A

PROJECT REPORT ON

"AUTOMATIC SOLAR TRACKING WITH MPPT"

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF

BACHELOR OF ENGINEERING

(ELECTRICAL ENGINEERING)

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(2015 -2016)

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DECLARATION

We declare that this written submission represents our idea in our own words and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be the cause for disciplinary action by the institute and can also evoke penal action from the sources which have not been properly cited or from whom proper permission has not been taken when needed.

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ABSTRACT

The project deals with use of alternative energy resource for power generation which can be used to supply power in domestic application. Solar energy is a very large, inexhaustible source of energy and Green Energy System. Solar energy has a major advantage for no impure outlets but problem associated with solar is less efficiency and high cost. The power from the sun intercepted by the earth is approximately 1.8×10^{11}MW, which is many thousand times larger than the present consumption rate on the earth of all commercial energy sources. Solar tracking system can be used as a power generating method from sunlight. This method of power generation is simple and is taken from natural resource. This needs only maximum sunlight to generate power. This project presents for power generation and sensor based solar tracking system to utilize the maximum solar energy through solar panel by setting the equipment to get maximum sunlight automatically in real time. This proposed system is tracking for maximum intensity of light. When there is decrease in intensity of light, this system automatically changes its direction to get maximum intensity of light. The proposed method is to design an electronic circuit to sense the intensity of light and control the DC motor driver for the panel movement, and construct a Buck-Boost converter for to step up and step-down the voltage, and store the maximum utilized output voltage in Lead-Acid Battery.

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CHAPTER 1

INTRODUCTION

The need for renewable energy is the energy which comes from natural resources such as sunlight, wind, rain, tides and geothermal heat. These resources are renewable and can be naturally replenished. Therefore, for all practical purposes, these resources can be considered to be inexhaustible, unlike dwindling conventional fossil fuels. The global energy crunch has provided a renewed impetus to the growth and development of clean and renewable energy sources. Clean Development Mechanisms (CDMs) are being adopted by organizations all across the globe. Apart from the rapidly decreasing reserves of fossil fuels in the world, another major factor working against fossil fuels is the pollution associated with their combustion. Contrastingly, renewable energy sources are known to be much cleaner and produce energy without the harmful effects of pollution unlike their conventional counterparts.

1.1 DIFFERENT SOURCES OF RENEWABLE ENERGY

1. WIND POWER

Wind turbines can be used to harness the energy available in airflows. Current day turbines range from around 600 kW to 5 MW of rated power. Since the power output is a function of the cube of wind speed, it increases rapidly with an increase in available wind velocity.

2. SOLAR POWER

Solar energy can be utilized in two major ways. Firstly, the captured heat can be used as solar thermal energy, with applications in space heating. Another alternative is the conversion of incident solar radiation to electrical energy, which is the most usable form of energy. This can be achieved with the help of solar photovoltaic cells or with concentrating solar power plants.

3. SMALL HYDROPOWER

Hydropower installations up to 10MW are considered as small hydropower and counted as renewable energy sources .These involve converting the potential energy of water stored in dams into usable electrical energy through the use of water turbines.

4. BIOMASS

Plants capture the energy of the sun through the process of photosynthesis. On combustion, these plants release the trapped energy. This way, biomass works as a natural battery to store the sun's energy and yield it on requirement.

5. GEOTHERMAL

Geothermal energy is the thermal energy which is generated and stored within the layers of the Earth. The gradient thus developed gives rise to a continuous conduction of heat from the core to the surface of the earth. This gradient can be utilized to heat water to produce superheated steam and use it to run steam turbines to generate electricity. The main disadvantage of geothermal energy is that it is usually limited to regions near tectonic plate boundaries, though recent advancements have led to the propagation of this technology.

1.2 RENEWABLE ENERGY TRENDS ACROSS THE GLOBE

The current trend across developed economies tips the scale in favor of Renewable Energy. For the last three years, the continents of North America and Europe have embraced more renewable power capacity as compared to conventional power capacity. Renewable accounted for 60% of the newly installed power capacity in Europe in 2009 and nearly 20% of the annual power production.

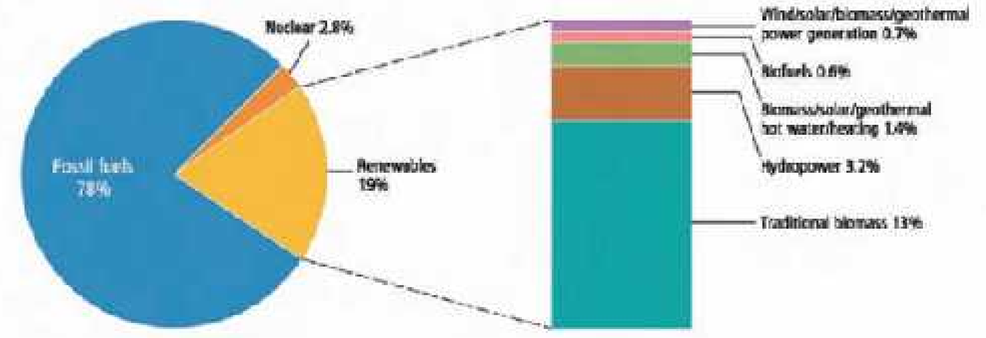


Fig 1.1 Energy consumption pattern

As can be seen from the figure 1.1, wind and biomass occupy a major share of the current renewable energy consumption. Recent advancements in solar photovoltaic technology and constant incubation of projects in countries like Germany and Spain have brought around tremendous growth in the solar PV market as well, which is projected to surpass other renewable energy sources in the coming years. 14 By 2009, more than 85 countries had some policy target to achieve a predetermined share of their power capacity through renewable. This was an increase from around 45 countries in 2005. Most of the targets are also very ambitious, landing in the range of 30-90% share of national production through renewable. Noteworthy policies are the European Union's target of achieving 20% of total energy through renewable by 2020 and India's Jawaharlal Nehru Solar Mission, through which India plans to produce 20GW solar energy by the year 2022.

CHAPTER 2

PROBLEM DEFINITION

2.1 PROBLEMS WITH SOLAR GENERATION AND ITS SOLUTION

Solar energy is very most promising future power generation energy resource. However, there are many problems associated with its use; the main problem is that it is dilute source of energy. Even in the hottest regions on the earth, the solar radiations flux available rarely exceeds 1 KW/m, which is a low value for technological utilization. Problem associated with the use of solar energy is that its availability varies widely with time and place. The variation in availability occurs daily because of the day night cycle and also seasonally because of the earth's orbit around the sun and due to irradiance in temperature due to changing atmospheric conditions.

Recently, research and development of low cost flat panel solar panel, thin film devices, concentrators systems and many more innovation concepts have increase. In the future, the cost of small solar modular unit and small hybrid solar & wind or solar & hydro power plants will be economically feasible for large scale production and use of solar energy.

In this paper we have presented the photovoltaic solar panel operation. The foremost way to increase the efficiency of a solar panel is by using

1. A mechanical solar tracking system which tracks the sun from east to west for maximum point of light intensity.
2. Use of maximum power point tracker (MPPT) which is an electronic device regulates the output to get maximum efficiency.

To rectify these above problems the solar panel should be such that it always receives maximum intensity of light. For existing solar panels, which are without any control systems typical level of efficiency varies from 10% to 4% - a level that should improve measurably if the present interest continues. For mechanical tracking system we have selected a single axis mechanical tracking system using a bipolar stepper motor for our design.

In addition we attempted to design the system by using an algorithm of selected MPPT method which is Perturb and Observe method and implement it by using a DC-DC convertor and we have selected Buck-Boost converter.

2.2 OBJECTIVE OF PROJECT

The aim of the project is to utilize maximum solar energy through solar panel. For this a digital based automatic sun tracking system and MPPT circuit is being proposed. The solar panel traces the sun from east to west automatically for maximum intensity of light. PV generation system generally uses a microcontroller based charge controller connected to battery and load. A charge controller is used to maintain proper charging voltage on battery by concept of load impedance matching. And input voltage from the solar array, the charge controller regulates the charge to the battery preventing overcharge. By using a microcontroller based design we are able to control both operations with more intelligent control and thus increase the efficiency of the system.

2.3 METHODOLOGY

The prototype model of a solar microcontroller based SOLAR maximum power tracking will be made in the following steps:

1. Complete layout of the whole set up will be drawn in form of a block diagram.
2. Day and night sensor will first sense the condition and give its output to the microcontroller.
3. The photovoltaic panel will be mounted at an optimum angle of 67 degree in the month of April for the latitude of MUMBAI as referred from Solar Electricity handbook 2013 edition solar electricity from the vertical as on a D.C motor driven by a driver I.C. such that the panel moves and the microcontroller checks the output voltage at various points.
4. Identification of points where maximum voltage and hence maximum power received by the solar panel.
5. Maximum power will be detected by MPPT Algorithm developed, then fed to Analog to Digital converter and stored in microcontroller.
6. The motor and hence the panel will be stopped when maximum power will be received by the solar panel and then it will start charging the battery.

CHAPTER 3

LITERATURE REVIEW

Studies show that a solar panel converts 30-40% of energy incident on it to electrical energy. A Maximum Power Point Tracking algorithm is necessary to increase the efficiency of the solar panel.

There are different techniques for MPPT such as Perturb and Observe (hill climbing method),Incremental conductance, Fractional Short Circuit Current, Fractional Open Circuit Voltage, Fuzzy Control, Neural Network Control etc. Among all the methods Perturb and observe (P&O) and Incremental conductance are most commonly used because of their simple implementation, lesser time to track the MPP and several other economic reasons.

Under abruptly changing weather conditions (irradiance level) as MPP changes continuously, P&O takes it as a change in MPP due to perturbation rather than that of irradiance and sometimes ends up in calculating wrong MPP. However this problem gets avoided in Incremental Conductance method as the algorithm takes two samples of voltage and current to calculate MPP. However, instead of higher efficiency the complexity of the algorithm is very high compared to the previous one and hence the cost of implementation increases. So we have to mitigate with a tradeoff between complexity and efficiency.

Daniel. A. Pritchard had given the design, development, and evaluation of a microcomputer-based solar tracking system in 1983. Then many studies for solar tracking appeared using the microprocessor, Saxena and Dutta in 1990, A. Konar and A.K. Mandal in 1991, and A. Zeroual in 1997 using electro-optical sensors for sun finding. The microcontroller is used as base for automatic sun tracker to control a dc motor in 1998 by F. Huang, and used as base for maximum power point tracking controller by Eftichios Koutroulis in 2001. Hasan A.Yousef had given the PC-based fuzzy logic controller design and Implementation to control a sun tracking system in 1999, the tracking system was driven by two permanent magnet DC motors to provide motion of the PV panels in two axes. Chee-Yee Chong, in 2000 had given the process architectures for track fusion, they presented different approaches for fusing track state estimates, and compared their performance through theoretical analysis and simulations, they used the concept of multiple targets tracking because it had shown that tracking with multiple sensors can provide better performance than using a single sensor.

Many studies for novel maximum power point tracking (MPPT) controller for a photovoltaic (PV) energy conversion system was proposed by Yeong Chau Kuo in 2001, K. K. Tse in 2002, and Henry Shu-Hung Chung in 2003, Kimiyoshi Kohayashi in 2004. Z.G. Piao, proposed a solar tracking system in 2003, using DC motors, special motors like stepper motors, servo motors, real time actuators, to operate moving parts, it was highly expensive. A. A.Khalil, had presented a sun tracking system in 2003.This Tracking system easy to implement and efficient for solar energy collection. Many methods was proposed to achieve the objective of maximum power point tracking (MPPT), and the active sun tracking scheme without any light sensors.

S. Armstrong et al. had proposed a quantitative measure of the effectiveness MPPT efficiency in 2005, a vector methodology was used to track the direction and path of the sun throughout the day. And Rong-Jong Waihad had given grid connected photovoltaic (PV) generation system with an adaptive step-perturbation method and an active sun tracking scheme in 2006.

Cemil Sungur had given the electromechanical control system of a photovoltaic (PV) panel tracking the sun using Programmable Logic Controls (PLC) in 2007. Many FPGA-based PV systems fuzzy MPPT control was proposed, A. Messai, A. Mellit describes the hardware implementation of a two-inputs one-output digital Fuzzy Logic Controller (FLC) on a Xilinx FPGA using VHDL language in 2009, Cheng, Ze; Yang, Hongzhi; Sun, Ying had proposed a simple, reliable method in 2010.

In this project we will construct an efficient solar system with micro controller having a good response with improved efficiency which can be achieved by implementing a microcontroller based automatic solar tracking system with maximum power point tracking.

Out of many MPPT algorithms, Perturb and observe (P&O) algorithm is mostly used for increasing the efficiency of PV system due to its simpler implementation, high reliability and better efficiency.

CHAPTER 4

SOLAR CELLS AND THEIR CHARACTERISTICS

4.1 INTRODUCTION TO SOLAR CELLS AND THEIR CHARACTERISTICS

Photovoltaic or solar cells, at the present time, furnish one of the most-important long duration power supplies. Since a typical photovoltaic cell produces less than 3 watts at approximately 0.5 volt dc, cells must be connected in series-parallel configurations to produce enough power for high-power applications. Cells are configured into module and modules are connected as arrays. Modules may have peak output powers ranging from a few watts, depending upon the intended application, to more than 300 watts. Typical array output power is in the 100-watt-kilowattrange, although megawatt arrays do exist.

4.2 STRUCTURE OF PHOTOVOLTAIC CELLS

A photovoltaic (PV) cell converts sunlight into electricity, which is the physical process known as photoelectric effect. Light which shines on a PV cell, may be reflected, absorbed, or passed through; however, only absorbed light generates electricity

One layer is an “n-type” semiconductor with an abundance of electrons, which have a negative electrical charge. The other layer is a “p-type” semiconductor with an abundance of holes, which have a positive electrical charge. Although both materials are electrically neutral, n-type silicon has excess electrons and p-type silicon has excess holes. Sandwiching these together creates a p-n junction at their interface, thereby creating an electric field. Figure: 3.1 shows the p-n junction of a PV cell. When n-type and p-type silicon come into contact, excess electrons move from the n-type side to the p-type side. The result is the buildup of positive charge along the n-type side of the interface and of negative charge along the p-type side, which establishes an electrical field at the interface. The electrical field forces the electrons to move from the semiconductor toward the negative surface to carry current. At the same time, the holes move in the opposite direction, towards the positive surface, where they wait for incoming electrons.

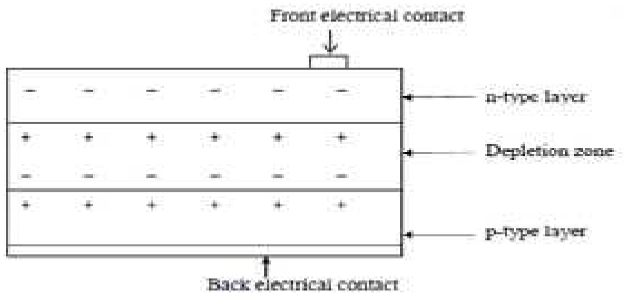


Fig 4.1 Structure of P-V cell

4.3 PHOTOVOLTAIC CELL MODEL

The use of equivalent electric circuits makes it possible to model characteristics of a PV cell. The PV model consists of a current source (I_{SC}), a diode (D) and a series resistance (R_S). The effect of parallel resistance (R_P), represents the leakage resistance of the cell is very small in a single module, thus the model does not include it. The current source represents the current generated by photons (I_{PH}), and its output is constant under constant temperature and constant incident radiation of light.

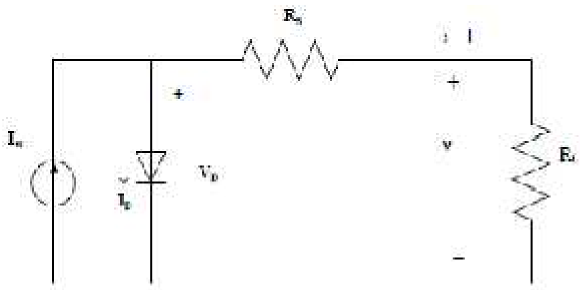
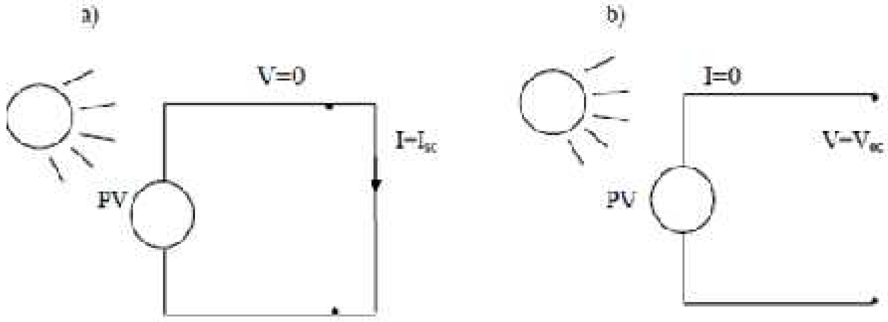


Fig 4.2 Equivalent circuit diagram of P-V cell

Current-voltage (I-V) curves are obtained by exposing the cell to a constant level of light, while maintaining a constant cell temperature, varying the resistance of the load, and measuring the produced current. I-V curve typically passes through two points:

1. Short-circuit current (I_{SC}): is the current produced when the positive and negative terminals of the cell are short-circuited, and the voltage between the terminals is zero, which corresponds to zero load resistance.
2. Open-circuit voltage (V_{OC}): is the voltage across the positive and negative terminals under open-circuit conditions, when the current is zero, which corresponds to infinite load resistance.



SHORT CIRCUIT CURRENT OPEN CIRCUIT VOLTAGE

Fig 4.3 SC and OC modes of P-V cell

The current-voltage relationship of a PV cell is given below:

$$I = I_{SC} - I_D \quad \text{.......} (4.1)$$

$$I_D = I_S[e^{\frac{qV_D}{nKT}} - 1] \quad \text{.......} (4.2)$$

From equation (1) and (2) we get,

$$I = I_{sc} - I_s[e^{\frac{qV_D}{nKT}} - 1] \quad \text{.......} (4.3)$$

Where, I= output current (A)

I_{SC}= short circuit current (A)

I_S= reverse saturation current (A)

V_D= voltage (V) across the diode

q= electron charge (1.6×10^{-19}C)

k= boltzmann's constant (1.381×10^{-23} J/K)

T= junction temperature (K)

n= diode ideality factor (1~2)

The reverse saturation current can be calculated by setting $V_D = V_{oc}$, I=0 and n=1.6

$$I_S = \frac{I_{sc}}{e^{\frac{qV_{oc}}{nKT}}} - 1 \quad \text{.......} (4.4)$$

4.4 EFFECTS OF SOLAR IRRADIANCE ON MPP

There are two key parameters frequently used to characterize a PV cell. Shorting together the terminals of the cell, the photon generated current will follow out of the cell as a short-circuit current (I_{SC}). When there is no connection to the PV cell (open-circuit), the photon generated current is shunted internally by the intrinsic p-n junction diode. This gives the open circuit voltage (V_{OC}). The PV module or cell manufacturers usually provide the values of these parameters in their datasheet.

In a PV cell current is generated by photons and output is constant under constant temperature and constant incident radiation of light. Varying the irradiation we can get different output levels.

The current voltage relationship of a PV cell is given below,

$$I = I_{sc} - I_S[e^{\frac{qv}{KT}} - 1] \text{ (from 4.3)}$$

To a very good approximation, the photon generated current, which is equal to is directly proportional to the irradiance (G), the intensity of illumination, to PV cell is

$$I_{sc} \infty G$$

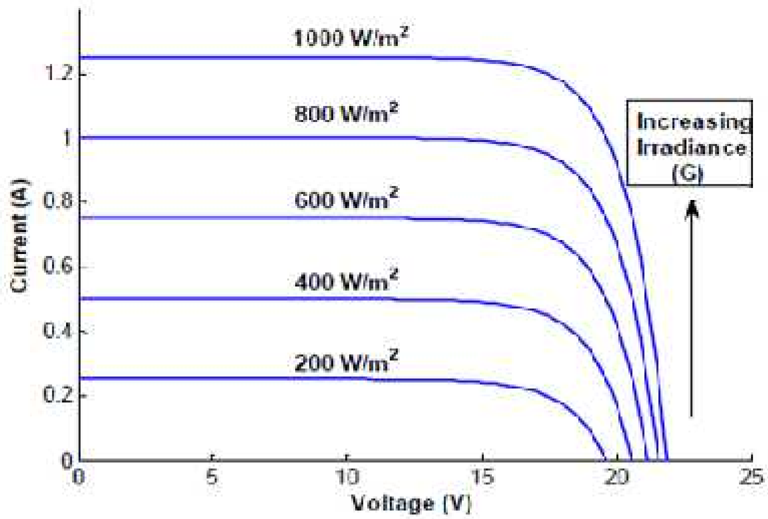


Fig 4.4 I-V curve with different irradiance

EFFECTS OF TEMPERATURE ON MPP

I-V characteristic of a PV module varies at various module temperatures. At first, calculate the short circuit current (I_{SC}) at a given cell temperature (T).

$$I_{sc}\,(T) = I_{sc}\,(T_r)[1 - a(T - T_r)] \;..............(4.5)$$

T_r= reference temperature of PV cell (298K, measured under irradiance of 1000W/m^2;

a=the temperature co-efficient (percent change in I_{sc} per degree temperature)

I_s=reverse saturation current of diode

V_{oc}=open circuit voltage

The I_s of diode at the T_r is given by the equation with the diode ideality factor,

$$I_s = \frac{I_{sc}}{e^{\frac{qV_{oc}}{KT_r}}} - 1 \;.................. (\text{from } 4.4)$$

The reverse saturation current is temperature dependent and the current (I) at a given temperature (T) is calculated by the following equation

$$I_S(T) = I_s(T_r)\left(\frac{T}{T_r}\right)^{\frac{3}{n}} e^{\frac{2E_g}{nK}\left(\frac{1}{T} - \frac{1}{T_r}\right)} \;.......(4.6)$$

Using equation (2.12) to (2.15), I-V characteristic of the panel is plotted for three different temperatures, T=273K, 298K and 323K and are shown in figure:

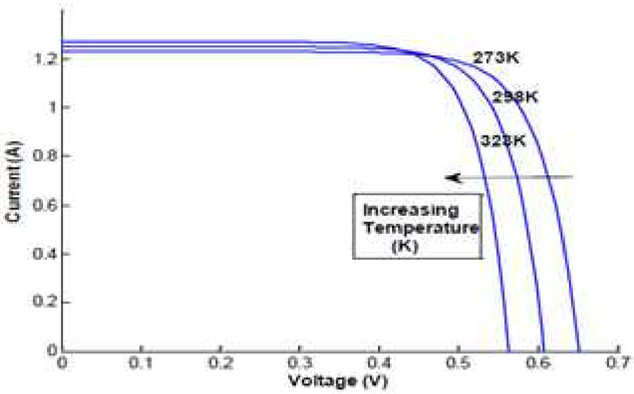


Fig 4.5 I-V CURVE FOR VARYING TEMPERATURE

With the increase of temperature the I-V characteristics of a PV cell shifts toward lefts and so the MPP decreases with increase in temperature. Because of the photovoltaic nature of solar panels, their current-voltage, or IV, curves depend on temperature and irradiance levels. Therefore, the operating current and voltage which maximize power output will change with environmental conditions.

CHAPTER 5

MAXIMUM POWER POINT TRACKING

Maximum Power Point Tracking, frequently referred to as MPPT, is an electronic system that operates the Photovoltaic (PV) modules in a manner that allows the modules to produce all the power they are capable of. MPPT is not a mechanical tracking system that “physically moves” the modules to make them point more directly at the sun. 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. Additional power harvested from the modules is then made available as increased battery charge current. MPPT can be used in conjunction with a mechanical tracking system, but the two systems are completely different.

The Peak Power Tracker is a microprocessor controlled DC/DC step down converter used by a solar power system to charge a 12v battery. It steps the higher solar panel voltage down to the charging voltage of the battery. The microprocessor tries to maximize the watts input from the solar panel by controlling the step down ratio to keep the solar panel operating at its Maximum Power Point.

(Peak Solar Panel Watts**) / (**Battery Voltage**) =** MPPT Amps (*i.e. 240W/12V = 20A)*

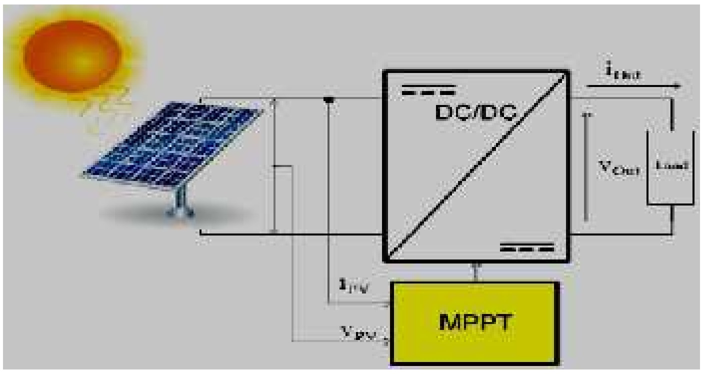


Fig 5.1 General MPPT block

5.1 MPPT TRACKING TECHNIQUES

A typical solar panel converts only 30 to 40 percent of the incident solar irradiation into electrical energy. Maximum power point tracking technique is used to improve the efficiency of the solar panel. According to Maximum Power Transfer technique, the output power of a circuit is maximum when the source impedance matches with the load impedance. In the source side a buck converter is connected to a solar panel in order to enhance the output voltage. By changing the duty cycle of the buck converter appropriately by PWM signal the source impedance is matched with that of the load impedance. There are various MPPT techniques are proposed.

5.2 MPPT METHODS

There are some conventional methods for MPPT. Seven of them are listed here.
These methods include:

1. Perturb and Observe method
2. Incremental Conductance method
3. Constant Voltage method
4. Open Circuit Voltage method
5. Short Circuit Current method
6. Temperature method
7. Temperature Parametric method

Among those methods, the Perturb and Observe (P&O) and Incremental Conductance (INC) methods are widely used although they have some problems such as the oscillation around MPP and confusion by rapidly changing atmospheric conditions.

In this paper perturb and observe MPPT algorithm is used. In this method the controller adjusts the voltage by a small amount from the array and measures power, if the power increases, further adjustments in the direction are tried until power no longer increases. This is called P&O method. Due to ease of implementation and cost effectiveness, it is the most commonly used MPPT method.

MPPT technique	Convergence speed	Implementation complexity	Periodic tuning	Sensed parameters
Perturb & observe	Varies	Low	No	Voltage
Incremental conductance	Varies	Medium	No	Voltage, current
Fractional V_{oc}	Medium	Low	Yes	Voltage
Fractional I_{sc}	Medium	Medium	Yes	Current
Fuzzy logic control	Fast	High	Yes	Varies
Neural network	Fast	High	Yes	Varies

Table 5.1: Comparison of MPPT Techniques

5.3 PERTURB AND OBSERVE METHOD (P&O):

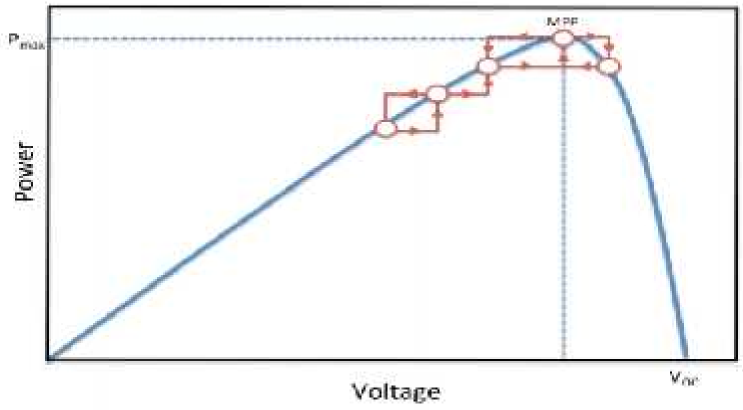


Fig 5.2 PV c/s of PV module with P&O method

THE PERTURB AND OBSERVE METHOD FOR MPPT

The voltage to a cell is increased initially, if the output power increase, the voltage is continually increased until the output power starts decreasing. Once the output power starts decreasing, the voltage to the cell decreased until maximum power is reached. This process is continued until the MPPT is obtained. This result is an oscillation of the output power around the MPP. PV module’s output power curve as a function of voltage (P-V curve), at the constant irradiance and the constant module temperature, assuming the PV module is operating at a point which is away from the MPP. The P&O algorithm periodically increment or decrement the output terminal voltage of the PV cell and comparing the power obtained in the current cycle with the power of the previous one . If the power is increased, then it is supposed that it has moved the operating point closer to the MPP. Thus, further voltage perturbations in the same direction should move the operating point toward the MPP. If the power decreases, the operating point has moved away from the MPP, and the direction of perturbation should be reversed to move back toward the MPP.

One of the disadvantages of perturb and observe method is that based on the algorithm, the system will continue to oscillate around the maximum power point. This can lead to inefficiencies, especially in situations when the irradiance is low and the power-voltage curve begins to flatten out. When this occurs, the perturb and observe method can sometimes have difficulty determining when it has actually reached the maximum power point. In addition sometimes this algorithm will perform several iterations in the wrong direction if it is affected by rapidly changing conditions. However, Perturb and Observe method is widely recognized as the most common method for maximum power point tracking because of its simple design.

BENEFITS:

P&O is very popular and most commonly used in practice because of

1. Its simplicity in algorithm.
2. Ease of implementation.
3. Low cost.
4. It is a comparatively an accurate method.

DRAWBACKS:

There are some limitations that reduce its MPPT efficiency.

1. It cannot determine when it has actually reached the MPP. Under steady state operation the output power oscillates around the MPP.

2. For our project we choose the Perturb and observe algorithm as it has more advantages over drawbacks. The oscillation problem can easily be minimized using minimization techniques by controller.

TECHNIQUES FOR MINIMIZATION

The advent of digital controller made implementation of algorithm easy. The problem of oscillations around the MPP can be solved by the simplest way of making a bypass loop which skips the perturbation when the power is very small which occurs near the MPP. The tradeoffs are a steady state error and a high risk of not detecting a small power change. Another way is the addition of a “waiting” function that causes a momentary cessation of perturbations if the direction of the perturbation is reversed several times in arrow, indicating that the MPP has been reached. It works well under the constant irradiation.

THE PERTURB AND OBSERVE ALGORITHM

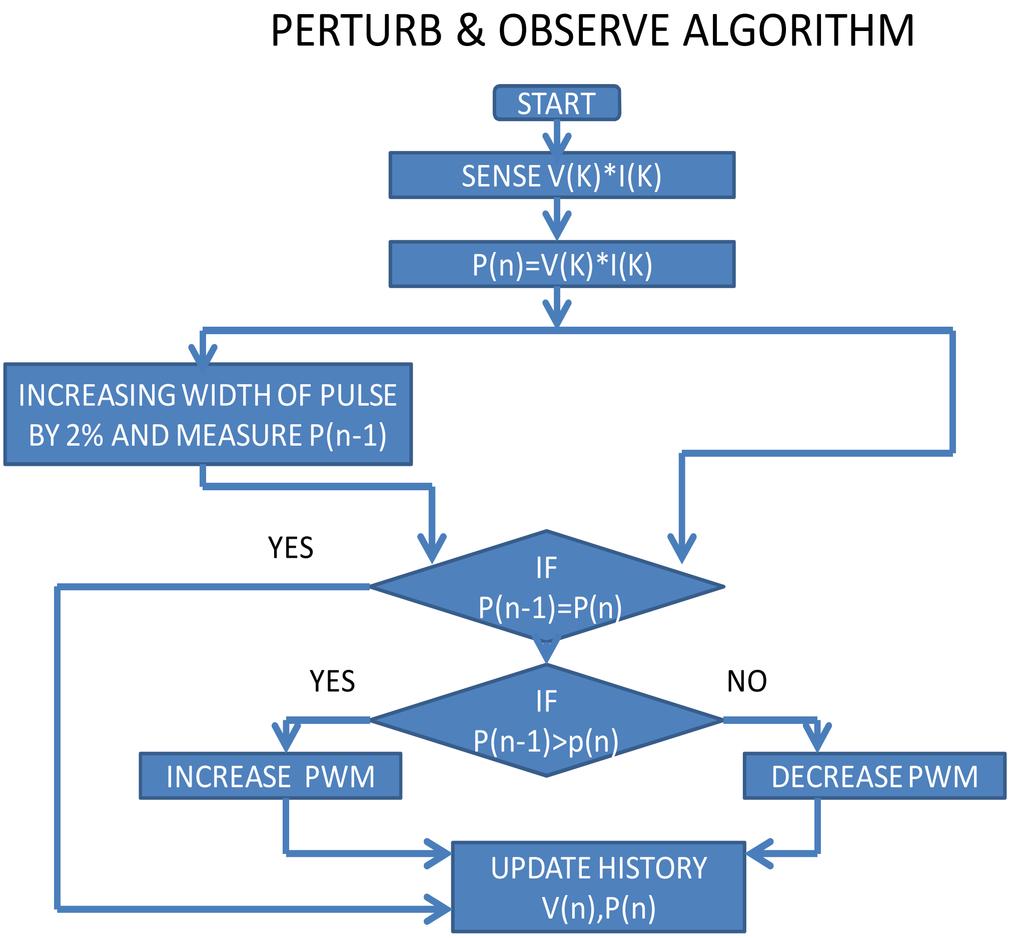


Fig 5.3: P&O Algorithm Flowchart

CHAPTER 6

SOLAR TRACKING

6.1 CONTINUOUS SOLAR TRACKING PRINCIPLE:-

Continuous solar tracking refers to the process of maneuvering a photovoltaic panel, solar concentrator or optic reflector with an associated power generating payload in such a way that the reflector follows and lock’s onto the course trajectory of the sun’s movement throughout the full day-time cycle. In this way, the solar harvesting means or solar reflector optimally reflects the solar energy towards the solar power generator or energy converter. The power generating device can be a thermal energy converter or silicon based concentrated photovoltaic (CPV) type system.

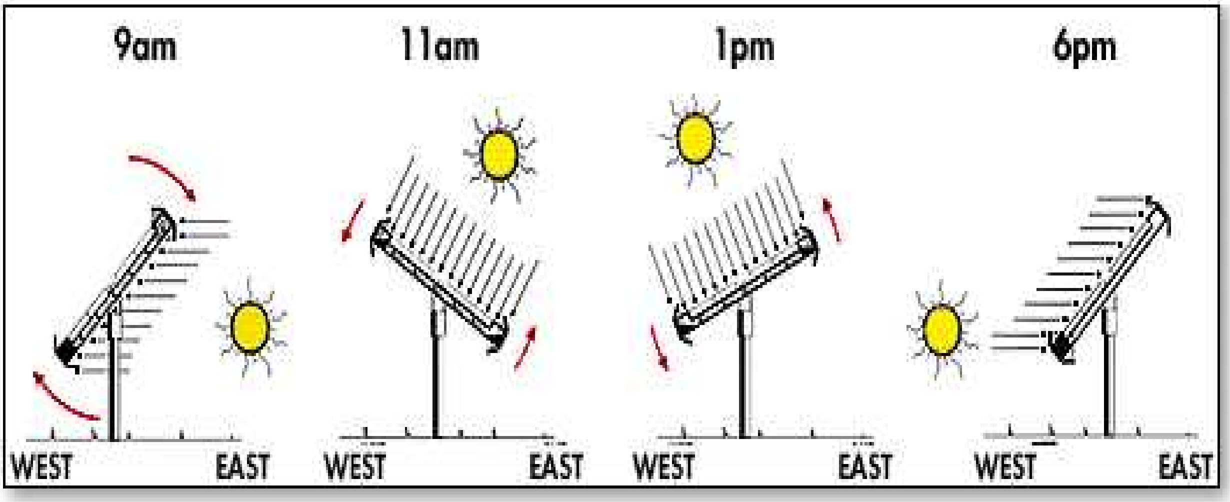


Fig 6.1: Tracking of solar panel with direction of sun

6.1.1 DESCRIPTION

This is a power generating method from sunlight. This method of power generation is simple and is taken from natural resource. This needs only, maximum sunlight to generate power. This project helps for power generation by setting the equipment to get maximum sunlight automatically. This system is tracking for maximum intensity of light. When there is decrease in intensity of light, this system automatically changes its direction to get maximum intensity of light.

A Solar Tracker is basically a device onto which solar panels are fitted which tracks the motion of the sun across the sky ensuring that the maximum amount of sunlight strikes the panels throughout the day. After finding the sunlight, the tracker will try to navigate through the path ensuring the best sunlight is detected. The Solar Tracking System is made as a prototype to solve the problem. It is completely automatic and keeps the panel in front of sun until that is visible. The unique feature of this system is that instead of taking the earth as its reference, it takes the sun as a guiding source. Its active sensors constantly monitor the sunlight and rotate the panel towards the direction where the intensity of sunlight is maximum. The power generated from this process is then stored in a lead acid battery and is made to charge an emergency light and is made to glow during night.

6.2 SUN TRACKING FORMULAE BASED ON AZIMUTHAL ANGLE TRACKING:

The sun angle plots for the azimuth angle (and elevation) angle can now be used to determine the solar tracking speed and gear ratio requirements. It was noted before that the partial differential of the solar path movement angle curves (slope at each point) equates to the solar tracking speed (degrees per minute), as illustrated in Figure below .The sun path on the azimuth axis typically moves faster, and the point of maximum sun movement speed can be identified on the graph.

Solar azimuth and elevation angles of the daytime sun path for a certain geographical location with the slope of the azimuth curve representing of the maximum sun movement speed superimposed. One can determine the speed of the sun in degrees per minute by using the parameters obtained from the figure (at the point of maximum slope)in the formula given in Equation below:

$$SunSpeed(degree/min) = \frac{\Delta_{SunAngle}(degrees)}{\delta_{time}(minutes)} \ldots (6.1)$$

Equation 5.1 computes the speed of the sun in degrees per minute. However, to relate the speed of the sun to motor speed, we need to convert the sun speed to revolutions per minute (rpm or RPM). Still referring to Figure above one can therefore determine the speed of the sun in rpm by dividing by 360 as in Equation 6.2 below:

$$SunSpeed(rpm) = \frac{SunSpeed(degree/min)}{360^{\circ}} \quad ...(6.2)$$

To determine this minimum required rotational speed for a tracking motor, one can use Equation 6.3 with the sun speed (rpm, determined in Equation 6.2) as follows:

Min Motor Shaft (rpm) = Sun Speed (rpm) * Gear ratio..... (6.3)

where the Gear ratios determined as follows:

$$Gear_{ratio} = \frac{(Motor_{input\ speed})}{(Gearbox_{output\ speed})} \quad ......(6.4)$$

If the motor and gearbox combination cannot reach the minimum required speed calculated in Equation 6.3, then a different gear ratio (gearbox or transmission system) or higher speed motor needs to be selected knowing that one can determine the maximum angular speed of the sun in rpm (Equation 6.2), one can alternatively determine the minimum required rotational motor speed for a given gear ratio that is more realistic or practical. This makes it possible to select a typical solar tracking gearbox or transmission system and then select a motor with sufficient speed to meet the requirement in Equation 6.3.

In this regard, Equation 6.5 can be used to relate the speed of the motor and gear drive axles to the eventual rotational speed of the solar tracking system axis. This formula is valuable to determine the rotational speed of the tracker on either axis from the motor shaft rpm and the gear ratio of the gearbox or transmission system on that axis, and is very handy when the motor speed is fixed or if the motor gear drive can only operate within a certain rpm range.

$$SunTrackerSpeed(rpm) = \frac{MotorShaft(rpm)}{Gear_{ratio}} \quad ...(6.5)$$

Using Equation 6.5 in a typical practical example, we will show how to compute the rotational speed of the solar tracking axis shaft (rpm) from the motor shaft speed (rpm) and the gear ratio.

CHAPTER 7

SYSTEM DESCRIPTION

7.1 BLOCK DIAGRAM OF SYSTEM

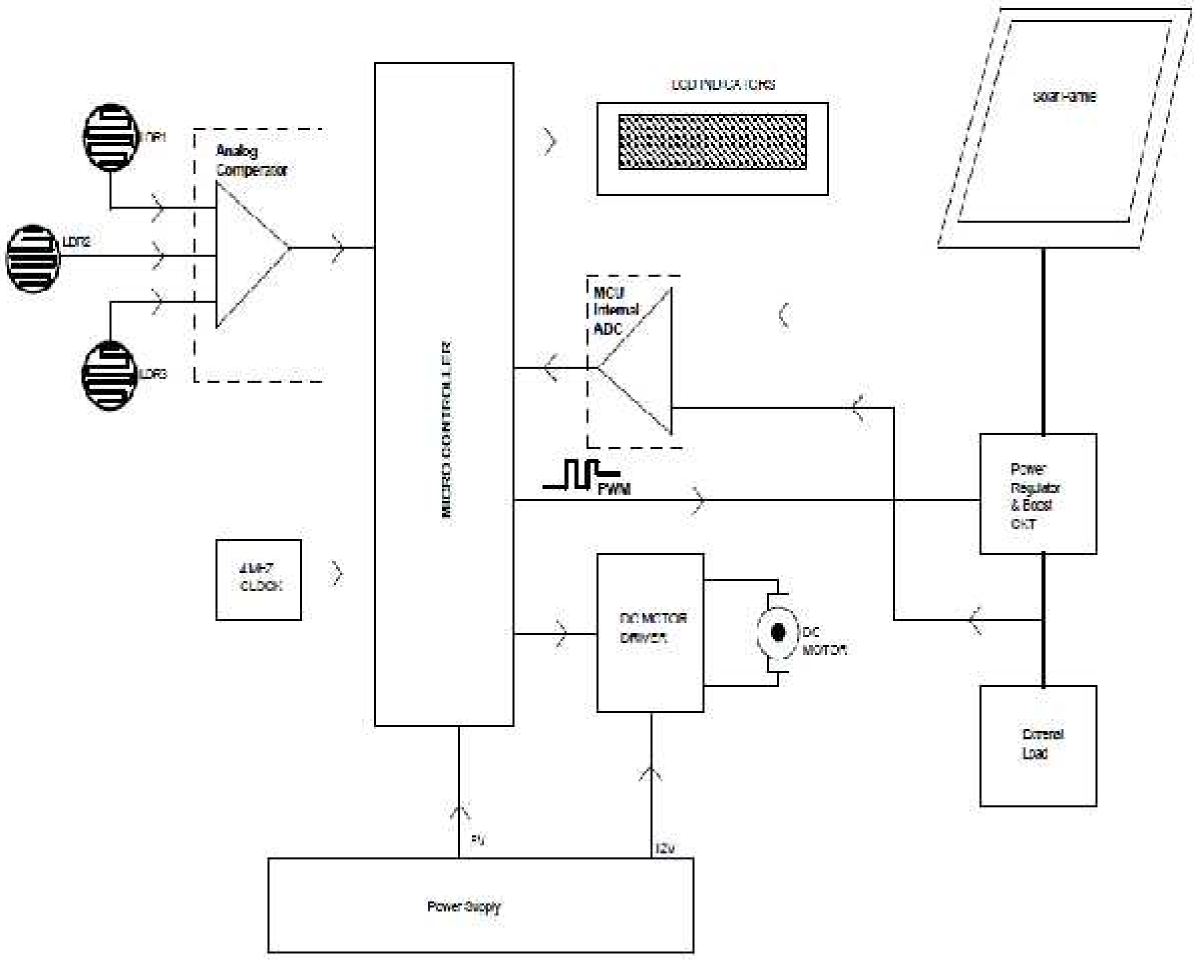


Fig 7.1 Block diagram representation of project

PROTOTYPE

Fig 7.2 Actual image of prototype

7.1.1 TECHNICAL SPECIFICATION OF SYSTEM

- Working Voltage – 12V DC
- Completely automatic system
- LDR based Sun Light detection Tracking
- On board MPPT circuit actuated with Microcontroller
- Onboard individual preset to Set LDR Sensitivity
- LDR Detection LED indication
- Solar Panel direction LED indication
- DC motor output to move the solar panel
- On board H –Bridge/Driver IC to Controlled DC Motor
- Onboard regulator for regulated supply to the kit
- Diode protection for reverse polarity connection of DC supply to the PCB
- Operating Current - 1000ma Approx
- On board Power LED (Green) indicator
- Microcontroller based design for greater flexibility.

HARDWARE DESCRIPTION

7.2 MICROCONTROLLER (PIC16F877)

Features:

- High performance RISC CPU
- Only 35 single word instructions to learn
- All single cycle instructions except for program branches which are two cycle
- Operating speed: DC - 20 MHz clock input DC - 200 ns instruction cycle
- Up to 8K x 14 words of FLASH Program Memory, Up to 368 x 8 bytes of Data
- Memory (RAM) Up to 256 x 8 bytes of EEPROM Data Memory
- Pinout compatible to the PIC16C73B/74B/76/77
- Interrupt capability (up to 14 sources) • Eight level deep hardware stack
- Direct, indirect and relative addressing modes
- Power-on Reset (POR)
- Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation
- Programmable code protection
- Power saving SLEEP mode
- Selectable oscillator options
- Low power, high speed CMOS FLASH/EEPROM technology
- Fully static design (ICSP) via two
- In-Circuit Serial Programming pins
- Single 5V In-Circuit Serial Programming capability
- In-Circuit Debugging via two pins
- Processor read/write access to program memory
- Wide operating voltage range: 2.0V to 5.5V
- High Sink/Source Current: 25 mA
- Commercial, Industrial and Extended temperature ranges
- Low-power consumption

7.2.1 PIN DIAGRAM:

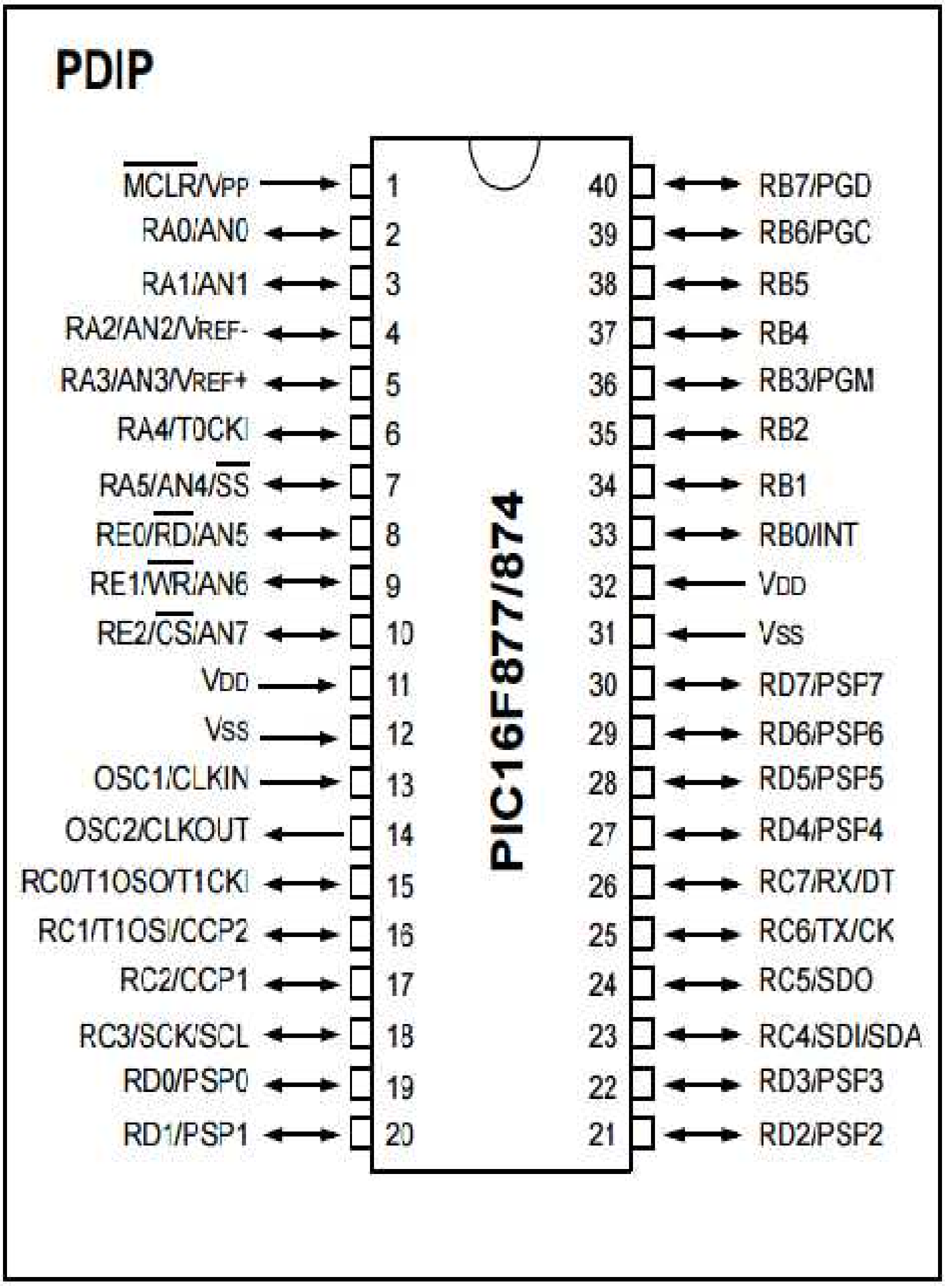


Fig 7.3 pin diagram of PIC16F877

7.2.2 PIC16F877 BLOCK DIAGRAM:-

Device	Program FLASH	Data Memory	Data EEPROM
PIC16F874	4K	192 Bytes	128 Bytes
PIC16F877	8K	368 Bytes	256 Bytes

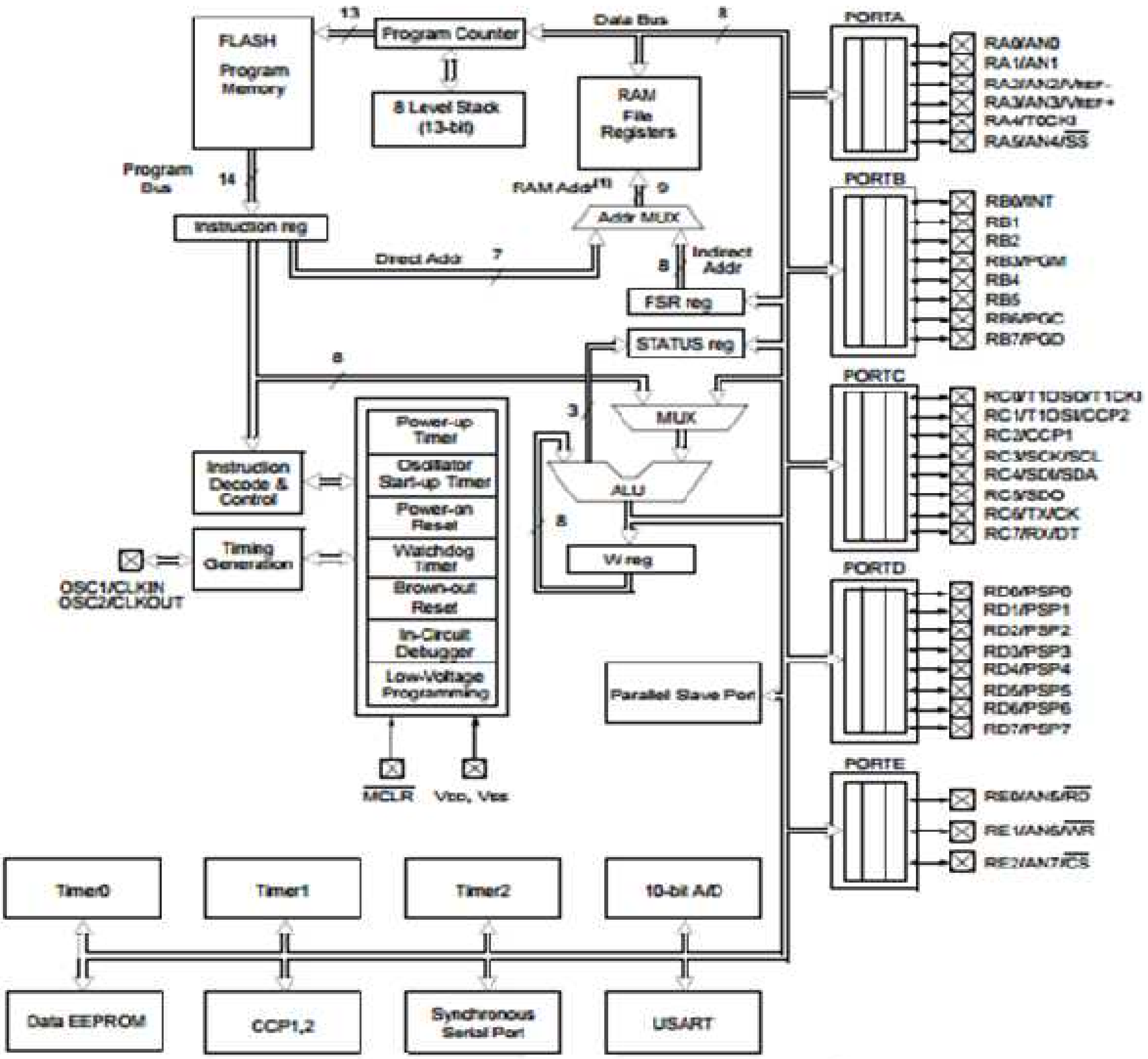


Fig 7.4 Architecture of PIC16F877

7.3 DC-DC CONVERTER

A DC-DC converter is an electronic circuit which converts a source of direct current (DC) from one voltage level to another. The DC-DC converters are widely used in regulated switch-mode dc power supplies and in dc motor drives applications. Often the input of these converters is an unregulated dc voltage, which is obtained by rectifying the line voltage, and therefore it will fluctuate due to changes in the line voltage magnitude. Switch-mode DC-DC converters are used to convert the unregulated dc input into a controlled dc output at a desired voltage level. The heart of MPPT hardware is a switch-mode DC-DC converter. MPPT uses the converter for a different purpose: regulating the input voltage at the PV MPP and providing load matching for the maximum power transfer.

BUCK-BOOST CONVERTER

To obtain a stable voltage from an input supply (PV cells) that is higher and lower than the output, a high efficiency and minimum ripple DC-DC converter required in the system for residential power production. Buck-boost converters make it possible to efficiently convert a DC voltage to either a lower or higher voltage. Buck-boost converters are especially useful for PV maximum power tracking purposes, where the objective is to draw maximum possible power from solar panels at all times, regardless of the load.

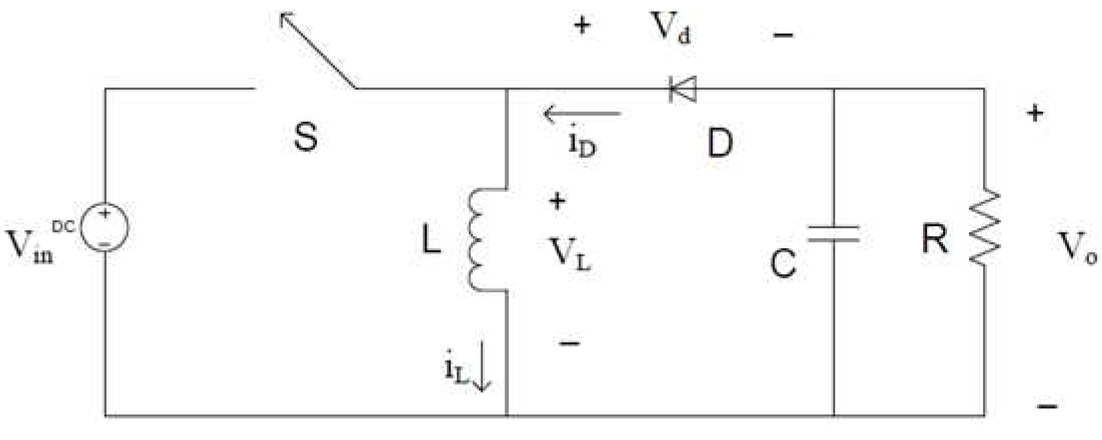


Fig 7.5 Basic schematic diagram of buck-boost converter

The buck boost converter can be obtained by the cascade connection of two basic converters: step up (Boost) and step down (Buck) converter.

In PV applications, the buck type converter is usually used for charging batteries. The boost topology is used for stepping up the voltage. The grid-tied systems use a boost type converter to step up the output voltage to the utility level before the inverter stage.

The input output voltage conversion ratio is the product of the conversion ratios of the two converters in cascade (assuming that the switches sin the both converters have the same duty ratio).

$$\frac{V_0}{V_{in}} = \frac{D}{1-D}$$

This the output voltage to be higher or lower than the input voltage based on the duty ratio.The cascade connection of the step up step down converters can be combined into single buck boost converters, when the switch is closed the input provides energy to the inductor and the diode is reversed biased. When the switch is open the energy stored in the inductor is transferred to the output. No energy is supplied to the output in this interval. The output capacitor is considered to be very large which results in a constant output voltage.

The basic principle of the buck–boost converter is fairly simple.

- While in the On-state, the input voltage source is directly connected to the inductor (L). This results in accumulating energy in L. In this stage, the capacitor supplies energy to the output load.
- While in the Off-state, the inductor is connected to the output load and capacitor, so energy is transferred from L to C and R.

CONTINUOUS CONDUCTION MODE

In the continuous mode the current can flow continuously through the inductor. When the switch is turned-on, the input voltage source supplies current to the inductor, and the capacitor supplies current to the resistor (output load). When, the switch is opened, the inductor supplies current to the load via the diode D.

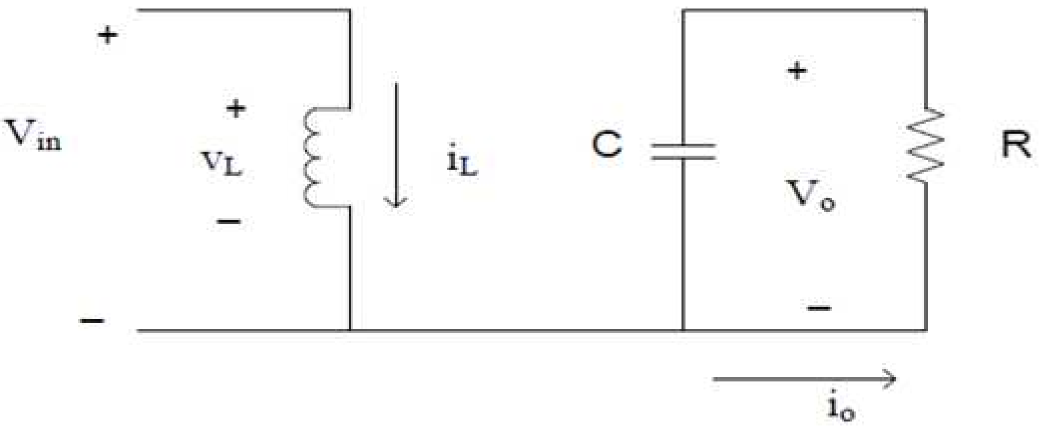


Fig 7.6 Continuous mode operation

Equating the integral of the inductor voltage over one period to zero yields

$$V_{in}.D.T_s + (-V_0)\,|(1-D)T_s = 0$$

$$\frac{V_0}{V_S} = \frac{D}{1-D}$$

DISCONTINUOUS CONDUCTION MODE:-

In the discontinuous mode the current cannot flow continuously. The amount of energy required by the load is small enough to be transferred in a time smaller than the whole commutation period. In this case, the current through the inductor falls to zero during part of the period.

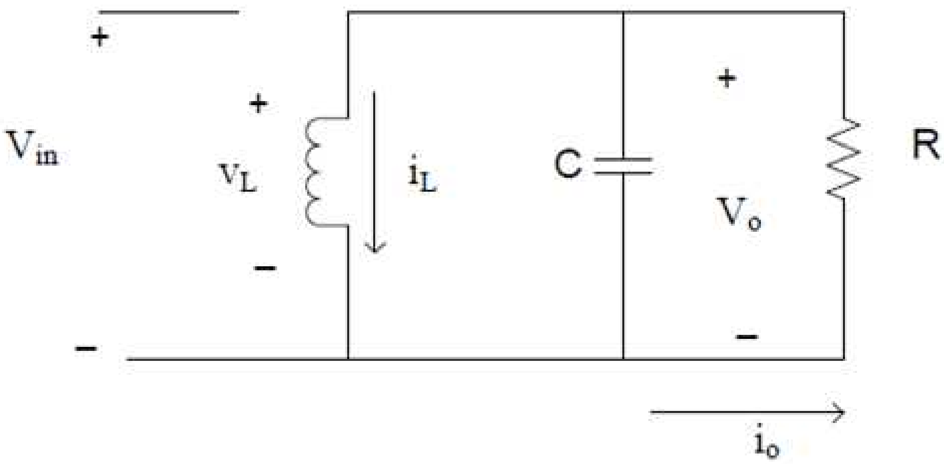


Fig .7.7 Discontinuous mode operation

BENEFITS:

1. Buck-boost DC-DC switching converter is good for home appliances for high efficiency.
2. Minimum ripple voltage.
3. Programmable without external components.

DRAWBACKS:

The disadvantage of the buck boost converter is that input current is discontinuous because of the switch located at the input.

7.4 LIGHT DETECTING RESISTORS:-

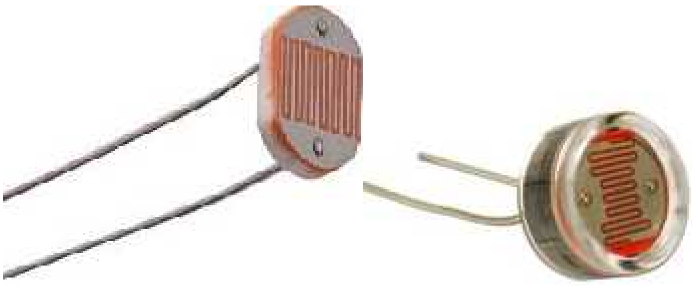


Fig 7.8 LDR

Some components can change resistance value by changes in the amount of light hitting them. One type is the Cadmium Sulphide Photocell (Cd) The more light that hits it, the smaller its resistance value becomes. There are many types of these devices. They vary according to light sensitivity, size, resistance value etc. Pictured at the left is a typical CDS photocell. Its diameter is 8 mm, 4 mm high, with a cylinder form. When bright light is hitting it, the value is about 200 ohms, and when in the dark, the resistance value is about 2M ohms.

HOW IS COMPARATOR DETECTED WITH LDR?

These provide the signal to micro controller to move the solar panel in the sun's direction. LDR1 and LDR3 are fixed at the edges of the solar panel along the X axis, and LDR2 is fixed at the center of solar panel and LDR1 and LDR3.

LDR1, 2, and 3 connected to comparators A1, A2 and A4, respectively. Presets PR1, PR2 and PR3 are set to get low comparator output at pins 1, 2 and 14 of comparators A1, A4 and A2, respectively. Comparator active low output signal fed to MCU Port Pin P1.0, P1.1 and P1.2.

Port Pin P1.0, P1.1, and P1.2 Used as a digital Input Port and is pulled up via 10K resistors (R4, 5 and 6). LED L1 to L3 indicates LDR Detection is operated. LED has a current limiting resistor in series.

CIRCUIT DIAGRAM OF LDR:-

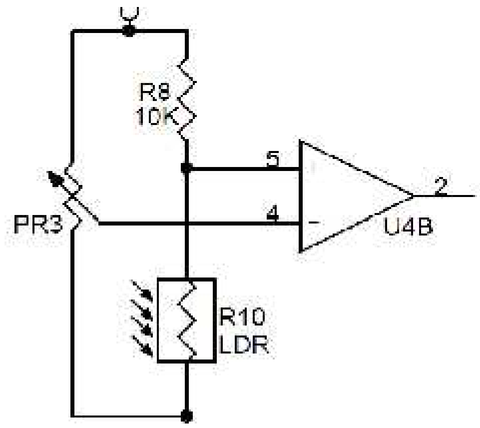


Fig 7.9 Equivalent circuit diagram of LDR

7.5 COMPARATOR (LM339)

These comparators are designed for use in level detection, low−level sensing and memory applications in consumer, automotive, and industrial electronic applications.

FEATURES:

1. Single or Split Supply Operation
2. Low Input Bias Current: 25 nA (Typ)
3. Low Input Offset Current: 5.0 mA (Typ)
4. Low Input Offset Voltage
5. Input Common Mode Voltage Range to GND
6. Low Output Saturation Voltage: 130 mV (Typ) @ 4.0 mA
7. TTL and CMOS Compatible
8. ESD Clamps on the Inputs Increase Reliability without Affecting Device Operation
9. NCV Prefix for Automotive & Other Applications Requiring Site and Control Changes
10. These Devices are Pb−Free, Halogen Free/BFR Free and are RoHS Compliant

ADVANTAGES

– High-Precision Comparators
– Reduced VOS Drift Over temperature
– Eliminates Need for Dual Supplies
– Allows Sensing Near GND
– Compatible With All Forms of Logic
– Power Drain Suitable for Battery Operation

PIN DIAGRAM:

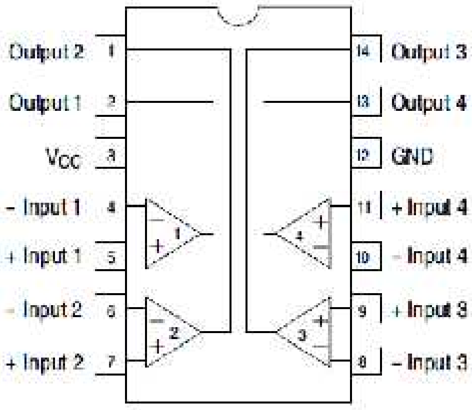


Fig 7.10 pin Diagram of LM339

DESCRIPTION

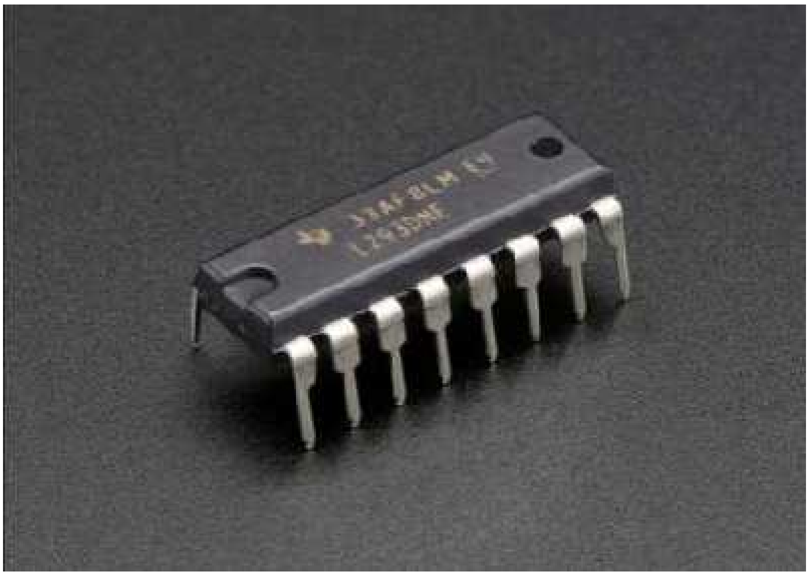
LM339 is a comparator IC with four inbuilt comparators. A comparator is a simple circuit that moves signals between the analog and digital worlds. It compares two input voltage levels and gives digital output to indicate the larger one. The two input pins are termed as inverting (V-) and non-inverting (V+). The output pin goes high when voltage at V+ is greater than that at V-, and vice versa. In common applications, one of the pins is provided with a reference voltage and the other one receives analog input from a sensor or any external device. If inverting pin (V-) is set as reference, then V+ must exceed this reference to result in high output. For inverted logic, the reference is set at V+ pin. This comparator is designed for use in level detection, low-level sensing and memory applications in consumer automotive and industrial electronic applications.

MAXIMUM RATINGS:

Rating		Symbol	Value	Unit
Power Supply Voltage		V_{CC}		Vdc
	LM239/LM339/LM2901, V		+36 or ±18	
	MC3302		+30 or ±15	
Input Differential Voltage Range		V_{IDR}		Vdc
	LM239/LM339/LM2901, V		36	
	MC3302		30	
Input Common Mode Voltage Range		V_{ICMR}	0.3 to V_{CC}	Vdc
Output Short Circuit to Ground (Note 1)		I_{SC}	Continuous	
Power Dissipation @ T_A = 25°C		P_D		
Plastic Package			1.0	W
Derate above 25°C		$1/R_{\theta JA}$	8.0	mW/°C
Junction Temperature		T_J	150	°C
Operating Ambient Temperature Range		T_A		°C
	LM239		−25 to +85	
	MC3302		−40 to +85	
	LM2901		40 to +105	
	LM2901V, NCV2901		40 to +125	
	LM339		0 to +70	
Storage Temperature Range		T_{stg}	65 to +150	°C
ESD Protection at any Pin (Note 2)		V_{ESD}		V
Human Body Model			1500	
Machine Model			200	

Table 7.1 Pin Diagram of LM339

7.6 MOTOR DRIVER L293D:-



FEATURES:

1. Output current 1A per channel
2. High noise immunity
3. Separate logic supply
4. Over temperature protection

DESCRIPTION

A DC Motor is connected to port P3.4 and P3.5 of the micro controller through a H-bridge motor driver IC (U2). The DC Motor requires 12 volts at a current of around 250 mA, which cannot be provided by the micro controller. So the driver IC is added.

L293D is a dual H-bridge motor driver integrated circuit (IC). Motor drivers act as current amplifiers since they take a low-current control signal and provide a higher-current signal. This higher current signal is used to drive the motors.

L293D contains two inbuilt H-bridge driver circuits. In its common mode of operation, two DC motors can be driven simultaneously, both in forward and reverse direction. The motor operations of two motors can be controlled by input logic at pins 2 & 7 and 10 & 15. Input logic 00 or 11 will stop the corresponding motor. Logic 01 and 10 will rotate it in clockwise and anticlockwise directions, respectively.

Enable pins 1 and 9 (corresponding to the two motors) must be high for motors to start operating. When an enable input is high, the associated driver gets enabled. As a result, the outputs become active and work in phase with their inputs. Similarly, when the enable input is low, that driver is disabled, and their outputs are off and in the high-impedance state.

PIN DIAGRAM:

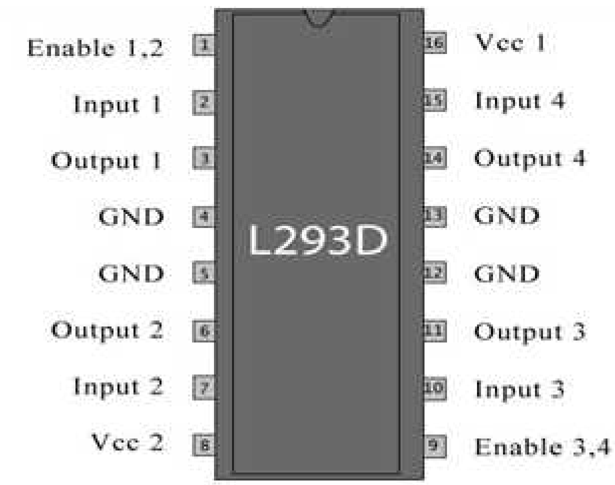


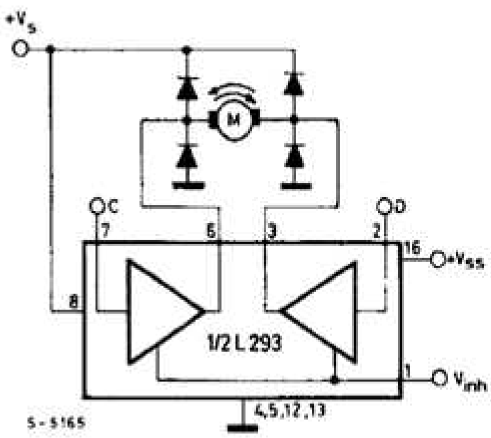
Fig 7.11 Pin diagram of L293D IC

PIN NO.	FUNCTION	NAME
1.	Enable pin for motor 1:Active high	Enable 1,2
2.	Input 1 for motor 1	Input 1
3.	Output 1 for motor 1	Output 1
4.	Ground (0V)	ground
5.	Ground (0V)	Ground
6.	Output 2 for motor 1	Output 2
7.	Input 2 for motor 1	Input 2
8.	Supply voltage for motors 9-12V (upto 36 V)	Vcc2
9.	Enable pin for motor 2:Active high	Enable 3,4
10.	Input 1 for motor 1	Input 3

11.	Output 1 for motor 1	Output 3
12.	Ground:0V	Ground
13.	Ground:0V	Ground
14.	Output 2 for motor 1	Output 4
15.	Input 2 for motor 1	Input 4
16.	Supply voltage:5V (up to 36 V)	Vcc1

Table 7.2 Pin diagram description of L293D IC

CIRCUIT DIAGRAM OF L293D:-



BIDIRECTIONAL CONTROL OF DC MOTOR

Fig 7.12 Circuit diagram of L293D

Inputs	Function	
V_{inh} = H	C = H ; D = L	Turn Right
	C = L ; D = H	Turn Left
	C = D	Fast Motor Stop
V_{inh} = L	C = X ; D = X	Free Running Motor Stop

L = Low H = High X = Don't Care

Table 7.3 Truth table of L293D

THEORY OF H – BRIDGE (DC MOTOR DRIVER)

H-bridge, sometimes called a "full bridge" the H-bridge is so named because it has four switching elements at the "corners" of the H and the motor forms the cross bar. The basic bridge is shown in the figure to the right. The key fact to note is that there are, in theory, four switching elements within the bridge. These four elements are often called, high side left, high side right, low side right, and low side left (when traversing in clockwise order).

The switches are turned on in pairs, either high left and lower right, or lower left and high right, but never both switches on the same "side" of the bridge. If both switches on one side of a bridge are turned on it creates a short circuit between the battery plus and battery minus terminals. If the bridge is sufficiently powerful it will absorb that load and your batteries will simply drain quickly. Usually however the switches in question melt.

To power the motor, you turn on two switches that are diagonally opposed. In the picture to the right, imagine that the high side left and low side right switches are turned on. The current flow is shown in green.

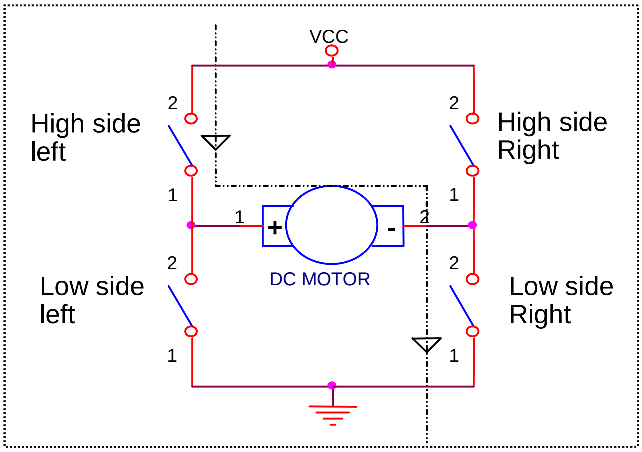


Fig 7.13 Current direction flowing through dc motor (h bridge)

The current flows and the motor begins to turn in a "positive" direction. What happens if you turn on the high side right and low side left switches? Current flows the other direction through the motor and the motor turns in the opposite direction. Actually it is just that simple, the tricky part comes in when you decide what to use for switches. Anything that can carry a current will work, from four SPST switches, one DPDT switch, relays, transistors, to enhancement mode power MOSFETs.

7.7 POWER SUPPLY:-

The power supply circuit. It’s based on 3 terminal voltage regulators, which provide the required regulated +5V and unregulated +12V.

Power is deliver initially from standard 12V AC/DC adapter or 12V battery. This is fed to diode D1. The output of which is then filtered using 1000uf electrolytic capacitor and fed to U4 (voltage regulator). U4 +5V output powers the micro controller and other logic circuitry. LED L7 and its associate 1K current limiting resistors provide power indication. The unregulated voltage of approximately 12V is required for Motor driving circuit (U2) and DC Motor.

7.8 VOLTAGE REGULATOR (LM7805):-

Fig 7.14 Voltage regulator IC

FEATURES:

• Output Current up to 1A
• Output Voltages of 5, 6, 8, 9, 10, 12, 15, 18, 24V
• Thermal Overload Protection
• Short Circuit Protection
• Output Transistor Safe Operating Area Protection

7.8.1 DESCRIPTION:

The MC78XX/LM78XX/MC78XXA series of three terminal positive regulators are available in the TO-220/D-PAK package and with several fixed output voltages, making them useful in a wide range of applications. Each type employs internal current limiting, thermal shut down and safe operating area protection, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.

7.9 LCD DISPLAY (16 CHARACTERS, 2 ROWS):

ABSOLUTE MAXIMUM RATING:

Parameter	Symbol	Testing Criteria	Standard Values			Unit
			Min.	Typ.	Max	
Supply voltage	V_{DD}-V_{SS}	-	4.5	5.0	5.5	V
Input high voltage	V_{IH}	-	2.2	-	V_{DD}	V
Input low voltage	V_{IL}	-	-0.3	-	0.6	V
Output high voltage	V_{OH}	$-I_{OH}$=02mA	2.4	-	-	V
Output low voltage	V_{OL}	I_{OL}=1.2mA	-	-	0.4	V
Operating voltage	I_{DD}	V_{DD}=5.0V	-	1.5	3.0	mA

Table 7.4 Specifications of LCD display

BLOCK DIAGRAM

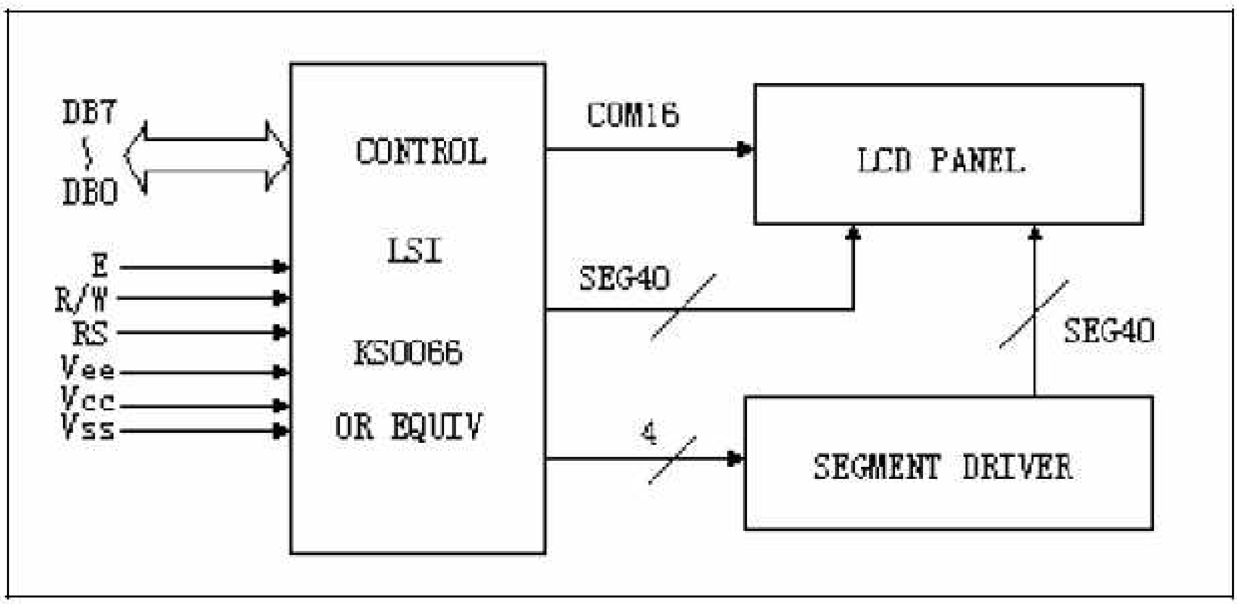


Fig 7.15 Block diagram of LCD Display

CHAPTER 8

CIRCUIT DIAGRAM AND OPERATION

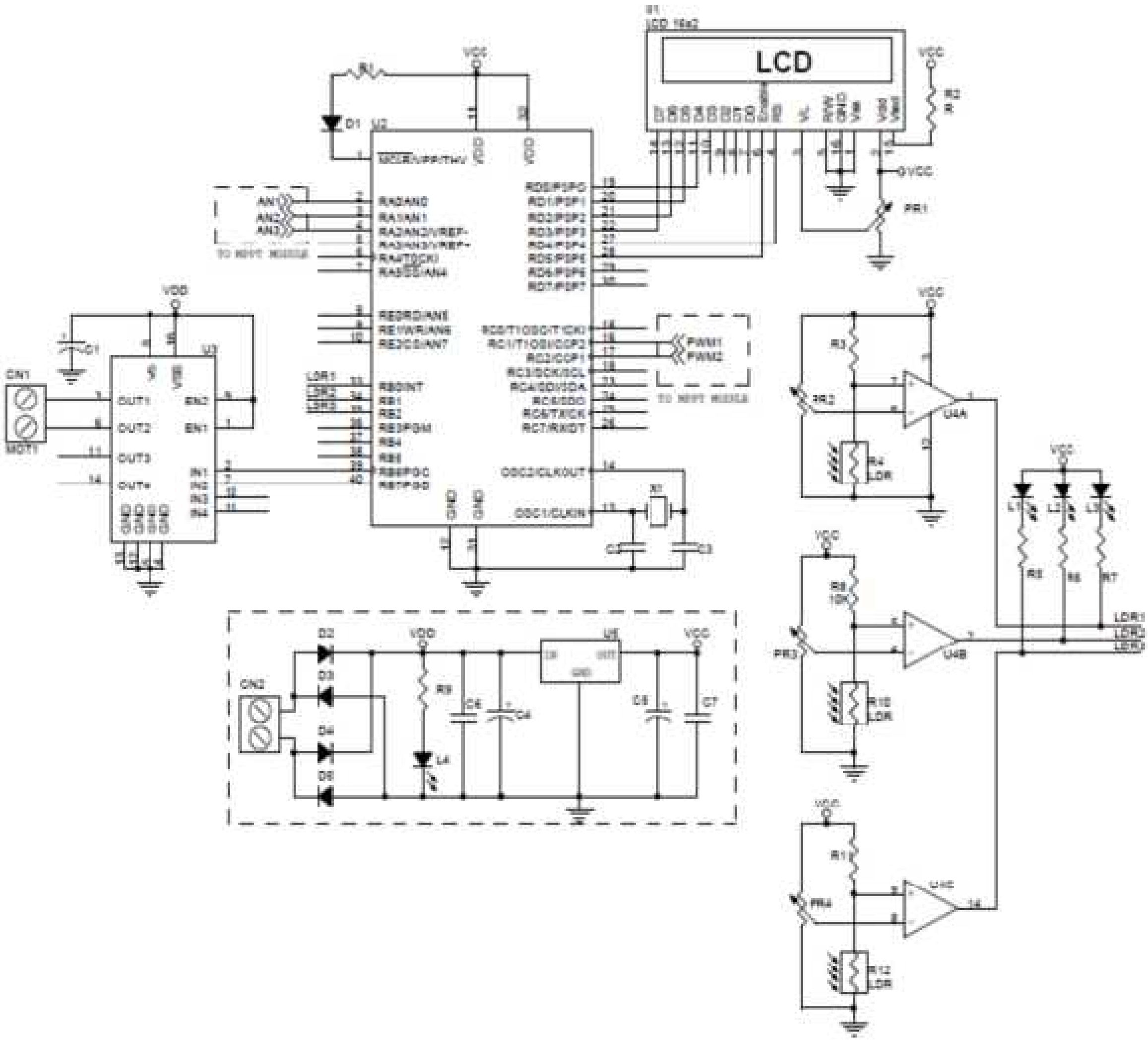


Fig 8.1 Proposed Circuit diagram

MPPT CIRCUIT DIAGRAM

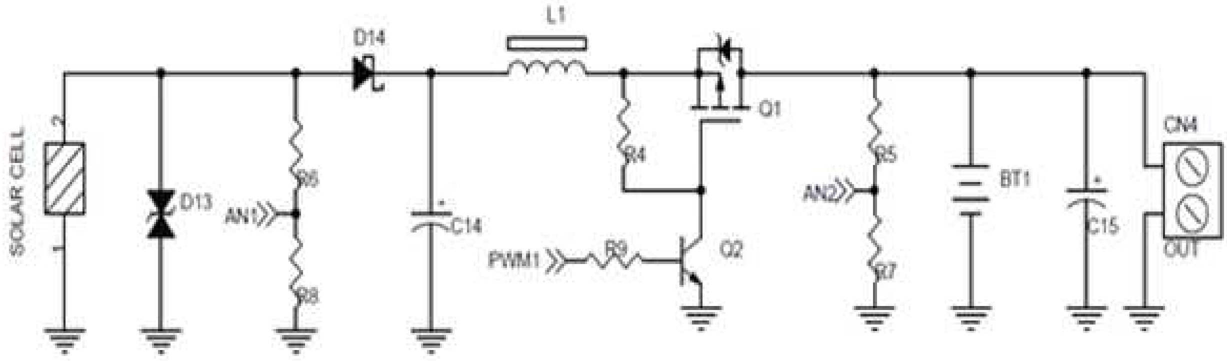


Fig 8.2 Circuit diagram of proposed MPPT

CIRCUIT OPERATION

8.1 OPERATION OF MECHANICAL SOLAR TRACKING

For single axis rotation we have to take two LDR s therefore we rotate the panel in east west direction and hence we take east LDR and west LDR .now whenever light intensity falls on the east and west LDR the comparator compare the voltage between two LDRs.. When it compares then there are two possibilities:

If V (east) -V (west) > threshold or maximum voltage then corresponding transistors in motor driving circuit are biased and moves motor in east

If V(east)-V(west) < threshold or maximum voltage then corresponding transistors in motor driving circuit are biased and moves motor in west and one more possibility not mentioned in algorithm .

If V (east)-V (west) = threshold or maximum voltage then motor automatically moves in the east direction by biasing the corresponding transistors.

Thus signal generated by comparator are fed as input to the microcontroller .microcontroller PIC16F887 generates a output signal which feds as a input to motor driver circuit which rotates the solar panel at desired position

8.2 OPERATION FOR MPPT CIRCUIT

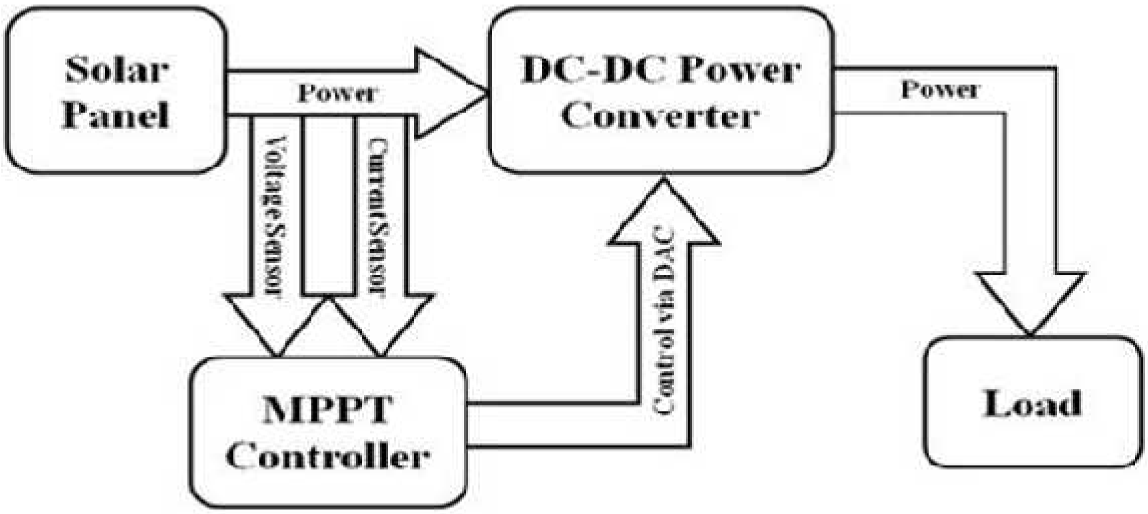


Fig 8.3 General Block diagram of MPPT

1. MPPT is used to extract excess voltage from the solar panels up to the peak limit. This is done with the help of above circuit diagram.
2. D13 is a Schottky diode used as a protection diode .It prevents the overvoltage which damages the circuit. Also it prevents back emf or reverses current in the diode.
3. AN1 and AN2 are voltage divider circuits used for sensing the voltage.
4. D14 is a zener diode used to bypass all low level voltage signals and allow only high voltage sensing to be done.
5. Q1 is a MOSFET DRIVER used as a switching device. MOSFET is used for high frequency signal generally in the range from 20-200 kHz.
6. A diode is connected in parallel to MOSFET to protect the diode from getting damaged i.e. from overvoltages.
7. A resistor R4 is shunted across MOSFET DRIVER Q1 to bypass excess current from it.
8. PWM1 is used to switch at the maximum power point where the excess voltage is recorded.
9. BT1 is the battery voltage which is sensed continuously till the battery is charged.

8.2.1 ANALOG TO DIGITAL CONVERSION (ADC):

VOLTAGE SENSING:

The microcontroller consists of built in Analog- to- Digital (ADC) converters. These enable the conversion of our analog inputs into quantized values. The ADCON registers will need to be configured with their required binary values to enable ADC to begin. The voltage inputs from the panel and the battery must be "stepped down" by using voltage division principle. The node voltages between the two resistors connected to the panel is fed to one ADC pin (AN0). Similarly, the node voltages from the resistors connected to the battery are connected to AN1 (pin 3).The ADC of the microcontroller divides these analog inputs into 1024 quantized levels. These values are 0 (for 0V input) and 1023 (for 5V input). In this way, voltage sensing of the panel and battery is achieved.

CURRENT SENSING:

To read the current supplied by the PV module, a shunt resistor is placed in series with an ADC input. This value is amplified and connected to the ADC port AN2. The shunt resistor gives a voltage that is proportional to the current, e.g.: if 1A gives 5mV, 10A gives 50mV. This voltage output is then connected to another ADC port, AN2 and run in the algorithm as an input.

PULSE WIDTH MODULATION:

The charging of the battery at Maximum Power Point (MPP) is achieved by carrying out the process of Pulse Width Modulation (PWM) at the switch mode of the DC- DC converter. The pulse width modulation uses time proportioning. This divides the signals into and low states. The proportion of time spent in the high state is known as the duty cycle. Our algorithm uses different duty cycles to match the impedances of the PV array and the battery to reach the MPP. The duty cycle like the ADC, must be quantized into digital outputs. For this purpose the PORTB and PORTC are declared as outputs and the PWM port is initialized with input frequency (25000 Hz). The duty cycle of the PWM pin (CCC1/ pin 13) is set with a quantized value which is 0 for minimum (0%) duty cycle and 255 for maximum (100%) duty cycle.

CHAPTER 9

RESULTS

1. EXPERIMENTAL OBSERVATIONS (TAKEN IN SUNLIGHT AS IRRADIANCE SOURCE)

SR NO.	TYPE OF LOAD	INPUT VOLTAGE (Volts)	OUTPUT VOLTAGE (Volts)	OUTPUT CURRENT (Amperes)	POWER DRAWN (Watts)
1	NO LOAD	20 V	20 V	0	0
2	12 V FAN	19.50 V	13.5 V	300 mA	4.05 W
3	MOBILE BATTERY	20V	13.5 V (regulated to 5V for output)	110 mA	1.98 W

Table 9.1 Experimental Observations

2. EXPERIMENTAL OBSERVATIONS (FILAMENT BULB AS IRRADIANCE SOURCE)

SR NO.	TYPE OF LOAD	INPUT VOLTAGE (Volts)	OUTPUT VOLTAGE (Volts)	OUTPUT CURRENT (Amperes)	POWER DRAWN (Watts)
1	NO LOAD	20 V	20 V	0	0
2	12 V FAN	19.50 V	13.5 V	300 mA	4.05 W
3	MOBILE BATTERY	20V	13.5 V (regulated to 5V for output)	110 mA	1.98 W

Table 9.2 Experimental Observations

COMMENT: From above Observations it can be said that MPPT system is optimizing the output Voltage value to track Maximum Power Point (MPP) from Solar Panel.

CHAPTER 10

COMPONENTS AND COST ESTIMATION

SR.N	NAME	DESCRIPTION	RATING	QUANTITY
1	R1 ~ 7	RESISTOR	10KΩ	7
2	R8	RESISTOR	220 Ω	13
3	R14	RESISOTOR	1K Ω	1
4	R15,16,17	5mm LDR		4
5	PR1-3	POT RESISTOR	10K Ω	3
6	C1,7	CAPACITOR	100KPF DISC (0.1UF / 104)	2
7	C2	CAPACITOR	10UF / 25V Electrolytic	1
8	C3-4	CAPACITOR	33PF Ceramic disc	2
10	C6	CAPACITOR	47UF / 25V Electrolytic	1
11	X1	CRYSTAL OSCILLATOR	4 MHZ	1
12	D1	DIODE	1N4007	4
13	L1-6	RED LED	3mm-5mm	6
14	L7	GREEN LED	5mm	1
15	D14	CLAMPING DIODE	P6KE36C	1

16	D13	SCHOCTKEY DIODE	MBR2045	1
17	C14	STRAY CAPACITOR	1000micro F	1
18	L1	INDUCTOR	22000micro H	1
19	Q1	MOSFET(P channel)	IRFZ9540	1
20	U1	MICROCONTROLLER	PIC16F887	1
21	U2	MOTOR DRIVER	L293D	1
22	U3	COMPARATOR	LM339	1
23	U4	5V VOLTAGE REGULATOR	LM7805	1
24	M1	DC GEARED MOTOR	12V ,10 RPM	1
25	T1	CHARGING TRANSFORMER	12-0-12	1

Table 10.1 Component list

OTHER COMPONENTS

IC sockets, PCBs, Soldering machine, etc.

TOTAL COST OF PROJECT: approximated to about Rs.12, 000/-

CHAPTER 11

ADVANTAGES, APPLICATIONS & FUTURE SCOPE

11.1 ADVANTAGES

1. Solar tracking systems are used to continually orient photovoltaic panels towards the sun and can help maximize the investment in PV system.
2. They are beneficial as the sun's position in the sky will change gradually over the course of a day and over the seasons throughout the year.
3. Energy production is at an optimum and energy output is increased year round. This is especially significant throughout the summer months with its long days of sunlight available to capture and no energy will be lost.
4. For those with limited space this means that a smaller array only needs to be installed, a huge advantage for those smaller sites with only a small area to place solar tracker.
5. Typical PV module produces power with maximum power voltage of around 17 V when measured at a cell temperature of 25°C, it can drop to around 15 V on a very hot day and it can also rise to 18 V on a very cold day. Cold weather, cloudy or hazy days: Normally, PV module works better at cold temperatures and MPPT is utilized to extract maximum power available from them.
6. MPPT solar charge controller is necessary for any solar power systems need to extract maximum power from PV module; it forces PV module to operate at voltage close to maximum power point to draw maximum available power.

11.2 APPLICATION

MPPT solar charge controller can be applied to other renewable energy sources such as small water turbines, wind-power turbines, etc. Thus by implementing MPPT charge controller system we can improve the efficiency of a wind power plant which serves to be an important power generation resource in future. Increase the sensitivity and accuracy of tracking by using a different light sensor. A phototransistor with an amplification circuit would provide improved resolution and better tracking accuracy/precision. Utilize a dual-axis design versus a single-axis to increase tracking accuracy.

FUTURE SCOPE

Fig 11.1 SOLAR IMPULSE 2

Fig 11.2SOLAR ARRAY GRID

Currently MPPT system is compatible with only one Solar Panel. If we connect it to the grid or parallel with no of solar panel it tends to calculate the average MPP of whole grid and cannot operates on individual MPP of each panel leading to loss of power.

Also there is a recent trend of green energy leading to inventions like SOLAR IMPULSE 2 and many other green energy ideas. Hence, this project has a very wide scope in future to find its application in Green Energy Revolution

CHAPTER 12

CONCLUSION

PV has a powerful attraction because it produces electric energy from a free inexhaustible source, the sun, using no moving parts, consuming no fossil fuels, and creating no pollution or green house gases during the power generation. So, it is our wish to make the P-V system more efficient so that it can help for betterment of life. This project has presented a means of controlling a sun tracking array with an embedded microcontroller system, a working software solution for maximizing solar cell output by positioning a solar array at the point of maximum light intensity. This project presents a method of searching for and tracking the sun and resetting itself for a new day. Development of a project based on maximum solar power tracking with various parameters being controlled by a microcontroller and maintained further to an optimum value required for charging of battery; using the stored solar energy only. An increase in output of solar panel due to the implementation of maximum solar power tracking .The proposed project is very useful for hilly areas where there is scarce sunlight in winters .And will have very fast response and will occupy minimum space It can be built even on the rooftop of houses, in highly populated hilly areas. Energy can also be stored at a large scale and maybe utilized for heating the house water in winters available in tanks of house.

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ANNEXURE 1

PROGRAMMING OF MICROCONTROLLER:-

```
Include Pic16f887.Lib

Include PWM.Lib

Include Adc.Lib

Include LCD_16_2.Lib

Include Variable.Lib

Define Osc 4

---------------------------------------------------------------------------

Define CCP1 PORTC.1

Define  LDR1    = PORTC.4

Define  LDR2    = PORTC.5

Define  LDR3    = PORTC.6

Define  LDR4    = PORTC.7

Define  M0      = PORTB.1

Define  M1      = PORTB.0

---------------------------------------------------------------------------

DelayMS50

Cls

Print At 1,"Wel Come TO"

Print At 2,"Solar Charger"

DelayMS3000
```

```
.MAIN:

GoSubRead_ADC
Cls

Print At 1,"V=",VOLT1, ".", MV1, "/", VOLT2, ".", MV2

Print At 2,"A:" , (i/1000)

DelayMS100

If VOLT1 > 5 Then

If VOLT2 < 12 Then

PWM_Val = PWM_Val + 1

GoSubPWM_Out

EndIf

If VOLT2 > 12 Then

PWM_Val = PWM_Val - 1

GoSubPWM_Out

EndIf

Else

PWM_Val = 0

GoSubPWM_Out

EndIf

GoSubSun_Track

GoToMain
```

```
Read_ADC:
   ADC_VAL1[0] = Adin,0
   ADC_VAL1[1] = Adin,0
   ADC_VAL1[2] = Adin,0
   ADC_VAL1[3] = Adin,0
   ADC_VAL1[4] = Adin,0
   ADC_VAL1[5] = Adin,0
   ADC_VAL1[6] = Adin,0
   ADC_VAL1[7] = Adin,0
   ADC_VAL1[8] = Adin,0
   ADC_VAL1[9] = Adin,0
DelayMS 5
   ADC_VAL2[0] = Adin,1
   ADC_VAL2[1] = Adin,1
   ADC_VAL2[2] = Adin,1
   ADC_VAL2[3] = Adin,1
   ADC_VAL2[4] = Adin,1
   ADC_VAL2[5] = Adin,1
   ADC_VAL2[6] = Adin,1
   ADC_VAL2[7] = Adin,1
   ADC_VAL2[8] = Adin,1
   ADC_VAL2[9] = Adin,1
```

```
DelayMS 5
   ADC_VAL3[0] = Adin,2
   ADC_VAL3[1] = Adin,2
   ADC_VAL3[2] = Adin,2
   ADC_VAL3[3] = Adin,2
   ADC_VAL3[4] = Adin,2
   ADC_VAL3[5] = Adin,2
   ADC_VAL3[6] = Adin,2
   ADC_VAL3[7] = Adin,2
   ADC_VAL3[8] = Adin,2
   ADC_VAL3[9] = Adin,2
DelayMS 5
   HVD=((ADC_Val1+1)/875)
   VOLT1=HVD/10
   MV1=(HVD)//10
   HVD=((ADC_Val2+1)/875)
   VOLT2=HVD/10
   MV2=(HVD)//10
value =  ADC_Val3
TEMP = value * 4.89
i=  TEMP/0.47
Return
------------------------------------------------------------------------------
```

```
Sun_Track:

If LDR1 = 0 AndLDR2 = 0 AndLDR3 = 0 Then
M0 = 0
 M1 = 0
ElseIfLDR1 = 0 AndLDR2 = 0 AndLDR3 = 1 Then
M0 = 0
M1 = 0
ElseIfLDR1 = 1 AndLDR2 = 1 AndLDR3 = 1 And LDR4 = 0 Then
M0 = 0
M1 = 1
DelayMS2000
M0 = 0
M1 = 0
ElseIfLDR1 = 1 AndLDR2 = 1 AndLDR3 = 1 Then
M0 = 0
 M1 = 0
ElseIfLDR1 = 0 AndLDR2 = 1 AndLDR3 = 1 Then
M0 = 1
M1 = 0
DelayMS50
M0 = 0
M1 = 0
```

```
ElseIfLDR1 = 1 AndLDR2 = 0 AndLDR3 = 1 Then
M0 = 0
 M1 = 1
DelayMS50
M0 = 0
M1 = 0
ElseIfLDR1 = 1 AndLDR2 = 1 AndLDR3 = 0 Then
M0 = 1
M1 = 0
DelayMS50
 M0 = 0
 M1 = 0
End If
Return
--------------------------------------------------------------------------
PWM_Out:
CCP1CON.4 = PWM_Val()
Return
```