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SIMULATION AND PERFORMANCE COMPARISON OF DIFFERENT TYPES OF BOOST CONVERTERS

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Abstract: Power losses and their consequences have the negative effect of decreasing the power density and the efficiency in Electric Vehicles. Generally the converter efficiency is needed in all the designs. For this reason, an efficiency optimization methodology is required to help reduce that problem. Specifically, in the power converters that interface the storage unit with the electric motors and their inverters, an efficiency optimization is essential to reduce the power losses and thereby downsize the cooling components and the storage unit. In this work, the topology under evaluation is the two-phase interleaved boost converter using different magnetic components such as coupled and non-coupled inductors. This topology is known as effective for high power density applications. This paper presents a methodology that optimizes the efficiency of the chosen topologies through a complete power loss modelling of each component. Moreover, a design procedure is proposed to integrate the loss model and the characteristics of the selected components as the base to obtain the objective function, which is later solved using analytical calculations. Finally, the optimization methodology is validated by experimental tests Among the several DC – DC Converters, the analysis stays to prove which converter yields a best efficiency, Voltage ripple and Current ripple In this Paper the simulation and comparison is done to decide which converter is good and efficient

The following DC-DC converter is going to be compared.

1. Boost Converter.
2. Bridge Boost Converter.
3. Interleaved Boost Converter.
4. Soft Switched Boost converter.

Key words: Optimization ,DC-DC converters, Efficiency, Ripple, Power losses.
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I. INTRODUCTION

Electric Vehicles (EV) are an emerging alternative to deal with some environmental problems because they have been improved to reduce the fuel dependency, reducing greenhouse emissions and thereby helping to deal with global warming. However, EV have to use large, heavy, and expensive storage units in order to obtain sufficient power and autonomy to supply the daily needs of the users. These storage units must provide power and energy to motors of several tens of kW. This fact makes that the power losses in the power electronic subsystems become large and thereby robust cooling systems may be required. As a consequence, additional storage cells are needed to compensate the power losses and the required energy to move the extra mass and volume of the cooling systems. The result is a reduction in the efficiency and the power density of the entire vehicle.Thus, an improvement in the efficiency of the DC-DC converter that interfaces the storage unit with the electric motors would improve the performance of the vehicle. In this study, an optimization methodology is presented as a technique to increase the efficiency of power converters in EV. The used topology in this study is the well-known two-phase interleaved boost converter. Two different configurations of this topology are evaluated: the interleaved converter with non-coupled inductors and the Loosely Coupled-Inductor (LCI) converter. It illustrates the schematics of both converters.

These topologies were selected because of their outstanding performance in high power density applications since they use the techniques of interleaving phases and magnetic coupling, which are effective to downsize power converters. The two magnetic components, Non-coupled and LCI, are compared, and their efficiency characteristics are evaluated in order to select the most suitable option. Finally, an efficiency characterization of the LCI converter is carried out with the purpose of selecting the most suitable operating point that offers the lowest power losses. Moreover, this optimization is implemented using an analytical calculation that compares the power losses of each component and finds the most suitable design point in accordance with the switching frequency. The intention of the optimization procedure presented in this paper and the

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evaluation of the scale model of Table I is to offer a design tool of DC-DC converters, especially two-phase interleaved boost converters. This tool can be helpful for a designer when a high efficiency is required.

In this study a dc-dc converter that interfaces the storage unit with the motor is studied in order to reduce the mass, volume and cost of additional storage components and heat sinks. Therefore ,the main goal of this converter is to transfer sufficient power at high efficiency, having low cost and small size and weight.

In this paper a methodology to optimize the efficiency in dc-dc converters is conducted by the combinations of three techniques. the first one is the emerging technologies of semiconductor such as Gallium Nitride and Silicon Carbide, and multilayer ceramic capacitor. The second one is a complete power loss analysis in function of the switching frequency and the flux density in the inductor. Finally, the third technique is the inductor area product analysis in order to select an optimal size of the core.

The boost converter operating in continuous current mode (CCM) is widely used in power factor correction (PFC) for its high power factor (PF) and low inductor current ripple. However, the power switch is hard-switching, and the boost inductor is relatively large. Critical current mode (CRM) boost PFC converter achieves zero-current turn-on for the power switch and zero-current turn-off for the diode, avoiding the reverse recovery problems, and the input PF is nearly unity. Although, the inductor is small, the input current is relatively large and it requires a large electromagnetic interference (EMI) filter. Therefore, CRM is only suitable for low power applications. When multiple converters paralleled or interleaved, the output power can be extended without sacrificing the advantages of the single-phase converter, and it can also reduce the input and output current ripples, leading to a smaller EMI filter.

Therefore, with the development of the control strategies and the promotion of high power density and efficiency power supply, the interleaved CRM boost PFC converter is widely used recently. The concept of coupled inductor has been applied successfully in the interleaved voltage regular modules for the improvement of the transient response and the inductor current ripple . Meanwhile, coupled inductor employed in the interleaved boost PFC converter also exhibits improved performance, such as increased efficiency, smaller size, and reduced EMI filter.

Since the former researches are mainly focused on the coupled inductor effects on the interleaved boost PFC converter in CCM, the objective of this paper is to investigate the characteristics of interleaved CRM boost PFC converter with the boost inductors coupled. First, the switching frequency and the inductor current are deduced. Second, such coupling effects on the converter as the minimum switching frequency, the flux linkage in the magnetic core legs, and the input current are presented. Third, the proper coupling coefficient is discussed.

II. EXISTING SYSTEM

The efficiency optimization methodology for DC-DC converters is conducted by the combinations of three techniques: The first one is the use of emerging semiconductor technologies such as Gallium Nitride and Silicon Carbide. The second one is a complete power loss modeling in function of the switching frequency and the flux density in the inductors. These two techniques are applied to the two magnetic components of Fig. 1. Finally, an efficiency characterization of the LCI converter is carried out with the purpose of selecting the most suitable operating point that offers the lowest power losses. Moreover, this optimization is implemented using an analytical calculation that compares the power losses of each component and finds the most suitable design point in accordance with the switching frequency. The results of the efficiency optimization are validated by several experimental tests of a 1kW prototype. The parameters of Table I were selected as a scale model of 1/45 of power and the same voltages of the DC-DC converter of the C (III Generation). This model was chosen due to the available equipment for tests and safety conditions. The intention of the optimization procedure presented in this paper and the evaluation of the scale model of Table I is to offer a design tool of DC-DC converters, especially two-phase interleaved boost converters. This tool can be helpful for a designer when a high efficiency is required.

Power losses and their consequences in the addition of storage cells have the negative effect of decreasing the power density and the efficiency in Electric Vehicles. For this reason, an efficiency optimization methodology is required to help reduce that problem. Specifically, in the power converters that interface the storage unit with the electric motors and their inverters, an efficiency optimization is essential to reduce the power losses and thereby downsize the cooling components and the storage unit. In this work, the topology under evaluation is the two-phase interleaved boost converter using different magnetic components such as coupled and non-coupled inductors, which are topologies known as effective for high power density applications. This paper presents a methodology that optimizes the efficiency of the chosen topologies through a complete power loss modeling of each component. Next generation components such as Super Junction Mosfets,

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GaN and SiC diodes and Mosfets are compared to obtain the most efficient and suitable material to be implemented to the topologies, especially to the converter with coupled-inductor.

A. BLOCK DIAGRAM

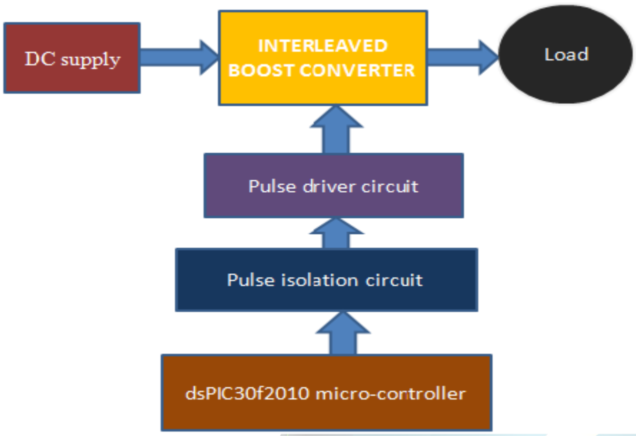
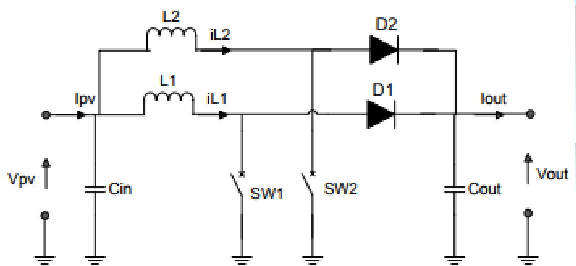


Fig 1.1 Block diagram of Existing system

2.2 DESIGN OF INTERLEAVED BOOST CONVERTER

The interleaved boost converter circuit is shown, this part is provided to design and determine the elements and parameters of the circuit based on frequency switches operation and on energy from a photovoltaic source as follows

Fig 1.2 Circuit diagram of interleaved boost converter



In designing an interleaved boost converter, a typical constraint is the maximum output ripple. Once the frequency, input voltage, and output voltage are defined, this ripple is directly related to the inductor value. The design specifications and procedure are the same as the conventional boost converter presented in Chapter four. The following parameters are also needed.

2.3 SIMULATION OUTPUT

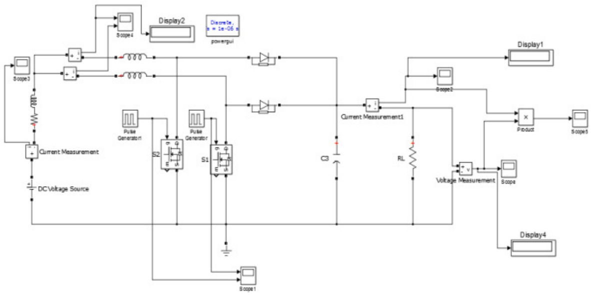
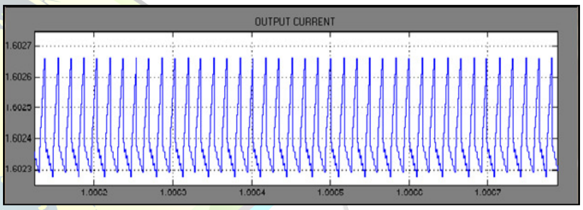
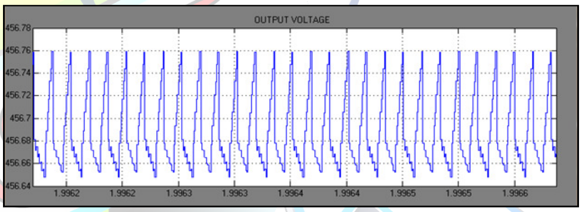


Fig 1.3 Simulation of interleaved boost converter

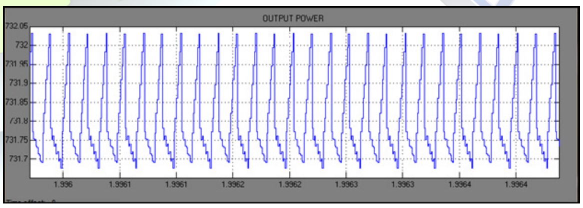
OUTPUT CURRENT



OUTPUT VOLTAGE



OUTPUT POWER



III.PROPOSED SYSTEM

Proposed System wants to compare the result with the analysis of Following converters.

1. Boost Converter.
2. Bridge Boost Converter.
3.Interleaved Boost Converter.
4. Soft Switched interleaved Boost Converter.

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3.1 BOOST CONVERTER

DC/DC converter is needed for converting a given DC voltage to a desired DC voltage at relatively high efficiencies. The main purpose of DC/DC converter is to supply a regulated DC output voltage to a variable load resistance from an unstable DC input voltage. The below discussion deals with the fundamental concepts of the DC/DC boost converter along with design and analysis for a photovoltaic system.

The input of DC/DC converters is an unregulated DC voltage, which is obtained by PV array and therefore it will be fluctuated due to changes in intensity and temperature. In these converters the average DC output voltage must be controlled to be equated to the desired value although the input voltage is changing. From the energy point of view, output voltage regulation in the DC/DC converter is achieved by constantly adjusting the amount of energy absorbed from the source and that injected into the load, which is in turn controlled by the relative durations of the absorption and injection intervals.

3.2 BLOCK DIAGRAM FOR BOOST CONVERTER

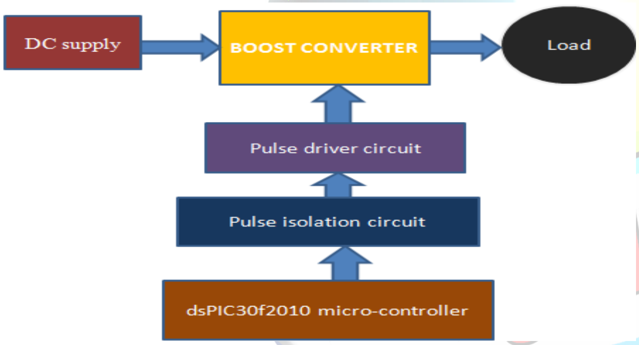

Fig 1.4 Block diagram of boost converter

3.3 CIRCUIT DIAGRAM FOR BOOST CONVERTER

The schematic circuit diagram for DC/DC boost converter is shown in the fig.4.1.The DC/DC boost converter only needs four external components: Inductor, Electronic switch, Diode and output capacitor. The DC/DC converter has two modes, a Continuous Conduction Mode (CCM) for efficient power conversion and Discontinuous Conduction Mode (DCM) for low power or stand-by operation. In this project, only CCM is considered. The equivalent circuit diagram for boost converter in CCM is shown in fig 1.5

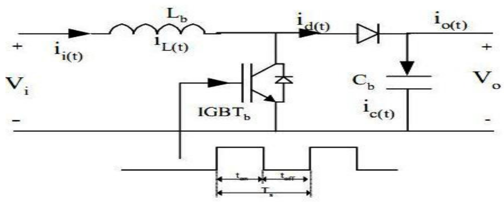

Fig.1.5 Circuit diagram of boost converter

3.4 BRIDGE BOOST CONVERTER

The single-phase diode rectifier associated with the boost converter is widely employed in active PFC. In principle, the combination of the diode bridge rectifier and a dc-dc converter with filtering and energy storage elements can be extended to other topologies, such as buck, buck-boost, and Cuk. The boost topology is very simple and allows low-distorted input currents, with almost unity power factor using different dedicated control techniques. Typical strategies are hysteresis control, average current mode control and peak current control. More recently, on-cycle control and self control have also been employed. The converter in presents appreciable conduction losses because the current always flows through three semiconductor elements, which are two diodes in series with diode Db or switch S, depending on the state of S. Therefore, the converter efficiency is compromised, especially at low input voltage.

Besides, to achieve high power density and faster transient response, the converter is supposed to operate at high switching frequencies. However, as the switching frequency increases, the output diode operated in high voltage provides significant reverse-recovery loss in a hard-switching boost converter. The reverse-recovery problem of the output diode affects the switching devices in the form of additional turn-on loss. The reverse-recovery loss of the diode is the most significant due to its large current at the minimum input voltage. Other adverse effects of the reverse-recovery problem include electromagnetic interference and additional thermal management

3.5 BLOCK DIAGRAM OF BRIDGE BOOST CONVERTER

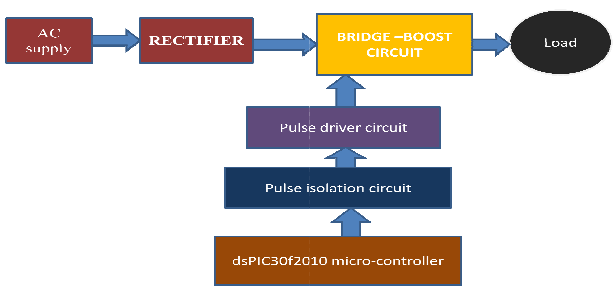

Fig 1.6 Block diagram

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3.6 CIRCUIT DIAGRAM FOR BRIDGE BOOST CONVERTER

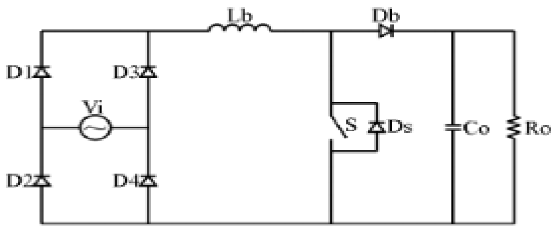

Fig 1.7 Circuit diagram of bridge boost converter

3.7 INTERLEAVED BOOST CONVERTER

Energy conversion efficiency is an important factor for the long-term feasibility of photovoltaic systems. Significant work has been carried out into improving the effectiveness of solar arrays in recent years. In addition, there has been substantial research into novel power converter topologies for maximum energy efficiency. However, in photovoltaic applications, even the most promising power converter topologies do not necessarily guarantee optimum performance under all operating conditions. For instance, the efficiency of the power conversion stage may be excellent during periods of high irradiance, but significantly lower in poorer light conditions. This work attempts to address this problem, by seeking to achieve higher energy conversion efficiency under sub-optimal conditions. In this thesis, stand-alone photovoltaic systems using DC-DC boost converters are considered. An interleaved boost converter with novel switch adaptive control scheme is designed to maximize system efficiency over a wider range of real-time operating atmospheric conditions and with different load conditions without incurring significant additional cost.

3.8 BLOCK DIAGRAM FOR INTERLEAVED BOOST CONVERTER

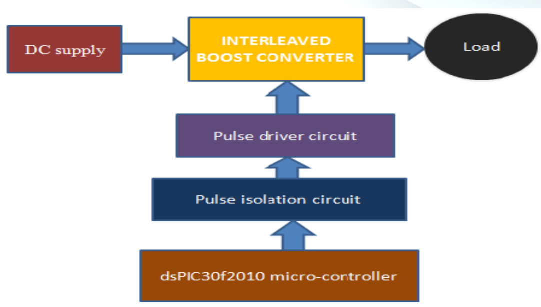

Fig 1.8 Block diagram for interleaved boost converter

3.9 CIRCUIT DIAGRAM FOR INTERLEAVED BOOST CONVERTER

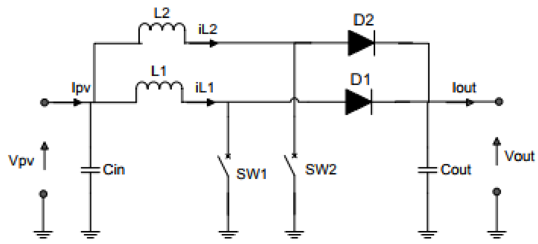

Fig 1.9 circuit diagram of interleaved boost converter

3.10 SOFT SWITCHED INTERLEAVED BOOST CONVERTER

Power electronics will play a vital role in energy saving. Energy efficiency can make a major contribution to meeting the global energy demand. A boost converter is a particular type of power converter with an output DC voltage greater than the input. This type of circuit is used to 'step-up' a source voltage to a higher, regulated voltage, allowing one power supply to provide different driving voltages. In recent years, interleaved boost converter is well suited for high performance applications. The advantages of IBC include increased efficiency, reduced size, reduced electromagnetic emission, faster transient response and improved reliability. The switching losses pre-dominate causing junction temperature to rise which is a major drawback of PWM switching. The soft switching phenomena known as zero-voltage switching (ZVS) and zero-current switching (ZCS) can reduce switching losses. For zero-voltage switching (ZVS), the transistor will be turned on at zero Vdc voltage to reduce the turn on switching loss. For zero-current switching (ZCS), the transistor will be turned off at zero Id current to reduce the turn off switching loss. The soft switching techniques reduce the switching losses enabling high frequency operation and consequently reducing the overall system size and hence to increase the power density.

3.11 BLOCK DIAGRAM OF SOFT SWITCHED INTERLEAVED BOOST CONVERTER

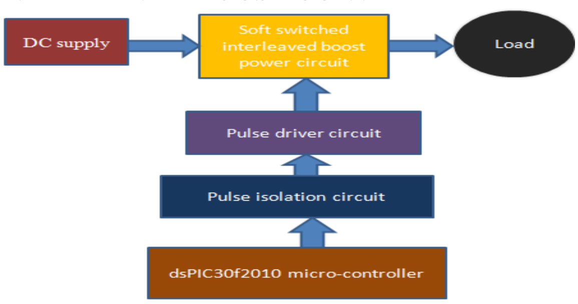

Fig 1.10 Block diagram

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3.12 CIRCUIT DIAGRAM

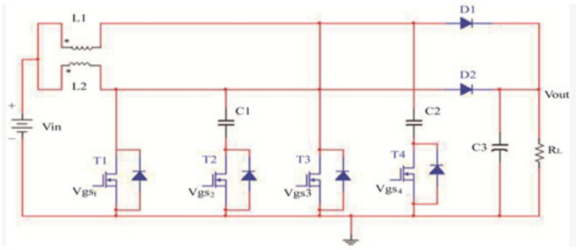


Fig 1.11 Circuit diagram of soft switched interleaved boost converter

IV. SIMULATION OUTPUT

4.1 BOOST CONVERTER

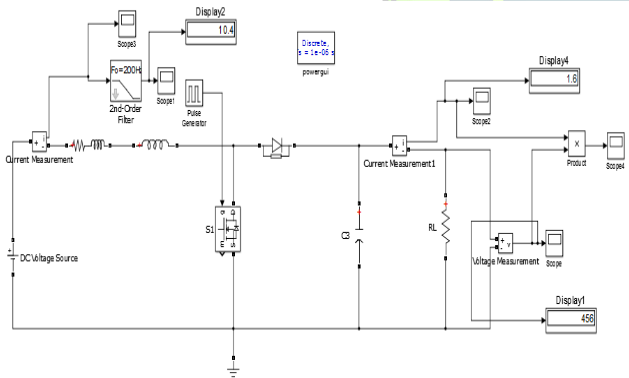
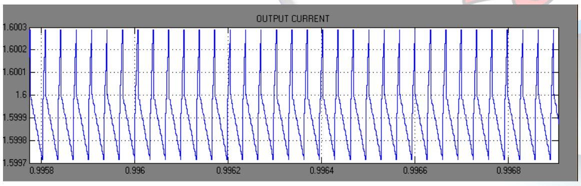
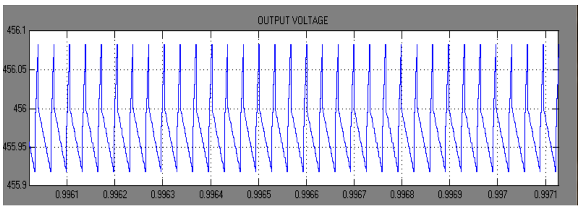


Fig 1.12 simulation of boost converter

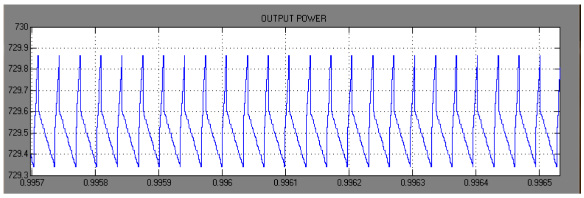
OUTPUT CURRENT



OUTPUT VOLTAGE



OUTPUT POWER



4.2 BRIDGE BOOST CONVERTER

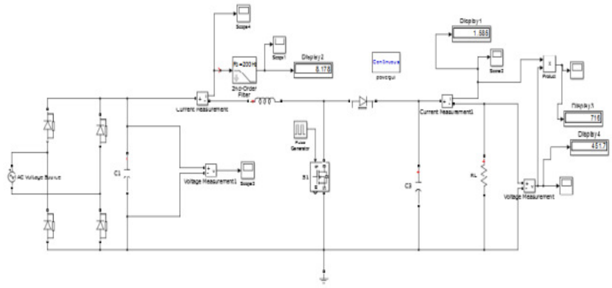
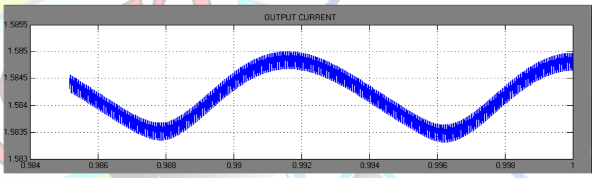
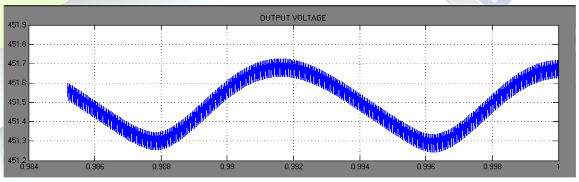


Fig 1.13 simulation of bridge boost converter

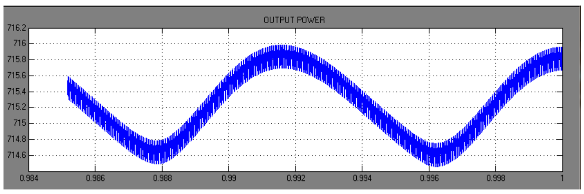
OUTPUT CURRENT



OUTPUT VOLTAGE



OUTPUT POWER



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4.3 INTERLEAVED BOOST CONVERTER

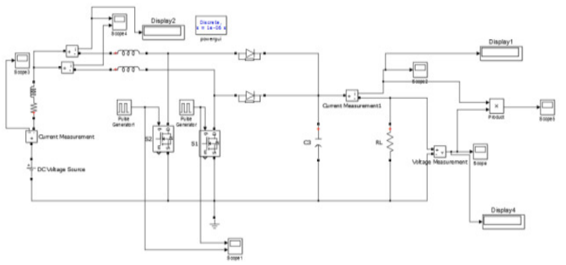
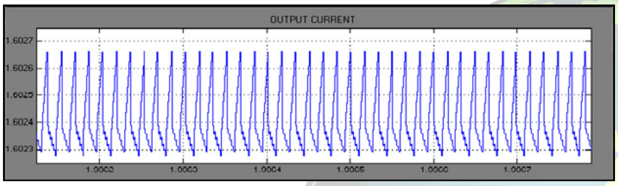
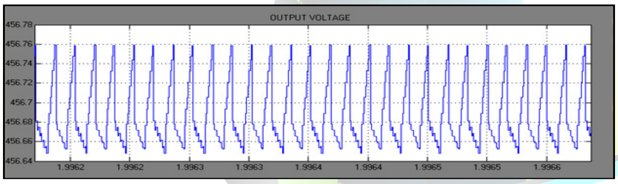


Fig 1.14 simulation of IBC

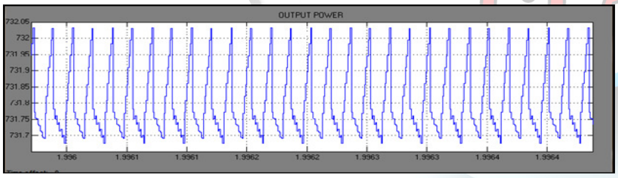
OUTPUT CURRENT



OUTPUTVOLTAGE



OUTPUT POWER



4.4 SOFT SWITCHED INTERLEAVED BOOST CONVERTER

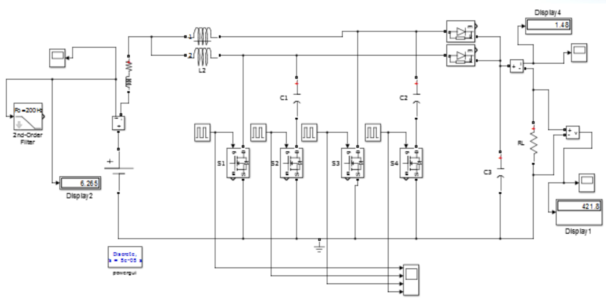
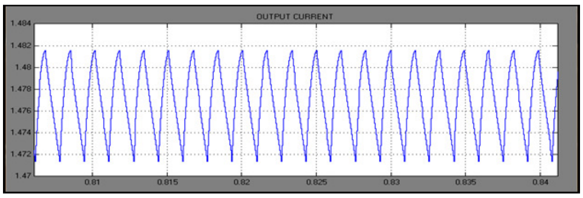
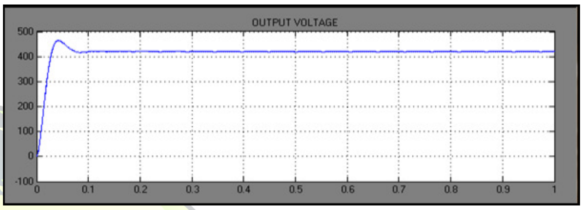


Fig 1.15 simulation of SSIBC

OUTPUT CURRENT



OUTPUT VOLTAGE



OUTPUT POWER

V. COMPARISON OF DC-DC CONVERTERS

S.No	Converters	Inductor ripple(H)	Output current ripple(I)	Output voltage ripple(V)	Efficiency
1.	Boost Converter	9.48	2.02	0.035	72.96
2.	Bridge Boost Converter	7.38	1.63	0.10	87.54
3.	Interleaved Boost Converter	7.5	1.64	0.026	88.70
4.	Soft Switched Interleaved Boost Converter	5.28	1.2	1.18	99.64

VI. CONCLUSION

In this paper, the comparison and simulation of various boost converters were made among the listed converters in Table 5.17,Soft Switched Interleaved Boost Converter(SSIBC) as maximum efficiency and low inductor ripple and output current ripple. By using SSIBC, the output voltage can be maintained constant and it is found that it has the ability in the input current sharing as well as reducing the ripple current. Further, this converter always operates in CCM inherently. By using Digital PWM techniques, the proposed converter can achieve faster steady state response

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when the supply voltage or load changes. Further, research efforts play a major role in constructing high frequency and high efficiency soft switching converter for power factor correction (PFC) of electronic power supplies incorporated in telecommunication switching systems. Any one method of different current control techniques like average current control, hysteresis control and non-linear carrier current control can be utilized by means of digital implementation. Output voltage ripple factor reduction techniques leads the future research scope.

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