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AN INTELLIGENT SOLAR TRACKING SYSTEM FOR EFFICIENT ENERGY HARVESTING IN AGRICULTURE: A GSM-BASED APPROACH

Sangeeta Kurundkar, Aniket Andhale, Rajesh Chaudhari, Mansi Chavan, Utkarsha Dongarjal, Varad Gadgil
Email :- *sangeeta.kurundkar@vit.edu*, *aniket.andhale22@vit.edu*, *rajesh.chaudhari22@vit.edu*, *mansi.chavan22@vit.edu*, *utkarsha.dongarjal@vit.edu*, *varad.gadgil22@vit.edu*.
Department of Electronics and Telecommunication, Vishwakarma Institute of Technology,666, Upper Indira Nagar, Bibwewadi, Pune – 411037

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***Abstract*—In recent years, solar energy has gained popularity as an alternative to conventional energy sources, especially in rural agricultural areas where regular access to power might not be practical. The effective and reliable operation of solar panels can be difficult, especially in places where it may not be possible to do routine maintenance and monitoring. In this study, we introduce a dual-axis solar tracking system for farming that uses GSM technology for remote monitoring and management. The system has a number of features, including energy generation and utilisation, panel protection, humidity and temperature detection, and backup plans. The overall goal of this research article is to further the design of solar tracking systems that can offer dependable and long-lasting energy options for agriculture in rural locations. A promising development that could increase the effectiveness and dependability of solar panels and make them more acceptable for usage in remote agricultural areas is the dual-axis solar tracking system for agriculture using GSM technology that is given in this study.**

Keywords*—Solar, Agriculture, Dual-axis, sensors, GSM, Hybrid.

I. INTRODUCTION

Because of the possible financial savings and environmental advantages it provides, solar energy use in agriculture has grown in popularity in recent years. Farmers can utilise solar panels to power irrigation systems, water pumps, and other farm machinery, giving them a dependable and sustainable energy source.[1] However, operating solar panels efficiently and dependably can be difficult, particularly in remote locations where it may not be possible to perform routine maintenance and monitoring. With the help of this system, farmers will be able to monitor the condition of their solar panels in real-time and regulate and modify their operations as necessary.[2] We will go through the many aspects of this solar tracking system in this study paper, including its capability for remote monitoring and control, humidity and temperature sensing, panel protection, energy generation and utilisation, and backup plans. We will also look at how this approach may help farmers become more productive, save money, and preserve the environment.

II. LITERATURE SURVEY

Due to potential financial savings and environmental advantages, solar energy use in agriculture has grown in popularity in recent years.[3] However, operating solar panels efficiently and dependably can be difficult, particularly in remote locations where it may not be possible to perform routine maintenance and monitoring. One such device uses GSM technology for remote monitoring and control and is a dual-axis solar tracking system for agriculture.

In this review of the literature, we will look at some of the recent studies on solar tracking systems and their uses in agriculture.

A dual-axis solar tracking system was investigated by Sinha and Sarkar (2017) in their study on how to use solar panels more effectively in agriculture.[4] The dual-axis solar tracking technology greatly increased the solar panels' efficiency, according to the study, leading to higher energy yields and cost savings.

A solar tracking system was suggested in a different study by Khatib et al. (2018). This system used a microcontroller-based algorithm to change the tilt angle of the solar panels in accordance with the location of the sun.[5] The method was found to greatly increase the solar panels' energy efficiency and decrease the requirement for manual adjustments.

The usage of a solar tracking system that included a microcontroller-based algorithm to change the angle of the solar panels was also investigated in a study by Patel and Patel (2018).[6] According to the study, the method increased solar panel efficiency and decreased the need for human adjusting.

The dual-axis solar tracking system for agriculture that we have developed makes use of GSM technology and adds features like remote monitoring and control, humidity and temperature sensing, panel protection, energy production and usage, and backup plans to the existing research on solar tracking systems. Solar panels may become more effective and dependable as a result of these attributes, making isolated agricultural areas a better fit for their use.

III. PROBLEM STATEMENT

Due to its ability to offer dependable and sustainable energy solutions in isolated agricultural areas, solar energy has grown in popularity as an alternative energy source in recent years. However, elements like variations in temperature and humidity, panel protection, and the requirement for routine maintenance and monitoring can have a significant impact on the effectiveness and dependability of solar panels.

Different solar tracking systems that can increase solar panel efficiency have been developed through existing research. Many of these systems, however, are missing characteristics that are specially made for agricultural applications, like the capability of remote monitoring and control, cleaning of solar panels, and protection from overheating and rain for panels.

Because of this, there is a need for a solar tracking system that is especially made for agricultural applications and includes characteristics that can increase the effectiveness and dependability of solar panels in far-flung agricultural areas.[7] These issues are intended to be addressed, and a sustainable and dependable energy solution for agriculture in remote places is provided by the dual-axis solar tracking system for agricultural using GSM technology that is described in this research article.

IV. OBJECTIVES

This research paper's major goal is to create a dual-axis solar tracking system for agricultural use that uses GSM technology and has characteristics tailored for agricultural uses.[8] The technology is intended to increase the effectiveness and dependability of solar panels in rural agricultural settings where it may not be practical to do routine maintenance and monitoring.

The ensuing specific goals will be followed in order to fulfil this goal:

1. To create a dual-axis solar tracking system with functions like humidity and temperature detection,

panel protection, energy production and utilisation, and backup plans.

2. Adding GSM technology to the system to allow for remote system monitoring and control.

3. To assess the system's performance in terms of energy generation, effectiveness, and dependability.

4. To assess the usefulness of the created system for agricultural applications by comparing its performance to that of current solar tracking systems.

5. To offer suggestions for future study and advancements in the field of solar tracking devices for agricultural uses.

The accomplishment of these goals will help to create dependable and sustainable energy options for agricultural in remote locations, with potential advantages for improved productivity, cost savings, and reduced environmental impact.

V. METHODOLOGY

The following phases will make up the process for creating a dual-axis solar tracking system for agricultural use using GSM technology:

1. Identification of needs: Based on the available literature and discussions with industry professionals, the first step is to determine the needs for a solar tracking system in agricultural applications.

2. The next step is to design and create the solar tracking system, taking the given criteria into account. A dual-axis tracking mechanism, temperature and humidity sensors, panel protection devices, water cooling systems, lithium-ion battery storage, and GSM technology for remote monitoring and control will all be included in the system.

3. Implementation: In cooperation with nearby farmers or agricultural professionals, the created system will be put into practise and tested in a field environment. On a designated piece of property, the system will be placed, and its operation will be checked periodically.

4. Data collection and analysis: Information on energy output, reliability, and efficiency will be gathered through the solar tracking system. In order to assess how well the system is performing, the data will be analysed using the relevant statistical techniques.

5. Comparative analysis with Current Devices: Taking into account a number of predetermined parameters, including value for money, productivity, dependability, and relatively simple upkeep, the operation of the proposed system is going to be contrasted with that of conventional solar energy tracking systems for use in agriculture.

6. Monitoring of efficiency: Using the information gathered, examination, and evaluation against similar systems, the constructed system's efficiency can be assessed. The assessment will shed light on the mechanism's potential advantages for farming in faraway regions, like improved productivity, lower expenses, and little negative ecological impact.

7. Suggestions for Enhancement: In light of the findings of the assessment, suggestions for additional refinements and future studies in the field of solar tracking systems for use in farming shall be given.

In order to design and evaluate a solar tracking system with dual axes for utilisation in farmland that uses GSM technology for communication, the technique described here provides an organised method. The goal is to offer dependable and environmentally friendly power sources for agricultural in distant places.

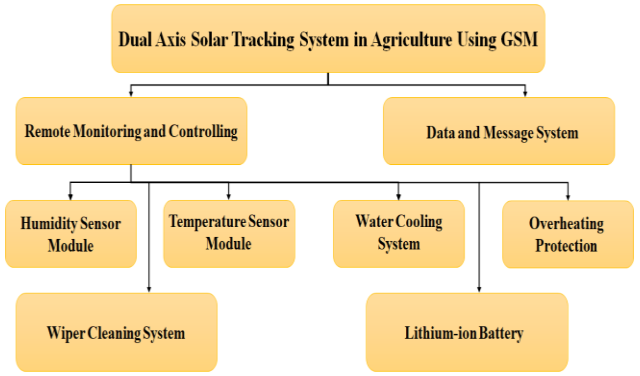

Fig. 5.1 Features

VI. WORKING PRINCIPLE

The dual-axis solar tracking system for agricultural land that uses GSM technology works upon the simple foundation of following the trajectory of the sun in order to maximise the output of solar cells.[9] In order to maximise the quantity of sunlight which could be captured, the entire structure is built to follow the sun's motion in the vertical as well as horizontal planes.

In order to assess the present weather circumstances and modify the position of the photovoltaic cells correspondingly, the structure employs both temperature and humidity sensors.[10] The system will engage the water cooling processes if the ambient temperature rises excessively in order to protect the panel. The vertical shaft of the servo motor swings downwards to shield the photovoltaic cells from harm in case of rain.

The device has a cleansing function as well to keep the solar cells clear of dust and grime that might lower their effectiveness.[11] A wiper that sweeps over the screen's area and removes any dirt serves as its cleaning device.

A battery made of lithium-ion stores the electrical energy generated by the sunlight from the solar panels and may be utilised for powering a variety of tools and machines on the farm.[12] To prevent wasteful use of energy and to guarantee that each device can utilise the energy at their disposal, the entire system has a fixed limit for usage of energy.

The framework also has a number of safeguards in place to guard against damage to elements.[13] The system will immediately shut down and notify its user that repair and inspection are required if any part is broken. It also contains an overheating prevention feature which shuts it down while it engages its cooling process to guard against harm.

The system's implementation of GSM technology also enables distant control and observation, allowing individuals to keep tabs on the system's functioning and get reports on the health of their farmland. In order to arrive at wise choices regarding utilisation of energy along with long-term viability, consumers can additionally get statistics on energy generation and utilisation.

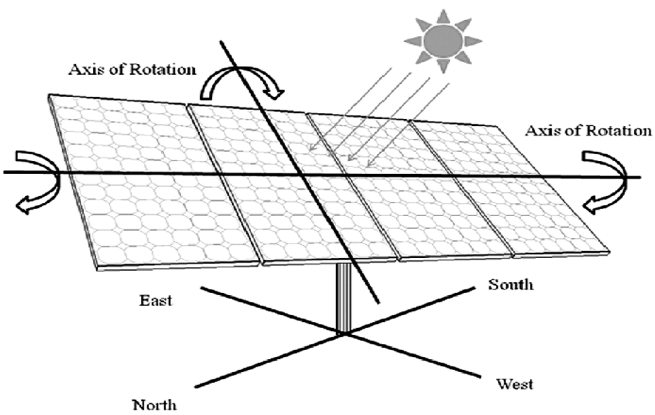

Fig 6.1 Mechanism of dual-axis tracker[14]

HARDWARE REQUIREMENTS:

For the dual-axis solar tracking system employing GSM technology to work effectively, numerous physical components are needed. These consist of:

1. Solar panels: The system's main element that transforms sunlight into electric power.[15] Depending on how much energy is necessary to run the equipment and gadgets on the farm, the quantity of photovoltaic cells required will vary.

2. Servo motors: In order to track the motion of sunlight, these types of motors are employed for shifting the solar cells in the vertical as well as horizontal planes.

3. Capacitive humidity sensor: This device measures the ambient levels of humidity, that may influence how well the solar cells work.

4. Thermocouple temperature sensor: This component measures the temperature of the solar panels and their surroundings.

5. Water cooling system: This is used to keep the photovoltaic cells cooler if they become excessively hot.

6. Actuator installed on a water line valve: This controls the circulation of water to the water's cooling unit.

7. Wiper: This is employed to maintain the solar panels' optimal performance by cleaning them.

8. Lithium-ion battery: A lithium-ion battery is utilised for conserving the electricity generated by solar cells.

9. Fans and heat sinks: These are employed to keep the machinery cool in a situation when it overheats.

10. Microcontroller: This is utilised to manage and keep an eye on the system's parts and operations.

11. GSM module: This enables the entire system to be monitored and controlled remotely.

12. LCD display: This shows data on the functionality and state of the machine.

13. Protective casing: This is used to guard against harm to the framework's parts.

14. Wiring and connectors: These are employed to link all of the system's components collectively.

The precise hardware specifications will be determined by the system's overall dimensions, complexity, and power requirements for the agricultural sector.

SOFTWARE REQUIREMENT:

For the dual-axis solar tracking system employing GSM technology to work properly, it needs a number of software elements as well. These consist of:

1. Microcontroller programming: The system's microchip must be designed to manage and operate the system's numerous parts, such as the servo motors, sensors, and cooling system.

2. GSM module programming: The equipment's GSM module must be configured to allow for distant control and tracking via phone calling or texts.

3. User interface: To allow users to observe and manage the system from a distance, the system needs a user interface. It might be a straightforward online dashboard or a specific smartphone application.

4. Data storage and analysis: To track the system's efficiency and spot possible problems, the equipment must store and analyse the information obtained from the sensors, such as temperature and humidity measurements.

5. Cloud computing: The system may be connected to online computing resources, enabling virtual analysis of information and preservation, as well as having access to sophisticated analytics instruments and techniques for machine learning.

6. Fault detection and diagnosis: The system may be fitted with software algorithms that attempt to identify and assess system defects, such as failures of parts or overheating.

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7. Energy management: The system may come with algorithms that use software to control usage of energy and guarantee that the panel's generated energy gets utilised responsibly and effectively.

The precise need for software shall be determined by the system's scope and difficulty, and also by the demands of its users and the land used for agriculture.

VII. RESULT

In order to increase the effectiveness of photovoltaic cells utilised for farming and permit centralised control and monitoring of the entire system, a dual-axis solar energy tracking system for agricultural employing GSM technology has been developed. The system has sensors for temperature and humidity measurement, a wiper for cleaning solar panels, a water-based cooling mechanism and a vertical-axis servo drive for weather protection, and a battery made of lithium-ion for storing energy from the sun.

The equipment can also be completely managed and operated via a GSM module, allowing consumers to get alerts about the state of the network and any scheduled service that needs to be done. In the event of a breakdown, the system also has an alternative method to change the photovoltaic panels' inclination.

Sensors, servomotors, a microprocessor, a GSM module, and a lithium-ion battery are among the component's necessary to operate the entire system.[16] Coding for GSM modules, microcontrollers, user interfaces, internet-based computing, detection of faults and diagnostics, and handling energy are among software development needs.

The technology enables automated control and monitoring of the system and is anticipated to increase the effectiveness of sunlight generated by solar panels utilised for agriculture and reduce power expenses. The system may also be modified to meet the unique requirements of various farm customers and areas.

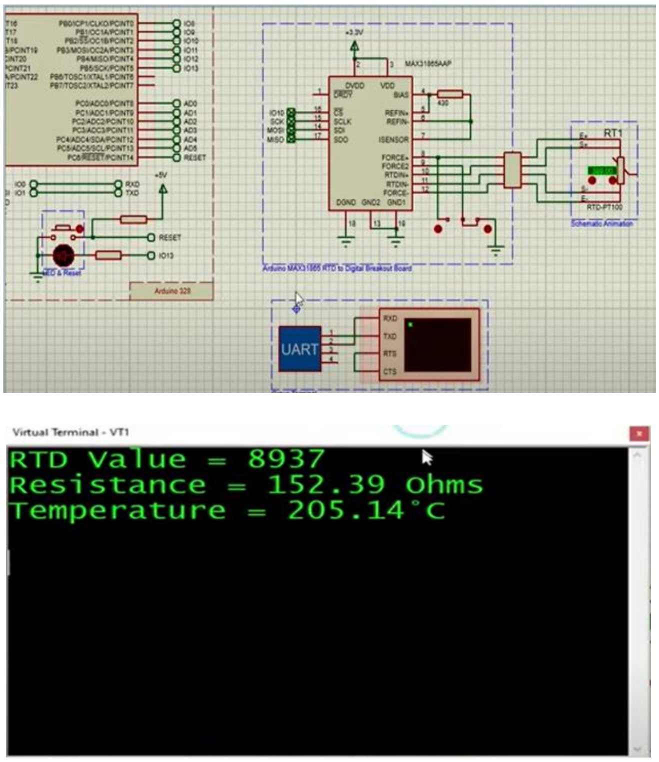

Fig. 7.1 Simulation for temperature sensing and its output

VIII. DISCUSSION

A possible method to increase the effectiveness of photovoltaic cells for agricultural purposes and enabling distant observing and management of the entire setup is the dual-axis sunlight tracking system designed for use in the agricultural sector.[17] The entire system functions, involve employing sensors to measure both humidity and temperature, a windscreen wiper for wiping down the photovoltaic cells, and a water-based cooling device and a vertical-axis servo mechanism for safeguarding the panels from excessive heat and rain, are intended to improve the efficiency of the photovoltaic panels and increase their longevity.

The device's lithium-ion battery storage capacity and energy administration capabilities, which include the capacity to establish restrictions on use of energy, can assist in reducing energy expenses in farming.[18] Clients may get actual time information as well as notifications regarding the condition of the system because of the system's remote monitoring and control capabilities utilising a GSM module and cloud-based computing, which enables rapid reaction to service needs or failures.

However, the setup of the system necessitates thorough investigation of the needed software and hardware, along with the distinctive needs for various farmland and customers.[19] Providing a hybrid system with less capabilities and lower costs can help consumers who find the expense of the system a barrier.

To summarize, a solar tracking system with dual axes for farming which uses GSM technology holds the ability to increase photovoltaic effectiveness, reduce utility bills, and allow for automated monitoring and control.[20] The entire system's software and hardware parts need to be optimised, and more study is necessary to determine the system's financial viability and scaling in other farming situations.

IX. CONCLUSION

Utilising GSM technology, a dual-axis solar tracker in farmland has been developed, which provides a viable way to increase the efficiency of solar panel efficiency, save money on electricity, and allow distant control and surveillance. The users can gain from the functions of the system, such as sensors that monitor humidity and temperature, cleanup processes, including protective methods. To guarantee the system's best efficiency and financial viability, attention should be paid to the appropriate software and hardware in addition to the distinctive demands of various farming sectors and clients. For consumers with less demanding needs, the adoption of a hybrid system can potentially offer a more affordable option. In general, more study is needed to optimise each component of the system and determine the technique's financial sustainability and scaling in various farming contexts.

X. ACKNOWLEDGMENT

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