DC – DC CONVERTER INTEGRATED WITH VOLTAGE MULTIPLIER FOR HIGH VOLTAGE GAIN

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Abstract-Power generation from solar PV has long been seen as a clean sustainable energy technology which draws upon the planet's most plentiful and widely distributed renewable energy source – the sun. The high-voltage gain converter is widely employed in many industry applications, such as photovoltaic systems, fuel cell systems, electric vehicles, and high-intensity discharge lamps. DC converters has major significance in the renewable grid -connected power applications because of the low voltage of PV arrays and fuel cells. In order to connect them to the grid the voltage level has to be adjusted according to the electrical standards in the countries. Regular small scale photovoltaic (PV) cells do not provide enough high voltage. These systems generate low output voltage which is not suitable for grid connected power applications. As a result, a high voltage gain converter is essential. By using traditional boost converters, we cannot achieve the required high voltage gain, even with an extreme duty cycle. Therefore modified SEPIC converter is proposed in this paper for achieving high voltage gain by voltage multipliers. The voltage multiplier helps to enhance the voltage gain. This converter has the advantages of simple circuitry, reduced size, and low cost. The proposed topology is able to produce a voltage gain 7 times as that of input voltage at 97% efficiency.

I. INTRODUCT ION

Global energy consumption tends to grow continuous ly. To satisfy the demand for electric power against a background of the depletion of conventional, fossil resources the renewable energy sources are becoming more popular. According to the researches despite its fluctuating nature and weather dependency the capacity of renewable resources can satisfy overall global demand for energy. The international investments and R&D efforts are focused on reduction of Renewable energy production cost. Photovoltaic energy[10] represents one of the most efficient and effective alternative renewable energy sources for many applications, such as Space satellites, remote radio communications, boost stations and marine parts etc.A photovoltaic system, or solar PV power system, is a power system designed to supply usable solar power by the means of the photovoltaic.

Worldwide growth of photovoltaics has been fitting an exponential curve for more than two decades. During this period of time, photovoltaics (PV), also known as solar PV, has evolved from a pure niche market of small scale applications towards becoming a mainstream electricity source. When solar PV systems were first recognized as a promising renewable energy technology, programs, such as feed-in tariffs, were implemented by a number of governments in order to provide economic incentives for investments. For several years, growth was mainly driven by Japan and pioneering European countries. As a consequence, cost of solar declined significantly due to improvements in technology and economies of scale, even more so when production of solar cells and modules started to ramp up in China. Since then, deployment of photo voltaics is gaining momentum on a worldwide scale, particularly in Asia but also in North America and other regions, where solar PV is now increasingly competing with conventional energy sources as grid parity has already been reached in about 30 countries.

It comprises of an collection of several collections. Including solar panel to absorb and control sunlight into electricity, a solar inverter to modify the electric current from DC to AC, as well as mounting, cabling and other electrical accessories to set up a working system. The combination of PV with dc-dc converters are now widely used in many applications. A dc-dc boost converter is required to improve the low voltage at the PV cell into the high voltage at dc load.

II. EASE OF USE

A. Conventional boost converter[7-10], employed in these applications have several advantages such as simple structure, continuous input current, and reduced switch voltage stress, but it is very difficult to obtain high voltage conversion ratio and high efficiency simultaneously .This is due to the existence of parasitic resistances, which leads to inherent degradation in the step-up ratio and efficiency as the operating duty cycle increases.

B. Maintaining the Integrity of the Specifications

In this paper, the topology employing modified SEPIC converter integrated with voltage multiplier is presented which increases static gain equal or higher than 7 times with reduced switch voltage. Apart from the conventional topology the new topology has more desired Characteristics. In the conventional topology hard switching operation is used. Due to several disadvantages of such operation, they cause extreme switching as well as conduction losses. By implementing soft switching techniques, such losses can be decreased significantly.

The step-up stage normally is the critical point for the design of high efficiency converters due to the operation with high input current and high output voltage, thus a careful study must be done in order to define the topology for a high step - up applications. Some classical converters with magnetic coupling as fly back or current-fed push-pull converter can easily achieve high step-up voltage gain. However, the power transformer volumes are a problem for the development of a compact converter. The energy of the transformer leakage inductance can produce high voltage stress, increases the switching losses and the electro-magnetic interference (EMI) problems, reducing the converter efficiency.

The main objective is to design a high-efficiency dc-dc converter with high voltage gain and reduced switch stress to provide a stable constant dc voltage. To achieve this goal, the manipulation of a voltage multiplier is adopted to increase the voltage gain . Moreover, the problem of the leakage inductor and the reverse recovery in the conventional boost converter also can be solved so that it can achieve the aim of high-efficiency power conversion. In addition, the feedback control methodology is utilized in the proposed converter to overcome the voltage drift problem of the power source under the variation of loads

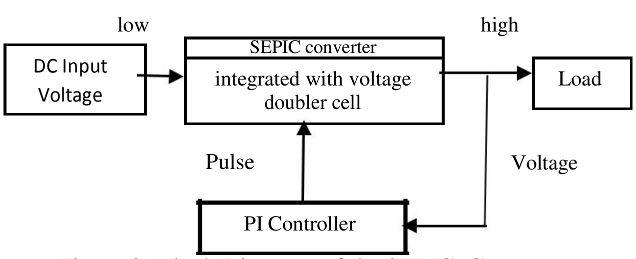

Figure 2: Block Diagram of the SEPIC Converter integrated with Voltage Multiplier

The single-ended primary-inductor converter (SEPIC) is a type of converter allowing the electrical potential (voltage) at its output to be greater than, less than, or equal to that at its input. The output of the SEPIC is controlled by varying the duty cycle of the control MOSFET.A SEPIC is essentially a boost converter followed by a buck-boost converter, therefore it is similar to a traditional buck-boost converter, buthas advantages of having non-inverted output (the output has the same voltage polarity as the input), using a series capacitor to couple energy from the input to the output and being capable of true shutdown: when the switch is turned off, its output drops to 0 V, following a fairly hefty transient dump of charge.

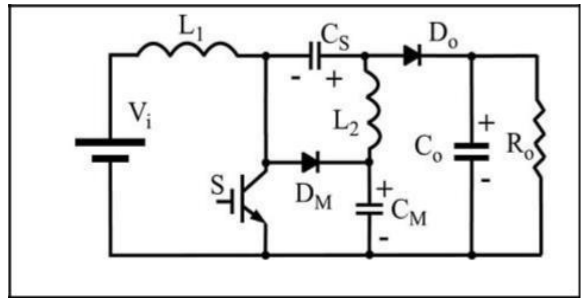

Figure 1 Circuit of SEPIC Converter

This paper presents the idea of implementing the SEPIC converter with voltage multiplier using matlab software. After the system is built and simulated , the result is analyzed and performance parameters are analyzed such as voltage gain and efficiency.

The schematic diagram for a modified SEPIC[1],[2],[3],[4] is shown in the figure 3. As with other switched mode power supplies (specifically DC-to-DC converters), the SEPIC exchanges energy between the capacitors and inductors in order to convert from one voltage to another. The amount of energy exchanged is controlled by switch S1, which is typically a transistor such as a MOSFET. MOSFETs offer much higher input impedance and lower voltage drop than bipolar junction transistors (BJTs), and do not require biasing resistors as MOSFET switching is controlled by differences in voltage rather than a current, as with BJTs.

A SEPIC is said to be in continuous-conduction mode if the current through the inductor L_1 never falls to zero. During a SEPIC's steady-state operation, the average voltage across capacitor C_1 (V_{C1}) is equal to the input voltage (Vin). Because capacitor C_1 blocks direct current , the average current through it (I_{C1}) is zero, making inductor L_2 the only source of DC load current. Therefore, the average current through inductor L_2 (I_{L2}) is the same as the average load current and hence independent of the input voltage.

The input voltage can be expressed as:

$$V_{IN} = V_{L1} + V_{C1} + V_{L2}$$

Because the average voltage of V_{C1} is equal to V_{IN}. Since the voltages are the same in magnitude, their effects of the mutual inductance will be zero, assuming the polarity of the windings is correct. Also, since the voltages are the same in magnitude, the ripple currents from the two inductors will be equal in magnitude. The average currents can be summed as follows

$$I_{D1} = I_{L1} - I_{L2}$$

A. *Continuous Mode*

When switch S1 is turned on, current I_{L1} increases and the current I_{L2} goes more negative.The energy to increase the current I_{L1} comes from the input source. Since S1 is a short while closed, and the instantaneous voltage V_{C1} is approximately V_I, the voltage V_{L2} is approximately $-V_I$. Therefore, the capacitor C_s supplies the energy to increase the magnitude of the current in I_{L2} and thus increase the energy stored in L_m. The easiest way to visualize this is to consider the bias voltages of the circuit in a d.c. state, then close S_1.

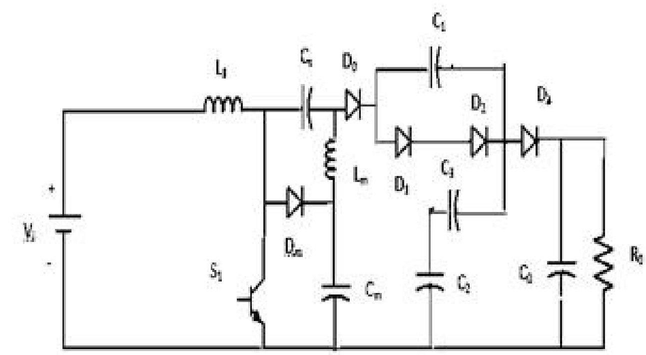

Figure 3 Modified SEPIC Converter Integrated with Voltage Multiplier

When switch S_1 is turned off, the current I_{Cs} becomes the same as the current I_{L1}, since inductors do not allow instantaneous changes in current. The current I_{Lm} will continue in the negative direction, in fact it never reverses direction. It can be seen from the diagram that a negative I_{Lm} will add to the current I_{L1} to increase the current delivered to the load. Using Kirchhoff's Current Law, it can be shown that $I_{D0} = I_{Cs} - I_{Lm}$. It can then be concluded, that while S1 is off, power is delivered to the load from both L_m and L_1. C_s, however is being charged by L_1 during this off cycle, and will in turn recharge L_m during the on cycle.

Because the potential (voltage) across capacitor C_s may reverse direction every cycle, a non -polarized capacitor should be used. However, a polarized tantalum or electrolytic capacitor may be used in some cases, because the potential (voltage) across capacitor C_s will not change unless the switch is closed long enough for a half cycle of resonance with inductor L_m, and by this time the current in inductor L_1 could be quite large.

The capacitor C_s is required to reduce the effects of the parasitic inductance and internal resistance of the power supply. The boost/buck capabilities of the SEPIC are possible because of capacitor C_s and inductor L_m. Inductor L_1 and switch S_1 create a standard boost converter, which generates a voltage (V_{S1}) that is higher than V_I, whose magnitude is determined by the duty cycle of the switch S_1. Since the average voltage across C_s is V_I, the output voltage(V_O) is $V_{S1} - V_I$.

If V_{S1} is less than double V_I, then the output voltage will be less than the input voltage. If V_{S1} is greater than double V_I, then the output voltage will be greater than the input voltage.

B. Discontinuos Mode

A SEPIC is said to be in discontinuous -conduction mode or discontinuous mode if the current through the inductor L1 is allowed to fall to zero.

II. VOLTAGE MULTIPLIER

Here two capacitors are simultaneously charged to the same voltage [6]in parallel. The supply is then switched off and the capacitors are switched into series. The output is taken from across the two capacitors in series resulting in an output double the supply voltage. There are many different switching devices that could be used in such a circuit, but in integrated circuits MOSFET devices are frequently employed.

III. PI CONTROLLER

The simplest way to maintain a constant output is to use a feedback loop that will change the output automatically instead of by manual control (using visual feedback from a voltmeter). The feedback loop should be able to increase the duty cycle to raise the output when the output is too low and decrease it when the output is too high. To do this, the output will need to be compared to a reference voltage which remains constant even if the input changes. The error between the output and the reference voltage is then amplified and added to a set bias voltage. The resulting voltage is then used as the control voltage for PWM[11]. When the output is too low, the amplified error increases which causes the control voltage to increase. The increase in control voltage increases the duty cycle until the output is correct.

When the output is too high, the amplified error becomes negative which decreases the duty cycle to correct output. Both of these scenarios work together to constantly make slight adjustments to the duty cycle so that the output remains stable.

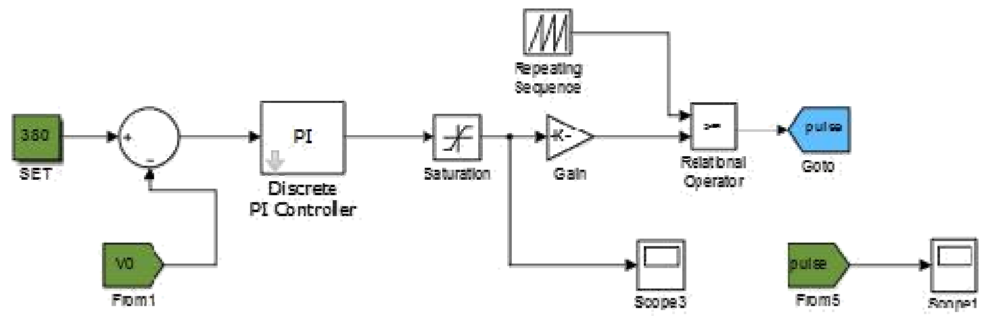

Figure 4 PI Controller

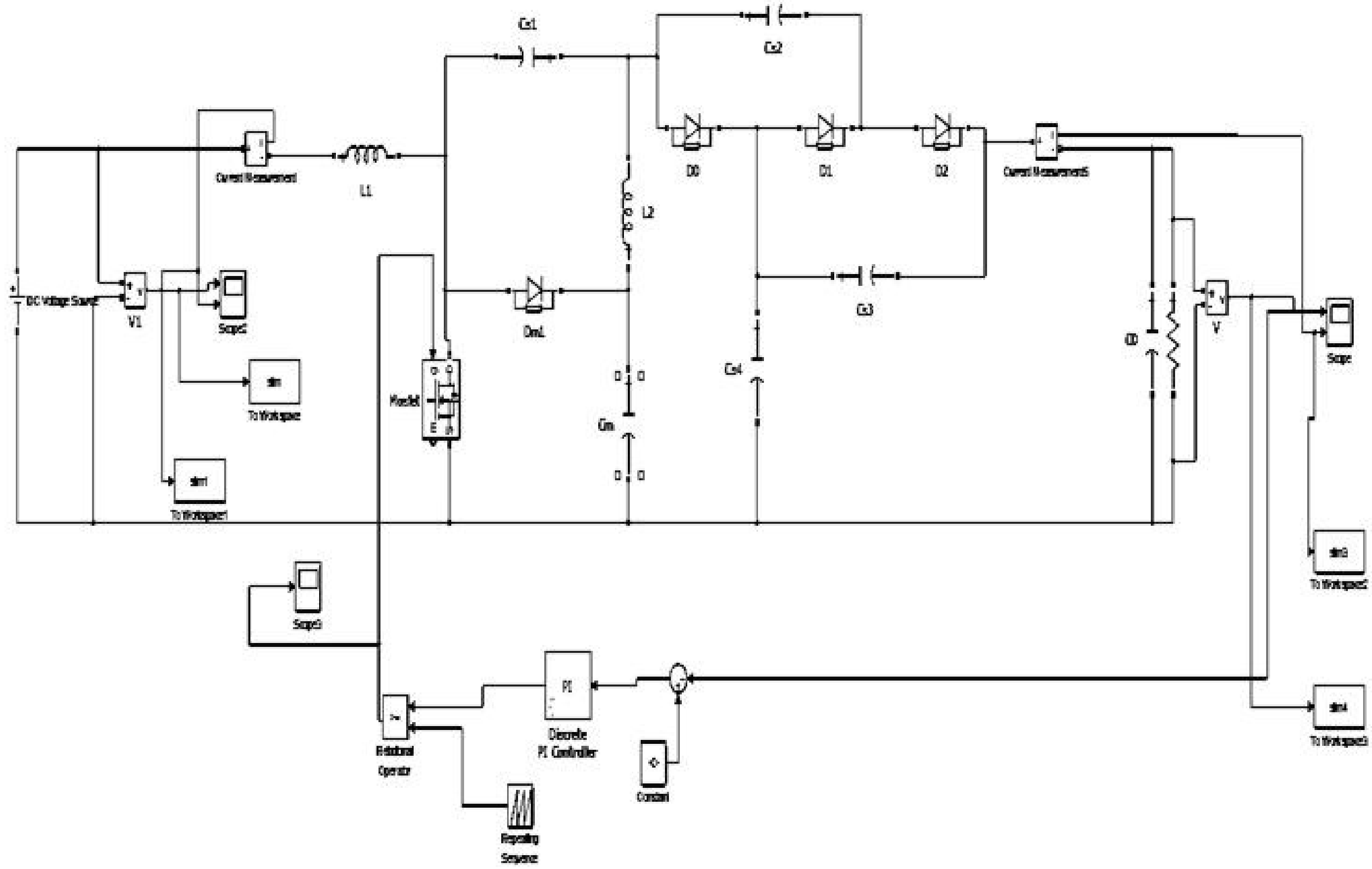

Figure 5 Simulink Model of SEPIC Converter integrated with Voltage Multiplier

Input for the system is from the PV module which is 100 volt give to both Conventional Boost Converter and the Modified SEPIC converter integrated with voltage Multiplier and the output is analyzed in the simulation work. Sim Power Systems uses the Simulink environment, allowing you to build a model using simple click and drag procedures. Not only can you draw the circuit topology rapidly, but your analysis of t he circuit can include its interactions with mechanical, thermal, control, and other disciplines. This is possible because all the electrical parts of the simulation interact with the extensive Simulink modeling library

Since Simulink uses MATLAB as its computational engine, designers can also use MATLAB toolboxes and Simulink block sets.

The output for both the sytem is given below the result and difference between them in tabulated in table 1. As shown the output is much higher when compared to the input from the PV module. This can be compared form the output obtained in the graphs below.

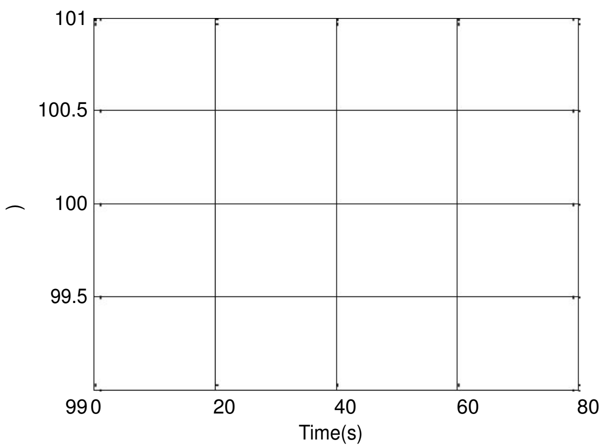

Figure 6 Input Voltage for Conventional and SEPIC Converter

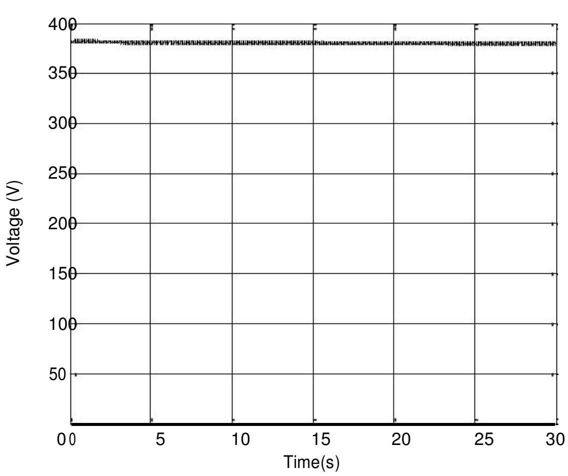

Figure 7 Output Voltage of Conventional Converter

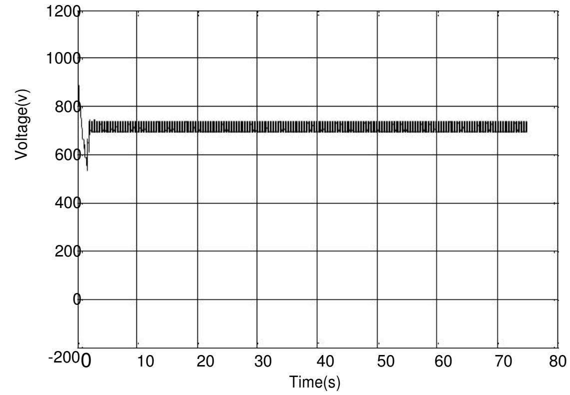

Figure 8 Output Voltage of SEPIC Converter

S.NO	OBTAINED RESULTS		
	CONVERTER TYPE	INPUT	OUTPUT
1	Boost Converter Integrated With Voltage Multipier	100V	380V
2	SEPIC Converter Integrated With Voltage Multiplier	100V	750V

Table 1 Comparison Results

The simulation ressult for both the existing system and proposed system is given above.This gives a clear idea on the change in output which is varied from 380v to 750v accordingly .The modified SEPIC converter integrated with voltage multiplier gives the ideal change in the output.

IV. CONCLUSION

In the paper, SEPIC converter along with voltage multiplier achieves high voltage gain and improved efficiency. Comparisons are made between the proposed system and the existing system. Compared to the previous topology the proposed converter have higher voltage gain and efficiency, low voltage stress along the semiconductor devices, and continuous input and output current. Therefore, the proposed converter are competitive alternative for practical applications where high voltage transfer gain is demanded, such as renewable energy systems with simple structure and high efficiency. Finally, simulation and experimental results are analyzed.

V. REFERENCES

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