International Journal of Ethics in Engineering & Management Education
Website: www.ijeee.in (ISSN: 2348-4748, Volume 3, Issue 10, October 2016)

MPPT with Single DC-DC Converter and Inverter for Grid Connected Hybrid Wind-Driven PMSG-PV System

T. Soumya[1]
M. Tech Scholar (POWER SYSTEM)
Dept. of. EEE
Princeton Institute of Engineering and Technology for Women
Ghatkesar, Hyderabad, Ts, India

J.Anjaiah[2]
Associate Professor & HOD
Dept. of. EEE
Princeton Institute of Engineering and Technology for Women
Ghatkesar, Hyderabad, Ts, India

S. Nirosha[3]
Assistant Professor
Dept. of. EEE
Princeton Institute of Engineering and Technology for Women
Ghatkesar, Hyderabad, Ts, India

Abstract: **A new topology of a hybrid distributed generator based on photovoltaic and wind-driven permanent magnet synchronous generator is proposed. In this generator, the sources are together connected to the grid with the help of only a single boost converter followed by an inverter. Thus, compared to earlier schemes, the proposed scheme has fewer power converters. Model of the proposed scheme in *d-q* axes reference frame is developed. Two low cost controllers are also proposed for the new hybrid scheme to separately trigger the DC-DC converter and the inverter for tracking the maximum power from both the sources. The integrated operations of both the proposed controllers for different conditions are demonstrated through simulation and experimentation. Steady-state performance of the system and transient response of the controllers are also presented to demonstrate the successful operation of the new hybrid system. Comparison of experimental and simulation results are given to validate the simulation model.**

Keywords: **DC, PMSG, PV, *d-q* axes, MPPT, LED**

1. INTRODUCTION

A new topology of a hybrid distributed generator based on photovoltaic and wind-driven permanent magnet synchronous generator is proposed. In this generator, the sources are together connected to the grid with the help of only a single boost converter followed by an inverter. Thus, compared to earlier schemes, the proposed scheme has fewer power converters. Model of the proposed scheme in *d-q* axes reference frame is developed. Two low cost controllers are also proposed for the new hybrid scheme to separately trigger the DC-DC converter and the inverter for tracking the maximum power from both the sources. The integrated operations of both the proposed controllers for different conditions are demonstrated through simulation and experimentation. Steady-state performance of the system and transient response of the controllers are also presented to demonstrate the successful operation of the new hybrid system. Comparison of experimental and simulation results are given to validate the simulation model.

In a hybrid wind-PV system along with battery was explained, in which both the sources were Connected to a common DC bus through individual power converters, then the DC bus was connected to the utility grid through an inverter.
Various possible combinations of hybrid PMSG-PV systems are illustrated in the literature. Earlier, a six-arm converter topology was attempted, in which the outputs of a PV array and wind generator were subjected to a boost operation through individual switches to match the DC bus voltage, a hybrid wind-PV system along with battery was explained, in which both the sources were connected to a common DC bus through individual power converters, then the DC bus was connected to the utility grid through an inverter. Grid connected PMSG-PV hybrid system with battery backup was described, where the DC link voltage was fixed to battery voltage, but the maximum power extraction from wind-driven PMSG was not performed. A grid connected hybrid system where the PV array and wind-driven PMSG were connected to a common DC link through a multi input DC-DC converter was proposed earlier in. A PMSG – PV hybrid system with multi-input DC- DC converter and multi-input inverter was also brought out in . In all the above hybrid DG systems with PMSG-PV attempted so far, the system either had individual power converters for each of the sources or a battery backup. Further, each converter was controlled using complex algorithms for peak power tracking.

2. PROJECT DESIGN

A hybrid distributed generator based on photovoltaic and wind-driven permanent magnet synchronous generator is proposed. In this generator, the sources are together connected to the grid with the help of only a single boost converter followed by an inverter.

2.1. Proposed System Technique

In all the above hybrid DG systems with PMSG-PV attempted so far, the system either had individual power converters for each of the sources or a battery backup. Further, each converter was controlled using complex algorithms for peak power tracking. In order to minimize the conduction and switching losses of the devices, it is necessary to have the minimum number of power converters (power conversion stages) and this has been attempted in this paper. In addition, it

IJEEE

International Journal of Ethics in Engineering & Management Education

Website: www.ijeee.in (ISSN: 2348-4748, Volume 3, Issue 10, October 2016)

is desirable that power supplies in consumer sites employ fewer power electronic conversion stages in order to improve the overall efficiency.

2.2. Advantages of Proposed Technique

- Battery storage is not necessary.
- Switching losses is low
- Continuity of power supply is possible
- Highly efficient

The block diagram of proposed DG scheme is given in where a direct driven PMSG and a PV array are the sources. The PMSG output is rectified and fed into a DC-DC boost converter. The rectifier output voltage varies with the wind-speed. The PV array terminals are connected to the output of the DC-DC converter to form a common DC link for the proposed system. The inverter input terminals are tied to this common DC link. The PV array voltage (VPV) is fixed to the output voltage of the DC-DC converter (VDC) since the output terminals of both the PV array and the DC – DC converter are tied together. The output voltage of the DC-DC converter is automatically varied by a PV MPPT controller (Controller 1) to PV array's maximum power point voltage. Under this condition, the maximum current for the given irradiation is drawn from the PV array by the action of current controller (controller 2) of the inverter. The basic Perturb & Observe (P&O) algorithm is employed albeit with an inverted duty-cycle adjustment in controller 1. This revised adjustment in the proposed scheme is because of the DC-DC boost converter being fed by a stiff DC source (rectifier output) instead of the PV array.

2.3. Maximum power point tracking (MPPT)

Maximum power point tracking (MPPT) is a technique that charge controllers use for wind turbines and PV solar systems to employ and maximize power output. PV solar comes in different configurations. The most basic version is one where power goes from collector panels to the inverter (often via a controller) and from there directly onto the grid. A second version might split the power at the inverter. This is called a hybrid inverter.

3. PERMANENT MAGNET SYNCHOROUS GENERATOR

A permanent magnet synchronous generator is a generator where the excitation field is provided by a permanent magnet instead of a coil. The term synchronous refers here to the fact that the rotor and magnetic field rotate with the same speed, because the magnetic field is generated through a shaft mounted permanent magnet mechanism and current is induced into the stationary armature.

Solar-Wind hybrid Power system is the combined power generating system by wind mill and solar energy panel. It also includes a battery which is used to store the energy generated from both the sources. Using this system power generation by windmill when wind source is available and generation from PV module when light radiation is available can be achieved. Both units can be generated power when both sources are available. By providing the battery uninterrupted power supply is possible when both sources are idle. Fig.1. shows the functional block diagram of hybrid wind solar energy system. The power generated from wind mill is of AC voltage which is converted through AC-DC rectifier. A special type of converter is used to step up or step down through MOSFET switching called "SEPIC" converter for wind mill. For solar system cuk converter is used for the regulation. The micro controller incorporated in this scheme, which regularly refers the operation of sources and switches the corresponding converters and fed into change the battery or to the load through inverters. The output of the inverter is connected with the load and after that the voltage is stepped up by a transformer. The driver circuit is used to give the gate signal for the MOSFET of converters.

1. Photovoltaic solar power Solar panels are the medium to convert solar energy into the electrical energy. Solar panels can convert the energy directly or heat the water with the induced energy. PV (Photo-voltaic) cells are made up from semiconductor structures as in the computer technologies. Sun rays are absorbed with this material and electrons are emitted from the atoms .This release activates a current. Photovoltaic is known as the process between radiation absorbed and the electricity induced. Solar power is converted into the electric power by a common principle called photo electric effect. The solar cell array or panel consists of an appropriate number of solar cell modules connected in series or parallel based on the required current and voltage. 2. Wind Power The wind energy is a renewable source of energy. Wind turbines are used to convert the wind power into electric power. Electric generator inside the turbine converts the mechanical power into the electric power. Wind turbine systems are available ranging from 50W to 3-4 MW. The energy production by wind turbines depends on the wind velocity acting on the turbine. Wind power is able to feed both energy production and demand in the rural areas. It is used to run a windmill which in turn drives a wind generator or wind turbine to produce electricity.[3] 3. Batteries The batteries in the system provide to store the electricity that is generated from the wind or the solar power. Any required capacity can be obtained by serial or parallel connections of the batteries. The battery that provides the most advantageous operation in the solar and wind power systems are maintenance free dry type and utilizes the special electrolytes. These batteries provide a perfect performance for long discharges.[4] 4. Inverter Energy stored in the battery is drawn by electricals loads through the inverter, which converts DC power into AC power. The inverter has in-built protection for Short-Circuit, Reverse Polarity, Low Battery Voltage and Over Load. 5. Microcontroller The microcontroller compares the input of both Power system and gives the signal to the particular relay and charges the DC Battery. The DC voltage is converted into AC Supply by Inverter Circuit. The MOSFET (IRF 540) is connected to the Secondary of the centre tapped transformer. By triggering of MOSFET alternatively, the current flow in

International Journal of Ethics in Engineering & Management Education
Website: www.ijeee.in (ISSN: 2348-4748, Volume 3, Issue 10, October 2016)

the Primary winding is also alternative in nature and we get the AC supply in the primary winding of the transformer.

4. DC-DC CONVERTERS

DC to DC converters are important in portable electronic devices such as cellular phones and laptop computers, which are supplied with power from batteries primarily. Such electronic devices often contain several sub-circuits, each with its own voltage level requirement different from that supplied by the battery or an external supply (sometimes higher or lower than the supply voltage). Additionally, the battery voltage declines as its stored energy is drained. Switched DC to DC converters offer a method to increase voltage from a partially lowered battery voltage thereby saving space instead of using multiple batteries to accomplish the same thing.
Most DC to DC converters also regulate the output voltage. Some exceptions include high-efficiency LED power sources, which are a kind of DC to DC converter that regulates the current through the LEDs, and simple charge pumps which double or triple the output voltage.

4.1. Modules Description

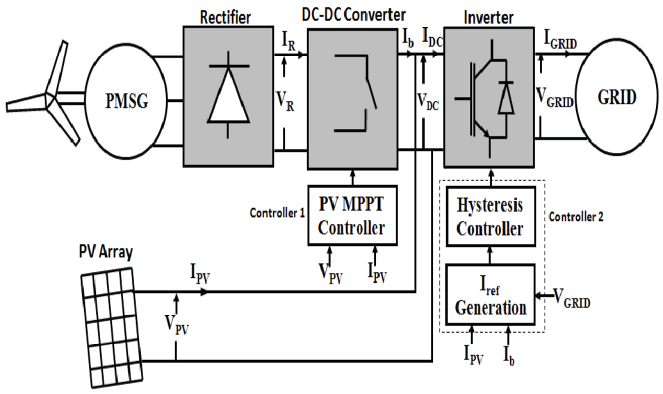

Fig.1. Modules Description: Circuit Diagram

4.2. Operation Of Proposed Converter

The PMSG output is rectified and fed into a DC-DC boost converter. The rectifier output voltage varies with the wind-speed. The PV array terminals are connected to the output of the DC-DC converter to form a common DC link for the proposed system. The inverter input terminals are tied to this common DC link. The PV array voltage (VPV) is fixed to the output voltage of the DC-DC converter (VDC) since the output terminals of both the PV array and the DC – DC converter are tied together. The output voltage of the DC-DC converter is automatically varied by a PV MPPT controller (Controller 1) to PV array's maximum power point voltage. Under this condition, the maximum current for the given irradiation is drawn from the PV array by the action of current controller (controller 2) of the inverter. The basic Perturb & Observe (P&O) algorithm is employed albeit with an inverted duty-cycle adjustment in controller 1. This revised adjustment in the proposed scheme is because of the DC-DC boost converter being fed by a stiff DC source (rectifier output) instead of the PV array. The output voltage of the current controlled inverter is tied to the grid voltage and the frequency and the phase requirement for synchronization are automatically met. The current fed to the grid by the inverter (IGRID) follows the reference current signal (Iref), which is automatically varied by controller 2 for drawing the maximum current from both PMSG & PV array. In the proposed scheme, the setting of DC voltage reference of the DC-DC converter to the peak power point voltage of the PV array and the reference current setting of current controlled inverter corresponding to the maximum current extractable from both the sources, results in peak power extraction from both the sources.

4.3. Model Of The Proposed System

A model of the proposed DG system is developed to investigate the system performance. PMSG has been described by its steady state equivalent circuit. The rectifier DC output voltage (VR) and current (IR) in terms of stator phase voltage VS (rms) and stator current IS(rms).

Supply voltage varies with wind-speed and hence the rectifier output voltage VR is a varying DC. This varying DC feeds the DCDC converter. The output voltage of the DC-DC converter .where is duty-cycle of the DC-DC converter. The rectifier output is connected to the models of DC – DC converter, PV array and the inverter. The *d* axis and *q* axis circuits of the system . In the proposed scheme, δ and Iref are varied to extract the maximum IDC at any instant of time. the proposed DG system can be simulated on any platform.

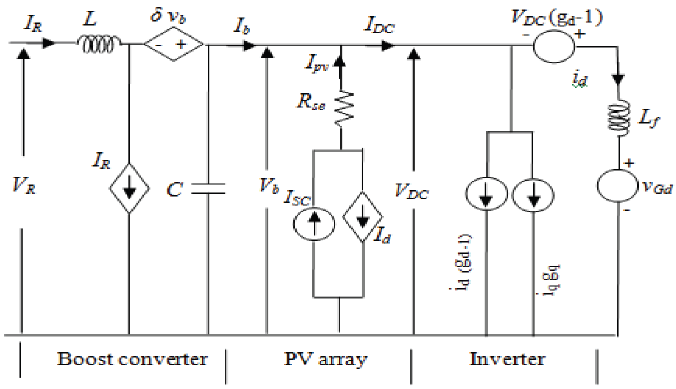

Fig.2.DC-DC Converter (PMSG)

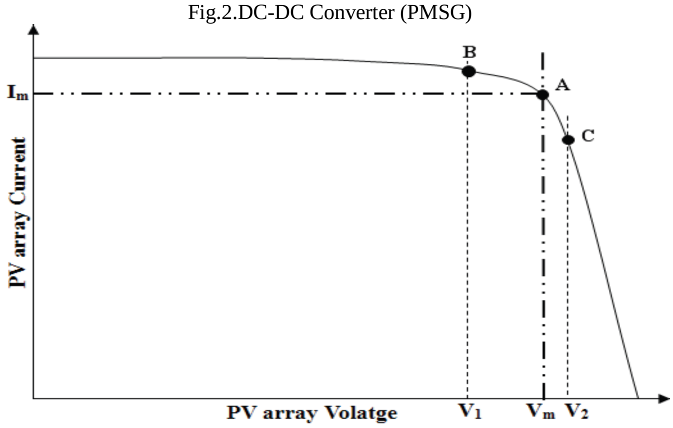

Fig.3.curve of the PV array

International Journal of Ethics in Engineering & Management Education
Website: www.ijeee.in (ISSN: 2348-4748, Volume 3, Issue 10, October 2016)

4.4. *Operation Of The Controllers:*

Case 1 (PV and PMSG generating power)

The wind and solar sources are generating power together in this case and the variation of duty-cycle of the DC-DC converter will eventually disturb the PV array's terminal voltage (since VDC = VPV). The rectifier voltage varies with the wind-speed and the duty-cycle of the boost converter needs to be automatically adjusted such that VDC is equal to the peak power point voltage (Vm) of the PV array. At this point (VPV = VDC = Vm), the PV array delivers the maximum current (Im) which is concurrently drawn by the current controlled inverter. The operation of controller 1 is explained . As shown in the Fig. 5, the DC link voltage may be, say V1 (B) or V2 (C) depending upon the present duty-cycle of the DC–DC converter. To operate the PV array at its maximum power point (A), the DC-DC converter output (DC link voltage) is adjusted to Vm by varying the duty-cycle of the DC-DC converter by controller .The duty-cycle variation of controller 1. where $\Delta\delta$is the perturbation in duty-cycle, sgn is Signum function. ΔP is the difference in PV array power and ΔVPV is difference in PV array voltage before and after perturbation. If ΔP and ΔVPV are both either positive or negative then the duty-cycle increases and vice-versa if different.

The duty cycle variation in this scheme is hence exactly opposite to the duty-cycle variation of a P&O controller used in existing schemes, where a PV array precedes a boost converter. The main objective of controller 2 is to vary the inverter output current fed to the grid. The reference current (Iref) for this hysteresis current controller is derived based on the available maximum power from the both the sources for a particular condition (i.e. irradiation and PMSG shaft torque).VPV, is at maximum power point value by the action of controller 1. Current drawn from the boost converter (Ib) and PV (IPV) together is maximized by changing .Where Δ(IPV+Ib) is the change in the sum of IPV and Ib and K is the step in perturbation of Iref. It is clear from, if current to be drawn from boost converter increases, Iref also increases correspondingly. At steady-state, the reference current value or a particular condition of irradiation.

Case 2 (PMSG alone generating power)

It is obvious that during night time, the current transducer connected to the PV terminal will not give any response. In such a case, the controller 1 will skip the PV-MPPT algorithm and work in a voltage control mode. By taking the voltage transducer output (VDC) as feedback signal, the controller 1varies the duty-cycle of the boost converter to maintain the DC link voltage to a DC value corresponding to the rated RMS voltage of the grid. As IPV is zero in this case, the controller 2.to extracts the maximum power from the PMSG alone.

Case 3 (PV alone generating power)

When PMSG is not generating power, there is no input to the DC-DC converter and hence no triggering pulse is generated by controller 1. The controller 2 varies Iref such that to feed the maximum power from PV array alone.

5. SIMULATION RESULTS

5.1. *Hysteresis Current Controller (Controller 2)*

The complete schematic of controller 2 is given in Fig. 6. High frequency op-amps (LM-318) are used to construct the hysteresis-current-controller. IPV and Ib are sensed by the current transducers and digitized by the internal ADC module of the microcontroller. Based on (15), Iref is determined and available as digital output from the microcontroller. This digital value is subsequently processed by a Digital to Analog Conversion (DAC) IC to obtain a DC value which Corresponds to the peak value of Iref. This DC value is multiplied with the sine wave reference extracted from the grid voltage, by a multiplier IC and fed to the hysteresis current- controller as the reference current signal. When PV array (or PMSG) alone generates power, Ib (or IPV) will be zero and Iref is perturbed and adjusted automatically to extract the maximum power from PV array (or PMSG). When both the sources are generating, Iref will be perturbed based on (15) and adjusted to maximize the DC link current IDC for the corresponding irradiation and wind-speed conditions. As the sine wave reference is taken from the grid, the inverter output current will have grid frequency and will be in phase with the grid voltage.

5.2. *Simulation Design*

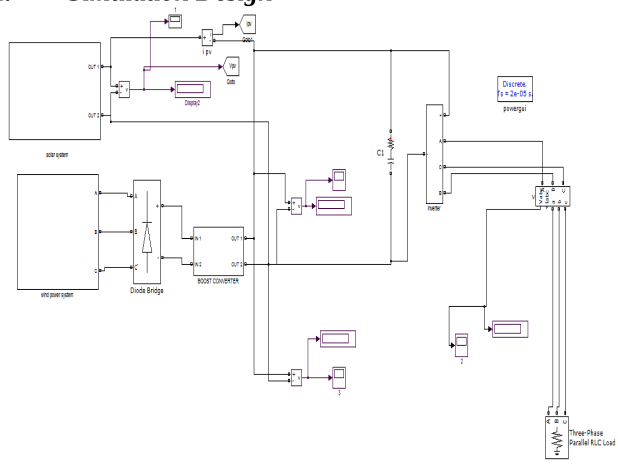

Fig.4.Project Mail Module

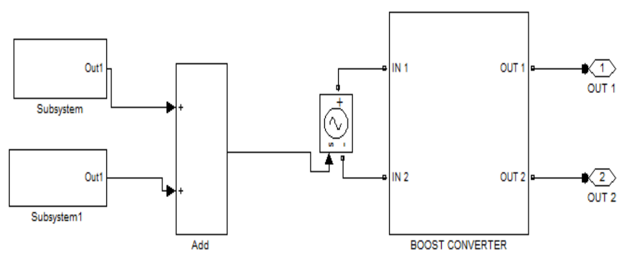

Fig.5. Main/subsystem

International Journal of Ethics in Engineering & Management Education
Website: www.ijeee.in (ISSN: 2348-4748, Volume 3, Issue 10, October 2016)

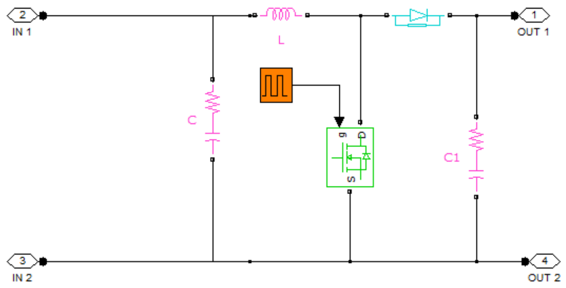

Fig.6. Main/subsystem/BOOST CONVERTER

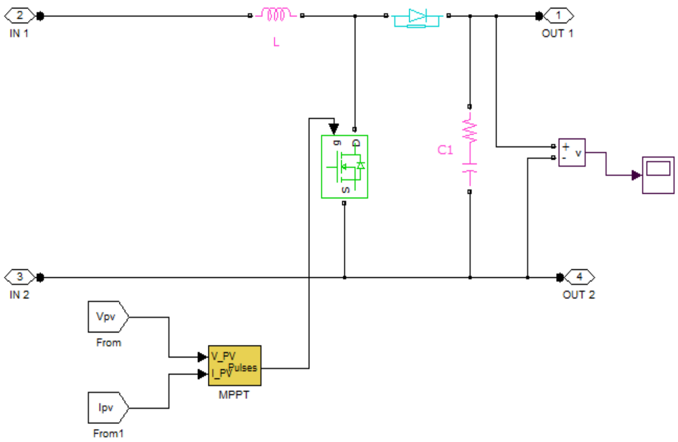

Fig.7. Main/BOOST CONVERTER

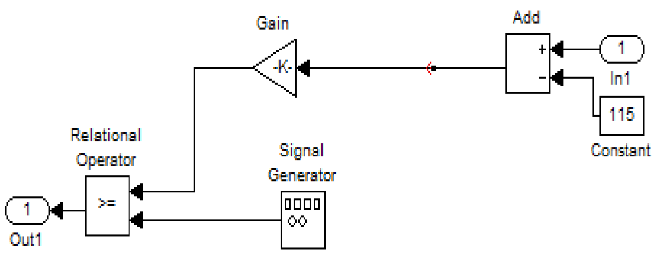

Fig.8. Main/PI CONTROLLER

5.3. *Output voltage waveform*

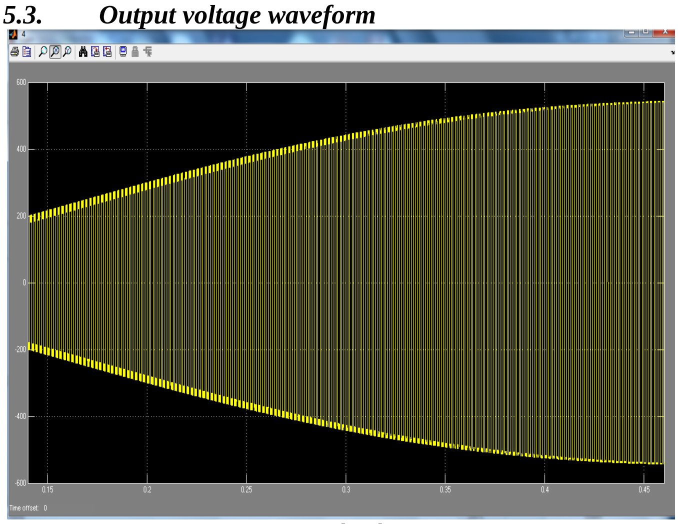

Fig.9.Load Voltage.

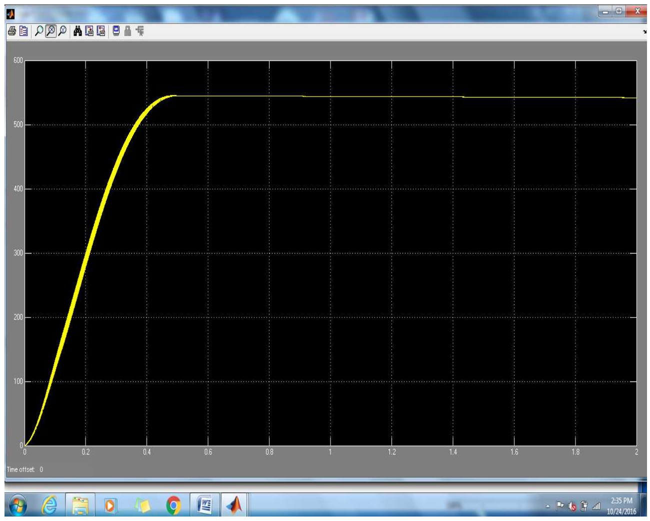

Fig.10. Boost Converter Voltage at Wind side.

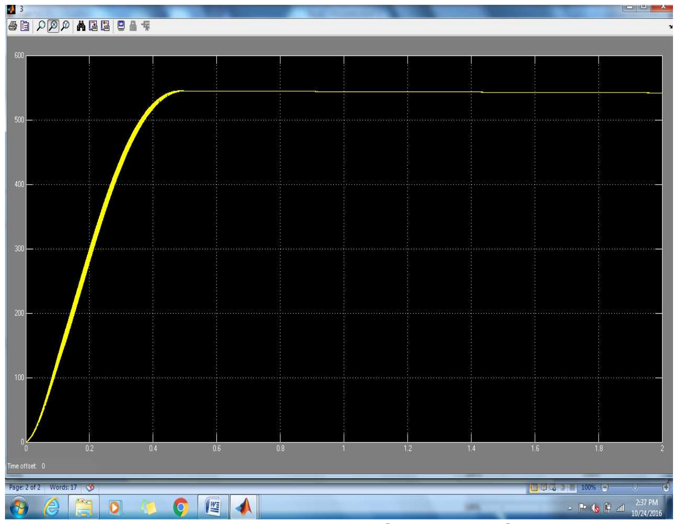

Fig.11. Boost Converter Voltage at PV side.

REFERENCES

[1]. J.Byun, S.Park, B.Kang, I.Hong, S.Park, "Design and implementation of an intelligent energy saving system based on standby power reduction for a future zero-energy home environment", IEEE Trans. Consum. Electron., vol.59, no. 3, pp.507-514, Oct. 2013.

[2]. Jinwei He, Yun Wei Li, Blaabjerg, F., "Flexible Microgrid Power Quality Enhancement Using Adaptive Hybrid Voltage and Current Controller," IEEE Trans. Ind. Electron., vol.61, no.6, pp.2784-2794, June 2014

[3]. Weiwei Li, Xinbo Ruan, Chenlei Bao, Donghua Pan, Xuehua Wang, "Grid Synchronization Systems of Three-Phase Grid-Connected Power Converters: A Complex-Vector-Filter Perspective," IEEE Trans. Ind. Electron., vol.61, no.4, pp.1855-1870, April 2014.

[4]. C. Liu, K.T. Chau, X. Zhang, "An Efficient Wind-Photovoltaic Hybrid Generation System Using Doubly Excited Permanent-Magnet Brushless Machine", IEEE Trans.Ind.Electron,vol.57, no.3, pp.831-839,Mar.2010.

[5]. S. Arul Daniel, N. Ammasai Gounden, "A novel hybrid isolated generating system based on PV fed inverter-assisted wind-driven induction Generators," IEEE Trans. Energy Convers., vol. 19, no. 2, pp.416-422, June 2004.

International Journal of Ethics in Engineering & Management Education
Website: www.ijeee.in (ISSN: 2348-4748, Volume 3, Issue 10, October 2016)

About the authors:

Mrs. T. Soumya[1] Pursuing M.Tech in Power System, Dept. of. EEE at Princeton College of Engineering and Technology-JNTU Hyderabad, she Completed B. Tech in EEE from Brilliant Institute of Engineering and Technology-JNTU Hyderabad, her Research interests includes power electronics, Control Systems

Mr .J.Anjaiah[2] received the Master of Technology degree in Power Electronics from the Vagdevi College of Engineering-JNTUH, he received the Bachelor Of Engineering degree from Arjun College of Technology And Sciences. He is currently working as Associate Professor and a Head of the Department of EEE with Princeton institute of engineering and technology for women. Hyderabad His interest subjects are power electronics control systems machines and etc.

Ms. S.NIROSHA[3] received the Master of Technology degree in Power Electronics from the Princeton College of Engineering And Technology-Jntuh; She received the Bachelor Of Engineering degree from Balaji Institute of Engineering And Sciences-JNTUH. She is currently working as assistant Professor of EEE with Princeton institute of engineering and technology for women, Hyderabad. Her interest subjects are electrical circuits, switch gear and protection and etc.