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A DEVICE TO HARVEST RESIDUAL DAY LIGHT TO BE USED FOR INDOOR POWER REQUIREMENTS

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ABSTRACT

Solar energy has received a considerable attention from industries that are active in the field of electricity. This project is aimed at using a solar panel inside a building and use residual day light as a source of energy to power equipments for a short time period. The device stores solar energy extracted from the residual daylight in a battery bank for a long time period. The battery is charged at any voltage above the threshold voltage given by the solar panel. Power inverter directly converts direct current (DC) from the battery to alternating current (AC). In order to achieve the frequency of home electrical appliances it has used an integrated circuit (IC) component to generate clock signals. Design has a charge controller and it uses a boost converter (step-up converter) to step up the voltages from the low values. For the protection of the power inverter, a varistor circuitry is used. The advantage of this system is this photovoltaic solution can be used inside a building similar to a table. Since this device harvest energy from renewable source, the cost for the electricity would be saved[1].

Keywords: Power inverter, Charge controller, Boost converter, Battery bank

1. INTRODUCTION

Nowadays people use renewable energy sources such as photovoltaic solutions in order to fulfill their electrical needs. Usually solar panels need an unobstructed and south-facing area to obtain maximum power. Obstructing sun may cause them to be not effective as they could be[2]. This project is also about a renewable energy source which harvests energy from residual daylight inside buildings. It resolves the problem of accommodating large spaces for energy sources. This is also a photovoltaic solution, but the advancement from the predecessors is that size of this is similar to a normal office table. Since the shape of the device is similar to an office table, this can be used as an office table. Since the device harvests solar energy from the residual day light inside buildings, in buildings which are designed to have maximum day light the photo energy does not waste completely. The device can be used to absorb this renewable energy and can be consumed later.

2. EXPERIMENTAL

Following fig 1 explains the processes of each step in the device with respect to fig 2. In this setup, a sealed lead-acid battery is used as the battery bank. The capacity of the battery is 45 Ah. Polycrystalline silicon solar panel of 235 W is used to collect photo energy and other electrical equipments are designed to provide the maximum efficiency for the device.

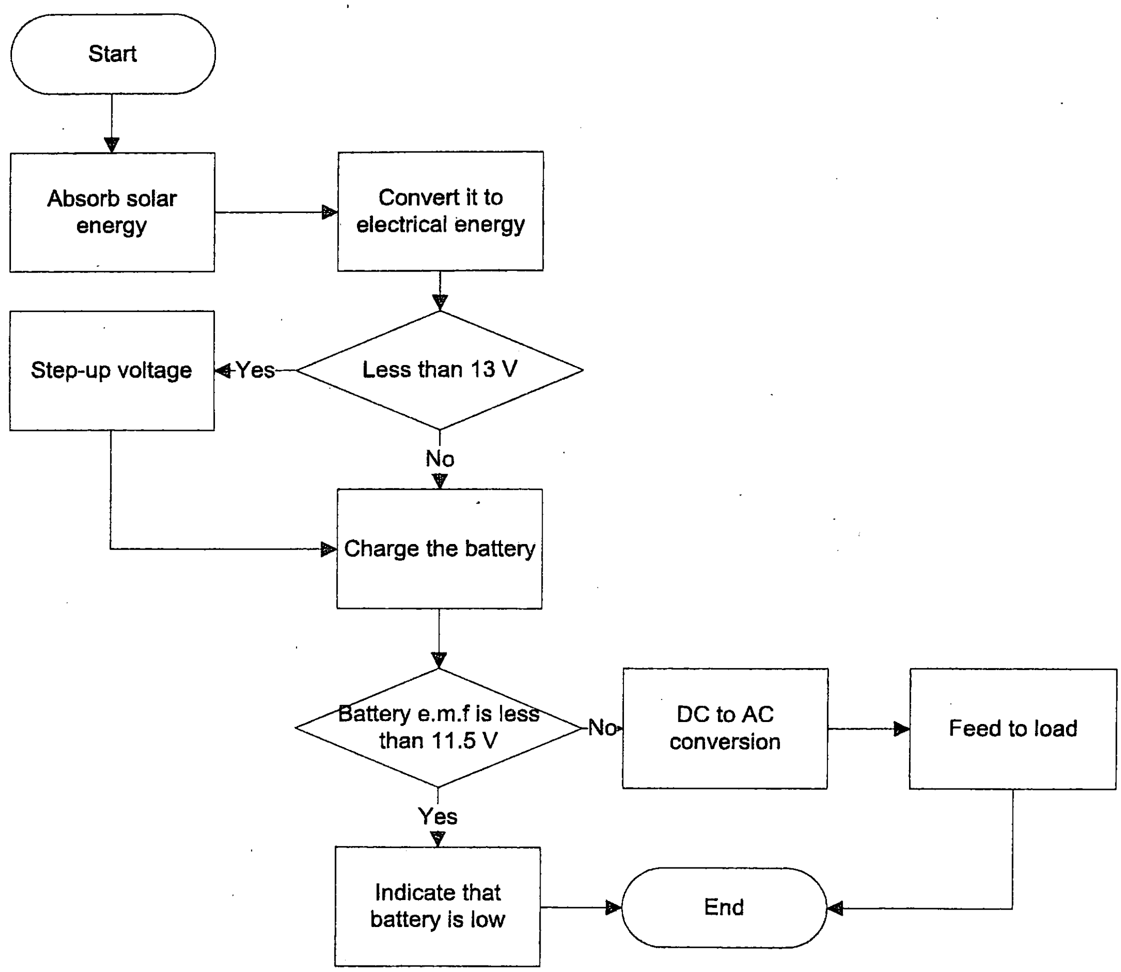

Figure 1: Flow chart of the system

The solar panel of the device fixed as a table absorbs the photo energy and then the energy is converted to electrical energy by the photovoltaic effect in the solar panel. Sometimes this electricity is of low voltage. This low voltage is stepped-up by a boost converter (step-up converter) in the charge controller as a battery can be charged using this stepped-up voltage.

DC to AC inverter operates only when the electromotive force (e.m.f.) of the battery is greater than the reference voltage of 11.5 V. Else it indicates by lighting a light emitting diode (LED). DC to AC inverter converts 12 V DC voltage into 230 V sine wave with the frequency of 50 Hz. Fig. 2 shows the operation of each component as an overview. DC to AC inverter is used immediate to the battery. In order to protect the power (DC to AC) inverter from electrical current surges, a surge protector is used.

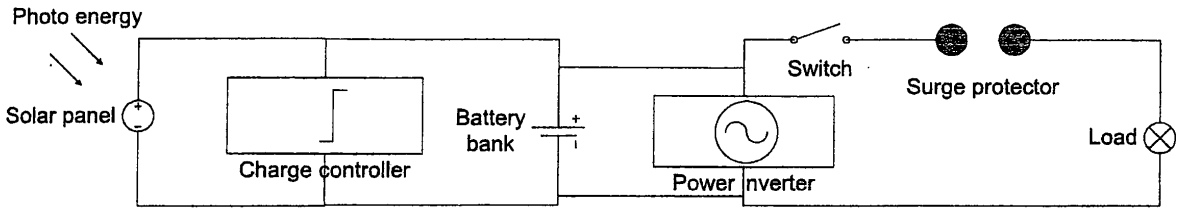

Figure 2: Operation of the device

The solar panel receives energy inside the building. Charge controller directly receives the energy from the solar panel which is converted to higher voltage than the received voltage if the voltage is below the threshold (fig 1). In the charge controller step, a boost converter is used. The function and the charge controller circuitry is explained below

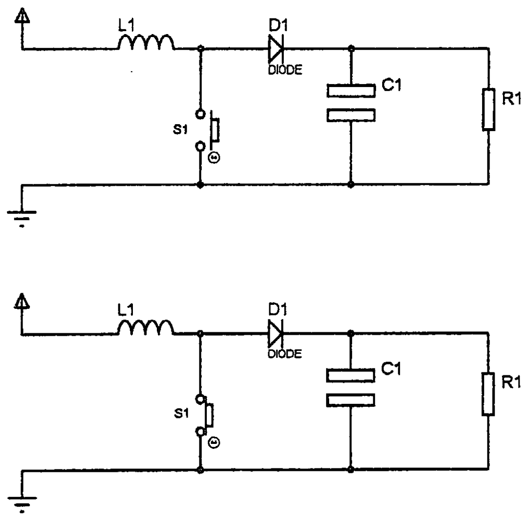

Figure 3: Boost converter used inside the charge controller

The circuit simply explains the function of a boost converter. When the switch (S1) is closed, inductor (L1) stores a portion of magnetic energy. Sudden opening of the switch (S1) changes the current through the inductor (L1), and implements a back e.m.f. as to resist the current change in the inductor. This increased voltage stores in the capacitor and releases to the load[3].

In this circuitry, it has used a programmable integrated circuit to control the switch (S1). This has made the circuit to convert the voltages accurately as in ideal conditions.

Following diagram describes the function of the power inverter which takes energy from the battery bank.

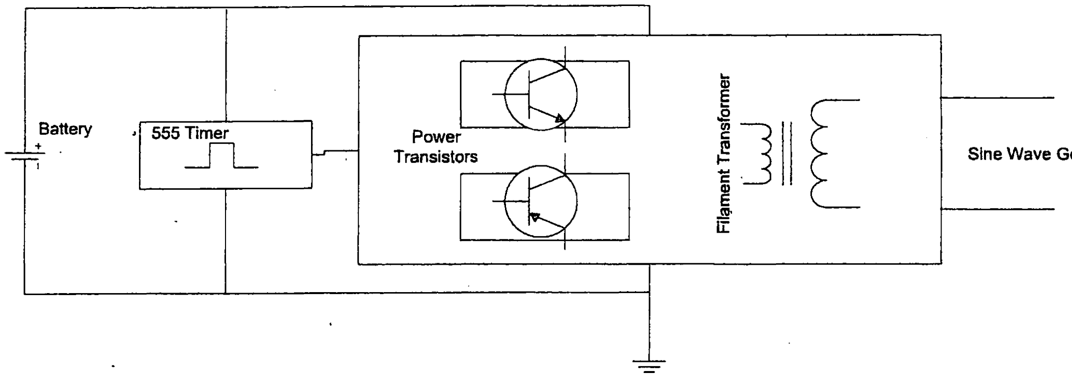

Figure 4: DC to AC power inverter's main components

Here, the clock signal generator generates clock signals at the frequency of 50 Hz. But those are square wave signals. Generated clock signals are fed to power transistors which generate high current pulses according to the 555 Timer outputs. The square wave pulses which are received to the filament transformer change their shapes into sine wave signals and also this transformer increases the amplitude of the signal.

The received signal can be used for any domestic electrical equipment. But in some equipments, they use Switch Mode Power Supply (SMPS) as their power supply. In these equipments, large voltages are freed in the input terminals. These freed voltages are called electrical surges. In order to avoid the surges go to the inverter circuit, a varistor circuit is used. This varistor circuit is called the surge protector/remover. Following figure shows the surge protector operation.

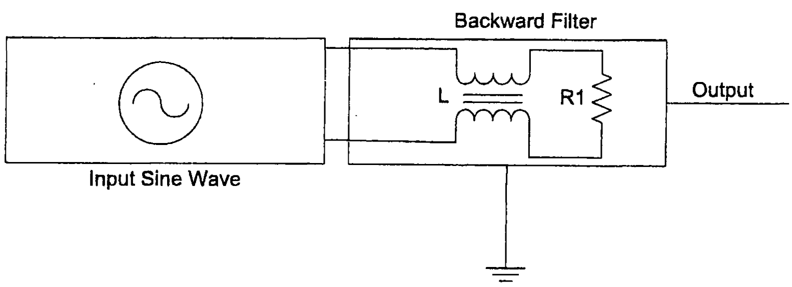

Figure 5: Surge remover operation block diagram

The inductor couple in this part of the circuitry is arranged in series in order to remove unwanted signals. Only sine waves pass the inductor couple since they are wound in opposite direction. R1 is the load resistance called varistor which dissipates the power of the surge when an input voltage is given from the output terminals. Inductor couple blocks one sided surges and direct them to the varistor (R1). High frequency signals are grounded through capacitors.

3. RESULTS AND DISCUSSION

This device is able to power a 15 inch laptop (65 W) for nearly a six hours time with idling the laptop. If the storing time is nearly ten to fifteen days, the device operates successfully (depending on the electricity consuming item). A 10 W electrical lamp and a 35 W electrical fan were simultaneously used to test this device since the measurement can be taken for the feasibility evaluation of using this device. The device was possible to successfully operate them for nearly four hours.

The total cost for the device with a polycrystalline silicon solar panel, table frame, 45 Ah lead-acid battery and other circuits designed was nearly 32000 Sri Lankan rupees.

Usage of lithium-ion cells instead of lead-acid cells will serve well in the battery bank since their self discharge rate is smaller compared to sealed lead acid batteries[4]. This will reduce the charging time of the battery. In contrast with the normal lead acid cells, sealed lead acid batteries are cost alternative to the lithium-ion cells[5].

In order to reduce the size of the circuitry, timer IC can be replaced by a programmable microcontroller since its operation can be changed at any time[6].

In this project, a panel which consists of polycrystalline silicon solar cells is used. Instead of using polycrystalline silicon solar cells, usage of monocrystaline silicon solar cells will increase the efficiency of the device[7]. But it will also increase the cost of the device.

Thin film GaAs or InGaP/GaAs/InGaAs would be successful alternatives for silicon solar cells in this device and they would generate electrical energy than now since their efficiencies are greater than silicon solar cells[8].

4. CONCLUSION

Even though this is a preliminary product for harvesting indoor renewable energy, it has proved that this can handle a considerable amount of throughput. For darker conditions this device can step-up voltages and store them in the battery using its charge controller. With the integration of AC conversion this is equally contributed to the domestic electrical needs. Since this device is similar to a normal table, this can save the additional space required for power generators inside buildings. For high power devices this would not be suitable since they require large amount of stored energy. The efficiency of the device can be increased by maximizing the day light in the building design.

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REFERENCES

[1]. Omar, E., Haitham A., Frede B., *Renewable and Sustainable Energy Reviews* 39 (2014) 749

[2]. Eric C. F., *Green Building & Remodeling*, John Wiley & Sons, 2011

[3]. Michal, V., *IEEE Transaction on Power Electronics,*27 (2012) 1

[4]. Abe, H.,Murai, T., Zaghib, K. *Journal of Power Sources* 77 (1999) 110

[5]. Power Sonic, *Sealed Lead-Acid Batteries Technical Manual*, Power-Sonic Corporation, 2009

[6]. Hruskovic, M., Hribik, J., *Radioelektronika*, 19(2009) 39

[7]. Fraunhofer ISE, *Photovoltaics Report*, 2014

[8]. Martin A. G., Emery, K.,Hishikawa, Y., Warta, W., Dunlop E. D., *Solar cell efficiency tables (Version 45),1(2014)2*