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# A Novel on Solar Wind Hybrid Model for Efficiency Improvement

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***Abstract: The need for renewable energy sources is on the rise because of the acute energy crisis in the world today. India plans to produce 20 Gig watts Solar power by the year 2020, whereas we have only realized less than half a Gig watt of our potential as of March 2010. Solar energy is a vital untapped resource in a tropical country like ours. Recently, energy generated from clean, efficient, environmentally and eco-friendly sources has become one of the major challenges for engineers and scientists. In this paper the Solar and wind model has been discussed. The stochastic behavior of solar energy, MPPT control technique of PV arrays is required to operate at maximum power point. The main contribution in this paper is efficiency to improve the efficiency of the Solar Panel by means of P&O and Incremental Conductance techniques. The complete model has been discussed and output waveforms were obtained. The collaboration of wind energy system along with solar system can give the more added advantage to the system. Boost converter operated by MPPT controller so it can able to deliver more accuracy. The Simulink model of Solar-Wind hybrid circuit is designed and waveforms are obtained.***
***Keywords – SOLAR-WIND Hybrid System, DC-DC Converter, Maximum Power Point Tracking(MPPT),Perturb and Observe (P&O), Incremental Conductance, PV array.***

## I. INTRODUCTION

The mass usage of conventional fossil energy has resulted in reduction of fuel deposit and has affected the atmosphere causing pollution and greenhouse effect. There arises the problem of energy shortage due to the non-renewable nature of fossil fuel energy. There is necessity for development of clean and renewable energy in order to replace conventional fossil energy. Solar energy is promising with its abundance nature and

Photovoltaic generation as the utilization method has been applied in large scale. Therefore many methods have been implemented in order to improve the efficiency of the standalone PV system. Due to the nonlinear characteristics of the PV panel, the maximum power from the PV panel is tracked by specific control algorithms implemented within the converter known as maximum power point tracking algorithm. The block diagram of the overall solar standalone system is shown in Fig. 1.For maximum efficiency operation the instantaneous matching of power between the load and the power extracted from the source is obtained[1].

### *A. Irradiation*

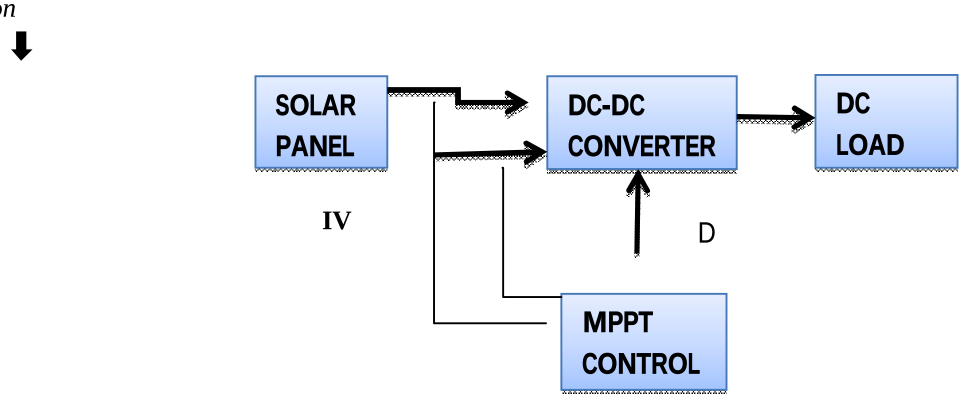


Fig. 1.1 Block diagram of the proposed system

A bare single cell cannot be used for outdoor energy generation by itself. It is because the output of a single solar cell is very small. It requires protection against dust,moisture, mechanical shocks and outdoor harsh conditions. In order to reach theworking voltage and reasonable power, the solar PV cells are connected in series or in parallel to form PV module. In this workthe PV panel is modeled for the working voltage of 36V and it forms the basic building block of the system. The effect of variation with temperature and irradiance is analyzed in the literature [1]. The standard test condition of PV is 1000W/m2.The power varies as the insolation level varies. The power obtained from the PV is low during rainy and cloudy weather conditions. So in order to improve the power extracted,maximum power point tracking which results in change in electrical characteristics of PV has been proposed in the literature.

The MPPT algorithm is integrated to a DC-DC converter.Though MPPT algorithm is used, the power does not remain constant throughout and there is achance for the load to get damaged. To prevent it, the closed loop load control is implemented to provideconstant maximum power to the system at all irradiation. Renewable energy sources or systems haverelatively low voltage output characteristics and hence demand ahigh step up voltage gain and high efficiency. DC-DC step-up converters are recurrently adopted for low power conversion systems to boost the voltage according to the load.

## II. ANALYSIS OF DC-DC CONVERTERS

In photovoltaic based system there is requirement for boosting up its lower voltage to a relatively high voltage so that high voltage gain and good regulation can be obtained.

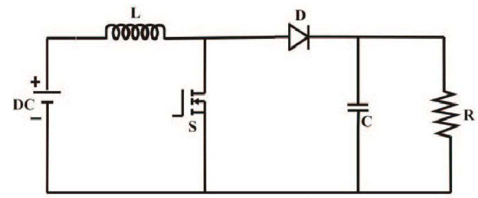


Fig. 2.1 Circuit diagram of conventional boost converter

The conventional boost converter shown in Fig.2.1 provides less gain value and it cannot provide gain greater than six times the applied voltage due to parasitic components. Extreme duty cycle degrades the overall conversion efficiency due to the reverse recovery effect of the output diode as stated in . Therefore, a conventional boost converter requires high rated current, voltage and bulky filter to reduce large input current ripple. Positive output super lift Luo converter shown in Fig.3.uses geometric progression for voltage regulation. The ripple voltage and ripple current are reduced when compared with conventional boost converters. The converter has high power density but low efficiency and gain.

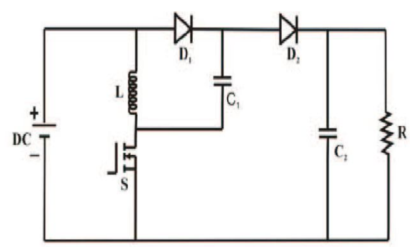


Fig.2.2 Circuit diagram of Positive output super lift Luo converter

The high step up non isolated DC-DC converter shown in Fig.2.2 has high gain even without extreme duty cycle and has a non-floating power switch. It limits the starting inrush current but it does not limit current during overload conditions.

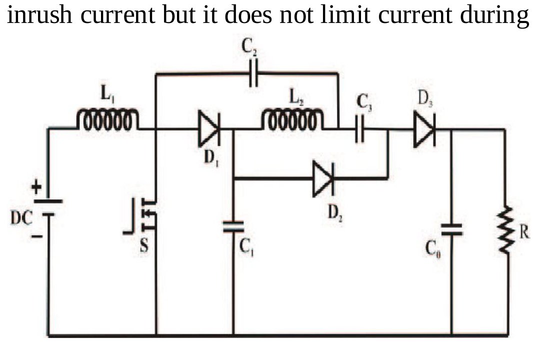


Fig.2.3 Circuit diagram of non-isolated DC-DC converter

## III. MODELING OF PROPOSED BOOST CONVERTER

The converters using switched inductor and switched capacitor type proposed in uses transformerless switched capacitor type and voltage lift type. The converters involving the combination of boost and flyback converters proposed in, results in leakage induction losses which cause voltage spikes on active switches during turn-off condition. It can be minimized by the use of small resistors or resistor-capacitor-diode snubber to dissipate the leakage energy but it results in suppression of efficiency. In the switched coupled inductor DC-DC converter proposed in the turns ratio of the coupled inductor is reduced resulting in the reduction of the conduction losses, other losses, cost and complexity and is proposed in this work.

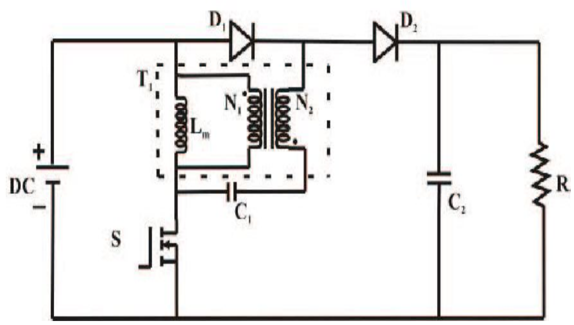

Fig.3.1 Circuit diagram of step up converter

The converter shown in Fig.3.1 consists of diode D1, D2, coupled inductor, switch S1, magnetizing inductor Lm, capacitor C1, C2and a resistive load. The magnetizing inductance is integrated into the primary winding N1 of coupled inductor T1. The operation of the magnetizing inductor remains in the same way as the inductor present in theconventional boost converter. The components in the converter are ideal and the values of thecapacitor are large in order to withstand the high voltage.Theturns ratio of the coupled inductor is chosen in the ratio of 1:3 in order to provide high gain. The step up DC-DC converter in continuous conduction mode operates in two modes. In first
mode switch, S1 is turned on diode D1 is forward biased and diode D2 is reverse biased. The switched capacitor C1 gets charged from the source voltage through coupled inductor. The charging current flowing from the input source to the switched capacitor prevents the flow of inrush current when the switch is turned on. During this process, the magnetizing inductor is also charged from the input sourceVin.Thereforethis mode is known as the energy storage mode. In the second mode of operation switch S1, D1 are turned off and the diode D2 is forward biased.Therefore, the source Vin, Lm, C1and N2 winding are found to bein series and they charge the capacitor C2 and the load Thereforethis mode is known as the energy release mode.
The coupledinductor in thisconverter acts as an energy storage device and as energy transfer device during the turn on and turn off stages. The gain value of the converter is high because the switchedcapacitor charges from the input source, secondary winding N2 and magnetizing inductance. The output voltage is the sum of input source, the voltage on the switched capacitor, the primary and the secondary voltages of the coupled inductor. The conduction losses are minimized and other losses are minimized since the starting inrush current is limited. The leakage inductor energy of the coupled inductor can be easily recycled and is given to the load. Therefore the power conversion efficiency is improved. On comparing the proposed converter with the flyback converter, it is found that the proposed converter has low voltage stress on the switch and it requires a lower duty ratio in order to obtain high voltage ratio.

## IV. MAXIMUM POWERPOINT TRACKING

### *A. An Overview Of Maximum Power Point Tracking*

A typical solar panel converts only 30 to 40 percent of the incident solar irradiation into electrical energy. Maximum power point tracking technique is used to improve the efficiency of the solar panel.According to Maximum Power Transfer theorem, the power output of a circuit is maximum when the Thevenin impedance of the circuit (source impedance) matches with the load impedance. Hence our problem of tracking the maximum power point reduces to an impedance matching problem.In the source side we are using a boost convertor connected to a solar panel in order to enhance the output voltage so that it can be used for different applications like motor load. By changing the duty cycle of the boost converter appropriately we can match the source impedance with that of the load impedance.

### *B. Different Types Of Mppt Techniques*

There are different techniques used to track the maximum power point. Few of the most popular techniques are:Fractional open circuit voltage method, Fractional short circuit current method**,** Perturb and Observe (hill climbing method)**,** Incremental Conductance method**,** Neural networks method**,** Fuzzy logic control method.

### *C. Perturb & Observe Method*

The Perturb & Observe algorithm states that when the operating voltage of the PV panel is perturbed by a small increment, if the resulting change in power P is positive, then we are going in the direction of MPP and we keep on perturbing in the same direction. If P is negative, we are going away from the direction of MPP and the sign of perturbation supplied has to be changed.

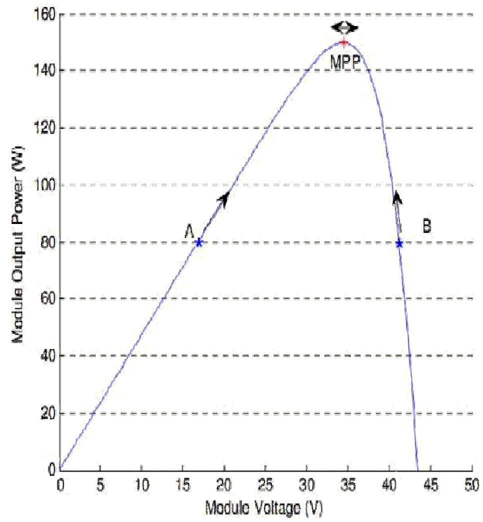


Fig.4.1 Solar Panel Characteristics Showing MPP And Operating Points A And B

Figure 4.1 : Solar panel characteristics showing MPP and operating points A and B Figure 4.1 shows the plot of module output power versus module voltage for a solar panel at a given irradiation. The point marked as MPP is the Maximum Power Point, the theoretical maximum output obtainable from the PV panel. Consider A and B as two operating points shown in the figure above, the point A is on the left hand side of the MPP. Therefore, we can move towards the MPP by providing a positive perturbation to the voltage. On the other hand, point B is on the right hand side of the MPP. When we give a positive perturbation, the value of P becomes negative, thus it is imperative to change the direction of perturbation to achieve MPP.

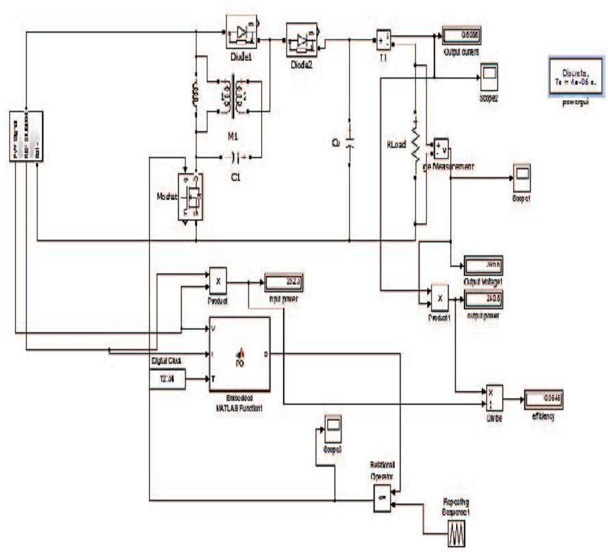

Fig.4.2 MATLAB-Simulink of the proposed converter with P&O method

### *D. Incremental Conductance*

The maximum power point tracking (MPPT) technology improves the effective use of solar energy and the efficiency of PV power generation system A several maximum power point tracking (MPPT) algorithms have been proposed including Hill climbing perturb and observe (P&O) , incremental conductance (INC), and artificial-intelligence-based algorithms .algorithms are widely introduced to PV systems due to their simplified control structures and easy implementation.

Incremental conductance method is the algorithm that exhibits better performance than other techniques is due to the high tracking accuracy at steady state and good adaptability to the rapidly changing atmospheric conditions. The conventional incremental conductance algorithm usually uses fixed iteration step size determined by the requirements of the accuracy at steady state and the response speed of the MPPT. To solve the tradeoff between the accuracy of the dynamic and steady state, a new INC MPPT with variable step size is proposed in this paper. The simulation results show that the proposed method can effectively improve the steady-state and dynamic performance simultaneously.

Incremental conductance method is the algorithm that exhibits better performance than other techniques is due to the high tracking accuracy at steady state and good adaptability to the rapidly changing atmospheric conditions. The conventional incremental conductance algorithm usually uses fixed iteration step size determined by the requirements of the accuracy at steady state and the response speed of the MPPT.

Solar energy is one of the most dominant renewable energy. By the end of 2015, total installed capacity of Chinese photovoltaic generation is 43.18GW, of which distributed photovoltaic account for about 14%. During the 13th Five Year Plan, the installed targets of PV is 150GW, and distributed photovoltaic generation will break through 46% of the total. With the rapid development of photovoltaic power generation, distributed photovoltaic power generation has a broad application prospect Due to the high cost of PV modules, we need to improve the efficiency of the photovoltaic array as much as possible.

The output voltage, current, power of PV array which are influenced by the external environment show nonlinear characteristics. So we need to adjust the load characteristics of the PV array to work at MPP in real time, and the MPPT technology is the key to improve the efficiency of photovoltaic power generation. Conventional MPPT control methods mainly include: constant voltage tracking(CVT), perturbation and observation (P&O), and incremental conductance(INC) method. Due to these three methods have some shortcomings, the improved MPPT control method are often constructed at present.

Incremental conductance uses two voltage and current sensors to sense the output voltage and current of the PV array. Here we are sensing both current and voltage simultaneously. Hence the error due to change in irradiance is eliminated. However the complexity and cost of implementation increases. Based on fact that slope of P-V

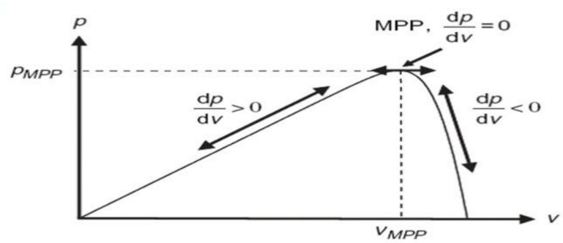


Figure 4.3 Characteristic curve for Incremental Conductance Method

$\frac{dp}{dv}$=0 at MPP………………………………(1)

$\frac{dp}{dv}$>0 at Left MPP…………………………(2)

$\frac{dp}{dv}$<0 at Right MPP……………………….(3)

### *E. Solar-Wind Hybrid Model System*

The proposed simulation representation is a combination of wind energy conversion system and solar PV system. According to many renewable energy experts, a small "hybrid" electric system that combines home wind electric and home solar electric (photovoltaic or PV) technologies offers several advantages over either single system. Because the peak operating times for wind and solar systems occur at different times of the day and year, hybrid systems are more likely to produce power when you need it. In much of the United States, wind speeds are low in the summer when the sun shines brightest and longest. The wind is strong in the winter when less sunlight is available. Many hybrid systems are stand-alone systems, Which operate “off-grid”—not connected to an electricity distribution system. For the times when neither the wind nor the solar systems producing , most hybrid systems provide power through batteries and / or an engine generator powered by conventional fuels, such as diesel. If the batteries run low, the engine generator can provide power and recharge the batteries.

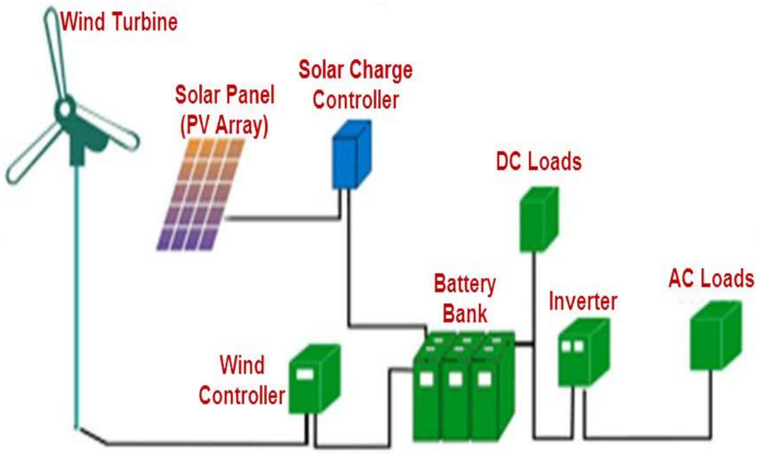


Fig 4.4 Circuit Diagram of Solar-Wind Hybrid System

Hybrid Wind-Solar System for the rural exchanges can make an ideal alternative in areas where wind velocity of 5-6 m/s is available. Solar-wind power generations are clear and non-polluting. Also they complement each other. During the period of bright sunlight the solar energy is utilized for charging the batteries, creating enough energy reserve to be drawn during night, while the wind turbine produce most of the energy during monsoon when solar power generation is minimum. Thus the hybrid combination uses the best of both means and can provide quality, stable power supply for sustainable development in rural areas.

*F. Advantages of Renewable Energy Systems*

*1)* Provides un-interrupted power supply to the equipmen
*2)* Provide clean, green, reliable, pollution free, low emission and distributed technology powe
*3)* Saves from high-running cost of generator and increasing diesel cos
*4)* The system gives quality power out-put of 48 volt DC to charge directly the storage battery or provide direct power to telecom installations
*5)* The system can be designed for both off-grid and on-grid applications
*6)*

## V. SIMULATION RESULTS

*A. Simulation Circuit Diagrams*

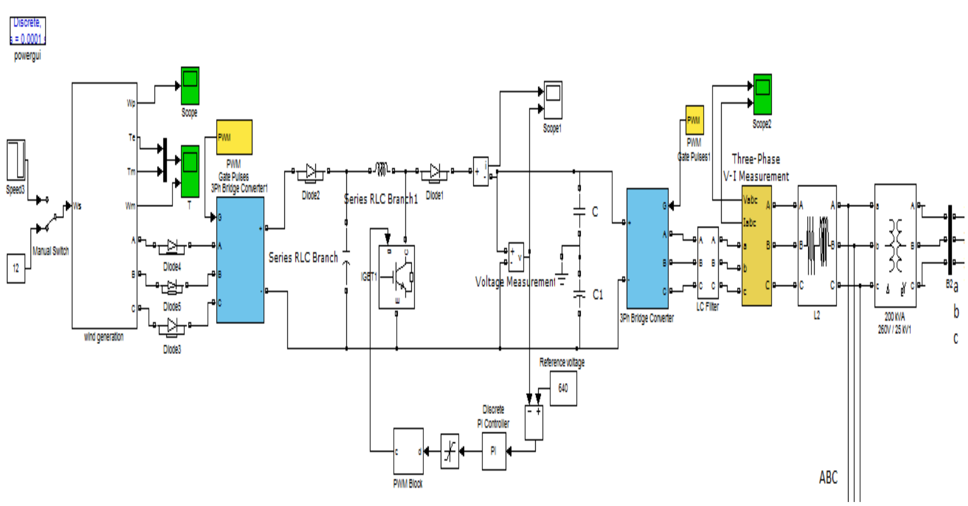


Fig:5.1 Simulation Circuit for Solar-Wind Hybrid System(Part 1)

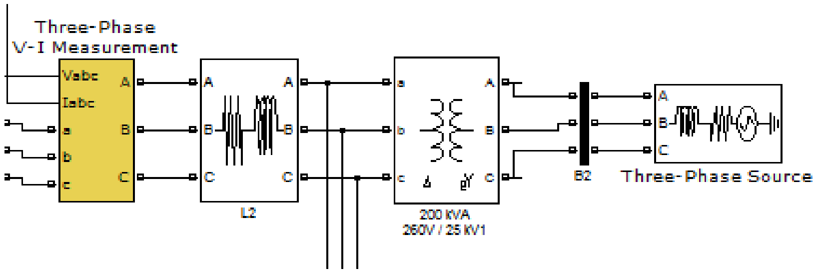


Fig:5.2 Simulation Circuit for Solar-Wind Hybrid System(Part 2)

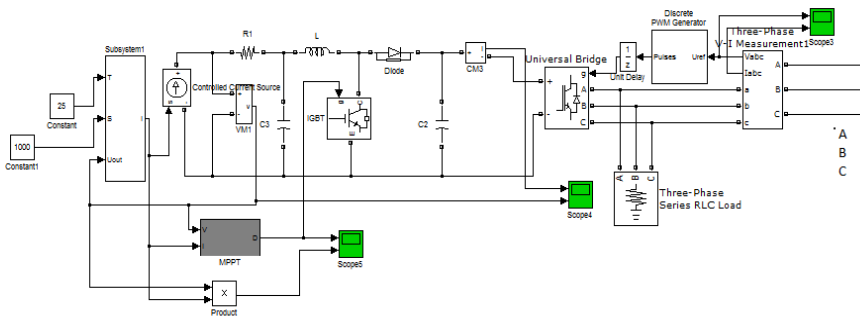


Fig:5.3 Simulation Circuit for Solar-Wind Hybrid System(Part 3)

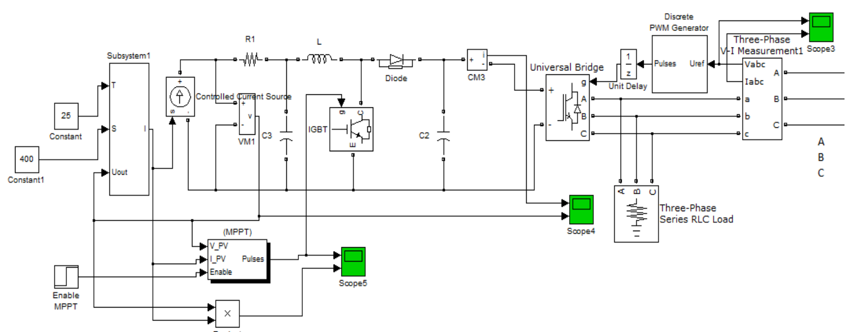


Fig:5.4 Simulation Circuit of MPPT Technique for INC Method

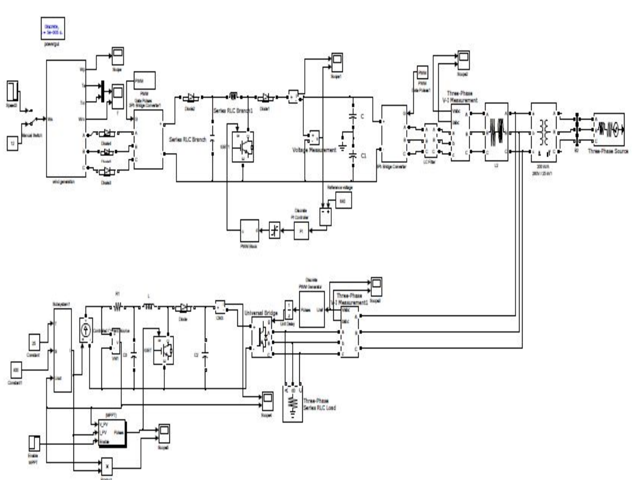

Fig:5.5 Simulink model of wind-solar hybrid system

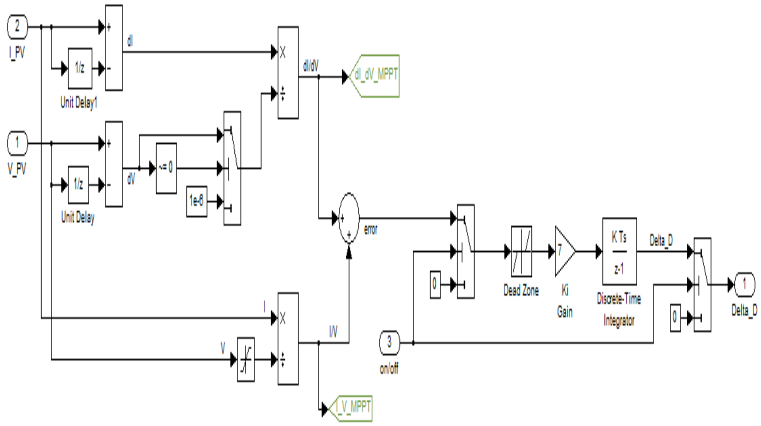


Fig:5.6 Simulation Circuit of MPPT Technique for INC Method Subsystem1

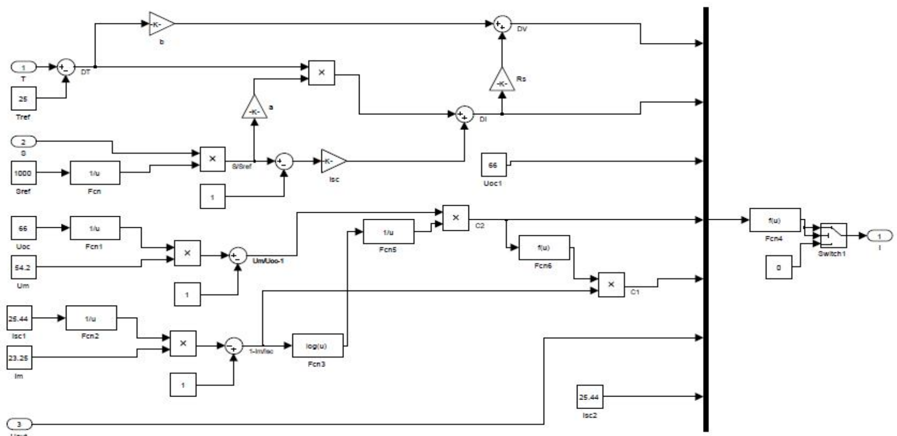

Fig:5.7 simulation model for PV array

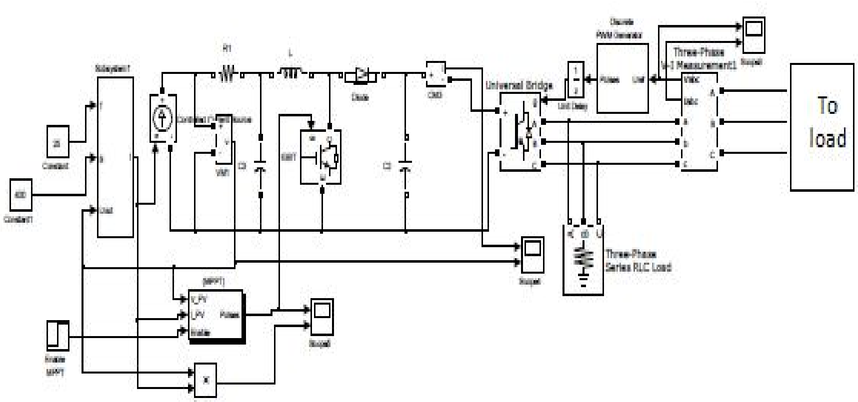


Fig:5.8 Simulink model of PV system

In the above figure overall view of PV system can be designed. In this system MPPT is tracked by using MPPT controller and it has input voltage and current. It also generate duty cycle to theBoost converter and this DC voltage convert into three phase AC voltage by using voltage source inverter.

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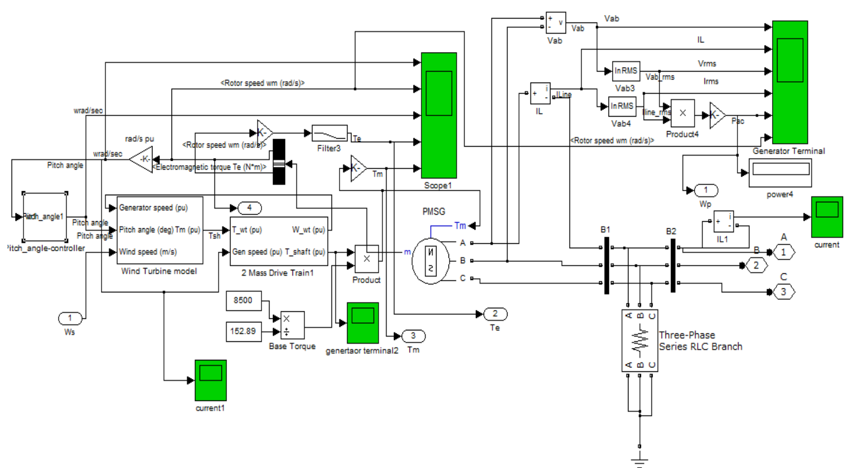


Fig:5.9 Simulation model for wind turbine

## B. *Simulation Graphs*

In order to model the solar panel accurately we can use two diode model but in our project our scope of study is limited to the single diode model. Also, the shunt resistance is very high and can be neglected during the course of our study.

When the voltage and the current characteristics are multiplied we get the P-V characteristics as shown in Figure 3.3. The point indicated as MPP is the point at which the panel power output is maximum.

*1 ) Output Characteristics Curves With Different Irradiation*

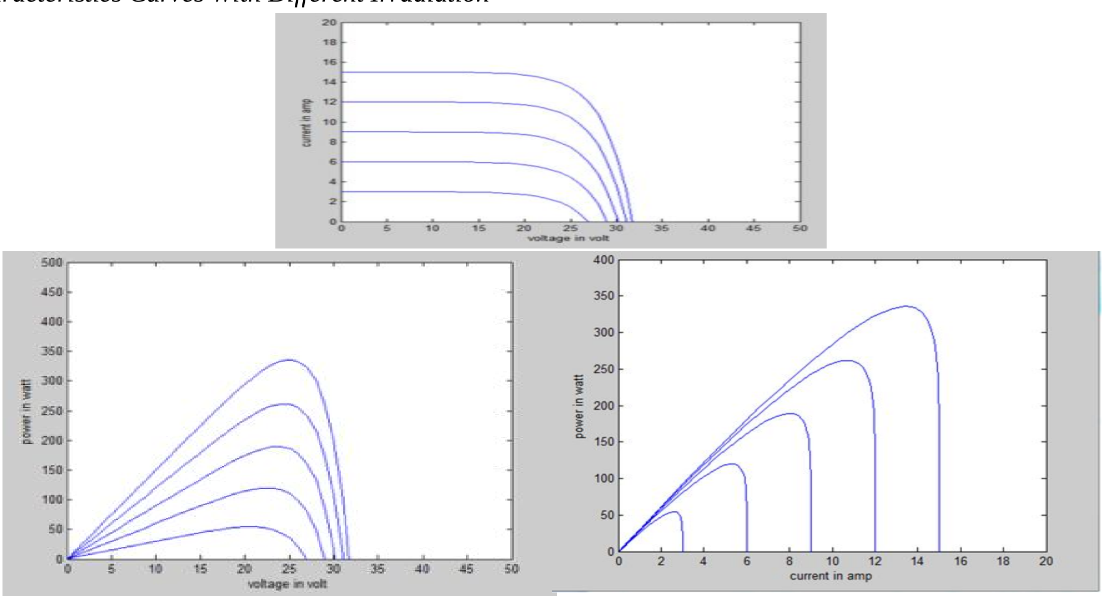


Fig:5.10 Simulation Result of I-V Characteristics
Simulation Result of P-V Characteristics
Simulation Result of P-I Characteristics

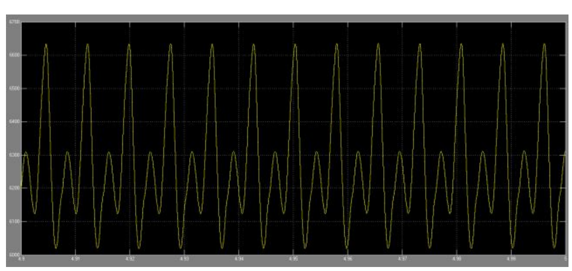

Fig: 5.11 Simulation Result of Wind System

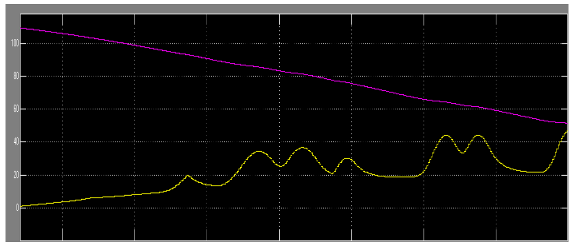

Fig: 5.12 Simulation Result of Torque Curves

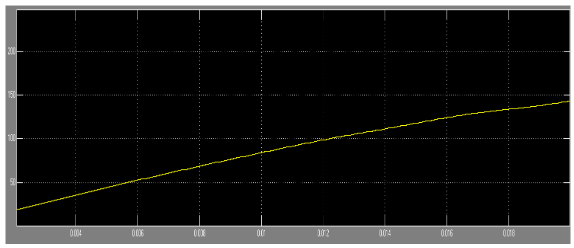

Fig:5.13 Simulation Result of Wind Speed

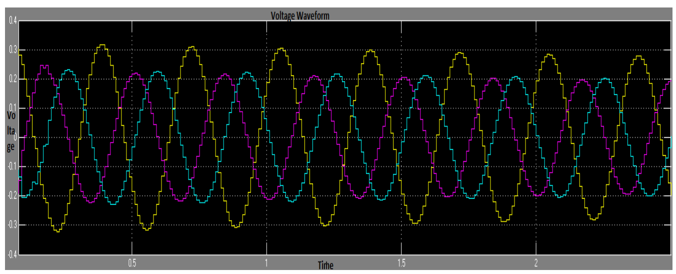


Fig:5.14 Simulation Result of Three Phase Bridge Converter Voltage Waveform

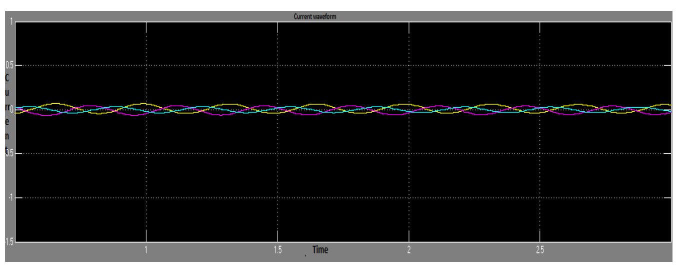


Fig:5.15 Simulation Result of Three Phase Bridge Converter Current Waveform

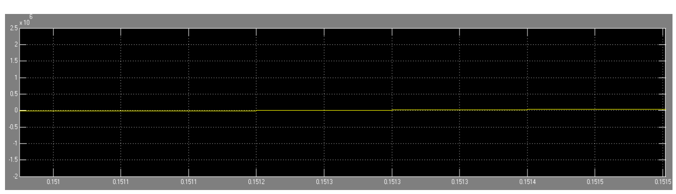

Fig:5.16 Simulation Result of Torque Speed

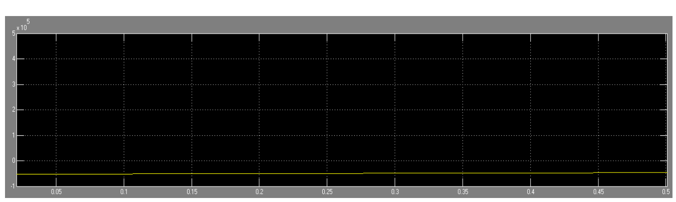

Fig:5.17 Simulation Result of Wind speed For INC Method

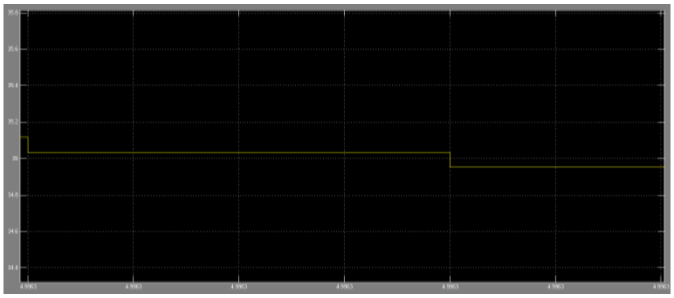

Fig:5.18 Simulation Result of Wind torque for INC Method

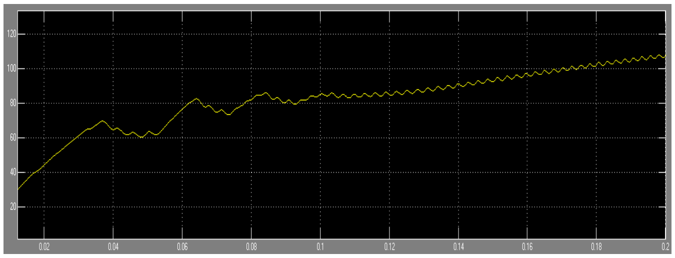

Fig:5.19 Simulation Result of Torque Speed for INCMethod

TABLE: COMPARISION TABLE

| Algorithm | MPP Tracking Efficiency (%) |
|---|---|
| P&O | 88.1 |
| INC | 92.5 |

Table :5.20 MPP Tracking Efficiencies of Different Methods

## VI. CONCLUSION

In this paper a detailed analysis of various maximum power point tracking algorithms were carried out .Incremental Conductance method holds good performance than any other methods under normal and varying atmospheric conditions. The increasing demand of electricity with clean hybrid power station wind solar can be used.

The performance of P&O and Incremental Conductance has efficiencies is 88.1 and 92.5%. The simulation results verify the feasibility and effectiveness of the methods. Incremental conductance is evident method under changing condition of insolation, irradiation and temperature.

The hybrid model is mostly implemented in Irrigation applications, road lighting, house lighting , landscape lighting , pump irrigation , fishing boat and telecommunication system.

## VI.FUTURE SCOPE

In future incremental conductance method is widely used in solar photovoltaic applications because it can provide approximately 93 Percentage efficiency.The main applications are Irrigation system, Road lighting and Home applications.

Hybrid solar wind charger is a practical project in which the electric power generated from solar energy and wind energy are used for charging the batteries.

The project can also implemented by using Fuzzy Logic Control and Neural Networks for efficiency improvement.

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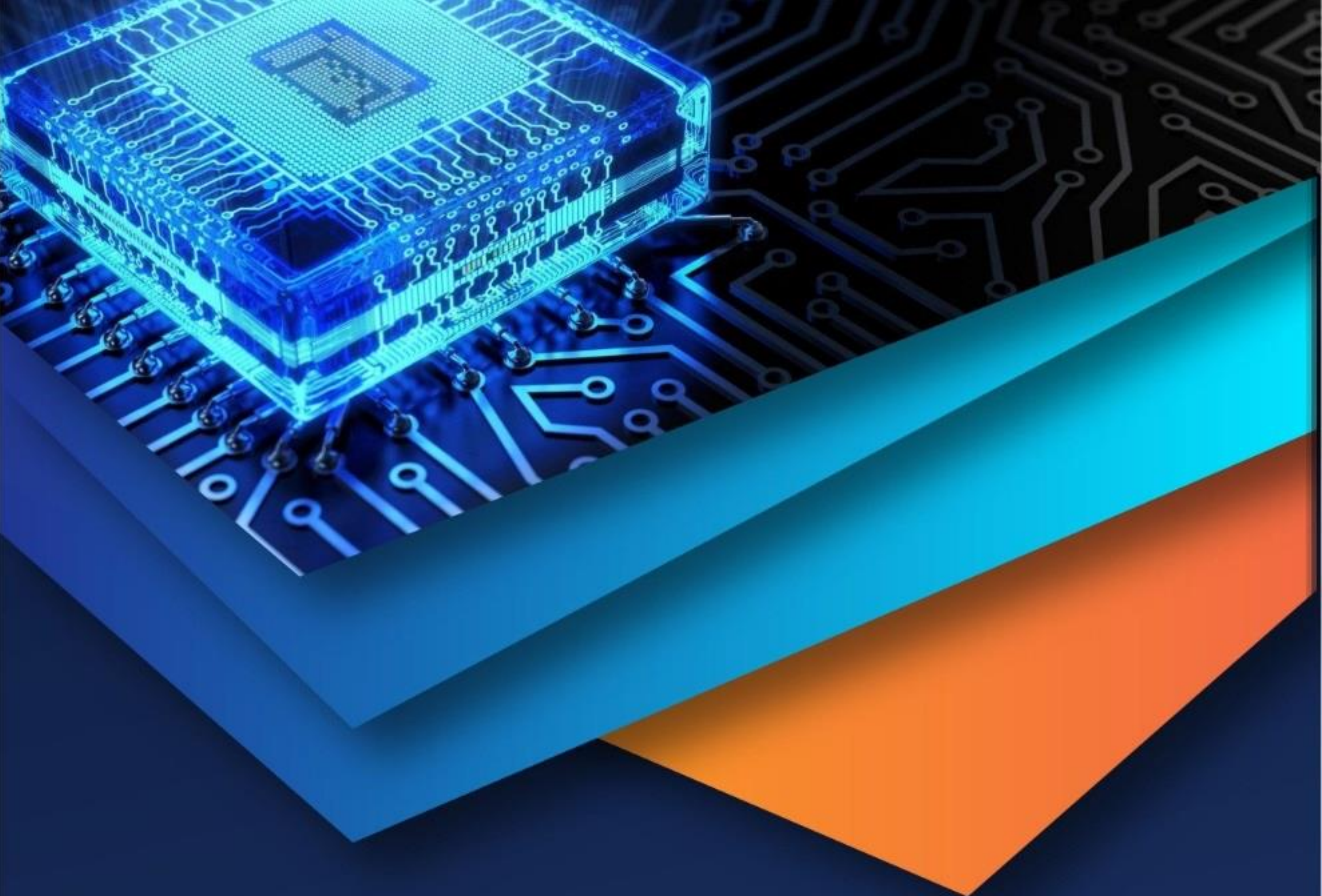


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