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Solar Panel Powered Cooling Unit Using Buck Converter

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ABSTRACT- This paper aims to develop the circuit model of a cooling unit called Peltier unit which is powered by a solar panel using a DC-DC step down converter is known as buck converter. The cooling unit is which is portable and requires less power can be used anywhere to keep certain things cool especially in areas where electricity shortage is a big problem and so using this module in such areas can be highly beneficial.

KEYWORDS-Solar energy, Peltier module, Buck converter, Solar battery, Fossil fuel.

I. INTRODUCTION

With the advent of solar energy into the power generation scenario, small efficient and cost effective solar panels are being developed and so they can be used even in the remote locations where it is difficult for the power grid to reach but sunlight is abundant. Solar power generation through photovoltaic models is a crucial part of renewable energy generation which basically has to most important advantages over conventional fossil fuels like coal and petroleum; first, of being a clean energy source as it does not produces pollution resulting in greenhouse gas emission and, second, are being a renewable energy source as it is practically limitless, while fossil fuel like depleted quickly and take millions of years to replenish. Also powergeneration from solar panels allows system to off grid in case of black out and so all together makes it more reliable and self-sustained. These panels are being manufactured in many sizes and some even have the ability to be flexible. This allows them to be used for various purposes like powering small equipment into generate light and heat. Cooling various things such as food items and water has become a necessity these days, especially when going away from home; so an easy to carry, portable cooling unit no external source of power supply is a very important thing. This is what is being presented here in this paper. Also power electronics device like power converters which are compact and chief, are available that can convert power efficiently thus minimising the losses by using the switching characteristics of semiconductors such as MOSFETS, diodes and other circuit elements. So using compact and low power solar panel, a dc-dc step down converter and a peltier cooling unit is a small, portable cooling model is made and the power converter allows efficient control of output voltage of the converter or input to the cooling unit hence regulating the temperature or cooling of the converter as required.

II. OBJECTIVES

The main objective of the project is to build the cooling unit, which is operated by the solar energy, freely available inthe nature. The motto of this project is to minimize the cost and use of the free energy available in the nature. The Buck converter is the DC-DC step down converter, which supplies the energy to the cooling unit.

III. PROBLEM STATEMENT

Normally cooling units consume more power and costlier in nature. These are difficult to carry from one place to another place. These are difficult to use in electricity shortage areas.

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IV. LITERATURE SURVEY AND BACKGROUND

The paper [1] talks about a system where they have proposed a system which uses Peltier module for refrigeration and heating using embedded system. In the [2] paper, there is a new technique through which we can ensure on the use of peltier effects. The authors in paper [3] discuss about a Embedded controller in farmers pump by solar energy. In [4] solar energy harvesting for wireless sensor nodes.

In yet another research paper [5] Theoretical limits of photovoltaic solar energy conversion. In paper [6] minimizing power consumption in drying systems propelled by thermal or solar energy. In paper [7] is similar to [2] Solar Refrigeration using Peltier Module.

V. COMPONENTS REQUIREMENTS

The main components requires in this module are

- Solar panels.
- Peltier module.
- Buck converter.
- Battery.
- Arduino Nano.(Atmega328).

A. Solar panels: A solar cell generates about ½ volt. That's not much for practical use. So multiple cells are wired together in series to create higher voltage, creating a solar module, commonly referred to as a solar panel.

Fig. 1 Solar Panel

A typical 12 Volt (V) solar panel has 36 cells in series. The larger a solar cell is, the higher the current. So the cells of a 200 Watt (W) panel are generally bigger than a 100W panel. Multiple solar modules wired together then creates a solar array. This voltage is optimised 100 watt solar panel is ideal for use in powering ON or OFF grid solar power systems and for directly charging 12V batteries. It's rigid anodised aluminium frame and toughened 3.2mm tempered glass prevents damage due to frost, snow and high winds giving it a design life of over 25 years of consistent free power.

B. Peltier module: Thermoelectric technology is an active thermal management technique based on the Peltier effect. this phenomenon involves the heating or cooling of the junction of two thermoelectric materials (bismuth and telluride) by passing current through the junction.

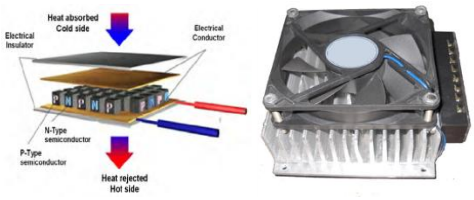

Fig. 2 Peltier Module.

During operation, direct current flows through the TEC module causing heat to be transferred from one side to the other. Creating a cold and hot side[7].

C. Buck converter: A buck converter (step-down converter) is a DC-to-DC power converter which steps down voltage (while stepping up current) from its input (supply) to its output (load).

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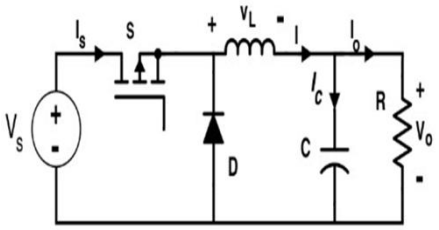

Fig. 3 Buck Converter.

Buck converters are used to buck or reduce output from solar panel. Panel output voltage is fed into gate of MOSFET. On switching MOSFET, current flows. As inductor starts building up oscillations by developing magnetic field across it due to which voltage is "buck" up or reduced. When MOSFET is turned off, EMF is suddenly reversed in the inductor that opposes further drop in current. It supplies current to the load itself via Diode [7].

D. Solar battery: Battery life can be extended by storing the batteries at a low temperature, as in a refrigerator or freezer, which slows the side reactions. Such storage can extend the life of alkaline batteries by about 5%; rechargeable batteries can hold their charge much longer, depending upon type.

Fig.4 Solar Battery.

To reach their maximum voltage, batteries must be returned to room temperature; discharging an alkaline battery at 250 mA at 0 °C is only half as efficient as at 20 °C. Alkaline battery manufacturers such as Duracell do not recommend refrigerating batteries[7].

E. Arduino Nano (atmega328p): Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators.

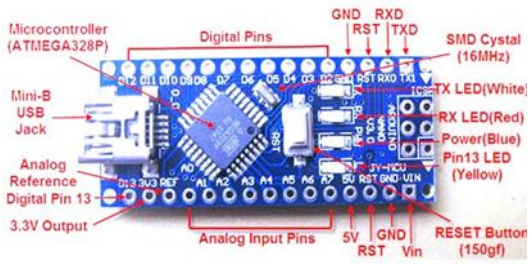

Fig.5 Arduino Nano

The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing).

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VI. CIRCUIT DIAGRAM

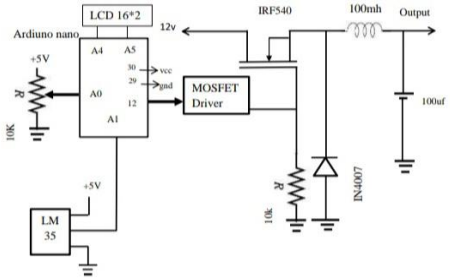

Fig. 6 Circuit Diagram for Module

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- 12V AC supply from the transformer is given to the full bridge rectifier, bridge rectifier converts the supply from AC-DC.
- 1000µf capacitor is used to reduce the voltage ripples, then the 7805 regulator is used to reduce the voltage from 12V to 5V because microcontroller based Arduino Nano requires only 5V of supply. There is capacitors of 100µf and 0.1µf, used to reduce the voltage ripple.
- Arduino Nano is microcontroller based IC used to control the pulse width modulation(PWM) signals. Here potentiometer is used manage the duty cycle of signal by varying the duty cycle, cooling effect can be altered. Then power supply from Arduino microcontroller is flows towards buck converter through the MOSFET driver. Here MOSFET driver is used to drive the gate terminal of the MOSFET.
- If the supply is directly given from Arduino Nano to buck converter circuit there is some drop in the voltage.
- To manage the drop and for the sufficient amount of current driver is used, Then the supply is given to the peltier unit through Buck converter. Peltier unit is cooling unit works on the peltier effect.
- Here Buck converter is used to manage the variation in the supply. When there is a variation in supply Buck converter should manage it otherwise Peltier unit is going to damage.

VII. DESIGN AND IMPLEMENTATION

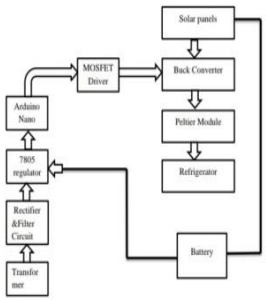

Fig. 7 Design implementation

A. System Design: A Schematic layout of the laboratory setup is developed is shown in the figure7. The solar panel powered cooling unit using buck converter laboratory setup has been architected to ensure modularity & cater for future expandability and upgradability.

B. System Implementation: The system implementation needs proper co-ordination between hardware and software components, so system implementation is divided into various blocks as discussed below.

- Solar PV Units.
- Buck converter.

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- Peltier Module.
- Experimental setup.

C. Solar PV Units: The solar photovoltaic unit is basically a semiconductor pn junction cell which generates a typical photovoltaic voltage of 0.6v in open circuit upon illumination by sunlight photons.

Eg=Electron volts(conduction band)-Electron volts(valence band) ---------(1)
The panel is modelled after small mono crystalline cells. The open circuit voltage V and short circuit current I are related by the following equations.

V=N x B x T x ln(I/Io) ---------- (2)

Where NBT comprises of N as charge carrier density, B as Boltzmann constant and T as temperature, it has a value of 25meV and Io is the reverse saturationcurrent. Efficiency of solar cell (n) is given by the following expression [8].

η= (power output) ÷ (power input)----------(3)

D. Buck Converter: Power electronics has become well integrated into all the electrical machines and even in the electrical power grid. The various converters used employ solid state semiconductor devices like MOSFET and Silicon controlled rectifier which can be switched On and Off just by applying gate pulses. So using the On and Off mechanism, AC voltage can be converted into DC voltages and vice versa, even changing their magnitudes. Also DC-DC converters and AC-AC, frequency as well as magnitude converters are available.

For an ideal buck converter the output voltage Vo, input voltage Vin and duty cycle are related as follows:
Vo= D x Vin ---------- (4)
In practical cases, due to losses by switching, resistance of the inductor and in the diode, the output voltage is less than the value predicted by the above equation. The output voltage is the average value of the varying voltage across the output load [8].

E. Peltier Unit: Peltier unit is basically a cooling unit based on a thermoelectric principle known as peltier effect. This effect states that when ever a voltage is applied across a plate made of two differently conducting materials and having a heat conductive material in between them, then a temperature difference is observed across both the plates and heat is extracted from one plate while it is released from the other plate.

Gc or Gh= K x I ----------(5)
Where;
K is differential peltier coefficient between the two elements used.
I is the current flow in amperes.
Gc and Gh are the cooling and heating rates respectively, in watts.

F. Experimental Setup: This section shows the images of various stages of development of the project, The figure 8 shows the arrangement, consisting of solar panel and peltier unit. Figure 9 shows the arrangement, consisting of refrigerator, buck converter and arduino nano etc. At last stage figure 10 shows the overall system setup to experimental testing.

Fig. 8 Experimental Setup of Solar Panel and Peltier module.

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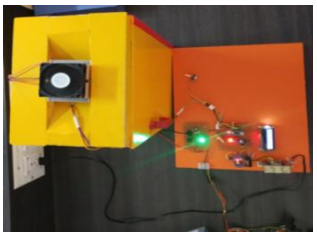

Fig. 9 Experimental Setup of Refrigerator, Buck Converter Ardiuno Nano etc.

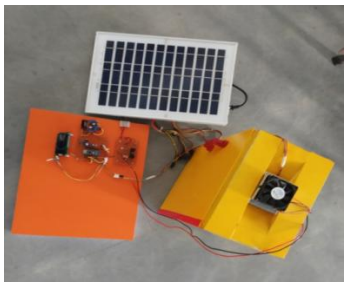

Fig. 10 Experimental Setup of Overall System

VIII. COMPONENTS REQUIRED AND QUANTITY

Table. I Quantity Details

Sl.No	Device	Quantity
1	200w, Solar Panels	1
2	MOSFET	1
3	Temparature Sensors	1
4	Peltier module	1
5	Buck converter	1
6	Battery	1
7	Arduino nano	1
8	Filter circuit	1
9	Step down transformer	1

IX. EXPERIMENTAL RESULTS

- Solar panel convert the sun energy into electrical energy
- The power is supplied to the buck converter to maintain the voltage variation.
- Buck converter gives the supply to the load which is peltier unit which maintain the cooling temperature of the refrigerator.

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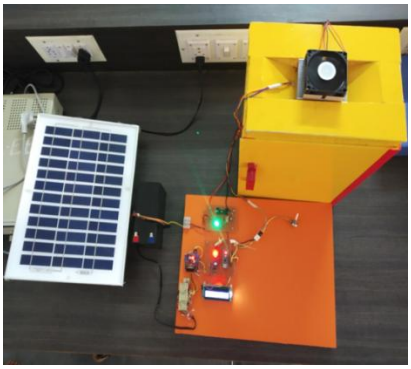

Fig. 11 Results for the Module.

X. CONCLUSION

In current, the refrigeration system is extensively used as a cooling agent but it consumes lot of electricity and releases various types of gases like CO2, which is harmful for the atmosphere. So the solar panel powered cooling unit using buck converter is effective and efficient to allow for cooling. And solar energy is a renewable energy source it does not produce harmonic gases.

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