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DESIGN AND DEVELOPMENT OF ELECTRIC VEHICLE CHARGING STATION FOR ELECTRIC VEHICLES USING HYBRID SOURCES

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Abstract : In this paper, a solar photovoltaic (PV) array, a battery energy storage (BES), a diesel generator (DG) set, and a grid-based electric vehicle (EV) charging station (CS) is utilized to provide the incessant charging in islanded, grid-connected, and DG set connected modes. The CS is primarily designed to use the solar PV array and a BES to charge the EV battery. However, in case of exhausted storage battery and unavailable solar PV array generation, the CS intelligently takes power from the grid or DG set. However, the power from DG set is drawn in a manner that it always operates at 80%–85% loading to achieve maximum fuel efficiency under all loading conditions. Moreover, in coordination with the storage battery, the CS regulates the generator voltage and frequency without a mechanical speed governor. It also ensures that the power drawn from the grid or the DG set is at unity power factor even at nonlinear loading. Moreover, the point of common coupling voltage is synchronized to the grid/generator voltage to obtain the ceaseless charging. The CS also performs the vehicle to grid active/reactive power transfer, vehicle to home, and vehicle-to-vehicle power transfer for increasing the operational efficiency of the CS. The operation of the CS is experimentally validated using the prototype developed in the laboratory.

Index Terms **– Diesel generator (DG) set, electric vehicle (EV) charging station, power quality, solar photovoltaic (PV) generation.**

I. INTRODUCTION

Since they do not contribute to air pollution, electric vehicles (EVs) have recently gained a reputation for being very eco-friendly. Due to its practicality, electric vehicles (EVs) have already attracted three million customers. Forecasts indicate that 100 million EVs will be on the road by 2030 [1]. In any case, a vast electrical grid and an extensive system of charging stations would be necessary for the proposed notion to materialise. If the energy required to charge electric automobiles (EVs) originates from environmentally friendly and sustainable sources, it might be argued that EVs are sustainable. The use of fossil fuels to generate electricity, on the other hand, does little to reduce emissions and instead transfers pollution from vehicles to power plants. Thus, it would be beneficial for the environment and possible to eliminate emissions entirely by producing power from renewable sources PV output is the most efficient green energy source currently available for charging electric vehicles (EVs). Reason being, whether you're in the city or the country, solar PV electricity is always available [2]. Alternative, risk-free energy sources include hydropower, fuel cells, and wind. It is still rather simple to reach the Indian subcontinent for the majority of the year. Unlike wind and water power, which have their limitations, solar photovoltaic panels may be installed almost anywhere. Coastal regions benefit most from wind energy, whereas hilly regions get the biggest benefits from water energy. Current charging systems are already difficult, and adding a step to change the power makes them even more so. There is a way to charge electric cars (EVs) that doesn't use green energy, but this is still the case.

There must be a link between the main control system and each step of the change process to make sure it works. Because of this, it is very important to make a system that can work in a number of useful and adaptable ways. To do this, you need to keep control of a lot of different sources the same. A full study has been done to help the area of computer science that studies green energy grow. They said that green energy is very important for making sure that electric cars will be around for a long time [3]. The Cs. EVs were charged by Chandra Mouli et al. using solar power and a high-power, two-way EV charger [4]. The assigned charger can't work with AC charging, which is a shame. Monteiro et al. [5] made a converter with three ports. It has both a solar grid and a charger for electric cars. The charger's design doesn't take into account the changes it makes to the power grid, which is a shame.

The idea put forward by Singh et al. [6] was to build an electric car charging system that uses a modified z-source converter and is linked to the grid. On top of that, the islanded mode isn't meant to work with the charger. Because of this, if the power goes out, it can't charge electric cars. Chaudhari et al. [7] offered a mixed planning method as a way to better handle energy storage in their paper. With this way, solar PV systems should be able to make more power while also lowering the costs of running the CS system. You can get the most out of the solar PV array (when there is doubt) and depend less on the power grid, according to Kineavy and Duffy [8]. They suggested using the power from the business building's photovoltaic (PV) system along with the electric vehicle (EV) charging station (CS).

In their study, Zhang et al. [9] looked at the best times to set up charging stations for electric cars at work where there are two charge options. The charging station (CS) driven by a solar panel array can also be put in place on-site to get the best service for the least amount of money and to make the power grid less busy while charging [10]. Kandasamy et al. [9] studied how long a storage battery would last on a business building that had a solar PV array system. For electric cars, charging stations (CS) that run on wind energy are very helpful because they are available all day, every day [6]. You can find a number of research works on this subject.

Electric vehicle batteries are currently utilised as a distributed energy reserve for several applications due to their high energy storage capacity. A solar photovoltaic array-based charging system was proposed by Singh et al. [4] for use in active power filtering, reactive/active power transfer between vehicles and the grid (V2G), and operation between houses and cars. They constructed a grid-connected residential solar array system and an electric vehicle (EV) [9]. A method for controlling power in an integrated PV-storage residential battery system was proposed by Razmi and Doagou-Mojarrad [3]. This method makes advantage of multimode control. According to the reviewed literature, the majority of computer science (CS) studies devoted to renewable energy have concentrated on bettering various aspects of charging, including storage unit size, scalable renewable power sources, driving style, charging time, cost, and scheduling. However, as of late, very few publishers have really implemented the CS using renewable energy sources.

Furthermore, opinions on the practicality of CS are more evenly distributed. Furthermore, the majority of research focuses on the performance of CS whether it is either isolated or linked to a grid. Connected to the electrical grid, the solar PV screen still can't do all of its tasks, so it's useless even if it's getting sunshine. Solar systems have a hard time producing electricity while operating independently due to the sun's erratic light. Hence, a battery for storing is necessary to mitigate the impacts of fluctuating solar power.

II. SAMPLING AND SYSTEM MODELLING

Charging station components shown in Figure .1 comprise solar PV arrays, DG sets, storage batteries, and grid electricity. Both the electric vehicle's (EV) charging and the power supply for the load attached to the CS are handled by these parts. A boost converter is used to link the solar power source PV array to the dc connection of the VSC, while the storage battery is directly connected to the dc link. (EVs, grid connections, single-phase SEIGs, and nonlinear loads on the AC side of VSCs are all connected by coupling inductors).

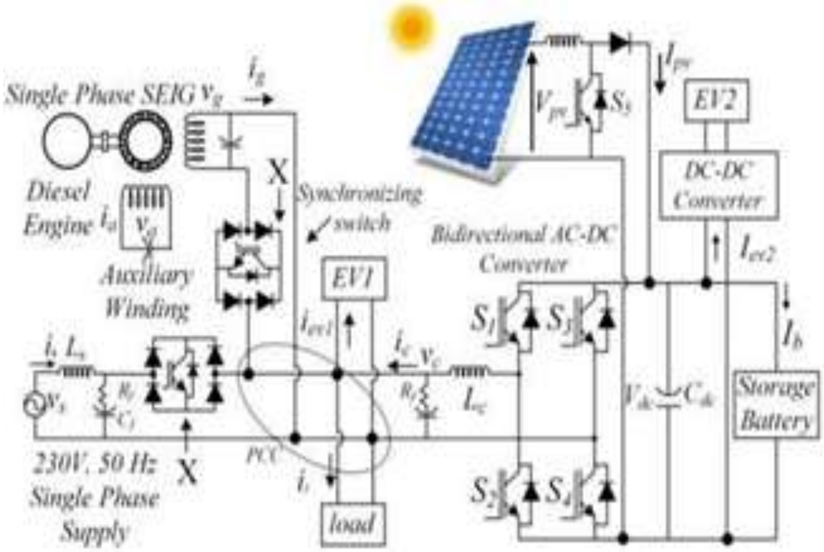

Fig :1 Topology of a CS

Reducing switching harmonics is achieved at the PCC by use of a ripple filter. This causes the currents from the generator and the grid to be sinusoidal. An additional winding connected to a capacitor serves to stimulate the SEIG. Along with the main wire of the SEIG, a tiny capacitor is alsolinked in parallel. To regulate the times at which the CS connects and disconnects from the grid, Connecting the grid/DG set to the PCC, a time switch is set up.

It is feasible, as this experience demonstrates, to utilise a tiny, portable engine to completelycharge the battery pack of an electric automobile in an emergency, although the process may be time-consuming. After confirming the i3's compatibility with the generator, they installed it in the trunk to assess the generator's ability to economically increase the vehicle's range.

III. MANAGEMENT TECHNIQUES

This article examines different control mechanisms employed in the field of computer science. Voltage Source Converter control in Islanded Mode (where there is no Distributed Generation Set and Grid). In the case of a grid outage, the CS's islanding management mechanism will keep the system running, allowing for the sustained production of solar energy and the charging of electric vehicles with both AC and DC electricity. The storage battery may be used for both DC charging and PV generation from solar panels without requiring major changes to its functioning. Nevertheless, An individual VSC controller is required to create a local voltage reference for AC charging in the eventthat there is no voltage reference during a power loss. By applying it is depicted in Figure 2, the isolated controller creates an internal voltage reference of 230 V and 50 Hz. In order to generate thereference voltage, this logic takes the combined frequencies and runs them via a sine function.

To get the current of the reference converter, we first use a PI controller to reduce voltage difference. Then, we compare the resulting reference value to the converter input voltage. The generation of reference current and the reduction of errors are expressed as

$$\begin{aligned} i_c^*(s) = i_c^*(s-1) + z_{pv}\left\{v_{ce}(s) - v_{ce}(s-1)\right\} \\ + z_{iv}v_{ce}(s). \qquad (1) \end{aligned}$$

The measured current of the converter is compared to the standard current, and the results aresent through a hysteresis controller, the gate signals are generated.

IV. MANAGEMENT OF THE VSC OPERATING IN DG SET OR GRID-LINKED MODE

The main job of the controller when it's in grid-connected mode is to figure out how much power to send to the grid. In order to maximise fuel economy, it operates in continuous power modewhile the DG set is attached. Regardless, controllers are always required to take electric vehicle (EV)harmonic and reactive current needs into consideration. By comparing the EV current with the grid or DG set reference current, it finds out. When an electric car is linked to the grid, the reference current is determined only by the active current flowing through the vehicle. By integrating the EV'sactive and reactive currents, the reference DG set current can be determined when operating in connected mode. This study recovers the EV's basic frequency current using ANC [7]. Whenever thequadrature and in-phase unit templates cross zero, the fundamental current is integrated using the sample and hold logic to produce the active and reactive currents. This is how much active and reactive current there is in grid connected mode:

$$\begin{aligned} I_{sp} &= I_p - I_{ef2} - I_{pf} \\ I_{sq} &= 0. \qquad (2) \end{aligned}$$

In grid-connected mode, the electric vehicle's (EV) active current is the only one considered;the reactive current is set to zero. This enables the electric vehicle to attain a power factor of unity. Conversely, the DG set operates in connected mode makes advantage of the EV's reactive and activecurrent components. The DG set connected mode current levels for active and reactive power are asfollows

$$\begin{aligned} I_{sp} &= I_p - I_{ef2} - I_{fp} - I_{pf} \\ I_{sq} &= I_{vq} - I_q \qquad (3) \end{aligned}$$

The EV2 feed-forward term is denoted as Ief2, whereas the PV array feed-forward term is Ipf. The EV's active current is Ip, while its reactive current is Iq. The frequency and voltage regulatorsutilised in the linked mode of a DG set are referred to as "Ifp" and "Ivq" respectively. The integrationof energy from EVs into the grid is supervised by Ief2. When talking about PV arrays connected to the grid, the term "Ipf" describes the feed-forward component that controls the problem of storage battery overcharging. Charging the storage battery in CC/CV mode is not feasible since the DC connection comes into direct touch with the energy storage. But there is a way to make sure the storage battery is never overcharged. Storage batteries connected to the grid are protected from overcharging by injecting solar PV-produced power into the grid. Figure 2 shows how the feed- forward term for the solar PV array is integrated into the grid-connected mode's control system, which accomplishes this. The amount of electricity that the PV array sends to the grid is increased by an adjustable gain factor in the feed-forward term. The charge level of the storage battery determines a constant, indicated as "", which is a numerical number between zero and one. So, the "" becomes a "1" when the storage battery is fully charged. After the storage battery dies entirely, though, the "" becomes a "0." Excitingly, the following is the grid or DG set reference current:

$$i_s^* \text{ or } i_g^* = I_{tp} \times u_p + I_{tq} \times u_q \qquad (4)$$

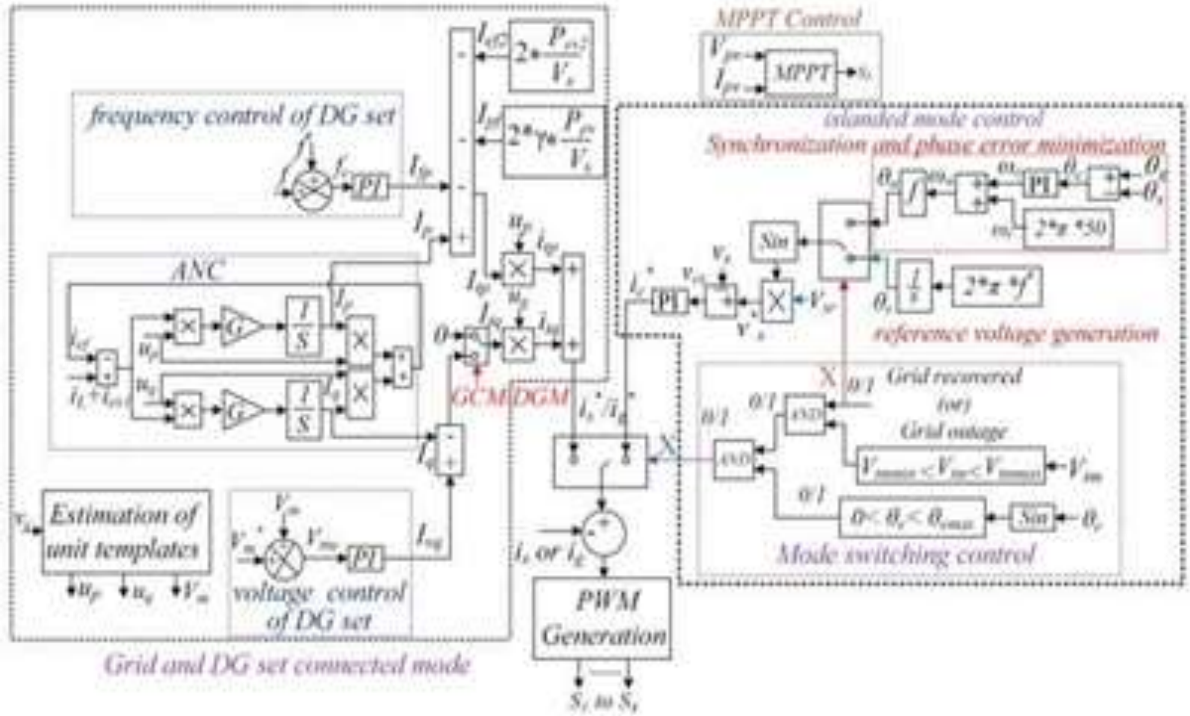

FIG. 2 UNIFIED MANAGEMENT OF THE VSC IN LINKED, GRID, AND STANDALONE MODES FOR DG SETS.

In this context, "up" and "q-p" might be either the grid voltage (vg or vs) or the DG set's synchronization signals. As seen in Figure 2, the hysteresis controller produces switching signals bycomparing the grid/DG set's measured and reference currents. Voltage and frequency control in DGsystems is the subject at hand. In order to get the DG set up and running at just the right frequency and voltage, the VSC's decoupled control is used. Reactive power controls the voltage and active power regulates the frequency in a decoupled control system. The voltage and frequency are regulated using a pair of PI controllers. The proportional-integral (PI) control algorithm used for voltage regulation is expressed as

$$I_{vq}(s) = I_{vq}(s-1) + z_{vp}\{V_{me}(s) - V_{me}(s-1)\} + z_{vi}V_{me}(s) \qquad (5)$$

The gains of the PI controller are denoted as zvi and zvp, whereas the calculation for Vme is V ∗ m- Vm. Zkfp, Zfi, and fe are the discrete formulations of the frequency PI controller, whichrespectively represent the PI gains and frequency error. The coupling of the frequency and voltage controller outputs to produce grid-connected control is illustrated in Figure 2. However, in grid- connected mode, the controllers do not produce any outputs due to the regulation of voltage and frequency by the grid. When connected via a DC-DC converter to a DC power supply, the EV2 EVcontrol operates in CC/CV mode, which stands for constant current/constant voltage. Until the Electric vehicles (EVs) switch to Constant Current (CC) charging mode when their battery terminalvoltage is higher than what's needed to fully charge the battery. When the battery gets close to beingfully charged and achieves the terminal voltage that is required, the charging process for electric vehicles switches to Constant Voltage (CV) mode. As shown in Figure 3, the CC/CV charging modeis controlled by two PI controllers.2. Current reference current is supplied via the external voltage loop to the stage of contemporary control.

An estimation of the reference charging current is

$$I_{ev2}^*(s) = I_{ev2}^*(s-1) + z_{evp}\{V_{er}(s) - V_{er}(s-1)\} + z_{evi}V_{er}(s) \qquad (7)$$

The gains of the controller are represented by Zevi and Zevp, while the error in the EV batteryvoltage is denoted by Ver. The reference and measured battery currents dictate the switching signalsfor the converter, which are produced by the pulse width modulation generator and PI controller. Thecomputation of the duty cycle for the PI controller is given as,

$$d_{\mathrm{ev}}(s) = d_{\mathrm{ev}}(s-1) + z_{\mathrm{ep}}\{I_{\mathrm{er}}(s) - I_{\mathrm{er}}(s-1)\} + z_{\mathrm{ei}} I_{\mathrm{er}}(s) \qquad (8)$$

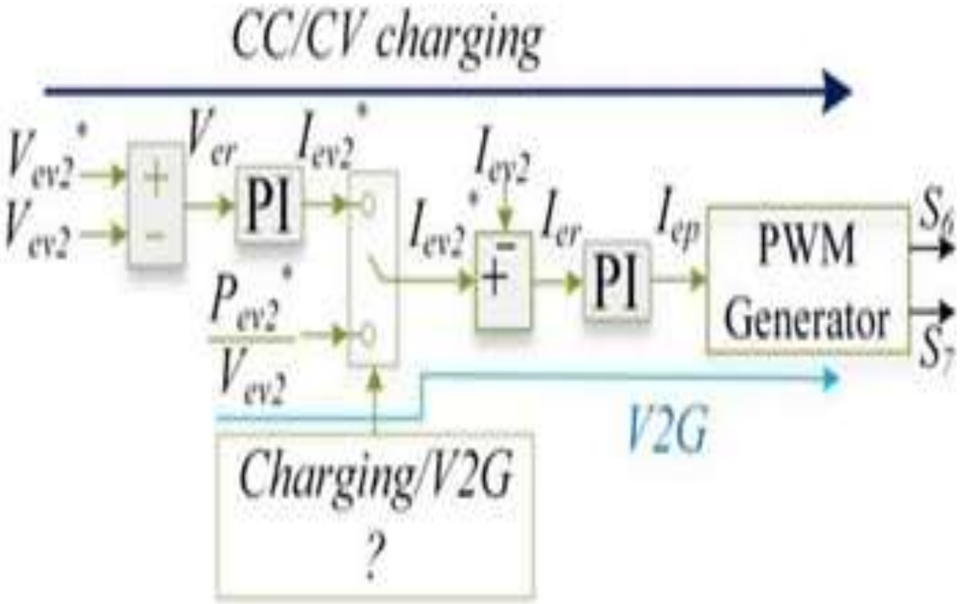

Fig. 3 EV2 control for V2G power transfer and CC/CV charging

V. PULSE WIDTH MODULATION

The average power delivered can be reduced by dividing an electrical signal into discrete pieces using pulse-duration modulation (PDM). Quickly turning the supply and load switches allowsone to control the average voltage (and current) that is supplied to the load. When the switch is switched on, the total power provided to the load is greater than when it is off. Along with MPPT, itis an important way to limit the amount of electricity that solar panels can produce so that the batterycan manage it. When controlling inertial loads, such motors, which have a delayed reaction owing totheir inertia, Pulse Width Modulation (PWM) works extremely well. The reason behind this is because these loads see less impact from sudden switching. A sufficiently high PWM switching frequency is required to prevent load impact. So, it's important for the load to perceive a smooth waveform.

The switching frequency of the power supply might change drastically depending on the loadand the particular application. Consider the many on and off cycles that an electric stove must complete in the span of one minute. However, 120 Hz is the minimum frequency required to operatea light dimmer. In contrast, a motor drive must toggle between tens of kilohertz and a few kilohertz.As a last point, switching frequencies in the tens to hundreds of kilohertz (kHz) range are required by audio amplifiers and computer power supplies. Very little power is lost by switching devices when using pulse width modulation (PWM), which is its main advantage. When a switch is turned off, very little electricity flows through it, and when the load gets power, the voltage drop across theswitch is almost nonexistent. Power loss is minimal in both cases since current and voltage are interdependent. Because digital controllers are binary, it is easy to determine the appropriate duty cycle using Pulse Width Modulation (PWM). For some communication systems, controlling the dutycycle of a communication channel is the key to data transmission, and pulse width modulation (PWM) is one such method.

VI. RESULTS AND DISCUSSION

Simulink, a graphical programming interface, aims to make the representation of system behaviour look intuitive. It offers a visual interface for addressing numerical problems without requiring programming. The models incorporated in a foundation consist of squares, symbols, and explanations:

- Squares are numerical capacities; they can have changing quantities of sources of info and yields.All of the squares in this collection map to common mathematical functions.
- Within the Include, Subtract, and Sum Blocks, the Squares Add, Subtract, and Include operations aremutually exclusive. You may change the icon's shape and the list of signs inside the square parameterto change its form.

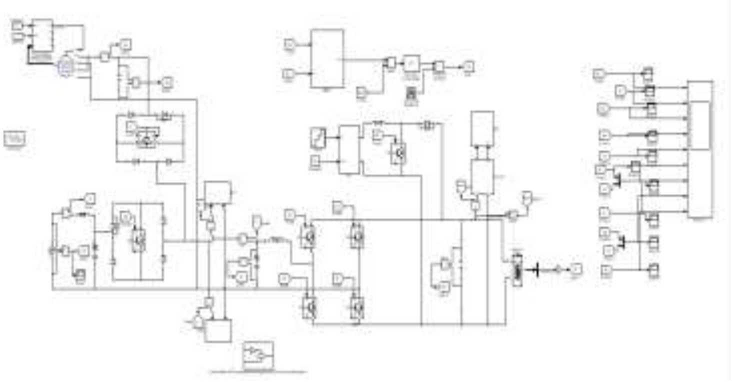

Fig. 4 Topology of a CS

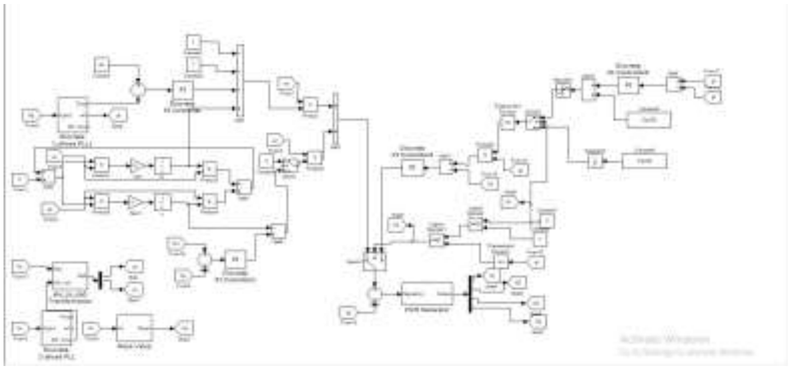

Fig. 5 unified management of the VSC in linked, grid, and standalone modes for DG sets

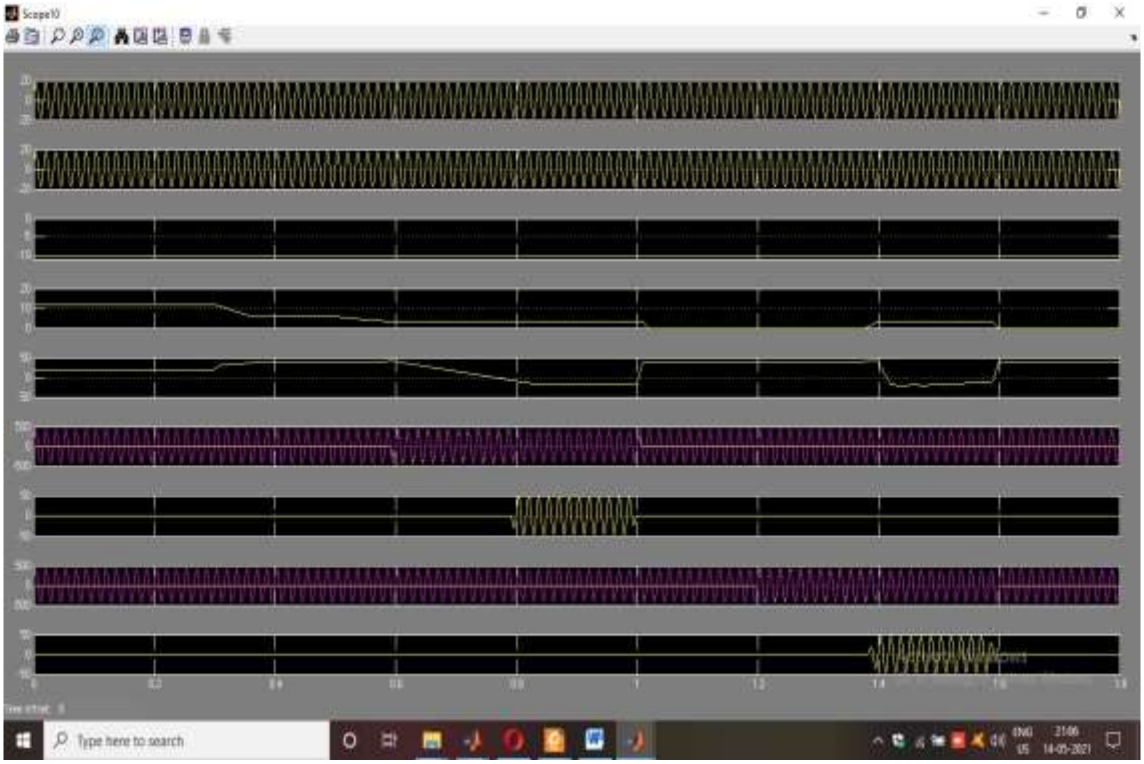

FIG.6 SIMULATION OUTCOMES ILLUSTRATING THE VARIOUS WAYS OF OPERATION

The amounts of gains in the controller are shown by zep and zei. Ier shows the mistake in thebattery current. For the V2G power transfer, the power reference says that the EV2 battery is empty,so the controller chooses the other way, as seen in Fig 5.The baseline power controls the EV2 feed-forward part shown in Figure 5.2. In charge of making sure that different systems or processes workwell with each other and that switching from one to the next goes smoothly. Depending on how muchpower it needs to make and charge, the CS can run in different modes. To make the mode change goas smoothly as possible and keep charging going as long as possible, a plan for mode changes needsto be made. This mode change code changes from a connected DG set that is island-based to a connected grid form island-based. To use this method, first find the change in phase between the twovolts. Then, line them up so they can work together. The PI processor changes the frequency of the voltage that the voltage source converter (VSC) makes when the system is grounded. That's why thischange was made, as shown in Fig 5.2. To turn down the phase, the PI device given as

$$\Delta\omega(s) = \Delta\omega(s-1) + z_{\mathrm{pa}}\{\Delta\theta(s) - \Delta\theta(s-1)\} + z_{\mathrm{ia}}\Delta\theta(s) \qquad (9)$$

Zia and Zpa are utilised for control tuning and to display the phase difference. Figure 5 displays the differences in operation of the CS in islanded mode and also provides a list of scenariosrequiring a mode transition. After the synchronisation criteria are satisfied, the control code sends the synchronising switch the "1" signal.

To evaluate the CS's performance, we look at results from both experimental and simulation-based data. From the Model Figure 5. displays the simulation results, which demonstrate that the CScontinues to function. Initially, the CS is set to "islanded" mode. Electric vehicles linked at the PCCreceive energy from the PV array, which allows them to be charged. If the PV panels produce moreelectricity than is required to charge electric vehicles, the surplus will be stored by the energy storagesystem. From 1000 W/m2 to 300 W/m2 is the decrease in solar energy in about 0.32 seconds. In order for the backup battery to continue charging, the PV array's output decreases. After 0.48 seconds, the electricity from the PV array stops, indicating that the backup battery is dead. The storage battery can charge to its maximum capacity if its SOC is greater than its SOCmin. The CS islinked to the grid by the CPU after the synchronising procedure is complete and the batteries are dead. At 0.79 seconds, the CS initially drew electricity from the grid. Therefore, the DG set powersthe CS in the absence of power from the grid or backup batteries. The CS can rapidly transition between modes according to production and demand, as shown in Figure 5.

Conclusion

A system for charging electric vehicles has been put up, which includes a storage battery, a grid link, a photovoltaic (PV) array, and a control system based on distributed generation (DG) sets.Scientific investigations have shown that the CS can, with only one VSC, function in three distinct modes: islanded, grid-connected, and DG set-connected. Results from the tests also demonstrated that the CS works well in a variety of steady-state and dynamic situations caused by variations in solar irradiation, electric vehicle charging current, and loads. The ANC-based control algorithm wasshown to be successful in sustaining exchange of energy with the infrastructure at Unity Power Factor or acceptable DG set loading, according to the test results in both grid connected and DG set modes.

In addition, the findings have shown that CS can operate independently as a generator, and the voltage quality is excellent. Also, the distributed generation (DG) set is more likely to be loadedoptimally, and the photovoltaic (PV) array is more likely to work at its maximum power output. Theflexibility to operate in island, grid-connected, and DG set linked modes, together with automatic mode switching, has enhanced the reliability of charging. The CS's conformity to IEEE standards guarantees a constant voltage and current Total Harmonic Distortion (THD) below 5%, proving thecontrol's efficacy. According to the statement, this control system, when combined with the providedcontrol, can effectively use different types of energy and provide reliable and affordable charging forEVs.

"Electric Vehicle Charging Station Market Addition," the newest research from Acumen Research, delves deeply into the industry's revenue forecasts, market share, SWOT analysis, and regional coverage. In addition to a thorough geographical study, the research examines the market'sdevelopment potential and significant hurdles. Furthermore, it examines the anticipated results of thebusiness, taking into account the expansion strategies employed by prominent players in theindustry.Wireless charging stations will be a future innovation, and there will be an increasing number of these stations equipped to charge hybrid electric vehicles using cutting-edge technology.

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