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Implementation of Coordinated Control and Power Flow Management Strategy for a Solar Powered EV Charging System

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Abstract— This paper introduces a novel coordinated control with electricity flow management system (CC-PFMS) as an element of a system that integrates solar panels to charge electric vehicles. The goal of developing the CC-PFMS was to make it capable of integrated power balancing in several modes of operation with multiple energy sources. Other than that, the design of the charging mechanism is irrelevant; it will just facilitate the change in power source. The major advantage of the proposed method is that it can find and maintain stable functioning regardless of changing factors like solar irradiance, car availability, or battery charging/discharging states. In order to test the new approach, we employ a 1.5 kW charging system that includes a photovoltaic (PV) supply and is connected to the national utility grid. A number of modes of operation, comprising G2V, V2G, PV2V, solar power, G2V+PV2V, V2G+PV2G, & PV2V+PV2G, have been adequately simulated by CC-PFMS using MATLAB. Findings from investigations carried out in the experimental setup likewise supported the predictions made by the computer model.

INTRODUCTION

With a quarter of all emissions coming from energy consumption going toward climate change, the transportation industry is definitely not a minor player. One more practical option would be EVs, meaning electric vehicles. Among the many reasons electric cars are seen as environmentally beneficial is their lack of impact on air pollution. Electric vehicles (EVs) are being heavily promoted by a number of countries via the implementation of policies and incentives aimed at encouraging their widespread use. As an added bonus, this tech influences the actual electrical system. Even more problematic would be the broad adoption of electric vehicles coupled with uncontrolled charging, which would lead to an increase in the daily maximum power usage. There can be greater numbers of power outages, equipment strain, and compromised power quality if charging electric vehicles is not regulated. In contrast, the positive aspects of EV adoption might be shown by managing EV charging or using EVs as small distributed generators, especially in V2G mode. Future transportation options, such as electric vehicles (EVs), symbolise a more sustainable and equitable society.

Connected to a low-voltage charging station, these cars generate zero emissions. In order to accomplish this goal, vehicular autonomy (EVs) will undoubtedly be important. It has been released into the air in significant quantities by vehicles powered by fossil fuels or internal combustion engines. Electric cars have the potential to employ non-conventional energy sources such as batteries, fuel cells, even ultra-capacitors as opposed to more conventional ones. For best results, utilize these sources either on their own or in combination with more conventional approaches. Consequently, there are primarily three types of electric vehicles: fuel cell electric vehicles (FCEVs), hybrid electric vehicles (HEVs), and battery electric vehicles (BEVs). The battery is a big deal when it comes to electric cars. However, recent research has shown overall battery life is no longer a concern. Electric cars are an effort to reduce humankind's environmental footprint by doing away with the use of harmful internal combustion engines. Important terms to use when talking about electric vehicles are "voltage-to-grid" (V2G) and "grid-to-vehicle" (G2V).

When it comes to charging electric cars, the gold standard is G2V, or grid-to-vehicle. The term "vehicle-to-grid" (V2G) refers to nothing more than a method by which an automobile may produce its own power. When electric vehicles enter vehicle-to-grid mode, they connect to the power grid. One of the several uses for voltage-to-grid (V2G) technology is to integrate renewable energy sources into the grid, optimize pricing, balance electrical loads,

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and decrease peak energy demand. When trying to flatten a load profile, the V2G optimal logic control method is quite beneficial. An issue-free V2G operation is ensured by using an aggregator. An aggregator is a digital medium that allows service providers to more readily provide offerings to customers in an electronic format. Using V2G technology might be a great solution to the problem of demand peaks on the power grid or distribution network.

Many problems with distribution networks may be reduced by using sound approaches. We examine the impact of EVs on the power consumption profile here. Uncertain traffic patterns pose the greatest threat to vehicle-to-grid technologies. Changing charging habits to make EVs use less electricity to manage their battery cycles is one strategy to lower the cost of battery deterioration. Offering frequency control services via electric vehicles is one approach. The whole profile of loads is examined in connection to the efficiency and charging time of electric car batteries. Efficient transportation and energy supply systems lead to lower operating costs and fewer emissions, therefore optimizing V2G systems is a top priority. making the power source more precise, stable, and reliable. In the future, electric cars will do double duty as a distributed power source and a strain on the power grid. In terms of distributing the workload across the entire structure, they will be equally important.

Electric vehicles (EVs) are being studied for their dual roles as energy suppliers and loads. Additionally, their influence on system performance and their contribution to system assistance during peak hours are also significant aspects of this research. Predominantly, this research intends to model and examine microgrid integration with renewable power sources and EVs. This research presents an analysis of a smp with EVs using MATLAB/Simulink. The paper is structured as follows: first, it gives a general outline of the charging infrastructure; second, it gives some technical overview of the consequences of electric cars. briefs the reader on the technology, difficulties, and harmonic components of the electric car. The findings and simulation (micro grid study with electric car) are later covered in the conclusion.

REATED WORK :

1.=> 2016 by James et al.

The charging of electric vehicles should be coordinated so that the aggregator may optimize their profit via e-commerce. Melbourne, Australia: IEEE International Conference on Smart Grid Communications (2006).

In this study, we use a model creative predicting control (MPC) based energy trading method to maximize aggregate profit by coordinating the charging of electric vehicles. There is a lack of evaluation of microgrid voltage profiles and peak demand in this work.

Vaddanya n et al. (2018) in 2.

"Uncertainty mitigation through optimal coordinated bidding for an electric vehicle aggregator

held in Cyprus as part of the IEEE International Energy Conference (ENERGYCON).

A stochastic hybrid integer linear programming model for optimal aggregator bidding is presented in this paper. It can't take into consideration unidentified user behavior until simulation results show microgrid performance or power quality.

Mao et al. (2019) 3

An article called "Intelligent management of energy algorithms & EV-charging scheduling" was published in Energy Management, volume 12, issue 2, for page 265.The research mitigates the effects of load fluctuations and energy costs by combining genetic algorithms with sequential quadratic programming. Yet, problems with microgrid-level stability of voltage or losses remain still unsolved.

4. In 2018, Moghaddam et al.

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Page 76–88 in the first edition of the fourth volume of IEEE Proceedings of Mobility and Science, an article titled "a sophisticated charging strategy for charging an electric car station" draws attention to this subject. The authors use optimization of ant colonies to reduce billing fees and customer wait times for electric vehicle users. Efficient distribution and harmonics are not part of the research.

“A review of EVs charging: From the perspective of energy optimization and charging techniques.” Transport. Res. D, vol. 62, pp. 386–417. Comprehensively discusses EV charging approaches, especially smart and fast charging, and their impact on energy demand, system efficiency, and cost optimization.

Amjad et al. (2018) said in 6.

"A survey of electric vehicle charging: Looking at energy optimization on charging methods." Transport Research D, vol. 62, pp. 386-417. Explores the many techniques of charging electric vehicles, with a focus on smart and rapid charging, and how they affect energy usage, system efficiency, and optimized costs.

Amin et al. (2020)

"Better MV network reconfiguration with an integrated method for optimal electric vehicle charging scheduling."

An approach to electric car charging scheduling that is synchronized. Publication: Energy, volume 213, article number 118882. Through the use of user demand modeling, the research devises a plan to improve the grid's load distribution by cutting peaks and filling valleys.

Methodology:

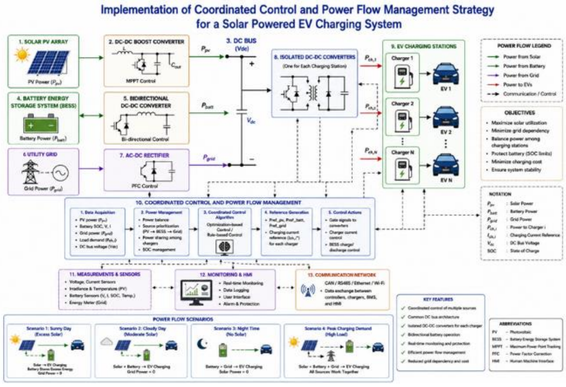
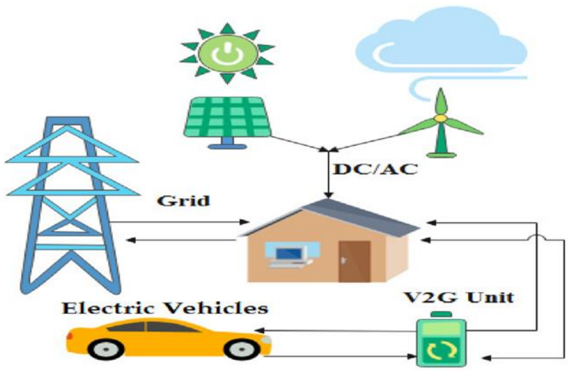


Figure 1 **Layout**



Charging these autos at a low voltage station eliminates pollution. To accomplish this goal, electric vehicles (EVs) are going to be indispensable. Cars powered by internal combustion engines (ICEs) have released significant amounts of carbon dioxide into the atmosphere. Alternative energy sources such as batteries, fuel cells, and ultra-capacitors may power electric cars rather of conventional fuels like gasoline or diesel. If you want better results, utilize these sources on their own or combine them with more conventional approaches. So, there are primarily three types of electric vehicles: fuel cell electric vehicles (FCEVs), hybrid electric vehicles (HEVs), and battery electric vehicles (BEVs). A key component of EVs is the battery. Yet, recent research has shown how battery life is of no longer a concern. Electric cars seek to reduce humankind's environmental effect by doing away with the need for harmful internal combustion engines. The terms "voltage-to-grid" (V2G) and "grid-to-vehicle" (G2V) are necessary when talking about electric vehicles.

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1. SUSTAINABLE ENERGY OPTIONS

2.1 THE FIRST PART

Energy consumption is increasing over the world, and lowering emissions of carbon dioxide is a top priority. This has accelerated the search for renewable energy sources. Traditional power generation techniques depend on nonrenewable fossil fuels; however, renewable energy sources including wind, hydroelectricity, geothermal, solar, and biomass provide an alternative. We examine the possibility of integrating photovoltaic (PV) RES powered by solar and wind energy into the proposed grid in this chapter. Understanding the fundamentals, technical details, power-generation capabilities, and control strategies for optimizing these resources is essential for constructing a robust and long-lasting power system.

2.2 Direct Conversion of Solar Radiation into Electricity A popular renewable energy source, solar photovoltaic (PV) technology uses innovative semiconductors to directly convert sunlight into electricity. This section explores the fundamentals of solar power plants in a microgrid setting, including their components, how they work, the electricity they provide, and how they integrate with other systems.

2.2.1 Solar PV Energy Conversion:

The FundamentalsSolar PV energy conversion relies on the quantum mechanical process that occurs in certain materials when light is absorbed, leading to the creation of electron-hole pairs and the subsequent flow of current.

2.2. Two Specifics Regarding Solar PV System Architecture and PartsMany interconnected parts make up a solar photovoltaic (PV) system, which converts sunlight into energy. Sunlight is transformed into DC power by the solar PV system's many photovoltaic cells, which are typically composed of silicon. Safe and reliable power flow is guaranteed by a solar energy controller, which controls and avoids overcharging the battery bank. So long as there is sunlight, the battery bank can store DC energy (direct current) and provide a steady flow of electricity. An inverter, which converts the DC power into AC power, is necessary for the majority of appliances or the power infrastructure to make use of the stored energy. The correct operation of a solar photovoltaic system depends on each of these parts.

2.2.3 Factors Affecting the Power Output of PV Systems

Solar photovoltaic (PV) systems may create varying amounts of power depending on a number of conditions, among which are more important than others. The amount of sunlight that reaches the photovoltaic modules is an important factor. Per square foot, it is measured in watts (W/m^2). A higher irradiance level leads to a higher power output. Temperature is also important since it affects the efficiency of the PV modules, which means that less electricity is

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produced as the temperature rises. Also, even a little shade over PV modules may significantly reduce the system's total energy output, thus shadowing might be rather crucial. Since they govern the quantity of sunlight that enters the PV modules and, therefore, the quantity of power produced, the angle or orientation of the modules are equally important. When these parameters are optimized, solar systems generate power of the greatest quality.

Polarized Ray Adapter
3.1 A Brief Overview of PV Systems

A PV power producing system connected to the grid is shown schematically in Figure 3.1.
The following are the primary elements of a photovoltaic power generation system:
An inverter, a solar cell
3. Framework
4. MPPT

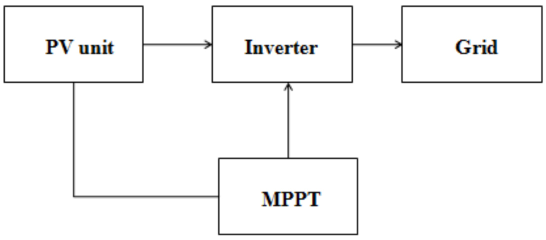

Fig.3.1 System diagram for power production

PV unit: A group of photovoltaic cells, or PV cells, may convert direct current, also known as DC, energy from light into electricity by means of the photovoltaic effect.
The first component of a photovoltaic (PV) system is the inverter, which converts the DC output to AC power.
2. Grid: The inverter sends its output power to a nearby electrical grid, which then uses it to generate electricity.
Thirdly, maximum power point tracking (MPPT): This piece of power conversion gear is essential for getting the most out of the PV modules. Whenever maximum power is being applied, it keeps an eye on the voltage.
Table 3.1 below details the PV system specs taken into account while designing the PV power plant.

Number of solar panels	6
Number of cells in each panel	72 cells
Total number of cells in 6 panels	432 cells

Table 3.1 Specifications of considered PV system

In Table 3.2The quantity of power generated by the PV panels is clearly visible.

SPECIFICATIONS	Voltage	Current	Power
One solar cell	0.5 V	5 A	2 W
One solar panel	37.1V	5.11A	190 W
Six solar panels	222.6 V	30.6 A	1140W

Table 3.2: Energy produced by the potential photovoltaic system

Installing an inverter connected to the PV unit and the grid converts the DC power provided through the PV unit to AC electricity. Table 3.3 displays the inverter specifications.

Utilizing the alternating current (AC) electricity provided by the inverter, power is generated and then sent to the grid. Table 3.4 contains the grid specifications.
It is possible to study the dynamic performance, stability, and resilience of different control approaches by using analytical models. Obtaining a mathematical model of the system is necessary for investigating these characteristics on a three-stage grid-linked PV system. All of the following are modeled as part of the proposed system:
Solar cell and photovoltaic array simulation
Model 2: Inverter with Three Phases
A three-step model for fundamental changes
A mathematical framework of these parts will be built and their operation will be shown in this chapter.

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3.1.1 Modeling of solar cells and arrays

It is a simple photodiode with a p-n junction that converts light energy into usable electricity. A schematic representing an analogous circuit for a PV cell is shown in Fig.3.2. A diode linked in series to the current source, a switching , a series resistivity, plus a current source representing the current from the PV cell are all components of this concept.

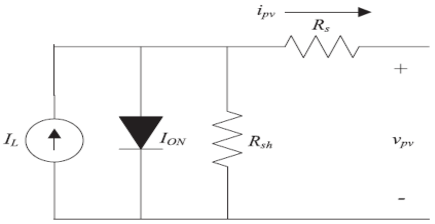


Fig.3.2 Analytical diagram of the solar cell

3Light-Generated Inductance,""Light generated current" describes the current that goes through a solar cell when two crucial processes are underway.

Absorbing incoming photons is the initial step in creating electron-hole pairs. In order for the solar cell to generate an electron-hole pair, the incoming photon's energy must be greater than the band gap. Meta stability refers to the average length of time it takes for p-type electrons or n-type electron holes to recombine, which is equal to the time frame of the minority transport lifetime. Since the electron-hole pair responsible for producing light is destroyed during carrier recombination, the capacity to generate current or power is also eliminated.

The term p-n junction, which physically divides the electron and hole, collects carriers as the second stage in avoiding this recombination. The carriers are separated at the junction of p and n by an electric field. The electric field at the p-n junction may change the minority messenger light into the bulk carrier if it reaches there. When the base and emitter of a solar cell are connected (a short circuit), the light-forming carriers go via open circuit.

3.1.5 SEVs, or solar-powered electric vehicles,

Known as a sunny electric vehicle (SEV), this kind of electric vehicle gets its electricity mostly or totally from sunlight. The photovoltaic (PV) cells that make up solar panels, which are installed on the roof of the car, convert solar energy into electric power instantly. Converted solar energy is the only source that SEVs utilize, hence it powers all or part of the vehicle's propulsion, electronics, speech, navigation, security, and all auxiliary components. A lot like regular automobiles, sensors aid the driver. There, you may monitor the vehicle's energy use, solar power harvesting, and other metrics using the data you get.

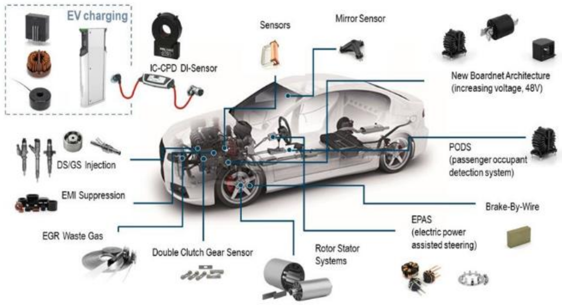
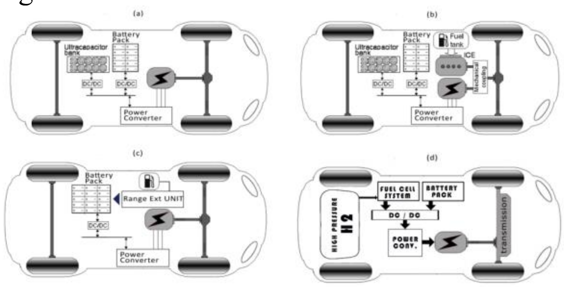


Figure 3.1 Overview of Electric Vehicle Parts.



A battery vehicle (B), a hybrid electric vehicle (C), a range-extended electric vehicle (D), and a fuel cell electric vehicle are the main types of main electric vehicles shown in Figure 3.2, which shows simplified drivetrain architectures.

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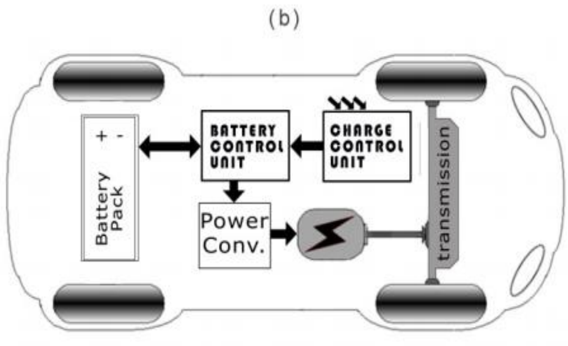
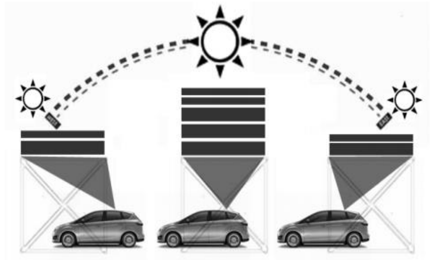


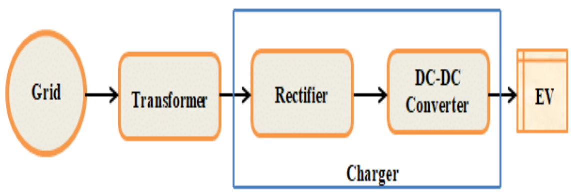
Enhanced Sunroof for SEVs Utilizes CPV Technology (Figure 3.3 (A)). (B) A Solar Electric Vehicle with a Minimalist Drive Train.



Concentrating parking lenses and C-Max SEV charging technology are shown in Figure 3.4.

3. A Location to Charge Electric Vehicles

Electric car charging stations are insufficient. You may find charging stations in two distinct varieties: public and private. The government has installed a modest number of charging stations in different cities in emerging countries, while the vast majority of terminals are private. There has been an increase in charges at some private stations. Figure 3.5 shows a block diagram of an EVCS, broken down into its component parts: the transformer, rectifier, and converter. The two main components of an electric vehicle charger are the rectifier and the converter. the available specs of the EVs.



A schematic of a charging station for electric vehicles (Figure 3.6).

Electric Vehicle Specifications in India: A Table

Parameter	Easy Bike and Auto-Rickshaw	Electric Motorcycle
Power	500–1000 W	1200–2500 W
Voltage	36/48/60 V	60/72 V
Battery	20–30 Ah	20 Ah lead-acid gel battery
Charging time	6–7 h	6–8 h
Maximum speed	30–40 km/h	50–80 km/h
Driving distance	70–100 km	60–80 km

We need to look at the implications of EVs since EV loads are increasing daily. How the electrical system is impacted by the widespread EV penetration is shown in Fig. 2 below. However, with the ability to minimize emissions of greenhouse gases and integrate with smart grid technologies, EV adoption remains the most cost-effective mode of transportation. Negative consequences for the electrical system's network, however, are significant.

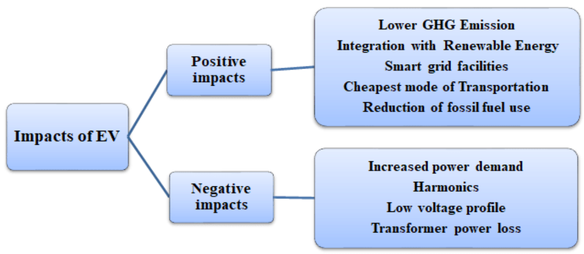


Figure 3.7 Impacts of Electric Vehicle.

4. MOTORS THAT USE RENEWABLE ENERGY TO IGNITE MICROGRIDS:

Section 4.1: A CONCISE REVIEW

Microgrids that include sources of renewable energy (RES), such as electric vehicles (EVs),

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have greatly improved modern power infrastructures. The technical details, advantages, and disadvantages of the procedure are covered in this chapter. The suggested system for this kind of integration is also included. With growing environmental concerns and a need for stronger energy infrastructure, the suggested system is designed to improve grid stability, encourage the use of renewable energy sources, and boost energy efficiency.

4.2. A Micro GrID Component Review

Different types of loads, energy storage devices, and power generating sources make up a microgrid, which may function either standalone or in tandem with the larger grid. Key components of the proposed micro in this study include:

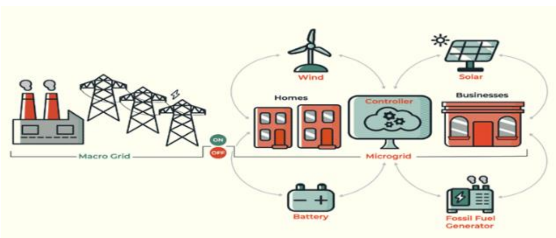
When renewable energy generation falls short, diesel generators (DGs) may step in as dependable and substantial power sources. The microgrid receives green energy from photovoltaic (PV) farms, where solar panels transform sunshine into power.

A wind farm is another kind of renewable energy that uses a system of turbines to collect wind energy.

Electric vehicles have the potential to be a distributed power supply and load simultaneously thanks to Vehicle-to-Grid (V2G) technology.

A strong microgrid, made up of all these components, can provide enough electricity to power a wide range of structures, including homes, businesses, and even electric vehicle charging stations.

4.3 DESIGN OF SYSTEMS AND MODELS



The suggested microgrid design aims to maximize the integration of electric cars with renewable power sources, as stated in paragraph 4.3.1 of the book. Two main mechanisms allow the microgrid to function:

This mode allows for the purchase or sale of electricity on an as-needed basis due to its connection to the main grid.The microgrid may function autonomously in island mode by generating and storing its own electricity. Microgrid design allows for adaptability to grid conditions and renewable resource availability, allowing for seamless mode changes.

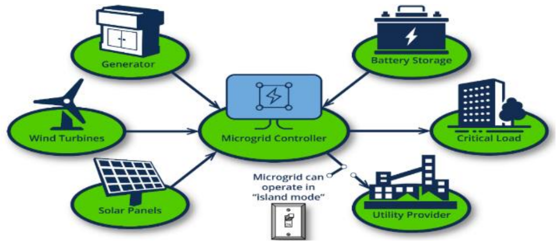


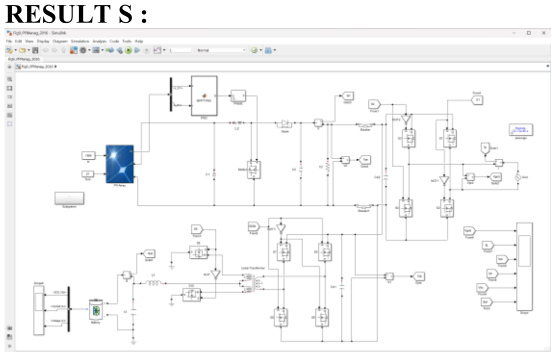
Figure.4.2 Microgrid structure

4.3.2 Coordination and Energy Transfer

Power flow management via a central control system ensures efficient distribution of generated energy to satisfy load demands. Using complex algorithms, this control system is able to do:

The utilization of energy from renewable sources is maximized, fossil fuel use is decreased, and the microgrid's load is balanced via energy management. Frequency or voltage control are used to keep the microgrid operating parameters constant, particularly during grid-connected to islanding mode transitions.

RESULT S :



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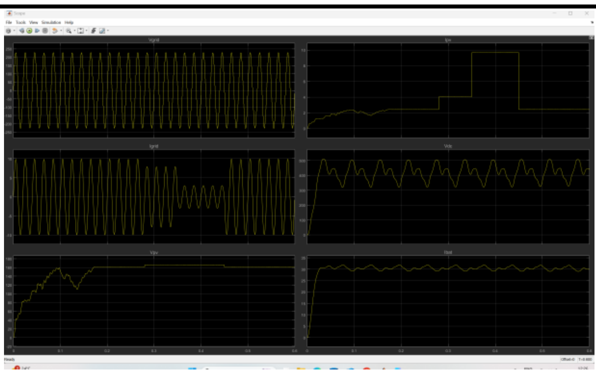

fig 9

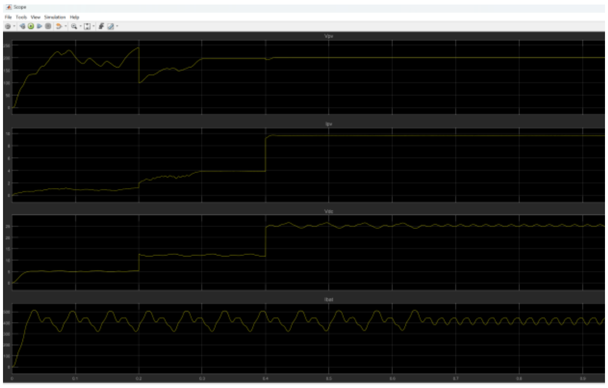

Fig 11

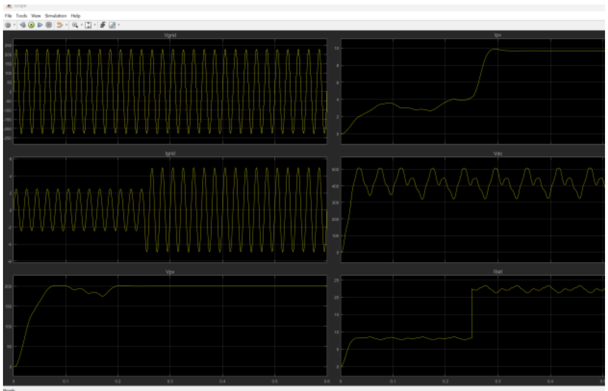

Fig 13

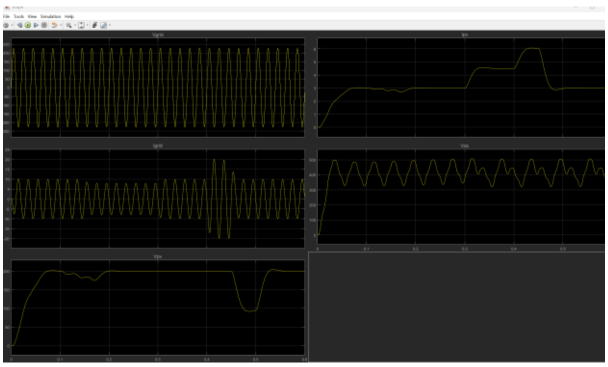

Fig15

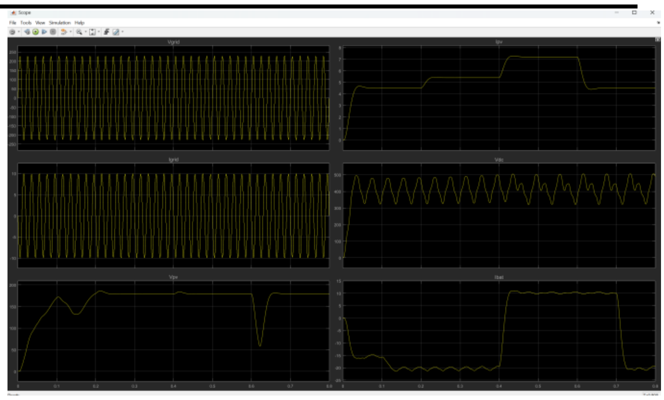

Fig17

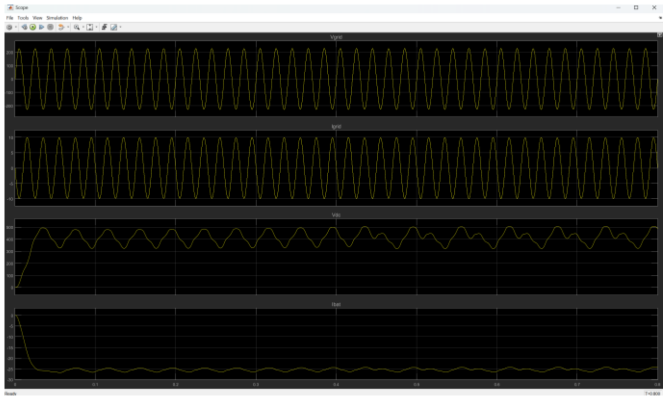

Fig19

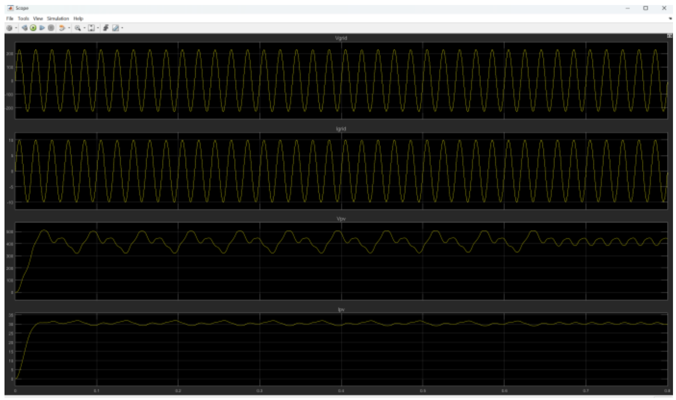

fig21

CONCLUSION

This study develops the CC-PFMS control method for reliable power management in solar-integrated EV chargers (Fig. 25). Allow me to provide the experimental setup: (a) Photovoltaic (PV) simulator, (b) alternating current supply, (c) a solar-boost converter, (d) a PSFB converter, (e) a totem-pole PFC converter, (f) a Semiconductor - TMS320F28027F, (g) a DSO, and (i) a load.

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First, by calculating the stability margin of the converters, we discover that the power supply system is stable in a closed loop. In this research, we offer a CC-PFMS control method, which has important control features including the ability to balance power, regulate the voltage at the DC link, manage the charging and discharging of electric vehicle batteries, and control the UPF. Providing consistent performance in seven distinct environments, this solar combined charging system allows for the most efficient use of existing energy resources. The performance study demonstrates the effectiveness of the suggested technique under various scenarios, including shifting PV irradiances or the charging/discharging statuses of EV batteries. Correct power balancing, economical operation, and reliable performance in all tested scenarios are what an EV charger system with solar integration can expect from the CC-PFMS. All system variables, including grid current or DC link voltage, are able to stay well within the limits set by the IEEE 519-2022 specification because to the recommended control method's excellent system performance.

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