CONSTRUCTION AND IMPLEMENTATION OF SUN TRACKING SOLAR PANEL SYSTEM

A thesis

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Department of Mechanical Engineering

SONARGAON UNIVERSITY (SU)

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All praise and thanks are due to Allah, the Lord of all worlds.

Abstract

Solar energy is a very important medium for the expansion of renewable energy resources. This paper describes the design and construction of a microcontroller-based sun position solar tracking with IoT load control system. Solar is an unconventional energy source, considering that we have created solar panels so that we can meet our electricity needs. Our system can follow the solar energy automatically. The system controller decides to move according to the algorithm of the time and tilts the panel towards the maximum power given by the LDR with the help of servo motor. The motor is used to rotate the LDR to realize maximum solar power. A solar tracker is basically a device on which solar panels are drawn that tracks the movement of the sun across the sky to ensure that the maximum amount of sunlight hits the panels throughout the day. The sun ray absorbs the solar panel and store the charge in a battery. The battery will provide DC power. An inverter will convert DC to AC and supply in a load. This load will be control by IoT system. Also, the battery voltage will show in IoT. These are the main process of our project.

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Chapter 1
Introduction

1.1 Background

Industrial and domestic reliance on the use of fossil fuel is today facing challenges in demand environmental consideration. Dual Axis floating solar panel follow the sun continually and provide constant power output throughout the day with high efficiency by doing azimuth & altitude tracking. 40-50% more energy. 15% more yields due to the cooling effect of water. In Bangladesh, there are huge unused coastal area, pond, canal, and 57 major rivers that will be effective for dual axis floating solar PV Estimated 1,500 $km^2$of ponds, Bangladesh has immense potential for dual axis floating PV.

1.2 Problem Identification

Solar power, which is available only in fixed installations, is the major problem. The ability of power that can be generated is restricted as part of this issue. The other factor is that the solar tracking system's purchase price is very high for a family that uses more electricity than normal, so more than one solar panel will need to be installed to generate enough power.[1] So, this concept is all about solving the problem that is going on at 180 degrees, this solar tracking system will detect rotation. So, compared to where the solar panel stays in just one direction, the solar panel mentioned here is extremely large. [2] Solar energy faces another problem.

Usually fixed solar energy panels would not be directly oriented towards sunlight as a result of the continuous motion of the Earth. If the consequence of this system is that it does not achieve the highest efficiency.[3] The solar tracking device is the larger solution for achieving full output power due to this method. This is the primary reason that why the project for the solar tracker is implements. The solar tracker must obey the sunlight in order to get additional power output. The cost of purchasing more solar panels is, indirectly, likely to be reduced. In order to manage sunlight, these devices also slowly take the time users need to change the position of solar energy.[4]

1.3 Motivation

The world's advanced nations are currently working on renewable energy. It is necessary to work with renewable energy to give a beautiful world to the next generation. Our government has also received small projects on renewable energy sources. So, we want to do something about renewable energy sources. As such, our country is a landless and densely populated country. One thing we have seen is that many countries are successfully producing solar power from floating solar power plants.

1.4 Aims and Objectives

We have some specific objectives for this project and they are pointed below:

- To design and build a **Dual Axis Solar Tracker System.**
- To taking notes from our real-time test.
- To follow the position of the sun for maximum energy efficiency.

1.5 Thesis Outline

- **Chapter 1: Introduction.** This chapter is all about background study, problem identification, motivation and aims and objectives.
- **Chapter 2: Literature Review-** Here briefly describe about floating solar panel project, its advantages, disadvantages, application and some live floating solar panel project.
- **Chapter 3: Methodology –** Here briefly discuss about project methodology, Block Diagram, circuit diagram, required instrument cost analysis, working principle, work plan etc.
- **Chapter 4: Hardware and Software Analysis -** This chapter is discussed about instrument and software. Hardware and Software details and its working procedure.
- **Chapter 5: Result And Discussion**– This chapter is all about our project advantages, limitation, application and discussion.
- **Chapter 6: Conclusion –** Here briefly discuss about project future scope of work and conclusion.

Chapter 2
Litreture Review

2.1 Litrature Survey

This literature review reveals the detailed work that has been carried out till date on the topic of Solar Tracking. N. Othman, M. I. A. Manan, Z. Othman, S. A. M. Al Junid have designed a two-axis sun tracking system with the use of five LDRs and an Arduino nano controller [1].

The objective of this research is to design and construct the automatic dual axis solar tracker for maximum sun energy utilization. The only point of worry is that this system should consume energy as minimum as possible so that the difference between power conversion and power consumption would increase and hence the net profit of the system. Arduino UNO controller has been used and it is programmed in C language. LDRs are used to detect the maximum sunlight position in the sky and the program written performs calculations and drives the servo motors to make PV panels perpendicular to the sun [2].

The sun not only travels from east to west but there is a change of angle in north to south direction also. So the north and south directions should also be taken care of. Dual axis trackers do that. These trackers track the sun on a horizontal as well as vertical axis. Because of this operating ability the dual axis trackers have more output power than the single axis trackers. Light Dependent Resistors are used to find the brightest spot of the sun in the sky. LDRs are connected to Arduino UNO controller which gets to know the position of the sun in the sky and hence rotates the motors towards the sun[3].

Two Servo motors are used for panel rotation which also fulfils the low cost and lightweight criteria [4]. Md. Tanvir Arafat Khan, S.M. Shahrear Tanzil (2010) have designed and constructed a micro-controller based solar tracking system using LDRs to sense the intensity of sunlight and stepper motors to move the Photo-Voltaic (PV) panels in accordance with the sun [5].

Fabian Pineda, and Carlos Andres Arredondo (2011) have designed and implemented a two-axis sun module positioning by sensing the maximum brightness point in the sky. A geodesic dome based sensor has been built for the bright point tracking [6]. Authors Salabila Ahmad et

al. have designed and constructed an open loop two axes sun tracking system with an angle controller. The hardware is selected such as it will maximize the power collected and minimize the power consumed as the efficiency parameter lies in between these two power parameters [7].

Solar tracking also helps in transmitting sunlight to dark area like basement. Authors Jifeng Song et al. have implemented the high precision tracking system based on a hybrid strategy for concentrated sunlight transmission via fibres [8]. Author Cemil Sungur (2008) has presented the multi-axes sun tracking system with PLC control. The azimuth and altitude angles of the sun are calculated for a period of 1 year at 37.6º latitude where Turkey is located. According to these angles, an electromechanical system which tracks the sun according to azimuth and altitude angle is designed and implemented [9].

Authors A.chaib et al (2013) have presented the heliostat orientation system based on PLC robot manipulator. It is presented that by mounting certain no. of heliostats and facing them towards central power tower water can be heated and turbines can be driven for energy conversion purpose. By applying MATLAB program for determining the sun's position for heliostat orientation and by using PLC robot manipulator it is presented that maximum amount of energy gets converted from solar to electricity. Concentrated Solar Power (CSP) is used in this experiment [10].

Authors Tao Yu and Guo Wencheng (2010) have introduced automatic sun-tracking control system based on Concentrated Photo Voltaic (CPV) generation. CPV generation works effectively when light panels trace the sun accurately. Stepper tracking control technology is used. This control relies on control circuit with ARM and camera which can provide powerful computational capability [11].

Shreyasi Chakraborty. Nilanjana Mukherjee. Rashmi Biswas in 2017. Due to their many benefits, renewable energy sources are becoming one of the top priorities for today's world. In particular, to meet our ever-increasing energy needs, solar energy is emerging as a potential source of inexhaustible and unpolluted energy. However, solar panels, which are fundamental components of the conversion of solar energy, are installed at a certain angle and with diurnal and seasonal shifts, are unable to track the direction of sunlight. Using a micro-controller combination, we built a solar tracking system[12].

To meet our ever-increasing energy needs, solar power is emerging as a potentially inexhaustible and non-polluting energy source. Arduino prototype driven automated solar tracking system is primarily designed using Arduino Micro-controller, LDRs, and stepper motors Three phase motors are typically used to transfer solar power based on the accumulated incident light controlled by LDRS[13].

The software controls this solar panel's vertical tilt point, and it rotates horizontally. Then according to the sunlight incident, it could follow the direction of the sun, not just the vertical rotation as well as the horizontal rotation of the solar panels. This system is therefore capable of optimal lighting and can minimize the cost of electricity production by providing a minimum number of solar panels with proper alignment with all sunlight[14].

Rathika Kannan. Kavitha S in june 2017 Solar tracking system was made with stepper motor tracking system to increase the efficiency of output power of the PV plate. Solar energy is becoming ever more an alternative energy source. It is a device that tracks a solar array's rotation, so it is always associated with the direction of the sun Developed and mounted in this article, the solar tracker offers a safe and inexpensive way to align a solar panel with the sun to optimize its energy output. In the proper orientation the solar monitoring system is configured to align the photovoltaic solar panel with the sun for direct radiation[15].

Ankit Anuraj Rahul in 2018. As an important tool for renewable energy, solar energy is increasingly rising. Solar tracking helps to collect more solar energy, since a profile that is perpendicular to the sun's rays can be maintained by the solar panel. Whilst initial costs are high for the implementation of a solar tracking device, this paper offers a cheaper solution. The control circuit of the solar tracker relies on an ATMega16 micro-controller. It is intended to sense sunlight through the LDR, and then switches with the stepper motor to align the solar panel where maximum sunlight can be obtained. The stepper motor is more controllable, more energy-intensive, more powerful and has good precision tracking and little environmental impact compared to any other motor type[16].

Shreyasi Chakraborty. Nilanjana Mukherjee. Rashmi Biswas in 2017. Due to their many benefits, renewable energy sources are becoming one of the top priorities for today's world[17]. In particular, to meet our ever-increasing energy needs, solar energy is emerging as a potential source of inexhaustible and unpolluted energy. However, solar panels, which are fundamental components of the conversion of solar energy, are installed at a certain angle and with diurnal

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The software controls this solar panel's vertical tilt point, and it rotates horizontally. Then according to the sunlight incident, it could follow the direction of the sun, not just the vertical rotation as well as the horizontal rotation of the solar panels. This system is therefore capable of optimal lighting and can minimize the cost of electricity production by providing a minimum number of solar panels with proper alignment with all sunlight[20].

2.2 Summary

From the literature discussed above, we gained a lot of knowledge and we inspired to do this project. We were able to do it with everyone tireless work.

Chapter 3
Methodology

3.1 Methodology

Our used methodology for the project:

- Creating an idea for the design and construction of **Construction and Implementation of Sun Tracking Solar Panel System**. And designing a block diagram & circuit diagram to know which components we need to construct it.
- Collecting all the components and programming the microcontroller to control our desired system.
- Setting up all the components in a PCB board & soldering. Then assembling all the blocks in a board and finally running the system to check if it actually works or not.

3.2 Block Diagram:

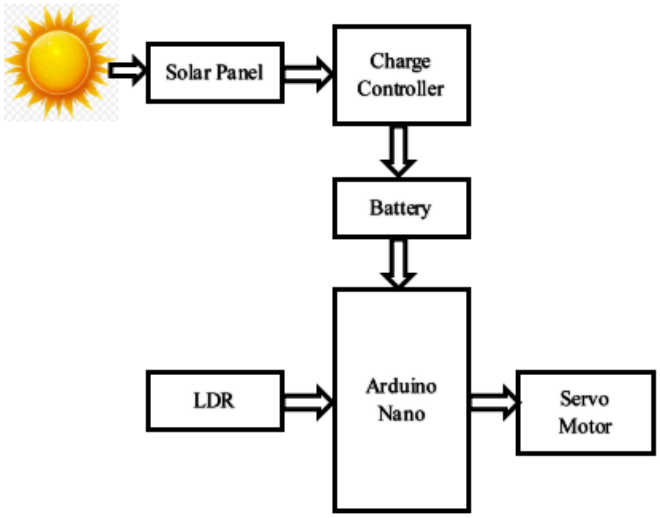


Figure 3.1: Block Diagram

3.3 Circuit Diagram:

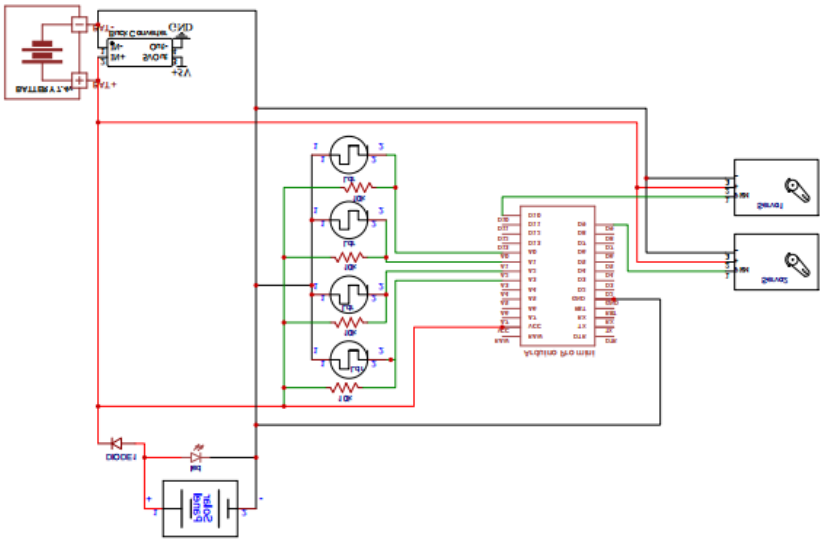


Figure 3.2 : Circuit Diagram

3.4 Working Principle

In this project, we use a 6v solar panel as a primary power source. This solar panel detects sunlight automatically built-in LDR sensor, an LDR sensor operated by the micro-controller (Arduino Pro mini). This micro-controller also operates a servo motor to rotate solar panels horizontally and vertically. The main work of this project is when the sun is incident in the solar panel then it will charge and store in a 6V battery. Then we use a buck converter to convert 6v to 5v for operating the micro-controller. this micro-controller runs on a 5 DC volt. Finally, we added a single feature light that runs on DC current.

3.5 Project Prototype Image



Figure 3.3: Complete Project Prototype

3.6 Project Cost Analysis

Sl. No	Particulars	Specification	Qty.	Unit Price (Taka)	Total Price (Taka)
01	Arduino	Pro Mini	1	580	580
02	Solar Panel	6V	1	650	650
03	Buck Converter	LM2596	1	130	130
04	Battery	3.7 V	2	150	300
05	Servo Motor	SG90	2	300	600
06	LDR	5V	4	10	40
07	Others				1860
				Total	4160/=

Chapter 4
Hardware and Software Analysis

4.1 Required Components and Software

Hardware

1. Arduino Nano
2. Solar Panel
3. Buck Converter
4. Battery
5. Servo Motor
6. LDR

Software

1. Arduino IDE Software
2. Easy EDA Software

4.2 Solar Panel:

A solar panel is a set of solar photovoltaic modules electrically connected and mounted on a supporting structure. A photovoltaic module is a packaged, connected assembly of solar cells. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions (STC), and typically ranges from 100 to 320 watts. The efficiency of a module determines the area of a module given the same rated output - an 8% efficient 230 watt module will have twice the area of a 16% efficient 230 watt module. A single solar module can produce only a limited amount of power; most installations contain multiple modules. A photovoltaic system typically includes a panel or an array of solar modules, an inverter, and sometimes a battery and/or solar tracker and interconnection wiring.

Solar cell modules produce electricity only when the sun is shining. They do not store energy, therefore to ensure flow of electricity when the sun is not shinning, it is necessary to store some of the energy produced. The most obvious solution is to use batteries, which chemically store electric energy. Batteries are groups of electro chemical cells (devices that convert chemical energy to electrical energy) connected in series.



Figure 4.1: Solar Panel

Battery cells are composed of two electrodes immersed in electrolyte solution which produce an electric current when a circuit is formed between them. The current is caused by reversible chemical reactions between the electrodes and the electrolyte within the cell. Batteries that are re-chargeable are called secondary or accumulator batteries. As the battery is being charged, electric energy is stored as chemical energy in the cells. When being discharged, the stored chemical energy is being removed from the battery and converted to electrical energy. In East-Africa, the most common type of secondary battery is the Lead-acid battery.

Solar Charger Controller:

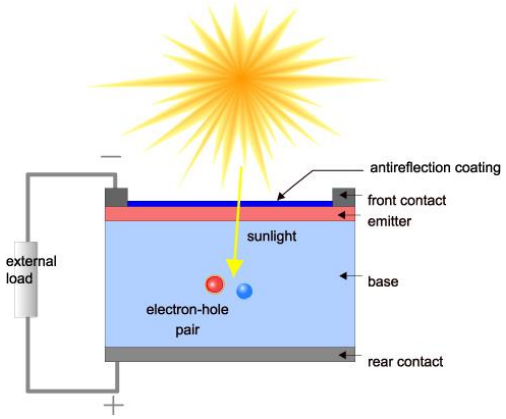


Figure 4.2: Solar Panel Schema Diagram

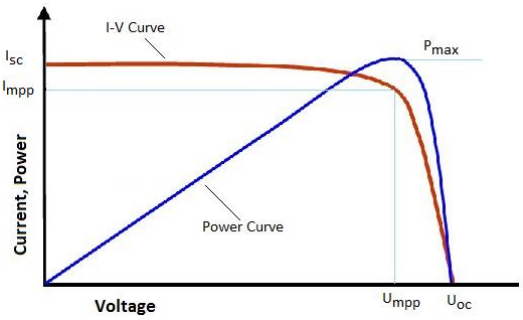


Figure 4.3: Solar Sell System Curve

Here is a solar charger circuit that is used to charge Lead Acid or Ni-Cd batteries using the solar energy power. The circuit harvests solar energy to charge a 6 volt 4.5 Ah rechargeable

battery for various applications. The charger has voltage and current regulation and over voltage cut-off facilities.

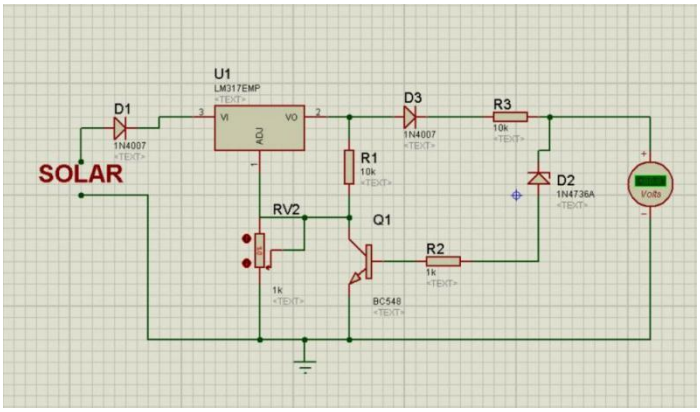


Figure 4.4: Solar Charger Controller Circuit

The circuit uses a 12 volt solar panel and a variable voltage regulator IC LM 317. The solar panel consists of solar cells each rated at 1.2 volts. 12 volt DC is available from the panel to charge the battery. Charging current passes through D1 to the voltage regulator IC LM 317. By adjusting its Adjust pin, output voltage and current can be regulated. VR is placed between the adjust pin and ground to provide an output voltage of 9 volts to the battery. Resistor R3 Restrict the charging current and diode D2 prevents discharge of current from the battery.

Transistor T1 and Zener diode ZD act as a cutoff switch when the battery is full. Normally T1 is off and battery gets charging current. When the terminal voltage of the battery rises above 6.8 volts, Zener conducts and provides base current to T1. It then turns on grounding the output of LM317 to stop charging.

4.3 Servo Motor:

A servo motor is an electrical device that can push or rotate an object with great precision. If you want to rotate and object at certain angles or distances, you use servo motors. It is made by a simple motor which is driven by a servo mechanism. If the motor is DC driven then it is called DC servo motor and if it is AC driven motor then it is called AC servo motor. We can get a very high torque servo motor in a small and light weight packages. These are being used in various applications like toy cars, RC helicopters and planes, robotics, machines etc.



Figure 4.5: Servo Motor

Servo motors are rated at kg / cm (centimeters per kilogram). Most hobby servo motors are rated at 3 kg / cm or 6 kg / cm or 12 kg / cm. This kg / centimeter tells you how much weight your servo motor can lift at a certain distance. For example: A 6 kg / cm servo motor should be able to lift 6 kg if the load is suspended 1 cm away from the motor shaft, to be less than the carrying capacity. The position of the servo motor is determined by the electric pulse and its circuitry is placed next to the motor.

Servo Mechanism:

It consists of three parts:

1. Controlled device
2. Output sensor
3. Feedback system

All motors have three wires. Of which two will be used for the supply (positive and negative) and one will be used for the signal transmitted from the MCU. The servo motor is controlled by PWM (Pulse with Modulation) which provides the control wires. Has minimum pulse, maximum pulse and repetition rate. The servo motor can rotate 90 degrees in two directions, creating its neutral position. The servo motor expects to see a pulse every 20 milliseconds (ms) and the pulse length will determine how far the motor rotates. For example, a 1.5 mm pulse will turn the motor to 90 °, for example, if the branch is less than 1.5 mm shaft, it will move to 0 to, and if it is longer than 1.5 mm, the sardo will turn to 180 to.

The servo motor operates on the PWM (pulse width modulation) principle, meaning that the angle of rotation is controlled by the duration of the pulse applied to its control pin. Basically the servo motor is made up of a DC motor which is controlled by a variable resistor (potentiometer) and some gears. The high speed force of the DC motor is converted to torque

by the gears. We know that work = force x DISTANCE, less in DC motor force and more in distance (speed) and in servo, forces are higher and distance is less. The pentiometer server is connected to the output trench to calculate the angle and stop the DC motor at the required angle.

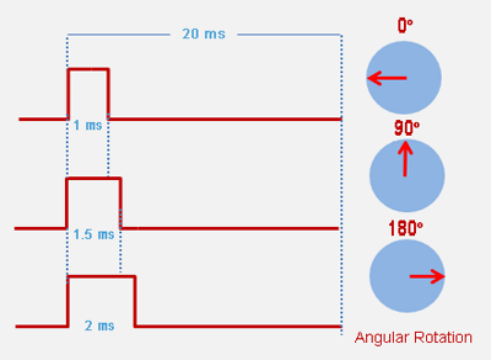


Figure 4.6: Schematic Diagram of servo motor

The servo motor can be rotated from 0 to 180 degrees but depending on the output it can go up to 210 degrees. This degree of rotation can be controlled by applying an electric pulse of appropriate width to its control pin. Servo examines pulses every 20 milliseconds. The 1 ms (1 millisecond) width pulse servo can rotate 0 degrees, 1.5 mm 90 degrees (neutral position) and 2 ms pulse it can rotate 180 degrees. All servo motors work directly with your + 5V supply rails but we need to be careful about how much current the motor will use. If you plan to use more than two servo motors, you should design a suitable servo solder.

4.4 Buck Converter:

The converter (step-down converter) is a DC-to-DC converter that reduces the voltage from the input (supply) to the output (load). It is an intermittent power supply (SMPS) project that usually involves at least two semiconductors (including a diode and a transistor), a capacitor, an inductor or two. To reduce the voltage, filters made of capacitors (sometimes combined with inductors) are usually added to the output (single-pass filter) and input (supply-side filter) of such a converter.

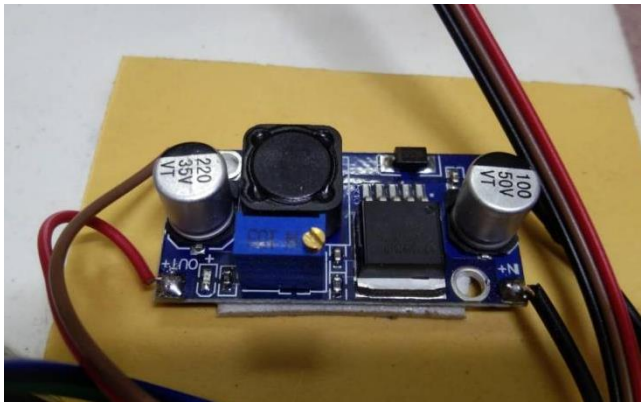


Figure 4.7: DC -DC Buck Converter

DC-DC Buck Step Down Module LM2596 Power Supply is a 3-A load converter, capable of carrying a 3-A with a beautiful line and load pattern. These devices are available at an output voltage of 3.3 V, 5 V, 12 V, as well as a variable output voltage. The LM2596 system operates at a frequency change of 150kHz, thus allowing more precision filtering than would be required with high frequency converters.

Specifications of DC-DC Buck Converter Step Down Module LM2596 Power Supply :

- Conversion efficiency: 92% (highest).
- Switching frequency: 150KHz..
- Output ripple: 30mA9max).
- Load adjustment: ± 0.5%.
- Voltage adjustment: ± 0.5%.
- Dynamic response rate: 5% 200 uS.
- Input voltage: 4.75-35V.
- Output voltage: 1.25-26 V (adjustable).
- Output current: rated current 2A, maximum 3A (additional heat sink required).
- Conversion efficiency: up to 92% (higher output voltage, higher efficiency).
- Switching frequency: 150KHz..
- Rectifier: Asynchronous straightening.
- Module properties: non-isolated top-down module (fee).

- Short circuit protection: current limitation since recovery.
- Operating temperature: industrial grade (-40 to +85) (output power 10 W or less).

4.5 Arduino Nano:

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments. Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling Lights, motors, and other actuators.

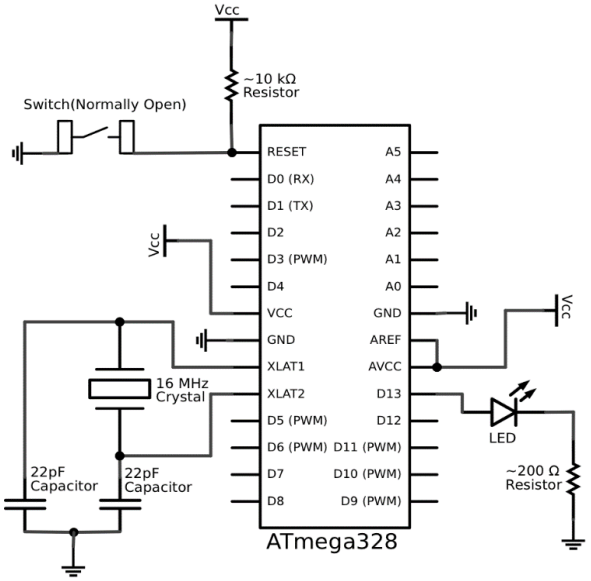


Figure 4.8:Schematic Diagram of Arduino Nano

The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software on running on a computer (e.g. Flash, Processing, MaxMSP).

Arduino Nano is a surface mount breadboard embedded version with integrated USB. It is a smallest, complete, and breadboard friendly. It has everything that Diecimila/Duemilanove has (electrically) with more analog input pins and onboard +5V AREF jumper. Physically, it is missing power jack. The Nano is automatically sense and switch to the higher potential source of power.

Nano's got the breadboard-ability of the Boarduino and the Mini+USB with smaller footprint than either, so users have more breadboard space. It's got a pin layout that works well with the Mini or the Basic Stamp (TX, RX, ATN, GND on one top, power and ground on the other). This

new version 3.0 comes with ATMEGA328 which offer more programming and data memory space. It is two layers. That make it easier to hack and more affordable.

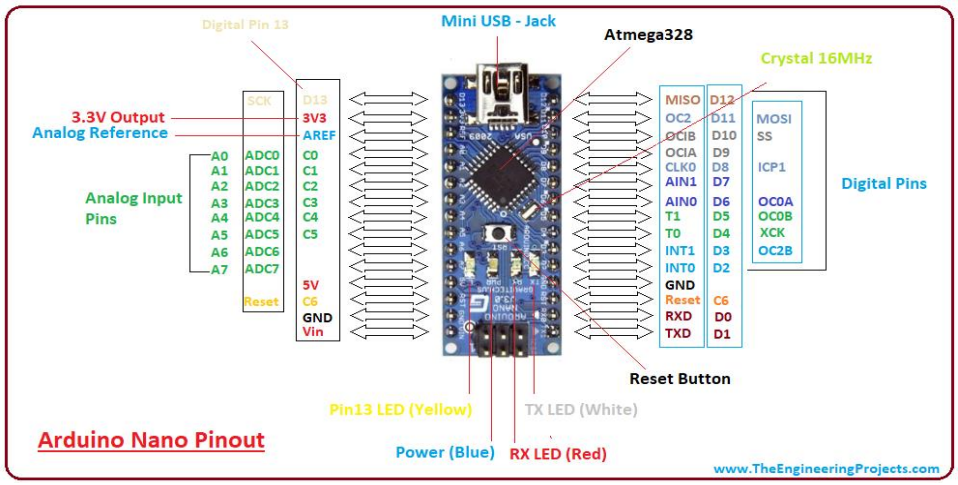


Figure 4.9**:** Arduino Pin Output

Specifications:

- Microcontroller: Atmel ATmega328
- Operating Voltage (logic level):5 V
- Input Voltage (recommended):7-12 V
- Input Voltage (limits):6-20 V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analog Input Pins: 8
- DC Current per I/O Pin: 40 mA
- Flash Memory: 32 KB (of which 2KB used by boot loader)
- SRAM : 2 KB
- EEPROM: 1 KB
- Clock Speed: 16 MHz
- Dimensions: 0.70” x 1.70”

Features:

• Automatic reset during program download

• Power OK blue LED

• Green (TX), red (RX) and orange (L) LED

• Auto sensing/switching power input

• Small mini-B USB for programming and serial monitor

• ICSP header for direct program download

• Standard 0.1 spacing DIP (breadboard friendly)

• Manual reset switch

Micro Controller IC ATmega328p:

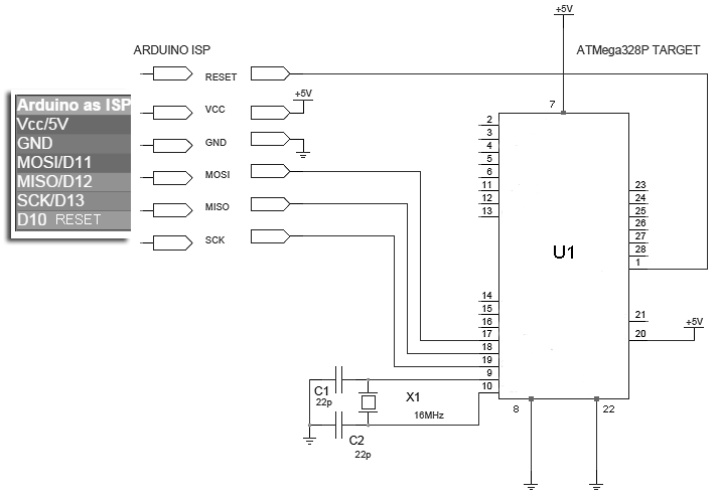


Figure 4.10: Schematic Diagram of Micro controller IC AT mega 328p

The high-performance Microchip pico Power 8-bit AVR RISC-based microcontroller combines 32KB ISP flash memory with read-while-write capabilities, 1024B EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, a 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. By executing powerful instructions in a single clock cycle, the device achieves throughputs approaching 1 MIPS per MHz, balancing power consumption and processing speed.

4.6 LDR:

The LDR sensor module is used to detect the presence of light / measure the intensity of light. The output of the module is higher in the presence of light and it is lower in the absence of light.



Figure 4.11: LDR Sensor

Features:

- Adjustable sensitivity (via blue digital potentiometer adjustment)
- Operating voltage 3.3V-5V
- Output Type: Analog voltage output -A0
- Digital switching outputs (0 and 1) -D0
- With fixed bolt hole for easy installation
- Small board PCB size: 3cm * 1.6cm
- Power indicator (red) and the digital switch output indicator (green)
- Using LM393 comparator chip, stable

Pin outs:

- External 3.3V-5V VCC
- External GND GND
- DO digital output interface, a small plate (0 and 1)
- AO small board analog output interface
- Can detect ambient brightness and light intensity

4.7 Battery

Lithium batteries are primary batteries that have metallic lithium as an anode. These types of batteries are also referred to as lithium-metal batteries. They stand apart from other batteries in their high charge density and high cost per unit. Depending on the design and chemical compounds used, lithium cells can produce voltages from 1.5 V (comparable to a zinc–carbon or alkaline battery) to about 3.7 V.

Disposable primary lithium batteries must be distinguished from secondary lithium-ion or a lithium-polymer, which are rechargeable batteries. Lithium is especially useful, because its ions can be arranged to move between the anode and the cathode, using an intercalated lithium compound as the cathode material but without using lithium metal as the anode material. Pure lithium will instantly react with water, or even moisture in the air; the lithium in lithium ion batteries is in a less reactive compound.



Figure 4.12 : 3.7V Battery

Lithium batteries are widely used in portable consumer electronic devices. The term "lithium battery" refers to a family of different lithium-metal chemistries, comprising many types of cathodes and electrolytes but all with metallic lithium as the anode. The battery requires from 0.15 to 0.3 kg of lithium per kWh. As designed these primary systems use a charged cathode, that being an electro-active material with crystallographic vacancies that are filled gradually during discharge.

Product Specification:

Table 2: Battery Specification

Voltage	3.7 V
Product Type	Lithium-Ion
Battery Capacity	2200mAh
Weight	45 g
Model Number	ICR 18650

4.8 Arduino IDE

The digital micro-controller unit named as Arduino Nano can be programmed with the Arduino software IDE. There is no any requirement for installing other software rather than Arduino. Firstly, Select "Arduino Nano from the Tools, Board menu (according to the micro-controller on our board). The IC used named as ATmega328 on the Arduino Nano comes pre burned with

a boot loader that allows us to upload new code to it without the use of an external hardware programmer.

Communication is using the original STK500 protocol (reference, C header files). We can also bypass the boot loader and programs the micro-controller through the ICSP (In Circuit Serial Programming) header. The ATmega16U2 (or 8U2 in the rev1 and rev2 boards) firmware source code is available. The ATmega16U2/8U2 is loaded with a DFU boOn Rev1 boards: connecting the solder jumper on the back of the board (near the map of Italy) and then resetting the 8U2. On Rev2 or later boards: there is a resistor that pulling the 8U2/16U2 HWB line to ground, making it easier to put into DFU mode. ot loader, which can be activated by:

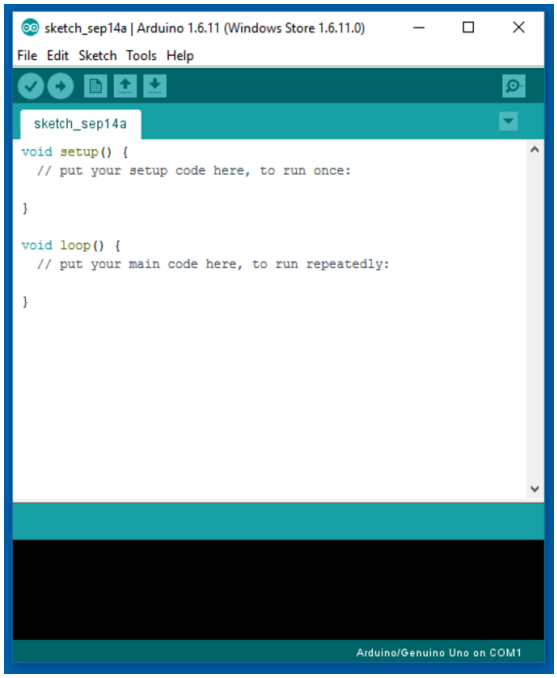


Figure 4.13: Arduino Software Interface IDE

The Arduino Nano is one of the latest digital micro-controller units and has a number of facilities for communicating with a computer, another Arduino, or other micro-controllers. The ATmega328 provides UART TTL at (5V) with serial communication, which is available on digital pins 0 -(RX) for receive the data and pin no.1 (TX) for transmit the data. An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer.

The '16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, an .in file is required. The Arduino software includes a serial monitor

which allows simple textual data to be sent to and from the Arduino board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial Communication on pins 0 and 1). A Software Serial library allows for serial communication on any of the Nano's digital pins. The ATmega328 also supports I2C (TWI) and SPI communication.

The Arduino software includes a Wire library to simplify use of the I2C bus. Arduino programs are written in C or C++ and the program code written for Arduino is called sketch. The Arduino IDE uses the GNU tool chain and AVR Lab to compile programs, and for uploading the programs it uses argued. As the Arduino platform uses Atmel micro-controllers, Atmel's development environment, AVR Studio or the newer Atmel Studio, may also be used to develop software for the Arduino.The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them.

Writing Sketches

Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom righthand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor.

Sketchbook

The Arduino Software (IDE) uses the concept of a sketchbook: a standard place to store your programs (or sketches). The sketches in your sketchbook can be opened from the File > Sketchbook menu or from the Open button on the toolbar. The first time you run the Arduino software, it will automatically create a directory for your sketchbook. You can view or change the location of the sketchbook location from with the Preferences dialog. Beginning with version 1.0, files are saved with a. ino file extension. Previous versions use the .pde extension. You may still open. pde named files in version 1.0 and later, the software will automatically

rename the extension to .ino.

Tabs, Multiple Files, and Compilation

Allows you to manage sketches with more than one file (each of which appears in its own tab). These can be normal Arduino code files (no visible extension), C files (.c extension), C++ files (.cpp), or header files (.h).

Uploading

Before uploading your sketch, you need to select the correct items from the Tools > Board and Tools > Port menus. The boards are described below. On the Mac, the serial port is probably something like /dev/tty.usbmodem241 (for an Uno or Mega2560 or Leonardo) or /dev/tty.usbserial-1B1 (for a Duemilanove or earlier USB board), or /dev/tty.USA19QW1b1P1.1 (for a serial board connected with a Keyspan USB-to-Serial adapter). On Windows, it's probably COM1 or COM2 (for a serial board) or COM4, COM5, COM7, or higher (for a USB board) - to find out, you look for USB serial device in the ports section of the Windows Device Manager.

On Linux, it should be /dev/ttyACMx , /dev/ttyUSBx or similar. Once you've selected the correct serial port and board, press the upload button in the toolbar or select the Upload item from the Sketch menu. Current Arduino boards will reset automatically and begin the upload. With older boards (pre-Diecimila) that lack auto-reset, you'll need to press the reset button on the board just before starting the upload. On most boards, you'll see the RX and TX LEDs blink as the sketch is uploaded. The Arduino Software (IDE) will display a message when the upload is complete, or show an error.

Libraries

Libraries provide extra functionality for use in sketches, e.g. working with hardware or manipulating data. To use a library in a sketch, select it from the Sketch > Import Library menu. This will insert one or more #include statements at the top of the sketch and compile the library with your sketch. Because libraries are uploaded to the board with your sketch, they increase the amount of space it takes up. If a sketch no longer needs a library, simply delete its #include statements from the top of your code.

Third-Party Hardware

Support for third-party hardware can be added to the hardware directory of your sketchbook

directory. Platforms installed there may include board definitions (which appear in the board menu), core libraries, bootloaders, and programmer definitions. To install, create the hardware directory, then unzip the third-party platform into its own sub-directory. (Don't use "arduino" as the sub-directory name or you'll override the built-in Arduino platform.) To uninstall, simply delete its directory. For details on creating packages for third-party hardware, see the Arduino IDE 1.5 3rd party Hardware specification.

Serial Monitor

This displays serial sent from the Arduino or Genuino board over USB or serial connector. To send data to the board, enter text and click on the "send" button or press enter. Choose the baud rate from the drop-down menu that matches the rate passed to Serial.begin in your sketch. Note that on Windows, Mac or Linux the board will reset (it will rerun your sketch) when you connect with the serial monitor. Please note that the Serial Monitor does not process control characters; if your sketch needs a complete management of the serial communication with control characters, you can use an external terminal program and connect it to the COM port assigned to your Arduino board.

4.9 Easy EDA Software

Easy EDA is a web-based EDA tool suite that enables hardware engineers to design, simulate, share - publicly and privately - and discuss schematics, simulations and printed circuit boards. Other features include the creation of a bill of materials, Gerber files and pick and place files and documentary outputs in PDF, PNG and SVG formats. Easy EDA allows the creation and editing of schematic diagrams, SPICE simulation of mixed analogue and digital circuits and the creation and editing of printed circuit board layouts and, optionally, the manufacture of printed circuit boards.

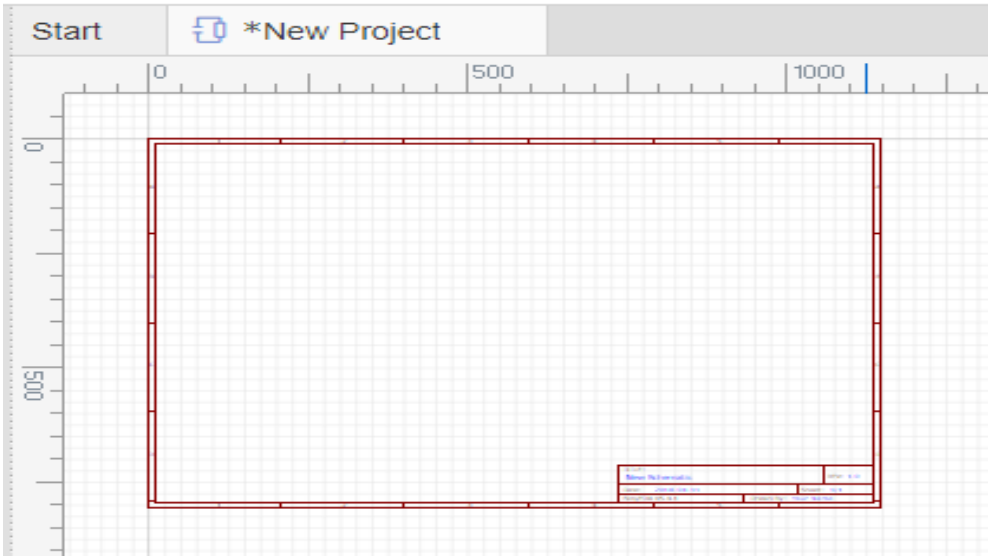


Figure 4.14: Easy EDA Software Interface

Subscription-free membership is offered for public plus a limited number of private projects. The number of private projects can be increased by contributing high quality public projects, schematic symbols, and PCB footprints and/or by paying a monthly subscription.Registered users can download Gerber files from the tool free of charge; but for a fee, Easy EDA offers a PCB fabrication service. This service is also able to accept Gerber file inputs from third party tools.

Chapter 5
Result and Discussion

5.1 Result

After finally completing this project, we ran it & we observed the output of this project. We can see that it is working well as expected. After making our project we observe it very careful. It works as we desire. Our project give output perfectly and all equipment are work perfectly. We check how much it works and we get perfect output from this project.

- Finally, we have completed our project successfully & check our project its run accurately according to our objective.
- At first, we start our system.
- After project on LDR sensor detect the sunlight direction and move accordingly.
- Solar Panel Store charge in battery.

5.2 Data Table:

STATIONARY/NORMAL SOLAR SYSTEM

SL NO	Time	Battery Charge	Solar Volt (Watt)	Ampere	Pout (Volt*amp)
1	After 15 min	0.25v	0.855w	0.30A	0.256w
2	30 min	0.50v	0.957w	0.33A	0.315w
3	45 min	0.75v	1.03w	0.35A	0.361w
4	60 min	1.0v	0.90w	0.31A	0.278w
5	75 min	1.25v	0.78w	0.27A	0.210w
6	90 min	1.5v	0.976w	0.33A	0.322w
7	105 min	2.0v	1.14w	0.38A	0.434w
8	120 min	2.5v	1.21w	0.42A	0.511w
9	135 min	3.0v	1.48w	0.49A	0.72w
10	150 min	3.5v	1.386w	0.45A	0.623w
11	165 min	4.0v	1.28w	0.41A	0.524w
12	180 min	4.5v	1.57w	0.50A	0.787w
13	195 min	5.0v	1.76w	0.55A	0.97w
14	210 min	5.5v	1.67w	0.52A	0.870w
15	225 min	6.0v	1.86w	0.57A	1.05w
16	240 min	6.5v	1.935w	0.59A	1.414w
17	255 min	6.75v	1.98w	0.60A	1.188w
18	270 min	7.0v	2.158w	0.65A	1.40w
19	285 min	7.25v	2.108w	0.62A	1.306w
20	300 min	7.4v	2.03w	0.58A	1.177w

- Average Pout =14.437/20 = 0.721W

SINGLE AXIS SOlAR TRACKER

SL NO	Time	Battery Charge	Solar Volt (Watt)	Ampere	Pout (Volt*amp)
1	After 5 min	0.1v	1.152w	0.36A	0.414w
2	25 min	0.5v	1.306w	0.42A	0.548w
3	50 min	1.0v	1.212w	0.38A	0.46w
4	75 min	1.5v	1.14w	0.35A	0.399w
5	100 min	2.0v	1.32w	0.40A	0.528w
6	125 min	2.5v	1.512w	0.42A	0.635w
7	150 min	3.05v	1.62w	0.48A	0.78w
8	175 min	3.50v	1.47w	0.44A	0.64w
9	200 min	4.0v	1.82w	0.52A	0.9464w
10	225 min	4.45v	2.017w	0.57A	1.15w
11	250 min	4.95v	2.13w	0.59A	1.25w
12	275 min	5.50v	2.485w	0.67A	1.664w
13	300 min	6.0v	2.59w	0.70A	1.81w
14	325 min	6.5v	2.597w	0.68A	1.765w
15	350 min	7.0v	3.081w	0.79A	2.43w
16	370 min	7.4v	3.157w	0.82A	2.58w

- Pout average =17.99/16= 1.124w

DUAL AXIS SOLAR TRACKER

SL NO	Time	Battery Charge	Solar Volt (Watt)	Ampere	Pout (Volt*amp)
1	After 10 min	0.4v	2.33w	0.58A	1.351w
2	20 min	0.8v	2.41w	0.60A	1.446w
3	30 min	1.2v	2.132w	0.52A	1.108w
4	40 min	1.6v	1.7w	0.40A	0.68w
5	50 min	2.0v	1.88w	0.44A	0.827w
6	60 min	2.4v	2.44w	0.46A	1.366w
7	70 min	2.8v	3.03w	0.70A	2.121w
8	80 min	3.2v	3.18w	0.72A	2.28w
9	90 min	3.6v	2.97w	0.66A	1.96w
10	100 min	4.0v	2.68w	0.58A	1.554w
11	110 min	4.6v	2.596w	0.55A	1.4278w
12	120 min	5.0v	2.35w	0.49A	1.1515w
13	130 min	5.4v	2.64w	0.54A	1.425w
14	140 min	5.8v	2.92w	0.60A	1.752w
15	150 min	6.2v	3.81w	0.79A	3.009w
16	160 min	6.8v	3.68w	0.77A	2.833w
17	170	7.0v	4.06w	0.82A	3.32w
18	180	7.4v	4.14w	0.89A	3.684w

- Average Pout =33.2953/18 =1.85W

Result Eficency

Result

Stationary/Normal Axis Efficiency

$\eta = P_{out}/P_{in} \times 100\%$

= 0.721/18* 100%

= 4.0%

Here,

P_{in}= 18W

P_{out}= 0.721W

Single Axis Efficiency

$\eta = P_{out}/P_{in}$ * 100%

= 1.124/18* 100%

= 6.24%

Here,

P_{in}= 18W

P_{out}= 1.124W

Dual Axis Efficiency

$\eta = P_{out}/P_{in}$ * 100%

= 1.85/18* 100%

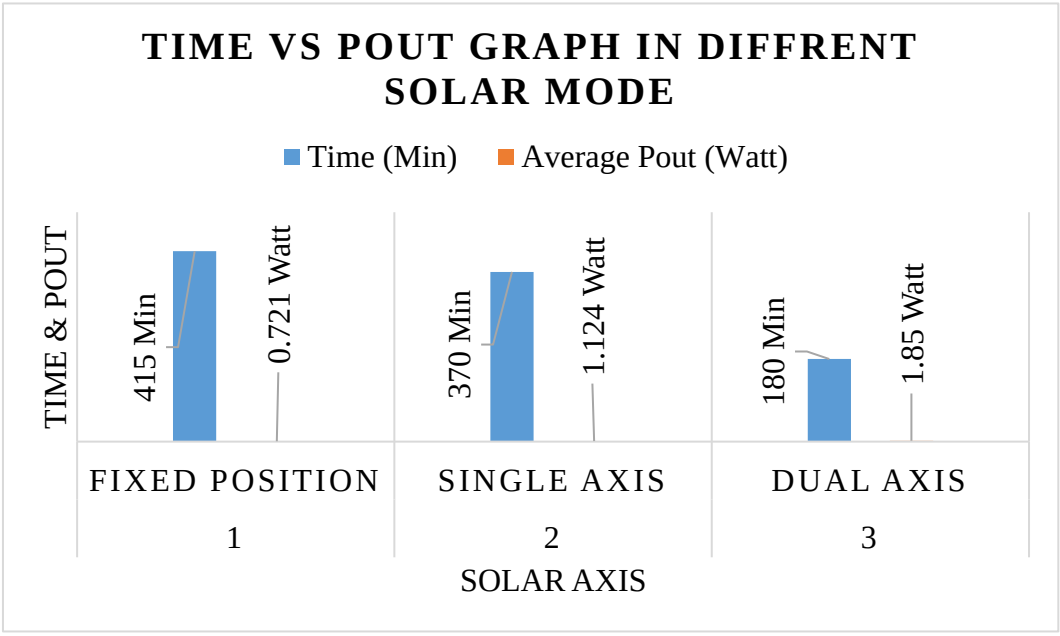
= 10.27%

Here,

P_{in}= 18W

P_{out}= 1.85W

Result Graph:



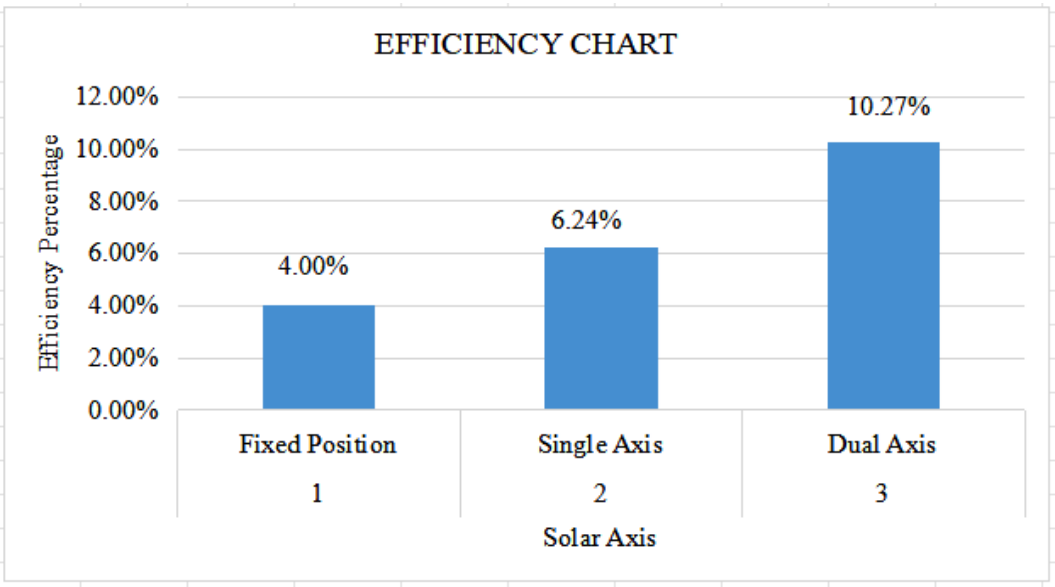


Figure 5.1 Graph Chart

5.3 Advantages

There are certainly many advantages of our project and some of the major ones have been given below:

- The power sources are natural and the battery is rechargeable.
- Less power consumption with best utilization.
- The whole system is automatic and saves energy by detecting the presence of light.
- The system is user friendly.
- The system is good for the environment as it utilizes renewable energy sources.

5.4 Application

Our project has many application areas and actually we need to use it in many places to verified the exact person which have the proper access. Some of the application areas of the project has been pointed out below:

- The system can be implemented to work on different projects.
- It can be implemented in area where power wastage takes place a lot.
- It can be implemented in areas where there's power shortage.
- This system can work to power almost anything that runs on electricity

5.5 Limitation

Although our project has many applications and advantages but there are some limitations of the project as well and the good thing is that these limitations are minor and doesn't affect the efficiency of the system. Limitations are given below:

- The system needs to be more efficient to produce more energy.
- Due to using renewable energy sources, electrical energy production is less and most of the energy is not converted rather wasted.
- On rainy days, foggy weather and some problems may occur which can hamper energy production.

5.6 Discussion

While working on our project, we did face some difficulties as it is a very complex system but the end results, we came up with were quite satisfactory. We have put the whole system through several tasks to validate our work and also have taken necessary notes for future improvements. Some future recommendations that we have involves improvement in system design and wiring, adding features for more efficient.

Chapter 6
Conclusion

6.1 Conclusion

We presented a means of dual axis solar tracking system continually orient PV panels towards the sun with the help of Micro controller, LDR sensor, and Servo Motor in the PV system. Average power gain of dual axis solar tracker. In the long run this project will be beneficial, and sustainable for water bodies area. Dual axis PV system provide the reasonable solution for limited land resource and creating clean and emission free power generation.

6.2 Future Scope

We are thinking about adding many features to our project in the future to get more desirable outcomes. Some of the steps that we are thinking about taking are given below:

- In the future we are looking forward to improved of our whole system design to make it more efficient.
- In the future this tilting mechanism with a collector can be implemented on large solar plants and also can be operated automatically.
- This mechanism can be implemented on solar cookers, ovens, carriers and on thermal solar heaters.

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Appendix

```
#include <LiquidCrystal_I2C.h>
LiquidCrystal_I2C lcd(0x3F, 16, 2);  // I2C address 0x3F, 16 column and 2 rows 27or3F
#include <Servo.h>
#include <Wire.h>

int solar;
float input_voltage = 0.0;
int moisture=A7;
int soil;
int pump=11;



// horizontal servo
Servo horizontal;
int servoh = 90;
int servohLimitHigh = 180;
int servohLimitLow = 0;

Servo vertical;
int servov = 90;
int servovLimitHigh = 180;
int servovLimitLow = 0;

// LDR pin connections
int ldrTR = A3; // LDR top right
int ldrTL = A2; // LDR top left
int ldrBR = A1; // LDR bottom right
int ldrBL = A0; // LDR bottom left

/*// LDR pin connections
```

```
int ldrTR = A2; // LDR top right
int ldrTL = A3; // LDR top left
int ldrBR = A0; // LDR bottom right
int ldrBL = A1; // LDR bottom left
*/
int dtime ; // change for debugging only
int tol ;

int avt ; // average value top
int avd ; // average value bottom
int avl ; // average value left
int avr ; // average value right

int dvert;  // check the difference of up and down
int dhoriz; // check the difference of left and right
int tr ; // top right
int tl ; // top left
int br ; // bottom right
int bl ; // bottom left

int analog_value ;
int analog_value1 ;
float t1 ;


void setup() {
// put your setup code here, to run once:
Serial.begin(9600);
lcd.init();  // initialize the lcd
lcd.clear();
lcd.backlight(); // open the backlight
pinMode(A6,INPUT);
```

```
pinMode(moisture,INPUT);
pinMode(pump,OUTPUT);
horizontal.attach(8);
vertical.attach(12);
// move servos
horizontal.write(50);
vertical.write(50);

delay(500);
}

void loop() {
soil=analogRead(moisture);
Serial.print("moisture");
Serial.println(soil);
if(soil<200){
digitalWrite(pump,LOW);
lcd.setCursor(0, 1);  // start to print at the first row
lcd.print("Normal         ");
}
if(soil>900){
digitalWrite(pump,HIGH);
lcd.setCursor(0, 1);  // start to print at the first row
lcd.print("Feild is dry ");
}

// put your main code here, to run repeatedly:
int tr = analogRead(ldrTR); // top right
int tl = analogRead(ldrTL); // top left
int br = analogRead(ldrBR); // bottom right
int bl = analogRead(ldrBL); // bottom left
int analog_value = analogRead(A6);
```

```
input_voltage = (analog_value * 5.0) / 1024.0;
Serial.print("solar:");
Serial.print(input_voltage   );
lcd.setCursor(0, 0);
lcd.print("solar");
lcd.print(input_voltage   );



tr = analogRead(ldrTR); // top right
tl = analogRead(ldrTL); // top left
br = analogRead(ldrBR); // bottom right
bl = analogRead(ldrBL); // bottom left
dtime = 0; // change for debugging only
tol = 50;

avt = (tl + tr) / 2; // average value top
avd = (bl + br) / 2; // average value bottom
avl = (tl + bl) / 2; // average value left
avr = (tr + br) / 2; // average value right

dvert = avt - avd;  // check the difference of up and down
dhoriz = avl - avr; // check the difference of left and right

Serial.print(tl);
Serial.print(" ");
Serial.print(tr);
Serial.print(" ");
Serial.print(bl);
Serial.print(" ");
Serial.print(br);
Serial.print("  ");
```

```
Serial.print(avt);
Serial.print(" ");
Serial.print(avd);
Serial.print(" ");
Serial.print(avl);
Serial.print(" ");
Serial.print(avr);
Serial.print("  ");
Serial.print(dtime);
Serial.print("    ");
Serial.print(tol);
Serial.print("  ");
Serial.print(servov);
Serial.print("    ");
Serial.print(servoh);
Serial.println(" ");

if (-1 * tol > dvert || dvert > tol) {
if (avt > avd) {
servov = ++servov;
if (servov > servovLimitHigh) {
servov = servovLimitHigh;
}
}
else if (avt < avd) {
servov = --servov;
if (servov < servovLimitLow) {
servov = servovLimitLow;
}
}
vertical.write(servov);
}
```

```
if (-1 * tol > dhoriz || dhoriz > tol) {
if (avl > avr) {
servoh = --servoh;
if (servoh < servohLimitLow) {
servoh = servohLimitLow;
}
}
else if (avl < avr) {
servoh = ++servoh;
if (servoh > servohLimitHigh) {
servoh = servohLimitHigh;
}
}
else if (avl = avr) {
// nothing
 }
 horizontal.write(servoh);
}
delay(dtime);

}
```