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COMPARATIVE STUDY OF VARIOUS MPPT TECHNIQUES

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Abstract

The active solar energy harvesting techniques by using the Photovoltaic cells, which converts the solar energy directly into the Electric Energy. The energy harvesting from the Sun is required so that maximum utilization can be taken. In this paper, a model which extract the maximum power of photovoltaic module and increases the efficiency of the overall system in terms of power generated by the photovoltaic module is compared with previously proposed models. All the techniques and concept required and used to design the model are explained and the results are shown in comparative form. The comparison of results shows that a model designed by using dc-dc boost converter with incremental conductance algorithm have maximum power.

Keywords:

Boost converter;
Buck boost converter;
CUK converter;
Photovoltaic cell;
MPPT.

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1. Introduction

To minimize the pollution in the environment, every country in world concentrating on the economic and non-polluted source of energy. So every government focused on solar energy. Solar energy can change easily in the most suitable form of energy i.e. electrical energy. Electricity generated by non-renewable sources are very expensive and generates a lot of pollution in the environment. The high price electricity also evokes electricity theft problem [17]-[30]. All world now concentrating on the economic way of electricity generation by solar. A solar panel is made of the photovoltaic cell. These Panels are a little bit expensive and have less efficiency. If the efficiency of photovoltaic cell increased, the cost of per unit must be optimized. To extend the

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maximum power from the solar panel, many researchers around the world working. They are developing new technology by using electronics components. In figure 1 the photovoltaic module act as a dc source for charging batteries with the help of charge controller and also this power is used to run ac appliances by use of DC to AC converters. The rapid growth in the semiconductor technology and power electronics devices, PV energy is of increasing the interest of researcher in photovoltaic cell electrical power generation. These Modules can be collectively used for large-scale power generation and power transmission as well as for domestic purpose on small scale. Converters, controllers, MOSFET, and Maximum power [13]-[16] point tracking (MPPT) techniques are developed to enhance the efficiency of the photovoltaic cell. In [10] the complete description of the incremental conductance algorithm for MPPT is used with the buck-boost converter. [10] Presented a lot in designing the parameters of a buck-boost converter and also explains that why this converter is better than others. [1] Proposed an incremental conductance algorithm of MPPT with buck converter. [2] Shows the variable incremental conductance method with direct control method using a boost converter to enhance the photovoltaic efficiency. Incremental Conductance MPPT Algorithm Based Solar Photo Voltaic System using CUK Converter [3] also shows good output. Modeling and Simulation of Incremental Conductance MPPT Using Self Lift SEPIC Converter [8] provide a better output voltage and current. In our paper, we are showing performance comparison of various MPPT Techniques.

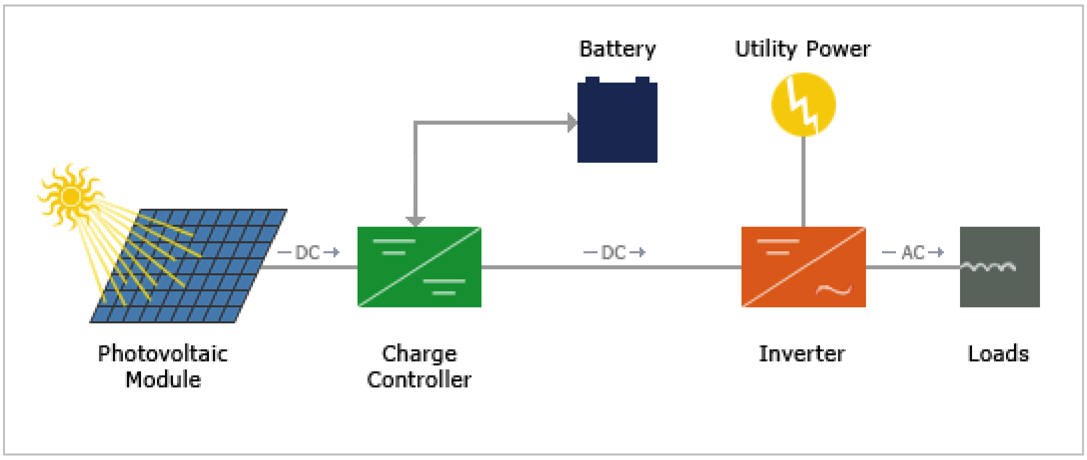


Figure 1.*Basic Photovoltaic System*

2. Motivation

If efficiency of the solar module will be high then it can overtake a large amount increment of solar module of Conventional resources of electricity. It is a very powerful, pollution free and reliable source of electric energy generation to work upon [11].

3. MPPT

MPPT, Maximum Power Point Tracking [3] is the technique of harvesting solar energy. There are number of ways already present and variety of work is in process to extract maximum power from Sun. Among them, Incremental Conductance method used with buck-boost convertor is explained in this paper.

4.Problem Formulation

The energy harvesting from the sun is required so that maximum utilization can be taken. A model is designed which will extract the maximum power of photovoltaic module and increases the efficiency of overall system in terms of power generated by the photovoltaic module. The model will be designed by using dc-dc boost converter with incremental conductance algorithm to achieve maximum power.

4.1. I-V and P-V curves of solar cell

A characteristic I-V (Current-Voltage) curve is shown in [9]. In this curve there is a knee point Pmax, which matches with the maximum power point of power voltage cure where Power is maximum.

A characteristic P-V (Power-Voltage) curve in [9] is shownedthe peak point of the curve is the point where the power will be maximum and it is different for different isolations. Only for a Particular voltage [31-50] power is maximum. The convertor can be buck, boost, buck-boost, SEPIC, Cuk, etc. There are several kinds of convertors present. It depends on our own specification of the solar module and choice of load that which convertor is to choose. The operating point of the load needs not to match with the maximum power point of the characteristic curve of the solar module. So, by adding the buck boost convertor in between the load and the solar panel the impedance of the solar module and the load is matched and try to make the operating point to coincide with the maximum power point.

This impedance change occurs by changing the duty cycle which controlled by the MPPT and hence the pulse width is modulated by MPPT algorithms [7]. Curves in [7] shows the operating point of the load or load line does not match with the maximum power point of the solar module characteristic curves.

4.2. MPPT Techniques

The choice of method [7] depends on the efficiency, accuracy, complexity, speed of tracking [50]-[75], losses of hardware etc. Depending on these factors and also on the type of load chosen any of the above method can be opted. The other IC algorithm [10] requires measurement of solar irradiation S also with voltage- VPV and current- IPV. Figure 2 is representing block diagram of incremental conductance method.

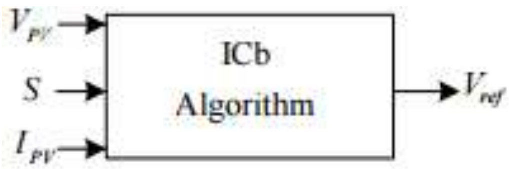


Figure 2. *Incremental Conductance method (IC) block diagram*

5. Methodology

Buck-Boost convertor is used because it can buck as well as boost the voltage levels with the change in the duty cycle accordingly and its efficiency is also high in comparison to other convertors. It also provides the inverted output voltage and also it can be used in non-inverting way by applying an inverting operational amplifier circuit. The details of the methods used are given in below sections. In [10] the dP/dV curve is shown, the slope at the point before and after the maximum power point [4]-[6], which is not equal to zero but, at maximum Power Point it become zero.

Same thing we analyse in the V-I curve in the terms of dI/dV. In [10] it is shown that the dI/dV curve, it is less then or greater then –I/V before and after maximum power point and at maximum power point it is equal to –I/V. The algorithm we are using here is based on the conductance that is I/V of the circuit. The voltage and the current are sensed and then their derivative is calculated or change in present value [75]-[83] and the last value is calculated.

5.1 PV system with MPPT

The circuit diagram in figure3 contains a buck-boost Converter, the circuit of incremental conductance algorithm and PWM with a fixed reference voltage. In the circuit, the components we have used are all ideal and we have neglected the internal resistances of inductors as well as the capacitors. The buck-boost Converter is used for the impedance matching and the incremental conductance method is used for the purpose to decide the location of the operating point of the load.

The specifications and the parameters of the buck-boost Converters are calculated according to the parameters chosen. In the circuit, the solar panel voltage output is taken by using a capacitor of 30µF. This capacitor maintains the voltage constant. The current is drawn by the load accordingly, but due to the buck-boost Converter in between the voltage and current level at the output changes.

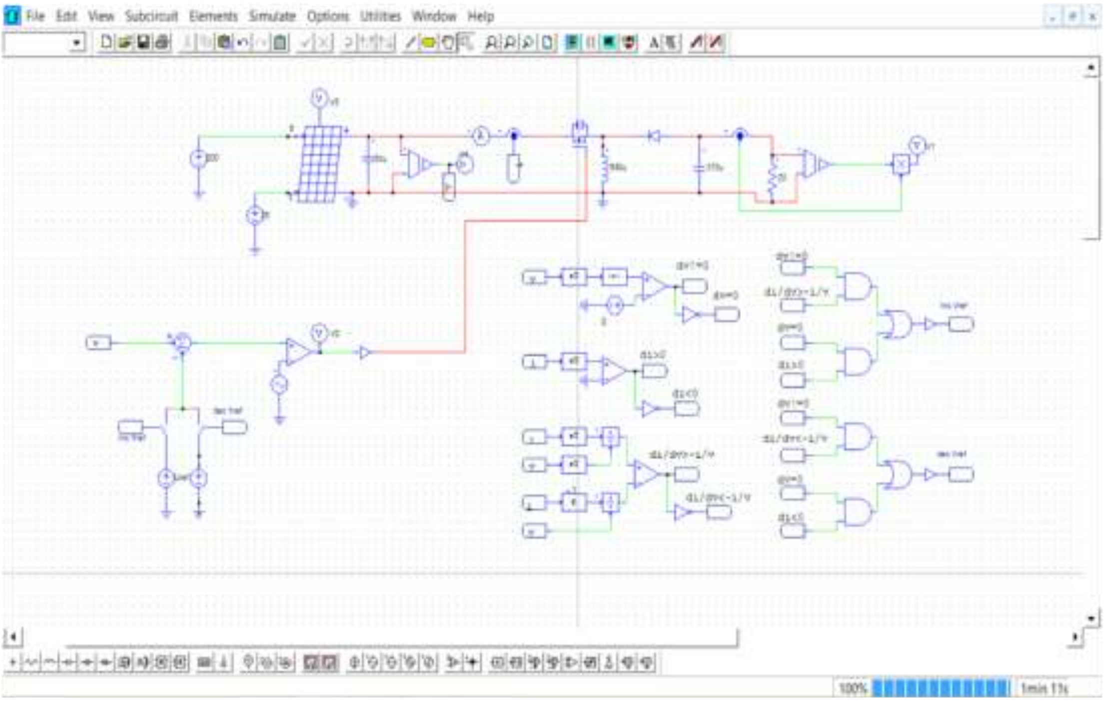


Figure 3.*Circuit diagram of PV system with MPPT Technique*

6. Comparison of MPPT Techniques

In [2] Maximum Power Point is tracked by using the incremental conductance method with boost convertor and the simulation is done with Simulink. The results of output voltages, current and Power are compared with buck Boost converter in Table 1. The output current and voltage waveforms at 100W/m2 of insolation and 23 degree C temperature are shown and compared with the output waveforms of the buck boost convertor at same values of input.

From the figure 4 it is clear that the curves of the buck boost convertor with specifications used in this work are smoother, less distorted and contains less spikes in comparison to the boost convertor used in paper [2]. Also the boost convertor can only boost up the voltage from a fixed value and cannot step down the voltage levels when required. But, the buck boost convertor can step up as well as step down the voltage levels as per the requirement. Although, output of the Buck Boost convertor is inverted in nature but the polarity can be easily changed just by using inverting amplifier whenever required. So the voltage curve shown in figure 4 is the output with inverting amplifier and hence noninverting.

In [3], the Maximum Power Point is tracked by using the incremental conductance method with CUK convertor and simulation is done with Simulink. The results of output voltage and current at a fixed value of solar insolation are compared in figure 5.In [3] the CUK convertor with the incremental conductance algorithm is designed and the output voltage and current of the convertor is analysed when a fixed value of solar insolation is applied to the photo voltaic module.

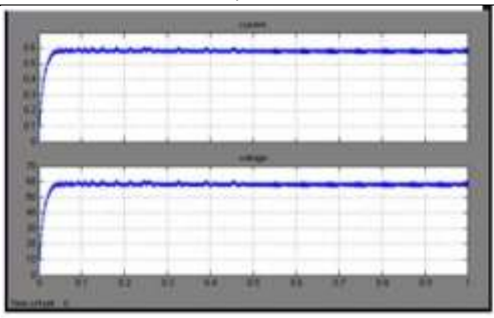
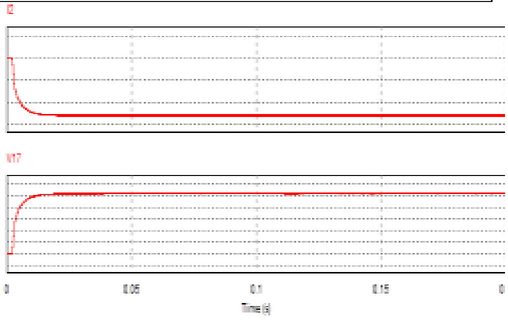
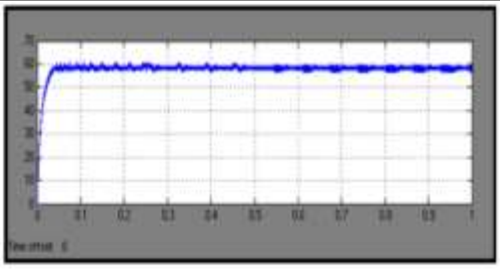
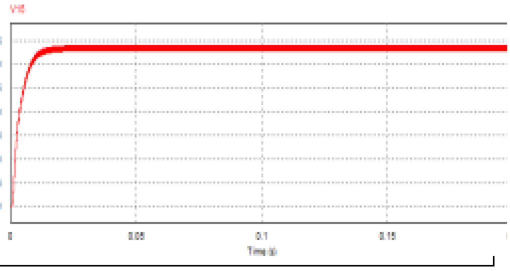
	Method Using Boost Converter in Matlab/Simulink	Buck Boost Converter in PSIM
Current and Voltage Curves		
Power Curves		

Figure 4.*Comparison of Variable Incremental Conductance Method with Direct Control Method Using Boost Converter*

The PV module is 120 watt and hence the voltage level is high. In figure 5both output voltage and output current waveforms of CUK convertor and Buck boost convertor are shown and compared. From figure 5it can be clearly seen that the output voltage and current waveforms of buck boost convertor is more stable than the output waveforms of CUK convertor at a fixed solar insolations. Here the solar insolation value is taken as half sun for both the convertors. The voltage levels depend upon the specifications of the solar module used. Here the module is chosen 60 watts with 36 cells. So the output voltage is 25 V at half sun, but the curve is more stable than the curve in CUK convertor. Also the variation in output waveforms of buck boost convertor is lesser than the variation in CUK convertor. The number of inductive and capacitive elements is also more in CUK converter then the buck boost convertor used here. Hence, buck boost convertor is more economic and efficient than CUK convertor.

In [8] the Maximum Power Point is tracked by using the incremental conductance method with Self lift SEPIC convertor and with SEPIC convertor also. The results of output voltages, current and Power are compared in figure 6.In [8] the Self Lift SEPIC converter output waveforms are shown and compared with the traditional SEPIC convertor output waveforms. The comparison is concluding that the self-lift SEPIC convertor gives better output, more stable and increases the level of Power, Voltage, and Current better than SEPIC convertor. So, here in figure 6the Output voltage, Current and Power Curves with respect to time of the Self lift SEPIC convertor are compared to the Buck Boost convertor output. From figure 6it is clearly seen that the waveforms for both the self-lift SEPIC Convertor and Buck Boost convertor are almost same for similar input values and they are also boosting up the voltage, current and Power levels in similar ratio. But in buck boost convertor the electronic components or elements used are lesser than used in self-lift SEPIC convertor. In self-lift SEPIC convertor, number of inductor is three and also capacitors are three and in Buck Boost convertor only one inductor and one capacitor is there still the output result is similar for both. So, the overall losses will be less in buck boost convertor and also the disturbances and heat generated will be less here. Economy wise also self-lift SEPIC convertor is costly in comparison to buck boost convertor as number of components is more in that. So as whole Buck Boost convertor is more efficient then self-lift SEPIC convertor shown in [8].

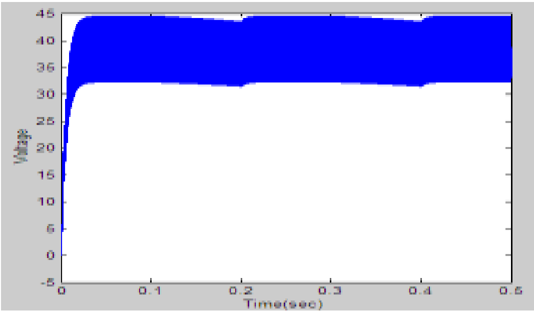
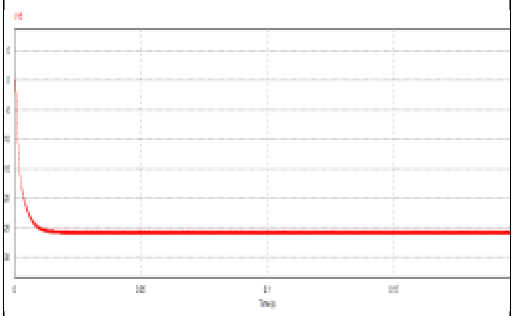
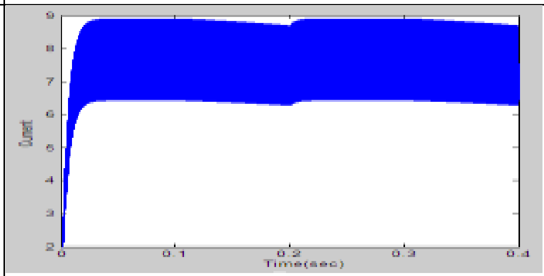
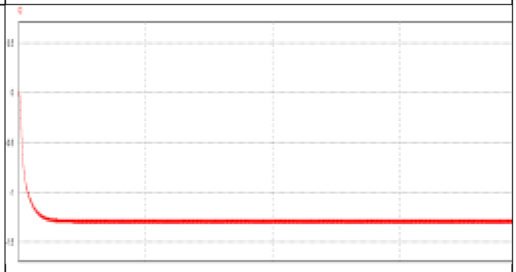
	CUK Converter	Buck Boost Converter in PSIM
Output Voltage		
Output Current		

Figure 5.*Comparison of Incremental Conductance MPPT Algorithm Based Solar Photo Voltaic System using CUK Converter with Buck Boost Converter*

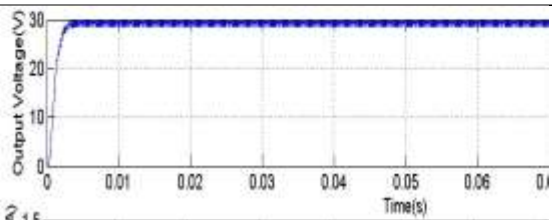
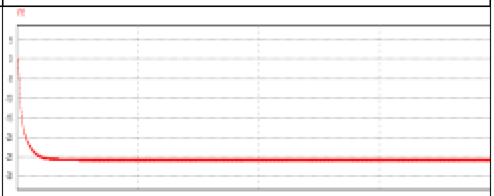
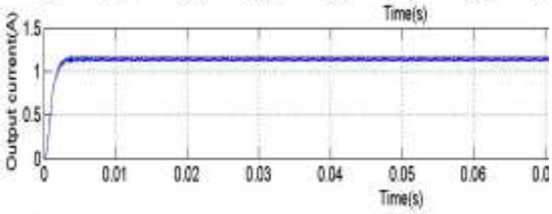
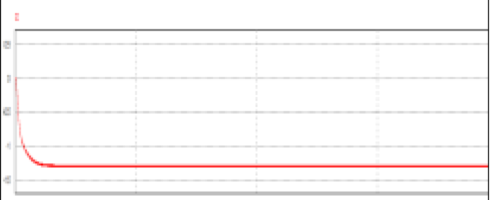
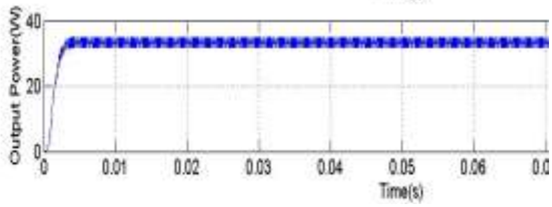
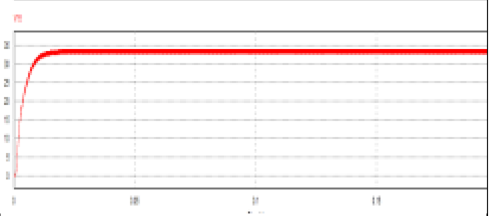
	self-lift SEPIC Convertor	Buck Boost Converter in PSIM
Output Voltage		
Output Current		
Power Curve		

Figure 6.*Comparison of Incremental Conductance MPPT Using Self Lift SEPIC Converter with Buck Boost converter*

7. Conclusion

From comparisons it can be concluded that the output of the buck boost convertor with IC algorithm of MPPT is stable even in changing weather conditions and tracks maximum power efficiently and economically. This system can be maximum efficient if it will be use with the Sun tracker. By using that we can utilize complete solar energy falling on our solar module in complete 12 hours of sun. Also by adding a good controller to the system shown in this thesis, it can be made fully automatic and no voltage from outside will be required. It will behave as a feedback system. Any controller can be added like PI, PID, PLC, also Microcontrollers can be used to vary the duty cycle.

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