Space-Based GPS Solar Tracking System

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Abstract. The pivotal focus of this study is to analyse solar tracing, a technique that uses global positioning system (GPS) technology to locate the sun's potentially hazardous scene and boost the power production of a PV panel. Using the encoded information, the microcontroller's navigation module can make an educated guess as to which way the bath is facing. The primary aim of the investigation is to improve efficiency and effectiveness in order to derive the greatest possible benefit from the gold standard. As this system is automatically managed and its parameters were approximated using less precise methodologies, it requires little maintenance. Solar tracers, which are controlled by solar gathering devices, are commonly used for this purpose. Several shortages in the renewable energy industry's labor force will be filled as businesses adapt to the new technologies. Because of this innovation, the PV plate and the accompanying technologies that work with it will be more productive than ever before. These mechanical devices, created by the solar celestials, will be used to predict the path of the sun's rays, monitor its radiation, and increase productivity. As a direct result of the computation and findings, it was decided that the mechanically controlled solar tracer is the most stable approach for having to boost photovoltaic efficiency with the PV tray. Maximum efficiency can be attained in both domestic and industrial settings with the help of this technology.

Keywords: Sun, tracing, GPS Module, Sun Tracing Method, Battery, Astronomical Equations, PV panel, tracing angle

1 Introduction

As fossil fuels degrade at an alarming rate, the demand for and consumption of energy will rise in the coming years. Hence, extracting energy from inexhaustible resources will fulfil humanity's entire energy requirements. Solar energy is the most widely accessible non-renewable resource, and because it is the most environmentally friendly energy source, it attracts the attention of budding engineers. The PV panel used in this technology absorbs the sun's light energy, which is then converted into electricity. As this technology keeps developing, it will help reduce carbon dioxide emissions. The irradiance of solar power frequently influences the adaptability and capability of PV panels. Concern for renewable energy sources has been constantly increasing

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because of current concerns about pollution of the air, water, and non-renewable resources like fossil fuels. As is well known, the purpose of this study is to increase efficiency and build the smallest, least expensive solar tracking system possible. The core goal of the research is to put into effect a project that uses trigonometric and mathematical procedures in line with the positional geometry of the sun to anticipate the apparent location of the sun. These kinds of devices stand out when compared to sensor-based tracers because they do not require a clear sky to record the sun's rays, are unaffected by additional light sources, which could also mislead the sensor when they are close by, and provide excellent accuracy. In this system, we suggest one that's more effective since it uses astronomical equations to track the location of the sun.

2 Literature Survey

2.1 A Single-gradient Sun ray Tracing Method and Monitoring Software

To improve the photovoltaic (PV) panels' energy production, a portable solar tracking system is applied in this paper. While this portable system records the highest solar radiation values, another important advancement is the development of a more effective solar tracking system. This leads to the proposal of a system that constantly records and analyses the generated voltage, solar irradiation value, and panel position. The improved control circuit constantly reads the voltage, actual panel direction, and irradiation data before sending it via Radio Frequency (RF) transmission to the values stored module attached to the desktop.

The desktop receives the information from the value accretion cards via the USB (Universal Serial Bus) transmission protocol. These data are kept track of via a computer screen and are also saved in a database. So, the suggested system can watch the retrospective irradiation and voltage data gathered through tracking system performance [8-16].

2.2 Execution of a Sun ray Tracing Method with GPS Kid Integration

By arises in the east and settling in the west, the sun casts light on the entire planet. A panel must face the sun directly throughout the day for optimal efficiency and output because direct sunlight produces the best results. The sun moves through the sky every day, so a solar tracking device was created to aim a solar panel directly at the sun. A solo gradient tracing controller method was used in its construction, and it tracks the sun using astronomical equations that use time, date, and location to determine the sun's position. The proposed system relies on an Arduino AT-mega 328P as its main part and is tasked with determining the current location of the sun using a real-time clock (RTC), a global positioning system (GPS) module, and a Solar location Algorithm (SPA). To correct for any discrepancy between the measured and calculated angles, the system also uses an accelerometer to regularly measure the panel's position. After being built, the device was tested by being used for 10 hours, and successful results were obtained [13].

3 Problem Statement

The demand for electrical energy is experiencing exponential growth. The contemporary power system utilises an extensive range of power sources. Scientists are endeavoring to enhance the effectiveness of the power network. Another aspect of this research that seeks to enhance the effectiveness of renewable electricity is the solar tracking system. Solar panels are ordinarily immovable and do not move with the sun. Due to this restriction, PV plates can only perform adequately when the sun is present, and as we all know, the penetration of illumination fluctuates or alters with the period of day. A sun light tracer system controls the sun's trajectory across the sky, aiming to continue the PV plate upright to the sun's beams, allowing the panel to absorb far more sunlight throughout the day.

4 System Implementation

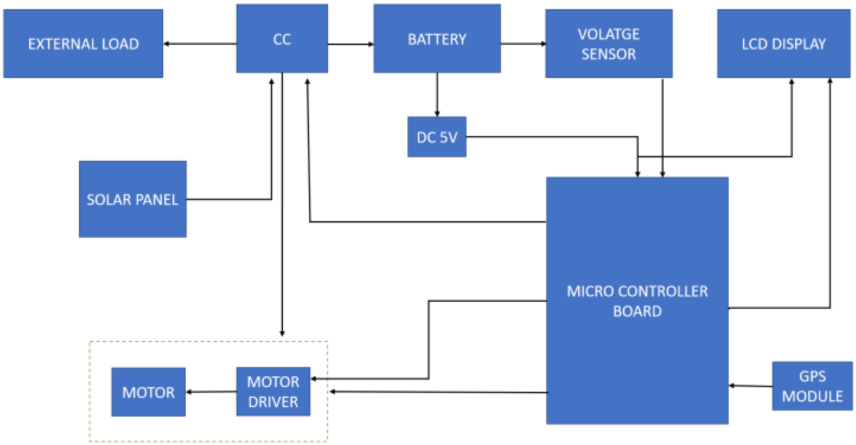

Fig.1. Block Diagram

Fig.1. shows the block diagram of the celestial tracer will first monitor the positioning and precise direction of the incoming sunlight as it rises. It is conceivable to monitor the whereabouts of the primary source using the GPS module in the tracer. The essential documentation was then gathered from the GPS module. The information currently being gleaned is sent to the microcontroller because it is aware of the location and the position. The microcontroller will then send the controlling signal to the motor driver, who will then drive the servo motor to rotate or tilt the mounted panel because these motors have continuing high torque and can move the panel at the desired angle.

The solar panel has been installed such that the driver of the motor may substantially move it into the horizontal position each time.

The microcontroller that is being implemented in the proposed system is one that accumulates many types of data, especially daytime and solar panel temperature estimations. Also, when we require displaying it, we may deploy an LCD screen to show the user of the system the information they need to know. Depending on the panel option, the PV panel that was originally installed will transition the solar energy that has been received into the requisite electrical energy. The essential components, namely potential and solar panel current are erratic in nature. In the interests of charging the battery, it is essential to preserve the potential by sustaining an ongoing input of electricity. A significant portion of this procedure takes place in buck boost synchronous generators. By leveraging the charge controller, it is feasible to avoid overcharging and deep discharge of the battery that is now being used, which will extend the battery's lifespan.

Whenever the voltage sensor is used properly, it will detect an indication of the potential difference and provide the perceived details to the microcontroller, which will then use it to create the proper indication for the charge controller to regulate the entire system. The different systems that are connected consume the electricity that is being powered. With the help of this technology, we can harness the sun's energy to its full potential and power a variety of residential and non-residential resources [1-7].

5 Elements used in this System

5.1 GPS Module

The important role of this module will be given the latitude and longitude of the location where the object is placed. As a time is on-board in this module, so time and date are necessary for the embedded controller for the finding of location. It has an intrinsic global coincident and all chronic serial recipient and vector. It is an extremely elastic serial transmission element. The embedded controller analyzes the getting value from the GPS. This controller has the capability to break by Rx transition and that is main for co-eval.

5.2 LDR (Light Dependent Resistors)

LDRs are very small illumination detecting component and it also known as photo resistors. An LDR is a type of control device whose resistance modifies as the quantity of luminance dropping on it modifies. The resistance of the LDR reduces with the improved in illumination depth. This resource permits us to use them for forming illumination detecting chip.

5.3 Resistor

Resistor is a non-resistant double end device. It is an electrical device which blocks the flow of current through the device. Dynamic resistors that can scatter high watts of power as a temperature perchance used as controller. It is opposite to conductor. Unit is ohm.

5.4 LCD (Liquid Crystal Display)

The instructor catalog stocks the requirement in the LCD. The information provides to the LCD to do a preset action like configure it, gladding its display, fix the pointer location, managing print etc. The memory buffer register stocks the value to be printed on the LCD. The value is the ASCII of the alphabets to be printed on the LCD. LCD attributes are limited by the microcontroller.

5.5 Arduino Uno

It is the foremost module for interfacing the device by coding. It is the most powerful module. It is an embedded controller device according to ATmega328.It has 14 inlet/outlet ports, 6 identical ports, a USB port, a reboot pin. It consists of all requirements that necessary for the controller; it linked to the desktop with USB. It is a unique device. It is cheap and maintenance free device. It very simple end comfortable for work.

5.6 Wi-Fi module (ESP 8266)

The ESP8266 is a less budget wireless semiconductor chip, with internal protocol internet program, and one-chip unit process, developed by ESP modules in Shanghai, China.

This tiny system permits one-chip unit to link to a Wi-Fi network and make easy proto correlations using Hayes-style procedures. However, at first, there was nearly no lexicon authentication on the chip and the procedures are welcomed. The cheap cost and the reality that there were little outer most elements on the system, which requested that it should be cheap in quantity, covered most spammers to survey the system, the port, and the program on it, in addition to express the Chinese authentication.

5.7 Motor Driver

This system needs a rotation of the motor to reach the High Power. It rotates based on the information. When it gets information of the sun’s direction it rotates according to the sun’s direction. Every pulse rotates the motor step by step. It is limited by the driver circuit. Driver circuit gives the pulses to the motor to rotate.

5.8 Charge controller

It is an electronic element that conducts the power to the storage device from the PV plate. It protects the storage device and it does not extremely charge during the morning time and that power does not return to the PV plate. Some of the controllers are high cost and more effective. It is under two types. They are MPPT and PMW.
PMW charge controller: In this type the PV plate is directly connected to the storage device.
MPPT charge controller: It calculate the maximum potential and modify it to the solar potential to the storage potential.

5.9 Battery

It is a storage device that transform chemical energy into electric energy. It assumes that conversion of negative ions from one substance to other through the circuit. It is an inception of power containing more voltaic cell with outer link for charging the devices. When contributing charge, its positive end is cathode and its negative end is anode. It stores power in the form of power. Power is the product of voltage and current. Normally storage device is a Direct Current.

5.10 Solar panel

It is used to transform the luminosity into electrical energy. Sunlight is the collection of light quanta. Cosmic sequence produce power in the morning which is utilized in dark time. The PV array Collects the Photons and transforms it into electrical energy and send that to the storage device through the charge controller as a direct current. Solo PV string generates only a small quantity of power. The panels are joined in chain like arrangement to get maximum potential. The Panels are joined in side-by-side arrangement to get maximum current.

6 PROTOTYPE

Figure.2.a) Prototype With & Without the Light

Figure.2.b) Prototype with LCD Display

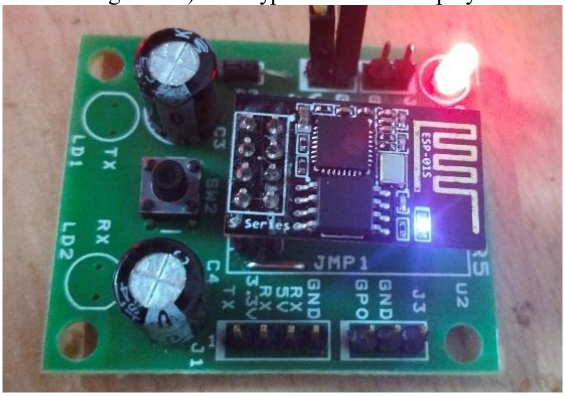

Figure. 2.c) Prototype with ESP8266 with Wi-Fi Module

A Subsection Sample The Figure. 2.a),b) and c) shows the prototype model of the proposed method. It clearly shows the prototype in working condition.

7 PROTOTYPE DESCRIPTION

The way our suggested model operates is to gather more electrical energy from all directions and determine the system's position. Utilizing LDR, a solar panel gathers solar energy, which is then transformed into electrical energy. For later use, the battery stores the electrical energy that has been gathered. For the 360-degree rotation in our suggested method, we used an MG995 Motor to achieve the highest efficiency. The GPS Module will pinpoint the location. The time, date, location, and electricity consumed are determined using astronomical equations. With the help of the Wi-Fi ESP8266 kid, the gathered values are displayed on the LCD I2C Display and stored in the cloud. The gathered information can be further examined. The information kept in the server in order to remember it for the future.

8 ASTRONOMICAL EQUATIONS WITH THE TRACING METHOD

These equations are referred from the reference [14]. The azimuth and the slope gradients of the ultimate source that is sun is estimated by the celestial mathematical computation. To reduce excessive power requirements, the earth's orbit is updated every minute in equations (1) and (2). By employing the direction, meridian, and time information that can be gathered from the Global positioning system solar tracer, these mathematical calculations are provided as the input data for calculating the location of the earth. The total count of the days is defined as 'TD' and it is computed using equations (1), (3) and (4)

$$TD = 367 \times A - ((4+3) \times A + ((B + (3+3)) / (4*3)))) / 4 + ((137.5*2) \times B) / 9 + D - 730530 \quad (1)$$

where A, B and D represents data in terms of year, month and year which is been derived by the PNT system.

Orbital inclination "r," slope from ascending node "n," mean variance "B," mean length "k," erratic enigma "O," and declination "a" are obtained by the (2), (3),(4),(5),(6) and (7)

$$r = 0.016709 - (1.151 \times 10^{-9} \times d) \quad (2)$$

$$n = 282.9404 + (4.70935 \times 10^{-5} \times d) \quad (3)$$

$$B = 356.0470 + (0.9856002585 \times d) \quad (4)$$

$$k = B + n \quad (5)$$

$$O = B + [(180/\pi) \times r \times sine(B) \times (1 + e \times cosine(B))] \quad (6)$$

$$\alpha = 23.4393 - (3.563 \times 10^{-7} \times d) \quad (7)$$

The rectangular coordinates 'x' and 'y' for an ecliptic coordinate is computed using the equations (8) and (9)

Equation (10) estimates the real variance (Q), while equations (11), (12), (5), and (6) determine the cosmic inclination (P) and the distance (V) necessary to compute it (7)

$$x = cos(E) - r \quad (8)$$

$$y = sin(E) \times \sqrt{1 - r^2} \quad (9)$$

$$Q = tan^{-1}\left(\frac{y}{x}\right) \quad (10)$$

$$V = \sqrt{x^2 + y^2} \quad (11)$$

$$P = Q + n \quad (12)$$

The right-angle meridian coordinates are transformed to the central equator coordinates using the equations (13) and (8)

$$x_{equat} = r \times cosine(P)$$

$$y_{equat} = (r \times cosine(P)) \times cosine(\alpha) \quad (13)$$

$$z_{equat} = (r \times cosine(P)) \times sine(\alpha)$$

RR that is Right Rise and DMS that is Declination of the Main Source is estimated by using the equations (14) and (15)

$$RR = tan^{-1}\left(\frac{y_{equat}}{x_{equat}}\right) \quad (14)$$

$$DMS = tan^{-1}\left(\frac{z_{equat}}{\sqrt{x_{equat}^2 + y_{equat}^2}}\right) \quad (15)$$

The GST which is Global Surface Temperature and the Sidereal is been defined by the equations (16) and the equation (17). The hour angle (ha) id estimated by using the equation (18).

$$Global\ Surface\ Temperature = L/15 + 12 \quad (16)$$

Sidereal =Global Surface Temperature +TU+LN/15 (17)

TIME =Sidereal– RR (18)

The equations (19), (20), and provide the z-axis alteration in the orientation of the apex (21). The degree of the celestial tracer is specified by the parameter's latitude in equations (19), (20), and (21).

$x_{hor=}$ (cosine(TIME) × cos(DMS) × sine(latitude))— (sine(DMS) × cosine(latitude)) (19)

$y_{hor=}$ (sine(TIME) × cosine (DMS)) (20)

$z_{hor=}$(cosine(TIME)×cosine(DMS)×cosine(latitude))—(sine(DMS)×sin(latitude)) (21)

Finally, the azimuth and the gradient of the sun are estimated using the equations (22) and (23)

$$azimuth = (tan^{-1}\frac{y_{hor}}{x_{hor}}) - 180 \quad (22)$$

$$Gradient = sin^{-1}(z_{hor}) \quad (23)$$

8.1 Theory of Tracking

These formulae are based on the source [3]. Based on astronomical equations, a device is suggested that tracks the sun's position. The most crucial element of the solar tracing method became these equations for better management and computational purposes. When compared to the published astronomical tables, the majority of the equations discussed in this section are presented in various formats with varying degrees of accuracy. Declination Angle (24) and the Equation of the Time (ET), which is described in equations (25) and (26), are the two usual variations for these equations for the effective tracing on the sun's location. (27).

8.2 Algorithmic Calculations

- *Tilt of Inclination*

δ(n)=19.0986E10 {(6918*1000000) – (399912*1000000) cosine(i) + (1000000*70257)sine(i) – 0.006758 cosine(2*i) + 0.000907 sine($2 * i$) – (2697*100000)cosine($3 * i$) + 0.001480 sine($3 * i$)} (24)

Where the i is the day gradient in terms of gradient, as it is expressed in, $i = 2 * pi$(n-1)/total no. of days in a year

- *Time Equation*

TE(n) =(114.59)*{(75*1000000) + 0.001868 cosine(i) – 0.032077 sine(i) – 0.014615 cosine($2i$) – 0.04089 cosine($2i$) (25)

Where the i is the day gradient in terms of gradient, as it is expressed in, $i = 2 * pi$(n-1)/Total no. of days in a year

- *O'clock Inclination, OI*

OI = ± (Minutes from local solar noon)/4 (26)

- *Dawn and Dusk Time*

The phrase "HRS" describes the amount of time between local noon and dawn.

The phrase"HSS", which represents for the duration from local noon till sunset,

HSS= - HRS = acosine (- tan (K) tan (δ))/15 (27)

Regional noon Time = 12.00 – ET(minute)/60 (28)

Dawn Time = Local noon Time – HRS (29)

Dusk Time = Local noon Time + HSS (30)

Day Length = 2 HSS (31)

8.3 Tracing Angle

There are two main variations of equations which describe the gradient of the dual axis which includes Tilt Angle and the Polar Angle

Regional Time = Greenwich Mean Time + Longitude height /15 (32)

Tilt Angle = (30+30+30) – Absolute (K - δ) (33)

Polar Angle = (30+30+30) – (Regional noon Time – Regional Time)/4 (34)

Normally these equations follow the STTA and the SPTA, where

STTA – Starting Tracking Angle,

STTA= PA (Sunrise + Hold Time) (35)

SPTA – Stop Tracking Angle

SPTA = Polar Angle(Dawn – Hold Time) (36)

Hold Time is defined as the chosen time which is used to hold the tracing after the sunset where the sun's irradiance is normally low at this time. The predictor factors of time, date, and place regularly have the greatest influence on the location of the sun. As a result of these various parameter elements, it is feasible to figure out where on the globe the sun will be. Inevitably, these elements pinpoint the sun's precise location.

9 COMPARISON WITH THE EXSISTING AND PROPOSED SYSTEM

SI.NO	EXSISTING SYSTEM	PROPOSED SYSTEM
1	No Cleaning System	Presence of Automatic Cleaning Indication
2	Single / Dual axis	Both Single and Dual Axis
3	Used only in large land areas	Can accommodate even in roofs of house

10 Conclusion

In conclusion, it is abundantly obvious that the system contributes significantly to generating the greatest amount of solar energy from sunrise to dawn. In this paper, we suggest a method for tracking the sun using an embedded microprocessor system and an algorithm that makes use of astronomical equations to predict the sun's location. The application on the different sites is extremely important to the tracking accuracy and requirement. The generation of the sun's trajectory path is successfully acquired, and this control system has been calculated successfully. Also, this tracker has the ability to move the PV panel back to its original location.

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