An Anti-islanding Control Scheme For Grid tied PV Inverter System

Mr. Atul G. Hake[1], Mr. Shamkumar B. Chavan[2], Dr. Mahesh S. Chavan[3]

[1]*M. Tech Scholar, Department of Technology, Shivaji University, Kolhapur, India.*
[2]*Assistant Professor, Department of Technology, Shivaji University, Kolhapur, India.*
[3]*Professor, KIT College of Engineering, Kolhapur , India.*

***

Abstract - *This paper presents simulation results of islanding detection and avoidance of grid tied Photovoltaic inverter system. The proposed system uses passive anti-islanding detection technique in which islanding shall be detected by continuously observing voltage and current across the load. This paper shows the simulation results of single phase photovoltaic inverter with isolation transformer connected across PV inverter and grid. To extract maximum power from a PV module MPPT algorithm is employed. A cascaded boost converter is implemented to increase the DC voltage to desired level, also an inverter has been implemented for conversion of DC input into AC supply. The simulation is done using SIMULINK/Sim power systems.*

***Key Words*: Anti-islanding scheme, Photovoltaic anti-islanding, PV inverter, Boost converter, PV inverter model.**

1. INTRODUCTION

Islanding is the condition in which PV system keeps supplying electric power to portion of grid even though the portion is isolated from the main utility grid which is dangerous to utility workers, human and animal beings [3][5]. Several deaths, injuries are reported due to this worldwide. To avoid this damage distributor generator must have mechanism to detect islanding and stop producing power in least possible time, this is known as Anti-islanding [1]. The islanding detection scheme can be characterized broadly into two types such as remote technique and local technique [2]. The local techniques further divided into following types

- Passive technique in inverter
- Active technique in inverter
- Hybrid technique

Passive islanding detection methods consist of measurement of system parameters such as phase, voltage and frequency while active islanding method consist of observation of effects of disturbance intentionally created on grid. The remote islanding detection scheme is based upon communication between inverter grid and utility grid or load. This technique is reliable than local islanding detection scheme but is expensive hence it is difficult to implement.

Integration of PV system with utility grid has challenges for anti-islanding schemes. These control methods detects the islanding condition and trip the PV system. If system fails to perform anti-islanding, generators can lead to problems like treats to human safety and degradation in power. The electricity which is obtained from solar power can be used for domestic and industrial purposes. The solar energy is enough for power requirements of household applications.

Nowadays trend of power sector has been shifted to renewable energy. The Sun radiates extremely large amount of energy called as solar energy or in other words as a radiant energy. The energy radiated by sun in one day is more than that used by whole world in one year. Very few amount of visible light emitted by sun reaches earth's surface i.e. one part in two billion and which is enough to fulfill nation's energy need. Producing electricity from sun is not same as producing heat from sun. The sun produces about 90 % energy as a light energy and remaining consists of X-rays and other radio signals.

1.1 PV INVERTER CONFIGURATION

The generalized block diagram of proposed anti-islanding control scheme for grid-tied PV inverter system is shown in fig. 1. A control unit shall be developed in such a way that it will have firmware to use MPPT algorithm for extraction of maximum power from PV module. It will monitor the parameters like voltage, current and frequency and control the islanding in the inverter system.

The boosted output of a cascaded boost converter is given as input to the full bridge inverter where we get the AC output. Switching of inverter switches is done by using PWM scheme. To remove harmonics and THD in the AC output of an inverter LC filter is used.

2. SIMULATION

A simulation model of proposed anti-islanding control scheme for grid tied PV inverter system is shown in Fig. 2. The simulation is done using MATLAB/ SIMULINK, the model contains PV array, Cascaded Boost converter, Inverter, PWM,

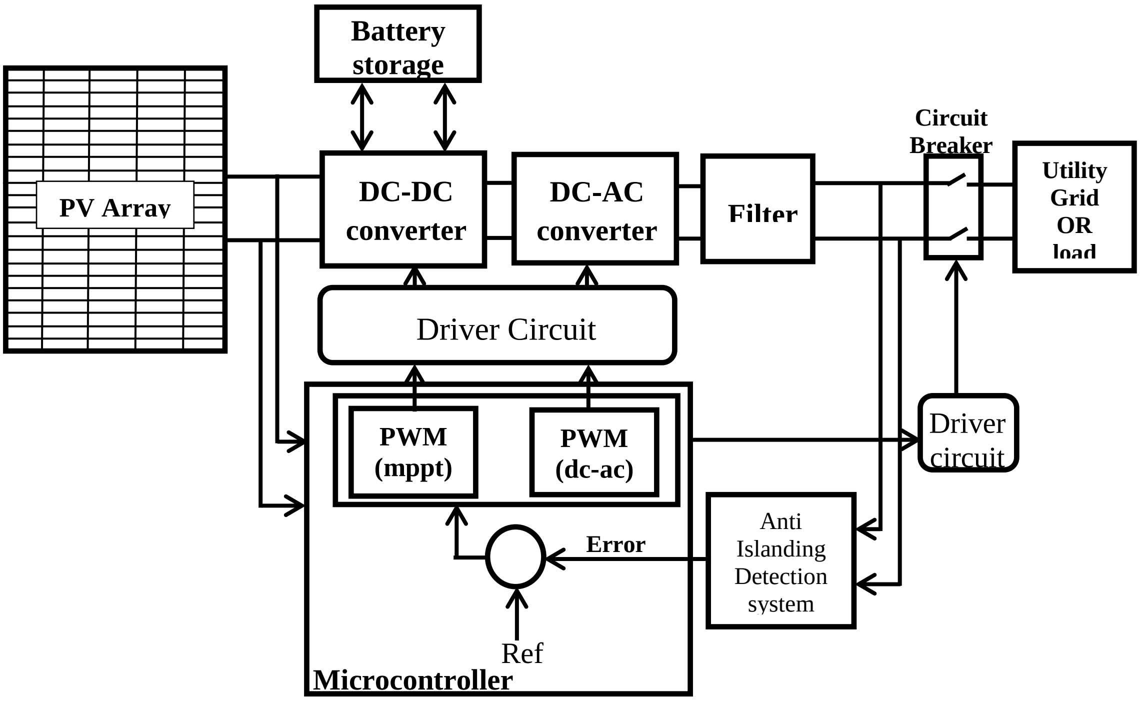

Fig-1: Generalized block diagram of proposed anti-islanding control scheme

generator, transformer and Filter. Transformer is used for isolation between PV system and load. The simulation model of cascaded boost converter is shown in fig. 3, in which two stages of boost converters are used.

The first stage of boost converter has input inductor L which stores energy in the form of magnetic field from PV cell and this previously created magnetic field is destroyed to maintain the current towards load and is delivered to capacitor C by controlling the switching of IGBT 1.

This boosted output is given as input to the second stage of boost converter, so we get double boosted voltage at the output of module.

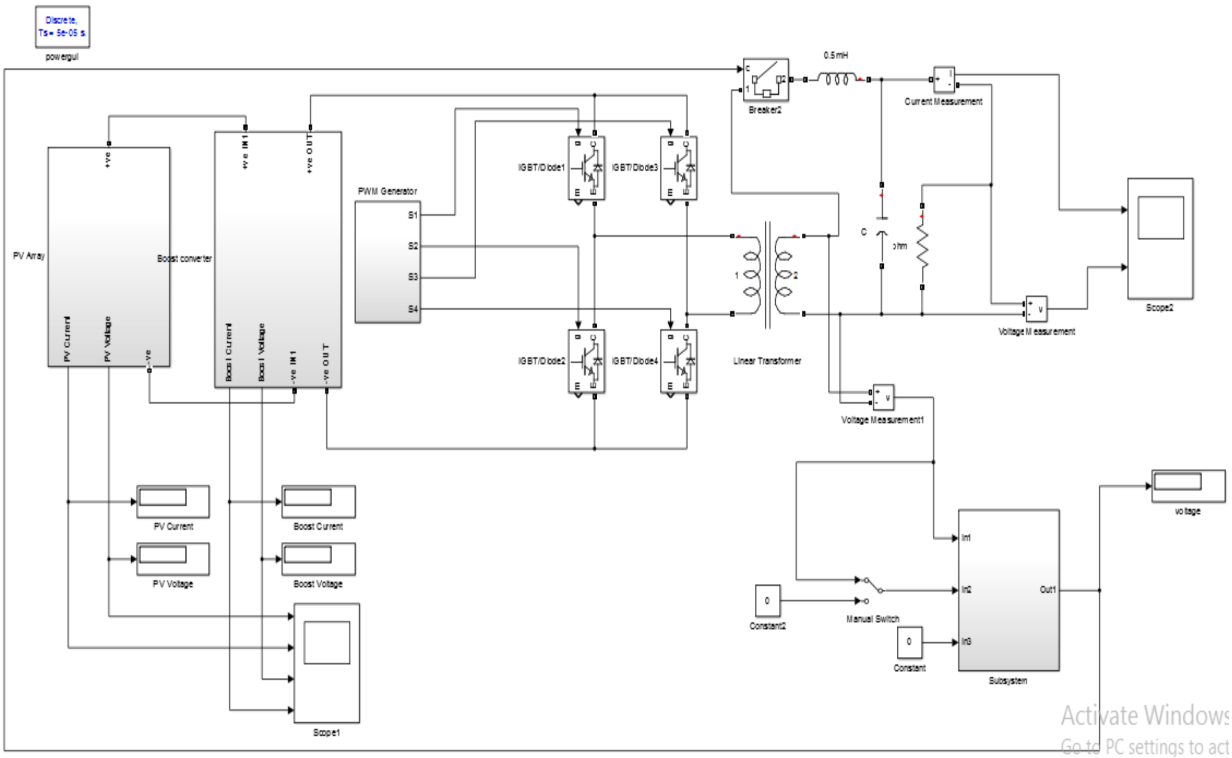

Fig-2: Simulation Model of Proposed Anti-islanding Control Scheme

In designing procedure the duty cycle ***D*** and switching frequency f_s plays an important role [6].

$$Duty\ cycle = 1 - \frac{V_{i(min)} \times \eta}{V_o} \qquad (i)$$

$$L = \frac{V_i \times (V_o - V_i)}{\Delta I_L \times f_s \times V_o} \qquad (ii)$$

$$C_{o(min)} = \frac{I_{o(max)} \times D}{f_s \times \Delta V_o} \qquad (iii)$$

A regulated output of boost converter is delivered to next stage i.e. inverter. Here simulation of H-bridge inverter is done.

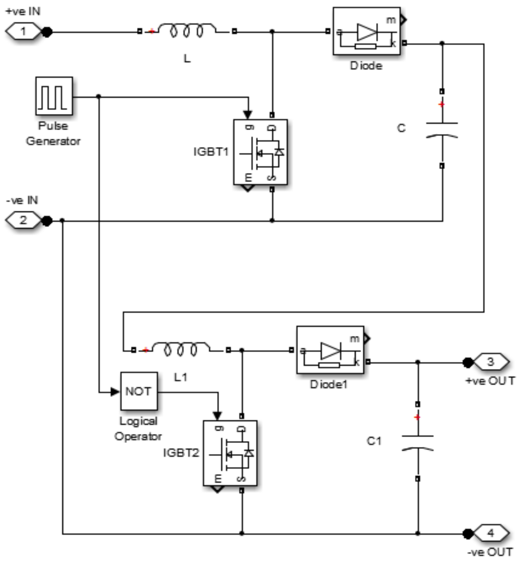

Fig-3: Simulation of Cascaded Boost converter system

Transformer is used for simply isolation purpose. The output of inverter is filter out using LC filter through transformer. PWM generator is used to switch IGBTs in inverter section of fig.2.

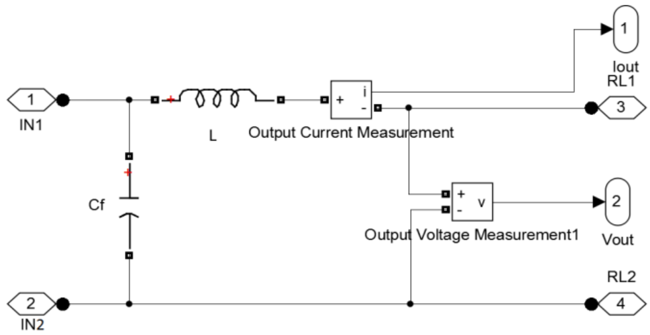

Fig-4: Filter Circuit

At an output of inverter LC filter is employed [7] to get a sinusoidal output. LC filter is designed using expression (iv).

$$F = \frac{1}{2\pi\sqrt{LC}} \qquad (iv)$$

The simulated inverter shall be designed by considering reliability issues of converters and inverters as discussed in ref. [4].

3. RESULTS AND DISCUSSIONS

The Simulation results of a PV inverter system are as follows:

The voltage and current waveforms of PV cell and boost converter are shown in fig. 5 respectively.

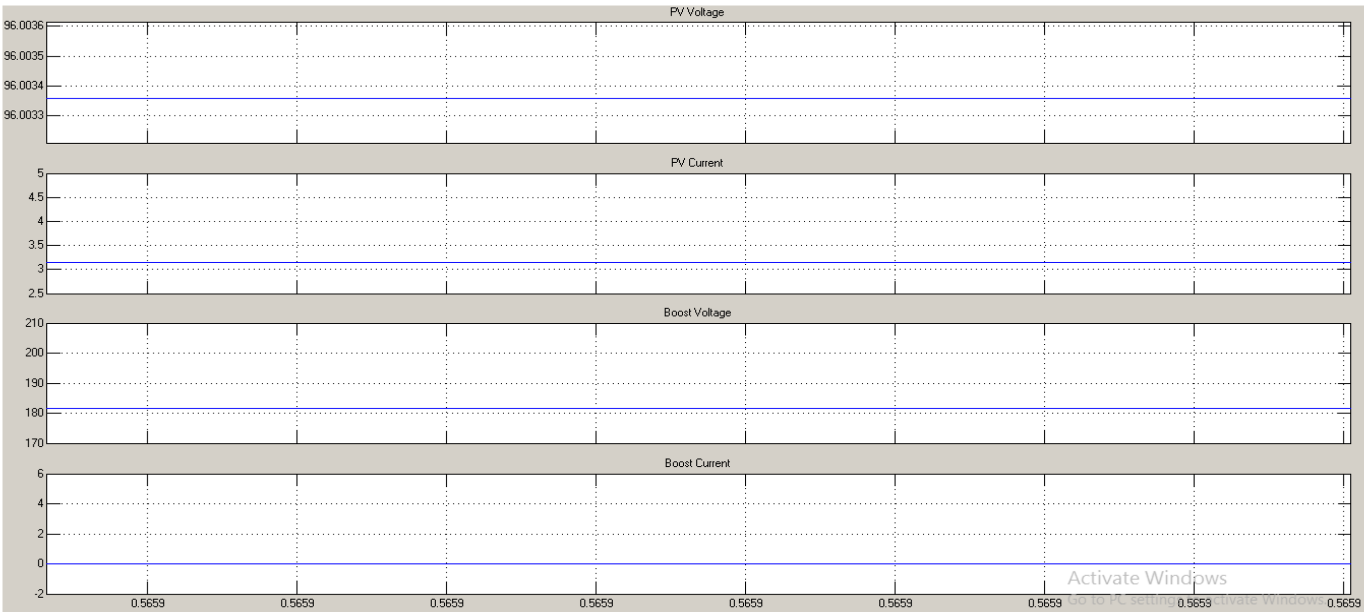

Fig-5: Output voltage and current waveforms of PV cell and Boost converter at no load condition.

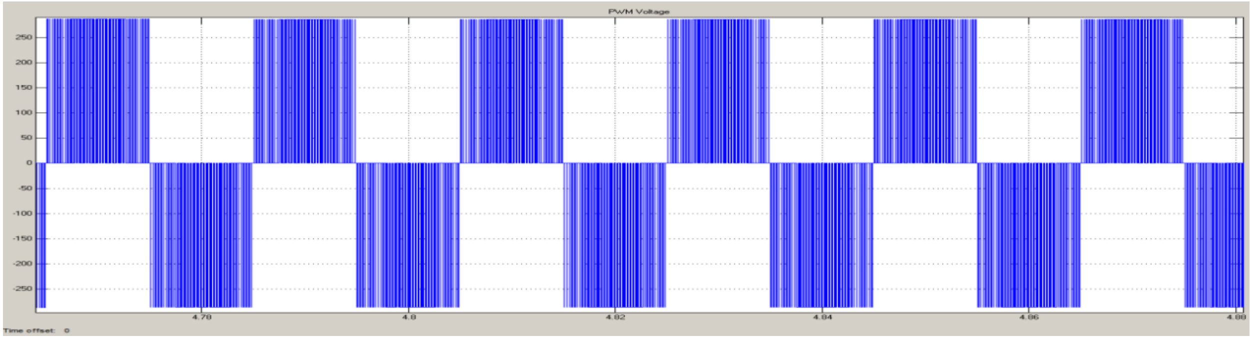

Fig-6: Output of an Inverter without filter.

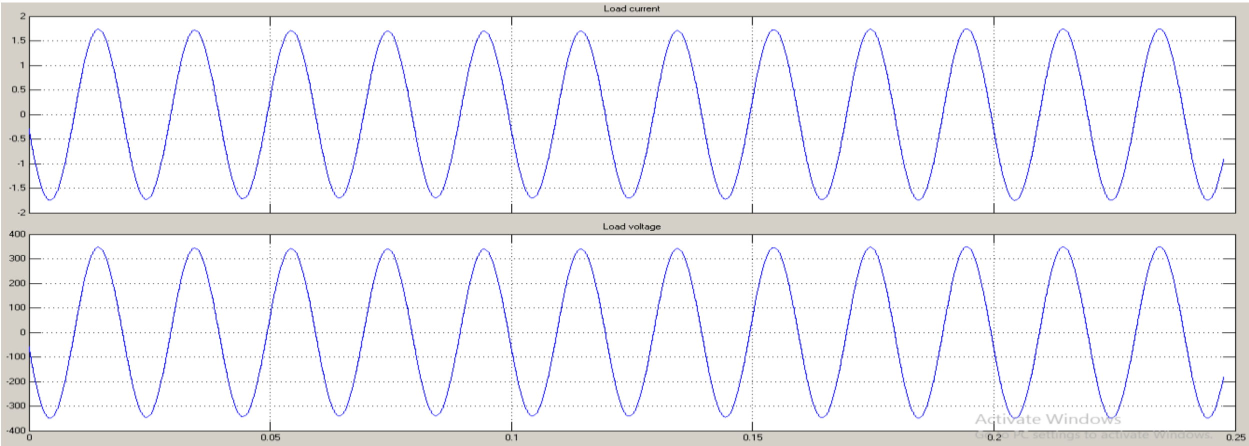

Fig-7: Output Current and Voltage of an inverter with LC filter

The PV cell is designed to produce 96V and 6.5A current. The simulation of proposed system is done by considering a maximum power point. The cascaded boost converter is designed to deliver output voltage of 350V DC. The output of boost converter is given to an inverter. The full bridge Inverter switches are controlled by using PWM scheme and modulation index is taken as 0.6. PWM output of an inverter is shown in fig. 6. Fig. 7 shows the output current and voltage waveforms, these readings are taken for resistive load of 200 ohm. Figure shows waveforms having 230Vrms voltage and current of 1.3 A

Fig. 8 shows the output of inverter after anti-islanding implementation. Here the inverter produces 230 Vrms, once islanding occurs the inverter shuts down. The output power after implementation of anti- islanding scheme is as shown in figure 8. It can be seen that after detecting islanding inverter is isolated from grid.

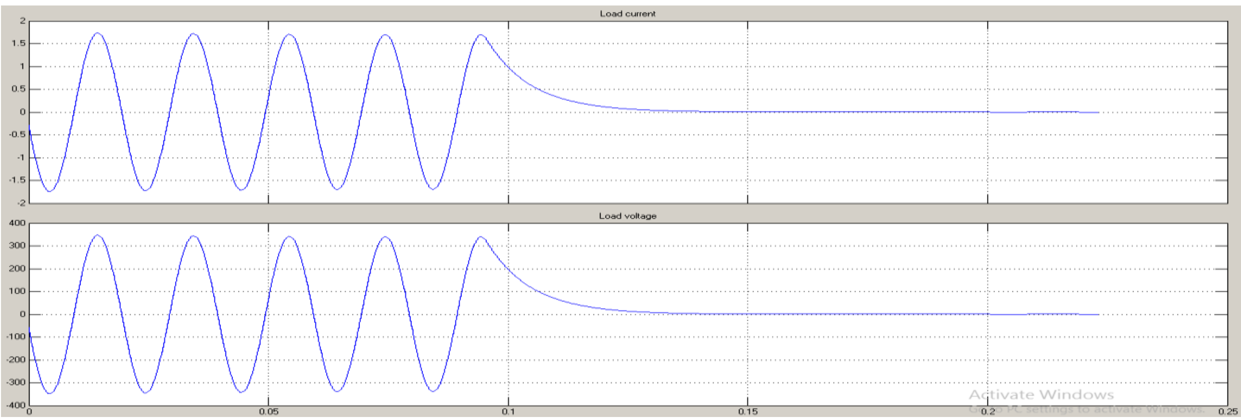

Fig-8: Output Current and Voltage of an Inverter after Implementating Anti-Islanding control scheme

Table-1: Component Specification

Parameters	Specification
PV Voltage	96 V
PV Current	6.5 A
Insolation	1000 Watt/m^2
Temperature	25^{0}C
Boost Inductor (L)	400 Mh
Boost Capacitor(C)	1000 μF
Duty Cycle(D)	70%
Efficiency of Boost(η)	81%
Switching Frequency(f_s)	240KHz
PWM Carrier Frequency (f_c)	2KHz
PWM Modulation Index(m_a)	0.6
Filter Inductor(L)	0.5 mH
Filter Capacitor(C_f)	47 μF
Load Resistor (R_L)	200 Ohm
Output Voltage (V_{rms})	230 V
Output Current (I_{rms})	2.2 A
Output Frequency (f_o)	50 Hz

4. CONCLUSION AND FUTURE WORK

A simulation result shows that the passive islanding detection technique works efficiently. Here islanding detection is achieved by observing voltage across the load and anti-islanding technique is implemented as early as possible. Also PV power can be efficiently converted into AC power. Hence with the help of anti-islanding technique damages to the human beings, instruments can be avoided.

Hardware execution of a proposed system is in progression, with the help of suitable high speed microcontroller voltage and current observation across the load should takes place which will helpful for faster islanding detection and avoidance by turning of the inverter. The proposed system uses transformer which provides isolation and is one of the advantage of system.

ACKNOWLEDGEMENT

Authors are thankful to Shivaji University, Department of Technology, Kolhapur , India for providing necessary facilities for completion of this manuscript.

REFERENCES

[1] V. RamaKrishna Prasad, Y. Nagaraja, "*An Anti-islanding Technique for Protection of Distribution Generation*" , International Journal of Engineering Trends and Technology (IJETT) – Vol.23 No. 4, May 2015, pp. 177-182.

[2] Lekshmi K R, Anju James, Sindhura Rose Thomas, Ammu Susan Sabu, , *"Passive Anti-islanding Protection for Grid Connected Solar Photovoltaic Power Plant: A Case Study"*, International Journal of Engineering Research & Technology (IJERT), Vol. 4, April-2015, pp.1057-1062.

[3] Ku Nurul Edhura Ku Ahmad, Nasrudin Abd Rahim, Jeyraj Selvaraj, Ahmad Rivai, Krismadinata Chaniago, *"An effective passive islanding detection method for PV single-phase grid-connected inverter"*, Elsevier, 13th sep 2013, pp. 155-167.

[4] Shamkumar Chavan, Maheshkumar Chavan, "Power switch faults, diagnosis and tolerant schemes in converters of photovoltaic systems- A review", International journal of advanced research in Electrical, Electronics and instrumentation Engineering, Vol. 3, issue 9, Sept. 2014, pp.11729-11737.

[5] N. Chayawatto, K. Kirtikara, V. Monyakul, C. Jivacate, D. Chenvidhya, *"A Simplified DC-AC Converter with Feedback Current Control Model for PV Grid Connected System under Islanding Phenomena"*, Asian J. Energy Environ., Vol. 8, Issue 3 and 4, 2007, pp. 181-210.

[6] Asmarashid Ponniran , Abdul Fatah Mat Said, *"DC-DC Boost Converter Design for Solar Electric System"*, International Conference on Instrumentation, Control & Automation, October 20-22, 2009, Bandung, Indonesia, pp.210-214.

[7] Xu Renzhong, Xia Lie, Zhang Junjun, and Ding Jie, *"Design and Research on the LCL Filter in Three-Phase PV Grid-Connected Inverters"*, International Journal of Computer and Electrical Engineering, Vol. 5, No. 3, June 2013, pp.322-325.