Efficient PFC with Switched Inductor DC-DC Converter for Battery Charging Application

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***Abstract*-DC: -DC converter performances have been proved to be solution for battery charging applications.Most of the two-stage converters for electric bike battery charging comprise of a boost converter for power factor correction (PFC) followed by a dc-dc converter with universal input voltage. These two-stage conversions suffer from poor efficiency and increased component count. In this project, The single ended cuk converter has been replaced by SEPIC converter to overcome the problem associated with DC-DC converter. The problem associated with DC converter such as high amount of ripple, create harmonics, invert the voltage, create overheating and effective efficiency can be minimized and achieved best efficiency by SEPIC converters.It is focused on design, comparison of DC-DC with the SEPIC converter as using closed loop feedback control. In comparison DC-DC converter to SEPIC converter, single-stage switched inductor SEPIC converter based PFC converter is proposed, which offers high step-down gain, low current stress, high efficiency, and reduced component count. The operational analysis and design equations for various components of the proposed converter are carried out in continuous current mode. This project presents simulation, and experimentation on the proposed converter rated output for 48V. Furthermore, the dynamic performance of the proposed converter with battery charging is investigated in Constant Voltage mode and Constant Current mode with respect to the wide range of supply variations.**

Keywords:- DC-DC Converter,Two stage converter,Sepic converter,Power Factor Correction(PFC),Battery.

I. INTRODUCTION

In the present state increased environmental pollution like emission of greenhouse gases and other toxic element by the overuse of petroleum fuel fed in the vehicles,it causes due to several disadvantages like high maintenance, low efficiency, increased noise pollution, increased environment pollution, and cost effectiveness in this problem to be rectified by using Electric vehicles (EV) and electric hybrid vehicles (EHV) are the alternate choice in inter-city transport applications due to several advantages like low maintenance, high efficiency, reduced noise pollution, reduced environment pollution, and cost effectiveness in this advantage exponential increase in the growth of electric vehicles in future, and also power electronics technology extensive usage for battery charging power quality problem is created particularly harmonic pollution in the distribution system.The harmonics is the electric voltages and currents that appear on the electric power system as a result of non-linear electric loads.Harmonics frequencies in the power grid are a frequent cause of power quality problems.Increased harmonics level in the power system it reduced the life of distribution transformer in this problem to increased installation of battery charging in urban areas.so improved power quality using DC-DC converter for battery charging application.The DC-DC converter circuit also regulate the output voltage that regulates the current through the LED’s and simple charge pumps which double or triple the output voltage.The DC-DC converter is an electronic circuit or electromechanical device that convert a source of direct current from one voltage level to another.It is a power electronics device which is capable of producing desired direct voltage level at the output.DC-DC converter have become one of the most widely used power convertes.The DC-DC converter are divided into two types:two stage and single stage.The two stage conversion it is a type of cuk converter it is used in the system has increased component count and reduced efficiency.In order to overcome this disadvantage two stage converter has been proposed single stage converter of SEPIC converter closed loop it has increased efficiency and reduced component count.As compared two stage converter and single stage converter the two stage converter have a more number of switches and single stage converter have a less number of switches.In this proposed system number of switches is reduced the switching losses also decreased and increased efficiency of entire system.Most application of the SEPIC converter control the voltage automatically.The DC-DC converter has a five types:Buck converter,Boost converter, Buck-Boost converter,Cuk converter,SEPIC converter.In addition to above,the Cuk converter is a type of DC-DC converter that has an output voltage magnitude that is either greater than or less than the input voltage magnitude and the SEPIC is the single-ended primary-inductor converter is a type of DC/DC converter that allows 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 transient. The SEPIC converter allows a range of dc voltage to be adjusted to maintain a constant voltage output.This paper focuses on the to avoid the negative polarity at the same output voltage by using SEPIC converter closed loop system.The single-ended primary-inductance converter(SEPIC) is a DC-DC converter topology that provides a positive output voltage from an input voltage varies from above to below the output voltage.(3) Finally, the feasibility of the proposed inverter will be verified through simulation results by using MATLAB/ SIMULINK.

POWER FACTOR CORRECTION TECHNIQUES FOR AC/DC

The power factor (PF) of an AC source is defined as the ratio of the real power, in watts, flowing into the load to the apparent power in the circuit, which is the product of current and voltage. It is represented as PF = Real Power (W)/Apparent Power (VA). The PF equation shows that it is a number between 0 and 1. Hence, when both current and voltage are in phase and sinusoidal, PF is 1. However, if both are sinusoidal but out of phase, the apparent power is more than the real power, and PF is the cosine of the phase angle between current and voltage waveforms. In practice, PF = 1 is an ideal situation where the load is pure resistive and linear. In reality, off-line AC/DC power supplies found in electronic systems are switch-mode, presenting a nonlinear load. Because most power supplies today are switch-mode, they draw a non-sinusoidal waveform, resulting in a phase angle between input current and voltage. When the current waveform does not follow the voltage waveform, it results in a PF below 1. Besides power losses, < 1 PF causes harmonics that travel down the neutral line and disrupt other devices connected to the AC mains line. The lower the PF number, the higher is the harmonics content on the AC line, and vice versa.

PASSIVE PFC'S

The simplest way to control the harmonic current is to use a passive filter that passes current only at line frequency (e.g., 50 or 60 Hz). This filter reduces the harmonic current, which means that the nonlinear device now looks like a linear load. Using filters built with capacitors and inductors, power factor can be brought to near unity. However, the drawback is that the filter requires a large-value high-current inductor and a high-voltage capacitor, which is bulky and expensive.

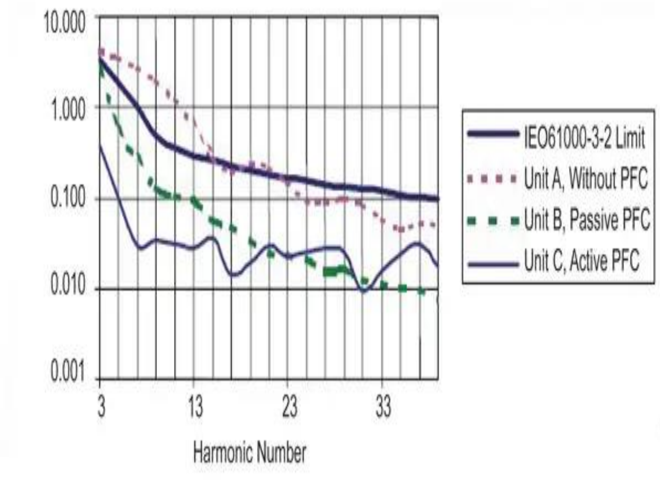


Figure1:Input Harmonics of three PC power supplies Relative to IEC61000-3-2 Limits

Figure 1: By comparison, power supply with active PFC controller output forms passive PFC to exceed the IEC61000-3-2 specifications for harmonics on the mains line.

Figure 1 shows the input harmonics for three different 250 W PC power supplies, compared with the limits according to EN/IEC61000-3-2 specifications for Class D devices. The harmonic amplitudes are proportioned to the input power of these devices. The performance of the passive PFC, as shown in this graph, just barely complies with the limit for the third harmonic. The unit with active PFC meets and beats the IEC61000-3-2 specs.Despite being simple to design and use, passive PFC circuits offer a few disadvantages. First, the bulkiness of the inductor restricts its usability in many applications. Second, for worldwide operation, a line-voltage range switch is required. Incorporation of the switch makes the appliance/system prone to operator errors if the switch selection is not properly made. Finally, the voltage rail not being regulated leads to a cost and efficiency penalty on the DC/DC converter that follows the PFC stage.

ACTIVE PFC'S

Besides performance, the rising cost of copper and magnetic core material, coupled with the falling cost of semiconductors, has tilted the balance in favour of active PFC solutions, even in the most cost-sensitive consumer equipments. In the following scheme (Figure 2), the active PFC circuit is placed between the input rectifier and the storage capacitor, followed by the DC/DC converter. The PFC IC with associated circuitry shapes the input current to match the input voltage waveform and achieve PF that is 0.9 and higher.

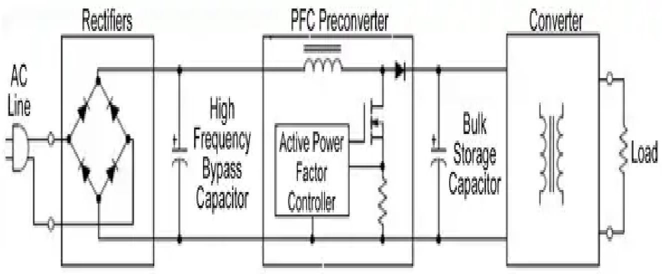


Figure2.PFC preconverter Stage

Figure 2: The active PFC controller circuit is placed between the input rectifier and the storage capacitor. Fundamentally, there are three different types of active PFC controller chips. These include critical-conduction mode (CrM), continuous-conduction mode (CCM), and discontinuous-conduction mode (DCM). There are several manufacturers offering a variety of these active PFC ICs, but each supplier offers its own versions and reasons for using them. The CrM control scheme keeps the inductor current at the borderline limit between continuous and discontinuous conduction. Consequently, some vendors prefer to call it boundary-conduction mode or BCM. Since the wave shape is always known in this scheme, the relationship between the average and peak current is also

known. ON Semiconductor supplies a variety of voltage-mode CrM PFC ICs for medium-power applications up to 300 W.In most PFC circuits, normally an input inductor is used in series with line bridge rectifier in order to smooth the line current. The input inductor can operate in either continuous conduction mode (CCM) or discontinuous conduction mode (DCM). In DCM, the input inductor is no longer a state variable since its state in a given switching cycle is independent on the value in the previous switching cycle. The input inductor operating in DCM cannot hold the excessive input energy because it must release all its stored energy before the end of each switching cycle.The preferable type of power factor correction (PFC) circuit is the active PFC since it makes the load behave like a pure resistor, leading to near unity load power factor and generating negligible harmonics in the input line current. Most active PFC circuits as well as switched mode power supplies (SMPS) on the market today comprise a front-end bridge rectifier followed by a high frequency dc-dc converter. Several of the most popular topologies for PFC converters are the followings: fly-back converter, buck-boost converter, boosts converter, SEPIC converter and CUK converter.This project reports an input ac switch based single phase SEPIC ac-dc converter topology. The converter has single stage separate SEPIC ac to dc topologies each working for positive and negative supply cycles through a combination of inductor and capacitor keeping the input current smooth and in-phase with the supply voltage. The SEPIC topology of the converter has advantages of input boost topology stage and overall boost buck gain. The input boost stage allow the same controller philosophy be used as used in conventional boost PFC rectifiers.

OBJECTIVE:

A single-stage switched inductor SEPIC converter based power factor correction converter is proposed.It is used to avoid the negative polarity and also the revese current to the input from the Li-Ion battery.In the exising system open circuit method is used.In the proposed system closed loop control is used.To reduced number of component count (i.e.)Switches.It is easy to increase the efficiency.To design which is applicable for renewable energy source such as solar, wind etc.Compared to conventional method cost is less.

EXISTING BLOCK DIAGRAM

In the existing system has the open loop circuit system in this application.It is maintained negative voltage in the constant range.

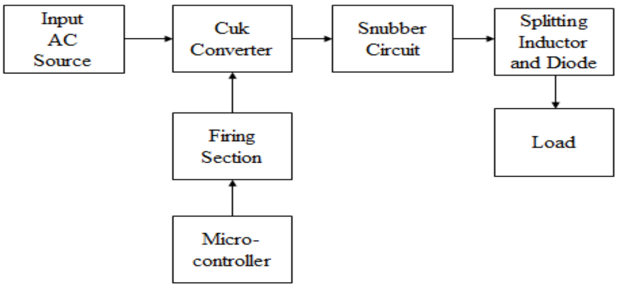


Fig3.Block Diagram of CUK converter

Fig:3.1: EXISTING SYSTEM EXPLANATION

A simple ZVS buck converter with a coupled inductor with small additional components. However, a large current is built up in the coupled winding in light-load conditions and therefore greatly increases conduction loss. The two stage PFC converters are widely practiced in which the power factor correction is carried out in the first stage and voltage/current regulation is done in the second stage.

The input AC supply(200V) is given to the cuk converter in this converter used to operate output voltage magnitude that is either greater than or less than the input voltage magnitude and also micro controller to give the firing pulse to the cuk converter.The 5V DC supply is externally given to the microcontroller.The output of the converter is given to the snubber circuit.It is used to reduced the harmonics to improve the power quality in the system.The output of the snubber circuit to the spilliting inductor and diode.It is used to avoid the negative current from the load to source.The load is a Li-Ion battery. The exsisting system it is an a open loop system.

The load voltage is 48V and the load current is 10A and also the load power is 500W

The exsisting system is made up on two stage converter it is used to increase the current stress, reduced the efficiency.

DISADVANTAGE OF THE EXISTING SYSTEM

Two-stage converters suffer from poor efficiency and high component counts. The Buck-Boost converter cannot provide low output voltage over a wide input voltage range due to an extremely low duty ratio.The Cuk reverses the polarity but by making an isolated version you can maintain the polarity.

PROPOSED BLOCK DIAGRAM

In the proposed system has the closed loop circuit system in this application.It is maintained positive voltage in the constant range.

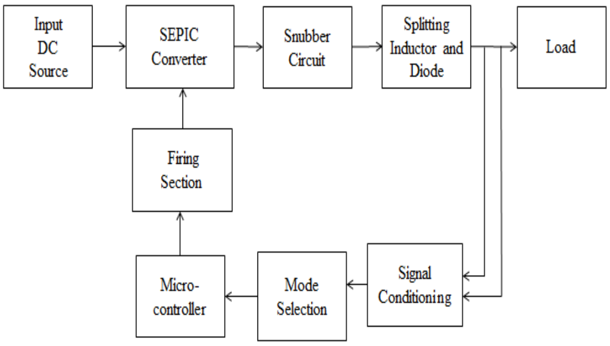


Fig4.Block Diagram of SEPIC converter

The single-ended primary-inductor converter (SEPIC) is a type of DC/DC converter that allows 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 (the output has the same voltage polarity as the input), using a series capacitor to couple energy from the input to the output (and thus can respond more gracefully to a short-circuit 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.An switched inductor SEPIC converter based improved power quality converter for universal application of electric bike batteryThis converter facilitates the reduction in conduction and switching losses due to low switch current stress.A single phase diode bridge rectifier (DBR) followed by a switched inductor SEPIC converter is used for controlling the output voltage feeding the load.

ADVANTAGE OF THE PROPOSED SYSTEM

The voltage drop and switching time of diode D1 is critical to a SEPIC's reliability and efficiency. The diode's switching time needs to be extremely fast in order to not generate high voltage spikes across the inductors, which could cause damage to components. The resistances in the inductors and the capacitors can also have large effects on the converter efficiency and output ripple. Inductors with lower series resistance allow less energy to be dissipated as heat, resulting in greater efficiency (a larger portion of the input power being transferred to the load). Capacitors with low equivalent series resistance (ESR) should also be used for C1 and C2 to minimize ripple and prevent heat build-up, especially in C1 where the current is changing direction frequently.

EXISTING CIRCUIT DIAGRAM

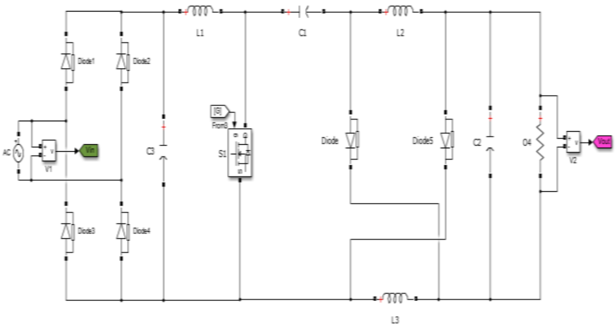


Fig5.Circuit Diagram of CUK converter

On the other hand, conventional single-switch topologies, such as buck–boost, fly back, SEPIC, and Cuk converters have the potential of both PFC feature and step-down conversion capability.Similar to the buck–boost converter with inverting topology, the output voltage of non-isolated Ćuk is typically also inverting, and can be lower or higher than the input. It uses a capacitor as its main energy-storage component, unlike most other types of converters which use an inductor. It is named after Slobodan Ćuk of the California Institute of Technology, who first presented the designThere are variations on the basic Ćuk converter. For example, the coils may share single magnetic core, which drops the output ripple, and adds efficiency. Because the power transfer flows continuously via the capacitor, this type of switcher has minimized EMI radiation. The Ćuk converter allows energy to flow bidirectional by using a diode and a switch.The CUK converter as the dual of the Buck-Boost converter has current input and current output stages. The basic SEPIC is a modification of the basic Boost and the Cuk topologies. At steady state, the average voltage across the input inductor is zero.

PROPOSED CIRCUIT DIAGRAM

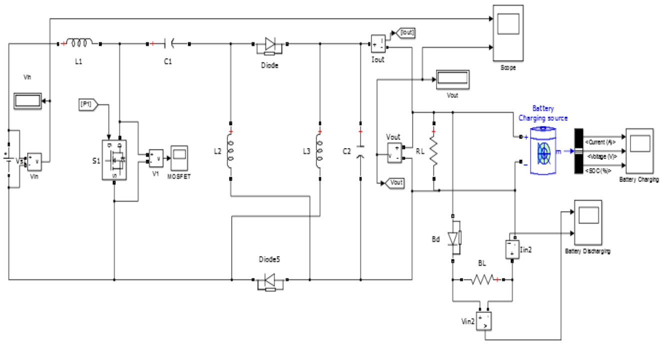


Fig6.Circuit diagram of the SEPIC converter

CIRCUIT TOPOLOGY

The proposed PFC Converter is derived from a SEPIC converter by splitting inductor (Lo) into two equal inductors (L2, L3); the rectifier diode D0 into two diodes (D, D5) and re-arranged to form a switched inductor circuit comprising of SW1, Lo, Do.The intermediate inductor inter-connections change from series to a parallel connection during every period of the switching cycle.The switched inductor SEPIC converter is designed to operate in CCM. The voltage, us continuous in a switching period.

OPERATIONAL MODES OF THE CIRCUIT

To simplify the steady-state analysis of proposed converter, few assumptions are made such as ideal switching devices and inductors, with no switching delay. It is further assumed that for a given sampling time, supply voltage remains constant. The duty cycle varies for each sampling time as supply voltage keeps on changing. Depending upon the switching state of switch S1, two modes of operations are identified. These operating modes repeat several times in one cycle of the line frequency (i.e. 50Hz). The waveforms of voltage and current of circuit elements are depicted.At the time instant t=0, when switch S1, turns ON, diodes Do1, Do2 turn off. The inductor currents (Lo1, Lo2) increase from their respective initial value. Therefore, this mode is called as inductor charging mode.When switch S1 turns off at t=D(t)Ts, the diodes Do1, Do2 turns on. The equivalent circuit depicting current path.

OUTPUT OF THE BATTERY

The output should be obtained in various measurement voltage and the current measurement and also charging of battery and discharging of battery is plotted.The during charging of the battery the voltage should be increased
And also the current is decreased.The during discharging of the battery process is inverse of the charging that means voltage should be decreased and the current should be increased.The state of charging is mentioned about percentage
of charging (%)

OUTPUT VOLTAGE AND CURRENT WAVEFORM

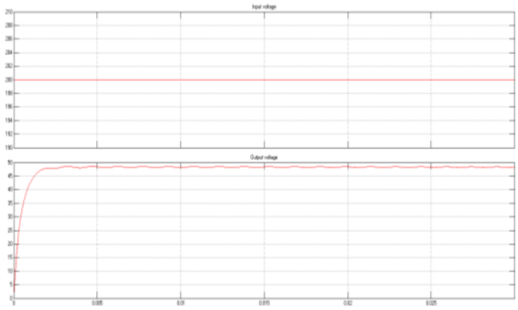
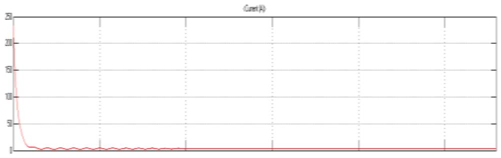


Fig 7. Waveform of output voltage and current

CHARGING OF BATTERY WAVEFORM



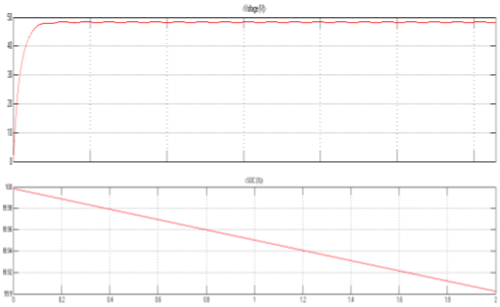


Fig 8.Waveform of the battery charging

Parameter	DC-DC CONVERTER			
	CUK CONVERTER		SEPIC CONVERTER	
	INPUT	OUTPUT	INPUT	OUTPUT
CURRENT	6.25A	10.4A	0.2A	1A
Voltage	230V	48V	200V	48V

CONCLUSION

The proposed SEPIC converter topology has exhibited high efficiency with reduced number of components in the circuit as well as improved harmonics spectrum at the output side. Simulated results have implied the fact that proposed PFC converter constant charging current flows into the battery maintaining desired DC voltage.Therefore, proposed EV battery charger with SEPIC converter is considerably reliable and suitable option for battery charging applications with remarkable qualities like high step-down gain, low current stress and also the positive voltage at the output load voltage

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