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An Implementation of Multimode Operating Capability for Electric Vehicle Charging Station

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Abstract: *In this paper, uses a photovoltaic (photovoltaic) array, battery energy storage (BES), diesel generator set (DG), and grid-based EV charging station (CS) for island and grid connectivity modes. Provides endless charging with and connected DG set. Charging stations are primarily designed to charge electric vehicle (EV) batteries using a solar system and BES. However, when the battery is depleted and the PV system creates a field that is inaccessible, the charging station intelligently absorbs electricity from the grid or DG-Set (diesel generator). However, the power of the DG set is always deducted to operate at 80-85% load to achieve efficient fuel economy under all load conditions. In addition, the charging station regulates the generator voltage and frequency in the same way as a battery, without a mechanical speed controller. Also, ensure that the power drawn from the mains or DG set has a power factor of 1 (UPF) even with an indirect load. In addition, the electrical output of the PCC (Standard Connection Point) is compatible with the mains voltage / generator for continuous charging. Charging stations also enable the transfer of real / active power of the car, return of the car, and transmission of the car's power to the car, increasing the efficiency of the charging station. The operation of the charging station has been experimentally verified using a prototype developed in the laboratory*.

Keywords: **EV Charging Station, Solar PV Generation, Power Quality, DG Set**.

1. INTRODUCTION

Electric vehicles (EVs) are now considered one of the most efficient means of transportation with zero towing emissions. Considering the benefits of electric vehicles, there are already 3 million vehicles on the road and are expected to exceed 100 million by 2030 [1]. However, the implementation of the proposed system requires rechargeable infrastructure and high energy capacity. In addition, electric vehicles are sustainable only when electricity from renewable and sustainable sources is needed for charging.

However, generating electricity using fossil fuels does not reduce pollution and removes fossil fuels from vehicles to power plants. Therefore, by using renewable energy sources to generate electricity, we can completely eliminate emissions and benefit from nature. Among the various renewable energy sources available, PV arrays, wind, hydro, and fuel cell-based energies, PV is available almost everywhere, whether in or out of the country. Therefore, it is the best solution for EV charging. City [2]. The Indian subcontinent is available almost all year round. Unlike solar systems, wind and hydropower are specific. Wind power is very useful in coastal areas, and hydropower is useful in hills. Renewable energy-based charging stations are the most likely solution for EV charging, but when integrated into existing charging systems, they introduce additional power conversion phases that increase system complexity and power consumption. In addition, each change phase requires individual control and integration with existing controls. Therefore, it is important to design an integrated multifunctional and multimodal system with integrated controls. Coordination between different sources is essential..

Much effort has been made to improve charging stations based on renewable energy. Ugil Murella et al. [3] discussed the importance of renewable energy for the sustainability of EV charging stations. Mulietal. [4] Use solar energy to charge the EV with a double-headed high-power EV charger. However, the designed charger does not provide AC charging. Monterio et al. [5] introduced a 3-hole converter to connect the same PV component and EV charger. However, the designed charger ignores the current distortion of the power grid generated by the charger. Shin et al. [6] We propose a modified Z source converter for PV design of the same element / grid connected to the EV charger.

However, the charger is not designed to work on the island. Therefore, EV charging cannot be provided without the grid. Chaudharietal. [7] Described a hybrid model that combines battery storage management to reduce operating costs for charging stations and maximize PV output. Kineavy et al. [8] uses the energy generated at the PV site (installed in a commercial building) in combination with an EV charging station to minimize the impact on the power grid (in uncertain circumstances) on a variety of solar powers. We are proposing to use a photovoltaic system. Zhang. [9] Studied full charging of EV charging stations in a dual charging mode operating environment.

Powerful charging stations for PV arrays (CS) are also suitable for deployments that provide the highest quality service at minimal cost while minimizing the impact of the charging network [10]. Kandasa myetal. [11] Investigate the loss of battery life in commercial buildings based on the PV array system. Wind power CS is also beneficial for EVs as it can be used day and night, and many publications are available in this area [12]-[14].

Due to the large amount of energy stored in EV batteries, EVs are also widely used as a power source to provide a variety of compatible services. Shin et al. [15] introduced PV array-based CS to provide active grids, active power filters, and homes with a place to charge and run vehicle capacity. Saxena et al. [16] Use grids connected to EV and residential PV array systems. Razmi et al. [17] proposed a power management strategy to control a variety of integrated PV live battery systems for grid and standalone applications. Erdincetal. [18] and Kikuzato et al. [19], Hafizetal. [20] Introduced the following smart home functions B. EV. It can be used as storage to power both consumers and consumers from home to home and from grid to grid.

A detailed analysis of the revised manual suggests that the work presented in the renewable energy charging station area focuses on improving various aspects of charging, including: B. Renewable energy source, final device size, driving pattern, charging time, charging cost, charging plan, etc. However, in the current scenario, only a handful of books use renewable energy charging stations.

In addition, there is not much discussion about the performance of charging stations under real-world conditions. In addition, most books only discuss CS performance in grid tie mode or island mode. However, since it is an operation mode only in grid tie mode, even if the sun (solar radiation) is available, if the grid is not available, the PV panel cannot be used. Similarly, in standalone operation, PV power is cut off by the remaining solar radiation.

Therefore, a backup power supply is required to minimize the effects of fluctuating solar radiation. However, once the battery is fully charged, maximum power point tracking (MPPT) should be turned off to prevent overcharging of the stored battery. Therefore, this document introduces PV arrays, grids, power storage, CS-based DG sets, DG connection grids and connection mode DG sets operating on the island to ensure that PV power is used in all operating conditions. increase. Other publications [15] describe both ways to connect to islands and grids. However, the two modes are controlled separately and automatic mode switching between the two modes is introduced.

Therefore, without a power supply in automatic switching mode, the same PV power supply will be interrupted and EV charging cannot continue. Therefore, this document introduces the logic of automatic mode switching. This allows the controller to automatically switch between different operating modes depending on the output power of the PV member and the need to charge the EV. Due to nighttime availability and the temporary nature of the PV system, accumulators with the same PV components are used for continuous and reliable CS performance.

However, due to the limited storage capacity of the battery, it is not always possible to provide a backup copy. Therefore, if the same PV power is not available, CS will need grid support and power storage will be excluded. However, due to the limited availability of the grid, especially in remote areas, a DG set may be required to maintain charge continuity. However, the performance of the DG set is affected by the type of load and is not fully utilized. In general, DG sets are designed for a very limited number of harmonics with a current load [21].

Therefore, EV chargers typically use a converter and then slow down using a power factor adjustment circuit and a DC-DC converter, so EV charging is the performance of the DG set due to the presence of harmonics in the current EV.Will greatly affect.

However, in this document, due to the harmonics of the EV charger provided by the power converter (VSC) and current operating requirements, the DG set will always be charged at least 80% of the estimated value. The main contributions to this paper are:

- PV design and test validation using the same components, power storage and integrated DG grid set supports uninterrupted DC and AC charging of electric vehicles.
- An integrated controller design that allows the charging station to operate in island mode, grid, and connected DG-Set with just one VSC, without hardware switching.
- Switching mode design that allows the charging station to simply switch modes for continuous charging.
- Vehicle-to-Grid (V2V) control system for Car-to-Grid (V2V) charging and Car-to-Grid (V2G) power support design for grid support.
- Operation of active power plant filters to reduce line current so that power exchange occurs at a power factor of 1.

This is required to comply with the charging station and the IEEE-519 standard.

- DG frequency and voltage control strategies different from automatic frequency control.

- A strategy to supply additional PV participants generated from the grid to avoid battery overcharging.

2. SYSTEM DESCRIPTION

As shown in Figure 1, the presented charging station uses solar power, batteries, DG sets, and grid power to charge the EV and power the load connected to the charging station. The PV array is connected to a DC voltage source converter (VSC) port with a boost converter, and the battery is connected directly to the DC port.

The grid, single-phase SEIG (Self Excited Induction Generator), EV, and indirect load are connected to the AC side of the VSC via a link inductor. PCC ripple filters are used to eliminate the exchange of harmonics between the mains and the current generator and make these currents sinusoidal. The excitation capacitor is connected to the SEIG auxiliary window. Small capacitors are also connected to all SEIG major curves. Synchronous switches are used between the main / DG-Set and the PCC to control the connection / disconnection of the main / DG-Set's charging channels.

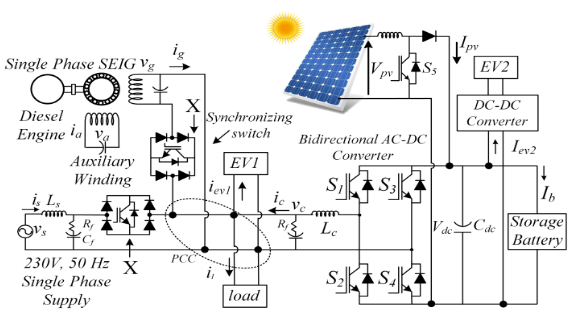

Fig. 1 Topology of charging station

3. CONTROL STRATEGIES

Various control strategies used in the CS, are discussed here

A. Control of VSC in Islanded Mode(Absence of DG Set and Grid)

CS-on-island control guarantees stable CS performance even in the absence of a grid. In other words, AC and EV-DC charging remains the same, and solar power generation is not interrupted. DC charging and solar power can be controlled by batteries without making many changes to the controller. However, AC charging requires a separate VSC controller that uses voltage readings in the output range, as electrical standards are not available without a grid. Therefore, the island controller produces 230V and 50Hz internal voltage references according to the concept shown in Figure 2. It combines frequency and continuity signs to generate a reference voltage. The generated reference is compared to the terminal voltage of the converter. The converter finally provides a current reference converter after electrical error is reduced using proportional integral (PI) control. The current generation error reductions and references are displayed. Represented as.

$$i_c^*(s) = i_c^*(s-1) + z_{pv}\{v_{ce}(s) - v_{ce}(s-1)\} + z_{iv} v_{ce}(s)$$

B. Control of VSC in DG Set or Grid Connected Mode

In grid tie mode, the controller is responsible for determining the amount of power being modified by the grid. In DG kit connection mode, the DG kit operates in fixed power mode for maximum fuel efficiency. However, in both cases, the controller must compensate for the current demand for the corresponding active EV.

This is achieved by measuring the current grid indicator or DG set from the current EV in grid connection mode, which is currently limited. Only the active current of the current EV is considered. However, in the DG set connection mode, the current reference DG set is measured using both active EV current and active EV current. In this task, Adaptive Notch Suppression (ANC) outputs the current frequency of the EV. As you proceed with sampling and logic acquisition, all zero power exceeds the quadrature unit template to provide the most active and efficient current power respectively.

$$i_s^* \, or \, i_g^* = I_{tp} \times u_p + I_{tq} \times u_q$$

C. DG Set Control for Voltage and Frequency

By using a single DG set, the frequency and power of the DG set is controlled using the VSC shortcut controller. In another tuning, the frequency is tuned through the active power and the voltage is tuned through the active power. Therefore, two PI controls are used to control voltage and frequency.

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

D. Control of EV2

The EV connected to the DC port via a DC-DC converter is controlled by current / continuous voltage (CC / CV). The EV will be charged in CC mode until the terminal voltage of the EV battery reaches the voltage corresponding to the fully charged state. However, as soon as you get close to the desired terminal, the voltage will almost completely go into charging mode and EV charging will go into CV mode. The CC

/ CV charging mode is controlled by two PI controls, as shown in Figure 3.

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

E. Synchronization and Switching Control

Charging stations operate in different ways depending on power generation and charging requirements, so individual switching strategies can help you make smooth changes from one mode to another and not interrupt the charging process. Is required. Generated in the connected grid and placed on the islands of the DG set in the connected mode is the condition under which the logic switching mode is built. In this technique, the phase difference between the two voltages is detected first and the regulator synchronizes the two voltages in phase.

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

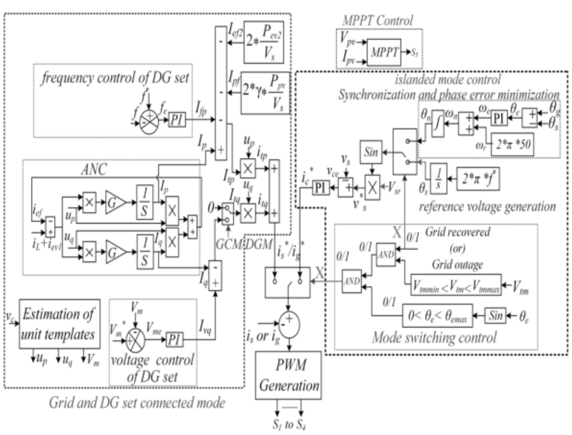

Fig. 2 Unified control of VSC for standalone and grid and DG set connected mode

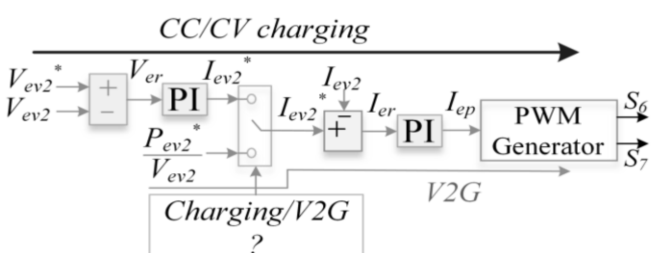

Fig. 3 EV2 control for CC/CV charging and V2G power transfer

4. RESULTS

The simulation results shown in Figures 5.5 to 5.10 show the uninterrupted operation of CS. Initially, the CS operates in island mode and is powered by the same PV to charge the EV connected to the PCC. The production of photovoltaics exceeds the charging demand of electric vehicles, so the rest of the production is stored in electricity storage. In 0.32 seconds, the sunlight changes from 1000 W / m2 to 300 W / m2. As a result, the same PV capacity is reduced and the battery starts charging and keeps charging. At 0.48 seconds, the same PV power will be zero and the battery will run out. The battery fully supports charging as long as SOC> SOCmin. After the battery is completely discharged, the controller will connect the CS to the grid after synchronization. After 0.79 seconds, CS started drawing power from the grid. From this point onwards, CS is supported by the DG-Set due to grid availability and battery storage capacity, as shown in Figure 5.7. From the imitation results, we can see that the charging station automatically changes modes according to the power generation and demand.

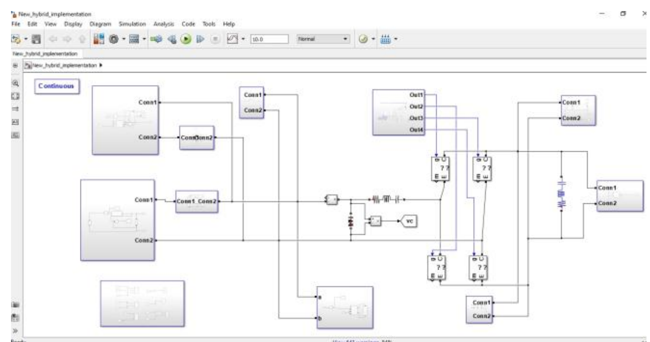

Fig 4 Simulink model of charging station topology

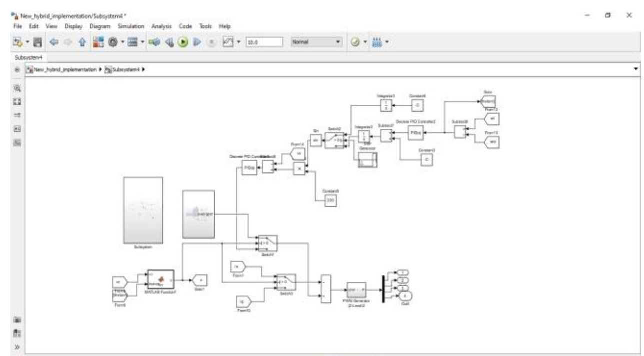

Fig 5. Simulink model of control schemes for unified control of VSC

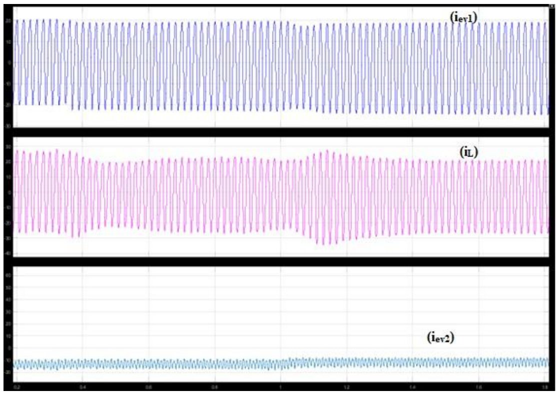

Fig 6. Simulated outputs currents of EV1 (iev1), EV2 (iev2)and load (iL)

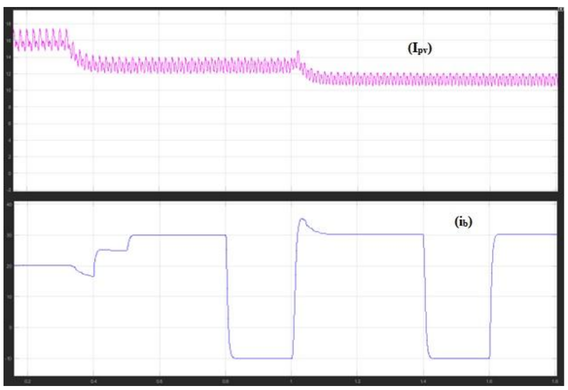

Fig 7 Simulated outputs currents of PV current (Ipv)& battery charging and discharging current (ib)

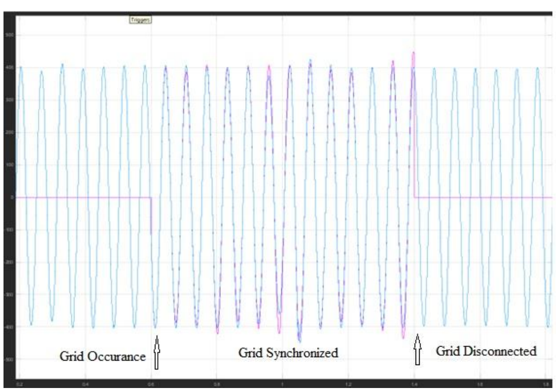

Fig 8 Simulated output voltages of supply voltage (VS) and DC link voltage (VC)

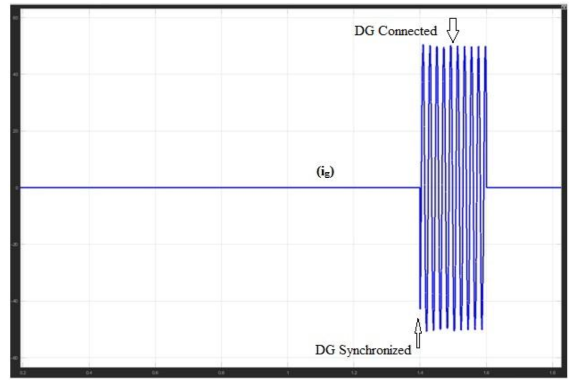

Fig 9 Simulated output current of generator (ig)

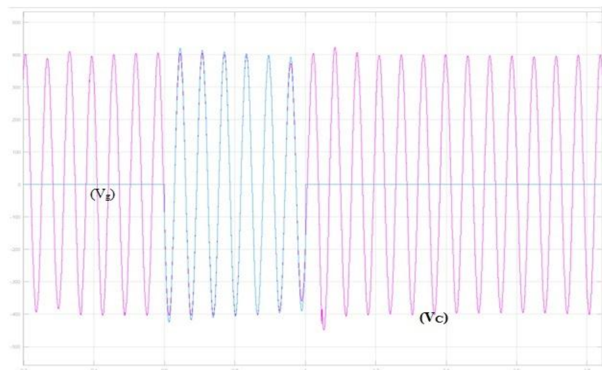

Fig 10 Simulated output of generator voltage (Vg) and DC link voltage (V_C)

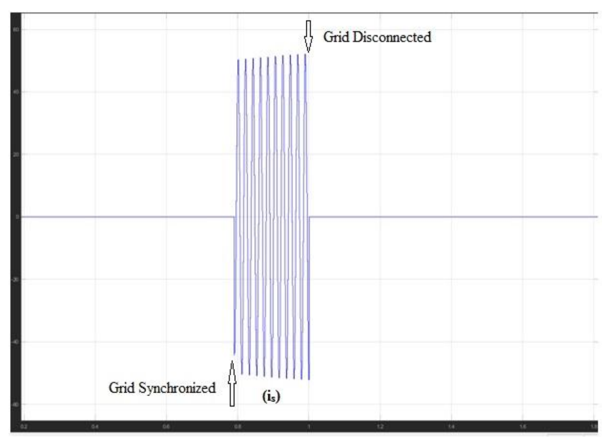

Fig 11 Simulated output current of generator (is)

5. Conclusion

EV charging implements PV configurations, battery storage, grids, and DG-based charging stations. The results presented validate the multimode performance (island power, grid connection, and DG connection set) of a CS with only one VSC. The test results also confirmed the satisfactory performance of the charging station under different stable and dynamic conditions resulting from changes in solar radiation, changes in the current charging EV, and changes in load. The performance of the charging station as an independent voltage generator is guaranteed by the results presented..

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