Comparison of MPPT with Constant Current Method and P & O Method Using CUK Converter

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Abstract: This paper presents simulation and comparison of maximum power point tracking (MPPT) used in solar array power systems with constant current method and Perturb method P & O method. The main difference of the proposed system to existing MPPT systems includes the improvement in the output voltage, output current and efficiency. In this model we have used cuk converter which is an isolation converter and selection of converter is an big challenge in the PV Module for getting better performance because PV module is more affected by the Atmospheric condition .In this paper MPPT P& O technique give proper and optimize outputs.

Keywords — Perturb technique (P & O) method, maximum power point tracking (MPPT), photovoltaic (PV) system, Cuk converter, Renewable energy sources, dc-dcconverters.

I. INTRODUCTION

Nowadays among all renewable energy sources solar energy become the most effective and efficient because of its increase in excellent electrical energy generating capability and reduction of global warming , greenhouse emissions as in [3].Renewable energy become the source of power generation in the new millennium and the most popular tend of application to power grid to overcome the traditional energy resources as in [7].Regarding the environmental issues such as air pollution and CO2 gas emissions it is being promoted to study Photovoltaic generating systems actively to cope up with these result Although solar electric power generation is advantageous, it has certain problems that the efficiency of power generation is low when radiation of sun is dim, especially under low radiation states and weather conditions which is usually changing, therefore the amount of electric power generated by solar arrays is also reduced because of the intensity of solar radiation.as in [2,5].In future solar energy will be the best energy resource as in [1]. Increase in ambient temperature and fast climatic changes on solar panels can reduce the photo voltaic (PV) array output power as in [1]. Application of solar energy is an important concept , that are either in standalone PV systems (water dumping, domestic and street lighting, electric vehicles, military and space applications) or grid connected systems (hybrid system, power system as in [1]. PV systems add much needed flexibility to the energy resource, thereby decreasing the dependence on fossil fuels as in [7]. PV systems consists of a PV generating cell module array, energy storage devices such as batteries, AC and DC consumers and elements of power conditioning. Photovoltaic generator is the whole assemble of solar cell connections, controllers, protective parts, supports etc.. Renewable energy sources are beneficial because they consume nearly zero fossil fuel (eg.coal, Natural gas oil), require low maintenance and are less costly than conventional energy generation system, where transportation charges of fossil fuels are high. The cost of the solar arrays is expected to decrease continuously in the future, making them attractive for residential and industrial applications, and the technology is being developed as in [11].

II. MPPT METHODS

The entire PV systems operates with the maximum power and maximum efficiency when there is a unique point on the V-I or V-I or V- P curves called the maximum power point (MPP) Therefore Maximum power point techniques(MPPT) Were introduced to maintain the PV array's operating point Point at the MPP as [1].Due to certain circumstances almost well-known such as the temperature solar radiation, output of solar arrays and so on…., in order to give maximum power output MPPT strategy is proposed as in [4] with consequently the current voltage (I-V) curves and the maximum power point (MPPs) of the Photo voltaic modules(PV) will change with the solar array under different solar radiation and temperature the maximum power point is tracked, through the MPPT solar array which puts as much array is possible in different states as in [4].

To extract the maximum power from the PV array's the real time becomes in- dispensable in PV generation systems as in [9]. Solar cell V-I characteristics are nonlinear and the

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changes nature in the radiation and temperature .Therefore to locate the MPP through calculation models or by search algorithms. Mainly the Maximum power point tracking is used to maintain the operating point in the PV array modules as in [1]. In the literature many MPPT techniques have been proposed such as Perturb and Observe method(P&O),incremental conductance method method (I&C),the artificial neural network method, the fuzzy logic method etc …Given there are large number of methods for MPPT,a survey of methods would be very much beneficial in considering the methods vary in complexity, sensors required, convergence speed cost range of effectiveness and efficiency implementation in hardware popularity and in the other aspects as in [10].

The problem considered by MPPT technique is exact or automatically to find out , the Vmpp or Impp a which a PV array should operate to give the maximum output power Pmpp under a given temperature and irradiance as in [10]. The maximum power production is based on the load-line adjustment under varying atmospheric conditions. The load in many cases requires a power level to be maintained constant, Because of the fluctuating nature of the output delivered by PV array for the stand alone PV systems as in [8-1].

Photo voltaic system is composed of PV modules and Balance of System components (BOS). The components that BOS include are the array structure , the passive or active trackers, connectors,ac and dc wiring, overcurrent protections, disconnections ,interconnectors, inverters charge controllers,MPPTcontrollers,energy storage devices and system controllers.The durability of the PV array modules and balance of components as been improved consistently using various MPPTs as in [6] .

Even though a large number of some algorithms are able to track the MPPs, the Perturb and Observe (P&O) method. The P&O technique, which moves the operating point towards the maximum power point by periodically increasing or decreasing the array voltage often used in many photovoltaic applications and also this method works well when the insolation does not vary quickly with time, however this fails to quickly track the MPPs as in [14].The incremental conductance method (I & O) tracks the maximum power points by comparing the incremental and instantaneous conductance's of the solar array.

The incremental conductance is estimated by measuring small changes in the array voltage and current, these small changes may be induced by deliberate control action. The harmonic components of the array voltage to be measured and used to check and adjust the array reference voltage as in [14-9]. Of the above both mentioned P&O and I&C method Hill climbing algorithm is an another method for maximum power point.

This method directly seeks the maximum power point by measuring gradient of the output power to the output voltage and has desirable adaptability to slowly fluctuating luminance temperature and even variations of the PVs own characteristics. The main drawback is .it has in terms of the speed response to seek the optimum operating point where the maximum power output can be obtained as in [11,1-6]. To achieve the maximum power output at real time becomes indispensable in PV generation system, therefore a MPPT controllers and techniques are available in many research papers and MPPT controllers most of them are indispensable tools in PV generation systems that has been proposed as in [12].

These P&O and Incremental and conductance method are widely used especially for the low cost of implementation. Microcontrollers, fuzzy logic, neural network, pilot cells and DSP based implementations for MPPT techniques have been proposed as in [11,2-10]. The P&O MPPT algorithm is mostly used, due to its ease of implementation. It is based on the following criterion: if the operating voltage of the PV array is perturb in a given direction and if the power drawn from the PV array will increases, this means that the operating point has moved toward the MPP and, therefore, the operating voltage must be further perturbed in the same direction.

P&O method is commonly used direct MPPT algorithm for PV system. To implement this, duty cycle is initiated and MPPT sampling frequency is set. The input current and voltage signals are sensed and sampled at MPPT sampling frequency as in [9-15] .Otherwise, if the power drawn from the PV array decreases, the operating point has moved away from the MPP and, therefore, the direction of the operating voltage perturbation must be reversed. The proposed Perturb and observe algorithm is the modification in the conventional algorithm that it continues the search space of the algorithm reducing the complexity and improving the performance Of the conventional algorithm under uniform and varying weather conditions.

To ease the implementation of a continuous process and its observation and the perturbation till the operating point Converges at the MPPT as in [14]. The algorithm compares the voltage, Current ,power and efficiency of k-1 samples in the Perturb technique P & O method & Observe algorithm which has been extensively used due to ease of implementation as explained in the flowchart . This is a continuous s process of observation and perturbation till the operating point converges at the MPP.

The algorithm mainly compares the power and voltages of Ti (K) with the sample at a time (K-1) and predicts the time to approach to MPP. A small voltage perturbation changes the power of the solar panel if the power alteration is positive, the voltage perturbation is continued in the same track. But if power is negative, it indicates that the MPP is

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far away and the perturbation is decreased to reach the MPP.

The whole PV curve is checked by small perturbations to find the MPPT that increases the response time of the algorithm. Conversely ,if the perturbation size is enlarged, it generates the steady state oscillations about the MPPT Researchers have proposed modifications in the P&O algorithm to overcome the response time problem and the steady state oscillations.

The problems confronted in the conventional algorithm as identified above can be eliminated by the proposed modifications. The proposed algorithm limits the search space to only 10% area of the power curve that not only decreases the response time but also diminishes the steady state oscillations. Comparison of common MPPT methods are given in table 1

TABLE I **COMPARISON OF COMMON MPPT METHODS**

MPPT Technique	Speed	Complexity	Reliability	Implementation
Fractional Voc	Medium	Low	Low	Digital/Analog
Inc Cond	Varies	Medium	Medium	Digital
Hill Climbing	Varies	Low	Medium	Digital/Analog
Fuzzy logic	Fast	High	Medium	Digital
Neural network	Fast	High	Medium	Digital

The advantages of the proposed technique are as follows adaptive algorithm that varies the perturb value automatically according to the system changes, simple to implement as only a PI-controller is needed, there will be no oscillation during the tracking and the steady state operation low computational burden required, hence, the fast tracking using low-cost controllers is achievable. It does not require any pre-set constants that they are needed for the technique. This technique does not require any adaptive modifications, but suffer from high computational load due to aggressive functions.

Photovoltaic effect is the principle on which a PV cell can produce electricity from sunlight or solar energy. From the physical principles of a solar or PV cell, we can describe it with the single diode equivalent model as given in [16] and figure 1

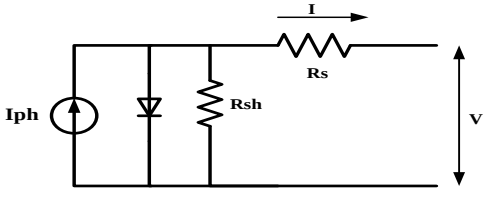

Figure : 1

III SELECTING A PROPER CONVERTER

When proposing an MPP tracker, the major job is to choose and design a highly efficient converter, which is to be supposed to operate as a main part of the MPP the efficiency of switched-mode dc-dc converters is widely discussed in [1] .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.

Even though 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's response, make it less efficient.

On the other hand, the Cuk converter has very low switching losses and the highest efficiency among non-isolated dc-dc converters. It can also provide a better output current characteristics due to the inductor on the a output stage

Thus, the Cuk converter configuration is a proper converter to be employed in designing the MPPT. The Cuk converter has two modes of operation.

The first mode of operation is when the switch is clouded (ON), and it is conducting as a short circuit. The equations for the switch conduction mode are as follows:

$vL1=Vg$

$vL2= -v1-v2$

$ic1 = ic2$

$ic2 = i2- v2/R$

On the second mode when the switch is open (OFF), the diode is in 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:

$vL1=Vg – v1$

$vL2= -v2$

$ic1 = i1$

$ic2 = i2- v2/R$

The principles of Cuk converter operating conditions state 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:

$Vo/Vin = -(D/1-D)$

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

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Analyses of the Cuk converter and its specifications are provided and comparative study on different schemes of switching converters is presented in the below figure.

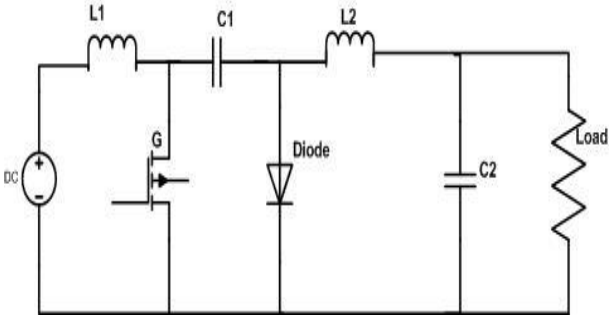

Figure 2 : Electrical circuit of the cuk converter used in PV Array modules

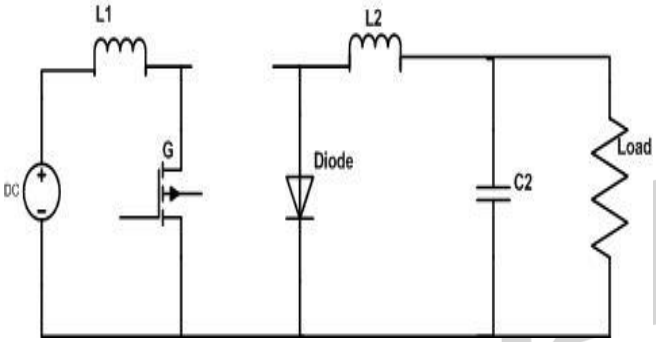

Figure 3 (a) : Different switching modes

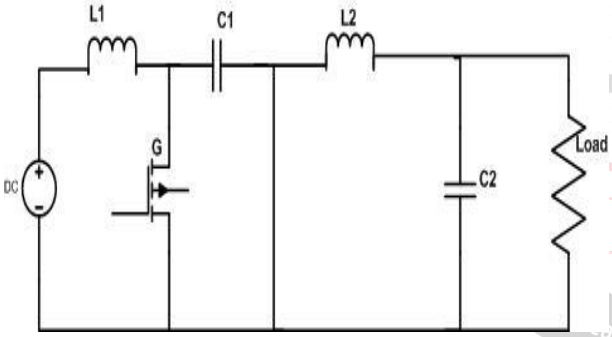

Figure 3 (b): Different switching modes

The components of the Cuk converter used in simulation and the hardware setup were as follows:

1) Input inductor L1 = 5mH
2) Capacitor C1 (PV side) = 47µF
3) Filter inductor L2 =5mH
4) Switch: insulated-gate bipolar transistor [IGBT]
5) Freewheeling diode
6) Capacitor C2 = 100µf

The power circuit of the proposed system consists of Cuk converter with a gate drive circuit, the control of the switching circuit is done using the control circuit. The control tasks involve measuring the analog voltage and current of the PV module using current and voltage sensors , convert them to digital using an analog to digital converter , process obtained from the microcontroller. The predefined values are used to compare the values to take the next step, to revert the pulse width modulation techniques to the gate drive, hence to control the switching of the IGBTs. The control loop frequently happens with respect to the sampling time, and the main program continues to track the MPPTs.

IV COMPARISON OF MATLAB SIMULINK RESULTS OF MPPT CONSTANT CURRENT METHOD AND P &O METHOD

In this paper the MATLAB Simulink is used to find the difference between the performance of MPPT techniques by analyzing the results of both techniques output voltage, output current, efficiency In this paper we have compared two MPPT techniques, one is MPPT constant current method and another one is P& O method .in this paper selecting a proper converter is very important to incorporated with PV module and proposed MPPT techniques used. In this paper we have used cuk converter .Cuk converter is the best converter for this proposed model. The outputs of Constant current method are given below figures

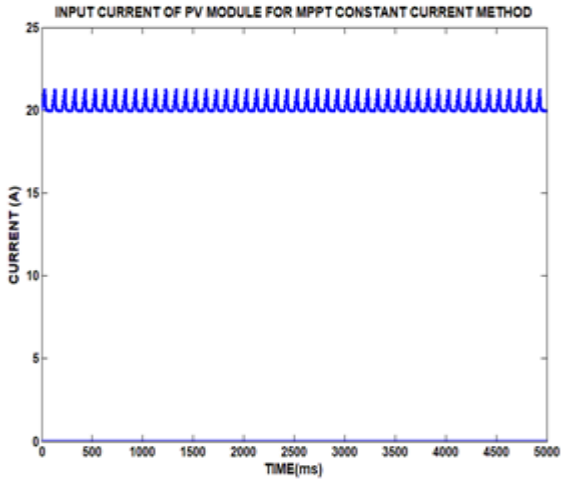

Figure 4

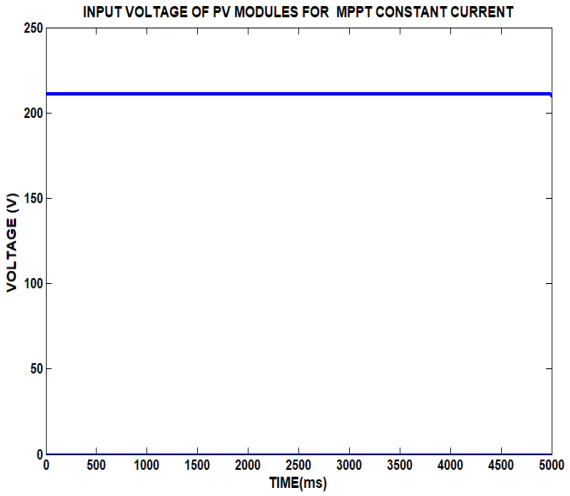

Figure 5

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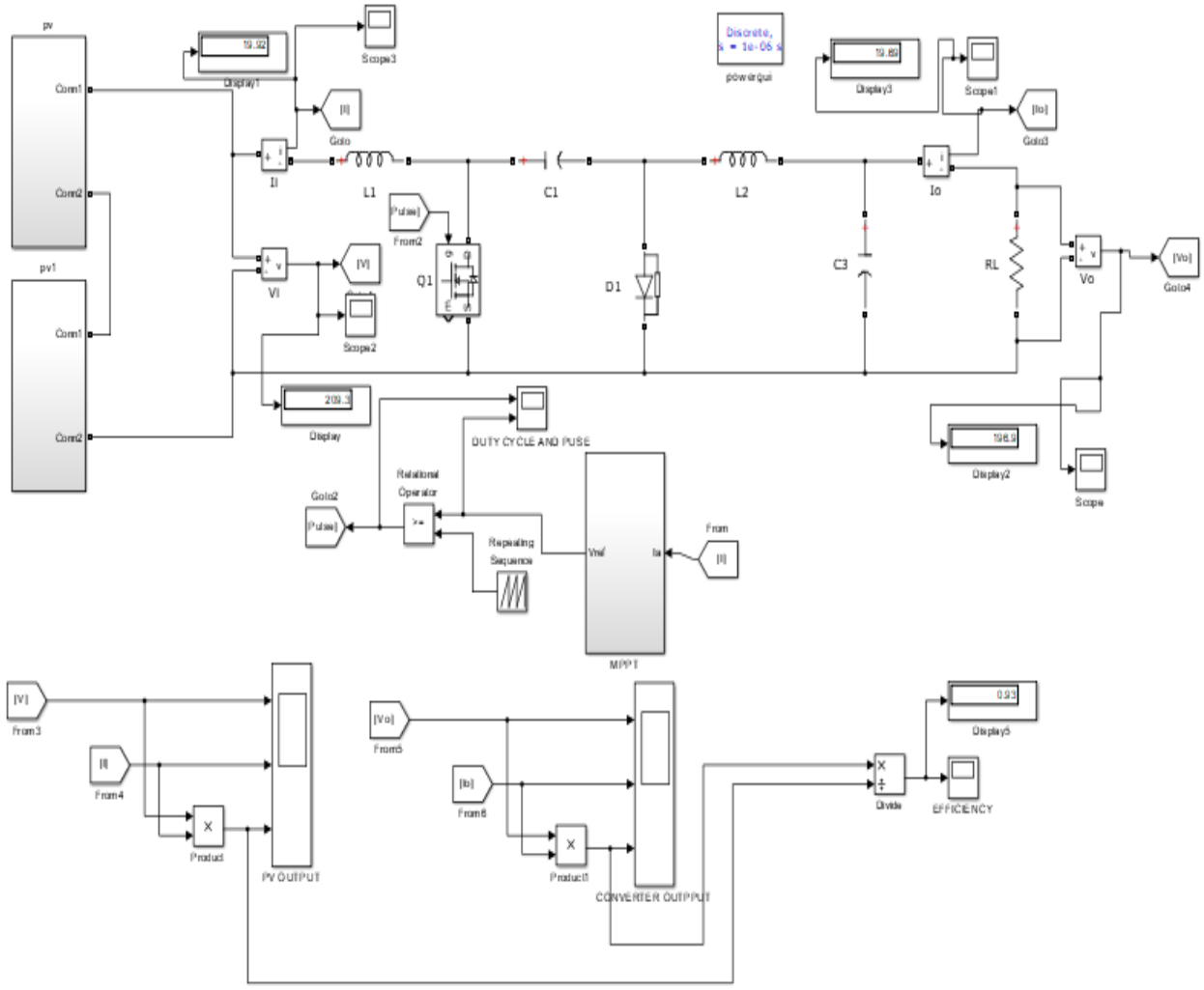

Figure 7 :Constant current MPPT

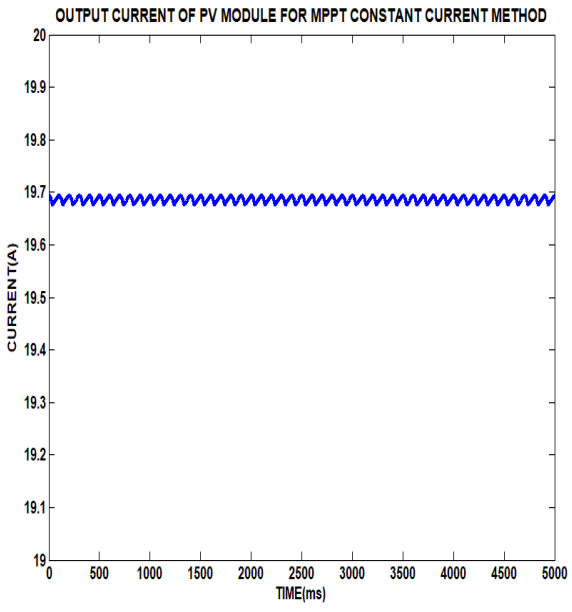

Figure 6

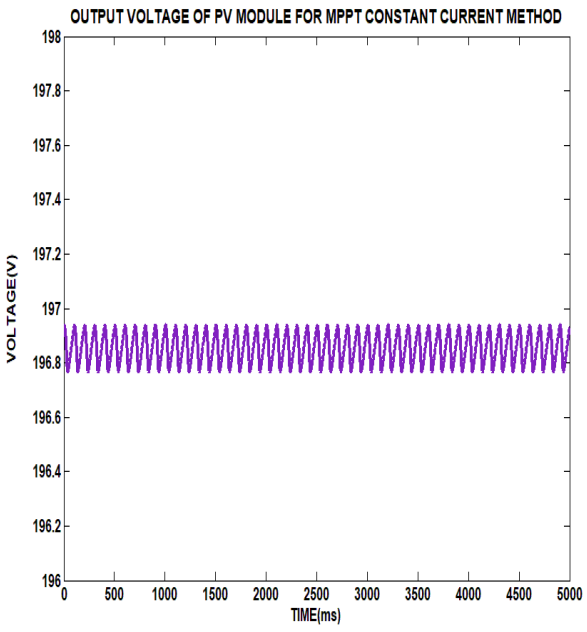

Figure 8

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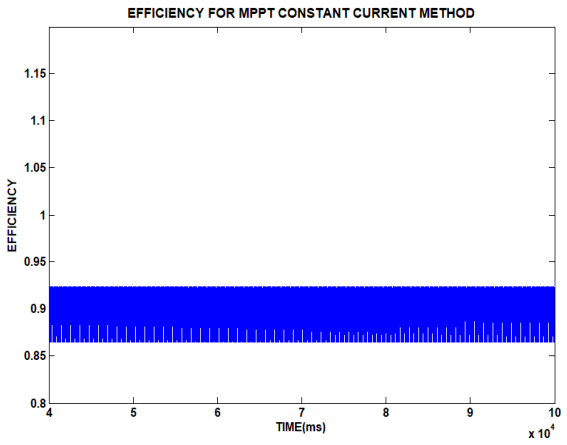

Figure 9

PV Module is designed in the MATLAB Simulink used in the both the MPPT techniques is given below. The PV modules gives input current and input voltage to the cuk converter .Cuk converter is an isolation converter it has two inductance and two capacitance and one freewheeling diode. Freewheeling diode is used to eliminate the negative voltage spike and the load performance will be good.

In this constant current method MPPT technique, the current obtained from the PV module is 19.92A.This is actual value and it is compared with 20A.This 20 A is nothing but reference current used in the embedded MATLAB Simulink model block. If the current which is obtained from the PV modules is greater than the Iref = 20A the delay will happen .Then the delay signal is added with the signal from the memory .Finally we got a reference value and it is compared to triangular wave whose frequency is 10000 Hz. And we finally got the PWM wave or pulse for the IGBT of the cuk converter. The embedded MATLAB Simulink function is given below

```
function y = fcn(u)

%#eml
I=u;
Iref = 20;

if(I>Iref)
    d=-0.001;
else
    d=0.001;
end
y = d;
end
```

In constant current MPPT method we are only using output current of PV modules where as in the perturb P & O technique we are using both the current and voltage which is obtained from the PV modules and the voltage values is 20.4V and current values is 22.18A is stored in the memory unit. The both signal is get compared between the both constant signal and it is given tom the three input one output switch .Finally the signal output obtained in this block is used to produce the PWM wave or pulse for the cuk converter. The input current given to the cuk converter is graph is given below

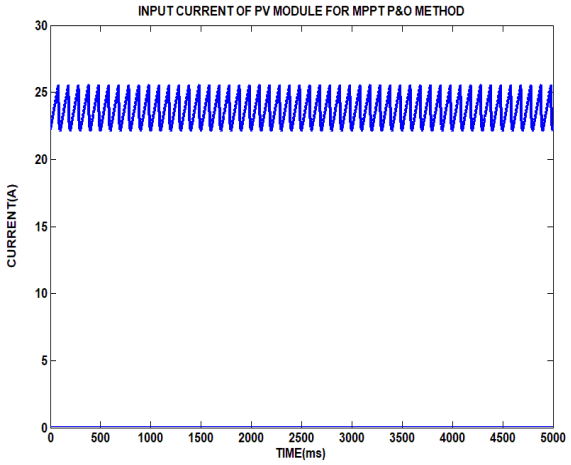

Figure 10

In this previous proposed MPPT technique constant current method the Simulink out give the clear cut Idea about the output current is 19.69 A and output voltage is 196.9 .In this technique the efficiency is poor when compare to the second proposed technique P & O technique .MPPT P& O techniques results are given below. In this constant current method steady state value is always fluctuating when compare to P & O techniques .Only we were using current as the reference in the constant current method so it is very difficult to obtain the proper value of the current in the bad climatic condition .Because the current and voltage produced in PV module that is solar array is mainly due to solar light which is very less in winters. The input voltage given to the cuk converter for P & O technique graph is given below

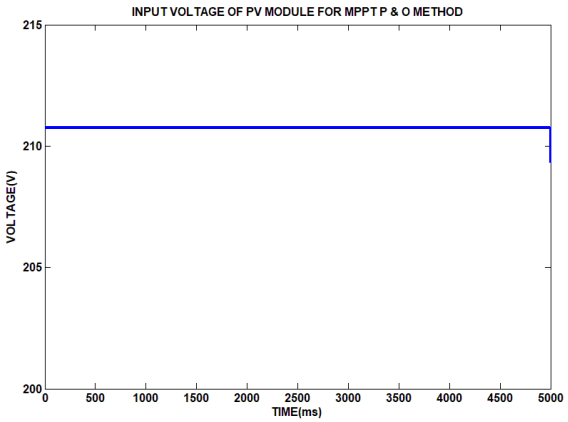

Figure 11

In this propsed model P & O method is also called as hill climibing method.The output current obtained is about to be 20.61A which is much better than the exsisting model constant current MPPT technique.This P & O technique gives much better performance when compare to the constant current method.The P & O technique Results of

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output current and out put voltage are give bellow figure 11 and figure 12

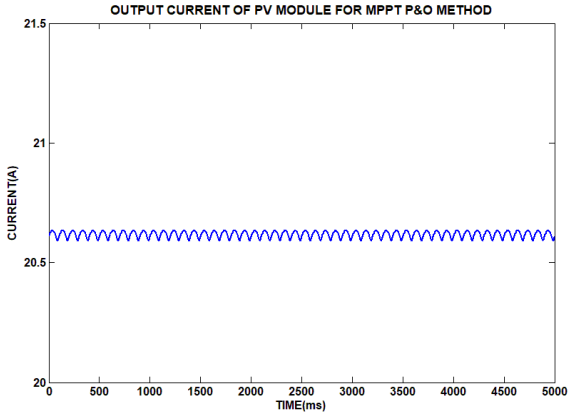

Figure 12

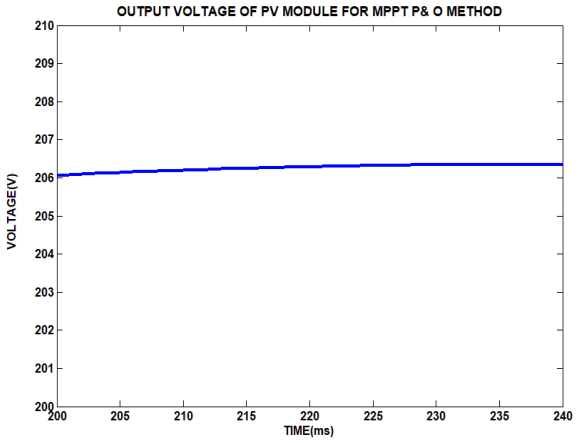

Figure 13

The out put voltage obtained in the P & O MPPT technigue is 206.1V which is higher than the exsisting model constant current MPPT technique method. The results of MPPT P & O techniques used in the paper shows that the P & O techniques has better performance and better voltage regulation and it efficiency was 95 % when compare to the Constant current method. When ever we are adopting a technique we will see cost should be low and user friendly, it should be long lasting and it should give high efficiency. The results of efficiency of the proposed model P & O technique is given bellow the figure 13.

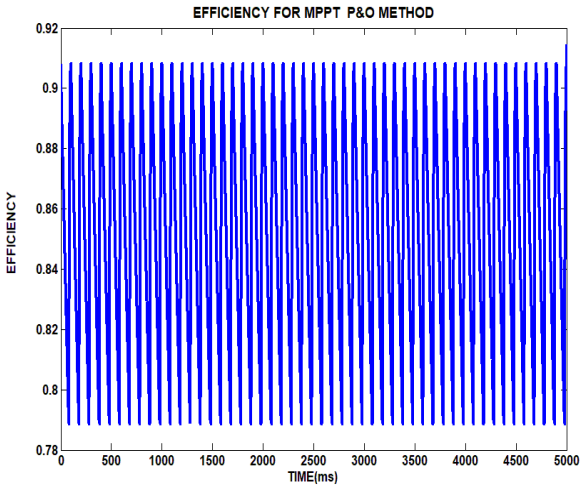

Figure 14

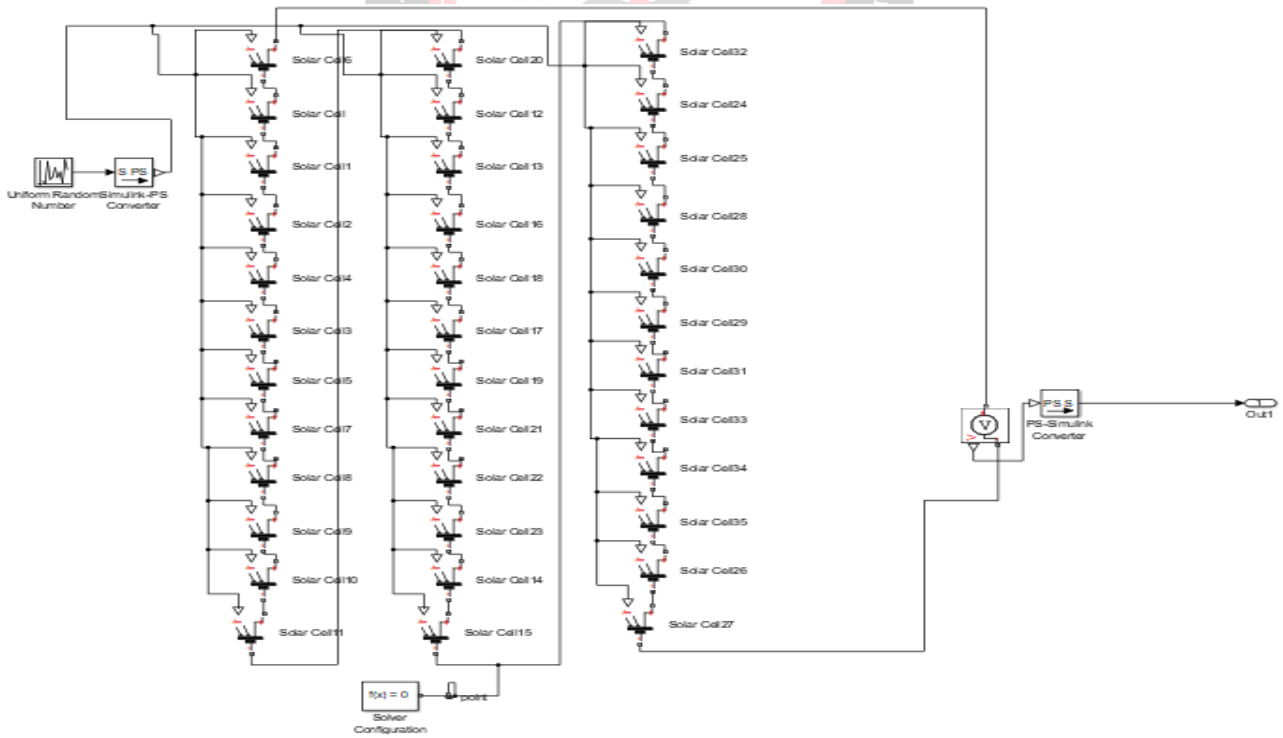

Figure 15: Setup of PV modules

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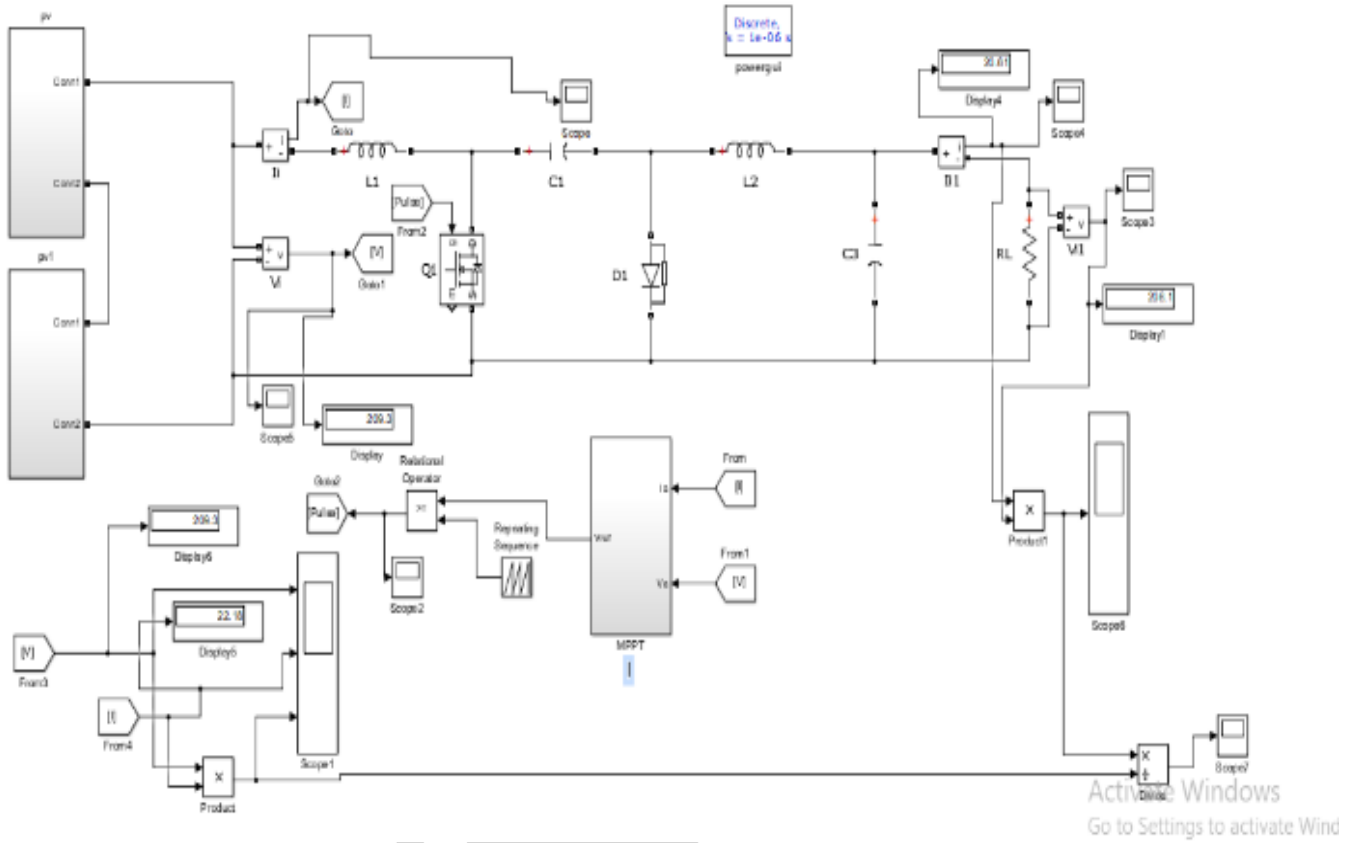

Figure 16 :P& O MPPT model

The setup of PV solar array modules Figure 14 are given above and the MATLAB Simulink also given above figure 15.This shows the P& O Simulink model is simple and it uses the both voltage and current as the reference for building the pulse to the IGBT of the cuk converter. The P & O technique is good in optimizing the values and to overcome the drawbacks of the other MPPT techniques. In this modern era PV modules play an important role as a best renewable source for the countries where the solar energy is more abundant.

V CONCLUSION

This paper mainly give the clear cut of idea of different MPPT techniques and its better performance also. In this paper we have used P & O techniques which much better than the existing model and MPPT technique. The main output in this paper is to improve the efficiency, output voltage and output current of the converter in order to supply the load in any bad whether condition and situation Most commonly used, simplicity and ease in Implementation of the method with good performance is P& O method. An innovative P & O implementation is presented in this paper. In this paper the proposed technique of this the unique performance is presented where it utilizes the rate of change of array of power and treats it by proportional-integral controller to generate the adaptive perturb According to the system changes the advanced P & O techniques gives changes automatically the algorithm and its values. When the proposed technique to be implemented for various controllers it is advised to use PI (Proportional Integral) Controller.

Operation of the system is steady state and there is no oscillations when this technique is done. For the low cost controller operation is achievable by using this technique and there will be low computational burden. This proposed P&O technique is performed with nil preset constants. The P& O method continuously controls the current or the voltage in the direction of increasing power by perturbing the PV voltage or current and observing power. When the compared to P&O and Constant current method optimized value is not satisfied for constant current method there will be ripples are quite more difficult to solve . For MPP tracking P&O method is good and efficiency is also high. For measuring the transient voltage and current values constant current method is difficult to calculate and hence it is not widely used. Based upon the existing control techniques the proposed P & O technique is less complexity .It has been observed that this method has been achieved with no oscillations and with steady state operating condition. In this paper hence by comparing with other proposed algorithms P & O method contribute to the operating conditions. The major sources of losses is from power oscillations available at PV module which is not fully utilized , therefore the proposed PI-P&O technique can be used for high performance operation of the system. Good performance of the system is obtained from this technique

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when there is sudden insolation change in conditions and for transient start up.

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