A PROJECT REPORT ON

SOLAR PANEL WITH SUN POSITION TRACKING

Submitted in partial fulfillment of the requirements for the award of

Bachelor of Engineering degree in Electronics and

Communication Engineering

By

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SATHYABAMA INSTITIUTE OF SCIENCE AND TECHNOLOGY

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **K. SAI CHANDANA (38130101)**, **U.NEERAJA LAKSHMI (38130227)** who carried out the Project entitled "**Solar panel with sun position tracking**". Under the guidance of Dr.G.SUNDARI, during the period NOVEMBER 2021 to MAY 2022.

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SOLAR PANEL WITH SUN POSITION TRACKING

ABSTRACT

Solar energy is rapidly advancing as an important means of renewable energy resource. Solar tracking enables more solar energy to be generated because the solar panel is able to maintain a perpendicular profile to the sun's rays. Though initial cost of setting up a solar tracking system is high, this paper proposes a cheaper solution.

Design and construction of a prototype for solar tracking system with single degree of freedom, which detects the sunlight using Light Dependent Resistors (LDR), is discussed in this paper.

The control circuit for the solar tracker is based on an Node MCU microcontroller. This is programmed to detect the sunlight through the LDRs and then actuate the servo motor to position the solar panel where it can receive maximum sunlight. Compared with any other type of motor, the servo motor is more controllable, more energy efficient, more steady and has high tracking accuracy and suffers little environmental effect.

Theoretical analysis and research results have been shown in this paper to advocate that the designed system realized precise automatic tracking of the sun and can greatly improve the utilization of solar energy.

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CHAPTER 1: INTRODUCTION

Bustling civilization is the vein through which modern civilization is operated. Energy day by day is put to use at its best to fulfil the desires and ambition of the peoples at large. Each and every corner of our life is caged with various layers of impediment and in this response, energy is becoming an indispensable factor. Therefore, the source of energy needs to be endless/ perpetual in order to carry this colossal population ahead. Human beings being evolutionary in nature are perhaps the best ever creation of nature is always in the race of envisaging the probable and available comforts and benefits in every possible angle in this perilous world. The evidential matrix manifests that in a dichotomy of various opinions what options best expedite the scarcity of energy in an immensely heterogeneous society like ours. Our motto is to endeavour in forwarding such noble goal of energy conservation.

Taking a look at the present scenario it is evident that conventional sources of energy such as coal, natural gas, oil, etc. are at the edge of extinction. Being in mortal combat with time itself to fulfil every demand for energy the demand for these resources for energy has escalated to its zenith. The conventional use of energies due to the burning of fossil fuels like coal, oil and natural gas, the whole environment is getting polluted. The present project, therefore, is orchestrated with components like LDR module, Servo Motor, Photovoltaic array etc. according to which while the functioning of, unlike other use of the conventional energies, would not emit any pollution and inturn act as a reservoir of energy taken from the Sun itself. As adumbrated no other energy is more abundant than solar energy as per as its availability and freeness are concerned, utilization of which, compounded with rest of the fact of its conversion into electrical energy. Historically if counted, in the year 1881 for the first time ever solar panel was invented. Later on, all through the hands of Russell Ohl in the year, 1941 concept of the solar cell was conceived and subsequently workability of a solar panel has also advanced in comparison with the earlier span. Though it is improbable still it is not impossible as per as tracking of the mother energy is concerned in furtherance to which attempt has been taken through this project to confine every drop of energy from being left out. The Servo Motor adjacent with the system with the help of LDR module by measuring the intensity of the sun rays fixed on the upper edge of the solar panel will help the solar panel to revolve around proportionately with the movement of the Sun itself in order to grab and store the maximum amount of energy as it can. In pursuance of such objectivity, this project comes forth into existence.

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 ripples of hope in the midst of this bustling civilization. The survivability of this system lies upon its workability. In the trend of comparison with other mind-boggling systems, it could be a trailblazer.

CHAPTER 2: LITERATURE REVIEW

The paucity of available resources has forced contemporary society to look for measures to consummate the demands of the latter. With the nurturing civilization, the depletion of conventional fuels, due to human practices has been an alarm to sustainable development issues. The scarcity of energy and its source guided us towards the optimistic approach of using the alternative resources bestowed to humankind–Solar, tidal etc.

The Sun has been looked upon as an imperative source of energy. Solar energy is an eco-friendlyresource as compared to its counterparts. The advancement of technology has out-turn foster techniques to utilize this energy into its own good use. Be it as thermal energy, electricity, fuel production and many more. Photovoltaic or concentrated solar power (CSP) systems are operated to transfigure the solar power expropriated by the earth into electricity. Solar tracking device utilizes this expropriated solar power through the channel of photovoltaic arrays, an oriented scaffolding of photovoltaic/solar cells.[1]

Solar cells, also known as photovoltaic cells are used to convert light energy into electricity. Photovoltaic cells work on the principle of the photovoltaic effect, which is similar to the photoelectric effect. Differences being that the electrons in photovoltaic are not emitted instead contained in the material around the surface, creating a voltage difference. Solar cells are forged with crystalline silicon. It is the most commonly used material in a solar cell. The use of silicon inthe solar cell has been very efficient and low cost. Two forms of crystalline silicon can be used tomake solar cells. Other than silicon, solar cells can be fabricated with cadmium telluride (CdTe), Copper indium gallium (di)selenide (CIGS) etc. the fabrication of solar cells with materials othersilicon is slightly expensive, thus making silicon the best material to be used in solar tracking systems.[2]

One of the finest and extensively used material, monocrystalline silicon has an efficiency of about15-20%. While under high temperature the performance of the cell material drops by 10-15% of the initial.

Polycrystalline silicon is another form, cheaper than the latter but has the same band gap as that of monocrystalline silicon. Though it has the same band gap energy, it lags in efficiency, hence this material is used in low-cost products.

Amorphous silicon cells can work under extremely high temperatures, but the efficiency of thesecells is comparatively lower than the other silicon forms. [3]

The technologies which use CdTe, CIGS, Amorphous Thin-Film Silicon (a-Si, TF-Si) in the fabrication of solar cells are known as thin film photovoltaic modules. These thin-film solar cellsare relatively cost-effective than the solar cells of crystalline silicon. [4]

Table 1:Types of Solar cell based upon the material:

Cell Technology	**Crystalline Silicon**	**Thin Film Silicon**
Types	• Mono-crystalline silicon (c-Si) • Poly-crystalline silicon(pc-Si/ mc-Si)	• Amorphous Silicon (a-Si) • Cadmium telluride (CdTe) • Copper indium gallium(di)selenide (CIG/CIGS)
Temperature resistivity	Lower	Higher
Module Efficiency	13-19%	4-12%

There are several other factors on which the efficiency of a solar cell depends.

- Cell temperature
- Energy Conversion Efficiency
- Maximum power point tracking [5]

Solar panels are a cumulative orientation of photovoltaic cells. The PV cells are arranged in a solar panel or a PV array such that is serves the purpose of exciting the electron of the material consisting inside the solar cells using photons. The average amount of sunlight received by solar panels particular depends on the position of the sun. [6]

Being a repository of energies, Sun witnessed to be the eminent and ever continuing source of emitting radiation from it. A part of this source of natural energy is received by the solar panel. Certain ways have been developed to utilize this energy source as an alternative to other non- renewable sources. Considering its multitudinous flourishing ways in which it can be applied to bring about the change in conserving other resources, the manipulation of the energy source is encouraged. [7]

Solar panels are hence used to utilize solar power in electrical means. They are aligned different arenas to collect maximum solar power. Though, solar panels can be used to absorb or collect solar power, there work is bounded to certain hours of the day and the sunlight pouring directly on them, i.e. the angle between the sunrays and the panel is orthogonal. While at other hours of the day, theangle of the sunrays is different, hence the amount of the solar power captured is very less.

To overcome such pitfalls, and encapsulate the maximum available of solar energy the solar tracking systems were introduced. A solar tracking system is designed with the intention of keeping the angle between the sunrays and the solar array 90°. The solar tracking system have three different modules-

- The mechanism
- Driving motors
- The tracking controller.

CHAPTER 3:OVERVIEW OF EMBEDDED SYSTEMS

3.1 Overview of embedded systems

An embedded system is a special-purpose computer system designed to perform one or a few dedicated functions, often with real-time computing constraints. It is usually embedded as part of a complete device including hardware and mechanical parts. In contrast, a general-purpose computer, such as a personal computer, can do many different tasks depending on programming. Embedded systems have become very important today as they control many of the common devices we use.

Since the embedded system is dedicated to specific tasks, design engineers can optimize it, reducing the size and cost of the product, or increasing the reliability and performance. Some embedded systems are mass-produced, benefiting from economies of scale.

Physically, embedded systems range from portable devices such as digital watches and MP3 players, to large stationary installations like traffic lights, factory controllers, or the systems controlling nuclear power plants. Complexity varies from low, with a single microcontroller chip, to very high with multiple units, peripherals and networks mounted inside a large chassis or enclosure.

In general, "embedded system" is not an exactly defined term, as many systems have some element of programmability. For example, Handheld computers share some elements with embedded systems — such as the operating systems and microprocessors which power them — but are not truly embedded systems, because they allow different applications to be loaded and peripherals to be connected.

Embedded systems provide several functions

- Monitor the environment; embedded systems read data from input sensors. This data is then processed and the results displayed in some format to a user or users
- Control the environment; embedded systems generate and transmit commands for actuators.
- Transform the information; embedded systems transform the data collected in some meaningful way, such as data compression/decompression

Although interaction with the external world via sensors and actuators is an important aspect of embedded systems, these systems also provide functionality specific to their applications. Embedded systems typically execute applications such as control laws, finite state machines, and signal processing algorithms. These systems must also detect and react to faults in both the internal computing environment as well as the surrounding electromechanical systems.

There are many categories of embedded systems, from communication devices to home appliances to control systems. Examples include;

3.2 Block diagram of an embedded system:

An embedded system usually contains an embedded processor. Many appliances that have a digital interface -- microwaves, VCRs, cars -- utilize embedded systems. Some embedded systems include an operating system. Others are very specialized resulting in the entire logic being implemented as a single program. These systems are embedded into some device for some specific purpose other than to provide general purpose computing . A typical embedded system is shown in Fig 1

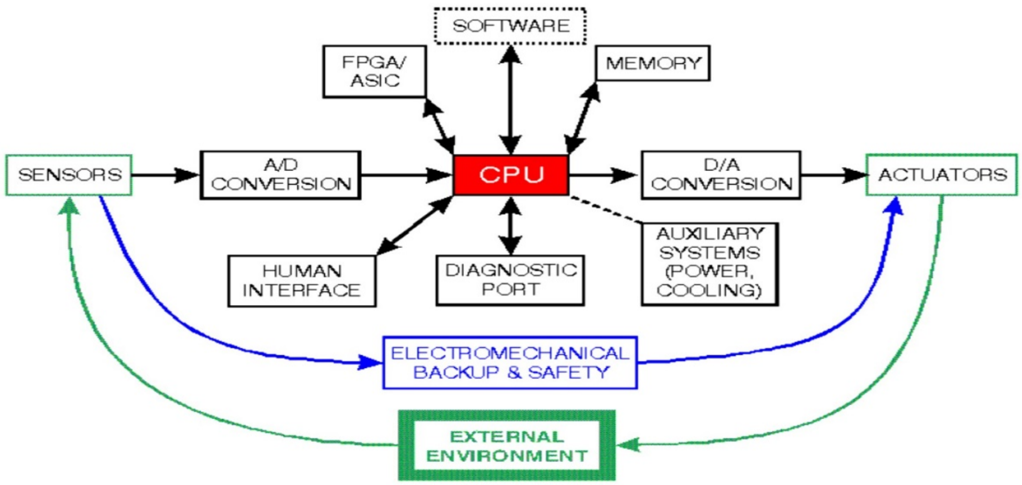

Fig -1 Block diagram of a typical embedded system

CHAPTER 4: MATERIALS AND METHODOLOGY

4.1 EXPERIMENTAL MATERIALS:

- Node MCU
- Solar panel
- LDR
- Servo motor

4.1.1 NODE MCU :

Node MCU is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Expressive Systems, and hardware which is based on the ESP-12 module. The term "Node MCU" by default refers to the firmware rather than the development kits. The firmware uses the Lua scripting language. It is based on the eLua project, and built on the Expressive Non-OS SDK for ESP8266.

Node MCU was created shortly after the ESP8266 came out. On December 30, 2013, Expressive Systems began production of the ESP8266. The ESP8266 is a Wi-Fi SoC integrated with a Tensilica Xtensa LX106 core, widely used in IoT applications (see related projects). Node MCU started on 13 Oct 2014, when Hong committed the first file of node mcu-firmware to GitHub. Two months later, the project expanded to include an open-hardware platform when developer Huang R committed the Gerber file of an ESP8266 board, named devkit v0.9. Later that month, Tuan PM ported MQTT client library from Contiki to the ESP8266 SoC platform, and committed to Node MCU project, then Node MCU was able to support the MQTT IoT protocol, using Lua to access the MQTT broker. Another important update was made on 30 Jan 2015, when Devsaurus ported the u8glib to Node MCU project, enabling Node MCU to easily drive LCD, Screen, OLED, even VGA displays.

How to start with Node MCU?

Node MCU Development board is featured with Wi-Fi capability, analog pin, digital pins and serial communication protocols. To get start with using Node MCU for IoT applications first we need to know about how to write/download Node MCU firmware in Node MCU Development Boards. And before that where this Node MCU firmware will get as per our requirement. There is online Node MCU custom builds available using which we can easily get our custom Node MCU firmware as per our requirement. To know more about how to build custom Node MCU firmware online and download it refer getting started with Node MCU

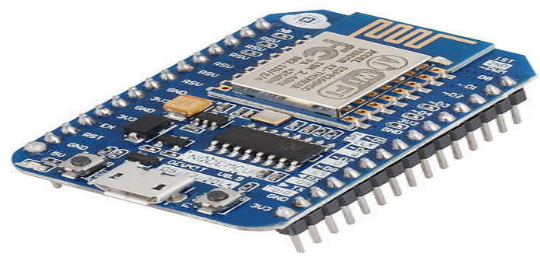

Fig-2: Node MCU

How to write codes for Node MCU?

After setting up ESP8266 with Node-MCU firmware, let's see the IDE (Integrated Development Environment) required for development of Node MCU.

Node MCU with ESPlorer IDE:

Lua scripts are generally used to code the Node MCU. Lua is an open source, lightweight, embeddable scripting language built on top of C programming language. For more information about how to write Lua script for Node MCU refer getting started with Node MCU using ESPlorerIDE. That's the reason why Node MCU not accept further Lua scripts/code after it is getting flashed by Arduino IDE. After getting flashed by Arduino sketch/code it will be no more Lua interpreter and we got error if we try to upload Lua scripts. To again start with Lua script, we need to flash it with Node MCU firmware. Since Arduino IDE compile and upload/writes complete firmware, it takes more time than ESPlorer IDE.

4.1.2 Solar panel:

The term solar panel is used colloquially for a photo-voltaic (PV) module.

A PV module is an assembly of photo-voltaic cells mounted in a framework for installation. Photo-voltaic cells use sunlight as a source of energy and generate direct current electricity. A collection of PV modules is called a PV Panel, and a system of Panels is an Array. Arrays of a photovoltaic system supply solar electricity to electrical equipment.

4.1.3 LDR- LIGHT DEPENDENT RESISTOR:

What is a Light Dependent Resistor or a Photo Resistor?

A **Light Dependent Resistor** (LDR) or a photo resistor is a device whose resistivity is a function of the incident electromagnetic radiation. Hence, they are light sensitive devices. They are also called as photo conductors, photo conductive cells or simply photocells. They are made up of semiconductor materials having high resistance. There are many different symbols used to indicate a **LDR**, one of the most commonly used symbol is shown in the figure below. The arrow indicates light falling on it.

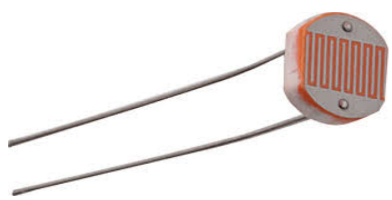

Fig-3: LDR

Working Principle of LDR:

A **light dependent resistor** works on the principle of photo conductivity. Photo conductivity is an optical phenomenon in which the materials conductivity (Hence resistivity) reduces when light is absorbed by the material. When light falls i.e. when the photons fall on the device, the electrons in the valence band of the semiconductor material are excited to the conduction band. These photons in the incident light should have energy greater than the band gap of the semiconductor material to make the electrons jump from the valence band to the conduction band. Hence when light having enough energy is incident on the device more & more electrons are excited to the conduction band which results in large number of charge carriers. The result of this process is more and more current starts flowing and hence it is said that the resistance of the device has decreased. This is the most common **working principle of LDR.**

Characteristics of LDR:

LDR's are light dependent devices whose resistance decreases when light falls on them and increases in the dark. When a **light dependent resistor** is kept in dark, its resistance is very high. This resistance is called as dark resistance. It can be as high as 1012 Ω. And if the device is allowed to absorb light its resistance will decrease drastically. If a constant voltage is applied to it and intensity of light is increased the current starts increasing. Figure below shows resistance vs. illumination curve for a particular **LDR**. Photocells or LDR’s are non linear devices. There sensitivity varies with the wavelength of light incident on them. Some photocells might not at all response to a certain range of wavelengths. Based on the material used different cells have different spectral response curves.

Applications of LDR:

LDR’s have low cost and simple structure. They are often used as light sensors. They are used when there is a need to detect absences or presences of light like in a camera light meter. Used in street lamps, alarm clock, burglar alarm circuits, light intensity meters, for counting the packages moving on a conveyor belt, etc.

4.1.4 SERVO MOTOR:

A **servomechanism**, or **servo**, is an automatic device that uses error-sensing negative feedback to correct the performance of a mechanism. The term correctly applies only to systems where the feedback or error-correction signals help control mechanical position or other parameters. For example, the car's cruise control uses closed loop feedback, which classifies it as a servomechanism.

RC servos are hobbyist remote control devices servos typically employed in radio-controlled models, where they are used to provide actuation for various mechanical systems. Due to their affordability, reliability, and simplicity of control by microprocessors, RC servos are often used in small-scale robotics applications. RC servos are composed of an electric motor mechanically linked to a potentiometer. A standard RC receiver sends Pulse-width modulation (PWM) signals to the servo. The electronics inside the servo translate the width of the pulse into a position. When the servo is commanded to rotate, the motor is powered until the potentiometer reaches the value corresponding to the commanded position.

RC servos use a three-pin 0.1" spacing jack (female) which mates to standard 0.025" square pins (which should be gold-plated, incidentally). The most common order is Signal, +voltage, ground. The standard voltage is 6VDC, however 4.8V and 12V has also been seen for a few servos. The control signal is a digital PWM signal with a 50Hz frame rate. Within each 20ms timeframe, an active-high digital pulse controls the position. The pulse nominally ranges from

1.0ms to 2.0ms with 1.5ms always being center of range. Pulse widths outside this range can be used for "over travel" -moving the servo beyond its normal range. This PWM signal is sometimes (incorrectly) called Pulse Position Modulation (PPM). The servo is controlled by three wires: ground, power, and control. The servo will move based on the pulses sent over the control wire, which set the angle of the actuator arm. The servo expects a pulse every 20 ms in order to gain correct information about the angle. The width of the servo pulse dictates the range of the servo's angular motion.

A servo pulse of 1.5 ms width will typically set the servo to its "neutral" position or 45°, a pulse of 1.25 ms could set it to 0° and a pulse of 1.75 ms to 90°. The physical limits and timings of the servo hardware varies between brands and models, but a general servo's angular motion will travel somewhere in the range of 90° - 120° and the neutral position is almost always at 1.5 ms. This is the "standard pulse servo mode" used by all hobby analog servos.

RC servos are usually powered by the receiver which in turn is powered by battery packs or an Electronic speed controller (ESC) with an integrated or a separate Battery eliminator circuit (BEC). Common battery packs are either Ni-Cd, NiMH or lithium-ion polymer battery (Li-Po) type. Voltage ratings vary, but most receivers are operated at 5 V or 6 V.

4.2 BLOCK DIAGRAM:

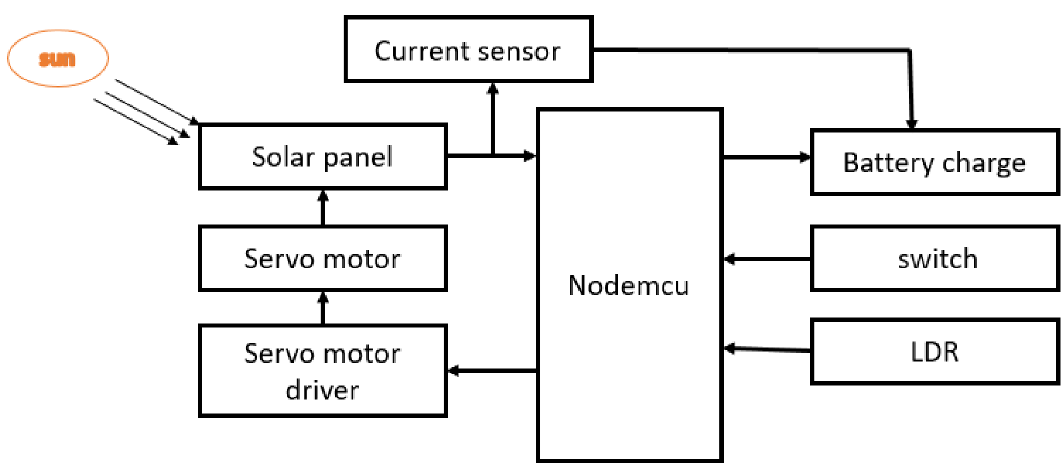

Fig-4 Block diagram

4.3 METHODOLOGY:

4.3.1 THEORY OF USING TWO LDR:

4.3.1.1 Concept of using Two LDR:

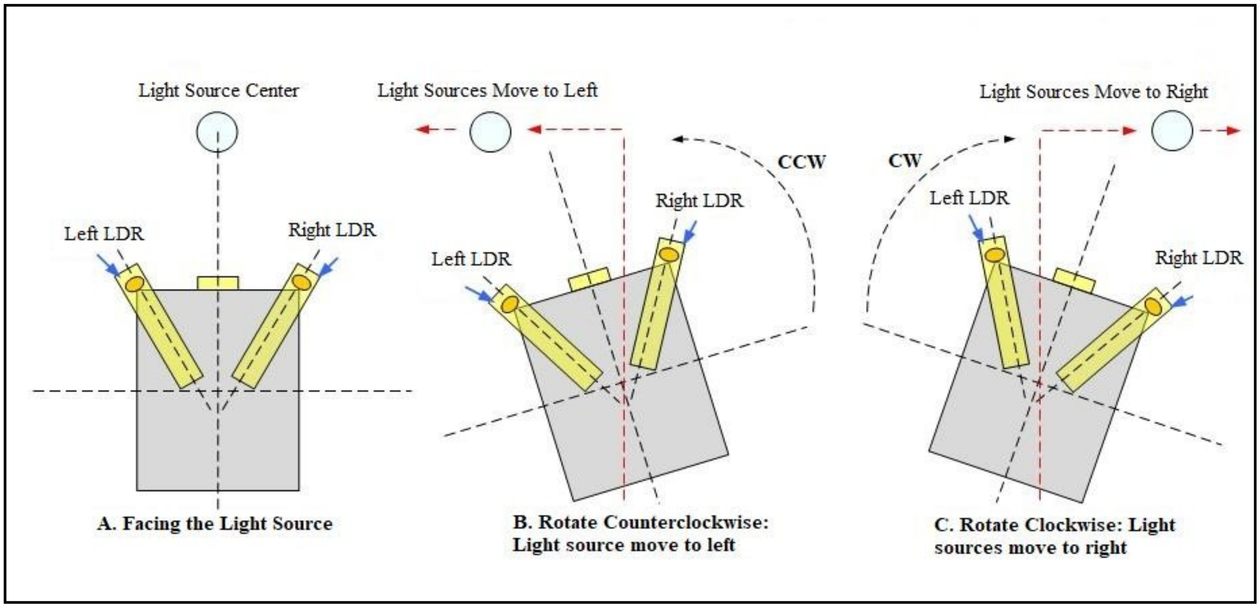

Fig-5 Moving of light source using two LDR’s

The figure(Fig-2) depicts the notion for the instalment of the light dependent resistors (LDR). A secure state is attained when the light intensities of the two LDR become the same. The principal sourceof light energy, the Sun, moves from east to west. This movement of the Sun causes the variationin the level of light intensities falling on the two LDRs. The designed algorithm compares the variation in the light intensities inside the microcontroller and the motor then is operated to rotatethe solar panel, so it moves aligned with the trail of the light source.

4.3.2 THEORITICAL BACKGROUND OF SOLARTRACKER:

4.3.2.1 The Earth-Rotation and Revolution:

Rotation, the position of the sun changes continuously throughout the day. It is due to the motion of earth that we experience sun at different angles in the sky. Earth exhibit two types of motion. One is the motion of earth along its own axis, and the other is the earth revolving around the sun. the motion of the earth along its own axis, known as **rotation**, results in the phenomenon of days and nights. One rotation of the earth takes 23 hours and 56 minutes. On its own axis, the motion of the earth is west to east.

Revolution, that is the motion of the earth around the sun is responsible for the different seasons in the year. The earth takes 365 days to revolve around the sun. Earth revolves around the sun in an elliptical orbit and the plane covered by the earth during the revolution is known as an ellipsis. The axis of rotation and ellipsis makes an angle of 66.5 degrees between themselves. This is the explanation behind the summer/winter solaces and spring autumn equinoxes. Due to these motions of the earth, the amount of sunlight received throughout the year varies. Sunlight is the electromagnetic radiation from the sun expropriated by the earth. The total power given off by the sun into space is much more than that intercepted by the earth.

The absorption of solar radiation on the surface of the earth also varies with different parameters. Latitude and longitude are one of the prescribed parameters. Latitude the horizontal imaginary line, parallel to the equator, is the angle suspended by the arc linearly join a person's position and the equator, at the center of the earth. On the contrary longitudes are the vertical imaginary lines, where longitude is the angle suspended by the arc joining the north-pole and south-pole as well as passing through the given location, linearly with the Greenwich meridian, at the center of the earth. The latitude and longitude express north-south and east-west directions respectively on the earth.

The sunlight is observed at different angles depending on the place on the earth and the angles ofthe sun. The sun's angle can be classified into the following: -

- Elevation Angle
- Zenith Angle
- Azimuth Angle

The elevation angle is the angle made by the sun with the horizon. The elevation angle is 0 degree at sunrise and 90 degrees around noontime, at the equator. The elevation angle is different at a different time of the day and different for different latitudes. The depicted formula can be used todetermine the elevation angle.

$$\alpha = 90 + \varphi - \delta$$

When the equation above gives a number greater than 90° then subtract the result from 180°. It means the sun at solar noon is coming from the south as is typical the northern hemisphere.

φ is the latitude of the location of interest (+ve for the northern hemisphere and −ve for the southern hemisphere). δ is the declination angle, which depends on the day of the year.

Zenith angle is akin with elevation angle. The only difference being it is measured along the vertical. Therefore, it's the angle between the sun and the vertical i.e. Zenith Angle = 90° – elevation angle.

$$\zeta = 90° - \alpha$$

Azimuthal Angle, this is the compass direction from which the sunlight is coming. At solar noon, the sun is directly south in the northern hemisphere and directly north in the southern hemisphere. The azimuth angle varies throughout the day. At the equinoxes, the sun rises directly east and sets directly west regardless of the latitude. Therefore, the azimuth angles are 90 degrees at sunrise and 270 degrees at sunset.

Sunrise and Sunset time can be formulated by the following formulas-

$$\text{Sunrise} = 12 - \frac{1}{15°}\cos^{-1}(-\tan\varphi \tan\delta) - \frac{TC}{60}$$

$$\text{Sunset} = 12 + \frac{1}{15°}$$

$\cos^{-1}(-\tan\varphi \tan\delta)$

$- TC$

60 —

Where φ being the latitude of the place, δ being the declination angle and TC is the TimeCorrection.

4.3.2.2 -Table 2:Types of Solar Tracker:

Type	Specification
Active Solar Tracker	• It uses motors and gear trains or direct drive actuators, to follow themovement of the sun. • Directed by a controller. • Deactivates during darkness based on the design of the system. • It uses a light sensor to locate the angle at which maximum sunlightcan be absorbed. • The MCU directs the solar panel to change the angle.
	• It uses a liquid, easily compressible and boiled.

Passive Solar Tracker	• It is driven by the solar heat. • The fluid moves when heated, like a teeter-totter and hence the solarpanel moves.
Chronological Solar Tracker	• Works with the rotation of the earth. • Have no sensors. • Depends on the geographical location. • Uses a controller to calculate the moment and position of the earthwith respect to the sun at a given time and location.

4.3.3 UBIDOTS:

The purpose of this section is to help you understand what happens in the backstage when communicating with Ubidots, so you can replicate this in your firmware. For this reason, we avoid the use of examples using libraries. However, if you'd like to use one of our libraries (Python, C, and more), check out our compatible devices and API clients sections.

How Ubidots Works?

Every time a device updates a sensor value in a variable, a data-point or "**dot**" is created. Ubidots stores dots that come from your devices inside variables, and these stored dots have corresponding **timestamps**.

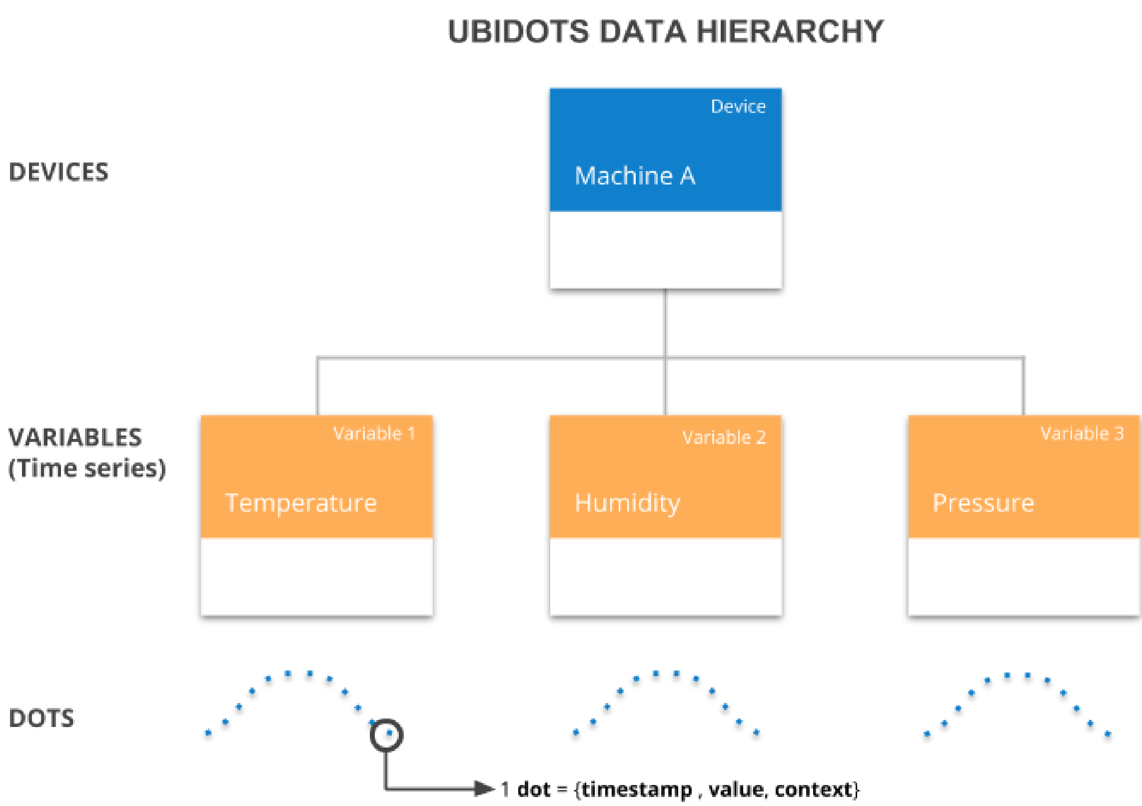

Fig-6 Ubidots

Each dot contains these items:

TABLE-3 Each Dot Contains:

Item	**Description**	**Mandatory**
value	A numerical value. Ubidots accepts up to 16 floating-point length numbers.	YES
timestamp	Unix Epoch time, in milliseconds. If not specified, then our servers will assign one upon reception.	NO
context	An arbitrary collection of key-value pairs. Mostly used to store the latitude and longitude coordinates of GPS devices.	NO

Ubidots is an agnostic platform, this means that it does not really care what hardware device you are using, as long as you're able to interact with us through at least one of these protocols:

- HTTP
- MQTT
- TCP/UDP

HTTP:

HTTP is the main internet protocol for information exchange in the Internet. It also supports data encryption, which is usually called *secure HTTP* or *HTTPs*. When you use a web browser (MS Edge, Firefox, Google Chrome, etc) you are sending and receiving packages using *HTTP* or *HTTPs*. Because of this, it was not surprising to see HTTPs become a popular option for data exchange within IoT.
When a developer is to implement HTTP communication, then he should look for a *REST full* Application Programming Interface, or *REST API*, which exposes all the endpoints required to interact with a third party application (like Ubidots).

CHAPTER 5: EXPERIMENTAL RESULTS, ANALYSIS

5.1 Experimental Results

The results for the project were got from LDRs for the solar tracking system and the panel that has a fixed position. The results were recorded for four days, recorded and tabulated. The outputs of the LDRs were dependent on the light intensity falling on their surfaces. Arduino has a serial that communicates on digital pins 0 and 1 as well as with the computer through a USB. If these functions are thus used, pins 0 and 1 can be used for digital input or output.

Arduino environment's built in serial monitor can be used to communicate with the Node MCU board. To collect the results, a code was written that made it possible to collect data from the LDRsafter every one hour.

The values from the two LDRs are to be read and recorded at the given intervals. The LDRs measure the intensity of light and therefore they are a valid indication of the power that gets to the surface of the solar panel. The light intensity is directly proportional to the power output of the solar panel.

5.1.1: LDR Outputs for cloudy day:

TABLE-4

Time (Hrs)	LDR1(V)	LDR2 (V)
0630	0.277	0.276
0730	0.504	0.509
0830	1.757	1.933
0930	1.631	1.783
1030	1.900	1.798
1130	2.910	2.969
1230	1.990	1.990
1330	1.985	1.990
1430	0.976	0.985

1530	0.941	0.892
1630	0.824	0.594
1730	0.128	0.981
1830	0.982	0.968

5.1.2: LDR outputs for bright sunny day:

TABLE-5

Time (Hrs.)	LDR1 (V)	LDR2 (V)
0630	1.477	1.487
0730	2.804	2.839
0830	3.203	3.990
0930	3.990	3.990
1030	4.130	4.149
1130	4.500	4.590
1230	4.990	4.990
1330	4.888	4.990
1430	4.976	4.985
1530	4.941	4.892
1630	4.873	4.790
1730	3.964	3.940
1830	2.708	2.815

5.2 Analysis

From the tables(4,5,6), it can be seen that the maximum sunlight occurs at around midday, with maximumvalues obtained between 1200 hours and 1400 hours. In the morning and late evening, intensity of sunlight diminishes and the values obtained are less that those obtained during the day.After sunset, the tracking system is switched off to save energy. It is switched back on in the morning.

For the panel fitted with the tracking system, the values of the LDRs are expected to be close. This is because whenever they are in different positions there is an error generated that enables its movement. The motion of the panel is stopped when the values are the same, meaning the LDRs receive the same intensity of sunlight. For the fixed panel, the values vary because the panel is at a fixed position. Therefore, at most times the LDRs are not facing the sun at the same inclination. This is apart from midday when they are both almost perpendicular to the sun.

Days with the least cloud cover are the ones that have the most light intensity and therefore the outputs of the LDRs will be highest. For cloudy days, the values obtained for the tracking system and the fixed system do not differ too much because the intensity of light is more or less constant. Any differences are minimal. The tracking system is most efficient when it is sunny. It will be able to harness most of the solar power which will be converted into energy. In terms of the power output of the solar panels for tracking and fixed systems, it is evident that the tracking system willhave increased power output. This is because the power generated by solar panels is dependent on the intensity of light. The more the light intensity the more the power that will be generated by thesolar panel

CHAPTER 6: CONCLUSION

6.1 CONCLUSION

- An Arduino solar tracker was designed and constructed in the current work. LDR light sensors were used to sense the intensity of the solar light occurrence on the photo-voltaic cells panel.
- Conclusions of this system is summarized as ,the existing tracking system successfully sketched the light source even it is a small torch light, in a dark room, or it is the sun light rays.
- The cost and reliability of this solar tracker creates it suitable for the rural usage. The purpose of renewable energy from this paper offered new and advanced idea to help the people.

CHAPTER 7: REFERENCES

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