

Isolated Current-Fed Ac to Dc with Sepic Converter for Electric Vehicle Applications

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Abstract--- Due to increased environmental conditions, highly complicated regulations of emission, for transportation, an alternative form is identified by the use of electric vehicles. Power electronic circuits (PECs) is integral of modern electric vehicles. DC to DC converters and DC to AC inverters are in PECs. Load utility and high power electric motor are supplied by DC to AC inverter and low voltage load and low power are supplied by DC to DC converter. There are different classes of DC to DC Converters. For charging of high power electric load, there must be an increase in output. So, it uses SEPIC converter. A type of DC-DC converter corresponds to Single-ended primary-inductor converter (SEPIC). In its output, it allows, electrical potential equal to, less than or greater than input voltage. Control transistor's duty cycle controls the SEPIC output. Voltage conversion is done in SEPIC by exchanging energy between inductors and capacitors. Modification of buck-boost converter corresponds to SEPIC boost converter. Both are similar. There are few advantages of SEPIC converter. They are, non-inverted input- same polarity of input and output voltage, between output and input, energy is coupled by using a series capacitor- to a short circuit output, better response is produced, true shutdown is possible- output goes to 0V, if switch is off. In CCM operation mode, it is easy to control this converter. Duty cycle can be changed to get a output voltage is wide range as there is a same gating pulse at both switches. Recent non-coupled inductor converters are used to make a comparison with proposed converter, with respect to number of elements, diode and switches voltage stress, voltage gain. In proposed converter, with respect to output voltage, on switches, less percentage of voltage stress is produced. High voltage gain is produced by proposed converter with less number of components when compared with other converters

Keywords--- PEC, SEPIC, Buck- Boost Converter, CCM, MATLAB.

I. INTRODUCTION

In recent years, development of DC to DC converters with high voltage gain are increased due to low DC output voltage power sources in applications. Applications like uninterruptable power supplies, hybrid electric vehicles, energy storage systems, DC distribution networks, fuel cells, photovoltaic systems, low power wind turbines uses this DC to DC converters with high voltage gain. Renewable energy sources like FCs and PVs are having low DC output voltage.

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In these systems, in order to regulate and boost levels of the voltage, used a high step-up DC to DC converters. Converter's input current should be a continuous one with low ripple for obtaining maximum power point tracking. Operation of FCs depends on regulation of output power. So, continuous input current DC to DC converters are used. This enhances, system's dynamic performances.

There is a need of continuous input current and high gain of voltage transfer for using DC converter in renewable energy sources. Because of input current with discontinuity, it is not suitable to use traditional buck-boost converter. Output voltage is same as boost converter's switch voltage stress. High voltage switches are required for high output voltage. Switching and conduction losses are increased due to this. Due to conduction loss increase, efficiency and voltage gain are reduced if operating duty cycle nears unity.

For motion control applications, power electronics' tighter control and greater efficiency are used. Traditional electronic and electro-mechanical systems are replaced by this. Static-var compensators, flexible ac transmission system (FACTS), high-voltage dc (VHDC) converter stations are included in power transmission applications.

Custom Power System, frequency conversion, dynamic filters and dc-to-ac conversion are includes in power distribution. Due to better efficiency, low cost, reduced size, simplicity, non isolated high step-up DC to DC converters commonly preferred when compared to isolated topologies.

Coupled inductor converters and non-coupled inductor converters are the classes of High step-up non isolated DC to DC converters. Coupled inductor turns ratio can be increased to produce high voltage gain by coupled inductor converters. During turn off process, across switches, voltage spikes are produced by coupled inductor leakage inductance in isolated converter topology. In order to enhance energy and energy recycle, uses an addition circuit of clamping.

Without isolated transformers and coupled inductors, high static step up gain can be produced by this converter type. Complexity is increased and efficiency is reduced due to addition of multiple voltage multiplier stages and high number of components. Because of SEPIC converter's unique characteristics, it is used in industrial and power electronics applications.

DC to DC converter corresponds to SEPIC. It can be operated in step up or down mode. Battery operated equipment uses this. MOSFET gate signal's duty cycle is varied in this. Voltage can be stepped up or down. If duty cycle is greater than 0.5, voltage will be stepped up else it will be stepped down. Voltage can be stepped up or down by using different topologies of conversion like buck-boost, boost and buck. For various application, limitations like inverted output voltage, output current and input current made it as an unreliable one.

For designing conventional power converter, high efficiency maintenance is a difficult one. This is more serious in design on step up or down voltages. In SEPIC DC to DC power conversion, they are obtained. Various passive and active components are used in various designs. Over heat production and ripple rectification are done by using coupling capacitor with low equivalent series resistance (ESR) and Non- inverted output. For wide operation range, it can be used.

II. LITERATURE SURVEY

NQ Trong ,et.,all,2018, presented low-voltage stress current-fed full-bridge isolated power factor correction converter modification. Good common mode noise performance, high input current quality, enhanced efficiency are the major features of this isolated conventional current-fed full-bridge Power Factor Correction converter. Between two winding layers, it does not require, complicated isolation tapes/pads, due to the occurrence of spike-free-voltage on transformer windings. On MOSFETs, voltage spike are eliminated completely by proposed topology, as indicated by results of experimentation. High performance MOSFETs are used for enhancing efficiency. Around 2% of efficiency is improved.

C Li.,et.,all,2018, presented a Soft-Switching Single Stage Isolated AC-DC Converter. For applications like Single-Phase High Power PFC, it can be used. Matrix-based isolated AC-DC converter and boost converter are combined to form a proposed circuit. This topology has less number of semiconductor when compared with traditional PFC plus DC/DC configuration in current path. Diode front end is not used. This decreases conduction loss. Soft switching of switches can be realized by including two communication inductors and clamping capacitor of small size. Traditional PWM method is used by this converter. EMI filter can be designed using this. Light load efficiency is increased by this. Traditional PFC controller with gate distribution circuit can be used to control the circuit.

C Iannello.,et.,all,2017, presented a Full Bridge ZCS PWM Converter which can be used in applications of high power and voltage. Full bridge zero current switched (FB-ZCS) PWM converter is analyzed in this paper. Parasitic components like rectifier diode's junction capacitance, high voltage transformer's capacitance and leakage inductance are used in the proposed converter for implementing operation of ZCS. At high voltage side, rectifier diodes are operating with ZVS. In applications of high voltage, topologies feasibility is shown by results of simulation. Incorporation of parasitic components, fixed frequency operation are unique merits of this proposed topology when compared with commonly used full bridge resonant converters.

M Narimani.,et.,all,2016, presented a Phase-Shift Modulation based Single-Phase Single-Stage Three-Level Power Factor Correction AC-DC Converter. With standard phase shift PWM, new three-level AC-DC single-stage converter is able to operate. Under light load conditions, better efficiency can be produced by proposed converter as shown by results. Two switches are turned on by an energy from an input inductor.

T Nussbaumer.,et.,all,2015, Design Guidelines for Interleaved Single-Phase Boost PFC Circuits, This paper displays the structure rules for a solitary stage PFC with the emphasis on negligible complete volume, the impact of interleaving of a few lift stages is investigated as a measure for minimization increment. The determination of the fitting changing recurrence to accomplish a general upgraded framework is examined. All contemplations in this paper are completed both for the CCM and for the DCM. DCM can be worked totally with no present detecting gadget. Besides, the impact of interleaving of at least two lift stages and the impact of the turning recurrence on the volume of every PFC part have been examined.

III. PROPOSED METHODOLOGY

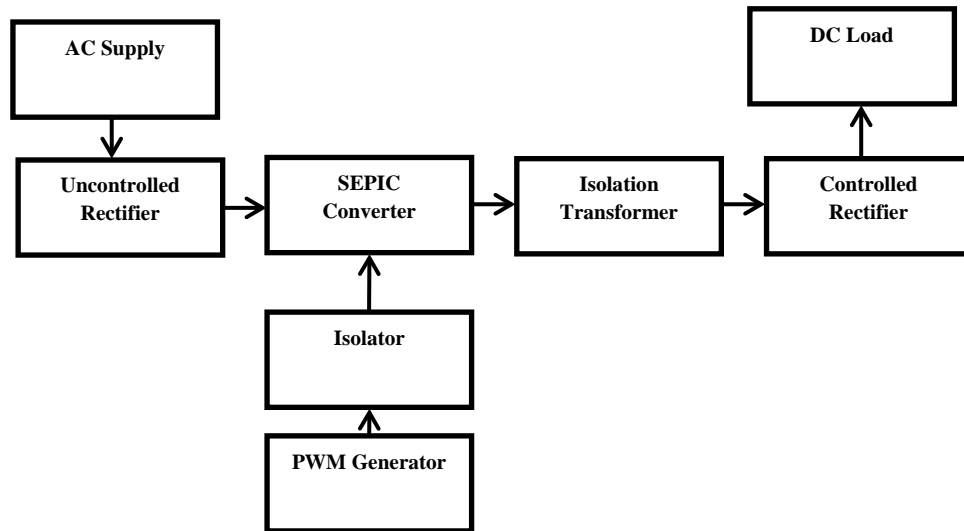


Figure 3.1: Block Diagram of Proposed System

A type of DC-DC converter corresponds to Single-ended primary-inductor converter (SEPIC). In its output, it allows, electrical potential equal to, less than or greater than input voltage. Control transistor's duty cycle controls the SEPIC output. Voltage conversion is done in SEPIC by exchanging energy between inductors and capacitors.

Switch Q1 is used for controlling amount of exchange of energy as shown in figure 3.1. MOSFET is used as a switch. When compared with bipolar junction transistors (BJTs), low voltage drop and high input impedance is offered by MOSFET. Biasing resistors are not required by this. Voltage difference controls MOSFET. Current difference controls BJT.

Modification of buck-boost converter corresponds to SEPIC boost converter. Both are similar. There are few advantages of SEPIC converter. They are, non-inverted input- same polarity of input and output voltage, Between output and input, energy is coupled by using a series capacitor- to a short circuit output, better response is produced, true shutdown is possible- output goes to 0V, if switch is off. Applications requiring only boost or buck converter can use that only. In few cases, output and input voltages needs to be same.

Converter which is increasing or decreasing voltages can be used in this conditions. Single capacitor and inductor are used in Buck-boost converters. So, they are very cheap. Huge input ripple current effects this converter. Harmonics are produced by this ripples. So, LC filter or huge value of capacitor needs to be used in most of the application. Voltage inversion is another drawback of buck-boost converters which makes complication of its usage. Both these issues are solved by an additional inductor and capacitor in Cuk converter. On components, huge amount of electrical stress is produced by operation of buck-boost and Cuk converter. Overheating or failure of device may be produced by this. Every issue is solved by SEPIC converter.

The operation of circuit is simulated by using MATLAB and the control parameters are taken as input by a voltage divider circuit and it is fed to the PWM controller in the analog pins. Based on the input the controller generates the switching signal for the gate terminal of mosfet. Since the output of controller is less i.e., around 5

volts and 20 mA, its boosted using a current amplifier IC7667 and fed to the mosfet switch. Based on the PWM pulse the output from the converter varies which is again fed back into the controller. The controller is isolated from the load using opto isolator IC, i.e., EL817. The DC motor is connected as the load which indicates an electric vehicle.

IV. CONTINUOUS MODE

Figure 3.2 shows SEPIC which is in continuous-conduction mode. In this, current across inductor L1 is never reached zero value. Input voltage will be equals average voltage across capacitor C1, in steady state operation of SEPIC. Direct current DC are blocked by capacitor C1. So, average current is zero, across it. In this case, load current is entirely given by inductor L2.

Average load current equals average current through inductor L2. Input voltage don't have any effect on it. On same core, wounded two conductors, because of this. With correct winding polarity, mutual inductance effect will be zero, for same magnitude voltages. There will be equal magnitude of ripple current produced by two inductors, as they are having voltage of same magnitude.

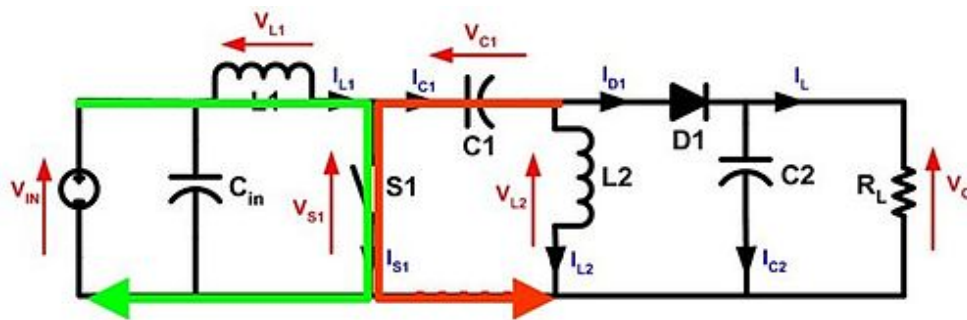


Figure 3.2: Circuit Diagram of Continuous Mode 1

Figure 3.3 shows turned off condition of switch S1. In this case, current I_{L1} and current I_{C1} are . This is because current's instantaneous changes are not allowed by inductors. In negative direction, current I_{L2} is flowing. This direction will not be reversed. To load, delivered current is increased by adding negative I_{L2} with current I_{L1} . $I_{D1} = I_{C1} - I_{L2}$ as per Kirchhoff's Current Law. From both L1 and L2, load receives power if while S1 is off, as shown. During off cycle, L1 charges C1 and during on cycle, L2 is recharged by this.

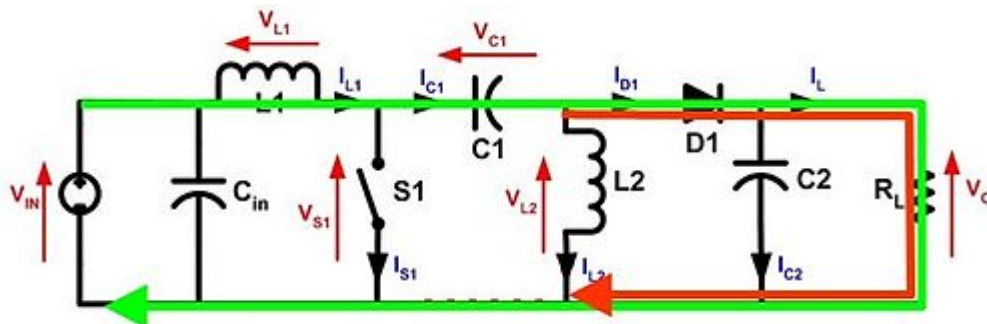


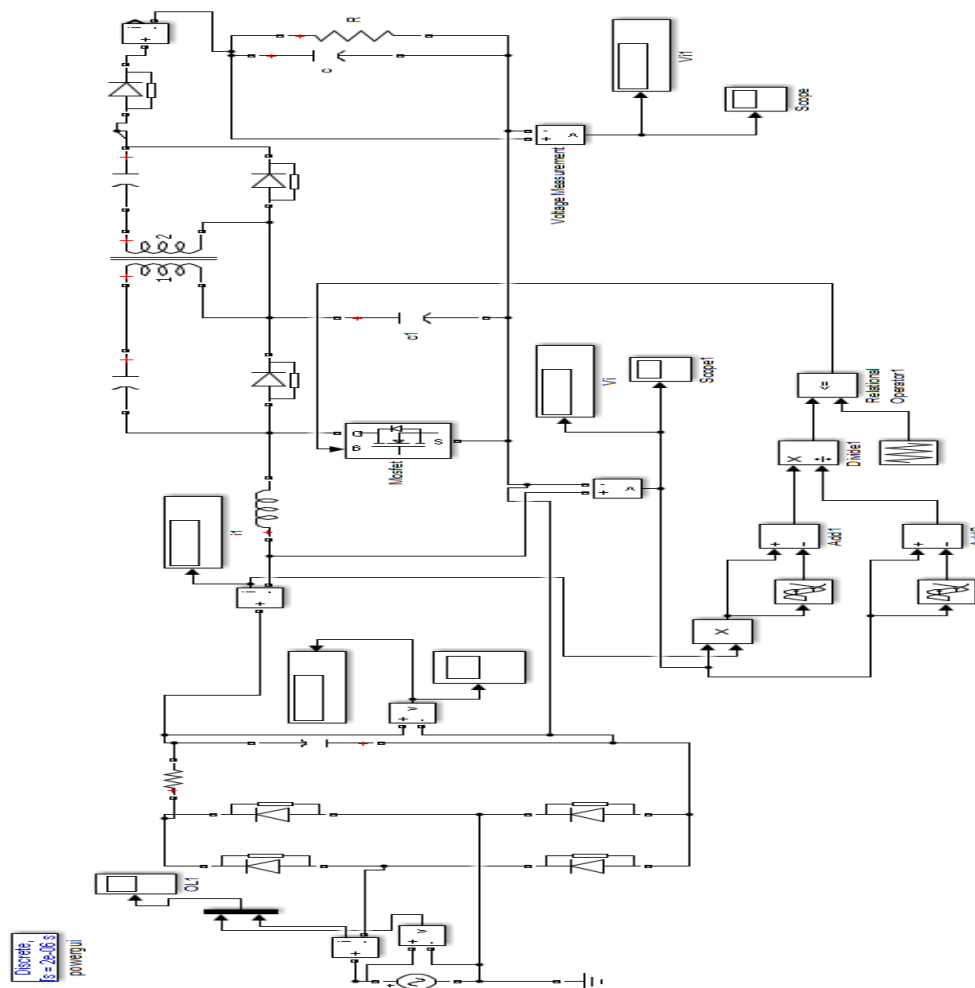
Figure 3.3: Circuit Diagram of Continuous Mode 2

A non-polarized capacitor is need to be used. This is due to the fact that, in every cycle, there will be change in a direction of potential across capacitor C1. In few cased, we may use polarized tantalum or electrolytic capacitor. In this, if switch is closed for a duration of half cycle of resonance with inductor L2, potential across C1 will be changed. There will be huge current across inductor L1.

Power supply's internal resistance and parasitic inductance effect can be reduced by using capacitor C_{IN} . Inductor L2 and capacitor C1 made the possibility of SEPIC boost/buck capability. Standard boost converter is created by switch S1 and inductor L1. voltage (V_{S1}) is generated by this and it will be greater than V_{IN} . Switch S1's duty cycle defines the magnitude of produced voltage. Across C1, average voltage is V_{IN} , output voltage is given by $(V_O) = V_{S1} - V_{IN}$.

Output voltage is less than input voltage, if V_{S1} is less than double V_{IN} , else, it will be grater than input voltage. In a SEPIC converter, two conductors are coupled to form a switched-power supplies. This structure is similar to transformer-isolated SMPS topology basic and Fly back converter.

V. SIMULATION MODEL AND OUTPUT WAVEFORMS



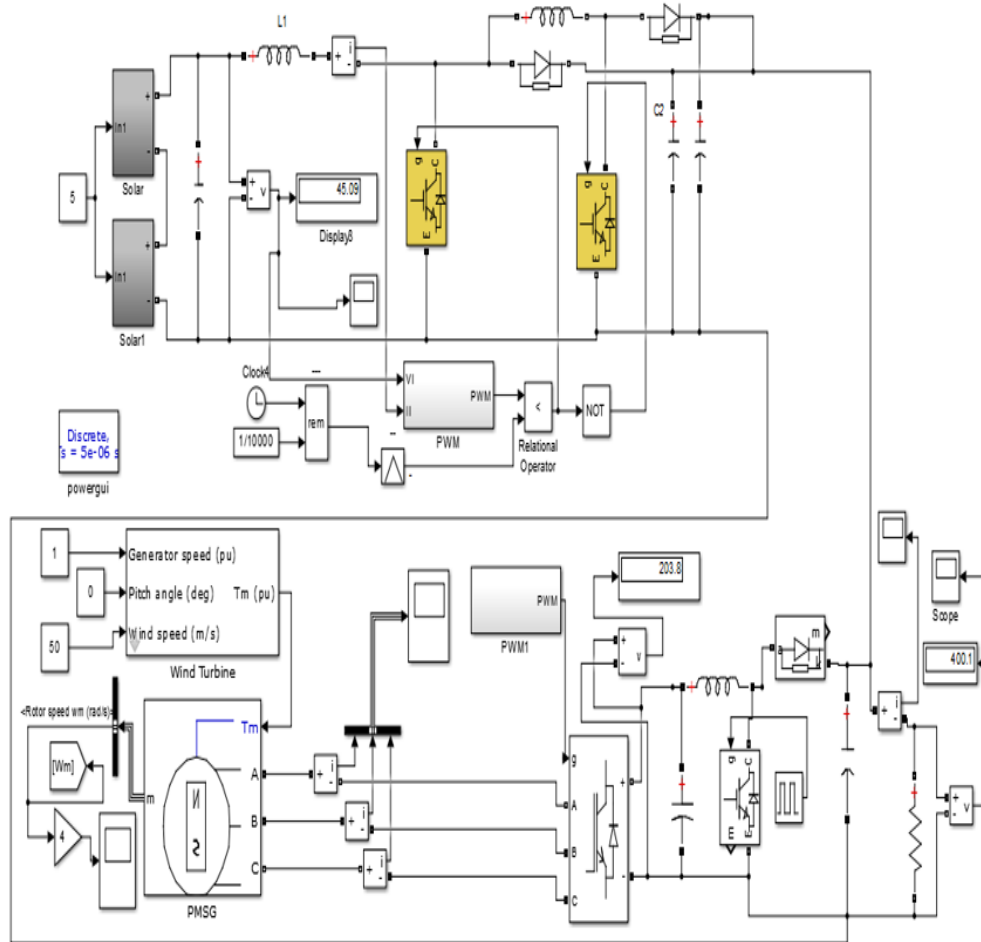


Figure 4.1: Proposed System Simulation Model

VI. OUTPUT WAVEFORMS

The input AC supply simulation results is given by graph shown in Figure 4.1. Figure 4.2 shows single phase AC supply with the frequency of 50 Hz.

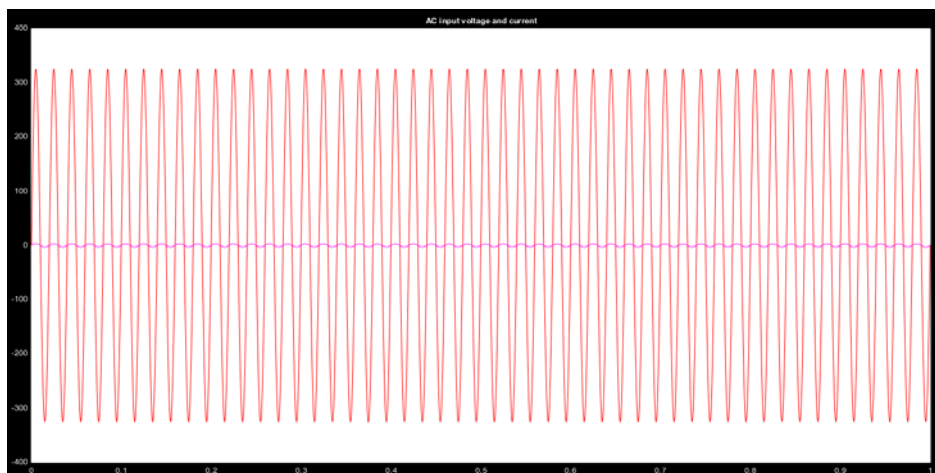


Figure 4.2: Output Waveform of Input AC Supply

Input DC voltage of SEPIC converter is given by graph shown in Figure 4.3, It indicates that value of DC voltage kept on oscillating due to the output from an uncontrolled rectifier.

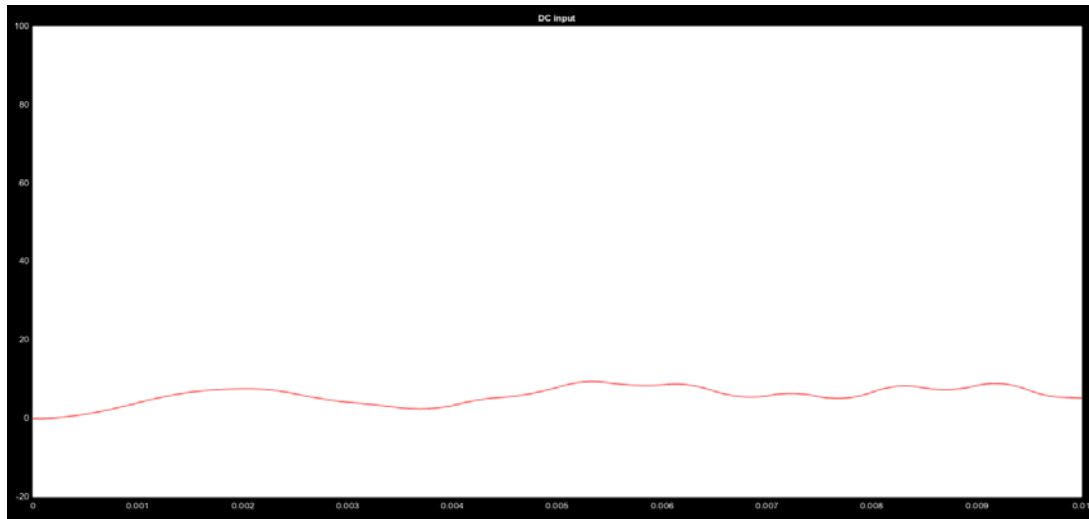


Figure 4.3: Output Waveform of Input DC Voltage Supply

Output DC voltage of SEPIC converter is given by graph shown in Figure 4.4, It indicates that value of DC voltage remains constant and it remains in the maximum value. The output of SEPIC converter depends on the PWM pulses provided to the converter which is generated from the PWM block.

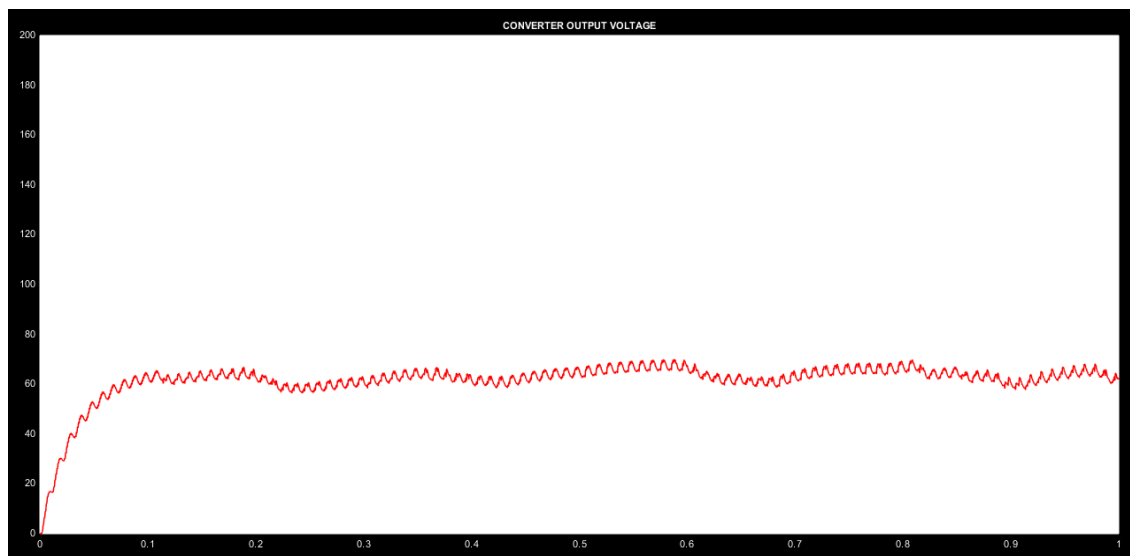


Figure 4.4: Output Waveform of Output DC Voltage Supply

VII. CONCLUSION

For the applications of electric vehicles, SEPIC converter included isolated current-fed AC to DC is proposed in this work. Four components are added with SEPIC converter in ordered to modify it and proposed system is simple to implement. Isolated system, non-inverting output voltage, very high voltage gain, continuous input current are the major advantages of proposed system. It does not require any coupled inductors and transformers for producing high

voltage gain. So, across switches, there wont be any voltage overshoot.

Use of clamping circuit is also avoided. Lowe voltage switches having low and compact design are used to reduce conduction losses.

Recent non-coupled inductor converters are used to make a comparison with proposed converter, with respect to number of elements, diode and switches voltage stress, voltage gain. When to other topologies, high value of gain is proposed by proposed converter as, shown by results. In proposed converter, with respect to output voltage, on switches, less percentage of voltage stress is produced. High voltage gain is produced by proposed converter with less number of components when compared with other converters. MATLAB Simulink is used for analyzing, output results of proposed converter.

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