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Grid-Connected PV-Wind-Battery Based Multi-Input Transformer Coupled Bidirectional DC-DC Converter with Multilevel Inverter Fed AC Load

KUNATI MADHU[1], V. SUNIL KUMAR REDDY[2]

[1]PG Scholar, Dept of EEE, MJR College of Engineering &Technology, Piler, AP, India,E-mail: madhuyadav11205@gmail.com.

[2]HOD, Dept of EEE, MJR College of Engineering &Technology, Piler, AP, India, E-mail: skit07250@gmail.com.

Abstract: In this project, a control strategy for power flow management of a grid-connected hybrid PV-wind-battery based system with an efficient multi-input transformer coupled bidirectional dc-dc converter is presented. The aim of our project is to satisfy the load demand, manage the power flow from different sources, inject surplus power into the grid and charge the battery from grid as and when required. A transformer coupled boost half-bridge converter is used to harness power from wind, while bidirectional buck-boost converter is used to harness power from PV along with battery charging/discharging control. A single-phase full-bridge bidirectional converter is used for feeding ac loads and interaction with grid. The proposed converter architecture has reduced number of power conversion stages with less component count, and reduced losses compared to existing grid-connected hybrid systems. Then we are going to test the single phase multilevel converter to feed ac loads and interaction with grid.

Keywords: PV-Wind-Battery Based System, Multi-Input Converter (MIC), Maximum Power Point (MPP).

I. INTRODUCTION

Fast consumption of fossil fuel holds, results in expanding vitality request and concerns over environmental change persuade control power generation from renewable energy sources. Sunlight based photovoltaic (PV) and wind have risen as well known vitality sources due to their eco-friendly nature and cost adequacy. Nonetheless, these sources are irregular in nature. Consequently, it is a test to supply steady and consistent power utilizing these sources. This can be tended to by proficiently coordinating with energy storage components. The interesting correlative conduct of sun powered insolation and wind speed pattern combined has led to the exploration on their combination bringing about the hybrid PV-wind frameworks. For accomplishing the reconciliation of numerous renewable sources, the customary approach includes utilizing devoted single-input converters one for each source, which are associated with a typical dc-link. Be that as it may, these converters are not successfully used, because of the discontinuous way of the renewable sources. Moreover, there are numerous power transformation stages which decrease the proficiency of the framework. Hybrid PV-wind based system of power and their interfaces with the power network are the imperative research territories. Proposed multi-input half breed PV-wind control generation framework which has a buck/buck-help combined multi-input dc-dc converter and a full-connect ac inverter. This system is essentially centered around enhancing the dc-interface voltage direction.

The utilization of multi-input converter (MIC) for cross breed control frameworks is pulling in expanding consideration on account of decreased part number, upgraded control thickness, smallness and concentrated control. Because of these favorable conditions, numerous topologies are proposed and they can be characterized into three gatherings, non-detached, completely segregated and halfway disengaged multi-port topologies. All the state of the art on converter topologies presented so far can oblige just a single renewable source and one energy storage element. Though, the proposed topology is fit for interfacing two renewable sources and a energy storage element. Consequently, it is more solid as two distinct sorts of renewable sources like PV and wind are utilized either separately or at the same time without increment in the segment tally contrasted with the existing state edge topologies. The proposed framework has two renewable power sources, load, lattice and battery. Subsequently, a power flow management system is basic to adjust the power flow among every one of these sources. The primary goals of this framework are as per the following:

- To investigate a multi-object control scheme for optimal charging of the battery utilizing numerous sources.
- Supplying un-interruptible energy to loads.
- Ensuring departure of surplus power from renewable sources to the network, and charging the battery from framework as and when required.

The network associated half breed PV-wind-battery based framework for family unit applications which can work either in remain solitary or grid associated mode. This framework is reasonable for family unit applications, where an ease, basic and reduced topology equipped for independent operation is attractive. The center of the proposed framework is the multi input transformer coupled bidirectional dc-dc converter that interconnects different power sources and the capacity component.

II. PROPOSED CONVERTER CONFIGURATION

The proposed converter comprises of a transformer coupled boost double half-bridge bidirectional converter fused with bidirectional buck-boost converter and a solitary stage full-connect inverter. The proposed converter has decreased number of power transformation stages with less part check and high productivity contrasted with the existing grid associated plans. The topology is straightforward and needs just six power switches. The schematic graph of the converter is delineated in Fig.1. The boost double half-bridge converter has two dc-interfaces on both sides of the high recurrence transformer. Controlling the voltage of one of the dc-link, guarantees controlling the voltage of the other. This makes the control procedure basic. Besides, extra converters can be incorporated with any of the two dc-joins. A bidirectional buck-help dc-dc converter is coordinated with the essential side dc-connection and single-stage full scaffold bidirectional converter is associated with the dc-connection of the auxiliary side. The contribution of the half-bridge converter is designed by associating the PV exhibit in arrangement with the battery, accordingly incorporating an inherent boosting stage for the scheme.

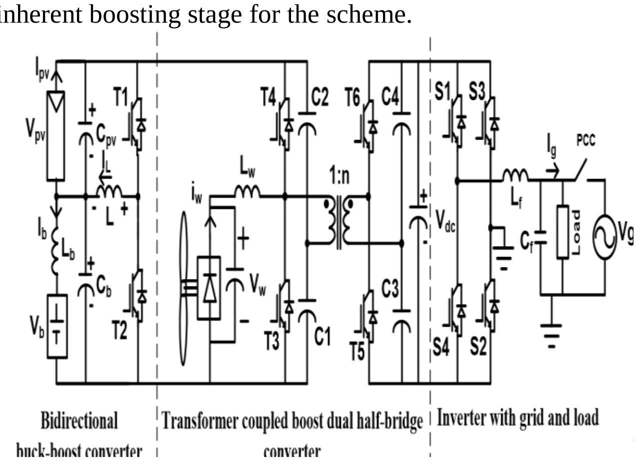

Fig.1. Proposed converter configuration.

The boosting capacity is further improved by a high frequency step-up transformer. The transformer likewise guarantees galvanic segregation to the heap from the sources and the battery. Bidirectional buck help converter is utilized to bridle control from PV alongside battery charging/ releasing control. The one of a kind element of this converter is that MPP following, battery charge control and voltage boosting are refined through a solitary converter. Transformer coupled boost half-bridge converter is utilized for harnessing power from wind and a solitary stage full-connect bidirectional converter is utilized for sustaining air conditioning burdens and association with framework. The proposed converter has diminished number of force change stages with less segment tally and high proficiency contrasted with the current network associated converters. The power flow of wind source is controlled through a unidirectional boost half-bridge converter. For acquiring MPP successfully, smooth variety in source current is required which can be gotten utilizing an inductor. In the proposed topology, an inductor is put in arrangement with the wind source which guarantees constant current and accordingly this inductor current can be utilized for keeping up MPP current. During the ON time of T 3, the primary voltage $V_P = -V_{C1}$.The secondary voltage $V_S = nV_p = -nV_{C1} = -V_{C3}$, or $V_{C3} = nV_{C1}$ and voltage across primary inductor L_w is V_w. When T_3 is turned OFF and T_4 turned ON, the primary voltage $V_P = V_{C2}$. Secondary voltage $V_S = nVp = nV_{C2} = V_{C4}$ and voltage across primary inductor L_w is $V_w - (V_{C1} + V_{C2})$. It can be proved that $(VC1 + VC2) = \frac{Vw}{(1-Dw)}$. The capacitor voltages are considered constant in steady state and they settle at $V_{C3} = nV_{C1}$, $V_{C4} = nV_{C2}$. Hence the output voltage is given by

$$Vdc = VC3 + VC4 = n\,\frac{Vw}{(1-Dw)} \tag{1}$$

In this manner, the yield voltage of the auxiliary side dc-connection is an element of the obligation cycle of the essential side converter and turns proportion of transformer. In the proposed design as appeared in Fig. 2(a), a bidirectional buck-support converter is utilized for MPP following of PV exhibit and battery charging/releasing control. Promote, this bidirectional buck-support converter charges/releases the capacitor bank C1-C2 of transformer coupled half-connect help converter in view of the heap request. The half-connect help converter extricates vitality from the twist source to the capacitor bank C1-C2. Amid battery charging mode, when switch T 1 is ON, the vitality is put away in the inductor L. At the point when switch T_1 is killed and T_2 is turned ON, vitality put away in L is exchanged to the battery. On the off chance that the battery releasing current is more than the PV current, inductor current gets to be distinctly negative. Here, the stored energy in the inductor increases when T 2 is turned on and decreases when T_1 is turned on. It can be proved that$V_b = \frac{D}{1-D} V_{Pv}$. The output voltage of the transformer coupled boost half-bridge converter is given by,

$$V_{dc} = n(V_{C1} + V_{C2}) = n(V_b + V_{pv}) = \frac{nV_w}{1-D_w} \tag{2}$$

This voltage is n times of primary side dc-link voltage. The primary side dc-link voltage can be controlled by half-bridge boost converter or by bidirectional buck-boost converter. The relationship between the average value of inductor, PV and battery current over a switching cycle is given by IL = Ib + Ipv. It is evident that, Ib and Ipv can be controlled by controlling IL. Therefore, the MPP operation is assured by controlling IL while maintaining proper battery charge level. IL is used as inner loop control parameter for faster dynamic response while for outer loop, capacitor voltage across PV source is used for ensuring MPP voltage. An incremental conductance method is used for MPPT.

A. Limitations And Design Issues

The output voltage V_{dc} of transformer coupled boost dual half-bridge converter, depends on MPP voltage of PV array VPV mpp, the battery voltage V_b and the transformer turns ratio n.

III. PROPOSED CONTROL SCHEME FOR POWER FLOW MANAGEMENT

A lattice associated half and half PV-wind-battery based framework comprising of four power sources (grid, PV, wind source and battery) and three power sinks (network, battery and load), requires a control conspire for power flow management to adjust the power flow among these sources. The control reasoning for power flow management of the multi-source framework is produced in view of the power adjust standard. In the remain solitary case, PV and wind source produce their comparing MPP power and load takes the required power. For this situation, the power adjust is accomplished by charging the battery until it achieves its greatest charging current farthest point Ibmax. After achieving this farthest point, to guarantee control adjust, one of the sources or both need to go astray from their MPP control in view of the heap request. In the lattice associated framework both the sources dependably work at their MPP. Without both the sources, the power is attracted from the lattice to charge the battery as and when required. The condition for the power management of the system is given by:

$$V_{pv}I_{pv} + V_W I_W = V_b I_b + V_g I_g \quad (3)$$

The peak value of the output voltage for a single-phase full bridge inverter is,

$$\hat{V} = m_a V_{dc} \quad (4)$$

and the dc-link voltage is,

$$V_{dc} = n\,(V_{pv} + V_b) \quad (5)$$

Hence, by substituting for Vdc in (4), gives,

$$V_g = \frac{1}{\sqrt{2}} m_a n (V_{pv} + V_b) \quad (6)$$

In the boost half-bridge converter,

$$V_w = (1 - D_w)(V_{pv} + V_b) \quad (7)$$

Now substituting Vw and Vg in (3),

$$V_{pv}I_{pv} + (V_{pv} + V_b)(1 - D_w)I_w = V_b I_b + \frac{1}{\sqrt{2}} m_a n (V_{pv} + V_b) I_g \quad (8)$$

After simplification,

$$I_b = I_{pv}\left(\frac{1-D_{pv}}{D_{pv}}\right) + I_w\left(\frac{1-D_w}{D_{pv}}\right) - I_g\left(\frac{m_a n}{\sqrt{2}D_{pv}}\right) \quad (9)$$

from the above conditions it is obvious that, if there is an adjustment in power decreases from either PV or wind source, the battery current can be directed by controlling the lattice current Ig. Thus, the control of a solitary stage full-connect bidirectional converter relies on upon accessibility of network, power from PV and wind sources and battery charge status. Its control procedure is delineated utilizing Fig. 2. To guarantee the supply of continuous energy to basic burdens, need is given to charge the batteries. In the wake of achieving the most extreme battery charging current point of confinement Ibmax, the surplus power from renewable sources is bolstered to the grid. Without these sources, battery is charged from the framework.

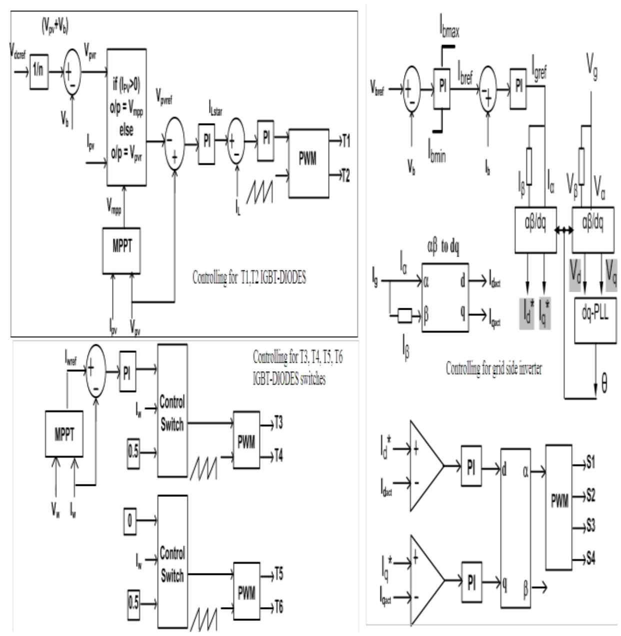

Fig.2. controlling for circuit shown in fig.1.

Future Scope:

- Maximum Power Point (MPP) can be tracked by using other techniques.
- For more reliable operation and better battery life, battery charge controller can be suitably designed.

IV. EXTENSION TOPIC

A. Multilevel Inverters

Power electronic converters, the coveted output voltage is integrated by joining a few separate dc voltage sources .Solar panels, energy units, batteries, and ultra capacitors are the most well-known free sources used. These converters have single-and three-phase applications. The principle focal points of multilevel converters are low harmonic distortion of the produced output voltage, low electromagnetic outflows, high productivity, the capacity to work at high voltages, and modularity .In genl, multilevel converters are classified into diode-cinched flying capacitor and fell H-link multilevel topologies. Applications of diode clamped multilevel converters incorporate high-power ac motor drives in buss, pumps, fans, and factories. The flying capacitor multilevel converter has been used as a piece of high-information transmission high-switching frequency applications, for instance, medium-voltage balance drives. Finally, the fell H-associate multilevel converter has been linked with high-control and stunning applications, for instance, static volt-ampere receptive dynamic channels, responsive power compensators, photovoltaic power change uninterruptible power supplies, and alluring reverbtion imaging. In addition, one of the creating applications for multilevel power electronic converters is electric-drive vehicles in which the balance motor is driven by batteries .The procedure used to switch fell H-link cells can be develop either in light of the fundamental switching frequency, i.e., staircase direction, or the beat width tweak (PWM) framework.

In the key switching frequency approach, the switching setbacks are less, however the music in the output voltage waveform appear at cut down frequencies. A couple of methods are proposed in the composition to explicitly wipe out sounds in the output waveforms of multilevel converters. In the PWM switching methodology, the sounds in the output waveform appear at higher frequencies, yet in light of a higher switching frequency, the switching loss are more noteworthy. Fig. 1 demonstrates the piece chart of a fell H-link inverter system, which comprises of fundamental and assistant H-link cells. In early executions every H-link cell was provided by an independent dc source. Afterward, look into demonstrated that just a single cell should be provided by a dc power source; the remaining cells can be encouraged by capacitors. The technique proposed utilizes the switching state excess for capacitor voltage regulation, where the voltage level of the helper cell more often than not is chosen to be a large portion of that of the primary H-link cell. In any case, examines have demonstrated that managing the capacitor voltage is not as simple as at first anticipated. The presence of repetitive switching states has been thought to be sufficient for capacitor voltage regulation. Be that as it may, the output current of the inverter and the time span of the repetitive switching states extraordinarily affect the charging or releasing examples of the substitution capacitors.

V. SIMULATION RESULTS

The steady state response of the system during the MPPT mode of operation is shown in Fig. 3. The values for source- 1 (PV source) is set at 35.4 V (Vmpp) and 14.8 A (Impp), and for source-2 (wind source) is set at 37.5 V (Vmpp) and 8 A (Impp). It can be seen that Vpv and Ipv of source-1, and Vw and Iw of source-2 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. The system response for step changes in the source-1 insolation level while operating in MPPT mode is shown in Fig. 5. Until 2 s, 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 source-1 insolation level is increased. As a result the source-1 power increases and both the sources continue to operate at MPPT as shown in Figs. 3 to 9. Though the source-1 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, insolation of source-1 is brought to the same level as before 2s. The power supplied by source-1 decreases. Battery continues to get charged at the same magnitude of current, and power injected into the grid decreases.

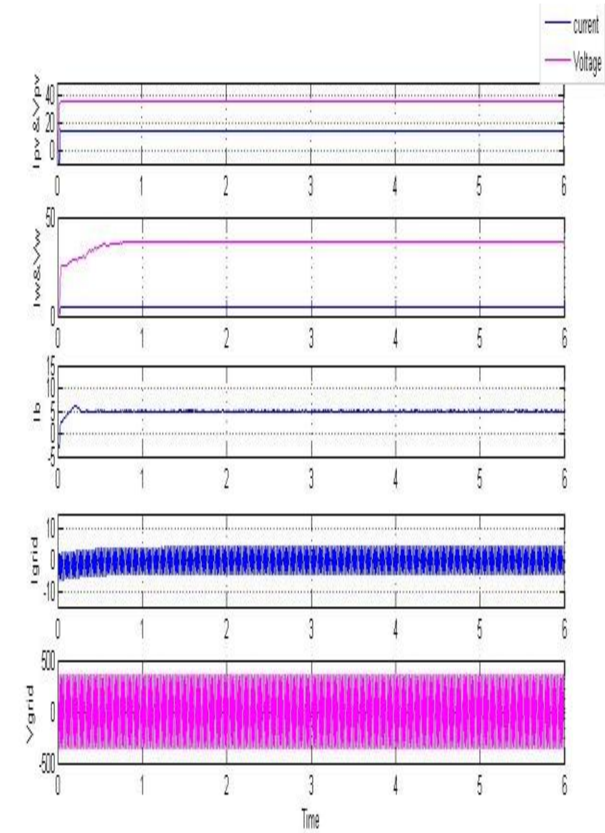

Fig.3. Ipv and Vpv, Iw and Vw, Ib, Igrid and Vgrid when both PV and wind sources are active.

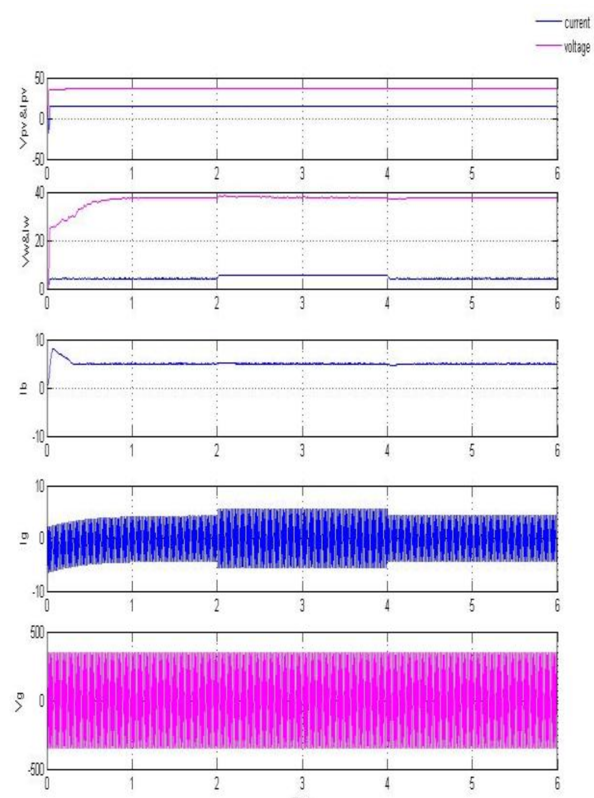

Fig.4. Ipv and Vpv, Iw and Vw, Ib, Igrid and Vgrid When wind sources increases .

The same results are obtained for step changes in source-2 wind speed level By connecting a multi level inverter we know the harmonics are going to decrease and that can be used in grid current and voltage. In this we are used a single phase diode clamped multilevel inverter on the grid side.

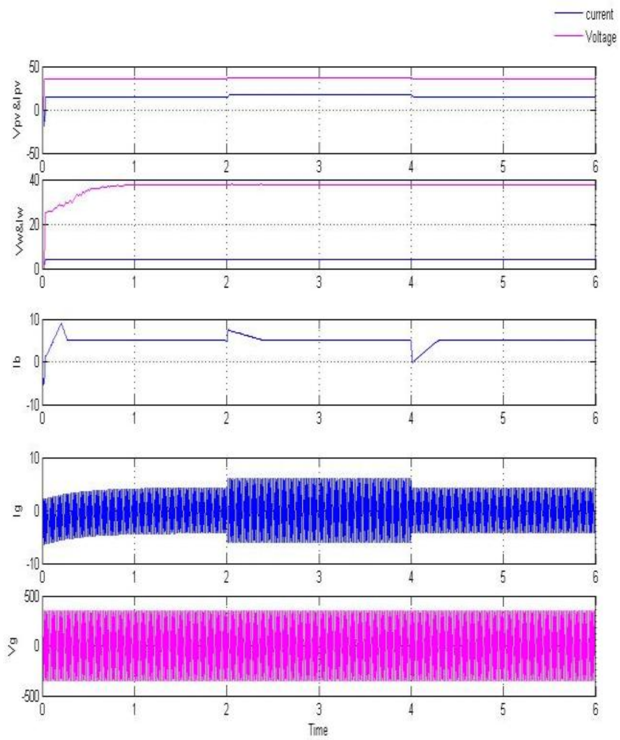

Fig.5. Ipv and Vpv, Iw and Vw, Ib, Igrid and Vgrid When PV sources increases.

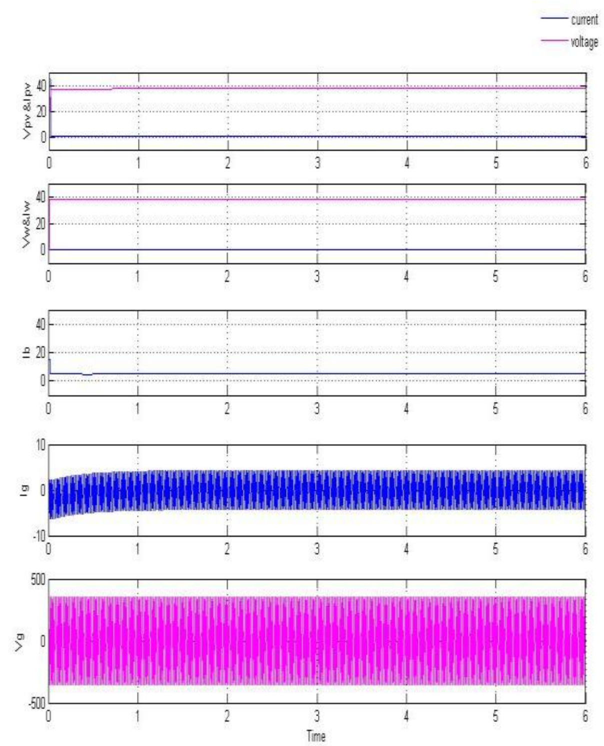

Fig. 6. pv and Vpv, Iw and Vw, Ib, Igrid and Vgrid When both PV and wind sources are inactive.

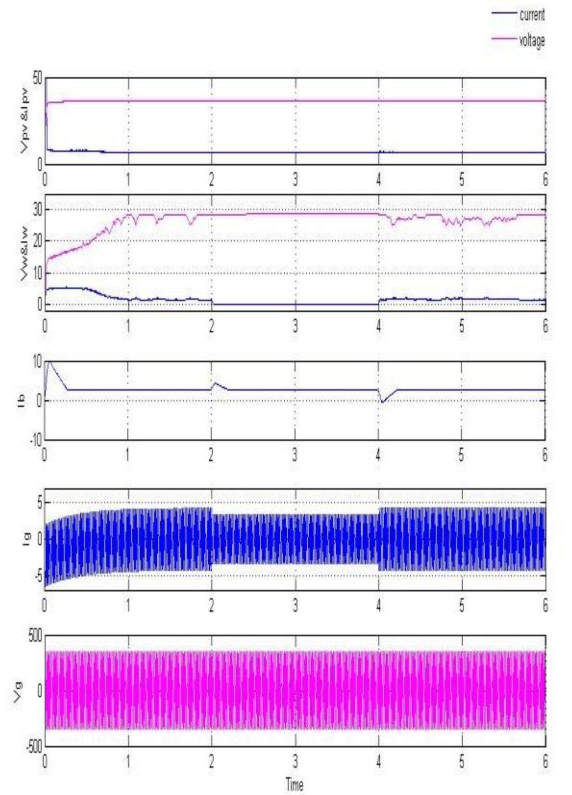

Fig.7. Ipv and Vpv, Iw and Vw, Ib, Ig and Vg When wind sources decreases suddenly.

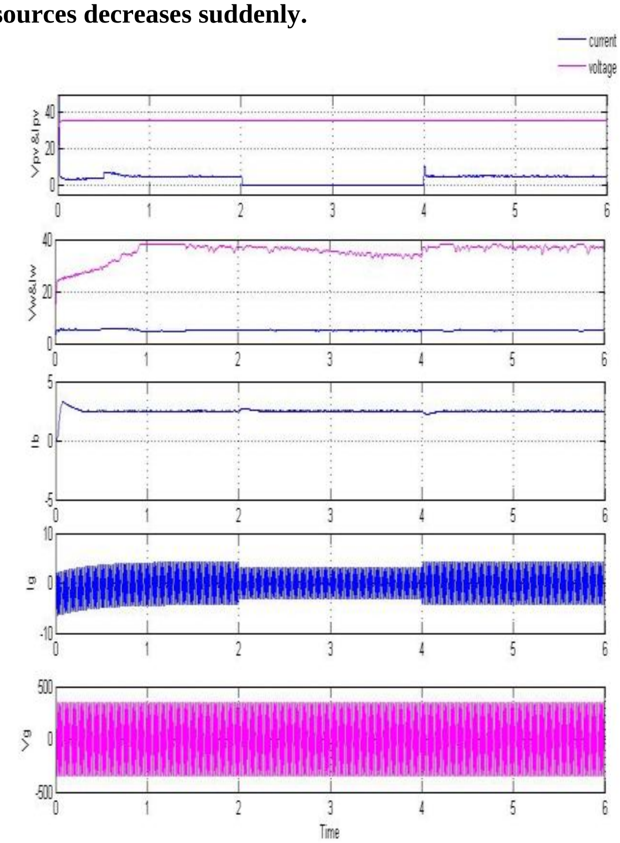

Fig.8. Ipv and Vpv, Iw and Vw, Ib, Igrid and Vgrid When PV sources decreases suddenly.

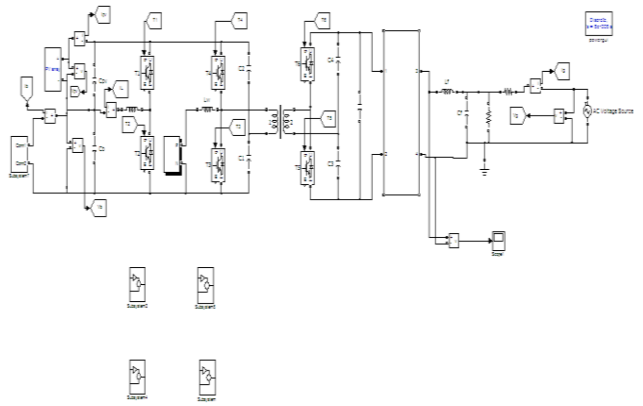

Fig.9. Simulation model for grid connected pv wind battery with multilevel inverter.

We can observe it in below table

TABLE I:

	I_g	V_g
Base	0.81%	0.10%
ext	0.08%	0.09%

VI. CONCLUSION

The proposed hybrid system provides an elegant integration of PV and wind source to extract maximum energy from the two sources. It is realized by a novel multi-input transformer coupled bidirectional dc-dc converter followed by a conventional full-bridge inverter. A versatile control strategy which achieves better utilization of PV, wind power, battery capacities without effecting life of battery and power flow management in a grid-connected hybrid PV-wind-battery based system feeding ac loads is presented. Detailed simulation studies are carried out to ascertain the viability of the scheme, by placing multilevel inverter we observer the improvement.

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Author’s Profile:

V.Sunil Kumar Reddy, working as a Head Of The Department, EEE in MJR College of Engineering & Technology, Piler, A.P, and he obtained Graduation Degree in Electrical and Electronics Engineering from SKIT in 2011, affiliated to JNTUA University, he obtained Master’s Degree in Electrical Power Systems from JNTUA, A.P. He is having 6 years of teaching experience in Engineering Colleges, Email: skit07250@gmail.com.

Kunati Madhu, currently he is pursuing his Master Degree in the department of Electrical & Electronic Engineering, MJR College of Engineering&Technology,Piler, A.P. India,
Email: madhuyadav11205@gmail.com.