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Research Article

SOLAR WIND HYBRID SYSTEM TO POWER MOBILE BASE STATION

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ABSTRACT

Operation of telecom networks require extensive use of diesel generators for power supply, which has lead to a disadvantage of increasing the greenhouse gas emission and enlargement of carbon footprints. To avoid these effects we are using solar and wind hybrid system. As there is adequate availability of solar energy and average wind speed, we are utilizing solar and wind power hybrid system with durable battery backup for providing reliable cellular mobile services. A microcontroller is used to monitor the power from solar panel and wind generator. The switching action is provided from microcontroller to the battery charger based on power received from solar panel and wind generator. The system charges the battery using wind and solar power only, which will make it more cost effective, efficient and reliable. Maximum power point tracker battery charger is used for exploiting maximum power from photovoltaic panel and wind turbine to charge the battery which will increase durability and battery life. To make full use of wind and solar energy improved simulated annealing particle swarm optimization algorithm is used. This system comprises of solar panel, wind turbine, charge controller and charge storage unit (Battery).

INTRODUCTION

The Indian telecom sector has grown expeditiously in last decade and still expected to grow intensively. In present days, the mobile operators are undergoing serious difficulty in limiting financial loss. At the same time, there has been an increase in cost due to higher cost of spectrum as well as the lack of reliable 24x7 grid power[2]. One solution to solve this problem is to bring down the operation costs. In the absence of poor and unreliable electrical power infrastructure, these operation costs are influence over energy costs at the cell sites. As the network expands more into rural areas, the cost of cellular network rises further as the power shortage increases.

More than 70% of the 400,000 Base Transceiver Sites (BTS) sites in India are faced with the lack of power supply for over 8 hours a day; many face much larger power cuts[2]. During power cuts, the telecom operators have to power cell sites with diesel generators and battery backups, which today have excessive costs. The Indian telecom industry absorbs more than 2 billion litres of diesel and discharges 5 metric tons of CO2. Hence if the telecom industry has to expand in the rural areas, there is need for an alternative sources of energy.

The alternative to cut the cost is to use renewable sources of energy to power mobile base station.

Powering BTS sites with diesel have two adverse Implications.

1. High Costs: The cost involved in using diesel is very high and it is estimated that the Indian telecom industry spends over 85 billion rupees on diesel every year [3].
2. The depletion of a non renewable energy source which leads to high carbon Footprints and is hazardous for the environment [4].

The use of renewable energy sources like solar energy and wind energy can be explored as a feasible option for replacing diesel in powering the BTS sites worldwide and specifically in India.The more suitable form of renewable energy in today's world is the solar energy and wind energy. The solar electric system converts sun radiation into DC electricity. To get usable electric voltages the solar cells are connected in series parallel combination. The wind energy is utilized for power generation by converting the kinetic energy of wind in to rotational motion by using a wind turbine. This rotational motion is converted into usable electrical energy.

Solar and wind energy are clean, environmental friendly. Because of this advantages they are used by energy sectors.

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However, they have some drawbacks. Wind and solar energy depend on weather and climate conditions. Solar energy is not available for 24 hours and wind is not continuous at all time. So, solar wind hybrid system is used. The solar wind hybrid system provides power periodically. Microcontroller is used to monitor power from wind turbine and solar panel and the switching action is provided from microcontroller to the charge controller based upon power received from solar panel and wind turbine.

Due to simplicity of particle swarm optimization (PSO) algorithm it has been widely used in optimization computation. Since PSO algorithm does not make full use of information that is obtained in the calculation process and only uses the globally optimal and locally optimal information in each iteration, in addition, PSO algorithm cannot eliminate the relatively inferior solution without preferred mechanism itself, leading to "premature" or slower convergence speed [5].

To solve this problem, a hybrid algorithm is designed by combining PSO algorithm that has strong global search ability with other optimization algorithms that has a good local search ability [6]. The most important characteristics of the simulated annealing algorithm are to step out local optimal area and find the global or approximate optimal, which has nothing to do with the choice of the initial point [7]. Therefore, simulated annealing particle swarm optimization (SAPSO) algorithm is presented to enhance the global search ability and escape from local optimal ability of PSO algorithm.

Base Station Powered By Renewable Energy

Mobile communication technologies such as base station and mobile phones have become very common technologies throughout the world. Roughly three billion users spend large portion of their income on these communication technologies. However, the remaining half of the world currently has short access, in large part due to poor network. Mobile telecom networks require an excessive amount of power. The Indian telecom industry absorbs more than 2 billion litters of diesel and discharges 5 metric tons of CO_2. The alternatives to improve base-station efficiency are solar powered base station and wind powered base station. The use of diesel generators to power base-stations requires regular maintenance, are costly to run, and causes air pollution. By utilizing solar power to run the base-stations reduce the operational cost.

Due to expressive increase in power demand for future mobile networks (LTE, 4G and 5G) wind powered base station has become powerful solution to decrease fossil fuel consumption. The systems with only solar or wind generation are rich but there are problems linked with both of them. The solar power is not available for 24 hours and wind is not continuous all the time. So a hybrid system containing solar and wind has been designed to control these problems. A stand-alone wind system with solar panel system is the best hybrid combination of all renewable energy systems.

Block Diagram of Proposed System

Fig. 1 shows the block diagram for solar wind hybrid system.In this module there are two resources wind resource and solar panel. Wind turbine converts the kinetic energy of wind into rotational motion using wind turbine and this rotational motion is converted into usable electrical voltage. This ac voltage is given to the AC- DC rectifier to convert it into DC signal. Then DC signal is given to DC- DC converter. The DC-DC converter is used for charge regulation or battery regulation which limit rate at which electric current is added to or drawn from electric batteries. The DC-DC converter used is SEPIC (Single Ended Primary Induction Converter).The output of SEPIC converter is controlled by duty cycle of controlled transistor. SEPIC converter exchanges energy between capacitor and inductor. DC-DC converter is connected to microcontroller. MPPT control circuit is implemented in microcontroller, that has A/D converter and PWM signal mode. It read the voltage and current of wind turbine through A/D ports of microcontroller and calculate output power. It also calculate power by reading the voltage and current of battery side in same way. The buck converter is controlled by microcontroller . Microcontroller sends corresponding control signal to buck converter and control duty cycle of converter by PWM signal through controller to accordingly increase, decrease or turn off the DC-DC converter. Driver unit is used to give gate signal to DC-DC converter. Battery is used to store the energy so that device can be powered when sun is not shinning and wind energy is not adequate to generate power.

Solar panel uses energy of incident photon on its surface and convert it into electrical energy. This energy is given to the DC-DC converter. DC-DC converter used is buck converter. As the power from solar panel is greater than that we required to charge battery buck converter is used. Buck converter matches the voltage and current solar panel to battery voltage and current. Solar energy is given to microcontroller which reads voltage and current from solar panel and battery by using ADC ports and it gives the control signal to the buck converter and duty cycle of buck converter is controlled by microcontroller. The driver unit is used to give gate signal to the MOSFET. If the load is of AC type then the DC energy stored in the battery is converted into AC power by using inverter.

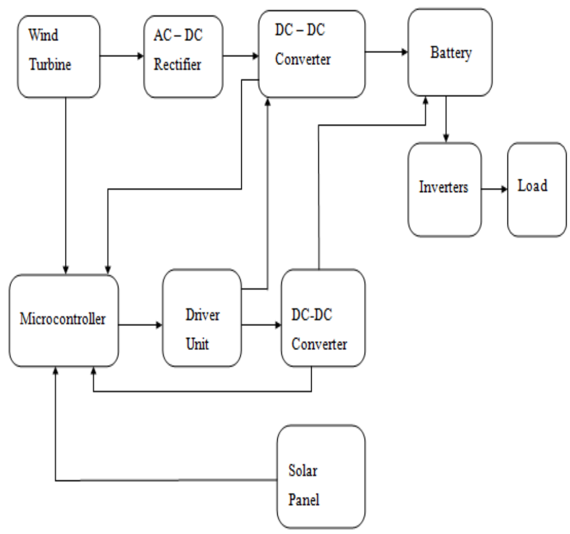

Fig. 1 Block Diagram of Solar Wind Hybrid System

Design of Buck Converter

The LM2576 is a Step Down Converter which is the most basic forward mode converter. Its basic schematic can be seen in Figure 2 .The operation of this regulator has two different time periods. The first time period occurs when the series switch is on, the input voltage is connected to the inductor. The output of the inductor is the output voltage, and the diode is reverse biased. During the first time period, since there is a constant voltage source connected across the inductor, the inductor current begins to increase linearly ramp upwards, as described by the following equation:

$$I_{L(ON)} = \frac{(V_{IN} - V_{OUT})\, t_{ON}}{L}$$

During this "on" period, energy is stored in the inductor in the form of magnetic flux. The next time period is the "off" period of the power switch. When the power switch is off, the voltage across the inductor reverses its polarity and is clamped at one diode voltage drop below ground by the rectifier diode. The current now starts flows through the rectifier diode thus maintaining the load current loop. This removes the stored energy from the inductor. The inductor current during this time is:

$$I_{L(OFF)} = \frac{(V_{OUT} - V_D)\, t_{OFF}}{L}$$

This second period ends when the power switch is turned on. The converter is regulated by varying the duty cycle of the power switch. The duty cycle is given as follows:

$$D = \frac{t_{ON}}{T}$$

Where T is the period of switching.

For the step down converter with ideal components, the duty cycle can be given as:

$$D = \frac{V_{OUT}}{V_{IN}}$$

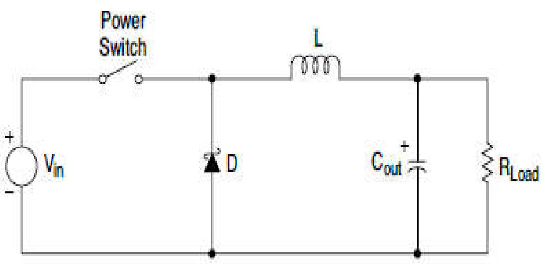

Fig.3 Basic BUCK Converter.

Procedure to design BUCK converter

$V_{IN\,(max)} = 40V$

$V_{OUT} = 14.2$ V

$I_{Load\,(max)} = 3A$

Selection of programming resistors R_1 and R_2:

$$V_{OUT} = V_{ref}\,(1 + R_2/R_1) \qquad \text{......(1)}$$

Where, $V_{ref} = 1.23V$

Resistor R_1 can be between 1K and 5K.So, we have selected $R_1 = 2K\Omega$.

Therefore, from equation no. (1)

$R_2 = 18.97\ K\Omega$

Input capacitor selection(C_{in}) :

A 100µf, 150V aluminium electrolytic capacitor located near the input and grout pin provides sufficient bypassing.

Catch diode selection(D_1):

Use 40V 1N5822 schottky diode.

Output capacitor selection (C_{OUT}):

$$C_{OUT} \geq 13300^* \frac{V_{IN(max)}}{V_{OUT}^* L}$$

$C_{OUT} \geq 170.2944$

So, we have selected capacitor of 220 µf.

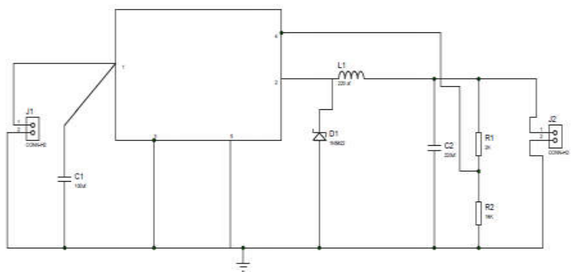

Fig. 4 Schematic of Designed BUCK Converter

EXPERIMENTAL RESULTS

The input to the system is given from variable power supply and solar panel. This input is given to the SEPIC converter which will step down the input voltage to 14.2V that is required to charge the battery. The fig.5 shows test setup.

Fig. 5 Experimental Setup

When the input voltage is below the threshold voltage then battery get charged by solar power. Fig. 6 shows message on LCD when input voltage is below the threshold voltage.

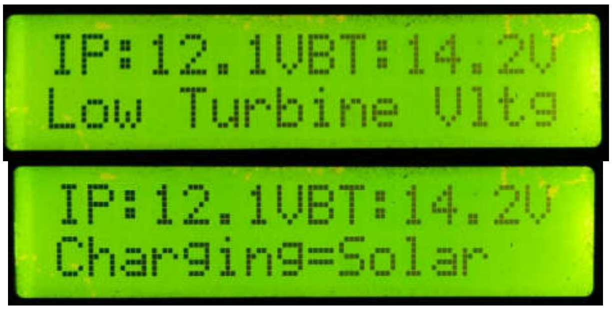

Fig. 6 Message Displayed on LCD when input voltage is below threshold voltage.

Fig. 7 Message Displayed on LCD When Input Voltage is Above threshold voltage

CONCLUSION

In coming year, man will have to more depend on renewable energy sources. The wind energy is not continuous all time and solar energy is not available for 24 hours we have designed solar wind hybrid system.Because of the disadvantages involved in using solar or wind energy individually, a hybrid system which avoids the individual advantages will become more famous in coming years. In this paper a new SEPIC rectifier stage for solar wind hybrid system has been presented.

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