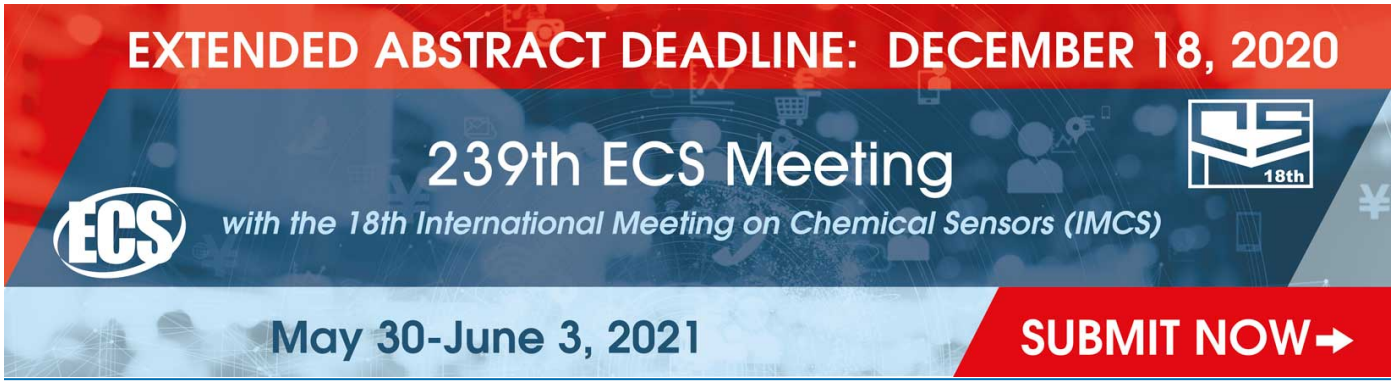
PAPER • **OPEN ACCESS**

PV-Wind-Battery based Bidirectional DC-DC Converter for Grid Connected Systems

To cite this article: Alex Stanley Raja Thaveedu *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **955** 012070

View the article online for updates and enhancements.



This content was downloaded from IP address 103.69.147.140 on 16/12/2020 at 10:37

IOP Conf. Series: Materials Science and Engineering **955** (2020) 012070 doi:10.1088/1757-899X/955/1/012070

PV-Wind-Battery based Bidirectional DC-DC Converter for Grid Connected Systems

Alex Stanley Raja Thaveedu[1] , Senthil Kumar Ramaswamy[2] and Shivaprakash Thirumurugan[3]

[1] Assistant Professor, Department of Electrical and Electronics Engineering, Bannari Amman Institute of Technology, Sathyamangalam, Erode.
[2] Professor, Department of Electrical and Electronics Engineering, Vivekanandha college of Engineering for women, Tiruchengode.
[3] PG scholar, Department of Electrical and Electronics Engineering, Bannari Amman Institute of Technology, Sathyamangalam, Erode.

Email: alexstanleyraja@bitsathy.ac.in

Abstract. The control strategy of solar, wind, battery that connected with bi-directional DC to DC converter are used for grid connected power flow management. Generally all sources of produce the power that should satisfy the load demand without scarifies our basic needs. The power can be acquired from different source and should manage the power flow to the all places in the horizontal level. The surplus power is injected to the grid and the battery should charge from grid, it can be used for latter when it required. A half bridge boost converter coupled with transformer is utilized to collect the power from wind, meanwhile a bi-directional buck- boost converter is utilized to collect the power from solar and battery charging/ discharging. AC power is fed to AC load through single phase full bridge bidirectional converter and this helps to communication with grid. The proposed method that reduces the number of switches components losses and mainly the power conversion stage. The simulation results are obtained by using MATLAB/ Simulink that shows the performance of control strategy of power flow management in different modes.

1. Introduction

In today's world, electricity plays vital role, even a toy needs source to work. There are many ways to produce electricity, depends upon the source that comes under two classifications Renewable and Non- Renewable. Renewable energy can be collect from nature and it is replenish everywhere, for example Solar, Wind, Rain etc, Non-Renewable is an energy that can be collect in fossil fuels and it cannot be replenish everywhere [1]. But the satisfaction of needs is achieved mostly through Non-Renewable energy source when compared to renewable Energy. Hence initially the world goes with Non-Renewable energy, now days there is a scarcity of energy source.

Due to high consumption of the fossil fuels there is a rapid reduction in fuels, but in our nation the usage of electricity is very high. In this concern to reduce the usage of fossil fuel, we can use the renewable energy to generate the electrical energy. There is many source some of them are solar (PV), Wind turbine, Tidal, etc., these energy are more eco-friendly and available easily.

There is an idea to develop production of electricity with Renewable Energy source that integrated with grid by the help of Power electronics Devices that equals the need and satisfaction of consumer.

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd

2. Existing Method

In existing items the solar and wind are harvested and produce electricity then boosted by individual converters and need to integrate these energy to the grid separately after the needs of consumer is satisfied with the help of inverters or in another way the energy is given directly to the grid with the help of inverters and according to the energy give the amount will be given to the producer with land rent or in another way the storage is not done in the while harvesting the energy. Some of the disadvantages in existing method are given below [2].

- In this method the more electronic switches are used and complexity of connections is more. If no of electronic switches are hiked then there will be produced the harmonics in the transmission line while interconnected to the grid.
- It will increase the Switching stress and gate protection circuit is also hiked, results in high economic losses and life time of the switch are reduced.
- The development in PV can augment the voltage trespassing and turning power flow in low-voltage distribution systems.

3. Proposed Method

To design a boost dual-half-bridge bidirectional converter run together with a bidirectional buck–boost converter and a single phase full bridge inverter, with less component count and high efficiency compared with the existing grid-connected schemes [3]. This topology is transparent and requires only six power switches, reduced number of power conversion stages with less component count, high efficiency and has reduced number of power conversion stages with battery charge control and voltage boosting are acquired through a single converter.

The figure 1 shows the Block Diagram of the entire unit.

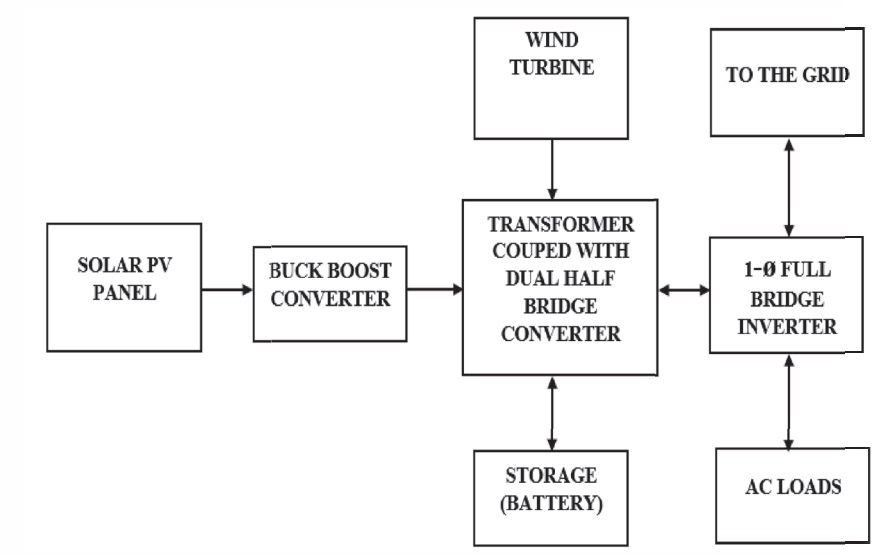


Figure 1. Block Diagram

Following are the Hardware component used in the project.

- Multi Input Transformer
- Bi-directional DC-DC converter
- Dual Half Bridge Converter
- Single Phase Full Bridge Inverter
- PV panel, Wind Turbine and Battery

3.1. Bi - Directional Dc To Dc Converter

Bi - Directional DC – DC converter is the converter which converts constant DC voltage into variable DC voltage. In conventional DC - DC Converter the flow is in Uni-directional[4]. Mostly this converter is used while the storage device like battery or ultracapacitor or fly wheel is utilized in the circuit.

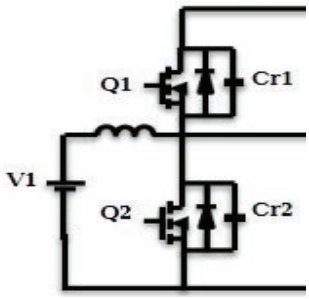


Figure 2. Bi - Directional DC to Dc converter

The Figure 2 shows the Bi- Directional DC to Dc converter. In case the system is get failed the entire system get out to the grid due to weather condition or any other disturbance, but with the help of this converter we can give the battery supply to the grid without any interruption until the battery drain. In this one of the major disadvantage is there is need of simple transformer, that occupies more space.

3.2. Dual Half Bridge Converter

The Figure 3 shows circuit diagram of the Dual Half Bridge Converter.

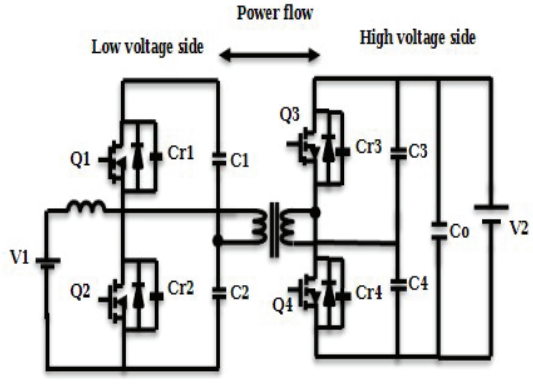


Figure 3. Dual Half bridge converter with simple isolation transformer

The converter is mostly used instead of Flyback Converter, Sepic Converter due to high efficiency and accuracy. In our project at high voltage side the single phase full bridge inverter is used instead of battery. In this the high frequency isolation transformer is used to protect the entire source unit like Solar PV panel, Wind Turbine, Battery from over load condition. This converter is also used for noise reduction and voltage balance [5]. There are two stage converters are present in this before primary side of the transformer it converts the DC to AC, after secondary side of the transformer the it converts the AC to DC. The transformer is used for isolation purpose.

3.3 Single Phase Full Bridge Inverter

Inverter is a power electronic circuit that converts the input DC voltage to output AC voltage. In single phase full bridge inverter is consists of 4 switches T1, T2, T3, T4 no two switches are on at same leg in case it on then there is problem of short circuit. In this the T1 & T2 are a set of pair and T3 & T4 are a set of pair. When T1& T2 are on the input DC voltage is appears across the load. The Figure 4 shows the circuit diagram of the Single Phase Full Bridge Inverter. Similarly the T3& T4 are on the input DC voltage is appears across the load as AC output voltage.

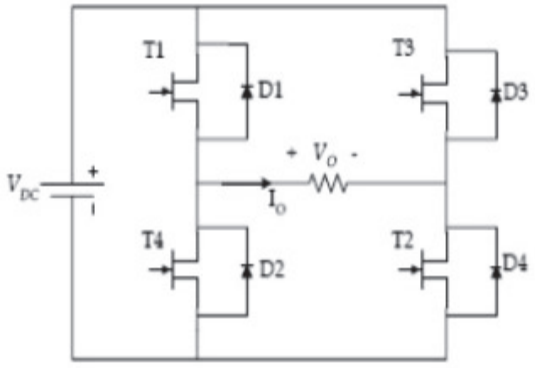


Figure 4. Single Phase Full Bridge Inverter

4. Working and Power Flow Management

Initially solar panel and battery are connected in series, and then both are parallelly connected to the Bi-Directional buck boost converter. In the same circuit the Wind turbine is connected to the Transformed Coupled with 1st Boost Dual Half Bridge Converter[6]. The transformer's primary winding is connected to the input side and secondary winding is connected to the output side that is load and grid side. The output of transformer is connected to the 2nd part of the Dual Half Bridge Converter. Then it is connected to the inverter[7]. The Inverter give the AC voltage to the Grid and Load. Here instead of Solar panel and wind turbine the battery is used to reduce the complexity of simulation circuit but the parameters are similar to the solar panel and wind turbine.

The output voltage of the secondary DC link ok is depends on function of Transformer turns ratio and duty cycle primary side converter. battery charging and discharging control, PV array is controlled by bidirectional buck- boost converter and also converter charges/ discharges the capacitor bank C1 and C2. when T1 is On the battery is in charge mode and inductor L also stores the energy. T2 is ON and T1 OFF the energy stored in the inductor is take over by the battery. the inductor current will becomes negative when the battery discharging is more than PV current. When

T2 is in ON the energy stored in inductor L increases. T1 is ON the energy decreases. it can be provided that Vb (D/1 -D)Vpv.

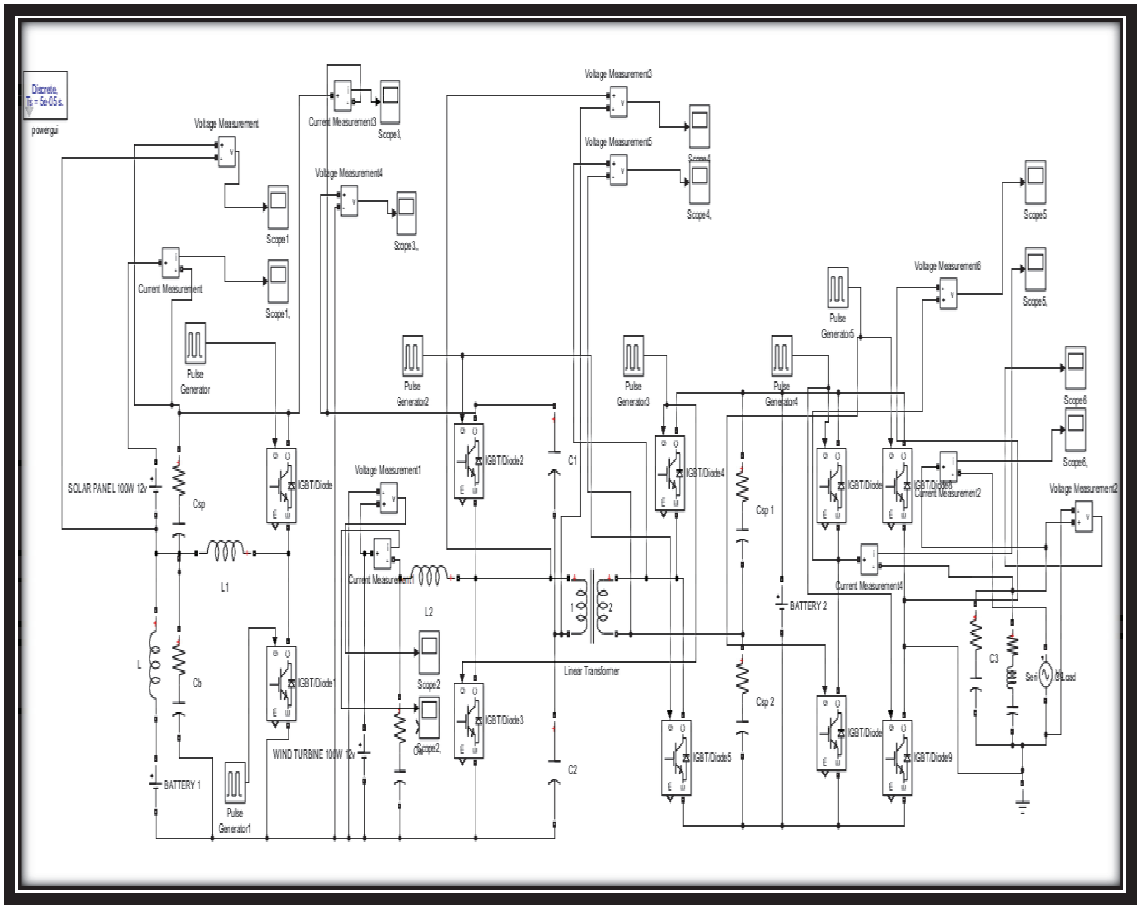


Figure 5. MATLAB Simulation

Hybrid grid consist of four power source PV, Wind, Battery and there are three power observers battery, grid and load, to manage the power flow among this there is a need of control scheme for power flow management.

Based on the power balance principle, the control scheme for power flow management of multi-source system is developed. the required power for load and operation is taken from generated power itself, when energy sources are bunk off battery will be charged by the grid. the equation for the power balance of the system if given by

$$V_{pv}I_{pv}+V_wI_w=V_bI_b+V_gI_g \quad \text{---1}$$

The output voltage peak value of the single phase full bridge inverter

$$V_{dc} = n(V_{pv}+V_b). \quad \text{---2}$$

In the boost half-bridge converter

$$V_w = (1 - D_w)(V_{pv} + V_b). \quad \text{---3}$$

Now, substituting V_w and V_g

$$V_{pv} I_{pv} + (V_{pv} + V_b)(1 - D_w)I_w = V_b I_b + \sqrt{2} m_a n (V_{pv} + V_b) \quad \text{---4}$$

After simplification

$$I_b = I_{pv}\left(\frac{1 - D_{pv}}{D_{pv}}\right) + I_w\left(\frac{1 - D_w}{D_{pv}}\right) - I_g\left(\frac{m_a n}{\sqrt{2} D_{pv}}\right).$$

Hence, the control of a single-phase full-bridge bidirectional converter depends on the availability of grid, power from PV and wind sources, and battery charge status.

The Simulation is carried out on the MATLAB Simulink model. The values for source (PV source) is set at 12V (Vmpp) and 100W and for source-2 (wind source) is set at 12(Vmpp) and 100w that is approximately 8A (Impp) for both sources. It can be seen that Vpv and Ipv of source-1, and Vw and Iw of source- 2. The battery charged with the constant magnitude of current and the remaining power is fed to the grid. The battery charged with the constant magnitude of current, and the remaining power is fed to the grid[6]. Upto 2 seconds source 1 and source 2 charges the battery with constant current, the excess power is fed to the grid at 2 seconds

The insolation level of source 1 is increased, so the source power is increased likewise both source what's continuously. The battery continues to charge at constant current and power balance is succeeded by boosting the power supply to the grid. at 4 seconds The source 1 is come back same level as before 2 seconds. Now the source 1 power is decreased but the battery charge in the same magnitude and power injector to the grid is reduced, similarly results will be obtained when the steps are followed in the source 2. at 2 seconds the absence of source 1 the battery charges at the same magnitude of current and at 4 seconds source 1 brought back to the same level.

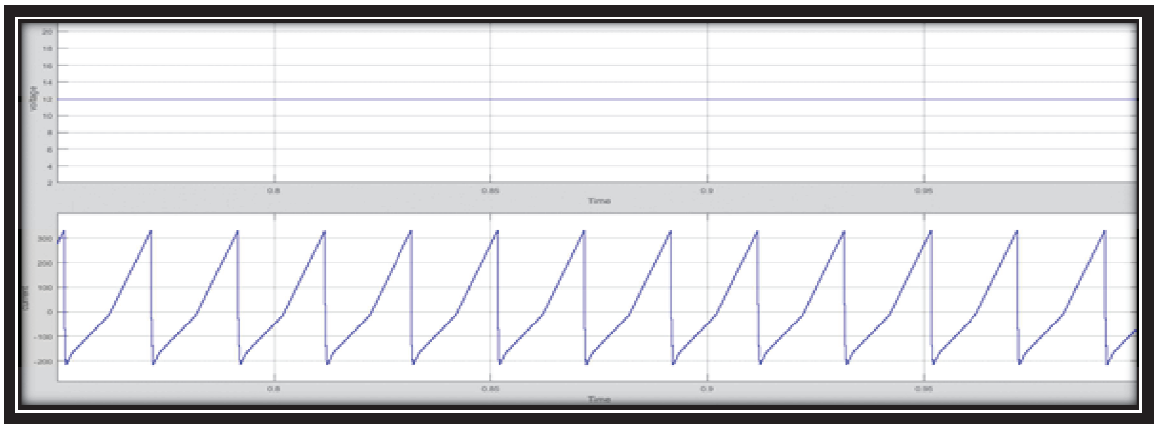


Figure 6. Simulation Result of Solar PV Panel Voltage vs Time and Current vs Time

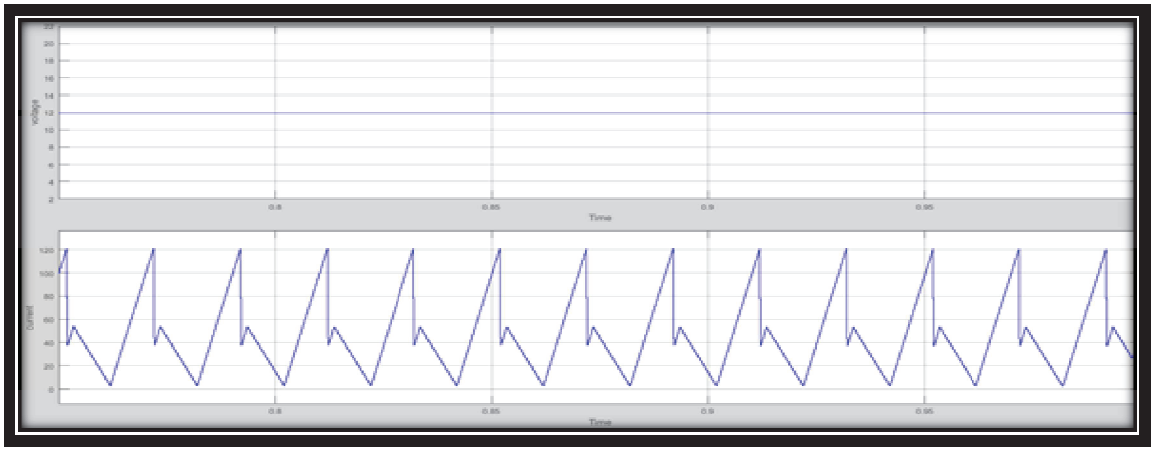


Figure 7. Simulation Result of Wind Turbine Generated Voltage vs Time and Current vs Time

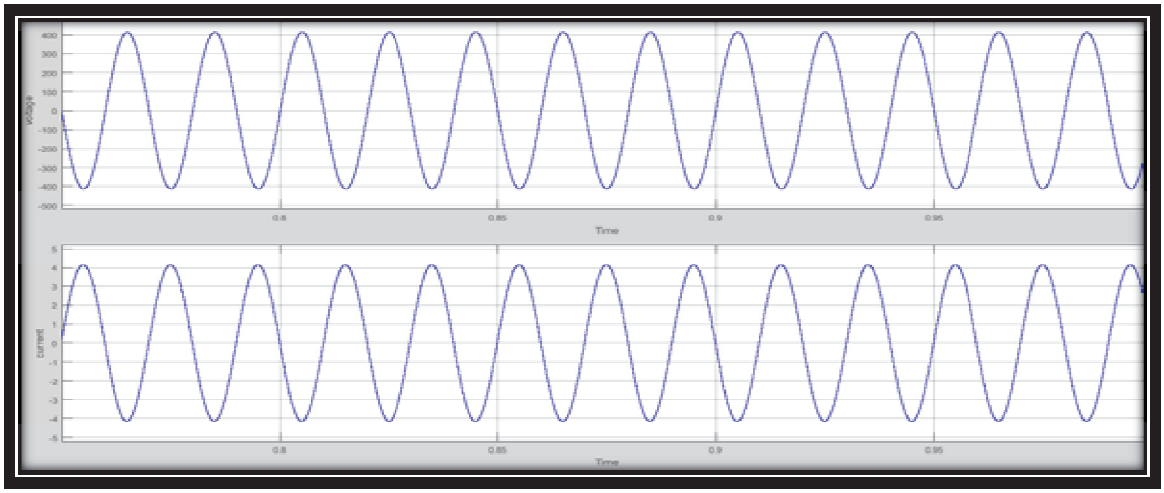


Figure 8. Simulation Result of Vg's Voltage vs Time and Current vs Time

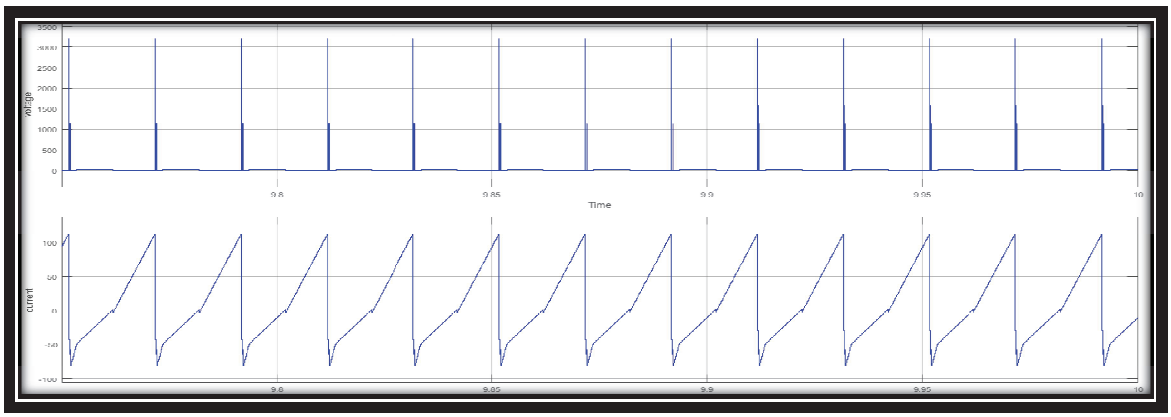


Figure 9. Simulation Result of Boost converter Voltage vs Time and Current vs Time

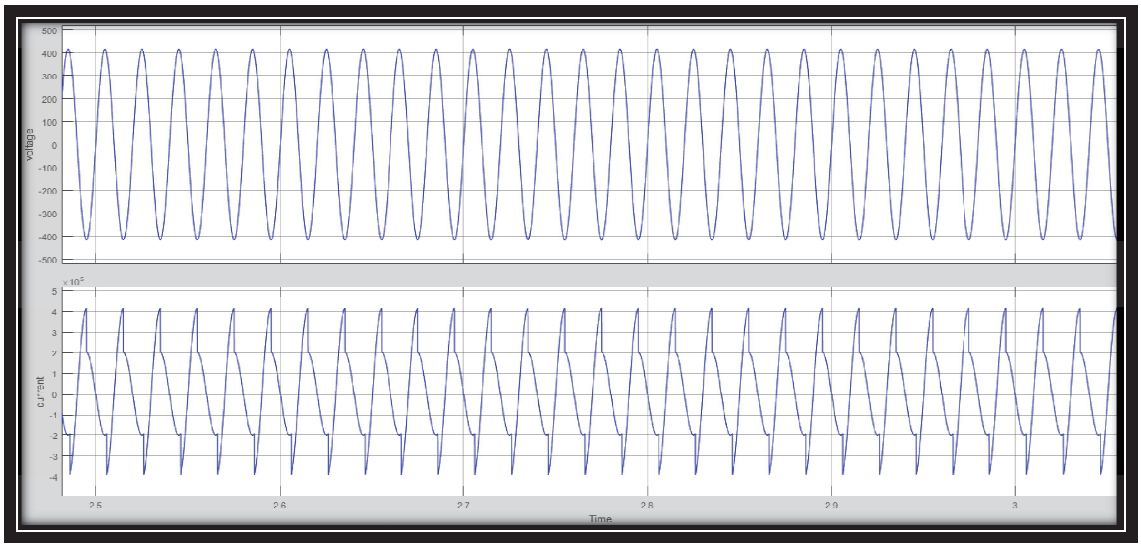


Figure 10. Simulation Result of Inverter Voltage vs Time and Current vs Time

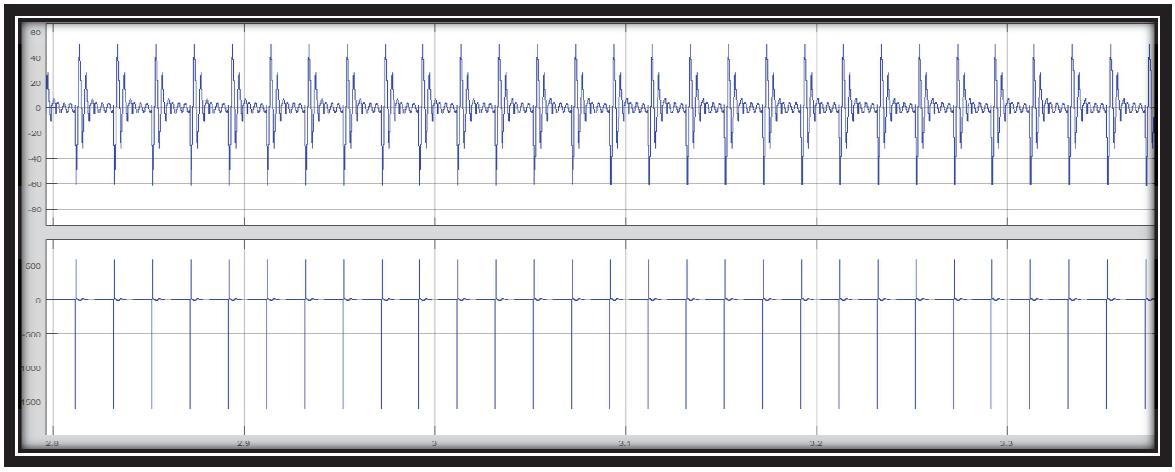


Figure 11. Simulation Result of Transformer Input Voltage vs Output Voltage

At 2 seconds the absence of source 1 the battery charges at the same magnitude of current and at 4 seconds source 1 brought back to the same level. There is no change in the battery charging similarly absence of source 2.

5. Conclusion

Hybrid grid connected wind, battery, grid, PV depends on power expulsion tactics for household appliance is proposed. this combined system gives detailed integration of wind PV source to get more energy from the two sources. It is implemented by coupled bidirectional DC to DC Converter and full bridge inverter. The flexible controlling approaches gives more utilisation of wind, PV, battery capacities without change in in battery life. this system give power to AC load. This experimental research are closely obtained in MATLAB simulation and it is highly supportive. This product has capable of providing uninterruptible power to AC load, PV, wind, Grid.

6. References

[1] Liu C, Chau K T and Zhangne X 2010 *IEEE Trans. Ind. Electron.* **57** pp 831–839.

[2] Xu L, Ruan X,Mao X, Zhang B and Luo Y 2013 *IEEE Trans. Sustain. Energy* **4** pp 774–785.

[3] Dali M, Belhadj J and Roboam X 2010 *Energy* **35** pp 2587–2595.

[4] Kellogg W D, Nehrir M H, Venkataramanan G and Gerez V 1998 *IEEE Trans. Energy Convers.***13** pp 70–75.

[5] Bae S and Kwasinski A 2012 *IEEE Trans. Smart Grid* **3** pp 1867–1876.

[6] Lin W M, Hong C M and Chen C H 2011 *IEEE Trans. PowerElectron* **26** pp 3571–3581.

[7] Qi W, Liu J, Chen X and Christofides P D 2011 *IEEE Trans. Control Syst.Technol.* **19** pp 199–207.