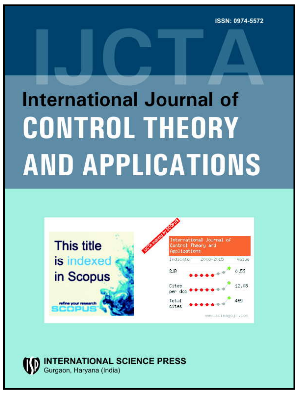

**International Journal of Control Theory and Applications**

ISSN : 0974-5572

Volume 10 • Number 6 • 2017

# A Hybrid Islanding Detection Technique for PV interfaced AC Distribution System

**Soumya A.V.[1], J. Belwin Edward[2] and Indu M.[3]**

[1] *Department of Electrical and Electronics Engineering Mar Baselios College of Engineering and Technology, Trivandrum, Kerala, India, Email: soumyanirudh@gmail.com*
[2] *School of Electrical and Electronics Engineering Vellore Institute of Technology, Vellore, Tamil Nadu, India, Email: jbelwinedward@vit.ac.in*
[3] *Department of Electrical and Electronics Engineering Mar Baselios College of Engineering and Technology, Trivandrum, Kerala, India, Email: indumadhu.m@gmail.com*

***Abstract:*** The expanded infiltration of inverter associated Distributed Generation (DG) in the utility systems requests a proper level of observing and location fundamentally under islanding conditions. This paper proposes a photovoltaic (PV) system, interfaced with AC distribution system consolidating a hybrid islanding detection procedure. Beta algorithm is used for Maximum Power Point Tracking. The MPPT is accomplished by varying the duty cycle of the converter. A three-phase grid tie inverter is utilized for interfacing with the grid. Under unscheduled islanding operation, the photovoltaic source will keep providing power which causes potential hazard to the line specialists and client types of gear. This requires the authorization of a quick and exact islanding discovery strategy. In-order to detect the occurrence of islanding, a hybrid anti- islanding system utilizing Voltage Unbalance, Total Harmonics Distortion and Sandia Frequency Shift technique is proposed here. The achievability of the system are verified in MATLAB/Simulink.

***Keywords:*** Islanding, Anti-islanding detection, Boost converter, Voltage unbalance, Total Harmonic Distortion, Sandia frequency shift, Photovoltaic system.

## 1. INTRODUCTION

In the present situation to meet the shortage of demand for power, inclusion of renewable energy sources based appropriated era DG is continuously expanding [1]. DG advancements incorporate photovoltaic, wind turbines, energy components, small scale turbines, gas turbines, interior burning motors and so forth. At the point when the distributed energy systems work in parallel with utility power systems there happen many issues regarding power quality. Notwithstanding this the most essential issue is the islanding identification [2].

Islanding is a condition that happens when DG sources supply the neighbourhood load and the utility grid is detached [1]. Unexpected islanding may emerge numerous security and assurance issue in the islanded segment of an electric power system (EPS). Accidental islanding (UI) brings about an uncontrolled frequency and voltage, which may harm or lessen the life of the apparatuses and the equipment present in the island. The security of the utility laborers is at hazard as they may get an electric shock because of a live DG in the island. Quick reclosing of the DG to EPS is another real worry as it might bring about the out of stage reclosing of the circuit breakers. The overwhelming mechanical torque and the high transient inrush current may even harm the islanded DG [3].

Since UI has adverse effects on the EPS, islanding detection techniques are used to detect the island and trip the circuit breaker between power system and distributed generation [13].

The rest of the paper is organized as follows. Proposed system and algorithms are explained in section II. Experimental results are presented in section III. Concluding remarks are given in section IV.

## 2. PROPOSED SYSTEM

In this paper, a PV interfaced AC Distribution system with a hybrid islanding detection strategy is proposed. The MPPT strategy utilized is the Beta technique. The DC-DC Converter utilized is the Boost Converter. A Grid-tie inverter is utilized for interfacing with the DC control with Grid. The system security is done utilizing a new hybrid islanding discovery system which consolidates the upsides of both uninvolved and dynamic islanding identification methods. The block diagram of the whole system with islanding recognition calculation is appeared in fig. 1.

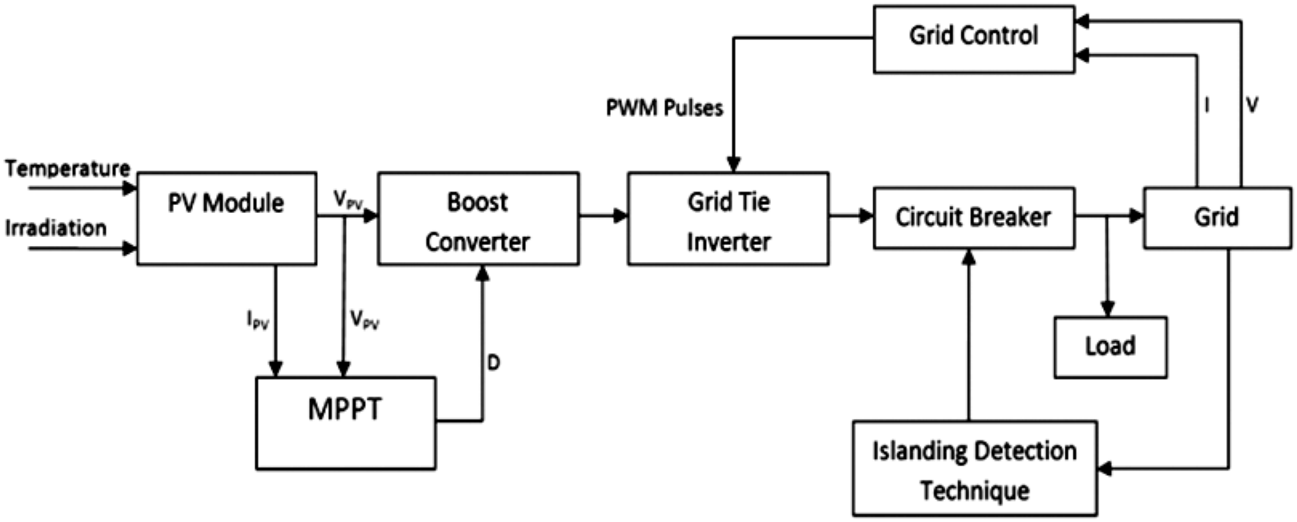

**Figure 1: Block diagram of the whole system**

### 2.1. Solar Photovoltaic System

A PV cell is fundamentally a p-n intersection manufactured into a thin wafer of semiconductor material. It can change over sun's radiation specifically into power by a marvel called photovoltaic impact. A PV cell displays nonlinear P-V and I-V qualities that change with cell temperature (T) and Solar Irradiance. A PV cell is generally demonstrated by a current source with a diode in anti- parallel. The resistance (Rs) connected in series represents to the prevention that happens amid the stream of charge from n–p and the parallel resistance (Rp) represents to the leakage current. For a perfect sunlight based cell, Series resistance is zero and Parallel resistance is interminability. The one diode identical circuit is appeared in fig.2. The single diode model is typically utilized as it is anything but difficult to actualize contrasted with the two diode show which is more unpredictable. In the single diode model, the diode character element is thought to be a steady, while in the two diode show it is taken as an element of info voltage.

The equations for mathematical modelling is given by,

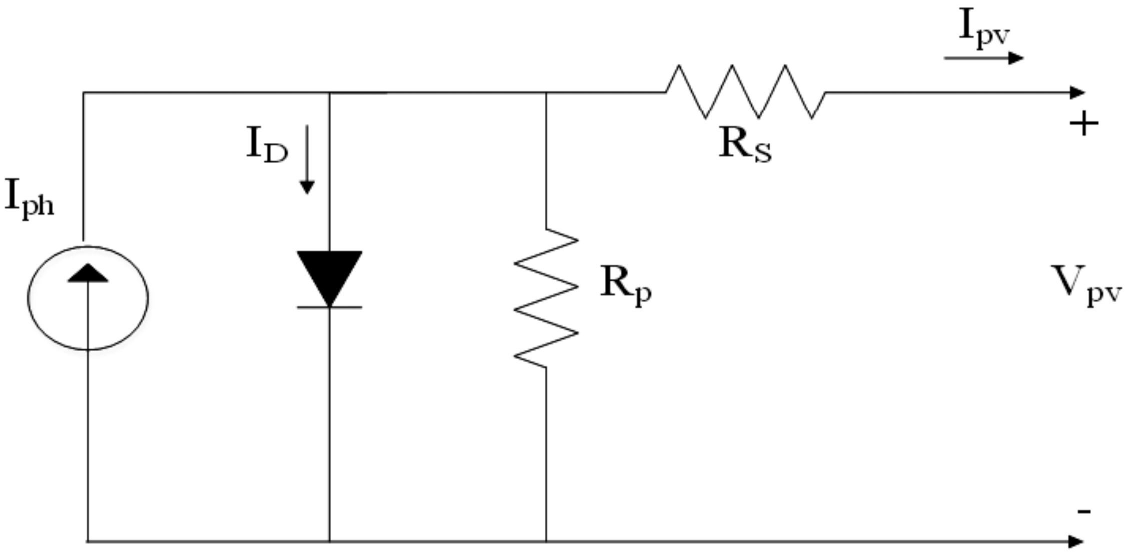

**Figure 2: Single diode equivalent model of PV cell**

$$I = N_{ph} I_{ph} - N_p I_o \left( \exp\left[ \frac{q\left( \frac{V}{N_s} + 1R_s / N_p \right)}{AkT} \right] - 1 \right) - \frac{V + 1R_s}{R_p} \tag{1}$$

where

$$I_{ph} = \left[ I_{sc} + k_1 \left( T_c - T_{ref} \right) \right] G \tag{2}$$

$$I_s = I_{RS} \left[ \frac{T_c}{T_{ref}} \right]^3 e \left[ \left( \frac{qE_g \left( T_c - T_{ref} \right)}{T_{ref} T_c KA} \right) \right] \tag{3}$$

Where, I is the current, V is the voltage of the PV module, $I_{ph}$ is the photo-current, $I_0$ is the reverse saturation current, $N_p$ is the number of cells associated in parallel, $N_s$ is the number of cells associated in series, q is the charge of an electron (1.6*10-19C), k is Boltzmann's constant (1.38*10-23J/K), An is p-n intersection ideality figure, (1 <a < 2, a = 1 being the perfect esteem) and T is the PV module temperature. The PV module parameters are appeared in Table 1 [1]. From the open circuit voltage and short out current, the PV module of required power rating is displayed.

**Table 1**
**PV Module Parameters**

| *Electrical Parameters* | *Value* |
|---|---|
| Open Circuit voltage | 146 V |
| Short Circuit current | 1.261 A |
| Voltage at MPP | 118 V |
| Current at MPP | 0.935 A |

## 2.2. MPPT Technique

The MPPT technique used here is the Beta method [4]. Here an intermediate variable â is approximated through an equation to find the maximum power point.

$$\beta = \ln\left(\frac{I_{pv}}{V_{pv}}\right) - c * V_{pv} \tag{4}$$

$$c = \left(\frac{q}{(\eta K T N_s)}\right) \tag{5}$$

Here c is a constant which depends on electron charge (q), Temperature (T), Number of series cells ($N_s$), Boltzmann constant (K) and panel quality factor(η).

Even-though the operation conditions changes, the estimation of β at ideal point remains practically steady. By utilizing voltage and current of the board the estimation of β can be continuously figured and after that it is embedded on an closed loop with a constant reference. The estimation of β stays inside a thin band as the exhibit working point approaches the MPP. In this manner by following β, the working point can be rapidly met by extensive iterative strides. Fig. 3 demonstrates the simulink model of MPPT procedure.

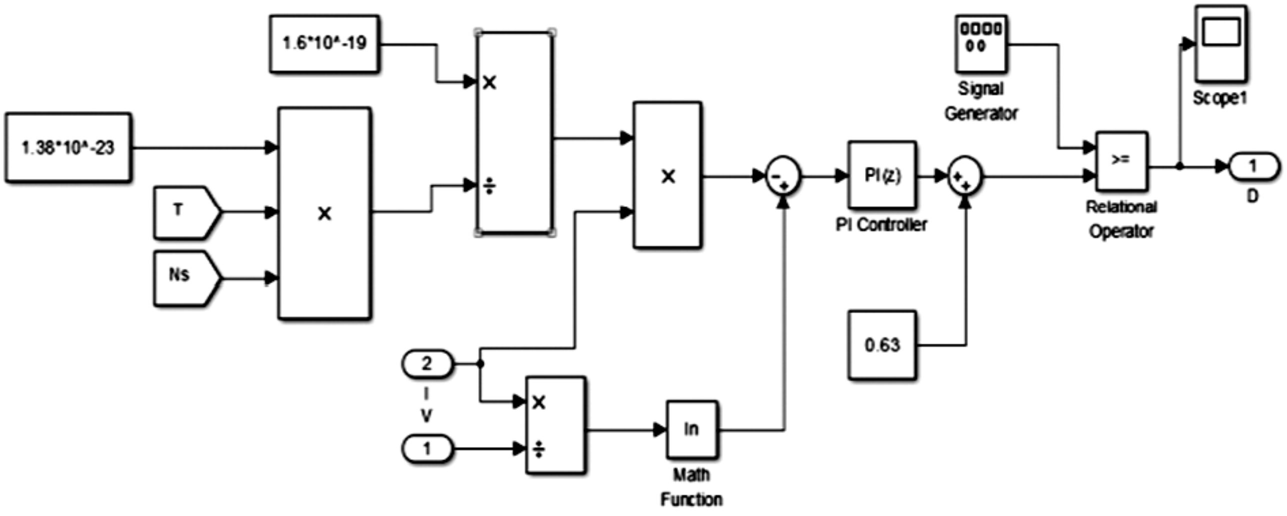

**Figure 3: Simulink model of MPPT**

## 2.3. Boost Converter

A Boost converter is a DC-DC converter which boosts up voltage from its feed in to its feed out. MOSFET and IGBT are utilized for exchanging reason. To diminish voltage swell, channels made of capacitors are ordinarily added to the converter output. Fig.4 demonstrates the schematic outline of boost converter with MOSFET as switch.

A DC-DC Converter in a MPPT system manages the PV maximum power point and gives load matching to greatest power exchange to occur. The boost converter coordinate the change in source impedance because of shifting climatic conditions by changing the duty ratio [12].

The design equation is given as

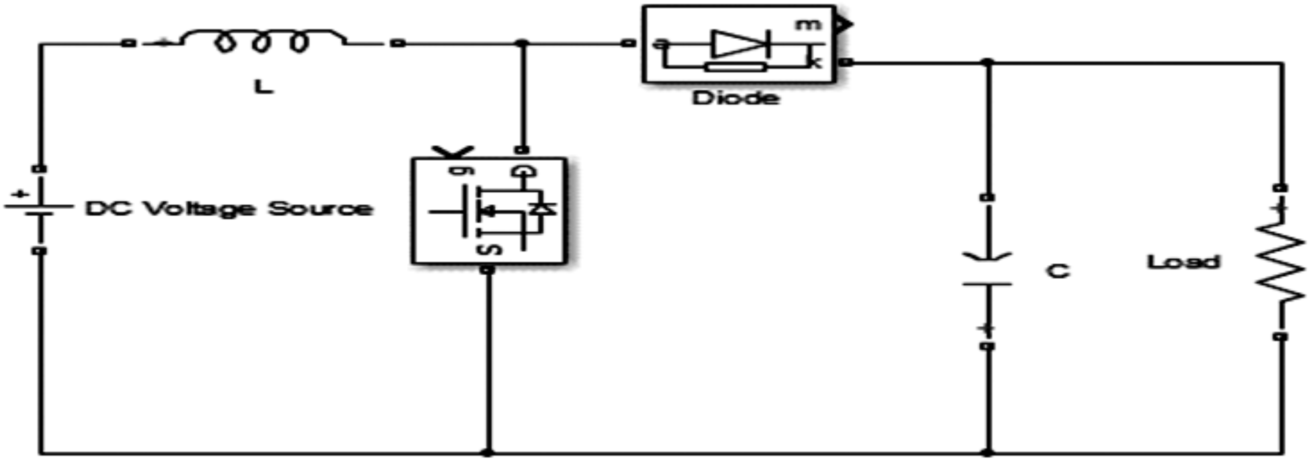

Figure 4: Schematic diagram of boost converter

$$V_o = \frac{V_{in}}{(1-D)} \tag{6}$$

$$L = \frac{D(1-D)R}{2f} \tag{7}$$

$$C = \frac{D}{2fR} \tag{8}$$

## 2.4. Grid-Tie Inverter

A PV Inverter is the interface between the PV cluster and utility system. The inverter controls the grid current by method for PWM control. Three noteworthy functions are performed by grid tie inverter. The primary function is to track the greatest dc control that can be accomplished by the PV exhibit. Second is to change over source DC energy to AC and to infuse it into the system synchronizedly with less distortion. Last is to recognize a fault in the utility side [6].

## 2.5. Hybrid Islanding Detection Technique

UL1741[7] or IEEE1547[8] are the norms to test the anti-islanding technique. The islanding condition is identified by observing parameter voltage imbalance [10]. The voltage irregularity shifts because of the topology of the system and burdens associated in the DG after the loss of mains.

The islanding operation can be found by monitoring the voltage variations in the three phase output voltage of DG. The voltage unbalance at the monitoring time (t) is given by

$$VU_t = \frac{NS_t}{PS_t} * 100 \tag{9}$$

where $NS_t$ and $PS_t$ are the magnitude of negative and positive sequence voltage at time t respectively. This value is compared with standard IEEE threshold value of voltage unbalance and if the $VU_t$ is greater than the standard value then there is a possibility that islanding has occurred [9]. Then the second parameter is the total harmonic distortion(THD). The THD at monitoring time t is given as

$$THD_t = \frac{\sqrt{\sum_{h=2}^{H} I_h^2}}{I_1} * 100 \tag{10}$$

where $I_h$ is the rms of harmonic components of h and $I_1$ is the fundamental harmonic component.

Presently the dynamic islanding recognition strategy i.e the Sandia frequency shift technique is embraced for affirmation of islanding occurrence. The fundamental rule of Sandia frequency shift (SFS) is a quickened frequency dip with positive feedback [10], [11]. Within the sight of network, the frequency won't be floated yet unexpectedly when the grid is feeling the loss of the frequency will drift. SFS is actualized through the idea of zero current portion to make quickened frequency float in light of the deliberate voltage. This zero current portion is likewise communicated as cleaving element which speak to the proportion between the length of zero fragment to the length of a half cycle. The cleaving element is differed by measured frequency float

$$cf_k = cf_0 + K\left(f_{k-1} - f_0\right) \tag{11}$$

where cf_0 is the underlying hacking component, f_(k-1) the frequency of the grid voltage measured at the PCC at cycle k-1, f_0 is the ostensible system frequency (50 Hz) and K is a positive criticism pick up which permits the identification time of the islanding condition to be balanced. At the point when both the frequency and phase has drifted from the typical working qualities it can be inferred that the islanding has happened and utilizing the above techniques could help distinguishing the islanding occasion rapidly and a tripping signal will be sent to the electrical switch for isolating the DG from the grid.

## 3. EXPERIMENT AND RESULT

The displaying of PV interfaced AC distribution system with islanding detection procedure is completed in MATLAB$^{TM}$/SIMULINK$^{TM}$. Fig. 5 demonstrates the simulink model of the whole system. The system comprises of PV board, Boost converter, inverter, grid and its control and the algorithm for islanding detection.

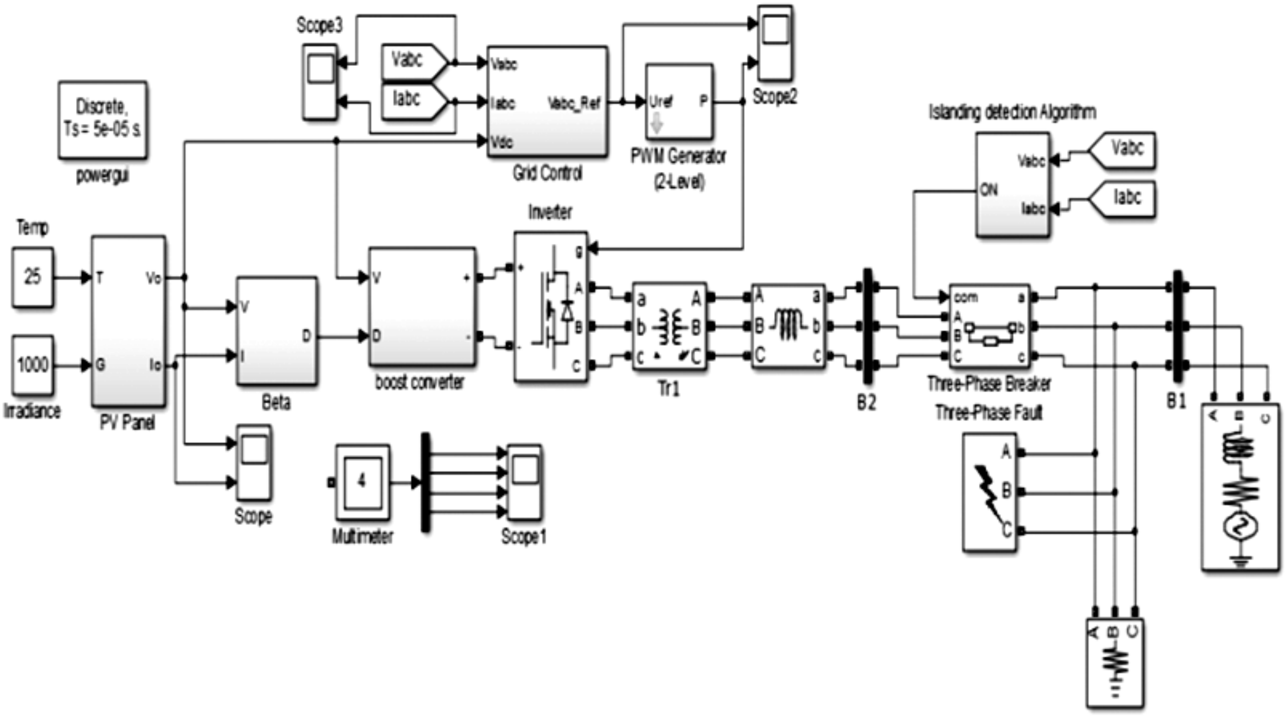

Figure 5: Simulink model of entire system

The PV system is modelled to get the rated power. The MPPT controller gives the pulses to the boost converter to acquire the maximum power. The boost converter is associated with a three-phase inverter to change over the DC to AC and to synchronize with the grid. The electrical switch (circuit breaker) on the utility side is

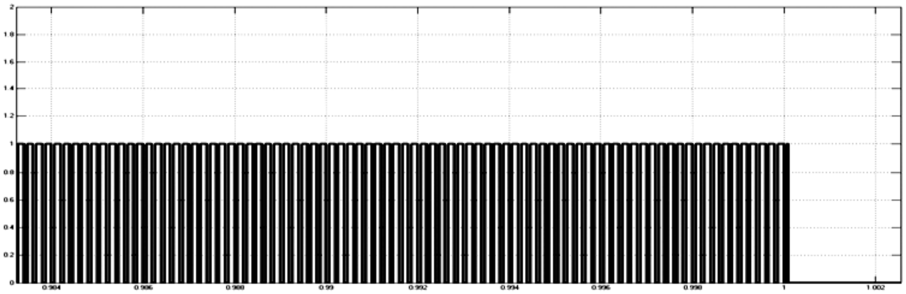

**Figure 6: The pulses to the switch of boost converter**
**( x axis : sec, y axis : 0.2/ div)**

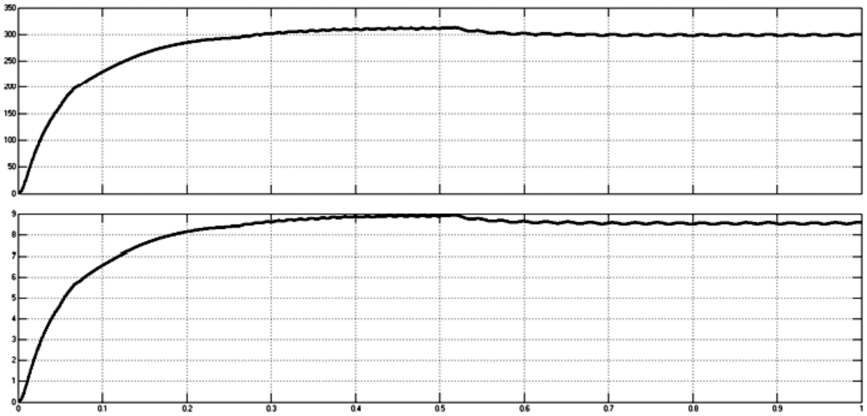

**Figure 7: Output voltage and current waveform of boost converter**
**(x axis: 0.1 sec/ div, $y_1$ axis (voltage): 50 V / div, $y_2$ axis (current): 1 A/div)**

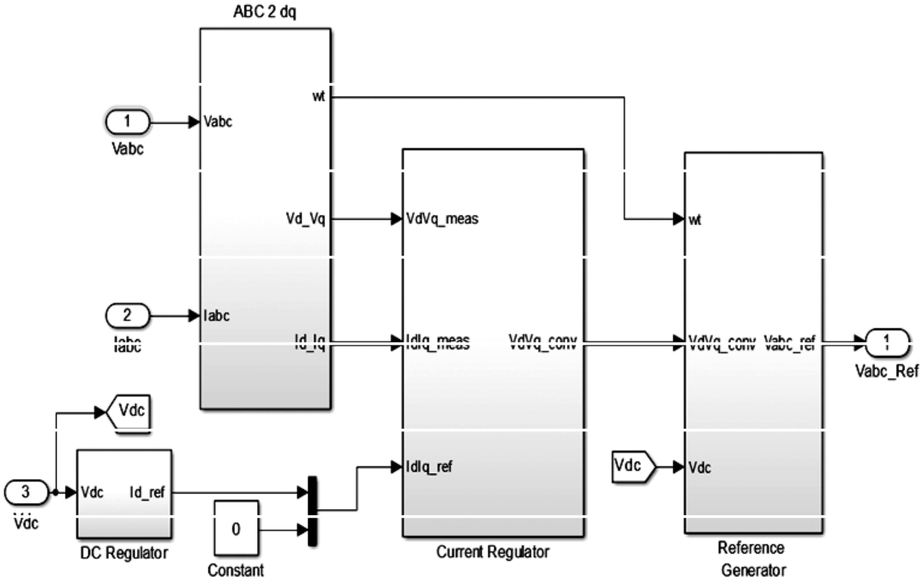

**Figure 8: Simulation model of grid control**

switched open when an islanding condition is identified. A three-phase fault is given for a brief span of time from 0.75 s to 1.25 s amid which the islanding condition is recognized by voltage unbalance, THD and SFS strategy after which the system recaptures the ordinary operation. The pulses to the switch of boost converter is given in Fig 6. The output voltage and current waveform of boost converter is given in Fig.7. The simulation model of grid control is shown in Fig. 8. The output pulses to the three stage inverter is shown in Fig.9.The simulation model of VU, THD and SFS is appeared in Fig.10. The final output pulses to enact the circuit breaker if there should arise an occurrence of islanding is given in Fig 11. The output voltage and current waveforms post fault conditions are analysed in Fig 12.

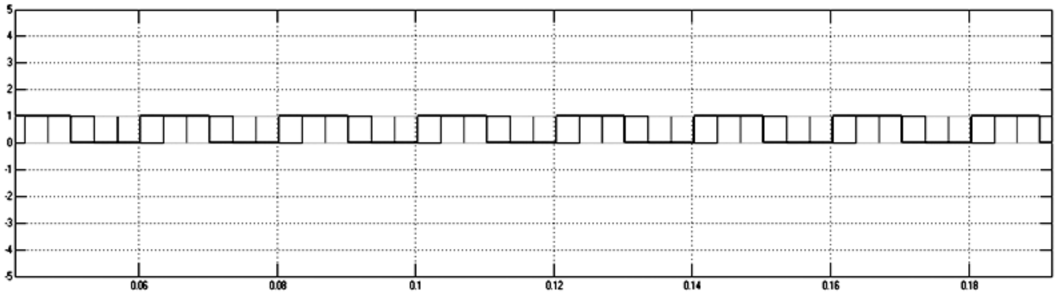

**Figure 9: Pulses to three phase inverter**
**(x axis: Time 0.02 s/ div, y axis: Amplitude 1 unit/div)**

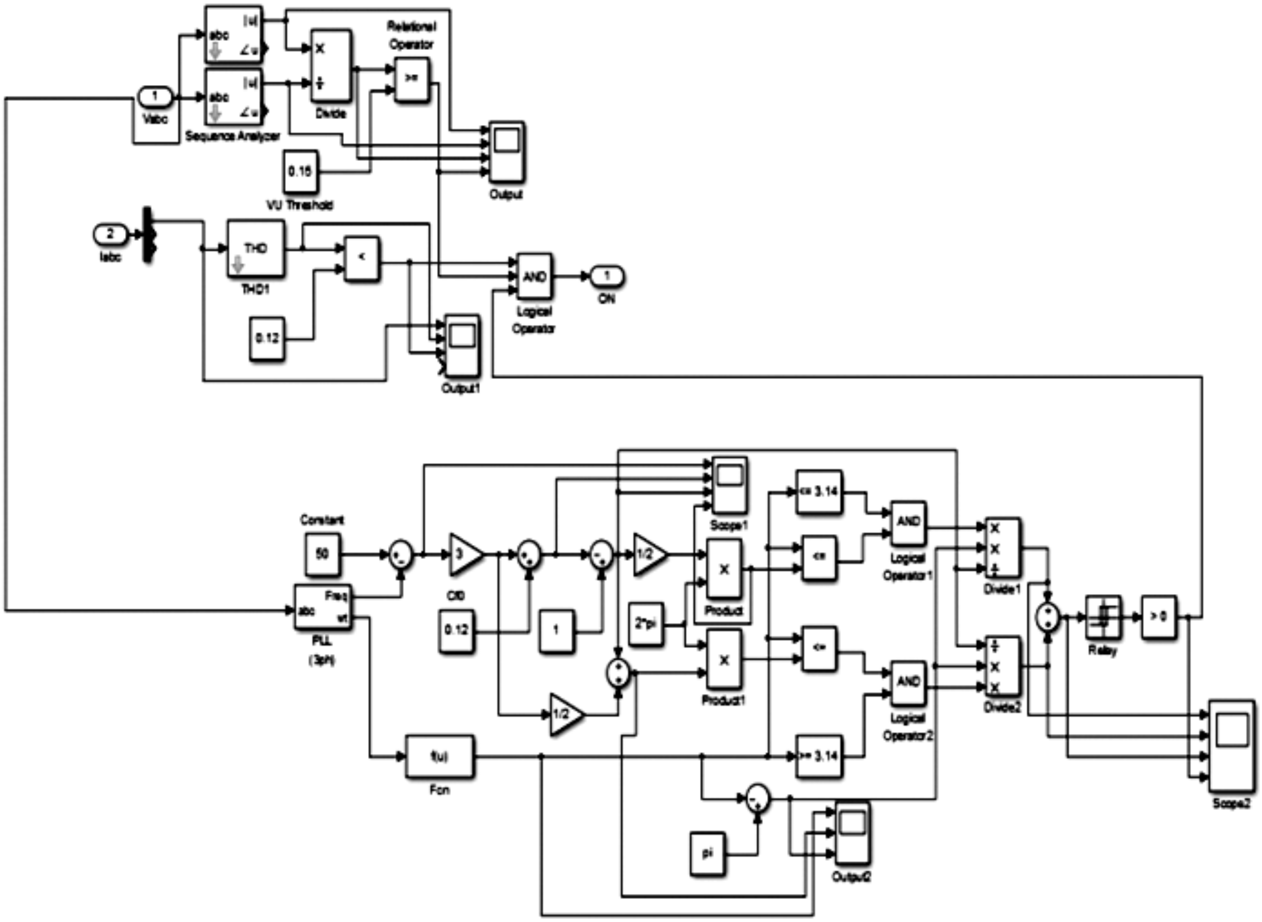

**Figure 10: Simulation model of VU, THD AND SFS**

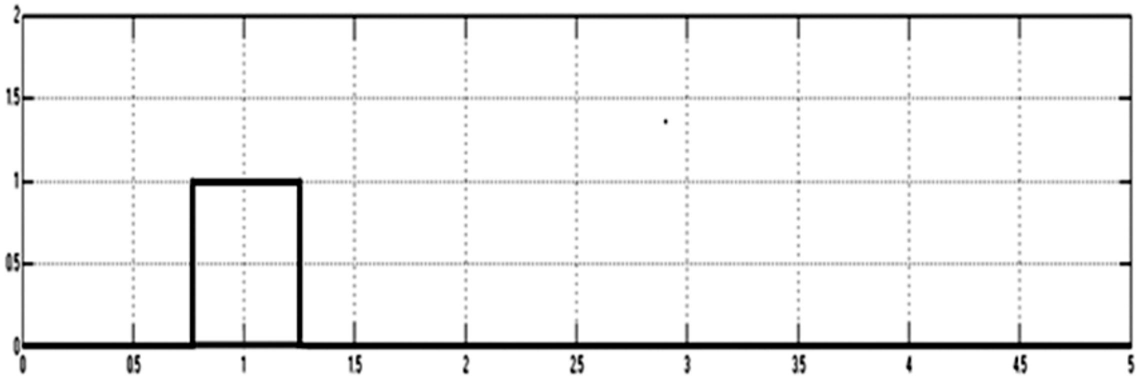

**Figure 11: Trip signal to circuit breaker**
**(x axis: Time 0.5 s/ div, y axis: Amplitude 0.5 unit/div)**

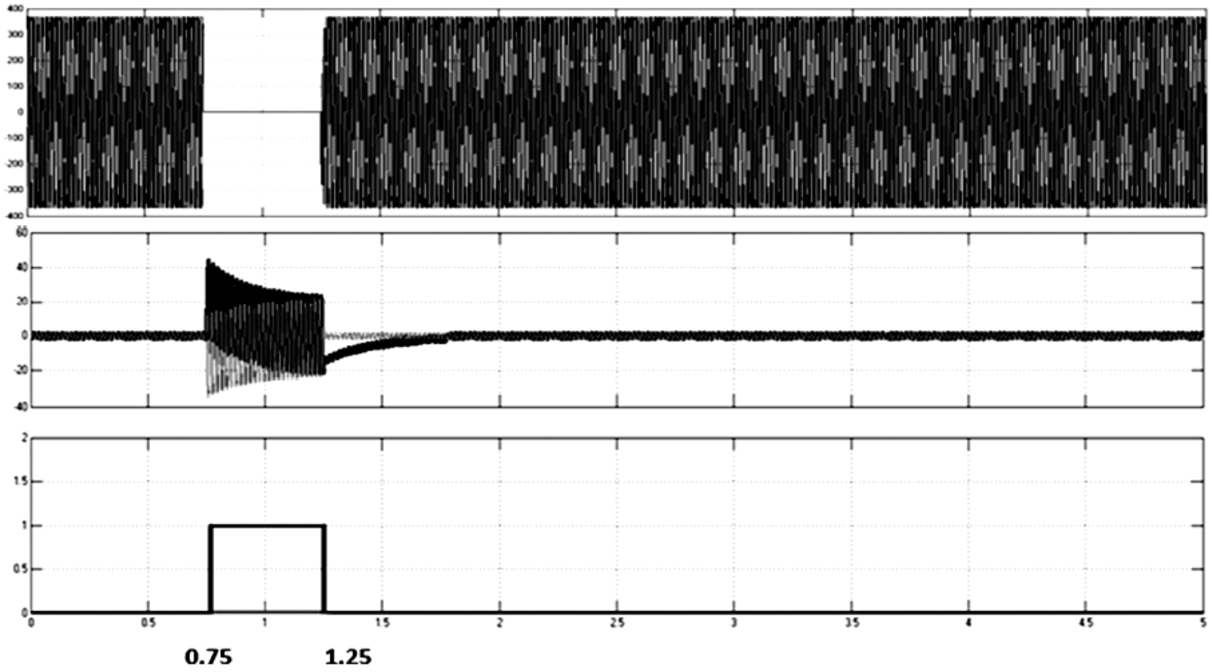

**Figure 12: voltage and current waveform at pcc during post fault**
**(x axis: Time 0.5 s/ div, $y_1$ axis: Voltage 100V/div, $y_2$ axis : Current 20 A/div)**

## 4. CONCLUSION

In this paper, a hybrid anti-islanding strategy for a PV interfaced AC distribution system is displayed. The parameters, for example, voltage unbalance notwithstanding the traditional parameters were utilized for anti- islanding identification. The active islanding identification technique utilized is the Sandia frequency shift strategy. This strategy blends the upsides of both passive and active islanding detection system. The proposed strategy screens the time domain change in voltage and identifies islanding when there is a deviation from the standard edge esteem and the goes for the frequency shift technique. This method was demonstrated on a grid associated PV system representing to a normal DG source. Modelling was done in MATLAB/Simulink and the outcomes are verified.

## REFERENCES

[1] Gab-Su Seo, Kyu-Chan Lee, and Bo-Hyung Cho, "A New DC Anti-Islanding Technique of Electrolytic Capacitor-Less PV Interface in DC Distribution Systems," *IEEE Trans on Power. Electron.,* vol. 28, no. 4, pp. 1632-1641, April 2013.

[2] A. M. Massoud, K. H. Ahmed, S. J. Finney, B.W. Williams, "Harmonic Distortion-based Islanding Detection Technique for Inverter-based Distributed Generation," *IET Renew. Power Gener.,* April 2009, Iss.4, pp.493-507.

[3] Ropp M., Ginn J., Stevens J., Bower W., Gonzalez S., "Simulation and Experimental Study of the Impedance Detection Anti-Islanding Method in the Single-Inverter Case," *Proc. IEEE Photovoltaic Energy Conversion Conf.,* May 2006, vol. 2, pp. 2379-2382

[4] R. Faranda, S. Leva, and V. Maugeri, "MPPT techniques for PV Systems: Energetic and cost comparison" Power and Energy Society General Meeting- Conversion and Delivery of Electrical Energy in the 21st Century, 2008 IEEE.

[5] N. Soumya Smitha Raj, B. Urmila, "PV fed ZETA Converter," *IJERA Power Electron. Con.,* vol. 3, no. 4, pp. 2292-2696, Aug. 2013.

[6] B. Blackstone, Y. Baghzouz and S. Premrudeepreechacharan, "Determining MPPT and Anti-Islanding Techniques in a Grid-Tie PV Inverter," *Proc. IEEE Conf.*, pp.409-413, June 2012.

[7] Inverters, Converters, and Controllers for Use in Independent Power Systems, UL STD 1741, 2002

[8] IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems, IEEE Std. 1547-2003, 2003

[9] Vivek Menon and M. Hashem Nehrir, "A Hybrid Islanding Detection Technique Using Voltage Unbalance and Frequency Set Point," *IEEE Trans. Power Syst.,* vol.22, no.1, Feb. 2007

[10] E. J. Estebanez, V. M. Moreno, A. Pigazo and M. Liserre, "Performance Evaluation of Active Islanding-Detection Algorithms in Distributed Generation Photovoltaic systems: Two Inverter Case," *IEEE Trans. Ind. Electron.,* vol.58, no.4, pp. 1185-1193, April 2011.

[11] Mahdiyeh Khodaprastan, Hesan Vahedi, "A Novel Hybrid Islanding Detection Method for Inverter based DGs using SFS and ROCOF," *IEEE Trans. Power Del.*, vol.22, no.2, pp.1758-1766, Jul. 2015.

[12] Indu M., Soumya A. V., "Boost Converter fed PV Interfaced AC Distribution System Incorporating Islanding Detection Technique", International Journal for Scientific Research &Development, Vol. 4, Issue 04, June 2016, pp: 1284-1288.

[13] Soumya A.V., Dr. J Belwin Edward., "Review of Islanding detection techniques for distributed energy sources", International Advanced Research Journal in Science, Engineering and Technology, Vol. 3, Special Issue 3, August 2016.