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PERFORMANCE ANALYSIS OF P&O AND INCREMENTAL CONDUCTANCE ALGORITHM FOR SPVM

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ABSTRACT

A comparative study between frequently used maximum power point tracking (MPPT) algorithm i.e. Perturb and Observe (P&O) and Incremental conductance under rapidly changing insolation condition (RCIC) to extract the maximum power from solar PV module is presented in this paper. Few comparison such as power, current, voltage at different insolation is done. The comparison shows that the IncCond has more tracking accuracy than P&O algorithm. MATLAB Simulink tools have been used for performance evaluation.

Keywords: MPPT, PV Module, P&O, IncCond.

I. INTRODUCTION

Energy has become an important and one of the basic infrastructures required for the economic development of a country. Energy security is imperative for sustained growth of economy. The combustion of fossil fuels in the past has already harmful effects on the delicate balance of nature on our planet. Today, about 20·1012kg of carbon dioxide are put into the atmosphere every year, mainly by burning fossil fuel. Today's plants are unable to absorb this huge amount of extra CO2. As a result the CO2 concentration in the atmosphere continues to mount adding considerably to the greenhouse effect which will increase the global mean surface temperature. The concern for environment, due to excessive use of fossil fuels, has led to a remarkable global effort to harness alternative energy resources.

Renewable energy sources plays an important role in electricity generation. Various renewable energy sources like wind, solar, geothermal, ocean thermal, and biomass can be used for generation of electricity and for meeting our daily energy needs. Energy from the sun is the best option for electricity generation as it is available everywhere and is free to harness. On an average the sunshine hour in India is about 6hrs annually also the sun shine shines in India for about 9 months in a year. Electricity from the sun can be generated through the solar photovoltaic modules (SPV). Photovoltaic systems have generated immense market and research interests recently due to the abundance of raw materials and their noiselessand environment friendly power-generating process [1].

The photovoltaic modules are made up of silicon cells. The silicon solar cells which give output voltage of around 0.7V under open circuit condition. When many such cells are connected in series we get a solar PV module. The SPV comes in various power output to meet the load requirement. The current rating of the modules depends on the area of the individual cells. Higher the cell area high is the current output of the cell. For obtaining higher power output the solar PV modules are connected in series and parallel combinations forming solar PV arrays. Maximization of power from a solar photo voltaic module (SPV) is of special interest as the efficiency of the SPV module is very low. A peak power tracker is used for extracting the maximum power from the SPV module .The present work describes the maximum power point tracker (MPPT) for the SPV module connected to a resistive load.

A number of different MPPT algorithms with varying levels of efficiency, complexity and implementation costs, have been proposed in the literature such as Perturb and observe, Incremental Conductance, Parasitic Capacitance, Voltage Based Peak Power Tracking, Current Based peak power Tracking, Fuzzy logic, Neural network. In high power applications, the cost of MPPT control is dwarfed by the cost of the photovoltaic (PV) array and power converters. However, in low power applications, the implementation cost of an MPPT algorithm must be given serious attention.

The constant voltage method is among one of the easiest and cheapest method to implement and extract maximum power point from the solar panel. As already mentioned panel voltage depends upon the solar radiation intensity and temperature. The VMPP and Voc has a linear relationship which can be given by

$$VMPP = kVoc \qquad (1)$$

Where Voc is the open circuit voltage which is provided by the manufacturer of the solar PV panel. VMPP is the voltage at the maximum power point. The factor k is usually between 0.71 and 0.78, therefore VMPP can be calculated by using above formulae and set as a reference.

The most commonly applied hill-climbing MPPT technique is the P&O algorithm [2]–[5]. The P&O algorithm perturbs the operating point of the PV generator by increasing or decreasing a control parameter by a small amount and measuring the PV array output power before and after the perturbation. If the power increases, the algorithm continues to perturb the system in the same direction; otherwise the system is perturbed in the opposite direction [6].Another very popular hill-climbing MPPT algorithm is the incremental conductance (INC) algorithm [7]–[13]. This MPPT algorithm is based on the fact that the power–voltage curve of a PV generator at constant solar irradiance and cell temperature levels has normally only one MP. At this MPP point, the derivative of the power with respect to the voltage equals zero which means that the sum of the instantaneous conductance and the incremental conductance equals zero[6].In this paper a PV array is modelled in Matlab /Simulink environment and its peak power is tracked using Incremental Conductance (INC) technique and Perturb and Observe algorithm. We have also studied the different materials of solar cell.

1.1 PV cell

Solar cell is basically a p-n junction fabricated in a thin wafer or layer of semiconductor. PV cells are made of semiconductor materials, such as silicon. When light energy strikes the solar cell, electrons are knocked loose from the atoms in the semiconductor material. If electrical conductors are attached to the positive and negative sides, forming an electrical circuit, the electrons can be captured in the form of an electric current that is,

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electricity. This electricity can then be used to power a load. A typical PV cell produces less than 2W at 0.5V approximately.

Table I: Comparison of semiconductor materials used in PV cell

Material	Efficiency(%)	(V)	J_{SC} (mA	FF(%)
Si(crystalline)	25.0 0.5	0.706	42.7	82.8
Si(multicrystalline)	20.4 0.5	0.664	38.0	80.9
GaAs(thinfilm)	27.6 0.8	1.107	29.6	84.1
CdTe(cell)	16.7 0.5	0.845	26.1	75.5
CIGS(Cell)	19.6 0.6	0.713	34.8	79.2

II. PV ARRAY SIMULINK MODEL

A PV array is a group of several PV modules which are electrically connected in series and parallel circuits to generate the required current and voltage.

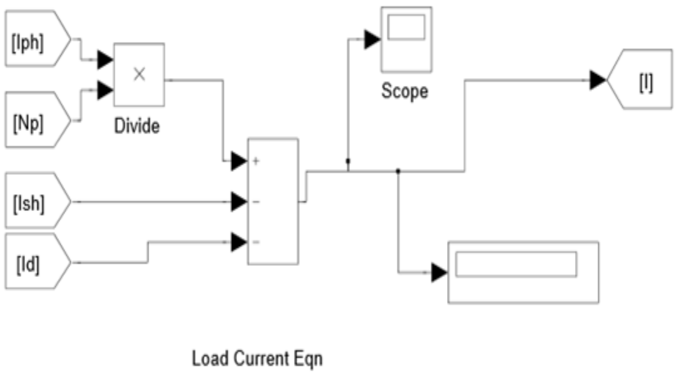

Figure 1: Simulink model for load current equation.

The terminal equation for the current and voltage of the array is given by:-

$$I = N_P I_{PH} - N_P I_S \left[e^{\frac{\frac{q\left(\frac{V}{N_S}+IR_S\right)}{N_P}}{KT_C A}} - 1 \right] - \qquad (2)$$

The photocurrent mainly depends on solar insolation and cell's working temperature, which is described as:

$$I_{PH} = [I_{SC} + K_I(\qquad (3)$$

Where,

$$I_{Sc} = I_{RS} \left(\frac{T_C}{T_{ref}}\right)^3 \exp\left[\frac{qE_C}{} \right. \qquad (4)$$

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The output characteristics of PV array are nonlinear and greatly affected by solar radiation, temperature and load condition [14]. Its power changes non-linearly with respect to the voltage and current. Hence there is only one voltage and current at which Maximum Power Point (MPP) exists for certain climate conditions [15].

III. PHOTOVOLTAIC SYSTEM ANDMPPT ALGORITHMS

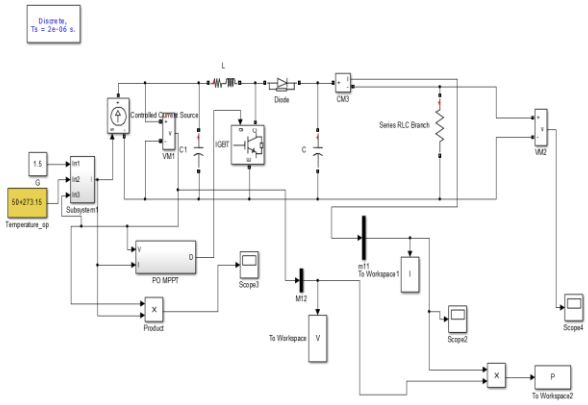

Figure 2: Simulink model of PV system with IncCond algorithm.

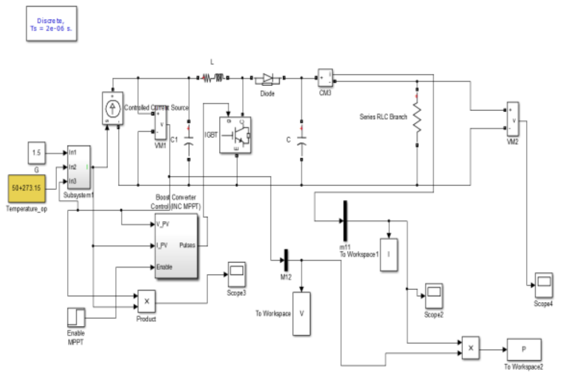

Figure 3: Simulink model of PV system with IncCond algorithm.

Figure 2, is a Simulink model PV system which comprises (1) PV module, (2) Converter, and (3) MPPT unit. At any instant in time the system feeds V*PV* and IPVto the MPPT algorithm to track the reference voltage corresponding to MPP. This is followed by the generation of an appropriate duty cycle using load matching. By varying D (duty cycle) output voltage can be changed and it is always more than input voltage. A MPPT is used to harvest the maximum power from the solar PV module and transferring that power to the load [16].

3.1 P&O Algorithm

In this algorithm, operating voltage of the PV module is perturbed and resulting change in power is observed. Let I(k),V(k) be the output current and the output voltage of the PV module at instant then the output power is given by:

P(k)=I(k)*V(k) (5)

The incremental output power at instant k+1 is given by:

=P(k+1)-P(k) (6)

The reference voltage corresponding to MPP at any instant in time is calculated based on the sign of according to the following expression:

$V_{ref}(k+1)$ [Sgn *C] (7)

Where C is the step size and sgn() is defined as:

sgn (x) =

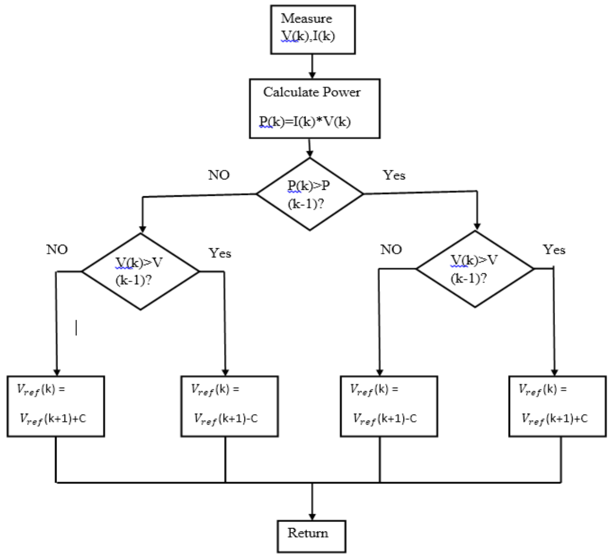

Figure 4: Flowchart of Perturb and observe (P&O).

3.2 IncCond Algorithm

The inability of P&O algorithm to accurately track the MPP under RCIC has led researchers to propose the

IncCondalgorithm [17].This algorithm makes use of the equation

P=V*I(8)

(Where P= module power, V=module voltage, I=module current);

diff with respect to dV

dP/dV=I+V*dI/dV (9)

Depending on this equation the algorithm works. At peak power point

dP/dV=0 (10)dI/dV=-I/V(11)

If the operating point is to the right of the Power curve then we have

dP/dV<0 (12)

dI/dV<I/V (13)

If operating point is to the left of the power curve then we have

dP/dV>0 (14)

dI/dV>I/V (15)

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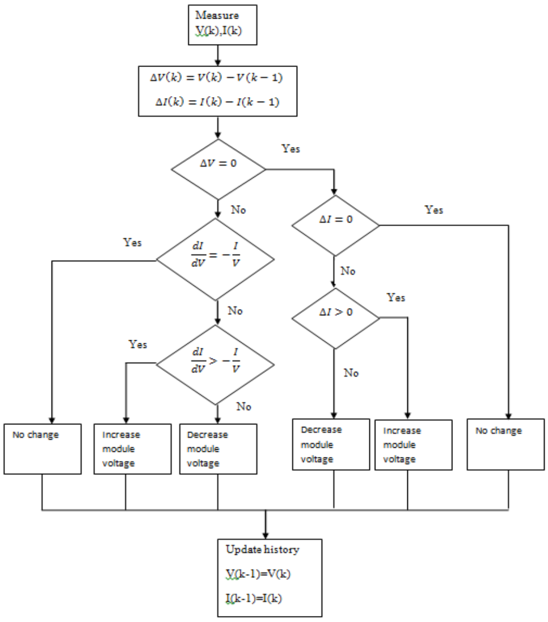

Figure 5: Flowchart of Incremental conductance.

IV. RESULTS

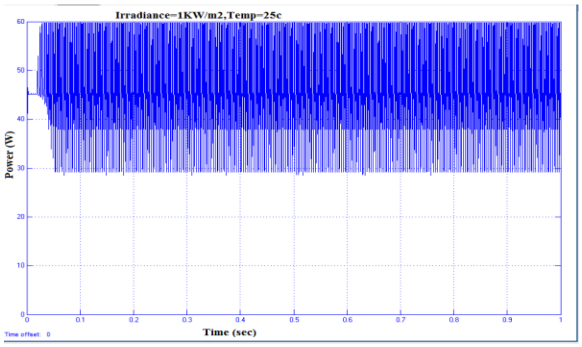

Figure 6: Output Power at Irradiance 1KW/m2 and Temp=25 ^{o}C with P&O MPPT algorithm.

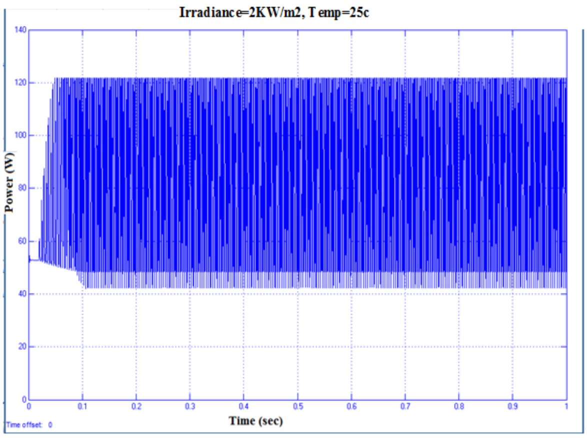

Figure 7: Output Power at Irradiance 2KW/m2 and Temp=25 ^{o}C with P&O MPPT algorithm.

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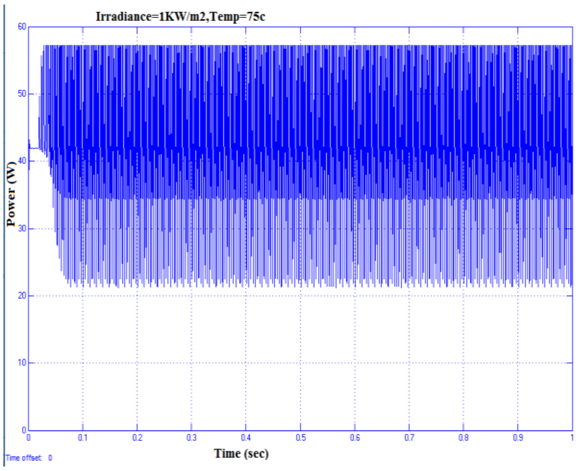

Figure 8: Output Power at Irradiance 1KW/m2 and Temp=75 °C with P&O MPPT algorithm.

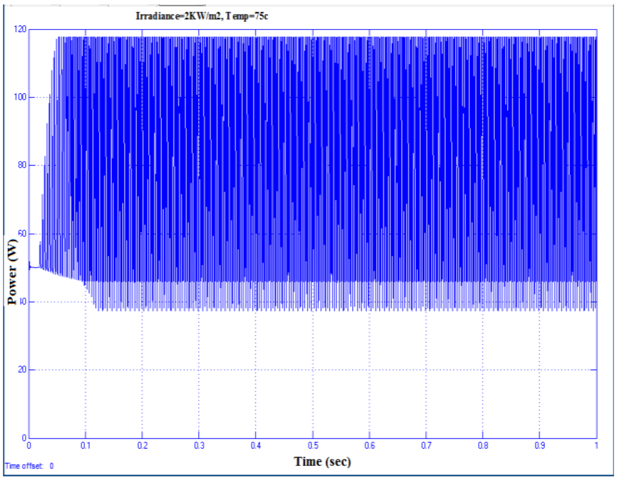

Figure 9: Output Power at Irradiance 2KW/m2 and Temp=75 °C with P&O MPPT algorithm.

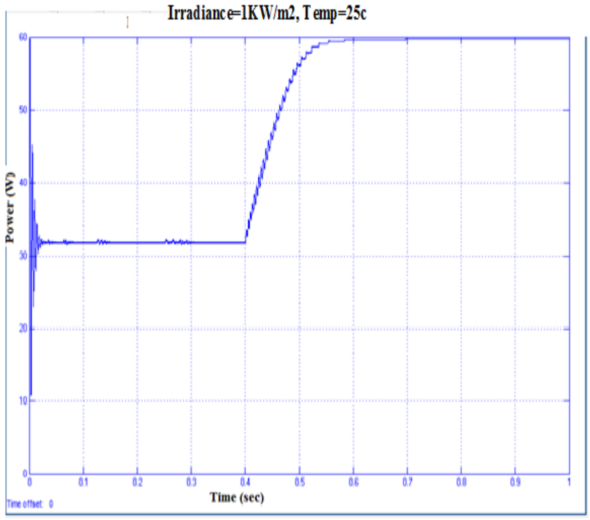

Figure 10: Output Power at Irradiance 1KW/m2 and Temp=25 oC with IncCond MPPT algorithm

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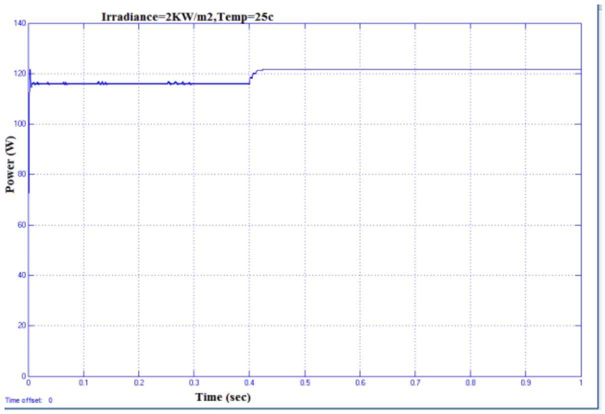

Figure 11: Output Power at Irradiance 2KW/m2 and Temp=25 ^{o}C with IncCond MPPT algorithm

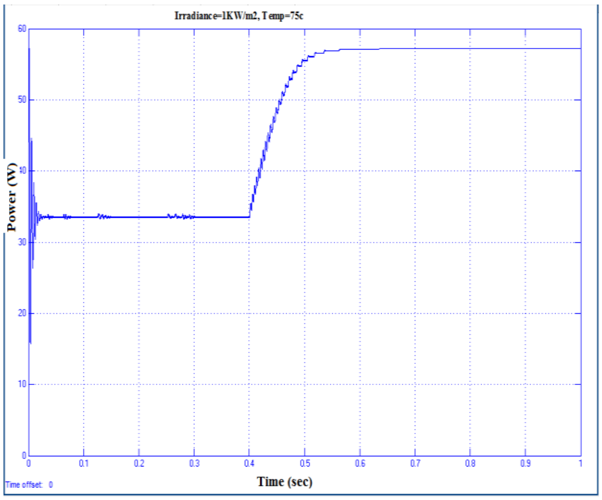

Figure 12: Output Power at Irradiance 1KW/m2 and Temp=75 ^{o}C with IncCond MPPT algorithm

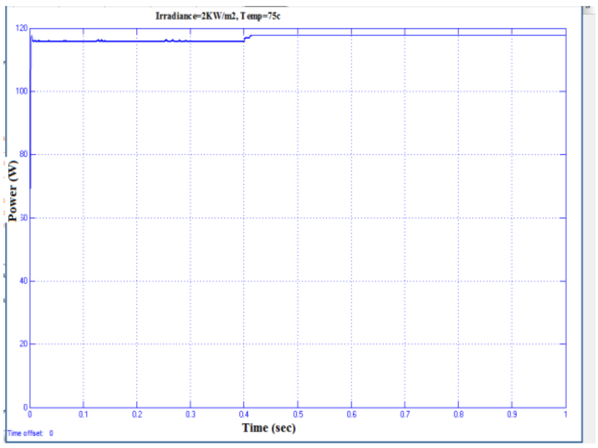

Figure 13: Output Power at Irradiance 2KW/m2 and Temp=75 ^{o}C with IncCond MPPT algorithm

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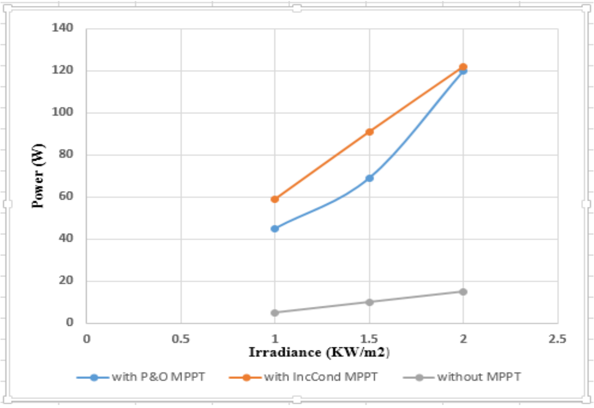

Figure 14: Output Power at constant Temperature 25 ^{o}C and variable irradiance.

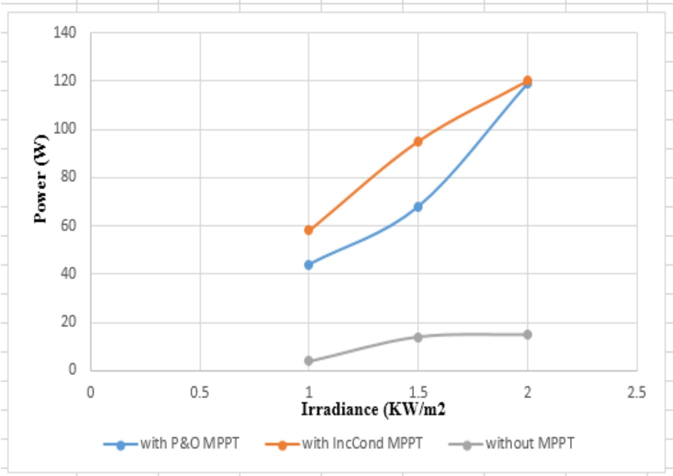

Figure 15: Output Power at constant Temperature 50 ^{o}C and variable irradiance

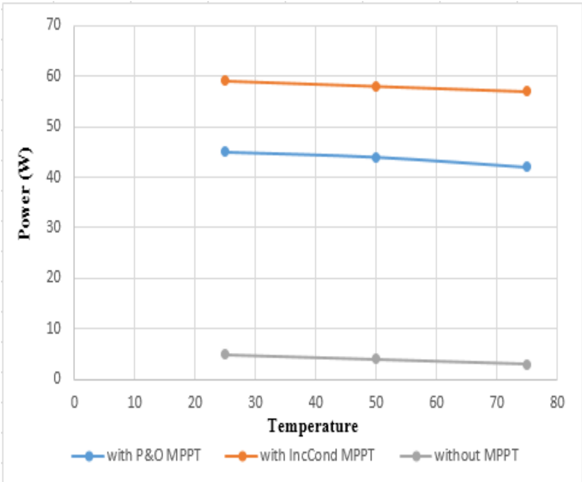

Figure 16: Output Power at constant Irradiance 1KW/m2 and variable temperature.

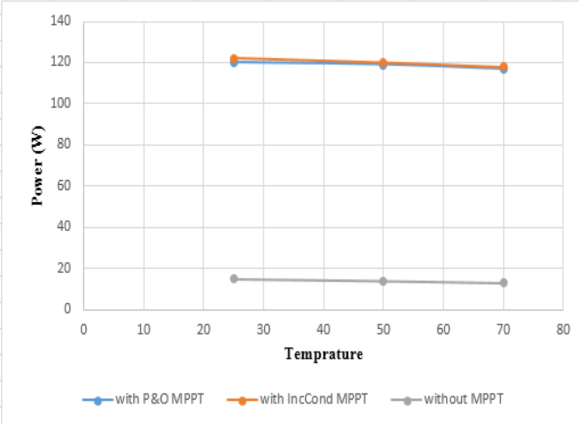

Figure 17: Output Power at constant Irradiance 2KW/m2 and variable temperature.

V. CONCLUSION

In this paper we have compare the performance of two MPPT algorithm i.e. P&O and IncCond algorithm. The IncCond shows better results than the P&O,the P&o produces more fluctuations in the results.From above results it is also clear that with increase in irradiance the output power increases and with increase in temperature the output power decreases.

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