Modelling And Performance Analysis Of PV Panel Using Incremental Conductance Maximum Power Point Tracking

M. Manikanda prabhu*, Dr. A. Manivannan**

*(Department of Energy Engineering, Regional Centre, Anna University Tirunelveli Region, Tirunelveli - 07.

** (Assistant Professor, Department of Energy Engineering, Regional Centre, Anna University Tirunelveli Region, Tirunelveli – 07).

Abstract--- **Photovoltaic (PV) energy is the most important energy resource since it is clean, pollution free, and inexhaustible. Maximum power point tracking (MPPT) is used in photovoltaic (PV) systems to maximize the photovoltaic array output power, irrespective of the temperature and radiation conditions and of the load electrical characteristics the PV array output power is used to directly control the dc/dc converter, thus reducing the complexity of the system. This project is proposed to find the MPPT in solar PV panel using incremental conductance algorithm. CUK converter is used to achieve the power. It is simulated by the MATLAB simulink to track the maximum output power. Achieved maximum power is given as the input to the wind turbine. After attaining synchronous speed input power to the turbine is stopped and the achieved output power is given to the grid. In this output is compared with the input of the MPPT. There is a increase in efficiency of about 44%. Several characteristics of the PV panel were discussed here to know the increase in percentage of efficiency. MPPT power is finally send to the operation of wind turbine and their speed has also been calculated.**

Keywords --- Photovoltaic System, Modelling of PV Arrays, Incremental conductance Algorithm, CUK Converter and Simulation Results.

I.INTRODUCTION

Renewable sources of energy acquire growing importance due to its enormous consumption and exhaustion of fossil fuel. Also, solar energy is the most readily available source of energy and it is free. Moreover, solar energy is the best among all the renewable energy sources since, it is non-polluting. Energy supplied by the sun in one hour is equal to the amount of energy required by the human in one year. Photo voltaic arrays are used in many applications such as water pumping, street lighting in rural town, battery charging and grid connected PV systems. As known from a Power-Voltage curve of a solar panel, there is an optimum operating point such that the PV delivers the maximum possible power to the load. The optimum operating point changes with solar irradiation and cell temperature. This paper deals with Incremental conductance MPPT algorithm method due to its simple approach [1]. Regarding the endless aspect of solar energy, it is worth saying that solar energy is a unique prospective solution for energy crisis. However, despite all the fore mentioned advantages of solar power systems, they do not present desirable efficiency. In addressing the poor efficiency of PV systems, some methods are proposed, among which is a new concept called "maximum power point tracking"(MPPT). In this paper incremental

conductance with CUK converter is used for maximum power point tracking [11][14].

II. DIRECT CONTROLLING METHOD

Conventional MPPT systems have two independent control loops to control the MPPT. The first control loop contains the MPPT algorithm, and the second one is usually a proportional (P) or P–integral (PI) controller. The IncCond method makes use of instantaneous and IncCond to generate an error signal, which is zero at the MPP; however, it is not zero at most of the operating points. The main purpose of the second control loop is to make the error from MPPs near to zero. Simplicity of operation, ease of design, inexpensive maintenance, and low cost made PI controllers very popular in most linear systems [11].

However, the MPPT system of standalone PV is a nonlinear control problem due to the nonlinearity nature of PV and unpredictable environmental conditions, and hence, PI controllers do not generally work well. In this paper, the IncCond method with direct control is selected. The PI control loop is eliminated, and the duty cycle is adjusted directly in the algorithm. The control loop is simplified, and the computational time for tuning controller gains is eliminated. To compensate the lack of PI controller in the proposed system, a small marginal error of 0.002 was allowed.

The objective of this paper is to eliminate the second control loop and to show that sophisticated MPPT methods do not necessarily obtain the best results, but employing them in a simple manner for complicated electronic subjects is considered necessary [3]. The feasibility of the proposed system is investigated with a dc–dc converter configured as the MPPT. In, it was mentioned that the power extracted from PV modules with analog circuitry can only operate at the MPP in a predefined illumination level.

III.SELECTION OF CONVERTER

A DC-to-DC converter is an electronic circuit which converts a source of direct current from one voltage level to another. It is a class of power converter. Electronic switch-mode DC to DC converters operate by storing the input energy temporarily and then releasing that energy to the output at a different voltage and current.

Just like a transformer, they essentially just change the input energy into a different impedance level. So whatever the output voltage level, the output power all comes from the input; there's no energy manufactured inside the converter. In fact some energy is used by the converter circuitry and components while doing their job. It is this principle that makes a DC-DC Converter essential for MPPT. The converter presents an electrical load to the solar panel that varies as the output voltage of the converter varies. This load variation in turn causes a change in the operating point (current and voltage characteristics) of the panel. Thus by intelligently controlling the operation of the DC-DC converter, the power output of the panel can be intelligently controlled and made to output the maximum possible [11].

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. 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 converter has low switching losses and the highest efficiency among non isolated dc–dc converters [11][14].

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. 1 and 2 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:

$$v_{L1} = V_g$$

$$v_{L2} = -v_1 - v_2$$

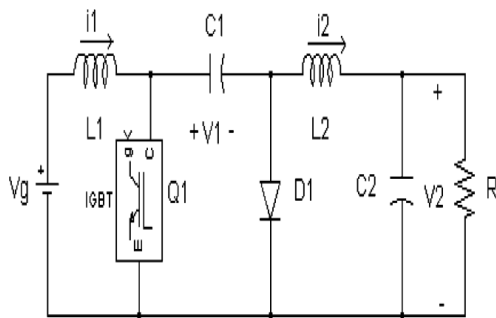$$i_{c1} = i_2$$

$$i_{c2} = i_2 - v_2/R$$

Fig-1: Electrical circuit of the CUK converter used as the PV power-stage interface [3]
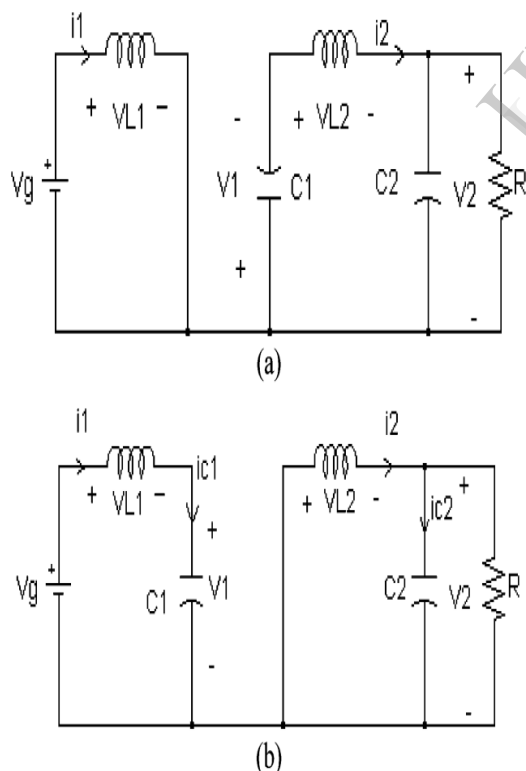

(a)

(b)

Fig-2: Cuk converter with (a) switch ON and (b) switch OFF [3]

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:

$$v_{L1} = V_g - v_1$$

$$v_{L2} = -v_2$$

$$i_{c1} = i_1$$

$$i_{c2} = i_2 - v_2/R$$

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. Some analyses of CUK converter specifications are provided in , and a comparative study on different schemes of switching converters is presented in the literature The components for the CUK converter used in simulation was selected as follows:

1) Input inductor L1 = 5 mH;

2) Capacitor C1 (PV side) = 47 μf;

3) Filter inductor L2 = 5 mH;

4) Switch: insulated-gate bipolar transistor [(IGBT)—IRG4PH50U];

5) Freewheeling diode: RHRG30120;

6) Capacitor C2 (filter side) = 1 μF;

7) Resistive load = 10 Ω;

8) Switching frequency = 10 kHz;

The power circuit of the proposed system consists of a CUK converter and a gate drive, and the control of the switching is done using the control circuit. The control loop frequently happens with respect to the sampling time, and the main program continues to track the MPPs.

IV. SIMULATION CIRCUIT

Fig 3 shows the simulation circuit of IncCond MPPT of PV panel. PV panel varies with respect to solar irradiation and temperature. Output of PV panel is given to MPPT controller. Triggering pulse of MPPT controller is given to IGBT switch. Then the output is fed to the load. The entire system has been modelled on MATLAB™ 2009a. The block diagram of the solar PV panel is shown in Figure 4 and Figure 5.

The inputs to the solar PV panel are temperature, solar irradiation, number of solar cells in series and number of rows of solar cells in parallel. As stated above this unit is responsible for providing the input to the solar cell.

This block is simulated using the Simulink blocks available in the MATLAB library. This unit gives the light generated current using the characteristic equations modelled in the form of
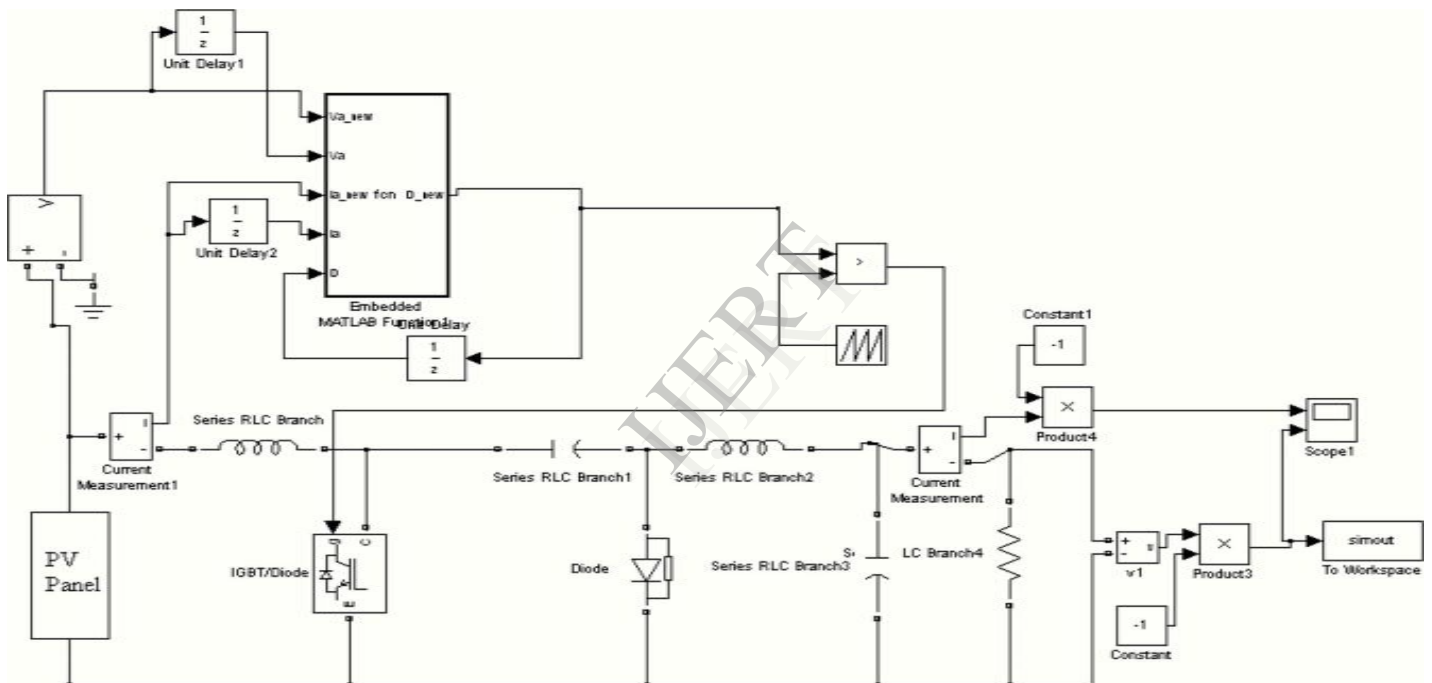

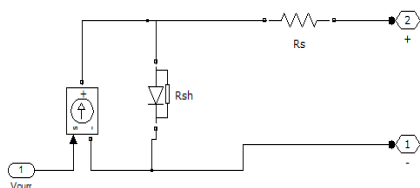Fig – 3: Simulink Model for Incremental conductance MPPT

Fig-4: PV panel module

function blocks.

The controlled voltage source and the current source inverter have been used to interface the modelled panel with the rest of the system and the CUK converter which are built using the Sim Power Systems module of MATLAB. The block diagram for the model shown in Figure 9 is a simulation for the case where we obtain a varying voltage output.
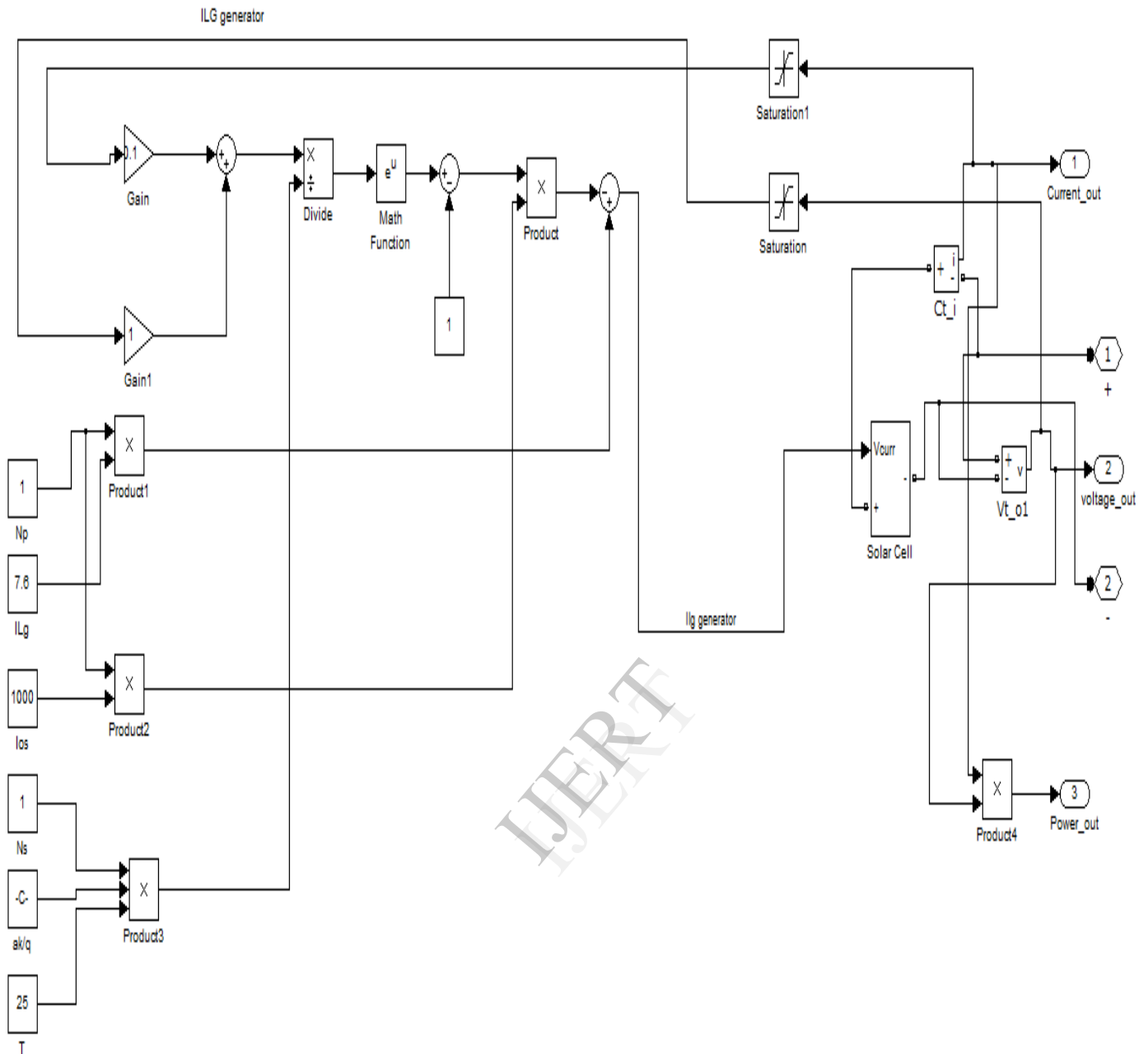
Fig-5:Matlabmodeling circuit of PV panel

This model is used to highlight the difference between the power obtained on using an MPPT algorithm and the power obtained without using an MPPT algorithm. To compare the power output in both the cases stated above, the model is equipped with a manual switch as shown. When the switch is thrown to the left the circuit bypasses the

MPPT algorithm and we obtain the desired power, voltage and current outputs through the respective scopes. Contrarily when the switch is thrown to the right, the embedded MPPT function block is included in the circuit and we obtain the desired outputs through the respective scopes [3][6].

Fig 6 shows the modified simulation circuit of PV panel. In this output of PV panel circuit is given to the wind turbine motor. The balance power is given to the grid. Output of PV panel is given to the MPPT controller. By comparing with voltage and current it generates a signal and that signal is given to the CUK converter. It has three modes of operation. Finally the achieved maximum power is given to the load.

MATLAB. The plots obtained in the different scopes have been shown below. The simulation was first run with the switch on no MPPT mode, bypassing the MPPT algorithm block in the circuit.
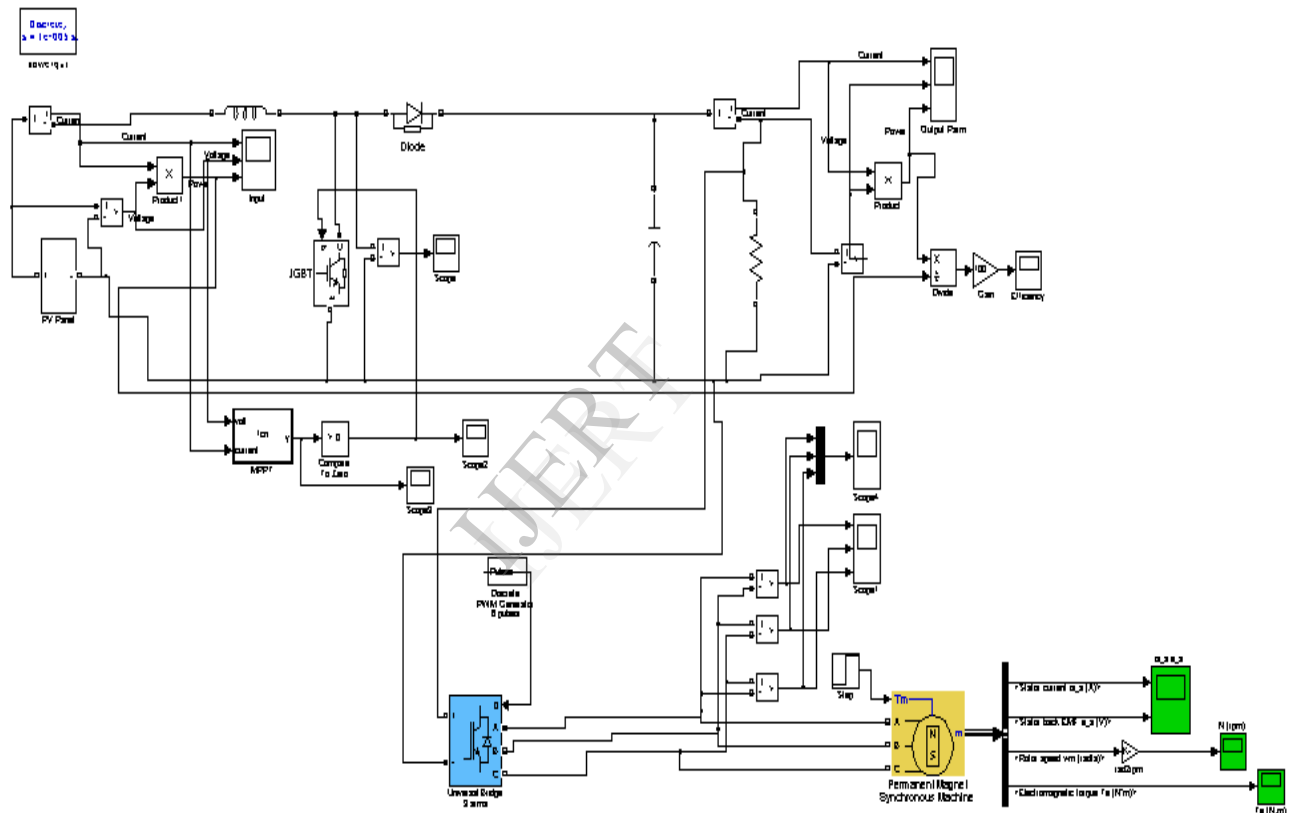

Fig-6: Simulink Model for Incremental conductance MPPT hybrid with windmill rotor

V.SIMULATION RESULTS

The analyses were made up of the procedure and efficiency has been calculated by using MATLAB. The model shown in Fig 9a and 49b was simulated using SIMULINK and

Fig 7 shows the voltage, current and power characteristics of PV panel. It was seen that without MPPT algorithm, the power obtained at the load side was around 118 W as shown in Fig 7 for

a solar irradiation value of 85 W/sq. cm. They varies with respect to time. Rise and falls in the curve is due to the variation of irradiance and temperature. Here the maximum current is of around 6A and maximum voltage is of around 40V.
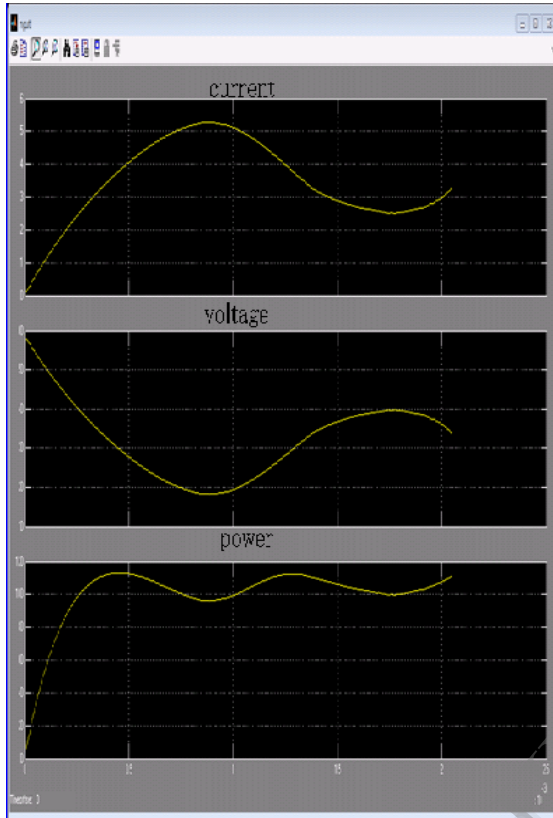

Fig -7: Input characteristics of PV panel

Fig 8 shows the output characteristics of the load under the concept of MPPT. During charging of the CUK converter voltage and current forms a straight line. Once the charging completed voltage and current increases in the reverse direction. Reverse direction is due to the characteristics of the CUK converter. Power increases in the forward direction. They varies with respect to load. Output characteristics depend upon the performance of load.

Fig 9 explains about the efficiency characteristics of the PV panel. Efficiency depends upon 3 parameters, such as input characteristics, output characteristics, and time. Efficiency of PV panel has been expected up to 90%. Efficiency depends upon the single PV cell performance.
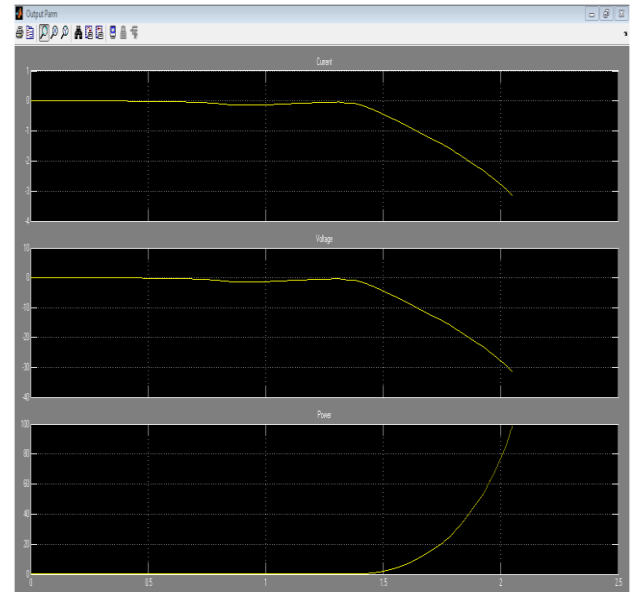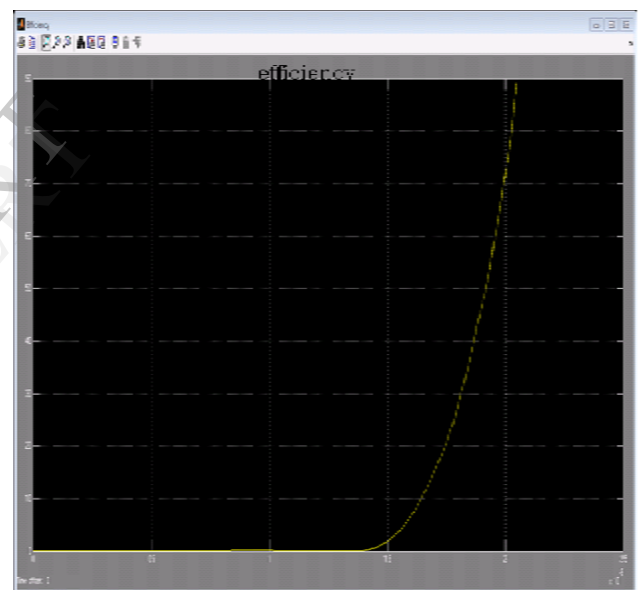

Fig-8: Output characteristics of pv panel

Fig-9: Efficiency curve of Incremental conductance MPPT PV panel

Fig 10 shows the stator characteristics of motor. It gives the idea of about stator current and stator electro motive force. They varied with respect to time. Maximum stator current is 11.5A. Maximum EMF that can be attained by the stator is 60V.

Fig 11 shows the rotor characteristics of motor. It is used to determine the rotor speed in RPM. They depend up on the voltage applied on it. The maximum speed attained by it is 970RPM
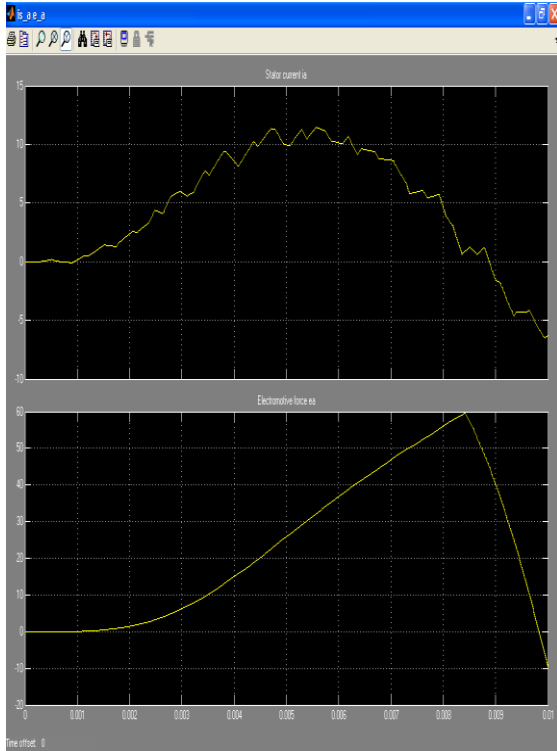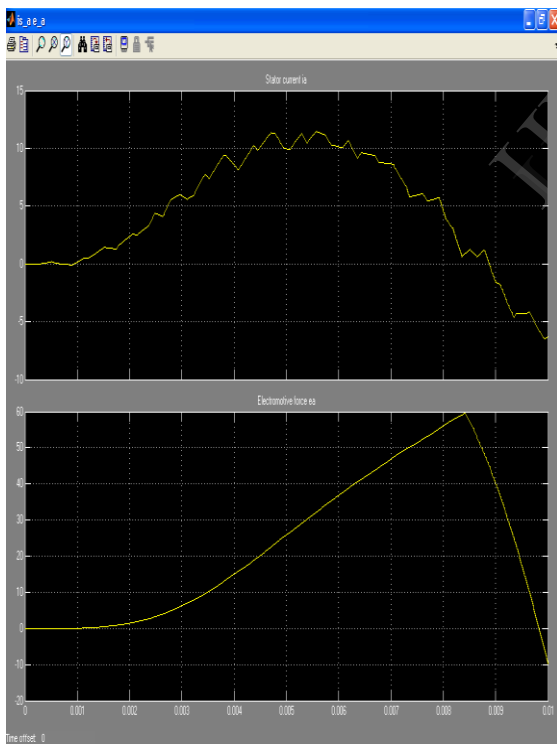
Fig-10: Stator characteristics of motor

Fig-11:Rotor characteristics of motor

Fig 12 shows the torque characteristics of motor. Torque gradually increases and then decreases. Maximum torque can be obtained by it is 14NM. The above all varied with respect to time.
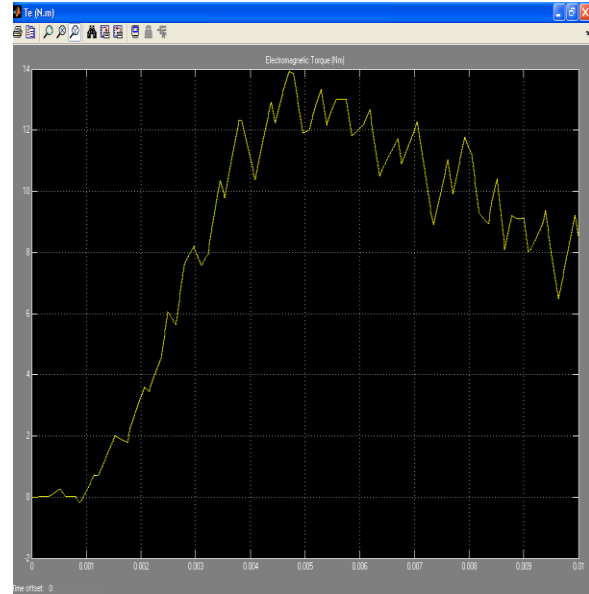

Fig-12: Torque characteristics of motor

VI. CONCLUSION

The paper proposes a simple MPPT method that requires only measurements of Incremental conductance. The proposed MPPT algorithm is called Incremental conductance Method. However, by using this MPPT method we have increased efficiency by 44%. This method computes the maximum power and controls directly the extracted power from the PV. The proposed method offers different advantages which are: good tracking efficiency, response is high and well control for the extracted power.

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