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Solar Based Dual Air Conditioning System Home Application

Amrin Ayyub Khan [1], Aafsha Ruhi Khan[1], Abhishek Marsattiwar[1], Vaseem Sheikh[1], Chetna Bhadang[1], Sagar Mishra[1], Ashar Khan[1] , Prof. Irfan Ahmed[2]

[1]B.E. Student, Department of Electrical Engineering, A. C. E. T. Nagpur, Maharashtra, India

[2]Associate professor, Department of Electrical Engineering, A. C. E. T. Nagpur, Maharashtra, India

ABSTRACT

With advancement of new technology and inventions , the focus is done on the use of renewable source of energy. Use of solar energy is one of the modern way of heating as well as cooling. This paper presents the modification of domestic cooler into solar based dual air conditioning system foe home applications. Thus the system is able to work throughout the year by providing cool air in summer season and warm air in winter season. Apart from dual function conditioning, speed controlling is also done in the system. The speed control is provided with the help of Arduino ATmega328 making it easy for the people to operate as maximum work is done using microcontroller, The only manual task is to provide sheet for heating in winter season.

Keywords: PV Panel, Arduino, MATLAB Simulation, DC Motor.

I. INTRODUCTION

Solar air conditioning refers to any air conditioning system that uses solar power. The conversion of solar energy into electrical energy can be done through passive solar, solar thermal energy conversion and photovoltaic conversion, we are using photovoltaic conversion for this air conditioning system. U.S. Energy Independence and Security Act of 2007 created 2012 funding for a new solar air conditioning research and development program, which should develop and demonstrate multiple new technology innovations and mass production economies of scale. Solar air conditioning might play an increasing role in zero energy plus buildings design. Solar Photovoltaic (PV) system convert solar energy directly into electrical energy. The basic conversion device used is known as a solar photovoltaic cell or a solar cell. A solar cell is the most expensive component in a solar (PV) system (about 60% of the total system cost) though its cost is falling slowly. Commercial photocells may have efficiencies in the range of 10-20% and can produce electrical energy 1-2 kwh per sq. meter per day in ordinary sunshine. Room occupants also add heat to the room since the normal body temperature is much higher than the room temperature. Need of such a source which is abundantly available in nature, which does not impose any bad effects on earth. Thermal comfort is determined by the room's temperature, humidity and air speed. Radiant heat (hot surfaces) or radiant heat loss (cold surfaces) are also important factors for thermal comfort. Relative Humidity (RH) is a measure of the moisture in the air, compared to the potential saturation level. The solar based dual air

conditioning system have complete application in bright sunshine days but if any fault occurs in panel or for maintenance and in rainy days a provision of auxiliary supply source is made. This project is also concentrated upon the speed control of the motor using arduino. The control and regulation is made possible and hence it gives a better efficiency to the system than any traditional domestic cooling system. A complete block diagram is as shown in the figure.

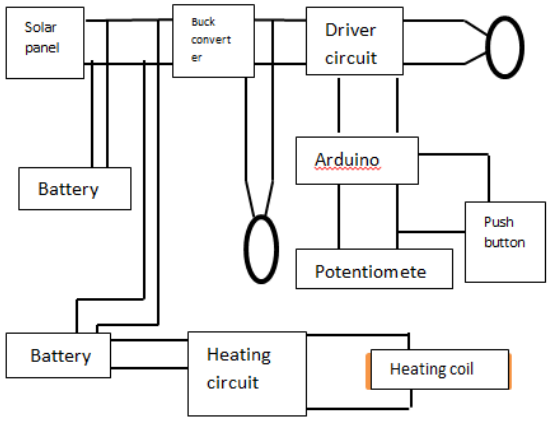


Figure 1. Block diagram of solar based dual air conditioning system.

II. COOLING PROCESS OF SOLAR COOLER

The solar based dual air conditioning system can be mainly operated for cooling purpose in humid condition. The construction and working of cooler is simple as that of normal domestic cooler. The main advantage of this cooler is that it uses solar energy for it's complete mechanism and Arduino posrt. The Arduino provide speed control to the motor which is not possible to regular domestic cooler. The performance efficiently by using the circuitry as basic converter, driver circuit, Arduino, potentiometer has increased. The air is drawn from atmosphere which is cooled by a honeycomb structure placed on backside of the complete hardware of cooler when that structure rotates the water in the task also actuate and produce cool air. The main advantage of solar based dual air cooler system is that there is no requirement of any pump for the circulation of water. The cold air is thrown out from the outlet. The push button is placed along with potentiometer for forwarding and reversing of the motor. When forward push is ON the potentiometer produces analog signal converting into digit from by Arduino the speed control can also be done easily. Hence cooling for solar based dual air conditioning system is achieved by solar panel and also battery as an auxiliary source of power.

Main components used are :

1. Photovoltaic panel
2. Battery
3. Buck converter
4. Driver circuit and Arduino port
5. Potentiometer and push button
6. DC motor

1. PHOTOVOLTAIC PANEL : In order to create low power remote and independent electronic devices it is necessary to collect and convert energy directly from the environment .the PV system directly converts sunlight into electricity by photovoltaic effect. The voltage current available at the terminals of PV device may directly fed small loads such as lighting system and DC motors. PV cell is basically a semiconductor diode whose PN junction is exposed to light. Different types of PV cell available at commercial scale are: monocrystalline and polycrystalline. The major advantage of using PV cells are :

1) Short lead time for designing and installing new system.
2) Output power matching with peak load demands.
3) Static structure.
4) Longer life.

5) High power capability per unit of weight.
6) Inexhaustible and Highly pollution free.
7) Mobile and portable and produce no noise.

Solar cell efficiency vary from 6% for amorphous silicon based solar cell to 42.8% with multiple junction research lab cell. For commercial purpose multicrystalline PV cell efficiency varies from 14-19%. Efficiency of a PV device is dependent on the spectral distribution of solar radiation.

The characteristics of PV cell is mainly dependent on three parameters:

1) Open circuit voltage Voc : Voc varies little with solar radiation change, a rise in temperature produces decrease in voltage.
2) Short circuit current Isc: It is directly proportional to solar radiation and is relatively steady with temperature variation.
3) Maximum power point MPP: for best utilisation PV cell must be operated at their MPP, it varies with illumination , temperature radiation dose and other effect.

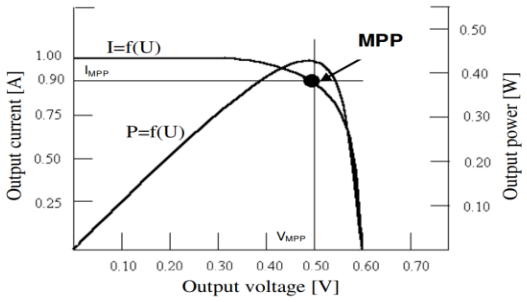


Figure 2. Typical I-V and P-V characteristics of photovoltaic cell.

PV cell modelling:

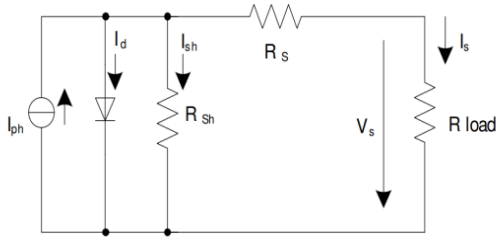


Figure 3. The equivalent circuit for the one diode model.

The simplest way of representing solar cell is single diode model. It consist of current source in parallel to diode. The parameters required are short circuit current Isc, open circuit voltage Voc and diode ideality factor a. The ideality factor of a diode is a measure of how closely the diode follows the ideal diode equation. A single PV cell is realised as a current source placed in parallel with a diode and ideal output current equation is given as:

$$I = I_{ph,cell} - I_{o,cell}\left[\exp\left(\frac{qV}{akT}\right)-1\right] \quad \ldots\ldots(1)$$

Practical equation is given as :

$$I = I_{ph,cell} - I_{o,cell}\left[\exp\left(\frac{q(V+IRs)}{akT}\right)-1\right] - \left[\frac{(V+IRs)}{Rp}\right] \quad \ldots\ldots(2)$$

Where: I_{ph} = photo voltaic current, I_o =saturation current of the diode, q=electron charge in coulombs =1.602*10-19C, K=Boltzmann constant =1.380*10-23 J/K, a=diode ideality factor, Rs=series resistance ,Rp=parallel resistance ,T=Temperature in Kelvin.

The photo voltaic current Ipv is a function of the irradiance (G) and is formulated as:

$$I_{ph} = \left[I_{ph\_STC} + K_i\Delta T\right]\left(\frac{G}{G\ STC}\right) \quad \ldots\ldots\ldots(3)$$

Where; I_{ph_STC}=light generated current under standard test conditions (STC) ,ΔT= T-T_{STC} (in kelvin), G= surface irradiance of cell (W/m2), G_{STC}=1000W/m2, Irradiance under STC Ki = short circuit current coefficient.

The diode saturation current Io is given as:

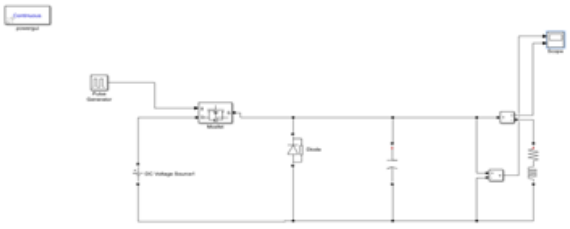
$$I_o = I_{o\_STC}\left(\frac{T}{T\ STC}\right)^3 \exp\left[\frac{qEg}{ak}\left(\frac{1}{T\ STC} - \frac{1}{T}\right)\right] \quad \ldots\ldots\ldots(4)$$

Where: I_{o_STC} = normal saturation current under standard test conditions (STC) ,T_{STC}= temperature under standard test conditions ,Eg= band gap energy of the semiconductor.

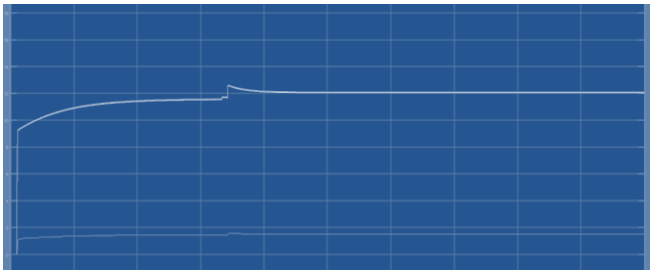
2. BATTERY : The solar based dual air conditioning system have complete application in bright sunshine days but if any fault occurs in panel or for

maintenance and in rainy days a provision of auxiliary supply source is made. The most prominent source of auxiliary supply used is lead acid battery.(The rechargeable and portable battery having the ratings as 12V ,7.5Ah).

3. BUCK CONVERTER : Buck converter is placed after positioning solar panel supply and battery supply (which is a auxiliary DC form of supply to the system). The simulation of the chopper is done on the software MATLAB r2017a. The conceptual model of the buck converter is best understood in terms of the relation between current and voltage of the inductor. The buck converter for solar cooler here is made by using capacitor of 100μF, inductor 100μH, capacitor 1000μF with IC LM2576T and diode IN5822. The buck converter is used in the circuit in order to control voltage level. 18 V DC is obtained from solar panel which in terms used for the air conditioning. The fluctuations in voltage level can cause problem in motor circuitry and other components like arduino and driver circuit etc. Hence buck converter is used to control the excessive voltage level and providing required voltage by buck down unnecessary increased voltage. The voltage range of buck operation is adjusted at 12V. If voltage range cross this value then it buck that voltage smoothening the operation. The complete operation is done through simulation on MATLAB and control is provided through arduino making it more user friendly. The MATLAB model of the buck converter along its waveform is explained here.



Graphical output obtained after simulation :



4. DRIVER CIRCUIT AND ARDUINO : There are several ways of making the driver circuits using transistors, L293D/ L298N, Relays. Out of which L298N is preferred as it is very popular Dual H-Bridge Motor Driver IC. This module allow easy and independent of control two motors up to 2A each in both directions. Normal DC motors requires current greater than 250mA. ICs like 555 timers, ATmega16 Microcontroller, 74 series ICs cannot supply this amount of current. If it directly connect motors to the output of any of the above IC's, they might get damaged.

There is a need of a circuitry that can act as a bridge between the above-mentioned ICs and the motors. L298N driver circuit independently control two motors in both clockwise and anti-clockwise direction of rotation. Continuous maximum output current per channel is 2A, Peak maximum output current per channel (<100μs) is 3A as per the requirement. Driver circuit takes input from buck converter and is mainly used to limit the fluctuation and harmonics produced due to the operation of arduino for motor control.

The Arduino Uno has a number of facilities for communicating conversion with a computer. Arduino uses a hardware known as the Arduino development board and software for developing the code known as the Arduino IDE (Integrated Development Environment). The ATmega328 provides UART TTL (5V) serial communication,

which is available on digital pins 0 (RX) and 1 (TX). An ATmega8U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The Arduino Uno can be programmed with the Arduino software, It communicates using the original STK500 protocol. The speed control of the cooler can be done by using Arduino which require following ratings of the components with different range of operation. Microcontroller ATmega328 with Operating Voltage 5V. The recommended input Voltage is 7-12V in limit with 6-20V. Digital I/O Pins 14 (of which 6 provide PWM output) and Analog Input Pins are 6. DC Current per I/O Pin 40 mA DC Current for 3.3V Pin 50 mA.The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. The input voltage to the Arduino board when it's using an external power source is Vin. The regulated power supply used to power the microcontroller and other components on the board which can supplied by USB or another regulated 5V supply and Maximum current draw is 50 mA. The complete speed control action is done using Arduino ATmega328. Driver circuit take input from buck converter which is adjusted at the voltage of 12V. if ardunio is directly connected to motor it will damage the port and system will collapse. Driver circuit placing in between this two can help in performing the smooth speed control operation.

5. POTENTIOMETER AND PUSH BUTTON : Push button which is operated for forwarding and reversing of the motor plays an important role in the system. Potentiometer is used to provide signalling to the arduino port. Potentiometer which is operated manually is provide pulse width variation to give voltage variation for speed controlling. Hence PWM method can be achieved so as to perform proper heating and cooling operation.

6. DC MOTOR : PMDC motor is highly efficient since no electrical energy is used or losses incurred for developing or maintaining motor's magnetic field. Its size is more compact and a better dynamic performance can be expected due to higher flux density in air gap. PMDC has an essentially simplified construction and is maintenance free. An increase in torque requires a decrease in angular velocity and vice versa. Complete system of air conditioning system is work on 12V which is required to rotate the fan.

III. SPEED CONTROL OF SOLAR COOLER

Armature resistance control of DC Motor is a conventional method to control speed by varying the armature circuit resistance. The voltage drop in the variable resistance reduce the applied voltage to the armature, as a result, the speed of motor is reduced. But, the main hindrance is with change in resistance parameter which increases losses proportionally. So as to minimise this losses in solar based air cooling, voltage control method is used. Arduino port which is a multi-purpose device is mainly used for speed control by varying voltage levels so as to provide automatic and advance mode to the system. Hence the complications of controlling the speed of solar based dual cooler has successfully performed. The PMDC motor having simple construction can be easily controlled by Arduino and driver circuit. A purposeful isolation between Arduino and motor via driver circuit is provided hence efficiency of the system is obtained more than resistance speed control method. Solar based dual air conditioning system have arduino ATmega controller which is a multifunctional

device. The basic concept of operation is based on signalling provided to the arduino. Potentiometer is used to vary the signals which control the speed of motor.

The speed controlling of dual solar based air cooler can be done through pulse variation. The potentiometer is provided with voltage level variation control which level variation control with voltage level variation control which gives analog signal to the Arduino. For a particular speed of operation, the analog signal provided to the port is converted into a digital signal and through programming speed of motor can be controlled. Programming on Arduino can be easily done through Arduino software. ATmega 328 is loaded with a DFU boothloader, which can be activated by connecting the solar jumper on the back of board and then resulting the 8U2. Pulse Width Modulation (PWM) process for speed control of a DC motor can be achieved through programming on Arduino quite easier and modern method of operation.

IV. HEATING MECHANISM OF SOLAR COOLER

The mechanism of heating of Solar Based Dual Air Cooler consist of simple construction and working. Sensing temperature so as to work for the better atmospheric condition tripping timer or temperature sensor can be used. After attaining a particular room temperature the tripping circuit operate at t=0. The mechanism works as when temperature goes down a certain value, it will trip for heating circuit and if temperature is increasing beyond it's specific configuration, it will close the cooling circuit and opens heating circuit at t=0. As the performance is based on both cooling and heating application, air heating also possesses a relevant task along with an air cooling. For heating the requirement of load is more than that of cooling, hence battery is needed. In the process of heating, there is a tunnel which is made up of aluminium sheet, attached horizontally to the centre top of the cooler. The reason behind using aluminium sheet is the melting point (660.3℃) which is perfect for the heat dissipation without any setback. The DC coils generates intense heat until its sufficient for the surface of heating the aluminium sheet. The DC coil used in car for cigarette combustion heats the aluminum sheet in which it is wounded. Generally 4-5 DC coils on same proportion of aluminum sheet are placed which when heated produced hot air which moves upward by rotation of centrifugal fan & further heated to an extent at the mouth of fins. The hot air is thrown out from the opening mounted on head of the cooler in a managed proportion. This process require a requisite time to perform and consequently both the purpose & consequently both the purpose of cooler are obtained.

V. CONCLUSION

Simulation tools are very mandatory for developing and handling mathematical simulations for analysing the behaviour of PV system and buck converter. They embolden the process of progressing the study of new system like power converters etc. for reducing cost and time. In this paper the study on the mathematical modelling of PV array, buck converter, speed control mechanism using microcontroller is studied and applied. This cooler is most efficient device for domestic cooling and also serves the purpose of energy saving.

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