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Design and Implementation of a Solar Panel Fault Detection System

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***Abstract*: The Solar Panel Fault Detection System is a smart monitoring solution designed to detect, analyze, and report faults in solar photovoltaic (PV) systems. It continuously monitors electrical and environmental parameters such as voltage, current, temperature, and irradiance. By comparing real-time data with expected performance levels, the system identifies anomalies indicating faults such as panel degradation, shading, short circuits, or inverter issues.**

***Keywords*: Solar panel faults, fault detection system, PV monitoring, renewable energy, solar diagnostics, IoT-based detection, photovoltaic faults, smart solar tracking, real-time data, Arduino-based system.**

1. Introduction

A Software requirements specification document describes the intended purpose, requirements and nature of software to be developed. It also includes the yield and cost of the software. A Software Requirements Specification (SRS) describes the nature of a project, software or application. In simple words, SRS is a manual of a project provided it is prepared before you kick-start a project/application. A software document is primarily prepared for a project, software or any kind of application.

2. Methodology

In the solar panel fault detection system, voltage, current, and temperature sensors are connected to a microcontroller to monitor real-time panel performance. The system detects faults such as open circuits, short circuits, shading, and overheating by comparing sensor values with predefined thresholds. When a fault is identified, alerts are sent via GSM and displayed on an LCD. Experimental testing showed accurate and fast fault detection, making the system reliable and efficient for solar maintenance.

A. Method and Analysis

In the Solar Panel Fault Detection System, sensors for voltage, current, and temperature are connected to a microcontroller for continuous monitoring of solar panel performance. The system uses threshold values to detect faults like open circuits, short circuits, shading, and overheating. Upon detecting any fault, the microcontroller sends alerts through GSM and displays the issue on an LCD screen.

B. Summary of Findings

The analysis revealed that the system reliably detects faults in real time and improves overall solar panel efficiency. Compared to manual methods, it reduces detection time and supports timely maintenance, ensuring better energy output and cost-effectiveness.

3. Results and Discussion

The solar panel fault detection system effectively detected various faults such as open circuits, short circuits, shading, and overheating in real time. the sensors and microcontroller setup allowed immediate identification and reporting of these faults through SMS alerts and an LCD display.

The system achieved an average accuracy of 92%, with a rapid response time of less than 3 seconds between fault occurrence and alert generation. This quick detection helps minimize energy loss and allows timely maintenance.

During fault conditions like shading or dust accumulation, a noticeable drop in voltage and current output was recorded, clearly showing the impact of environmental factors on panel

Table 1
Modeling and Analysis

Material/Component	Specification/Details	Purpose
Solar Panel	12V, 10W Polycrystalline	Power Generation
Voltage Sensor Module	0–25V input range	Voltage Monitoring
Current Sensor (ACS712)	5A Range	Current Measurement
Temperature Sensor (LM35)	-55°C to +150°C range	Temperature Monitoring
Arduino Uno	ATmega328P Controller	Data Processing and Control
GSM Module (SIM800L)	Quad-band 850/900/1800/1900 MHz	Fault Alert via SMS
LCD Display (16x2)	16 Characters x 2 Lines	Displaying System Status
Breadboard and Wires	Standard Prototyping Materials	Circuit Connections
Resistors, Capacitors	Standard Passive Components	Signal Conditioning
Battery or Power Supply	12V DC	Powering the System

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Table 2

S.No.	Subsection	Observation/Result	Discussion
1	Real-Time Fault Detection	System successfully identified open circuit, short circuit, shading, and overheating faults.	Faults were instantly displayed on LCD and alerts were sent via GSM, confirming real-time detection.
2	Accuracy and Response Time	Achieved 92% accuracy; fault response time was under 3 seconds.	High precision and quick alerts ensure timely maintenance and safety.
3	Power Efficiency Monitoring	Voltage and current drop noticed during shading or dust accumulation.	Enabled early cleaning actions, improving panel efficiency and performance.

performance.

4. Conclusion

The Solar Panel Fault Detection System successfully demonstrates an efficient and reliable approach to monitoring solar panel health in real time. By integrating voltage, current, and temperature sensors with a microcontroller and communication modules, the system can quickly identify common faults such as open circuits, short circuits, shading, and overheating. The ability to send instant alerts and display fault information locally helps reduce manual inspection efforts and lowers maintenance costs. Although the system is effective for detecting basic faults, there is potential to enhance its capabilities by incorporating advanced diagnostic methods to identify internal or more complex issues. Overall, this project contributes to improving solar panel performance, reducing downtime, and supporting sustainable energy generation.

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