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Voltage Regulation Of Hybrid Wind-Solar Energy System

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Abstract— The objective of my project work is to regulate the voltage and generate power using hybrid wind-solar energy, buck- boost converter , battery storage and a new rectifier topology. Environmentally friendly non-conventional energy sources are becoming more prominent . A new system configuration of the front-end rectifier stage for a hybrid wind/photovoltaic energy system is proposed. This configuration allows both sources varying in nature, have to be regulated and access power if any will be stored in a battery as a backup. The two sources to supply the load separately or simultaneously depending on the availability of the energy sources. Change in the input voltage of buck-boost converter from 9v to16v, regulates standard output voltage 12v constant irrespective of variation in input voltage with the help of PWM. As the input increases, pulse width goes on decreases. Accordingly adjust the duty cycle of the MOSFET, charges the battery through buck-boost to drive the load. Over load protection is done by microcontroller 89c51 by turning off inverter and also control the operation of the buck-boost converter by closed loop. The nature of buck-boost converter, additional input filters are not necessary to filter out high frequency harmonics. The fused multi input rectifier stage also allows Maximum Power Point Tracking (MPPT) is used to extract maximum power from the wind and sun when it is available.
Keywords- *Maximum Power Point Tracking (MPPT)*

I. INTRODUCTION

With increasing concern of global warming and the depletion of fossil fuel reserves, many are looking at sustainable energy solutions to preserve the earth for the future generations. Other than hydro power, wind and photovoltaic energy holds the most potential to meet our energy demands. Alone, wind energy is capable of supplying large amounts of power but its presence is highly unpredictable as it can be here one moment and gone in another. Similarly, solar energy is present throughout the day but the solar irradiation levels vary due to sun intensity and unpredictable shadows cast by clouds, birds, trees, etc. The common inherent drawback of wind and photovoltaic systems are their intermittent natures that make them unreliable.

However, by combining these two intermittent sources and by incorporating maximum power point tracking (MPPT) algorithms, the system's power transfer efficiency and reliability can be improved significantly.[1]

When a source is unavailable or insufficient in meeting the load demands, the other energy source can compensate for the difference. Several hybrid wind/PV power systems with MPPT control have been proposed and discussed in works [1]- [5].

A simpler multi- input structure has been suggested by [5] that combine the sources from the DC-end while still achieving MPPT for renewable source. The structure proposed by [5] is a fusion of the buck and buck-boost converter. The systems in literature require passive input filters to remove the high frequency current harmonics injected into wind turbine generators [6]. The harmonic content in the generator current decreases its lifespan and increases the power loss due to heating [6].

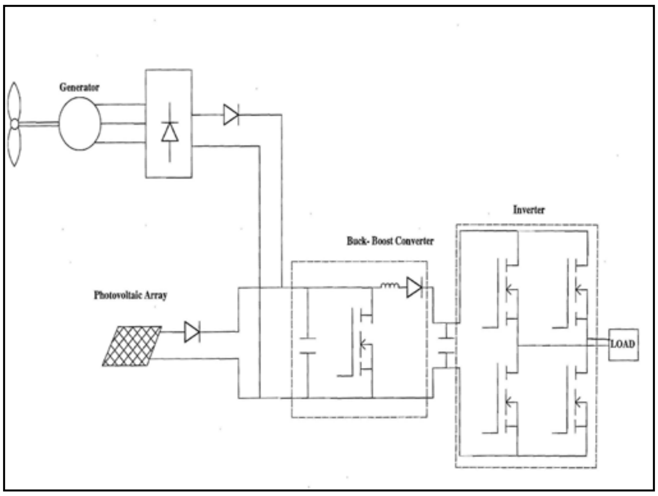

Fig. 1 hybrid wind-solar sources connected to buck-boost converter

Fig1 shows that hybrid wind-solar sources connected to DC/DC buck-boost converter and to the high frequency inverter and to the load. This new system configuration of the front-end rectifier stage for a hybrid wind/photovoltaic energy system is proposed. This configuration allows both sources varying in nature, have to be regulated and access power if any will be stored in a battery as a backup. The two sources to supply the load separately or simultaneously depending on the availability of the energy sources.

II. BLOCK DIAGRAM

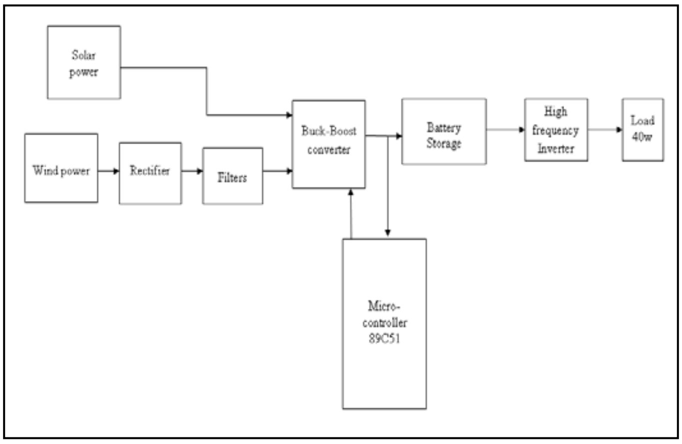

Fig.2 block diagram of hybrid system with buck-boost converter

Fig 2 shows that new system with closed loop topology has, hybrid wind-solar energy sources are connected to buck-boost converter, where variable DC voltage to the buck-boost converter is converted into standard constant DC voltage. That constant DC voltage is stored in a battery as a backup. If any change in the output of the buck-boost converter, output is fed back to the microcontroller, such that to get constant voltage. Over load protection is done by microcontroller 89c51 by turning off inverter and also control the operation of the buck-boost converter by closed loop. Voltage regulation of the hybrid system is controlled by PWM technique i.e, by varying the duty cycle of the MOSFET.

III. OPERATION

Hybrid systems are the ones that use more than one energy resources. Integration of systems (wind and solar) has more influence in terms of electric power production. Such systems are called as “hybrid systems”. Hybrid solar-wind applications are implemented in the field, where all-year energy is to be consumed without any chance for an interrupt. It is possible to have any combination of energy resources to supply the energy demand in the hybrid systems, such as oil, solar and wind. This project is similar with solar power panel and wind turbine power. Differently, it is only an add-on in the system.

Photovoltaic solar panels and small wind turbines depend on climate and weather conditions. Therefore, neither solar nor wind power is sufficient alone. A number of renewable energy expert claims to have a satisfactory hybrid energy resource if both wind and solar power are integrated within a unique body. In the summer time, when sun beams are strong enough, wind velocity is relatively small. In the winter time, when sunny days are relatively shorter, wind velocity is high on the contrast.

Efficiency of these renewable systems show also differences through the year. In other words, it is needed to support these two systems with each other to sustain the continuity of the energy production in the system. Control unit decides which source to use for charging the battery with respect to condition of the incoming energy in fig 3.

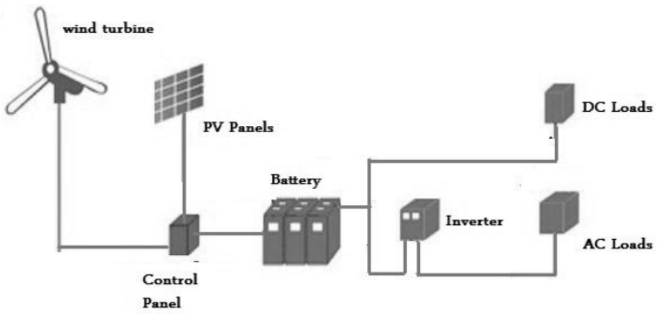

Fig 3 Hybrid system

With respect to the circuit shown in fig 1 the circuit consists of wind and solar energy as a sources. Solar energy is tracked by MPPT by using microcontroller 16f877. Wind energy is converted to AC to DC by using rectifier. Variable DC from both the sources, varied from 9v to 16v . supplied to the buck-boost converter. Gets the constant 12v output voltage from buck-boost converter. If any change in the output voltage, microcontroller 89c51 controls the output voltage by closed loop , such that it maintains 12v constant. Buck-boost converter is designed with under- voltage and over- voltage protection. Over load protection is done by microcontroller 89c51 by turning off inverter and also control the operation of the buck-boost converter by closed loop. Voltage regulation of the hybrid system is controlled by PWM technique i.e, by varying the duty cycle of the MOSFET. As the input increases, pulse width goes on decreases, shown in fig 4 and fig 5. Accordingly adjust the duty cycle of the MOSFET, charges the battery through buck-boost to drive the load.

IV. HARDWARE DESIGN

The details of the components used in this experiment are shown in table 1.

Table 1

	Components	ratings
1	Microcontroller	16f877a, 89c51
2	Integrated circuits	Uc3843N, L293D, SG3524
3	MOSFET	IRF540
4	Transistor	Bc547
5	Operational amplifier	Lm324

V.EXPERIMENTAL RESULTS

Voltage regulation of the hybrid system is controlled by PWM technique i.e, by varying the duty cycle of the MOSFET. As the input increases, pulse width goes on decreases, shown in table 2.

Table 2

Buck-boost input voltage	Buck-boost output voltage	Pulse width*5 (µs)
8.8	12.54	1
9	12.56	1.2
10	12.67	1.6
11	12.75	0.8
12	12.84	0.5
13	12.94	0.3
14	13.1	0.2
15	13.36	0.15
16	13.42	0.11

Design specifications

Table 3

Output power	40W
Output inverter voltage	230V
Buck-boost's MOSFET switching frequency	20 khz
Inverter 's MOSFET switching frequency	33 khz

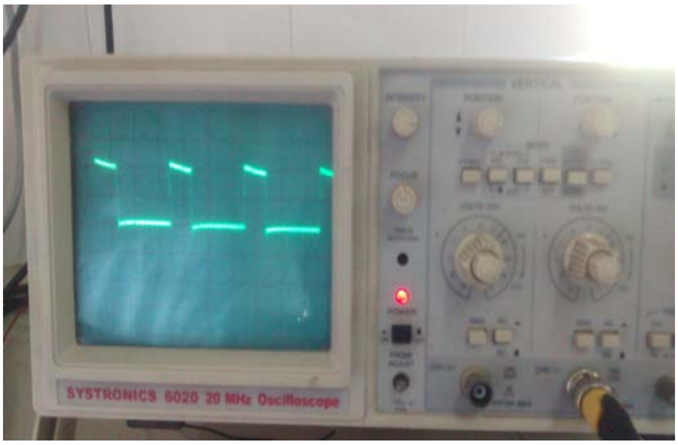

Fig 4:Switching pulses of buck-boost captured using DSO

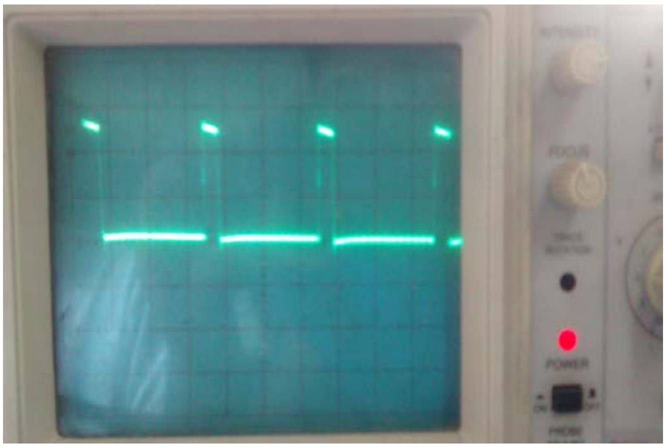

Fig 5 :Switching pulses of buck-boost captured using DSO

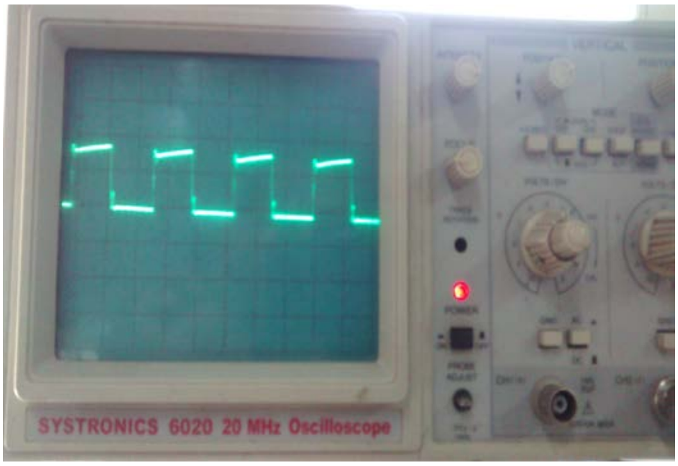

Fig 6: Switching pulses of inverter (with load) captured using DSO

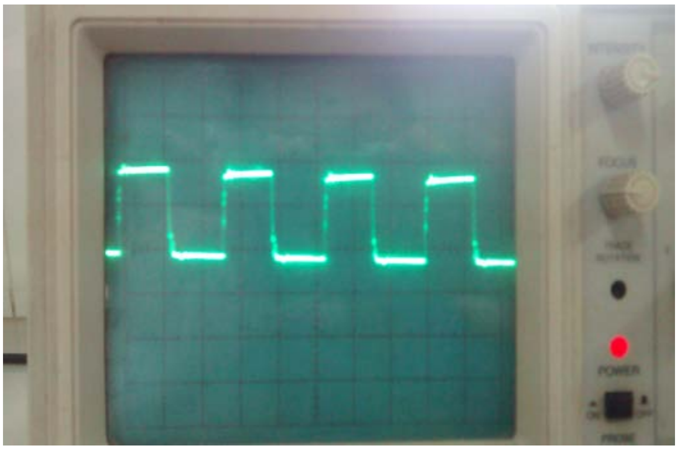

Fig 7: Switching pulses of inverter (without load) captured using DSO

VI. SIMULATION RESULTS

The computer simulation model using matlab simulink has been developed to regulate voltage of hybrid wind- solar energy system.

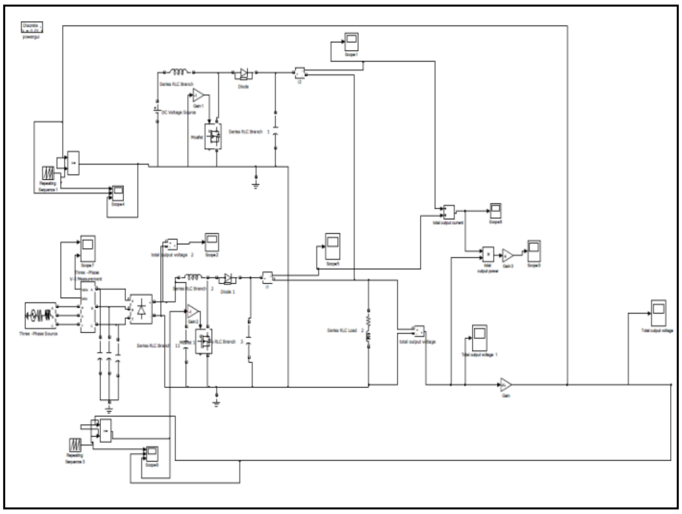

Fig.8: Simulation model of Hybrid System

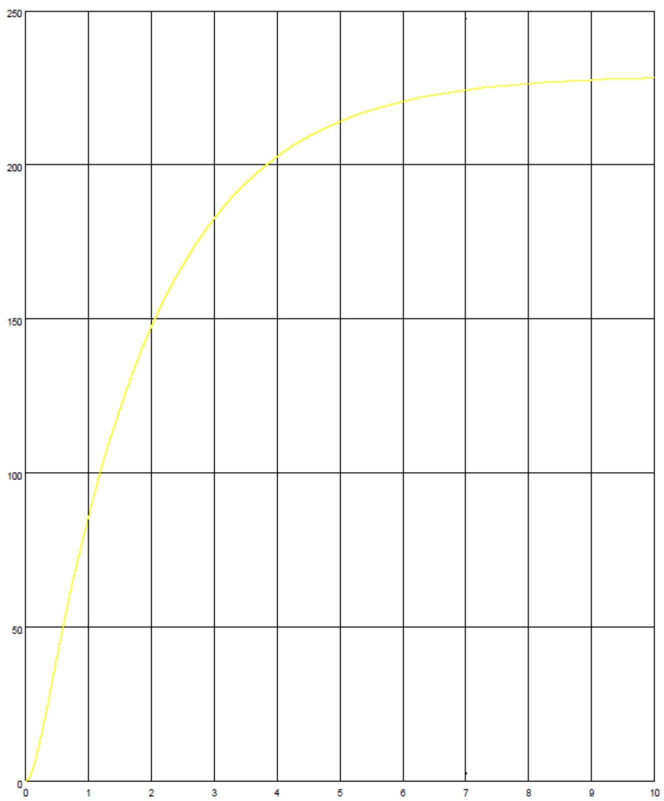

Fig.9: Simulation model of Output Voltage of the Hybrid System

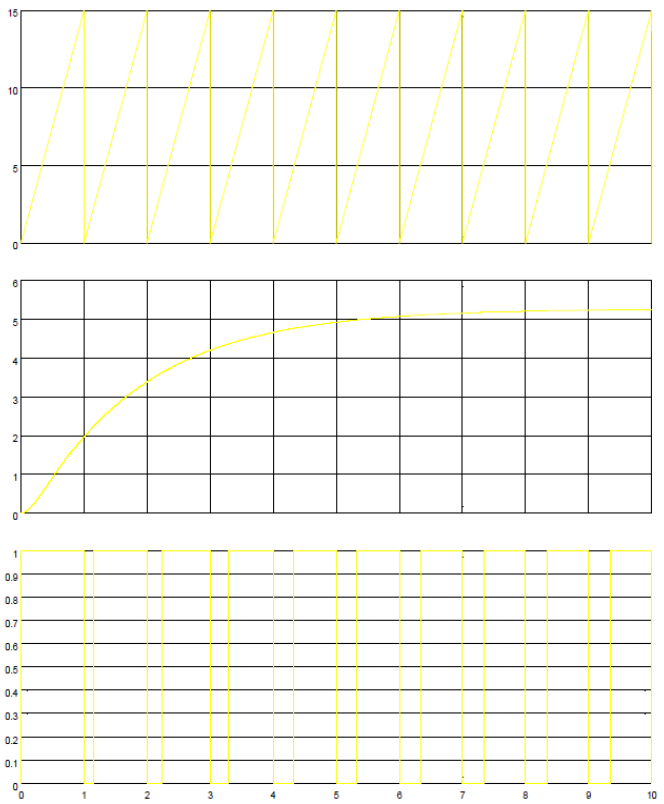

Fig.10: PWM Pulses

VII. CONCLUSION

In this paper a new multi-input buck-boost for hybrid wind/solar energy systems has been presented. The features of this circuit are:

1. Voltage regulation of the hybrid system is controlled by PWM technique
2. both renewable sources can be stepped up/down (supports wide ranges of PV and wind input);
3. Additional input filters are not necessary to filter out high frequency harmonics;
4. Individual and simultaneous operation is supported. Simulation results have been presented to verify the features of the proposed topology.
5. Buck- boost converter with over voltage and under voltage protection
6. Over load protection is done by microcontroller 89c51 by turning off inverter and also control the operation of the buck-boost converter by closed loop.

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