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Hybrid Inverter Incorporating Solar, Wind, Battery, on Grid and off Grid for Household Devices

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ABSTRACT
This hybrid inverter is a combination of photo voltaic (PV) array, wind turbine and grid system with battery storage unit. Due to the intermittent nature of the solar and wind energy battery storage can be used as an uninterruptable power source, which is able to feed a certain amount of power to the load under all conditions, This paper proposes to select suitable energy source among available sources and then fed to PWM controlled inverter. Power transfer takes place in different modes of operation, like solar mode, wind mode, hybrid mode and battery mode, which gives us user-friendly operation. If power from solar array and wind turbine was inefficient to drive load individually then hybrid mode is enabled. The hybrid mode is a combination of either solar power and wind power or solar power and battery power. For controlling purpose PIC microcontroller is used. All the simulation and experimental results are presented.

Keywords - Photovoltaic array, PIC controller, PWM inverter, wind turbine.

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I. INTRODUCTION

Photovoltaic and wind energies can hold the most potential to meet our energy demands. solar energy is present throughout the day but the solar irradiation levels vary due to sun intensity and unpredictable shadows also wind energy is capable of supplying large amounts of power but its presence is highly unpredictable due to the intermittent nature of solar and wind that makes them unreliable [1]. The combined utilization of these two renewable energy sources, the power transfer efficiency and reliability of the system can be improved significantly [2]. This hybrid inverter consists of two or more energy sources with energy storage devices. This project will combine photovoltaic and wind with on grid or off grid to make hybrid system. When a source is unavailable or insufficient to drive load, the other energy source can compensate the difference. In this system if both solar and wind energy sources are unavailable or insufficient to drive load individually then combine them into single source to reach maximum demand from both the renewable energy sources. Also combine individual solar or wind energy to storage unit to drive load without any interrupt. The systems consist of driver section controlled by controller section which decides modes of operation. Driver section has a common dc bus, connected to PWM inverter.

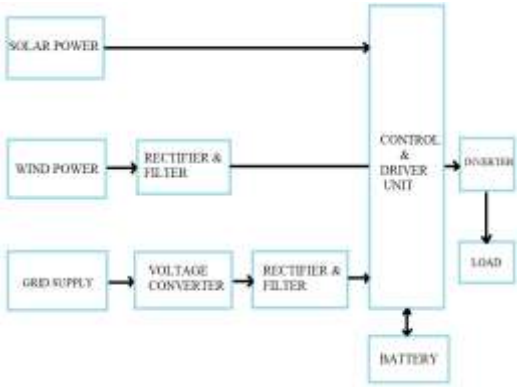

Fig.1 Block diagram of hybrid energy system

II. DESCRIPTION

2.1 Controller Section

The circuit diagram of controller section is shown in below figure, there are three inputs, where first inputs is connected to the output of the PV array, second input connected to the output of a wind generator via bridge rectifier and filter, it convert ac power into dc power also removes harmonics into it, third one is connected to grid supply. The controller select suitable energy source among available sources like solar energy, wind energy, grid supply and battery. The selection of energy source depends on priority of energy sources and power obtained from sources etc. The energy sources are prioritized according to need, here solar energy gives high priority second one is wind power after grid supply,

here controller utilize maximum power from renewable energy sources.

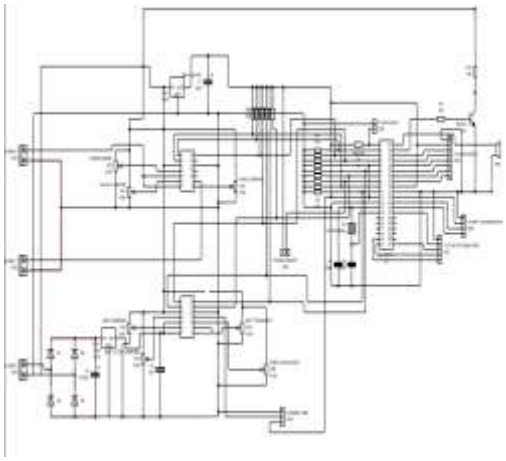

Fig.2 Circuit diagram of controller section

The lead- Acid battery is used to drive control unit and inverter. Battery plays important role in hybrid inverter; changes in solar and wind generation output will cause immediate changes in inverter operation [3]. Battery charge through battery charging unit contain relays and charge controller, it will protect battery from over voltage and over charging. The PIC microcontroller is used to monitor and controlling purpose. It continuously check voltage from energy sources and compares with reference voltages, system works in different modes of operations depends on voltages of individual energy sources. The working of this system is classified into five conditions, in first condition solar power is available. The PV generated energy is given to solar charge controller, avoid over voltage and over charging of battery, output controlled voltage is given to inverter section as well as battery section, here controller system continuously monitor output power and control it according to load. In second condition is hybrid mode use solar as well as battery power to drive the load or solar with wind power, apply only when solar or wind energy was unable to drive load individually. In third mode inverter works on wind power, in this mode wind drive the lode as well as charge the battery. In forth condition inverter will operate on grid supply, here it will drive load directly on grid supply and battery will be charge. In fifth condition inverter works on battery power only. Also inverter protect from short circuit and over load condition. Processor continuously monitor the output current, if it will exceed certain level then it will turn off inverter. Also inverter will give low battery warning signal by comparing battery voltage continuously. Processor also generate PWM signal to drive h bridge inverter. In PIC18F4550, Timer2 can be used for PWM generation. It generates a 10-bit PWM pulse, to set the duty cycle it uses 10-bit register. The higher 8 bits (MSBs) DC1B9: DC1B2 of this register are in CCPR1L register (8-bit) and lower 2 bits(LSBs) DC1B1: DC1B0, which are used for a decimal portion in duty cycle, are in CCP1CON register at bit 5 and 4 respectively. So the 10-bit value for duty cycle is represented by CCPR1L: CCP1CON<5:4>. Inverter has 16*2 lcd display which will show real time status of inverter.

2.2 Diver section

Driver section shown in below figure performs switching operations, like connecting energy sources to inverter, battery charging, disconnect power from inverter under over load and low voltage conditions.

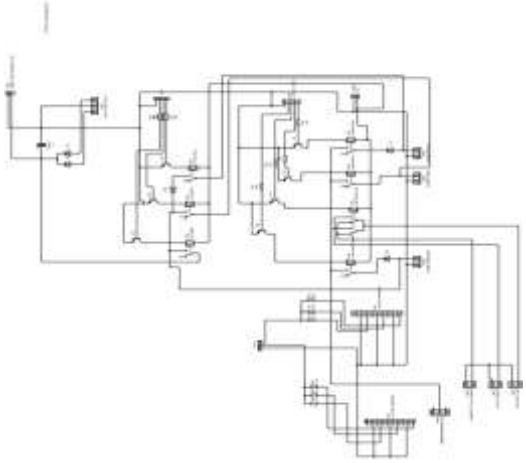

Fig.3 Circuit diagram of Driver Section

The electromagnetic relays are used to perform switching operations. The 500W hybrid system is implemented using 30a relays works on 12v DC supply. The acs712 current sensor is placed to detect over load and short circuit condition, it prevent excessive current flowing through circuit.

2.3 H bridge inverter

The inverter converts dc power to ac power at desired output voltage and frequency. The full bridge inverter is built from two half bridges connected to form what is known as a H-bridge inverter. Its arrangement is shown in figure 4. The output voltage of an inverter has a periodic waveform that is not sinusoidal but can be made to closely approximate this desire waveform. The PWM technique is used, circuit gives a chain of constant amplitude pulses in which the pulse duration is modulated to obtain the necessary specific waveform on the constant pulsing period [4]. In PWM, the controlled output voltage is easily obtained by switching the device ON and OFF many times within a cycle to generate a variable voltage output which is normally low in harmonic content.

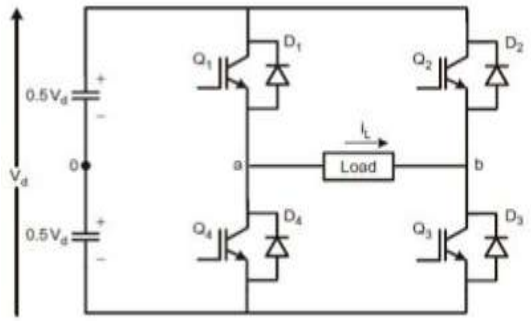

Fig.4 H bridge Section

It comprises of DC voltage source, 4 power switches (usually bipolar junction transistors-BJTs, metal-oxide semiconductor field effect transistors MOSFETs, insulated gate bipolar transistors- IGBTs or gate turned on transistors-GTOs) and the load. To create a square-wave output voltage, the device pairs Q1Q3 and Q2Q4 are switched alternatively at a delay of 180 degrees. When Q1 and Q3 are ON with Q2Q4 OFF for a duration t, also with Q2Q4 ON and Q1Q3 OFF at t [5].

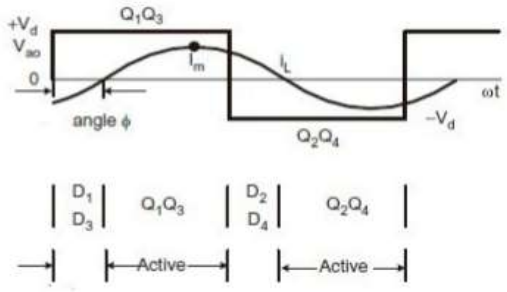

Fig.5 Load voltage and current waveform

A method of controlling the output voltage of the inverter in figure 5 called phase shift control. In this hybrid system IRFB4310 MOSFET's are used.

III. SIMULATION MODEL

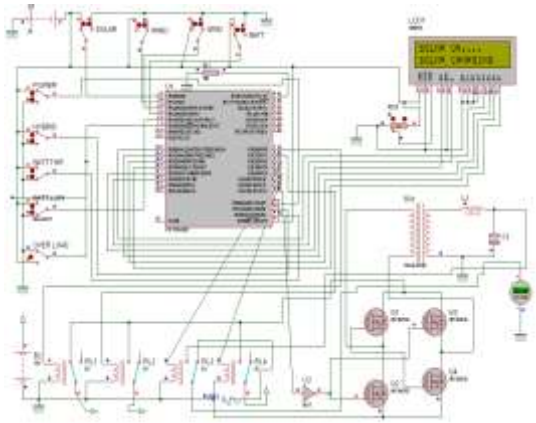

Fig.6 Simulation model for grid tie solar wind hybrid energy system

3.1 Simulation results

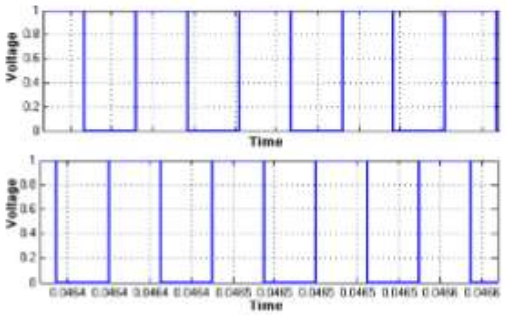

Fig.7 Pulses for Q1, Q2 & Q3,Q4

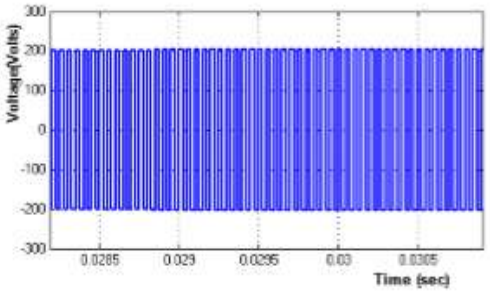

Fig.8 Inverter output voltage

IV. HARDWARE IMPLEMENTATION

Fig.9 Inverter hardware

Fig.10 Inverter display and power switch

V. CONCLUSION

In this paper hybrid inverter system for household devices has been presented. Simulation of hybrid inverter proposed using SIMULINK. A 500W hybrid energy system is practically

implemented and tested. The features of this circuit are: Individual and combined operation is supported, Load demand is met from the individual as well as combination of PV array, wind turbine and the battery, Additional input filters are not necessary to filter out high frequency harmonics. This hybrid system is controlled and monitored to get maximum power from solar array and wind turbine.

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