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Simulation of solar PV Boost converter, MPPT controller and Inverter analysis

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Abstract:-

The demand for energy is increasing nowadays due to the increase in population and to meet their needs. Solar energy is associated with the power and heat of the sun's rays. Solar energy is clean and available in most places. DC-DC converters are power semiconductor devices that act as electronic switches. Design Maximum Power Point Tracking (MPPT) for incremental conduction technology for voltage regulation of the boost converter. The incremental conductivity (IC) method was proposed to overcome the shortcomings of the PO algorithm when subjected to rapidly changing environmental conditions. Check the effectiveness of the proposed boost converter in comparison to the operating point and low output voltage for the PV and regulated voltages obtained from the boost converter. Three-phase inverter using VSC control method to use various GTO, IGBT, MOSFET, ideal switching techniques to get the best results from the method. The simulation results showed that Power (KW), VDC Boost, VDC Inverter, Irradiation (W/m^2), Temperature (Deg. C), Duty Cycle. The MATLAB /Simulation results shown in result section..

Key Words :- DC-DC Converter , MPPT, Incremental conductance technique, boost converter, Inverter, GTO, IGBT, MOSFET.

1Introduction:-

Solar energy is the united with the power and heat of the sun's rays. Solar energy is clean and available in most of the places. Photovoltaic energy conversion is the simple process and a smart method of converting the incident sun irradiance into an electrical energy with the help of solar cells. To achieve the maximum output efficiency condition, a control strategy known as maximum power point tracking (MPPT) is needed to identify the PV operating point that allows extraction of maximum power from the array. Many MPPT methods have been reported, including current mode model, voltage operating mode, Peak converter with Predictive Digital Current Control, Hill Climbing, Incremental Conductance, Perturb and Observe, Particle Swarm Optimization, and Neural Network. These algorithms give better result when the PV modules are subjected to uniform solar irradiation. This process gives only one MPP in its P-V characteristic curve with respect to given temperature and insulation. Many maximum power tracking (MPT) techniques have been considered in the past but techniques using microprocessors with appropriate MPT algorithms are favored because of their flexibility and compatibility with different PV arrays. Although the efficiency of these MPT algorithmic usually high, it drops noticeably in cases of rapidly changing atmospheric conditions. We have to see there is no regulation supply for DC. DC-DC converters consist of power semiconductor devices which are operated as electronic switches. In this paper we used boost converter for regulation of DC-DC supply. Boost converter operation of the switching devices causes the inherently nonlinear characteristic of the DC-DC converter. The output voltage of boost converter alone is usually unstable, oscillates, it has large overshoot and long settling time. Also it is unable to give the desired low voltage input to higher voltage at output side and load variations. Consequently, this converter requires a controller with a high degree of dynamic response. Maximum Power Point Tracing System has been usually applied to the converters because of their simplicity to obtain the desired voltage. It is difficult to account the variation of system parameters and also it produce longer rise time and settling time which in turn influence the voltage regulation of buck converter. Therefore, in this thesis the use of Boost converter to regulated the supply for desirable output voltage.

2 MPPT Incremental conductance Technique:-

The amount of energy generated from a photovoltaic (PV) system depends mainly on the following factors, such as temperature and solar radiation. Given the high cost and low efficiency of a photovoltaic system, it must be operated at a point of maximum power (MPP) that varies with solar radiation or load variation. Maximum Power Point Number Tracking (MPPT) technology has been developed for photovoltaic systems and the main problem is how to automatically find optimum operating points (voltage and current) at maximum photovoltaic power output under changing atmospheric conditions. Most MPPT control strategies rely on the characteristics of the photovoltaic panels in real time. MPPT Controller Analog controllers have traditionally performed MPPT control. However, the use of digital controllers is increasing rapidly because they offer several advantages over analog controllers. First, digital controllers are programmable, so they can implement advanced algorithms with relative ease. It is much easier to code the equation, $x = y \times z$, than to design an analog circuit to do this. For that reason, design modification is much easier with digital controllers.

3 Incremental Conductance Control Algorithm:-

The incremental conductivity (IC) method was proposed to overcome the shortcomings of the PO algorithm when subjected to rapidly changing environmental conditions. With the help of voltage and current measurement, I/V conductance and incremental dI/dV conduction are determined so that the operating voltage can be decided to increase or decrease according to the operating point on the left or right side. MPP respectively.

The incremental conduction method is based on the fact that the slope of the power curve of the photovoltaic array is zero at the MPP, positive on the left side of the MPP and negative on the right, as shown in the following equation 1 -4. Power and voltage Shown in Figure 1.

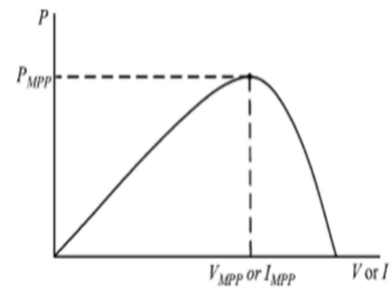

Fig. 1 Characteristic curve of Power and Voltage

Therefore, the MPP can be found out by comparing the instantaneous conductance (I/V) with the incremental conductivity (ΔI/ΔV) as shown in the following flowchart. Vref is the reference voltage at which the PV array is forced to operate. In MPP, Vref is equivalent to VMPP. Once MPP is reached, PV array operation is maintained at this point until no change in I is observed, indicating a change in atmospheric conditions and MPP. The algorithm decreases or increases the Vref to track the new MPP.

$$\frac{dP}{dV} = I\frac{dV}{dV} + V\frac{dI}{dV} = I + V\frac{dI}{dV} = \qquad (1)$$

$$\frac{dI}{dV} < -\frac{I}{V}\ right\ of\ MPP \qquad (2)$$

$$\frac{dI}{dV} = -\frac{I}{V}\ at\ MPP \qquad (3)$$

$$\frac{dI}{dV} > -\frac{I}{V}\ left\ of\ MPP \qquad (4)$$

Knowing that P = VI, the slope of power curve at MPP can be written as:

According to equation 1, the incremental conductance (IC) algorithm provides enough information to locate the MPP. This is made possible by means of the respective measurement and comparison of, dI/dV and I/V.

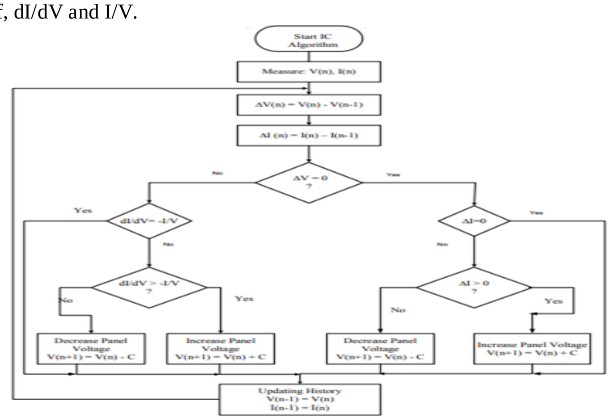

Fig. 2 Flow chart of Incremental conductance Technique

4 BOOST Converter:-

A boost converter is a power converter whose output DC voltage is greater than its input DC voltage. It is a type of Switch Mode Power Supply (SMPS) that consists of at least two semiconductor switches (a diode and a transistor) and at least one energy storage element. A boost converter is sometimes called a boost converter because it "boosts" the source voltage. Since energy must be conserved (P = VI), the output current is less than the source current. The boost converter has the same components as the buck converter, but it produces a higher output voltage than the converter source. Boost converters begin their voltage conversion with current flowing through the inductor (the switch is closed). Then they close the switch without letting the current go through a path other than the diode (it acts as a one-way valve) then the current wants to incident really fast and the only way to do this is to lower its voltage is to amplify (similar to inrush) at the end that connects to the diode and the switch. If the voltage is high enough, it opens the diode, and through a diode, current cannot flow back. This is the very basic concept of a boost converter.

5 MATLAB Simulation And Results：-

The research conducted in this thesis started with analysis of a proposed method for designing, Boost converters. As shown in the schematic diagram of the proposed topology in fig. () .The system is mainly composed of four parts. The first part in the block diagram is solar photovoltaic. The solar photovoltaic generated the electrical power and output of the solar photovoltaic to the DC-DC converter like Boost converter. The second part of the block diagram is high gain DC-DC converters, the input power source at low value is continuously supplied to the main circuit and the on/off modes of the power electronic derived switch is controlled by receiving a proper signal from the MPPT controller depending on the value of the switching frequency.

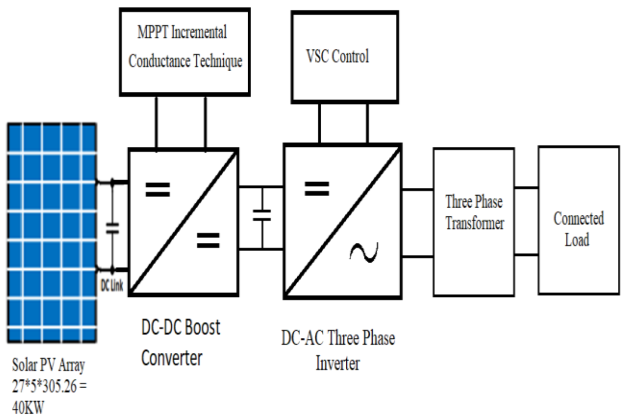

Fig. 3 Block Diagram MPPT incremental conductance technique used at Boost Converter

The third part of the block diagram is three phase inverter. It is convert dc supply to ac supply. The inverter is switched ate different switching techniques like GTO,IGBT,MOSFET, Ideal Switch and the output of the inverter is all switching techniques are shown in table. The fourth Part of the block diagram is output of the inverter is through to load. The inverter is supply power to three phase transformer. Transformer primary winding is connected to star connection with ground and secondary winding are connected to Delta connection. The designing system of this new topology is a combination MPPT Incremental conductance controlled DC-DC fundamental Boost converter and voltage switching capacitors to achieve a high or low voltage ratio.

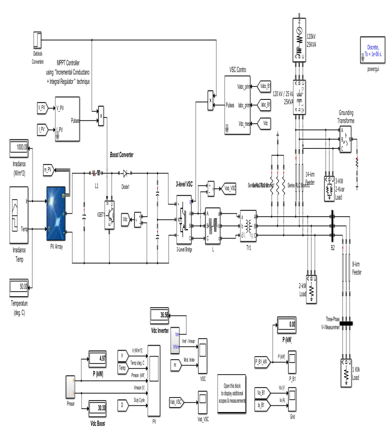

Fig. 4 MATLAB simulation model of MPPT incremental conductance technique used at Boost converter

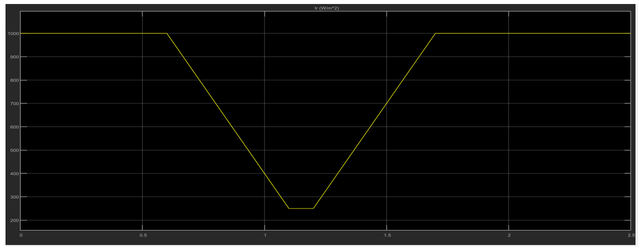

Fig. 5 MATLAB Simulation Result for Boost converter Solar Panel Radiation in Ir(W/m^3)

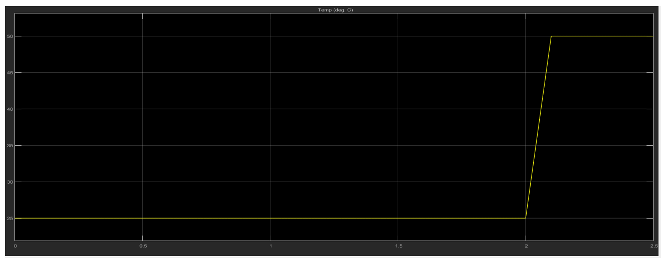

Fig.6 MATLAB Simulation Result for BOOST converter Solar Penal Temperature (Deg. C)

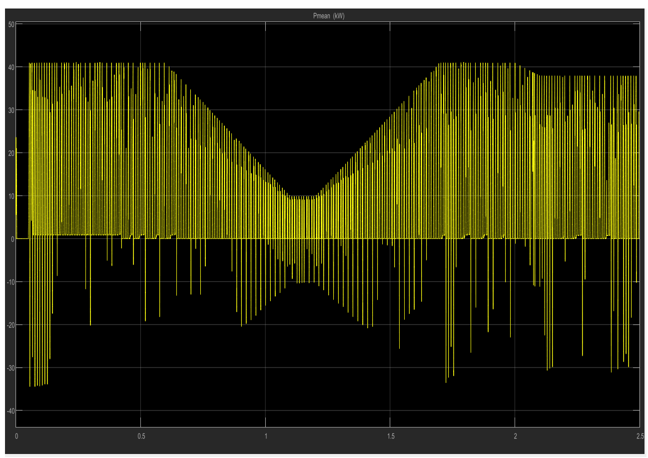

Fig. 7 MATLAB Simulation Result for BOOST converter Solar panel Mean Power in KW

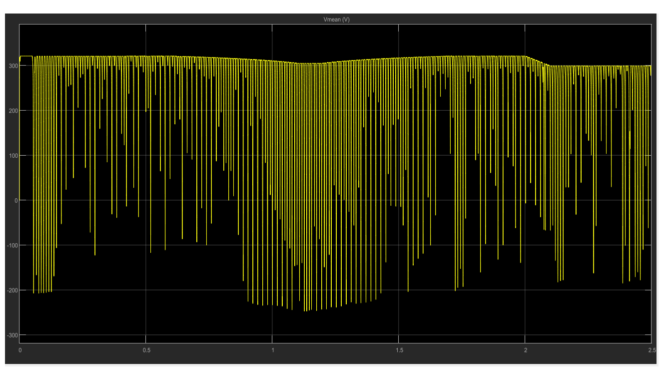

Fig.8 MATLAB Simulation Result for BOOST converter Solar Panel Voltage (Volt)

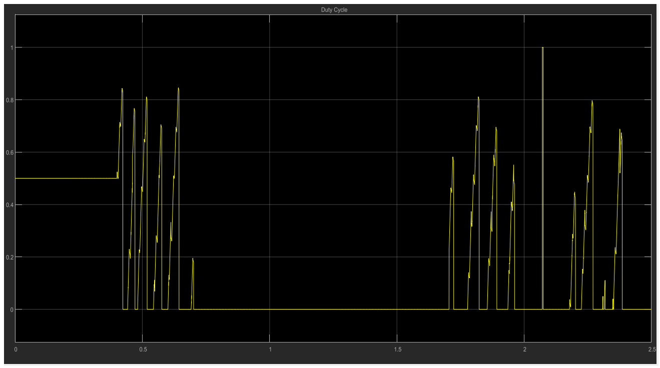

Fig. 9 MATLAB Simulation Result for BOOST converter Duty Cycle from Incremental conductance controller

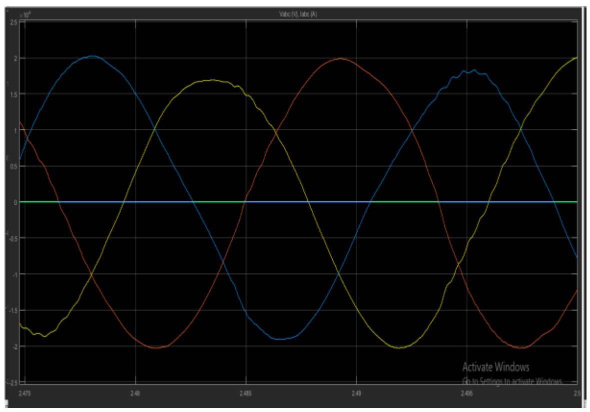

Fig. 10 MATLAB Simulation Result for BOOST converter Mean output Voltage (VOC inverter)

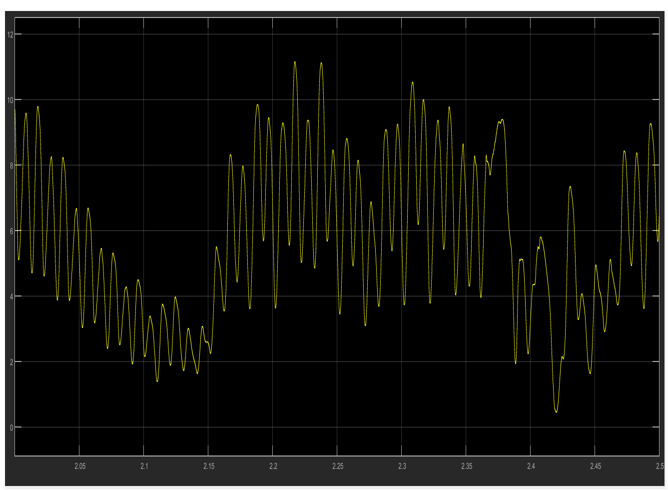

Fig. 11 MATLAB Simulation Result for BOOST converter Power P_B1 (kW)

The table shown the measurement of switching mode for the inverter and solar photovoltaic system.

Table 5.1 IGBT, GTO, MOSFET, IDEAL SWITCH V-I Measurement

MEASUREMENTS:	IGBT	GTO	MOSFET	Ideal switching
'U_Vdc 1	352.91 V 81.90°	249.54 Vrms 81.90°	324.54V 91.21°	305.11 V 74.26°
U A: B2	20268.82 V 81.93°	14332.22 Vrms 81.93°	21456.21 V 21.35°	20450.32 V 21.43°
U B: B2	20268.81 V -158.07°	14332.21 Vrms -158.07°	19456.54V 105.36°	20578.92 V -105.70°
U C: B2	20268.86 V -38.07°	14332.25 Vrms -38.07°	20589.35V -25.32°	19895.23 V -85.72°
V-I Measurement'	20209.23 V 81.35°	14290.11 Vrms -38.65°	17546.23 V 38.21	20101.54 V 75.35°
'I A: B2	64.67 A 81.96°	45.73 Arms 81.96°	54.78 A 96.35°	47.67 A 23.96°
'I B: B2	64.67 A -158.04°	45.73 Arms -158.04°	54.78 A 38.12°	47.67 A -121.04°
'I C: B2	64.67 A -38.04°	45.73 Arms -38.04°	54.78 A -58.21°	47.67 A -12.04°
V-I Measurement'	64.67 A -98.65°	45.73 Arms -98.65°	54.78 A 95.16°	47.67 A -87.65°

Table 5.2 Solar Photovoltaic Details

Solar PV details			
Maximum power W	305.226	Light generated current IL	6.0092
Open Circuit Voltage Voc	64.2	Diode saturation Current Io	63014e-12
Cells Per Module	96	Diode ideality factor	0.94504
Short circuit current Isc	5.96	Shunt resistance Rsh	269.5934
Voltage at maximum power point Vmp	54.7	Series resistance Rs	0.37152
Temperature coefficient of Voc	-0.27	Parallel String	27
Current at maximum power point Imp	5.58	Serices connected modules per string	5
Temperature coefficient of Voc	0.061745		

Table 5.3 MPPT Instrumental conductance detail

PWM Switching frequency	5000
Time window used by MPPT control	200e-6
Initial value of duty cycle	0.5
Step time	0.05
Initial value	0
Final value	1

6 Conclusion :-

In this paper, a solar photovoltaic (PV) system with Boost converter and VSC control based three phase inverter was presented. For the general configuration, a topology of central inverter with individual DC/DC converter was introduced to model the grid interface of solar arrays. Then DC transmission lines were also emulate the short distance between solar arrays and the central inverter. For the distribution network, two segments of distribution lines with three-phase resistive load were developed to simplify the real distribution network.

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