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INCREASING THE EFFICIENCY AND MONITORING THE PERFORMANCE OF SOLAR PANEL USING IOT

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ABSTRACT: *This project demonstrates the study of improving the efficiency of the solar panel using active cooling method and dust control. Solar energy is one of the most extensively exploited natural resource. As per the characteristics of the solar panel, it will give maximum output when the panel is maintained with fixed temperature. The increase in temperature beyond the fixed value and the deposition of dust on the solar panel decreases the output by a large percentage. In order to overcome this problem ACTIVE COOLING METHOD is used. In industries, to monitor the performance of the solar panel, IoT based systems and various other sensors are used. In this module TEMPERATURE sensor is used to measure the temperature of the panel and LDR sensor is used to sense the dust on the solar panel. The CURRENT sensor is used to monitor the performance of the solar panel. The active cooling method uses water as the cooling agent to maintain the temperature and remove the dust particle.*

Key Words*:* *Temperature sensor, current sensor, LDR sensor, Active cooling method.*

Index Terms – ***introduction ,objective ,principle of solar cell ,effect of radiation ,temperature effect ,cooling ,dust effect ,proposed system ,experimental setup ,methodology ,inferences ,dust constrains ,hardware components ,conclusion.***

I. INTRODUCTION

Energy is the basic necessity for humanity today. It allows better quality of life. Nowadays uninterrupted energy has become a must for society for day-to-day use. When blood is to body electricity is to economy of any country and without it the economy will tremble and it will be very difficult to sustain. Energy is one of the leading issues around the world and every country is looking for energy resources as its demand is rising sharply. Non-renewable energy supplies are either too costly or detrimental to the atmosphere and will likely end in the near future as well. That is why the planet is moving in the direction of renewable energy resources that are naturally replenished in a relatively short time.

Although hydroelectric is a very cheap source of renewable energy, it is not available in all parts of the world, although solar has the potential to take over the entire generation of electricity. Over the ages, the sun has been supplying energy in both forms: light and heat. Nowadays, solar energy is used to produce electricity using photovoltaic cells.

II. OBJECTIVE

The objective of the project is to improve the efficiency of the solar panel. As the increased temperature and the dust accumulation decreases the solar panel output. Our project focuses on decreasing the temperature and cleaning the solar panel to gain the lost efficiency.

III. PRINCPAL OF SOLAR CELL

Solar cells consist of semi-conductive materials, such as silicon, which are doped with different impurities. This creates uneven distribution on one side of the junction of free electrons (n-type) and abundance of holes (p-type) on the other side of the junction. Solar light contains photons that strike the solar panel and excite the loosely bound electrons that are designed to move in solar cells in only one direction, thereby generating electron-hole pairs at the corresponding junctions and receiving electricity in the external circuit.

The solar cell produces 0.5 - 0.6volt DC under no load and open circuit condition. The current and voltage (power) value of a photo voltaic cell mainly depends on its efficiency, size and it is proportional to the intensity of light striking the surface of cell. For example, under peak sunlight conditions, a typical commercial PV panel of surface area 160 cm-2 (25 inch-2) will produce 2 watts peak power. If the intensity is 60 percent of peak it will produce about 1.2 watts. The intensity adds a lot to efficiency. Extensive research shows that output of a PV cell *can be increased by two methods: fabrications and passive devices. Passive devices are used widely to enhance the efficiency as fabrication is expensive one.*

IV. EFFECT OF RADIATION

Solar cell output is strongly affected by the amount of solar radiation. It is one of the most complex factors that modify the performance of the solar array. It is a measure of the amount of solar radiation that falls on a given surface from the sun.

It is commonly measured in watts (W/m2) per square meter. Under ideal conditions a solar panel would obtain a radiance of 1000 W / m2 but sadly in most settings this is not accurate. Solar radiation depends on geographic position, orientation of sun to solar panel, and amount of energy lost by reflection from particles of dust or from fog or clouds.

V. TEMPERATURE EFFECT

The conducting materials consist of free electrons, and the nucleus of atoms retain several electrons closely. If radiation is strong, further photon packets reach the panel and the atoms and electrons absorb this energy, and they interfere with each other releasing more electrons from the atoms and thus increasing the temperature. Rising temperature contributes to increased resistance to current flow. Efficiency depends on temperature, as well.

The solar panel decreases at high temperature production as opposed to a lower temperature. Efficiency of the PV module decreases 0.5 percent according to estimation for every degree rise in temperature. PV modules are usually manufactured at 25oC (77oF) and can be operated above 20oC.

VI. COOLING

Under concentrated solar radiation the performance of solar cell reduces 50% when its temperature rises from 46oC to 84oC. An effective cooling system is also completely necessary to improve the performance of the solar cell and to avoid deterioration and damage to the cell. Photovoltaic panels can actively or passively be refrigerated. The difference between active and passive is that active system requires some external power to run while passive system needs no additional power source.

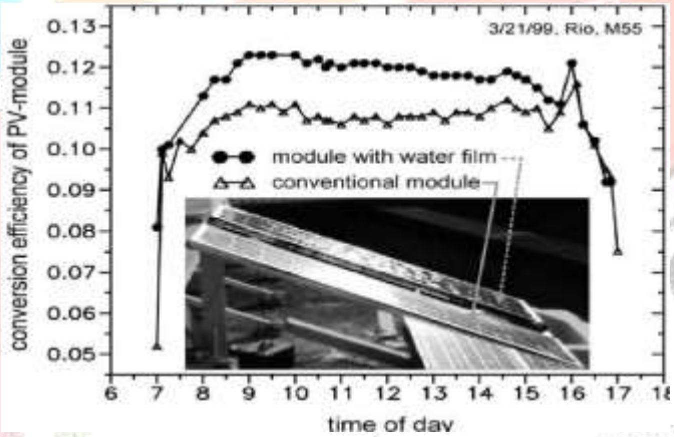

Chart -1: Relation between conventional and cooled panel

VII. DUST EFFECT

As said earlier, the solar panel is made up of PV modules. The amount of dust particles which deposit on the panel also degrades its efficiency. As the dust particle which deposit on the panel will reflect the sun rays which is entering the panel. Due to this the absorbing radiation decreases and so the efficiency of the panel is also reduced.

VIII. PROPOSED SYSTEM

In this proposed system, water is used as a cooling agent. This water is also used to remove the dust particle as well. The temperature above the solar panel decreases the voltage thereby decreasing the output power. The solar panel works efficiently at 26oC. The temperature increase above the rated value of 25oc decreases the voltage by .25%. The threshold value is set to 26oC. Whenever panel temperature rises beyond the threshold value the water pump is turned on automatically to reduce the temperature.

The dust accumulation on the solar panel decreases the output power by 33 % of efficiency. The dust particles present on the top of the panel blocks the amount of light entering the panel thereby decreasing the output. Thus, a reference value is set for the dust particle and whenever the value of dust exceeds beyond the reference value the water pump is turned on.

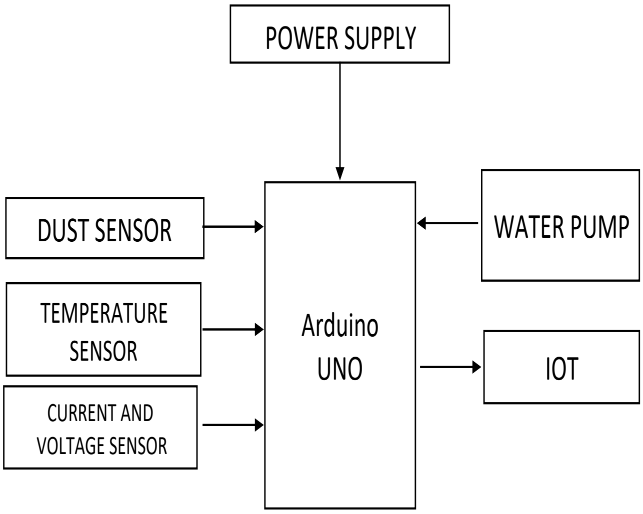

Fig -1: Block Diagram of Proposed System

Along with this, the current and voltage output values of the solar panel are measured using current and voltage divider circuit. All these values are recorded in IoT for future reference.

IX. EXPERIMENTAL SETUP

The proposed following approach of improving solar panel efficiency is based on active cooling system. For this experiment a mono-crystalline solar panel made of silicon semiconductor was used. In this experimental technique water is used as a cooling agent.

This is used for improving efficiency of PV module. On the solar panel base, which was further fed from a rubber pipe from a water tank filled by an electric motor, was fixed a PVC plastic pipe with holes at the rim.

Temperature sensor and dust sensor are used to measure the temperature value and dust value. The output current and output voltage are measured using current and voltage divider circuit.

All these data are recorded in IoT. The Node MCU Wi-fi module is used to send the data and stored in the cloud.

X. METHODOLOGY

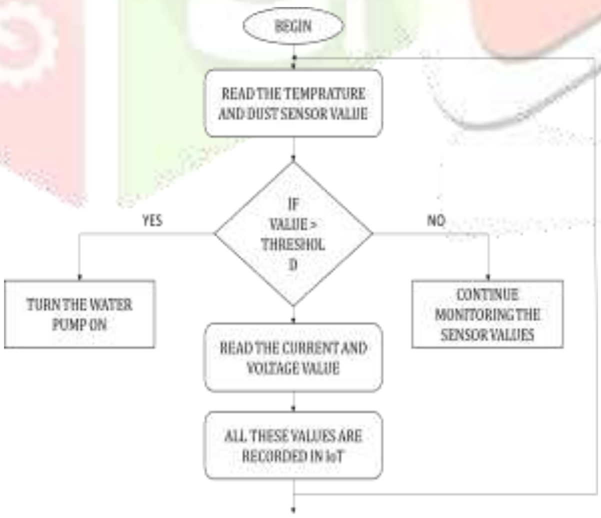

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Fig -2: Flow Chart

XI. INFERENCES

Table -1: Temperature effect

s.no	Temperature	Voltage before cooling	Voltage after cooling	Voltage gain
1	38	32.5	34.7	2.2
2	41	30.1	32.5	2.4
3	45	29.7	32	2.3
4	50	27.12	30.2	2.9

XII. DUST CONSTRAINS

Table -2: Dust effect

Modules	Parameter	Initial value	Clean module after one exposition year	Dusty module after one exposition year	Difference absolute	Difference relative (%)
Monocrystalline PV module	Pmax (W)	145	144.59	32.17	-112.42	-77.75
	Vmax (V)	17.9	17.83	20.79	2.96	16.60
	Imax (A)	8.1	8.06	1.57	-6.49	-80.52
	Voc (V)	22.7	22.7	22.7	0.00	0.00
	Isc (A)	8.5	8.47	2.09	-6.38	-75.32
	FF (%)	75.14	73.64	60.4	-0.13	-17.98
Polycrystalline PV module	Pmax (W)	230	217.37	178.19	-39.18	-18.02
	Vmax (V)	29.2	28.04	30.09	2.05	7.31
	Imax (A)	7.88	7.75	5.93	-1.82	-23.48
	Voc (V)	36.6	36.16	36.16	0.00	0.00
	Isc (A)	8.44	8.33	6.61	-1.72	-20.65
	FF (%)	74.48	72.09	70.64	-0.01	-2.01

XIII. HARDWARE COMPONENTS

- *Arduino UNO*
- *Dust sensor*
- *Temperature sensor*
- *Current and voltage sensor*
- *Water pump motor*
- *IOT*

A. ARDUINO UNO

The Arduino Uno is a microcontroller board grounded on the ATmega328 (datasheet). It comprises of 14 digital input/output pins (out of which 6 can be utilized as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a facilitation for USB connectivity, a power jack, an ICSP header, and a reset button. Its designs comprise of assistances that supports the microcontroller in every possible way.

In order to get to work with it one has to simply connect it to a computer with a USB cable or power it with an AC-to-versions namely Arduino Uno and Genuino Uno which could be. The variations are observed with reference to the region.

Fig -3: Arduino UNO

A.1. SPECIFICATION

- *ATmega328-AU microcontroller with UNO Bootloader Installed.*
- *USB Programming Facilitated by the CH340G.*
- *USB-B Connector and cable included.*
- *Input voltage - 7-15V.*
- *0-5V outputs with 3.3V compatible inputs.*
- *14 Digital I/O Pins (6 PWM outputs).*
- *6 Analog Inputs.*
- *ISP Header.*
- *32k Flash Memory*
- *16MHz Clock Speed*

B. TEMPERATURE SENSOR

LM35 is a temperature measuring device having an analog output voltage proportional to the centigrade temperature. It provides output voltage in centigrade (o Celsius). It does not require any external calibration circuitry. The LM35 system has an edge over Kelvin-calibrated linear temperature sensors. LM35's frequency is of 10mV / o Celsius. Production also decreases as temperature increases.

It is a 3-terminal sensor used to measure the temperature of the ambient environment from-55 to 150 (o Celsius). LM35 has a more reliable temperature response than the thermistor response.

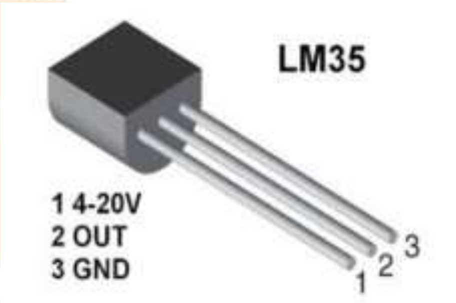


Fig -4: Temperature Sensor

B.1 SPECIFICATION

- *Calibrated directly in ° Celsius (Centigrade)*
- *Linear + 10.0 mV/° Celsius scale factor*
- *0.5°C accuracy guarantee able (at +25°C)*
- *Rated for full −55° to +150°C range*
- *Suitable for remote applications*
- *Low cost due to wafer-level trimming*
- *Operates from 4 to 30 volts*
- *Less than 60 µA current drain*
- *Low self-heating, 0.08°C in still air*
- *Nonlinearity only ±1/4°C typical*
- *Low impedance output, 0.1 Ω for 1 mA load*

C. DUST SENSOR

The dust sensor is an optical sensor whose operating theory is based on the detection of the infrared light produced by an ILED diode, which is reflected by the dust particles and collected by a phototransistor.

Fig -5: Dust Sensor

C.1 SPECIFICATION

- *Power: 2.5V~5.5V.*
- *Operating current: 20mA(max)*
- *Operating temperature: -10℃~65℃*
- *Storage temperature: -20℃~80℃*

D. VOLTAGE DIVIDER

A voltage divider is a basic circuit that converts a big voltage into one smaller. We can establish an output voltage, which is a fraction of the current, using only two series resistors and an input voltage.

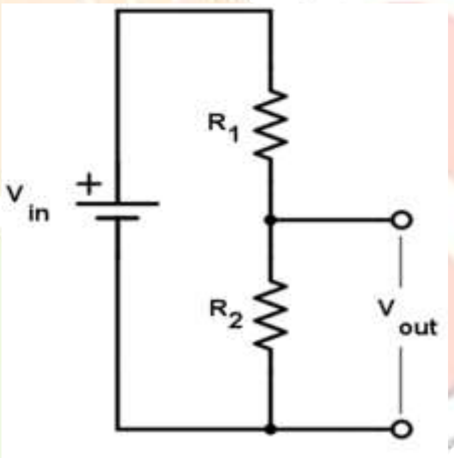


Fig -6: Voltage Divider Circuit

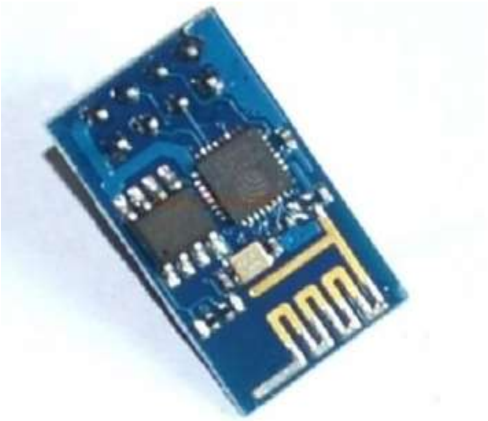
E. WATER PUMP MOTOR

A water pump motor is a DC motor device that moves fluids. A direct current motor converts electrical power into mechanical power. Direct motor works on the principal, when a current carrying conductor is placed in a magnetic field, it experiences a torque and has a tendency to move. Water pumps operate by rotary mechanism and consume energy to perform mechanical work by moving the fluid.

Water pumps operate through many energy sources, including manual operation, electricity, engines, or wind power. It comes in many sizes, from microscopic for use in medical applications to large industrial pumps.

F. NODE MCU

ESP8266 is a Wi-Fi module, which offers a complete and self-contained Wi-Fi networking solution. It either host the application or it allows to offload all Wi-Fi networking functions from another application processor. When the program is hosted by ESP8266, and is the only program processor in the system, it can boot up directly from an external flash. It has built-in cache to boost device performance in these applications, and reduce memory requirements.



Alternatively, as a Wi-adapter, wireless internet networking may be applied through the UART interface or the Processor AHB bridge interface to any microcontroller-with easy connectivity.

F.1 SPECIFICATION

- *SDIO 2.0, SPI, UART*
- *32-pin QFN package*
- *Integrated RF switch, 24dBm PA, DCXO, and PMU*
- *Integrated RISC processor, on-chip memory and external memory interfaces*
- *Integrated MAC/baseband processors*
- *Quality of Service management*
- *I2S interface for high fidelity audio applications*
- *On-chip low-dropout linear regulators for all internal supplies*
- *Proprietary spurious-free clock generation architecture*
- *Integrated WEP, TKIP, AES, and WAPI engines*

XIV. CONCLUSION

The module developed in this paper has demonstrated an ability to increase the efficiency of the panel by using water as a cooling agent. Whenever the temperature and dust increase beyond the threshold value water pump is turned on. This experimental setup has proved that the efficiency of the cooled panel is high compared to the conventional solar panel before cooling.

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