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Power Factor Improvement by Using Modified Sepic Converter

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Abstract

DC to DC converters are the electronic devices used to step up or step down the DC voltage level, whenever the equipment fails to operate at maximum efficiency. If a electrical device as a power factor less than one, that means more input current must be supplied for a given output power dissipation and more powerful source is required to deliver the required output power.

The main objective of this project is to improvement of power factor of the system by using MSEPIC converter and also the theoretical and experimental (simulation) results with the MSEPIC converter are comparing with the classical boost converter topology by using MATLAB software.

Key Words: *Power factor, MSEPIC converter, classical boost converter topology.*

1. Introduction

A Power system is a structural arrangement of Generators, transmission lines, anddistributed systems. Generating stations and a distribution system are interconnected throughtransmission lines, which also connect one power system to another.The commercial use of electricity had started in late 1870's. The first complete Electric power system comprising : a Generator, Cable ,Fuse, meter and loads; was built by Thomas Edison in1882 was a DC system. By 1886, the limitations of DC systems had been increased apparent. Theycould deliver power only a short distance from the Generation. The development of the Transformer and AC Transmission by L.Gaulard andJ.D.Gibbs of Paris, France, led to AC Electric power systems. By the turn of the century, the ACsystem had won out over the DC system for the following reasons:. Voltage levels can be easily transformed in AC systems, thus providing the flexibilityfor the use of different voltages for generation , transmission, and consumption.AC generators are much simpler than DC generators. AC motors are much simpler and cheaper than DC motors,Electric power system varies in size and structural components. However, they allhave the same basic characteristics. Synchronous machine is used for power generation.Transmission of power over a significant distance to consumers spread over a wide area requires atransmission system comprising sub systems operating at different levels . Industrial loads areinvariably three-phase; single phase residential and commercial loads are distributed equally form a 3balanced three phase system. Electric power is produced at generating stations and transmitted toconsumers through a complex network of individual components, including transmission linestransformers and switching devices. The transmission network is classified into the followingsubsystems:

(a) Transmission system
(b) Sub Transmission system
(c) Distribution system.

2. Introduction to DC-DC Converters

DC –DC converters are power electronic circuits that convert a dc voltage to a different voltagelevel. There are different types of conversion method such as electronic, linear, switched mode,magnetic, capacitive. The circuits described in this report are classified as switched mode DC-DCconverters. These are electronic devices that are used whenever change of DC electricalpower from one voltage level to another is needed. Generically speaking the use of a switch orswitches for the purpose of power conversion can be regarded as an SMPS. From now onwardswhenever we mention DC-DC converters we shall address them with respect to SMPS. A fewapplications of interest of DC-DC converters are where 5V DC on a personal computermotherboard must be stepped down to 3V, 2V or less for one of the latest CPU chips; where1.5V from a single cell must be stepped up to 5V or more, to operate electronic circuitry. In all ofthese applications, we want to change the DC energy from one voltage level to another, whilewasting as little as possible in the process. In other words, we want to perform the conversionwith the highest possible efficiency. DC-DC Converters are needed because unlike AC, DC can'tsimply be stepped up or down using a transformer. In many ways, a DC-DC converter is the DCequivalent of a transformer. They essentially just change the input energy into a differentimpedance level. So whatever the output voltage level, the output power all comes from theinput; there is no energy manufactured inside the converter. Quite the contrary, in fact some isinevitably used up by the converter circuitry and components, in doing their job.

3. Study of DC-DC Converters

There are a variety of DC-Dc converters are possible. But from the list of the converters only thefirst four of the converters are to be described which are basically of non-isolated input outputterminals.

3.1The Buck Converter

The buck converter is a commonly used in circuits that steps down the voltage level from theinput voltage according to the requirement. It has the advantages of simplicity and low cost.Figure 1 shows a buck converter the operation of the Buck converters start with a switch that isopen (so no current flow through any part So circuit) When the switch is closed, the currentflows through the inductor, slowly at first, but building up over time. When the switch is closed 12the inductor pulls current through the diode, and this means the voltage at the inductors "output"is lower than input.

Analysis of the buck converter begins by making these assumptions:

1. The circuit is operating in the steady state.
2. The inductor current is continuous(always positive)
3. The capacitor is very large, and the output voltage is held constant at voltage Vo. This restriction will be relaxed later to show the effects of finite capacitance.
4. The switching period is T, the switch is closed for time DT and open for time (1-D)T.
5. The components are ideal

The key to the analysis for determining the voltage Vo is to examine the inductor current and inductor voltage first for the switch closed and then for the switch open. The net change in inductor current over one period must be zero for steady state operation. The average inductor voltage is zero. There are two types of operational mode for this circuit

a) Continuous Conduction Mode and

b) Discontinuous Conduction Mode.

3.2 The Boost Converter

A boost converter (step-up converter) is a power converter with an output DC voltage greaterthan its input DC voltage. It is a class of switching mode power supply (SMPS) containing atleast two semi-conductors switches (a diode and a transistor) and at least one energy storageelement. Filters made of capacitors (sometimes in combination with inductors) are normallyadded to the output of the converter to reduce output voltage ripple. A boost converter issometimes called a step-up converter since it "steps up" the source voltage. Since power (P = VI)must be conserved, the output current is lower than the source current. The boost converter has the same components as the buck converter, but this converterproduces an output voltage greater than the source."Boost" converters start their voltageconversion with a current flowing through the inductor (switch is closed). Then they close theswitch leaving the current no other path to go than through a diode (functions as one way valve)The current then wants to slow really fast and the only way it can do this is by increasing it'svoltage (akin to pressure) at the end that connects to the diode, and switch. If the voltage is highenough it opens the diode, and one through the diode, the current can't flow back. This is thevery basic concept of boost converter.

3.3 SEPIC CONVERTER:

The single-ended primary- inductor converter(SEPIC) is a type of DC/DCconverter that allows the electrical potential(voltage) at its output to be greater than ,less than, orequal to that at its input .The output of the SEPIC is controlled by the duty cycle of the controltransistor.

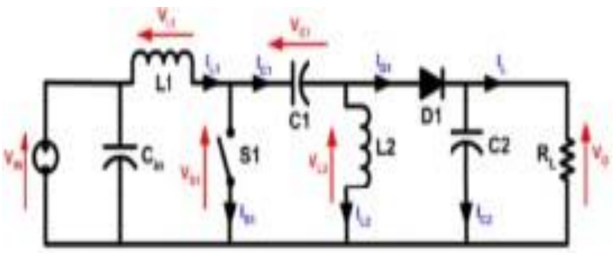

Fig1 :SEPIC converter

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 (the output has the same voltage polarity as the input), using a series capacitor to couple energy from the input to the output. The evolution of switched-power supplies can be seen by coupling the two inductors in a SEPIC converter together, which begins to resemble a Fly back converter, the most basic of the transformer- isolated SMPS topologies.

4. M -SEPIC CONVERTER:

4.1Operating principle of M-SEPIC converter

The modified SEPIC dc–dc has an additional diode DM and capacitor (CM) at the classical SEPIC converter, the inclusion of the diode and the capacitor reduces the switch voltage and provides additional advantages. The modified SEPIC converter operates as a voltage follower and the input current presents low current ripple such as a classical SEPIC converter, designing the converter in DCM and using a low value for the inductor L2 and a high value for the inductor L1.

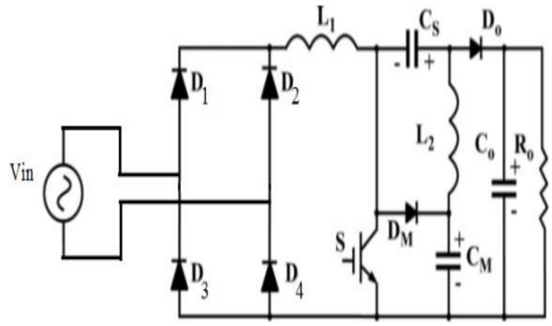

Fig2: Modified SEPIC Converter.

The modified SEPIC converter operating in Discontinuous Conduction Mode (DCM) presents three operational stages. For analysis the steady state operation is considered and all the components are assumed to be ideal. The voltages across all the capacitors are considered constant during a switching period. In DCM operation when the power switch is turned off the currents in all diodes of the circuit are equal to zero. Therefore, the DCM operation occurs when DO and DM diodes are not conducting before the switch is turn-on. It has a diode bridge and an ac source at the input side. High value of the input inductor L1 is chosen to reduce the input current ripple. Inductor L2 is kept low so as to operate it as a voltage follower. At steady state the voltage across both the inductors are zero and the sum of the input voltage Vin and capacitor CS voltage is equal to the capacitor CM voltage.

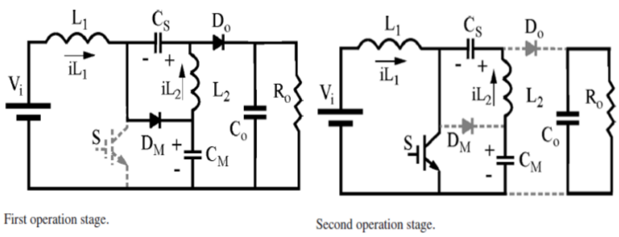

Fig3: Operation of SEPIC Converter

*First stage ([t0, t1]*At the instant t_0 , the switch S is turned-off and the energy stored in the input inductor L_1 is

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transferred to the output through the capacitor C_S and output diode D_0, and also to the capacitor C_M through the diode D_M. Therefore, the switch voltage is equal to the capacitor C_M voltage. The energy stored in the inductorL2 is transferred to the output through the diode D_0.

Second stage ([t1, t2] At the instant t_1 , the switch S is turned –on and the diodes D_M and D_0 are blocked, and the inductors L_1 and L_2 store energy. The input voltage is applied to the input inductor L_1 and the voltage VCS- VCM is applied to the inductor L_2. The voltage V_{CM} is higher than the voltage V_{CS}.

The voltage in all diodes and the power switch is equal to the capacitor C_M voltage. The output voltage is equal to the sum of the $C_S$and C_M capacitors' voltages. The average L_1 inductor current is equal to the input current and the average L_2 inductor current is equal to the output current.

Table :Design parameters

Nominal input Voltage (Vrms)	127V
Output Voltage V_0	400V
Line Frequency	50Hz
Inductor L_1	6.8mH
Inductor L_2	540µH
Capacitor Cs	220nF
Capacitor C_M	220nF
Capacitor C_0	120µF
Diode D_M-D_0	UF5408
Duty Ratio	0.38

5.MATLAB SIMULATION RESULTS

The power factor correction converter known as the modified sepic converter were simulated using matlab software and the following results were obtained. When an operating voltage of 127v rms is given at the input side and the power factor of the total system was improved to 0.96.

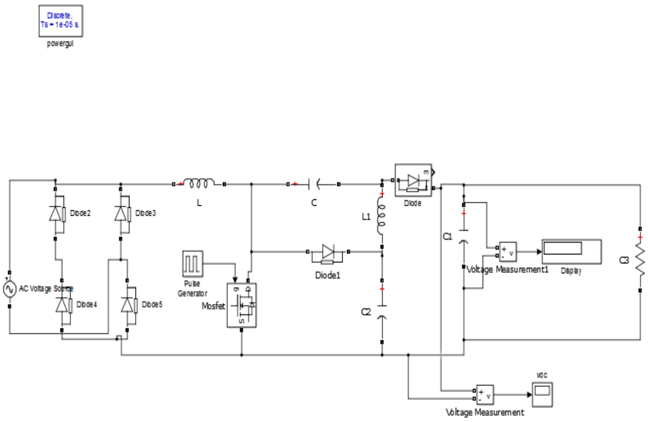

Fig4:Block diagram of M-SEPIC converter

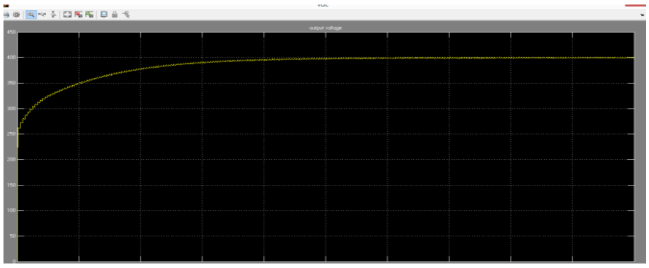

Fig5: Output voltage of M-SEPIC converter is 400v,and duty ratio is 0.38

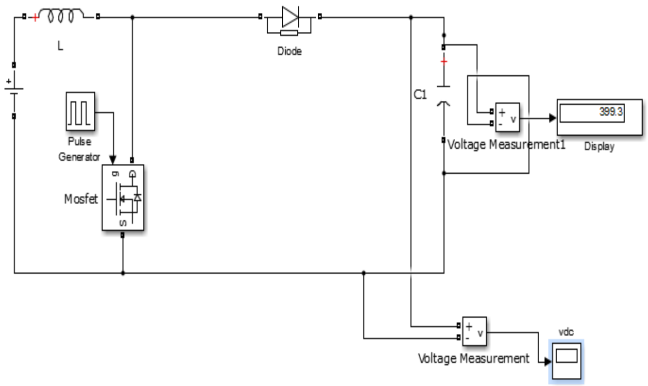

Fig6:Block diagram of Boost converter

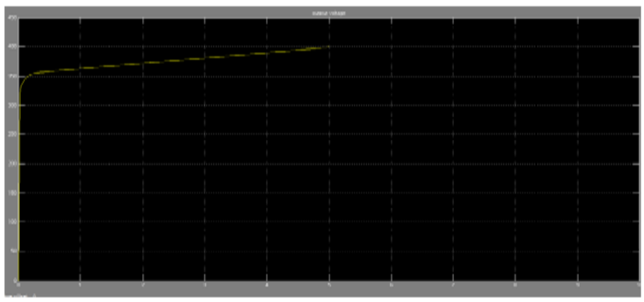

Fig7: output voltage of M-SEPIC converter is 400v,andduty ratio is 0.38

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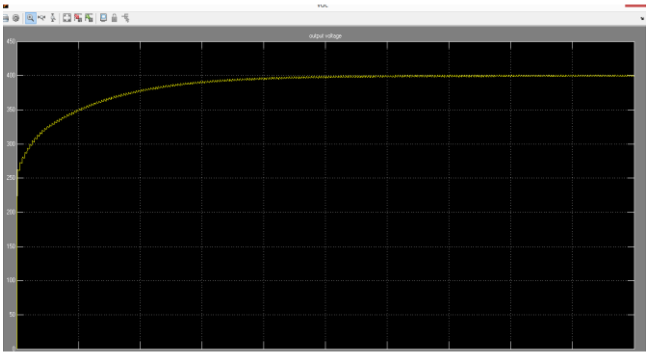

Fig8: output voltage of Boost converter is 400v and duty ratio is 0.40

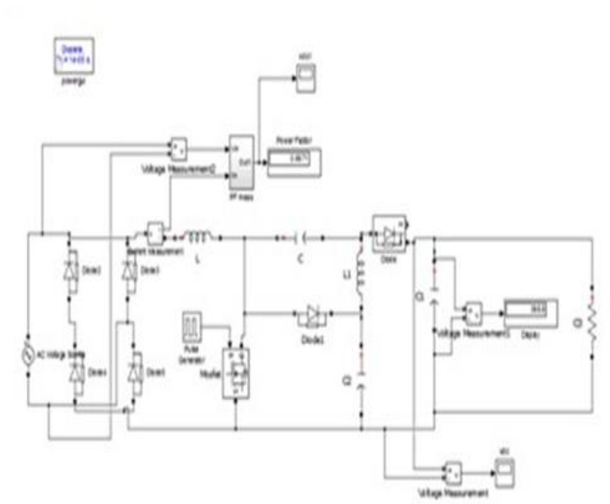

Fig9: M-Sepic converter without converter

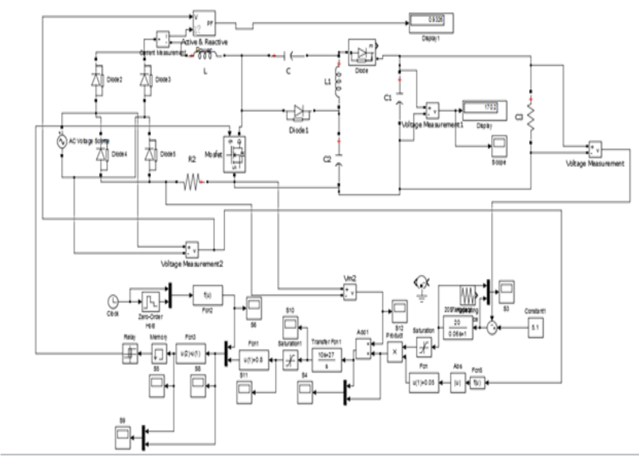

Fig 10: M-Sepic converter with converter

5 CONCLUSION

The M-SEPIC converter output is obtained at low duty ratio compared with other DC-DC Converters. Reduction in duty cycle helps in increase a wide range of voltage variation in the output voltage, for the same M-SEPIC converter power factor is improved by using feedback controller when compared with absence of feedback controller. By using M-SEPIC converter switching stress also reduces. Finally, the power factor improved and also reduces duty ratio

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