OPTIMAL PERFORMANCE OF HYBRID WIND SOLAR SYSTEM WITH QZSI

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ABSRACT

Renewable energy systems, such as photovoltaic (PV) and wind power generation (WPG), are playing a more and more important role in energy production. However, the output power of PV and WPG are usually strongly fluctuant due to the randomness and intermittence of solar and wind energy, which requires a large capacity of energy storage to satisfy the load demand when the system works in stand-alone mode, and results in a strong impact on the utility grid when the system works in grid-connected mode. Here we are going to utilize that two combined generation very wisely using mppt concept; and there by using mppt technique we are charging and discharging the battery based on power generation & typical load conditions respectively. Due to which battery life is increased. Here wind power generation is considered as primary source as it exists day fully comparing with solar generation. As we know impedance topology is able to provide constant current even at load variations; we utilized that topology for grid loads.

Keywords: ***Qzsi, Mppt, PV Cell , Simulation,Wind***

I. INTRODUCTION

As energy demands around the world increase, the need for a renewable energy sources that will not harm the environment has been increased. Some projections indicate that the global energy demand will almost triple by 2050[1]. Renewable energy sources currently supply somewhere between 15% and 20% of total world energy demand. PV and Wind Energy System, WES, are the most promising as a future energy technology. A 30% contribution to world energy supply from the renewable energy sources by year 2020 [2] as in would reduce the energy related CO2 emission by 25 %.

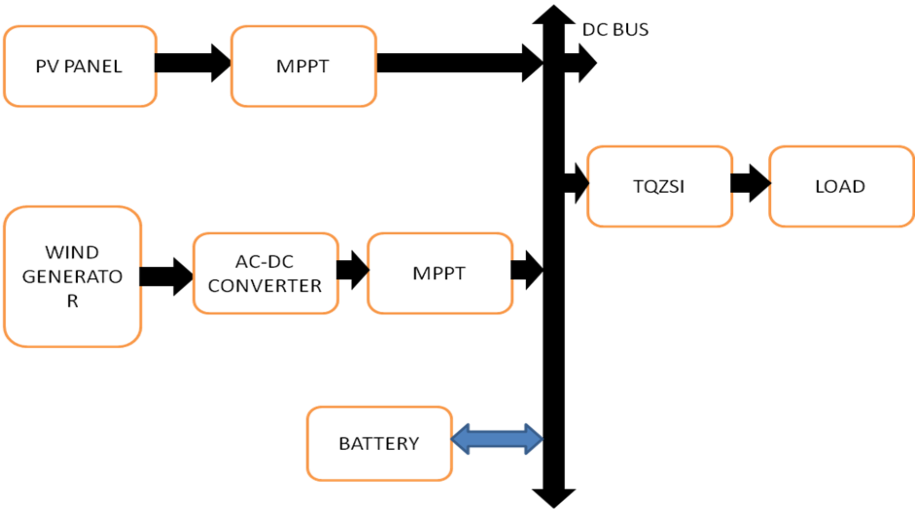
With their advantages of being abundant in nature and nearly non pollutant, renewable energy sources have attracted wide attention. Wind power is one of the most promising clean energy sources since it can easily be captured by wind generators with high power capacity. Photovoltaic (PV) power is another promising clean energy source since it is global and can be harnessed without using rotational generators. In fact, wind power and PV power are complementary to some extent since strong winds are mostly to occur during the night time and cloudy days whereas sunny days are often calm with weak winds . Hence, a wind–PV hybrid generation system can offer higher reliability to maintain continuous power output than any other individual power generation systems. In those remote or isolated areas, the stand-alone wind–PV hybrid generation system is particularly valuable and attractive.

To maximize a photovoltaic (PV) and wind energy system's output power, continuously tracking the maximum power point (MPP) of the system is necessary. Most of the researches haven't modelling and simulation of PV/Wind HEPS techniques by using MPPT at the point of connection of operation in details. So, the main objective of this paper is maximizing the PV output power and wind output power independently by tracking the maximum power on every operating condition by using MPPT technique and interconnected to utility grid.

II. SYSTEM CONFIGURATION

2.1 Hybrid Renewable Energy Systems

A combination of different but complementary energy generation systems based on renewable energies or mixed is known as a hybrid power system. Hybrid systems capture the best features of each energy resource. Hybrid systems can provide a steady community level electricity service, such as marine, village or lighthouse electrification, offering also the possibility to be upgraded through grid connection in the future. Furthermore, due to their high levels of efficiency, reliability and long term performance these systems can also be used as an effective backup solution to the public grid in case of blackouts or weak grids, and for professional energy solutions such as telecommunication stations or emergency rooms in hospitals. When designing a hybrid system it is important to choose a good combination of components, their dimensions and to determine a good strategy to manage the system that would be reliable and economical for a long time. A large number of resources will result in large investment costs, while a system with a small number of components can result in the interruption of electricity supply in the electricity system. Climatic conditions may affect the choice of renewable energy sources. For example, PV hybrid systems are ideal in areas with warm climates and in areas where there is large number of sunny hours.



This paper presents quasi z-source inverter. It has the following characteristics.

1) It combines the advantages of both ZSI and SBI. The gain of the proposed circuit is the same as the ZSI. It also has the same component count as the SBI.

2) The proposed inverter possesses good EMI noise immunity similar to ZSI and SBI.

3) The proposed inverter draws continuous input current from the dc source, which makes it suitable for renewable applications.

4) It does not require dead-band for the switching signals, and hence, output waveform distortion is avoided.

5) It does not require extreme duty ratio operation to achieve high voltage boost.

2.2 Energy Management and Optimization Principles

According to the connection bus, the network architecture of WSB can be classified into three types: dc-bus, ac-bus, and hybrid-bus, among which, the dc-bus architecture has been widely used in small-scale DPGS for its convenient control and interface of renewable energy to the system. The PV panel and wind turbine are connected to the dc bus by the dc/dc and ac/dc converters, respectively, which can realize the maximum power point tracking (MPPT) function. The battery cells are connected to the dc bus dc/dc converter in a concentrated location, which are used to control the dc bus voltage. Please note that the storage system is composed of many battery modules connected in series or parallel. The balance circuits among different modules are usually included in the system. The dc voltage is converted to ac voltage through an inverter. The power generated by WSB provides the demanded power for the local load and can be transferred into the utility grid through a step-up transformer.

2.3 Optimal Sizing Principles of Wsb

For a given load demand, fully utilizing the complementary characteristics of wind and solar can achieve a smaller fluctuation of output power, which results in a reduction of the required battery capacity. It is obvious that there exists power exchange between the WSB and utility grid in grid connected mode. A strongly fluctuant power injected into the grid may lead to the voltage or frequency at key nodes exceeding their limitation and large losses. Thus, how to smooth the fluctuation of power injected into the grid must be taken into account when optimizing the capacity of PV/WPG/battery. In addition, the lifetime of WSB is usually restricted by the lifetime of the battery, which is mainly affected by the batteries DOD, the charge/discharge current, and the charge/discharge rate and the charge/discharge cycles. Thus, these factors must be considered. According to the analysis above, the proposed optimal sizing method is based on the following principles:

a) Achieving high power supply reliability

b) Making full use of the complementary characteristics of wind and solar

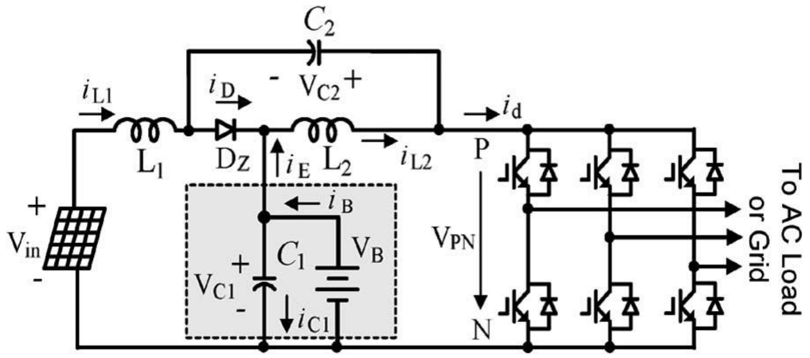
c) Ensuring a small fluctuation of power injected into the grid

d) Optimizing the battery’s charge and discharge state

e) Minimizing the total cost of WSB

III. REVIEW OF THE QZSI TOPOLOGY

The QZSI circuit differs from that of a conventional ZSI in the LC impedance
network interface between the source and inverter. The unique LC and diode network connected to the inverter bridge modify the operation of the circuit,allowing the shoot-through state which is forbidden in traditional VSI. This network will effectively protect the circuit from damage when the shootthrough occurs and by using the shoot-though state, the (quasi-) Z-source network boosts the dc-link voltage The impedance network of QZSI is a two port network .It consists of inductors and capacitors connected as shown in fig. This network is employed to provide an impedance source, coupling the converter to the load. The dc source can be a battery, diode rectifier, thyristor converter or PV array.



3.1 Operating Principle and Equivalent Circuit of Qzsi

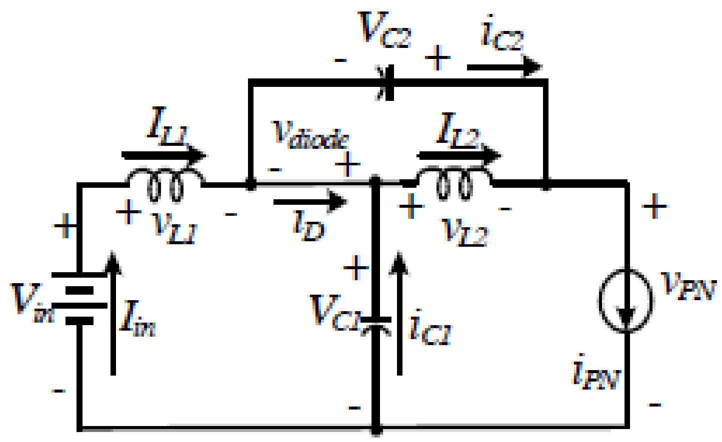
The two modes of operation of a quasi z-source inverter are:

(1) Non-shoot through mode (active mode).

(2) Shoot through mode.

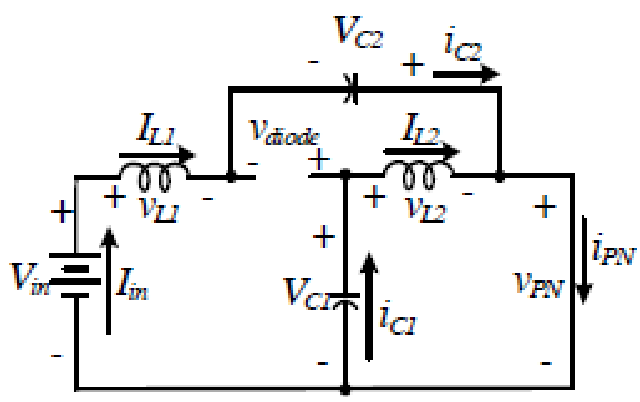
3.1.1 Active Mode

In the non-shoot through mode, the switching pattern for the QZSI is similar to that of a VSI. The inverter bridge, viewed from the DC side is equivalent to a current source. , the input dc voltage is available as DC link voltage input to the inverter, which makes the QZSI behave similar to a VSI.



3.1.2 Shoot Through Mode

In the shoot through mode, switches of the same phase in the inverter bridge are switched on simultaneously for a very short duration. The source however does not get short circuited when attempted to do so because of the presence LC network, while boosting the output voltage. The DC link voltage during the shoot through states, is boosted by a boost factor, whose value depends on the shoot through duty ratio for a given modulation index.



IV.MATHEMATICAL MODEL OF THE COMPONENTS IN WSB

4.1 Photovoltaic Generation Model

Assuming that the PV array is equipped with a MPPT controller, thus, the output power of PV array can be expressed as

$$P_{\mathrm{pv}} = f_{\mathrm{pv}} P_{\mathrm{pv\_r}} \frac{G}{G_{\mathrm{STC}}} [1 + \alpha_T (T - T_{\mathrm{STC}})]$$

Where is the rated output power of PV array, is the de rating factor considering shading, wiring losses and snow cover, etc. and are the solar radiation and temperature on PV cell under standard test conditions, respectively. And are the solar radiation and temperature in current time, respectively, and is the temperature coefficient of power. It should be noted that the PV panel title angle, rotating capability, etc. can also affect the output power of PV array beside and . In this study, these factors are taken into account when calculating the solar radiation on PV panel.

4.2 Wind Power Generation Model

The output power curve of the wind turbine (WT), which can be described as

$$P_{\mathrm{wt}} = \begin{cases} 0 & v_w < V_{\mathrm{ci}} \text{ or } v_w > V_{\mathrm{co}} \\ P_{\mathrm{wt\_r}} \dfrac{v_w - V_{\mathrm{ci}}}{v_r - V_{\mathrm{ci}}} & V_{\mathrm{ci}} \le v_w \le V_r \\ P_{\mathrm{wt\_r}} & V_r \le v_w \le V_{\mathrm{co}} \end{cases}$$

Where is the wind speed, is the rated wind speed, and are the cut-in and cut-out wind speeds, respectively.

4.3 Mppt Methods

MPPT algorithms are necessary in renewable energy sources to gain maximum power and efficiency. There is a large number of algorithms that are able to track MPPs. Over the past decades many methods to find the MPP have been developed. These techniques differ in many aspects such as required sensors, complexity, cost, range of effectiveness, convergence speed, correct tracking when irradiation and/or temperature changes, hard ware needed for the implementation. Having a curious look at the recommended methods, P&O and incremental conductance are the algorithms that were in center of consideration because of their simplicity and ease of implementation. However the P&O algorithm cannot compare the array terminal voltage with actual MPP voltage, since the change in power is only considered to be a result of array terminal voltage perturbation. As a result, they are not accurate enough because they perform steady state oscillation, which consequently waste the energy By minimizing the perturbation step size, oscillation can be reduced, but a smaller perturbation size slows down the speed of tracking MPPs. Thus, there are some disadvantages with these methods, where they fail under rapidly changing atmospheric conditions. The IncCond method is the one which overrides over the aforementioned drawbacks. In this method, the array terminal voltage is always adjusted according to the MPP voltage. It is based on the incremental and instantaneous conductance of the PV module. The slope of the PV array power curve is zero at the MPP, increasing on the left of the MPP and decreasing on the right-hand side of the MPP. The basic equations of this method are as follows

$$\frac{dI}{dV} = -\frac{I}{V} \quad \text{at MPP} \qquad (1)$$

$$\frac{dI}{dV} > -\frac{I}{V} \quad \text{left of MPP} \qquad (2)$$

$$\frac{dI}{dV} < -\frac{I}{V} \quad \text{right of MPP} \qquad (3)$$

Where, I and V are the PV array output current and voltage respectively. The left-hand side of the equations represents the IncCond of the PV module, and the right- hand side represents the instantaneous conductance. From (1)–(3), it is obvious that when the ratio of change in the output conductance is equal to the negative output conductance, the solar array will operate at the MPP. In other words, by comparing the conductance at each sampling time, the MPPT will track the maximum power of the PV module. The accuracy of this method is proven in, where it mentions that the IncCond method can track the true MPPs independent of PV array characteristics. Incremental conductance algorithm is based on t he fact that the slope of the curve power vs. voltage (current) of the PV module is zero at the MPP, positive (negative) on the left of it and negative (positive) on the right. By comparing the increment of the power vs. the increment of the voltage (current) between two consecutive samples, the change in the MPP voltage can be determined. MPPT method, where it has made a comprehensive comparison between P&O and the IncCond method with boost converter and shows that the efficiency of experimental results is up to 95%. Efficiency was observed to be as much as 98.2%, but it is doubtful of the IncCond method reliability issues due to the noise of components. Some modifications and reformations were proposed on this method so far, but since this method inherently has a good efficiency, the aforementioned amendments increase the complexity and cost of the system and there was no remarkable change in system efficiency. The disadvantage of the perturb and observe method to track the peak power under fast varying atmospheric condition is overcome by IC method. The IC can determine that the MPPT has reached the MPP and stop perturbing the operating point. If this condition is not met, the direction in which the MPPT operating point must be perturbed can be calculated using the relationship between dl/dV and –I/V. This relationship is derived from the fact that dP/dV is negative when the MPPT is to the right of the MPP and positive when it is to the left of the MPP. This algorithm has advantages over P&O in that it can determine when the MPPT has reached the MPP, where P&O oscillates around the MPP. Also, incremental conductance can track rapidly increasing and decreasing irradiance conditions with higher accuracy than perturb and observe method.

The below algorithm shows that, how the controller follows the mathematical method to generates the required pulses to track the maximum power from the system.

The respective algorithm of incremental conductance MPPT method is shown below.

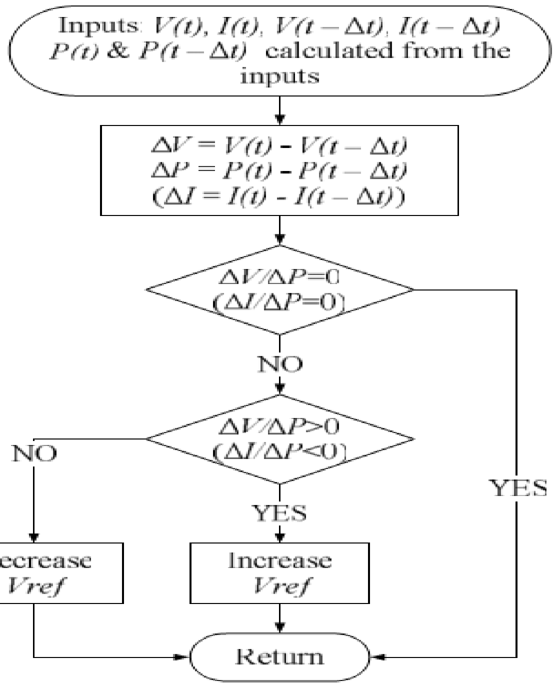
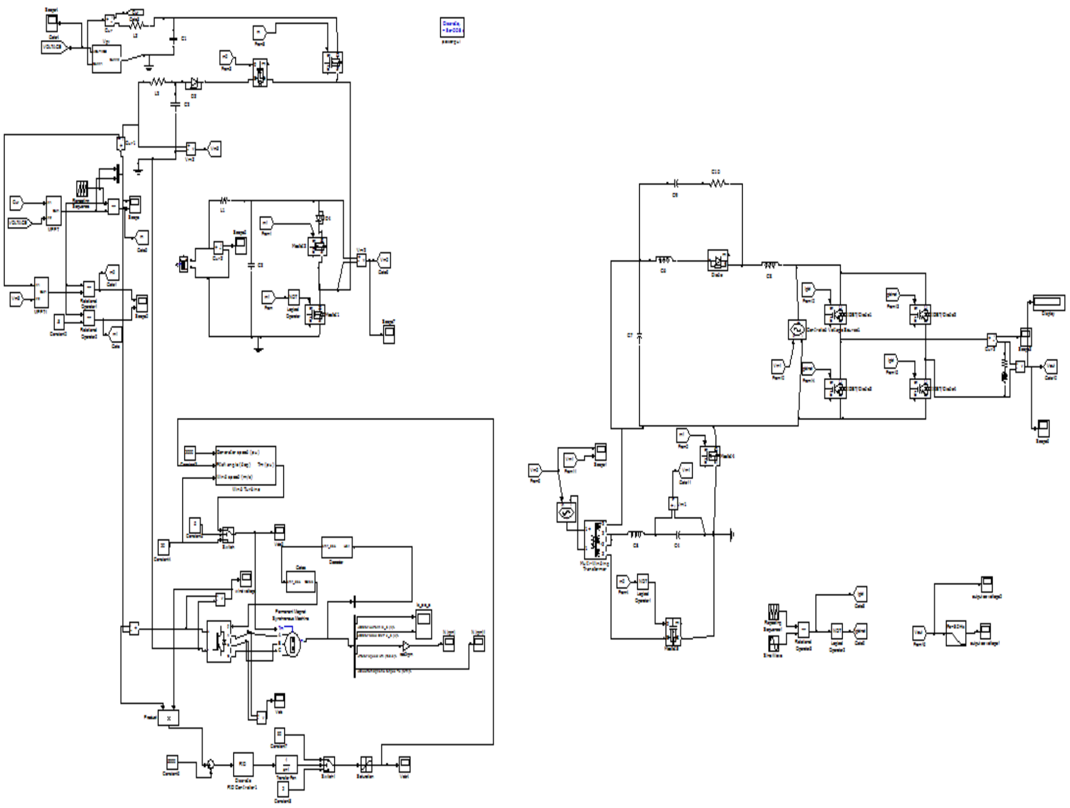


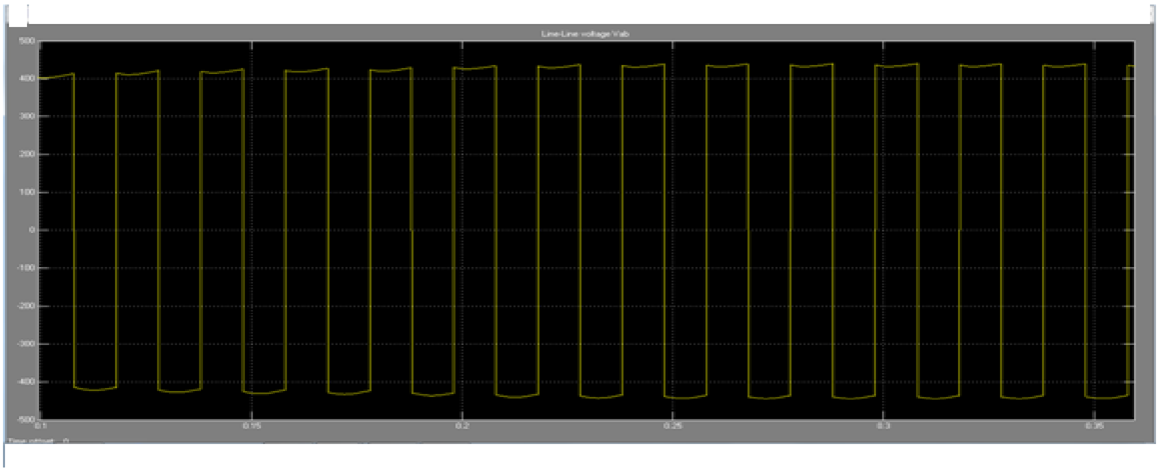
Fig .Inc Cond Algorithm

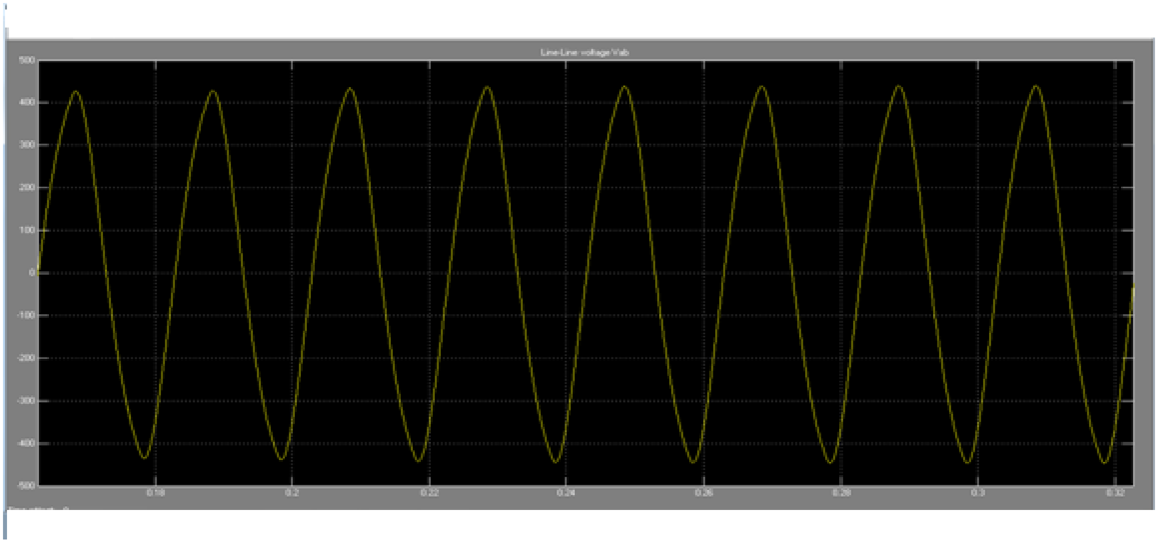
V. SIMULATION CIRCUIT



VI. SIMULATION RESULTS

6.1MATLAB Simulation





VII. CONCLUSION AND FUTURE ENHANCEMENT

This project is focused on hybrid power generation using single phase inverter. The input is from three different sources namely solar power from photo voltaic cell, wind power from wind generator and a battery source. Battery source acts as effective backup storage. This system provides continuous power supply. A common dc bus is responsible for the dc outputs from the sources and act as a single input to the inverter. Further this inverter converts it into ac and boost the voltage and given to the respective loads. Here we are going to utilize that two combined generation very wisely using mppt concept; and there by using mppt technique we are charging and discharging the battery based on power generation & typical load conditions respectively. Due to which battery life is increased. Here wind power generation is considered as primary source as it exists day fully comparing with solar generation. As we know impedance topology is able to provide constant current even at load variations; we utilized that topology for grid loads. This project proposes a simple system for continuous power supply with the effective utilization of renewable energy sources. This system can be made as a closed loop for further developments.

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