NATIONAL INSTITUTE OF TECHNOLOGY , AGARTALA

Industrial Instrumentation
Project ReportFile

SOLAR PARAMETER TRACKING

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Section: B, Group: 1

Semester: 6th

Session: 2024-25

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ACKNOWLEDGEMENT

We are profoundly grateful to **Mr. Rajesh Kumar** Sir of the **Electrical Engineering Department** at the **National Institute of Technology, Agartala**, whose invaluable academic insights, unwavering guidance, and steadfast encouragement have laid the foundation for this project. His dedication to teaching and his readiness to share his expertise have been instrumental in shaping our work and inspiring us to achieve excellence. Our deepest and most sincere thanks go to **Dr. Diptanu Dey** Sir. His generous permission, invaluable expertise, and unwavering support have been the cornerstone of our project's success. His comprehensive guidance not only helped shape our approach but also inspired us to strive for excellence. His willingness to share his profound knowledge and his readiness to assist us at every stage have been truly remarkable. Through detailed suggestions, insightful feedback, and continuous encouragement, he has empowered us to overcome challenges and refine our work. We are immensely grateful for his mentorship, which has had a lasting impact on both our project and our academic journey. Furthermore, we wish to acknowledge and thank everyone who has, in one way or another, supported us during this journey. Your contributions, whether through technical assistance, constructive feedback, or moral support, have played a crucial role in making this project a success.

Thanking You

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Objective:

The primary objective of this project is to design and implement a cost-effective, real-time solar parameter monitoring system that tracks essential environmental and electrical parameters affecting the performance of a solar panel. The system aims to:

- Monitor sunlight intensity, temperature, humidity, and voltage output from the solar panel.
- Provide real-time feedback using an LCD display.
- Lay the foundation for potential integration with data logging or IoT platforms for enhanced utility.

Introduction:

Solar energy is rapidly becoming a cornerstone in the transition toward sustainable and renewable energy sources. With its abundance and minimal environmental impact, solar energy is widely used in domestic, industrial, and remote applications. However, its efficiency is highly dependent on environmental parameters such as sunlight intensity, ambient temperature, and atmospheric conditions.

Traditional solar systems often lack real-time feedback mechanisms to evaluate their performance and efficiency. Monitoring solar parameters in real time allows users and engineers to assess solar panel efficiency, troubleshoot issues, and forecast energy production. This becomes increasingly important as solar systems scale up in size or are deployed in remote areas.

The **"Solar Parameter Tracking"** project aims to create a simple yet powerful system to monitor key environmental variables that affect solar panel performance. By utilizing components such as the Arduino UNO, Light Dependent Resistor (LDR), DHT11 temperature and humidity sensor, and a 5V solar panel, the system is capable of gathering, processing, and displaying vital information through a 16x2 LCD interface with I2C communication. This setup not only makes the system accessible for educational purposes but also sets the stage for further enhancements in data logging, remote monitoring, and smart solar solutions.

Working Principle

The Solar Parameter Tracking system is designed to monitor and display real-time environmental parameters—**light intensity**, **temperature**, and **humidity**—which influence the performance of a solar panel. The system uses an **Arduino UNO** as the central controller that gathers data from two sensors: an **LDR (Light Dependent Resistor)** and a **DHT11 sensor**.

The **LDR** detects sunlight by changing its resistance based on the light falling on it. This change is read as an analog voltage through the Arduino's analog input pin. A brighter environment results in a higher analog reading, indicating stronger sunlight.

The **DHT11 sensor** measures ambient temperature and humidity and sends digital data to the Arduino through a single data pin. The Arduino extracts the values using a dedicated library, converting raw data into temperature (°C) and humidity (%) values.

The collected sensor data is displayed on a **16x2 LCD screen**, allowing efficient communication using only two wires. This setup enables real-time monitoring of the surrounding environment.

A **5V solar panel** is integrated into the system to demonstrate solar power generation under different lighting conditions. While not measured directly in this version, the light intensity detected by the LDR reflects the panel's exposure to sunlight.

Overall, the system offers a practical and low-cost way to study solar performance influenced by environmental parameters. It also serves as a foundation for more advanced solar tracking or energy optimization systems.

Components Used

Component	Specification	Purpose
Arduino UNO	Microcontroller based on ATmega328P, 16 MHz clock speed, 14 digital I/O pins, 6 analog pins	Central controller for reading sensors and controlling the system.
LDR (Light Dependent Resistor)	5V, resistance varies based on light intensity (10kΩ with voltage divider)	Detects ambient light intensity.
DHT11 Sensor	Temperature range: 0–50°C, Humidity range: 20–80%, Accuracy: ±2°C for temperature, ±5% for humidity	Measures temperature and humidity.
16x2 LCD	16 columns × 2 rows, 5V power supply	Displays real-time data (temperature, humidity, light intensity).
5V Solar Panel	Voltage: 5V, Current: Varies with light intensity (typically 150mA–200mA)	Powers the system, demonstrating solar energy generation.
Resistors	10kΩ (for voltage divider with LDR)	Used for setting up the voltage divider for the LDR.
Jumper Wires	Flexible wires with male-to-male or male-to-female connectors	Used for connecting components on the breadboard.
Breadboard	Standard size breadboard for prototyping circuits	Used to assemble the components and test the circuit.

Circuit Diagram Explanation

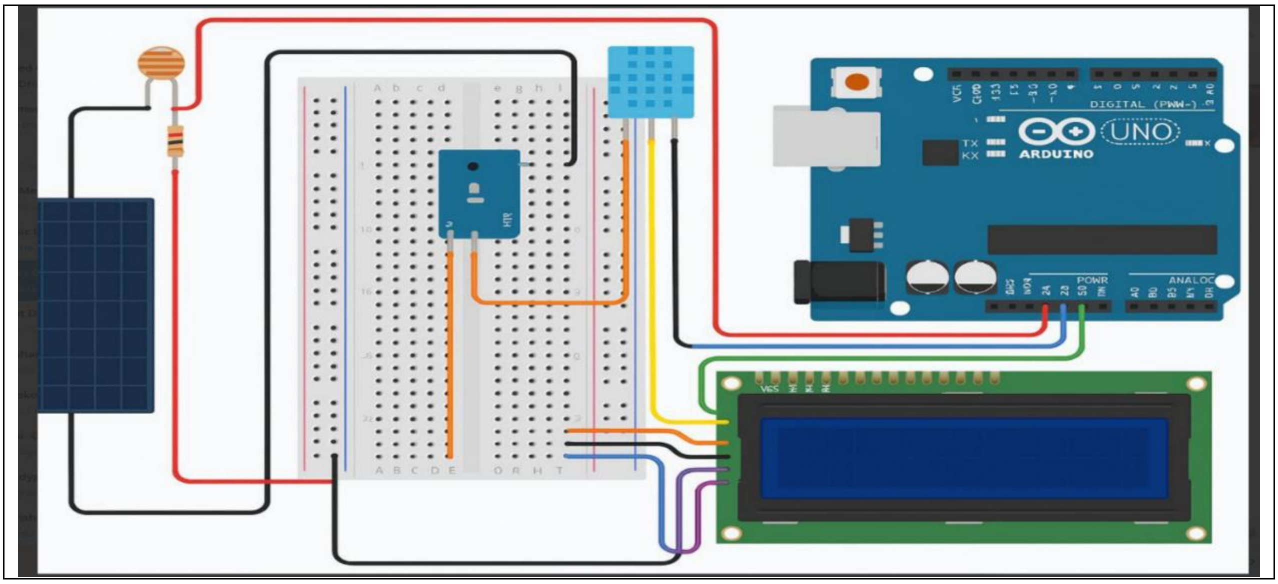

Fig : circuit diagram

1. The project is powered by a **5V solar panel**, which supplies voltage to the entire system through the breadboard power rails.

2. An **Arduino UNO** acts as the main controller, reading sensor inputs and displaying data on an LCD.

3. The **LDR (Light Dependent Resistor)**:

- Connected in a **voltage divider** with a resistor.
- One side goes to **5V**, the other to **GND** through the resistor.
- The voltage in between is connected to **Analog pin A0** of the Arduino.
- Used to measure **light intensity** based on varying resistance with light.

4. The **DHT11 sensor**:

- Measures **temperature** and **humidity**.
- Has three pins: **VCC**, **GND**, and **Data**.
- Data pin is connected to **Digital pin 2** of the Arduino.
- Sends **digital signals** to the Arduino for temperature and humidity readings.

5. The **16x2 LCD interface**:
    - Displays real-time sensor data.
    - Connected using only two data lines:
        - **SDA → A4**, **SCL → A5** on Arduino.
    - Requires **VCC** and **GND** connections as well.
6. The Arduino reads and processes the sensor data continuously.
7. The results (light intensity, temperature, and humidity) are displayed on the LCD in real-time.

Code :

```
#include <LiquidCrystal.h>
#include <DHT.h>

LiquidCrystal lcd(7, 8, 9, 10, 11, 12);

#define DHTPIN 3
#define DHTTYPE DHT11
DHT dht(DHTPIN, DHTTYPE);

const int ldrPin = A0;
const int solarPin = A1;

void setup() {
  lcd.begin(16, 2);
  dht.begin();
}

void loop() {
  int lightIntensity = analogRead(ldrPin);
  int solarVoltage = analogRead(solarPin);
  float voltage = (solarVoltage / 1023.0) * 5.0;

  float humidity = dht.readHumidity();
  float temperature = dht.readTemperature();


  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("LDR: ");
  lcd.print(lightIntensity);

  lcd.setCursor(0, 1);
  lcd.print("Solar V: ");
  lcd.print(voltage);
  lcd.print("V");

  delay(2000);

  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Humidity: ");
  lcd.print(humidity);
  lcd.print("%");

  lcd.setCursor(0, 1);
  lcd.print("Temp: ");
  lcd.print(temperature);
  lcd.print(" C");

  delay(2000);
}
```

Hardware Pictures:

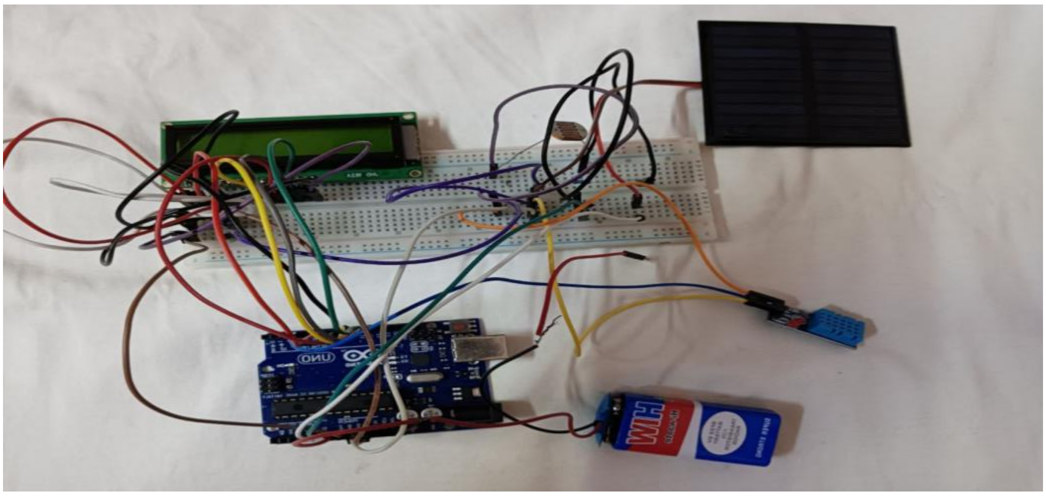

Fig: Before power supply

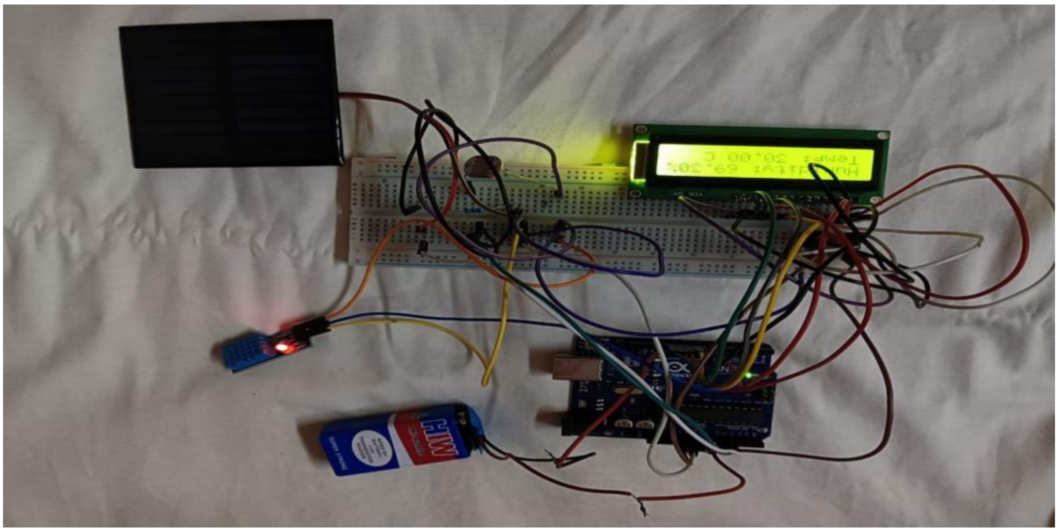

Fig: After power supply

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Applications of Solar Parameter Tracking System

1. Solar Panel Performance Monitoring

- Tracks **light intensity**, **temperature**, and **humidity** to assess how they affect solar panel efficiency.
- Helps in understanding how environmental changes like weather, time of day, and seasonality influence solar energy output, ensuring the system operates at optimal conditions.

2. Solar Energy Efficiency Research

- Useful for **researchers** in analyzing how temperature, humidity, and light conditions impact the energy generation capabilities of solar panels.
- Provides valuable data to improve **solar panel designs** and develop strategies for **energy optimization** by understanding the relationship between environmental conditions and solar panel performance.

3. Renewable Energy Monitoring in Smart Grids

- Integrates with **smart grids** for monitoring solar energy generation in real-time, allowing for **load balancing** and **energy forecasting**.
- Ensures that solar energy is efficiently distributed, adjusts energy storage, and optimizes solar panel performance based on environmental conditions, contributing to a **more reliable energy system**.

4. Climate and Environmental Studies

- Collects data on **temperature**, **humidity**, and **light intensity**, which can aid in **climate research** and environmental monitoring.
- Useful for studying how environmental factors like weather and seasonal changes impact both solar energy production and the **local ecosystem**, providing insights for **agriculture**, **urban planning**, and sustainability efforts.

5. Off-Grid Solar Power Systems

- Ideal for **off-grid** locations where solar panels are the primary power source, as it helps in monitoring and optimizing **solar energy generation**.
- Ensures **efficient battery management** by tracking solar power production in real-time, preventing **overcharging** or **undercharging**, and maximizing energy usage in remote locations.

6. Educational and Demonstration Tool

- An excellent tool for teaching **solar energy principles** in schools and universities by demonstrating how light, temperature, and humidity influence solar panel efficiency.
- Provides **hands-on experience** for students, making complex concepts like renewable energy and solar technology more accessible and engaging.

7. Home and Commercial Solar Monitoring

- Helps **homeowners** and **businesses** track solar energy production in real-time, ensuring panels are functioning at peak efficiency.
- Allows for better **energy management**, reduces waste, and alerts users about the need for maintenance or adjustment, thereby optimizing energy consumption and reducing costs.

Advantages of the Solar Parameter Tracking System

1. Real-Time Monitoring

- Provides continuous, real-time tracking of key environmental parameters such as **light intensity**, **temperature**, and **humidity**, enabling instant analysis of solar panel performance.

2. Improved Solar Panel Efficiency

- By monitoring **light intensity** and **temperature**, the system helps in optimizing solar panel orientation and usage, ensuring that solar panels operate at their **maximum efficiency** under varying conditions.

3. Cost Savings

- The system helps **identify inefficiencies** or faults in solar panels early on, reducing maintenance costs and avoiding unnecessary energy waste, which can lead to **long-term savings** in energy bills and repair costs.

4. Energy Optimization

- Provides crucial data to maximize **solar energy generation** by adjusting energy consumption patterns and panel settings based on environmental factors, improving overall **energy efficiency**.

5. Sustainability and Environmental Benefits

- Facilitates the **optimization of solar energy systems**, reducing reliance on non-renewable energy sources and contributing to a **greener environment**.
- Supports the development of **sustainable energy solutions** by providing detailed insights into how environmental factors impact solar power generation.

6. Easy Integration with Other Systems

- The system can be integrated with **smart grids** or **energy storage systems** for automated adjustments and more efficient energy distribution, promoting better **grid management** and **renewable energy integration**.

7. User-Friendly and Cost-Effective

- The use of affordable components like **Arduino UNO**, **LDR**, and **DHT11 sensor** makes the system low-cost and easy to implement, making it accessible for educational purposes, small businesses, and even home users.

8. Educational Value

- Provides an interactive learning tool for students and researchers to better understand solar energy systems, renewable energy principles, and environmental factors affecting energy generation.

9. Remote Monitoring Capability

- With additional modifications, the system can enable **remote monitoring**, allowing users to check the performance of solar panels in real-time from anywhere, enhancing convenience and flexibility.

Future Scope:

1. Solar Panel Output Monitoring
- Add voltage and current sensors (e.g., INA219) to monitor and display the actual power output of the solar panel.

2. Wireless Data Transmission
- Implement Wi-Fi (ESP8266) or Bluetooth for remote monitoring and wireless data transmission to mobile devices or computers.

3. Weather Forecast Integration
- Integrate weather forecast data to predict environmental conditions and adjust system operations in advance.

4. Data Logging and Analysis
- Add SD card storage or cloud-based logging for historical data collection, enabling trend analysis and long-term performance evaluation.

5. Advanced Environmental Sensors
- Upgrade to more accurate sensors like DHT22 or BME280 for better temperature, humidity, and pressure measurements.

6. Panel Positioning Adjustment
- Integrate a motorized tracking system to automatically adjust the solar panel's orientation for maximum sunlight exposure.

7. Battery Management System (BMS) Integration

- Add a BMS to monitor battery health and optimize charging/discharging cycles in off-grid systems.

8. Mobile Application for Monitoring

- Develop a mobile app for users to remotely monitor and control the system from their smartphones**.**

9. Energy Consumption Feedback

- Include energy consumption tracking to provide feedback on real-time energy use and optimize efficiency.

Conclusion:

The **Solar Parameter Tracking System** provides a practical solution for monitoring key environmental factors such as **light intensity**, **temperature**, and **humidity**, which influence solar panel efficiency. Utilizing **Arduino UNO**, **LDR**, and **DHT11 sensors**, the system offers valuable real-time data to optimize solar energy production and usage.

This system is versatile, with applications ranging from **solar energy research** and **off-grid systems** to **smart grid integration**. It not only aids in improving solar panel efficiency but also contributes to **sustainable energy** efforts. Future enhancements, including **wireless data transmission**, **panel tracking**, and **battery management**, promise to further elevate the system's potential for widespread use in renewable energy solutions.

References:

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Tools:

https://chatgpt.com/ , https://www.deepseek.com/