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PERFORMANCE ANALYSIS OF CLOSED LOOP CONTROL OF DUAL STAGE GRID CONNECTED SOLAR SYSTEM

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Abstract- This review paper presents the dual stage grid-connected solar system. This technology is still under development phase. Current harmonic mitigation, reactive power correction, and load voltage regulation are all common uses for power electronics converters. It necessitates dc link voltage support, that can be delivered by any source of energy such as solar, wind, or geothermal, that serves as a voltage source and also injects the active power generated by the source. With the online estimation of the reference power accessible, the fluctuating nature of power owing to changes in solar radiation and temperature of injected power may be compensated for. The simulation studies are carried out for 3-phase application using power system simulator.

Keywords: Photovoltaic system, Boost converter, Inverter, grid.

I.INTRODUCTION

A photovoltaic panel matrix converts sunlight into DC power, while a PCU is a device that transforms power DC to AC. The obtained AC power is either utilized by local loads or fed into UG. PV systems are occasionally supplemented with storage devices to improve power availability. A battery storage bank is not essential for grid-connected PV system, which considerably reduces the initial and ongoing expenditures. On the other perspective, the grid acts as a bank in the PV system, enabling for the deposit and withdrawal of additional electric power as needed. PV modules are often built on roof , when a PV system is installed in a residence, which reduces the size of the mounting structure and the quantity of land required. Power conditioning equipment controls and converts the DC electricity generated by PV arrays to high quality AC power before being pumped to UG. The number of power stages in a PV system is used to classify it. In the past, single-stage centralized inverter systems were used. The majority of ongoing and prospective technology is focused on two-stage inverters. All control duties are handled by an inverter in single-stage systems. DC–DC converter comes before inverter in a dual-stage system, and the both converters share control functions. Dual-stage systems provide more control flexibility than other systems, cost of increased expense and reduced system performance. The converter configurations have been presented in a variety of ways over the last decade.

The regulation of the PV array's output voltage or current generate the max electricity at a given irradiance and temp is one of the most essential roles of PCUs. According to PCU, current delivered to grid should have same frequency as grid and phase shift with voltage at the POC, in range of acceptable limits. Furthermore, the harmonic content of the current should be within the regulatory limitations. Voltage boosts are commonly used in PV systems to obtain grid voltage and reduce power losses. By DC–DC converters or MLIs, this goal could be achieved. It's ideal for this since it provides a decent mix of performance and affordability in high voltage or power applications. The grid voltage and output voltage waveforms are synchronized. As a result, ripple current will be dumped into the UG using PWM inverter. The LC filter filters off high-switching frequency components from the inverter's output current.

II.SYSTEM DISCRIPTION

The majority of PV system performance analysis necessitates the use of a model to translate the PV array's DC power output at maximum from the irradiance received and the ambient temperature. The best technique to define, use a single or two diode model. In order to accomplish exact model, better operation, the reason of PV performance degradation, utilized to construct (I-V) and (P-V) characteristic curves for PV modules. The accuracy and complexity of the models documented in the literature vary, as does their suitability for different research. Temperature and irradiance fluctuations affect the behaviour of the solar array. As a result, the PV cell mathematical model is implemented as a current controlled by voltage and sensitive to two input parameters are, temp (ºC) and solar irradiation (W/m^2).

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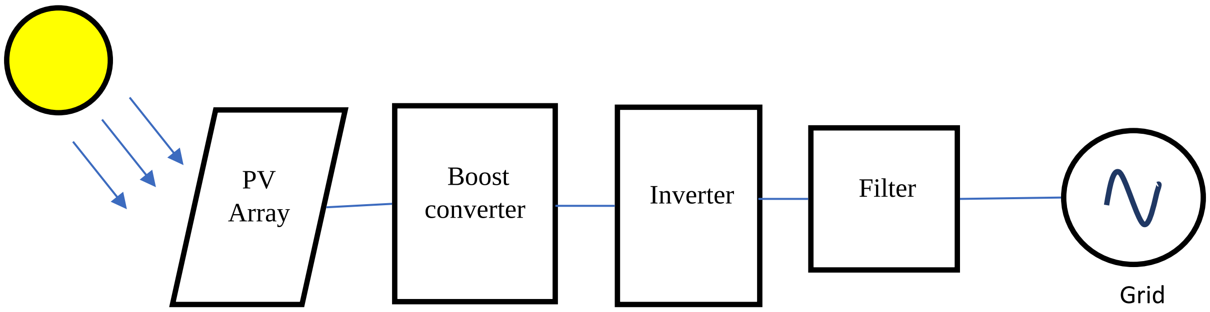

Figure 1 System configurations

a.Photovoltaic array modelling

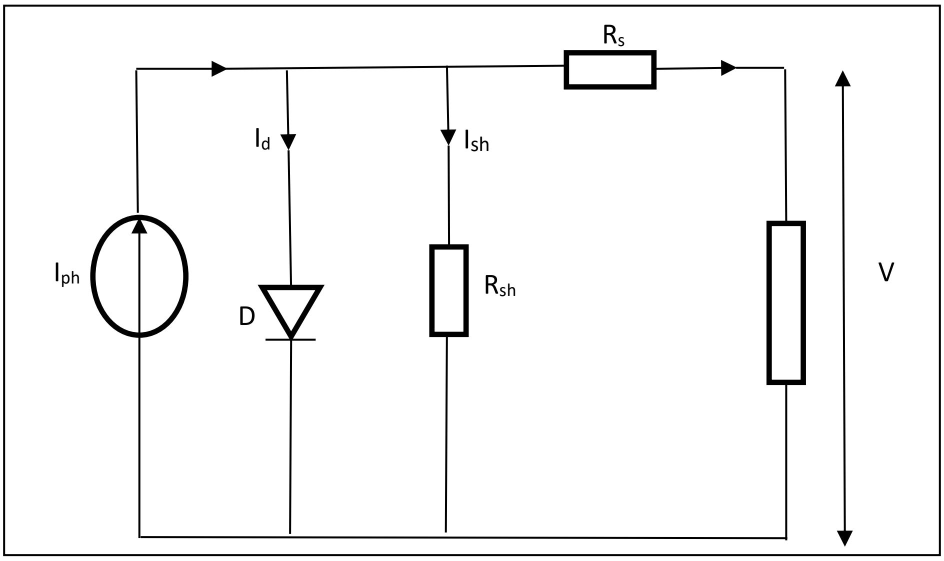

Figure 2 Equivalent circuit of the photovoltaic array.

It is sufficient express many types of pv cells when temp effects are taken into account, and it is confirmed that polycrystalline cells are taken into account. The series resistor, Rs, is the inclination of the (I–V) characteristic curve is demonstrated to be affected by Rs, making accurate between the mppt and the open circuit voltage.

b.DC-DC Boost converter

When compared to other renewable energy sources, photovoltaic modules have a poor efficiency. The input in such systems is frequently variable because to variations in solar energy, whereas the output must be constant. As a result, to link the PV device to the inverter and apply an MPPT algorithm to maximize the PV array's power generation, an intermediary conversion stage must be used. In this circumstance, DC–DC boost converter is useful. It can work in one of two modes, depend on the converter's storage capacity and switching period. The DC–DC boost converter setup and along with control are shown in this diagram.

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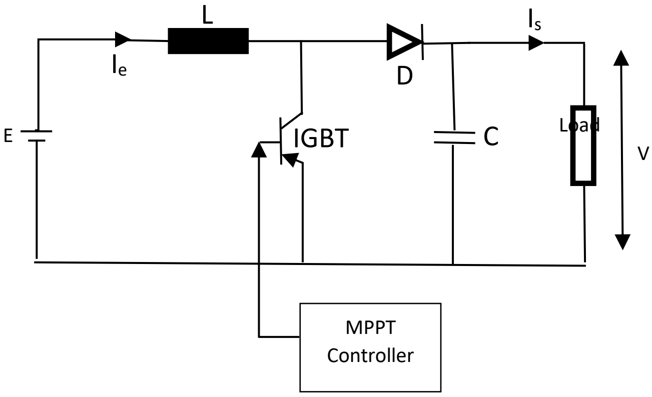

Figure 3 Controller and configuration of a DC–DC boost converter.

Because PV generator generates DC power in response to solar irradiation and temperature, there are a variety of techniques for find the maximum power point (MPPT) of PV array's current-voltage characteristics (I-V) and extracting the maximum electrical power, all of which necessitate calculations using voltage and current sensors. Soft commutation is the most appealing feature of three-phase DC-DC converters. This feature is crucial because it allows them to function at a high switching frequency while yet maintaining high efficiency and a manageable heat sink size. In addition, when the switching frequency rises, the transformer's size and weight decrease.

MPPT control system

The MPPT methods are easy to use and track the MPP in a shorter amount of time. Both systems have the benefit of requiring no idea of PV generator's parameters, allowing MPP to be monitored independently of irradiance, temperature, or degradation, resulting in high endurance and reliability.

The Control technique of the system is based on IC technology. To establish the right way to determine Photovoltaic array reference voltage, Vref, compare (I/V) to (ΔI/ΔV) at each sample period to quickly locate the MPP, at MPP, Vref equals Vmpp. Until change in I, which denote change in radiation or climatic conditions, PV array activity is maintained until the MPP is reached. To keep track of the new MPP, the algorithm reduces or increases Vref. This approach, in comparison to the P&O technique, allows for better monitoring of the MPP in rapidly changing atmospheric circumstances.

c.DC-AC stage

The DC/AC controller includes both the external DC-bus voltage control loop and the internal current control loop. To maintain a sinusoidal current, the internal control loop regulates rapid fluctuations in AC current. The ref current (I_{ref}) is generated by a PLL sinusoidal signal reference. The key components of this power control system include a synchronisation optimization technique on PLL, MPPT, continuous side input power control, and dumped current control into grid.

- **PLL**: It enables inverter current to be synchronised with the grid voltage, as well as the generation of a sinusoidal and clear reference signal with power factor unity.
- **Input power control**: A feed-forward technique is used to manage the power configuration of PV system, which eliminates DC/DC converter. The feed-forward increase the PV system's dynamic reactivity. It ensures that it responds quickly to changes in input power.
- **Current control**: The PI controller employs the grid voltage feed-forward approach.

It regulated so that it not only delivers a low harmonic current, and also permits reactive power to be injected to be managed in the grid by selecting the appropriate power factor based on grid requirement: active or reactive power. As a result, allow the quantity of active and reactive electricity delivered into grid to be adjusted according to the grid's needs. To obtain a high-reliability inverter as well as a number of grid-connected PV inverter control ways. It controls the grid current with a phase lock loop (PLL).

III. CONTROL STRUCTURE FOR GRID-CONNECTED THREE-PHASE INVERTER

Vector control is a significant technique for controlling DC–AC converters in three-phase systems in both stationary and dynamic regimes, allows the abstraction of nonlinear equations that control the behaviours of system in separate rotational shafts.

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a) **dq control**

In dq control, by transforming grid current and voltages into rotating frame of ref with grid voltage. The abc-dq transformation is then used to convert variable control values into continuous values. To reduce the disparity between the reference and observed active and reactive values, the current components are adjusted. To remove current error and deliver the proper ac current waveform, the control system should give the correct switching states for the inverter based on a comparison of the reference and measured currents. Due to their acceptable combinational performance, linear PI controller, which is linked to the d-q control structure, is a well-known reference tracking technique. In any event, despite all of these improvements, PI controllers' low-order harmonic correction capabilities remain severely limited. The phase-locked loop approach is often used in PV systems to extract phase angle of grid voltages.

b) αβ–Control

In this, the abc-module is used to convert the grid currents into a stationary reference frame. Each grid current has its own abc controller, which is distinguished by its capacity to achieve high gain near resonance frequency, effectively remove error between controlled signal and its ref. The proportional resonant controller, which has been demonstrated to have high dynamic characteristics in various studies and is gaining widespread acceptance in current control systems, instead of PI controller. The usage of feed forward is not required.

c) abc control

In abc control, a separate controller is used for each grid current; however, by including additional factors into the controller design, it is possible to have three separate controllers. Because of their high dynamics, nonlinear controllers such as hysteresis or dead beat are favoured in abc control. The sample frequency has a direct relationship with the performance of these controllers. As a result, this application benefits from the advancement of digital systems including DSP or field-programmable gate arrays. The phase angle generated by a PLL system is used to establish the three current references. The difference between each one and the measured current is supplied into the controller. In the current loop, hysteresis or dead-beat controllers no need for modulator. When PI or PR controllers to generate duty cycles for a PWM signal, a modulator is necessary. Although the PI Control system is most commonly associated to dq control, it can also be utilized in the abc frame.

IV. REQUIREMENTS OF REACTIVE POWER

Power factor and reactive power control are the challenging aspects of connecting a PV array to the grid. It regulated so that it not only delivers a low harmonic current, and also permits reactive power to be injected to be managed in the grid by selecting the appropriate power factor based on grid requirement: active or reactive power. As a result, allow the quantity of active and reactive electricity delivered into the grid to be adjusted according to the grid's needs. To obtain a high-reliability inverter as well as a number of grid-connected PV inverter control ways.

A grid current and DC link voltage control mechanism with several closed loops is presented. It employs traditional PI and bang–bang controllers in its control structures. It controls the grid current with a phase lock loop (PLL). Ref has implemented the input output Feedback Linearization Control methodology to PV inverters, which is widely used in the control of electrical motors and PWM rectifiers. The outcome is a complex inverter model with switching functions. The inserted reactive power (inductive or capacitive) has been continuously controlled and managed by altering the power factor within that particular range to ensure high inverter reliability. It overcomes the limits of today's grid-connected systems, which use inverter topologies that only send active power to grid and inject no reactive power.

IV. RESULTS

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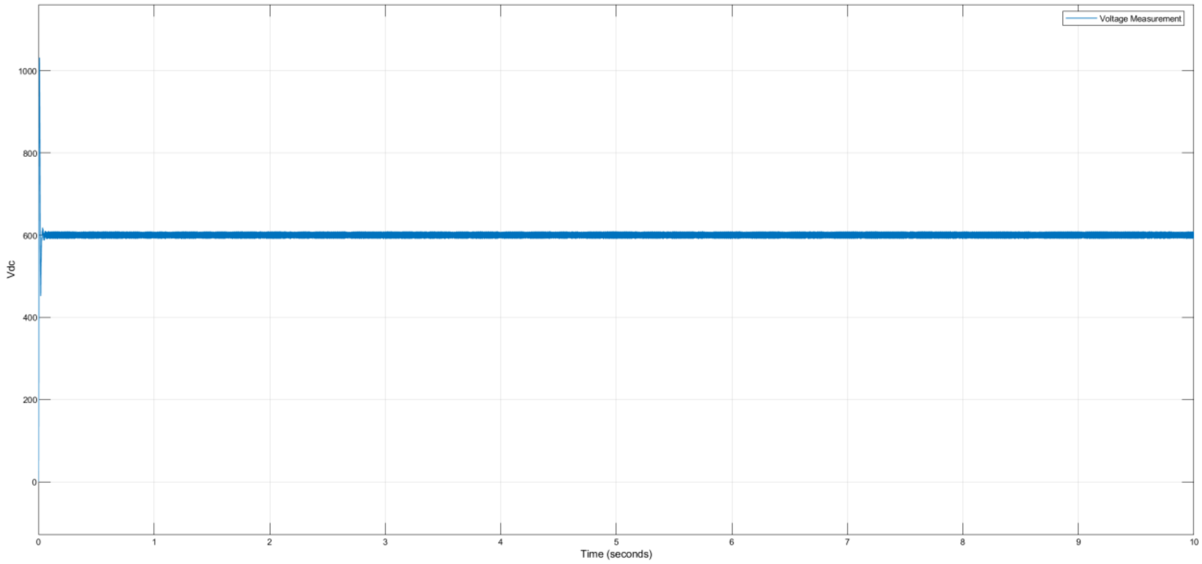

Figure 4 DC voltage of boost converter.

The PV system generate the voltage which is given to the boost converter. As shown in above figure, the voltage is generated by the boost converter after that it provide an input for inverter.

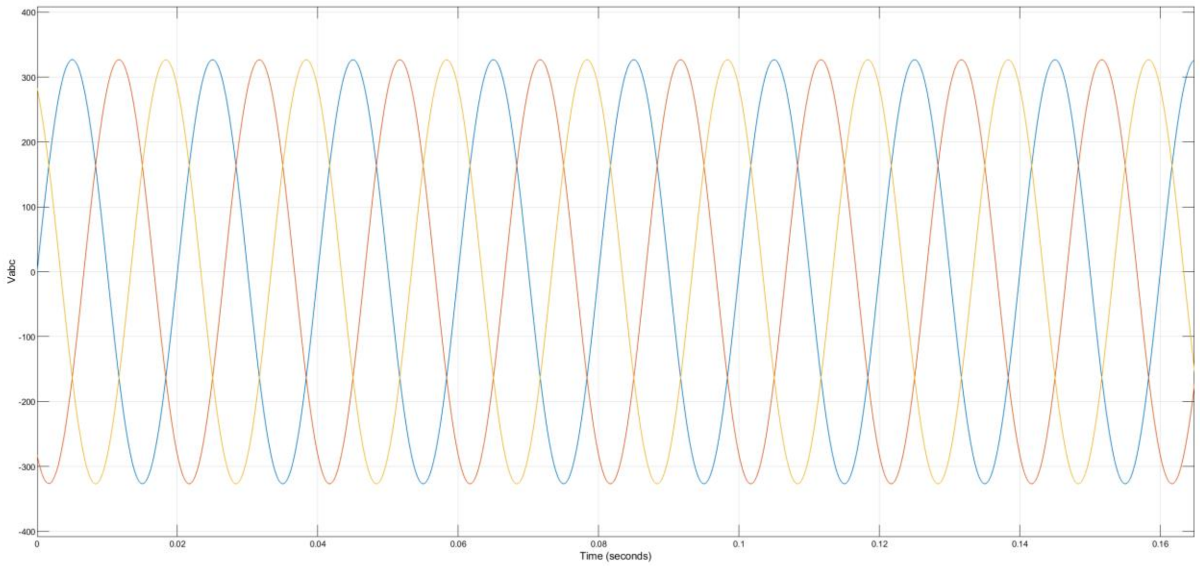

Figure 5 Grid voltage of the system.

For grid connected solar system the voltage waveform should be sinusoidal as shown in above figure and power factor

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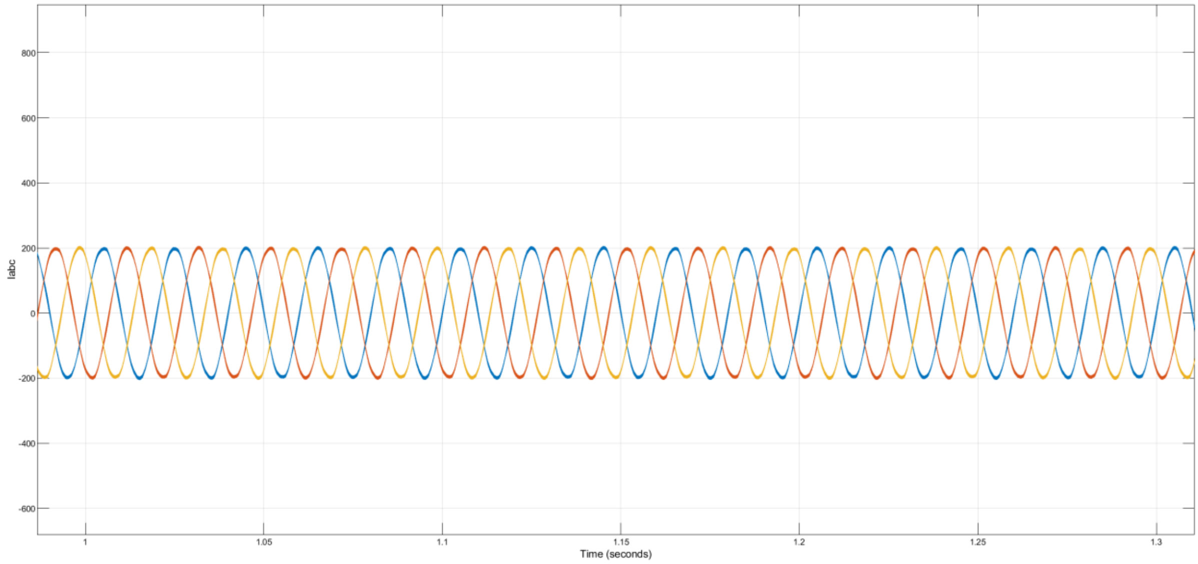

Figure 6 Grid current of the system.

Above shown simulation result is having grid current varies with irradiation and temperature of sun, current will rise or decline according to them.

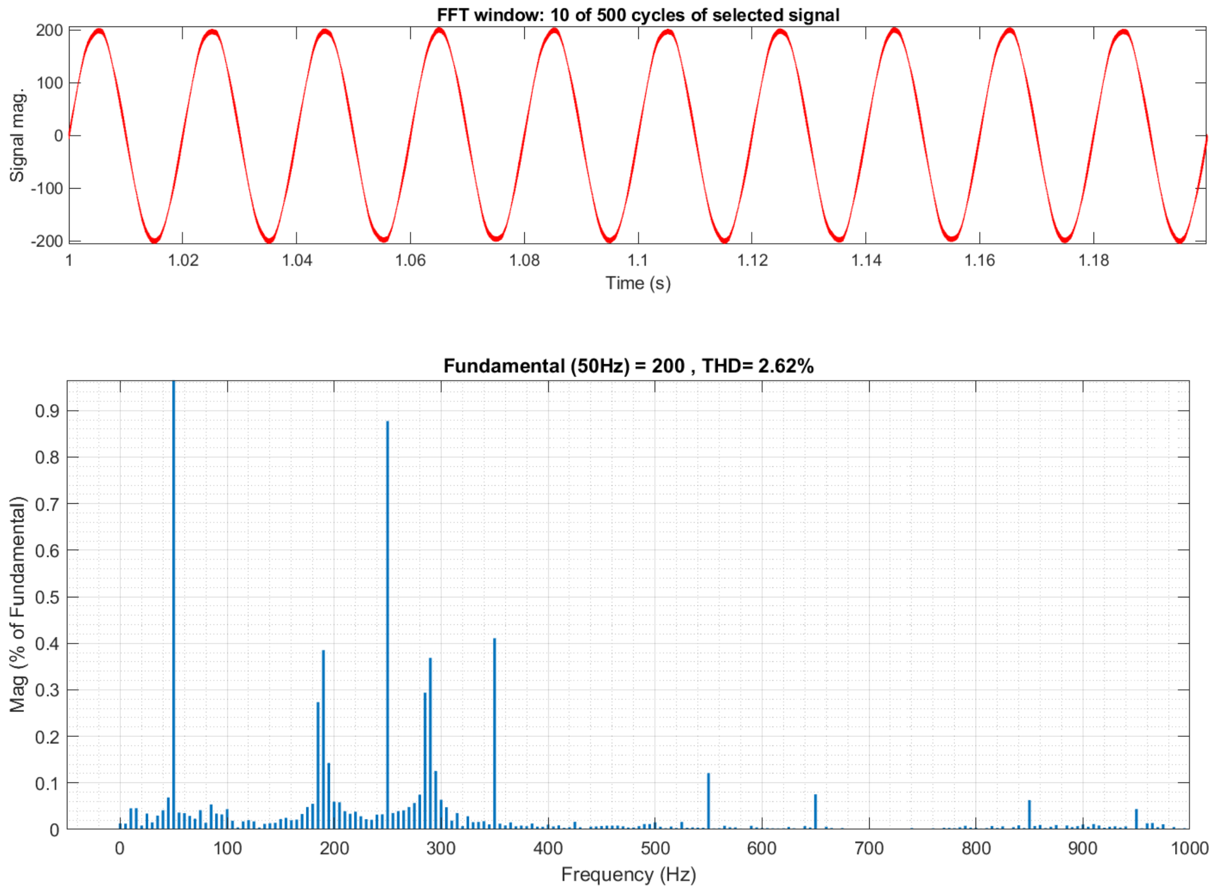

Figure 7 THD analysis of grid current of the system.

THD analysis of grid current has shown in above figure, as per as IEEE standard THD should be less than 5%. And calculated THD is less than 5%.

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V. CONCLUSION

This model for a grid-connected solar system serves purposes it enhances power quality by providing active power generated by PV system and compensates for non-linear loads. The results show that integrating PV power is simple when source current is sinusoidal and power factor is unity. In this work, the importance of grid connected solar system with power quality improvement via dual stage. First stage, DC voltage of the PV system is boost by DC-DC converter and MPPT is used in this stage which provide a maximum power by comparing instant and incremental value. And second stage, DC-AC conversion is done with PLL and PWM controller. The PLL controller work as closed loop which sense the grid voltage. Every switch of inverter under controlled by PWM signals. To generate this pulses dq-abc transformation is used. The input of the dq frame is output of PLL and input reference signal taken from MPPT through PLL controller. The PLL controller can withstand conditions like harmonics, noise, surges, spikes and etc. When we run the simulation, it is observed that as the irradiance level change, automatically inverter output current also change. Since this manufacture has grown its impact on the AC grid system which is also growing automatically. It also aimed to reduce the leakage current and provide a high-quality output current and decrease total harmonics distortion. The behaviour of grid connected solar system under various disturbance has been investigated, obtained result shows good system response.

VI. FUTURE SCOPE

- Soft switching converters reduce switching losses, reduce the size of the inductor and capacitor, and increase efficiency when used at high frequencies.
- The gate pulses for all transistors in the PV system are generated by a digital controller, resulting in a simpler and less expensive structure.

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