Perturb And Observe Based Maximum Power Point Tracking For Grid-Tied Photovoltaic Application Using Z- Source Inverter

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Abstract - this paper describes perturb and observe maximum power point tracking method for PV energy system based on a single-stage grid-tied *Z* source inverter. Initially, it provides a brief review of *Z*-source inverters; MPPT with using perturbs & observes method. After that, it introduces the projected MPPT system. Finally, it provides simulation result on different accepts. It introduces maximum power point tracking (MPPT) that is P&O method for better result and improve the power quality. Perturb & observe (P&O) method technique is used to extract maximum power from the PV array and feed it to grid. The stochastic behavior of solar energy necessitates MPPT of PV system to operate at maximum power point and make the system economical. Comparing Z source inverter technique with previous inverter. Improve power quality and indicates significant improvement in PV system performance.

Keywords — *impedance source inverter (ZSI), maximum power point tracking (MPPT) ,photovoltaic system(PV),Maximum power point(MPP),perturb&observe(P&O),total harmonic distortion(THD),model predictive control(MPC).*

I. INTRODUCTION

Solar energy is the most widely available source of renewable and sustainable energy that can play a leading role in the program of reducing greenhouse emissions. Nowadays, energy storage and conversion plays the vital role in the field of distributed generation. This project reviews some of traditional inverter topology such as current source inverter and voltage source inverter with their drawbacks hence introducing newer topology as z-source inverter. In this project we use MPPT method like (P&O) method with using PV application. By using new technique and topology adding better result with using Z source inverter. By getting the output and crack the barrier and limitation of previous inverter adding new concept of maximum power point tracking (P&O) [6] . By using new technique improve the power quality. The Maximum Power Point Tracking (MPPT) is a technique used in power electronic circuits to extract maximum energy from the Photovoltaic (PV) Systems [1].My work focus on improve the power quality and reduces the losses with THD, Boosting voltage and current with negligible oscillation. Unlike the previous works, the proposed method uses a fixed switching frequency and an adaptively predicted voltage step that can change according to the proximity to the MPP. This improves the tracking response causes by variations in solar irradiance level and minimizes the oscillation around the MPP.

Objective of the project is fast and accurate dynamic tracking and significant improvement in PV system performance with negligible oscillation and THD and give fast dynamic response.

- Increase the grid side voltage and current which will use by utility.
- Use of Solar PV cell with new tracking technique for improves response of PV cell as a source input.
- Cost of system is reduced.

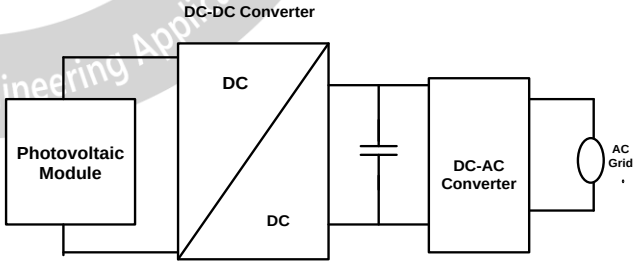

Fig.1. Two-stage grid-tied PV system configuration

Conventional grid-tied PV systems typically use a two-stage power conversion topology: an upstream dc/dc power conversion stage from the PV module to a dc-link energy buffer (such as a capacitor), and a downstream dc/ac power conversion stage from the energy buffer to the grid[9]. Several control techniques and analysis have been developed in the literature for each of these conversion stages. The general schematic of a conventional two-stage grid-tied PV system is illustrated in Fig.1. The use of a two-stage topology is necessitated due to the inherent limitation

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of the dc/ac inverters for stepping up/down the voltage freely. Commonly, the conventional inverters classified as voltage-source inverters (VSI) can only step-down the voltage while the current-source inverter(CSI) can only step up the voltage[1]-[2]. The MPP voltage of a PV module can be higher/lower than the grid voltage based on the environmental conditions, necessitating a power conversion system that can step up/down the voltage freely to track the MPP accurately. Recently a new converter topology, denoted impedance source converter is developed by researchers that undermine the limitation of VSI and CSI.

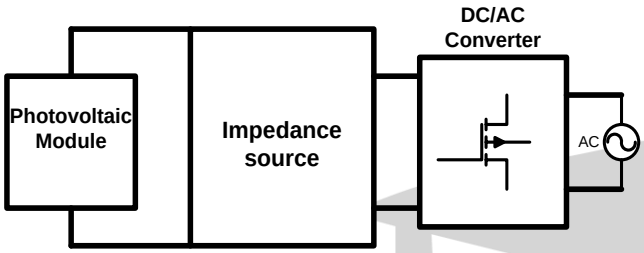

Fig.2.Single-stage impedance-source grid-tied PV system configuration

In particular, a class of dc/ac inverters designed based on the concept of impedance source conversion, denoted as *Z*-source inverter (ZSI), can step up/down the voltage freely, and thus is very well suited for designing single-stage PV harvesting systems.

II. SYSTEM DESCRIPTION

A. *Photovoltaic cell (PV)*

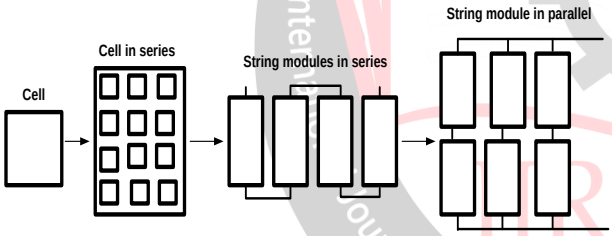

Fig.3. PV Cell, Module and Array

The most important advantages related with PV arrays are that it consists of no moving parts, noiseless and maintenance costs are very less. It is also a dirt free source of energy. Sun produces large amount of energy that within 1hour it can give more than sufficient energy for human population in one year. Still, due to the low efficiency of current solar panels, power conversion of sunlight to electrical is very less. This conversion efficiency is also decrease when there is no load match between PV side and grid load side. To make the most of the power derived from the solar panel it is significant to operate the panel at its maximum power point, due to this MPP increase in output efficiency. This is generally a very few inches size and produce 1 W power. For obtaining the higher amount of power numbers of these cells are united in series and parallel circuits on panel having the region of some feet .Therefore, solar array is determined by the groups of modules, for generation of required amount of current and voltage electrically coupled combination of series and parallel is essential.

B. *Impedance source converter*

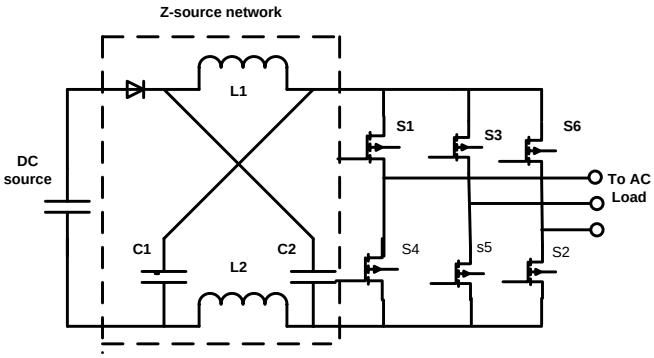

Fig.4. 3-φ impedance source inverter

Z source network can be utilized in a large range of power conversion application to provide a flexible means of power conversion between different types of sources and loads. ZSI can be denoted as simple impedance source inverter. The characteristic of a ZSI is its potential to control shoot-through switching states for boosting the output voltage. In shoot-through states of ZSI both switches of same phase leg of the inverter are turned ON simultaneously. Due to insertion of the shoot-through states, modulation strategies are required for controlling of ZSI. Three distinguished modulation strategies for ZSI are constant boost technique, maximum boost and simple boost technique. The simple boost modulation strategy and traditional carrier based are operate in same way.Its voltage gain is given,

$$G = MB = \frac{V_{ac}}{\frac{V_O}{2}}$$

In above equation, where B is denoted as boosting factor of the impedance network. V_{ac} is denoted as inverter amplitude output voltage. v_0 is the link of dc voltage. The term boosting factor is given below.

$$B = \frac{1}{1-2D}$$

Where D is denoted as the shoot through duty ratio.

C. *MPPT Techniques: (Perturb &Observe method)*

The atmosphere like whether and load are frequently changes for that controlling purpose this MPPT is used. For making certain maximum power which will obtained from the photovoltaic arrays a dynamic tracking system is important. The following are the different type of algorithm in that we used P&O technique algorithm which shows in figure 5.

The solar panel MPPT is used for the improvement of efficiency. Accurate and robust tracking of MPP, less power ripple in MPP, fast junction are the main advantages of MPPT technique. MPPT methods include perturb & observe technique, hill climbing technique, power matching scheme technique, incremental conductance algorithm,

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fractional open circuit technique, curve fitting technique, In this above technique P&O algorithm is used as grounds to develop the new model predictive-based MPPT technique that features better energy efficiency which can more well prevaricate against active environmental conditions. From above MPPT technique we used the P&O method that is perturbs and observe method [6].

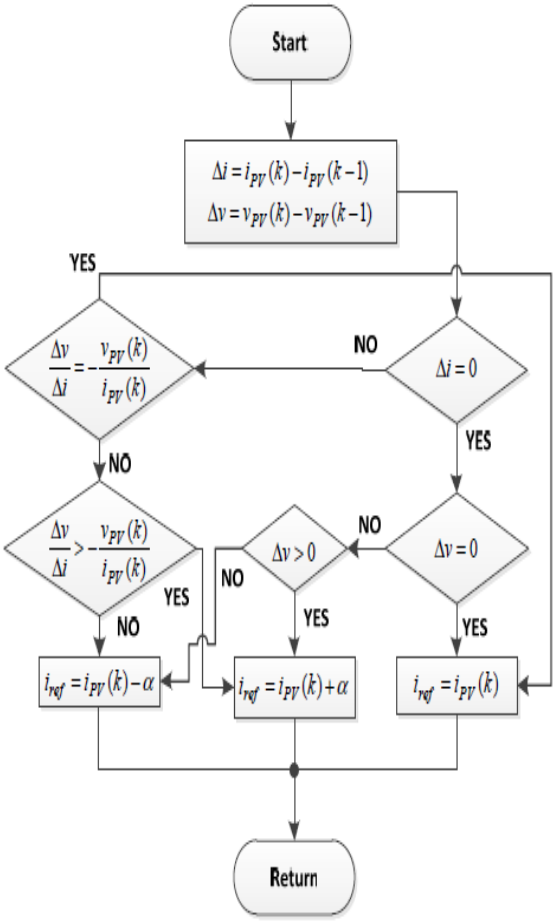

Fig.5. Perturb and observe method.

The perturb & observe algorithms are most commonly used in control of MPPT for their simple structure & to their less number of measured parameter. The concept behind of this method which is shown in Fig. 5.P&O algorithm is based on observation of PV array output power. Its perturbation is by changing the current or the voltage of PV array operation. The figure.5 can be taken from the paper which mention in reference [6].Based upon the previous value until it reaches to maximum power point P&O algorithm continuously increase or decrease reference voltage and current.

- $\frac{dp}{dv} > o$ Moves the operating point of PV array to the MPP. Operating point of PV array ids perturbed in specific direction, its known as perturbation .After this P&O algorithm continue to perturb in same direction
- $\frac{dp}{dv} < 0$ Operating point of PV array away from the maximum power point .After this two condition algorithm reverses the direction of perturbation.

From above explanation & algorithm it is clear that On the LHS of the MPP there is linear increase in power with respect to voltage. But on RHS of the MPP there is increase voltage with decrease in power. So, this Perturb & Observe algorithm will try to maintain the maximum power point by perturbing voltage with respective power. At maximum power point change in power with respect to change in voltage is zero. In direct duty ratio perturbation, the specific perturb fixed value of voltage can be controlled by duty ratio controlled parameter For comparing PV side voltage & current with output side voltage &current the duty ratio system PI controller is used.

III. PROPOSED MPPT SYSTEM

There are two parts of block diagram first one is PV with grid-tied impedance source converter system and another block diagram of maximum power point tracking projected system.

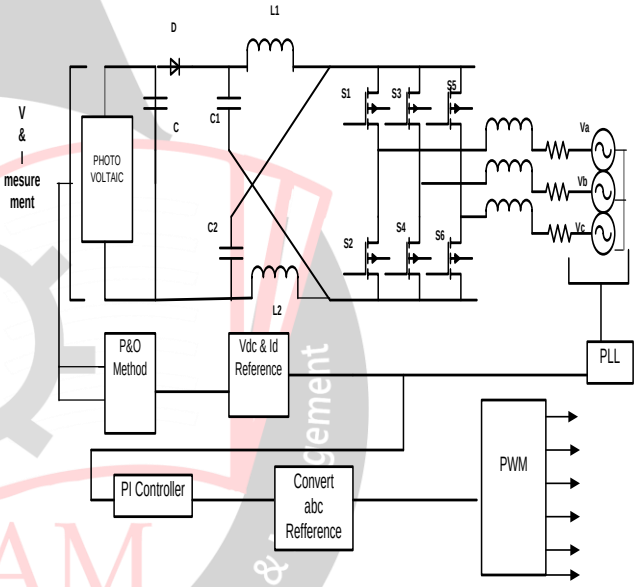

Fig.6. Block diagram of proposed MPPT system

Start from PV system, in this PV system there are two terms will be evolved as input first one is solar irradiance amplitude and temperature which will depend on the environmental condition. In this the algorithm of perturb and observe is set. After run that algorithm the energy can store in capacitor then it connected to z source inverter which will boost the voltage. The z source inverter (ZSI) has the unique buck-boost capability which provides an output voltage range from zero to infinity regardless of input voltage. This output voltage range can be obtained with an unique switching state, termed state as "shoot-through" state. This state is obtained when both upper and lower switches of the same phase leg are turned on. Z-source based grid connected system is shown in fig.6. Here PV module is used as a dc input. As we know that PV is not much sufficient to feed power to the grid, the impedance network is connected at the output of PV. The three levels MOSFET six pulse inverter is used to feed AC. For synchronization of inverter frequency with grid frequency,

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a closed loop controller is designed, which is also responsible for the firing switches of the inverter.In this control unit phase lock loop is utilized to synchronized inverter frequency with grid frequency. The I is then multiplied with ref fundamental grid voltage and the resultant obtained is then compared with the grid voltage.

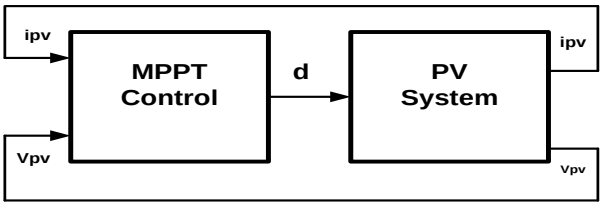

Fig.7. Direct duty ratio control.

The sine wave obtained from the control unit is then compared with the triangular carrier wave to obtain the pulses. For providing boost to the inverter shoot through state is necessary; this shoot through state is generated by using maximum power point tracking (MPPT) method. The Perturb and observe (P&O) method of maximum power point tracking is used in this work. The Perturb and observe method, will track the maximum power at any environmental condition and gives the maximum power at the output of PV. Here the Perturb and observe method is also used to provide shoot through state for providing the maximum boost to the inverter. Perturb & Observe (P&O) is the simplest method of tracking MPP. The time complexity of this algorithm is very less. The PV voltage is sensed by voltage sensor and so the implementation of cost is less .It keeps on perturbing in both the directions. When this happens the algorithm reaches the MPP and we can set an appropriate error limit. In this method less voltage and power can be control by controller; if the power continues to increase then further adjustments are carried out in that direction and is continued till there is not an increase in power, which eventually leads to maximum point. In this proposed maximum power point tracking system the PV side voltage and current, after ZSI grid side voltage and current can be compare in controller. For the synchronization of inverter frequency with grid frequency, closed loop system controller can be designed in proposed system. After conversion a b c references it gives as a input to pulse width modulator. This pulse can generate signal which will gives to inverter .after this process filter is connected for reduced the oscillation and get pure sinusoidal waveform. This is called a 'Perturb and Observe' method.

IV. SIMULATION RESULT & DISCUSSION

All proposed controller is used in MATLAB/Simulink

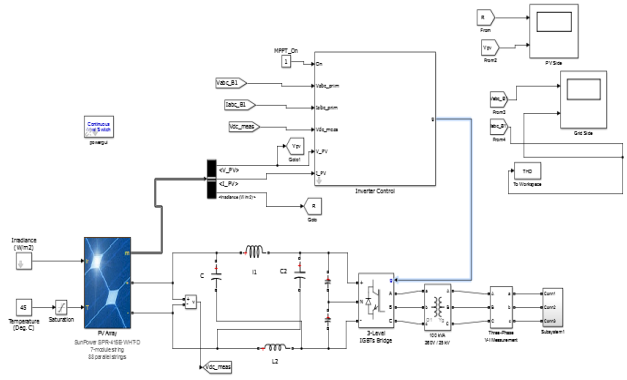

Fig.8. Simulation Model

All system parameters are given in SUNPOWER SPR-415E-WHT-W PV module with power 415W No cells /module 128.The performance of perturb & observe MPPT is evaluated by looking in to three important terms. The response to a step change in solar irradiance level, operation in steady state to evaluate the oscillation around maximum power point, and operation in the event of gradually changing solar irradiance.

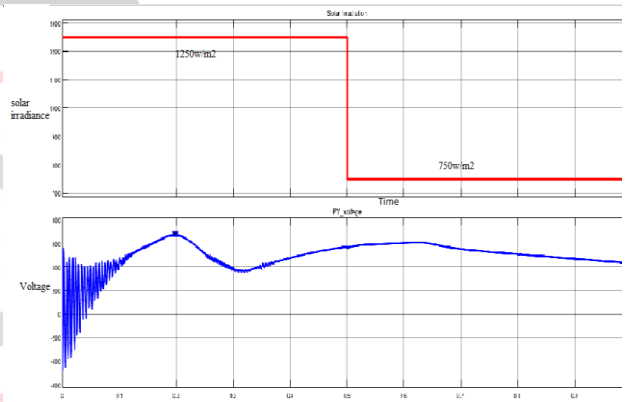

Fig.9.Response of PV voltage and current to a step change in solar irradiance

Above simulation fig.9. Shows the response of photo voltaic current and voltage to a step change in solar irradiance 1250W/$m^2$to 750W/m^2.The above result demonstrate fast and accurate dynamic tracking performance with convergence time of less than 0.5sec for P&O MPPT.The PV side voltage and current waveform shows less ripple at the time of changing solar irradiance level.

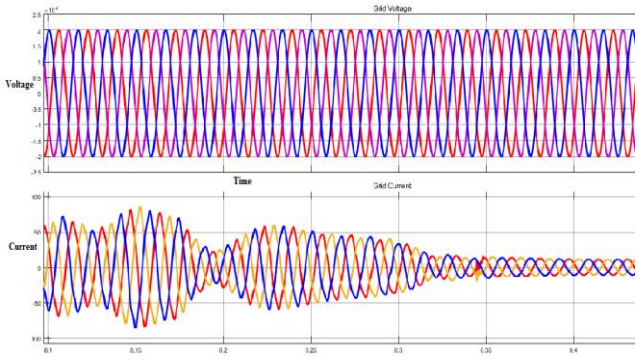

Fig.10.three phase grid side voltage and current in case of step change in solar irradiance level

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The above simulation waveform shows the 3 phase grid side voltage and current waveform. The voltage and current at the time of stepped down solar irradiance level is 456.5 V ad 21.5A .as we seen that power quality is improved that is 200KW from input of 415W with unity p.f in solar irradiance and FFT.

Fig.11. shows the FFT spectrum analysis of grid side current with unity power factor .That graph will shows frequency vs fundamental graph .The calculated total harmonic distortion (THD)is 1.89% with fundamental of 11.84.

In fig.12. Shows the harmonic distortion of grid side current in listed form. The list shows the oscillations of third, fifth, seventh, ninth are 0.28%, 0.45%, 0.49% and 0.08% respectively.

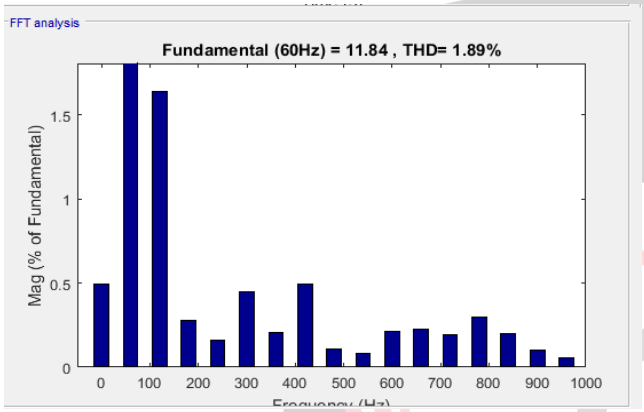

Fig.11.FFT spectrum analysis of grid side current

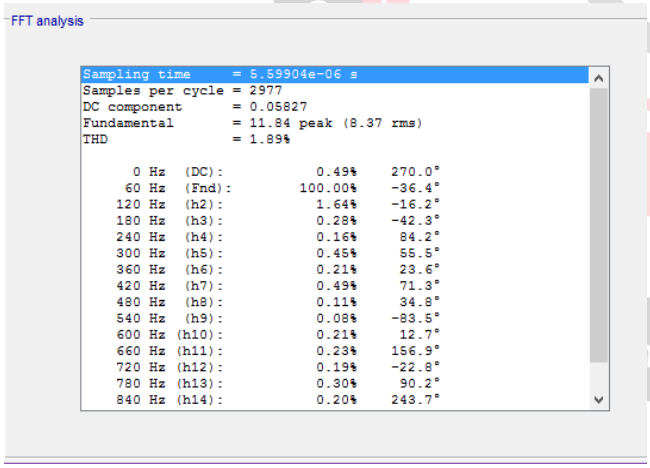

Fig.12.Harmonic distortion of grid side current

V. CONCLUSION

In this study, perturb and observe based MPPT used for highly resourceful organize scheme for impedance source inverter based photovoltaic system. In this paper presented control system for grid tied PV system using P&O MPPT for efficient tracking. The experimental results demonstrate PV side voltage and current, step change in solar irradiance (1250to750) with fast active response that is line side network

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