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A Comparative Analysis of MPPT with Tracking Panel Mechanism and Fixed Panel Arrangement

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***Abstract*: The growing demand of electricity day by day and growing concern regarding environment pollution has bring humans to think about an alternate for production of energy using clean, renewable sources such as solar energy. In all renewable energy sources the solar energy is the best, to convert sun ray's to electrical energy. In this paper firstly mechanical tracking of the sun, using Arduino is proposed to extract maximum irradiation from the sun by keeping the solar panel perpendicular to the irradiation. Secondly by getting the maximum solar irradiation as input to the solar panel, output from the PV (i.e. voltage and current) fed to a power interface Buck-Boost converter through a MPPT control technique to operate the operating point always at peak. Electrical tracking is done using P&O algorithm MPPT technique. The objective is to get maximum irradiation and Maximum power at each and every moment.**

***Index Terms*: Mechanical Tracking, Arduino, Maximum irradiation, Perturb and Observe(P&O) Maximum Power Point Tracking(MPPT)**

I. INTRODUCTION

The energy coming from the sun is huge in amount. This is many thousands of present day requirement. So proper production of this energy may lead the country in each and every aspect. There are some other factors which make this very much suitable for use in day to day life that are, it is free from pollution very clean source of energy. Secondly it is free available in huge amount in every corner of the world. It is free from noise because Solar energy equipment does not require any heavy mechanical section. The main motive is to extract or capture maximum irradiation upon the solar panel to maximize the overall output power. A way of getting this is by positioning the panels in such a way that the rays of the sun should fall perpendicularly on the solar panel [1],[2]. So to do this it is necessary to have a system that can move the solar panel with the movement in the sun. The purpose of making solar panel every time perpendicular to the sun's radiation is to extract maximum irradiation [1],[2]. If sun radiation remains perpendicular to the solar panel whole day then it would be able to produce more power. It would capture maximum irradiation of light, so more number of electron and hole will be generated. In this paper a practical implementation of solar panel with tracking system is proposed [2]. Which move with movement in the sun. This design is based on Arduino containing ATmega328 microcontroller, dc geared motor and a sensor to detect light intensity that is taken light dependent resisters arranged in a simple circuit. Main motive of this mechanical tracking is to get maximum irradiation from the sun throughout the day [2]. This can be done by mounting a solar panel on a platform that can rotate solar panel with movement in the sun and by this way it can track the sun throughout the day. The main purpose of going for this is to because the sun is not at fixed at one position throughout the day, so we need to go for a system that can track the sun as it moves from it's initial position [3]. In mechanical solar tracking device solar panel is mounted on a tracker platform that can track the motion of the sun across the sky. Solar tracker will keep solar panel perpendicular to irradiation. With the motive of produce more power, it is necessary to get maximum irradiation. This work proposes a cheapest design which track the solar panel with movement in the sun [1]. A rotating mounted platform is placed on the shaft of the dc motor, and when the dc motor gets a low and high signal/command it acts accordingly and motor is gets rotate if the getting signal is high and in the same way it stay at same position if getting signal is low, on the based on command if the dc motor gets rotate with that solar panel is also gets oriented this is because the LDR sensors lying on each side of the solar panel to capture/observe the difference in the light intensity. In advancement the purpose of going for electrical tracking using maximum power point tracking(MPPT) is to operate load line at peak power throughout the day to increase efficiency of solar panel [4],[5]. The implementation of electrical tracking bring an advantage because by using mechanical tracking we are getting maximum irradiation throughout the day, but it not meant that we are operating at peak power at each and every time, because with change in load, the load line can be shift from the peak power point in either left or right. So the purpose of going for electrical tracking is to keep the load line constant at peak of PV curve using a power interface Buck-boost converter, by sensing the output voltage and current from PV panel and then taking as reference [5]. The electrical tracking is done using Matlab Simulink model, to operate at maximum power point, because even though we are extracting maximum irradiation from the sun through mechanical tracking but extracting the maximum solar irradiance is not mean that getting maximum power

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throughout the day. So this electrical tracking is performed in MATLAB software to know the output voltage, current and power.

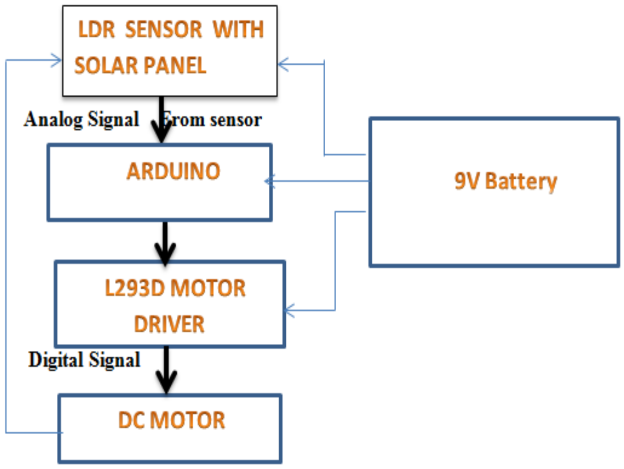

Fig : Proposed Block Diagram

MATHEMATICAL MODEL of PV PANEL:-

The current voltage relationship of PV module is as shown below

$$I = N_p I_{PH} - N_p I_S \left[\exp\left(q\left(\frac{V}{N_S} + \frac{IR_S}{N_P}\right)\right) - 1\right] - \frac{\left(\frac{N_P V}{N_S} + IR_S\right)}{R_{SH}} \tag{1}$$

The PV module photo current is as shown below

$$I_{Ph} = [I_{SC} + K_i(T - T_{ref})]\beta/1000 \tag{2}$$

The cell saturation current is as shown below

$$I_S = I_{RS}\left(\frac{T_C}{T_{ref}}\right)^3 \exp\left[\frac{qE_g\left(\frac{1}{T_{ref}} - \frac{1}{T}\right)}{KA}\right] \tag{3}$$

And reverse saturation current is given by as follows

$$I_{RS} = \frac{I_{SC}}{\left[\exp\left(\frac{qV_{OC}}{N_S KAT}\right) - 1\right]} \tag{4}$$

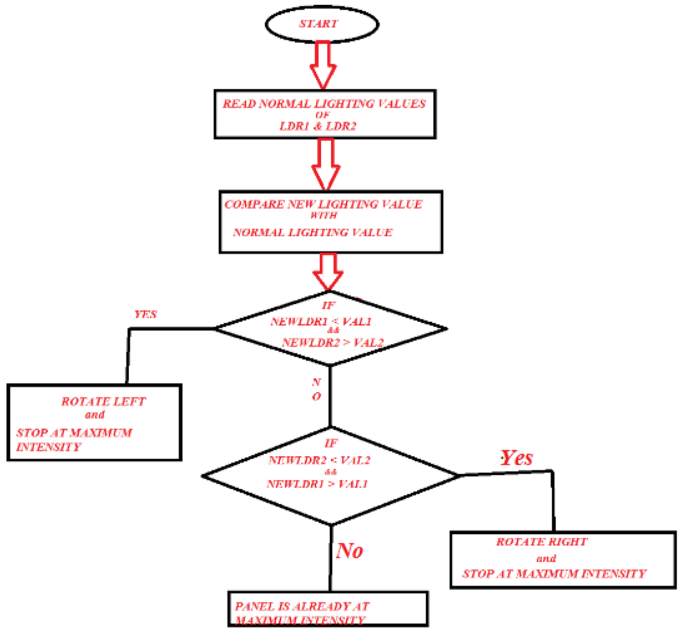

Fig2.: Flowchart of Mechanical Tracking

II. CONFIGURATION OF MOTOR DRIVER:-

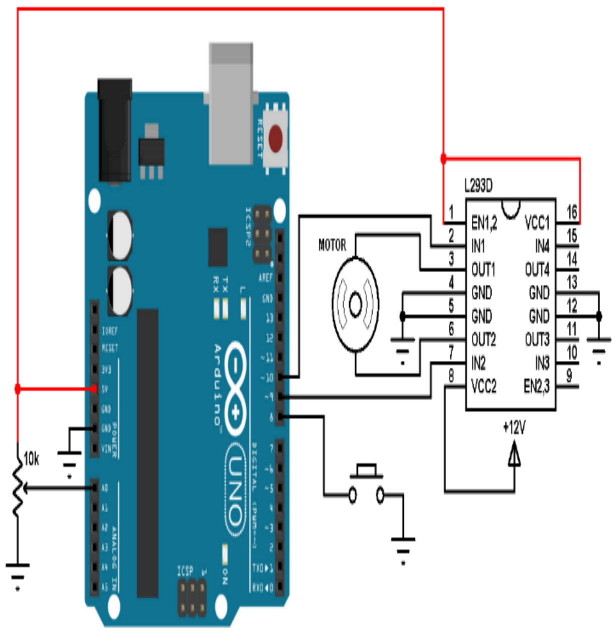

FIG3:- INTERFACING MOTOR DRIVER TO ARDUINO

III. WORKING PRINCIPLE OF PROPOSED MECHANICAL TRACKER:-

The block diagram of sun tracker solar panel is consisting mainly four units. The sensor unit is consisting LDR sensor (Light dependent resister).When there is movement in the sun then LDR detects the variation or change in intensity of light.

Once the variation in light intensity is detected then it is processed by Arduino. Arduino is a open source electronic platform that consist a on chip microcontroller it is easy to use and available in both software and hardware. It is able to read the inputs got from sensors like variation in light, variation in moisture etc. Microcontroller is programmed in such a way that whenever there is a change in intensity of light (By comparing both LDR), LDR senses the variation(on which LDR more intensity is coming) and based on intensity a signal send by the Arduino to the dc geared motor to keep the solar panel perpendicular to the irradiation. First coding is programmed in Arduino software, Then it is uploaded to the hardware setup of Arduino through USB cable. The movement of the dc motor depends on the input received by the LDRs. The motor will be in standstill position in the case if both LDR's are facing same intensity of light. If the intensity is not equal to both of the LDR's then a high signal would be send to motor to keep the panel perpendicular to irradiations. Motor will be rotate in either clockwise or anti-clockwise Until the intensity of light is not falling equally on both of the LDR's. the moment when the intensity on both LDR's is become equal at that moment Arduino will identify and it will send low signal to motor. By rotating solar panel and we have got maximum intensity or maximum irradiation falling on solar panel, and if the size of solar panel increases, we can increase motor rating.

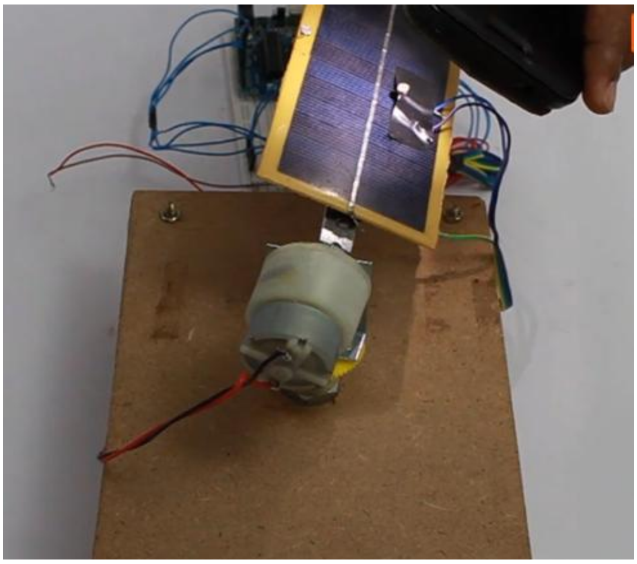

Figure 1: Configuration of the PV Panel on a Tracking System

Table: Irradiation Data at Particular Time

SI. No.	Time Hr	While Panel is Fixed		While Panel is Tracked	
		Irradiation (w/m^2)	Temp °C	Irradiation (w/m^2)	Temp °C
1.	6:00	0	24	5	24
2.	7:00	36	26	67	29
3.	8:00	100	32	158	35
4.	9:00	200	45	275	47
5.	10:00	407	44	520	49
6.	11:00	620	51	690	53
7.	12:00	756	56	800	57
8.	1:00	854	59	859	59
9.	2:00	877	58	877	58
10.	3:00	817	54	847	54
11.	4:00	644	49	670	50
12.	5:00	393	31	477	36

IV. ELECTRICAL TRACKER SYSTEM

But getting maximum irradiation is not guarantee to getting maximum power at each and every moment we need to go for MPPT technique. In the case of photovoltaic modules there is one single operating point at any given point in time where maximum power can be drawn, so we need to locate this point track this point and see that operating point of MPPT module is always at that point or hovering near or around that point. Now in addition of that we are connecting this solar panel to MPPT controller and boost converter to get maximum power at each and every moment. The process of doing this always trying to maintain the operating point of the PV panels at maximum power point is called MPPT. So keep operating point at MPP we need to introduce an interface here of our interface how job of that power interface is to see that load line is always at this operating point whatever may be the value of Ro.

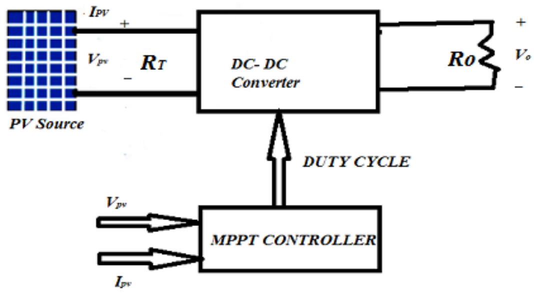

FIG: SYSTEM MODELING OF MPPT SCHEME

A. Different Parameters Used in PV Module:- The Solar 250W PV module is taken as the reference or set point PV module for simulation and electrical characteristics are:-

"Tref = 25 , Isc = 8.55 A, VOC = 37.6V, Pmax(Watt) = 249, Vmpp (V) = 31, Temperature coefficient of Voc (%/deg.C) = -0.35, Cells per module (Ncell) = 60,Temperature Coefficient of Isc (%/deg.C) = 0.06, Impp = 8.06

A = 1.6, q=1.6*10^-19,k=1.380658e-23"

B. Maximum Power Point Algorithm:-

To extract peak power each and every time MPPT is used. According to this theorem there is a single point on p-v curve if we are able to operate at that point we will get maximum power. According to this maximum power transfer theorem maximum power of any circuit can be maximize by impedence matching. i.e by adjusting source impedance equal to load impedance. In our present project model buck boost converter is used as a device for impedance matching to source as well load, by changing the duty cycle. In this paper perturb and Observe MPPT technique is used to extract maximum power.

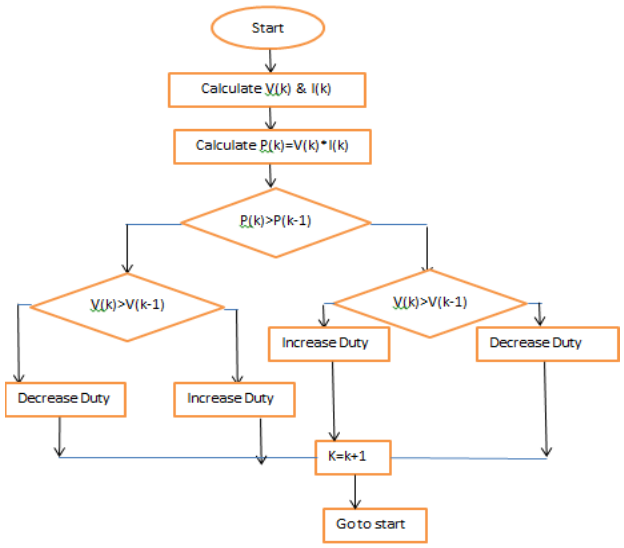

Fig.Flowchart for MPPT

V. MATLAB/SIMULINK MODEL USING MPPT TECHNIQUE:-

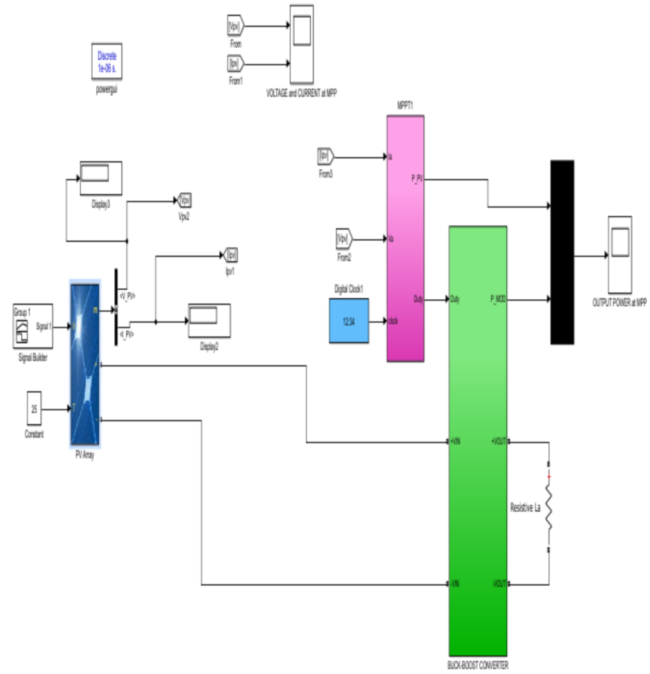

Fig.- MATLAB/SIMULINK Model of PV Module Using P & O Algorithm

VI. SIMULATION RESULT Of PV MODULE USING PERTURB And OBSERVE(P&O) MPPT ALGORITHM:-

A PV array fed buck boost converter duty cycle is generated through P&O algorithm to keep the operating point at peak on p-v curve. The simulation result of output voltage, current and power at different irradiation and different temperature are as shown in figure –

Temperature, T= 56°C

Irradiation= 756 w/m^2 , Time = 12:00 PM noon

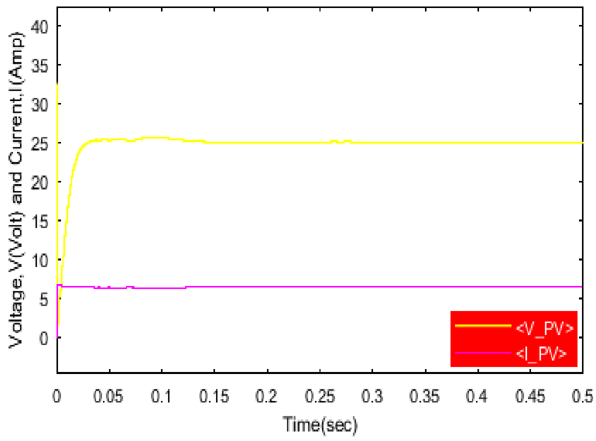

Fig.- Static solar module output voltage,current at MPP Time= 12:00 noon

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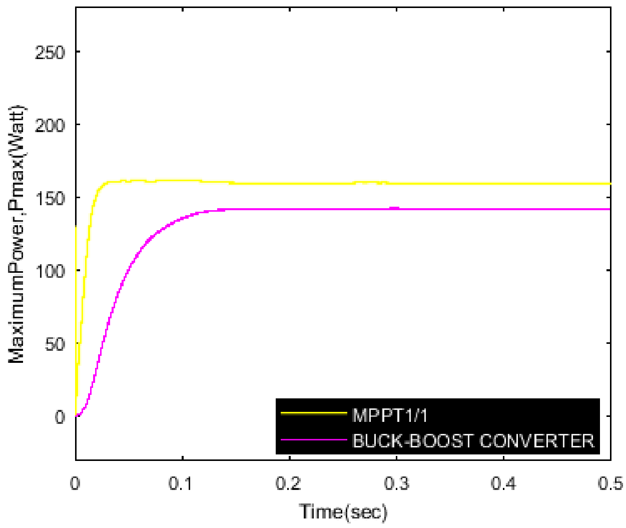

Fig.- Static solar module output power curve at 12 O'clock UsingP&O MPPT

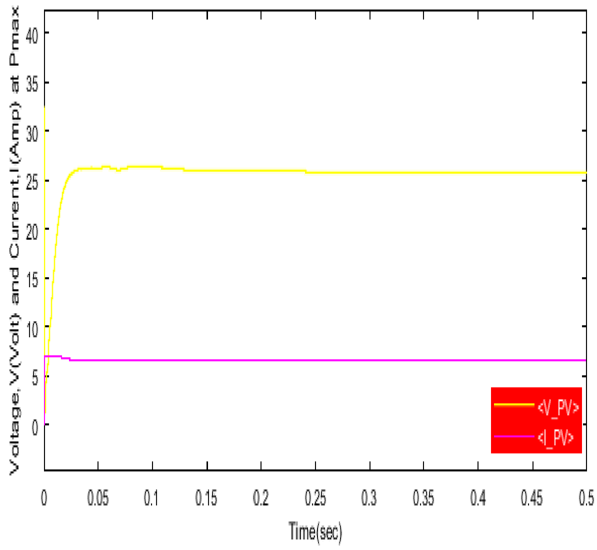

Fig.- Tracking PV Module output Voltage and Current curve at 12 O'clock Using P&O MPPT

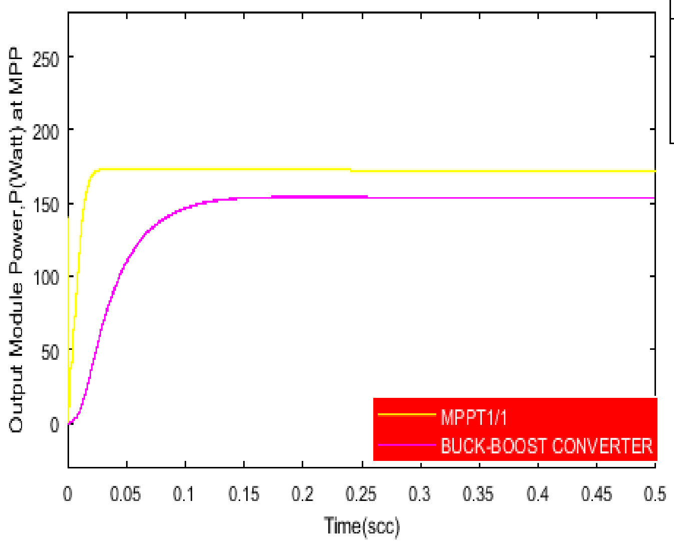

Fig.- Tracking PV Module output Power curve at 12 O'clock UsingP&O MPPT

From the various simulation resullts for different irradiation and different cell temperature it is clearly observed that output power is increased with increase in solar irradiance. Firstly irradiation is taken while panel is in fixed position, and usimg MPPT technique power iss obtained and the same time by tracking mechanism tracking panel irradiation and module temperature is taken in consideration to get a comparative analysis between while panel is in fixed arrangement and while panel is tracking. From the results it is clear that at every time output power of tracking panel was findout more than the static or fixed panel arrangement.

Table 2:- Output of PV Module at 12:00 PM

Status Time = 12 PM	Solar Irradiance falling on PV Module (w/m^2)	Module Temperature (°C)	PV Module Output Power Using MPPT (Watt)	Buck-boost converter Power (Watt)
While Panel was Fixed	756	56	158	138
While Panel Was Tracked	800	57	175	155

Table 3:- Output of PV Module at 5:00 PM

Status Time = 5:00 PM	Solar Irradiance falling on PV Module **(w/m^2)**	Module Temperature (°C)	Output Power Using MPPT **(Watt)**	Buck-boost converter Power **(Watt)**
While Panel was Fixed	393	31	49.5	34
While Panel Was Tracked	477	46	80	60

VII. CONCLUSION

In this paper mppt technique is performed on a mechanical tracking system as well on a fixed solar panel. After getting maximum irradiation by mechanically tracking the pv panel, the model is simulated in matlab/simulink. It have shown that output power of pv panel is increased while panel was set on a mechanical tracker system. The panel was loaded on a mechanical tracking system to get maximum irradiation by keeping the solar panel perpendicular to the irradiation, at each and every moment and it is also shown that with increase in solar irradiance, output power of pv panel is also increased and P&O technique was used to give optimum duty cycle to extract maximum power by maintaining the load line at peak of PV curve.

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