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Hybrid Source Based Transformer Coupled Bidirectional Dc-Dc Converter for Domestic Applications

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Abstract—

Hybrid power system can be utilized to decrease energy storage necessities. There is expanding interest for the utilization of exchange or sustainable power sources to accomplish perfect and ease power for Residential Application the PV-wind hybrid system restores the most reduced unit cost esteems to keep up a similar level of DPSP when contrasted with independent solar and wind systems. For all heap requests the levelised energy taken a toll for PV-wind hybrid system is dependably lower than that of independent solar PV or wind system. The PV-wind hybrid alternative is techno-financially feasible for provincial zap. This paper proposes a novel incorporated converter topology for interfacing between the energy storage system and the dc transport for a private microgrid application The proposed coordinated full-bridge dc–dc converter displays the accompanying elements: low number of dynamic gadgets contrasted with the converters generally connected to comparative applications, low information and yield current swell, high voltage proportion, bidirectional power stream, and galvanic disengagement.

Keywords: Battery charge control, full-bridge bidirectional converter, hybrid system, solar photovoltaic (PV), coupled boost dual-half-bridge bidirectional converter, wind energy.

I. Introduction

The interest for energy increments quickly because of the consumption of petroleum derivative stores. This outcomes in the utilization of sustainable power source assets, for example, solar photovoltaic and wind sources due to their eco-accommodating nature and cost viability. The basic innate disadvantage of Solar photovoltaic and wind systems are their irregular nature. To supply steady and consistent power, the battery is utilized as a reinforcement. This reconciliation of energy assets with the previously mentioned advantage brings about hybrid wind-PV systems. By fusing most extreme power point following calculations, the productivity and unwavering quality can be moved forward. A bidirectional various info non-secluded dc-dc converter is introduced to interface a ultra-capacitor and a battery for vehicular applications. The converter is fit for drawing power from various energy sources to supply the request of vehicle burdens [1]. At each information port, a few parts can be shared. Be that as it may, the adaptability of energy conveyance is constrained. The parallel or arrangement setup can be reached out at the yield to infer multi-port dc-dc converters [2]. The circuit structure is streamlined and the power thickness is enhanced in light of the fact that the power gadgets are totally partaken in the essential side. The two channel inductors in the bi-directional buck-support converters and the segregated transformer in the full-bridge topology are incorporated and supplanted by the coupled inductors. Facilitate, the beat width balance (PWM) in addition to - stage move (PPS) control system is acquainted with accomplish voltage direction inside a specific working extent [3]. In [4], the converter is fascinating for hybridizing sustainable power sources, for example, photovoltaic (PV) source, energy unit (FC) source, and battery. To bolster dc stacks, a low limit multi-port converter for a hybrid system is introduced. In [5], some power ports share a shared view and these power ports are disconnected from the staying, for coordinating port voltage levels. By utilizing beat width balance and stage edge move control plot, Voltage directions between any two ports can be accomplished. B. Mangu [6], proposed a system that expects to fulfill the heap request, deal with the power spill out of various sources, infuse the surplus power into the lattice, and charge the battery from the matrix as and when required. The proposed converter engineering has diminished number of power transformation stages with less segment check and decreased misfortunes contrasted and existing framework associated hybrid systems. This enhances the effectiveness and the unwavering quality of the system. All the condition of workmanship on converter topologies introduced so far can supply just single stage burdens. Though in the proposed topology, voltage boosting ability is expert by a voltage multiplier. Consequently, it can be utilized for three stage household applications. The proposed system has PV source, wind source, load, framework, and battery. Consequently, a power stream administration system is expected to adjust the power stream among every one of these sources. To create "clean" and proficient energy utilizing hybrid sustainable power source, keeping in mind the end goal to diminish both ecological contamination and the energy reliance. To Supply un-interruptible power to loads. To diminish the quantity of power transformation organizes and to guarantee departure of surplus power from the two inexhaustible sources to the matrix, and charging the battery from the network as and when required.

II. Related Work

With the reason for enhancing the proficiency of the drivetrain and to limit the reliance on the oil fills at least two wellsprings of the impetuses (counting ICE) are being utilized in the vehicles. This are known as the Hybrid Electric Vehicles (HEVs). The topological diagram of the different hybrid drive trains and the comparision between them has been introduced in [1, 2, 4]. The part and the prerequisite of the power gadgets and dc converter in the HEV innovation was investigated and clarified in [3, 5]. The comparision between the different no detached Bidirectional DC-DC converters on the premise of their execution has been done in [7,8,10]. Engine choice and the different drive prepare issues depending up on the footing drive necessities and operational execution has been done in [5, 6]. The power arrange plan technique and the ZVRT exchanging was presented in [9]. It likewise the executed the DCM operation for the power nook sity boost of the converter. The ideas of the delicate exchanging strategies for the effectiveness change and the gadget stretch decrease was displayed in the [4, 5]. The uni ed controller for a present mode controlled bidirectional DC-DC converter was introduced in [6, 8].

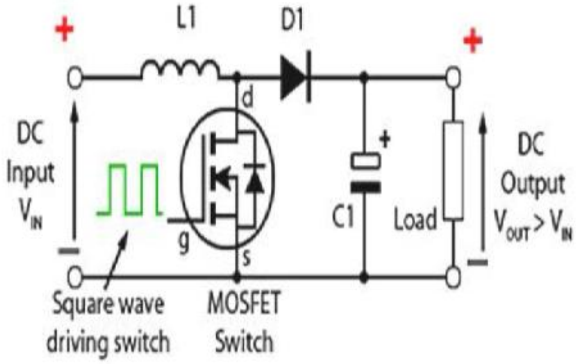
III. DC-DC CONVERTER

A DC-DC converter [3] is an electronic circuit which changes over a wellspring of DC starting with one voltage level then onto the next. The DC-DC converters are generally utilized as a part of controlled switch mode DC control supplies. The contribution of these converters is an unregulated DC voltage, and in this way it will be vacillated. In these converters the normal DC yield voltage must be controlled to be compared to the coveted esteem in spite of the fact that the info voltage is evolving. The control of the normal yield voltage in a DC-DC converter is a component of the on-time of the switch, the beat width and the exchanging recurrence. The yield voltage control relies on upon the obligation proportion D. The obligation proportion is characterized as the proportion of the on-time of the switch and the exchanging time frame. Obligation cycle is given by the Equation(1)

A. DC-DC Boost Converter

A converter that yields a voltage higher than the information voltage is called Boost converter [1]. Consequently help converter is regularly alluded to as a stage up converter or controller. The essential for a lift converter comprises of an inductor, diode, capacitor and switch. The DC contribution to a lift converter can be from many sources and in addition batteries, for example, amended AC from the mains supply, or DC from sun based boards, power modules, dynamos and DC generators. The DC input voltage is in arrangement with an extensive inductor going about as a present source. A switch in parallel with the present source and the yield is killed intermittently, giving vitality from the inductor and source to build the normal yield voltage.

The circuit chart of DC-DC support converter is appeared in Figure



1.

Fig. 1. Circuit diagram of DC-DC boost converter

The average output voltage is given by Equation 2.

$$V_O = \frac{V_{IN}}{1 - D} \qquad (2)$$

Where,

VO is the output voltage *VIN* is the input voltage *D* is the duty cycle

The charging and discharging operation of the DC- DC boost converter is based on the on and off condition of the switch in the circuit.

IV. MULTI-INPUT DC-DC CONVERTER

Numerous Input DC-DC converters are the uniqueSolution to join a few information control sources whose voltage levels as well as power limit are distinctive and to get managed yield voltage for the heap from them. Inmany applications, there is a prerequisite for numerous power sources to be associated together, giving the ability to a solitary burdens. Figure 2 demonstrates the different converter for various sources.

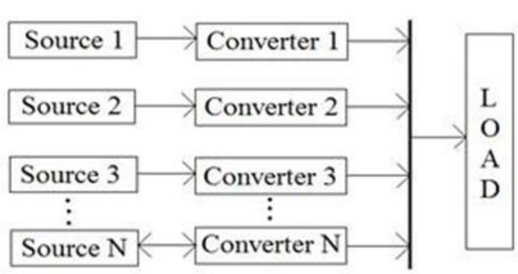


Fig. 2. Separate converters for each source

Source 1 to Source N-1 can be made out of any kindof vitality source mixes, for example, wind turbines, PV modules, FC, miniaturized scale turbines as well as electric matrix, and Source N could be a capacity unit, for example, a battery, ultra-capacitor, flywheel or superconducting attractive vitality stockpiling framework. All the vitality sources are unidirectional where the capacity component is bidirectional which can perform both charging and releasing operations. A solitary Multi-Input DC-DC Converter[18] replaces a few number of parallel associated single converters is appeared in Figure 3.

Fig. 3. An MIC for all sources

The structure of the two-input DC-DC boost converter is represented in Figure 4. The converter interfaces two input power sources V1 and V2, and a battery as the storage element. This converter is suitable alternative for hybrid power systems of PV, FC, and wind sources. Therefore, V1 and V2 are shown as two dependent power sources that their output characteristics are determined by the type of input power sources. In the converter structure, two inductors L1 and L2 make the input power ports as two current type sources, which result in drawing smooth DC currents from the input power sources. The RL is the load resistance, which can represent the equivalent power feeding an inverter.

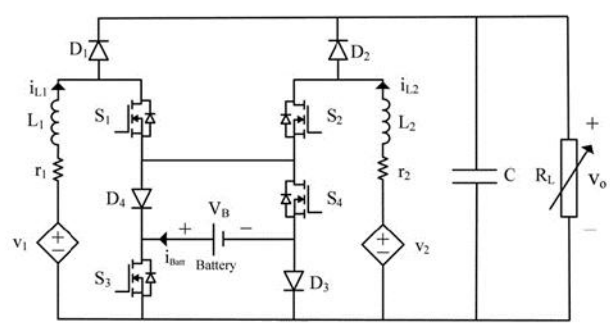


Fig. 4. Circuit topology of two-input DC-DC converter

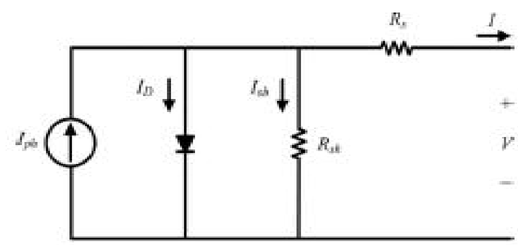
Four power switches S1, S2, S3 and S4 in the converterstructure are the primary controllable components that control the power stream of the half and half power framework. As like the customary lift converters, diodes D1 and D2 direct in correlative way with switches S1 and S2. The converter structure demonstrates that when switches S3 and S4 are turned ON, their comparing diodes D3 and D4 are contrarily one-sided by the battery voltage and afterward blocked. Then again, kill condition of these switches makes diodes D3 and D4 ready to direct information streams iL1 and iL2. In half breed control framework applications, the info control sources ought to be misused in ceaseless current mode.

V. PV SOURCE MODELLING

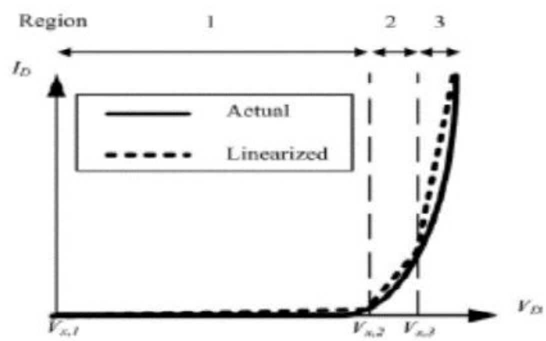
PV generator as input source has significant effect on the converter dynamics. The nonlinear V −I characteristic of a PV generator can be modeled using current source, diode, and resistors. The single-diode model shown in Fig. 1 (a) is widely used for the PV source modeling. This model gives an exchange off amongst exactness and intricacy. Thevenin's comparable model with non-consistent voltages and resistances has been proposed into firmly rough the normal for PV generator. The Thevenin's based model gives less difficult expectation and calculation to the greatest power purpose of PV exhibit under various working conditions. Thevenin's hypothesis is not substantial for a nonlinear model, but rather the nonlinear model could be spoken to by a direct one with non-consistent parameters. In for instance, the piece-wise linearization is utilized to linearize the diode. The parameters in Fig. 1(a) can be evaluated utilizing the maker's datasheet. As appeared in Fig. 1(b), the real diode trademark has been isolated into three locales and the trademark in every district is approximated as a straight line. Each line can be additionally spoken to by an arrangement of voltage source Vx,n and resistance one of the limit focuses with the end goal that the operation now has no guess mistake. The single-diode model of the PV generator with linearize diode is appeared in Fig. 1(c), where the diode is approximated by the voltage source Vx,n and resistance Rd . The estimations of Vx and Rd are subject to the operation district of the PV generator. The Thevenin's comparable model of Fig. 2(c) is appeared in Fig. 1(d). From the inference in, the Vpv_th,n and Rpv_ th,n can be ascertained by

$$V_{pv-th,n} = V_{x,n} + R_{D,n} \cdot \frac{R_{sh} \cdot I_{ph} - V_{x,n}}{R_{sh} + R_{D,n}}$$

$$R_{pv-th,n} = R_s + \frac{R_{sh} \cdot R_{D,n}}{R_{sh} + R_{D,n}} \quad (1)$$



(a)



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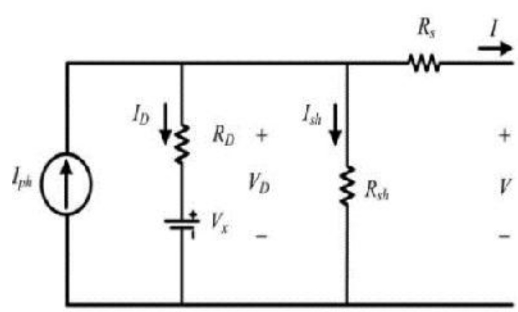
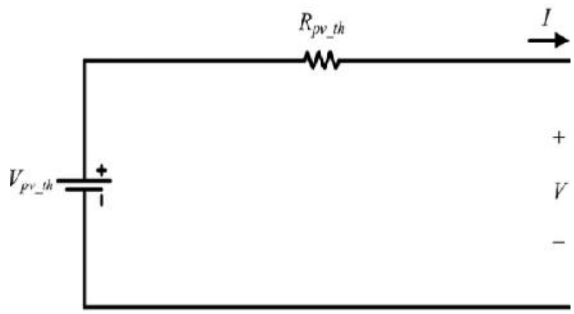


(c)



(d)

Fig. 5. Thevenin's equivalent circuit derived from the single-diode model.(a) Single-diode model of a PV generator.(b) V −I characteristic of diode: actual and linear approximation . (c) Single-diode model with linearize diode.(d) Thevenin's equivalent circuit for a single-diode model with linearized diode.

VI. WIND ENERGY MODELING

A. Power Output from an Ideal Turbine: The kinetic energy in a parcel of air of mass, m, flowing at speed, vw in the x direction

$$U = \frac{1}{2} m v_w{}^2 = \frac{1}{2}(\rho A x) v_w{}^2$$

Where, U is the kinetic energy in joule, A is the cross-sectional area in m2, is the air density in kg/m3, and x is the thickness of the parcel in m. If we visualize the parcel as in Fig. 6 with side, x, moving at speed, vw (m/sec), and the opposite side fixed at the origin, we see the kinetic energy increasing uniformly with x, because the mass is increasing uniformly.

The power in the wind, Pw, is the time derivative of the kinetic energy:

$$P_w = \frac{dU}{dt} = \frac{1}{2}\rho A v_w{}^2 \frac{dx}{dt} = \frac{1}{2}\rho A v_w{}^3$$

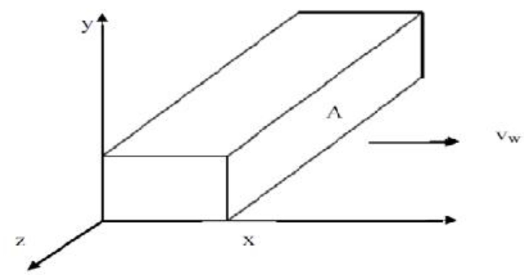


Fig. 6 Packet of air moving at speed, vw

The mechanical power extracted is then the difference between the input and output power in the wind:

$$P_{m,ideal} = P_1 - P_4 = \frac{1}{2}\rho(A_1 v_{w1}^3 - A_4 v_{w4}^3) = \frac{1}{2}\rho(\frac{8}{9} A_1 v_{w1}^3)$$

This states that 8/9 of the power in the original tube of air is extracted by an ideal turbine. This tube is smaller than the turbine, however, and this can lead to confusing results. The normal method of expressing this extracted power is in terms of the undisturbed wind speed, vw1, and the turbine area, A2. This method yields

$$P_{m,ideal} = \frac{1}{2}\rho\left[\frac{8}{9}\left(\frac{2}{3}A_2\right)v_{w1}^3\right] = \frac{1}{2}\rho\left(\frac{16}{27}A_2 v_{w1}^3\right)$$

The factor 16/27 = 0.593 is called the Betz coefficient. It shows that an actual turbine cannot extract more than 59.3 percent of the power in an undisturbed tube of air of the same area. In practice, the fraction of power extracted will always be less because of mechanical imperfections. A good fraction is 35 – 40 % of the power in the wind under optimum conditions, although fractions as high as 50 % have been claimed.

Aturbine extracts 40 % of the power in the wind, is extracting about two-thirds of the amount that would be extracted by an ideal turbine. This is rather good, considering the aerodynamic problems of constantly changing wind speed and direction as well as the frictional loss due to blade surface roughness.

B. Power Output from Practical Turbines:

The fraction of power extracted from the power in the wind by a practical wind turbine is usually given by the symbol Cp, standing for the coefficient of performance or power coefficient. Using this notation and dropping the subscripts of Eq. 6 the actual mechanical power output can be written as

$$P_m = C_p(\frac{1}{2}\rho A v_w^{\ 3}) = \frac{1}{2}\rho\pi R^2 v_w^{\ 3} C_p(\lambda,\beta)$$

$$\lambda = \frac{\omega_R R}{v_w}$$

$$\omega_R = \frac{2\pi n}{60}$$

Description of the Proposed System

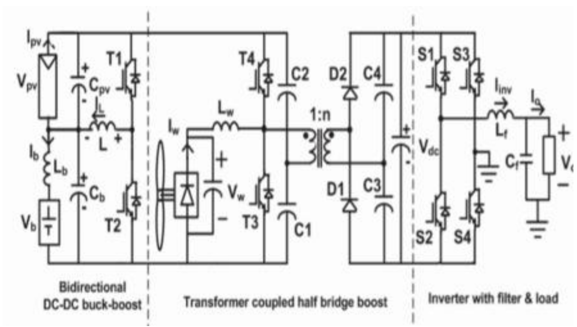


Figure 7**.** Proposed System Configuration

The proposed converter consist of dual half bridge converter ,boost converter and the full-bridge inverter ,solar PV panel, wind turbine and battery storage the half bridge boost converter has two DC link on higher frequency tranformer.so controlling the voltage on one of dc link, ensures the controlling the voltage of another side, this makes the control is simple. The bidirectional buck boost converter is connected on primary side of the transformer and inverter is integrated on the secondary side of the converter.

The galvanic isolation between the sources and load is achieved by the transformer. The bidirectional converter is used to supply the continuous power supply from the solar PV panel with the battery charging//discharging control. The half bridge converter is used to supply the power from the wind generator. The required 400v dc link voltage is achived only by four controllable switches, this reduced the number of circuit components and also increase the efficiency compared with the existing standalone schemes.

MPPT Mode for Wind Generator

When switch T_3 is ON, the current flowing through the source inductor increases. The capacitor C_I discharges through the transformer primary and switch T_3 as shown in Fig. 2 In secondary side capacitor C_3 charges through transformer secondary and anti-parallel diode of switch T_5.

When switch T_3 is turned OFF and T_4 is turned ON, initially the inductor current flows through anti- parallel diode of switch T_4 and through the capacitor bank. During this interval, the current flowing through diode decreases and that was flowing through transformer primary increases. When current flowing through the inductor becomes equal to that flowing through transformer primary, the diode turns OFF.

Since, T_4 is gated ON during this time, the capacitor C_2 now discharges through switch T_4 and transformer primary. During the ON time of T_4, anti-parallel diode of switch T_6 conducts to charge the capacitor.

During the ON time of T_4, the primary voltage $V_{P\ =}$-

$V_{c1.}$

The secondary voltage VP=nV_P or V_P= nV_{C1} and voltage across primary inductor LW is Vw. When T_5 is turned OFF and turned T_5 ON, the primary voltage

VP =Vc2.

The PV array voltage exhibits narrow variation in voltage range with wide variation in environmental conditions. On the other hand, the battery voltage is generally stiff and it remains within a limited range over its entire charge-discharge cycle. Further, limits the operating range of the batteries used in a standalone scheme to avoid overcharge or discharge.

Power Flow Management

The hybrid PV-wind-batte ry based system consisting of four power sources (grid, PV, wind source 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. The control philosophy for power flow management of the multi-source system is developed based on the power balance principle. In the stand-alone case, PV and wind source generate their corresponding MPP power and load takes the required power. In this case, the power balance is achieved by charging the battery until it reaches its maximum charging current limit Ibmax.

VII. RESULTS VERIFICATION BY SIMULINK

Detailed simulation studies are carried out on MATLAB/Simulink 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 I

Parameter	Value
Solar PV power Wind power Switching frequency	525W (Impp=14.8A) (Vmpp=35.4V) 300W (Impp=8A) 15kHZ
Transformer turns ratio	5.5
Inductor-half bridge boost converter,	500 μH
Inductor-bidirectional	3000
Primary side capacitors	500
Secondary side capacitors	500 secondary side

The steady state response of the system during the MPPT mode of operation is shown in Fig. 4. 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 (Imppp). 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.

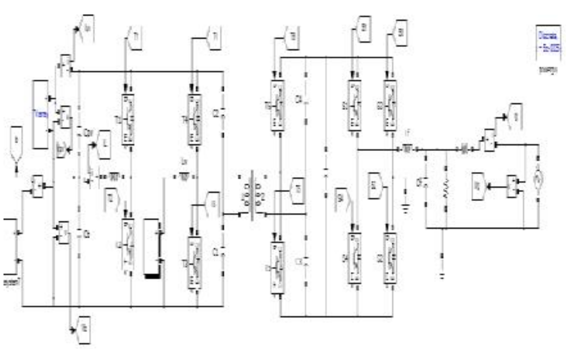
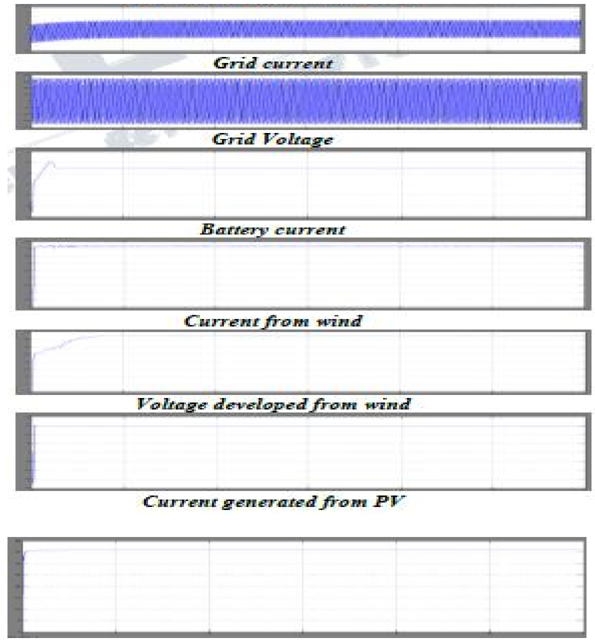
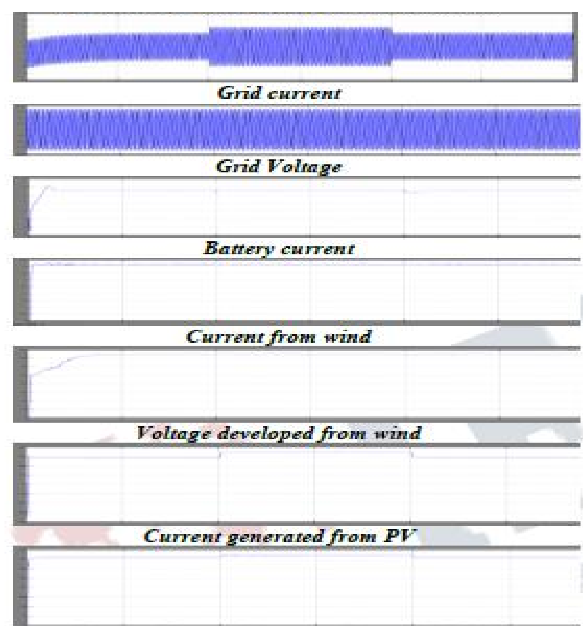


Fig.8. Simulink block diagram



Voltage generated from PV

Fig. 9. Steady state operation in MPPT mode.



Voltage generated from PV

Fig.10. Response of the system for changes in insolation level of source-1(PV source) during operation in MPPT mode.

VIII. CONCLUSION

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. The capability of the system to operate either in grid feeding or stand-alone mode. 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.

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