include L2 charging infrastructure, and potentially even L3 charging in upscale residences. Implementing EV-friendly electrical infrastructure in your house is a smart way to raise the market value of an older property, and installing an L2 charger is a fantastic place to start[7].

### Failure of electric vehicle powertrain maintenance

Electric automobiles are completely electrified vehicles, if we may channel our inner Yogi Berra for a second. There isn't a drop of gas in an EV unless you carry a jerry can to the neighbourhood Shell station to fill up your lawnmower. Therefore, there is no need for the typical internal combustion engine maintenance needs.I wonder how it may be feasible. To understand how and why maintenance for the electric powertrain is different from that of a conventional petrol engine, let's first look at its fundamental component[8].

### Routine powertrain maintenance importance

Every EV has one or more electric motors, generally positioned on the axle and driving the wheels directly. Like other electric motors, maintenance is not actually required have you ever attempted to tune up or replace the oil in your desk fan EV motors themselves shouldn't need any maintenance unless certain problems arise[9].

### Regenerative Braking

The fact that conventional brake services are seldom required is another unassuming benefit of EVs. The cause using regenerative braking techniques.Regenerative braking may seem complicated, but the basic idea is straightforward: when you let off of the accelerator, the electric motors that are turning the wheels briefly reverse direction. The battery receives a modest amount of charge back as a consequence of the motor's conversion to a generator during the reverse motion.There are two advantages to this. One benefit of strong regenerative braking is that it may help restore a few miles of range during routine stop-and-go drivingpossibly more if you're descending a steep downhill gradient. The extra benefit Brake repairs will be required much less often. That's because when they reverse spin, electric motors function somewhat like brakes.

The battery is the key area of concern for EV maintenance. EV batteries aren't magical, just like your mobile phone, television remote, or any other battery-powered gadget. As time passes, they will gradually lose their charge and range. Many EV manufacturers provide 10-year guarantees on their battery packs to allay concerns about this, but this doesn't alter the reality that an EV battery will eventually be roughly as useful as the battery in a ten-year-old car.

### Maintenance of EVs

Folks, that's the reality. Electric cars need substantially less maintenance and upkeep than most automobile owners are accustomed to, thanks to a powertrain design that has far fewer moving parts and almost removes the elaborate latticework of interrelated mechanical subsystems that characterises an internal combustion engine. Therefore, using an EV won't only save you money at the petrol pump. Long-term savings are another benefit. Consider that another strong argument for buying an electric vehicle as your future vehicle.

### Installation fees for EV chargers

Depending on where you reside and how hard the project is, installation charges might vary greatly. "That type of installation by a licenced electrician, including permitting, might generally start at $500 if you had a panel literally next to where you want to park your car and you're putting a charger in that's just a few feet away," Ehrenhalt adds. However, he claims that the average installation ends up costing between $1,500 and $3,000.

If you need to upgrade your electrical panel or underlying electrical service (the maximum quantity of power that may be provided to your home by the public utility), the total will increase significantly.According to Michael Anthony Harris, an electrician of Harris Electric Company of Washington, an EV charging station "is basically just a dedicated line" of electricity. Your panel must be able to support a dedicated line in order to operate one.In addition to the price of having the EV charger installed, plan to spend an extra $2,000 to $4,000 if you require a new panel. A comprehensive electrical service upgrade will cost you an extra $5,000 to $8,000, according to Harris.

### Examine charges

There are several kinds of EV chargers, including AC and DC chargers, standard (Level 1), and rapid chargers (Level 2 and 3). The Level 1 charger supports standard AC charging, charges more slowly (at least 3-4 hours), but may be used anyplace that has access to AC power. They often represent the most economical EV charging option. Fast charging for four-wheelers is available at level 2 chargers. Users of electric two-wheelers must purchase a fast charger that is especially compatible with their EV brand since most two-wheeler fast charging systems are exclusive to the manufacturer. With charging capacities over 32KW and reaching up to 150KW and beyond, DC rapid chargers (equal to Level 3 chargers) are the quickest chargers, enabling 80 percent charging in 15 to 30 minutes. Although DC rapid charging is the quickest charging method available, it is best suited for public charging stations or business areas and is not ideal for home settings.

## DISCUSSION

### Costs of EV Chargers

Installing a charging station for Level 1 electric car charging might cost as little as nothing or as much as $300. A 120 V outlet is already present in the majority of garages. If not, an electrician with the necessary training may install one for up to $300. You may install your own 120 V outlet for less than $50 if you are skilful[10].Expect to spend at least $1,500 to $1,800 for a combined solution that includes the charger and electrical installation if you want to charge Level 2 EVs at home[11].The price range for a 240 V, 40 A Level 2 EV charging station that is connected to a NEMA 14-50 outlet with a 20-foot J1772 cable is between $200 and $400. This kind of charging station lacks a fixed wall station and Wi-Fi capabilities. Prices range from $500 to $800 for models with Wi-Fi and a wall-mounted station[12].

### Charging Station's Configuration

It's time to get your house ready for an electric car charger now that the choice has been made. Most people are generally quite eager to figure out where, when, and how they may charge their electric cars when they reach this stage. The good news is that, once a system is in place, doing so will be as simple as charging your smartphone. Once your electric car charging station is installed, you can say goodbye to the neighbourhood charging station since you can recharge at home. There are probably not many things as enjoyable as leaving home each morning with a full charge.If you've determined that a level 1 charger is right for you, start by plugging it into a regular 120-volt outlet. You can shortly go if you just plug in your automobile. The main disadvantage of this is that it would take up to 50 hours to utilise this number of amps on a current electric car with a range of 200 miles on a full charge. This is far too sluggish for the majority of folks.Because of this, many owners of electric vehicles choose level 2 charging, which can provide a full charge from a 240v connection in five to six hours. Of course, this is faster than the other option. The following is a list of everything you will need to perform this if you want to do it in your own garage. The setup time might be lengthy and costly.

**Power panel**

The power panel is the most crucial component of your charging system, from one to 10. The power panel is the beginning and the conclusion of everything. All of the electricity that enters a house is distributed to every area of the house where it is consumed at the power panel.Amperes, sometimes known as amps for short, are used to assess power since they represent the smallest possible unit of electric current. Maximum current flow has been set. While subsequent systems were typically 100 amps, older panels that were installed before 1965 were sometimes only rated for 60 amps. Power panels used in installations made after 1990 are often rated for currents of up to 200 amps, with some considerably higher.The majority of modern electrically renovated houses have a 100-amp power panel. Finding out your home's capacity is simple. Simply check for the amperage displayed on the primary circuit breaker that controls the power input to the systems in your house.

**Examine Power Usage**

The maximum usage is determined by the amp rating. Before deciding to utilise a 240v level 2 charging system, it's critical to understand how much power your house uses. This is due to the possibility of overloading your home's electrical consumption capacity if the additional charging demand is added to the present usage. Home energy audits are the solution to this issue. You may pick up a leaflet from the Department of Energy that will explain how to do this if you don't know how. You may find instructions for doing this energy audit on the department's website.Remember that it is not a good idea to use your energy panel at more than 80% of its maximum capacity when installing a home charging station. For instance, if you’re most recent energy audit shows that you are only using 50 amps at present time, you will have an additional 50 amps available to support a level 2 charger.

**Charging station location**

As fantastic as the idea of having your own power station at home may seem, it's crucial to understand that you should get a professional to install your charging system if you don't feel comfortable doing it yourself. It may be quite risky to use these systems. Actually, it may be catastrophic for anybody who has even the slightest lack of knowledge of these systems. Conducting an audit is one thing, but providing electrical services is quite another.Installing a 240-volt connector or having a circuit hardwired into your power panel should be your next step if your energy audit shows that you have enough power for a charging station. Even though it will cost several hundred dollars, it is ideal if professional electrician performs this portion of the installation.

It may cost substantially more since you'll likely need to construct a bigger distribution panel if it turns out that your home's power panel is incapable of supporting a charging station. The price range for this job is between $1,000 and $3,000. The intricacy of the work that has to be done will determine the ultimate cost increase. Additionally, your electrician could inform you that in order to construct a charging station, he would need to run a line back to the street's power pole in order to provide the extra capacity. Such alterations to the infrastructure might drastically raise your prices. Other associated expenses like labour and the breaking and removal of concrete are not included. On the plus side, this effort would be sufficient to provide your house full-charge capability.

### Appropriate electric vehicle charger

Before you purchase an EV charger, you should take into account a number of important variables. First off, the battery size and operating range of the car you want to charge will be extremely particular. Up to 250 kilometres may be travelled by most contemporary electric cars on a single charge. This includes, among others, the Nissan Leaf, the Chevy Bolt, and the Tesla Model 3. It's a good idea to have a higher-capacity charger with any of them to charge your battery as rapidly as possible.It's crucial that the charger you choose can be powered by your main power panel. Your best option will often be a 30-amp, 240-volt Level 2 charger. With this level of charger, you can add a charge to your car at a distance of 21 miles, depending on your charge per hour. This ought to be more than enough to give your car an overnight charge at its maximum capacity.

### Cheaper Charging Alternative

Take heart if all of these possibilities still leave you a bit short on funds. There is still a cheaper alternative that will provide you with a charging station. Many owners of electric vehicles have a far more affordable choice in their homes that will nonetheless provide you with a level 2 charging station. Additionally, it will be far less expensive and troublesome than the previous alternative.The garage of the majority of American houses already has a 240v amp outlet. This is often referred to as the "dryer plug." Most often, a dryer or other large equipment is powered by it. Buying a 30-amp charger with the necessary plug and plugging it straight into the current socket is an easy and less costly solution to the difficulty mentioned above. Additionally, just disconnect your dryer and plug in your car to charge your electric vehicle. With this option, numerous charging problems become irrelevant since your system has already been modified to handle the extra watts that comes with a dryer.

It doesn't take much vision to anticipate the arrival of electric automobiles. Because of this, the majority of homeowners would be wise to think about installing an EV charging station in their residences. The procedure is far simpler than most people would have you think, as this article illustrates, particularly because there are likely alternative options available if the first one doesn't fit your needs and talents.It should go without saying that homeowners who are considering the future would be wise to determine what their current power capacities are in order to handle any potential future needs. Electric cars are another technology that is continuously advancing in the globe, and getting our houses ready for their arrival may be one of the wisest decisions any homeowner can make given that sooner or later, someone in the family will likely own an electric vehicle.

## CONCLUSION

An electric vehicle (EV) charging station is a piece of equipment that connects an EV to an energy supply so that electric cars, community EVs, and plug-in hybrids may recharge. An item of machinery known as an EV charger is used to charge electric automobiles. Its primary function is to keep an electric vehicle (EV) moving by recharging the battery. Electric vehicle supply equipment (EVSE), often known as a charging station or charge point, is a piece of infrastructure that provides electrical power for charging plug-in electric vehicles, such as neighbourhood electric vehicles, plug-in hybrids, electric trucks, and electric buses. The primary finding is that electric vehicles are unquestionably better for the environment and the quality of the air than petrol or diesel vehicles. Contrary to some popular scepticism and ambiguity over the environmental advantages of electric vehicles, the science is becoming more obvious.

**BIBLIOGRAPHY:**

[1] J. Hu, C. Ye, Y. Ding, J. Tang, and S. Liu, “A Distributed MPC to Exploit Reactive Power V2G for Real-Time Voltage Regulation in Distribution Networks,” *IEEE Trans. Smart Grid*, 2020, doi: 10.1109/TSG.2021.3109453.

[2] D. B. W. Abeywardana, P. Acuna, B. Hredzak, R. P. Aguilera, and V. G. Agelidis, “Single-Phase Boost Inverter-Based Electric Vehicle Charger with Integrated Vehicle to Grid Reactive Power Compensation,” *IEEE Trans. Power Electron.*, 2018, doi: 10.1109/TPEL.2017.2700944.

[3] M. Restrepo, J. Morris, M. Kazerani, and C. A. Cañizares, “Modeling and testing of a bidirectional smart charger for distribution system EV integration,” *IEEE Trans. Smart Grid*, 2018, doi: 10.1109/TSG.2016.2547178.

[4] R. K. Lenka, A. K. Panda, A. R. Dash, L. Senapati, and N. Tiwary, “A Unified Control of Grid-Interactive Off-Board EV Battery Charger With Improved Power Quality,” *IEEE Trans. Transp. Electrif.*, 2020, doi: 10.1109/TTE.2020.3172354.

[5] M. R. Khalid, I. A. Khan, S. Hameed, M. S. J. Asghar, and J. S. Ro, “A Comprehensive Review on Structural Topologies, Power Levels, Energy Storage Systems, and Standards for Electric Vehicle Charging Stations and Their Impacts on Grid,” *IEEE Access*. 2021. doi: 10.1109/ACCESS.2021.3112189.

[6] A. Verma, B. Singh, A. Chandra, and K. Al-Haddad, “An Implementation of Solar PV Array Based Multifunctional EV Charger,” *IEEE Trans. Ind. Appl.*, 2020, doi: 10.1109/TIA.2020.2984742.

[7] S. LaMonaca and L. Ryan, “The state of play in electric vehicle charging services – A review of infrastructure provision, players, and policies,” *Renewable and Sustainable Energy Reviews*. 2020. doi: 10.1016/j.rser.2021.111733.

[8] Y. Fu *et al.*, “Design Methodology of a Three-Phase Four-Wire EV Charger Operated at the Autonomous Mode,” *IEEE Trans. Transp. Electrif.*, 2019, doi: 10.1109/TTE.2019.2957635.

[9] C. W. Hsu and K. Fingerman, “Public electric vehicle charger access disparities across race and income in California,” *Transp. Policy*, 2021, doi: 10.1016/j.tranpol.2020.10.003.

# EXPLORING THE ROLE OF PV MODULE TECHNOLOGY

**Dr. Sreenivasappa Bhupasandra***

*Associate Professor,
Department of Electronics & Communication (Communication System Engineering),
Presidency University, Bangalore, INDIA
Email Id-sreenivasappabv@presidencyuniversity.in

## ABSTRACT:

*Performance of photovoltaic (PV) modules is inclined by a number of internal and external factors. Sometimes, the selection of a certain PV technology for "best performance" at a site is made only on the label specification or a single operating state, failing to take into account several factors that have an influence on various technologies and have affects that are clearly different. The selection of suitable PV technologies for moderate-to-aggressive soiling/climate conditions is assessed in this chapter using frequently at odds parameters of spectral effects (related to solar resource, module spectral response, and soiling layer properties) and module temperature. The linear model used in this work is based on the temperature coefficients of the module technologies and soiling rates. In this book chapter we discuss about the how to choose solar panel, efficiency of PV Modules, cell performance, standard warranty and power warranty etc.*

**KEYWORDS:** *Mono-Crystalline, Pv Module, Pv System, Solar Cell, Solar Panel.*

## INTRODUCTION

Since the previous ten years, solar energy use has increased. The introduction of solar energy in our society is being aided by factors such as rapidly falling costs, improved technology understanding, environmental pollution awareness, and, most importantly, widespread acceptance of photovoltaic (PV) technology among the general public. It is not surprising that the capacity for PV technology installation at residential structures is rapidly increasing year over year in an area where the average daily Sun hour's value is about 7-8.Although, there are many local suppliers, installers, and contractors offering their services to the public, many of them are unable to respond to inquiries about the selection of high-quality panels and instead rely primarily on the installer's advice when deciding which sort of PV module to use. This article will highlight a few crucial factors to consider from a layperson's point of view when making the choice to choose a good quality and standard PV module for your home solar system.

Let's look at the datasheet of a typical PV module to start the guidance. There is a lot of information on the kind and characteristics of a PV module in the datasheet, which is a sample of which is supplied below. The key is determining which factors, out of all, are significant to the consumer and influence their decision. Some are discussed next to calm the anxiety.

### Pros and Cons of Silicon

The light-absorbing semiconductor doped silicon is found in photovoltaic cells. While selecting a solar panel, the cell type is crucial.

### Mono crystalline

Mono crystalline cells are created from a single silicon source, while polycrystalline and amorphous cells are made from many silicon sources. Since they are so efficient, these cells work best in stiff installations. The cost of production is quite expensive.

**Polycrystalline**

Various silicon sources are used to create polycrystalline cells. They are less effective than mono crystalline cells, but the production method is simpler and less expensive.Non-crystal silicon cells are referred to as amorphous cells. Thin-film solar modules, also known as flexible solar modules, utilize them. The majority of the time, these modules are utilized to construct embedded solar systems, such window-integrated solar systems. Although these cells are less costly than mono- and poly-crystal cells, they are less efficient.

**PV module type**

When deciding whether to establish a PV system, one of the most fundamental decisions is whether to use mono crystalline or polycrystalline PV modules. Unfortunately, many people have trouble distinguishing between the two, even electrical engineers. Here are two examples of each category so that you can see the initial difference.With mono crystalline, which has significant gaps between the darker-colored cells that resemble white diamonds, it is possible to clearly distinguish between the two kinds of modules visually. Contrarily, polycrystalline panels are lighter in color and have horizontal and vertical stripes made up of gaps in the solar cells.

## LITERATURE REVIEW

El Houre et al. in, discussed that the expansion of PV emulators, particularly those based on power converters, was caused by the rising interest in testing solar systems and conversion components. By using various PV modelling techniques, these simulators enable the properties of PV modules and panels to be reproduced in a controlled environment. Three modelling approaches for three PV technologies, amorphous, CdTe, and mono-Siare examined in this work. Using experimental data from Morocco's Green Energy Park, the models are examined using the suggested assessment criteria. The actual criteria are based on the calculation time needed, the Root Mean Square Error, and the coefficient of determination. The research produces a system that enables the optimum modelling strategy for each PV module technology to be chosen. The control strategy for the PV emulator power supply is then designed via simulation work. Then, using the created PV emulator system, the experimental implementation of the control and modelling method selection mechanism based on module technologies takes place. the PV emulator is approved for use as an example of an amorphous technology module together with its control and modelling techniques.

B Mihaylov Bliss et al. in [1], discussed that PV module energy ratings, combined with power ratings, may make choosing a module technology easier. Module ratings must, however, have a specified level of uncertainty in order to be comparable. The technique for assessing this uncertainty is suggested in this study, which also emphasises how crucial it is to look into and take into account measurement correlation when estimating total uncertainty. The difference between the uncertainty estimates for the indoor measurement setup at CREST when correlations are neglected and taken into account ranges from 1.3% to 3%, respectively (at k=2). A poor choice of PV module technology might from underestimating the unpredictability.

Sandeep Mishraet al. [2], discussed that heat losses associated with photovoltaic (PV) module power output depend on the temperature coefficient of maximum power of the PV module. Another loss mechanism is shadowing, which may seriously impair the modules and eventually the system's power output. To reduce the impacts of shade on a PV module, a variety of techniques including passive, active, or smart bypasses and module level power electronics have been used. Up until now, there has been little concrete discussion of how a PV module performs while shaded, and descriptions have mostly been qualitative. To measure the behaviour of PV modules under all types of shadow, a probability-based term known as shading tolerance (ST) was recently devised. The ST observations, however, were only made at an ambient temperature of 25 °C. This paper's objectives are to categorise different PV technologies based on ST i.e.,to study whether ST is an inherent attribute of a PV module by constructing a connection between ST and ambient temperature, as well as to build a PV module selection map.

Mayeret al. in [3], discussed that for grid-connected photovoltaic (PV) power plants to be profitable and have a bright future, it is crucial to forecast their power output. A method that is often used to determine the anticipated power production from numerical weather forecast data is physically inspired modelling. Since the gap between the most and least accurate model chains is 13% in mean absolute error (MAE), 12% in root mean square error (RMSE), and 23-33% in skill scores for a PV plant on average, the model selection has a significant impact on the physical PV power forecasting accuracy. The power forecast performance analysis was carried out and confirmed for production data of 16 PV plants in Hungary with a one-year 15-min resolution for day-ahead and intraday time horizons on all conceivable combinations of three reflection loss, five cell temperature, four PV module performance, two shading loss, and three inverter models. Irradiance separation and transposition modelling are the two most crucial calculation processes, while inverter models are the least significant. Absolute and squared errors are incongruous measures since simpler models have the lowest RMSE and the lowest MAE when compared to more complex ones.

M. WaqarAkram et al. in, discussed that the photovoltaic (PV) business has grown exponentially over the last several years, emerging as a fantastic and promising renewable energy technology. But several instances of early failure and deterioration are also noted in the real world. In addition to this, as modules include flammable elements, there are fire dangers connected with PV modules deployed in the field, roof-mounted, and building integrated PV systems. Electrical arcs, short circuits, and hotspots are only a few of the several malfunctions and flaws that contributed to the fire. To create effective and lasting modules, defects must be promptly, quickly, and accurately detected and measured. The traditional visual monitoring and evaluation approach, which relies heavily on human faculties and often involves human mistake, is widely utilised in the sector. Furthermore, it takes a lot of time and is only feasible on a limited scale. The automation of PV monitoring and evaluation procedures is crucial given the growing usage of PV solar energy and the continuous construction of massive PV power plants throughout the globe. This document may be used as a one-stop resource for PV system inspectors since it focuses on module failures, fire dangers related to PV modules, failure detection/measurements, and computer/machine vision or artificial intelligence (AI) based failure detection in PV modules.

Zhenpeng et al. discussed that phase change materials (PCMs) have received a lot of attention recently in the field of thermal regulation in photovoltaic (PV) modules because the hybrid PV-PCM technology not only allows for higher photoelectric conversion efficiency but also allows for the extraction of thermal energy from PCMs for cascade utilisation. Despite the extensive research that has been done on PV-PCM systems, numerous obstacles remain unresolved, such as PCMs that need additional advancements from both a technological and financial standpoint. With a focus on the technology overview and material selection, a thorough literature review of the state-of-the-art features of PV-PCM systems is presented in this paper. In order to identify the critical elements influencing its performance, the notion of a hybrid PV-PCM system is first described along with its basic setup and energy balance. Additionally, a thorough analysis of 104 research publications published between 2004 and 2018 is used to explain the progression of PV-PCM research, highlighting the key accomplishments and challenges at each step. Additionally, PCMs are emphasised in this publication along with information on their categorization, characteristics, and use in prior PV-PCM research. A triangle including the materials selection criteria and the phase transition temperature determination approach is specifically suggested[4].

Hayder A in [5], explored that due to falling PV system costs and a greater focus on minimising $CO_2$ emissions for power generation, grid-connected rooftop solar (PV) systems are more used in both business and residential contexts. Due to established technology and affordable module prices, polycrystalline-silicon (p-Si) modules are most often employed in these PV systems. Due to improvements in performance in high-temperature conditions, more recent thin-film module technologies including amorphous Si (a-Si), Cadmium Telluride (CdTe), and Copper Indium Selenide (CIS) are also gaining market share. In this study, p-Si and CIS systems are subjected to identical ratings and environmental conditions (irradiance, temperature, rainfall, and dust). The case study simulates the generation of power from two 42 kWp PV systems and contrasts the findings with data collected over a one-year period from the installed systems at Pakistan's Lahore University of Management Sciences (LUMS) indicate that CIS is a superior option from the standpoint of performance ratio since it produces more energy annually than p-Si. However, the levelized cost of power for p-Si is higher, which makes this technology more commercially feasible in Pakistan. Additionally, compared to CIS-based systems, the area needed to deploy the p-Si system is substantially smaller, making it more appealing for locations with limited space. The knowledge gained from this investigation may help PV designers make the best choice of a rooftop PV system technology[6].

Hanif et al. discussed that in standalone photovoltaic (PV) systems, the usage of batteries is essential, and the physical integration of a battery pack and a PV panel in one device makes this notion possible while simplifying the installation and system scalability. However, one of the biggest issues with positioning a solar panel next to a battery pack is the impact of high temperatures. In order to choose an appropriate battery technology, this study will take the operating temperature as well as the anticipated current profiles into account. A literature study, an integrated model, the creation of an application-based test, and the execution of the ageing test make up the process for choosing batteries. In addition to selecting a battery technology, the integrated model was used to create a testing technique that mimicked the operating circumstances of the PV-battery Integrated Module (PBIM). Two typical temperatures were used to test two Li-ion pouch cells while using different charging/discharging strategies. After testing, LiFePO4 (LFP) cells outperformed LiCoO2 batteries (LCO), for example, the LCO cells' capacity faded 2,45% more than the LFP cells' did under the identical testing circumstances when the temperature was 45°C. LFP cells are chosen as a viable alternative to comprise the PBIM [5].

## DISCUSSION

In light of the above, poly crystalline panels are preferable if reducing your initial cost is a key factor in constructing a solar system to satisfy your needs. On the other hand, if quality is your first priority, you should choose mono crystalline solar panels without a second thought.However, mono crystalline solar panels are best used in situations when there is a lack of available installation space, particularly on residential buildings' roofs. You can harvest more energy from a smaller area since these sorts of panels are designed to be efficient. These may function well at higher temperatures because to their reduced temperature coefficient.The following considerations are necessary for the choosing process' guidance:

1. Poly crystalline modules are bigger in size for the same power rating. Mono crystalline modules are hence efficient with regard to space.
2. Mono crystalline modules have higher efficiencies than polycrystalline ones, producing more watts in the same amount of area.
3. Mono crystalline modules cost more than poly crystalline modules because mono crystalline cells have a greater level of purity.

**Cell Performance**

Each PV module is made up of a variety of small solar cells that are connected in a certain way based on the voltage and current demands of the system. Solar cell modules of 48, 60, and 72 cells are now widely available on the market. The solar cell efficiency is inversely correlated with the efficiency of PV modules. So it's crucial to ask about cell efficiency. Due to internal connection losses, the PV module efficiency is, however, always lower than the total of each solar cell's efficiency.

**Efficiency of PV Modules**

The most crucial element is PV module efficiency since it will impact the installed solar system's output. The nameplate data may be used to determine the PV module efficiency. It is important to remember that, with the exception of the module's area, all of the aforementioned characteristics alter depending on the atmospheric circumstances. The PV module's irradiance and IV curve are often supplied on the datasheet for reference. Depending on the irradiations, Vmpp and Impp change, as seen by the module's I-V curves.The smaller the installation area needed for a system with a given rating, the better the efficiency. Additionally, putting in efficient PV modules lowers the cost of the Balance of System (BoS), which lowers the price of the system's installation.

**Junction box compatible with MC4 and bypass diodes**

The PV module's negative and positive terminals are housed in a junction box at the back of the unit. A few bypass diodes may also be added in the junction box, depending on the arrangement, to improve the PV module's performance in shadowed areas. Imagine a collection of three rivers coming to the settlement to get a better sense. Each river contributes to the movement of the other two. However, if the flow of one river is interrupted, the water supply to the settlement will ultimately be reduced of the other two as well. Imagine now that each river has a bypass route so that each individual's flow may be maintained independent of the flow of any other rivers. In this manner, even if one river is stopped, the flow of the others may still be maintained. The string of cells and the bypass diodes are similar examples.

Bypass diodes cut off the string that is in the shadow and has low current, enabling the other strings to contribute their currents and boost the PV module's power production. The picture on the right shows a junction box with three bypass diodes.Demanding the MC4 (Multi Contact -4mm) type connection with the module leads will secure the connection capabilities of PV modules. Push-in MC4 connectors must be disconnected using a tool to prevent unintentional disconnections. The purchaser must confirm that all of the PV modules are connected using MC4 connections.

### NOCT, or normal operating cell temperature

NOCT is a condition that, like standard test conditions, accurately simulates the operating environment of the PV module. The real data that the customer is interested in is the rated power at NOCT. PV modules with a greater rated power should be used for the same NOCT value.Two distinct PV module parameters, for instance, are shown below at STC and NOCT. Both are rated at 310Wp at STC, according to the parameters. However, one is rated somewhat higher than the other at NOCT of 45°C (6W difference). For a 15kW system with 48 PV modules, the difference of 6W will rise to almost 300W.

### Standard warranty and power warranty

Before buying any solar panel, you must evaluate both kinds of warranties. While the power warranty is the minimum amount of power that the manufacturer guarantees that the PV panel will generate with respect to the number of years of its operation, the traditional warranty is the equipment/product warranty like any other electrical equipment and protects the customers from manufacturing defects. The typical warranty for contemporary PV panels is ten years. The power warranties offered by top solar panel manufacturers are minimum 90% of output for the first 10 years and minimum 80% of output for the next 25 years.

The linear warranty, which is better than the typically assured performance/power warranty, is a greater warranty connected to the power warranty. The PV panel with superior linear warranty should be chosen for your solar system since it assures a linear deterioration of PV Panel for the client's advantage. For instance, compared to the ordinary power warranty, which is 90%, the linear warranty guarantees a performance of 95% after 5 years.

### Tolerance to force

Another aspect to take into account when choosing the module is the power tolerance of the PV panels. For the purpose of building an effective and dependable system, the degree of departure from the promised output is crucial. There are PV modules on the market with various levels of power tolerance. Below is a list of some typical ones.One conclusion that can be drawn from the power tolerance range is that the panels are of higher quality when the range is less. High-efficiency modern PV panels have positive tolerances, which ensure minimum rated output at STC and NOCT circumstances. Positive power tolerances make sure the module produces power that is higher than or equal to what is specified.

This is crucial since the nameplate's -5% tolerances allow a 300W module with a test low as 285W to be acceptable. However, as we are aware, solar panels are strung together, and the module with the string's lowest output serves as the current limiter. One may not be able to use their system to its full potential. Accordingly, prior to system design and installation, a minimum tolerance should be determined and guaranteed. The minimum output will be 1500W in the worst case and 1575W in the best scenario in a system constructed of five 300W units with a tolerance of 0/+5%. In contrast, a system constructed of 5 units of 300W with a tolerance of 0/-5% would have a minimum output of 1425W at the worst and 1500W at the best[7]–[10].

### New Photovoltaic Module Technologies

Solar panels with half-cells a significant portion of the solar industry has been captured by the half cut cell technology. It is said to reduce a solar cell in half, making it superior than full-cell modules in many ways. Electrically speaking, since the half-cut cells have half the current of a typical cell, their performance is improved because ohmic losses are reduced. The darkening on one side has no influence on the other since half-cut modules operate as two distinct modules. Half cut cells are more durable than regular cells because mechanically, the smaller the size of a cell, the less it is impacted by stress factors.New photovoltaic module technologies show in figure 1.

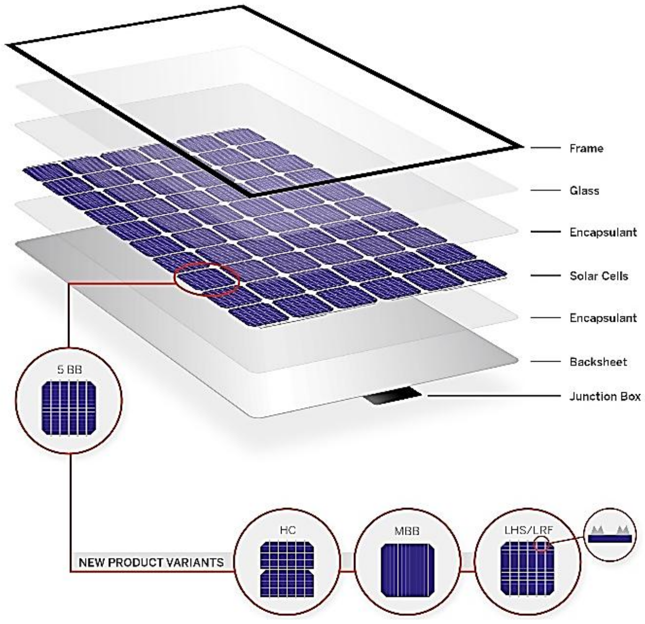

**Figure 1 New Photovoltaic Module Technologies** [Google].

Solar cells are sliced into five strips using a laser and then formed into shingles, as the name suggests. The five strips are joined together using conductive adhesive rather than soldering. The quantity and thickness of fingers linked to the bus bar are greatly reduced of the low current on each strip. The whole solar panel experiences less shadowing because of the thinness of the fingers and bus bars. The price of making the modules is the sole drawback of shingled technology. Additionally, production takes longer than with other module technologies.

### Tilling innovation

In the manufacturing process known as tilling, half-cut cells inside a module contact one another, creating little overhangs. After that, ribbons are used to link the solar cells. The production procedure is simple. Tilling has the benefit of improving module efficiency and decreasing ohmic losses.

### Paving technology

Paving reduces the distance between solar cells while bringing them closer together. Paved modules have a space between the cells of just 0.2 mm, whereas conventional modules have a distance between the cells of up to 2 mm.

### Bifacial PV modules and dual-glass PV modules

A white back sheet is included on the back of standard solar modules. The module is shielded by the rear sheet. In the rear, glass has not been used recently. Recently, some manufacturers began replacing the rear sheet with glass, which led to a 30% increase in the power output of the solar module. Double glass technology is what it is.Other producers began attaching bus bars and ribbons to the photovoltaic cells' back sides and utilizing glass to cover the module's back, boosting the power output in certain instances by up to 50%. This approach is known as bifaciality.Since some manufacturers believed that having glass on both sides eliminates the need for an aluminum frame and improves bifaciality, there are now framed and frameless bifacial and double glass photovoltaic modules available on the market.

The added weight of the photovoltaic modules is a drawback of these technologies.Most contemporary solar modules employ a technique called multi bus bar. Thinner bus bars are utilized with a larger amount of nine, twelve, or more bus bars rather than three or five thick ones. For bifacial modules, multi bus bar technology lowers osmic losses and improves bifaciality.Instead of boron, phosphorus is used to dope N-type solar cells. N-type cells provide various benefits over conventional P-type cells, including greater bifaciality factor, lower yearly deterioration, lower power temperature coefficient, and reduced light-induced degradation. The easiest N-type cell to convert a solar panel manufacturer from P-type (PERC), the most prevalent cell on the market, to TOPCON is the TOPCON cell. Hetero junction (HJT) cells have a straightforward production method but need a new manufacturing infrastructure.

## CONCLUSION

In rural places without power lines and with erratic fuel sources, PV systems offer the unique potential to provide local consumption with electricity. Solar photovoltaic electricity is endless and non-polluting. It supports local jobs while also promoting sustainable growth. The PV module's primary objective Solar panels, sometimes referred to as photovoltaic modules, are a web that collects solar radiation and converts it into sustainable energy. Each solar cell is built on a semiconductor material, often silicon. The amount of incident solar energy that is converted to electricity by a PV system is known as its conversion efficiency. Researchers have created PV cells with efficiencies close to 50%, despite the fact that the majority of commercial panels have efficiencies of 15% to 20%. Your solar panels will work best if they face south since the sun is above the equator at this time.

## BIBLIOGRAPHY:

[1] B. Mihaylov, M. Bliss, T. R. Betts, and R. Gottschalg, "Uncertainty in Photovoltaic Module Energy Rating," *Proc. 11th Photovolt. Sci. Appl. Technol. Conf. Leeds*, 2015.

[2] S. Mishra, H. Ziar, O. Isabella, and M. Zeman, "Selection Map for PV Module Installation Based on Shading Tolerability and Temperature Coefficient," *IEEE J. Photovoltaics*, 2019, doi: 10.1109/JPHOTOV.2019.2900695.

[3] M. J. Mayer and G. Gróf, "Extensive comparison of physical models for photovoltaic power forecasting," *Appl. Energy*, 2021, doi: 10.1016/j.apenergy.2020.116239.

[4] M. Tao, L. Zhenpeng, and Z. Jiaxin, "Photovoltaic panel integrated with phase change materials (PV-PCM): technology overview and materials selection," *Renewable and Sustainable Energy Reviews*. 2019. doi: 10.1016/j.rser.2019.109406.

[5] V. Vega-Garita, A. Hanif, N. Narayan, L. Ramirez-Elizondo, and P. Bauer, "Selecting a suitable battery technology for the photovoltaic battery integrated module," *J. Power Sources*, 2019, doi: 10.1016/j.jpowsour.2019.227011.

[6] H. Ali and H. A. Khan, "Techno-economic evaluation of two 42 kWp polycrystalline-Si and CIS thin-film based PV rooftop systems in Pakistan," *Renew. Energy*, 2020, doi: 10.1016/j.renene.2019.12.144.

[7] A. K. Hamzat, A. Z. Sahin, M. I. Omisanya, and L. M. Alhems, "Advances in PV and PVT cooling technologies: A review," *Sustain. Energy Technol. Assessments*, 2021, doi: 10.1016/j.seta.2021.101360.

[8] M. Yao and X. Cai, "An overview of the photovoltaic industry status and perspective in China," *IEEE Access*, 2019, doi: 10.1109/ACCESS.2019.2959309.

[9] A. C. Goodrich, D. M. Powell, T. L. James, M. Woodhouse, and T. Buonassisi, "Assessing the drivers of regional trends in solar photovoltaic manufacturing," *Energy Environ. Sci.*, 2013, doi: 10.1039/c3ee40701b.

[10] H. Mohammed, R. Gupta, O. Sastry, and D. Magare, "Assessment of different correlations to estimate distinct technology PV module operating temperature for Indian site," *Energy Sci. Eng.*, 2019, doi: 10.1002/ese3.332.

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# AN ANALYSIS OF CRYSTALLINE TECHNOLOGY FOR INDUSTRIAL USAGES

**Dr. Shilpa Mehta***

*Professor,
Department of Electronics & Communication (Communication System Engineering),
Presidency University, Bangalore, INDIA
Email Id-shilpamehta@presidencyuniversity.in

## ABSTRACT:

*An overview of present industrial technology, upcoming advancements, and long-term trends in the area of fabricating crystalline silicon solar cells for industrial use is provided. The study demonstrates that significant gains in productivity and cost may still be made. This chapter also demonstrates that, in order to reduce substrate costs and increase independence from silicon feedback availability issues, significant work is being made globally on smaller substrates and thin-film crystalline silicon cells placed on affordable carriers. Lower processing and manufacturing costs as well as better efficiency are results of advances in crystalline silicon technology. Over the last eight years, there has been positive experience with big systems that are typical of utility-scale applications. According to the argument, there currently seem to be a number of options within the crystalline silicon technological route that have a great chance of achieving the required cost for entrance into the utility market.*

**KEYWORDS:** *Amorphous Silicon, Crystalline Silicon, Crystalline Waterproofing, Crystalline Technology, Pores Capillaries, Proto Crystalline.*

## INTRODUCTION

When it comes to stability and durability, concrete is an excellent construction material. It is robust, adaptable, affordable, and practically ubiquitous. It is commonly utilized all over the world to construct anything from sidewalks to transit tunnels.Despite the fact that concrete is widely used, how effectively you preserve it, particularly from water, will determine how long it will last. Despite being a necessary component of concrete manufacture, installation, and curing, water is the main adversary of concrete throughout its service life.Very few materials are completely waterproof. Everything has some degree of permeability. And given the correct circumstances, a lot of objects that we would often consider waterproof allow water molecules to get through.

Usually, the outside foundation wall from where a leak is seen has an external membrane waterproofing system attached to the concrete's surface. Thus, repairs may become challenging. This is due to the fact that systems that are surface-applied are almost often applied to the side of the building that is buried underneath. It is thus difficult to reach. The membrane system, for instance, will be installed on the exterior of the perimeter wall of a parking facility below ground. Since the membrane is inaccessible, any failure will be difficult to fix.Even worse, it might be difficult to pinpoint the source of leaks while attempting to fix them from the inside because of this. It is probable that any leak found on the parking garages inside is the fracture.But it doesn't always imply that the membrane has already failed there, on the other side of the wall. In order to reach a fracture or other weak place in the concrete, water must first flow through a hole in the membrane and then follow the route of least resistance. Around corners, protrusions, pipes, laps, seams, and edges that have not been completely sealed are common places where water may enter.

Concrete constructions are made more durable and perform better thanks to crystalline technology, which also reduces maintenance costs and increases structural lifetime by shielding concrete from the damaging effects of hostile chemicals. These high-performance characteristics come about as a consequence of how crystalline technology functions in conjunction with concrete.By plugging and filling the pores, capillaries, and micro cracks in concrete structures with a non-soluble, extremely resistant crystalline formation, crystallization technology waterproofs and increases the durability of concrete buildings. Two straightforward chemical and physical interactions underlie the waterproofing effect. Chemical properties define concrete. When a cement particle hydrates, water and cement combine to form a solid, hard mass that is concrete. The process also produces hydrated or partly hydrated cement particles, calcium hydroxide, sulphates, and carbonates of sodium, potassium, and calcium, all of which are found in the capillary tracts of the concrete.

Concrete is exposed to additional chemicals of crystalline waterproofing. A chemical reaction takes place when these two chemical groupsthe crystalline compounds and the by-products of cement hydrationcome into contact. A non-soluble crystalline formation is what comes out of this process.Only the pores, capillary tracts, and shrinkage fractures of the concrete will experience this crystalline formation since it can only happen in environments with moisture. Crystalline waterproofing will develop and fill pores, cavities, and crevices wherever water travels.

Chemical diffusion occurs when crystalline waterproofing is applied to the surface, whether as a coating or as a dry-shake application to a new concrete slab. Diffusion is based on the idea that a solution with a high chemical density will move through a solution with a lower chemical density until the two solutions are equal.When concrete is wet before crystalline waterproofing is applied, a solution with a low chemical density is infused into the porous concrete. When crystalline waterproofing is applied to concrete, a very chemically dense solution is produced, starting the chemical diffusion process. Until the two solutions are equal in density, the crystalline waterproofing compounds must move through water.

The byproducts of cement hydration become accessible to the crystalline waterproofing chemicals as they penetrate and distribute throughout the concrete, enabling a chemical reaction to occur that in the formation of a non-soluble crystalline structure. The crystalline growth will develop behind the advancing chemical front as the chemicals keep permeating the water. Until the crystalline chemicals are exhausted or the water is exhausted, the reaction will go on. These compounds may be transported into the concrete up to 12 inches deep via chemical diffusion. The crystalline compounds can only diffuse to this depth if water has penetrated the substrate two inches, but they still have the ability to go ten inches deeper.

## LITERATURE REVIEW

Saga et al. explored that all the solar cell varieties, crystalline silicon photovoltaic (PV) cells are the most widely utilised, accounting for nearly 90% of global PV cell output in 2008. Crystalline silicon solar cells are anticipated to play a significant part in the development of the PV industry. The technologies now in use for the manufacture and utilisation of crystalline silicon photovoltaic cells are reviewed in this article. For research crystalline silicon PV cells, 25% has been reported as the best energy conversion efficiency to date. However, most industrial cells are still only capable of achieving efficiencies of 15-18%, with the exception of a few high-efficiency cells that can achieve efficiencies of up to 20%. Although high-efficiency research PV cells perform better than conventional PV cells, they are sometimes unsuitable for mass production owing to their intricate architectures and drawn-out manufacturing procedures. Regarding the associated material technologies, such as silicon ingot and wafer fabrication, various mono- and polycrystalline PV cell technologies are contrasted and explored. We review some of the most recent technologies that could result in efficiencies of more than 25% and commercially viable production costs. High energy conversion efficiency and low processing cost can only be achieved simultaneously through the development of advanced production technologies and equipment[1].

Musa T Zarmaiet al. in [2], explored that to guarantee that the photovoltaic (PV) module contains crystalline silicon solar cells and operates continuously for the full 20 years of its design life, it is essential to identify, implement, and use a dependable interconnection technology. The study of connecting technology used in the manufacturing of crystalline silicon solar cells has become crucial in light of estimates that 40.7% of this kind of PV module fail at interconnection and more recent indications of a rise in such failure in the tropics. When implemented, such a review has the potential to provide information that will strengthen system dependability, which will raise silicon PV module manufacturing share over its present figure of 90.956%. The properties of interconnect connectors in conventional cells and various non-standard crystalline silicon cells are presented in this paper. For each interconnection approach used, it compares series resistance, shadowing losses, and the resulting thermo-mechanical stress in the junction. The article compares the concepts, cell types, joint types, manufacturing processes, and production levels of various assemblies as well as connecting technologies used in these assemblies. The paper also evaluates and addresses the difficulties associated with silicon solar cells' connectivity from a material and technical dependability perspective. In comparison to traditional soldering technology, the evaluation points out that laser soldering technology has the potential to provide connectivity with superior dependability.

Buker et al. in [3], explored that monitoring solar panel field performance and deterioration rates in areas with various environmental exposures is essential. The purpose of this study is to evaluate the performance characteristics for a period of two and a half years and the rate of deterioration of poly-crystalline and hetero junction with intrinsic thin layer roof-top solar units in Central Anatolia. By examining each technology's effective peak power and temperature-corrected performance ratio, degradation rates of the photovoltaic units were calculated. Processing of the test-period measurement data shows that the thin-film technology has an approximately 0.1% lower deterioration rate than the poly-crystalline-based technology, which ranges from 0.67% to 0.83%, respectively. A deeper knowledge of performance and behaviour fluctuations of poly-crystalline and hetero junction with intrinsic thin layer roof-top solar modules after 2.5 years of exposure to the elements is made possible by the research.

Afgan et al. in [4], discussed that due to its flexibility, concrete is one of the most often used building materials. It is one of the most resilient building materials, offers higher fire resistance than timber structure, and progressively becomes stronger. However, because of its heterogeneous material makeup, it is porous and prone to degradation from the addition of moisture and other chemicals. Concrete waterproofing is crucial because water ingress, chloride diffusion, and chemical assault may quickly deteriorate a building, necessitating costly repairs and potentially jeopardising its structural integrity. Coatings are used in traditional techniques of preserving concrete, however they are not successful for extended periods of time since they degrade with time, losing their adherence to the surface and finally failing. Using concrete's natural permeability as a delivery mechanism for waterproofing chemicalsa technique known as crystalline waterproofing—is a more effective and efficient approach to waterproof it. With a non-soluble crystalline formation that forms a structural component, this technique fills the concrete's inherent porosity and spans fissures. The mechanism, testing, application, and benefits of crystalline waterproofing systems for concrete are discussed in this research.

Tian et al. in [5], explored that Photovoltaic (PV) technology is advancing quickly, and the worldwide installation is rising exponentially with the aim of achieving Net-Zero emissions. While this is going on, crystalline silicon (c-Si) PV panels, which make up the majority of end-of-life (EOL) solar PV panels, are becoming more common. Reusing EOL solar PV panels is an efficient technique to increase financial returns, and more academics are concentrating on research on solar PV panel recycling. Most current research on recycling technology remain in the experimental phase and often neglect issues with high cost, limited recycling value, and secondary contamination. In this review, we systematically summarised the EOL c-Si PV panel module recycling technologies and condition parameters in three sections: module disassembly, module delamination, and material recycling and reuse. Our goal was to establish an effective, affordable, and environmentally friendly recycling technology system. In each segment, we spoke about the advantages and disadvantages of present technology as well as future areas for study. This research sought to serve as a technical resource for the impending global wave of EOL PV module recycling.

Moreno et al. in [6], discussed thatcrystalline hydrophilic additives are being employed more often as effective ways to lower concrete's water permeability. Different cementations materials have shown their efficacy in preventing water penetration, yet little is known about how they work exactly. The effectiveness of the hydrophilic blended crystalline mix as a water-reducing additive has been verified in the current investigation. Additionally, a thorough analysis of how the additive's presence affects both the attributes of the fresh state and the hardened state is offered. Finally, the mechanism of the additive has been determined using characterization methods as Mercury Intrusion Porosimetry (MIP), X-ray Powder Diffraction (XRD), and Back-Scattered Scanning Electron Microscopy (BSEM) with Energy Dispersive X-ray Analysis (EDAX). There hasn't been any discernible negative impact on the characteristics of concrete as a result of the additive's inclusion. Given that a modest decrease in the w/c ratio for consistency equal to that of the concrete has been seen, along with an increase in the compressive strength values, the additive really seems to have had a favourable impact on the concrete. Its efficacy as a water permeability-reducing additive has shown positive results, with tests showing a reduction in water permeability of around 50%. The examined addition seems to work via hydration processes in the presence of water, creating new solid amorphous phases in the bulk of the concrete.

## DISCUSSION

Additionally, water-repelling chemical additives may be used.The term "hydrophobic" is sometimes used to describe admixtures that resist water. By altering the concrete's surface tension, these compounds prevent water from soaking into and through the pores of the concrete and instead cause water to bead upon contact. Many admixtures that resist water also have some pore-blocking qualities.Water may be kept out of concrete both above and below ground with the use of such items. However, they are ineffective in fending off hydrostatically pressed water. Water may push through and through concrete if its pores' surface tension is greater than that of the surrounding water.Water under pressure is capable of incredible feats. An efficient waterproofing system is necessary to be able to endure high hydrostatic pressure, a frequent situation seen in below grade foundations, tunnels, water containment tanks, and subterranean parking structures.

## Technology in crystalline form

Throughout the last three decades, the complete crystalline waterproofing system has grown in popularity all throughout the world. Integral crystalline waterproofing admixtures are used in this system. And when the concrete is being mixed, various admixtures are added. They then mix with the concrete to form the hardened concrete.By utilising the whole mass of the concrete as the waterproof membrane, they make the concrete waterproof by preventing the flow of water via its capillary pores, fissures, and joints. Exterior waterproofing membranes are not necessary.This crystalline technology interacts chemically with water and hydrated cement particles when added to or applied to concrete. It does this by generating insoluble needle-shaped crystals that impede water and waterborne pollutant routes by filling capillary holes and micro cracks in the concrete. Any moisture that is added to the concrete over its lifetime will cause crystallisation, providing long-lasting waterproofing protection.

Because of its special ability to remain dormant within the concrete for all time and respond to any incoming water incursion, this technology is also known as Smart Concrete. Therefore, if a fresh break develops in the concrete and water starts to seep through, the chemicals will react to create new crystals at the source of the leak and expand to block the water flow.This trait makes the concrete very valuable since it indicates that it has the capacity to heal itself. In the long term, it is thus far more trustworthy than surface-applied methods. The building nearly seems to be alive and has the ability to recover from injuries.

## Technology for Densification

Crystalline waterproofing solutions have been slowly gaining popularity as a better long-term means of offering concrete waterproofing protection in the present market for building materials. Due to the popularity of crystalline technology, several "Densification Products" are now being sold as crystalline technologies. This has led to concerns about how to distinguish densification technology, which is made of a hydrophobic, reactive base, from crystalline technology, which doesn't include silicates or other hydrophobic elements.Hydrophilic refers to a molecule's ability to momentarily interact with water (from the Greek hydro, which means water, and Philip, which means friendliness). Due to the hydrophilic nature of Corecryst technology, water is utilised throughout the crystallisation process.The term "hydrophobicity" refers to the quality of a moleculethat is repelled from a mass of water. It is derived from the combination of water in Attic Greek hydro- and for fear phobos. Densification are hydrophobic by nature and work by resisting water in connection to waterproofing. The formation of crystals does not involve the usage of water.

## Comparison of the catalytic function of careerist with the reactive function of silicate

A catalyst employs the catalytic process, which involves using a chemical component to speed up a chemical reaction. A catalyst is not consumed in the process, unlike reactive compounds like silicate-based substances. As a catalyst, careerist may participate in a variety of chemical reactions as long as there are hydrated cement particles and water present.Concrete's free lime reacts with densification by-products like silicates and stearates in a reactive process that consumes them. This kind of material has a limited supply since the reactive components ultimately run out. When a surface is waterproofed using a reactive technique, pores and capillaries close to the surface are sealed, limiting the response to the original surface area. This prevents further reactive elements from penetrating the concrete. Reactive materials are squandered if there are any extras.

Cement particles, water, and time are necessary for the development of Corecryst's special crystalline technology (which works with or without the presence of free lime). The process starts with the application of the crystalline materials and keeps getting better until there are either no more cement particles or water left. The process will continue to work until the water is no longer available since concrete contains enormous quantities of hydrated cement particles. The catalytic aspect of Corecryst's crystalline process enables the waterproofing abilities to activate should water become present in the future (due to increasing hydrostatic pressure, micro cracking, or some other reason). This will continue until the water has been stopped.

Densification methods start the reaction right away and keep going until either the reactive process is finished or all the reactive ingredients have shut all the original pores and capillaries in the concrete, preventing any further reaction from happening. In concrete, what often happens is a mixture, in which the reactive elements fill the pores and capillaries while depleting the silicates' reactive properties when they come into touch with the free lime. In the event of an over application, excess silicates remain latent on the surface and are unable to enter the concrete due to the first surface densification brought on by the interaction between the silicates and the free lime. These overabundances lead to a build-up of met silicate residue, which may cause osmosis and flooring system problems.

The catalytic nature of Careerist’s crystalline technology produces a permanent fix for water intrusion into the pores and capillaries as well as the capacity to self-heal micro cracks as they form should water become present at a later time. As previously mentioned, the crystal line’s catalytic properties enable it to constantly be there and ready to work, needing just the presence of water to restart the interaction between the cement particles and the water.

**Energy costs for production**

Because silicon is created by reducing high-grade quartz sand in an electric furnace, crystalline silicon has a high energy cost. This procedure's power generation might in greenhouse gas emissions. This coke-fired smelting procedure uses a lot of energy11 kilowatt-hours (kWh) per kilogram me of siliconand takes place at high temperatures of more than 1,000°C.This method may have somewhat inelastic energy needs per unit of silicon metal produced. But since silicon cells are more effective at converting sunlight into electricity, bigger silicon metal ingots are cut into thinner wafers with less waste, silicon manufacturing waste is recovered, and material prices have declined, significant energy cost reductions per (photovoltaic) product have been made.

**Toxicity**

With the exception of amorphous silicon, hazardous heavy metals are used in the majority of commercially successful PV systems. A CdS buffer layer is often used in CIGS, while the semiconductor used in CdTe technology itself contains hazardous cadmium (Cd). The solder used in crystalline silicon modules, which connects the copper strings of the cells, has a lead (Pb) content of roughly 36%. Furthermore, there are residues of Pb and sometimes Cd in the paste used for screen printing the front and back contacts. About 1,000 metric tons of Pb are thought to have been needed to produce 100 gigawatts of c-Si solar panels. However, lead is not absolutely necessary in the solder alloy.

### Aggregate silicon

There is no long-range periodic order in amorphous silicon (a-Si). Due to its poor electrical characteristics, amorphous silicon's use in photo voltaic as a standalone material is considerably constrained. But compared to single-junction solar cells, triple-junction solar cells may achieve better efficiency when used in combination with microcrystalline silicon. As opposed to the band gap of amorphous silicon, which is between 1.7 and 1.8 eV, this tandem construction of solar cells enables the production of thin-film materials with a band gap of around 1.12 eV (the same as single-crystal silicon). The ability to build tandem solar cells with a band gap comparable to that of single-crystal silicon while using the simplicity of amorphous silicon makes them appealing[7].

### Silicon nano-crystalline

Porous silicon comes in the form of nano crystalline silicon (nc-Si), often referred to as microcrystalline silicon (c-Si). It is an allotropic variety of silicon that has a par crystalline structure and shares an amorphous phase with amorphous silicon (a-Si). The difference between them is that nc-Si contains tiny crystalline silicon grains inside the amorphous phase. In contrast, polycrystalline silicon (poly-Si) is made entirely of crystalline silicon grains that are separated from one another by grain boundaries. The crystalline granules' grain size is the only factor accounting for the variation. Nano crystalline silicon is a preferable phrase since most materials having grains in the micrometer range are really fine-grained poly silicon. The phrase "nano crystalline silicon" refers to a variety of substances found in the silicon thin film's area of transition from the amorphous to the microcrystalline phase[8].

### Silicon protocrystalline

Proto crystalline silicon (p-Si) is more efficient than amorphous silicon (a-Si), and studies have shown that it may increase stability without completely removing it. A unique phase that develops into a microcrystalline form during crystal formation is known as a proto crystalline phase[9].Due to its highly organized crystalline structure, proto-crystalline Si also exhibits a comparatively low absorption in the vicinity of the band gap. In a tandem solar cell, proto crystalline and amorphous silicon may therefore be mixed. The top layer of this solar cell is made of thin proto crystalline silicon, which absorbs short-wavelength light, while the substrate underneath it absorbs longer-wavelength light[10].

### Crystallization produced by low temperature

Less obvious-integrated power generating than solar power farms has drawn attention in flexible solar cells. These modules may be positioned in places where conventional cells are impractical, such around a phone pole or cell tower. In this use, a flexible substrate, often a polymer, may have a photovoltaic material put to it. Such substrates are unable to withstand the high temperatures involved in conventional annealing. Instead, creative strategies for crystallizing silicon without affecting the underlying substrate have been thoroughly researched. Although they are often discussed in the literature, local laser crystallization, and aluminum-induced crystallization (AIC) are not frequently applied in industry.

Both of these processes use conventional technologies, such plasma-enhanced chemical vapor deposition (PECVD), to create amorphous silicon. During post-deposition processing, the crystallization processes diverge. A tiny coating of aluminum (50 nm or less) is physically vapor-deposited onto the surface of the amorphous silicon during aluminum-induced crystallization. The stack of material is subsequently vacuum-annealed at a temperature that is quite low, between 140 and 200 degrees Celsius. It is thought that the aluminum that diffuses into the amorphous silicon weakens the hydrogen bonds, permitting crystal formation and nucleation. Studies have revealed that polycrystalline silicon may be created at temperatures as low as 150 °C with grains that are on the order of 0.2 to 0.3 m. The duration of the annealing process affects the volume fraction of the film that crystallizes.

Polycrystalline silicon with adequate crystallographic and electrical characteristics is produced through aluminum-induced crystallization, making it a contender for the production of polycrystalline thin films for photovoltaic. Crystalline silicon nanowires and other Nan scale structures may be produced using AIC.Using a laser to locally heat the silicon without exceeding a certain upper-temperature limit on the underlying substrate is another way to accomplish the same goal. The amorphous silicon is heated using an exciter laser or alternatively green lasers like a frequency-doubled Nd:YAG laser to provide the energy required to nucleate grain formation. To promote crystallization without producing widespread melting, the laser fluency has to be carefully managed. A very little amount of the silicon film melts and then cools, causing the film to crystallize. The silicon layer should ideally be completely melted by the laser without causing any harm to the substrate. In order to do this, a coating of silicon dioxide may sometimes be included to serve as a heat barrier. This enables the use of substrates, such as polymers, that cannot be subjected to the high temperatures of traditional annealing. For totally integrated power generation plans that require mounting photovoltaic on common surfaces, polymer-backed solar cells are of interest.

## CONCLUSION

Solar cells made on crystalline silicon are already a dependable product. Efficiency levels on mono crystalline silicon will exceed 25% in the lab. With efficiencies exceeding 15%, multi crystalline silicon may be used for cost-effective industrial operations. The primary semiconducting component utilized in photovoltaic technology to create solar cells is crystalline silicon. As a component of a photovoltaic system, these cells are put together to create solar panels that produce electricity from sunshine. Because fewer solar cells must be produced and installed for a given output, higher efficiencies lower the ultimate installation cost. Crystalline silicon cells are very reliable; they have module lifetimes of more than 25 years and negligible long-term deterioration. Devices made with unfavorable crystalline silicon are getting close to their theoretical efficiency limit of 29.43%. An amorphous silicon/crystalline silicon hetero junction cell with both positive and negative connections on the back of the cell saw efficiency of 26.63% in 2017.

## BIBLIOGRAPHY:

[1] T. Saga, "Advances in crystalline silicon solar cell technology for industrial mass production," *NPG Asia Materials*. 2010. doi: 10.1038/asiamat.2010.82.

[2] M. T. Zarmai, N. N. Ekere, C. F. Oduoza, and E. H. Amalu, "A review of interconnection technologies for improved crystalline silicon solar cell photovoltaic module assembly," *Applied Energy*. 2015. doi: 10.1016/j.apenergy.2015.04.120.

[3] H. I. Dag and M. S. Buker, "Performance evaluation and degradation assessment of crystalline silicon based photovoltaic rooftop technologies under outdoor conditions," *Renew. Energy*, 2020, doi: 10.1016/j.renene.2019.11.141.

[4] U. H. Jalali and S. Afgan, "Analysis of Integral Crystalline Waterproofing Technology for

Concrete,” *Int. Res. J. Eng. Technol.*, 2018.

[5] X. Wang, X. Tian, X. Chen, L. Ren, and C. Geng, “A review of end-of-life crystalline silicon solar photovoltaic panel recycling technology,” *Solar Energy Materials and Solar Cells*. 2021. doi: 10.1016/j.solmat.2021.111976.

[6] J. L. G. Calvo, M. S. Moreno, P. Carballosa, F. Pedrosa, and F. Tavares, “Improvement of the concrete permeability by using hydrophilic blended additive,” *Materials (Basel).*, 2019, doi: 10.3390/ma12152384.

[7] S. Gulkowski, A. Zdyb, and P. Dragan, “Experimental efficiency analysis of a photovoltaic system with different module technologies under temperate climate conditions,” *Appl. Sci.*, 2019, doi: 10.3390/app9010141.

[8] Syafaruddin, Gassing, and F. A. Samman, “RADIAL BASIS FUNCTION AND THREE-LAYERED FEED-FORWARD NETWORK FOR THE OPTIMAL OUTPUT POWER OF PHOTOVOLTAIC MODULES,” *ICIC Express Lett.*, 2020, doi: 10.24507/icicel.16.05.555.

[9] C. Del Pero, N. Aste, and F. Leonforte, “The effect of rain on photovoltaic systems,” *Renew. Energy*, 2021, doi: 10.1016/j.renene.2021.07.130.

[10] A. Norgren, A. Carpenter, and G. Heath, “Design for Recycling Principles Applicable to Selected Clean Energy Technologies: Crystalline-Silicon Photovoltaic Modules, Electric Vehicle Batteries, and Wind Turbine Blades,” *J. Sustain. Metall.*, 2020, doi: 10.1007/s40831-020-00313-3.

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# AN EVALUATION OF THIN FILM SOLAR PANEL

**Mrs.Kamireddi Sunandana***

*Assistant Professor,
Department of Electronics And Communications Engineering,
Presidency University, Bangalore, INDIA
Email Id-sunandanak@presidencyuniversity.in

## ABSTRACT:

*Amorphous silicon (-Si), copper indium gallium selenide (CIGS), and cadmium telluride (CdTe) are the three primary thin film solar cell technologies that are discussed in this chapter in details. Comparing the development of these three technologies to their market share, dependability, and commercial applications. In contrast to multi crystalline solar cells, which have a market share of more than 55%, CIGS and CdTe are equivalent to -Si cells, which are nearly extinct in terrestrial applications. It is anticipated that crystalline solar cell technology would face competition from CIGS and CdTe thin film technologies. However, before exploring the possibility of developing integrated photovoltaic systems, the durability of thin film solar cells remains a challenge that demands a solution. In this book chapter we discuss about thecomponents of thin-film solar panels, thin film solar cell type, uses of thin film solar cell, solar power and cell reaction, solar cells based on silicon.*

**KEYWORDS:** *Cadmium Telluride, Copper Indium, Film Solar, Solar Cell, Thin-Film Solar.*

## INTRODUCTION

One or more thin layers (also known as thin films or TFs) of photovoltaic material are deposited onto a substrate comprised of glass, plastic, or metal to create thin-film solar cells. The usual thickness of thin-film solar cells ranges from a few nanometers (nm) to a few microns (m), which is much less than the wafer thickness of traditional crystalline silicon (c-Si) based solar cells, which may reach 200 m. Commercial applications for thin-film solar cells include amorphous thin-film silicon (a-Si, TF-Si), copper indium gallium diselenide (CIGS), and cadmium telluride (CdTe).

The active (sunlight-absorbing) layers used to create solar cells are often categorized into so-called generations, with the oldest or first-generation solar cells being built of single- or multi-crystalline silicon. The majority of solar PV systems today employ this as their primary technology. Second generation thin-film solar cells, such amorphous silicon (a-Si), cadmium telluride (CdTe), copper indium gallium selenide (CIGS), or gallium arsenide (GaAs), represent the majority of thin-film solar cells used today. Third-generation or emerging solar cells are those created with fresher, less well-known materials. This comprises a number of cutting-edge thin-film technologies, including CZTS, organic, dye-sensitized, quantum dot, and perovskite thin-film solar cells.

Due to their thin structure, thin-film solar cells are lighter and more flexible than first-generation silicon solar cells. This qualifies them for usage in solar systems that are incorporated into buildings and as semi-transparent photovoltaic glass that may be laminated onto windows. Some of the biggest photovoltaic power plants in the world employ stiff thin film solar panels (interleaved between two panes of glass) for other commercial uses. Additionally, compared to first-generation cells, the materials used in thin-film solar cells are often made utilizing simple, scalable processes that are more affordable, and this often in lesser environmental consequences like greenhouse gas (GHG) emissions. In terms of human toxicity and heavy metal emissions, thin-film cells often outperform both renewable and non-renewable sources of energy for the production of power.

As of 2023, some thin-film solar cells have achieved efficiencies of up to 29.1% for single-junction thin-film GaAs cells, exceeding the maximum of 26.1% efficiency for standard single-junction first-generation solar cells. This is despite initial challenges with efficient light conversion, especially among third-generation PV materials. As of 2023, multi-junction concentrator cells using thin-film technology have efficiency levels of up to 47.6%.

## LITERATURE REVIEW

Ruan et al. [1], explored that due to their ideal photovoltaic properties and ductility, thin-film solar panels (TFSPs) are frequently utilised in integrated photovoltaic and solar power systems. Due to the presence of potentially hazardous elements including zinc (Zn), copper (Cu), nickel (Ni), gallium (Ga), lead (Pb), indium (In), and chromium (Cr), these panels vary from conventional silicon-based solar panels. In this research, we looked at the environmental damage that may from disposing of TFSP as household waste after their useful lives are over. We tested whether metals may leak into the soil by burying TFSPs in three different kinds of soils while simulating metal leaching toxicity and acidic corrosion using acid extract. Our findings showed that during nitric acid extraction, the quantities of dissolved metals rose as both the contact duration with the acid and the acid concentration in the solution increased. In the burial experiment, heavy metals were released from TFSPs, and the rates of metal release varied with changes in both the concentration of TFSPs in the soil and the characteristics of the soil. The quantities of TFSPs added were connected with the elevated levels of heavy metals such Zn, Cu, Ni, Ga, Pb, in, and Cr in soil samples. The findings of this investigation proved that TFSPs contaminated soil even after being buried.

Yaghoobi et al. in [2], discussed that due to its potential to help societies shift from economies based on fossil fuels to those based on renewable energy sources, the use of photovoltaic (PVs) has been growing quickly over the last two decades. However, if certain difficulties like the availability of raw materials, manufacturing costs, and environmental effects are rigorously handled in their value chains, PVs as fuel-less energy sources will be sustainable. Thin film solar panels, one of the PV technologies, have shown the potential to achieve sustainability. Through life cycle assessment (LCA) and some environmental fate modelling, we evaluate several research regarding the effects of thin film PVs on the environment in this chapter. To address the environmental and energy implications and promote the development of PV technologies in a more sustainable manner, LCA assessments for these technologies must be carried out. Using data and information from the literature, three effect assessment techniques for LCAthe Energy Payback Time (EPBT), Cumulative Energy Demand (CED), and Greenhouse Gas Emission Rateare examined and contrasted. In general, the majority of findings point to the new thin film PVs, particularly perovskite solar cells, as having great potential to eventually provide the most environmentally friendly PV technology.

Wilkeninget al. in [3], investigated that Cadmium (Cd) and tellurium (Te) dissolution under conditions simulating the acidic- and the methanogenic phases of municipal solid waste landfills were evaluated using two standardised batch leaching tests (i.e., Toxicity Characteristic Leaching Procedure (TCLP) and California Waste Extraction Test (WET)) and a continuous-flow column test on a crushed, non-encapsulated CdTe thin-film solar cell. In both batch leaching studies, very small amounts of Cd and Te (8.2% and 3.6% of additional Cd and Te, respectively) were solubilized. On the other hand, during a 30-day period, 73% of the Cd and 21% of the Te were discharged into a continuous-flow column that was designed to replicate the acidic landfill phase. The amount of dissolved Cd was 650 times greater than the US-EPA's maximum contamination threshold for this metal in drinking water (0.005 mg L) and 3.24 times higher than the TCLP limit (1 mg L). Contrarily, there was very little Cd and Te released into the effluent of the continuous-flow column that simulated the methanogenic phase of a landfill. The striking variation in CdTe leaching behaviour seen in the columns may be attributed to the various aqueous pH and redox conditions supported by the microbial communities present in the columns, which is consistent with thermodynamic predictions.

Michal Tarabaet al. discussed that this study compares the various solar panel technologies used for residential applications. Amorphous and thin-film CIGS solar panels are the major emphasis of the article, however monocrystalline and polycrystalline solar panels are also addressed. The article contrasts the technology of a few different kinds of solar panels, as well as their benefits and drawbacks. The thesis also describes a measurement tool that uses the LabVIEW programming environment to measure solar panel power and light intensity. In the study, the quantity of electric power generated per square metre in severe weather circumstances is compared. All measurements are made under overcast skies with light snowfall on occasion[4]

Chen et al. explored that when an end-of-life (EoL) Cu(InGa)Se2 thin-film solar panel (CIGS TFSP) is discarded and buried in the ground, many metals, including zinc (Zn), nickel (Ni), aluminium (Al), chromium (Cr), gallium (Ga), lead (Pb), copper (Cu), and indium (In), may be discharged and in pollution. In this research in three distinct kinds of soils, including a commercial soil, a Mollisol, and an Oxisol, each of which had varying degrees of CIGS TFSP contamination. Both the quantity of CIGS TFSP applied and the length of the burial time were positively connected with the pollutant concentrations in these soils[5].

Huang et al. in [6], discussed that Amorphous Si thin film solar panels have many layers made up of nanometres-thick layers of brittle and hard materials. Nano-mechanical testing was used to look at the panel cross-section's deformation and material removal capabilities. With indenters of different geometries and weights, Nan indentation and Nan scratching were carried out. The ensuing deformation structures and processes were investigated using electron and atomic force microscopy. Below a certain scratch depth, when material removal occurred without fracture, plastic deformation of the fragile layers was seen. It was discovered that indenter shape and material parameters affected the critical depth. The maximum material removal and scratch depths were produced by the indenter tip with the least included angle. The removal effectiveness was enhanced by the faster scratching. The development of the ductile regime machining procedure for thin film solar panels may be done using the research findings from this study.

## DISCUSSION

### Components of thin-film solar panels

Technologies using thin films reduce the quantity of active material in a cell. The cell may be constructed using a flexible substrate like fabric or a stiff substrate comprised of glass, plastic, or metal. According to life cycle analyses, thin-film solar cells have a lower ecological effect and are often less expensive than crystalline silicon solar cells. They are also perfect for uses like solar systems that are incorporated into buildings because of how thin and flexible they are. Though certain thin-film materials exceed crystalline silicon panels in terms of efficiency, most film panels have conversion efficiencies that are 2-3 percentage points lower than crystalline silicon. Three of the most well-known thin-film technologies are amorphous silicon (a-Si), copper indium gallium selenite (CIGS), and cadmium telluride (CdTe).

## Classification of Thin-film solar cell

The most prevalent kind of thin-film solar cells is made of cadmium telluride. Compared to the more common silicon thin-film cells, they are less costly. Peak efficiency (the proportion of photons striking the surface of the cell that are converted into an electric current) for cadmium telluride thin-films is greater than 22.1 percent. The shortest payback time and lowest carbon footprint of any thin-film solar cell technology available in 2014 were both achieved by cadmium telluride thin-film technologies. Payback time is the amount of time it takes for the power generated by solar panels to offset their purchase and installation costs.Another kind of semiconductor used in the creation of thin-film solar cells is copper indium gallium selenite (CIGS). With laboratory efficiency of 21.7 percent and field efficiency of 18.7 percent, CIGS thin-film solar cells are the most efficient alternative cell material and a promising semiconducting material for thin-film technologies. Because CIGS cells have historically been more expensive than other cell types available on the market, they are not often utilized.

Although they are exceedingly costly to produce, gallium arsenide (GaAs) thin-film solar cells exhibit approximately 30 percent efficiency in laboratory settings. The market for GaAs solar cells has been significantly constrained by cost; spacecraft and satellites have been their primary applications.The earliest and most established form of thin-film are amorphous silicon thin-film cells. They are composed of amorphous silicon, which is less expensive to produce than crystalline silicon and most other semiconducting materials, as opposed to the standard solar cell wafers, which are made of crystalline silicon. Amorphous silicon is also well-liked since it is widely available, non-toxic, and reasonably priced. However, the typical efficiency is quite lowless than 10%.

## Uses for thin-film solar cells

Small strips that were utilized for watches and calculators in the 1980s marked the beginning of thin-film solar cells' applications. Because of their flexibility, which makes it easier for them to be installed on curved surfaces and be used in building-integrated photovoltaic, thin-film applications have significantly risen in potential during the early 21st century.

## Solar Power and Cell Reaction

Solar energy spectrum availability and solar photon to electric current conversion efficiency are taken into account while producing solar electric power. The ground-level solar irradiance as it is transmitted by the atmosphere must be matched to the solar cell sensitivity response for efficient conversion, which is required. 1 atmosphere (AM1) is the standard for the optical path at midday at the equator. Typically collected solar exposure angles have an average path length that is closer to 1.5 to 2 atmospheres. The spectrum irradiances at the Earth's surface through 1.5 atmospheres and at the top of the atmosphere (AM0).

The National Renewable Energy Lab (NREL) uses the AM1.5 model as a test bed after it was modified by the solar industry for assessing solar cell modules. Solar energy at wavelengths shorter than 350 nm is lost due to atmospheric absorption (ozone, water vapor, etc.) and scattering by aerosols, which imposes absorption bands in the irradiance spectrum. Below 320 nm, glass coverings also absorb. Silicon-based and CdTe materials absorb heavily and have excellent conversion efficiency at wavelengths below 1000 nm, where the majority of the solar irradiance energy distribution occurs. In order to boost efficiency and increase energy collection, specialized materials and layer combinations have been created. The spectrum responses for several solar cell materials. Amorphous silicon has a spectral bandwidth of 400–650 nm and a spectral bandwidth of 650–850 nm; hence, the response spans 400–850 nm when stacked. Comparing CdTe cells to silicon compositions, the former react across 400–850 nm with better quantum efficiency. The range of CIGS (CuInGaSe/S) is 400–1100 nm.

## Solar Cells Based on Silicon

As a source of renewable energy, the photovoltaic (PV) solar cell is developing and commercializing quickly. One of the objectives of the Department of Energy's Solar America Initiative (SAI) programmer is to enhance solar power output for industrial and residential energy demands at a much lower cost per KWhr. Greater conversion efficiencies as well as ongoing process and material development research are needed to reach this objective. Single crystal silicon was used to create the first high efficiency PV cells. Low light-to-electric current conversion efficiency is sacrificed for reduced manufacturing costs when ribbon silicon is produced using polycrystalline or amorphous growth methods. Due to its relatively small spectrum absorption breadth, 400 to 850 nm even with the compound structure indicated above, silicon-based technology has a fundamental conversion constraint. For wavelengths with low visible and near-IR energy absorption, this range only collects around 50% of the total solar terrestrial irradiance, hence thick layers of at least 150 m are needed to produce PV energy effectively. The handling and processing of thinner silicon is additionally hampered by big area wafer fragility problems. Due to practical and financial restrictions related to the manufacture of large diameter wafers from crystal ingots, cell size (area) is constrained. Smaller amounts of silicon may now be utilized due to the use of solar concentrator optics, which increases efficiency per unit area.

Thin-Film Solar Cells: Beyond Silicon Advances an attempt is being made to develop and produce PV cells based on advanced technologies in an effort to get beyond the material resource constraints and manufacturing costs connected with the first-generation silicon technology. Under 10X solar concentration, multifunction cells made of thin layers of III-V composition and featuring their broader spectrum response have doubled the efficiency of silicon cells. Structures with 3 and 4 connections respond spectrally to UV rays with wavelengths close to 1500 nm. Multifunction cells are made in small quantities at a high cost of manufacture, and they are used in orbiting space platforms where weight/kW affects costs and payload capacity significantly.

## Thin-Film Panels Made of Cadmium Telluride (CdTe)

When Bonnet, D. and Rabenhorst, H. examined a Cadmium supplied (CdS)/CdTe hetero junction that provided a 6% efficiency, they first developed the cadmium telluride (CdTe) thin-film solar technology. The technology has been enhanced to lower production costs and boost effectiveness. CdTe thin-film solar cells' chemical makeup.A P-N hetero junction absorber layer, which includes a p-doped Cadmium Telluride layer and an n-doped CdS layer that may also be created using magnesium zinc oxide (MZO), is used to create CdTe solar cells. Manufacturers use the close-spaced sublimation method or vapour-transport deposition to deposit components on the substrate.CdTe thin-film solar cells have an absorber layer on top of which is a Transparent Conductive Oxide (TCO) layer typically formed of fluorine-doped tin oxide (SnO2:F) or a similar substance. These components are positioned atop a metal or carbon-paste substrate, and zinc telluride (ZnTe) is used to provide the electrical contact for the cells.

Under Standard Testing Conditions (STC), CdTe thin-film solar panels had an efficiency of 19%, whereas individual solar cells had a 22.1% efficiency. This technology now has 5.1% of the global market, behind only crystalline silicon solar panels, which command 90.9% of it. CdTe thin-film solar panels are around $0.40/W in price.

### Thin-Film Panels Made of Copper Indium Gallium Selenite (CIGS)

Although the CIS thin-film solar cell was initially synthesized in 1953 by Hahn, H., the first advancement for Copper Indium Gallium Selenite (CIGS) thin-film solar cells was achieved in 1981 when the Boeing Corporation developed a Copper Indium Selenide (CuInSe2 or CIS) solar cell with a 9.4% efficiency. The first Copper Indium Gallium Selenide (CIGS) thin-film solar cell was produced in 1995 by researchers at the National Renewable Energy Laboratory (NREL), with a claimed efficiency of 17.1%. Thin-film solar panels made of Copper Indium Gallium Selenide (CIGS) have improved in manufacturing throughout time. Currently, a molybdenum (Mo) electrode layer is applied to the substrate during the sputtering process to create CIGS thin-film solar cells. The substrate is typically produced using a metal foil or polyimide.

By joining a p-n hetero junction, the absorbent layer is created. Copper indium gallium selenite (CIGS) is used to create the P-doped layer, which is positioned above the electrode. The CdS n-doped buffer is created using chemical-bath deposition.Above the CdS buffer, a layer of Intrinsic Zinc Oxide (i-ZnO) is used to shield the absorbent layer of the CIGS thin-film solar panel. In order to safeguard the cell, a thick coating of AZO compound manufactured from aluminum-doped zinc oxide (Al:ZnO) is applied to the materials.

The first CIGS thin-film solar panel produced by NREL had an efficiency of 17.1%, while the most effective one ever developed by Solar Frontier had a performance of 23.4%. Future advancements in the CIGS technology might make it even more attractive considering these materials have a 33% theoretical efficiency.Due to its excellent performance in low-intensity light conditions seen in space and tolerance to low temperatures, CIGS modules are more often utilised in space applications than in ordinary applications. The cost is now slightly over $0.60/W, which is significantly more costly than for other technologies, however future production generations promise to lower the cost for solar panels.Even though CdTe thin-film solar panels are more widely used, CIGS technology still accounts for 2.0% of the global PV industry. This is a thin-film solar technology that is still fairly well-liked, even though thin-film solar modules only account for around 10% of the market.

### Thin-Film Amorphous Silicon (a-Si) Panels

In 1975, Spear and LeComber made the first observation of doping in amorphous silicon (a-Si), and a year later, in 1976, it was shown that amorphous silicon (a-Si) thin-film solar cells could be produced. This technology has been met with high hopes, however the substance itself poses a number of difficulties, including weak bonding, subpar efficiency, and others. Amorphous silicon (a-Si) modules, unlike other thin-film solar panels, do not have an n-p heterojunction; instead, they have a p-i-n or n-i-p configuration, which varies from the n-p heterojunction by include an i-type or intrinsic semiconductor. Amorphous silicon (a-Si) thin-film solar panels may be produced in one of two ways: by manufacturing glass plates or flexible substrates. Currently, a-Si solar cells have an efficiency of 14.0%.

The cells are joined in a monolithic series using laser scribing and silicon layers after the substrate has been prepared, the TCO, and back reflector have been subjected to the deposition process, and thin hydrogenated amorphous silicon (a-Si:H)-based layers have been applied to the electrodes. Finally, frame and electrical connections are applied, and the module is enclosed.While producing amorphous silicon (a-Si) calls for a cheap material in small quantities, the cost of the panel as a whole is set at $0.69/W due to the expense of the conductive glass used in these panels and the lengthy production process. Presently, this technology accounts for 2.0% of the PV module retail market.

### Thin-Film Gallium Arsenide (GaAs) Panels

ZhoresAlferov and his students created the first Gallium Arsenide (GaAs) thin-film solar panel in 1970. Three years after their discovery in 1967, the team produced the first gallium arsenide (GaAs) solar cell of their continued efforts to develop the gallium arsenide semiconductor. In 1980, after another ten years, the technology was being investigated for particular uses such satellites and spacecraft. GaAs thin-film solar cells need a more involved manufacturing process than conventional thin-film solar cells.The substance must first be grown. In order to eventually build the layers for the cell, GaAs buffers are grown on Si substrates by being subjected to various temperature changes and other chemical procedures.

The substrate is treated for the production of the cell once the GaAs buffer has grown. The GaAs solar cell's electrode and bonding material are created in the first stage by depositing a platinum (Pt)/gold (Au) layer (10/50 nm), after which the substrate is bonded.The GaAs epitaxial layer that developed on the Si substrate is applied onto the new substrate once the bonding procedure is finished. Through electron beam evaporation, a Pt/Titanium (Ti)/Pt/Au layer with dimensions of 20/30/20/200 nm is deposited on the top contact layer to finish the assembly process.GaAs PV cells can attain high efficiency of up to 39.2% since they are multi junction III-V solar cells made of graded buffers, but the production time, material costs, and high growth materials make it a less practical option for terrestrial applications. GaAs thin-film solar cells have a rated efficiency of 29.1%.These III-V thin-film solar cells range in price from $70/W to $170/W, but according to NREL, this price may eventually drop below $0.50/W. This technology, which has the lowest market share since it is so costly and experimental, is not mass-produced and is mostly used in space applications[7].

### Application of thin-film solar panels

Thin-film solar panels are becoming popular and offer a wide range of fascinating uses. Some of the most well-liked uses for thin-film are listed below.

### Photovoltaic Integrated into Buildings

Building-Integrated Photovoltaic (BIPV), which heavily relies on thin-film solar technology, is one application that is beginning to gain widespread global popularity. Solar shingles, also known as solar roof tiles, and solar windows, also known as solar glass, are the two primary sub-branches of this technology.The objective of both applications is to provide homeowners and building owners the tools to maintain their structures' attractiveness while enabling the production of solar electricity. This technique combines thin-film solar technology with c-Si solar technology to give a particular level of generation efficiency.

### Applications for space

Space applications are one of the most significant uses for thin-film solar technology, notably Copper Indium Gallium Selenite (CIGS) and Gallium Arsenide (GaAs) technology. The technology is perfect for various applications because to its numerous benefits, including its extreme lightness, great efficiency, broad operating temperature range, and even radiation damage resistance.

### Vehicle roofs and maritime applications

The installation of flexible PV modules on the roofs of vehicles (often RVs or buses) as well as the decks of boats and other vessels is a typical usage for thin-film solar panels. With this use, modules may be installed on curved surfaces, generating solar electricity while maintaining the vehicles and boats' functionality and visual appeal.

### Portable programmer

The mobility and small size of thin-film solar technology are benefits. Calculators have used the technology for years, but with significant advancements, foldable solar panels, solar power banks, solar-powered laptops, and other devices make it possible to have solar power in off-the-grid settings[8]–[10].

### Voluminous applications

Commercial applications are a key area of attention for thin-film solar technology because of its adaptability. Although c-Si solar modules dominate the market, thin-film solar panels' efficiency is rising and their production costs are dropping, which might make thin-film solar panels the standard for most installations.The industrial level applications, particularly at the utility size, are a key area of interest for thin-film solar panels. Thin-film solar panels are an alternative to conventional c-Si solar panels that may eventually prove to be a superior investment since they deteriorate considerably more slowly.

## CONCLUSION

A type of solar panel technology known as thin-film solar panels is portable and adaptable while still producing green solar energy. They are composed of several thin photovoltaic (PV) layers that are between 300 and 350 times thinner than those found in conventional silicon cells. The photovoltaic effect allows the layers to collect light while also creating power. Amorphous, cadmium telluride (CdTe), copper gallium indium diselenide (CIGS), and organic photovoltaic panels are a few examples of thin-film solar panels. Different materials are used to make each type, which has an impact on the panels' overall price and effectiveness. A conducting sheet, a protective layer, and photovoltaic material are all components of thin-film panels. Due to their quick and efficient manufacturing processes, thin-film solar panels are frequently a more cost-effective solar energy choice than other solar technologies. They might not last as long as conventional solar panels and are less effective. Numerous products, including calculators, outdoor lighting, and tiny devices, use thin-film solar panels.

## BIBLIOGRAPHY:

[1] L. C. Su, H. D. Ruan, D. J. Ballantine, C. H. Lee, and Z. W. Cai, “Release of metal pollutants from corroded and degraded thin-film solar panels extracted by acids and buried in soils,” *Appl. Geochemistry*, 2019, doi: 10.1016/j.apgeochem.2019.104381.

[2] M. Zendehdel, N. Yaghoobi Nia, and M. Yaghoubinia, “Emerging Thin Film Solar Panels,” in *Reliability and Ecological Aspects of Photovoltaic Modules*, 2020. doi:

10.5772/intechopen.88733.

[3] A. Ramos-Ruiz, J. V. Wilkening, J. A. Field, and R. Sierra-Alvarez, “Leaching of cadmium and tellurium from cadmium telluride (CdTe) thin-film solar panels under simulated landfill conditions,” *J. Hazard. Mater.*, 2017, doi: 10.1016/j.jhazmat.2017.04.052.

[4] M. Taraba, J. Adamec, M. Danko, P. Drgona, and T. Urica, “Properties measurement of the thin film solar panels under adverse weather conditions,” in *Transportation Research Procedia*, 2019. doi: 10.1016/j.trpro.2019.07.077.

[5] L. Su, J. Chen, H. D. Ruan, D. J. Ballantine, and C. Lee, “Metal Uptake by Plants from Soil Contaminated by Thin-Film Solar Panel Material,” *J. Environ. Prot. (Irvine,. Calif).*, 2019, doi: 10.4236/jep.2019.102013.

[6] T. Sumitomo, H. Huang, and L. Zhou, “Deformation and material removal in a nanoscale multi-layer thin film solar panel using nanoscratch,” *Int. J. Mach. Tools Manuf.*, 2011, doi: 10.1016/j.ijmachtools.2010.11.012.

[7] M. S. Mozumder, A. H. I. Mourad, H. Pervez, and R. Surkatti, “Recent developments in multifunctional coatings for solar panel applications: A review,” *Sol. Energy Mater. Sol. Cells*, 2019, doi: 10.1016/j.solmat.2018.09.015.

[8] L. Richardson, “Thin Film Solar Panels: Do They Make Sense? | EnergySage,” *Energy Usage*, 2019.

[9] A. Kurjakov, M. Kurjakov, D. Miskovic, and M. Caric, “Electrical characteristics of thin film solar panels on a river boat under different microclimatic conditions,” *Facta Univ. - Ser. Electron. Energ.*, 2012, doi: 10.2298/fuee1202151k.

[10] T. Sumitomo, H. Huang, L. Zhou, and J. Shimizu, “Nanogrinding of multi-layered thin film amorphous Si solar panels,” *Int. J. Mach. Tools Manuf.*, 2011, doi: 10.1016/j.ijmachtools.2011.07.001.

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