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Research

ENHANCEMENT OF POWER QUALITY IN A PV-POWERED EV CHARGING STATION CONNECTED TO A THREE-PHASE GRID

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ABSTRACT
The improvement of power quality in a solar photovoltaic (PV) electric vehicle (EV) charging station is the main goal of this work. Both standalone and grid-connected modes of operation are available for the system. The EV battery is directly charged by the PV array in standalone mode. Surplus PV power is fed into the utility grid while it is in grid-connected mode. By lowering harmonic currents and adjusting for reactive power, the charging station also improves grid performance. Harmonic current compensation, EV battery charging and discharging control, and simultaneous charging or discharging with harmonic compensation are among the several functions it offers. With synchronization control for smooth grid reconnection, the control approach maintains total harmonic distortion below 5% in accordance with IEEE-519 standards, ensuring proper operation even under unbalanced grid voltages.

Keywords:
Solar Photovoltaic (PV) System, Electric Vehicle (EV) Charging Station, Power Quality Improvement, Harmonic Compensation, Reactive Power Compensation

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I INTRODUCTION

The use of electric cars (EVs) has increased due to growing pollution and environmental concerns, which has raised the demand for effective charging stations. Conventional EV chargers don't allow energy to be transferred back to the grid because they only allow unidirectional flow and rely on grid power. However, through vehicle-to-grid (V2G) operation, EV batteries can serve as energy storage during periods of high demand, allowing reactive power assistance and bidirectional power flow. A single-stage PV-based off-board EV charging station linked to a three-phase grid is shown in this work. A bidirectional converter lowers DC-link ripples and harmonics while regulating battery charging and discharging. The system ensures steady performance under fluctuating grid and solar conditions by improving grid power quality, compensating for reactive power, and operating in both grid-connected and freestanding modes.

II LITERATURE SURVEY

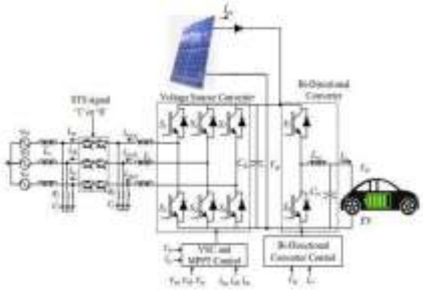
Significant developments in EV charging and grid integration technology have been highlighted in recent studies. By using renewable energy, solar EV charging encourages environmentally friendly mobility. Both light and heavy EVs are supported by universal off- board chargers, increasing efficiency and flexibility. Vehicle performance is improved by innovative motor control and battery charging circuitry. Wide voltage gain and increased efficiency are achieved using interleaved single-stage LLC converters. Effective V2G functioning is made possible by single-phase bidirectional chargers that use Cuk converters. Both V2G and G2V modes are supported by high-voltage gain bidirectional DC-DC converters. In three-phase V2G inverters, frequency adaptive repetitive control enhances power quality. Microgrid dependability is strengthened by energy storage sizing and placement. Economic research supports the advantages of V2B and V2G integration, whereas reactive power correction lowers losses.

III EXISTING SYSTEM

Conventional grid-connected chargers with little power quality control are the mainstay of the current PV-based EV charging station system. In conventional configurations, only grid-to- vehicle (G2V) operation is possible since EV batteries are directly charged from the three- phase grid via unidirectional converters. Vehicle-to-grid (V2G) usefulness is hindered by these systems' inability to allow bidirectional power transfer. They also provide reactive power adjustment and little harmonic mitigation, which might result in low power factor and higher total harmonic distortion (THD). If PV integration is available, it is often connected through distinct stages, which increases losses and system complexity. Additionally, the charging station's performance may deteriorate during voltage imbalances or grid disruptions. Therefore, the capacity of conventional technologies to enhance the overall stability and quality of grid power is restricted.

BLOCK DIAGRAM:

A solar PV array serves as the main energy source in the block diagram of the suggested PV- based EV charging station. It is coupled to a DC-DC converter with MPPT to extract the most power. A common DC-link capacitor that keeps the DC voltage steady is fed by the converter. The EV battery is connected to the DC-link via a bidirectional DC-DC converter, which permits both charging and discharging. The DC-link is connected to the utility grid via a three-phase Voltage Source Converter (VSC). The VSC ensures controlled power flow between the PV system, EV battery, and grid while performing harmonic mitigation and reactive power adjustment. The system is synchronized with grid frequency and voltage using a synchronization unit. For consistent and dependable operation, the entire system runs in both independent and grid-connected modes.

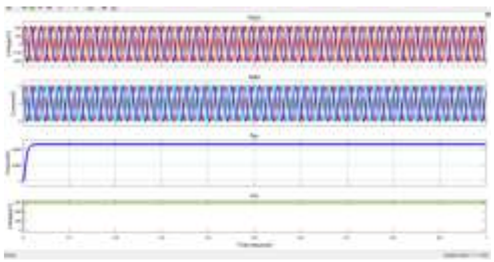


IV PROPOSED SYSTEM

To improve power quality and operating flexibility, the suggested solution offers a single-stage PV-based EV charging station interfaced with a three-phase grid. To guarantee effective energy extraction, a DC-DC converter with maximum power point tracking (MPPT) is attached to a solar PV array. In order to facilitate both charging and vehicle-to-grid (V2G) operation, the generated power is routed to a shared DC-link that is connected to the EV battery via a bidirectional DC-DC converter. The DC-link is connected to the utility grid via a three-phase voltage source converter (VSC). The system maintains overall harmonic distortion within IEEE standards, compensates for harmonic current, and supports reactive power. For dependable performance, it can function in both standalone and grid-connected modes.

V RESULTS

The suggested PV-based EV charging station connected to a three-phase grid shows a notable improvement in power quality performance, according to simulation results. Harmonic distortion in the grid current is successfully reduced by integrating a voltage source inverter with advanced control techniques and a regulated DC–DC converter. The grid operates steadily and dependably because the Total Harmonic Distortion (THD) is kept within IEEE standard bounds. Under different load and solar irradiation circumstances, power factor is enhanced to almost unity. The system also minimizes voltage fluctuations and mitigates current imbalances during EV charging. Furthermore, consistent power supply and effective energy use are guaranteed by the coordinated control between the PV array and the grid. Overall, the proposed system enhances grid stability, efficiency, and sustainable EV charging performance.



VI CONCLUSION

The suggested PV-based EV charging station effectively improves power quality while guaranteeing effective and dependable charging when connected to a three-phase grid. The system efficiently controls voltage and current under changing solar and load conditions by combining a solar PV array with a regulated DC–DC converter and a voltage source inverter. Total Harmonic

Distortion (THD) is greatly reduced and kept within acceptable IEEE standards with the use of sophisticated control mechanisms. Additionally, the system minimizes voltage sag, swell, and current imbalance problems while achieving near-unity power factor. Additionally, it facilitates smooth power transfer between the grid, EV load, and PV system. All things considered, the proposal offers a reliable, effective, and sustainable alternative for contemporary EV charging infrastructure.

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