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Design and implementation of low-cost IoT solution for monitoring parameters of Solar Panel

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Abstract— The most significant system for solar system monitoring is the solar parameters monitoring system. Solar energy, which is created by solar panels, is a renewable source of energy. Solar energy, which is created by solar panels, is a renewable source of energy. Voltage, light intensity, and temperature are among the characteristics monitored by the system. An Arduino Uno microcontroller board is utilized in the proposed monitoring system. Solar panels, an LDR sensor, an LM 35, an Arduino microcontroller, and resistors are all included in the system. Light. An LDR sensor detects light intensity, an L35 sensor measures temperature, and a voltage divider circuit keeps track of the voltage in this system.

Key Words: Solar Panel, Monitoring, Renewable Energy, Solar Panel, Arduino Uno.

1. INTRODUCTION

In many developing countries, power generation is a key component. Energy consumption is at an all-time high, as the industrial and commercial sectors grow. As a result, we're all being drawn to renewable energy sources to suit our energy needs. This might aid humanity in reducing greenhouse gas emissions and ozone layer depletion in the future. Solar photovoltaic technology is becoming increasingly popular due to its wide availability, low cost, and ease of installation and maintenance. When devices are connected through a communication protocol and a cloud platform, the Internet of Things (IoT) becomes smarter and easier to use. Basic elements like voltage, light intensity, and temperature have an impact on the performance of a solar panel. As a result, a real-time solar monitoring system is required to improve the PV panel's performance by comparing it to the trial result and implementing preventative actions. In recent years, solar energy has gotten a lot of buzz. In order to achieve high performance, machine intelligence methods are also employed to predict outcomes.

2. MATERIALS AND METHOD

The light intensity is monitored using an LDR sensor, voltage by voltage divider principle, and temperature by temperature sensor. All these data are displayed on a 16X2 LCD interfaced to Arduino Microcontroller. For integrating solar panels with the Arduino UNO, the system includes both hardware circuit design and software programming. A voltage divider circuit senses the solar PV voltage. A light-dependent ratio sensor measures light intensity, whereas an LM35 sensor measures temperature.

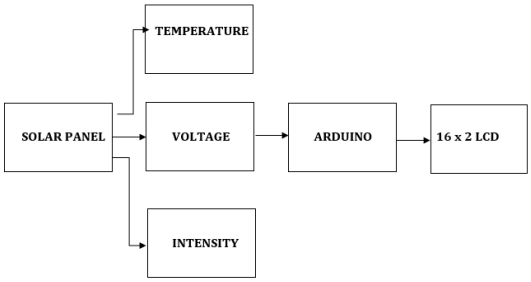

Fig 1: Block diagram of solar parameter monitoring system

2.1 System Components

2.2 System Simulation

2.2.1 Voltage Measurement

The Solar Panel Voltage may be measured up to 5 volts, which is quite simple. However, if we want to detect voltages greater than 5 volts, we'll need to add some more circuitry, such as a Voltage Divider. This circuitry varies in response to voltage, thus we need to know how much voltage to measure. Assume we require no additional circuitry to measure 5 volts. Simply connect the Solar Panel's output voltage to the Arduino's Analog pin, convert to digital, and display the result on an LCD or computer. Assume that you need to utilize the supplied circuitry to measure up to 10 volts showing in Fig 7.

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For measuring Voltage we have to follow the given Formula:
Voltage= (Analog value / resistor factor) * reference Voltage
Where:
Analog value= Analog output of Voltage divider
Resistor factor= 1023.0/(R2/R1+R2)
Reference Voltage= 5 volts
And let suppose:
R1= 1K
R2=1K
Resistor factor= 1023.0 * (1000/1000+1000)
Resistor factor=1023.0 * 0.5

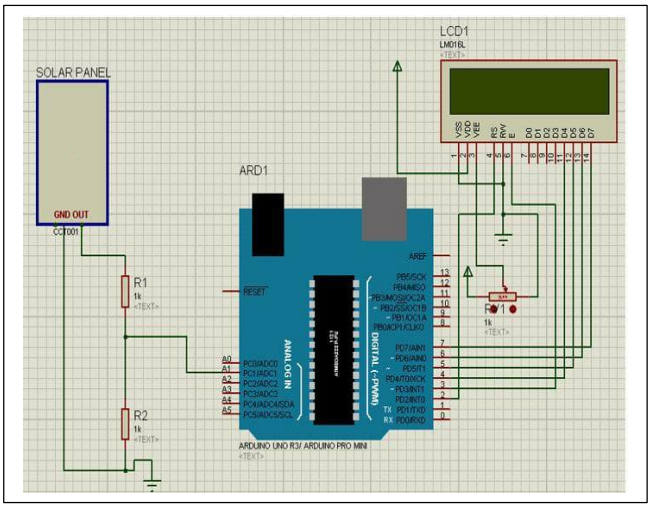

Fig 7: Circuit Diagram of Arduino based Digital Voltmeter

2.2.2 Light Intensity Measurement
Light Intensity, like Voltage Measurement, is a simple project to do. To determine the light intensity, we must first divide the voltage by a voltage divider and then measure the voltage. We'll obtain the Light Intensity Result later after some calculations. We'll need to employ an LDR (Light Dependent Register) for this, which is extremely common and widely accessible. You may now view the Light Intensity Measurement Circuit Diagram shown in Fig 8.

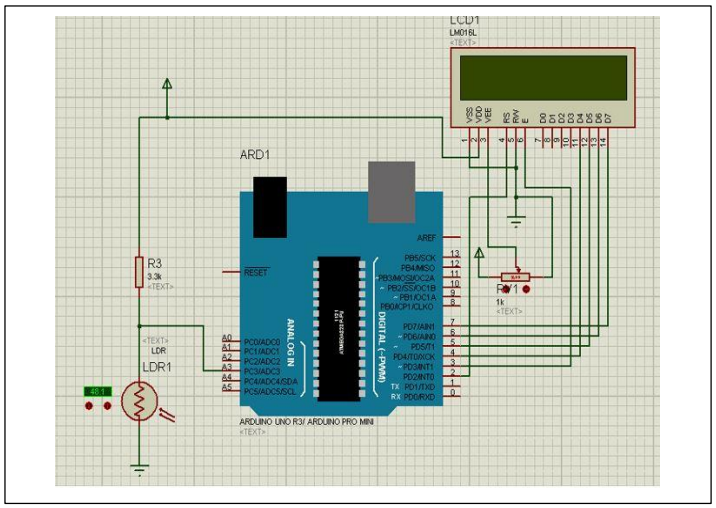

Fig 8: Circuit Diagram of Arduino based Light Intensity Meter

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2.2.2 Temperature Measurement

A 3.3K ohm resistor and an LDR are linked in series, and the center points are utilized as output. As light falls on the LDR, its resistance drops, resulting in the generation of analogue voltage, which is then applied to the Arduino.ent component.

Relation between RL (LDR) and Light Intensity (Lux) is given below:

RL=500/Lux

Output Voltage of this circuit can be calculated by using given formula.

Vout= 5 * RL / (RL+3.3 Where RL is Load Resistance (LDR Resistance varies according to light intensity).

Now by using given formula we can calculate Light intensity in lux (where lux in unit of light intensity).

Lux= (2500 / Vout – 500) / 3.3

For Measuring Temperature here we have used **LM35** that is gives 10 mV for every 1 degree Celsius. Circuitry is simple for this which is shown in Fig 9.

By using given formula we can calculate Temperature in Degree Celsius:

Temperature=Analog value*(5.0/1023.0)*100;

Where, 5 is reference voltage.

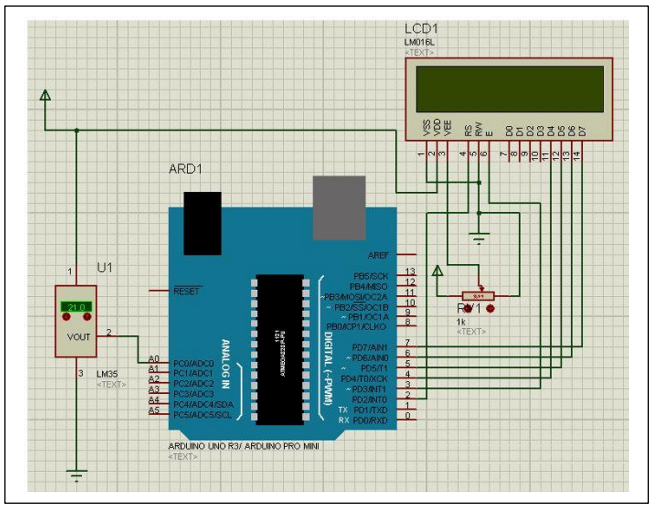

Fig 9: Circuit Diagram of Arduino based Digital Thermometer

The complete circuit diagram is showing in Fig 10

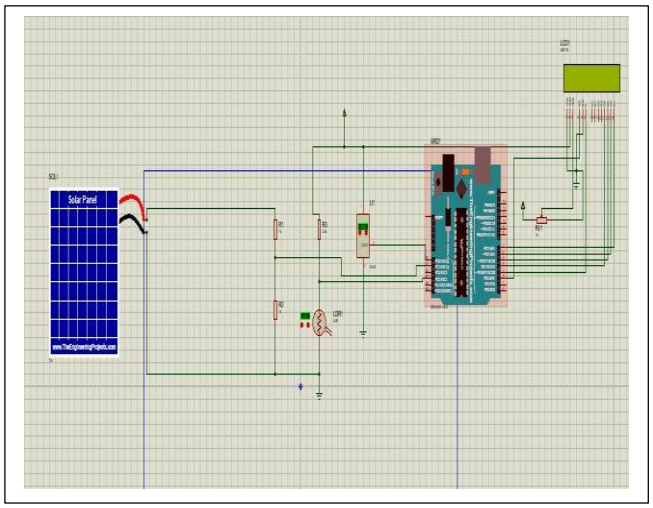

Fig 10: Circuit Diagram of Complete System

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2.3 Circuit Construction and Testing

The proposed circuit characteristics were initially simulated using PROTEUS 8 software, which was then utilized to choose components for the Arduino-based solar PV parameter-measuring system's fabrication. The circuit elements are mounted and soldered on the breadboard as part of the system construction. The hardware construction entails the connection of the system's physical components, which are made up of circuit units, as well as the interface between the voltage sensor, temperature sensor and light intensity sensor, and Arduino microcontroller. Figure 11 depicts the system's building step, which includes the assembly of the component elements on the zero PCB. The Arduino is programmed in C for the second stage, which offers central control for the system's operation. The testing was conducted on the 11th, 12th, of March 2022. The readings were taken from 9:00am to 6:00pm daily for each of the testing days. The results for voltage, light intensity, temperature and pressure were recorded on testing days.

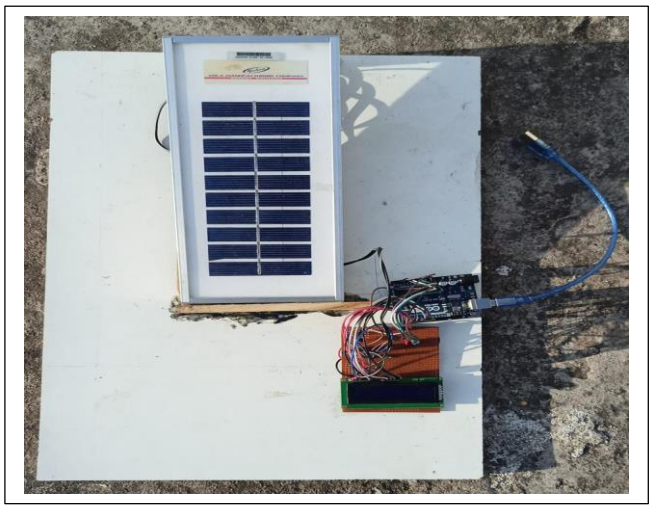

Fig 11: Hardware setup of Complete System

3. RESULT

Figures 12, 13 show the voltage and light intensity findings for the solar PV panel as a function of the hours of the day. On March 11th, 2022, the greatest voltage was 2.68V at 9.00am with a light intensity of 631lux, while the lowest voltage was 2.1V at 1.00pm with a light intensity of 902lux. The maximum voltage was 2.75V at 9.00AM with a light intensity of 650lux on March 12th, 2022, while the lowest voltage was 2.12V at 2.00pm with a light intensity of 909lux. Figure 15 shows graph of light intensity against time.

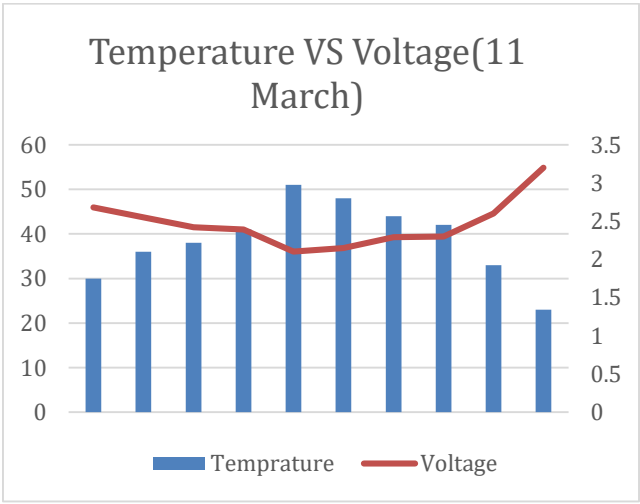

Fig 12: Temperature and Voltage for Day 1

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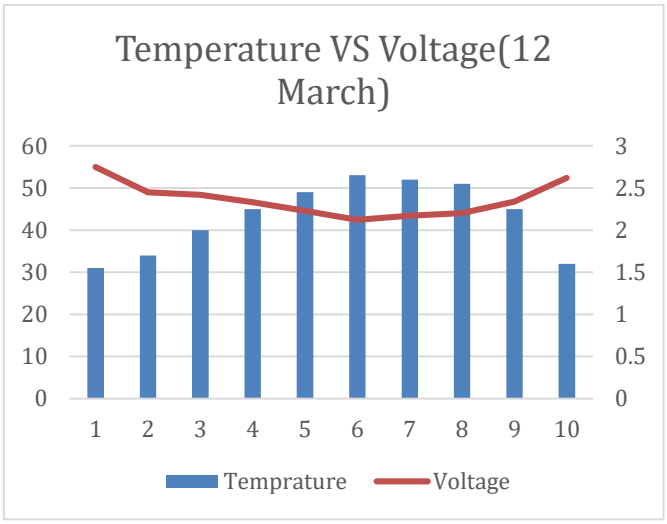

Fig 13: Temperature and Voltage for Day 2

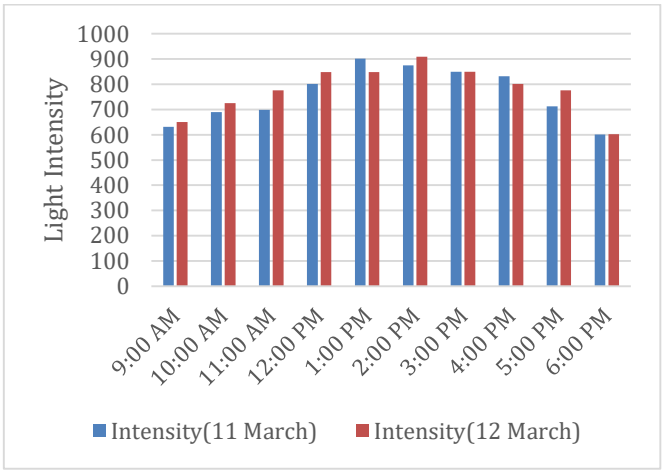

Fig 14: Graph of light intensity against time

4. CONCLUSION

One advised method of mitigating environmental repercussions is to use Renewable Energy technology. Because of the frequent power outages, it is critical to use renewable energy and keep track of it. The user will be guided through the process of tracking renewable energy usage. This is a cost-effective method. The efficiency of the system is expected to be around 95%. This makes it possible to use renewable energy more efficiently. The temperature sensor is important in solar energy storage studies. As a result, the electrical problem is less of a problem. We showed how we used Arduino to design and build a solar panel parameter reading node for environmental monitoring; the node can provide temperature, voltage, and light intensity information**.**

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