HYBRID PV-WIND-BATTERY BASED SYSTEM FOR HOUSEHOLD APPLICATIONS USING DC-DC CONVERTER

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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 proposed system aims 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. This improves the efficiency and reliability of the system.

Keywords— Remote Area operations, hybrid system, solar photovoltaic, wind energy Green Energy, Environment friendly, No emission, cost wise Cheap, less maintenance, fast developed renewable energy resources, battery charge control, maximum power point tracking, bi directional DC-DC converter.

1. Introduction

In a hybrid PV-wind system along with a battery is presented, in which both sources are connected to a common dc-bus through individual power converters. In addition, the dc-bus is connected to the utility grid through an inverter. The use of multi-input converter (MIC) for hybrid power systems is attracting increasing attention because of reduced component count, enhanced power density, compactness and centralized control. Due to these advantages, many topologies are proposed and they can be classified into three groups, non-isolated, fully-isolated and partially-isolated multi-port topologies. All the power ports in non-isolated multi-port topologies share a common ground. To derive the multi-port dc-dc converters, a series or parallel configuration is employed in the input side. Some components can be shared by each input port.

A tri-modal half-bridge topology is proposed. This topology is essentially a modified version of the half-bridge topology with a free-wheeling circuit branch consisting of a diode and a switch across the primary winding of the transformer. All the state of the art on converter topologies presented so far can accommodate only one renewable source and one energy storage element. Whereas, the proposed topology is capable of interfacing two renewable sources and an energy storage element. Hence, it is more reliable as two different types of renewable sources like PV and wind are used either individually or simultaneously without increase in the component count compared to the existing state of the art topologies. The proposed system has two renewable power sources, load, grid and battery. Hence, a power flow management system is essential to balance the power flow among all these sources. The main objectives of this system are as follows:

• To explore a multi-objective control scheme for optimal charging of the battery using multiple sources.

• Supplying un-interruptible power to loads.

• Ensuring evacuation of surplus power from renewable sources to the grid, and charging the battery from grid as and when required. The grid-connected hybrid PV-wind-battery based system for household applications, which can work either in stand-alone or grid connected mode.

This system is suitable for household applications, where a low-cost, simple and compact topology capable of autonomous operation is desirable. The core of the proposed system is the multi-input transformer coupled bidirectional dc-dc converter that interconnects various power sources and the storage element. Further, a control scheme for effective power flow management to provide uninterrupted power supply to the loads, while injecting excess power into the grid is proposed. Thus, the proposed configuration and control scheme provide an elegant integration of PV and wind energy source. The proposed converter consists of a transformer coupled boost dual-half-bridge bidirectional converter fused with bidirectional buck-boost converter and a single-phase full-bridge inverter. The proposed converter has reduced number of power conversion stages with less component count and high efficiency compared to the existing grid-connected schemes.

2. LITERATURE SURVEY

1. DYNAMIC MODELLING AND OPERATION STRATEGY FOR A MICRO GRID WITH WIND AND PHOTOVOLTAIC RESOURCES:

This project presents a dynamic modeling and control strategy for a sustainable micro grid primarily powered by wind and solar energy. A current-source-interface multiple-input dc-dc converter is used to integrate the renewable energy sources to the main dc bus. Potential suitable applications range from a communication site or a residential area. This project presented the dynamic modeling and operational strategy of a sustainable micro grid primarily powered by wind and solar energy. These renewable sources are integrated into the main dc bus through an MI CSI dc-dc converter. Wind energy variations and rapidly changing solar irradiance were considered in order to explore the effect of such environmental variations to the intended micro grid. In addition, the proposed micro grid is equipped with an ESS and is connected with the distribution grid. These diverse micro-energy resources can improve the micro grid performance and reduce power generation variability and vulnerability to natural disasters. Its power converter can also be designed in a smaller size with low production costs because MICs can remove unnecessary redundant components. this paper focused on the MPP tracking of the renewable micro-energy source power variations under the local ac demand changes and the variable dispatch power to the distribution grid. For the wind generator, this project used a variable speed control method whose strategy is to capture the maximum wind energy below the rated wind speed. Specifically, an input current control method was used for this variable speed control. In addition, a circuit-based PV system model with an incremental conductance control method was used for the simulation study. In contrast to previous works, this paper explored the system wide performance of the sustainable microgrid with an MI dc-dc converter when the micro-energy source power, the local ac load, and the dispatch power to the distribution grid change.

2. GRID-CONNECTED THREE-INPUT PV/FC/BATTERY POWER SYSTEM WITH ACTIVE POWER FILTER CAPABILITY:

This project develops a grid connected hybrid PV/FC/Battery power system proposed by authors. This system integrates photovoltaic (PV) array, fuel cell (FC) stack and battery as input power sources in a unified structure by means of a new three-input DC-DC boost converter which supplies a grid connected inverter. In this structure, each switching cycle of the proposed boost converter is divided into five switching periods in comparison with the conventional structure. These switching periods introduce five different duty ratios for the proposed boost converter. Because the summation of these duty ratios should be equaled to one in the prior paper, achieving a high-level output voltage at the DC-link is not possible. Therefore, this paper tries to presents some modifications in order to cancel this limitation of the duty ratios and control them independently. Consequently, a high-level output voltage is achieved in addition to tracking the maximum power of the PV source, setting the power of FC source, and charging or discharging the battery. Utilizing a unified structure and improving the control strategy of the proposed three-input DC-DC converter facilitate power management of the input sources in order to supply a grid connected residential load. All the system possible power operation modes are defined and managed by the power management control scheme. The proposed system is also able to compensate both reactive and harmonic current components drawn by nonlinear loads as active filter functionality.

The proposed control system facilitates power management of HDGS and accessing higher voltage levels because of independently control of the duty ratios. In addition, the system simultaneously is able to inject the generated harmonic currents and correct the power factor of a nonlinear domestic load. The active filtering capability does not require modifications to the power stage. Low harmonics content, simple and unified power electronic circuit, reliable control system, high efficiency and appropriate power management are the advantages of the proposed system.

3. MODELLING AND CONTROLLER DESIGN FOR THE MULTI-INPUT PV/WIND CHARGER:

The objective of this project is to propose a multi-input converter (MIC) for hybrid PV/wind power charger application which can simplify the power system, reduce the cost and deliver continuous power with higher reliability to the load. The proposed MIC consists of a forward-type pulsating voltage source cell (PVSC) and a buck-boost prime converter can realize the maximum power point tracking (MPPT) function for each PV/wind source. Moreover, due to the isolated configuration, the MIC can adopt PV/wind power sources with larger operation voltage difference. In this paper, the small-signal ac model is derived and the controller design is developed. Computer simulations and experimental results are presented to verify the accuracy of the proposed small signal ac model and the performance of the proposed MIC. This project is proposed a MIC for the hybrid PV wind power charger system which can simplify the power system, reduce the cost, deliver continuous power with higher reliability and overcome high voltage-transfer-ratio problems. The operation principle of the proposed MIC is introduced and the small signal ac model is developed. Computer simulations and prototype hardware circuit experimental results are presented to verify the accuracy of the proposed small signal model and the performance of controller for the proposed MIC for hybrid PV/wind battery charger system.

4. MULTI-INPUT TRANSFORMER COUPLED DC-DC CONVERTER FOR PV-WIND BASED STAND-ALONE SINGLE-PHASE POWER GENERATING SYSTEM:

Hybrid PV-wind based stand-alone systems have evolved as a promising solution for rural deployment where access to electrification is not viable. The conventional approach for the integration of multiple renewable sources and energy storage elements involves using dedicated single-input converters for each source and requires more number of converter stages leading to considerable reduction in reliability and efficiency of the system. In order to address this issue, a novel transformer coupled dual-source dc-dc converter followed by a conventional full bridge inverter is proposed. Transformer coupled half-bridge boost converter is used for harnessing power from wind, while bidirectional converter is used for harnessing power from PV along with battery charging/discharging control and a single phase inverter for feeding ac loads. The proposed converter architecture has reduced number of power conversion stages, less component count and losses as compared to the existing stand-alone schemes. These features improve the efficiency and reliability of the scheme.

A hybrid solar PV-wind based stand-alone power evacuation scheme for rural household application is proposed. It is realized by a novel multi-input transformer coupled dc-dc converter followed by a conventional full bridge dc-ac inverter. The input of the transformer coupled half bridge boost converter is formed by connecting the PV array in series with the battery, which is connected across the capacitor bank C1-C2 thereby incorporating an inherent boosting stage for the scheme. The boosting capability is further enhanced by a high frequency step-up transformer. Bidirectional converter is used for harnessing power from PV along with battery charging/discharging control. The unique feature of this converter is that MPP tracking of PV array, battery charging control and voltage boosting are accomplished through a single converter. Transformer coupled half bridge boost converter is used for harnessing power from wind and a single-phase inverter for feeding ac loads. High boost of PV and wind voltages, battery charging control, required dc-link voltage and galvanic isolation of the load from the sources and the battery are realized only with four controllable switches in the proposed converter configuration. This leads to an improvement in efficiency and reliability of the system. The proposed controller can operate in different modes of a standalone scheme and ensures proper operating mode selection and smooth transition between different possible operating modes.

6. Novel Integration of PV-Wind Energy System with Enhanced Efficiency:

An integration scheme of solar PV with a large capacity doubly excited induction generator based wind energy system is described. Both the grid and rotor side power converters of DFIG to inject PV power into the grid. Thus, it renders a cost effective solution to PV-grid integration by obviating the need for a dedicated converter for PV power processing. The system is able to feed significantly large PV power into the grid compared to an equivalent rating inverter used in the conventional PV-grid system. Proposed scheme prevents circulating power during sub-synchronous operation during the

All these features enhance system efficiency. The intermittent but complementary nature of solar PV and wind energy sources considerably improves the converters' utilization. Comprehensive system model is presented and used for designing the control strategy.

Nature has provided ample opportunities to mankind to make best use of its resources and still maintain its beauty. In this context, the proposed hybrid PV-wind system provides an elegant integration of the wind turbine and solar PV to extract optimum energy from the two sources. It yields a compact converter system, while incurring reduced cost. The PV generated power can be routed to the grid using both the rotor and grid side converters of the wind-DFIG system, during its sub-synchronous operation. It has been verified that unlike the conventional wind-DFIG system, the circulating power is significantly reduced with PV-DFIG integration at the DC link. Enhanced efficiency is observed compared to existing PV/wind hybrid systems. It is demonstrated that the proposed hybrid system provides an opportunity to integrate a higher capacity PV source than can be done through a dedicated converter as in a conventional solar PV system. Simulations and experimental results have shown that the proposed system optimally uses the daily available energy from solar and wind sources making the best possible utilization of its converters. Due to limited laboratory resources, a small, low power prototype has been used for validation. It is expected that some advantages of the proposed scheme (e.g. high converter utilization, reduction in circulating power, enhanced stability due to turbine inertia etc.) will be more pronounced for high power PV-wind farm systems. There is also a scope of designing the DFIG-wind turbine more optimally for the hybrid solution presented. The proposed hybrid combination can also render a neat stand-alone energy solution with minimum storage and can, in fact, be developed as a dispatch able source. Overall, the proposed system makes good use of the nature's complementary behavior for wind velocity and solar radiation. Sometimes this complementary trend may break down, in which case the proposed control scheme is well equipped to prevent converters' overloading at the cost of momentary loss of PV power. Such instances, however, are expected to be rare. [6]

7. STANDALONE HYBRID WIND-SOLAR POWER GENERATION SYSTEM APPLYING DUMP POWER CONTROL WITHOUT DUMP LOAD:

This project proposes a unique standalone hybrid power generation system, applying advanced power control techniques, fed by four power sources: wind power, solar power, storage battery, and diesel engine generator, and which is not connected to a commercial power system. Considerable effort was put into the development of active-reactive power and dump power controls.

The result of laboratory experiments revealed that amplitudes and phases of ac output voltage were well regulated in the hybrid system. Different power sources can be interconnected anywhere on the same power line, leading to flexible system expansion. It is anticipated that this hybrid power generation system, into which natural energy is incorporated, will contribute to global environmental protection on isolated islands and in rural locations without any dependence on commercial power systems.

The authors have proposed a unique standalone hybrid wind solar power generation system, which is characterized by PLL control and dump power control. In particular, dump power control allows for formation of a feedback loop in this system, meaning that there is no requirement for a dedicated high-speed line to transmit storage battery voltage and current data. In case the power line is used as a media for data transmission, the line voltage amplitudes can be applied as a means of data transmission; thus, there is no requirement for installation of any optical fiber transmission line or power line carrier system through which harmonic signals are applied to power line. In addition, neither dump load nor dump load control device are necessary. Under our dump power control, regulation of output is done without battery overcharging, and effective use of surplus power is made possible. This contributes to battery life extension and realization of a low-cost system. The system, through ac system interconnection, will also allow flexible system expansion in the future. Further, power sources including EG can be flexibly interconnected anywhere through the same power line, and power quality stability can be maintained by controlling the phase and amplitude of ac output voltage. It is expected that this hybrid system into which natural energy is incorporated, and which makes use of various power control techniques, will be applicable in rural locations, even those with poor communications media. The system will also contribute to global environmental protection through application on isolated islands without any dependence on commercial power systems.

8. Supervisory Control of Standalone Wind / Solar Energy Generation Systems:

The use of renewable energy technology to meet the energy demands has been increasing for the past few years. However, the important drawbacks associated with renewable energy systems are their inability to guarantee reliability and their intermittent nature. At present, standalone solar photovoltaic energy system cannot provide reliable power during night time or non-sunny days. The standalone wind system cannot satisfy constant load demands due to fluctuations in the magnitude of wind speeds from hour to hour throughout the year. This work focuses on the development of a supervisory model predictive control method for the optimal management and operation of hybrid standalone wind-solar energy generation systems. The proposed method is to design the supervisory control system via model predictive control which computes the power references for the wind and solar subsystems. The power references are sent to two local controllers which drive the two subsystems to the requested power references. The system is modeled in MATLAB SIMULINK and simulation results show that maximum power generated from hybrid system at varying environmental conditions.

This thesis focused on the development of a supervisory predictive control method for the optimal management and operation of hybrid wind-solar energy generation systems. This project proposed a supervisory control system designed via MPC which computes the power references for the wind and solar subsystems at each sampling time while minimizing a suitable cost function. The power references are sent to two local controllers which drive the two subsystems to the power references. The controllers are designed to get maximum power form wind results demonstrated the effectiveness and applicability of the proposed approach.

9. Supervisory Predictive Control of Standalone Wind/Solar Energy Generation Systems:

This work focuses on the development of a supervisory model predictive control method for the optimal management and operation of hybrid standalone wind-solar energy generation systems. We design the supervisory control system via model predictive control which computes the power references for the wind and solar subsystems at each sampling time while minimizing a suitable cost function. The power references are sent to two local controllers which drive the two subsystems to the requested power references. We discuss how to incorporate practical considerations, for example, how to extend the life time of the equipment by reducing the peak values of inrush or surge currents, into the formulation of the model predictive control optimization problem. In this work, we focused on the development of a supervisory predictive control method for the optimal management and operation of hybrid wind-solar energy generation systems. We proposed a supervisory control system designed via MPC which computes the power references for the wind and solar systems at each sampling time while minimizing a suitable cost function. The power references are sent to two local controllers which drive the two subsystems to the power references. We discussed how to incorporate practical considerations, for example, how to reduce the peak values of inrush or surge currents, into the formulation of the MPC optimization problem. Simulation results demonstrated the effectiveness and applicability of the proposed approach. Future work will include the investigation of large time span behavior of the hybrid wind-solar generation system taking into account information of future weather forecast, and investigation of the performance of the system under the condition that the future power demand is unknown.[9]

3. Comparative Analysis

From above surveyed papers, all the Solar PV panels are connected to Grid and Battery bank only. A micro grid nowadays plays a very vital role in all these systems. In this project, Extract maximum energy from elegant integration of PV and wind sources with multi input transformer coupled bidirectional DC-DC converter with versatile control and better utilisation without affecting life of battery and better power flow management.

4. Proposed System

The proposed converter consists of a transformer coupled boost dual-half-bridge bidirectional converter fused with bidirectional buck-boost converter and a single-phase full-bridge inverter is shown in (fig-1). The proposed converter has reduced number of power conversion stages with less component count and high efficiency compared to the existing grid-connected schemes. The topology is simple and needs only six power switches. The boost dual-half-bridge converter has two dc-links on both sides of the high frequency transformer. Controlling the voltage of one of the dc-links ensures controlling the voltage of the other. This makes the control strategy simple. Moreover, additional converters can be integrated with any one of the two dc-links. A bidirectional buck-boost dc-dc converter is integrated with the primary side dc-link and single-phase full-bridge bidirectional converter is connected to the dc-link of the secondary side.

The grid-connected hybrid PV-wind-battery based system for household applications, which can work either in stand-alone or grid connected mode. This system is suitable for household applications, where a low-cost, simple and compact topology capable of autonomous operation is desirable. The core of the proposed system is the multi-input transformer coupled bidirectional dc-dc converter that interconnects various power sources and the storage element.

Advantages:

- Less component count and reduced losses.
- Reduced number of power conversion stages.
- Inject surplus power into the grid and charge the battery from grid as and when required.

Applications:

- Household Application.
- Grid-connected hybrid PV-wind-battery system.

- Standalone hybrid PV-wind-battery system.

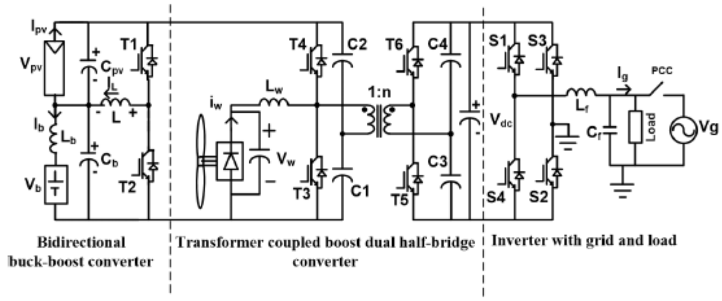

Fig 1.Circuit Diagram of Proposed system

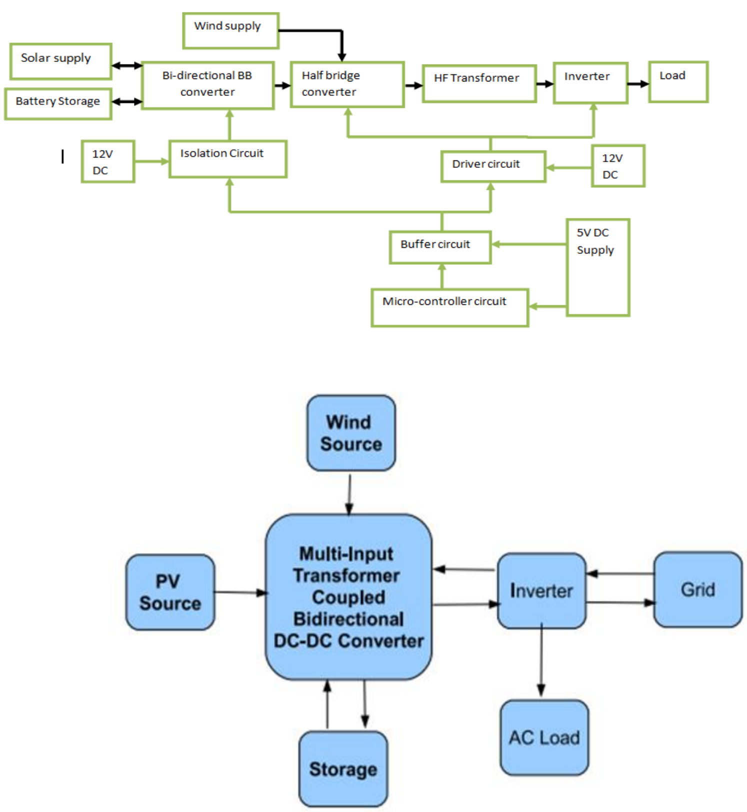

Fig 2. Block diagrams of proposed system

5. Result and Discussion

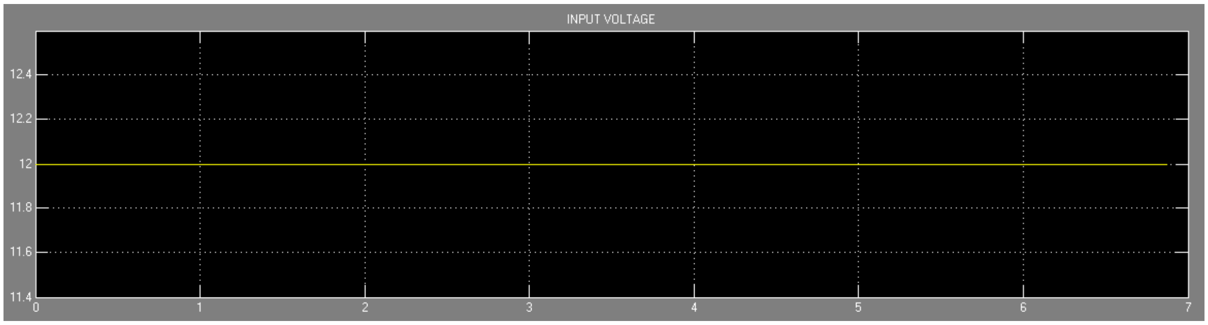

Fig 3.Input Voltage

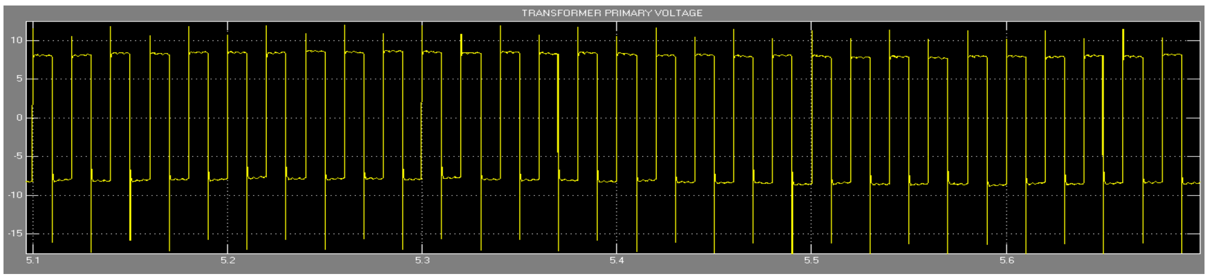

Fig 4.Transformer primary voltage

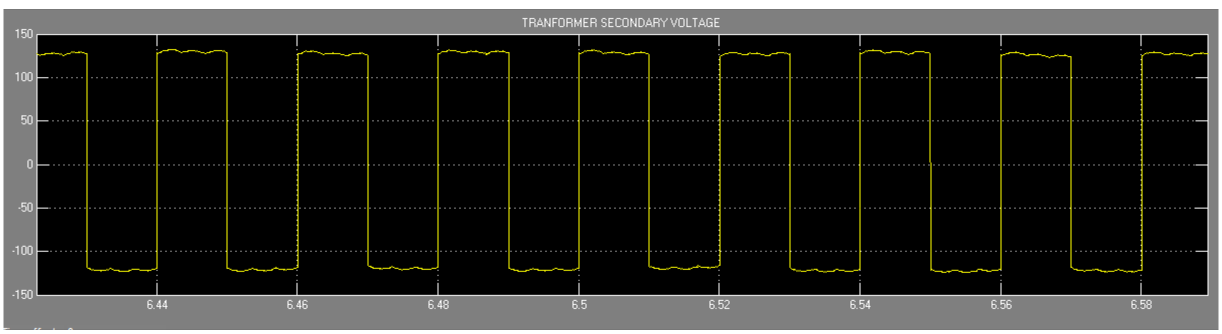

Fig 5.Transformer secondary voltage

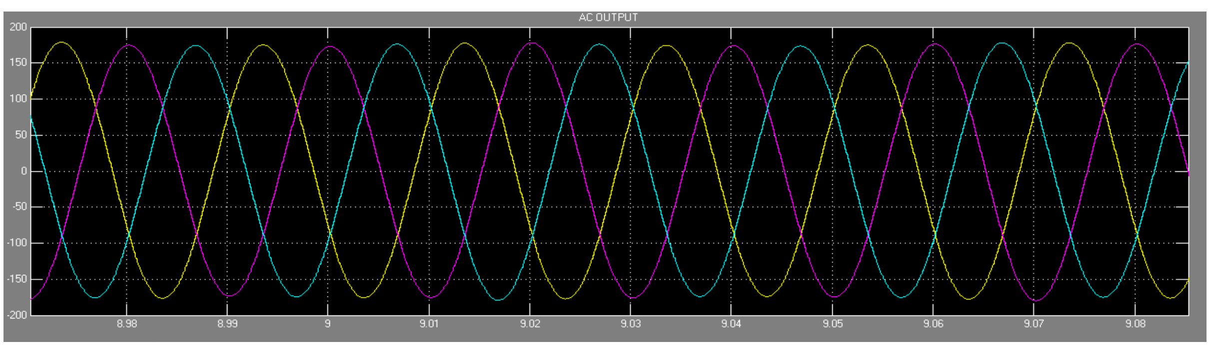

Fig 6.AC output

6. Conclusion:

A hybrid PV-wind-battery based power evacuation scheme for household application is proposed. 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. The experimental results obtained are in close agreement with simulations and are supportive in demonstrating 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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