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A Prototype to Enhance Efficiency of Solar Panel Using Water Cooling Systems

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Abstract: *The efficiency of solar cells or panels declines significantly as the surface temperature of the cells or panels rises. Water immersion cooling technique can be used to resolve heating of solar cell surface, i.e. it can be immersed in water to preserve surface temperature and have greater performance at high temperatures. In this analysis, the electrical parameters of a solar cell were determined, revealing that the cooling factor plays an important role in increasing electrical efficiency. Under real-world climatic conditions, a solar cell submerged in water was monitored; the cell surface temperature can be adjusted between 31 and 39°C.The electrical efficiency of the cell improves significantly. The results are discussed; panel productivity has improved by approximately 17.8 percent at a water depth of 1cm. The research will help the Concentrated Photovoltaic System by immersing the solar cells in various mediums.*

Keywords: *Solar Energy, Efficiency, Cooling, Temperature, Photovoltaic Cell.*

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1. Introduction

As the planet struggles with oil deficits, global warming, and the decoration of the atmosphere and energy supplies, there is a need for an alternative energy supply for power generation rather than the use of fossil fuels, water, and wind. In the coming decades, fossil fuels will be exhausted, hydropower plants will be dependent on annual rainfall, and wind power will be dependent on climate change. Solar energy is a comparable candidate for an alternative energy supply. Solar energy is a virtually limitless supply of energy. The electricity intercepted by the earth from the sun is roughly1.8×10^{11}MW, which is greater than the current usage average of all commercial energy sources on the planet. As a result, solar technology has the potential to meet all of the world's current and future energy needs on an ongoing basis. As a result, it is one of the most promising unconventional energy sources [1-4]. A solar cell is a battery that uses photo voltaic to directly transform the energy from sunlight into electrical energy. Charles Fritts created the first solar cell around 1883, using junctions produced by covering selenium (a semiconductor) with an incredibly thin layer of gold. A thin film cell sandwiched between two layers of glass was created in 2009. A standard PV module has an ideal conversion efficiency of about 15%.The residual energy is converted into heat, which raises the operating temperature of the PV system, affecting the electrical power output of the PV modules. This can also cause structural harm to the PV modules, shortening their life cycle and reducing conversion efficiency. If heat is not eliminated from the PV module, its output power decreases [5].When the solar cell is a silicon series solar cell, the temperature can exceed 80℃ degrees Celsius or higher. According to the literature, cell temperature has a significant impact on its performance. A temperature rise of 1K results in a 0.2 percent -0.5 percent decrease in photoelectric conversion yield. [6] Formalized paraphrase various studies have been performed in order to increase PV conversion performance; cooling is one of these studies that offers a successful solution to the low efficiency problem. Both water and air should be used as cooling fluids to keep the PV module cold and prevent a decrease in electrical quality [7-12].The performance of a solar-photovoltaic (PV) device is determined by more than just its specific electrical characteristics, which include maximum power, tolerance rated value percent, maximum power voltage, maximum power current, open-circuit voltage, short-circuit current, maximum system voltage, and maximum system current. However, many factors such as atmospheric temperature, relative humidity, dust storms and suspension of air, shading, global solar radiation level, wavelength, and angle of irradiance all have a detrimental impact [13,14].

2. Objective and Scope

The aim of this project is to improve the performance of solar panels by using an appropriate cooling system. The project's scope is that it would aid in lowering panel erosion and increasing panel durability.

3. Materials and Method

A commercial polycrystalline solar panel with a surface area of 3627cm2 was tested. Table 1 lists the characteristics of PV panels. The experimental rig consists of a 12W solar panel, a 12V battery, a volt meter, an ammeter, a solar lamp, and a cooling system. Figure 6 depicts a photograph of the experimental setup. The cooling system consists of a water cane with a capacity of 5 litres, a hose with a flow controlling knob, a water absorbing sponge, and a drain pipe for storing water.

Table 1: Solar panel specification

Peak power	**12W**
Type	Poly-crystalline
Open circuit voltage	21.3V
Maximum power voltage	17.5V
Maximum power current	0.68A
Operating temperature	-40°C to 80°C
Number of cells	36
Dimensions	32×27 cm

4. Proposed System

First and foremost, in order to activate the device, we must push the switch, after which the system will be activated. The temperature, current, and voltage sensors would then activate automatically. The temperature sensor can detect the temperature of the solar panel and communicate the value to the microcontroller. The data is compared to the set value by the microcontroller. If the value is higher than the set value, the microcontroller sends an instruction to turn on the pump motor, which will operate until the temperature falls below the set value. Simultaneously, the voltage sensor begins to detect the voltage of the battery bank. If the battery voltage falls below 9 volts, the microcontroller can give an instruction to turn off the load and turn on the charge controller. If the microcontroller detects a voltage greater than 13.1 volts, it sends an instruction to switch off the solar charge controller. This system even detects the system's current and displays it on the LCD panel. This machine would work in this manner.

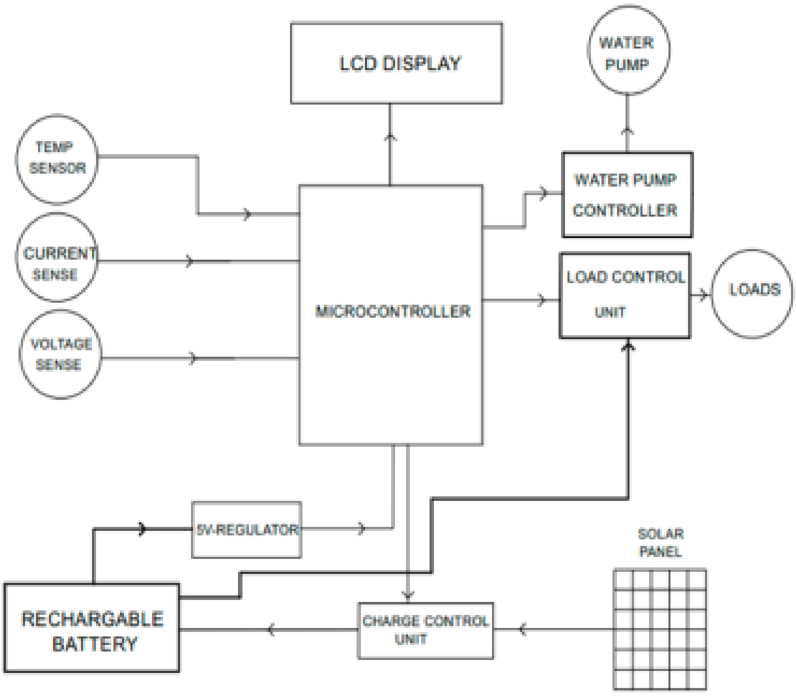

Figure 1: Block Diagram of Proposed System

5. Implementation Technique

Figure 2 depicts the flow diagram for carrying out this mission. In this proposed system, three sensors are used to detect temperature, voltage and Current. In this system a microcontroller is used for decision making device. As this system is automatically controlled to the microcontroller take the input from three sensors and take a decision according to reference value. Here the Temperature sensors measure the temperature and give this value to microcontroller. If the value is greater than 33 then the water pump will be automatically on and it will try to cool the solar panel. The Voltage sensor is used to measure the voltage and current sensor is used to measure the current generated from the solar panel. We can analysis the power by calculating the voltage and current. The power with cooling system and without cooling system can be calculated with the value of voltage and current sensor's value. By using the calculated value, the percentage of increasing the power with using cooler can be founded. The Circuit diagram of proposed system is showed in Figure 3.

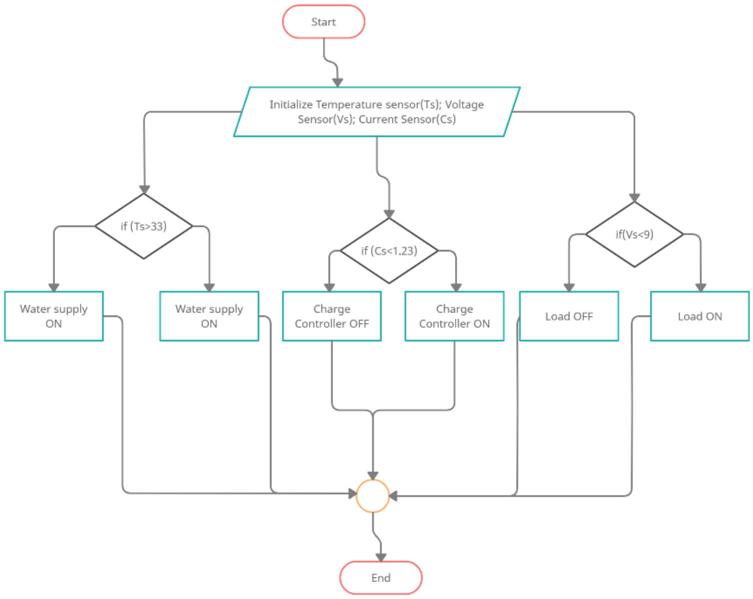

Figure 2: Flow Chart for Implement Circuit

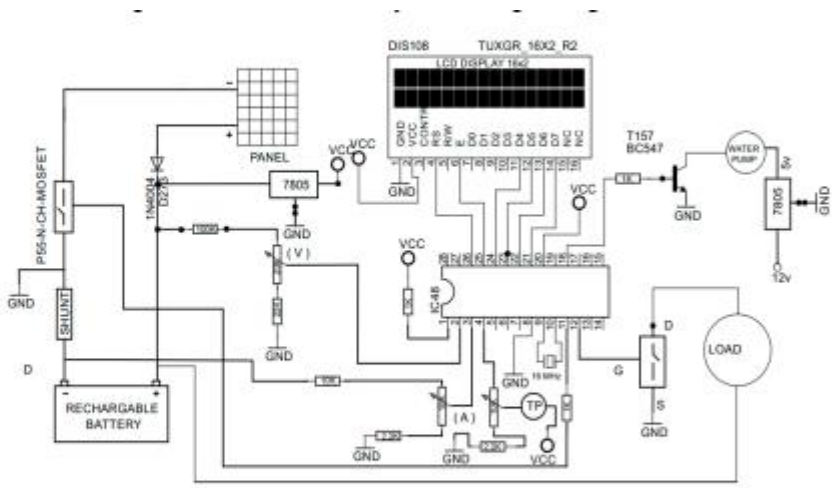

Figure 3: Simulation Circuit Diagram

6. Results and Discussion

6.1 Result:

It can be seen that solar irradiation is a function of time, as are the parameters influenced by solar irradiation, such as inlet and outlet temperatures, PV voltage and PV current. That is why the equation must be integrated with time. Figure 5 depicts the peak performance efficiency of a solar panel in relation to the mass flow rate of cooling water. As seen in Figure 5, a mass flow rate of two litters per hour of cooling water improved the efficiency of the solar panel. That may be the sponge's ability to absorb water. This means that if more than two liters of water flow per hour is not retained in the sponge, the peak productivity of the panel is reduced. It follows that a water flow rate of 2 liters per hour is ideal for performing the test. Figure 4 compare the effects of a solar panel without cooling and a two-liter-per-hour flow of cooling vapor. In Figure 5 the prototype of the implemented circuit has been showed.

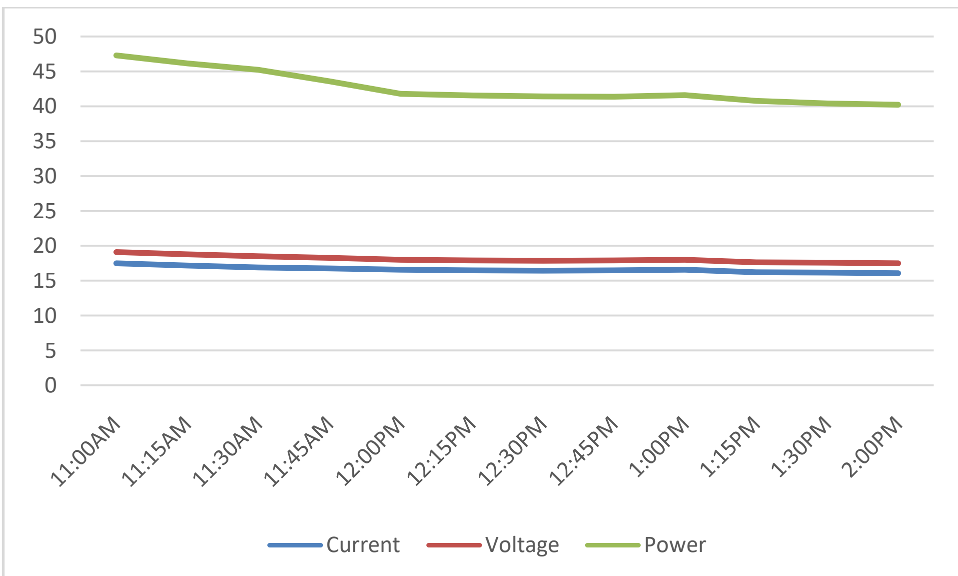

Figure 4: Solar panel’s Voltage, Current and Power with time without using Cooling system

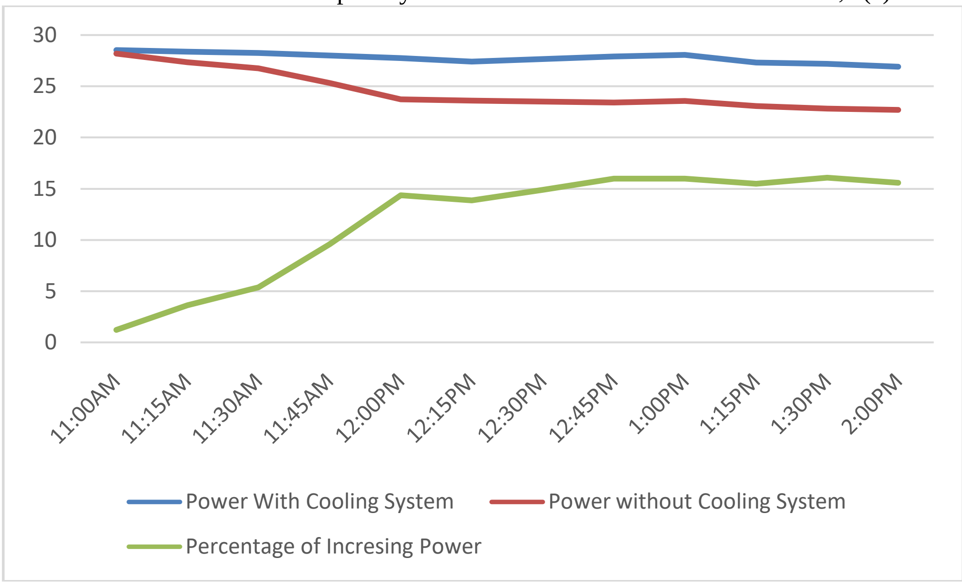

Figure 5: Comparisons on power output per hour of solar panel between cooling and without Cooling

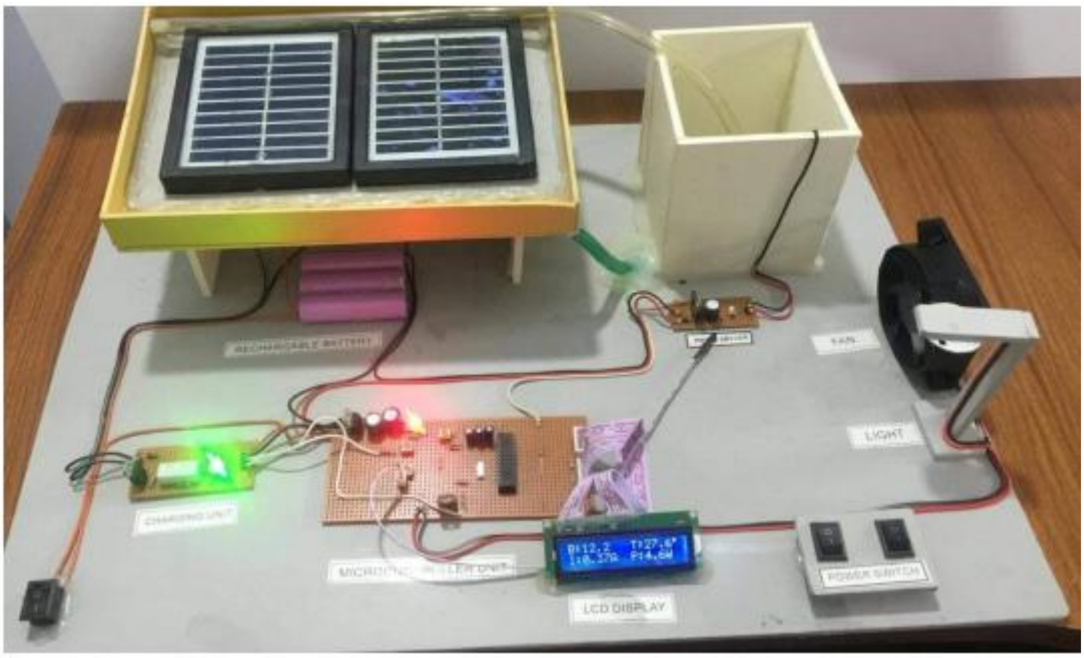

Figure 6: Implemented Circuit

Table 2: Charging time between cooling and without cooling

SL No.	Battery Voltage level (V)	Without clean/ cooling (Time)	With clean/cooling (Time)
01	12.0-12.1 v	4 min	3.40 min
02	12.0-12.1 v	4 min	3.40 min
03	12.2-12.3 v	5.10 min	4.30 min
04	12.3-12.4 v	7.0 min	6.2 min
05	12.4-12.5 v	10.0 min	8.0 min
06	12.5-12.6 v	15.0 min	12.0 min

Table 3: Measuring Power without using any cooling system

Sl. No	Time	Temperature(℃)	Voltage(V)	Current(I)	Power(W)
01	11:00AM	30	17.5	1.61	28.175
02	11:15AM	32	17.2	1.59	27.348
03	11:30AM	45	16.92	1.58	26.7336
04	11:45AM	50	16.76	1.51	25.3076
05	12:00PM	52	16.6	1.43	23.738
06	12:15PM	60.4	16.5	1.43	23.595
07	12:30PM	62.3	16.45	1.43	23.5235
08	12:45PM	63.5	16.5	1.42	23.43
09	1:00PM	64.1	16.6	1.42	23.572
10	1:15PM	64.6	16.25	1.42	23.075
11	1:30PM	64.8	16.18	1.41	22.8138
12	2:00PM	64.3	16.1	1.41	22.701

Table 4: Performance analysis of Power generation with and without cooling system

Sl. No	Time	Voltage (V)	Current (I)	Power (W) with Cooling System	Power (W) without Cooling System	Percentage Increase in power (%)
01	11:00AM	17.5	1.61	28.525	28.175	1.226993865
02	11:15AM	17.2	1.59	28.38	27.348	3.636363636
03	11:30AM	16.92	1.58	28.2564	26.7336	5.389221557
04	11:45AM	16.76	1.51	27.9892	25.3076	9.580838323
05	12:00PM	16.6	1.43	27.722	23.738	14.37125749
06	12:15PM	16.5	1.43	27.39	23.595	13.85542169
07	12:30PM	16.45	1.43	27.636	23.5235	14.88095238
08	12:45PM	16.5	1.42	27.885	23.43	15.97633136
09	1:00PM	16.6	1.42	28.054	23.572	15.97633136
10	1:15PM	16.25	1.42	27.3	23.075	15.47619048
11	1:30PM	16.18	1.41	27.1824	22.8138	16.07142857
12	2:00PM	16.1	1.41	26.887	22.701	15.56886228

6.2 Discussion:

From the above table and Figure it has been showed that after applying the cooling system in solar panel the power generate from the photovoltaic system has been increased and the efficiency is also increased. This implemented system is a microcontroller based prototype that is automatically controlled according to measurement of temperature and it is successfully working.

7. Conclusion

Free flow front water cooling of PV panels may boost the performance and durability of photovoltaic energy transfer – the open voltage of the panels increases as its temperature decreases, and its life cycle can be extended as a result of the lower operating temperature.

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