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Design and Implementation of Single Stage Boosting Inverter for Smartgrid Applications

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ABSTRACT

The proposed system is designed to support the integration of wind and solar power within micro grids. An aggregated model of renewable wind and solar power generation forecast is proposed to support the quantification of real-time scheduling. The use of a single power processing stage to interface multiple power inputs integrates power conversion for a hybrid power source. Basically the micro grid system needs more number of switching devices due to this switch loss is high. To overcome this issue the proposed circuit is designed with less number of switches.

***Index Terms*— wind, solar, micro grids, switch loss, smart grid, boosting inverter.**

INTRODUCTION

The demand for energy will continue to increase as long as world population increases and people continue to demand a higher standard of living. The challenge lies in providing this energy from dependable and sustainable sources while maintaining respect for the environment. Coal-fired power and other fossil fuel based energy sources are a proven source for the needed energy; however, they also cause undesirable effects on the environment.

Solar photo voltaic (PV) and wind have emerged as popular energy sources due to their eco - friendly nature and cost effectiveness. However, these sources are intermittent in nature. Hence, it is a challenge to supply stable and continuous

Power using these sources. This can be addressed by efficiently integrating with energy storage elements. The interesting complementary behavior of solar isolation and wind velocity pattern coupled with the above mentioned advantages, has led to the research on their integration resulting in the hybrid PV-wind systems.

RELATED WORK

With increasing concern of global warming and the depletion of fossil fuel reserves, many are looking at sustainable energy solutions to preserve the earth for the future generations. Other than hydro power, wind and photovoltaic energy holds the most potential to meet our energy demands.

The common inherent drawback of wind and photovoltaic systems are their intermittent natures that make them unreliable. However, by combining these two intermittent sources and by incorporating maximum power point tracking (MPPT) algorithms, the system's power transfer efficiency and reliability can be improved significantly.

When a source is unavailable or insufficient in meeting the load demands, the other energy source can compensate for the difference. Several hybrid wind/PV power systems with MPPT control have been proposed and discussed in works. Most of the systems in literature use a separate DC/DC boost converter connected in parallel in the rectifier stage as shown in Figure: to perform the MPPT control for each of the renewable energy power sources. Topology has been chosen which is a combination of a parallel-connected passive filter and a small rated active filter. This configuration has been well thought-out in this paper for its effective operation. There are so many control schemes to accomplish the desired results. But among them SRF (Synchronous Reference Frame) is one of the most conventional and practically applicable methods. For doing the synchronization SRF requires a PLL circuit. Though the performance of conventional PLL is low, that's why a control scheme of Synchronous Reference Frame method with the modified PLL has been represented.

A suitable Control technique for the controller is the main part of the active power filter operation. Conventional PI voltage and current controllers have been used to control the harmonic current and DC voltage of the shunt active Filter. But, they requires precise linear mathematical model of the system, which is difficult to achieve under variation in parameters, load disturbances and non-linearity. All these limitations are overcome by using fuzzy logic techniques. In this proposed research, fuzzy logic control technique is adopted with reference current estimator and hysteresis current controller. The performance of fuzzy logic controller with reference current estimator and hysteresis current controller is evaluated through computer simulations under nonlinear load conditions. The proposed structure utilizes only four power switches that are independently controlled with four different duty ratios. Utilizing these duty ratios, tracking the maximum power of the PV source, setting the FC power, controlling the battery power, and regulating the output voltage are provided. Depending on utilization state of the battery, three different power operation modes are defined for the converter. In order to design the converter control system, small-signal model is obtained in each operation mode.

HARDWARE SETUP

Block Diagram

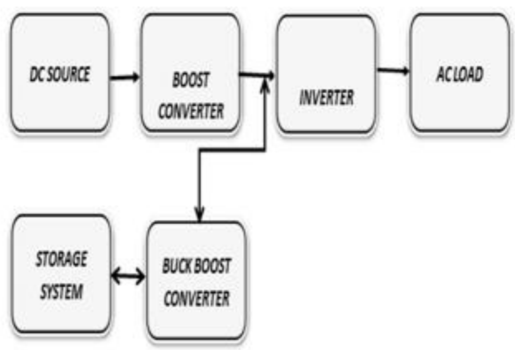

Fig 1. Existing method

The grid-connected hybrid pv-wind-battery based system for household applications, which can work either in stand-alone or grid connected mode. This system is suitable for household applications, where a Low-cost, simple and compact topology capable of autonomous Operation is desirable. The proposed converter consists of dc source, boost converter, bidirectional converter, inverter and ac load.. The proposed converter has reduced number of power conversion stages with less component count and high efficiency compared to the existing grid-connected schemes.

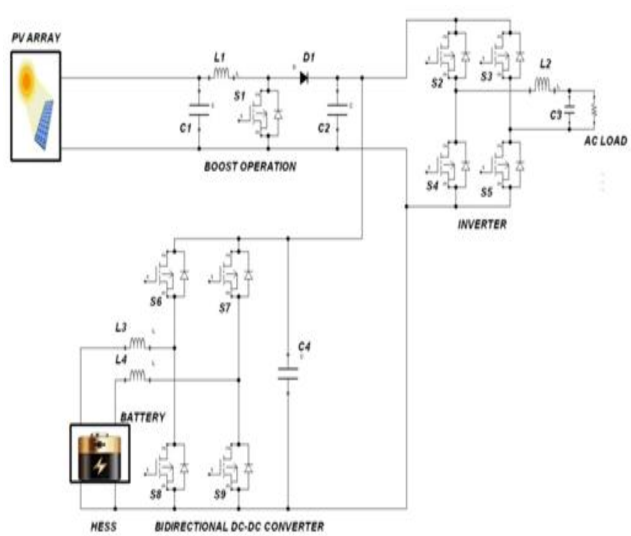

Fig 2. Circuit diagram of existing system

The input of the boost converter is formed by connecting the PV array in series. The boost converter is step up the dc voltage and given to the inverter circuit. And the inverter converts dc voltage into ac voltage send to the ac load. Bidirectional buck boost converter is used to harness power from PV along with battery charging/discharging control. The unique feature of this converter is that MPP tracking, battery charge control and voltage boosting are accomplished through a single converter. Bidirectional converter act as a buck converter while charging the battery from the dc bus and the bidirectional converter acts as a boost converter while discharging the battery and the power flow towards the load.

The power flow from dc source is controlled through a bidirectional converter. boost converter operates in continuous mode, the current through the inductor (I_L) never falls to zero.

$$\frac{\Delta I_L}{\Delta t} = \frac{V_i}{L}$$

The output voltage can be calculated as follows, in the case of an ideal converter (i.e. using components with an ideal behaviour) operating in steady conditions During the On-state, the switch S is closed, which makes the input voltage (V_i) appear across the inductor, which causes a change in current (I_L) flowing through the inductor during a time period (t) by the formula:

$$D = 1 - \frac{V_i}{V_o}$$

The values for PV source is set at 15 V and 15.8 A, and the battery is charged with the constant magnitude of current and remaining power is fed to the grid. The system response for step changes in the PV source insolation level while operating in MPPT mode. Both the sources are operating at MPPT and charging the battery with constant current and the remaining power is fed to the grid. At instant 2 s, the PV source insolation level is increased. As a result the PV source power increases and both the sources continue to operate at MPPT.

Though the PV source power has increased, the battery is still charged with the same magnitude of current and power balance is achieved by increasing the power supplied to the grid. At instant 4 s, insulation of PV source is brought to the same level as before 2s. The power supplied by PV source decreases.

Battery continues to get charged at the same magnitude of current, and power injected into the grid decreases. the sources are generating the power by operating at their corresponding MPPT and charging the battery at constant magnitude of current, and the remaining power is being fed to the grid. At 2 s, PV source is disconnected from the system. The charging current of the battery remains constant, while the injected power to the grid reduces. At instant 4 s, PV source is brought back into the system.

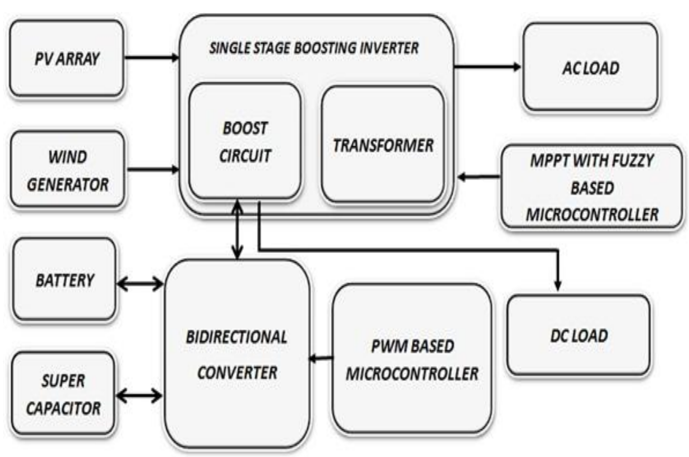

Fig 3. Block diagram of proposed system

The proposed converter consists of PV array, wind generator, bidirectional converter, and single stage boosting inverter, ac load and dc loads. The proposed converter has reduced number of switching devices with less component count and high efficiency compared to the existing grid-connected schemes.

The dc power from the renewable sources are send to the single stage boosting inverter circuit. Inverter operation is done by maintaining the two switches in normal frequency and the remaining one is maintained at high frequency. Single stage boosting inverter is boost up the dc voltage and convert into ac voltage bidirectional converter is having two switches only with this buck operation and boost operations are operated by the controller circuit. bidirectional converter is connected to the dc-link of the secondary side.

The input of the half-bridge converter is formed by connecting the PV array in series with the battery, thereby incorporating an inherent boosting stage for the scheme.

Bidirectional buck boost converter is used to harness power from PV along with battery charging/discharging control. The unique feature of this converter is that MPP tracking, battery charge control and voltage boosting are accomplished through a single converter.

The power flow from wind source is controlled through a unidirectional boost half-bridge converter. For obtaining MPPT effectively, smooth variation in source current is required which can be obtained using an inductor. Electric double-layer capacitors, also known as super capacitors, electrochemical double layer capacitors (EDLCs) or ultra capacitors are electrochemical capacitors that have an unusually high energy density when compared to common capacitors, typically several orders of magnitude greater than a high-capacity electrolytic capacitor.

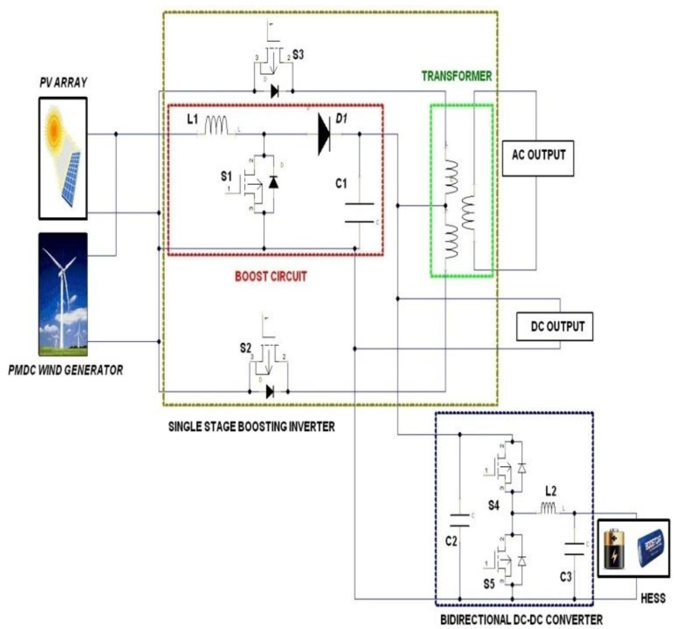

FIG 4. Circuit diagram of proposed system

The power flow from wind source is controlled through a unidirectional boost half-bridge converter. For obtaining MPPT effectively, smooth variation in source current is required which can be obtained using an inductor. Electric double-layer capacitors, also known as super capacitors, electrochemical double layer capacitors (EDLCs) or ultra capacitors are electrochemical capacitors that have an unusually high energy density when compared to common capacitors, typically several orders of magnitude greater than a high-capacity electrolytic capacitor.

Generally, capacitors are constructed with a dielectric placed between opposed electrodes, functioning as capacitors by accumulating charges in the dielectric material. In a conventional capacitor, energy is stored by the removal of charge carriers, typically electrons from one metal plate and depositing them on another. This charge separation creates a potential between the two plates, which can be harnessed in an external circuit. The total energy stored in this fashion is a combination of the number of charges stored and the potential between the plates.

When switch S1 is ON, the current flowing through the source inductor increases. The capacitor C1 discharges through the transformer primary and switches S2 and S3. Here the S1 acts as a boost converter and S2,S3 acts as a inverter. So the switch S1 operating under high frequency like 20 KHZ .where the switches S2,S3 acts as a inverter so that the fundamental frequency 50 hz given to the switches. Bidirectional converter operated by the switches S4, S5. The buck and boost operation is done by the switching pulses which is given from the controller circuit. Bidirectional buck-boost converter is used for MPP tracking of PV array and battery charging/discharging control. Further, this bidirectional buck-boost converter charges/discharges based on the load demand.

When switch S2 is turned OFF and S3 is turned ON, energy stored in L is transferred to the battery. If the battery discharging current is more than the PV current, inductor current becomes negative. Here, the stored energy in the inductor increases when S3 is turned on and decreases when S2 is turned on. It can be proved that Vb = D1−DVpv. This voltage is n times of primary side dc- link voltage.

SIMULATION

Simulation of Existing System

A grid-connected hybrid PV - battery based system consisting of two power sources (PV and battery) and three power sinks (grid, battery and load), requires a control scheme for power flow management to balance the power flow among these sources.

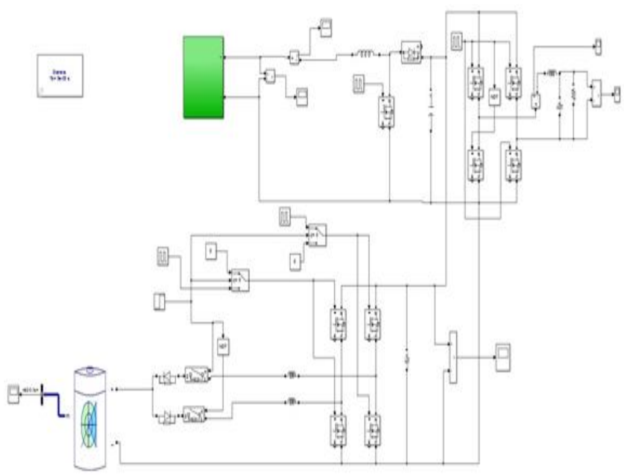

FIG 5. Existing simulation circuit

Detailed simulation studies are carried out on MATLAB platform for four different modes of operation and the results obtained for various operating conditions are presented in this section. Values of parameters used in the model for simulation of the proposed system are listed in Table 4.1.

The parameters for this system is shown in Fig. 4.1. The values for PV source is set at 15 V and 15.8 A. It can be seen that Vpv and Ipv of PV source, and Vw and Iw of wind source attain set values required for MPP operation. The battery is charged with the constant magnitude of current and remaining power is fed to the grid.

Parameter	Value
Solar PV power	237 W (I_{mpp} = 15.8 A) (V_{mpp} = 15 V)
Switching frequency	15 kHz
Inductor-boost converter	47 µH
Inductor-output	10 mH
Inductor-bidirectional converter	47µH
Capacitor-boost converter	1000µF
Capacitor-inverter	2200 µF
Capacitor-bidirectional converter	5000 µF
Battery capacity & voltage	50 Ah, 110 V

FIG 6. Simulation parameters of existing system

Simulation Of Proposed System

The single stage boosting inverter with bidirectional converter for smart grid application consisting of four power sources (PV, wind source, battery and super capacitors) and two power sinks (battery and load), requires a transformer coupled boost converter with bidirectional buck-boost converter. The proposed converter has reduced number of switching devices with less component count and high efficiency compared to the existing grid-connected schemes. Detailed simulation studies are carried out on MATLAB platform and the results obtained for various operating conditions are presented in this section. Values of parameters used in the model for simulation are listed in Table 4.2.

Parameter	Value
Solar PV power	320 W (I_{mpp} = 2 A) (V_{mpp} = 160 V)
Wind power	100 W (I_{mpp} = 4 A) (V_{mpp} = 25 V)
Switching frequency	20 kHz
Inductor- boost converter	6 mH
Inductor- inverter	100 mH
Inductor-bidirectional converter	47mH
Capacitor-bidirectional converter	100µF
Capacitor- inverter	100µF
Battery capacity & voltage	50 Ah, 110 V

Fig 7. Simulation parameters of proposed system

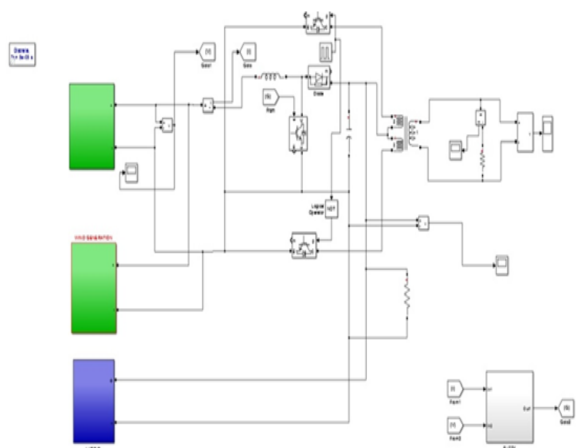

Fig 8. Proposed simulation circuit

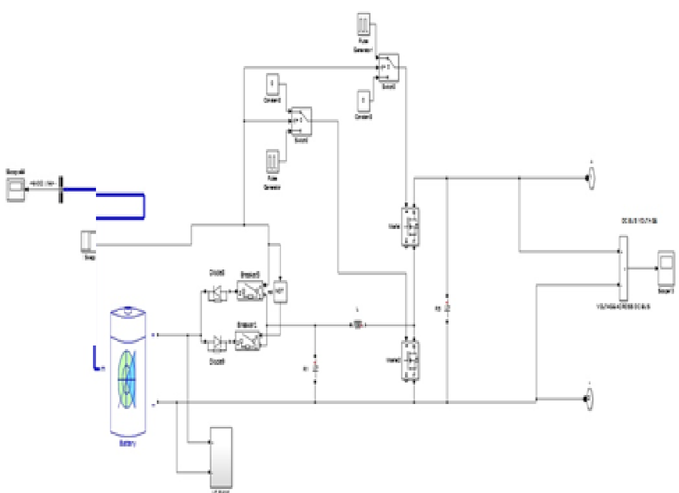

FIG 9. Bidirectional converter with energy storage

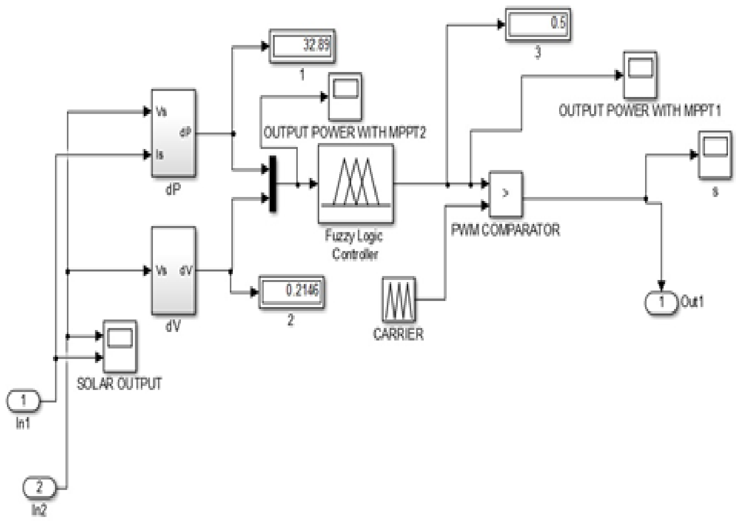

FIG 10. Fuzzy controller circuit

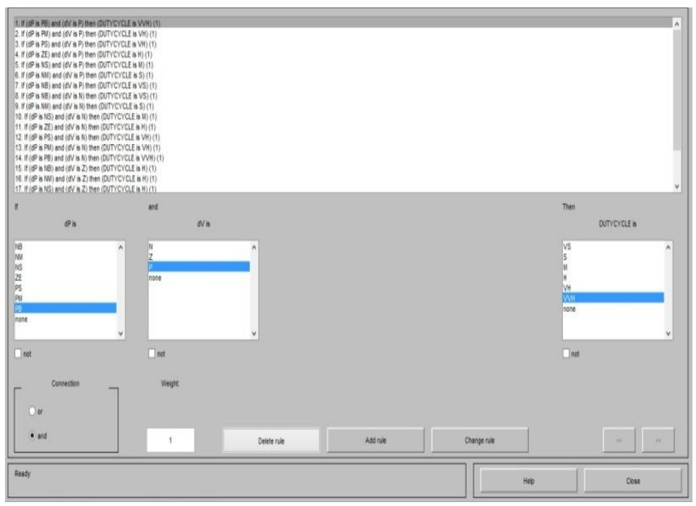

FIG 11. Fuzzy rules

RESULTS

Simulation of Existing System Results

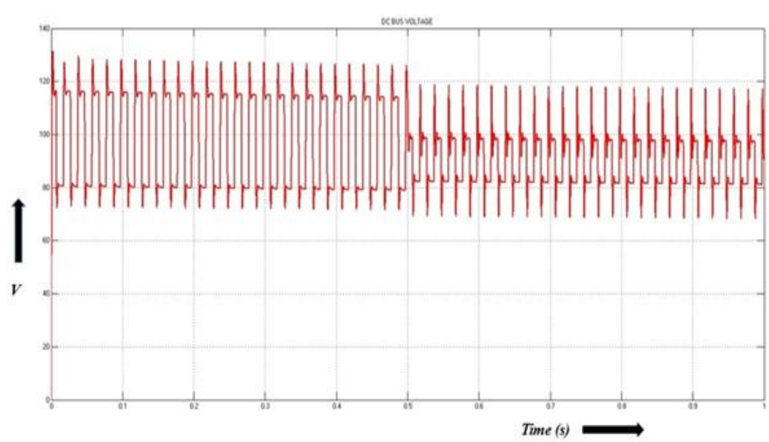

FIG 12. Dc bus voltage

The input voltage is drawn between time in x-axis and voltage in y- axis.

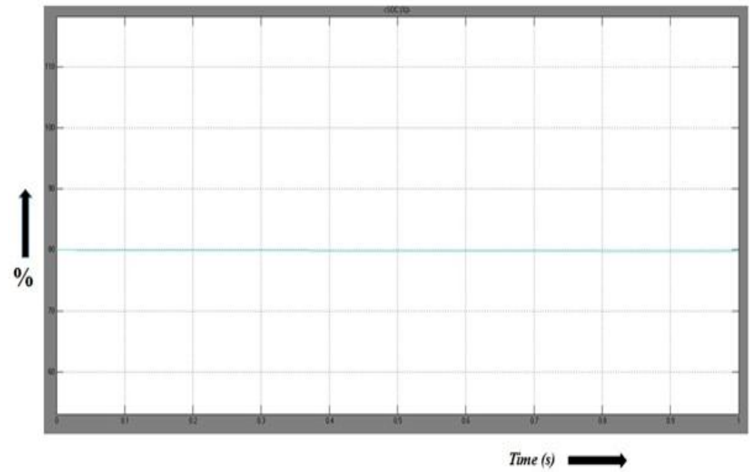

FIG 13. State of charge in battery

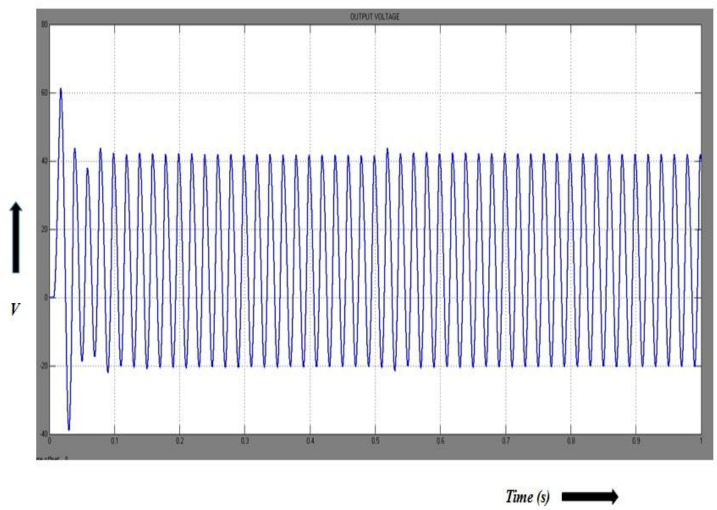

FIG 14. Output voltage

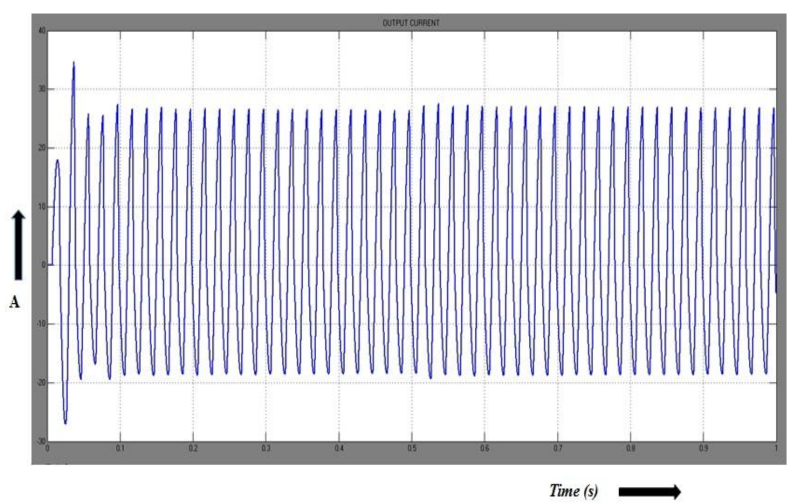

FIG 15. Output current

Simulation Of Proposed System Results

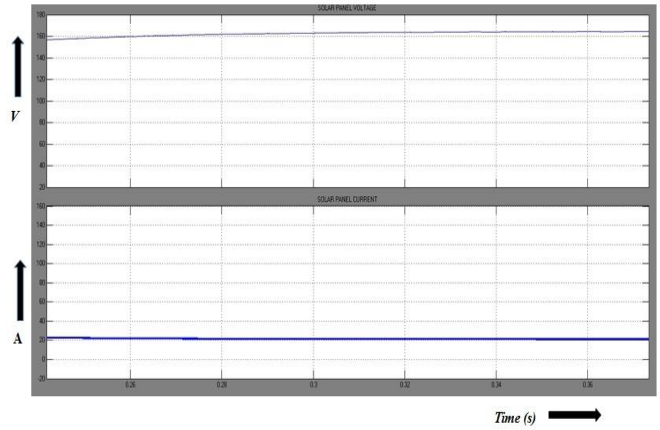

FIG 16. Solar panel voltage and current

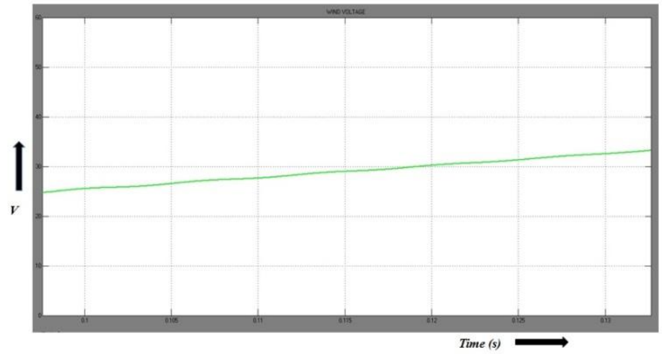

FIG 17. Wind voltage

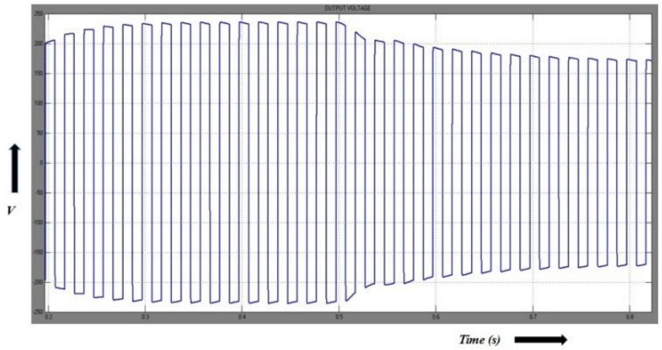

FIG 18. Output voltage

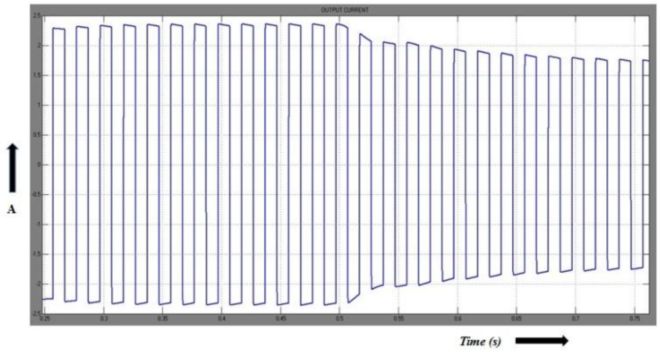

Fig 19. output current

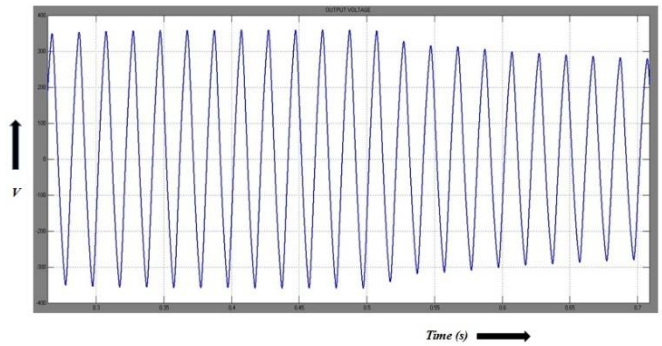

FIG 20. Output voltage with filter circuit

This is the output from simulation with filter. The x-axis represents times in seconds and the y- axis represents voltage in volts.

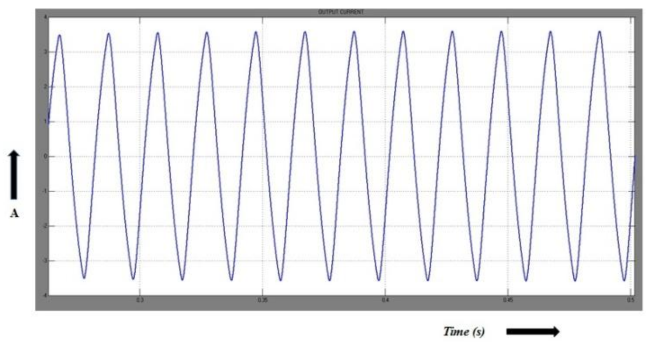

FIG 21. Output current with filter circuit

CONCLUSION

The grid-connected hybrid pv-wind-battery based system for household applications, which can work either in stand-alone Or grid connected mode. This system is suitable for household applications, where a Low-cost, simple and compact topology capable of autonomous Operation is desirable. The core of the proposed system is the multi-input transformer Coupled bidirectional dc-dc converter that interconnects various power Sources and the storage element. The proposed hybrid system provides an elegant integration of PV and wind source to extract maximum energy from the two sources. Detailed simulation studies are carried out to ascertain the viability of the scheme. The proposed configuration is capable of supplying un-interruptible power to ac loads, and ensures evacuation of surplus PV and wind power into the grid.

REFERENCES

[1]. B. Mangu, S. Akshatha, D. Suryanarayana and B. G.Fernandes,"Grid- Connected PV-Wind-Battery based Multi-Input Transformer Coupled Bidirectional DC-DC Converter for household Applications"*IEEE Journal of Emerging and Selected Topics in Power Electronics* (Volume:4 , Issue: 3) pp.1086 - 1095., 2016

[2]. F. Valenciaga and P. F. Puleston,"Supervisor control for a stand-alone hybrid generation system using wind and photovoltaic energy," *IEEE Trans. Energy Convers.*, vol. 20, no. 2, pp. 398-405, Jun. 2005.

[3]. S. K. Kim, J. H. Jeon, C. H. Cho, J. B. Ahn, and S. H. Kwon,"Dynamic modeling and control of a grid-connected hybrid generation system with versatile power transfer,"*IEEE Trans. Ind. Electron.*, vol. 55, no. 4, pp.1677-1688, Apr. 2008.

[4]. S. Bae and A. Kwasinski,"Dynamic modeling and operation strategy for a microgrid with wind and photovoltaic resources," *IEEE Trans. Smart Grid*, vol. 3, no. 4, pp. 1867-1876, Dec. 2012.

[5]. C. W. Chen, C. Y. Liao, K. H. Chen and Y. M. Chen,"Modeling and controller design of a semi isolated multi input converter for a hybrid PV/wind power charger system," *IEEE Trans. Power Electron.*, vol. 30, no. 9, pp. 4843-4853, Sept. 2015.

[6]. W. M. Lin, C. M. Hong, and C. H. Chen,"Neural network-based MPPT control of a stand-alone hybrid power generation system," *IEEE Trans. Power Electron.*, vol. 26, no. 12, pp. 3571-3581, Dec. 2011.

[7]. F. Valenciaga, P. F. Puleston, and P. E. Battaiotto,"Power control of a solar/wind generation system without wind measurement: a passivity/sliding mode approach,"*IEEE Trans. Energy Convers.*, vol. 18, no.4, pp. 501-507, Dec. 2003.

[8]. T. Hirose and H. Matsuo,"Standalone hybrid wind-solar power generation system applying dump power control without dump load," *IEEE Trans. Ind. Electron.*, vol. 59, no. 2, pp. 988-997, Feb. 2012.

[9]. S. A. Daniel and N. A. 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, Jun.2004.

[10]. R. Wandhare and V. Agarwal, "Novel integration of a PV-wind energy system with enhanced effciency," *IEEE Trans. Power Electron.*, vol. 30, no. 7, pp. 3638-3649, Jul. 2015.