Experimental Investigation and Development on Efficiency of Solar PV Panel

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Abstract: **-The project improves the solar panel efficiency using different techniques and phase changing materials. It improves the efficiency under different conditions. By the application of various phase changing materials on the Solar Panel, we were able to bring out the maximum efficiency. The designed system also measures various parameters like light intensity, voltage, current and temperature by using multiple sensor data acquisition. The project uses a solar panel to monitor sunlight and a PIC microcontroller. These measurements are then displayed by the microcontroller to a LCD screen.**

INTRODUCTION

The designed project measures and helps to determine the maximum voltage and power output of the solar panel using different materials under different conditions. The project uses a solar panel to monitor sunlight and a PIC microcontroller. Various materials are taken and experimental analysis is carried out to bring the maximum voltage and power output. These measurements are then displayed by the microcontroller to an LCD screen.

Solar power - unlimited source of energy:

Solar power is the key to a clean energy future. Every day, the sun gives off far more energy than we need to power everything on earth. That's why we're investing heavily in solar panel and plants.

Photovoltaic solar panels absorb sunlight as a source of energy to generate electricity. A photovoltaic (PV) module is a packaged, connected assembly of typically 6x10 photovoltaic solar cells. Photovoltaic modules constitute the photovoltaic array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications. The most common application of solar energy collection outside agriculture is solar water heating systems.

Theory and Construction:

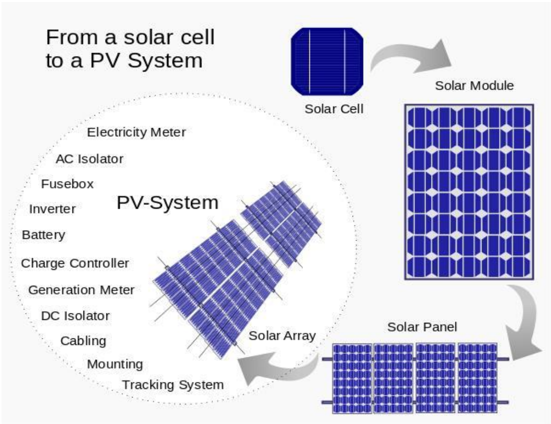

Fig 1: Construction of Solar Panel

Photovoltaic modules use light energy (photons) from the Sun to generate electricity through the photovoltaic effect. The majority of modules use wafer-based crystalline silicon cells or thin-film cells. The structural (load carrying) member of a module can either be the top layer or the back layer. Cells must also be protected from mechanical damage and moisture. Most modules are rigid, but semi-flexible ones based on thin-film cells are also available. The cells must be connected electrically in series, one to another.

A PV junction box is attached to the back of the solar panel and it is its output interface. Externally, most of photovoltaic modules use MC4 connectors type to facilitate easy weatherproof connections to the rest of the system. Also, USB power interface can be used.

Module electrical connections are made in series to achieve a desired output voltage or in parallel to provide a desired current capability (amperes). The conducting wires that take the current off the modules may contain silver, copper or other non-magnetic conductive transition metals. Bypass diodes may be incorporated or used externally, in case of partial module shading, to maximize the output of module sections still illuminated.

Some special solar PV modules include concentrators in which light is focused by lenses or mirrors onto smaller cells. This enables the use of cells with a high cost per unit area (such as gallium arsenide) in a cost-effective way.

Solar panels also use metal frames consisting of racking components, brackets, reflector shapes, and troughs to better support the panel structure.

BLOCK DIAGRAM

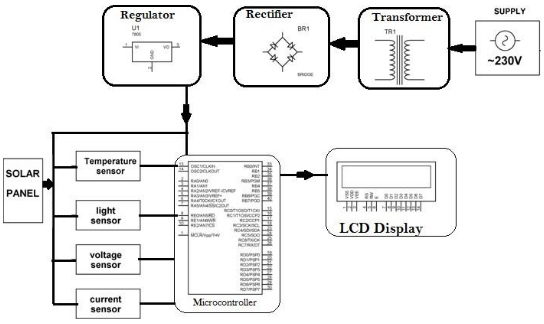

Fig 2: Block Diagram of System

HARDWARES USED

- Transformer (230 – 12 v ac)
- Voltage regulator (LM 7805)
- Rectifier
- Filter
- Microcontroller AT89S52
- LCD Display
- Solar Panel

Transformer:
Transformers convert AC electricity from one voltage to another with a little loss of power. Step-up transformers increase voltage, step-down transformers reduce voltage. Most power supplies use a step-down transformer to reduce the dangerously high voltage to a safer low voltage.

Fig 3: Transformer

The input coil is called the primary and the output coil is called the secondary. There is no electrical connection between the two coils; instead they are linked by an alternating magnetic field created in the soft-iron core of the transformer. The two lines in the middle of the circuit symbol represent the core. Transformers waste very little power so the power out is (almost) equal to the power in. Note that as voltage is stepped down and current is stepped up.
The ratio of the number of turns on each coil, called the turn's ratio, determines the ratio of the voltages. A step-down transformer has a large number of turns on its primary (input) coil which is connected to the high voltage mains supply, and a small number of turns on its secondary (output) coil to give a low output voltage.

TURNS RATIO = (Vp / Vs) = (Np / Ns)

Where,

Vp = primary (input) voltage. Vs = secondary (output) voltage
Np = number of turns on primary coil Ns = number of turns on secondary coil Ip = primary (input) current
Is = secondary (output) current.

Voltage Regulator:
The LM78XX/LM78XXA series of three-terminal positive regulators are available in the TO-220/D-PAK package and with several fixed output voltages, making them useful in a Wide range of applications. Each type employs internal current limiting, thermal shutdown and safe operating area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output Current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.

Rectifier:
A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), current that flows in only one direction, a process known as rectification. Rectifiers have many uses including as components of power supplies and as detectors of radio signals. Rectifiers may be made of solid-state diodes, vacuum tube diodes, mercury arc valves, and other components. The output from the transformer is fed to the rectifier. It converts A.C. into pulsating D.C. The rectifier may be a half wave or a full wave rectifier. In this project, a bridge rectifier is used because of its merits like good stability and full wave rectification. In positive half cycle only two diodes (1 set of parallel diodes) will conduct, in negative half cycle remaining two diodes will conduct and they will conduct only in forward bias only.

Microcontroller:
The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using Atmel's high- density non-volatile memory technology and is compatible with the industry standard 80C51 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer. By combining a versatile 8- bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcontroller which provides a highly-flexible and cost- effective solution to many embedded control applications. The AT89S52 provides the following standard features:

8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, a six- vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator, and clock circuitry.

EXPERIMENTAL ANALYSIS

The experiment is being carried out under three different situations:

NORMAL TEST:

	Luminosity	Current	Temperature	Voltage
9 AM	63.7 W	0.21 A	42.2 C	17.6 V
10 AM	63.7 W	0.21 A	43.1 C	17.4 V
11 AM	63.7 W	0.23 A	43.5 C	17.4 V
12 PM	63.7 W	0.24 A	44.3 C	17.2 V
1 PM	63.7 W	0.25 A	44.7 C	17 V
2 PM	63.7 W	0.25 A	45.5 C	17 V

This is the first condition being tested with the Solar PV Panel. It is observed under normal atmospheric condition without the application of any method.

The above table shows the readings noted at various times of the day at similar atmospheric conditions. The readings include the luminosity of light on the panel, the current produced, the temperature on the panel, and the output voltage produced.

From the above analysis, we obtained the minimum temperature as 42.2 degree Celsius along with a voltage of 17.6 volts and the maximum temperature obtained is 43.5 degree Celsius along with a voltage of 17 V.

We know that as the temperature on the Solar PV Panel increases, it may lead to reduce the output efficiency. In order to bring out the maximum efficiency in the Solar PV Panel, we should minimize the temperature of the Solar PV Panel.

Here we can see that at 42.2 degree Celsius, the voltage is 17.6 V. Similarly, at
43.5 degree Celsius, we can see that the voltage is 17 V. From this we are able to infer that temperature is inversely proportional to the voltage.

We can try to change the phase of the Solar PV Panel by applying a different method on it. This will help to change the factors applied on it and as a result, it will increase the efficiency of the Solar PV Panel.

Proceeding with the experimental analysis, we will be able to see the change in the readings. Phase changing materials are used for this purpose.

USING WATER:

	Luminosity	Current	Temperature	Voltage
9 AM	63.5 W	0.23 A	41.8 C	17.5 V
10 AM	63.5 W	0.23 A	41.0 C	17.8 V
11 AM	63.7 W	0.25 A	40.5 C	17.9 V
12 PM	63.5 W	0.26 A	40 C	18.0 V
1 PM	63.5 W	0.27 A	39.6 C	18.4 V
2 PM	63.5 W	0.27 A	39.5 C	18.5 V

The second mode of experimenting is by the application of water on the Solar PV Panel.
This is the second condition being tested with the Solar PV Panel. It is observed under normal atmospheric condition with the application of water over the Solar PV Panel.

The above table shows the readings noted at various times of the day at similar atmospheric conditions. The readings include the luminosity of light on the panel, the current produced, the temperature on the panel, and the output voltage produced.
From the above analysis, we obtained the minimum temperature as 40.5 degree Celsius along with a voltage of 18.3 volts and the maximum temperature obtained is 41.8 degree Celsius along with a voltage of 17.9 V.

We know that as the temperature on the Solar PV Panel increases, it may lead to reduce the output efficiency. In order to bring out the maximum efficiency in the Solar PV Panel, we should further minimize the temperature of the Solar PV Panel.

Here we can see that at 40.5 degree Celsius, the voltage is 18.3 V. Similarly, at
41.8 degree Celsius, we can see that the voltage is 17.9 V. From this we are able to infer that temperature is inversely proportional to the voltage.

We can try to change the phase of the Solar PV Panel by applying a different method on it. This will help to change the factors applied on it and as a result, it will increase the efficiency of the Solar PV Panel.

Proceeding with the experimental analysis, we will be able to see the change in the readings. Phase changing materials are used for this purpose.

USING WAX & WATER:

The third mode of experimenting is by the application of water and wax on the Solar PV Panel.

	Luminosity	**Current**	**Temperature**	**Voltage**
9 AM	63.7 W	0.23 A	41.6 C	17.6 V
10 AM	63.7 W	0.23 A	40.7 C	17.7 V
11 AM	63.7 W	0.24 A	39.8 C	18.8 V
12 PM	63.7 W	0.25 A	38.9 C	19.6 V
1 PM	63.7 W	0.26 A	38.3 C	20.2 V
2 PM	**63.7 W**	**0.26 A**	**37.2 C**	**20.7 V**

This is the third condition being tested with the Solar PV Panel. It is observed under normal atmospheric condition with the application of water and wax over the Solar PV Panel.

The above table shows the readings noted at various times of the day at similar atmospheric conditions. The readings include the luminosity of light on the panel, the current

After performing all the necessary experiments, we were able to get the maximum output voltage of the solar panel. Through various conditions and systems, we could get different results. The maximum output voltage was obtained when the panel was kept in the sun after applying wax.

When wax has been applied on the solar panel and kept under the sun, we could see that there was a drastic change in the voltage readings. The readings have increased a lot from the previous readings. The voltage output has reached almost the

produced, the temperature on the panel, and the output voltage produced.

From the above analysis, we obtained the minimum temperature as **37.2 degree Celsius** along with a voltage of **20.7 volts** and the maximum temperature obtained is **41.6 degree Celsius** along with a voltage of **17.6 V.**

We know that as the temperature on the Solar PV Panel increases, it may lead to reduce the output efficiency. In order to bring out the maximum efficiency in the Solar PV Panel, we should minimize the temperature of the Solar PV Panel.

Here we can see that at 37.2 degree Celsius, the voltage is 20.7 V. This is the maximum voltage obtained till now using the phase changing material.

We can conclude that the phase changing material **wax** has helped to bring out the maximum efficiency of the Solar PV Panel.

Wax is a cooling medium and therefore we were able to reduce the temperature of the Solar PV Panel. As a result, the output voltage was increased to the maximum when compared with the other conditions.

CONCLUSION

maximum. The output is almost constant throughout the period.

Since **wax** is a cool material, it helps to reflect the unwanted rays and store the useful radiations which are later converted into useful voltage. Therefore, after performing all the necessary experimental analysis, we can conclude that wax is the best material used among the three. It helped to gain the maximum output voltage as well as constant output throughout the period.

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