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Innovative Development of Automatic Solar Motion Control System

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Abstract: The purpose of this study is to create a two-axis solar tracking system by separating the movements of X and Y axis in a fixed pole structure. The system is developed using two servo motors controlled by microcontroller. This project also utilizes LDR sensors for tracking the intensity of light coming from the sun. An array of LDR sensors will be designated to measure the intensity of sunlight in both X and Y direction comparing the measurement to move the servo motors to position where greatest intensity was measured. The focus is to maximize the collection of solar energy by positioning the solar panels where the ray of sunlight is optimized. The projet involves evaluating the system's efficiency in collecting energy.

Keywords: Solar cell, Tracking system, Two-Axis

I. INTRODUCTION

In the face of escalating global energy demands and the imperative shift towards sustainable practices, renewable energy sources have emerged as pivotal solutions. Among these, solar energy stands out as a prominent contender, offering abundant and clean power potential. As countries strive to meet growing electricity needs while mitigating environmental impacts, harnessing the full capacity of solar energy becomes a critical pursuit In the context of Thailand, the nation's energy landscape has witnessed a substantial surge in electricity demand, currently peaking at 37,312 megawatts with an annual growth rate of 8.7%. Recognizing the significance of diversifying energy sources, Thailand has embarked on an ambitious trajectory to harness solar power. This transition is underscored by a comprehensive understanding of the multifaceted factors influencing energy consumption across sectors the industrial, business, and household sectors collectively constitute the primary consumers of electricity, each contributing to the intricate tapestry of Thailand's energy consumption landscape. Notably, the household sector, with its 8.8% annual increase, has become a focal point for energy planners and policymakers to address this mounting demand, strategic initiatives have been introduced, including the implementation of solar energy projects designed to capitalize on Thailand's geographical advantage of consistent sunlight exposure However, the inherent challenges of solar energy production, such as the sun's dynamic movement and fixed panel orientation, pose efficiency constraints. To overcome these limitations, this thesis explores the development and implementation of an Automated Solar Tracking System. This innovative technology aims to optimize solar panel positioning dynamically, ensuring maximum exposure to sunlight throughout the day. By doing so, it aspires to elevate the efficiency and reliability of solar energy capture, addressing intermittent energy accumulation associated with stationary solar panels The significance of this research extends beyond technological innovation; it aligns with Thailand's commitment to sustainable energy practices, contributing to the nation's efforts to reduce reliance on traditional power sources. As the world navigates towards a more sustainable energy future, this thesis endeavors to make a meaningful contribution by advancing the state-of-the-art in solar energy technology, particularly within the residential sector. Through the exploration of an automated solar tracking system, the research seeks to unlock new dimensions of efficiency, affordability, and accessibility in solar power, fostering a brighter and more sustainable future for Thailand and beyond.

II. METHODS

Delves into the development of an innovative automated solar tracking system employing the Arduino Mega 2560 microcontroller. Recognized for its versatile operating system, the Arduino Mega 2560 is programmed in C and C++, enabling precise control over various connected devices. The designed system utilizes Light-Dependent Resistors (LDRs) and solar cell sensors strategically positioned to detect sunlight. As sunlight interacts with the LDRs and solar cell sensors, signals are transmitted as inputs to the Arduino board for voltage drop analysis. This analysis triggers the Relay Module, commanding motors to rotate along the X and Y axes. As the motors rotate, attached Variable Resistors measure the degree of rotation, causing voltage drops at different positions. This voltage drop data is crucial for programming the system to cease motor rotation upon reaching predefined angles, optimizing solar panel alignment

2.1 Hardware Design

The creation of a mechanical model for an automatic solar tracking control system is attainable. The simulated response of the model will unveil information regarding the behavior of the automatic solar tracking control system, encompassing the outcomes of solar energy accumulation between the light-dependent resistor (LDR) and the solar cell sensor.

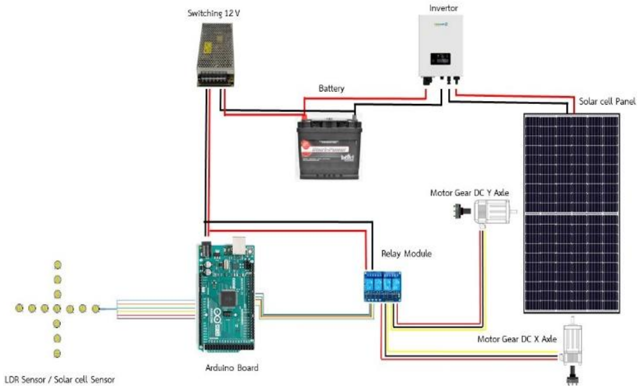

Fig 1 Design and Implement of Automatic Tracking System

The feature of the system includes the following

1. Board Arduino Mega
2. Sensor LDR
3. Sensor Solar cell
4. Solar Cell
5. Relay Module
6. Variable Resistor
7. Motor gear DC
8. Invertor
9. Battery
10. Switching

Fig 2 Structure Automatic Solar Tracking System

The circuit is designed to operate as follows: when sunlight hits the LDR and solar cell sensor, the light-receiving sensors send signals as inputs to the Arduino board for minimal voltage analysis. The output signals then command the relay module to control the rotation of the motors along the X and Y axes. As the motors rotate, the variable resistor, attached to the rotating sensors, follows suit. This rotation induces voltage drops at different positions. Consequently, the system can be programmed to stop motor rotation when it reaches predefined positions. This design allows precise adjustment of the solar panel orientation according to sunlight movement, optimizing energy harvesting

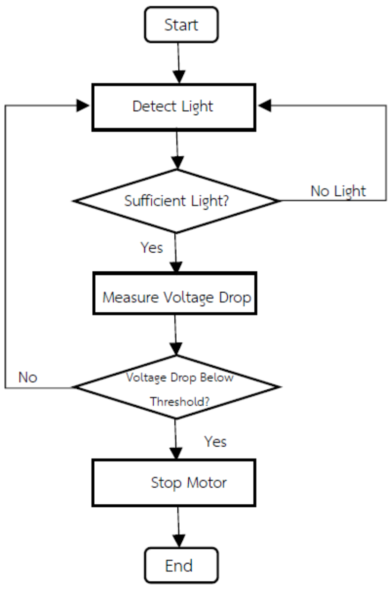

Fig 3 Flow chart of Process Method

2.2 Control System Design

2.2.1 Conceptual Design

The main concern in utilizing the tool lies in the precision, particularly with regards to the speed and stability of the equipment. This is due to constraints in both space and time. Consequently, every system tends to compromise during operation. After specifying the design objectives for the solar tracking control system, the actual design process can commence. The challenge lies in finding a balance between the trade-offs inherent in these tools.

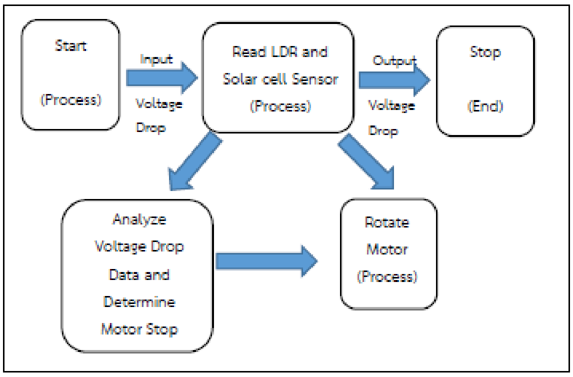

Fig 4The design concept

2.2.2 Arduino Mega 2560

The Arduino Mega 2560 board, designed specifically for various applications, features a sufficient number of Analog ports suitable for interfacing with sensors. This is advantageous because analog sensors provide several benefits, including cost-effectiveness, resource efficiency, and high precision. The board serves as a device to receive signals from light sensors, which generate analog signals. This characteristic of analog signals offers advantages such as cost-effectiveness, resource efficiency, and high precision. The board is employed as a signal receiver from light sensors that measure sunlight intensity. It allows programming commands for controlling the movement of solar panels automatically based on predefined conditions.

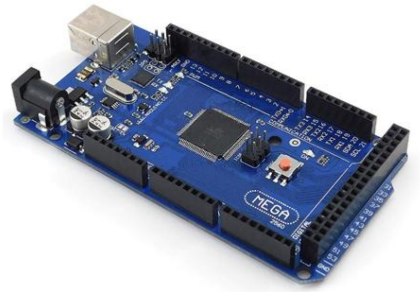

Fig 5 Arduino Mega 2560

2.2.3 Sensor LDR

The Light Dependent Resistor (LDR) serves as a light-independent resistor in this experiment. It is mounted on a semi-circular plastic sheet to capture light from the sun, receiving light in both the X and Y axes. The LDR produces an analog signal. When exposed to bright light, the current passing through the LDR is high due to its low resistance. Conversely, in the absence of light, the LDR has a high resistance, resulting in low current flow. This forms a voltage divider circuit by connecting it in series with a resistor. The signal obtained is then sent to the Arduino Mega board to control the servo motor's movement.

Fig 6 Sensor LDR

2.2.4 Sensor Solar cell

The 3-volt solar cell panel sensor captures light to generate electricity, comparing it with the LDR sensor. Both sensors, connected to a voltage divider circuit with a resistor, send signals to the Arduino Mega. This controls the servo motor, aligning the solar cell panel for optimal energy absorption. The solar cell panel operates efficiently in varying light conditions, not limited to direct sunlight

Fig 7 Sensor Solar cell

2.2.5 Solar cell Panel

A solar cell panel, designed for harnessing energy from sunlight, is an electronic device made of semiconductor materials. It has the capability to convert solar energy that falls onto its surface into direct current (DC) electricity. This allows it to power electrical devices. The solar cell panel moves in the direction of the sun's apparent motion, controlled by a servo motor. In summary, the solar cell panel utilizes sunlight to generate electrical energy, and its orientation is adjusted by a servo motor.

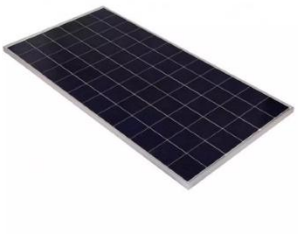

Fig 8 Solar cell panel

2.2.6 Relay Module

A relay module controls electrical loads, supporting both DC and AC. It operates with TTL logic signals in an Active Low configuration, and isolation is ensured through an opt coupler. The module can handle AC 250V/10A and DC 30V/10A loads. It includes an LED for relay status indication, making it suitable for applications like PLC control, smart homes, and industrial settings. Its compatibility with Arduino boards and other electronics adds versatility to its use. In essence, the relay module is a flexible component for managing electrical loads in various applications.

Fig 9 Relay Module

2.2.7 Variable Resistor

The variable resistor sensor rotates along with the motor, resulting in varying voltage drops at different positions. This allows programming to stop the relay module when it reaches the desired position. In summary, by associating the motor's rotation with the variable resistor sensor, the program can instruct the relay module to block, enabling the motor to stop at the intended position.

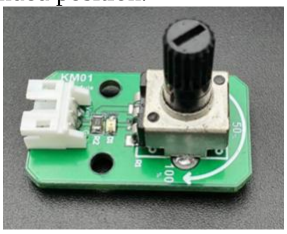

Fig 10 Variable Resistor

2.2.8 Motor Gear DC

The DC worm gear motor features a metal worm gear inside that ensures durability in operation. With high torque and low speed, this motor is suitable for various applications. It is a direct current (DC) motor with both high torque and variable speed capabilities. It receives electrical power from the relay module. In summary, the motor is a durable DC worm gear type with high torque, low speed, and the ability to receive electrical power from the relay module.

Fig 11 Motor Gear DC

2.2.9 The positioning of the LDR and solar cells

The positioning of LDR and solar cells in a curved arrangement, forming a semi-circle, is designed to achieve maximum light efficiency throughout the day.

The formula for calculating the position of the LDR in the desired direction can be expressed as follows:
Angle of Rotation=Initial Angle+(Position Number−1) ×Angular Separation

Where:
- Angle of Rotation is the angle of rotation of the LDR in the desired direction.
- Initial Angle is the initial angle where the first LDR is located.
- Position Number is the position of the LDR in the sequence
- Angular Separation is the angular separation between adjacent LDRs

The formula for calculating the position of Sensor2 with an Initial Angle of 45.0 degrees and an Angular Separation of 22.5 degrees is: Angle of Rotation for Sensor2=45.0+(2−1)×22.5=67.5 degrees

The answer is 67.5 degrees, indicating that Sensor2 should be placed at a position rotated by 67.5 degrees from the specified starting position at 45.0 degrees.

2.2.10 Software Development

The Internet of Things (IoT) refers to the concept of connecting everything to the Internet. This allows humans to use the Internet to control the operation of various devices, such as turning on and off electrical appliances, cars, and mobile phones. IoT technology serves as a communication tool that connects agricultural equipment, residential buildings, and everyday appliances to the Internet network, among other things

In addition, the system incorporates solar cells that move according to sunlight. The automated control system enables efficient energy production by aligning the solar panels with the optimal sunlight direction throughout the day.

2.2.11 C Language

The C programming language is a computer program developed to efficiently write programs and is globally recognized. Here's an example of a C program that prints "Hello, World!"—a common starting point for learning C:

```c
#include <stdio.h>

int main() {
    // This is the main function that will be called when the program r
    printf("Hello, World!\n");  // Display the message "Hello, World!"
    return 0;  // Return 0 to indicate that the program has executed su
}
```

Fig 12 Program C Language

2.2.12 C++ Language

C++ is an extension of the C programming language with additional features, including object-oriented programming. Here's a simple example of a C++ program that prints "Hello, World!":

```cpp
#include <iostream>

int main() {
    // This is the main function that will be called when the program r
    std::cout << "Hello, World!" << std::endl;  // Display the message
    return 0;  // Return 0 to indicate that the program has executed su
}
```

Fig 13 Program C++ Language

2.2.13 Differences between C language and C++ language

C++ surpasses C in various aspects, being an object-oriented programming (OOP) language that extends the capabilities of C. Derived from C, C++ introduces OOP features, providing flexibility and a modular structure, facilitating easier code organization and reuse. It enhances security, supports polymorphism, encapsulation, and inheritance, enabling efficient software development C++ is renowned for its adaptability, making it suitable for large and complex software projects. Its incorporation of OOP principles allows developers to create modular and scalable code, enhancing maintainability. Additionally, C++ prioritizes performance and efficiency, making it a preferred choice for programmers seeking versatility and robustness in software development.

```cpp
// Include the Servo library for motor control
#include <Servo.h>

// Define the number of sensors in X and Y axes
const int numSensorsX = 6;
const int numSensorsY = 6;

// Define the analog pins for solar cell sensors in X and Y axes
const int solarCellPinsX[numSensorsX] = {A0, A1, A2, A3, A4, A5};
const int solarCellPinsY[numSensorsY] = {A6, A7, A8, A9, A10, A11};

// Define the relay module pins for motor control
const int relayXPin = 2; // Replace with the actual pin connected to th
const int relayYPin = 3; // Replace with the actual pin connected to th

// Create servo objects for X and Y axes
Servo servoX;
Servo servoY;
```

Fig 14 The C programming language is used to control the motion of a two-axis solar tracker

III. EXPERIMENTAL AND RESULTS

Present data in a clear and organized manner. Use tables, graphs, charts, and figures to illustrate the data collected during experiments. This could include measurements of energy output, efficiency percentages, angles of incidence, and any other relevant parameters.

Comparison with Existing Systems: Compare the performance of your omni-directional solar collector with existing solar collectors that capture energy from a specific direction. Highlight the strengths and weaknesses of design in comparison to conventional designs

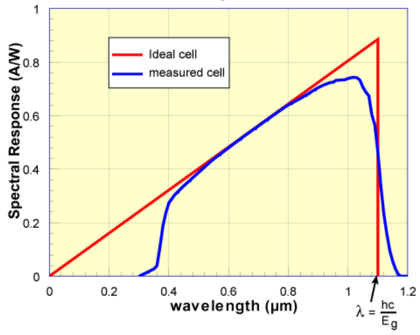

Fig 15 light response grap

Efficiency Analysis: Analyze the efficiency of solar collector. Discuss how it performed under different conditions, such as variations in solar intensity, time of day, and geographical location. Explain how Omni-directional approach improved efficiency compared to single-directional collectors.

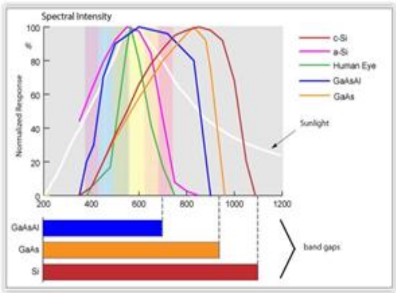

Fig 16 Radiated Energy graph

Tracking System Evaluation: if collector includes a tracking system, evaluate its effectiveness. Discuss how well it managed to follow the sun's movement and how this affected energy capture efficiency.

Discussion of Design Innovation: Elaborate on the innovative aspects of design. Explain how Omni-directional collector addresses common challenges faced by traditional solar collectors, such as limited energy capture during non-optimal angles of incidence.

Solar panel size (Watts per square meter)	Current (Amps)
100	0.5 - 1.0
200	1.0 – 2.0
300	1.5 – 3.0
400	2.0 – 4.0
500	2.5 – 5.0

Fig 17Solar Radiation Thailand

Practical Applications: Discuss potential real-world applications of innovative solar collector. Consider its usability in various settings, such as residential, commercial, or industrial installations. Highlight any specific industries or scenarios where design could excel.

Limitations and Future Work: Address any limitations of your study or design. This could include factors that might affect its performance under certain conditions. Propose potential improvements or modifications that could be explored in future research.

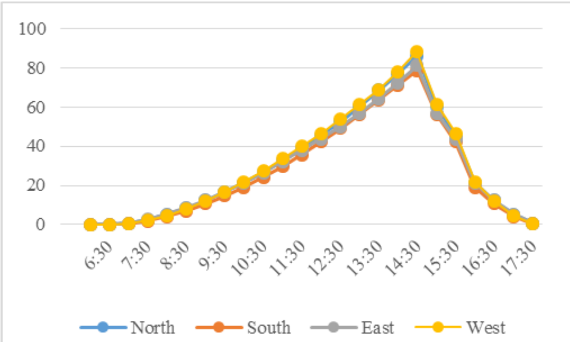

Fig 18 Amount of electric current from each direction

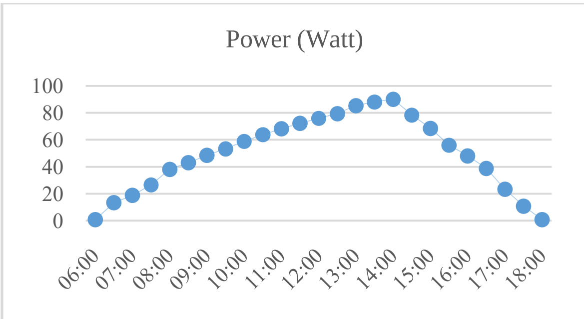

Fig 19 Automatic Two-Axis Solar Tracking System

IV. CONCLUSIONS

Summarize the principal discoveries of the study and underscore the importance of the results within the realm of solar energy harvesting, as well as the potential for widespread utilization of omni-directional collectors. The findings indicate that a mobile solar power generation system, which aligns with the sun's movement, outperforms static solar panels. The rotating system exhibits a higher efficiency of 15.25 percent compared to stationary solar panels.

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REFERENCES

[1]. Government Complex Commemorating His Majesty the King's 80th Birthday Anniversary 5 December 2007 (2022) Remarks, 2 March 2022, http://www. Governmentcomplex.com/detail.php?p=574

[2]. Advance electronic Training Center (2022). Servo Motor. June 17, 2022, from http://www. advanceelectronic.com/blog/detail/86/th/ (Servo-Motor).html

[3]. Technology Transfer and Propagation Division (2019). Electricity from solar energy15 March 2022, https://webkc.dede.go.th/testmax/sites/default/files/guide%20electricityfromsolar energy%20BLN_0.pdf

[4]. Energy Reform Co., Ltd. (2022). Does the temperature of solar panels affect the efficiency of electricity generation? 15 March 2022, https://energyreform-solar.com/2019/08/14/temperature of Solar panels/.

[5]. HaschaiSittirak (2010) Photosensitive resistor LDR http://sites.google.com/sites/magnelectronic

[6]. Neonics Co., Ltd. (2022). Temperature sensor 18 March 2022, https://www.neonics.co.th/thermometers/temper

[7]. R. Antonio-Mendez, J. Alejo, and O. Penaloza-Mej ˜ ´ıa, “Fuzzy logic control on fpga for solar tracking system,” vol. 25, pp. 11–21, 08 2015. [8] Y. Away and M. Ikhsan, “Dual-axis sun tracker sensor based on tetra hedron geometry,” Automation in Construction, vol. 73, pp. 175 – 183, 2017.

[8]. E. Kiyak and G. Gol, “A comparison of fuzzy logic and pid controller for a single-axis solar tracking system,” Renewables: Wind, Water, and Solar, vol. 3, p. 7, Feb 2016.

[9]. Smys, S., and G. Ranganathan. "Robot assisted sensing, control and manufacture in automobile industry." J ISMAC 1, no. 03 (2019): 180-187

[10]. Manoharan, Samuel, and NarainPonraj. "Precision improvement and delay reduction in surgical telerobotics." Journal of Artificial Intelligence 1, no. 01 (2019): 28-36.

[11]. S. Deepthi, A. Ponni, R. Ranjitha, and R. Dhanabal, “Comparison of Efficiencies of Single-Axis Tracking System and Dual-Axis Tracking System with Fixed Mount,” vol. 2, no. 2, pp. 425–430, 2013.