ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Special Issue 5, March 2016

Implementation of Modified SEPIC Converter for Stand-Alone PV Applications

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ABSTRACT: This paper presents the analysis of modified Single Ended Primary Inductor Converter converter(SEPIC) with high static gain for renewable energy application(PV). This topologies presents low switch voltage and high efficiency for low input voltage and high output voltage applications. The detailed analysis of with and without magnetic coupling of a SEPIC Converter and controls the charging and discharging interval of energy storage elements for various load operating conditions using Bi directional dc-dc converters were presented. During open and closed loop study, rectifier operation is carried out with diode rectifier and DC – AC conversion is done by using an inverter powered by PWM pulses. The simulation is carried out using MATLAB/SIMULINK and harmonic results were taken for various voltages.

KEYWORDS: SEPIC converter ,High static gain photovoltaic. bi-directional converter..

I.INTRODUCTION

With the ever-increasing demand for energy and growing concern about environmental issues, PV based systems are being increasingly employed in diverse applications both at domestic and commercial levels. Photovoltaic systems can be broadly classified into stand-alone system and grid-connected system. The stand-alone system is widely used in remote places. The integration of a PV system to the grid is rapidly increasing due to the improvement in the power electronics technology. In grid-connected PV systems (GCPVs), the generated PV power is fed to the grid, or it supplies the linear and nonlinear loads connected at the ac side the battery charger/discharger circuit for regulating dc link voltage decouples the dc link control from the ac current control and achieves faster regulation of dc link voltage. **Single-ended primary-inductor converter** (**SEPIC**) is a type of DC-DC 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 the duty cycle of the control transistor.A SEPIC is essentially a boost converter followed by a buck-boost converter, therefore it is similar to a traditional buck-boost converter, but has advantages of having non-inverted output, using a series capacitor to couple energy from the input.

The new trends in power electronics for the integration of wind and photovoltaic (PV) power generators are presented. The new power-electronic technology plays a very important role in the highest projected turbine rating, transmission and control reactive power, to achieve a low cost and high efficiency over a wide power range, and high reliability, the trend of the PV energy leads to consider that it will be an interesting alternative .where the wind energy systems current problems and disadvantages of this technology is high cost and low efficiency [1]. A novel maximum-power-point-tracking (MPPT) controller for a photovoltaic (PV) energy conversion system is presented. Using the slope of power versus voltage of a PV array,. The proposed system acts as a solar generator on sunny days, Conventional two-stage PV energy conversion systems are bulky, expensive, provide low efficiency, and are, thus, not suitable for small-scale PV energy conversion utilization [2].

The three major approaches for current-regulated inverters are ramp comparison, hysteresis control, and predictive current control. It provide less robust to filters inductance mismatch and better THD value [3]. Some of this problems are minimized by power-control strategies of a grid-connected hybrid generation system with versatile power transfer [4]**.** A substantial increase of photovoltaic (PV) power generators installations has taken place in recent years, due to the increasing efficiency of solar cells as well as the improvements of manufacturing technology of solar panels. These generators are both grid-connected and stand-alone applications. We present an overview research results. The paper concentrates on the operation and modeling of stand-alone power systems with PV power

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Vol. 5, Special Issue 5, March 2016

generators. To analyze the stand alone renewable energy the RPM-SIM simulator is used. [5] . Future ancillary services provided by photovoltaic (PV) systems could facilitate their penetration in power systems. In addition, low-power PV systems can be designed to improve the power quality. This paper presents a single-phase PV system that provides grid voltage support and compensation of harmonic distortion at the point of common coupling. The power provided by the PV panels is controlled by a Maximum Power Point Tracking algorithm based on the incremental conductance method specifically modified to control the phase of the PV inverter voltage. it has been modified to change the phase displacement between the grid voltage and the converter voltage and the maximum power extraction from the PV panels. [6]A hybrid fuel cell power system, which consists of a fuel cell and the battery are connected to the same voltage bus through an appropriate hybrid full-bridge LLC resonant unidirectional converter and a three-level buck/boost bidirectional converter, respectively. The battery is an standby energy source; the system dynamic characteristics are improved. the battery can also provide peak power at overload, so the power rating of the fuel cell can be decreased, which reduces the total system cost and the system operates with high efficiency, a power management control scheme, which controls the bidirectional converter according to the operation condition of the fuel cell and battery. [7]

II. EXISTING SYSTEM

A high step-up Modified SEPIC Converter without magnetic coupling is used in this system which decreases the efficiency and increases the cost. Thus, a high step-up converter is seen as an important stage in the system because such a system requires a sufficiently high step-up conversion with high efficiency. Theoretically Modified SEPIC Converter without magnetic coupling cannot achieve a high step-up conversion with high efficiency because of the resistances of elements or leakage inductance; also, the voltage stresses are large. This converter is being connected to the inverter and there by connected to the load.

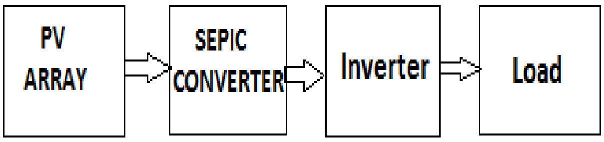

Fig 1. Existing System Block diagram

III. PROPOSED SYSTEM

In this proposed system dc voltage from PV panels are fed to the modified SEPIC converter. The modified SEPIC converter with magnetic coupling can operate with the double of the static gain of the classical boost converter for a high duty-cycle operation. however, a very high static gain is necessary in some applications.

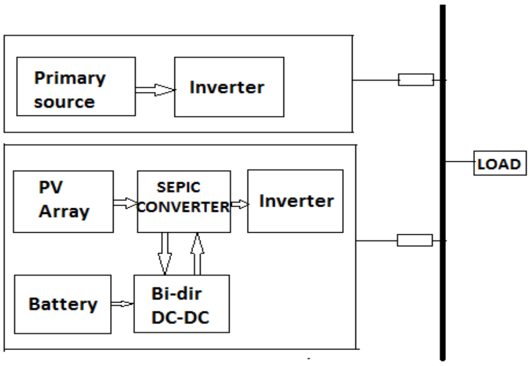

Fig 2 . Proposed System Block diagram

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SEPIC Converter with magnetic coupling cannot achieve a high step-up conversion with high efficiency because of the resistances of elements or leakage inductance. where the dc output from the converter is fed to the inverter which there by converts dc to ac voltage and supplied to the load. when excess amount of voltage is produced by the PV panels then it is stored in the battery through bi directional converters. Where the dc output from the converter is fed to the inverter which there by converts dc to ac voltage and supplied to the load. On sunny days the excessive power produced by the PV panel is stored in the battery through the bi directional converters.

SEPIC CONVERTER: Single-ended primary-inductor converter (SEPIC) is a type of DC-DC converter its output voltage to be greater than, less than, or equal to that at its input; the output of the SEPIC is controlled by the duty cycle of the control transistor. A SEPIC is similar to a traditional buck-boost converter, but has advantages of having non-inverted output using a series capacitor to couple energy from the input to the output and thus can respond more gracefully to a short-circuit output.

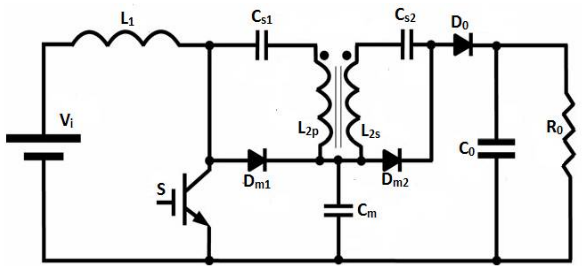

Fig3 . Modified SEPIC Basic Circuit

IV. MODES OF OPERATION

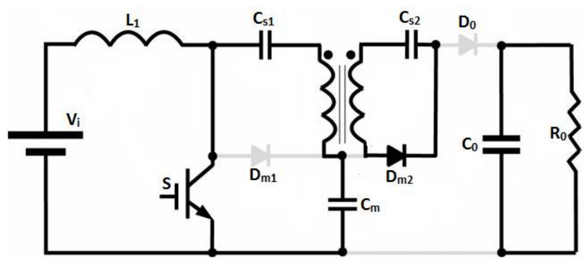

Fig4 . During mode1 operation

In mode 1 operation the power switch S is conducting and the input inductor L_1 stores energy. The capacitor C_{S2} is charged by the secondary winding L_{2S} and diode D_{M2} The leakage inductance limits the current and the energy transference occurs in a resonant way. The output diode is blocked, and the maximum diode voltage is equal to (Vo−Vcm). At the instant t_1 , the energy transference to the capacitor C_{S2} is finished and the diode D_{M2} is blocked.

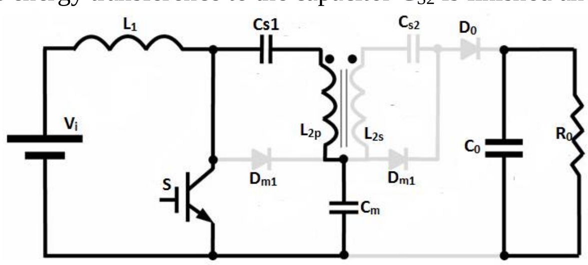

Fig5.During mode 3 operation

In mode 2 operation of SEPIC Converter at the instant t_1 , when the diode D_{M2} is blocked, to the instant t_2 when the power switch is turned OFF, the inductors L_1 and L_2 store energy and the currents linearly increase.

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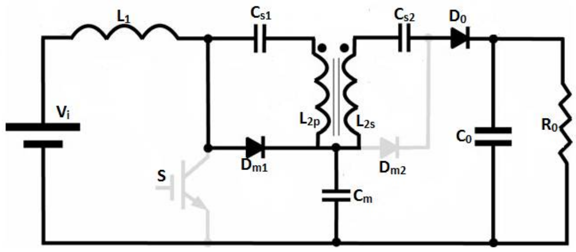

Fig6.During mode 3 operation

In mode 3 operation of SEPIC Converter at the instant t_2 the power switch S is turned OFF. The energy stored in the L_1 inductor is transferred to the Cm capacitor. Also, there is the energy transference to the output through the capacitors C_{S1}, C_{S2} inductor L_2 and output diode Do

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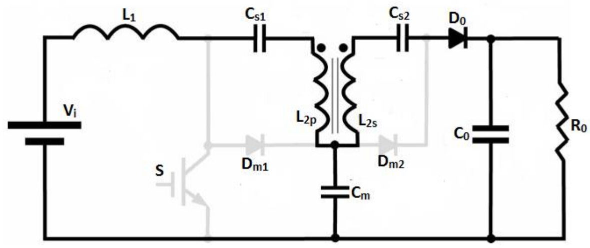

Fig 7. During mode 4 operation

In mode 4 operation of SEPIC Converter at the instant t_3, the energy transference to the capacitor Cm is finished and the diode D_{M1} is blocked. The energy transference to the output is maintained until the instant t_4 , when the power switch is turned ON.

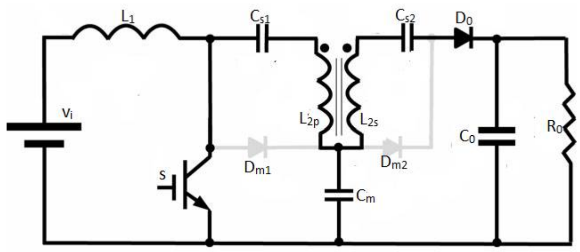

Fig 8. During mode 5 operation

In mode 5 operation of SEPIC Converter when the power switch is turned ON at the instant t4 , the current at the output diode Do linearly decreases and the di/dt is limited by the transformer leakage inductance, reducing the diode reverse recovery current problems. When the output diode is blocked, the converter returns to the first operation stage

DESIGN DESCRIPTION

The amount that the SEPIC converter steps up or down the voltage depends on primarily on the Duty Cycle and the parasitic elements in the circuit.
The output of an ideal SEPIC converter is,

$$V_o = \frac{D*Vi}{1-D}$$

Duty cycle of SEPIC Converter

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$$D = \frac{Vo}{Vi+Vo}$$

The circuit is designed using the below parameters obtained. This is summarized in the table below

PARAMETERS	MODIFIED SEPIC WITHOUT MAGNETIC COUPLING	MODIFIED SEPIC WITH MAGNETIC COUPLING
Input Voltage	15V	15V
Output Voltage	150V	300V
Output Power	100W	100W
Switching Frequency	24Khz	24Khz
Duty Cycle	0.82	0.82
Static Gain	10	20

Table 1: Device Ratings

V.SIMULATION RESULTS

Open Loop:

The simulation for modified SEPIC Converter has been carried out with the capacitance(c)=3.37uf ,Vs=15v,switching frequency =24KHz.The expected output of the is 300volt and current 2A

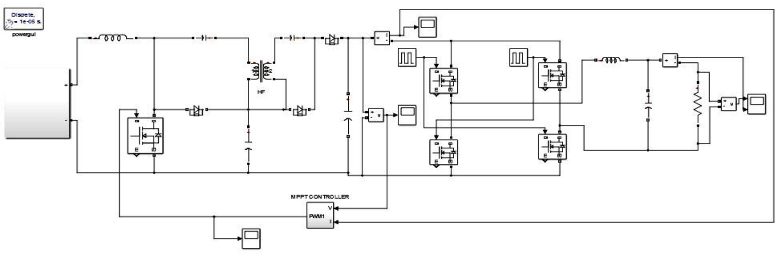

Fig 9. Open Loop circuit for SEPIC Converter

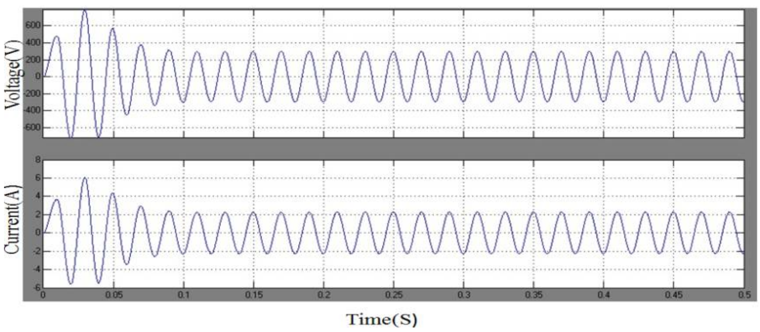

Fig 10.SEPIC Output Voltage and current waveforms

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HARMONIC SPECTRUM ANALYSIS

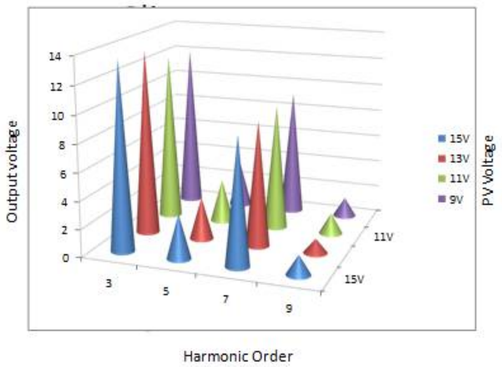

Fig 11.Spectrum analysis for open loop

Closed loop :

Proportional controller makes the operating point to oscillate around the settling point. To overcome this problem an integral controller is used, which gives zero steady state error, but this increases the response time. So, a derivative controller is used to decrease the response time.

The simulation for modified SEPIC Converter has been carried out with the capacitance(c)=3.37uf Vs=15v,switching frequency =24KHz.The expected output of the is 300volt and current 2A

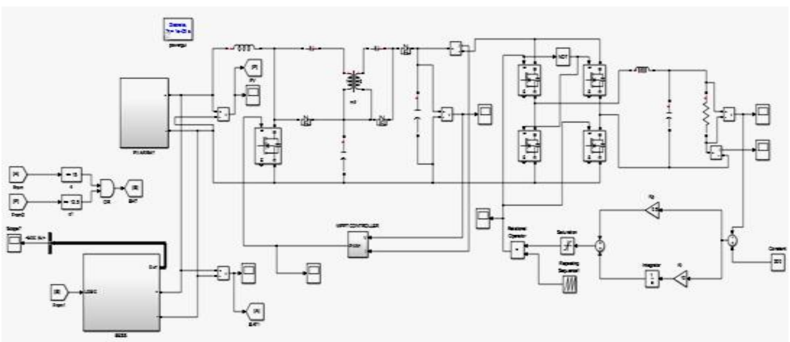

Fig 12. Closed loop circuit for SEPIC Converter

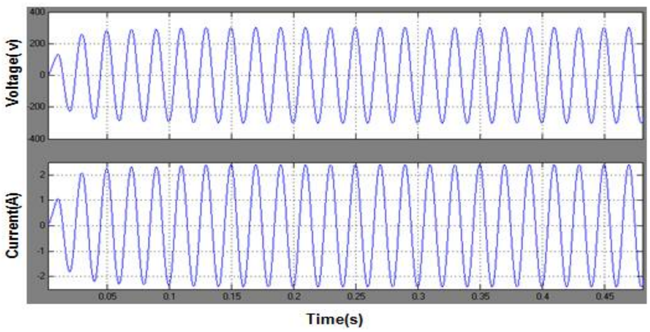

Fig 13. SEPIC Output Voltage and current wave forms

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HARMONIC SPECTRUM ANALYSIS

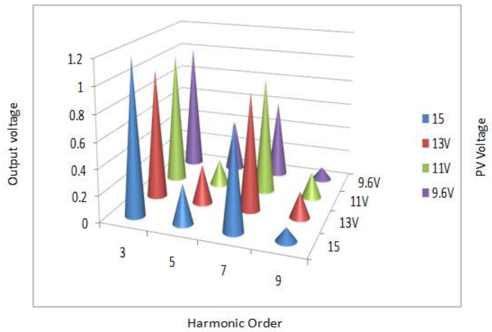

Fig 14..Spectrum analysis for closed loop

VI. CONCLUSION

In this study modified SEPIC Converter with high static static gain and high efficiency is presented. The load voltage and frequency in open and closed loop system obtained is same .Output voltage and frequency are maintained constant in closed loop. During rated Voltages, THD content of output voltage is just 1.31% in closed loop whereas in open loop it is 13.59%. Many of the harmonics order, are not present in closed loop control.

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