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Development and Testing of a Three Phase Two Stage Grid Tied Solar Photovoltaic Inverter with EV Charging Station (Support)

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Abstract: This study explains how a smart inverter system is developed and tested to connect solar photovoltaic energy with the main power grid and also support electric vehicle (EV) charging. It focuses on a 100KW three- phase solar inverter that includes smart features like a boost converter to increase the voltage from solar panels and Getting the most power from the sunlight requires use of Maximum Power Point Tracking(MPPT) .The two level inverter changes the solar DC power into AC with Pulse width Modulation(PWM) control also it can be used by the grid and the rectifier change the grid AC power into DC to charge the EV charging stations.The management system manages the electrical potential (voltage), keeps the inverter in synchronization to the grid through Phase- Locked Loop (PLL), and avoids sending unwanted reactive power, making the system clean and efficient. Tests done using MATLAB/Simulink show that the system works well even when sunlight levels change. It keeps the DC voltage stable and delivers the highest possible power.Besides helping the grid; this system can also charge electric vehicles using solar power, either directly or through the grid. This reduces the use of traditional energy sources for charging EVs. Overall, smart grid-connected inverters like this are very important for the shift to renewable energy, providing a clean, smooth, stable connection between solar power, the grid, and electric vehicles.

I. INTRODUCTION

In Nowadays, integrating solar energy into our life has become smooth because to it's a overflowing, renewable nature, and potential to supply energy to homes, industries, and even electric vehicles. However, we need more than just solar cells; in our world where everything relies on alternating current, we need a system that can convert DC (direct current) to AC (alternating current) usable by our devices. In other words, solar need inverters that can convert solar energy into useful electricity. My project highlights the design and development of a smart solar inverter system capable of performing more than mere energy conversion, starting with a three-phase two-stage inverter configuration that is customary to higher power systems. The first component comprises a boost converter, which lifts the voltage with the aid of a secondary power source. The second component is a grid-tied inverter that turns DC to AC. Higher efficiency levels result from using MPPT (Maximum Power Point Tracking) as it ensures the system gets optimal energy output from the sun, in this instance, dynamically shifting with the sunlight's position during the day. Moreover, PLL (Phase-Locked Loop) enables the inverter output to be synchronized with grid frequency, thus allowing seamless power transfer.

The solar PV system with dual stages employs two control loops. The internal loop consists of the inverter's current being controlled to synchronize with the phase and sinusoidal shape of the grid power. The external loop controls the power output of the inverter relative to the amount of power the solar panels are capable of generating, depending on the peak power.

Overall this arrangement also enables EV charging directly from solar power or through the grid, helping in decreasing our dependence on fossil fuels. We evaluated the system within the MATLAB/Simulink environment to assess its performance under varying sunlight conditions.

II. SYSTEM DESIGN

The layout of the system is illustrated in Figure 1 for a PV system linked to the grid with Electric vehicle charging station (EV). Here we have two stage connections, then first stage connection is boost converter it is DCDC Converter to control the PV output power by using MPPT theorem and boost the DC voltage from the solar panel array to a greater level. The second stage connection is three phase inverter it is DC-AC converter to ensure the inverter output is aligned with the grid voltage, ensuring efficient and safe grid connected operation as per PLL theorem. The output of the three-phase inverter is linked to an LCL filter. LCL filter the AC power to remove the harmonies and noise. The LCL output linked to the utility grid. The three phase Grid AC power converter to DC by using rectifier, then it is connected to EV charging station Figure 2 shows the block diagram of the system.

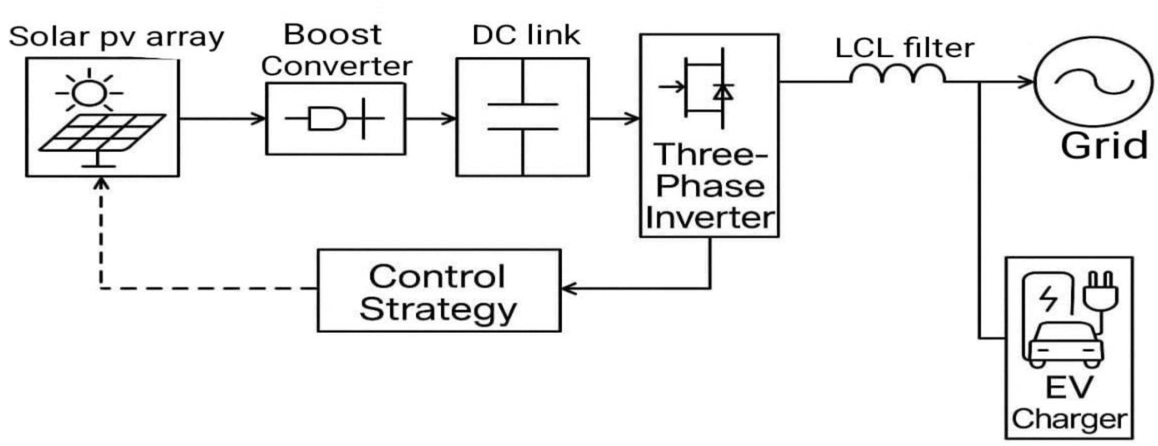


Figure:1. System Design of three phase two stage grid connected solar PV system with EV station

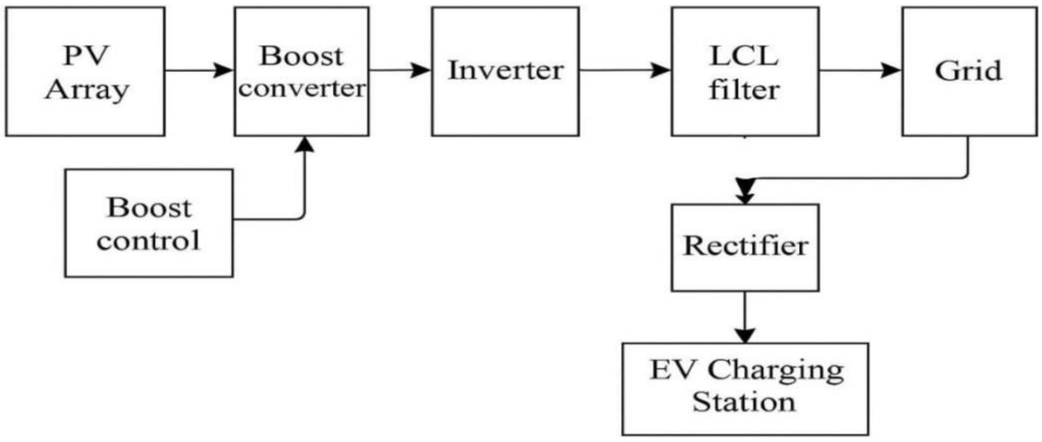


Figure-2: Block diagram of three phase two stage grid connected solar pv system with ev station.

III. CONTROL STATEGY

A. Boost Converter.

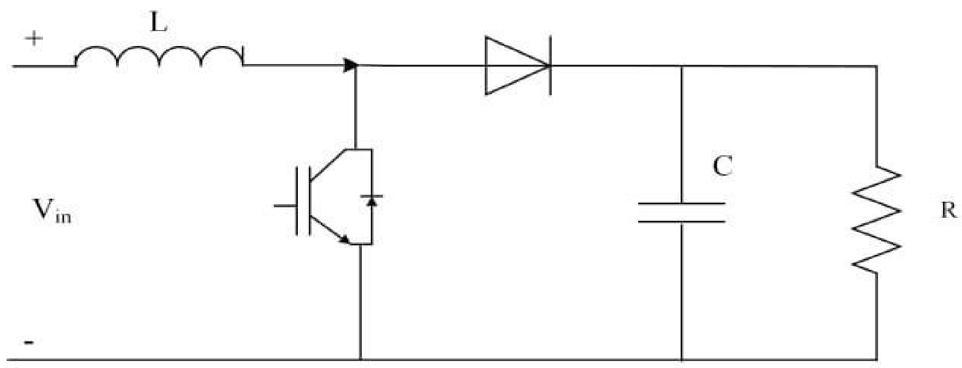


Figure-3: Boost converter control.

A boost converter is a converted to DC-DC converter that steps up (increases) the input voltage to a higher output voltage. It operates using two main components: a switching element (usually a MOSFET) and an energy storage Element (inductor and capacitor). The MPPT algorithm changes the PWM duty cycle to regulate the output voltage and extract maximum power from the solar modules. The step-up converter as shown in Figure 3.

B. MPPT Technique.

This method is referred to as the Disturb and Observe (D&O) technique is regularly used in solar PV systems to follow through MPPT (Maximum Power Point Tracking) Continuously adjusting the working point of the photovoltaic module.

In systems using a boost converter for MPPT, this algorithm helps regulate the input voltage to the converter, thereby increasing the power delivered to the output.

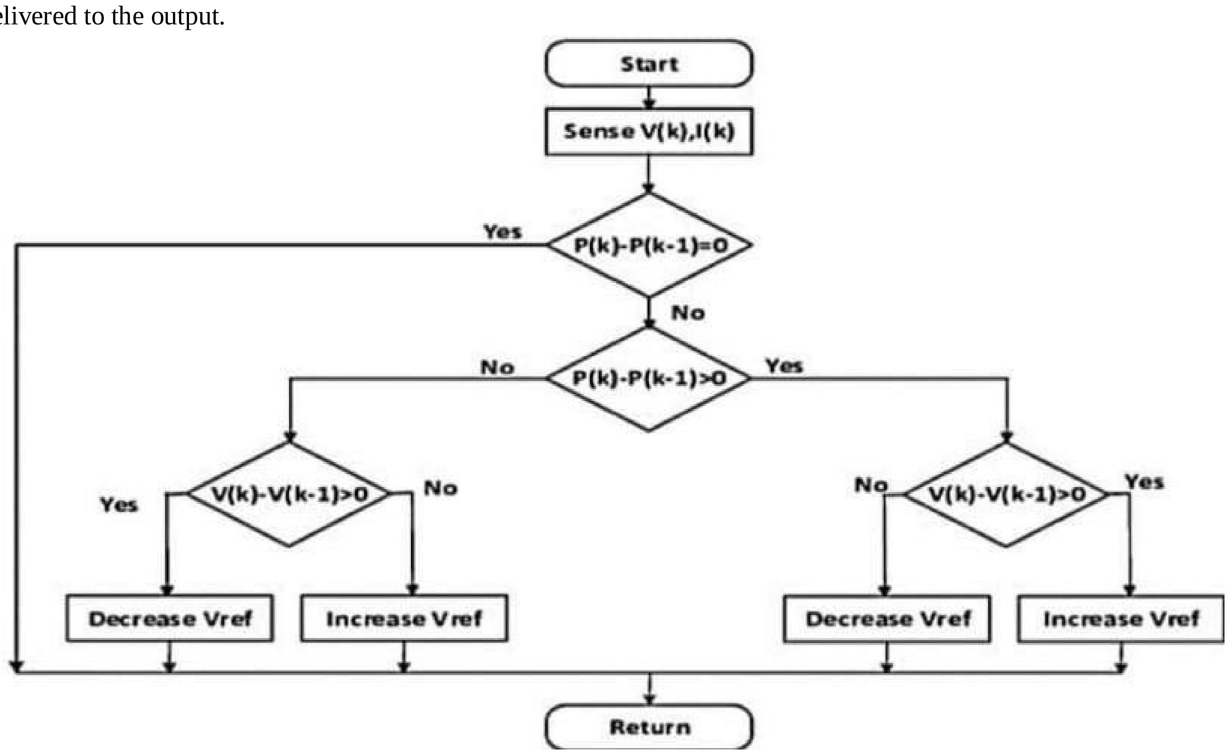


Figure-4: MPPT Algorithm flow chart.

C. Phase Lock Loop.

The output of the inverter matches the phase of the grid voltage using the Phase-Locked Loop (PLL) mechanism which ensures current flow is in phase. The grid connection will be stable, with a power factor of one, while active power is delivered smoothly and reactive power is gives to a minimum level.

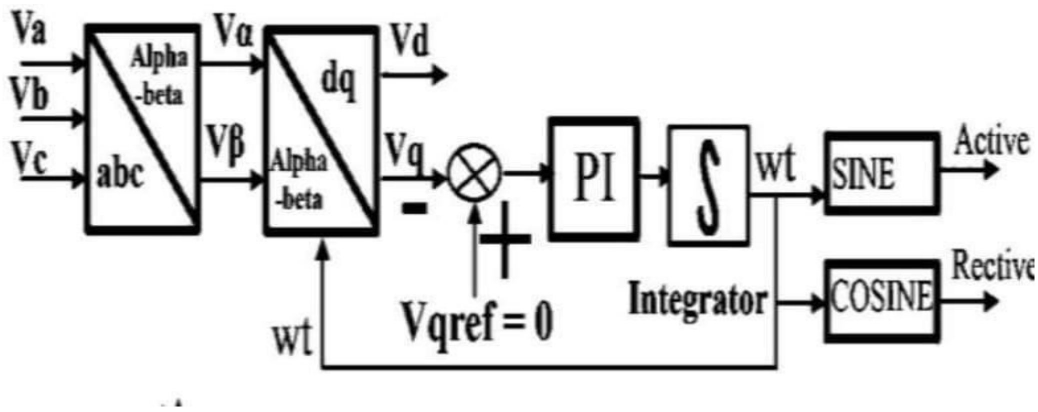


Figure.5; Phase Lock Loop controller

D. Grid Current Controller.

The Grid Current Controller (GCC) contains an outer loop which maintains voltage level on a dc bus while the inner loop controls current at a much faster time scale to verify that power transfer is indeed occurring and that grid quality requirements are fulfilled.

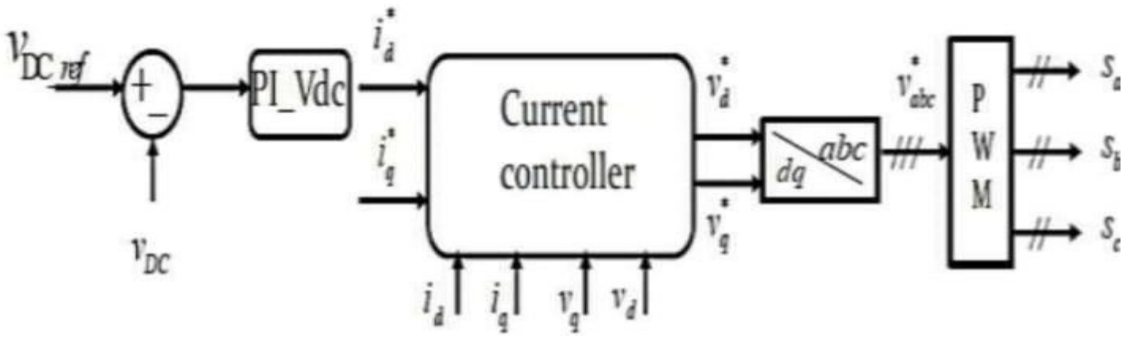


Figure-6: Gird Current Controller.

IV. GRID TO ELETRICAL VEHICLE CHARGING STATION

Grid to electrical vehicle (EV) charging station block diagram as shown in below .

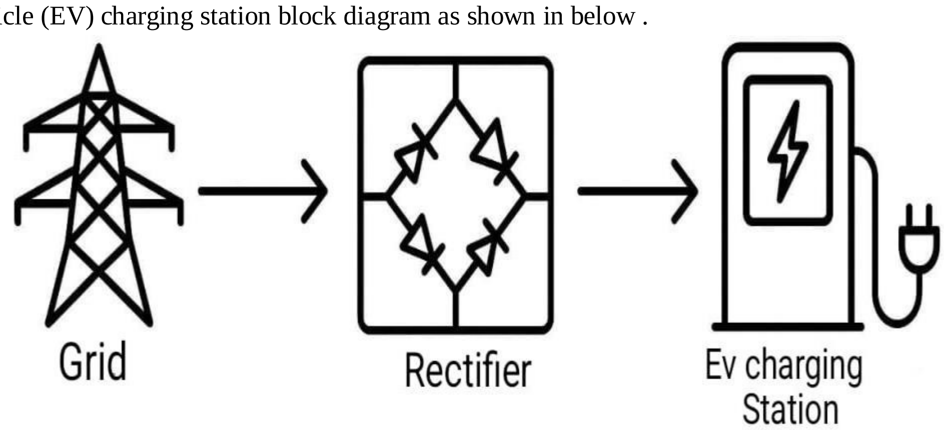


Figure-7: Grid to EV charging station.

The three phase grid to EV charging station ,by using rectifier AC to DC converted system. The rectifier design to six IGBT switches connected to capacitance and RL (resistance, inductance) to measure the voltage and current. Then finally output voltage is 320V. it is the constant value of the grid to same voltage forward to the EV station to charge the electrical vehicle. The design of rectifier as shown in below figure8.

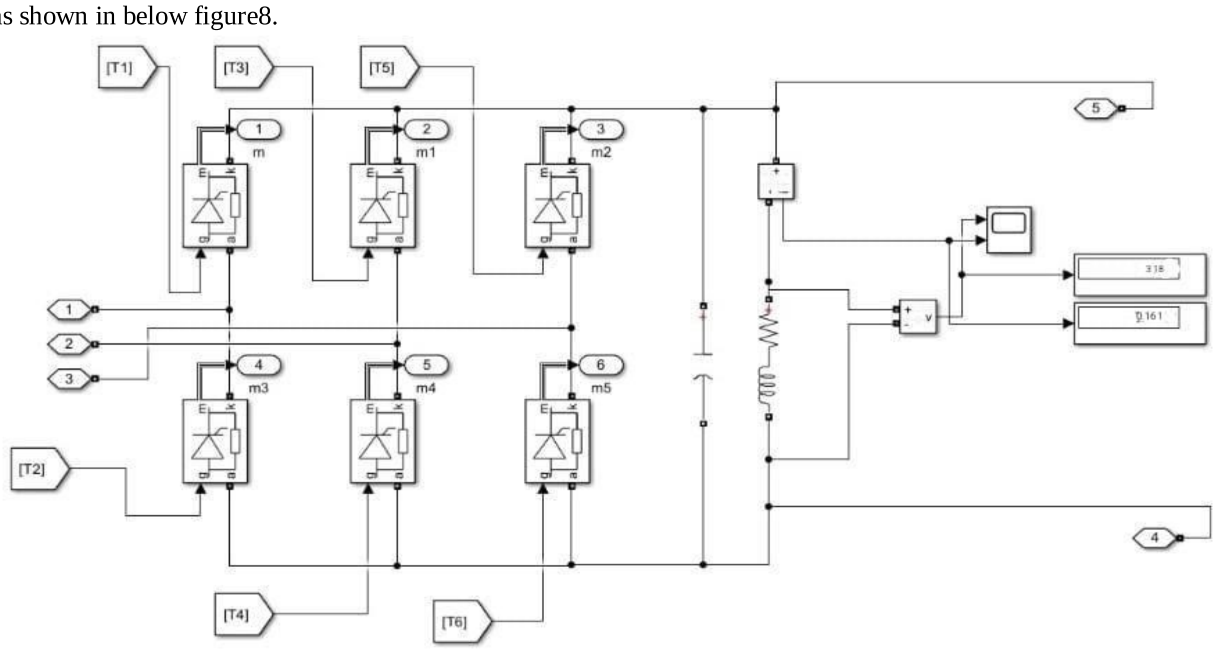


Figure-8: Rectifier Design

V. SIMULATION MODAL

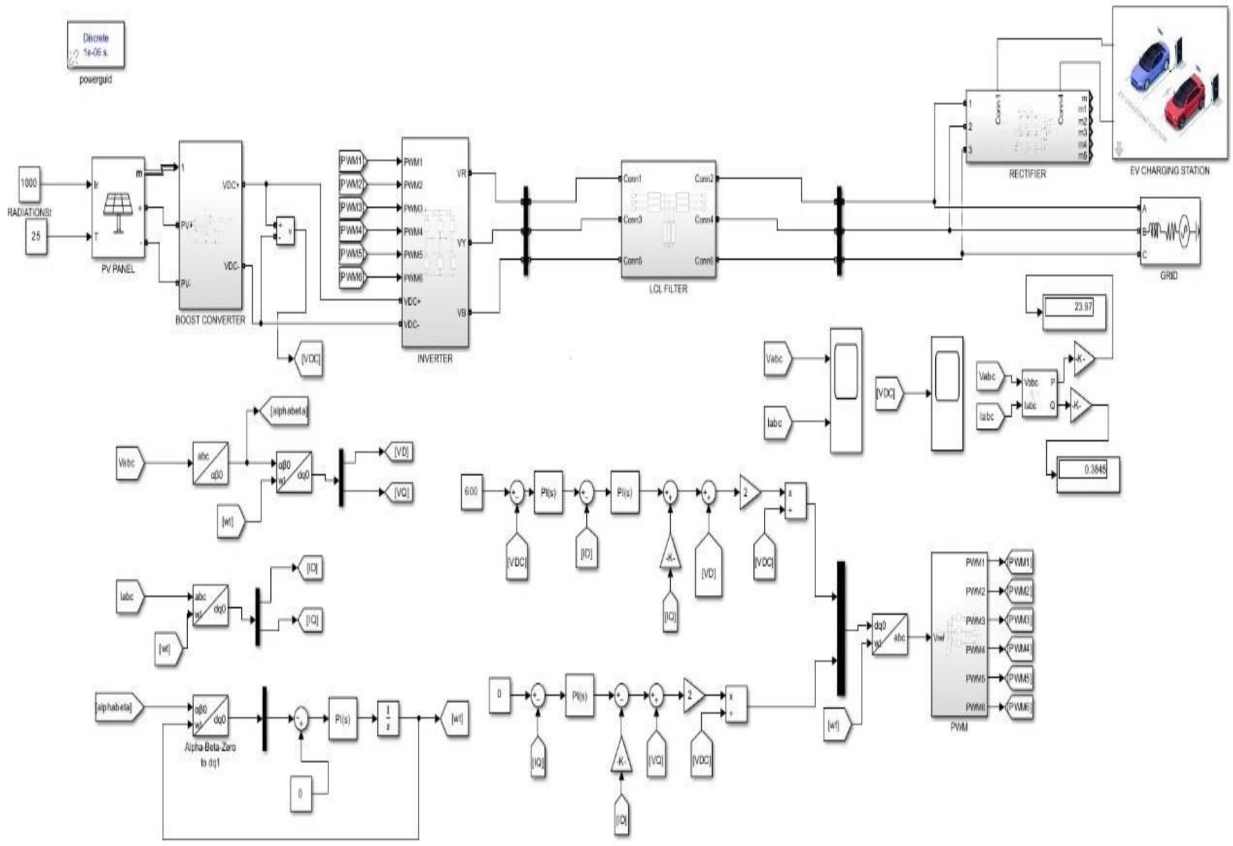
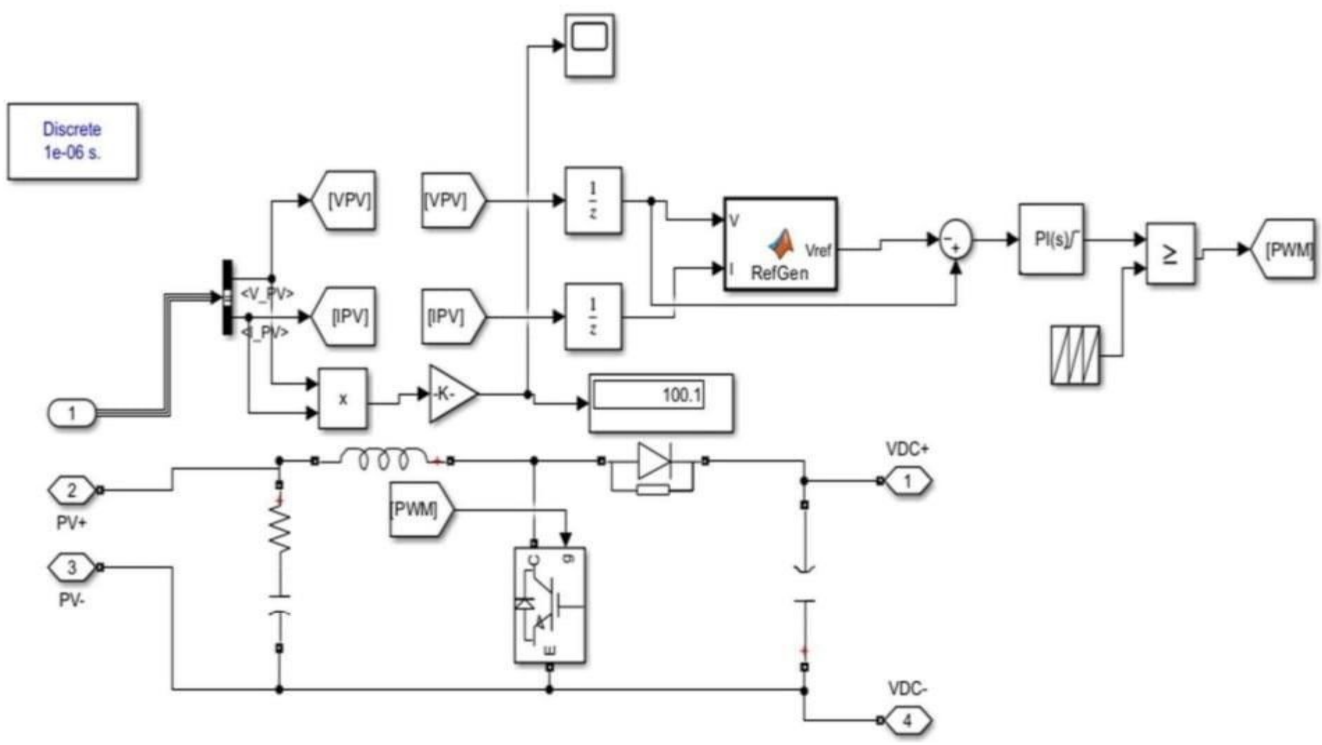


Figure-9: simulation modal of three phase dual stage grid connected PV system with EV charging station (A) Subsystem of Boost Converter.



The solar inverter was linked to the utility grid along with an EV station and was modeled and simulated in MATLAB/Simulink (2024b) to assess its effectiveness. Key characteristics of the setup include the following values for the LCL filter: inductor (L) = 500 microhenries, capacitor (C) = 100 microfarads, secondary inductance (L) = 500 µH. The inverter operates at a switching frequency of 10 kHz. The no-load of PV system's open-circuit voltage is 363 volts, and its MPPT voltage range spans from 400 to 500 volts. the finally output voltage power is 320V to charge the EV station without any disturbances and maintained voltage stable, clean and smooth power delivered to Grid and EV station.

6.1.Simulation Parameters.

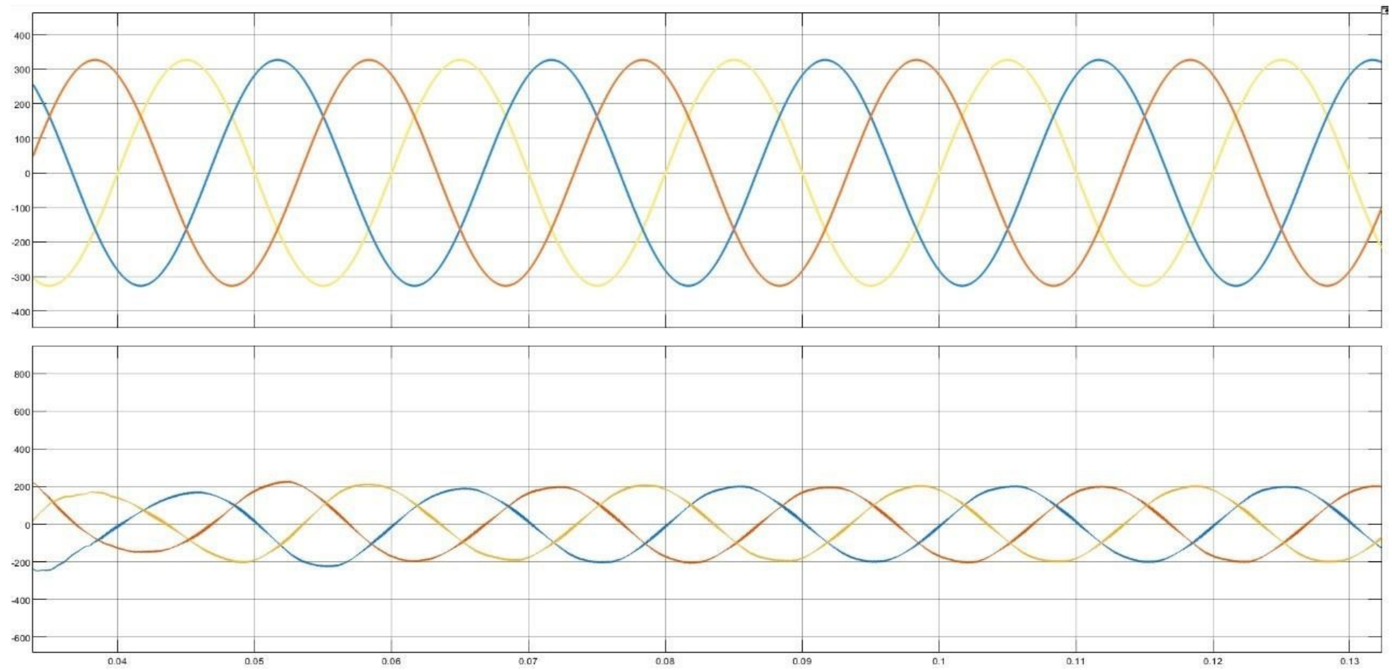
Table 1: Boost Converter Parameters

S.NO	Parameters	Values
1	Grid value	415V,50HZ
2	Inductor on the inverter side for the LCL filter	500µH

3	Inductor on the Grid side of the LCL filter	500µH
4	Filter capacitor in the LCL circuit	100µH
5	Inverter Switching rate	10KHZ
6	Capacitor in the DC link	3227µF

VI. SIMULATION RESULTS.

When solar irradiance set to 1000 W/m², 500 W/m², and 250 W/m², The anticipated peak power generation from the PV modules has been attained, as illustrated in the figures below. This confirms that the MPPT (Maximum Power Point Tracking) Technique is functioning correctly. The voltage and current waveforms of the grid with respect to the different levels of irradiance are shown in Figures 10(A, B, C).



Fig;10(A).Voltage and Current at the Grid under 1000W/m² irradiance

The waveform shows voltage and current at 1000W/m² irradiance, the voltage in 320V stable and the current will be 200A in grid side.

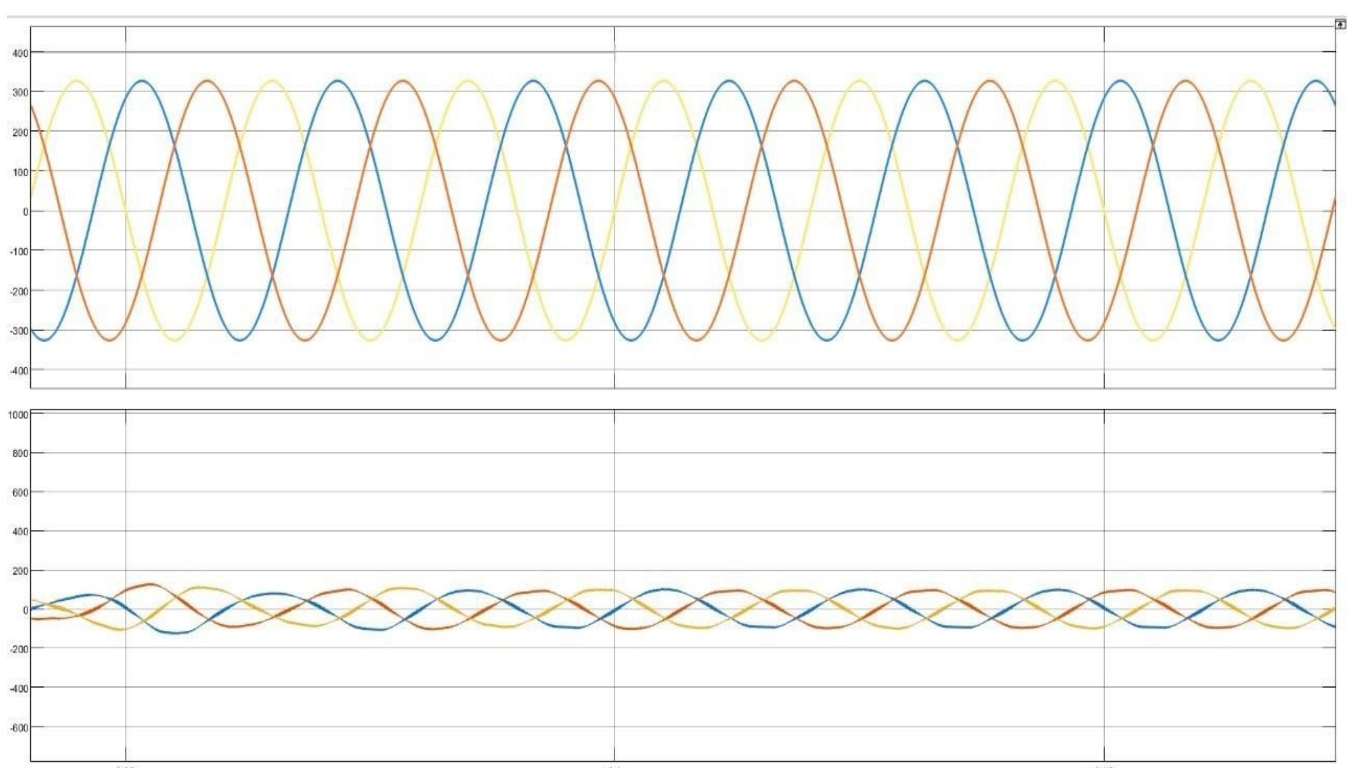


Fig.10(B).Grid Voltage and Current at 500W/m² irradiance.

The waveform shows voltage and current at 500W/m² irradiance, the voltage in 320V stable and the current will be 150A in grid side. The current value is lower than compare to above current but voltage will be same and stable voltage maintained.

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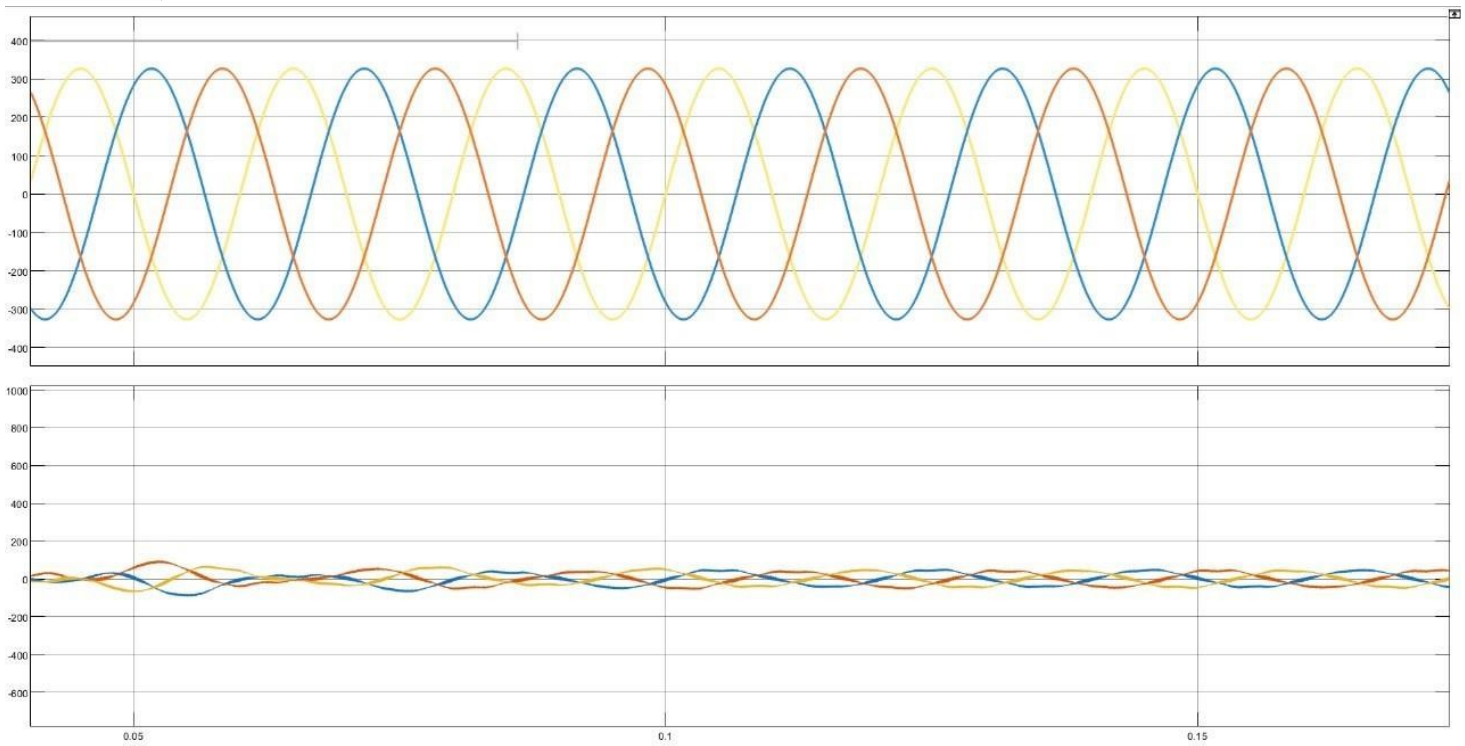
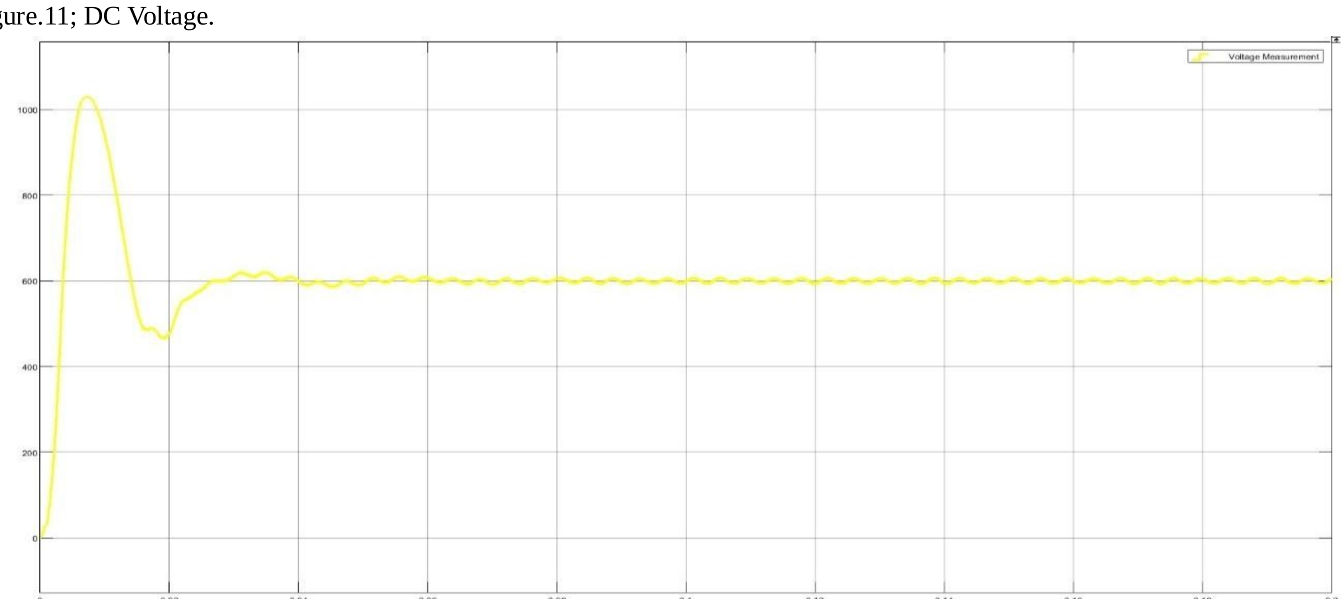


Fig.10(C). Grid and Current at 250W/m² irradiance.

The waveform shows electrical signals (voltage and current) under 250W/m² solar intensity irradiance, the voltage in 320V stable and the current will be 100A in grid side. The current value is lower than compare to above two current values but voltage will be same and stable voltage maintained.

Figure.11; DC Voltage.



As seen in above waveform, the the DC link maintains a steady voltage level of 600 volts regardless of any changes in the radiation on the PV Panel. The voltage will increased at 1000v and decrease 600v after it maintained constant voltage. by using boost mmpt controller with pwm.

Figure-12: EV Charging Station DC Voltage.

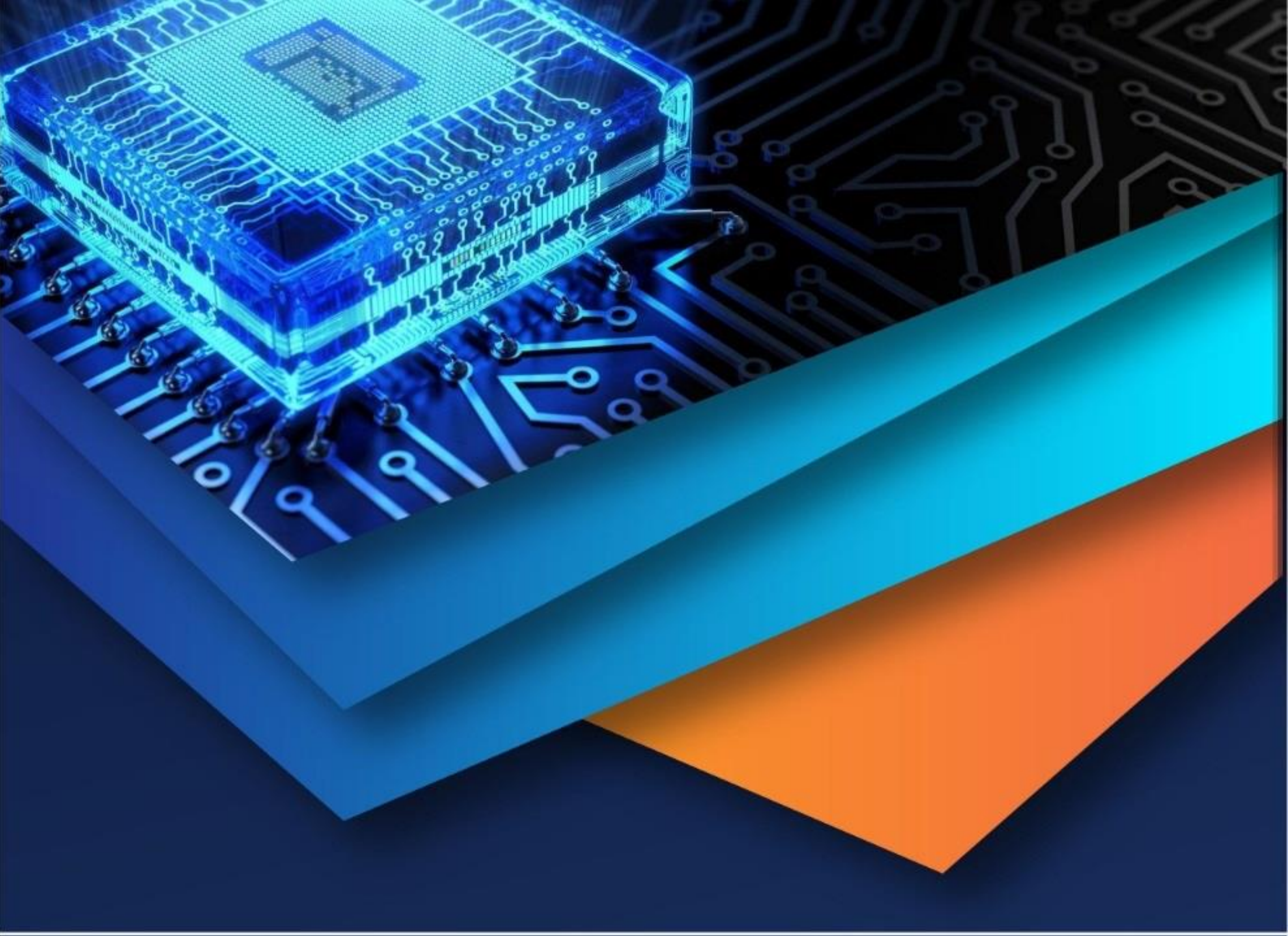
The above waveform is DC Voltage EV Side. Then it is 320V voltage maintained constant and stable DC Power transfer to into EV Charging Station to Charge the Electrical Vehicle.

VII. CONCLUSION

This project outlines the design of a solar inverter configuration with three-phase input and dual-stage processing that integrates solar energy into the power grid, including EV charging capabilities. The system comprises a boost converter that incorporates maximum power point tracking (MPPT) to capture the highest energy possible from solar panels during different weather conditions. A grid-tied the inverter transforms direct current into alternating current while guaranteeing proper regulation of the energy delivered to the grid. The control system framework for the inverter operates to keep the link voltage on the main electrical circuit at a predetermined level, maintaining synchronism utilizing a PLL to synchronize with the grid and draws current from the grid, aka operates at a unity power factor, for maximal energy exchange. Also, the system enables smart EV charging which enhances the sustainability of the solution. All in all this inverter system assists with the shift towards renew able energy sources integrated with electric grids by enabling clean dependable solar energy to be used at electric grid substations and charging stations for electric vehicles.

REFERENCES

[1] Mehta, G. and Singh, S.P(2014) 'Design of single-stage three-phase grid-connected photovoltaic system with MPPT and reactive power compensation control', Int. J. Power and Energy Conversion, Vol. 5, No. 3, pp.211-227.
[2] Zhou Dejia, Zhao Zhengming, M. Eltawil and Yuan Liqiang, "Design and control of a three-phase gridconnected photovoltaic system with developed maximum power point tracking," 2008 Twenty-Third Annual IEEE Applied Power Electronics Conference and Exposition, 2008, pp. 973-979.
[3] Khawla, E.M.; Chariag, D.E.; Sbita, L. A Control Strategy for a Three-Phase Grid Connected PV System under Grid Faults. Electronics 2019, 8, 906.
[4] F. Blaabjerg, R. Teodorescu, M. Liserre, and A. V. Timbus, "Overview of control and grid synchronization for distributed power generation systems," 2006.
[5] D. Beriber and A. Talha, "MPPT techniques for PV systems," International Conference on Power Engineering, Energy and Electrical Drives, no.May,pp.1437-1442 2013.
[6] M.Villalva, J.Gazoli, and E.Filho,"Comprehensive Approach to Modeling and Simulation of Photovoltaic Arrays," IEEE Transactions on Power Electronics, vol. 24, no. 5, pp. 1198-1208, 2009.
[7] D. Beriber and A. Talha, "MPPT techniques for PV systems," International Conference on Power Engineering, Energy and Electrical Drives, no. May, pp. 1437-1442,2013.
[8] A. Reznik, M.G.Simões, A. Al-Durra and S. M.Muyeen, "LCL Filter Design and Performance Analysis for Grid-Interconnected Systems," in IEEE Transactions on Industry Applications, vol. 50, no.2,pp.1225- 1232,MarchApril.
[9] Guille, C., & Gross, G. (2009)A conceptual framework for the vehicle-to-grid (V2G) implementation Energy PolicyDOI: [10.1016/j.enpol.2008.10.017]



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