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Energy Comparison of MPPT Techniques Using Cuk Converter

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Abstract--In this paper the energy comparison of two MPPT, P&O and Incremental conductance is done using cuk convertor. For comparison such as voltage, current and power output for each different combination has been recorded. MATLAB simulink tools have been used for performance evaluation on energy point.

Key words--Maximum power point tracking MPPT, photovoltaic cell PV, P&O, incremental conductance IC, CUK convertor

I.INTRODUCTION

Photovoltaic (PV) generation is becoming increasingly important as a renewable source since it offers many advantage such as incurring no fuel cost, not being polluted, requiring little maintenance, and emitting no noise among others.[1] PV module still have relatively low conversion efficiency, therefore, controlling maximum power point tracking (MPPT) for the solar array is essential in a PV system. The optimum operating changes with solar radiation and cell temperature. In general, there is a unique point on V-I or V-P characteristic curve, called maximum power point (MPP) at which entire PV system operates with maximum efficiency and produces its maximum power output.[2] Therefore Maximum Power Point Tracking (MPPT) techniques are needed to maintain the PV array operating point at its MPP.A variety of maximum power point tracking (MPPT) are developed. These techniques vary between then in many aspects including simplicity, convergence, speed, hardware maintenance, sensor required, cost range effectiveness. Perterb and observance[3] and increamental conductance technique[4] using cuk convertor with resistive load is studied in this paper.

II.PV EQUIVALENT CIRCUIT

Solar cells are connected in series and parallel to set up the solar array. Solar cell will produce dc voltage when it is exposed to sunlight. Fig.1 shows the equivalent circuit model for a solar cell. Solar cell can be regarded as a non-linear current source.[5] Its generated current depends on the characteristic of material, age of solar cell, irradiation and cell temperature.

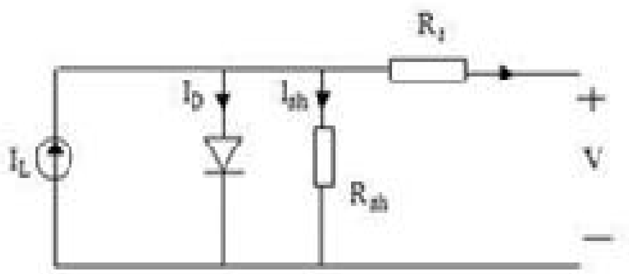


Fig.1:-Equivalent circuit model for a solar cell

III. CUK CONVERTER

When proposing an MPP tracker, the major job is to choose and design a highly efficient converter, which is supposed to operate as the main part of the MPPT. The efficiency of switch-mode dc–dc converters is widely discussed in [7]. Most switching-mode power supplies are well designed to function with high efficiency. Among all the topologies available, both Cuk and buck–boost converters provide the opportunity to have either higher or lower output voltage compared with the input voltage. Although the buck–boost configuration is cheaper than the Cuk one, some disadvantages, such as discontinuous input current, high peak currents in power components, and poor transient response,make it less efficient.On the other hand the Cuk convertor has low switching losses and the hieghest efficiency amond non isolated dc-dc convertor. It can also provide a better output-current characteristic due to the inductor on the output stage. Thus, the Cuk configuration is a proper converter to be employed in designing the MPPT. Figs. 2 and 3 show a Cuk converter and its operating modes, which is used as the power stage interface between the PV module and the load. The Cuk converter has two modes of operation. The first mode of operation is when the switch is closed (ON), and it is conducting as a short circuit. In this mode, the capacitor releases energy to the output. The equations for the switch conduction mode are as follows:

$v_{L1} = Vg$ (1)

$vL_2 = -v1 - v_2$ (2)

$ic_1 = i_2$ (3)

$ic_2 = i_2 - _{v2/R}$ (4)

make it less efficient. On the other hand, the Cuk converter has low switching losses and the highest efficiency among non isolated dc–dc converters.

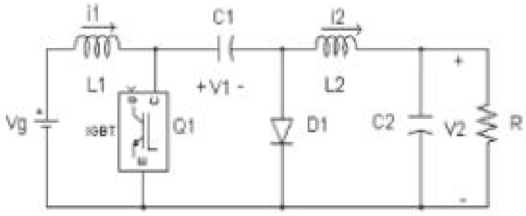


Fig. 2 Electrical circuit of the Cuk converter used as the PV power-stage interface

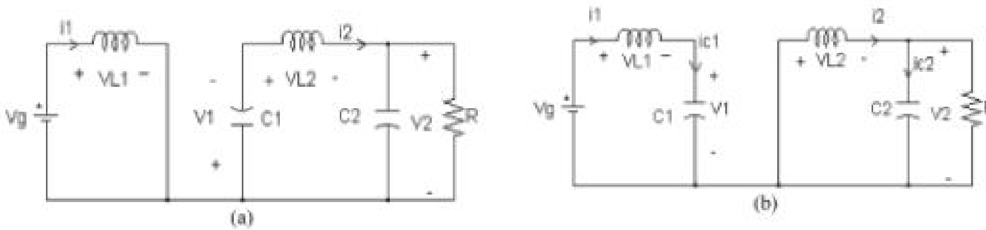


Fig.3.Cuk converters with (a) switch ON and (b) switch OFF

On the second operating mode when the switch is open (OFF), the diode is forward-biased and conducting energy to the output. Capacitor C1 is charging from the input. The equations for this mode of operation are as follows:

$v_{L1} = Vg - v_1$ (5)

$v_{L2} = -v_2$ (6)

$ic_1 = i_1$ (7)

$ic_2 = i_2 - _{v2/R}$ (8)

The principles of Cuk converter operating conditions state that the average values of the periodic inductor voltage and capacitor current waveforms are zero when the converter operates in steady state. The relations between output and input currents and voltages are given in the following:

$VO/Vin = -(D/1-)$ (9)

$Iin/Io = -(/1-D)$ (10)

IV.PERTURB AND OBSERVE (P&O)

In this algorithm a slight perturbation is introduce system [8]. This perturbation causes the power of the solar module changes. If the power increases due to the perturbation then the perturbation is continued in that direction [8]. After the peak power is reached the power at the next instant decreases and hence after that the perturbation reverses. When the steady state is reached the algorithm oscillates around the peak point. In order to keep the power variation small the perturbation size is kept very small. A PI controller then acts moving the operating point of the module to that particular voltage level. It is observed that there some power loss due to this perturbation also the fails to track the power under fast varying atmospheric conditions. But still this algorithm is very popular and simple.

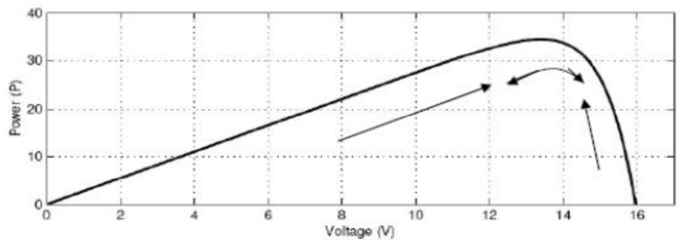


Fig. 4: Graph Power versus Voltage for Perturb and Observe Algorithm [3]

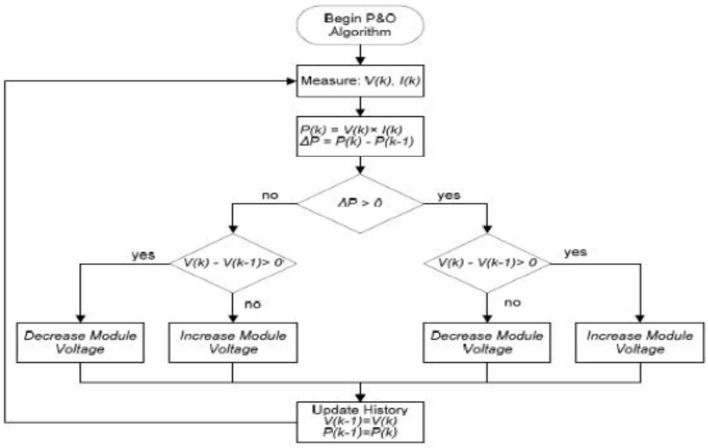


Fig. 5: Flow chart of the Perturb and Observe Algorithm [3]

V.INCREAMENTAL CONDUCTANCE (IC)

The disadvantage of the perturb and observe method to track the peak power under fast varying atmospheric condition is overcome by IC method [3].

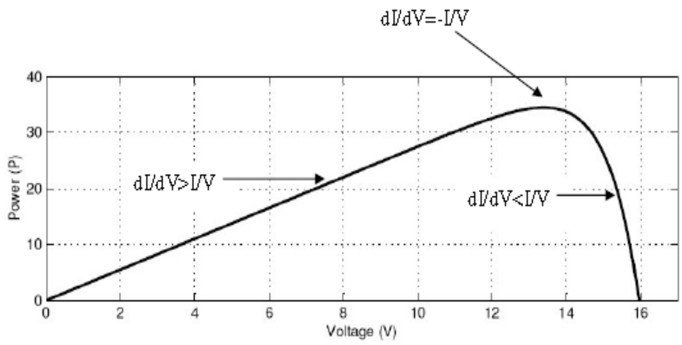


Fig.6: Graph Power versus Voltage for IC algorithm

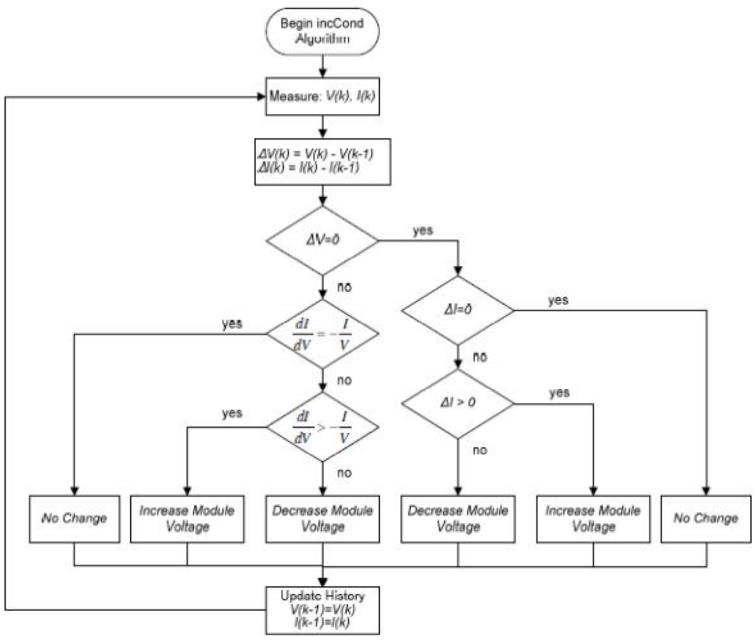


Fig 7 :-Flow chart of incremental conductance method

The IC can determine that the MPPT has reached the MPP and stop perturbing the operating point. If this condition is not met, the direction in which the MPPT operating point must be perturbed can be calculated using the relationship between dl/dV and –I/V [9 This relationship is derived from the fact that dP/dV is negative when the MPPT is to the right of the MPP and positive when it is to the left of the MPP. This algorithm has advantages over P&O in that it can determine when the MPPT has reached the MPP, where P&O oscillates around the MPP. Also, incremental conductance can track rapidly increasing and decreasing irradiance conditions with higher accuracy than perturb and observe [3]. One disadvantage of this algorithm is the increased complexity when compared to P&O [3].

VI. GRAPHICAL ENVIRONMENT MATLAB SIMULINK ENVIRONMENT

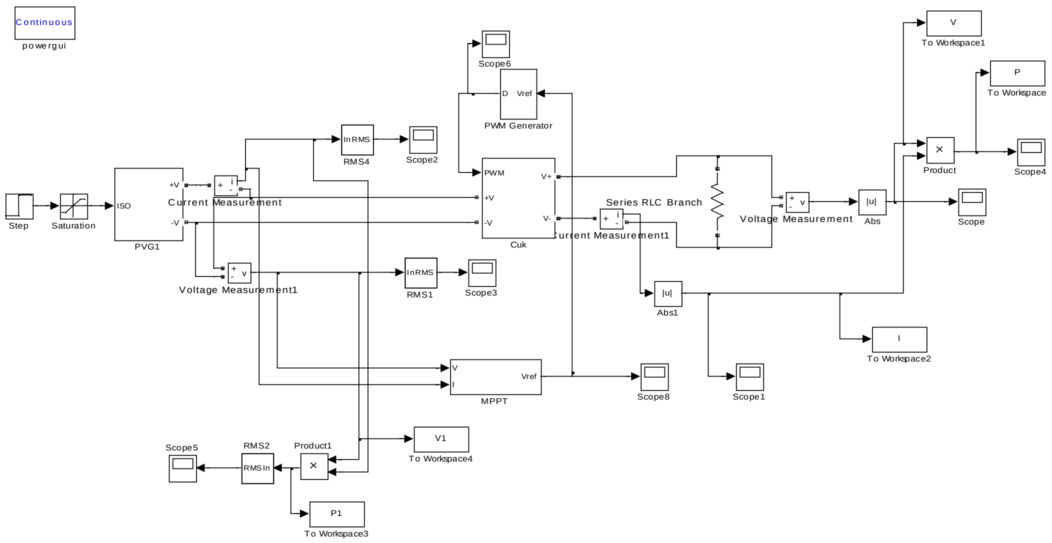


Fig 8:- Simulink model of Incremental conductance MPPT with resistive load.

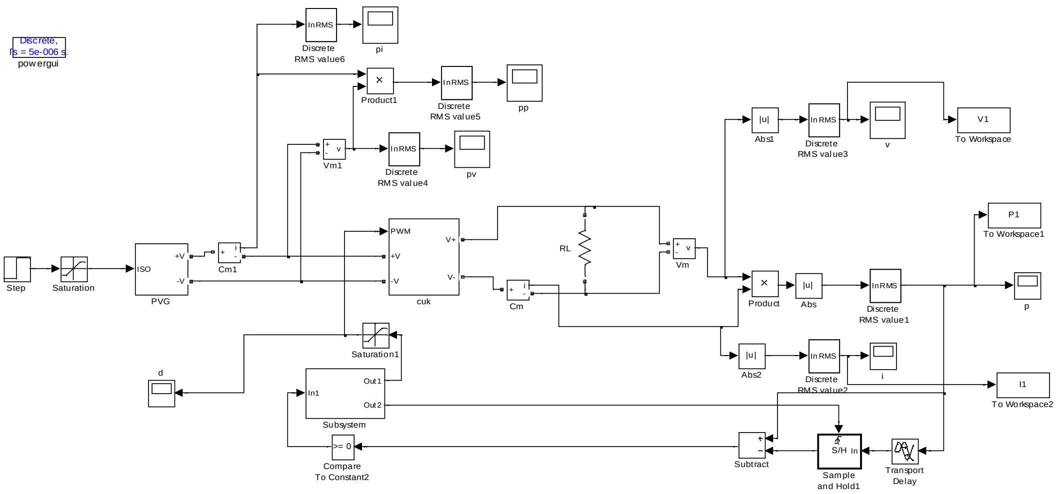


Fig 9:- Simulink model of PO MPPT with resistive load

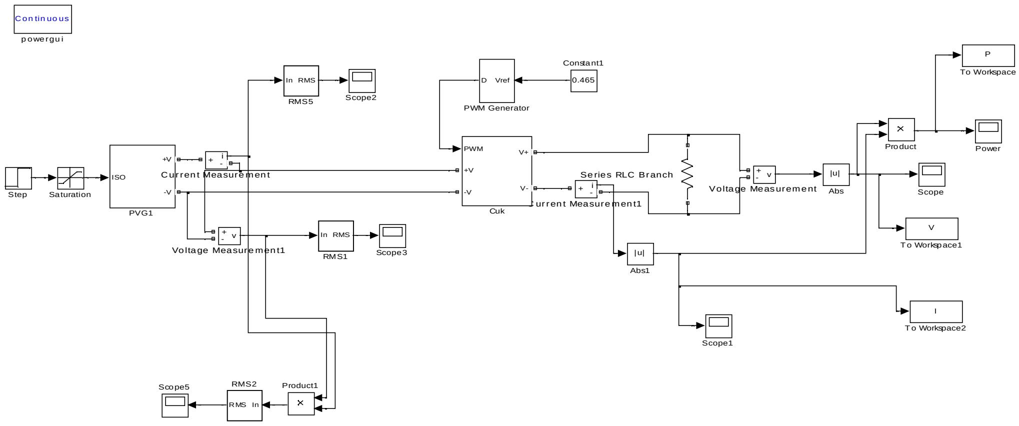


Fig 10:- Simulink model of with ought IC and P&O MPPT with resistive load

VII. RESULT

Result of comparison of o/p current, voltage and power with and without Perturb and observe method and Incremental conductance method is shown in figure below

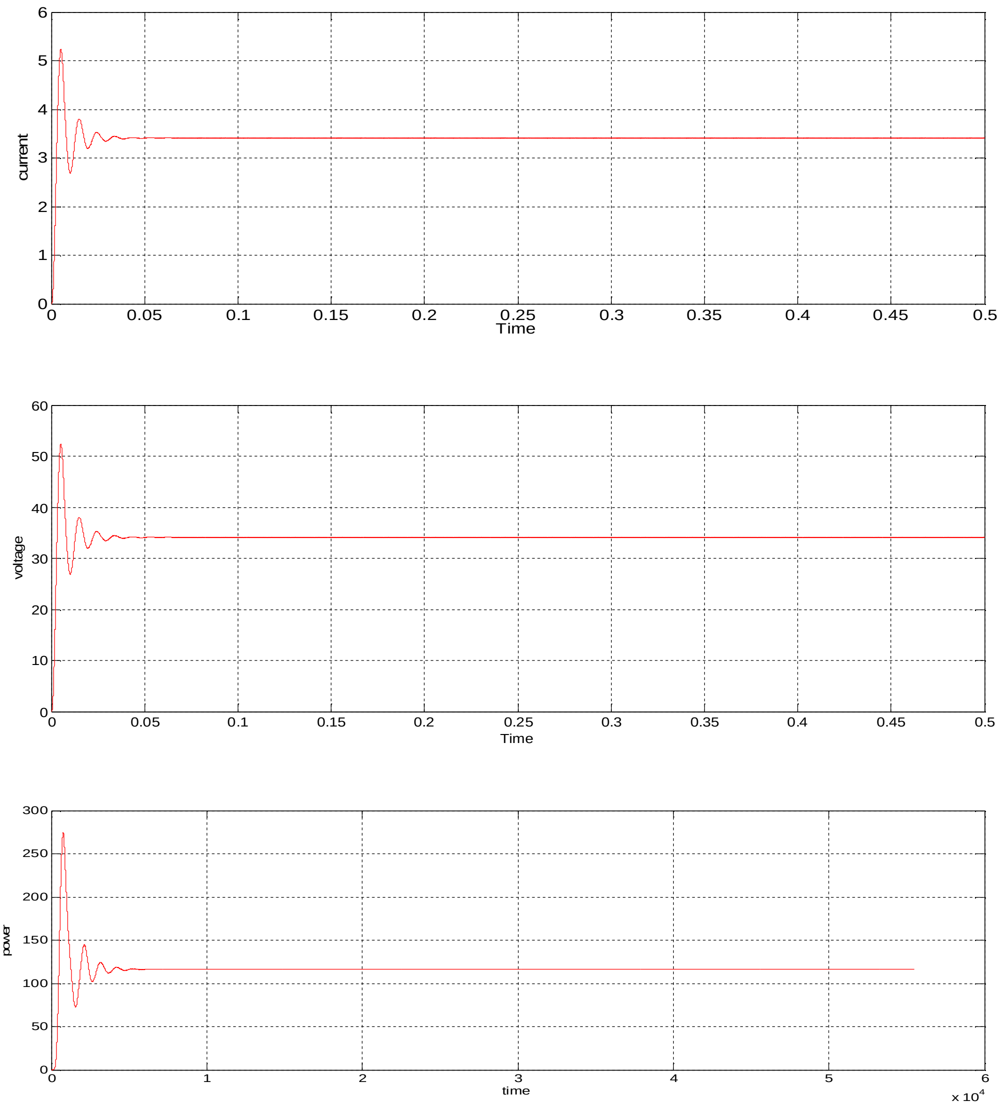


Fig. 11**.** Comparison diagram of o/p current, voltage & power without P&O and Incremental conductance method

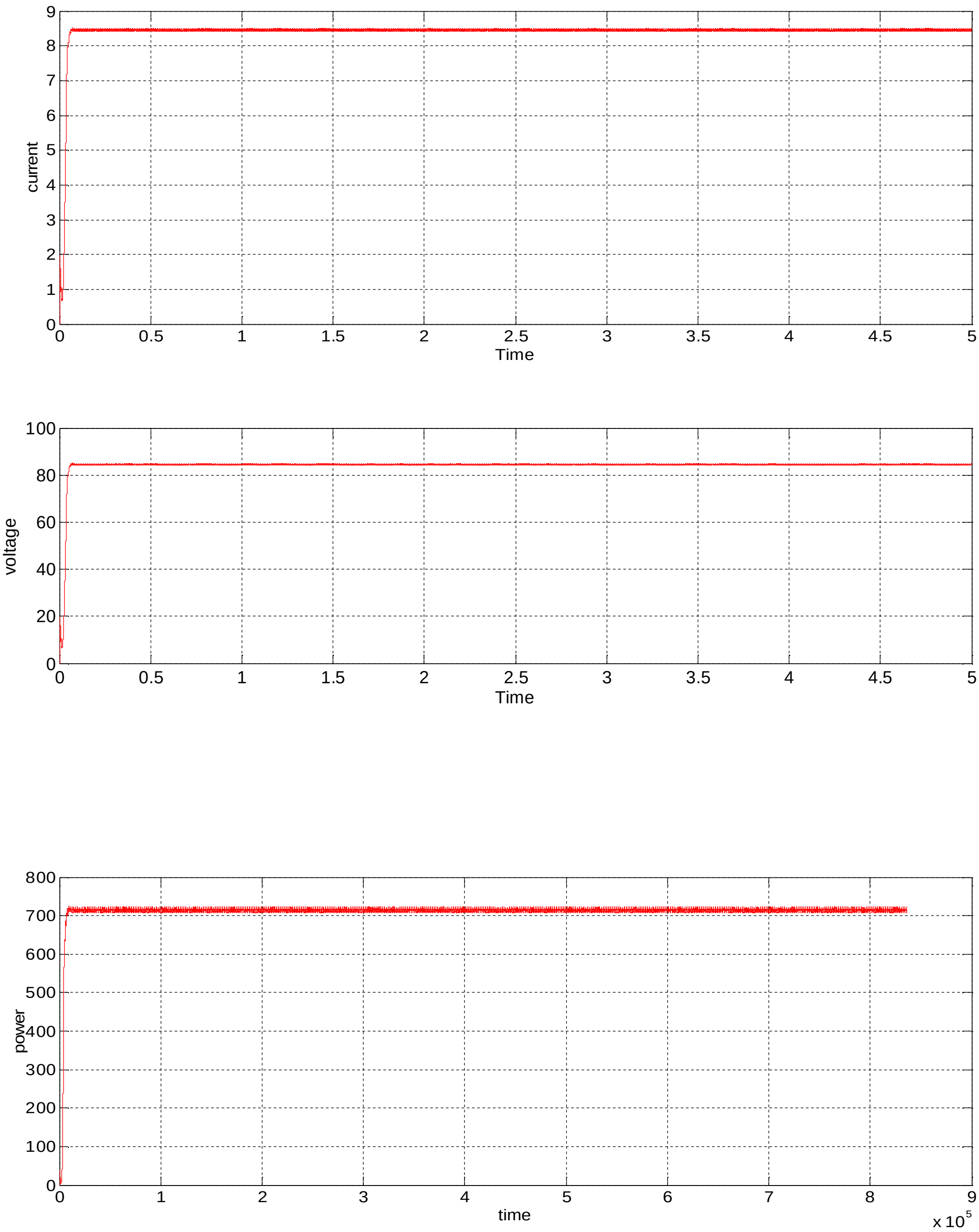
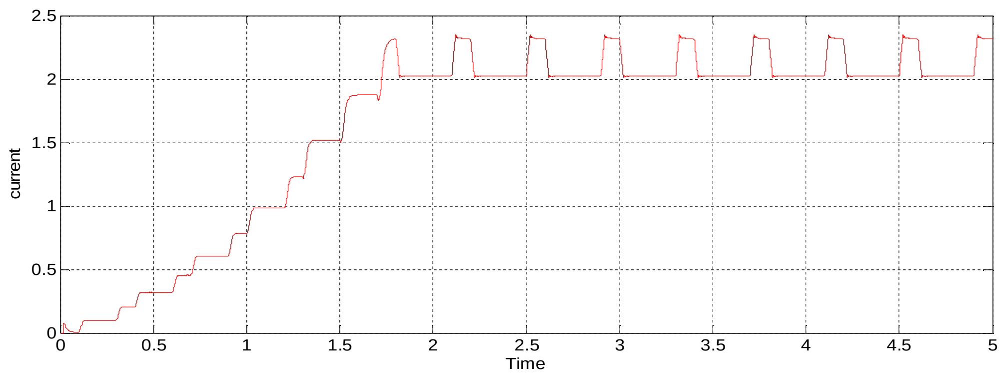


Fig. 12. Comparison diagram of o/p current, voltage & power with Incremental conductance method



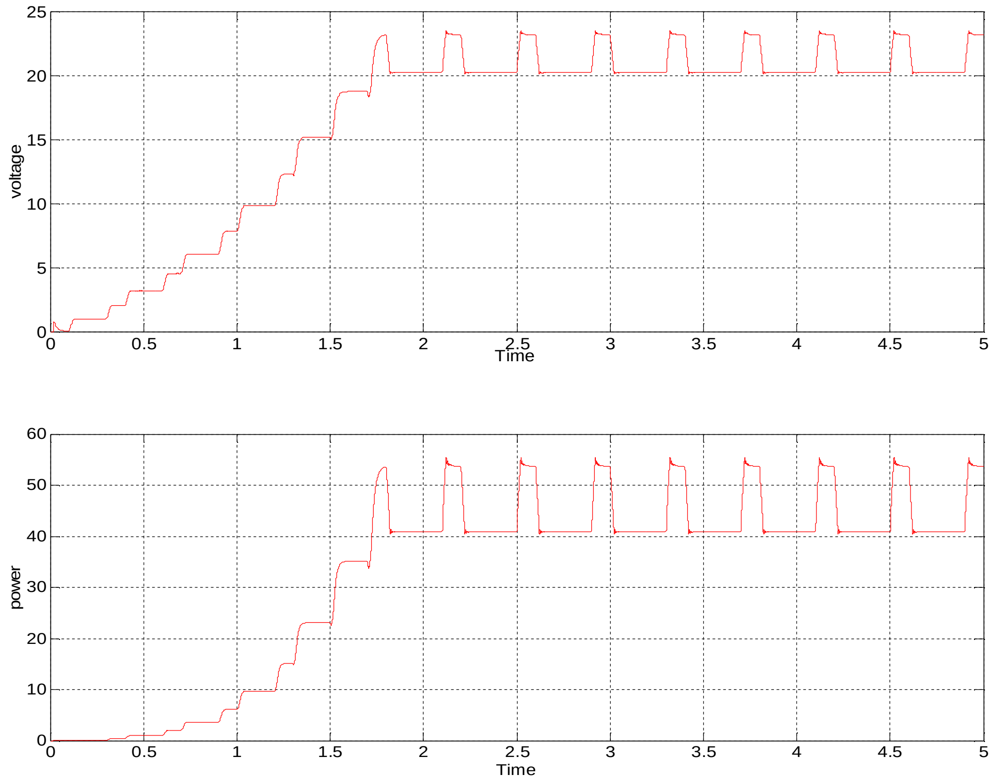


Fig. 14:- Comparison diagram of o/p current, voltage & power with perturb & observe method

VIII. CONCLUSION

This paper has presented a comparison of two most popular MPPT controller, Perturb and Observe Controller with Incremental Conductance Controller. One simple solar panel that has standard value of insolation and temperature has been included in the simulation circuit. From all the cases, the best controller for MPPT is incremental conductance controller. This controller gives a better output value for cuk converter.

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