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Design and Implementation of an Automated Solar Tracking System to Run Utility Systems at Minimal Loads During Load-Shedding by Charging Solar Batteries

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Abstract. An Automated Solar Tracker is a piece of equipment with solar panels that automatically follow the sun's path throughout the day. It makes sure that the panels get the most sunlight possible at all times. When a solar cell faces the sun, and the angle between its surface and its rays is 90 degrees, it makes the most power. Solar tracking makes it possible to get more energy out of the sun because the solar array can always face it. In this paper, a solar tracking system has been designed and built to collect energy from the sun, store it in a battery, and turn it into alternating current (AC) to power minimal utility systems during load-shedding. During this worldwide electricity crisis, this research aims to use as much solar energy as possible through solar panels and store it in batteries with the help of an inverter using the solar tracking system. Nearly 22% of the electricity in Bangladesh had produced by fuel oil- and diesel-powered plants, respectively. Since the price of diesel and fuel has gone up on the international market and many gas-powered power plant has limited gas, this has caused a lot of power outages. So, this research could help people in the middle class, the upper class, industries, or factories that need a backup power source. A servo motor, a pre-programmed Arduino ATMega 328, a Solar inverter, a Solar battery or Battery bank, LDR, 5V Converter, and some 10K resistors had used to build this prototype. Active LDR sensors always keep an eye on the light and move the panel to face the direction where the light is most vital. This research had done for low-power consumed types of equipment. It can use primarily in rural areas. Also, the efficiency of the power collected from the sun is improved using Automated STS (Solar Tracking System).

Keywords. Solar tracking system (STS), automation, solar panel, renewable energy, load-shedding, minimal load, LDR, Arduino.

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1. Introduction

The worldwide energy crisis that began in 2021 and continues to the present day is the most recent in a string of cyclical energy shortages experienced over the past fifty years. Countries like the United Kingdom, Germany, and China, amongst others, are feeling the effects of it more strongly than others. The oil, gas, and electricity markets are simultaneously experiencing the same crises [1]. People experienced flashes of the darkest period, when power outages were routine, as Bangladesh lurches into darkness due to power outages. Bangladesh was supposed to have put its dark past behind and to have enough power to meet demand after a period of rapid progress. What was formerly assumed to be a quick grid breakdown or technology fault is now the first indicator of an energy crisis. Many countries, including Bangladesh, have power and fuel shortages. Russia's recent invasion of Ukraine has increased energy prices for individuals and companies worldwide, affecting homes, industries, and entire economies — most badly in the poor globe [2]. With the Russian military buildup outside of Ukraine and the subsequent invasion, the energy supply that comes from Russia to Europe is now in jeopardy. As a result, European countries are diversifying their sources of energy imports [3]. During this moment of crisis, this research can be beneficial for running limited utility systems from the intensity of sunlight, a renewable source, by charging a battery as a backup power source. Sunlight, tides, wind, rain, and waves are all renewable energy sources. Solar energy comes from the sun. Solar energy has no limits. Solar energy is the cleanest and greenest type of electricity. The sun's power is 1.8x1011 MW, millions of times larger than world commercial energy use. It improves solar tracking. Solar Tracker follows the sun each day. Solar trackers boost the collector's solar energy and heat/electricity. Sunlighting, solar cells, and thermal arrays use solar trackers. Solar trackers enhance energy, efficiency, and output. This study aims to design an automated solar tracking system for charging a battery and power minimal-load utility systems. Solar Tracker is used for solar cells, thermal arrays, and daylighting. Solar panels are 19% efficient. Solar trackers increase productivity. Only the US and South Korea have used the new technology known as Solar Tracker. This initiative also did research for rural, low-cost, distant areas.

The remaining five parts have been arranged in reverse chronological order. The study's general literature review had presented in Section 2. Section 3 shows the methods, and section 4 concentrates on the entire working method and hardware implementation. Section 5 defines the research result and analysis briefly covered. Finally, Section 6 concludes by summarizing the results of this study.

2. Literature Review

On sophistication, prices, and performance. Heliostats are moveable mirrors that reflect the sun's position to a fixed place. Solar tracker accuracy varies with use. Concentrators, especially solar cell applications, require high accuracy to direct the concentrated sunlight to the powered device at the reflector's focal point or lens. Concentrator systems can't work without single-axis tracking [4]. Non-focusing applications require less accuracy and may work without tracking. However, tracking can boost a system's total output power during crucial demand hours (typically late afternoon in hot climes) [5]. Researchers have worked to improve solar panel energy generation. Double-sided panels [6], conversion phase improvement [7], building panel integration geometrically [8], etc.

Solar panels provide the most energy when angled toward the sun. Several researchers [9][10] created solar panel tracking devices. The main goal of this effort is to construct an Arduino-based solar panel tracker to boost solar panel energy production.

3. Methodology

This section describes how to build an Arduino-based horizontal single-axis solar tracker. It includes component specification, software design, and hardware design. This project tries to maximize solar panel use. A Solar Tracker is a gadget that tracks the sun's movements to ensure that solar panels receive maximum sunshine all day. Solar cells produce the most power when they face the sun at 90 degrees. With Maximum Electricity, the Solar panel charges the battery using a Solar inverter and provides load-shedding power. LDR1 & LDR2 had connected to Arduino's Analog pins. As illustrated in the diagram, a solar plate is parallel to the servo motor's axis, and both sensors are on it. The design and arrangement move the sun from LDR1 to LDR2 so the solar panel can collect optimum power to charge the battery and run the utility system using a solar inverter during a power outage.

3.1. Maximum Solar Power

Three cases must be followed to get maximum power from sunlight.

(1) **Case 1: Sun is on the left side:** Sun Light on LDR1 is high because the shadow of the barrier falls on LDR2, so the solar plate moves clockwise.

(2) **Case 2: Sun is on the right side:** Sun Light on LDR2 is high because the shadow of the barrier falls on LDR1, so the solar plate moves anticlockwise.

(3) **Case 3: Sun is in the Center**: Solar Light on both LDRs equal, so the plate will not rotate in any direction.

4. Working Procedure and Hardware Implementation:

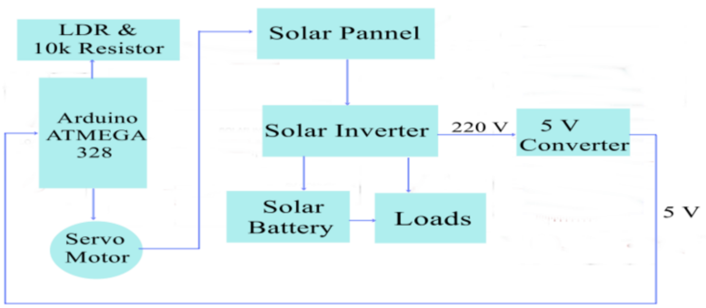

Figure 1. Block diagram of a working procedure for an Automated Solar Tracking System (STS) by Charging Batteries to Run Minimal Load on Utility Systems

First, a solar inverter is attached to a solar panel through an automated solar tracking system. It was done to enable the solar battery to be charged through the DC power generation by the solar panel in response to the amount of sunlight. Solar inverters can change DC electricity into AC and produce 220 V AC due to this conversion. It has two outputs: one is connected to a 5V constant converter, which transforms 220V AC into 5V constant DC to power the Arduino ATMega 328, and the other is attached to the loads, which are small loads that should be turned on during oad shedding or a power loss. The first output is connected to a 5V constant converter, which converts 220V AC into 5V continuous DC to power the Arduino ATMega 328. The board includes several components, including a servo motor, two 10K resistors, two LDR sensors, and an Arduino ATmega that has already been programmed. This configuration makes it feasible to rotate the solar panel to collect the maximum amount of solar energy possible. Because the solar inverter will deliver power to both the Arduino and the loads, the entire process will be able to be operated off of the power provided by the solar battery. The prototype for this project has been broken down into two parts: the hardware and the software. The results of the entire process are displayed in figure 1.

4.1. Hardware Implementation.

The Simulated design of the designed Prototype and Tested Implemented 10W Solar panel's Hardware Implementation had shown in figure 2 and figure 3.

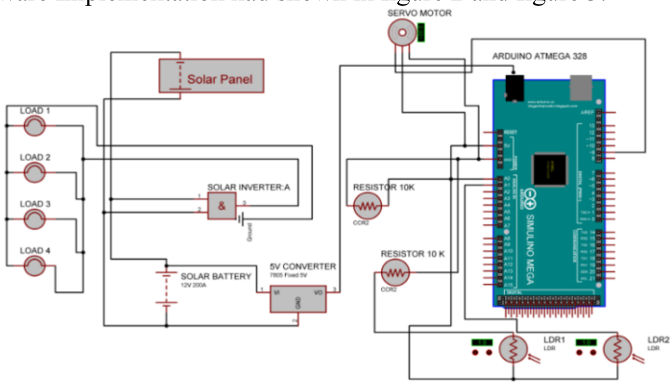

Figure 2. Simulated Design of an Automated Solar Tracking System (STS) by Charging Batteries to Run Minimal Load on Utility Systems

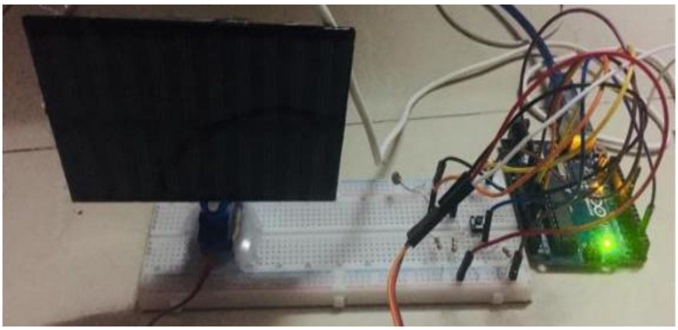

Figure 3. Implemented and Tested 10W Solar Panel Automated Solar Tracking System (STS) to Run at a Minimal Load by Charging Batteries

4.1.1. Specification of Components.

This section discusses the components used in this research.

(1) Arduino UNO: Arduino UNO uses ATmega328. It contains 14 digital I/O pins, six analog inputs, a USB connection, a power jack, an ICSP header, and a reset button.

(2) Solar Panel: A solar cell or a photovoltaic cell, is a type of electrical device that uses the physical and chemical phenomena known as the photovoltaic effect that converts the energy of sunlight into electricity.

(3) Servo Motor: Figure 3 shows a 4.8V to 6V servo motor used for testing. 5V at 40Hz is used commonly. Servo motors provide 45-degree and 90-degree angle control. When the duty ratio changes, the angle can be kept and rotated from 0 to 180 degrees.

(4) Light Dependent Resistor (LDR): Two light-dependent resistors (LDR) have been used to trace the synchronization of sunlight by detecting the brightness level of the sun.

(5) Solar battery: Solar batteries store the energy produced by photovoltaic panels in solar energy installations. Sometimes called sun batteries. Solar panels in an autonomous facility require a battery system to maintain constant power.

(6) Solar Inverter: A solar inverter turns the DC output of a PV solar panel into utility-frequency AC and charges the Solar battery.

(7) 5 V converter: Used for a continuous 5V supply.

4.2. Software-based Implementation.

In the software part, the code is constructed in C programming and inserted in Arduino IDE for the Automated Solar Tracking System shown in figure 4.

```
#include <Servo.h>      //including the library of servo motor
Servo sg90;
int initial_position = 90;
int LDR1 = A0;          //connect The LDR1 on Pin A0
int LDR2 = A1;          //Connect The LDR2 on pin A1
int error = 5;
int servopin=9;         //You can change servo just makesure its on arduino's PWM pin
void setup()
{

sg90.attach(servopin);
pinMode(LDR1, INPUT);
pinMode(LDR2, INPUT);
sg90.write(initial_position);   //Move servo at 90 degree
delay(2000);
}

void loop()
{
int R1 = analogRead(LDR1); // read  LDR 1
int R2 = analogRead(LDR2); // read  LDR 2
int diff1= abs(R1 - R2);
int diff2= abs(R2 - R1);

if((diff1 <= error) || (diff2 <= error)) {

} else {
if(R1 > R2)
{
initial_position = --initial_position;
}
if(R1 < R2)
{
initial_position = ++initial_position;
}
}
sg90.write(initial_position);
delay(100);
}
```

Figure 4. Software Code executed in Arduino IDE

5. Result and Analysis

A 12-hour test was done to determine the ideal time to use a 3KW 220V Solar Panel. table1. Hourly data. According to the Table 1., solar panels receive the most energy between 12:00 and 15:00.

Table 1. Data Sheet of Solar Power w.r.t Time for twelve hours.

Time	Power (KW)	Time	Power (KW)
6:00	0	12:00	2.45
7:00	0.5	13:00	2.66
8:00	0.9	14:00	2.7
9:00	1.05	15:00	2.66
10:00	1.55	16:00	2.45
11:00	2.12	17:00	2.05

6. Conclusion

Solar energy has no limits. Solar power must be boosted to alleviate the electricity crisis and provide future demand. An automatic solar tracker system is the best way to use this energy. This study shows a low-cost solar tracking device in action. Solar tracker modules improve solar energy harvesting. This tracker could increase solar energy extraction because it is more dependable and energy-efficient than traditional trackers. This research offered new and cutting-edge insights into renewable energy to support people, businesses, and factories that need at least minimal loads to operate when load-shedding for backup power is necessary.

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