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# Solar Panel Efficiency Calculation using Incremental Conductance Algorithm

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***Abstract*: Solar energy is a vital renewable source of energy in India. To extract and utilize this renewable source of energy photovoltaic solar panels are used. To gather the maximum amount of energy a good efficiency solar panels are used. The maximum efficiency is achieved when the maximum irradiation from the sun is received by the earth. The irradiation and temperature are proportional with time, a solar tracker should be developed and positioned to extract the maximum energy with respect to time. This paper is aimed to find the maximum tracking point and the maximum efficiency using Incremental Conductance (IC) algorithm. The IC method is the simplest and the easiest way to find the efficiency of the panels with respect to the time throughout the day.***

***Keywords: Efficiency, Incremental Conductance, MPPT, PV system.***

## I. INTRODUCTION

One of the promising natural source of energy which offers a replacement to fossil energy is solar energy. India lies near the equator so it receives adequate amount of sunlight throughout the year. The potency of solar energy in India is around 100 GW by 2022. Kamuthi Solar Power Project in Tamil Nadu is the largest single location plant in the world with capacity of 648 MW. PV panels is needed to harvest the solar energy and there are many advantages such as environment friendly and low maintenance cost. The major disadvantage of solar panels is that it needs a high installation cost and the efficiency of the panels is not high (less than 22%). To enhance its efficiency, a PV must always work at maximum power point which is proportional to the temperature and sun's irradiation. The maximum power point tracker consists of solar panel which is interfaced with an electronic circuit and a load. Various researchers have experimented to optimize PV by some methods, for instance: Perturb and Observe( P and O), Fuzzy Logic, Incremental Conductance, Neural Networks and Constant Voltage Controller algorithms. Constant Voltage Controller algorithm is a simple method and is implemented for traffic lights application. Second most widely used tracking algorithm is Perturb and Observe as its implementation is quite simple. One major drawback of these algorithms is that it gives a vague and distorted outputs due to shadow and environmental effects.

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## II. MATERIALS AND METHOD

### A. Incremental Conductance Algorithm

Incremental conductance is dependent on the power versus time or current versus time plot/graph. This incremental conductance method is:

$\frac{\Delta I}{\Delta t}$ = positive then MPPT not achieved

$\frac{\Delta I}{\Delta t}$ = negative Mppt not achieved

$\frac{\Delta I}{\Delta t}$ = zero or constant Mppt achieved

Below is the detailed method of the Incremental Conductance Algorithm in the form of flowchart

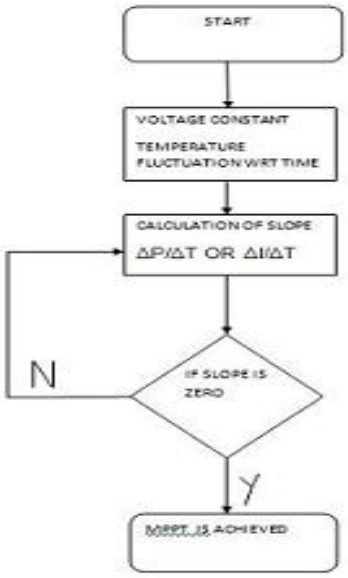


**Fig. 1. Flowchart of Incremental Conductance.**

### B. Block Diagram Of The Proposed System

The solar panel will rotate in both directions azimuthal direction as well as horizontal direction with the help of motor driver. The voltage is constant and the temperature changes with respect to time which is proportional to the current. The PV Panel will move in direction respective to the sun light.

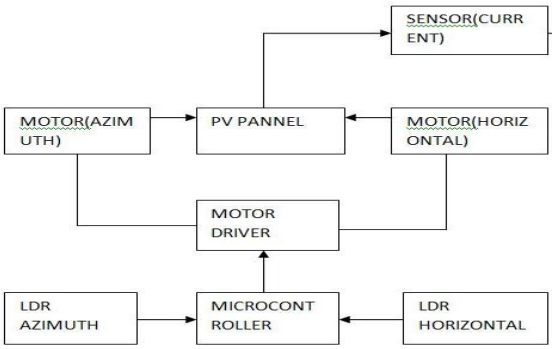


**Fig. 2. Block diagram of MPPT.**

The LDRs are placed in a position that it will help the motors to rotate in azimuthal as well as horizontal direction. The rotation of the motors is proportional to the earth's rotation. Each motor rotates at an angle of 180 degrees. The current received by the panel is monitored by ammeter.

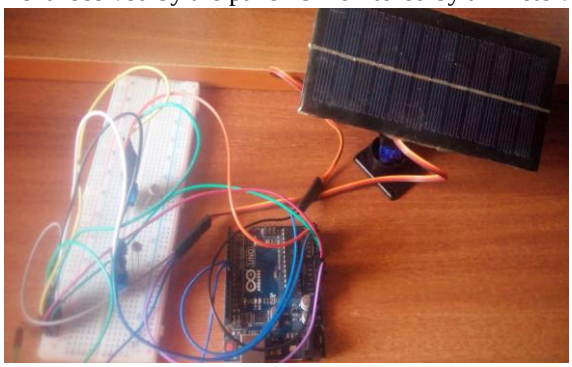

**Fig. 3. Implementation of proposed system.**

### C. Graphical Analysis

A graph between current versus time and power versus time is plotted by using MATLAB software. All the shadow effects and other environmental factors are not taken under consideration. The peak point on the graph states the maximum efficiency is achieved at that period of time. Only one highest maxima is considered as the MPPT point. The below graph has current in Amperes on y axis and time in hours in x axis. The graph increases linearly then at 14 hrs it decreases exponentially. At 14 hrs(2 P.M ) it shows the peak value of the current at that point MPPT is achieved. The similar relationship can be shown with the help of power versus time graph.

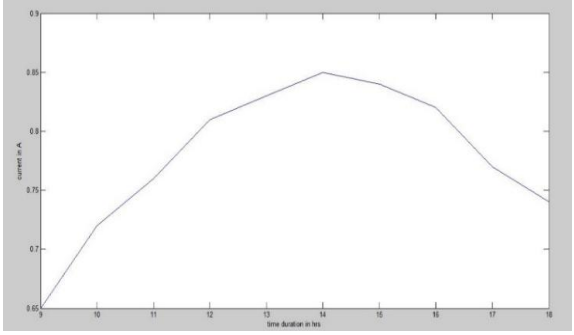

**Fig. 4. Current versus time graph.**

The below graph states power in W/m$^2$ on y axis and time in hours on the x axis. The pattern of the graph is similar to current versus time graph. From this graph we can study that the value of power is maximum at 14 hrs(2 P.M.) at that point MPPT is achieved.

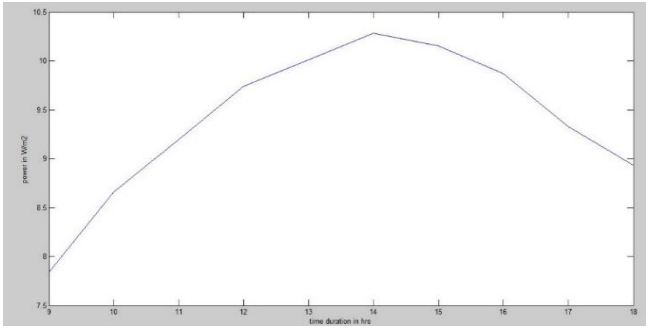

**Fig. 5. Power versus time graph.**

## III. RESULTS AND DISCUSSION

Based on the simulation results it was observed that the power received by the panel is maximum at 2 PM and is easily able to detect the irradiation changes to detect maximum power point (MPP). Earth receives 1000 W/m$^2$ but the area of the panel is 64.64 cm$^2$, respective to that area power received by the panel is different from power received by the earth. The maximum efficiency is 1.85% at 2 PM.

**Table- I: Calculation of efficiency**

| SR.NO | TIME | TEMP (DEGREE C) | POWER INCIDENT (W/m^2) | POWER CONVERTED (W/m^2) | CURRENT (AMPERE) | EFFICIENCY |
|---|---|---|---|---|---|---|
| 1 | 9 A.M | 29 | 1160 | 7.84 | 0.65 | 1.41% |
| 2 | 10 A.M | 32 | 1280 | 8.66 | 0.72 | 1.55% |
| 3 | 11 A.M | 34 | 1360 | 9.20 | 0.76 | 1.65% |
| 4 | 12 P.M | 36 | 1440 | 9.74 | 0.81 | 1.75% |
| 5 | 1 P.M | 37 | 1480 | 10.01 | 0.83 | 1.80% |
| 6 | 2 P.M | 38 | 1520 | 10.28 | 0.85 | 1.85% |
| 7 | 3 P.M | 37.5 | 1500 | 10.15 | 0.84 | 1.82% |
| 8 | 4 P.M | 36.5 | 1460 | 9.87 | 0.82 | 1.77% |
| 9 | 5 P.M | 34.5 | 1380 | 9.33 | 0.77 | 1.67% |
| 10 | 6 P.M | 33 | 1200 | 8.93 | 0.74 | 1.60% |

Based on the practical experimentations it was observed that the power received from the panel fluctuates with respect to time. The area of the panel is 104 cm$^2$ and the panel is of 6V.Below are the practical simulation results the current is calculated by using multimeter.

**Table- II: Practical Simulation Results**

| Time | Current in amperes | Power (W) | efficiency |
|---|---|---|---|
| 11 AM | 0.38 | 2.28 | 0.34% |
| 12 PM | 0.39 | 2.34 | 0.35% |
| 1 PM | 0.48 | 2.88 | 0.43% |
| 2 PM | 0.54 | 3.24 | 0.48% |
| 3 PM | 0.56 | 3.36 | 0.50% |

## IV. CONCLUSION

The simulation result concludes that the Incremental Conductance Method has better performance than the other algorithms like P&O algorithms, fuzzy logic etc. The efficiency is calculated as per that data provided but the major drawback lies in this method that it involves numerous mathematical calculations and the calculation of efficiency is may get altered due to shadow effect as we can get multiple maxima which can create distortions.

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