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Sun Tracking Solar Panel

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ABSTRACT:

Sun tracking solar panel systems, focusing on their design, functionality, and benefits. Sun tracking systems optimize solar panel orientation to maximize energy generation by continuously adjusting panel angles to follow the sun's path throughout the day. The abstract outlines the key components of sun tracking systems, including sensors, actuators, and control algorithms, highlighting their role in achieving high efficiency and energy output. Additionally, it discusses the advantages of sun tracking systems over fixed-tilt panels, such as increased energy production and improved return on investment. The abstract concludes with a summary of current research trends and future directions in the field of sun tracking solar panel technology.The design considerations encompass various factors such as accuracy, reliability, and cost-effectiveness. Integration of efficient algorithms for sun tracking, along with robust hardware components, ensures precise alignment of the solar panels with the sun's position throughout the day. Additionally, the system incorporates safety features to mitigate potential hazards and protect the components from adverse weather conditions.The increasing demand for sustainable energy sources has led to a surge in the adoption of solar power as a reliable alternative to conventional energy. However, a key challenge in solar energy harvesting is the efficient utilization of available sunlight, given the fixed orientation of conventional solar panels. Solar panels generally perform best when they are directly aligned with the sun, but due to the Earth's rotation, a fixed panel loses efficiency as the sun's position in the sky changes throughout the day. This problem can be addressed with a sun-tracking solar panel, which is designed to follow the sun's movement, thereby maximizing the solar energy captured.

Introduction

There are two main types of sun-tracking systems: single-axis and dual-axis trackers. Single-axis systems follow the sun's movement from east to west, while dual-axis trackers also adjust for changes in the sun's elevation, providing a more precise alignment. The key advantage of sun-tracking solar panels is their ability to increase energy output by 20-30%, making them a viable solution for maximizing solar power efficiency, especially in large-scale installations or areas with high solar potential.

In addition to enhancing energy capture, sun-tracking systems also make solar power more cost-effective over time by reducing the number of panels needed to achieve the same energy output as fixed systems. However, these benefits come with challenges such as higher initial costs and more complex maintenance requirements due to the mechanical components involved. Nevertheless, as solar technology continues to evolve, sun-tracking solar panels represent a critical advancement in the pursuit of clean, renewable energy.

When heat is the source of every creation, Sun produces the biggest ever energy in this solar system to produce and transcend life from one organism to the other. In this response, the project called "Automatic Solar Tracking System" serves the purpose of utilizing the maximum amount of energy taken from the Sun and to convert such energy into some other production. The basic endeavour is crooned to scoop out from this project in making this system an economically convenient subject, accessibility of which is easy and functioning of which is optimum in the end.

In the wake of technological advancement when the pace of time is at its best to pass by, this system is a time worthy production, produced to create the best of its kind. In a stretch, it could be signified that this project which is an extension of solar energy, is a renewable source of energy, never-ending phenomena. It's only 10 to 20 per cent of the solar cells that are being used commercially out of which the best potential of the cells gets reflected and therefore scope for better use of the solar cells exist. In the world of pollution, this system is an eco-friendly alternative, hence a valuable asset. When the ocean of pollution is encumbering every corner of life, this system would be able to create As the world increasingly shifts towards renewable energy sources, harnessing solar power has emerged as a leading solution for sustainable energy. Traditional solar panels are typically fixed in position, limiting their efficiency as they can only capture sunlight from a specific angle. The Sun Tracking Solar Panel Project addresses this limitation by incorporating technology that enables solar panels to follow the sun's trajectory throughout the day.

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2- SOFTWARE REQUIREMENTS

What is Aurdino IDE : The Arduino IDE (Integrated Development Environment) is a software application used to write, compile, and upload code to Arduino boards. It is a key component for developing projects that involve Arduino hardware. In terms of software requirements, the Arduino IDE typically includes the following:

Software Requirements for Arduino IDE:

Operating Systems:

Windows (Windows 7 or newer) macOS (OS X 10.10 or newer)

Linux (various distributions like Ubuntu, Fedora)

Java Runtime:

The Arduino IDE is built on Java, so it requires a Java Runtime Environment (JRE), but recent versions come bundled with the necessary runtime, so it's not something you need to install separately.

Processor:

32-bit or 64-bit processor (depends on the operating system). USB Drivers:

Specific USB drivers may be needed to communicate with Arduino boards over a USB connection, such as the CH340 or FTDI drivers, depending on the type of Arduino board.

Dependencies (for some versions on Linux):

Java-based libraries, gcc-avr,avr-libc, and avrdude for compiling and uploading code.

Optional Software:

Git (for version control and downloading libraries).

Internet browser for downloading the IDE and libraries.

The Arduino IDE allows developers to write code in the Arduino programming language, which is based on C/C++. It also features a simple interface for beginners and advanced users alike

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Figure 2.1: Aurdino IDE (default layout)

4- SUN TRACKING SOALR PANEL BASED ON SOLAR NETWORK

In this chapter we will discuss about Existing/Proposed System, block diagram and methodology for Sun Tracking Solar Panel based on Solar network.

Existing System

Sun tracking solar panels are an innovative solution designed to enhance the efficiency of solar energy systems by adjusting their orientation to follow the sun's movement throughout the day. These systems are increasingly popular in both residential and commercial solar installations, owing to their potential to significantly increase energy output. Let’s explore the various types of existing sun tracking systems, their components, advantages, challenges, and future trends.

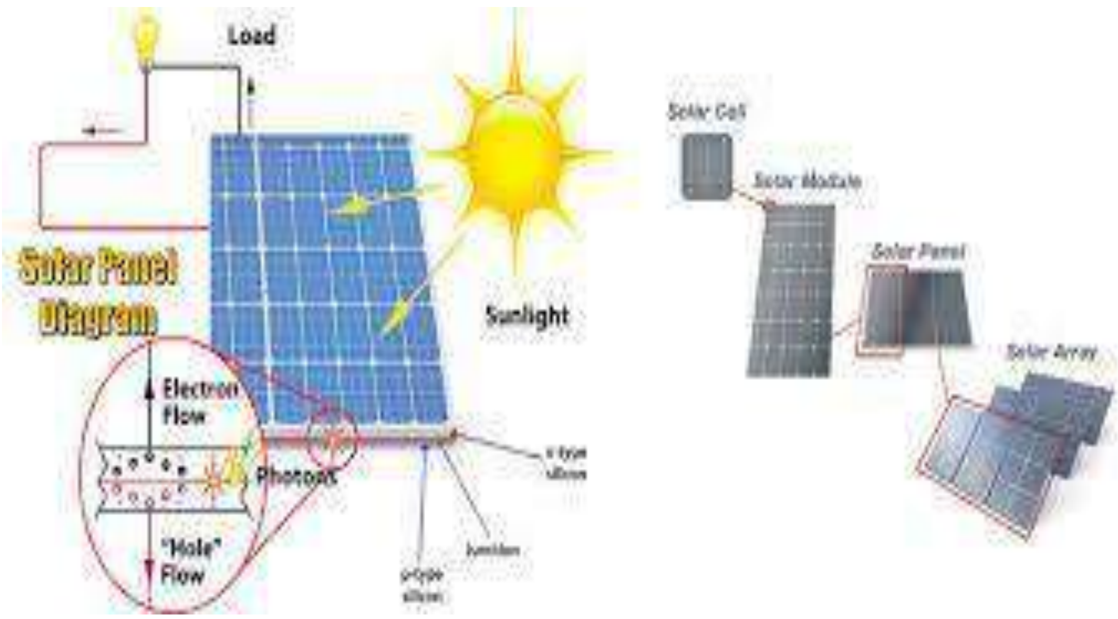

Figure : Solar Panel

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Sun-tracking systems operate based on the principle of keeping the solar panels oriented at an optimal angle relative to the sun. This is achieved through a combination of mechanical and electronic components, including light sensors, microcontrollers, motors, and structural mounts. The system continuously monitors the sun's position, either using light sensors or a pre-programmed astronomical calendar, and adjusts the panels accordingly to ensure they receive the maximum amount of direct sunlight.

Proposed System :

The sun tracking solar panel project aims to optimize solar energy capture by developing an efficient, cost-effective dual-axis tracking mechanism. This system will enhance the overall energy output of solar panels compared to fixed installations, making it ideal for residential, commercial, and utility-scale applications. The design integrates advanced sensors, microcontrollers, and real-time monitoring capabilities to ensure optimal alignment with the sun throughout the day and across seasons.

Photodiodes will be placed on the tracker to detect sunlight intensity. These sensors will guide the positioning of the panels, ensuring they are always oriented toward the sun.

Block Diagram

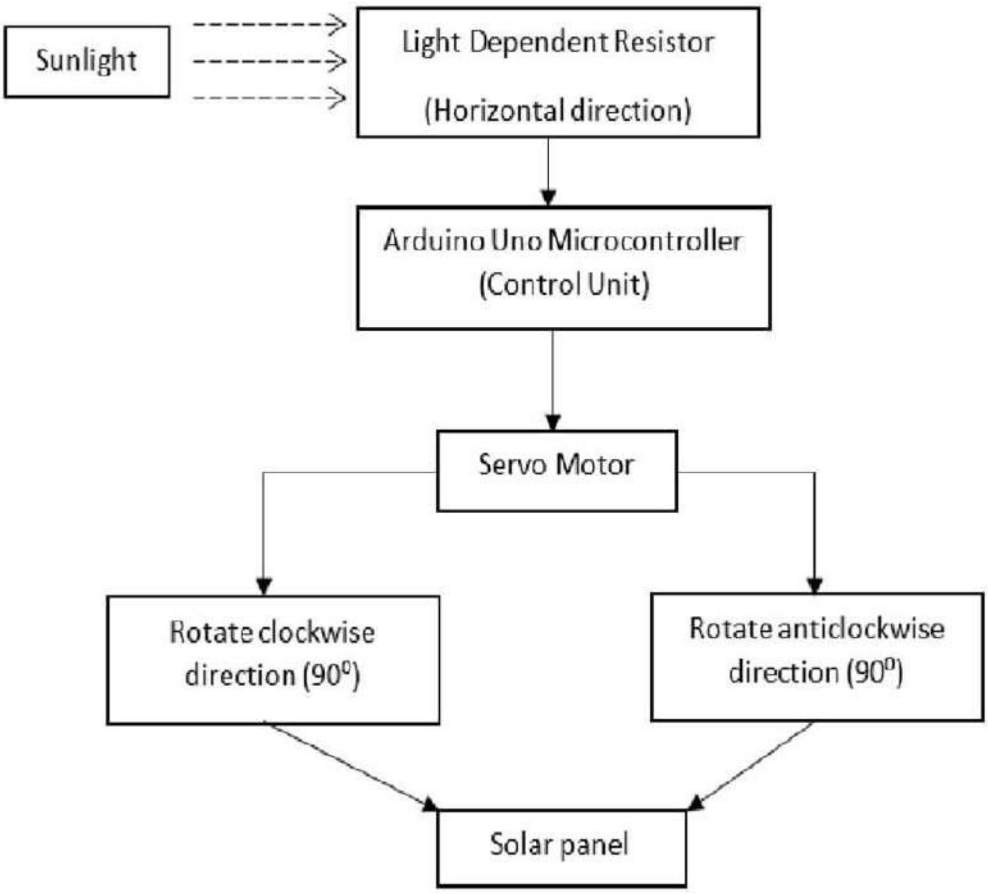


Figure 3.2: Block Diagram of Solar Panel

Methodology

Methodology for Sun tracking solar panel

Sun-tracking solar panels are designed to follow the sun's trajectory across the sky to maximize the energy capture and efficiency of the solar system. There are various methodologies and technologies used to achieve this, depending on the type of system, the desired precision, and the budget. Here's a detailed breakdown of common methodologies for sun-tracking solar panels:

Single-Axis Trackers:

Track the sun's movement from east to west. the axis of rotation is aligned north- south useful for areas with high direct sunlight.

Dual-Axis Trackers:

Track the sun's movement across both horizontal and vertical axes Can adjust to the sun's position throughout the year, making it ideal for locations with varying seasons.

Higher efficiency but also higher cost and complexity.

Time-Based Tracking:

Uses a pre-programmed algorithm based on the sun's position at specific times of the day and year. Relies on the astronomical position and does not require light sensors.Suitable for regions with predictable sunlight patterns.

Sensor-Based Tracking:

Utilizes light-dependent resistors (LDRs), photodiodes, or solar cells as sensors to detect the sun's position.The system adjusts the panel's position based on the relative light intensity sensed by different sensors. Real-time adjustment allows for high accuracy but can be impacted by cloud cover or obstructions.

Hybrid Tracking:

Combines both time-based and sensor-based tracking.Uses time-based tracking as a baseline and fine-tunes the position with real-time sensor input.Offers robustness against environmental variations and sensor errors.Higher efficiency but also higher cost and complexity.

Image Processing-Based Tracking:

Uses cameras and computer vision algorithms to detect the sun's position.More advanced and accurate but requires high computational power and maintenance.

Global Positioning System (GPS) Tracking:

Utilizes GPS data to determine the location of the solar panel and calculate the optimal angle based on time and location ideal for large-scale installations with moving platforms**.**

5-Advantages, Disadvantages and Applications

Advantages

1. Maximized Efficiency: They capture optimal sunlight throughout the day,
ensuring maximum power generation.

2. Longer Peak Performance: Sun-tracking panels maintain a near-constant angle to the
sun, extending the duration of peak power output.

3. Efficient Use of Space: They produce more energy per square meter, reducing the need
for additional panels and land.

Disadvantages

1. **Higher Initial and Maintenance Costs :**
   Sun-tracking systems have a higher initial investment due to the additional tracking mechanisms and complex installation requirements. Moreover, the moving parts require ongoing maintenance, which increases long-term operational costs compared to fixed solar panel systems.
2. **Increased Complexity and Risk of Mechanical**

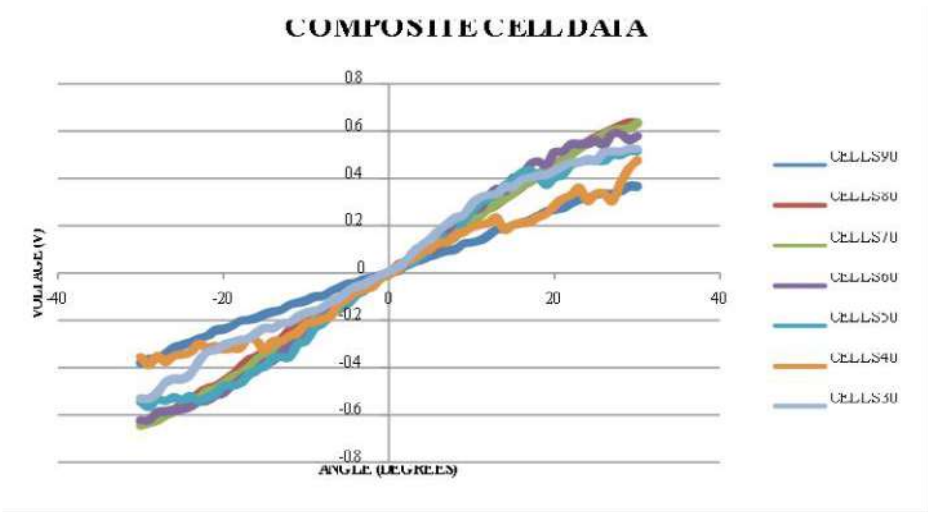
The added complexity of moving components introduces a higher risk of mechanical breakdowns or malfunctions, potentially causing downtime and reducing the overall reliability of the system. This is particularly problematic in harsh weather conditions or remote locations where repairs can be challenging.

3. **Limited Suitability for Certain Locations:**
   Sun-tracking systems are most effective in areas with high direct sunlight and spacious land. In regions with frequent overcast weather, limited space, or varying sunlight angles, the added benefits of tracking may not outweigh the costs and complexity, making them less practical for widespread use.

Applications :

1. **Utility-Scale Solar Power Plants :**
   Sun-tracking systems are widely used in large-scale solar farms to maximize energy production. Their ability to capture more sunlight helps power plants achieve higher outputs and increase their return on investment, making them ideal for large energy projects.
2. **Commercial and Industrial Solar Installations :**
   Commercial buildings, factories, and industrial facilities with large rooftops or open spaces can benefit from sun-tracking systems. The increased energy production can reduce energy costs, provide a reliable power source, and support sustainability goals.
3. **Agrivoltaics (Solar Farming) :**
   Sun-tracking solar panels are used in agricultural settings to create dual-use systems where both crop growth and energy generation occur simultaneously. Panels that track the sun cast less shade, allowing plants to receive adequate sunlight while still producing energy.

RESULTS



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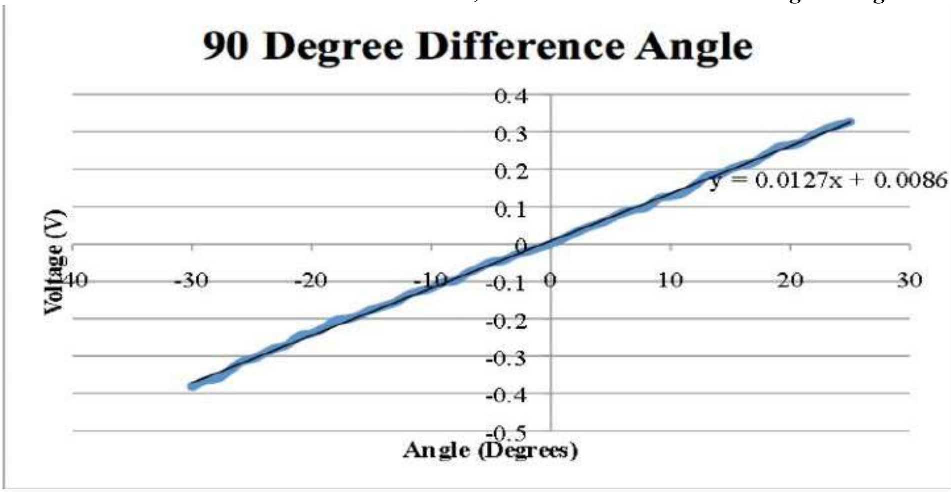
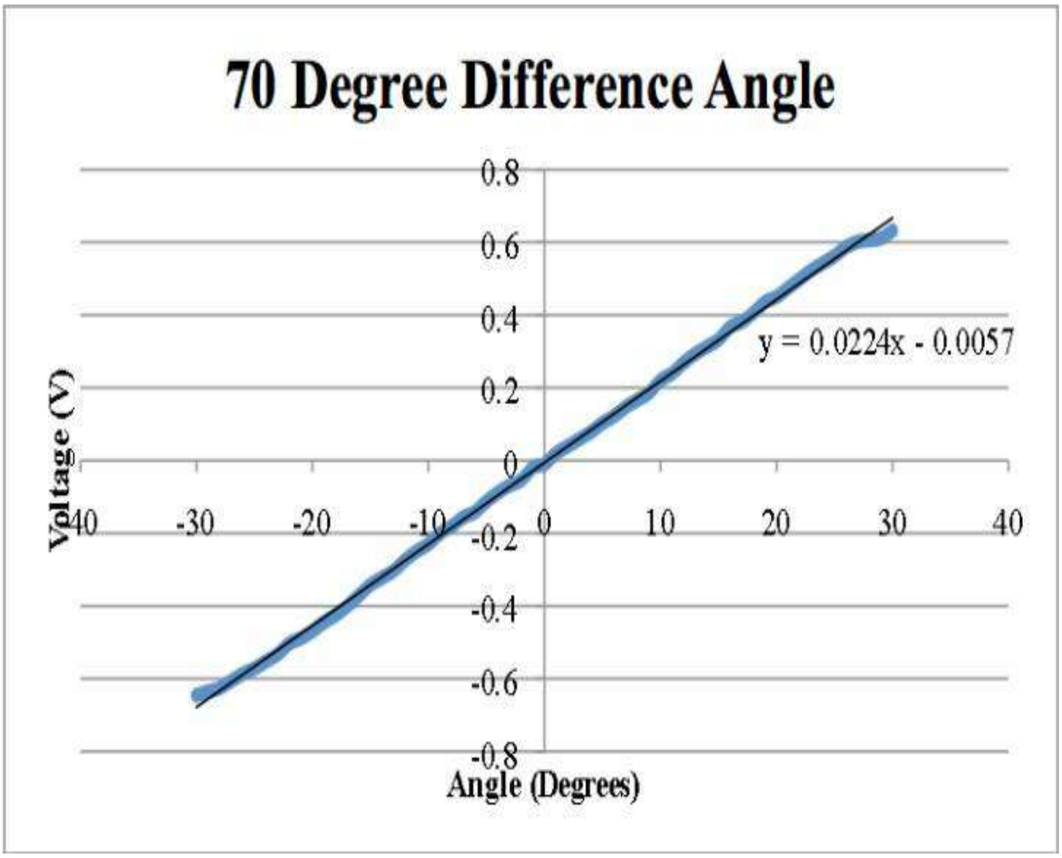


Figure 5.2: Probability Spectral Density with respect to SNR

The goal hear is to find the cell difference angle that has the greatest rate of change(the greater the rate of change the more sensitive).Most importantly it should have a large rate of change around the zero degrees on the x-axis.Consider all the cell difference angles at once is difficult to determine the one with the greatest rate of range,so the following graphs show each individual difference angle plot with the best fitting curve line super imposed on top



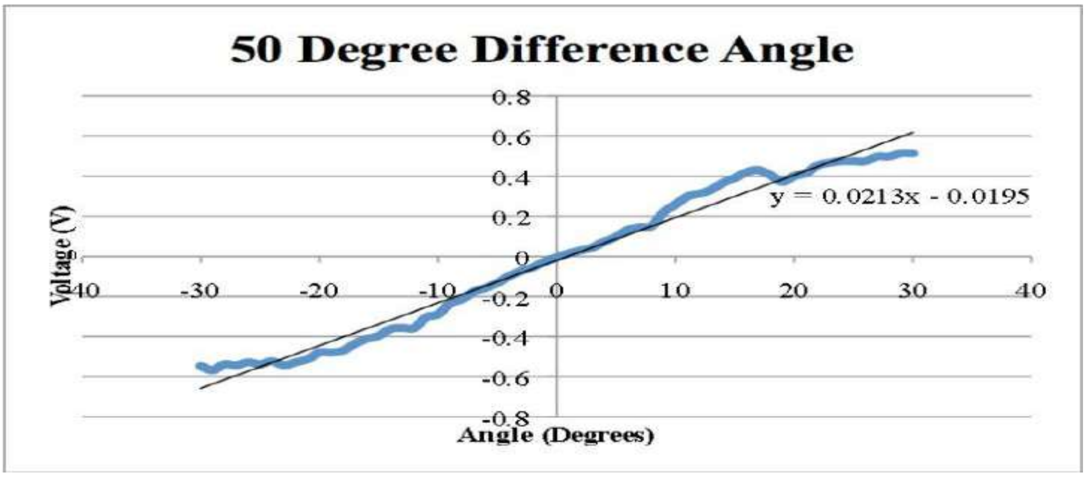
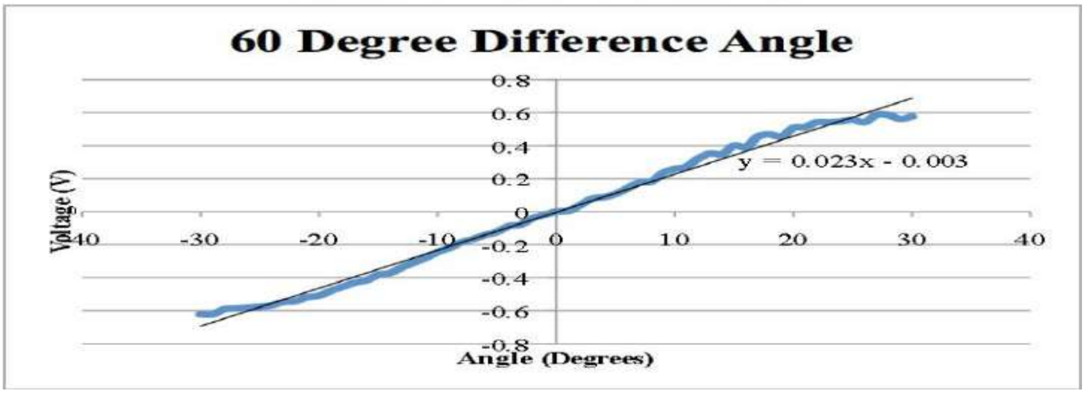
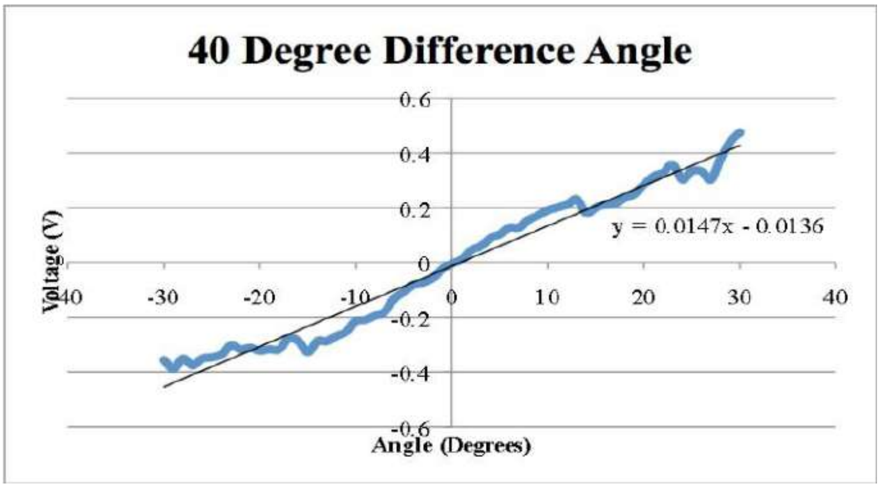


Figure4.4: 70 Degree Difference Angle





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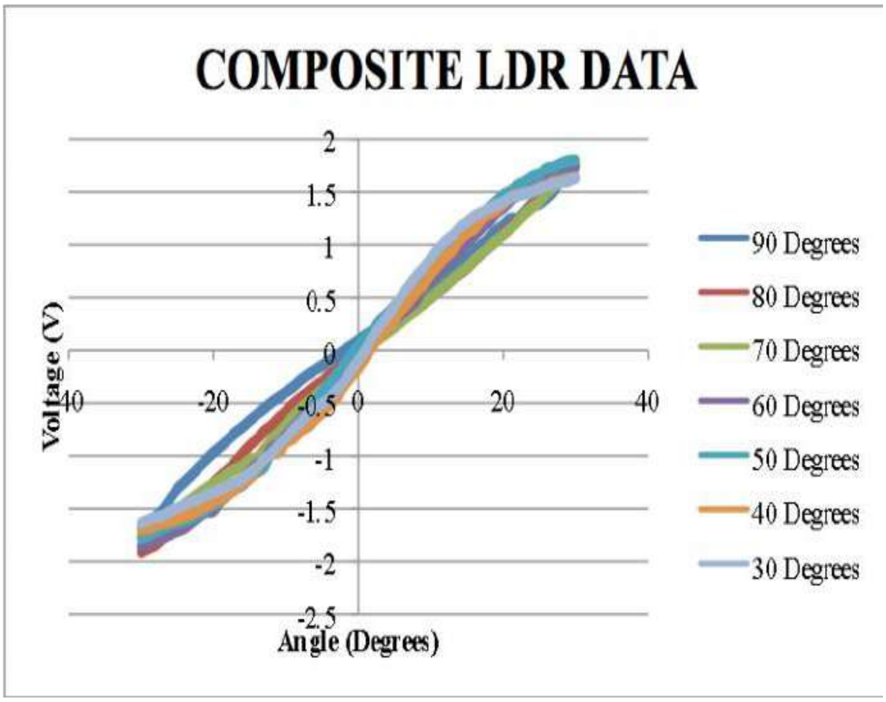
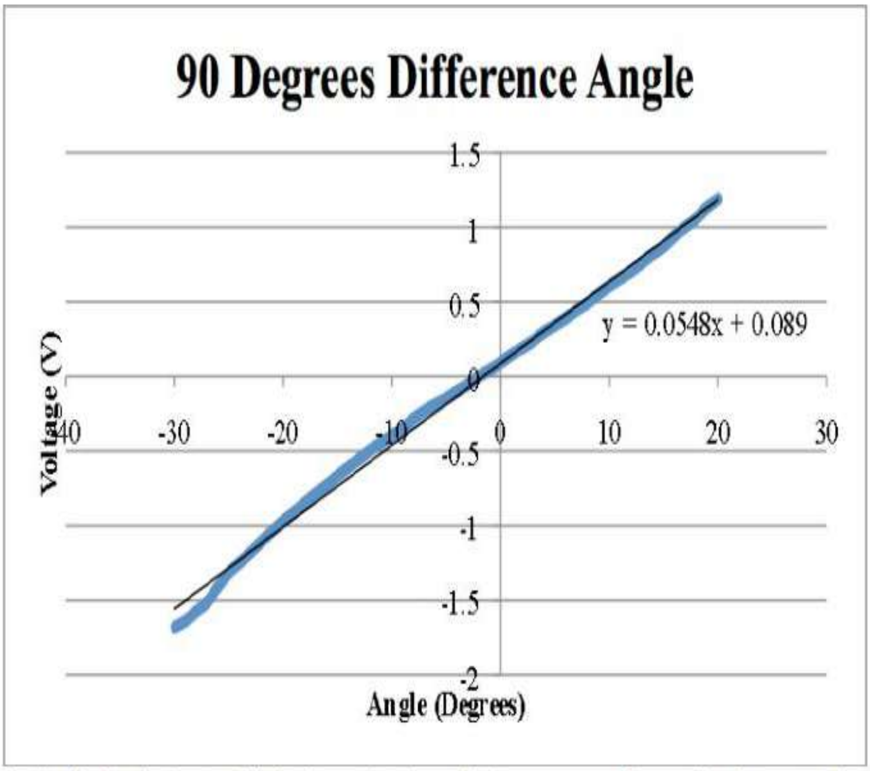
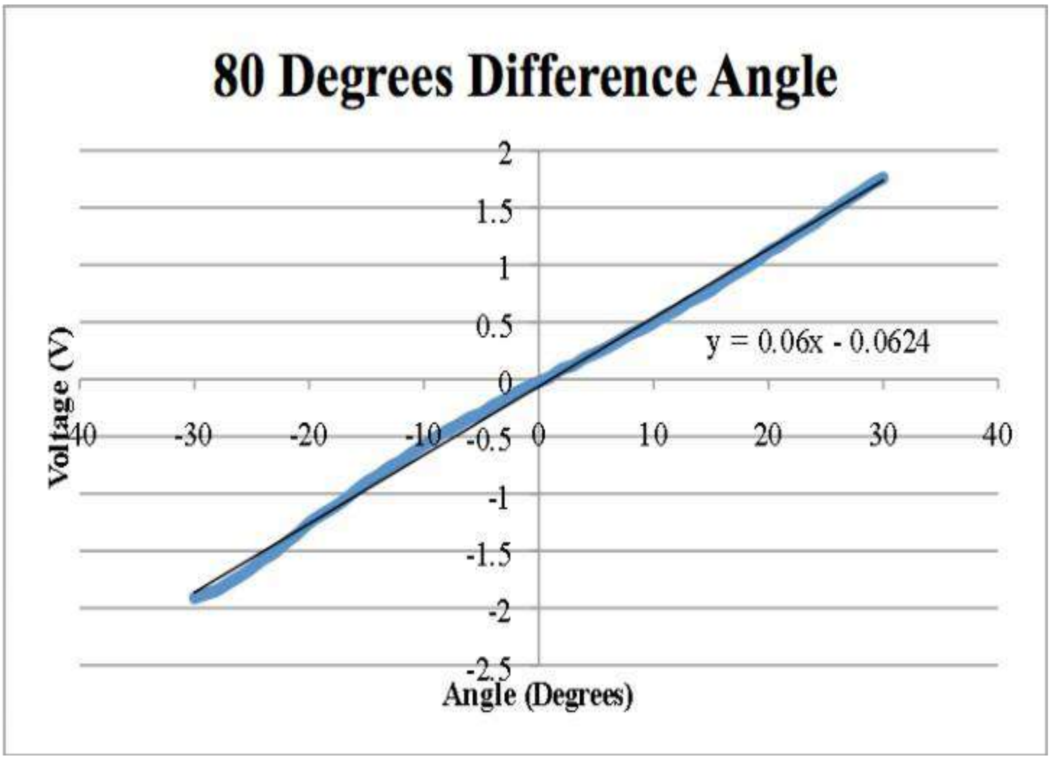
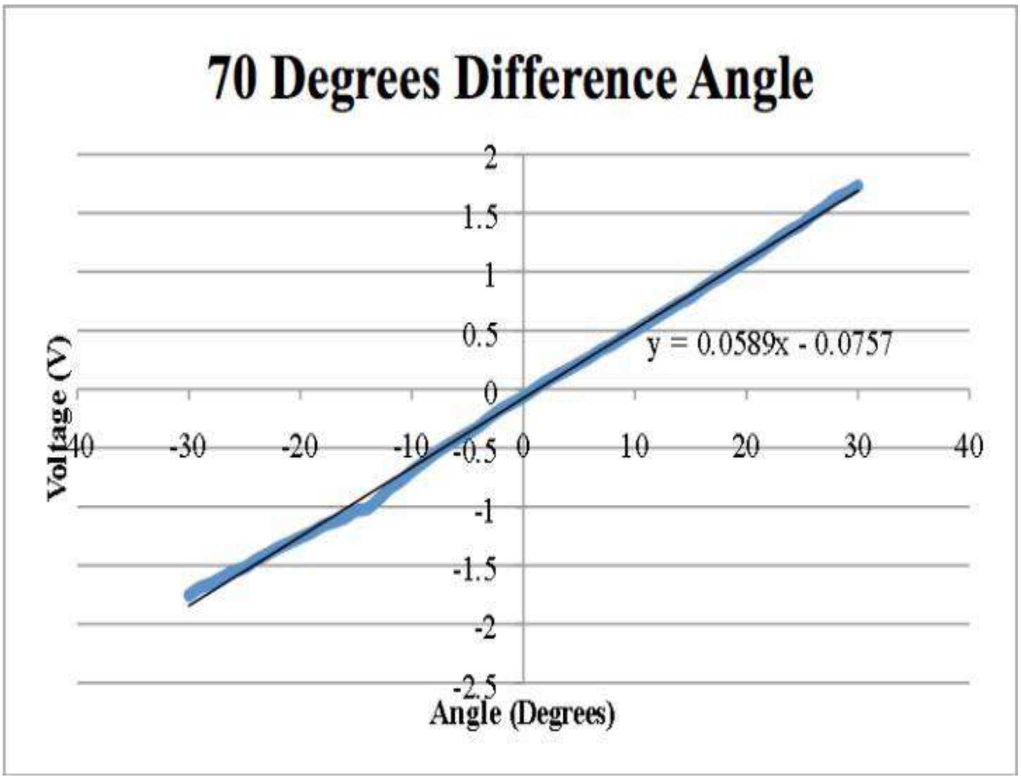


Next are the indivdual plots which show the best fitting curves for each.The actual collected data is show in the appendix:




80 Degrees Difference Angle
y = 0.06x - 0.0624
Voltage (V)
Angle (Degrees)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-40
-30
-20
-10
0
10
20
30
40


70 Degrees Difference Angle
y = 0.0589x - 0.0757
Voltage (V)
Angle (Degrees)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-40
-30
-20
-10
0
10
20
30
40

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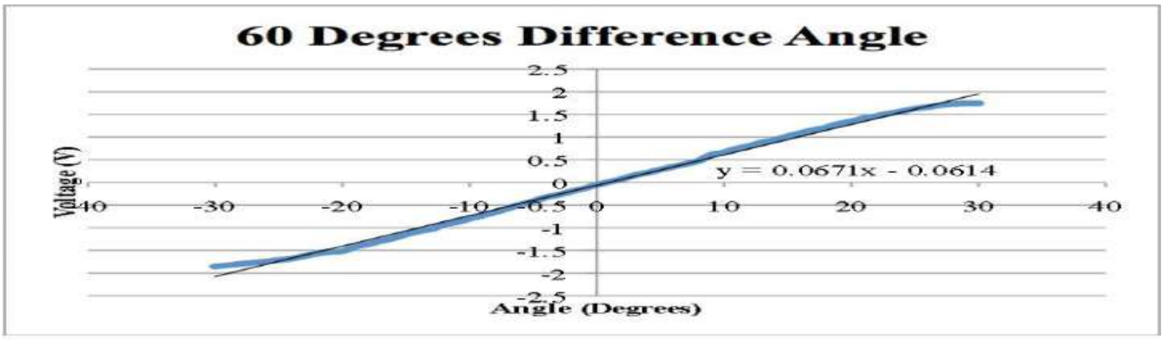
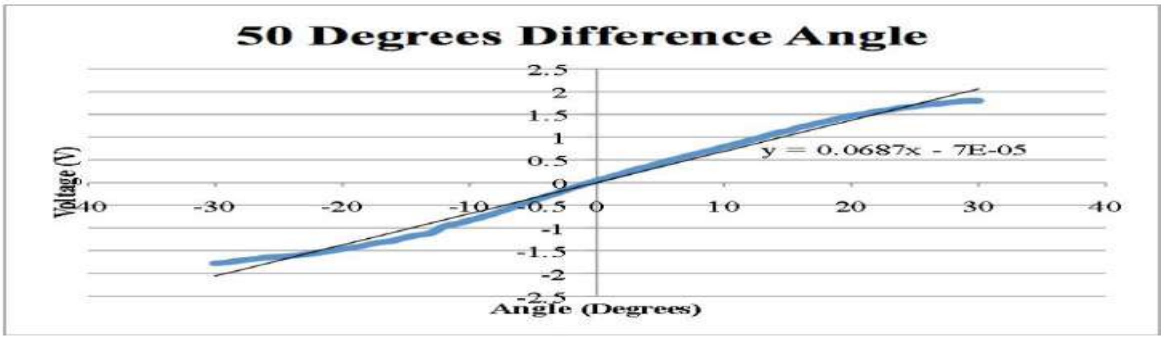


Figure 4.15:60DegreeDifferenceAngle



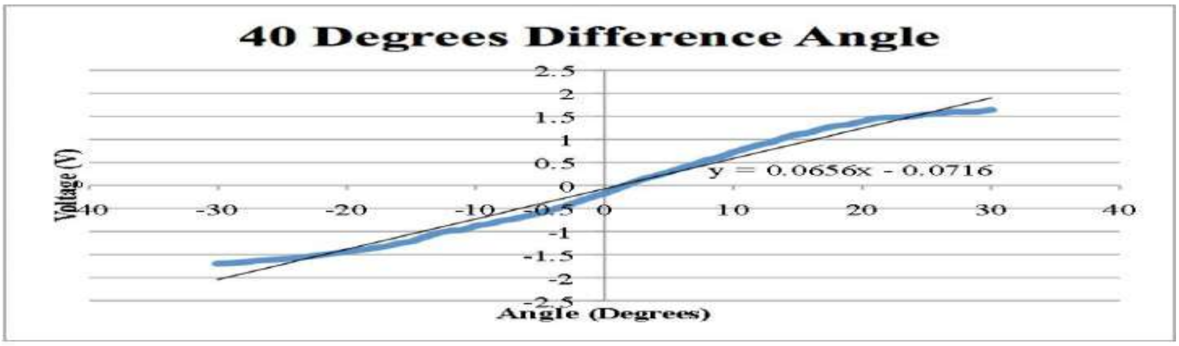
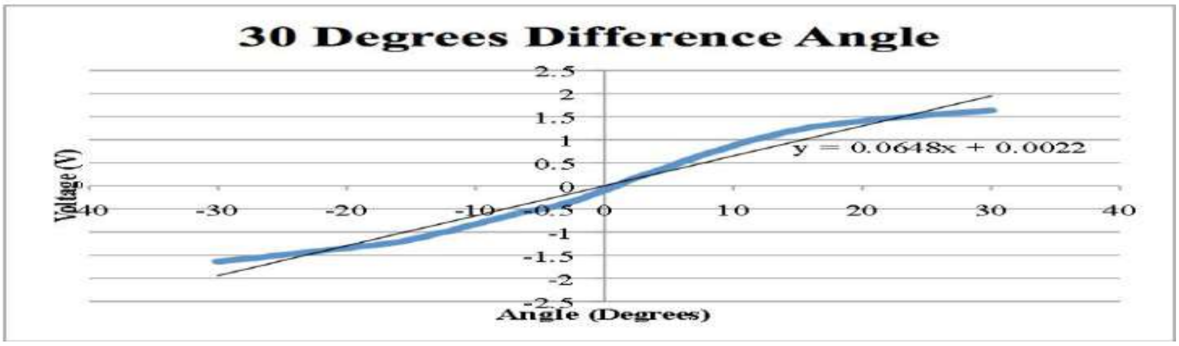


Figure 4.17:40DegreeDifferenceAngle



As can be seen from the graphs above the slope increasesas the difference angle decreases,but as the slope increases this area of increased sensativity narrows.In the figure above the area of greatest sensativity narrows down to-15 to 15 degrees around the zeroed position.For this reason 30 degrees would be the best option if LDRs were used because it has this steps lope. The slope be low and above-15 and 15 degrees respectfully are unimportant because the erthe solar tracker should never get to this point.

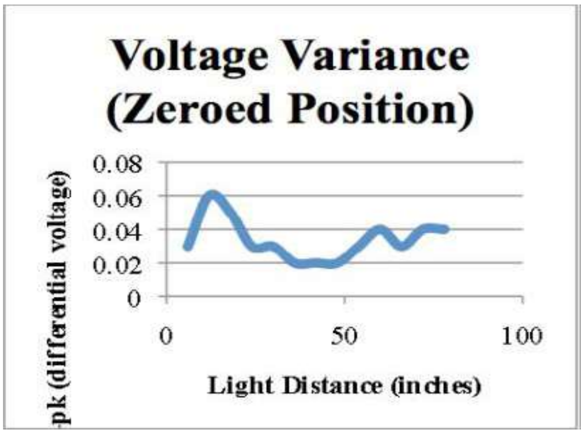


Figure4.19:Zeroed Position

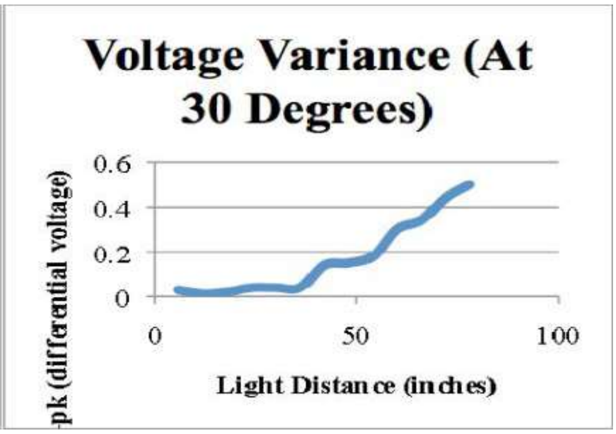


Figure4.20:Thirty Degrees

Finally the photodiodes were tested for their light sensativity. The experiments produced widely varying AC voltage values for the differential voltages it was determined that photodiodes were choice.The plots below show the voltage variation ranges for a difference angle of ninety degrees between cells under the same conditions as the other light dependent circuit elements. These plots were done for the light atanangle of zero degrees and thirty degrees around the cells

angle	cells 90	cells 80	cells 70	cells 60	cells 50	cells 40	cells 30
-30	-0.3812	-0.6305	-0.6452	-0.623	-0.5474	-0.3568	-0.532
-29	-0.3666	-0.6207	-0.6354	-0.623	-0.567	-0.3886	-0.532
-28	-0.3617	-0.6012	-0.6256	-0.5914	-0.5376	-0.3519	-0.5083
-27	-0.3421	-0.5914	-0.6061	-0.5865	-0.5425	-0.3763	-0.4643
-26	-0.3177	-0.5816	-0.5865	-0.5816	-0.5279	-0.3519	-0.4497
-25	-0.3079	-0.5572	-0.5718	-0.5767	-0.5376	-0.347	-0.4497
-24	-0.2933	-0.5376	-0.5523	-0.567	-0.523	-0.3372	-0.4301
-23	-0.2786	-0.5132	-0.5327	-0.5474	-0.5425	-0.303	-0.3763
-22	-0.2688	-0.4888	-0.5034	-0.5425	-0.5279	-0.3177	-0.3372
-21	-0.2444	-0.479	-0.4888	-0.5181	-0.5132	-0.3128	-0.3275
-20	-0.2395	-0.4594	-0.4692	-0.5083	-0.479	-0.3226	-0.3079
-19	-0.2248	-0.435	-0.4448	-0.479	-0.479	-0.3177	-0.2933
-18	-0.2053	-0.4008	-0.4252	-0.4545	-0.4692	-0.3177	-0.2835
-17	-0.2004	-0.3715	-0.4008	-0.4301	-0.435	-0.2786	-0.2786
-16	-0.1906	-0.3519	-0.3715	-0.4154	-0.4106	-0.2884	-0.2542
-15	-0.176	-0.3324	-0.3421	-0.3812	-0.3959	-0.3275	-0.2346
-14	-0.1662	-0.2981	-0.3226	-0.3715	-0.3617	-0.2884	-0.2346
-13	-0.1564	-0.2786	-0.303	-0.3372	-0.3568	-0.2884	-0.2151
-12	-0.1369	-0.2439	-0.2737	-0.3079	-0.3568	-0.2688	-0.2102
-11	-0.1271	-0.2297	-0.2493	-0.2786	-0.303	-0.2542	-0.1857
-10	-0.1173	-0.2102	-0.2297	-0.2444	-0.2884	-0.2151	-0.1711
-9	-0.1026	-0.176	-0.2004	-0.2199	-0.2346	-0.2102	-0.1613
-8	-0.0978	-0.1613	-0.1808	-0.1857	-0.2151	-0.1955	-0.1466
-7	-0.0782	-0.1417	-0.1564	-0.1662	-0.176	-0.1808	-0.1222
-6	-0.0635	-0.1222	-0.1417	-0.1417	-0.1564	-0.132	-0.1075
-5	-0.0489	-0.1026	-0.1124	-0.1222	-0.132	-0.1075	-0.0782
-4	-0.044	-0.0831	-0.088	-0.088	-0.0978	-0.0831	-0.0587

-3	-0.0293	-0.0684	-0.0684	-0.0782	-0.0733	-0.0733	-0.0489
-2	-0.0196	-0.0391	-0.0538	-0.0391	-0.0538	-0.0587	-0.0293
-1	-0.0098	-0.0147	-0.0196	-0.0196	-0.0244	-0.0244	-0.0098
0	0	-0.0098	-0.0098	0	-0.0049	-0.0049	0.0049
1	0.0147	0.0293	0.0196	0.0049	0.0147	0.0098	0.0244
2	0.0293	0.0489	0.0391	0.0391	0.0293	0.044	0.0489
3	0.044	0.0587	0.0587	0.0782	0.044	0.0587	0.088
4	0.0538	0.0831	0.0782	0.088	0.0733	0.088	0.1173
5	0.0684	0.0929	0.1026	0.1075	0.0978	0.1026	0.1417
6	0.0831	0.1173	0.1222	0.1417	0.132	0.1271	0.176
7	0.0929	0.1369	0.1466	0.176	0.1466	0.1271	0.2053
8	0.0978	0.1613	0.1662	0.1808	0.1515	0.1564	0.2297
9	0.1222	0.1857	0.1857	0.2346	0.2199	0.1711	0.2444
10	0.1271	0.2151	0.2199	0.259	0.259	0.1906	0.2884
11	0.1369	0.2444	0.2395	0.2737	0.2981	0.2004	0.3177
12	0.1564	0.2688	0.2688	0.3226	0.3128	0.2102	0.3275
13	0.1808	0.2884	0.2933	0.3519	0.3324	0.2297	0.3324
14	0.1857	0.3128	0.3128	0.347	0.3666	0.1808	0.3617
15	0.2004	0.3372	0.3324	0.4008	0.391	0.2004	0.3617
16	0.2102	0.3617	0.3666	0.391	0.4203	0.2102	0.391
17	0.2199	0.391	0.3812	0.4545	0.4301	0.2151	0.4008
18	0.2395	0.4154	0.4057	0.4692	0.4057	0.2346	0.4106
19	0.259	0.4301	0.435	0.4545	0.3715	0.2493	0.4154
20	0.2639	0.4497	0.4497	0.5083	0.4008	0.2835	0.4301
21	0.2737	0.479	0.4741	0.5132	0.4154	0.3128	0.4497
22	0.2933	0.4985	0.4985	0.5425	0.4545	0.3275	0.4643
23	0.3079	0.5327	0.523	0.5425	0.467	0.3568	0.4643
24	0.3177	0.5523	0.5425	0.5474	0.4741	0.303	0.479
25	0.3275	0.5718	0.5621	0.5572	0.4741	0.333	0.4741
26	0.334	0.5914	0.5865	0.5425	0.4741	0.333	0.5083
27	0.334	0.6061	0.6012	0.5865	0.4985	0.303	0.5132
28	0.345	0.6207	0.6061	0.5865	0.4985	0.38	0.5132
29	0.364	0.632	0.6109	0.5621	0.514	0.44	0.523
30	0.364	0.632	0.632	0.5767	0.514	0.475	0.523

7-CONCLUSION

Sun Tracking solar panel system represents a significant advancement in solar energy technology, offering superior efficiency and output by continuously aligning itself with the sun's position throughout the day. Unlike traditional fixed solar panels, which are positioned at a static angle, sun-tracking panels can adjust their orientation to follow the sun's path from sunrise to sunset. This dynamic positioning allows the panels to capture the maximum possible sunlight, especially during the early morning and late afternoon hours when the sun's angle is lower. As a result, the energy generation of sun-tracking panels can be significantly higher, often yielding 25-40% more power than their fixed counterparts.

The increased efficiency of sun-tracking solar panels makes them a compelling option for both residential and commercial applications, where maximizing energy output can lead to substantial long-term savings. In environments where space is limited or energy demands are high, such as urban rooftops or industrial installations, the enhanced performance of these systems allows for more energy to be harvested from a smaller footprint, reducing the need for additional panels. This can be particularly advantageous in areas with high electricity costs, where the financial benefits of increased power generation can quickly offset the initial investment in tracking technology.

Despite these challenges, the overall long-term return on investment for sun-tracking systems is often favorable. The increased energy output can lead to quicker payback periods, particularly in areas with abundant sunlight or high energy prices. Moreover, the environmental benefits of solar energy, such as reduced carbon emissions and a smaller ecological footprint, further enhance the value of sun-tracking panels. By optimizing energy production, these systems contribute to a more sustainable and efficient energy infrastructure.

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