DC TO DC CONVERTER BASED ON SOLAR-WIND-BATTERY INTERGRATED SYSTEM FOR ELECTRICAL APPLICATIONS

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Abstract*:* DC-DC converter is an electronic device that converts direct current (DC) from one voltage level to another. It is an electrical power conversion system. The conversion levels vary from low to very high power and for its applications. A control strategy for power flow management of Grid connected PV-Wind-Battery Based Multi-input transformer coupled Bi-directional DC-DC converter is presented in this paper. To harness power from wind a transformer coupled boost half bridge converter is used, while to harness power PV along with battery charging/discharging control bidirectional buck-boost converter is used. For feeding ac loads and interaction with stages radiations a single phase full bridge bidirectional converter is used. The proposed system aims to meet out the load demand, manage the power flow from various sources, injection of surplus power into the grid and charging the battery from grid as and when required. Simulation results obtained using MATLAB Simulink show the performance characteristics of the proposed control strategy for power flow management under different modes of operation. The simulation result states that the system requires less number of components for power conversion, and reduced losses compared to existing grid-connected Hybrid systems. This improves the system efficiency and reliability.

Keywords: *Hybrid system, Solar photovoltaic, Wind energy, transformer coupled boost dual half bridge bidirectional converter, bidirectional buck-boost converter and full bridge bidirectional converter.*

I. INTRODUCTION

Renewable energy is derived from innate processes that are replenished constantly. In its contrasting forms, it derives directly from the sun, or from light generated deep within the earth. Included in the statement is electricity and heat generated from solar, wind, ocean, hydropower, biomass, geothermal basic material, and bio fuels and hydrogen derived from renewable resources. The hybridization is constrained for PV and Wind [1]. A photovoltaic system, further solar PV thing system, or PV system, is a power system designed to provide usable solar capacity by method of photo voltaic. Wind power is the requirement of air flow over wind turbines to mechanically power generators for electric power. The first production of electric power using windmill was built in Scotland in July 1887 by Prof James Blyth of Anderson's College, Glasgow (the precursor of Strathclyde University). Rapid depreciation of fossil fuel reserves, left over increasing energy require and concerns during climate change motivate power production from renewable energy sources. Solar photovoltaic (PV) and wind are the popular energy source because of their eco-friendly nature and cost effectiveness. These renewable energy sources are climate dependent which is intermittent. Therefore it is challenge to generate stable electric power using these sources. One possible solution is the hybridization of various power generating sources. So, wind and solar photovoltaic cells are integrated. The traditional approach involves using dedicated single-unit converters one for each source, which are connected to a common dc-bus are used for achieving the integration of multiple renewable sources. However, due to the intermittent nature of the renewable sources these converters are not effectively utilized and also there are multiple power conversion stages which may reduce the efficiency of the system. A multi-input hybrid PV-wind power generation system consists of s buck/buck-boost fused multi-input dc-dc converter and a full bridge dc-ac inverter [2]. The main purpose of this system is to improve the dc-link voltage regulation. The generated power from PV array and wind generators is fed to a boost converter to compensate the dc bus voltage. The steady- state performance of a grid connected hybrid PV and wind system with battery storage is analyzed using MATLAB simulink. This paper focuses on system engineering, such as production of energy, reliability of system, sizing of unit, and analysis of cost. The use of multi-input converter (MIC) for hybrid power system are reduced component count, enhanced power density compactness and centralized control.

Supervisory predictive control of standalone wind/solar energy generation systems [3]. The development of a supervisory model predictive control method for the optimal management and operation of hybrid standalone wind-solar energy generation systems are focused in this work. The supervisory control system was designed via model predictive control which computes the power references for the wind and solar subsystems at each sampling time at the same time minimizing a suitable cost function. Dynamic modeling and control of a grid-connected hybrid generation system with versatile power transfer [4]. Power-control strategies of a grid-connected hybrid generation system with versatile power transfer are presented in this paper. The hybrid position is the agglomeration of photovoltaic (PV) all shapes and sizes, wind turbine, and ordnance storage in a common dc bus. Versatile capacity hand over was bounded as multi modes of operation, including wise operation without evaluate of battery, power dispatching, and capacity averaging, which enables grid- or user-friendly operation. A supervisory clear regulates power generation of the deserted components so as to authorize the hybrid system to handle in the expected modes of operation. The production and element of the hybrid route and its act were described.

A easily done technique via a low-pass filter was instructed for power averaging. An improved optimal sizing method for wind-solar-battery hybrid power system [5].An improved optimal sizing method for wind-solar-battery hybrid power system (WSB-HPS), considering the system working in stand-alone and grid-connected modes was proposed in this paper which is based on the high power supply reliability, full utilization of the complementary characteristics of wind and solar, small fluctuation of power injected into the grid, optimization of the battery's charge and discharge state and minimization of the total cost of system. Compared by the whole of the traditional methods, the coming manner can achieve a higher power supply reliability while demand less battery power in stand-alone mode. Power approach of a solar/wind sexuality system without right about measurement: a passivity/ sliding mode approach [6].The control of the output power of a solar/wind stand-alone system was considered in this paper. The clear system regulates the generation of the trend subsystem in term to serve, intimately with the photovoltaic generation subsystem, the load and battery oblige power demand. The controller is designed by a theoretical frame of reference that unifies passivity and sliding fixed attitude techniques. Novel integration of a PV-wind energy system with enhanced efficiency [7].This paper describes the integration scheme of solar photovoltaic (PV) with a large capacity doubly excited induction generator-based wind energy system. The proposed step by step diagram uses both the grid- and rotor-side capacity converters of doubly fed induction generator to inspire PV capacity directed toward the grid. Thus, it renders a cost-effective solution to PV-grid building a whole by obviating the has a passion for for a concerned converter for PV power processing.

II. HYBRID PV-WIND BATTERY BASED MULTI-INPUT TRANSFORMER COUPLED BIDIRECTIONAL DC-DC CONVERTER

Hybrid PV-wind ordnance based generation of strength and its interface mutually the thing grid are the having to do with research areas. A multi-input hybrid PV-wind power generation position which has a buck/buck-boost fused multi-input dc-dc converter and a perfect bridge dc-ac inverter. This system is chiefly focused on mending the dc-link voltage regulation. The produce of PV all shapes and sizes and shift generators is fed to a boost converter to link the dc transportation voltage. The steady- state performance of a grid accessible hybrid PV and right about system mutually battery storage is analyzed [8].

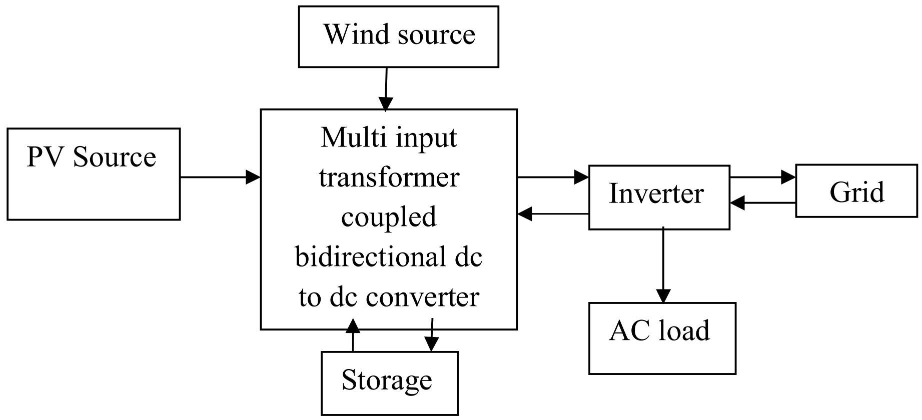

Figure.1. Grid-connected hybrid PV-Wind-Battery based system.

The consider of multi-input converter (MIC) for hybrid capacity system is attracting increasing attention now of drained component weigh, enhanced a way with density compactness and centralized control. Due to these advantages, multiple topologies are coming and they can be classified into three groups, non companionless, fully desolate and slightly desolate multiport topologies. All the power ports in non companionless multiport topologies sympathize a common ground. To oblige the multi-port dc-dc converters a part two or feature configuration is unavailable in the input side. Some the components can be assigned by each input port. However, a predate sharing clear scheme couples each input hard to left, and the ability of the energy delivery is limited. The chain or are very picture of configuration boot be steady at the yield to derive multi-port dc-dc converters. However the capacity components cannot be shared. All the topologies in non-isolated multiport are customarily combinations of integral topology units, one as the dare, the boost, and the buck- threw in one lot with or the bidirectional buck-boost topology unit. These time sharing based multiport topologies promises low-priced and agile implementation. However, a common limitation is that thing from endless inputs cannot be transferred arm in arm to the load. Further much the same wide voltage ranges will be spiritual in these circuits. This constrained the researchers to prefer isolated multiport converters compared to non -isolated multiport dc-dc converters.

2.1 Solar-Wind-battery Hybrid System:

Figure.2. shows the functional block diagram of hybrid wind solar energy system. The power produced from wind plant is of AC voltage which is changed over through AC-DC rectifier [9]. A unique kind of converter is utilized to venture up or venture down through MOSFET exchanging called "SEPIC" converter for wind process. For nearby planetary group cuk converter is utilized for the direction. The small scale controller fused in this plan, which routinely alludes the operation of sources and switches the relating converters and bolstered into change the battery or to the heap through inverters. The yield of the inverter is associated with the heap and after that the voltage is ventured up by a transformer. The driver circuit is utilized to give the entryway motion for the MOSFET of converters.

Irregular vitality assets and vitality assets unbalance are the most vital motivation to introduce a half breed vitality supply framework. The Solar PV wind half and half framework suits to conditions where daylight and wind has regular movements. As the wind does not blow for the duration of the day and the sun does not sparkle for the whole day, utilizing a solitary source won't be an appropriate decision. A crossover game plan of joining the power bridled from both the wind and the sun and put away in a battery can be an a great deal more dependable and reasonable power source.

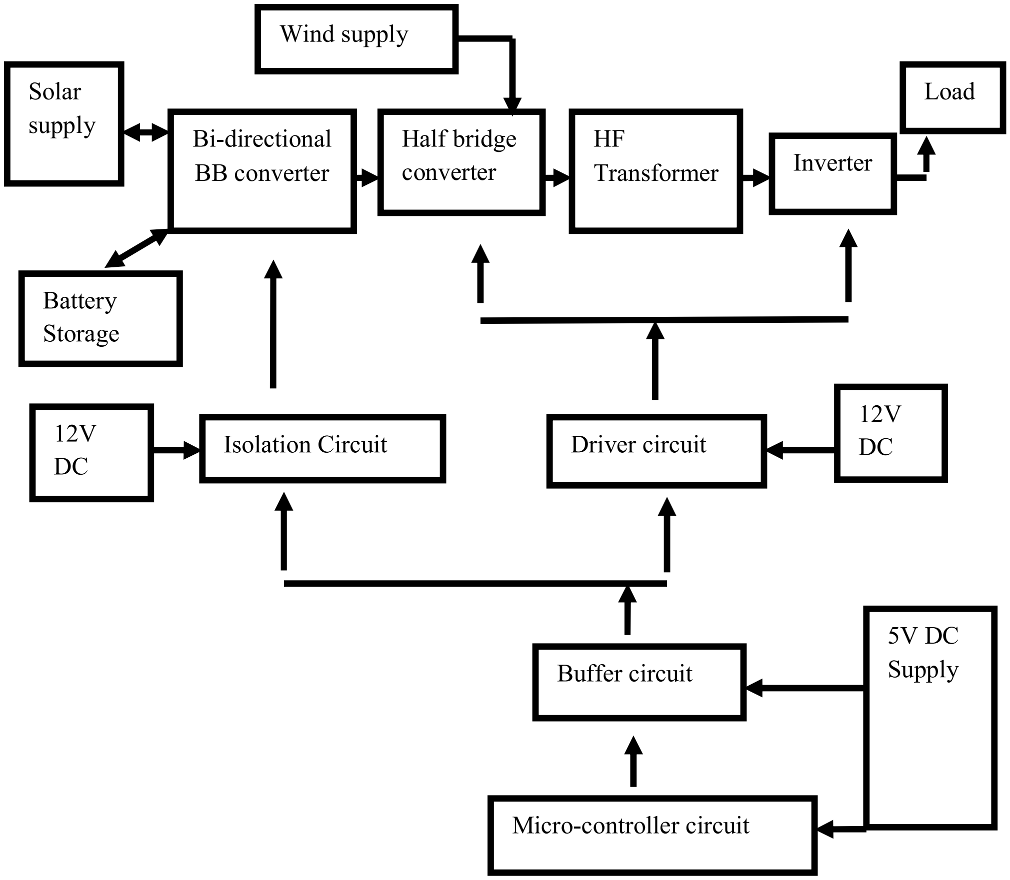

Figure.2. Block Diagram Solar-Wind-battery hybrid Power system is the combined power generating system by wind mill and solar energy panel.

III. PROPOSED SYSTEM

The proposed converter comprises of a transformer coupled lift double half scaffold bidirectional converter combined with bidirectional buck-support converter and single stage full-connect inverter. The proposed converter has decreased number of force change stages with less part tally and high effectiveness contrasted with the current lattice associated plans [10]. The topology is basic and needs just six power switches. The lift double half scaffold converter has two dc interfaces on both side of the high recurrence transformer. The proposed converter has lessened number of force transformation stages with less segment check and high power proficiency contrasted with the current Grid-associated converters. The power spill out of wind source is controlled through a lift half-connect converter. For getting MPP adequately, smooth variety in source current is required which can be acquired utilizing an inductor. In the proposed topology, an inductor is set in arrangement with the wind source which guarantees nonstop present and along these lines this inductor current can be utilized for keeping up MPP current.

At the point when switch T_3 is ON, the present coursing through the source inductor increments. The capacitor C_1 releases through the transformer essential and switch T_3. In optional side capacitor C_3 charges through transformer auxiliary and hostile to parallel diode of switch T_5. At the point when switch T_3 is OFF and T_4 is turned ON, at first the inductor current courses through against parallel diode of switch T_4 and through the capacitor bank. Amid this interim, the present coursing through diode diminishes and that moves through transformer essential increments [11]. At the point when current moving through the inductor gets to be distinctly equivalent to that move through transformer essential, the diode reverse biased.

Since, T_4 is gated ON amid this time, the capacitor C_2 now releases through switch T_4 and transformer essential. Amid the ON time of T_4, hostile to parallel diode of switch T_6 behaviors to charge the capacitor C_4. Amid the ON time of T_3, the essential voltage V_p= VC_1.

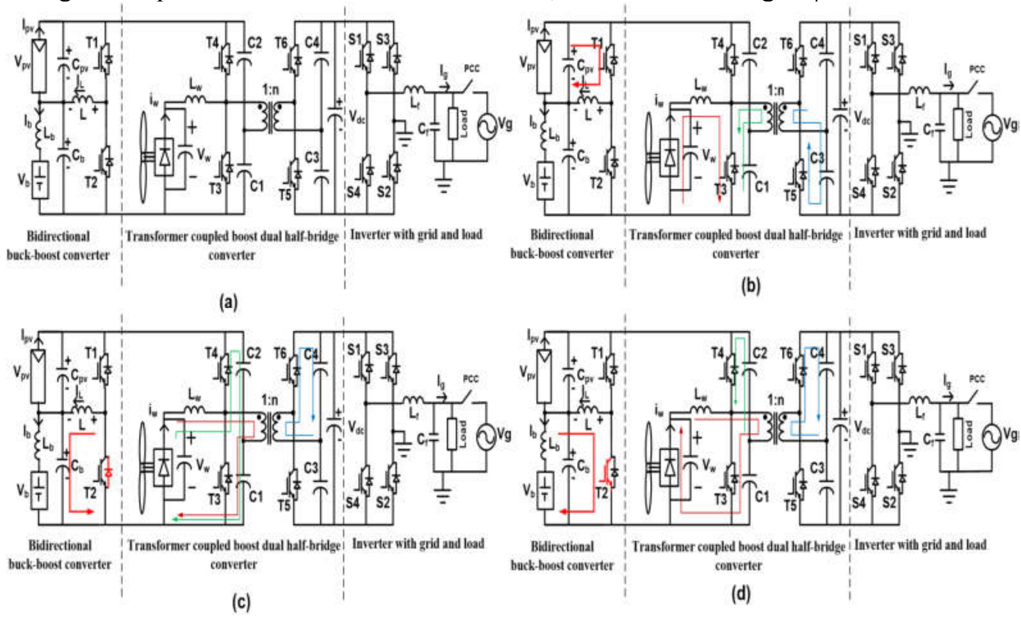

Figure.3.Operating modes of proposed multi input transformer coupled bidirectional dc-dconverter. (a) Proposed converter conFigureuration. (b) Operation durig switch T_3 ON (c) Operation during switch T_4 ON, And charging the capacitor bank (d) Operation during ON,capacitor C_2 discharge.

The secondary voltage V_S = nV_p = nV_{C1} = V_{C3}, or V_{C3} = nV_{C1} and voltage crosswise over essential inductor L_w is V_w. At the point when T_3 is OFF and T_4 turned ON, the essential voltage V_P = V_{C2}. Optional voltage V_S = nV_P = nV_{C2} = V_{C4} and voltage crosswise over essential inductor L_w is V_w (V_{C1} +V_{C2}). It can be demonstrated that (V_{C1} + V_{C2}) = V_w (1 D_w) . The capacitor voltages are viewed as consistent in relentless state and they settle at V_{C3} = nV_{C1},
V_{C4} = nV_{C2}. Subsequently the output voltage is given by

$$V_{dc} = V_{c3} + V_{c4} = n\frac{V_w}{(1-D_w)} \qquad (1)$$

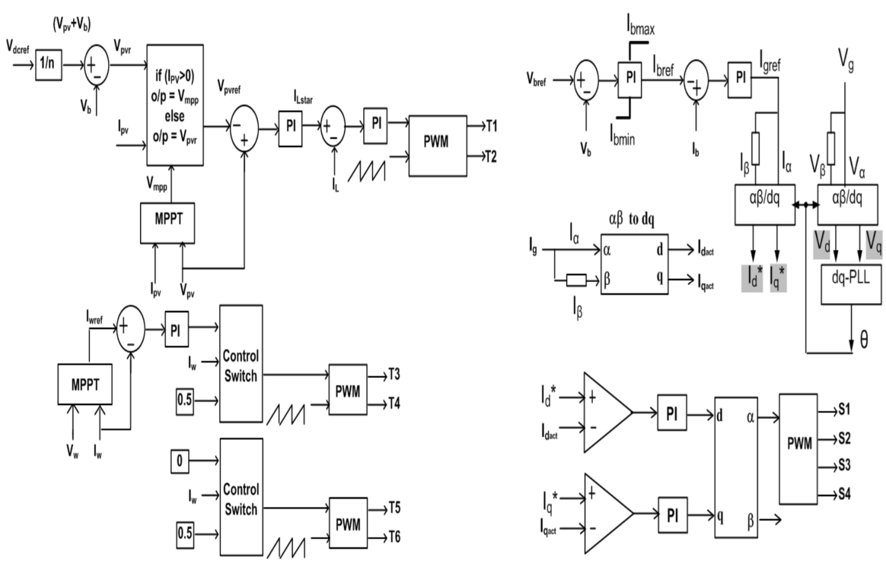

Figure.4. Proposed scheme for power flow management of a grid connected hybrid PV-wind-battery based system.

At the point when turn T_1 is turned OFF 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 while keeping up appropriate battery charge level. IL is utilized as internal circle control parameter for speedier element reaction while for external circle, capacitor voltage crosswise over PV source is utilized for guaranteeing MPP voltage. An incremental conductance technique is utilized for MPPT [12].
Here, the put away vitality in the inductor increments when T_2 is turned on and diminishes when T_1 is turned on. It can be demonstrated that $V_b = D_1$ DVpv. The yield voltage of the transformer coupled lift half-connect converter is given by,

$$V_{dc}I_{dc} = n(V_{c1} + V_{c2}) = n\left(V_b + V_{pv}\right) = n\frac{V_w}{(1-D_w)} \qquad (2)$$

3.1 Proposed control method for power flow management

A framework associated cross breed PV-wind-battery based framework comprising of four power sources (lattice, PV, wind source and battery) and three power sinks (network, battery and load), requires a control plot for power stream administration to adjust the power stream among these sources.

The control reasoning for power stream administration of the multi-source framework is produced in light of the power adjusts guideline. In the remaining 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 I_{bmax}.

Table 1 Simulation Parameters:

Parameter	Value
Solar PV power	525W (I_{mpp} = 14.8 A) (V_{mpp} = 35.4 V)
Wind power	S300 W (I_{mpp} = 8 A) (V_{mpp} = 37.5 V)
Switching frequency	15 kHz
Transformer turns ratio	5.5
Inductor-half bridge boost converter,	L_w 500 Mh
Inductor-bidirectional converter	L 3000 µH
Primary side capacitors	C_1-C_2 500Mf
secondary side capacitors	C_3-C_4 500Mf
Secondary side capacitor for the entire dc-link	2000 µF
Battery capacity & voltage	400 Ah, 36 V

After achieving this utmost, 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 matrix associated framework both the sources dependably work at their MPP. Without both the sources, the power is attracted from the network to charge the battery as and when required [13]. The condition for the power adjusts of the framework is given by:

$$V_{pv}I_{pv} + V_wI_w = V_bI_b + V_gI_g \qquad (3)$$

The peak value of the output voltage for a single-phase full bridge inverter is given by,
$V = m_a V_{dc}$ (4)
and the dc-link voltage is given by,

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

Hence, by substituting for V_{dc} in (4), gives,

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

In the boost converter, $V_w = (1 \quad D_w)(V_{pv} + V_b)$ (7)
Now, by substituting V_w and V_g in (3),

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

After simplification,

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

From the above condition it is apparent the, if there is an adjustment in power separated from either PV or wind source, the battery current can be directed by controlling the framework current I_g [14],[15].

IV. SIMULATION RESULTS

Definite recreation studies are completed on MATLAB/Simulink stage and the outcomes got for different working conditions are introduced in this area. Estimations of parameters utilized as a part of the model for recreation are recorded underneath. [16] The unfaltering state reaction of the framework amid the MPPT method of operation is appeared in Figure. The qualities for source-1 (PV source) is set at 35.4 V (V_{mpp}) and 14.8 An (I_{mppp}), and for source-2 (wind source) is set at 37.5 V (V_{mpp}) and 8 An (I_{mppp}). It can be seen that V_{pv} and I_{pv} of source-1, and V_w and I_w of source-2 accomplish set qualities required for MPPT operation.

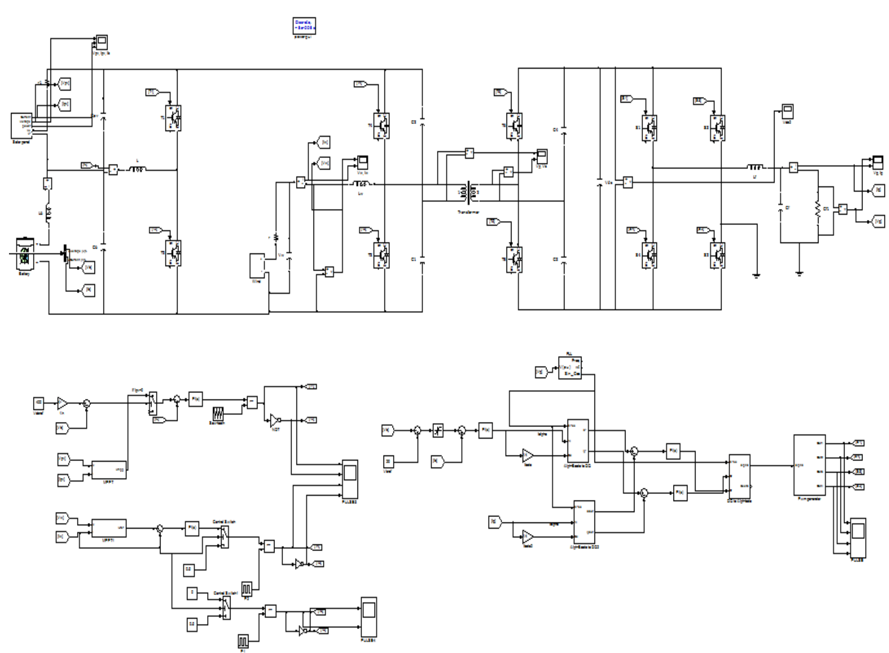

Figure.5. Simulation circuit diagram

The framework reaction for step changes in the source-1 segregation level while working in MPPT mode. Until 2s, both the sources are working at MPPT and accusing the battery of steady present and the rest of the power is nourished to the lattice. At moment 2s, the source-1 confinement level is expanded. Thus the source-1 control increments and both the sources keep on operating at MPPT [17]. In spite of the fact that the source-1 control has expanded, the battery is still accused of a similar size of current and power adjust is accomplished by expanding the power provided to the network. At moment 4s, protection of source-1 is conveyed to an indistinguishable level from before 2s. The power provided by source-1 diminishes. Battery keeps on getting charged at a similar greatness of current, and power infused into the lattice diminishes. Similar outcomes are gotten for step changes in source-2 wind speed level. These outcomes and wind control, battery is charged from the network.

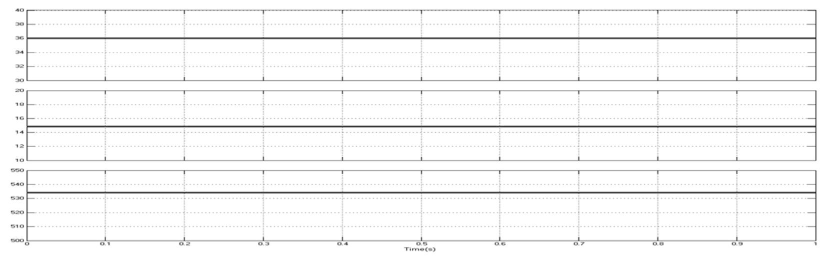

Figure.6. Input voltage, power and current from solar.

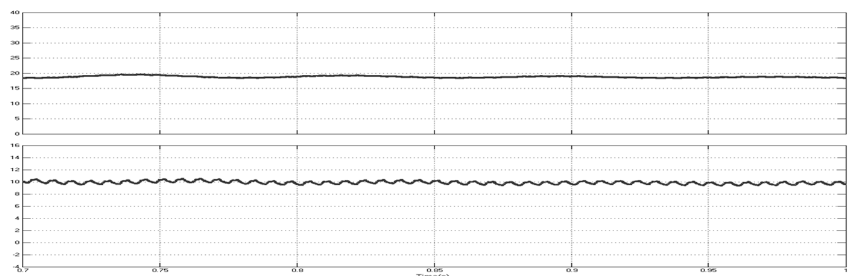

Figure.7. Input voltage and current from wind

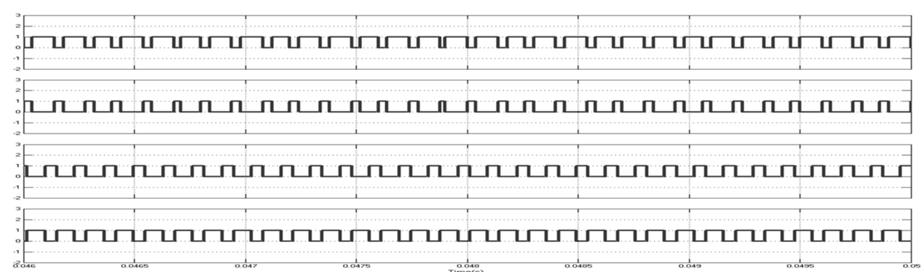

Figure.8.Gate pulse1

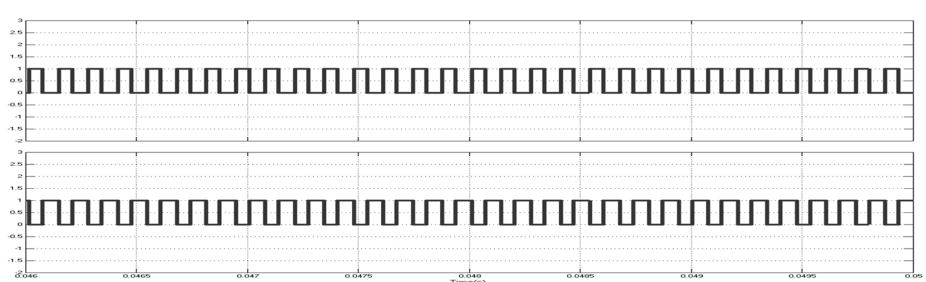

Figure.9.Gate pulse2

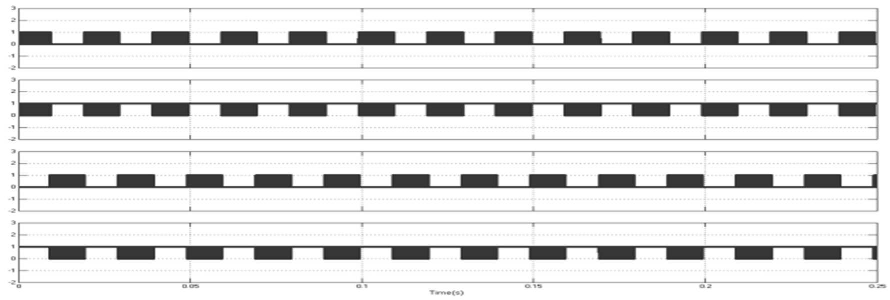

Figure .10.Gate pulse3

V. CONCLUSION

A grid connected hybrid PV-wind-battery based power departure conspires for household application is proposed. The proposed hybrid framework gives an exquisite coordination of PV and twist source to concentrate most extreme vitality from the two sources. It is acknowledged by a novel multi-input transformer coupled bidirectional dc-dc converter took after by an ordinary full-connect inverter. A flexible control technique which accomplishes better use of PV, wind control, battery limits without affecting existence of battery and power stream administration in a lattice associated hybrid PV-wind-battery based framework encouraging air conditioning burdens is exhibited. The simulation result studies are completed to determine the practicality of the proposed system. The trial comes about got are in close concurrence with reproductions and are steady in showing the capacity of the framework to work either in lattice encouraging or remain solitary mode. The proposed design is equipped for providing un-interruptible energy to air conditioning loads, and guarantees clearing of surplus PV and twist control into the matrix. Battery use ought to be diminished which consumes more capital cost.

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