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Performance of PV Systems with Power Optimizers and Distributed Power Electronics

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Abstract: -- **In the present day fossil fuels continue to be depleted and climate changes, a problem grows severe day by day. A photo-voltaic (PV) power generation system which uses renewable resources has been extensively used in emergency and generating facility. So overcome these problems we are proposing a new concept called sustainable energy harvesting with the help of boost converter by maximum power point tracking (MPPT) Technology in an ac distribution System by the use of bidirectional inverter. The Bidirectional Inverter input is obtained from the solar power conventional boost converter that efficiently harvests maximum energy from the solar panel. By the use of coupled inductor and switched capacitor technologies to obtain maximum voltage gain, the leakage inductor energy from the coupled inductor can be recycled. The voltage stress on active switch is reduced, which means the coupled inductor employed in combination with the voltage multiplier technique successfully accomplishes the higher voltage gain.**

There are various MPPT techniques among the various techniques we are chosen INC (Incremental Conductance). This will helps to improve the system efficiency by a low voltage rating and low conductance resistance. The duty ratio is modulated by the MPPT algorithm, designing and modelling of the proposed work is carried out and results are verified with the help of MATLAB/Simulink.

Keywords:- **Photo-Voltaic Cell, MPPT, Incremental Conductance Method, Boost Converter, Bidirectional Inverter**

I. INTRODUCTION

One of the major concerns in the power sector is the day-to-day increasing the power demand but the unavailability of enough resources to meet the power demand using conventional energy sources. With the development in power electronics technologies the renewable energy sources utilization become an increasing trend for electrical energy. Renewable energy sources like wind energy and solar energy are the prime energy sources which are being utilized in this regard. The continuous use of fossil fuels has caused the fossil fuel deposit to be reduced and drastically affected the environmental depleting the biosphere and cumulatively adding the global warming. The photovoltaic system is a feasible energy source in research and development work in power system and power electronics. For the better consumption of solar energy a high reliable, low cost, design are required for the PV integrated high step up topologies.

II. METHODOLOGY

The methodology of proposed High Step-up Boost Converter process flowchart as shown in below Figure 1.1 indicates the methodology process used in this research which consist of seven steps.

In order to harvest maximum energy from solar panel and to increase the harvested energy to a optimal level by using high step-up boost converter, in this journey we went with step by step. In first step we did the literature survey on both high step-up boost converter and MPPT controller. In second step we did the analysis of the converter and inverter concepts, in this case high step-up boost converter and bidirectional inverter will performs a better operation. In the third step we did the analysis and comparison of conventional system and the proposed system. In fourth step we constructed a solar high step-up boost converter and its components with the help of Matlab/ Simulink.

III. MAXIMUM POWER POINT TRACKING

The efficiency of solar cell is very low. In order to increase the efficiency, methods are to be undertaken to match the source and load properly. One such method is the Maximum Power Point Tracking (MPPT). This is the technique used to obtain the maximum possible power from a varying source. In photo-voltaic systems the I-V curves are non-linear, thereby making it difficult to be used to power a certain load. This is done by

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utilizing a boost converter whose duty cycle is varied by using MPPT algorithm. A boost converter is used on load side and a solar panel is used to power this converter.

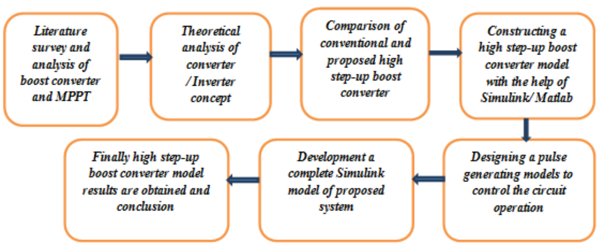

Fig.1: Flow chart of processing high step-up boost converter

IV.INCREMENTAL CONDUCTANCE METHOD

The incremental conductance algorithm of MPPT was developed by K. H. Hussein, I. Muta, T. Hoshino and M. Osakada; however the concept technique was developed by O. Wasyneczuk. They used derivative of conductance to determine the maximum power point (MPP). The MPP is determined by comparing instant conductance I/V to the incremental conductance ΔI/ΔV and the INC technique is based on the fact that slope of P-V curve is zero at MPP. This algorithm performs better than P and O algorithm in rapidly varying environment and is robust.

The incremental conductance method is based on the fact that the slope of the PV array power curve is zero at the MPP also positive on the left of the MPP and negative on the right, as given by the following equation and corresponding characteristics is shown in Fig 5.1.

$$\frac{dp}{dv} = 0, \text{ at MPP}$$

$$\frac{dp}{dv} > 0, \text{ left of MPP}$$

$$\frac{dp}{dv} < 0, \text{ right of MPP}$$

$$\frac{dP}{dV} = \frac{d(V*I)}{dV} = I + V * \frac{dI}{dV} = I + V * \frac{\Delta I}{\Delta V}$$

When the maximum power point reached the slope $\frac{dP}{dV} =$ **0.** Thus the condition would be; $\frac{dP}{dV} = 0$

$$I + V * \frac{\Delta I}{\Delta V} = 0 \quad \frac{\Delta I}{\Delta V} = -\frac{I}{V}$$

The PV array terminal voltage can be adjusted relative to the MPP voltage by measuring the incremental conductance (I/V*)* and instantaneous conductance (Δ*I*/Δ*V*). Once the MPP is reached, the operation of the PV array is maintained at this point unless a change in Δ*I* is noted.

In case of $\frac{dp}{dv} > 0$, the voltage is increased and in case of $\frac{dp}{dv} < 0$, the voltage is decreased to select the Maximum Power Point. Incremental conductance locates maximum power when the incremental conductance equal to the negative of instantaneous conductance. The incremental conductance uses a search technique that changes the reference or duty ratio. So the PV panel voltage V_{PV} changes searches for the condition of the equation and in the condition the maximum power point is found and searching will stop. The incremental conductance algorithm continues to calculate ΔI_{PV} until the result is no longer to zero. At the time the search started again. Incremental conductance algorithm is best suited for the rapidly varying irradiation conditions. The left portion of the PV curve has a positive slope. Here the Incremental conductance greater than instantaneous conductance. If a point corresponding to power lies anywhere in the left portion of PV curve, the voltage should increase to reach maximum power point. Thus the duty ratio of the converter is reduced and maximum power point is reached. Similarly, if a point corresponding to power is located anywhere on the right side of maximum power point, the voltage must reduce and corresponding duty ratio increased to reach maximum power point. The flow chart of incremental conductance algorithm is shown in figure 2.

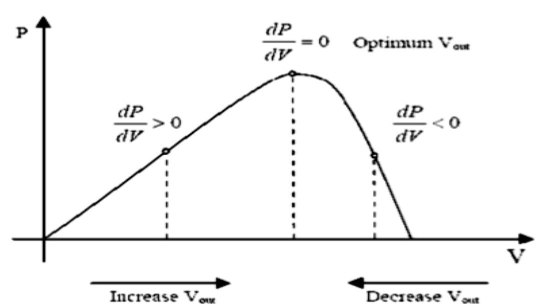

Fig.2: Power - Voltage curve of PV System

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V. SIMULINK MODEL OF SOLAR POWER OPTIMIZER WITH MPPT

The modelling diagram of figure.3 represents the whole PV system with MPPT along with the boost converter and bidirectional inverter has been implemented in the Matlab / Simulink is shown in figure 6.4, the output voltage of solar power converter is linked with a bi-directional inverter and the pulses are supplied for continuous operation of bidirectional inverter by sinusoidal pulse width modulation (SPWM).

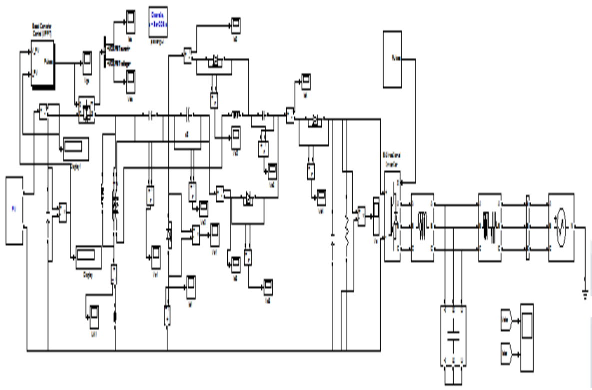

Fig.3: Complete Simulation Model of PV module with MPPT Algorithm for AC Distribution

VI. SIMULATION RESULTS

The simulation modelling of the high step-up boost converter with MPPT controller has been done. Simulation results of required performance of the system in the form of voltage and current waveforms. The simulation waveforms of DC output voltage of solar power converter, gate pulses generated to MOSFET drive with respect to the variation of two parameters such as conductance and incremental conductance by incremental conductance of MPPT controller and finally the voltage and current across the load as follows:

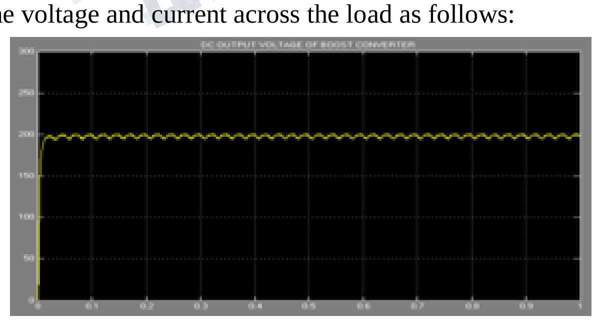

Fig.4: DC Voltage of High Step-Up Boost Converter

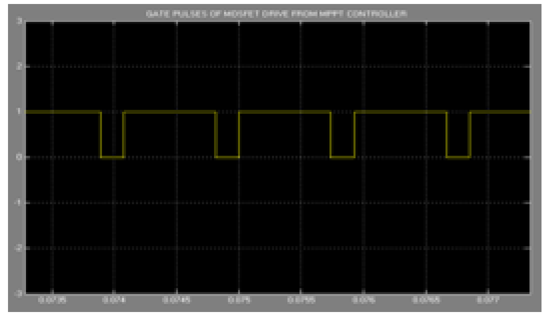

Fig.5: Generation of Gate Signal of Drive Circuit

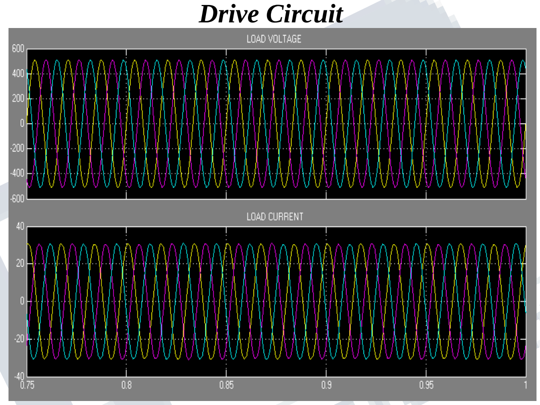

Fig.6: AC Output Voltage and Output Current

VII. CONCLUSION

The high step-up boost converter uses the coupled inductor with an appropriate turn's ratio design and switched-capacitor technology to achieve a high-voltage gain that is 20 times higher than the input voltage. Because the leakage inductance energy of a coupled inductor is recycled and the voltage stress across the active switch S_1 is constrained, the low R_{DS} (ON) of active switch can be selected to improve maximum efficiency up to 96.7%.To minimize the fluctuations and intermittent problems power electronic devices are viable options. Further, energy storage and use of dump load and MPPT could be used for reducing the power fluctuations in PV systems. The highest MPPT accuracy is 99.9% and the highest average accuracy is 97.9% at P_{PV} = 150 W.

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