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Performance Evaluation of Photovoltaic Cell Using MPPT Techniques

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ABSTRACT: It is very challenging to meet the requirement of electric energy with coal, oil and natural gases. In this paper we use two well-known MPPT algorithms: the perturb-and-observe(P&O)and the incremental conductance(INC)for photovoltaic system (PV)in multilevel capacitor clamped inverter. The present study describe the P-V and I-V characteristics of photovoltaic cell module. The study is analyzed with MATLAB simulator.

KEYWORDS: Photovoltaic (PV), Perturb-and-Observe (P&O), Incremental Conductance (INC),Maximum Power Point Tracking (MPPT), Multilevel Inverter (MLI)

I. INTRODUCTION

Electric energy is indispensable component of economic development, and this goes for all countries. It is relatively very important with increases in connection to technical progress, industrialisation and requirement of modern vantage. Increase in its production translates into better quality of life and the formation of wealth. In 2013 net electricity generation across the globe was 23,322 TWh out which 41% was generated by coal, 5% by oil, 21% by natural gas, 19% by renewable sources 10% by nuclear.It is observed that national renewable market is growing at very fast rate and expected to increase tremendously in approaching decagon of years. Few places and two nations Norway and Iceland are have 100% energy generation from renewable sources and many other countries have set benchmark of achieving 100% renewable energy like ways Denmark Government has decide to go for 100 % switching to renewable energy for energy supply (electricity ,mobility and heating /cooling) by year 2050[1].

As the conventional energy resources available are almost to their depletion, the renewable energy resources come into effect for electric power generation. Renewable contribution 19.2 percent to omnibus power utilization and 23 percent to their production of electrical energy in 2012 and 2013, respectively. This power utilization is split as 9 percent accounting for biomass, 3.8 percent hydro-electric power, 4.2 percent as energy in form of heat, and 2 percent is coming from photovoltaic and CSP. Global funding for renewable energy production totals to more than US$214 billion in year of 2013, U.S and China have extensively invested in solar, hydro, wind. Renewable power is presumptive from resource's which are naturally refill on a human timescale, such as geothermal heat, tidal waves, wind, biomass and solar energy [2].

MPPT technique is used to get the maximum power from the solar PV module and transferring that power to the load. A dc/dc converter use as an interface between the load and the module. By changing the duty cycle the load impedance as seen by the source is varied and matched at the point of the peak power with the source so as to transfer the maximum power. Therefore MPPT techniques are needed to maintain the PV array operating at its MPP. Many MPPT techniqueshave been suggested in the literature; Example are the Perturb and Observe (P&O) methods, Incremental Conductance (IC) methods etc[3].

II. PHOTOVOLATIC CELL SYSTEM

The PV module is the interface which converts light into electricity. Modeling this device, necessarily requires taking weather data (irradiance and temperature) as input variables. The output can be current, voltage, power or other.

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However, trace the characteristics *I*(*V*) or P(*V*) needs of these three variables. Any change in the entries immediately implies changes in outputs. That is why, it is important to use an accurate model for the PV module[4].

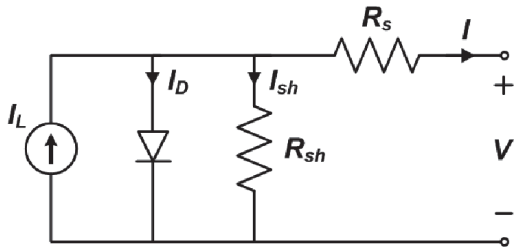

Fig.1Design of PhotoVolatic Cell

III. DC/DC CONVERTER

It Operate as a main part of the MPPT. A DC/DC device (step up/ step down) serves the aim of transferring most power from the PV module to the load. A DC/DC device acts as associate interface between the load, once proposing associate MPP, the foremost job is to settle on and style a extremely economical device, that is meant to control because of main part of the MPPT. The potency of switch-mode dc–dc converters is wide mentioned. Most switching-mode power provides square measure elegant to operate with high potency. Among all the topologies out there, each Cuk and buck–boost converters give the chance to own either higher or lower output voltage compared with the input voltage. Though the buck–boost configuration is cheaper than the Cuk one, some disadvantages, such as discontinuous input current, high peak currents in power parts, and poor transient response, build it less economical[4].

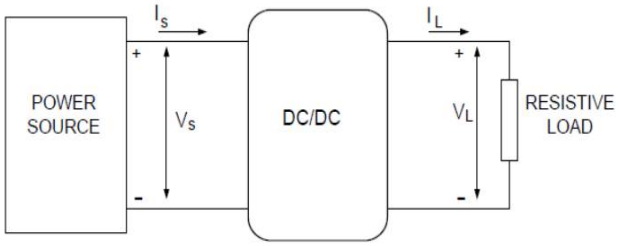

Fig.2 DC-DC Converter

IV. MPPT TECHNIQUES

Perturb and Observe

Introduction of a slight perturbation is done to system in this method to cause the power of solar module changes. If the power is increased due to perturbation then it is continued in that direction. Reaching to peak power the next instant decreases and the perturbation reverses. After reaching steady state the method oscillates around peak point. To keep the power variation small the perturbation size is also kept very small and the method is introduced is a way that is sets reference voltage of module in relation to the peak voltage. To set the particular voltage level the operating point is moved with the helps of PI controller. Under fast varying atmospheric conditions there some loss of power and perturbations also fails to track power.[3,6]

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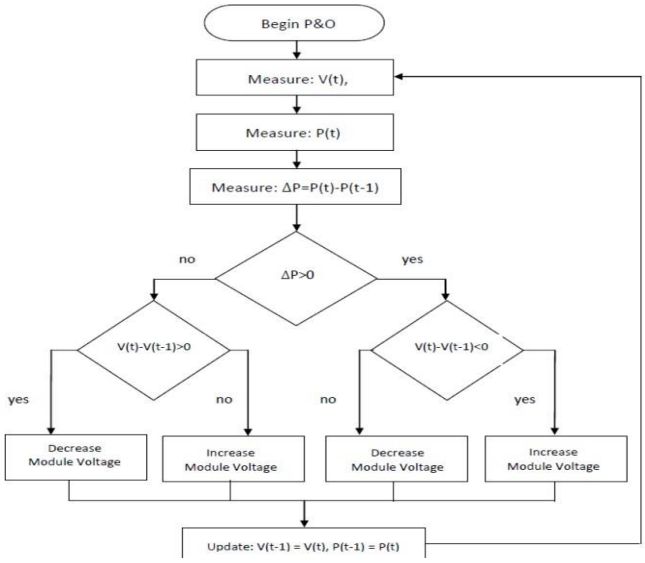

Fig.3 Algorithms For PERTURB And OBSERVE

Incremental Conductance

Perturb & observe algorithm's time complexity is very less but its very close to MPP. It doesn't stop at MPP & perturbing goes on both the directions. Due to this the algorithm reaches very close to MPP and an appropriate error limit is set. A wait function can be used to end up increasing time complexity of the algorithm. Due to change of MPPT method does not take account of rapid change in irradiation level & thus wrong MPP is calculated[5]. To avoid such wrong calculations use of incremental conductance method is done.The Perturb and observe method of fast varying atmospheric condition is overcome by IC method. It can determine MPPT reaching MPP and stop perturbing the operating point. If it is not well processed then perturbed can be calculated by using the relationship between di/dv & I/V. This techniqueis centered on the fact that the slope of the power curve of the panel is zero at the MPP. dp/dv is –ve when MPPT is right of MPP and +ve when MPPT is left of MPP.Advantage of this algorithm is that it can calculate when MPPT reached MPP; as P & O oscillates around MPP. IC can track the rapid increase and decrease of irradiation conditions with higher accuracy than P & O.[9]

(dP/dV)MPP=d (VI)/dV ……1
0=I+VdI/dVMPP…...……..……2
dI/dVMPP = - I/V……...……..…3

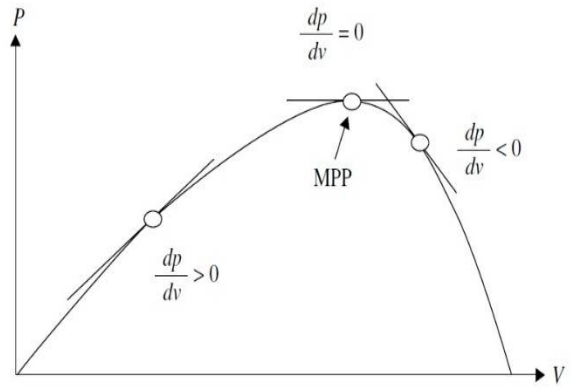

Fig.4 The basis of the IC method

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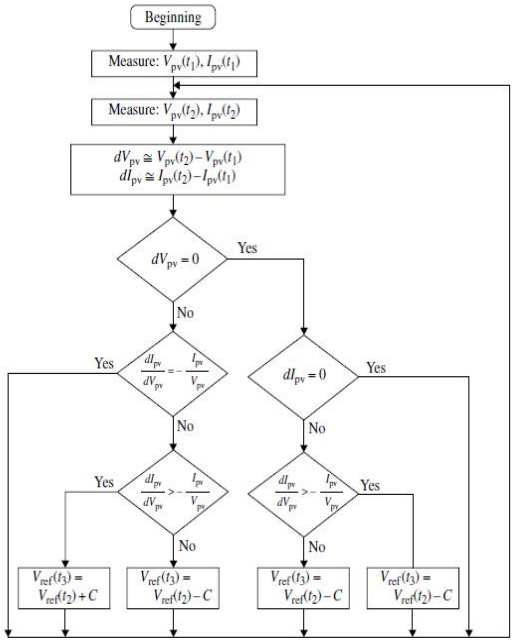

Fig. 5 Incremental conductance method

V. MULTILEVEL INVERTER

The smallest number is multilevel converter topologies is the voltage level of three. The multilevel VSC can work in both rectifier and inverter modes due to presence of bi-directional switches. Due to this reason it is mostly referred as converter in place of inverter in dissertation. Switching of either input or output nodes between multiple levels of voltage or current can be performed with the help of multilevel converter. The THD output approaches to zero when the level reaches to infinity. The limitation of achieving voltage levels is by voltage imbalance problems, voltage clamping requirements, circuit layout and packaging constraints complexity of the controller, and, mainly the capital and maintenance cost.[7,8]

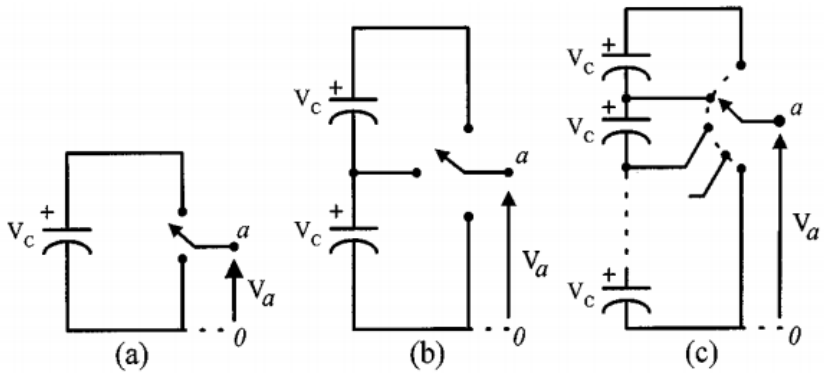

Fig.6 One phase leg of an inverter with (a) two levels, (b) three levels, and (c) n levels

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VI. SIMULATION ENVIRONMENTAND RESULTS

Different parameters i.e. *Voc*, *Isc*, *Vmp*, *Imp* and *Pmp* are given with an initial value for the experimental setup. After setting the values of aforesaid attributes as given in the below mentioned table 1, these are simulated the MATLABenvironment. An equivalent circuit of PV module used in the study is depicted in figure 7.

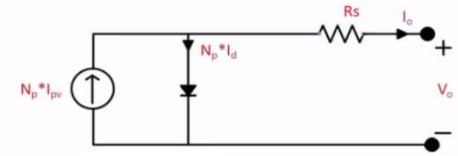

Fig.7 Equivalent circuit of PV module

Table:1 Parameter values for experimental setup

Attribute	Value
Voc (Open Circuit Voltage)	21.8V
Isc (Short Circuit Current)	3.11A
Vmp (Voltage at MPP)	17.44V
Imp (Current at MPP)	2.86 A
Pmp (Power at MPP)	50 W

P-V and I-V characteristics of PV module

Two major characteristics of PV module namely P-V i.e. Power and Voltage and I-V i.e. current and voltage are measured from the simulation. The results reveals that as voltage increases the power of the PV module increases upto a level but after a certain point it decreases very sharply as shown in Figure 8.

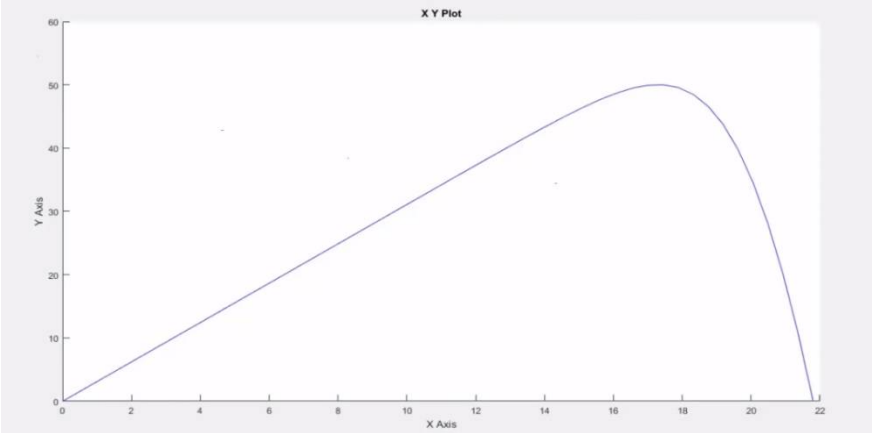

Fig.8 P-V characteristics of PV module.

The curve shown in figure 9 shows I-V characteristics i.e. current and voltage of PV module. The result reveals that with a constant value of current(I) when we increase voltage(V), after a ertain level of vaoltage the current sharply degrade and meet open circuit voltage.

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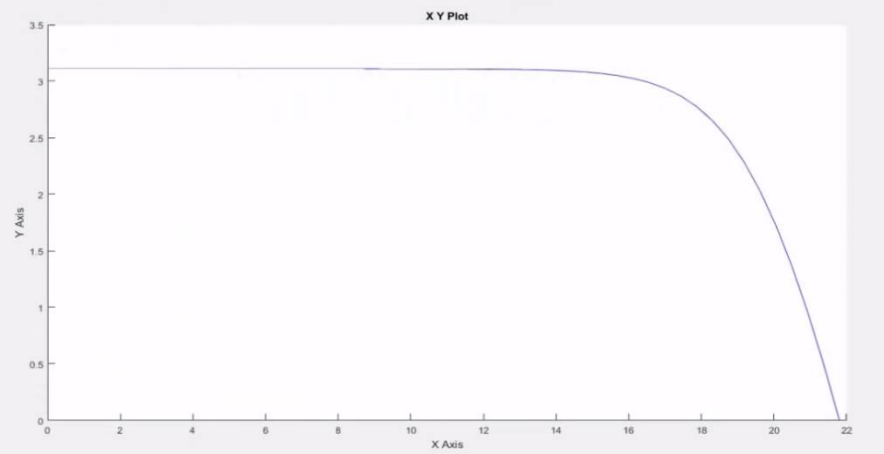

Fig.9 I-V characteristics of PV module.

Figure 10 shows the P-V and I-V characteristics with the varying temperature of PV module. The curve shows the results at 25^{O} C.

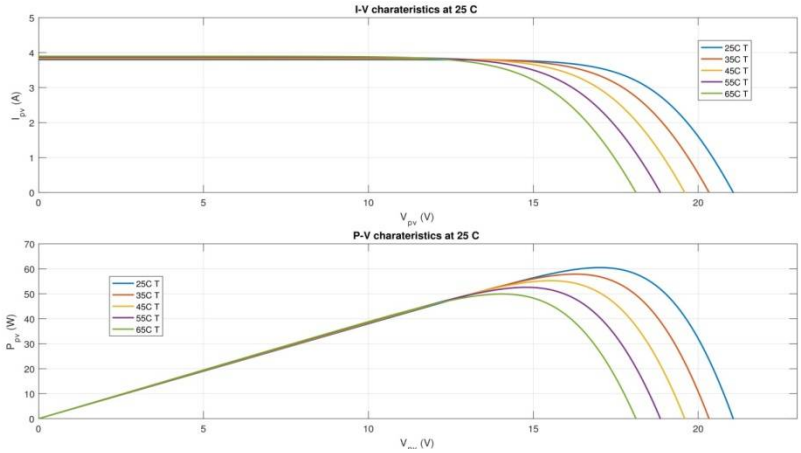

Fig.10P-V and I-V characteristics at varied temperature of PV module.

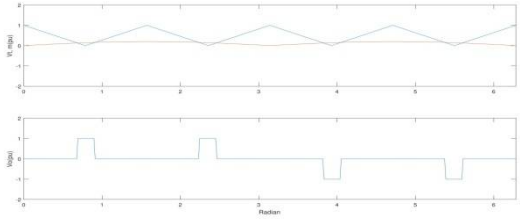

Fig.11 Inverter waveform

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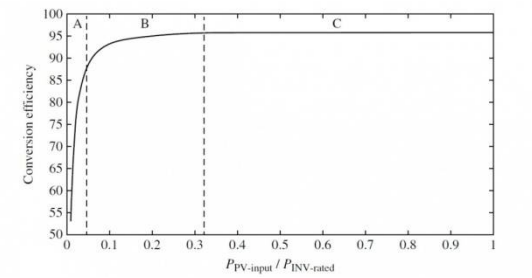

Fig.12Inverter efficiency

VII.CONCLUSION

The technique which is carried out in the present study is effective for MPPT of a solar array. The cuk and buck-boost converter was a major part of this study. The P&O algorithm implemented in the present work has the ability to track the MPP. The results reveals that as voltage(V) increases the power(I) of the PV module increases upto a level but after a certain point it decreases very sharply and with a constant value of current(I) when we increase voltage(V), after a certain level of voltage the current sharply degrade and meet open circuit voltage.

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