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An RTC Based Multilevel Solar Panel System

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***Abstract*: Solar energy has been considered as a feasible source of renewable energy over the past few decades as it has been and is still being used to power up our industrial and domestic applications and gain desired national production. Bangladesh, like some other third world countries, demand of energy is higher than the production met by the power sector, even after considering only 70% of the population who are hitherto under electricity coverage of national grid. The result of this shortage is load-shedding, and the people of urban areas suffer the most from it because of their dependency on electricity for daily activities. Although solar energy can be used to reduce the energy crisis of Bangladesh, the limited space for setting enough photovoltaic (PV) panels to meet the demand of city dwellers emerges as a constraint in implementing solar energy system in densely populated urban areas. A modified structure equipped with a rotating and sliding mechanism holding three solar panel has already been implemented. The panels are stacked one above another in a rack to minimize floor area, and track the sun using sun tracking system to maximize power generation.**

***Keywords*: Microcontrollers, Multilevel Systems, Servomotors, Solar Energy, Solar Panels.**

1. Introduction

Solar power is energy from the sun that is converted into thermal or electrical energy. Solar energy is the cleanest and most abundant renewable energy source available around the world. Modern technology can harness this energy for a variety of uses, including generating electricity, providing light or comfortable interior environment as well as heating water for domestic, commercial or industrial use. In rural Bangladesh, especially the coastal southwest, it is common to see tiny solar panels embedded even in humble thatch-roofed huts. This is mostly the work of Infrastructure Development Company limited, a government-backed Bangladeshi energy and infrastructure group that claims more than 90 percent of the country's booming home solar market. Since 2003, IDcol has installed solar panels in 3.95 million off –grid homes, reaching 18 million people. In terms of individual units served Bangladesh has become one of the world's largest markets for home solar systems. Solar energy is considered to play an instrumental role in the infrastructure of a country as a distributing source. Country like Bangladesh which has added several natural grids to the national power grids but still that is not enough. In 2015, despite the requirement of 10000 MW on an average, the installed capacity has reached to 12,071 MW of which only 75% is available.

In my seminar, I build the reflector to measure the comparison of power and energy between the solar panel with reflector and solar panel without reflector. The reflector has a triangular-square base so that strong wind cannot push it and its placement is necessary since the sunlight falls on the reflector at a measured angle. Here according to the theory, the consecutive distance between two panels has to be 1.5 times of the width of a panel so that shading over top and bottom panel can be eradicated also this will allow the panels to get maximum exposure. Total height of the system will be (1.5+1.5+0.5) or 3.5 time the panel width.

2. Overview

A. *System description*

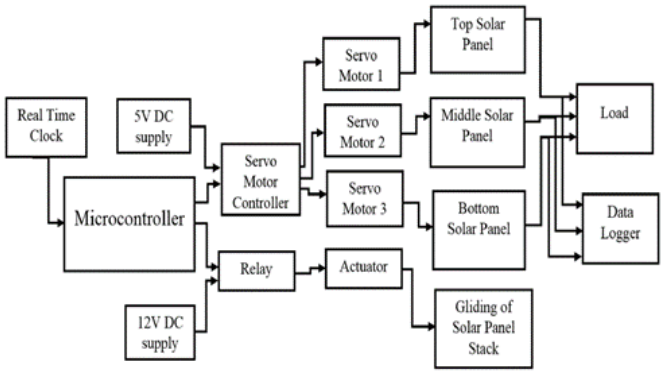

Fig. 1. Block diagram of the system

The Fig. 1, shows the block diagram of the overall multilevel solar panel system. In the existing physical system, three solar panels are stacked one above another which moves synchronously along with the direction of the sun. The rotation of the panels and the gliding of the panel stack is controlled by three servo motors and an actuator respectively. The servos and the actuator is controlled by a control unit consisting of a real time clock governing all the steps synchronously with time. All the electrical energy generated by the solar panels are accumulated in a battery from where load can draw the required power. The current and voltage generated by the panels are passed through voltage and current sensors of a data logger designed to record the values in a memory card. A multi-layered reflector panel is also constructed to reflect back the few passing away sun rays back to the panels and thus increasing the output of the panels. The prime objective of this seminar is

to analyze the efficiency of the sun tacking solar panel and also reconstruct and improve the efficiency level of the existing solar panel system.

B. Photovoltaic technology

Solar energy is known to be the most suitable and available renewable energy till this date. Solar panels are used to capture, store and use this energy. A solar panel is comprised of photovoltaic cells or PV cells. PV acquires its name from the process of converting light (photons) to electricity (voltage), which is known to be photovoltaic effect. The word photo means light and the word voltaic means producing electricity. So, photo voltaic process means producing electricity from sunlight and in this case, the sun is the source of light. The output power of a solar or photovoltaic cell is dependent on the amount of projected light on it. Factors such as, time of the day, season, position and alignment of the cells affect output power as well.

C. Solar panel

Solar panels are devices designed to absorb the sun's rays as a source of energy to generate electricity. It is called solar panel because the most powerful source of light available Sun, called by astronomers. Some scientists call them photovoltaic which, basically, means light-electricity. A solar cell is a form of photoelectric cell which is defined as a device whose electrical characteristics, such as current, voltage or resistance, differ when subjected to light. When a number of photovoltaic cells are connected together, a solar module is formed which will be able to produce electric power from sunlight. A solar panel is a combination of multiple PV cells in one plane. The efficiency of most solar panel varies from 11–15 percent. The efficiency rating denotes what percentage of sunlight striking a panel gets converted into electricity that can be used. The higher the efficiency, the smaller surface area is required in solar panel to produce the desired output electricity. Though the average percentage maybe very small, we can easily fit a typical roof with enough panels to cover energy needs. There are a number of different types of panels with variations in properties among these panels as well. The three most common categories of solar panels are:

- Mono-crystalline Silicone Solar Cell
- Polycrystalline Silicone Solar Cell
- Thin-Film Solar Cells (TFSC) (Amorphous Silicon Solar Cells)

Fig. 2. (a) Monocrystalline Silicon Solar Cells (b) Polycrystalline Silicon solar cells (c) Thin-Film Solar Cells (TFSC)

Monocrystalline solar cells are made out of silicon ingots, which are cylindrical in shape. To optimize performance and lower costs of a single monocrystalline solar cell, four sides are cut out of the cylindrical ingots to make silicon wafers, which is what gives monocrystalline solar panels their characteristic look. Being made out of the highest-grade silicon, monocrystalline solar panels have the highest efficiency and are also space efficient. Although performing the best among other categories of panels, they are the most expensive of all. Since cost efficiency is one of the major issues to be taken to consideration, it does not make it appropriate for the system to be designed. The first solar panels based on polycrystalline silicon, which is also known as polysilicon (p-Si) was first introduced to the market in 1981. Raw silicon is melted and poured into a square mold, which is cooled and cut into perfectly wafers. The process used to make polycrystalline silicon is simpler and costs very less and also, polycrystalline solar panels tend to have slightly lower heat tolerance than monocrystalline solar panels. Depositing one or several thin layers of photovoltaic material onto a substrate, such as glass, plastic or metal, is the basic gist of how thin-film solar cells are manufactured. Since the output of electrical power is little, solar cells built using amorphous silicon have usually only been used for small-scale uses, example- calculators. But, new advances have made them more attractive for few large-scale uses too. By using amorphous silicon, mass production is easy but amorphous solar panels are usually not very beneficial for maximum residential sites. These Panels are very low-cost but at the same time, they also need enormous space and the efficiency of amorphous modules to produce sunlight to electricity is half polycrystalline and half mono crystalline. Therefore, this will be not a sensible decision to choose the amorphous silicon. The current benefits that have been presented in polycrystalline solar panel have made it more preferable in term of efficiency as we get in monocrystalline panels. Among all advantages, it is the only one that has one special advantage and that is its output is not affected by any sort of shadows. So, for our usage, as we will attempt to use our panels in urban areas like Dhaka city, it is highly advised to use polycrystalline solar panel because of its efficiency.

D. Servo motor-MG 99

Servo motor (or servos) are self-contained electric devices that rotates or drive parts of a machine with great accuracy. A servo is a small device that uses a two wire DC motor, a gear train, a potentiometer, an integrated circuit, and an output shaft. of the three wires sticking out from the motor casing, one is for power, one is for ground, and one is a control input line. The rating of a servo is 6 volts and delivers 66.7 oz-in. of maximum torque at 70 r/min. They are fitted with a servo mechanism for accurate control of angular position. The RC servo motors typically have a rotation limit from 90° to 180°. Few servos do have rotation limit of 360° or more. But servos do not rotate continually. Their rotation is limited in between the fixed angles. Three servo motors are used in our system which consequently rotates the upper, middle and bottom panel as time goes on. The servo motors are not directly connected to the

Arduino but to the polulu mini maestro 12. The polulu runs the three servo motors of system

3. Circuit description

In this chapter basically we focused on our seminar and design of our prototype of the sun tracking system. After an extreme data collection on the available techniques and components, to meet the requirements of the system and to satisfy the objective of our project I have used suitable methods and implemented it through electrical circuits. I have a control circuit that is controlled by the microcontroller, Arduino. Arduino sends signal to the mini maestro which revolves the panels with the help of the servo motor. The mini maestro also calculates and compares the time with the help of RTC. We also made a multi-layer reflector and a fixed reflector for the panels.

A. Mechanical construction

An iron bar was connected vertically with heavy weight iron base through gas wielding, the stack that contains the solar panels is made of SS (Stainless Steel) bar and is connected to the vertical bar through ball bearing. It helps the panel easily rotate along a horizontal arc with the operation of the linear actuator. We have drilled the bar and made three holes on the SS bar to connect the panels and 3 inch iron rods were mounted on the SS bar through those holes with small ball bearing to which help the iron rods easily rotate around the horizontal axis. The iron rods are mounted on the main stack in such manner that they are bit tilted downwards and each of the rods contains two rectangular sized long iron plate in transverse manner so that the flexible solar panel can easily be attached to these iron rods. The remaining iron rod on the other side of the ball bearing is connected with servo motors and we have used servo horns for a better grip on them throughout the whole day. Theoretically it has been proposed that the distance between two consecutive holes containing iron rods is 1.5 times of the width of the solar panel.

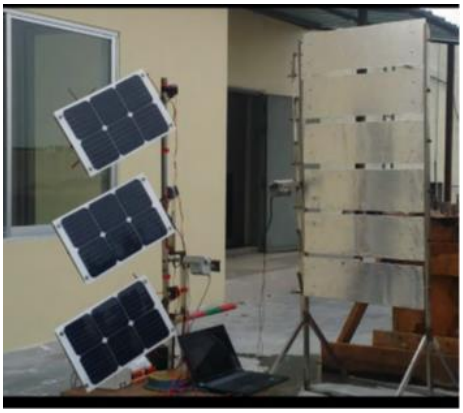

Fig. 3. Mechanical construction

B. Control circuit diagram

I have implemented our circuit by using one Arduino Mega, one Arduino Uno three MG995 servo motors, two RTC (real time clock), one 12V Actuator for the panel and one actuator for the reflector, a 2 relay module, one 3V Lithium battery, one polulu mini maestro 12 and a number of male to male and male to female connectors.

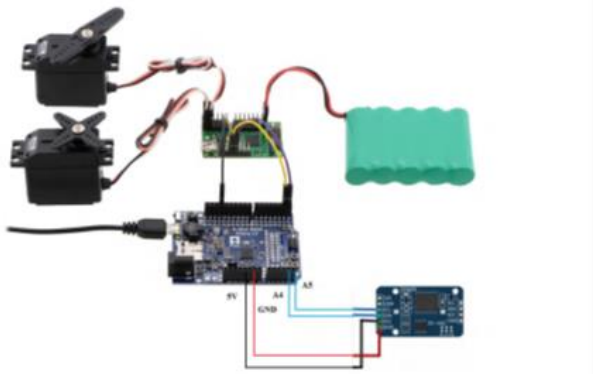

Fig. 4. The Control Circuit Diagram

So Arduino is connected to the PC or laptop via an USB cable which gives power to all the other components we have used except the actuator and relays. Arduino supply fixed 5V power to all the components. The polulu mini maestro is connected in pin number 10 and 11 of the Arduino via its RxD and TxD for transmission and reception of the signals. The RTC which gets its power supply from 3V lithium battery is connected in pin SCL and ground through pin number 5 and 6. As there is interference between the electric field and the magnetic field produced by the actuator, that's why the actuator is fully separated from the above circuit Fig. 4. The actuator is 12V and the interference cause a lot of problems. The first one is the real time clock gets reset as it cannot tolerate the huge power of the actuator and the second one is that there's a possibility of the other components to get burn or damage because of the huge power. That's why the power is provided to the actuator extremely via a battery.

4. Conclusion

The proposed system consists of three panels mounted in a rack one above another at a fixed distance from each other to minimize the floor area while shifted horizontally from each other by half the panel width to avoid shading of the lower panels. In the proposed system, the panels will be fitted with a tracking system to track the sun to maximize the energy collection. Further, a gliding mechanism is perceived for the panels that will enable the panels glide both ways and realign as the sun moves from east to west to avoid shading. Initial calculation, done for January to April shows that the proposed multilevel three panel system can harness up to 23% more energy than the three conventional fixed panel systems with 33% less area. Instead of continuous tracking, the developed system rotates the panels only 12 times a day, in a step of 15° in each rotation. The proposed system will be useful for large urban city dwellers, especially in third world countries, where not only electricity is in short supply, availability of roof top

space to install solar panels is also very limited. The sun based power sun following framework is more effective in light of the fact that sun oriented radiation can be a limitless well spring of sustainable power source in our nation as it is arranged close to the equator. In the event that the possibility of this sun following framework can be actualized, the framework will significantly diminish the power issue of our nation.

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