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Dual-Axis Solar Tracker

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ABSTRACT

The dual-axis solar tracker project aims to optimize the efficiency of solar panels by ensuring they are always aligned with the sun. Originating from the necessity to enhance solar energy capture, this project builds on the work of previous researchers who developed various solar tracking mechanisms. Historically, solar trackers have been implemented using different methods such as single-axis tracking systems and manual adjustments, but these methods often fall short in maximizing solar exposure throughout the day. Previous works have successfully integrated basic solar tracking with microcontrollers and sensors; however, they frequently lack real-time adaptability and mobile charging capabilities.

Our project addresses these gaps by incorporating a dual-axis tracking system driven by a microcontroller and Light Dependent Resistors for precise light tracking. The solar tracker employs a solar panel, capable of efficiently capturing solar energy. The energy captured is displayed on a display device, which provides real-time feedback on the system's performance. Additionally, the structure is supported by a pan-tilt mechanism that allows the solar panel to adjust its position along both horizontal and vertical axes, ensuring optimal alignment with the sun.

A notable feature of this project is the inclusion of a Type-C charging port, which enables the stored solar energy to be used for mobile device charging, providing a practical application of the captured energy. This innovation not only demonstrates the efficiency of the solar tracker but also offers a convenient and sustainable solution for mobile charging needs. Our system's design ensures enhanced solar energy capture, real-time adaptability, and practical usability, setting it apart from previous implementations in this field.

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KEYWORDS: *solar tracker, arduino*

INTRODUCTION

In today's technological era, mobile devices have become an integral part of daily life, essential for communication, navigation, and accessing information. However, one of the most common and frustrating issues faced by users is the frequent depletion of mobile phone batteries. This problem is particularly pronounced in outdoor and off-grid environments where access to conventional power sources is limited or nonexistent. In such scenarios, the inability to recharge mobile devices can lead to significant inconveniences and even critical situations.

Traditional charging methods for mobile devices typically depend on grid electricity. While this is usually sufficient in urban settings, it poses a significant challenge in remote or rural areas. The lack of infrastructure in these areas means that users often cannot rely on a stable and continuous power supply. Additionally, in emergency situations such as natural disasters, where power outages are common, the need for alternative charging solutions becomes even more critical.

Furthermore, the environmental impact of using non-renewable energy sources for electricity generation cannot be ignored. Fossil fuels, which are the primary source of grid electricity in many parts of the world, contribute to air pollution and greenhouse gas emissions. This not only exacerbates climate change but also leads to health problems among populations.

In light of these issues, there is a growing need for innovative and eco-friendly power sources that can provide reliable energy for charging mobile devices. Solar energy, being abundant and renewable, presents a viable solution. However, conventional solar panels with fixed orientations do not efficiently capture sunlight throughout the day, resulting in suboptimal energy generation. This inefficiency limits the practicality of solar power as a reliable charging solution.

Our project aims to address these challenges by developing a dual axis solar tracker that maximizes solar energy capture. By dynamically adjusting the orientation of the solar panel to follow the sun's movement, our system ensures continuous and optimal exposure to sunlight. This approach not only enhances the efficiency of solar energy generation but also provides a sustainable and reliable power source for charging mobile phones in off-grid and remote areas. The integration of a Type-C charging module further emphasizes the practical application of the captured solar energy, making it a convenient solution for modern mobile devices.

The frequent depletion of mobile phone batteries, limited access to grid electricity in remote areas, and the environmental impact of non-renewable energy sources underline the need for our dual axis solar tracker project. By leveraging solar power and advanced tracking technology, we aim to provide an efficient, sustainable, and practical solution for mobile phone charging, addressing both user convenience and environmental concerns.

Background Study

Solar energy is a clean and renewable resource that has gained immense popularity for powering various applications. Dual-axis solar trackers enhance energy collection by precisely orienting solar panels to follow the sun's movement in both horizontal (azimuth) and vertical (elevation) axes. These trackers maximize energy yield by ensuring panels are always perpendicular to incoming sunlight.

1. **Simple Dual Axis Solar Tracker by BrownDogGadgets:**

Objective: Create an inexpensive, computer-controlled dual-axis solar tracker suitable for educational purposes.

Methodology:

Utilized Arduino as the main processing unit.

Integrated light-dependent resistors (LDRs) to sense sunlight intensity. Employed servo motors for precise panel orientation.

Outcome:

A non-soldering, smart solar tracker capable of following the sun's path.

Improved energy collection efficiency compared to fixed panels. Ideal for small-scale applications and educational settings.

2. **Dual Axis Solar Tracker with Weather Sensor:**

Objective: Develop a dual-axis tracker with additional weather sensing capabilities.

Methodology:

Combined mechanical, electrical, and electronic engineering.

Integrated an Atmega microcontroller, servo motor, DC motor, rain sensor, and temperature/humidity sensor. Displayed weather data on an LCD.

Outcome:

Enhanced energy capture by adjusting panel angles based on weather conditions. Real-time monitoring of environmental parameters.

Suitable for home and small-scale installations.

3. **Dual Axis Solar Tracker Arduino Project Using LDR & Servo Motors:**

Objective: Create a dual-axis tracker using readily available components.

Methodology:

Utilized LDRs to detect sunlight intensity. Controlled servo motors via an Arduino.

Designed a step-by-step approach for building the tracker.

Outcome:

An affordable and efficient solar tracker. Increased energy output for charging batteries or powering devices. Suitable for hobbyists and DIY enthusiasts.

Methodology

Our dual axis solar tracker project encompasses several key components and processes to achieve efficient solar tracking and power generation. Below is an outline of the methodology, detailing the steps and mechanisms involved in the construction and operation of the solar tracker system.

1. **Instruments and tools:**

A. **Arduino Nano:** The Arduino Nano is a compact microcontroller board based on the ATmega328P. It is the central processing unit of our solar tracker, responsible for reading sensor inputs and controlling the servo motors to adjust the solar panel's position. Its small size makes it ideal for embedded applications. In our project, it processes data from the LDRs and calculates the optimal angles for panel orientation.

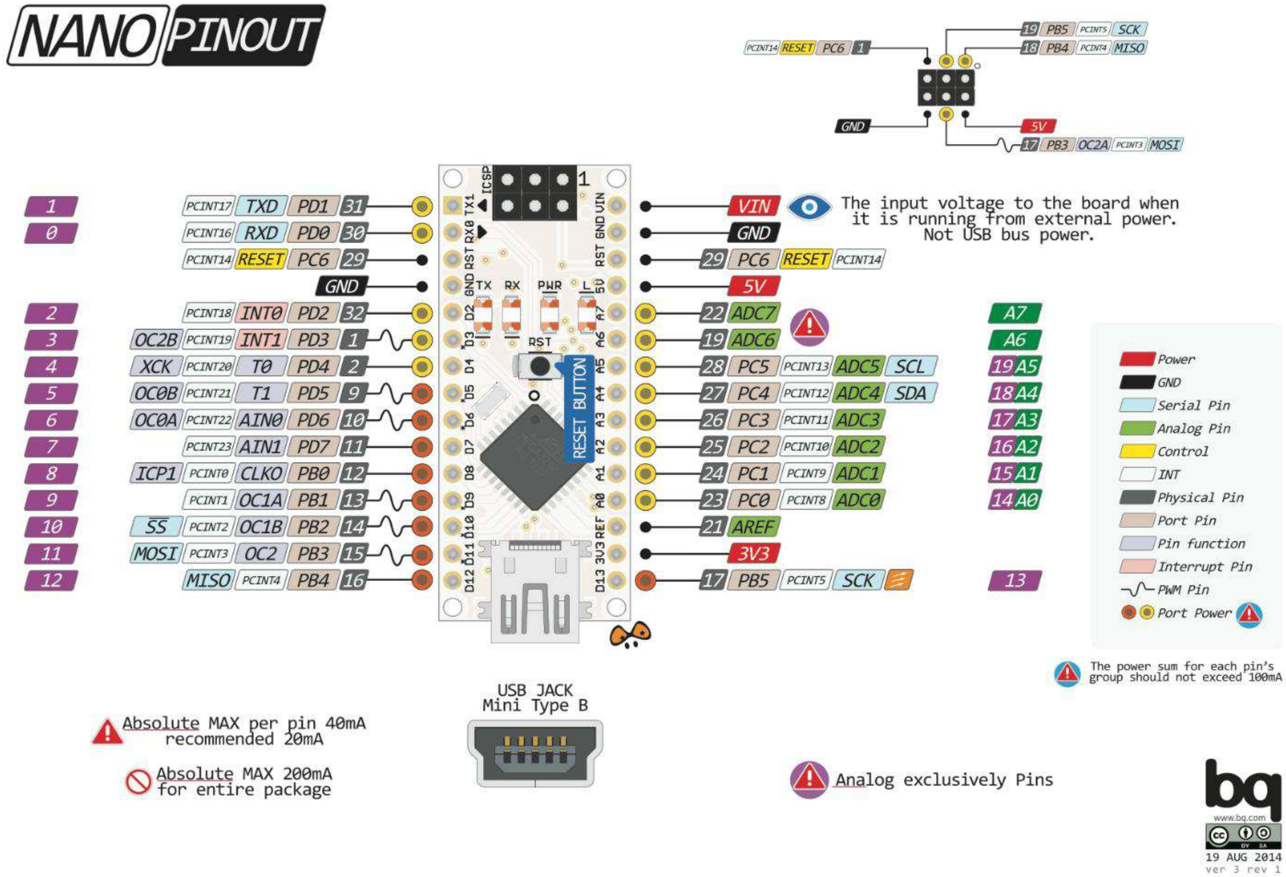

Fig 1: Arduino Nano Pin Diagram

B. Light Dependent Resistors (LDRs): LDRs are light-sensitive devices that change their resistance based on the amount of light hitting them. They are crucial for detecting the direction and intensity of sunlight. In our project, LDRs provide the necessary input to the Arduino Nano, which then adjusts the solar panel to maximize exposure to sunlight. This improves the efficiency of solar energy capture.

Fig 2: Light-dependent resistor (LDR)

C. Solar Panel: The solar panel converts sunlight into electrical energy. Our project uses a 6V, 500mA solar panel, suitable for small-scale energy generation like charging mobile devices. The panel's efficiency is enhanced by the dual axis tracking system, which ensures it is always optimally aligned with the sun. This component is key to harnessing renewable energy for sustainable power solutions.

Fig 3: Solar panel 6V 500mA

D. LCD Display: The LCD display shows real-time data from the LDRs and other system parameters. This feedback allows users to monitor the performance and efficiency of the solar tracker. It displays crucial information such as light intensity and battery charge level, providing an easy-to-read interface for users to understand the system's status and performance.

Fig 4: LCD Display 16X2

E. Battery and Charging Module: The battery stores the energy captured by the solar panel, ensuring that power is available even when there is no sunlight. It acts as a buffer, maintaining a steady supply of electricity to charge mobile devices and power the system components. This storage capability is crucial for ensuring continuous operation and reliability of the solar tracker, especially during periods of low sunlight or nighttime.

Fig 5: Battery

F. Pan-Tilt Mechanism: The pan tilt mechanism, controlled by servo motors, allows the solar panel to move along two axes. This dual axis movement ensures that the panel can follow the sun's trajectory throughout the day. By continuously aligning the panel with the sun, the system maximizes energy capture, making it much more efficient than fixed solar panels.

Fig 6: Pan tilt

G. Vero Board: The Vero board, also known as a stripboard, is used for constructing the electronic circuits in a neat and organized manner. It provides a platform for soldering components and making permanent electrical connections. This component is significant for creating a durable and reliable circuit layout, essential for the stability of the solar tracker's electronic system.

Fig 7: Vero Board

H. PVC Box (7 inch by 4 inch): Provides a protective enclosure for the electronic components, ensuring durability and resistance to environmental factors.

Fig 8: PVC Box

I. Male-Female Jumper Wires: These jumper wires are used to connect various components on the Vero board and other parts of the circuit. They are essential for creating flexible and temporary connections during the prototyping phase. In our project, they facilitate the connectivity between the Arduino, sensors, and display, ensuring smooth communication and power distribution, which is crucial for the system's overall operation.

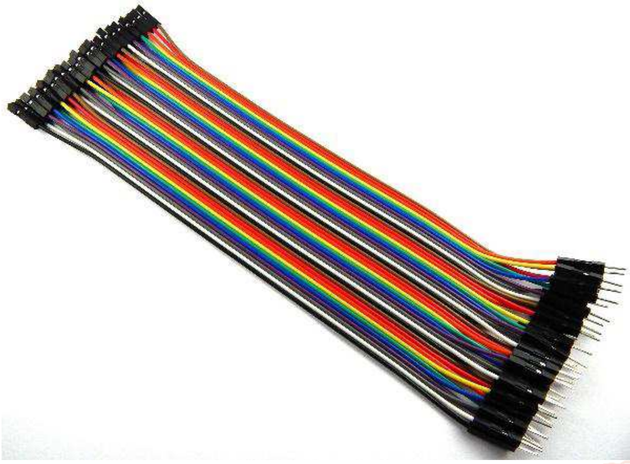

Fig 9: Male-female jumper wire

J. **Female-Female Jumper Wires:** Similar to male-female jumper wires, these are used to connect components that have female headers, providing versatility in the wiring of the circuit. They are particularly useful for connecting modules and sensors that do not have male pins. In our solar tracker, they help in making secure and adjustable connections, allowing for easy modifications and troubleshooting, which enhances the system's adaptability and maintenance.

Fig 10: Female-female jumper wire

K. **Heat Shrink Tubes:** Heat shrink tubes are essential components used to insulate and protect electrical connections. When exposed to heat, these tubes shrink to fit tightly around wires and connections, providing a secure and durable covering. This process not only insulates the connections from environmental factors like moisture and dust but also enhances the mechanical strength of the joints, preventing them from coming loose or getting damaged. Heat shrink tubes also help in organizing wires, reducing clutter, and minimizing the risk of short circuits. Their use is crucial in ensuring the reliability and safety of the electrical system in our dual axis solar tracker.

Fig11: Heat shrink tubes

L. **10K Ohm Resistor:** 10K ohm resistors are vital for regulating current flow within electronic circuits. They limit the amount of current that can pass through, protecting sensitive components such as sensors and microcontrollers from potential damage due to excessive current. In our dual axis solar tracker, these resistors help ensure stable and accurate readings from the Light Dependent Resistors (LDRs) by providing the necessary load. Additionally, they contribute to the overall stability of the circuit, preventing voltage fluctuations that could disrupt the system's operation. By maintaining a consistent current flow, 10K ohm resistors are crucial for the reliable performance of the entire tracking system.

Fig 12: 10K ohm register

M. **DC-DC Step up Converter:** The MT3608 is a high-efficiency, fixed-frequency, DC-DC step-up (boost) converter. It can take input voltages as low as 2V and boost them up to 28V, making it ideal for battery-powered applications where a higher voltage is needed. The MT3608 is capable of delivering up to 2A of current, depending on the input voltage and the efficiency of the conversion. It features an integrated switching FET and a feedback circuit, which helps maintain a stable output voltage. The module is compact and often includes a trimmer potentiometer to adjust the output voltage. Its high switching frequency reduces the size of external components, making it suitable for space-constrained projects. The MT3608 is commonly used in portable electronics, DIY projects, and any application requiring voltage step-up with minimal heat dissipation.

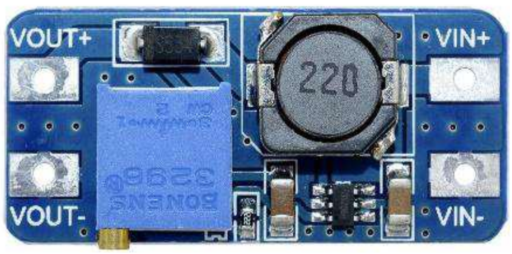

Fig 13: MT3608 DC-Dc Step up converter module

N. **Battery Charger:** The TP5100 is a high-efficiency, dual-cell lithium battery charger IC with a wide input voltage range. It supports both single-cell and dual-cell charging, making it versatile for various lithium battery configurations. The TP5100 can operate from 5V to 18V input, providing a flexible power source option. It integrates multiple safety features, including over-voltage, over-current, and over-temperature protection, ensuring safe charging operations. The IC can deliver up to 2A of charging current, significantly reducing the charging time compared to traditional chargers. The TP5100 is known for its low standby current, which helps prolong battery life when not in use. It also includes status indication features, allowing users to monitor the charging process easily. This IC is ideal for applications such as battery-powered devices, portable electronics, and DIY charging solutions.

Fig 14: TP5100 dual cell lithium battery charger IC

2. Flow of Work:

1. Start

2. Setup

A. Initialize Serial communication
B. Set pin modes for sensors
C. Attach servos
D. Set initial servo positions

3. Loop

A. Read sensor values
B. Calculate differences
C. Adjust yaw and pitch angles
D. Constrain angles within limits
E. Move servos
F. Print angles to Serial
G. Delay

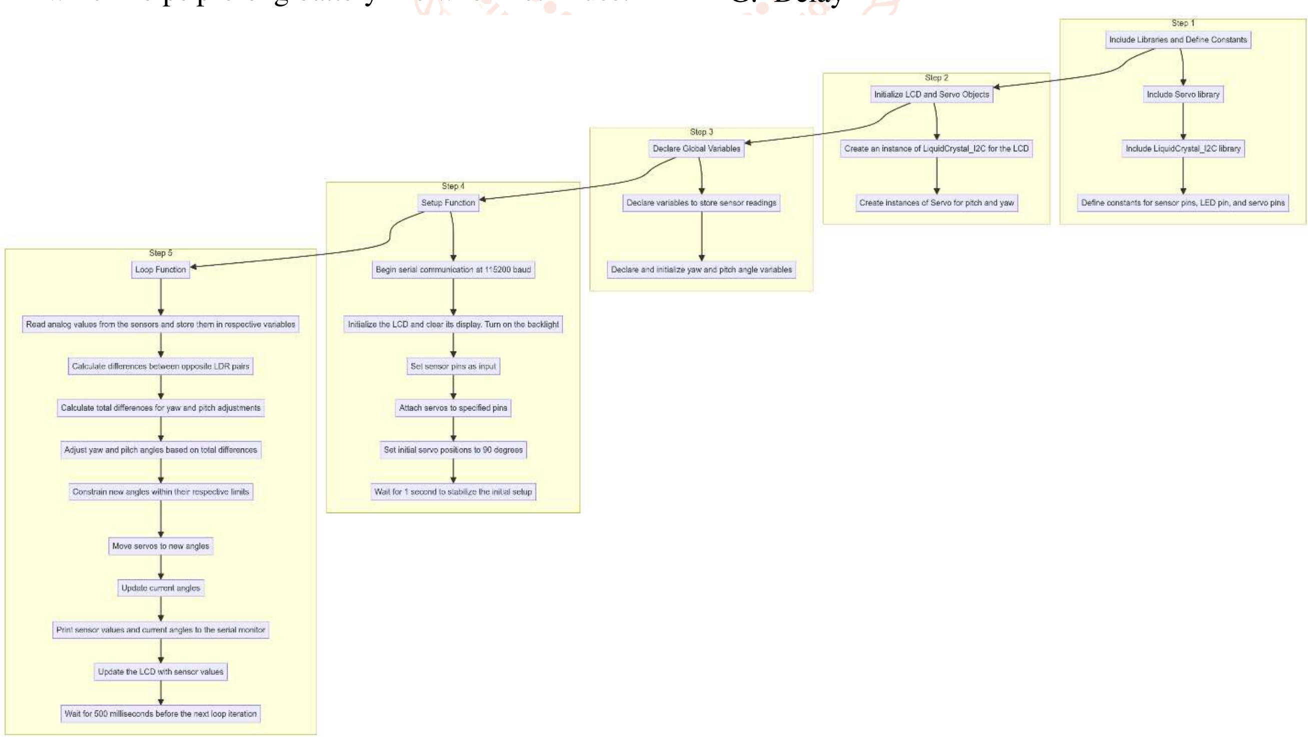

Fig 15: Flowchart

3. **Circuit Design:**

A. The LDRs are arranged in a cross-pattern around the solar panel, and each LDR is connected to an analog input pin on the Arduino.

B. The solar panel is connected to the battery and charging module through a diode to prevent backflow of current.

C. The pan-tilt mechanism is controlled by two servo motors, which are connected to the digital output pins of the Arduino. These motors adjust the position of the solar panel based on the light intensity readings from the LDRs.

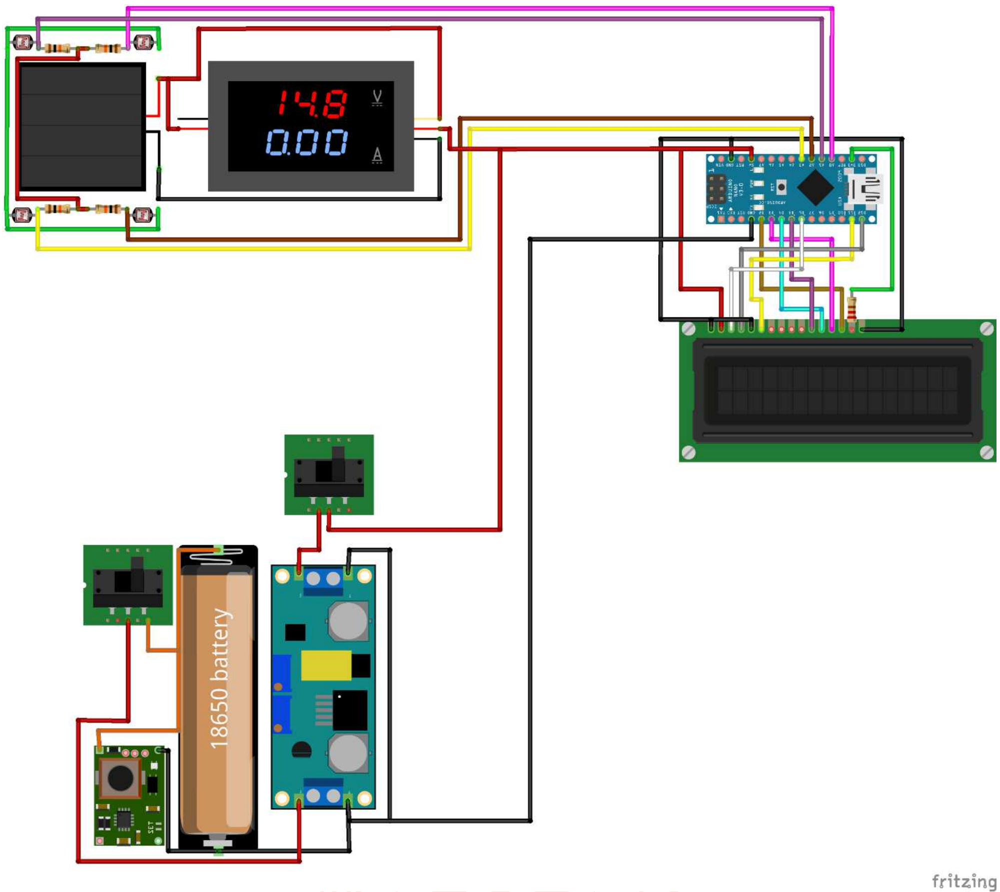

Fig 16: Circuit Design

This comprehensive methodology ensures that the dual axis solar tracker operates efficiently, providing a reliable source of solar energy for various applications. Through meticulous component selection, precise software programming, and thorough testing, the project achieves its goal of maximizing solar energy capture and utilization.

Implementation

Fig 17: Solar tracker

Building a dual-axis solar tracker involves a comprehensive integration of components and precise control mechanisms to maximize solar energy capture. The foundation of the project starts with setting up an Arduino Nano, which will act as the central controller for the entire system. The first step involves installing the Arduino Integrated Development Environment (IDE) on your computer and connecting the Arduino Nano via a USB cable. Once connected, necessary libraries for components like servos and LCD displays must be installed. The next crucial step is the placement and connection of four Light Dependent Resistors (LDRs). These LDRs, arranged in a cross pattern at the edges of the solar panel, are essential for detecting light intensity and determining the direction of the sun. Each LDR is connected to the analog input pins of the Arduino Nano using a voltage divider configuration to provide accurate light intensity readings.

Following the setup of the LDRs, the focus shifts to the pan-tilt mechanism that will allow the solar panel to move along two axes. The pan-tilt mechanism, equipped with servo motors, is critical for adjusting the solar panel's orientation to follow the sun's trajectory throughout the day. The servo motors are connected to the Arduino Nano's PWM digital pins, and their movement is controlled based on the input from the LDRs. The Arduino code is then written to continuously read the light intensity values from the LDRs and calculate the necessary adjustments for the servos. This involves comparing the LDR readings to determine the direction with the highest light intensity and moving the servos to align the solar panel accordingly.

The solar panel itself is the heart of the energy conversion process, converting sunlight into electrical energy. This energy is then managed and stored by integrating a TP5100 battery charger module and an MT3608 boost converter. The TP5100 efficiently handles the charging of a battery, which stores the captured solar energy for use when sunlight is not available. The MT3608 boost converter ensures that the voltage from the solar panel is stepped up as needed to provide a stable output for charging mobile devices via the Type-C charging module. This setup allows the system to not only capture solar energy but also store and utilize it efficiently, providing a reliable source of power for mobile device charging.

An LCD display is integrated into the system to provide real-time feedback and monitoring capabilities. This display shows crucial data such as the light intensity readings from each LDR and the battery charge status, giving users insight into the system's performance. The LCD is connected to the Arduino Nano, and the code is written to update the display with relevant information continuously. This user interface is essential for monitoring the system and making any necessary adjustments.

The project also involves meticulous assembly and wiring of all components on a Vero board, which serves as the platform for the circuit assembly. Male-female and female-female jumper wires are used to make flexible and secure connections between the components and the Arduino Nano. Ensuring that all connections are reliable and that there are no loose wires is crucial for the system's stability and performance.

To protect and insulate the electrical connections, heat shrink tubes are used. These tubes are placed over exposed wires and heated to shrink, providing a secure and durable covering that prevents short circuits and enhances the safety of the system. Additionally, 10K ohm resistors are utilized within the circuit to control the current flow, ensuring that the sensors and microcontroller operate correctly and are protected from potential damage due to excessive current.

With all components connected and the Arduino code uploaded, the initial testing phase begins. Each component is tested individually to verify proper functionality, followed by a system-wide test to ensure that the solar tracker operates as intended. The servos should move the pan-tilt mechanism smoothly, and the solar panel should adjust its orientation to follow the sun's movement accurately. Calibration is an essential part of this process, involving fine-tuning the servo positions and adjusting the threshold values in the code for accurate light detection.

Once the system is fully operational, it's important to test the power management aspect thoroughly. This involves checking the connections between the solar panel, battery charger, and boost converter, and ensuring that the energy conversion and storage are efficient. The system should be able to charge the battery using solar energy and subsequently use the stored energy to charge mobile devices through the Type-C charging module.

Throughout the implementation process, troubleshooting may be necessary to address any issues that arise. Common problems include inconsistent tracking due to incorrect LDR connections or servo calibration, power issues from loose connections or incorrect wiring, and display problems from incorrect LCD connections or code errors. Addressing these issues involves methodical checking of connections, re-calibration, and code adjustments.

Enhancements to the project can further improve its functionality and efficiency. Adding a data logging feature allows the system to record sunlight intensity and energy generation data over time, providing valuable insights for performance analysis and optimization. Implementing remote monitoring capabilities using wireless modules like Wi-Fi or Bluetooth enables users to monitor the system from a mobile app or web interface, enhancing convenience and accessibility. Exploring the use of more efficient solar panels and advanced power management components can further increase the system's overall efficiency and energy output.

In conclusion, building a dual-axis solar tracker from scratch involves a detailed and methodical approach, integrating various components to create a system that optimizes solar energy capture and provides a practical solution for mobile device charging. The use of an Arduino Nano for control, LDRs for light detection, and a pan-tilt mechanism for dynamic adjustment ensures that the solar panel remains aligned with the sun, maximizing energy capture. The efficient power management system, including the TP5100 charger and MT3608 boost converter, ensures that the captured energy is stored and utilized effectively. With a robust assembly, proper calibration, and thorough testing, this project not only addresses the immediate need for reliable mobile charging but also contributes to the broader goal of promoting sustainable energy solutions.

Result and Discussion

Table 1: Dataset where yaw move from left to right

SET	INPUT				OUTPUT	
	SensorFL	SensorFR	SensorBL	SensorBR	Yaw Angle	Pitch Angle
1	1000	1000	0	0	0	90
2	980	980	20	20	1	90
3	960	960	40	40	2	90
4	940	940	60	60	3	90
5	920	920	80	80	4	90
6	900	900	100	100	5	90
7	880	880	120	120	6	90
8	860	860	140	140	7	90
9	840	840	160	160	8	90
10	820	820	180	180	9	90
11	800	800	200	200	10	90
12	780	780	220	220	11	90
13	760	760	240	240	12	90
14	740	740	260	260	13	90
15	720	720	280	280	14	90
16	700	700	300	300	15	90
17	680	680	320	320	16	90
18	660	660	340	340	17	90
19	640	640	360	360	18	90
20	620	620	380	380	19	90
21	600	600	400	400	20	90
22	580	580	420	420	21	90
23	560	560	440	440	22	90
24	540	540	460	460	23	90
25	520	520	480	480	24	90
26	500	500	500	500	25	90
27	480	480	520	520	26	90
28	460	460	540	540	27	90
29	440	440	560	560	28	90
30	420	420	580	580	29	90
31	400	400	600	600	30	90
32	380	380	620	620	31	90
33	360	360	640	640	32	90
34	340	340	660	660	33	90
35	320	320	680	680	34	90

36	300	300	700	700	35	90
37	280	280	720	720	36	90
38	260	260	740	740	37	90
39	240	240	760	760	38	90
40	220	220	780	780	39	90
41	200	200	800	800	40	90
42	180	180	820	820	41	90
43	160	160	840	840	42	90
44	140	140	860	860	43	90
45	120	120	880	880	44	90
46	100	100	900	900	45	90
47	80	80	920	920	46	90
48	60	60	940	940	47	90
49	40	40	960	960	48	90
50	20	20	980	980	49	90
51	0	0	1000	1000	50	90
52	20	20	980	980	51	90
53	40	40	960	960	52	90
54	60	60	940	940	53	90
55	80	80	920	920	54	90
56	100	100	900	900	55	90
57	120	120	880	880	56	90
58	140	140	860	860	57	90
59	160	160	840	840	58	90
60	180	180	820	820	59	90
61	200	200	800	800	60	90
62	220	220	780	780	61	90
63	240	240	760	760	62	90
64	260	260	740	740	63	90
65	280	280	720	720	64	90
66	300	300	700	700	65	90
67	320	320	680	680	66	90
68	340	340	660	660	67	90
69	360	360	640	640	68	90
70	380	380	620	620	69	90
71	400	400	600	600	70	90
72	420	420	580	580	71	90
73	440	440	560	560	72	90
74	460	460	540	540	73	90
75	480	480	520	520	74	90
76	500	500	500	500	75	90
77	520	520	480	480	76	90
78	540	540	460	460	77	90
79	560	560	440	440	78	90
80	580	580	420	420	79	90
81	600	600	400	400	80	90
82	620	620	380	380	81	90
83	640	640	360	360	82	90
84	660	660	340	340	83	90
85	680	680	320	320	84	90
86	700	700	300	300	85	90
87	720	720	280	280	86	90
88	740	740	260	260	87	90

89	760	760	240	240	88	90
90	780	780	220	220	89	90
91	800	800	200	200	90	90
92	820	820	180	180	91	90
93	840	840	160	160	92	90
94	860	860	140	140	93	90
95	880	880	120	120	94	90
96	900	900	100	100	95	90
97	920	920	80	80	96	90
98	940	940	60	60	97	90
99	960	960	40	40	98	90
100	980	980	20	20	99	90

Table 2: Dataset where pitch move from left to right

SET	INPUT				OUTPUT	
	SensorFL	SensorFR	SensorBL	SensorBR	Yaw Angle	Pitch Angle
1	500	1000	500	1000	90	60
2	510	1010	510	1010	90	61
3	520	1020	520	1020	90	62
4	530	1030	530	1030	90	63
5	540	1040	540	1040	90	64
6	550	1050	550	1050	90	65
7	560	1060	560	1060	90	66
8	570	1070	570	1070	90	67
9	580	1080	580	1080	90	68
10	590	1090	590	1090	90	69
11	600	1100	600	1100	90	70
12	610	1110	610	1110	90	71
13	620	1120	620	1120	90	72
14	630	1130	630	1130	90	73
15	640	1140	640	1140	90	74
16	650	1150	650	1150	90	75
17	660	1160	660	1160	90	76
18	670	1170	670	1170	90	77
19	680	1180	680	1180	90	78
20	690	1190	690	1190	90	79
21	700	1200	700	1200	90	80
22	710	1210	710	1210	90	81
23	720	1220	720	1220	90	82
24	730	1230	730	1230	90	83
25	740	1240	740	1240	90	84
26	750	1250	750	1250	90	85
27	760	1260	760	1260	90	86
28	770	1270	770	1270	90	87
29	780	1280	780	1280	90	88
30	790	1290	790	1290	90	89
31	800	1300	800	1300	90	90
32	810	1310	810	1310	90	91
33	820	1320	820	1320	90	92
34	830	1330	830	1330	90	93
35	840	1340	840	1340	90	94
36	850	1350	850	1350	90	95
37	860	1360	860	1360	90	96
38	870	1370	870	1370	90	97

39	880	1380	880	1380	90	98
40	890	1390	890	1390	90	99
41	900	1400	900	1400	90	100
42	910	1410	910	1410	90	101
43	920	1420	920	1420	90	102
44	930	1430	930	1430	90	103
45	940	1440	940	1440	90	104
46	950	1450	950	1450	90	105
47	960	1460	960	1460	90	106
48	970	1470	970	1470	90	107
49	980	1480	980	1480	90	108
50	990	1490	990	1490	90	109
51	1000	1500	1000	1500	90	110
52	1010	1510	1010	1510	90	111
53	1020	1520	1020	1520	90	112
54	1030	1530	1030	1530	90	113
55	1040	1540	1040	1540	90	114
56	1050	1550	1050	1550	90	115
57	1060	1560	1060	1560	90	116
58	1070	1570	1070	1570	90	117
59	1080	1580	1080	1580	90	118
60	1090	1590	1090	1590	90	119
61	1100	1600	1100	1600	90	120
62	1110	1610	1110	1610	90	119

Table 3: Dataset where yaw and pitch move from left to right

SET	INPUT				OUTPUT	
	SensorFL	SensorFR	SensorBL	SensorBR	Yaw Angle	Pitch Angle
1	500	1000	500	1000	45	60
2	510	1010	510	1010	46	61
3	520	1020	520	1020	47	62
4	530	1030	530	1030	48	63
5	540	1040	540	1040	49	64
6	550	1050	550	1050	50	65
7	560	1060	560	1060	51	66
8	570	1070	570	1070	52	67
9	580	1080	580	1080	53	68
10	590	1090	590	1090	54	69
11	600	1100	600	1100	55	70
12	610	1110	610	1110	56	71
13	620	1120	620	1120	57	72
14	630	1130	630	1130	58	73
15	640	1140	640	1140	59	74
16	650	1150	650	1150	60	75
17	660	1160	660	1160	61	76
18	670	1170	670	1170	62	77
19	680	1180	680	1180	63	78
20	690	1190	690	1190	64	79
21	700	1200	700	1200	65	80
22	710	1210	710	1210	66	81
23	720	1220	720	1220	67	82
24	730	1230	730	1230	68	83
25	740	1240	740	1240	69	84
26	750	1250	750	1250	70	85

27	760	1260	760	1260	71	86
28	770	1270	770	1270	72	87
29	780	1280	780	1280	73	88
30	790	1290	790	1290	74	89
31	800	1300	800	1300	75	90
32	810	1310	810	1310	76	91
33	820	1320	820	1320	77	92
34	830	1330	830	1330	78	93
35	840	1340	840	1340	79	94
36	850	1350	850	1350	80	95
37	860	1360	860	1360	81	96
38	870	1370	870	1370	82	97
39	880	1380	880	1380	83	98
40	890	1390	890	1390	84	99
41	900	1400	900	1400	85	100
42	910	1410	910	1410	86	101
43	920	1420	920	1420	87	102
44	930	1430	930	1430	88	103
45	940	1440	940	1440	89	104
46	950	1450	950	1450	90	105
47	960	1460	960	1460	91	106
48	970	1470	970	1470	92	107
49	980	1480	980	1480	93	108
50	990	1490	990	1490	94	109
51	1000	1500	1000	1500	95	110
52	1010	1510	1010	1510	96	111
53	1020	1520	1020	1520	97	112
54	1030	1530	1030	1530	98	113
55	1040	1540	1040	1540	99	114
56	1050	1550	1050	1550	100	115
57	1060	1560	1060	1560	101	116
58	1070	1570	1070	1570	102	117
59	1080	1580	1080	1580	103	118
60	1090	1590	1090	1590	104	119
61	1100	1600	1100	1600	105	120
62	1110	1610	1110	1610	106	119
63	1120	1620	1120	1620	107	118
64	1130	1630	1130	1630	108	117
65	1140	1640	1140	1640	109	116
66	1150	1650	1150	1650	110	115
67	1160	1660	1160	1660	111	114
68	1170	1670	1170	1670	112	113
69	1180	1680	1180	1680	113	112
70	1190	1690	1190	1690	114	111
71	1200	1700	1200	1700	115	110
72	1210	1710	1210	1710	116	109
73	1220	1720	1220	1720	117	108
74	1230	1730	1230	1730	118	107
75	1240	1740	1240	1740	119	106
76	1250	1750	1250	1750	120	105
77	1260	1760	1260	1760	119	104
78	1270	1770	1270	1770	118	103
79	1280	1780	1280	1780	117	102

80	1290	1790	1290	1790	116	101
81	1300	1800	1300	1800	115	100
82	1310	1810	1310	1810	114	99
83	1320	1820	1320	1820	113	98
84	1330	1830	1330	1830	112	97
85	1340	1840	1340	1840	111	96
86	1350	1850	1350	1850	110	95
87	1360	1860	1360	1860	109	94
88	1370	1870	1370	1870	108	93
89	1380	1880	1380	1880	107	92
90	1390	1890	1390	1890	106	91
91	1400	1900	1400	1900	105	90
92	1410	1910	1410	1910	104	89
93	1420	1920	1420	1920	103	88
94	1430	1930	1430	1930	102	87
95	1440	1940	1440	1940	101	86
96	1450	1950	1450	1950	100	85
97	1460	1960	1460	1960	99	84
98	1470	1970	1470	1970	98	83
99	1480	1980	1480	1980	97	82
100	1490	1990	1490	1990	96	81

Limitations:

1. **Weather Dependence**: The system's efficiency is highly dependent on weather conditions, such as sunlight availability. During cloudy or rainy days, the energy captured will be less, which may impact mobile charging capabilities.
2. **Initial Setup Complexity:** The initial setup and calibration of the system require precise alignment and configuration of components, which might be time-consuming. However, once properly set up, the system runs efficiently with minimal maintenance.
3. **Limited Battery Capacity:** The project utilizes a battery to store captured solar energy, and the capacity of this battery determines the duration for which it can charge mobile devices. While the current battery setup is sufficient for basic needs, expanding the storage capacity can further enhance the system's utility.

Future Scope:

1. **Enhanced Battery Storage:** Upgrading to batteries with higher capacity or integrating multiple batteries can significantly increase the energy storage capability, allowing the system to provide power for longer periods and support more devices.
2. **Scalability for Larger Systems:** Designing scalable versions of the project that can be used in larger solar farms or commercial applications can extend the benefits of dual-axis tracking to more significant energy needs, contributing to broader renewable energy adoption.
3. **Portable and Compact Designs:** Creating portable and compact versions of the dual-axis solar tracker can make it suitable for use in various settings, such as outdoor events, emergency situations, and off-grid locations, enhancing its versatility and accessibility.
4. **Improved Sensor Technology:** Upgrading to more sensitive and accurate sensors for detecting light intensity can improve the precision of the solar tracker, ensuring it aligns more accurately with the sun’s position.

Conclusion

Our dual axis solar tracker project represents a significant advancement in the efficient utilization of solar energy. One of the primary challenges addressed by this project is the frequent depletion of mobile phone batteries, especially in off-grid and remote areas where access to conventional power sources is limited. By leveraging the abundant and renewable energy from the sun, our system provides a sustainable and reliable power source that mitigates the reliance on non-renewable energy sources and reduces environmental impact. The dual axis tracking system ensures that the solar panel is continuously aligned with the sun, maximizing energy capture throughout the day. This dynamic adjustment significantly enhances the efficiency of solar energy generation compared to fixed solar panels. The integration of an Arduino Nano as the central controller allows for precise monitoring and control of the system. The LDRs provide real-time data on light intensity, enabling the Arduino to adjust the panel's orientation for optimal sunlight exposure. The inclusion of an LCD display offers users a convenient interface to monitor system performance, including light intensity readings and battery charge levels. The battery storage system further ensures that energy captured during peak sunlight hours can be used when sunlight is not available, providing continuous power availability. Overall, our dual axis solar tracker project not only addresses the immediate need for reliable mobile device charging in remote areas but also promotes the use of renewable energy sources. By optimizing solar energy capture and providing a practical solution for energy storage and utilization, this project underscores the potential of solar technology in creating sustainable and eco-friendly power solutions. Through this innovative approach, we aim to contribute to a greener future while enhancing the convenience and reliability of mobile device usage in off-grid environments.

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