DESIGN & SIMULATION OF LOW POWER HOME UTILITY GRID CONNECTED PV SYSTEM USING P&O METHOD

[1] Yogita Sahu, [2]Amit Chouksey
[1]Research Scholar, [2] Professor
M.Tech., Digital Communication, Gyan Ganga College of Technology, Jabalpur

ABSTRACT: *For a grid connected Photo voltaic system Maximum Power Point Tracking algorithm which place a major role. A most suitable MPPT P&O technique is opted which is based upon the cost of implementation & no. of sensors requirement, complexity. Input to the PV module is solar insolation & temperature. From the solar panel voltage & current are extracted in order to find the power output. The simulation model is design for MPPT, PV module & Boost DC-DC, DC-AC converters. The various results simulated shows the improvement in P&O algorithm for MPP. Also the proposed simulated PV system requires less battery as the capacitor (feedback control) does reduce this requirement. In Voltage Source Inverter (VSI) are generally output voltage is lower than the supplied voltage. Hence, the traditional solar power generators require minimum two power conversion stages for getting desired voltage & frequency to synchronize with ac loads. In order to overcome these limitations of the traditional controllers, the proposed controller VSI has been used to give regulated output voltage of the boost dc-ac inverter in a uni-stage for variable loads. In order to design a grid connected PV system first of all PV module is modelled in MATLAB/Simulink based on the equivalent circuit in order to find best MPPT technique. In this work we have taken 6-module PV array. These PV array operates at MPP: Ppv = 6*85 W = 510 W & AC grid RMS voltage: 120 V.*

Keywords: - PV, MPPT, P&O, MPP, VSI, Grid connected system.

1. INTRODUCTION

Since the growing demand and increasing price of fossil fuels have direct impact on economy of each and every country, there is a timely need to search for alternate for the fossil fuels. The various pollutions, created due to non-renewable energy sources, are disturbing the natural pattern of our ecosystem and have numerous adverse effects on human health. These all set additional challenges for engineering society to drive towards alternate energy sources. Among the various renewable energy sources the solar energy has been proven to be modest and advantageous because of its pollution free and free in nature (Bull 2001). Generally the voltage source inverter (VSI) has widely used for solar power generation but its output voltage is always lower than the input voltage. So the conventional solar power generation needs minimum two power conversion stages for getting proper voltage and frequency to synchronize with single phase grid or ac loads. In order to overcome the above said limitations of the conventional controllers, the proposed controller VSI has been used to give regulated output voltage of the boost dc-ac inverter in a single stage under variable loads. In this work we have taken 6-module (85 W each) PV array with full sun (1,000 W/m2 insolation). PV array operates at MPP: Ppv = 6*85 W = 510 W & AC grid RMS voltage: 120 V. The overall system is modelled and simulated in MATLAB/SIMULINK environment. In order to design a grid connected PV system first of all PV module is modelled in MATLAB/Simulink based on the equivalent circuit in order to find best MPPT technique. Input to the PV module is solar insulation and temperature. From the solar panel voltage and current are extracted in order to find the power output. The simulation model is design for MPPT, PV module and Boost DC-DC, DC-AC converters. The various results simulated show the improvement in P&O algorithm for MPPT. Also the proposed simulated PV system requires less battery as the capacitor (feedback control) does reduce this requirement. Besides this, the solar energy is easy to adopt with the existing power converters (Arunkumar Verma et al 2010, Rong-Jong Wai et al 2008). The power electronic interface plays a vital role in bridging the solar energy with the domestic or single phase grid. The entire topology consists of MPPT solar charge controller; dc energy storage device and single stage boost dc-ac inverter. The single stage boost dc-ac inverter can be modelled by the bidirectional buck boost converter (Vazquez et al 2000). Initially the maximum energy from the solar photovoltaic array is extracted with the help of MPPT technique (Weidong Xiao et al 2007) and the extracted energy is stored in dc energy storage device (Yiwen He et al 2010) by solar charger. The existing control strategies, implemented for controlling the output of the boost dc-ac inverter, such as double loop control method (Domingo et al 2009 & Pablo Sanchis et al 2005) and sliding mode control method (Caceres et al 1999) involves difficulties like complex theory and variable switching frequency (Pablo Sanchis et al 2005). Therefore the main scope of this research work lies in the designing of a simple controller, MPPT and in the reduction of power conversion stages in grid connected solar power generation, since the conventional method consists of two power conversion stages (Rafia Akhter et al 2007) which results in more capital cost and more switching losses. There are four controllers such as Modified Non-Linear State Variable Structure (MNLSVS) controller, Sinusoidal Pulse Width Modulation (SPWM) technique based controller, Fuzzy Logic Controller (FLC) and Comparator based Non-Linear Variable Structure (NLVS) controller are proposed for boost dc-ac inverter. The proposed controllers are tested with inconsistent load and results are compared and analyzed in terms of inductor current, capacitor voltage and harmonic distortion.

Back-up battery storage in fuel cell. When low-voltage unregulated fuel cell (FC) output is conditioned to generate AC power, two stages are required: a boost stage and an inversion one. In this paper, the boost-inverter topology that achieves both boosting and inversion functions in a single-stage is used to develop an FC-based energy system which offers high conversion efficiency, low-cost and compactness. The proposed system incorporates additional battery-based energy storage and a DC-DC bi-directional converter to support instantaneous load changes. The output voltage of the boost-inverter is voltage-mode controlled and the DC-DC bidirectional converter is current-mode controlled. The load low frequency current ripple is supplied by the battery which minimizes the effects of such ripple being drawn directly from the FC itself. Analysis, simulation results are presented to confirm the operational performance of the proposed system.

amplifier. A DAQ system with LabVIEW application was developed for controlling the MOSFET gate-source voltage. The circuit is designed, implemented and tested under real conditions. The experimental results verified with simulation results and another way of testing which is resistor method.

[8] MerinGeorge et-al, "Cascaded Boost Converter for PV Applications", International Journal Of Innovative Research In Electrical, Electronics, Instrumentation And Control Engineering, Volume 2, Issue 4, April 2014.

This paper proposes a converter that achieves a high step-up voltage conversion ratio, which contains a coupled inductor, without extreme duty ratios and numerous turns-ratio; the leakage inductor energy of the coupled inductor is efficiently recycled to the load. Also, switch of the converter isolates energy from the PV panel when the ac module is off. This particular design protects installers and users from electrical hazards. These features explain module's high efficiency performance. A 15V input voltage, 200V output voltage, and 100W output power circuit of the proposed converter has been implemented. MATLAB is used for the study.

2. MAXIMUM POWER POINT TRACKING (MPPT) TECHNIQUE

The current-voltage behavior of solar panels nonlinearly depends on the solar irradiation intensity and environmental temperature. As shown in Fig.1, an increase in sun irradiation level and decrease in ambient temperature result in a higher output current and voltage. Consequently, the environmental condition variations change the maximum output power of solar panels.

There have been various models proposed for PV cells, and among all of these models one of the simplest (which characterizes the I-V behavior of a PV cell), uses a diode in parallel with a current source. Mathematical equations for this model have been discussed in next section.

As mentioned before, in the grid-connected PV system, the DC link capacitor is charged by solar array, and then power is switched out from the capacitor using the power converter (inverter) and the extracted power is injected to the utility grid. To ensure that solar arrays deliver maximum available power to the converter (inverter), an interface device between converter (inverter) and PV panels needs to be employed to control the flow of power.

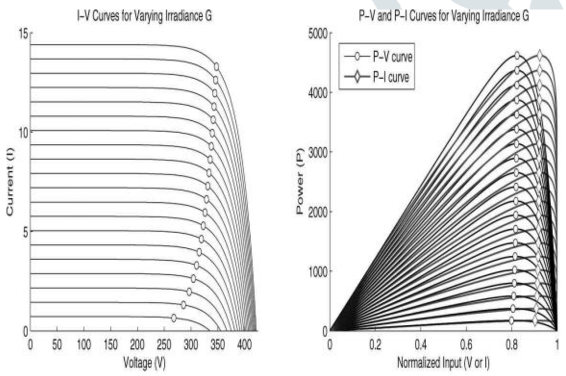


Figure 1: Nonlinear Behavior of Voltage-Current & Power-Current of PV Panels for Various Sun Irradiations.

Among various MPPT algorithms, convergence speed is one of the most important features which improves the efficiency and also increases the stability of the system. Brunton et al. have pointed out: "As irradiance decreases rapidly, the I-V curve shrinks and the MPV and MPI decrease. If the MPPT algorithm does not track fast enough, the control current or voltage will fall off the I-V curve." Consequently, any improvement in the rise time of MPPT improves the reliability of the system, increases the power extraction and results higher efficiency of the whole system.

The peak power point tracking techniques vary in many aspects, such as: simplicity, convergence speed, digital or analog implementation, sensors required, cost, range of effectiveness, etc. The MPPT implementation topology greatly depends on the end-users' knowledge. In analog world, short current (SC), open voltage (OV), and temperature methods (temperature gradient (TG) and temperature parametric equation (TP)) are good options for MPPT, otherwise with digital circuits that require the use of micro-controllers, perturbation and observation (P&O), IC (incremental conductance), and temperature methods are easy to implement. Figure 2 and Table1 present the comparison among different MPPT methods considering the costs of sensors, micro-controller, and the additional power components. In this table, *A* means absence, *L* low, *M* medium, and *H* is high.

Currently, the most popular and the workhorse MPPT algorithm is perturb and observe (P&O), because of its balance between performance and simplicity. However, this method suffers from the lack of speed and adaptability which are necessary for tracking the fast transient under varying environmental conditions.

3. PROPOSED METHODOLOGY

Perturb & Observe (P&O) is the simplest method and is widely used. In this technique we generally use only one sensor, that is the voltage sensor, to sense the PV module voltage and hence the cost of implementation is less and hence easy to implement without any complexity [3]. The time complexity of this algorithm is very less for calculating the maximum power but on reaching very close to the Maximum Power Point (MPP) it doesn't stop at the MPP and keeps on perturbing on both the directions so for that reason it have multiple local maximum at the very same point. First of all the algorithm which reads the value of the current and voltage from the photovoltaic module from that power is calculated the value of voltage and power at that instant is stored. Hence a slight perturbation is added in the increasing direction. The next values at the next instant are measured and power is again calculated. Hence by adjusting the maximum power duty cycle can be obtained based on it. In certain situations like changing atmospheric conditions and change in irradiance the maximum power point shifts from its normal operating point. In the next iteration it changes its direction and goes away from the maximum power point and results in multiple local maxima at the same point. So the maximum power point deviates from its original position. This difficulty which can be overcome by using an improved P&O method.

3.1 PROPOSED GRID-CONNECTED PV SYSTEM ARCHITECTURE

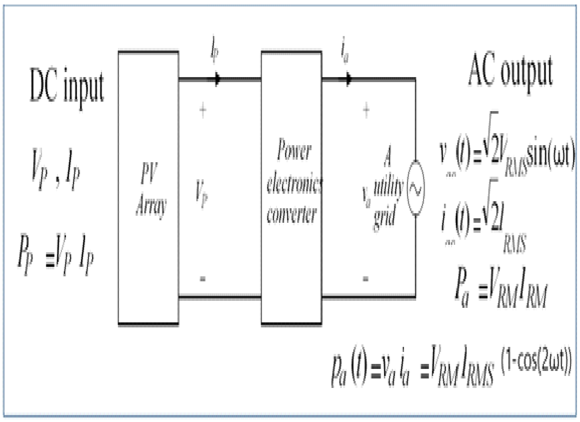


Figure 2: Grid Connected PV System Architecture

3.2 FUNCTIONS OF THE POWER ELECTRONICS CONVERTER

- Operate PV array at the maximum power point (MPP) under all conditions.
- Provide energy storage to balance the difference between and (t).
- Generate AC output current in phase with the AC utility grid voltage • Achieve power conversion efficiency close to 100%

3.3 DETAILED PROPOSED GRID-CONNECTED PV SYSTEM ARCHITECTURE

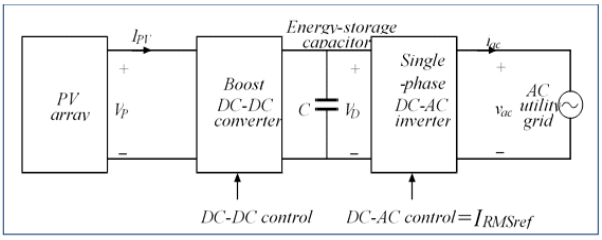


FIGURE 3: DETAILED ARCHITECTURE OF GRID CONNECTED PV SYSTEM

3.4 ROLE OF BOOST DC-DC CONVERTER

- Set the PV operating point (VPV, IPV) to MPP
- Efficiently step up VPV to a higher DC voltage VDC

3.5 ROLE OF DC-AC INVERTER

- Efficiently generate AC output current iac in phase with the AC grid voltage vac
- Balance the average power delivery from the PV array to the grid,

  Pac = Ppv * ηDC-DC * ηDC-AC

3.6 PROPOSED SIMULATION MODEL DESIGN PARAMETERS CALCULATIONS & SIMULINK MODEL OF GRID CONNECTED PV SYSTEM

- DC-AC inverter input voltage: VDC = 200 V
- Average power delivered to the grid: Pac = 600 W
- Capacitor C= 200 uF
- 6-module (85 W each) PV array with full sun (1,000 W/m2 insolation)
- PV array operates at MPP: Ppv = 6*85 W = 510 W
- AC grid RMS voltage: 120 V

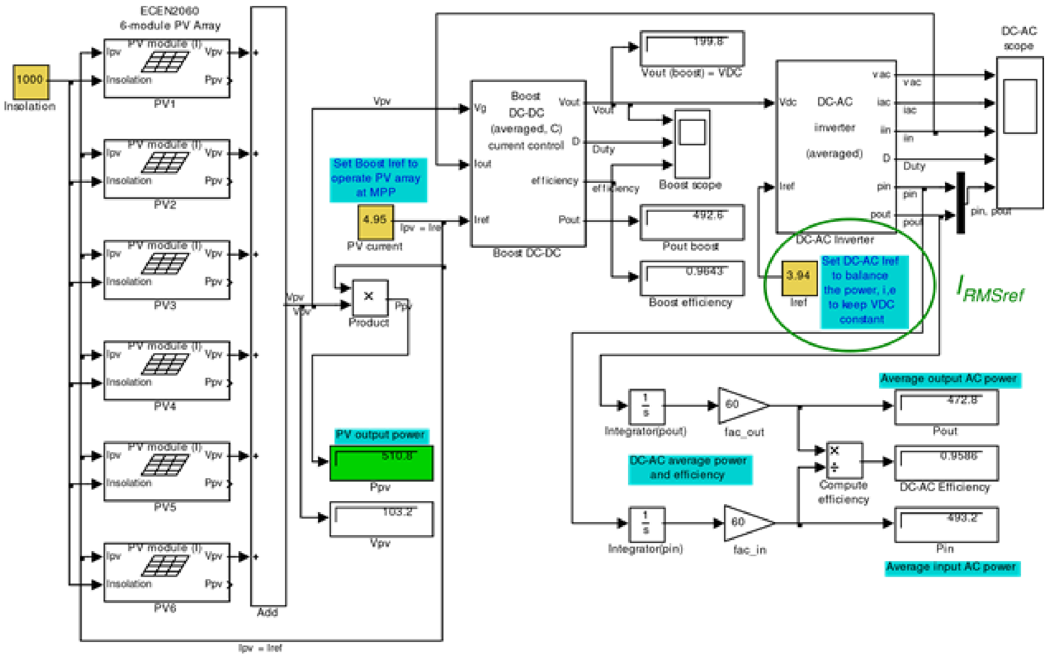


Figure 4: Proposed PV+ Boost DC-DC + DC-AC Inverter Model

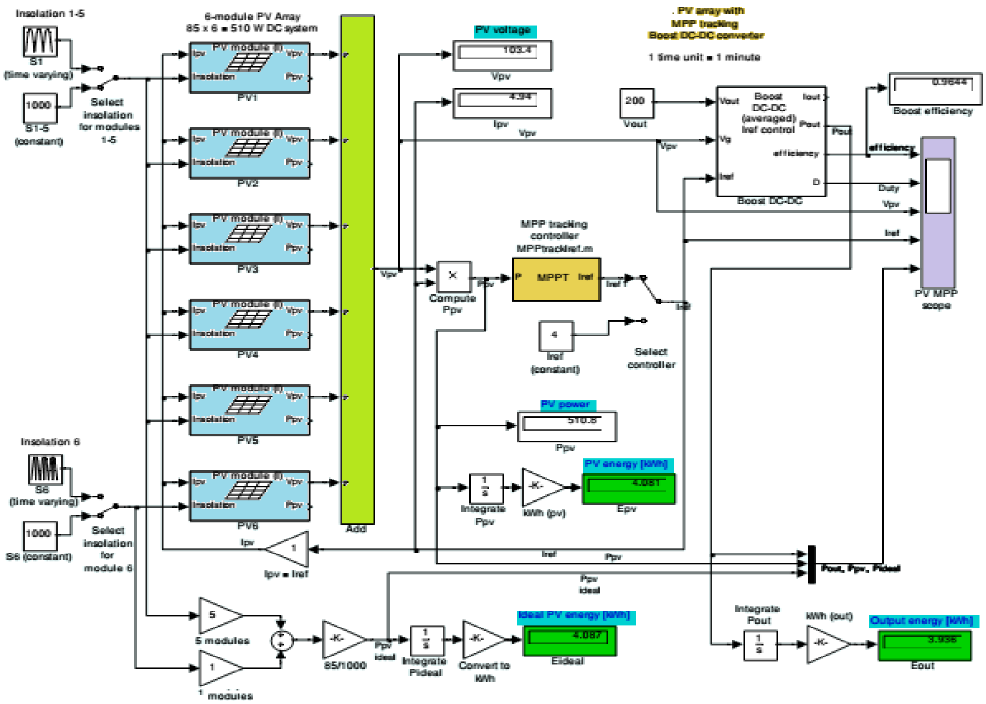


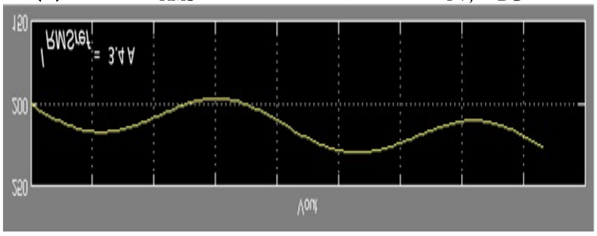
Figure 5: Simulation Model for PV Boost MPP

4. SIMULATION RESULTS

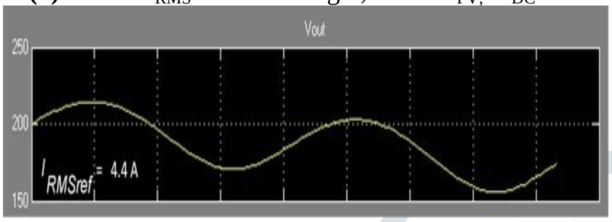
4.1 SIMULATION WAVEFORMS FOR IRMSREF AND BOOST OUTPUT VOLTAGE

Simulation Results for 3 different values of I_{RMS} ref and boost output voltage Vout (t) = V_{DC}(t) are:

Case (1): When I_{RMS} ref is Too low; Pac < $P_{PV;}$ V_{DC} increases



Case (2): When I_{RMS} ref is Too high ; Pac > $P_{PV;}$ V_{DC} decreases



Case (3): When I_{RMS} ref is in equilibrium; Pac ≈ $P_{PV;}$ V_{DC} starts at 200V & 200V

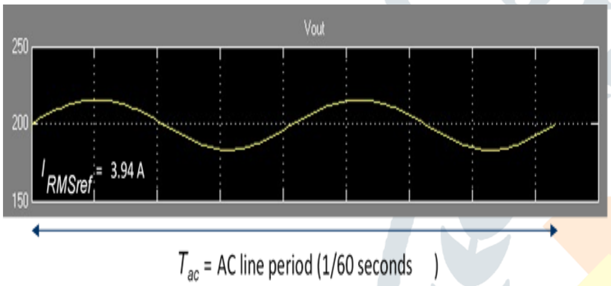


Figure 6: Simulation waveforms for I_{RMS} REF and boost output voltage

4.2 ENERGY STORAGE CAPACITOR WAVEFORM

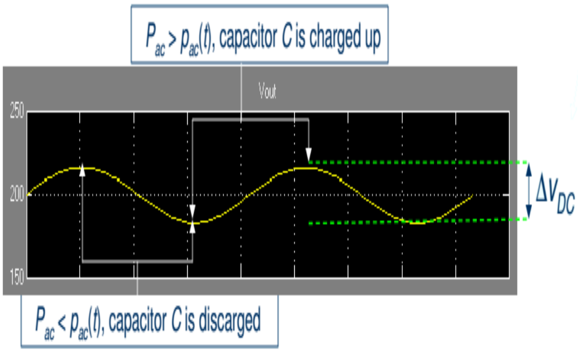


Figure 7: Energy Storage Capacitor Waveform

4.3 I-V CHARACTERISTICS OF PV SYSTEM

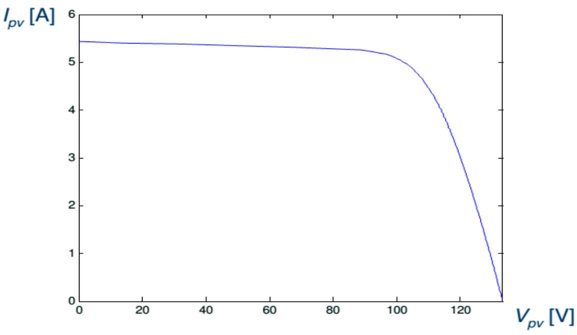


Figure 8: I-V Characteristics of PV System (Six 85 W Modules in Series, Full Sun)

4.4 P-V CHARACTERISTICS OF PV SYSTEM

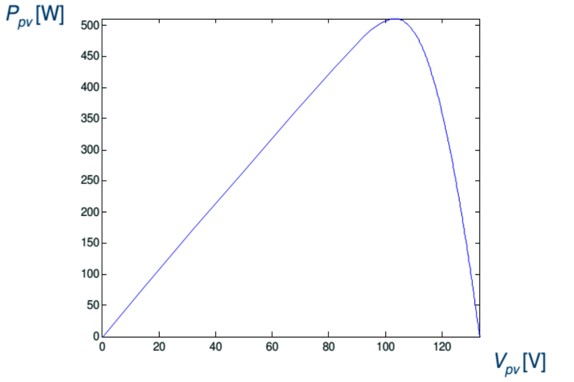


Figure 9: P-V Characteristics of PV System (Six 85 W Modules in Series, Full Sun)

4.5 P-I CHARACTERISTICS OF PV SYSTEM

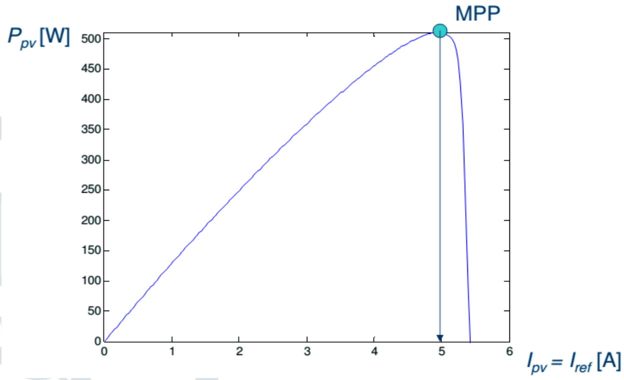


Figure 10: P-I Characteristics of PV System (I_{pv} = I_{REF} at MPP)

4.6 MPP TRACKING OPERATION

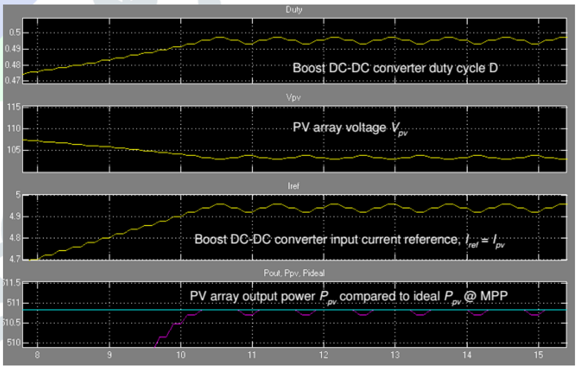


Figure 11: MPP Tracking Operation

5. CONCLUSION

In order to design a grid connected PV system first of all PV module is modelled in MATLAB/Simulink based on the equivalent circuit in order to find best MPPT technique. Input to the PV module is solar insolation and temperature. From the solar panel voltage and current are extracted in order to find the power output. The proposed grid system is designed for domestic load purpose and delivers 600 W average power. For a grid connected Photo voltaic system Maximum Power Point Tracking algorithm which place a major role. A most suitable MPPT P&O technique is chosen based on the implementation cost, number of sensors required, complexity. Input to the PV module is solar insolation and temperature. From the solar panel voltage and current are extracted in order to find the power output. The simulation model is design for MPPT, PV module and Boost DC-DC, DC-AC converters. The various results simulated shows the improvement in P&O algorithm for MPP. Also the proposed simulated PV system requires less battery as the capacitor (feedback control) does reduce this requirement.

REFERENCES

[1] Ye Yang et-al, "Sizing Strategy of Distributed Battery Storage System with High Penetration of Photovoltaic for Voltage Regulation and Peak Load Shaving", IEEE Transactions On Smart Grid, Volume 5, No. 2, March 2014.

[2] Yuen-Haw Chang et-al, "2-Stage 4-Phase Switched-Capacitor Boost DC-AC Inverter with Sinusoidal PFM Control", International Multi Conference of Engineers and Computer Scientists 2014 Vol II, IMECS 2014, Hong Kong.

[3] M.Sujith et-al, "Simulation Analysis Of 100kw Integrated Segmented Energy Storage for Grid Connected PV System", IJEET, Volume 3, Issue 2, pp. 164-173, 2012.

[4] Xiangli Li et-al, "The Research of Three-phase Boost/Buck-boost DC-AC Inverter", Scientific Research, Energy and Power Engineering, Volume 5, Pp-906-913, 2013.

[5] G.Vasumathi et-al, "Analysis of a High Efficiency Boost-Inverter with Back-up Battery Storage in Fuel Cell", International Refereed Journal of Engineering and Science (IRJES), Volume 4, Issue 1, Pp.52-59, January 2015.

[6] Mohit Bajaj et-al, "Design and Controlling of Proposed Efficient Boost-Inverter Implemented using Boost DC-DC Converter", International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE),Volume 2, Issue 5, May 2013.

[7] Anwar Sahbel et-al, "Experimental Performance Characterization of Photovoltaic Modules Using DAQ", ELSEVIER, TerraGreen 13 International Conference 2013.

[8] MerinGeorge et-al, "Cascaded Boost Converter for PV Applications", International Journal Of Innovative Research In Electrical, Electronics, Instrumentation And Control Engineering, Volume 2, Issue 4, April 2014.

[9] Kurati Rajendra Simha et-al, "Steady State and Dynamic Response for Bidirectional Buck–Boost Cascade Inverter", International Journal of Engineering Research, Volume 2, Issue 6, 2014.

[10] M. Ezzat et-al, "A Single-Phase Doubly-Excited DC-AC Buck-Boost Converter suitable for Feeding AC Loads from PV Systems", Innovative Systems Design and Engineering, Volume 2, No 5, 2011.