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Two Input DC-DC Boost Converter Based On VMC And IBC For Electric Vehicle Applications

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Abstract

A new two input–single output DC-DC converter based on voltage multiplier cell and interleaved concept is proposed in this paper. This converter can be used in electric vehicle to hybridize the two different sources. This paper presents two input DC-DC converter for providing high output voltage is shown. High boost voltage is obtained with low duty cycle. The main features of these converters are a high conversion ratio, high efficiency, simple topology and also to provide compact circuit where isolation is not required.The validity of the proposed converters are verified by simulation for different operating modes.

Keywords- DC-DC converter, Multiple input converter (MIC)

Introduction:

Because of high demand and depletion of fossil fuels like oil, gas, there is a great demand for renewable energy sources in electrical vehicles. In the transportation the electric vehicles are increasingly used because of their inherent advantages [1][2].In the electric vehicle for providing the required voltage level for load and input sources DC-DC converter is needed. The use of separate DC-DC converter for each input source lead to increase in cost and complexity of the system and also which in turn increase losses. Instead of that multi input converter is preferred over separate DC-DC converters.Multi input converters have two types namely: isolated and non isolated DC-DC converter. The high frequency transformer is used in isolated type to provide necessary electrical isolation [3][4].In the case of isolated type Multiple input converters, several switches are used which lead to increase in cost, size and complexity of the control circuit. The advantage of non isolated type DC-DC converter is lesser number of passive elements. The fuel cells are hot issue in electric vehicles. In order to boost the low input voltage to high output voltage, voltage multiplier cells are used [5].One of the challenges in designing the boost converter for high power application is to how to handle the high current at the input side. Among the various topologies IBC is a better solution for fuel cell systems due to its increased efficiency, reduced size, current sharing on high power applications, low input current ripple and improved reliability[6].The Interleaved boost converter has high voltage step up, reduced voltage ripple at the output, low switching loss, reduced electromagnetic interference and faster transient response. Also, the steady-state voltage ripples at the output capacitors of mc are reduced. Though IBC topology has more inductors increasing the complexity of the converter compared to the conventional boost converter it is preferred because of the low ripple content in the input and output sides. In order to reduce this complexity, this paper investigates the benefits of coupled, uncoupled and inversely inductors for mc [7]. IBC consists of a number of boost converters connected in parallel and controlled by the interleaved method which has the same switching frequency and phase shift [8]. In general, the transformers are used to provide high voltage which lead to losses in the circuit. Here two input voltage multiplier cell based DC –DC converter is proposed.The use of voltage multiplier cells with two input converter will reduce the problems associated with high frequency and high voltage transformer.

This paper is organised as follows: The existing converter structure, proposed converter structure for VMC and their operation modes are explained in chapter I. Chapter II discuss the proposed converter for IBC and their operating modes. Chapter III describes the simulation results. Chapter IV concludes the paper.

I. Existing Topology for Two Input DC-DC Boost Converter:

Figure1: Two input dc-dc boost converter

I.1 Proposed Converter for Two Input DC-DC Boost Converter with VMC:

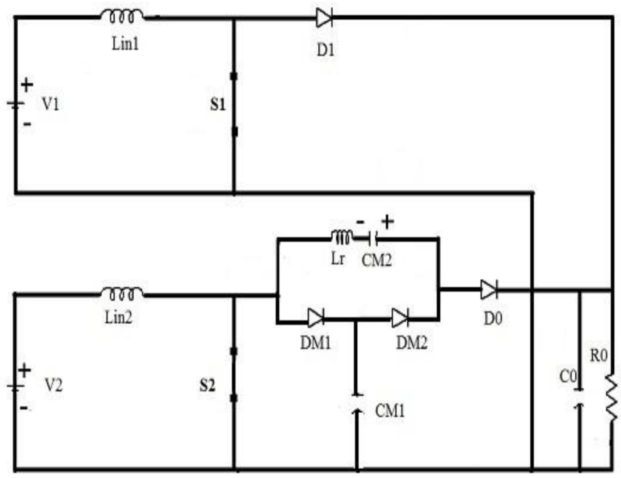

Figure 2: Proposed two input boost converter with VMC

I.2 Timing diagram of VMC:

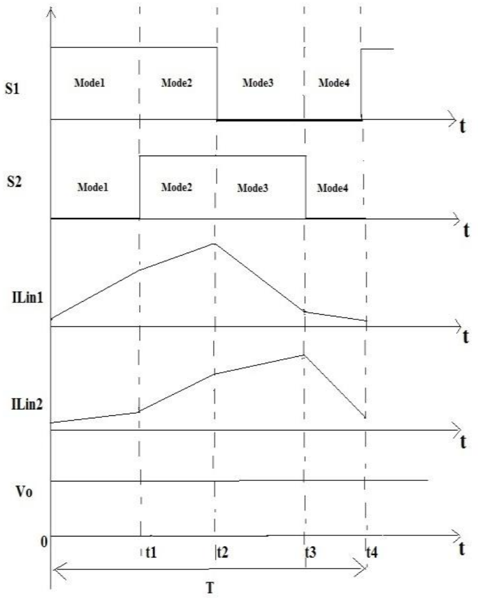

Figure 3: Timing diagram of VMC

I.3 Mode1 (0<t<t1):

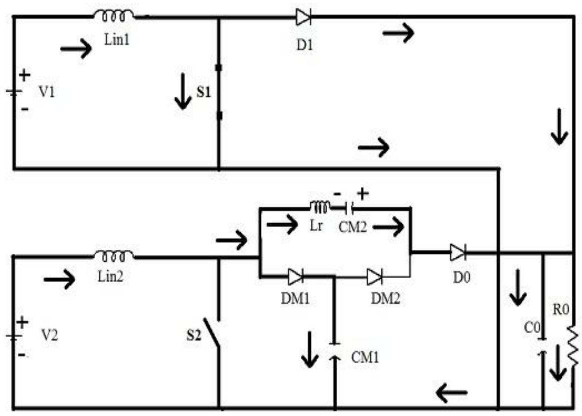

Figure 4: Mode 1

In this mode switch S1 is turned ON and S2 is turned OFF. The input voltage of V1 charges inductor Lin1 and the inductor of Lin2 discharges its energy to the multiplier capacitor CM1 through the diode DM1. The resonant inductor current (iLr) and CM1voltage rise linearly from zero until it reaches the value of the input inductor current (iLin2) and also the current in the diode DM1 is reduced at same proportion.

The resonant inductor current (iLr) charges the output capacitor Co through the diode Do.

I.4 Mode2 (t1<t<t2):

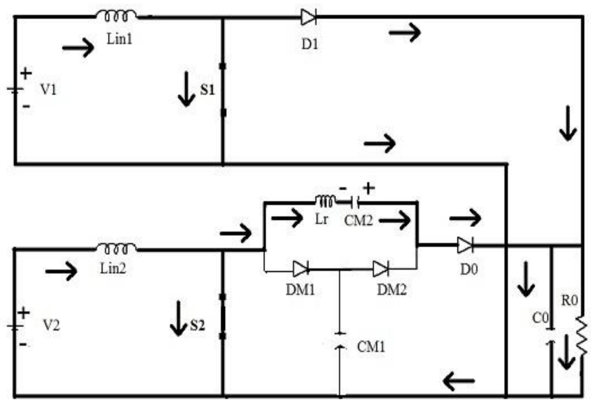

Figure 5: Mode 2

In this mode switches S1& S2 is turned ON. The input voltage of V1&V2 charges input inductor currents linearly (iLin1&iLin2).The current in the diode DM1 gets zero and this diode is blocked with low di/dt, minimizing the diode reverse recovery current. The resonant inductor current (iLr) is equal to the input inductor current (iLin2) during this stage and the energy of the input inductors are transferred to the output capacitor and load through the diode Do.

I.5 Mode3 (t2<t<t3):

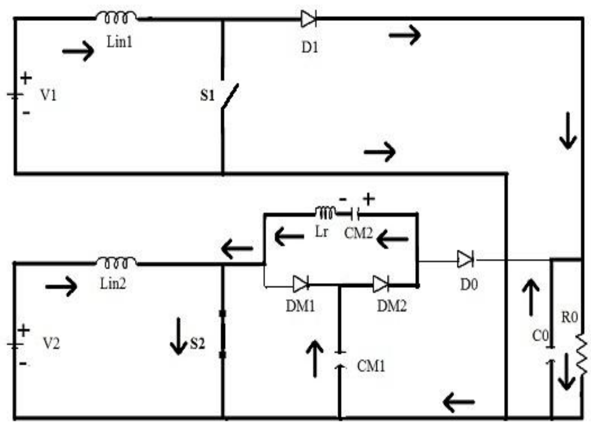

Figure 6: Mode3

In this mode switch S1 is turned OFF and S2 is turned ON. The output diode is blocked, now energy stored in capacitor CM1 is transferred to CM2 through diode

DM2. When there is a balance of energy between the multiplier capacitors, the diode DM2 is blocked also with low di/dt. During this time, voltage of the output capacitor is transferred to the load.

I.6 Mode4 (t3<t<t4):

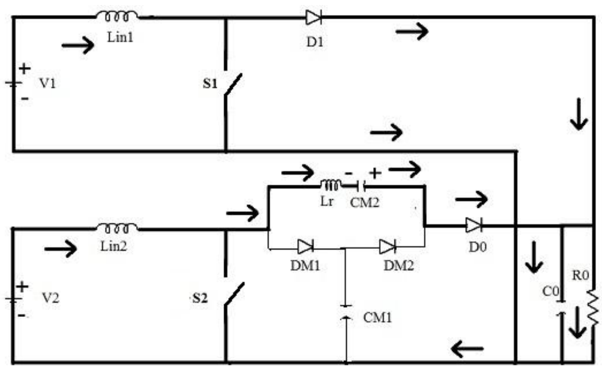

Figure 7: Mode 4

In this mode switch S1 is turned OFF and S2 is also turned OFF. The input voltage and the inductor currents charge the output capacitor Co through the diode Do and also voltages from V1&V2 are transferred to the load.

II. Proposed Converter for Two Input DC-DC Boost Converter with IBC:

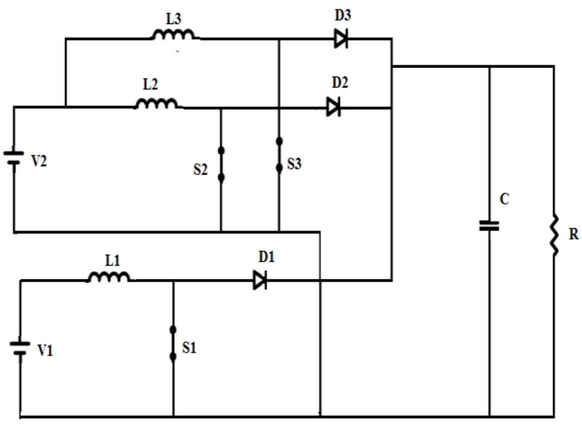

Figure 8: Proposed converter with IBC

The figure 8 shows the proposed converter using interleaving concept by adding inductor, diode, and a switch combination in parallel to the L2,D2,S2 elements.

II.1 Timing diagram for IBC:

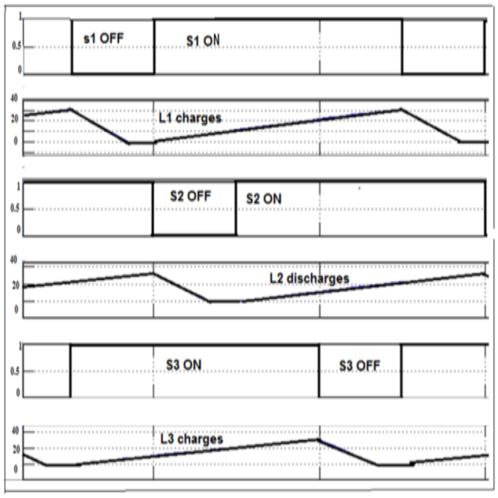

Figure 9: Timing diagram for IBC

II.2 Modes of Operation:
II.2.1 Mode1:

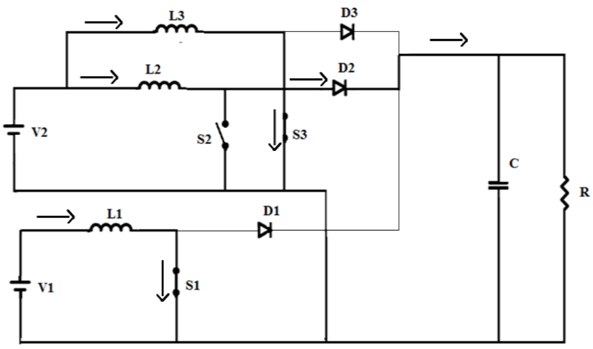

Figure 10: Mode 1

In this mode switches S1& S3 are turned ON and switch S2 is turned OFF. The Inductors L1 & L3 charges linearly through the input supply and at the same instant the energy stored previously in the inductor L2 is discharged through diode D2.The input through diode D2 charges the capacitor and also delivers supply to the load.

II.2.2 Mode2:
In this mode all the switches S1, S2, S3 are turned ON, so that the corresponding diodes D1, D2,D3 get reverse biased and become open circuit. so that no current

passes through them. The input voltage v1 charges L1 and the input voltage v2 charges input inductor L2 & L3.the capacitor still delivers supply to the load.

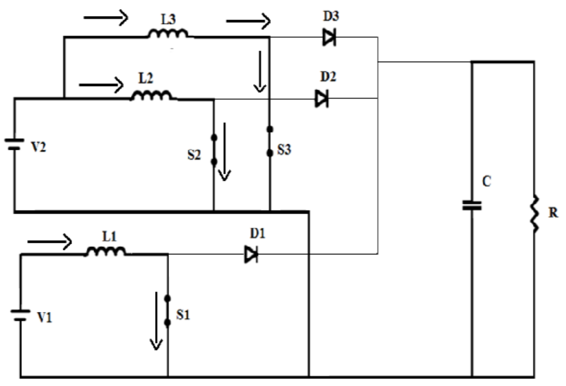

Figure 11: Mode 2

II.2.3 Mode3:

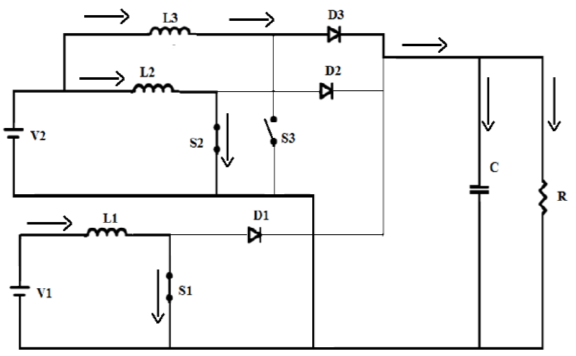

Figure 12: Mode3

In this mode switches S1& S2 is turned ON and the switch S3 is turned OFF so the diode D3 allows current to pass through it. The input inductor L1 & L2 charges linearly with the input supply given from V1 & V2 respectively. The energy stored previously in the inductor L3 is discharged through diode D3 to the capacitor and load.

II.2.4 Mode 4:

In this mode switches S2& S3 are turned ON and the switch S1 is turned OFF so the diode D1 is forward biased and allows current to pass through it. The input inductor L2 & L3 charges linearly and the energy stored in the inductor L1 previously is discharged through diode D1 to the capacitor C and load.

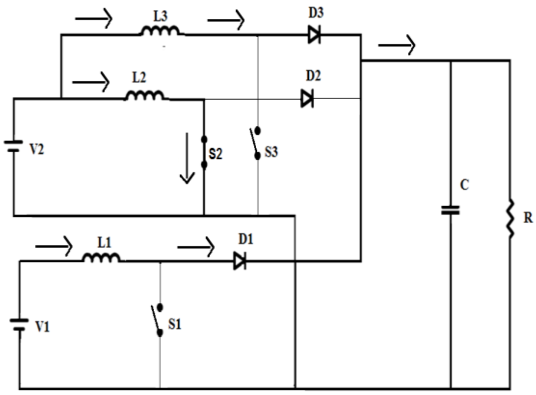

Figure 11: Mode 4

III. Results and Discussions:

In this Chapter, the proposed converters are modelled using MATLAB software. The simulation results are shown in the figure, the simulation diagram and the simulation output results also shown for the proposed converters. Figure1 shows the simulation of proposed Converter for VMC using MATLAB Simulink, it consists of the two DC voltage source input, 2 MOSFET switch, 3 inductors, 4 diodes, 3 capacitors and r load the voltage measurement connected with scope to verify the simulation output results and with the pulse generator to give the pulses for the circuit and finally the power GUI is connected. Figure2 shows the simulation of proposed Converter for IBC using MATLAB Simulink. The main principle of the DC to DC converter is based on boost type. The purpose of the project is to develop DC to DC converter (boost type) that converts the unregulated DC input to a controlled DC output with desired voltage level. The main objectives of this project are designing and constructing a DC to DC converter (boost type) circuit practically. The output voltage waveforms are mentioned in below figures.

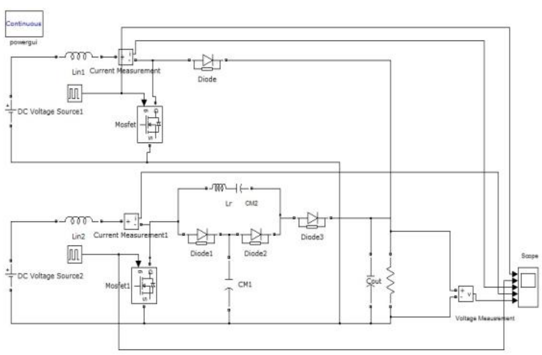

Figure12: Simulation Diagram of Proposed Converter with VMC

The parameters which are used for proposed converter for same input voltage

- Input Voltage of V1&V2=12V

- Output Voltage Vo= 138V
- Lin1&Lin2=0.1mH,Lr=0.9mH,
- CM1=CM2=1μF, Co=20mF, Ro=100Ω

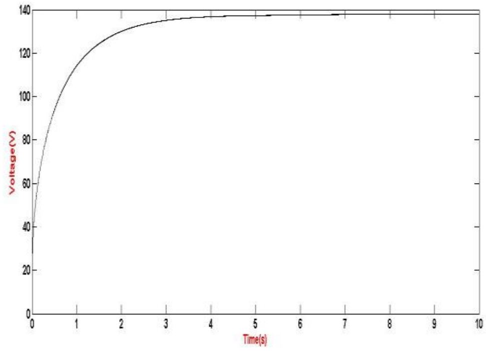

Figure 13: Output Voltage of VMC for same input

The parameters which are used for proposed converter for different input voltage

- Input Voltage of V1=20V,V2=10V
- Output Voltage Vo= 201V
- Lin1&Lin2=0.1mH,Lr=0.9mH,
- CM1=CM2=1μF,Co=20mF, Ro=100Ω

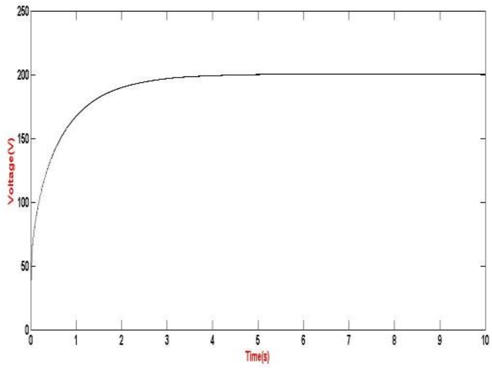

Figure 14: Output voltage of VMC for different input

The parameters which are used for proposed converter of IBC for same input voltage

- Input voltage V1=V2=12
- Inductor values =0.1mH
- Capacitor value =0.1F
- Load resistance = 50ohms

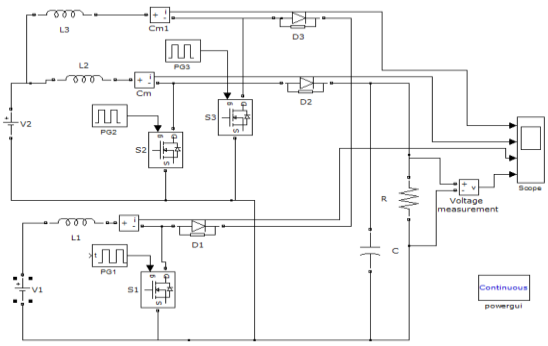

Figure 15: Simulation Diagram of Proposed Converter with IBC

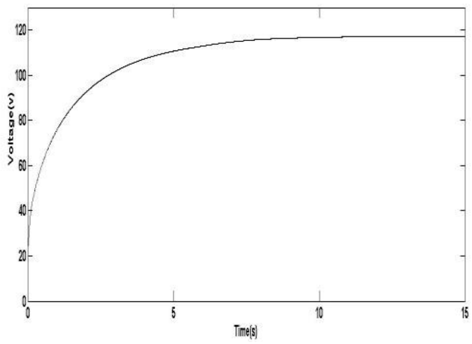

Figure 16: Output Voltage of IBC for same input

The parameters which are used for proposed converter of IBC for different input voltage V1=10 V2=15

- Inductor values =0.1mH
- Capacitor value =0.1

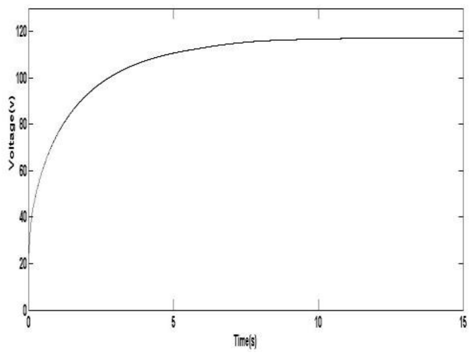

Figure 17: Output voltage of IBC for different input

III.1 Ripple Voltage of Existing Converter for same input Voltage

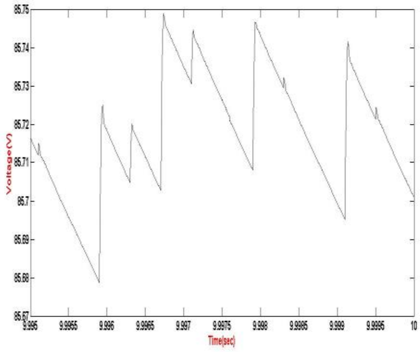

Figure 18: Ripple voltage of existing topology for same input

III.2 Ripple Voltage of VMC for same input Voltage

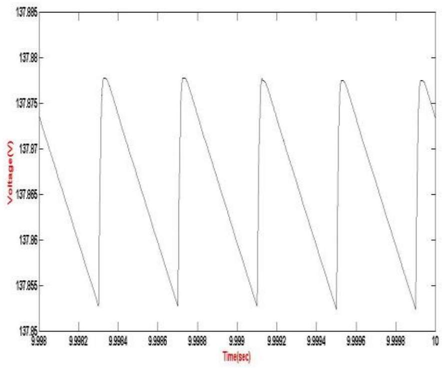

Figure 19: Ripple voltage of VMC for same input

III.3 Ripple Voltage of Existing Converter for different input Voltage

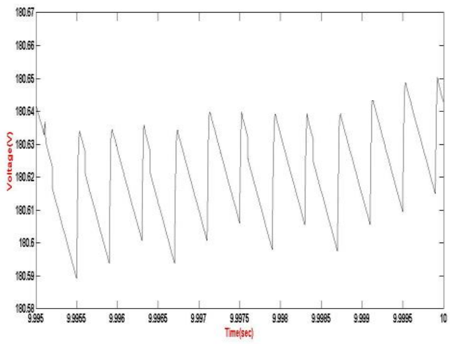

Figure 20: Ripple voltage of existing topology for different input

III.4 Ripple voltage of VMC for different input Voltage:

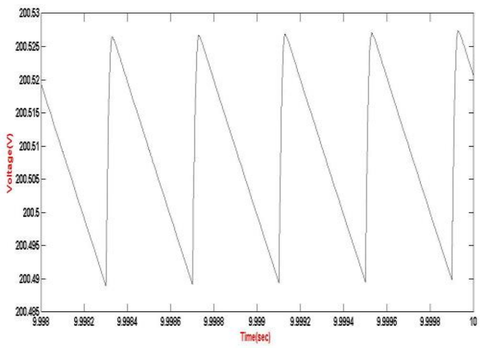

Figure 21: Ripple Voltage of VMC for different input Voltage

III.5 Ripple voltage comparison of existing method and proposed method of VMC

Table 1: Ripple voltage comparison

Input voltage		Output parameters	
V1(in volts)	V2(in volts)	Ripple voltage for existing method(in volts)	Ripple voltage for proposed method(in volts)
12	12	71	1.45
10	15	79	1.55

III.6 Ripple Voltage of IBC for Same Input Voltage

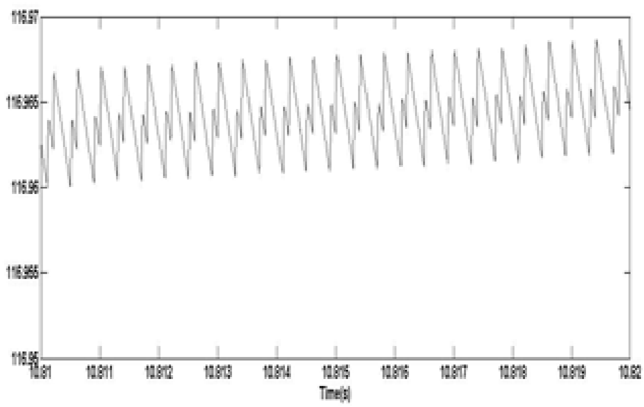

Figure 22: Ripple voltage of IBC for same input

III.7 Ripple Voltage of IBC for different input Voltage

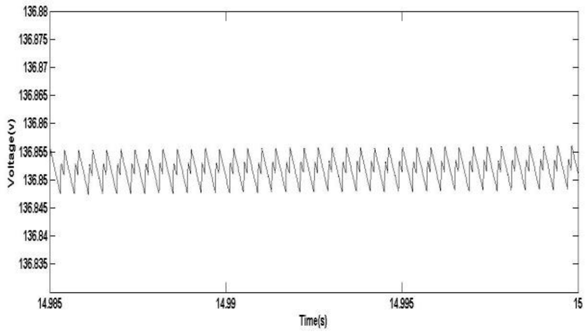

Figure 23: Ripple voltage of IBC for different input

III.8 Ripple voltage comparison of existing method and proposed method of IBC

Input Voltage		**Output Parameters**	
V1 (in volts)	V2(in volts)	Ripple voltage for existing method(in volts)	Ripple voltage for proposed method(in volts)
12	12	0.21V	0.02V
20	10	0.04V	0.03V

Conclusion:

A Two input dc-dc boost converter with voltage multiplier cell and interleaved technique is proposed in this project. Modified Two input boost converter with VMC and IBC was designed for solar, wind and battery. The proposed converters utilize minimum number of power switches and are able to step up the low-level input DC voltages into a high-level output DC. This system will be implemented in hybrid renewable energy source applications. In order to supply AC load, the system requires inverters to convert DC power to AC. The output voltages of two input boost converter without VMC and modified two input boost converter with VMC are compared. The simulation results of the proposed approach shows better efficiency of the two input boost converter with VMC compared with existing topologies.

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