CONSTRUCTION AND PERFORMANCE TEST OF DUAL AXIS SOLAR TRACKING SYSTEM

A Thesis

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SONARGAON UNIVERSITY (SU)

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ABSTRACT

This is a project of DUAL AXIS SOLAR PANEL TRACKING SYSTEM. The project is about making two axis solar panel tracker that can be working robotic system. The Solar Tracker is a device which follows the movement of the sun. We used four LDR (Light Dependent Resistor). They are light sensitive devices. They are also called as photo conductors. The working principle of an LDR is photo conductivity, that is nothing but an optical phenomenon. When the light is absorbed by the material then the conductivity of the material reduces. We use two servo motor. Servos are controlled by sending an electrical pulse of variable width. A servo motor can usually only turn 90° in either direction for a total of 180° movement, we use to ATMEGA328P microcontroller. The microcontroller is there for controlling automatically. The main objective of our project is to utilize the maximum solar energy through solar panel. The solar panel tracks the sun from east to west automatically for maximum intensity of light also ensure that the tracking system design and components are cost-effective, making it a viable option for both residential and commercial solar installations. After testing and result we get that dual-axis solar tracking systems generate on average 15-30% more energy compared to static systems.

TABLE OF CONTENTS

			Page No.
Acknowledgement			i
Abstract			ii
Table of Contents			iii
Table of Figure			v
List of Notation			vi
Chapter 1		Introduction	1-7
	1.1	Introduction	1
	1.2	Research problem statement	2
	1.3	Objectives	2
	1.4	Methodology of the study	3
	1.5	Contribution of the study	4
	1.6	Arrangement of the study	4
	1.7	Future Scope of this study	5
	1.8	Limitations of this study	6
	1.9	Advantage over traditional methods	6
	1.10	Objective of this work	6
Chapter 2		Literature Review	8-20
	2.1	Introduction	8
	2.2	Historical Background	8
	2.3	Resent research	9
	2.4	Solar panel	10
	2.5	The Model of the Project	12
	2.6	Photovoltaic cell model	12
	2.7	Maximum Power Point Tracking (MPPT)	14

	2.8	Solar Irradiation Sunlight	15
	2.9	Types of Solar Trackers & System	16
	2.10	Effect of the dust density on the inclination of solar panel	18
	2.11	Temperature Effect on Solar Panel	18
	2.12	Efficiency of Solar panel	19
	2.13	Advantages & Disadvantages of solar energy	19
Chapter 3		Hardware Development	21-30
	3.1	LDR (Light Dependent Resistor)	21
	3.2	Servo Motor	24
	3.3	Microcontroller	29
	3.4	CCS C Compiler	33
Chapter 4		Result and Analysis	34-36
	4.1	Introduction	35
	4.2	Comparison Output Values	35
Chapter 5		Conclusions and Recommendations	37-40
	5.1	Summary	37
	5.2	Recommendation	38
	5.3	Discussions and Conclusions	38
	5.4	Suggestion for Future work	40
REFERENCES			41
APPENDIX			42

List of Figure

No.	Figure Name	Page
1.1	Methodology of the study	3
2.1	Solar panel module	10
2.2	Block Diagram of this project	11
2.3	Our project	12
2.4	Photovoltaic cell block diagram.	12
2.5	Iv Curve for Pv cell	13
2.6	Maximum Power tracking	15
2.7	Solar Irradiation sunlight	15
2.8	Single Axis solar tracking system	17
3.1	Light Dependent Resistor	22
3.2	Quadrant wise LDR Positioning	23
3.3	The Sensing Element & Signal Processing	23
3.4	Standard Servo motor SG-90	25
3.5	Physical construction of servo SG-90	25
3.6	35473D Microcontroller	29
3.7	Block diagram of microcontroller	30
3.8	Pin diagram	31
3.9	CCS S compiler	33
4.1	Normal solar graph	36
4.2	Tracking solar graph	36

List of Notation

Words/Signs	Notation
h	Hour
s	Second
V	Voltage
I	Current
P	Power
MPPT	Maximum Power Point Tracking
LDR	Light Dependent Resistor
PV	Photovoltaic
DC	Direct Current
AC	Alternating Current
VOM	Volt-Ohm-Milliammeter
USB	Universal Serial Bus

Chapter 1

Introduction

1.1 Introduction:

Though in this era electricity is one of the most important part of our life, approximately 1.6 billion people still living without electricity. It's only for the high cost of power grid building and maintains. This vast quantity of energy crisis can be meeting up by renewable energy across the developing world. As people are much concerned with the fossil fuel exhaustion and the environmental problems caused by the conventional power generation, renewable energy sources and among them photovoltaic panels and wind-generators are now widely used. So Solar Energy is a good choice for electric power generation. The solar energy is directly converted into electrical energy by solar photovoltaic module. Photovoltaic sources are used today in many applications such as battery charging, water pumping, home power supply, satellite power systems etc. They have the advantage of being maintenance and pollution-free but their installation cost is high and in most applications; they require a power conditioner (de/de or de/ac converter) for load interface. Since PV modules still have relatively low conversion efficiency, the overall system cost can be reduced using high efficiency power conditioners which, in addition, are designed to extract the maximum possible power from the PV module. In PV power systems maximum power point trackers (MPPTs) has an important role. It's minimizing the output power of a PV system and also the arrow efficiency as well as its cost is lower than the other power system. An important characteristic of solar panels is that the available maximum power is provided only in a single operating point given by a localized voltage and current known, called Maximum Power Point (MPP). Another problem is that the position of this point is not fixed but it moves according to the irradiance, the temperature

and load. Because of the relatively expensive cost of this kind of energy we must extract the maximum of watts of solar panels. In this project we develop a Microcontroller based dedicated MPPT controller for solar PV module based on the incremental conductance method. [1,2]

1.2 Research problem statement:

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. So, this concept is all about solving the problem that is solar tracking system will detect rotation. Usually fixed solar energy panels would not be directly oriented towards sunlight as a result of the continuous motion of the Farth. 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. [3]

1.3 Objectives:

The objectives of this project are:

- To utilize the maximum solar energy through solar panel.
- To develop and fabricate the necessary model.
- To construct of dual axis solar tracking system.
- To test of performance of dual axis solar tracking system.

1.3 Methodology of the study:

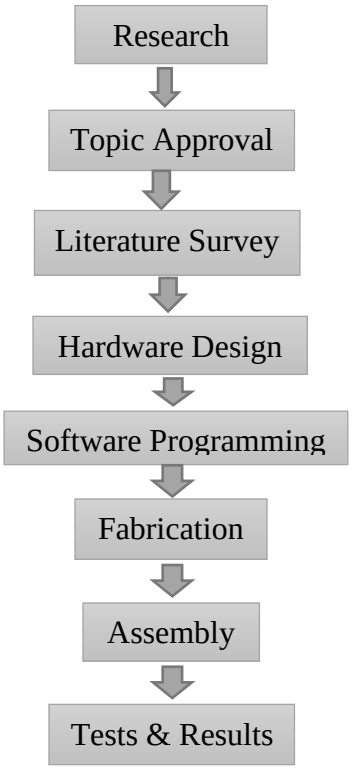


Figure 1.1 Flow chart of Methodology of the Study

Research: In Bangladesh, for both urban and rural residents, obtaining sufficient and dependable power is a key developmental problem. By using a solar tracker, the aim is to mitigate these issues by using the abundant sunlight available and to maximize efficiency by using the tracking mechanism.

Topic Approval: Upon analysis of the objectives the project was approved by the university panel

Literature Survey: The project team reviewed multiple published papers on the concerned topic from notable websites such as ieeexplore.iece.org, ijert.org, etc.

Hardware Design: The necessary hardware components were designed using software tools such as solid works and certain digital component designs were utilized from online resources such as Proteus.

Software Programming: The software program necessary to operate the sun tracking solar panel was modified from existing programs for single-axis tracking systems to suit a dual-axis operation using C++.

Fabrication: All the necessary custom hardware components are fabricated using 3D printing facilities.[4]

1.5 Contribution of the study:

The solar energy plays a vital role among all this energy now. As it has a drawback that it can only generate power against the solar panel until the intensity associated with the incident of solar radiation. We developed the solar panel system to overcome this which shift in accordance with the direct intensity associated with the event of solar radiation. This can be accomplished by controlling the solar through the servo motor, the correct algorithm and the best mechanical configuration and the microcontroller. Since the effect would increase in both efficiency and low cost connected with the solar power technology. Limited sources of fossil fuels, such as petroleum and coal, which are available now leads to global warming due to CO2 emissions [5]. The alternate source of energy is needed to reduce this type of emission. Energy from renewable sources such as solar, wind, geothermal and ocean tidal waves is being increasingly required to provide a reliable power supply and a safe environment for future generations.

1.6 Arrangement of the study:

- Complementing the introduction above, a through literature review of relevant work is presented in chapter 2. The review is accompanied by the motivation of present research.
- The research design, methodology of the research and different types of solar tracking systems are discussed in chapter 2.

- Chapter deals with the experiment result and analysis of the result from fixed, single axis and dual axis solar tracking system.
- Finally, the summary of observations and conclusions along with a brief reflection of future research are articulated in chapter.

1.7 Future Scope of this study:

Future scope:

In future, solar energy will be very important source. So, using MPPT solar charge controller can generate a huge amount of current successfully. In this way, the cost of the production can also be reduced. In a word, it can develop a high-power output MPPT system with a low cost. This complete system schematic includes the feature of maintenance free use, no requirement of fuel or lubricant, stainless steel hardware, built-in over-load, over-charge, low voltage protection, temperature compensated charging and low battery disconnect facility. Moreover, it ensures maximum continuous power at full load and simultaneously pollution free and noiseless maintenance. Furthermore, it has the ability to charge the battery in low voltage so it will get sufficient backup in case of power failure.[5]

Recommendation:

Future studies into maximum power point tracking could include the use of a different DC/DC converter and also some different MPPT algorithm such as Current MPPT (CMPPT) for example, could be implemented. Another extension of this project could be to design the DC/DC converter in full. The converter design could be done to optimize the components and in turn increasing the power efficiency. By optimizing the DC/DC converter the MPPT algorithms would achieve improved efficiencies and power tracking capabilities. Finally, a future work can also improve the developed software in order to

efficiently use the capabilities of the microcontroller. A final prototype could then be design and implemented in order to have a final portable prototype for the solar charger. The whole system into a single integrat

1.8. Limitations of this study:

- Computing with other analog system, it is costly.
- Programming of microcontroller is complex.
- It depends on temperature and radiation of sun.

1.9. Advantage over traditional methods:

At first it is pollution free and reduces the waste of other using of MPPT algorithm increase the system's efficiency. The LCD Display helps the users to inform about the condition of charge. For microcontroller it's easy to use and ensures reliability the system.

1.10. Objective of this work:

The main aim of our project is to utilize the maximum solar energy through solar panel. For this a digital based automatic sun tracking system is proposed. The solar panel tracks the sun from east to west automatically for maximum intensity of light.

Primary objectives:

The main aim of our project is to utilize the maximum solar energy through solar panel. AS the cost of traditional current source is increasing day by day, people can take the advantage of renewable energy. With more and more portable devices coming out all the time the need to use renewable energy is ever increasing. The development of this thesis is very important because nowadays there is a current need in the market for an alternative Energy device that can charge different types of batteries efficiently. The developed charging process is not very fast but can ensure an efficient loading and without any additional cost for the final user. The total system can be used both commercially and household generation. So, people can cover the crisis of electric energy, by their own-self. The total system, ensure the maximum efficiency with a low cost comparing other sources and generation system.

Secondary objectives:

The solar panel tracks the sun from cast to west automatically for maximum intensity of light. To fabricate two servo motors control interference with proposed circuit and construct a model prototype solar cell movement system with a mechanical assembly to move the panel from east to west as well as the sun track maximum angle. Finally, to design an electronic circuit to sense the intensity of light and to control servo motors drive for the panel movement. Ensure that the tracking system design and components are cost-effective, making it a viable option for both residential and commercial solar installations.

Chapter 2

Literature Review

2.1. Introduction:

Solar panel is made of tiny combination of solar cell and solar cell is the devices that are designed to convert light to electrical energy. Solar panel is mainly made from semiconductor materials such as silicon (Si), cadmium sulfide (CdS) and gallium arsenide (GaAs) can be used to make solar cells. The main purpose of using solar panel is getting the maximum energy by converting light energy to electric energy. Using solar tracker is the best way for getting the maximum energy because it's keeping the panels aligned with the sun's position and it's also an effective solution for get energy with solar panel.[3]

2.2. Historical Background:

1839- The Photovoltaic Effect: Edmond Becquerel, in 1839, discovered that when two electrodes were placed in an electrolyte (electricity-conducting solution), a voltage developed when light fell upon the electrolyte. The basic principles of solar power had been uncovered.

1876-Electricity from Light: A King's College Professor, William Grylls Adams, and his student, Richard Evans Day, found in 1876 that selenium produced electricity when exposed to light. They attached platinum electrodes to selenium and observed a current in the electrodes when the selenium was exposed to light.

1883-The First Working Solar Cell: American inventor Charles Fritts developed the first solar cell, applying selenium to a thin layer of gold. This method was only able to achieve 1% efficiency, making it impractical for general use.

1904-Einstein's Paper on Light & Electrons: In the snappily titled "On a Heuristic Viewpoint Concerning the Production and Transformation of Light," Einstein set out for the first time the relationship between light and electrons. Although controversial at the time, it was gradually accepted by the scientific community and led to his winning of the Nobel Prize in 1921. Later in 1916, Robert Millikan would experimentally prove "Einstein's theory of the photoelectric effect"

1954-A Major Breakthrough: Three researchers at Bell Labs - Daryl Chapin, Calvin Fuller, and Gerald Pearson discover silicon solar cells.

Late, 1950s Increasing Efficiency: Throughout the late 50s. Hoffman electronics developed increasingly efficient solar cells. It started out initially at an 8% efficient cell in 1957, before eventually increasing to a 14%-efficient, commercially available cell in 1960.

2.3 Resent research:

Newer and more efficient charger controllers have emerged that provide a better match between the PV panels and their load. Their goal is to use all the power from the PV panel(s) regardless of the voltage and current at any amount of insolation or at any temperature. The newer charge controllers employ a DC-to-DC converter section that is adapted to dynamically charge the battery (or to directly power a load) at the exact voltage and current that is most appropriate for that battery (or load). Although the newer charge controllers provide improved system efficiencies relative to the older models, they too often suffer from several shortcomings. More particularly, the charge controllers are slow to adapt to changing conditions of the PV panel(s) over the course of any given day, including low light conditions in the morning, evening and during cloud cover and also temperature changes sometimes associated with the changes in insolation.

The edges of clouds create particularly issues because they cause a rapid change in lighting which may be followed by a relatively rapid change in temperature. Because they do not quickly adapt to changing conditions, the charge controllers have limited efficiency, which

results in the need for extra (or larger) PV panels to be used for a given power output and high costs. Now-a-days all digital MPPT controllers are controlled microcontroller. They automatically adjust the output, move the panel for sunlight and also shut down for microseconds if necessary.

MPPT charge controllers are now commercially manufactured by several companies, such as outback power, Xantres XW-SCC, Blue Sky Energy, Apollo solar, Midnight solar, Morning star and a few others.[1]

2.4 Solar panel:

Solar panel is mainly designed as a panel which absorbed the sun's rays and convert light into electricity. Most of the time the most powerful source of light available is the Sun, called Sol by astronomers. It is called photovoltaic which means, basically, "light-electricity.

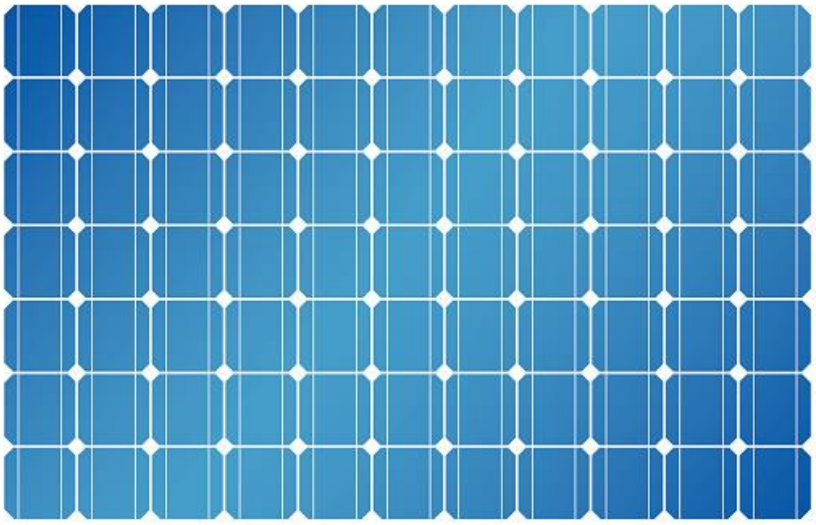


Fig 2.1: Solar panel module

A solar panel is a collection of solar cells. Lots of small solar cells spread over a large area can work together to provide enough power to be useful. Solar power generating systems

take advantage of this property to convert sunlight directly into electrical energy. Solar panels also called "solar modules produce direct current (DC), which goes through a power inverter to become alternating current (AC) -electricity that we can use in the home or office or other sectors.

When sunlight hits the semiconductor, an electron springs up and is attracted to the n-type semiconductor. This causes more negative electrons in the n-type semiconductor and more positive electrons in the p-type, thus generating a flow of electricity in a process known as the photovoltaic effect. The majority of solar modules use wafer-based crystalline silicon cells or thin-film cells based on cadmium telluride or silicon.

Future studies into maximum power point tracking could include the use of a different DC/DC converter and also some different MPPT algorithm such as Current MPPT (CMPPT) for example, could be implemented. Another extension of this project could be to design the DC/DC converter in full. The converter design could be done to optimize the components and in turn increasing the power efficiency. By optimizing the DC/DC converter the MPPT algorithms would achieve improved efficiencies and power tracking capabilities. Finally, a future work can also improve the developed software in order to efficiently use the capabilities of the microcontroller. A final prototype could then be design and implemented in order to have a final portable prototype for the solar charger. The whole system into a single integrated.[6]

Block Diagram of This Proposed Project:

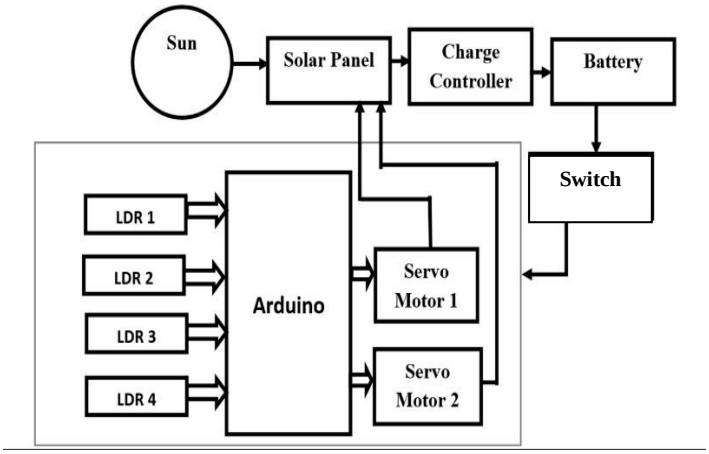


Fig 2.2 Block diagram of project

2.5 The Model of the Project:

The Proposed model of Dual Axis Solar Tracker System.

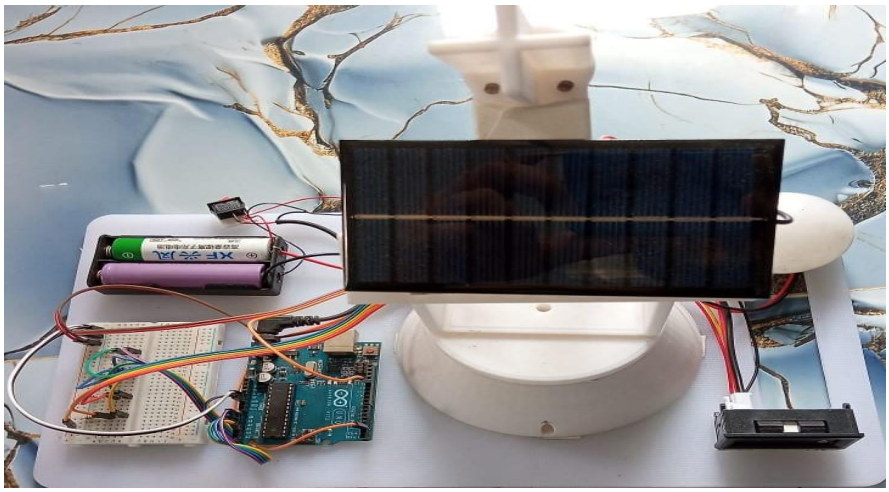


Fig 2.3 Our project

2.6 Photovoltaic cell model:

A simplest equivalent circuit of a solar cell is a current source in parallel with a diode. The output of the current source is directly proportional to the solar energy (photons) that hits on the solar cell. During darkness, the solar cell is not an active device, it works as a diode, i.e. A p-n junction. It produces neither a current nor a voltage. The diode determines the IV characteristics of the cell.[6]

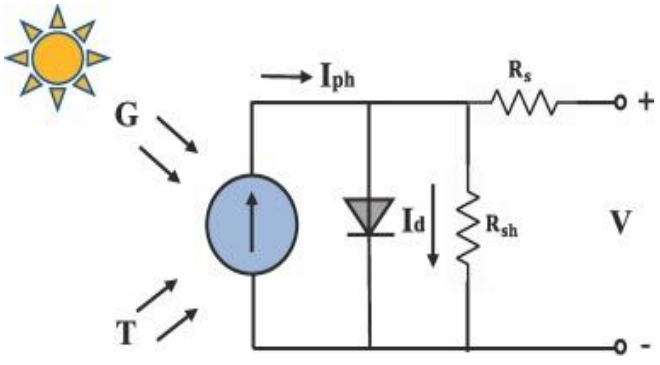


Fig 2.4 Photovoltaic cell block diagram

IV curve for a PV cell:

A general I-V characteristic of the solar cell for a given ambient irradiation 'G' and fixed cell temperature "T" is shown in Fig 3. For a certain resistive load, the load characteristic is a straight line with slope. Power delivered to the load depends on the value of the resistance only. In some cases, if the R load is very small; the PV cell operates in the M-N region of the IV curve, the PV cellact as a constant current source, which is almost equivalent to a short circuit current. However, if the R load is large, the PV cell operates in the P-S region of the IV curve, the PV cell act as a constant voltage source almost equivalent to the open circuit voltage. A PV cell is characterized by the following fundamental parameters in Fig -2.5.

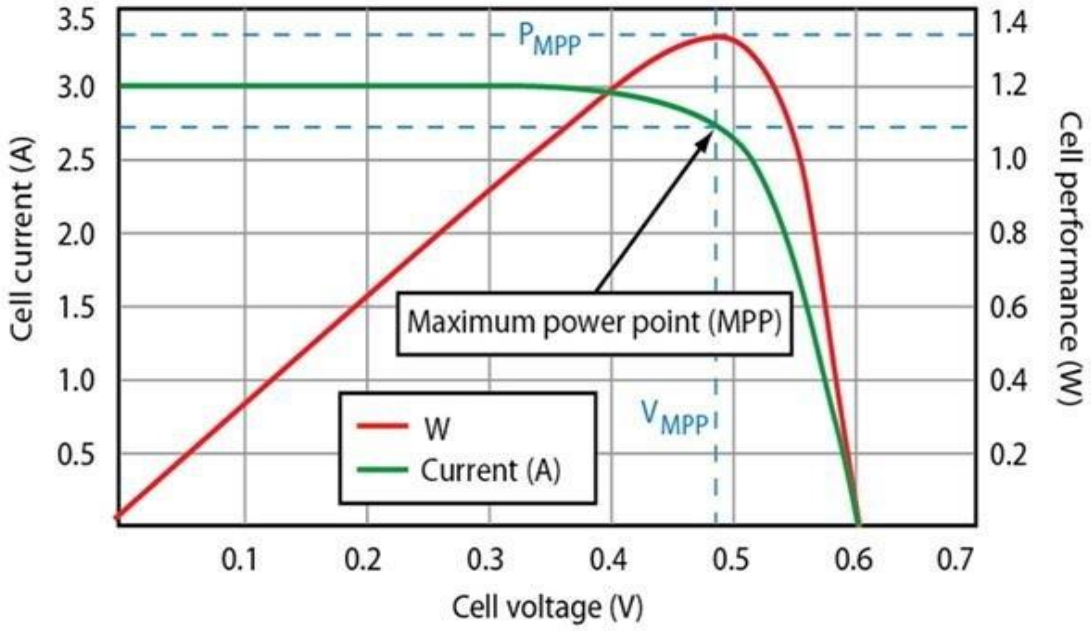


Fig 2.5: Iv curve of pv cell

1/V Characteristics of PV cell

- Short circuit current: Isc Iph (Greatest value of the current generated by a PV cell, which is produced by the short circuit condition: V-0.
- Open circuit voltage is a voltage drop across the diode D when the generated current I=0.It presumes the voltage of the PV cell in the night and it is expressed by

- Maximum power point is the operating point in Fig 2.3, where the power dissipated in the resistive load is maximum. Maximum efficiency is the ratio of the maximum power and the incident solar energy (photons). irradiation and A is the PV cell area. Pmax/Pin Vmax Imax/AG. Where is the ambient
- Fill factor (FF) is the ratio of the maximum power that can be delivered to the load and the theoretical maximum power which is the product of Isc and Voc. FF-Pmax/Voc Isc=Vmax Imax/Voc Isc. FF is a measure of real I-V characteristic which value much be higher than 0.7 for a good PV cell.[7]

2.7 Maximum Power Point Tracking (MPPT):

Maximum Power Point Tracking (MPPT) is an electronic system that operates the Photovoltaic (PV) modules that allows the modules to produce all the power they are capable of. MPPT is a fully electronic system that varies the electrical operating point of the modules so that the modules are able to deliver maximum available power.

- Let, the values of the current (1) and voltage (V) of the cell result in a maximum power output and a particular load resistance, R= V/I, as specified by Ohm's Law. The power P is given by PVI. From basic circuit theory, the power delivered
- from or to a device is optimized where the derivative of the I-V curve is equal and
- Opposite of the I/V ratio. This is known as the maximum power point (MPP). The load with resistance R=V/I, which is equal to the reciprocal of this value and draws
- The maximum power from the device is sometimes called the characteristic resistance of the cell. If the resistance is lower or higher than this value, the power drawn will be less than the maximum available, and thus the cell will not be used as efficiently as it could be. Maximum power point trackers utilize different types of control circuit or logic to search for this point and thus to allow the converter circuit to extract the maximum power available from a cell.[7]

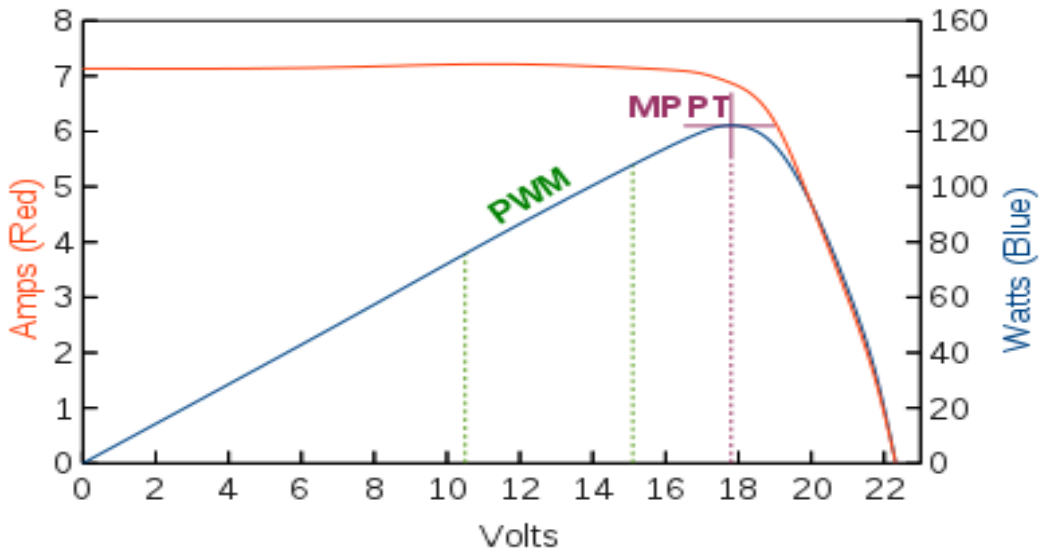


Fig 2.6 Maximum power tracking

2.8 Solar Irradiation Sunlight:

Electromagnetic radiation means which the sun delivers energy to the earth. The radiation flows evenly distributed from a surface which is close to spherical. The sunlight covers a broad range of wavelengths from roughly 250 nm (UV) over the Visible range (400-700 nm) up to several thousands of nm (IR).

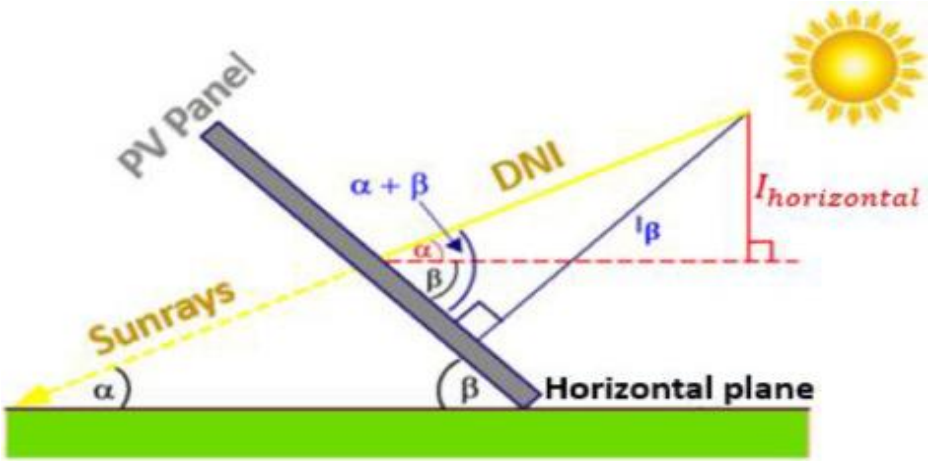


Fig 2.7 Solar irradiation sunlight

There is solar fusion that results from the temperature and pressure at the core of the sun. Protons converted into helium atoms at 600 million tons per second. Fusion gives rise to lots of energy in form of gamma rays that are absorbed by particles in the sun and re-emitted. This spectrum contains visible light and near-visible radiation, such as x-rays, ultraviolet radiation, infrared radiation, and radio waves. The visible light and heat of the sun makes life possible, and is called daylight or sunshine. Majority of the sun's harmful radiation deflects by the earth atmosphere.

2.9 Types of Solar Trackers & System:

Solar Trackers are almost worldly used in case of Solar Thermal Technology because it generates high amounts of energy from sunlight. It's a way to install the pv panel that the sunlight reaches them at perpendicularly or reduce the incidence angle as much as possible. Using tracker on solar panel makes this system smart and the tracker track the sun rays and it's rotated the panel according with rays. There are two types of tracker system and they are single axis solar tracker and dual axis solar tracker.

Single axis solar tracker:

Single axis trackers will track the sun from east to west on a single pivot point. With advanced tracking algorithms, it is possible to align them in any cardinal direction. Single axis solar tracker device, on the basis of LDR sensor values, orients the solar panel in accordance with the position of the sun. Average output power of single axis solar tracker is 2.958 w. Average practical efficiency of solar panel for single axis is 6.55%. Average power gain of single axis solar tracker up to 18.32%.

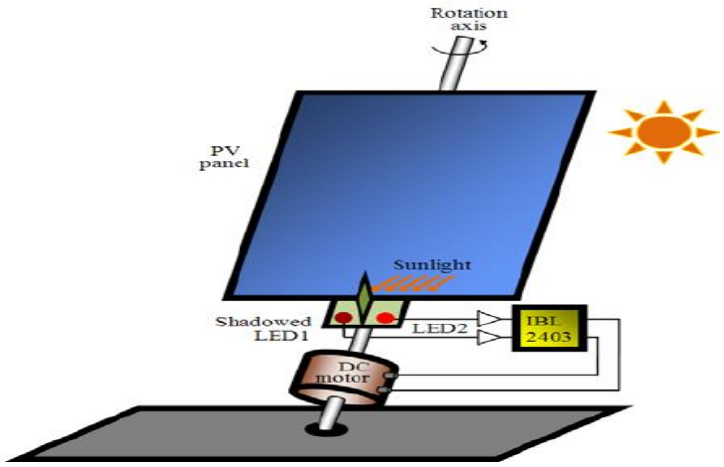


Fig 2.8 Single axis solar tracker

Dual axis solar tracker:

Dual axis tracking system uses the solar panel to track the sun from east to west and north to south. Dual axis solar tracker has two axis of freedom that act as axes of rotation. This axis is fixed with respect to the ground axis consider as a primary axis. But this one is also costly and complicated then single axis solar tracker. Dual axis solar tracker will be reliable and accurate and it is maximizing the output to static and single axis tracking system. This system uses four LDR's, two motors and a controller. The four LDR placed on at four different directions. The controller detects the signal from the LDR's and commands the motor to rotate the panel in respective direction.

Comparison between single and dual axis solar tracker:

Individually adjustable solar trackers feature just one degree of flexibility that acts as the tracker's central axis of rotation. This is often oriented along a North-South axis, although it is feasible to align them along any basic axis as well. In general, single-axis solar trackers are less expensive, more reliable, and have a longer lifetime than dual-axis solar trackers; nevertheless, when compared to dual-axis solar trackers, single-axis solar trackers produce less energy under sunny circumstances and have fewer technical advances.

In contrast to single-axis trackers, dual-axis trackers provide two degrees of freedom, allowing for a much greater range of motion. It is via the cooperation of the main and secondary axes that these trackers can direct the solar panels to particular locations in the sky. When compared to single-axis solar trackers, dual-axis trackers provide a greater degree of versatility as well as more precision in directional aiming, allowing them to be more efficient under sunny circumstances overall.

2.10 Effect of the dust density on the inclination of solar panel:

In general, the Dhaka city climate is weather: dry, hot and dusty at summer, and moderate temperature, little rain, and dusty at winter and maybe dusty along the year. It is known that the accumulation of dust on the solar panels leads to hide the sun radiation from photovoltaic cells, thus tend to decrease the performance of the system. In order to maintain the operation of the system in optimum level, the dust should be cleaned from time to other, the cleaning process can be carried out easily for small systems, but for the large system it will be too difficult process. The best way to limit this problem, solar panels should fix with a little inclination, at this position wind and rain can help to remove the most amount of the accumulated dust. According to the above explanation, it recommends to place the solar panels at an inclination angle of about 30° to eliminate the effect of this problem [6].

2.11 Temperature Effect on Solar Panel:

Temperature has a significant bad effect on the physical properties of silicon photovoltaic cells in terms of instantaneous energy production, and permanent effect. The permanent effect is the reduction of the solar panel service life, where practical experience has shown a decrease in the energy performance of solar panels by 8% after the first year of operation in Iraqi weather, where the cells expose to more than 100 °C. The instantaneous effect has too much reduction of solar panel performance with temperature rise. It is known that the

efficiency of photovoltaic cells decreases with the increase of temperature by about 0.4%°C [13], at the summer the efficiency of the solar panels reduced significantly to 60% of the design capacity, this amount of redaction is always shown on panel label.

Therefore, in Iraq weather at summer days the productivity of solar panels is less than panels productivity at winter, until as know that the intensity of light at summer is greater than at winter, causing a high PV temperature effect.

2.12 Efficiency of Solar panel:

The efficiency is the parameter which is most commonly used to compare with one solar panel to anthers panel. Efficiency is defined as the ratio of energy output from the solar cell to input energy from the sun. The efficiency of a solar cell is determined as the fraction of incident power which is converted to electricity and is defined as:

$P_{max} = V_{oc} l_{sc} FF$

$\eta = \frac{V_{oc} l_{sc} FF}{P_{in}}$

Where V_{oc} is the open-circuit voltage;

where l_{sc} is the short-circuit current; and

where FF is the fill factor

where η is the efficiency.

The input power for efficiency calculations is 1 kW/m² or 100 mW/cm². Thus, the input power for a100 × 100 mm² cell is 10 W and for a 156 × 156 mm² cell is 24.3 W.

2.13 Advantages & Disadvantages of solar energy:

There are several benefits that solar energy has and which make it favorable for many uses.

Advantages:

- Solar energy is a clean and renewable energy source.
- It is pollution free.
- Solar cells are free of any noise. On the other hand, various machines used for pumping oil or for power generation are noisy.
- Solar energy can be used in very remote areas where extension of the electricity power grid is costly.
- Once a solar panel is installed, the energy is produced at reduced costs.

Disadvantages:

- Solar power stations do not match the power output of conventional power stations of similar size. Furthermore, they may be expensive to build.
- Generation of electricity from solar is dependent on the country's exposure to sunlight. This means some countries are slightly disadvantaged.

Chapter 3

Components, Design & Implementation

3.1. LDR (Light Dependent Resistor):

LDR (Light Dependent Resistor) is called as light detecting sensor to build solar track which has included phototransistors, photodiodes and LDR. It is a made up of semiconductor materials which has high resistance. LDR is the most common in electronics and it is spread used in many types of electronics. LDR can use for street lamp, outside lights, a number of indoor home appliances, and so on. It is utilizing the light sensor circuit for automatic switch OFF the loads based on daylight's intensityby helping of a light sensor. In daylight the rays of sun fall on the photovoltaic panel and photo resistor and when the light falls on the resistor, then the resistance changes. This resistor's has different functions and resistance. Using LDR in a circuit or in a electronics project it is make circuiteffective and the collection of LDR parts of the circuit are easily available and accuracy of this circuitis more than accuracy of other circuits. It is so much helpful for saving energy. There are two types of photoresists or based on material used and they are Intrinsic Photo Resistors and Extrinsic Photo Resistors. Intrinsic Photo Resistors are made up of pure semiconductor devices like silicon or germanium. When the light falls on the Intrinsic Photo Resistors, the electrons get excited from the valence band to the conduction band and number of charge carriers increases on a resistor. Extrinsic Photo Resistors are doped with impurities and this impurity creates a new energy band above the valence band.

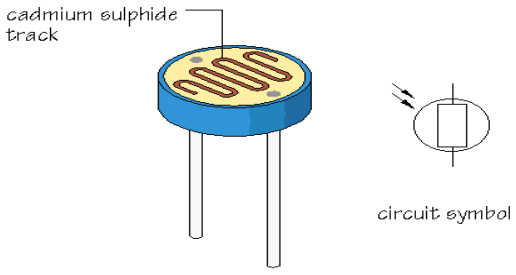


Fig 3.1 Light dependent resistor

Working Principle of LDR:

Photo Conductivity is the main principle of the light depended resistor. Photo conductivity is an optical method, which the material's conductivity is increased when light is absorbed by the materials. When the light (photon) falls on the materials, 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. The result of this process is more and more current starts flowing through the device when the circuit is closed and hence it is said that the resistance of the device has been decreased. This causes the free electrons or holes to conduct electricity and thus dropping the resistance (< 1 Kilo ohm). This is the working principle of light dependent resistor. The equation to show the relation between resistance and illumination can be written as,

RA.E^a

Where

E= Illumination (lux)

R=Resistance (Ohms)

A= Constants

The value of 'a' depends on the CdS used and on the manufacturing process. Values usually range between 0.7 and 0.9.

The Design and implementation of using Four LDRs:

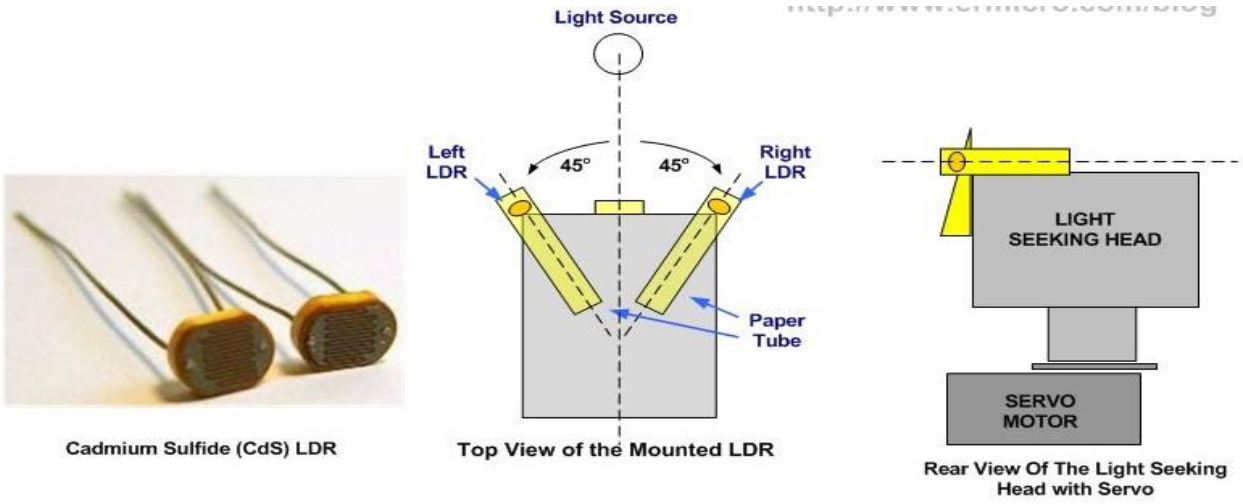


Fig 3.2 Quadrant wise LDR positioning

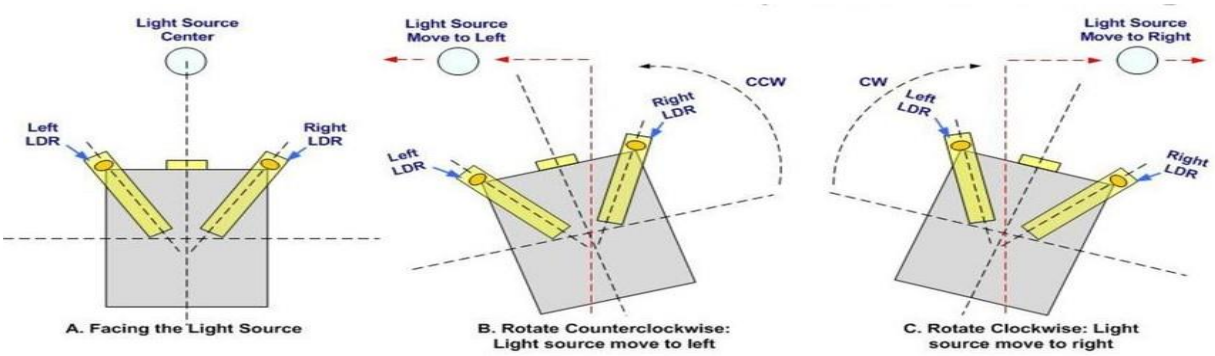


Fig 3.3 The sensing element and signal processing

There are several methods was proposed and used to track the position of sun light. We used four LDRs to track our module properly. A Light Dependent Resistor separated by a small plate to act as a shield to sunlight, as shown in the next figures. The two LDRs are connected to a bridge and the output of the bridge is connected to a comparator (the analog comparator of the microcontroller is used).

When LDR1 has higher light intensity than L.DR2 then the resistance of LDRI is smaller than that of LDR2 then voltage at AINO is higher than that of AIN1 and the output of comparator is high.

When LDR2 has higher light intensity than LDRI then the resistance of LDR1 is larger than that of LDR2 then voltage at AINO is smaller than that of AINI and the output of comparator is low. Then the output of the comparator is used in the UC program to control the stepper motor RVI variable resistor is used to balance the bridge when the two LDRs having the same light intensities (due to the mismatch between the two LDRs).

Similarly, we used the process for L.dR3 and LDR4 using Dark and Bright Fringes.

3.1.3 The minimum light detectable Equation:

It's a circuit used to detect the condition when there is no sunlight to turn off the tracking system

3.2 Servo Motor:

Servo motor is a self-contained electric devices and simple electrical motor, which is controlled with the help of servomechanism. It is a motor which has a output shaft and can be moved to a specific angular position by sending it a coded signal. The servo motor will maintain the position of the shaft When we changed the coded signal, the angular position of the shaft will change. Servo motors are used for various applications. They are normally small in size and have good energy efficiency. The cost of this motor also less than others motors and also simple to used. Servos are found in many places from toys to home electronics to cars and airplanes. Servos also appear behind the scenes in devices we use every day.

Servo motor also used in robotic projects for every moving of their joint. The servo circuitry is built inside the motor unit and comes with a position able shaft that is fitted with a gear.



Fig :3.4 Standard servo motor SG-90

The motor is controlled with an electric signal that determines the amount of shaft movement. In a market there are found two types of servo motor, one is made up of metal gear and another are made up of plastic gear. The metallic one is much heavier than other gear one. The size of metallic gear Servo motor is also bigger than plastic gear servo motor.

Components of servo motor SG-90

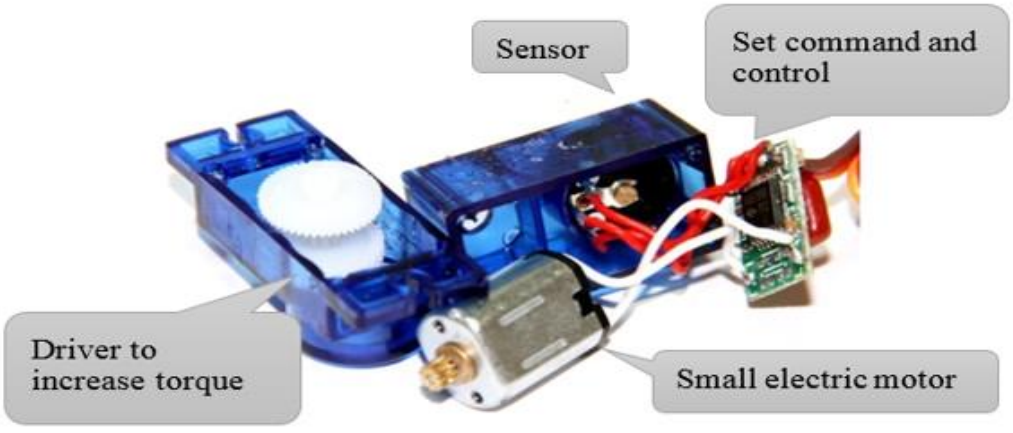


Fig 3.5 Physical construction of servo SG-90

In our work we used SERVO MOTOR SG90 and it's easy to use because it is small in size which makes our work comfortable. In briefly below we discussed on SG90.

SERVO MOTOR SG-90: It is tiny and lightweight with high output power. This servo can rotate approximately 180 degrees and it works just like the standard kinds

Specifications:

- Weight: 9 gm
- Dimension: 22.2 x 11.8 x 31 mm approx.
- Stall torque: 1.8 kgf cm
- Operating speed: 0.1 s/60 degree
- Operating voltage: 4.8 V (-5V)
- Dead band width: 10 µs
- Temperature range: 0 °C -55 °C

Servo Mechanism:

A servo system mainly consists of three basic components a controlled device, an output sensor, a feedback system. This is an automatic closed loop control system. Here instead of controlling a device by applying variable input signal, the device is controlled by a feedback signal generated by comparing output signal and reference input signal. When reference input signal or command signal is applied to the system, it is compared with output reference signal of the system produced by output sensor, and a third signal produced by feedback system. This third signal acts as input signal of controlled device. This input signal to the device presents as long as there is a logical difference between reference input signal and output signal of the system. After the device achieves its desired output, there will be no longer logical difference between reference input signal and reference output signal of the system. Then, third signal produced by comparing theses above said signals will not remain enough to operate the device further and to produce further output of the system until the next reference input signal or command signal is applied to the system.

Working Principle of Servo Motor:

A servo motor is basically a DC motor (in some special cases it is AC motor) along with some other special purpose components that make a DC motor a servo. In a servo unit, you will find a small DC motor, a potentiometer, gear arrangement and an intelligent circuitry. The intelligent circuitry along with the potentiometer makes the servo to rotate according to our wishes.

As we know, a small DC motor will rotate with high speed but the torque generated by its rotation will not be enough to move even a light load. This is where the gear system inside a servo mechanism comes into picture. The gear mechanism will take high input speed of the motor (fast) and at the output; we will get an output speed which is slower than original input speed but more practical and widely applicable. Say at initial position of servo motor shaft, the position of the potentiometer knob is such that there is no electrical signal generated at the output port of the potentiometer. This output port of the Potentiometer is connected with one of the input terminals of the error detector amplifier. Now an electrical signal is given to another input terminal of the error detector amplifier. Now difference between these two signals, one comes from potentiometer and another comes from external source amplified in the error detector amplifier and feeds the DC motor. This amplified error signal ts as the input power of the de motor and the motor starts rotating in [1] desired direction. As the motor shaft progresses the potentiometer knob also rotates as it is coupled with motor shaft with selp of gear arrangement. As the position of the potentiometer knob changes there will be an electrical signal produced at the potentiometer port. As the angular position of the potentiometer knob progresses the output or feedback signal increases. After desired angular position of motor shaft the palentiometer knob is reaches at such position the electrical signal generated in the potentiometer ecomes same as of external electrical signal given to amplifier. At this condition, there will be no utput signal from the amplifier to the motor input as there is no difference between external applied signal and the signal generated at potentiometer. As the input signal to the motor is nil at that position, de motor stops rotating. This is how a simple conceptual servo motor works.

Servo Motor Control:

Let us consider an example of servomotor that we have given a signal to rotate by an angle of 45° and then stop and wait for further instruction.

The shaft of the DC motor is coupled with another shaft called output shaft, with help of gear ssembly. This gear assembly is used to step down the high rpm of the motor's shaft to low rpm at output shaft of the servo system.

The voltage adjusting knob of a potentiometer is so arranged with the output shaft by means of another tar assembly, that during rotation of the shaft, the knob also rotates and creates an varying electrical potential according to the principle of potentiometer. This signal i.e. electrical potential is increased with angular movement of potentiometer knob along with the system shaft from 0° to 45°. This electrical potential or voltage is taken to the error detector feedback amplifier along with the input reference commends i.e. input signal voltage.

Advantages & Disadvantages of using Servo motor:

There are some advantages and disadvantages of using servo motor, In below we discused sho advantages and disadvantages of servo motor.

Advantages:

- Servo motors are the better option for high speed and high torque.
- Servo motors are available at much faster speed.
- Servo motors are accurate positioning
- Servo motors also maintain torque at high speed, up to 90%.
- Servo has efficiency of about 80-90%.
- Servo motors are small is size
- Servo motor has a resonance and vibration free operation.

Disadvantages:

- Servo motors are expensive to buy.
- Servo motors have required setup to stabilize feedback loop. Servo motor can be damaged for overloading.
- Servo motor has poor motor cooling. Servo motor design more mechanically complex.
- Servo motor maintenance requirements will also increase.

3.3 Microcontroller:

Amicrocontroller is a single chip micro-computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals. Basically, microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, implantable medical devices, remote controls, office machines, appliances, power tools, toys and other embedded systems. A microcontroller is available in different word lengths like ocessors (4bit, 8bit, 16bit 32bit, 64bit and 128-bit microcontrollers are available today). Hete ATMEGA328P microcontrollers.



Fig: 3.6 ATMEGA328P Microcontroller

Amicrocontroller contains one or more of the following components:

- Central processing unit (CPU)

- Random Access Memory (RAM)
- Read Only Memory (ROM)
- Input/output ports
- Timers and Counters
- Interrupt controls
- Analog to digital converters
- Digital analog converters
- Serial interfacing ports

Basic Block Diagram of Microcontroller:

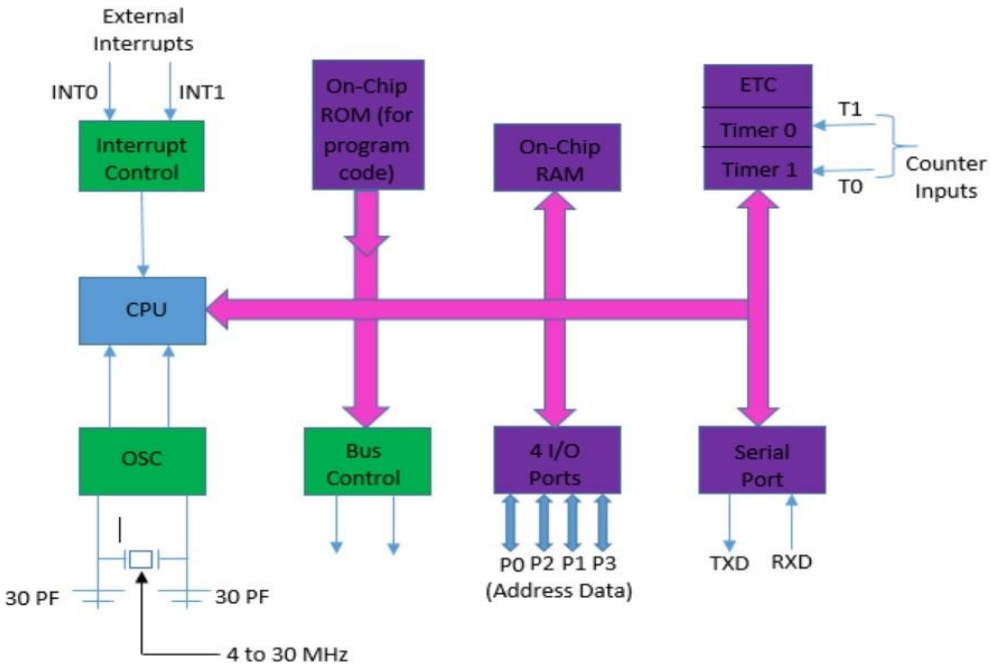


Fig: 3.7 Block diagram of microcontroller

ATMEGA328P Pin Diagram:

ATMEGA328P is one of the most popular and advanced microcontrollers from Microchip and it are implement in a circuit. The 28 pins make it easier to use the peripherals as the functions are etal out over the pins. This controller is widely used for experimental cause its application range high quality, ease of availability and low cost. [11]

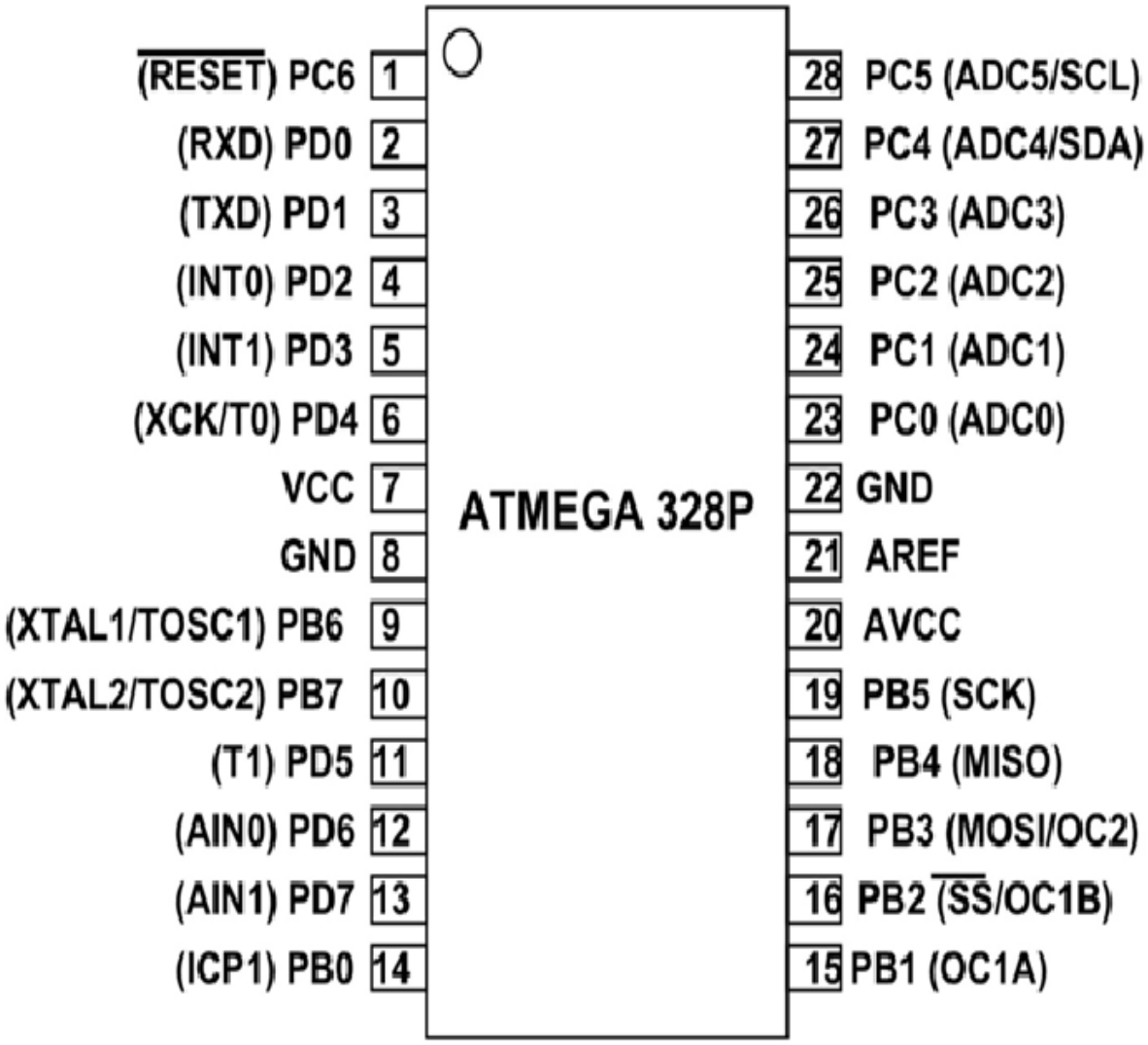


Fig: 3.8 ATMEGA328P Pin diagram

Pin and their functions:

Pin Number	Description Function
1	RESET (Reset Input)
2	RXD (USART Receive Pin)
3	TXD (USART Transmit Pin)
4	INT0 (External Interrupt 0)
5	INT1/OC2B (External Interrupt 1 / Timer2 Compare Match B)
6	T0/XCK (Timer/Counter0 External Counter Input / USART Clock)
7	Supply Voltage
8	Ground
9	XTAL1 (External Clock Input)
10	XTAL2 (External Clock Output)
11	T1/OC0B (Timer/Counter1 Input / Timer0 Compare Match B)
12	AIN0/OC0A (Analog Comparator Input / Timer0 Compare Match A)
13	AIN1 (Analog Comparator Input)
14	ICP1/CLKO (Input Capture / Clock Output)
15	OC1A (Timer1 Compare Match A)
16	SS/OC1B (SPI Slave Select / Timer1 Compare Match B)
17	MOSI/OC2A (SPI Master Out Slave In / Timer2 Compare Match A)
18	MISO (SPI Master In Slave Out)
19	SCK (SPI Clock)
20	Supply voltage for ADC
21	Analog Reference for ADC
22	Ground
23	ADC0 (Analog Input Channel 0)
24	ADC1 (Analog Input Channel 1)
25	ADC2 (Analog Input Channel 2)
26	ADC3 (Analog Input Channel 3)
27	ADC4/SDA (Analog Input / TWI Data)
28	ADC5/SCL (Analog Input / TWI Clock)

3.4 CCS C Compiler:

CCS stands for Custom Computer Services, a Microchip PIC Microcontroller Tool Solutions company. CCS C are the best compilers for beginners as they includes a lot of built in libraries which enable us to program a PIC Microcontroller without the deep knowledge of its internal architecture. I think CCS C is the best High Level Language Compiler for PIC Microcontroller as it is almost hardware independent.

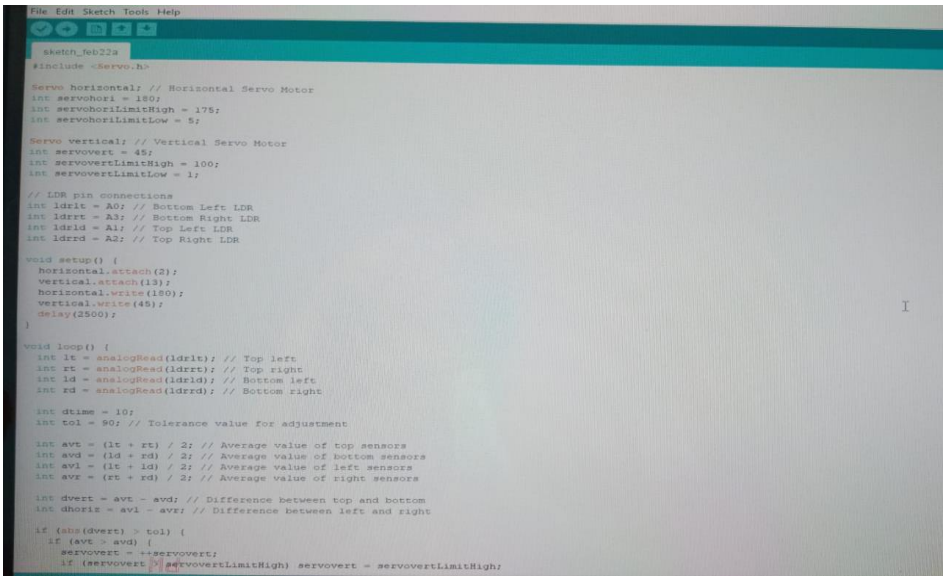


Fig: 3.9 CCS C compiler

Key Compiler Features:

Easily migrate between all Microchip PIC MCUs devices.

Minimize development time with: peripheral drivers and standard C constructs.

C++ style input/output streams with full data formatting to any device or for strings.

Use CCS libraries and object code royalty free

The integral one-bit type permits the compiler to generate very efficient Bit-oriented code

Easily define, set-up and manage interrupts.

Chapter 4

RESULT & DISCUSSION

4.1 Introduction

The rapid increase in energy demand cannot be resolved easily until there is an alternative way to meet the demand. So, the user will become less compulsive on the convenient fossil fuel energy. The stored energy also plays a significant role to avoid the imbalance of the power system. With the transition away from conventional fossil fuel-based energy sources, a variety of solar energy supplies are now available [18], Solar energy is one of the utmost major attempts to address the problem of global warming, as well as a source of renewable energy. Additionally, to being a cost-effective source of energy, it may assist in providing a substitute to conventional fossil fuel-based energy a resource. Consumption is actually contained within photovoltaic and thermal energy, necessitating the employment of solar tracking panels.

4.2 Comparison of output values between the static solar panel and solar panel with a tracking system:

Normal solar system:

SL NO.	Time	Solar Volt (V)	Ampere (A)	P_{out} (volt*amp)
1	9: 30 am	0.90	0.31	0.279
2	10:00 am	0.957	0.33	0.315
3	10:30 am	0.976	0.33	0.322
4	11:00 am	1.213	0.38	0.459
5	11:30 am	1.484	0.44	0.653

6	12:00 pm	2.158	0.65	1.397
7	12:30 pm	2.03	0.62	1.258
8	1:00 pm	2.15	0.55	1.182
9	1:30 pm	1.98	0.50	0.99
10	2:00 pm	1.86	0.41	0.762

Average output = 0.762 W

Dual axis tracking system:

SL NO.	Time	Solar Volt (V)	Ampere (A)	P_{out} (volt*amp)
1	9: 30 am	1.72	0.42	0.722
2	10:00 am	1.84	0.50	0.921
3	10:30 am	1.90	0.50	0.95
4	11:00 am	2.06	0.52	1.071
5	11:30 am	2.15	0.55	1.182
6	12:00 pm	2.10	0.82	1.722
7	12:30 pm	2.12	0.65	1.385

Average output = 1.136 W

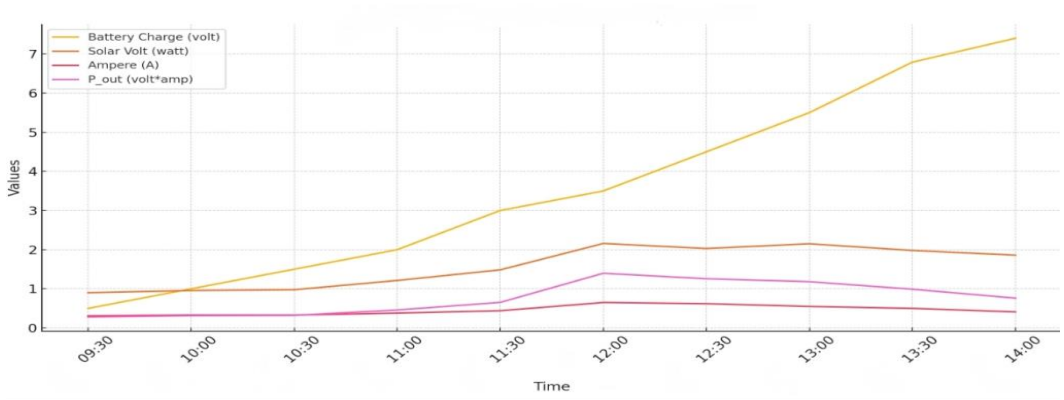


Fig: 4.1 Normal solar

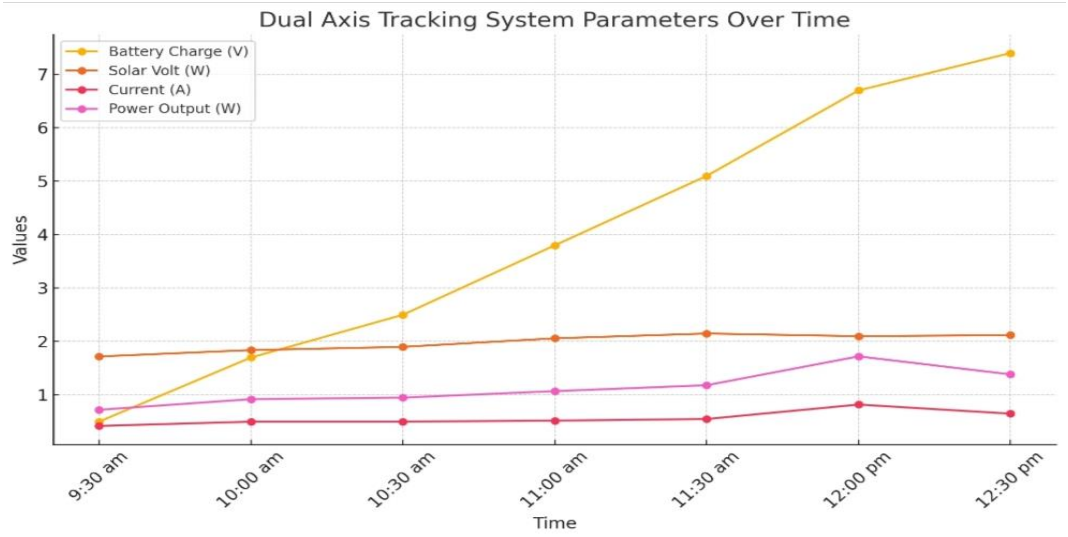


Fig: 4.2 Tracking solar

This section discusses the comparison results obtained by the outdoor experiments. The power outputs, and the overall efficiency between the static solar panel and solar with tracking mechanism are tabulated and plotted in the time graph. After testing and result we get that dual-axis solar tracking systems generate on average 15-30% more energy compared to static systems.

Chapter 5

CONCLUSIONS AND RECOMMENDATION

5.1 Summary:

The Microcontroller based multi axis solar tracking based solar panel is designed and successfully implemented to increase the efficiency of solar panel. The proposed dual axis solar tracker is more effective than the existing single axis solar tracker and fixed mount. The proposed solar tracker which automatically tracks the sun to grab maximum solar power with the help of microcontroller was effectively achieved. The implementation cost of microcontroller for tracking solar power is low and it's implementation is simple.

This paper included a practical work compare the performance of different photovoltaic systems; the solar tracker system was installed in Dhaka-Bangladesh to measure the solar radiation received. The impact of the use of single axis and double axis trackers and compared this influence to fixed solar panel, a solar tracker had been constructed, the three system were tested and got a logical knowledge. The influence of each device on solar energy systems were, the single axis tracker system tends to 29.83% Improvement of power generated relative to the fixed solar panel; the dual axis tracker system tends to 37.05% Improvement of power generated relative to the fixed solar panel while double axis tracker system tends to 7.7% rise compare to the fixed solar panel.

Finally, this project successfully enhances the potential of a stationary solar panel by effectively implementing a tracker using LDRs and Microcontroller which is a coherent method of increasing efficacy and solar power generation. The main destination of this project is to achieve the highest performance of a Multi axis solar tracking system.
With the available resources and time, the objective of the project was met.[8]

5.2 Recommendation

The following are a few suggestions that may be incorporated in the future to improve the model:

- In the future, more efficient sensors that are both cost effective and use minimal power may be considered for future projects. This would improve efficiency.
- A polycrystalline solar panel is utilized in this model; however, for greater energy otte model may be equipped with monocrystalline solar panels, which are more efficient whe production scale exceeds IKW.
- Use higher motors with greater torque values for larger panels, which helps produce a higher solar energy output.
- As sensor-based tracking can have limitations such as dust and clouds obstructing the sunlight.

In this project, we have worked on different sun angles and mainly the solar radiation for different systems. We have ignored different factors like humidity, sun intensity etc.

So, here is a scope to improve it more and make it more accurate.

5.3 Discussions and Conclusions

Discussion:

In this work, a MPPT charge controller is presented. A microcontroller is used to control the maximum power point tracking algorithm, which is used in PV systems to maximize the photovoltaic array o/p power.

An optimized and effective technique has been proposed considering the discussed drawbacks. The proposed system was simulated and constructed, and the functionality of the suggested control concept was proven. The proposed system was simulated and constructed, and the functionality of the suggested control concept was proven. From the

results acquired during the simulations and hardware experiments, it was confirmed that, with a well-designed system including a proper converter and selecting an efficient and proven algorithm, the implementation of MPPT is simple and can be easily constructed to achieve an acceptable efficiency level of the PV modules. The results also indicate that the proposed control system is capable of tracking the PV array maximum power and thus improves the efficiency of the PV system and reduces low power loss and system cost. This method protects the MPPT effects from environmental variations and leads us to proper direction to the tracker which makes it independent of environmental changes (particularly irradiation and temperature). The method has been modified based on the incremental conductance and the simulated tesult offers high efficiency during stable conditions as well as fast changing conditions and hence it maintains the advantage of the existing methods. The work executed in this project deals with analyzing and modeling of transformer less PV systems related to the leakage current phenomenon that can degrade solar panel performance and pose human Additionally, leakage current is an unwanted loss especially when it comes to distributed generation system. One of the major tasks of this research was to investigate and verify the transformer less topologies and control strategies that would minimize the leakage current of PV inverter topologies so that it can comply with the standard requirements, safety of human interaction and mitigation of unwanted losses.

Conclusion:

In conclusion, the dual-axis solar tracking system offers significant advantages in maximizing the efficiency and output of solar panels. By continuously aligning the panels with the sun's position throughout the day, the system ensures optimal solar energy absorption, resulting in improved power generation. The rapid increase in energy demand cannot be resolved easily until there is an alternative way to meet the demand. The micro grid can undertake to solve this sort of situation in future. Solar, wind and biomass energy are the main source of energy used for optimizing the overall system and hence tomake it efficient. So, the user will become less compulsive on the convenient fossil fuel energy. The stored energy also plays a significant role to avoid the imbalance of the power system.

To ensure the photovoltaic generator operating its maximum power point. MPPT controllers are often used. These controllers are intended for MPP tracking and to thus minimize the error between the operating powerand the reference maximum power which is variable according to the load and of the weather conditions. The MPPT based charge controllers are best suitable for wind and solar systems as they track the maximum power in case of power fluctuations at the input side due to environmental condition variation. Hence it is recommended to use the MPPT based charge controllers. Use of microcontroller-based systems provides huge computational capability and reduction in the hardware. The MPPT charge controller operates with high efficiency (90% or event higher) as compared to existing charge controllers.

5.4 Suggestion for Future work:

The main objective of this project is to achieve the highest performance a solar charge controller using MPPT system. This system successfully uses MPPT algorithm to reach our goal. Reaching a stable, true MPP at steady state instead of oscillating around this point would improve the system's efficiency and improve reliability.

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Appendix

```
#include <Servo.h>

Servo horizontal; // Horizontal Servo Motor
int servohori = 180;
int servohoriLimitHigh = 175;
int servohoriLimitLow = 5;

Servo vertical; // Vertical Servo Motor
int servovert = 45;
int servovertLimitHigh = 100;
int servovertLimitLow = 1;

// LDR pin connections
int ldrlt = A0; // Bottom Left LDR
int ldrrt = A3; // Bottom Right LDR
int ldrld = A1; // Top Left LDR
int ldrrd = A2; // Top Right LDR

void setup() {
  horizontal.attach(2);
  vertical.attach(13);
```

```
  horizontal.write(180);
  vertical.write(45);
  delay(2500);
}

void loop() {
  int lt = analogRead(ldrlt); // Top left
  int rt = analogRead(ldrrt); // Top right
  int ld = analogRead(ldrld); // Bottom left
  int rd = analogRead(ldrrd); // Bottom right

  int dtime = 10;
  int tol = 90; // Tolerance value for adjustment

  int avt = (lt + rt) / 2; // Average value of top sensors
  int avd = (ld + rd) / 2; // Average value of bottom sensors
  int avl = (lt + ld) / 2; // Average value of left sensors
  int avr = (rt + rd) / 2; // Average value of right sensors

  int dvert = avt - avd; // Difference between top and bottom
  int dhoriz = avl - avr; // Difference between left and right

  if (abs(dvert) > tol) {
```

```
  if (avt > avd) {
    servovert = ++servovert;
    if (servovert > servovertLimitHigh) servovert = servovertLimitHigh;
  } else {
    servovert = --servovert;
    if (servovert < servovertLimitLow) servovert = servovertLimitLow;
  }
  vertical.write(servovert);
 }

 if (abs(dhoriz) > tol) {
  if (avl > avr) {
    servohori = --servohori;
    if (servohori < servohoriLimitLow) servohori = servohoriLimitLow;
  } else {
    servohori = ++servohori;
    if (servohori > servohoriLimitHigh) servohori = servohoriLimitHigh;
  }
  horizontal.write(servohori);
 }

 delay(dtime);
}
```