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An Implementation of Wind Solar Hybrid Power System

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Abstract

In tradition we use non-renewable energy resources for power production. Now-a-days there is a need for large amount of electricity. But, due to the limited amount of non-renewable energy resources, we can't produce required amount of power. So, there is a need to move to the renewable resources like solar, wind, tidal, and geothermal energy. These power production systems are existing one. But due to the large fluctuation and minimum amount of power produced, we shift to hybrid power systems. Here, we proposed a method of wind-solar hybrid power systems. The proposed method is based on high power supply reliability and full utilization of wind and solar energy. In this paper, we implemented the hybrid system in train for internal power supplies such as light, fan, mobile chargers etc.,

Keywords: *Wind solar Hybrid power system, power saving mode, controller program and case study*

1. Introduction

Electricity becomes an essential one for our day-to-day life. Electricity production is the process of generating electricity from energy resources. There are many energy resources. It is mainly classified into renewable and non-renewable energy resources. Traditionally, non-renewable resources like coal, petrol etc., are used for electricity production. The population increases rapidly for the past few years at the rate of 1.58%. So, there is a vast need of electricity for sophisticated life. We have to improve sustainable energy for future use. For this purpose, we have to move to the renewable energy resources [1]. Based on eco-friendly environment, the renewable energy resources are more beneficial.

Initially, hydro energy is used. In hydro power plant, electricity is produced continuously. But the drawback is, when the dam is constructed, the natural water table varies. So, the salt content of drinking water increases. This leads to serious water scarcity problem. India is located at north of the equator between 8°4' and 37°6' north latitude and 68°7' and 97°25' east longitude. So, India receives large amount of solar energy. The electricity production from solar energy is more efficient one. But, the electricity is available only during summer season[2]-[3]. The another most common renewable energy resource is wind energy. Wind energy is available at free cost. But there is need for large amount of initial investment and wind is not available all the time. There is many other renewable resources like geo-thermal energy, natural gas, ocean energy and bio-fuel etc.,

With the increased demand of electricity, we have to move on Hybrid Power systems.[4] A Hybrid energy system usually consists of two or more renewable energy sources used together to provide increased system efficiency as well as greater balance in energy supply. Examples of hybrid systems are Wind – hydro system, Wind – diesel system, Wind – solar system and Photovoltaic – diesel system etc.,

1.2. STATE OF ART

Initially, there is lot of methods used to implement renewable energy resources. A simple probabilistic method has been developed to predict the ability of energy storage to increase the penetration of intermittent embedded renewable generation (ERG) on weak electricity grids and to enhance, the value of the electricity generated by time-shifting delivery to the network [1]. This delivers are greater energy benefits, but the drawback is the method is more expensive. To overcome this, a system was planned to achieve Minimum Cost Objective (MCO) and Minimum Emissions Objective (MEO) [4]. This includes satisfying energy demand, stability, reliability and battery constraints. For this purpose, epsiv-constraint and goal attainment methods are used . The epsiv-constraint method minimized the total cost. For designing the hybrid power system, a stimulation model of Hybrid2 model was developed to design the hardware and selecting the operating options based on overall system performance.

2. Proposed Method

In this paper, we prepare a wind solar hybrid power system. The reason for choosing wind and solar for hybrid system is: (i) The wind speeds are low in the summer when the sun shines brightest and longest. (ii) The wind is strong in the winter when less sunlight is available. Because the peak operating times for wind and solar systems occur at different times of the day and year, hybrid systems are more likely to produce power when you need it. (iii) This combination also works efficiently with greater energy output during the day with the Solar panels & collectors, with wind turbine generated energy at night. The main objectives of this method are

- Fully utilizing the complementary characteristics of wind and solar energy that can significantly reduce the fluctuation of output power.
- Here, an improved optimal sizing method is working in stand-alone modes.
- An optimization of the battery's charge/discharge state can also be realized.

The battery model is mainly adopted here to calculate the amount of energy that can be absorbed by or released from the battery bank at each time It is based on the concept of electrochemical kinetics, and a battery can be modeled as a two-tank system. The first tank contains "available energy," in which it can converts to dc electricity. The second tank contains "bound energy," which is chemically bound and therefore; it is not immediately available for release.Three parameters are used to describe this two-tank system,

The maximum battery capacity is the total amount of energy that the two tanks can contain. The capacity ratio is the ratio of the size of the available energy tank to the combined size of both tanks. The rate constant relates to the conductance between the two tanks, which is a measure of how quickly the battery can convert bound energy to available energy.

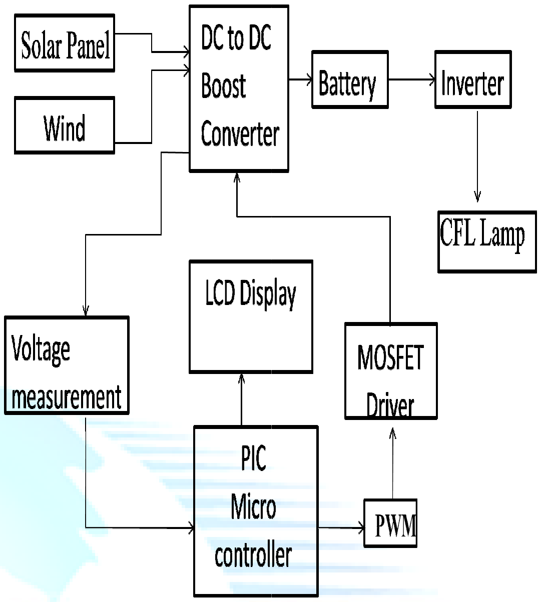

Fig.1 Block diagram for wind solar hybrid power system

The Photovoltaic cell is used in solar panel. When the sun hits the silicon semiconductor, the electrons are generated. The current flow is proportional to the incoming photons. The output from the solar panel and wind turbine is given to the microcontroller. The controller produces a Pulse width modulated signal which is used for controlling operation. The Driver circuit is used to drive the boost converter circuit. The boost converter is used to maintain the constant output voltage. This voltage is used to charge a battery which is used for internal train electricity purpose.

2.1 OPERATION

The driver circuit is used to control another circuit such as high power transistor. It consists of two transistors. Depending upon the ON and OFF conditions it switches the high power transistor. In the driver circuit there is a need of input to switch ON & OFF the transistors. The input is given as pulse width modulation by the controller. The boost converter is used to boost the voltage level from the solar panel and wind turbine to battery. The principle of boost converter is that the power is conserved, i.e. the output current is lower than source current circuit. The boost converter consists of inductor , switch, diode and capacitor. Depending upon the switch, the inductor produces magnetic field, which is rectified and the voltage is used to charge battery.

The advantages are High power supply reliability, Full utilization of wind and solar energy, Optimization of battery's charge and discharge state, Battery's life time is increased, Total cost is low, Power is expected at all the time, Low maintenance cost but long-term gain.

2.2 HARDWARE

The hardware implementation of this paper is very simple. The hardware consists of boost convertor circuit, driver circuit and PIC 16F877A microcontroller. The working of boost convertor is based on the power conversion law. So, the input and output power levels (P=VI) are same by increasing the voltage level and decreasing the current level at the output. The purpose of using the boost convertor is to produce high voltage level. The principle of the boost convertor is that the inductor restricts the changes of current by producing a magnetic field. By making the changes in the current level with the use of a switch, we can produce an alternating current. The switch many be BJT, MOSFET or IGBT. In this paper we are using MOSFET as a switch. The ac current is rectified and we get the output voltage that is greater than the input voltage. The input voltages are taken from the solar panel and wind turbine.

The driver circuit is used to control other circuit in a system. The driver circuit consists of two transistors. One is NPN transistor and other one is PNP transistor. The Pulse width modulated signal which was generated by microcontroller is used as a controlling signal. Due to the variations in the PWM pulse, the two transistors switch on and off alternatively. The output is a clock pulse which is used to drive the boost convertor. The microcontroller is used to control all the process. When the voltage from the solar panel and wind turbine varies, the microcontroller produces a pulse width modulated signal.

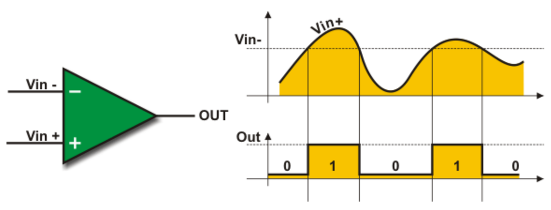

Fig.2 Analog to digital converter

The pulse width modulated signal is produced by analog to digital convertor circuit. The ADC is based on successive approximation technique. In this method, the comparator has two inputs: one as the input voltages from solar panel and wind turbine and other as the reference voltage. When the input voltage is higher than the reference voltage, the output is logic 1. Similarly, if the voltage is lower than the reference voltage, the output is logic0.

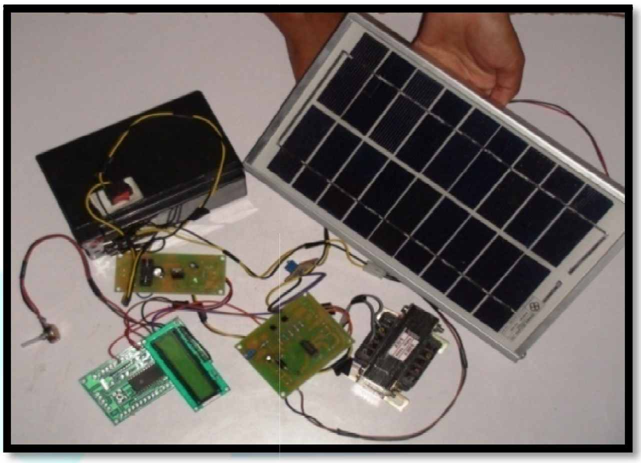

Fig.3 Hardware implementation of wind solar hybrid power system

2.3 SOFTWARE

In this proposed method, we are using embedded c language to control the overall operation of the system. The parameters are V is the input voltage from solar panel and wind turbine, a is a constant i.e. the required constant output voltage; Vs is the voltage from solar panel; Vw is the voltage from wind turbine; Link s is the connection from solar panel; Link W I the voltage from wind turbine.

The input voltages are measured. If the voltage level is greater than the required voltage level, then the excess power is stored on the battery. If the voltage of solar panel is greater the wind turbine, the solar panel power is stored and power from wind turbine supplied to load otherwise reverse conditions happen.

The analog to digital converter generates a 10-bit binary result and stores the conversion results into the ADC registers. The Modes and registers used are:

- ADRESH - Contains high byte of conversion result;
- ADRESL - Contains low byte of conversion result;
- ADCON0 - Control register 0; and
- ADCON1 Control register 1

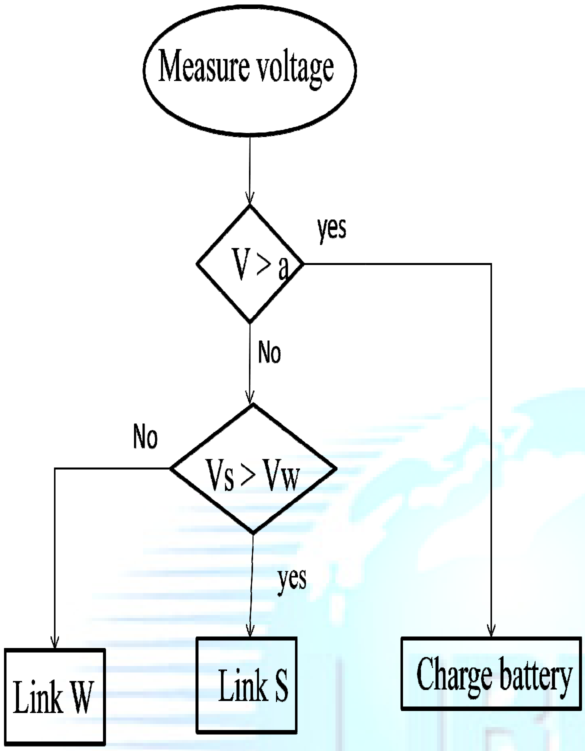

Fig.4 Flow chart for controller program

There are two formats: Right justified & Left justified. In the proposed method, we are using left justified because we want quick and crude result and short of space to store results. In this mode, the effective ADC range is: ADRESH = 0 @0V -> 255 @5V. First we have to configure the port by setting TRIS register and ANSEL register for analog input. Then configure the voltage reference in ADCON1 register and select ADC conversion clock. Select one of input channels CH0-CH13 to declare the ports. Select the data format (right justified or left juistified) using the ADFM bit of the ADCON1 register. Set the ADON bit of ADCON0 register to enable A/D converter. After enabling ADC, configure the interrupt by clearing the ADIF bit and setting the ADIE, PEIE and GIE bits. Denote the delay that is actually the acquisition time to pass. Set the GO/DONE bit of the ADCON0 register to start/ end the conversion. After ADC conversion is completed, read the results in ADRESH and ADRESL register.

3. Case Study

Initially, a trail run of Himalayan Queen train was done, it was powered by 200W Solar panel. The power can support light, fan and mobile chargers for 5 hours journey. As a next step, a normal passenger train Shivalik express was converted into a train with solar panel. The train run between Kalka and Shimla stations. Now-a-days, the northern railways are trying to convert the train into solar train.

Fig.5 The Shivalik express equipped with solar panel.

The train has been installed with solar-powered sockets, which will enable recharging of mobiles and cameras during their journey. The overall cost of converting the train into a solar power unit was around Rs 225,000, that is equal to $4500.

4. Conclusion

In this paper, an improved optimal sizing method for wind solar-battery hybrid power system is proposed. Compared with the traditional methods, the proposed method has several improvements as follows: 1) A more accurate and reasonable optimal sizing model is built with the consideration of the required installation area of DG and the operating reserve capacity of the system. 2) The battery's SOC, the charge/discharge current, the charge/discharge rate and the charge/discharge cycles are taken into consideration. Thus, the battery's charge and discharge state are optimized, which is helpful for prolonging the battery's lifetime.

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