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Design and Development of Enhanced Solar-Wind Hybrid Synchronized Power Generation System for Home Application

Amit Pandey[1]
[1]Centre for Development of Advance Computing, Mohali

Abstract: This paper represent an efficient solar- wind hybrid model for power generation. A vertical axis wind turbine and a solar panel are used to generate power. Power generated by two different means are simultaneously combined together to achieve better power utilization factor. DC-DC converters are used to combine two different power sources with synchronism. An enhanced microcontroller based charge controller circuit is designed to monitor and control the flow of charge. It logically connects power combination module to battery and battery to load. A simple cost effective inverter circuit is also developed along with automated load connector to provide sufficient power supply during brownout. The whole system is designed as each module can work independently and together with each other. This paper includes the physical design analysis as well as feasibility analysis of a solar-wind hybrid power generation system. This document gives formatting instructions for authors preparing papers for publication in the Proceedings of an IEEE conference. The authors must follow the instructions given in the document for the papers to be published. You can use this document as both an instruction set and as a template into which you can type your own text.
***Keywords*: Wind Hybrid, Charge Controller, Power Generation, Power Inverter.**

I. INTRODUCTION

For a developing country, it is very important to have continuous electrical power supply. A gap between supply and demand of energy has become higher than earlier. Demands of electrical energy has increased exponentially in last decade. For sustainable industrial development, a country should have capability of uninterrupted power supply. Limited availability of non-renewable natural resources create huge limitation on continuous power generation. It enables us to utilize renewable energy resources e.g. solar and wind for our power requirements. Solar energy is highest available and reliable resource of energy on planet earth. Solar energy is widely distributed all across the world. Solar photovoltaic cells are used to produce electrical energy from solar energy. Whereas wind energy has the second highest availability on earth's surface. Wind turbines are used to convert kinetic energy into electrical energy.

Solar and wind energy are highly reliable and available source of energy present on our planet. But both energy sources have its limitation regarding all day availability which changes with geographical variation on earth. This limitation can be downcast by combining two power sources simultaneously.

II. RELATED WORK

Many attempts have been done to utilize these two power sources simultaneously. Dixit and Bhatia [1], presents a model which continuously monitor generated power from different source and connect the battery sub system to the source with higher power generation capability. Meiqin, et.al.[2], presents a model with IC controlled SPWM controlled high frequency DC to DC controller. Meenakshi, et.al.[3] simulate a model with self-excited induction generator with neuro intelligent controller.

This paper presents a model for hybrid power generation system. In case when an energy source is not available temporarily then it is possible that a good amount of energy can be extracted from other sources individually. Proposed system intakes power from various independent sources and combine them together in synchronism to work as a single power source. It is a microcontroller based model which simultaneously combines power and utilize it for further use. Combined generated power enhance power supplied to storage unit and makes the system very reliable and efficient.

III.SYSTEM DESIGN

In this paper, a hybrid model for energy generation is presented. Solar and wind energy generation systems are used in synchronism to achieve effective power generation. Fig 1 shows the block diagram of this system

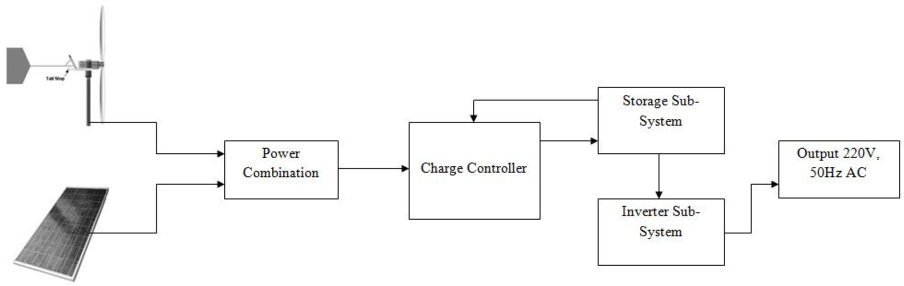

Fig. 1 Block diagram for Solar wind hybrid system

A. Power Combination

This circuit is used to combine various power sources. Multiple input-single output flyback transformer is used to combine these sources. Duty cycle and step size of the flyback transformer is controlled by an independent microcontroller (PIC18F452). It measures voltage and current generated by each power source periodically and control level of each input equivalent to others.

B. Charge Controller

Charge controller is used to control the flow of charge. It controls the input charge which is used to charge the battery system and control the charge to be in limit. It also prevents battery from over charging, deep discharging. It controls amount of charge flow through the battery to the load. Charge controller is used to make battery performance better and reduce safety risk. A separate microcontroller (P18F452) based charge controller is introduced here, which has status LED, various control relays and display LCD interfaced with it. Figure 2 shows block diagram of charge controller. Functions performed by microcontroller based charge controller:

1) Measure Combine generated voltage
2) Measure storage battery voltage
3) Decide whether to connect input to circuit or not
4) Decide when to start and stop battery charging
5) Decide when to switch on and odd the load
6) Display all the function on the LCD.

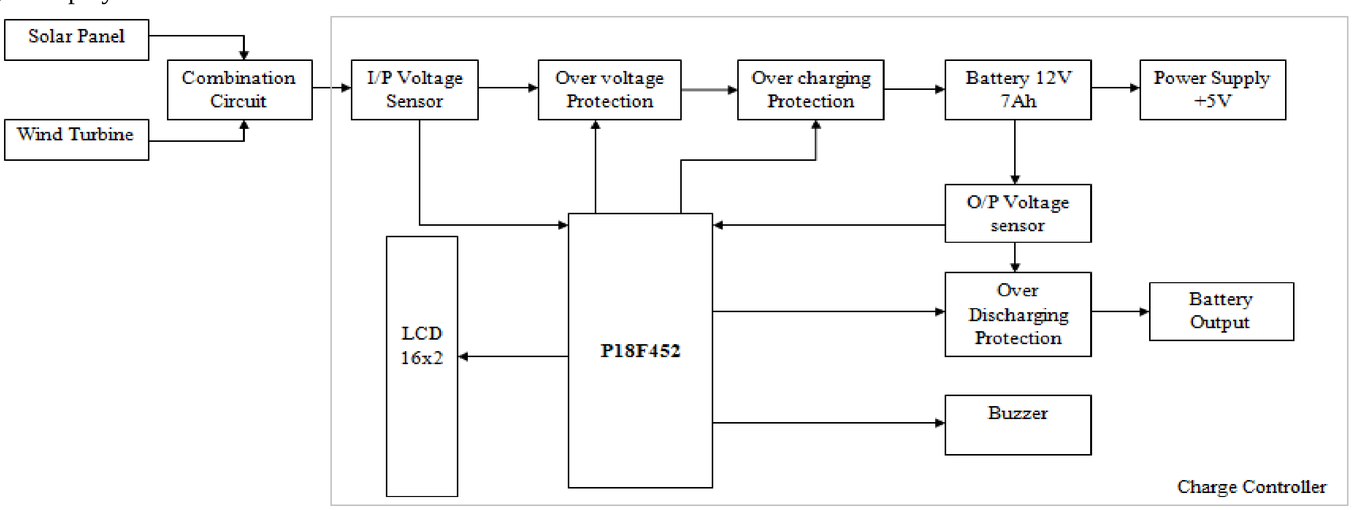

Fig. 2 Descriptive diagram of charge controller subsystem

C. Storage Sub-System

It is not necessary that all the energy generated by hybrid system can be used at that time. Demand of energy cannot always match with the production of energy. When production is going on the renewable energy resources then it becomes compulsory to store the energy for later use. Batteries are most commonly used for this purpose in these types of systems. The basic functions of battery storage in system are:

1) Storage capacity: To store electrical energy when it is generated and supply this energy when it is needed.
2) Stabilization: To provide power to external load with stable current and voltage levels.
3) Surge Current: To provide peak (Surge) current to the external loads.

D. Inverter Sub-System

It is an independent unit with another microcontroller (AT89S51). This microcontroller used to provide controlling signal to the inverting circuit. Power generated by the system stored in Battery storage for further use. Battery storage used to store DC power. Most of the home appliances work on AC system. For this reason stored DC power should be convert to the AC power. Invert Circuitry is used for this purpose to covert DC power to AC power. Microcontroller controlled MOSFETs are used to convert DC power to pure sine wave. Microcontroller also sense input power supply to check the status for brownout condition. Figure 3 represents block view of inverter subsystem. There are three basic parts in this inverter sub system are:

1) DC to AC conversion: This unit converts DC power to AC power with the use of ICs. 50 Hz wave form is created by this unit. This unit gives 12V AC supply as output for 12V DC input
2) Transformation unit: Transformer is use to boost up voltage level to the required output level. This unit gives 50Hz, 220V AC output with 12V DC input.
3) AC sensing unit: This unit used to sense Primary AC supply, whenever this supply is available then this unit cut off the battery to the load. When primary supply is not available this unit connects battery to the load.

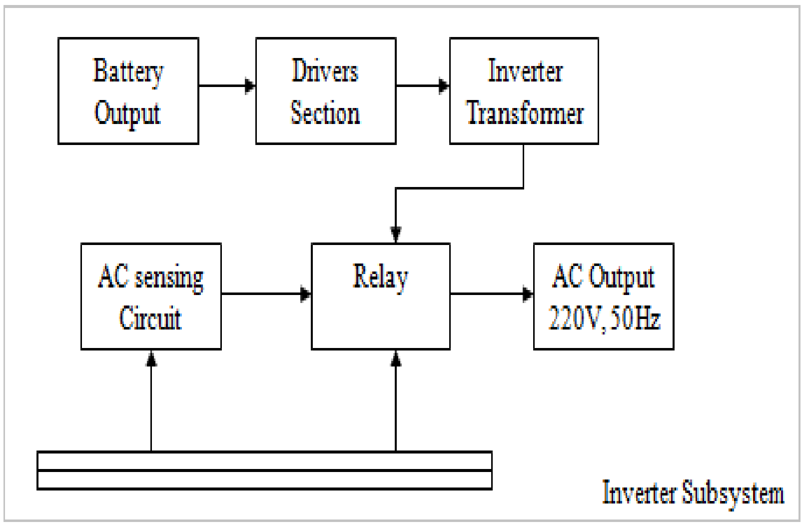

Fig. 3 Module diagram for Inverter Sub system

IV. WORK FLOW

Whenever device is turned 'ON', it starts with charge controller module. Microcontroller serially initializes all its peripherals like-status LED, LCD display, Relays etc. microcontroller checks for the input power from power combination circuit.

Power combination circuit powers up after charge controller module along with Inverter subsystem. Power combination module have its own microcontroller (P18F452) which starts to sense generated power. MOSFETs are used to provide basic reverse polarity protection to the microcontroller. Microcontroller sense generated voltage and current for each of the inputs and based on that it controls duty cycle for switching transformer of flyback transformer. 3-input 1-output flyback transformer has been designed with EE core. Flyback transformer primary winding is energized by each of the generating power supply in synchronism. A fixed output voltage is achieved at the secondary side of transformer. This combined power is then forwarded to the next module- charge controller module.

Charge controller again sense power generated from combination circuit and measures its voltage, current. Charge controller displays this generated power on the LCD. With the help of these sensing it provide all the protection related to the storage unit.

Inverter subsystem is also have an independent microcontroller based circuitry. It sense input power AC supply from grid continuously. Whenever grid power is not available, this modules instantaneously connects loads to the battery. Microcontrollers is also provides gate pulse to MOSFETs which are used to generate pure AC sine wave for supply. Inverter subsystem also used to separate grid supply to the backup supply.

V. SYSTEM DESIGN

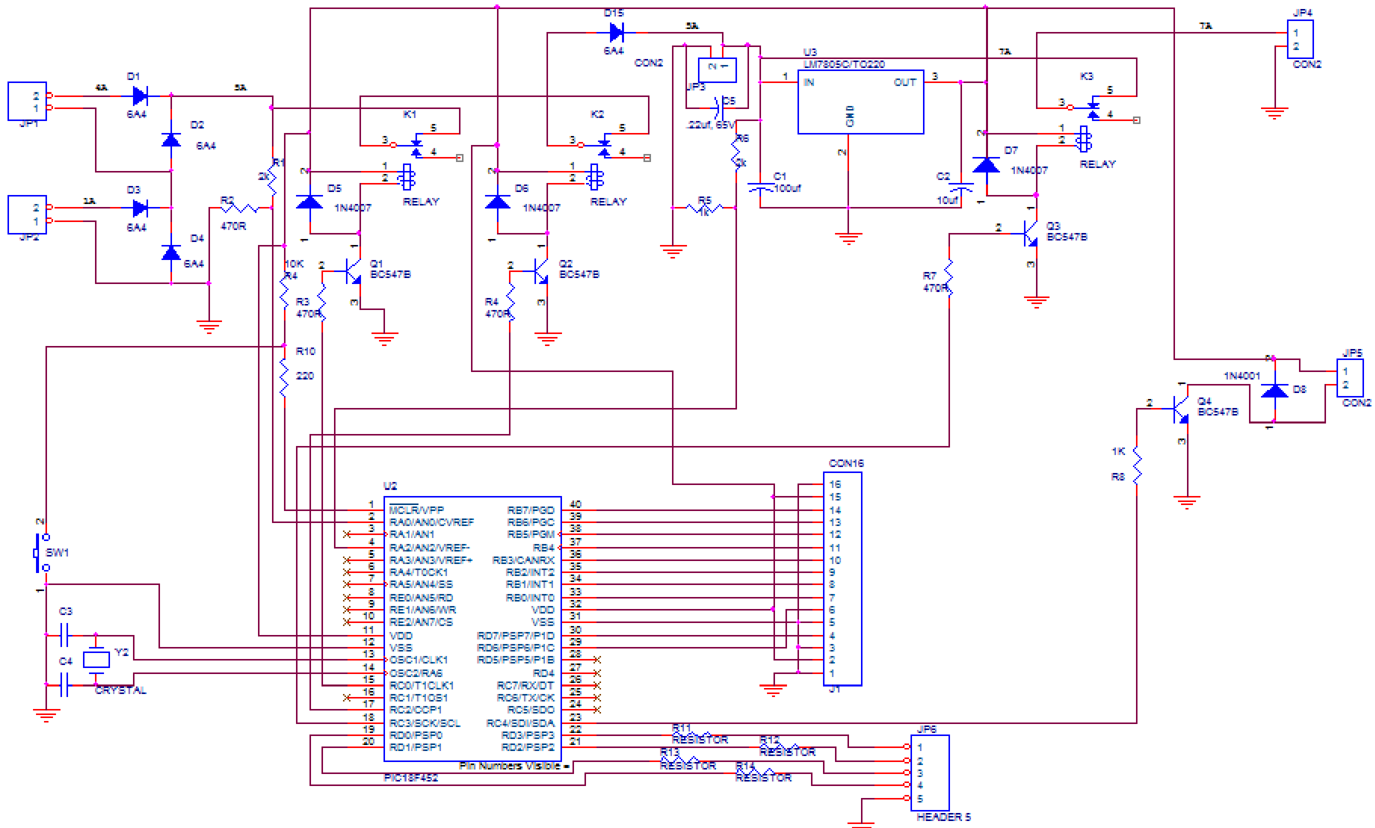

Fig. 4 Schematic view for the designed circuit.

Figure 4 shows schematic view of the charge circuit. Circuit contains two power connections with security and protection features with it. Combine voltage sensed by the microcontroller with for input power measurement. Battery is used as power storage unit. Microcontroller sense battery output voltage and then decides whether to connect charger or load. Buzzer and LED and LCD are used to display. For load connection grid supply should be sensed and connect the load accordingly.

Figure 5 &6 shows the outline for the designed product. Output of the system should be measured as the power generated by solar-wind hybrid power generation system. For battery charging, voltage is the key parameters so the chart given for power generation for specific time shows its values in volts. Voltage level generated by the both sources is combined together and formed appropriate voltage level for the battery charging.

Fig. 5 Open View of power combiner and designed system

Fig. 6 Front and Back view of final product

Table 1 shows solar wind hybrid voltage generation outputs for 15th June 2014 to 23rd June 2014 for peak day hour of 10:00AM to 4:00PM in Chandigarh (India).

TABLE I: ELECTRICAL OUTPUT (VOLTS)

Time	10:00	11:00	12:00	13:00	14:00	15:00	16:00
15/06 (Sunday)	13.0	15.4	17.3	18.5	19.9	17.3	12.2
16/06 (Monday)	15.4	17.4	17.9	18.6	18.8	18.6	17.3
17/06 (Tuesday)	10.1	12.3	11.7	11.1	9.8	13.9	11.7
18/06 (Wednesday)	13.4	14.2	12.4	13.1	14.8	16.5	18.1
19/06 (Thrusday)	6.8	2.4	1.6	2.1	1.8	10.5	13.9
20/06 (Friday)	19.4	16.3	16.9	17.6	17.9	17.3	16.3
21/06 (Saturday)	15.9	17.3	17.5	17.9	18.1	18.0	18.5
22/06 (Sunday)	16.1	17.2	18.3	18.2	18.6	19.0	17.8
23/06 (Monday)	18.2	18.3	18.9	19.3	19.8	15.6	16.9

For the given system the cost of its components and peripherals are calculated as in the table 2. This system is very cheap and easy to implement for house hold application in remote areas. For a developing country as India with this large terrain where supply of energy is not so feasible and reliable this system can provide an easy and cheap solution.

TABLE III: COST ANALYSIS

Items	Cost (in Rs.)
Wind turbine assembly 1kW (300RPM, 20N-M)	3000/-
Solar panel 100W (OC)	7000/-
Charge Controller Module (for 24V, 150A Storage)	2500/-
Power combiner module (3 input capability)	500/-
Inverter module (2kV)	2000/-
Total cost	15,000/-

VI. CONCLUSION

Standalone system can give us power but not as feasible and reliable to generate power all around the day. A hybrid system model is proposed in this work which combines power generation from two different types of energy sources makes power generation more reliable and efficient. This system can be used in the rural areas as well as remote area where grid supply is not available. This system reduce electrical energy crisis for home application. Public collaboration with government can make this system very handy and useful for a common man of the country.

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