An Integrated Boost Parallel Flyback Converter for Multi Load Applications

Medi Pallavi, S.L.V Sravan Kumar, N.Ravishankar Reddy

Abstract--- ***In this paper, Integrated Boost Parallel Fly-back Converter (IBPFC) with continuous mode is presented. The bulk capacitor will supply the voltage to two transformers. The two transformers turns ratio 1:1 The main advantage of this converter is high reliability, high power transfer efficiency and step up gain. Using this topology current stress on switches is reduced due to parallel operation. The parallel fly-back convertor and boost convertor dividing a common switch Q1; the input voltage VCB will be the parallel fly-back converter (PFC) is from the output of the boost convertor. The operating modes of IBPFC has been presented. A 24V input, 50Vand 50V outputs and 100W DC-DC isolated converter with 100 KHz of switching frequency is modeled using MAT-LAB Software and Simulation results have been presented.***

Index Terms— Integrated Boost Parallel Fly-back Converter (IBPFC), open loop control, continuous conduction mode (CCM).

I. INTRODUCTION

DC-DC Converted can be operated as switching mode regulators to convert Uncontrolled Dc voltage to a controlled DC output Voltage. Which can be operate as a power switches like an inductor, a capacitor and a diode to transfer power from starting of the circuit to end of the circuit.

The switches are conventionally passive or active type.

Passive switches contain of a diode. Whereas the active switches is MOSFET transistor. These switches are very fast to control the pulse width modulation. Signal dots when frequency and duty cycle are in ON and OFF conditions and very high power is generated at output. When duty cycle is in high mode. Commonly boost converters are used to step up the output voltage. Mainly DC-DC boost converter will operate in two modes continuous conduction mode (CCM), discontinuous conduction mode (DCM). When the boost converter works in CCM, inductor current will not be zero at any time where as a in DCM, inductor current will fall to zero after every switching cycle [1][2][3].

The fly-back converter (FC) is deriving from buck boost converter with the inductor split to from a transformer. The voltage ratios are multiplied with the voltages to isolation. It has only one switch and magnetic component. It is accomplished to generate high voltages. FC is mainly used in high voltage, low power application for its intelligibility, isolation and short circuit protection.

The fly-back converter provisions both step up and step down the input supply voltage and the same ground reference, polarity for input and output time maintaining. The advantages of fly-back converter is the primary side is isolated from the output side, It is able to supply multiple

voltages, It can be Isolated from the primary side, It has capacity to regulate the multiple output voltages with a single control, and it can operate with wide range of input voltages [4][5][6].

In an IBPFC with High step up Applications has been designed. IBPFC has the advantage of high step up voltage with boost converter and system isolation with PFC. The topology of traditional IBPFC is in the design of cascaded connection of a boost converter with FC. The input of fly-back converter is given to the output of the boost converter. Switch Q1 will act as main switch for the converter CB is the Bulk Capacitor. In IBPFC, the boost converter comprise of fixed dc voltage source Vin with each time period, corresponding to the fly-back converter input inductor Lin, diode D1 and D2, main switch Q1 and bulk capacitor CB.

In this, the parallel fly-back converter it is comprised of identical current source corresponding to the boost converter, upper and lower transformer, diode D3 and D4 switch Q1 and Q2, output capacitor C1&C2 and load resistance R1&R2 [7][8].

At high level power, it is useful to parallel two or more converters preferably using a one high power unit. It has some lead of paralleling, (a) it supplies more system reliability due to discharging, (b) that it has more switching frequency and hence reduces current pulsations at the input or output, and (c) it permit low capacity modules to regulate where a number of these will be paralleled to furnish high power ability. The issue of current splitting among the parallel converters can be rectified by means of current mode control, two fly-back converters are connected in parallel and these work at the same switching frequency, but the switches in the two converters are patterned to turn on a half time period a part from one another[9].

Hence, in this paper the analysis of IBPFC is discussed the design parameters of boost converter is 24V on primary side and the output voltage of PFC transformer (T2)50V& transformer (T1) 50v on secondary side. The boost converter output will be given to the input of the Fly-back converter and 100W power of IBPFC Operating at 100 KHz is designed.

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Circuit Analysis of IBPFC:

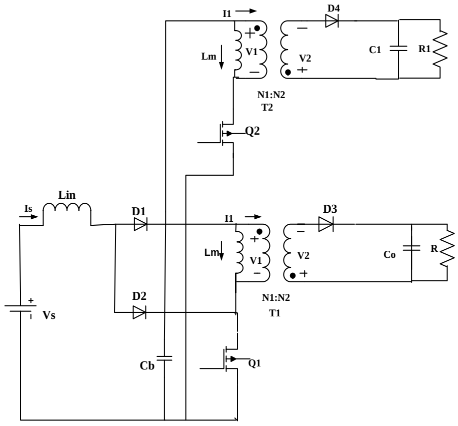

Fig. 1: Circuit Diagram of IBPFC

The working modes in one time period of switching cycle can be represented in four intervals of time, presented in Fig.2(a), Fig.2(b), Fig.2(c) and Fig.2(d). The corresponding waveforms are show in Fig.3.

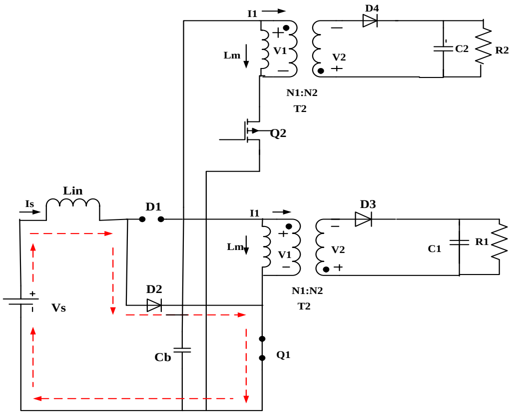

Fig. 2(a): Mode 1(0 < t < t_1)

Mode 1[0<t<t_1:Fig.2(a)]: During the first interval of first switching cycle the MOSFET (Q_1) is turned on and the current flows through +V_S-Lin-D_2-Q_1-(V_S). The current from the boost inductor (or) input current starts increasing and the current flowing through the remaining devices is zero.

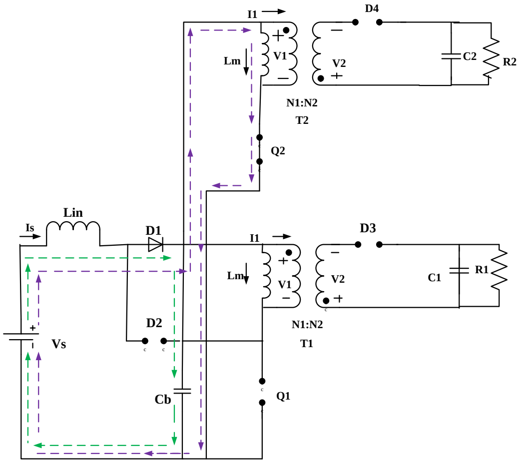

Fig. 2(b): Mode 2(t_1 < t < t_2)

Mode 2[t_1<t<t_2:Fig.2(b)]: During the second interval of first switching cycle the MOSFET(Q_2) is turned on, The current flows through switch Q_1 is zero. The current flows through +V_S-L_{in}-D_1-C_1-(-V_S).and the current flows through switch Q_2 current path +V_S-L_{in}-D_1-L_M-Q_2-(-V_S).in this mode the inductor of the boost converter starts discharging and capacitor C_B start charging through diode D_1.

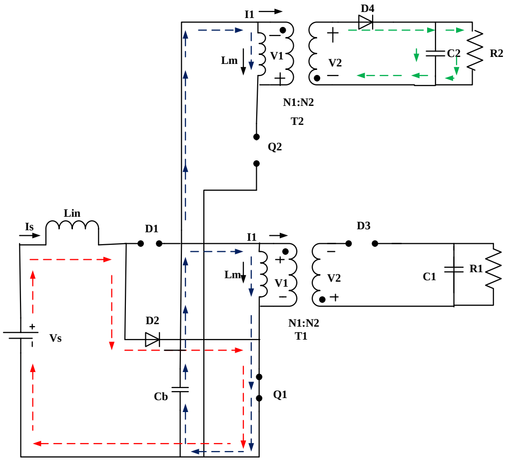

Fig. 2(c): Mode 3(t_2<t< t_3)

Mode 3[t_2<t<t_3:Fig.2(c)]: In Mode 3 again mode 1 will be operated as +V_S-L_{in}-D_2-Q_1-(-V_S).and some amount of capacitor current will flow through +C_B-L_M-Q_1-(-C_B) and C_B small current flows to L_M of transformer (T2). Due to L_M, the transformer (T2) charges the primary winding which magnetizes the secondary winding so diode D_4 will be forward biased by that the output voltage can be obtained.

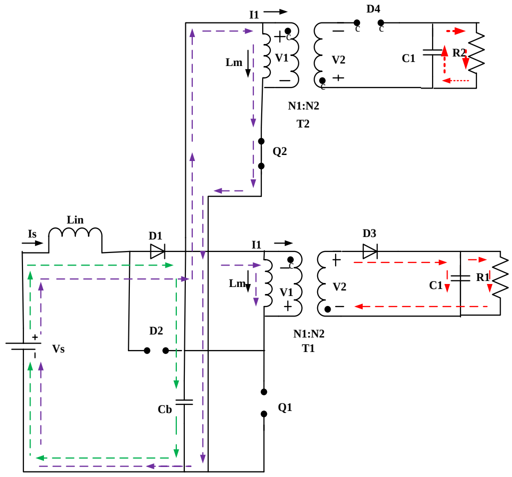

Fig. 2(d): Mode 4(t_3<t<t_4)

Mode 4[t_3<t<t_4:Fig.2(d)]: In Mode 4 again mode 2 will be conducting through +V_S–L_{in}-D_1-C_B-(-V_S) and +V_S-L_B-D_1-L_M-(-V_S) and in this mode, transformer (T1) is magnetized so the current flows to the load through diode D_3. Therefore the output voltage is obtained in the transformer (T1) side. After completion of mode 4, mode 3 operation follows and vice-versa.

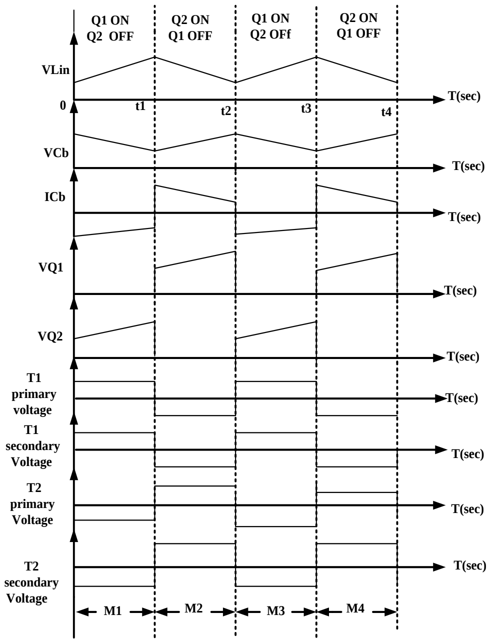

Fig. 3: Wave forms of IBPFC.

II. DESIGN PROCEDURE

The mathematical calculations are presented for IBPFC. For

The values given below.

Vs = 24V, V_{01} = 50V, V02 = 50V, I_{01} =1A, I_{02} =1, R_{01}&R_{02} =50Ω, F_s =100 KHz,

Boost output voltage

$$V_o = \frac{V_s}{1-D} \tag{1}$$

$$D = 0.52 \tag{2}$$

Boost Inductor Current,

$$I_{Lin} = \frac{I_0}{1-D} \tag{3}$$

$$I_{Lin} = 4.2916\,A \tag{4}$$

Boost Inductance,

$$L_{in} = \frac{V_{Lin} D}{f_S \Delta I} \tag{5}$$

$$L_{in} = 150\,\mu F \tag{6}$$

Boost Capacitance,

$$C_B = \frac{DI_{Cb}}{\Delta V_C\, f} \tag{7}$$

$$C_B = 500\,\mu F \tag{8}$$

From the Fly-back Converter,

Transformer [1]

$$L_{P1} = \frac{V_s KT}{I_{P1}} \tag{9}$$

$$L_{p1} = 0.04mH \tag{10}$$

Transformer [2]

$$L_{p2} = \frac{V_s KT}{I_{P2}} \tag{11}$$

$$L_{p2} = 0.04mH \tag{12}$$

Output Capacitor Value is taken as

$$C_1 = 1000\ \mu F\ /50W \tag{13}$$

$$C_2 = 1000\ \mu F\ /50W \tag{14}$$

IBPFC Efficiency,

$$\eta = \frac{(V_{01})\times(I_{01})+(V_{02})\times(I_{02})}{(V_S)\times(I_S)}\times 100 \tag{15}$$

$$\eta = \frac{(52.54)\times(1.051)+(50.54)\times(1.011)}{(24)\times(4.65)}\times 100 \tag{16}$$

$$\eta = 95\% \tag{17}$$

III. SIMULATION RESULTS

The MAT-LAB software using obtained the simulation results of open loop control Fig (4), Fig (5) shows the output Voltages V_{o1}&V_{02}. Fig (6),Fig (7) shows the output Currents I_{01}&I_{o2}.Fig(8),Fig(9) shows Switch Q_1&Q_2 Voltages. Fig(10),Fig(11) shows Inductor Voltage & Current. Fig(12),Fig(13) shows Bulk Capacitor Voltage &Current. Fig (14),Fig(15) shows Transformer 2 Primary Voltage & Current. Fig(16),Fig(17) shows Transformer 1 Primary Voltage & Current. Fig(18),Fig(19) shows Transformer 2 Secondary Voltage & Current. Fig(20),Fig(21) shows Transformer 1 Secondary Voltage & Current. Fig(22),Fig(23) shows Capacitor Vc1&Vc2 Voltages.

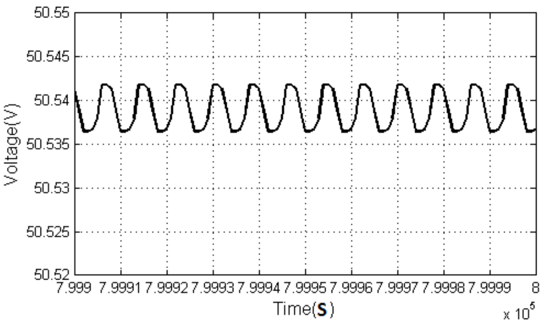

Fig. 4: Output Voltage (V_{01})

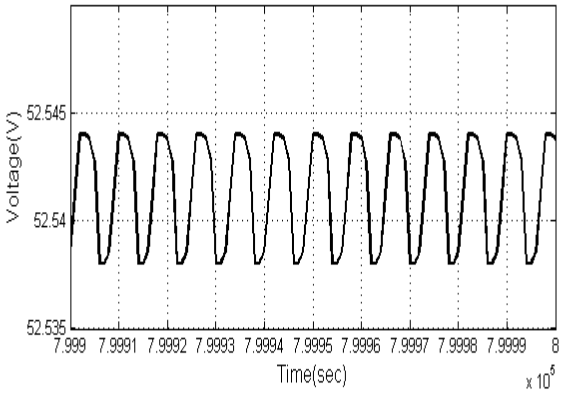

Fig. 5: Output Voltage V_{02}

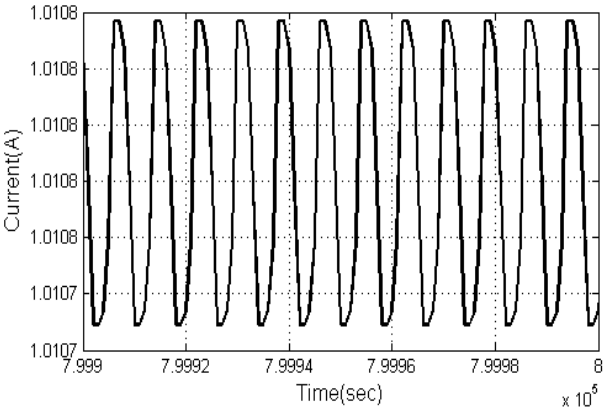

Fig. 6: Output Current (I_{01})

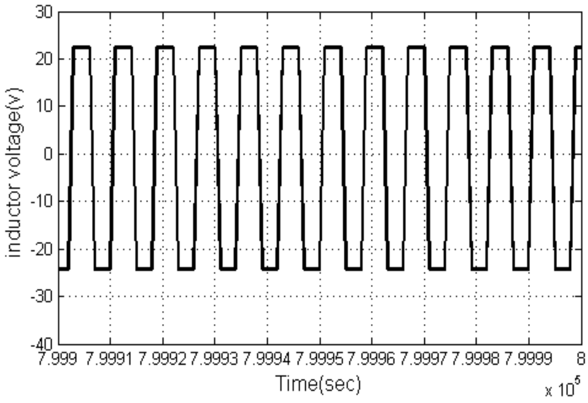

Fig. 10: Inductor Voltage

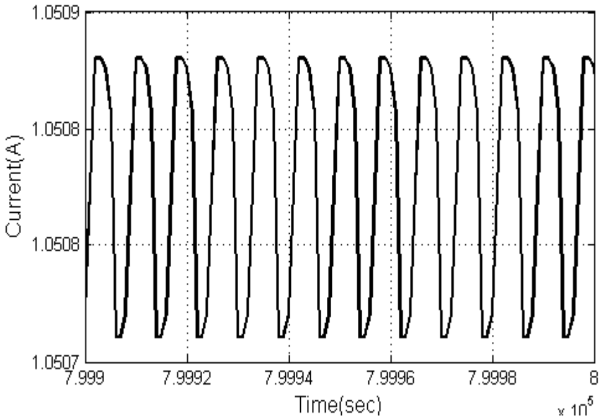

Fig.7: Output Current (I_{02})

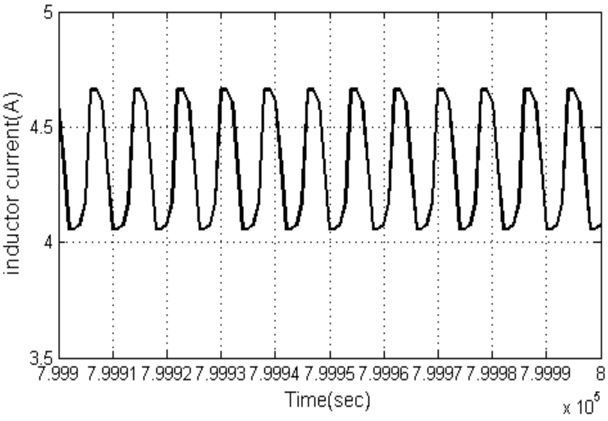

Fig. 11: Inductor Current

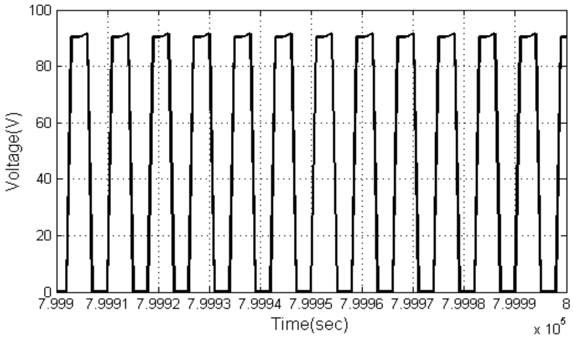

Fig. 8: Switch Q_1 Voltage

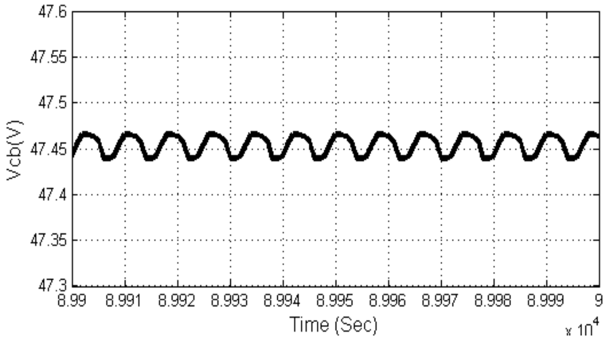

Fig. 12: Bulk Capacitor Voltage

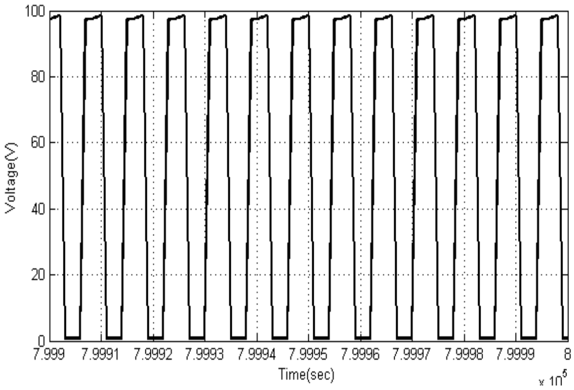

Fig. 9: Switch Q_2 Voltage

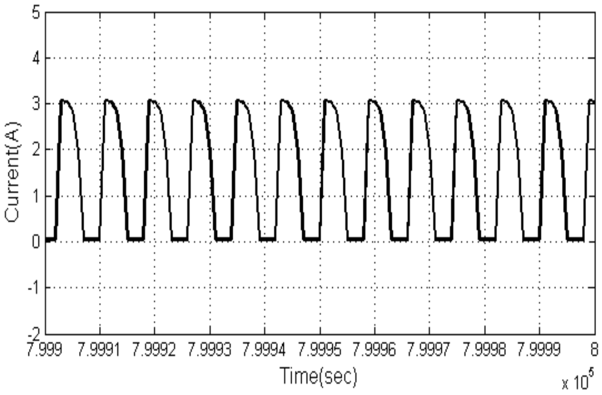

Fig. 13: Bulk Capacitor Current

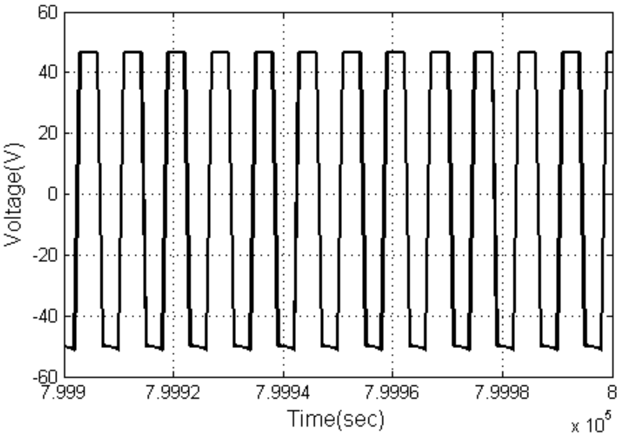

Fig. 14: Transformer 2 Primary Voltage

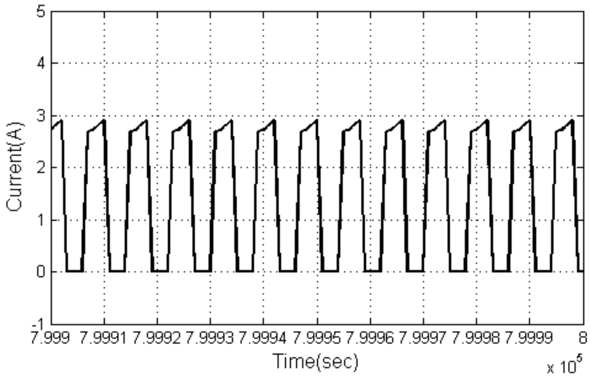

Fig. 15: Transformer 2 primary current

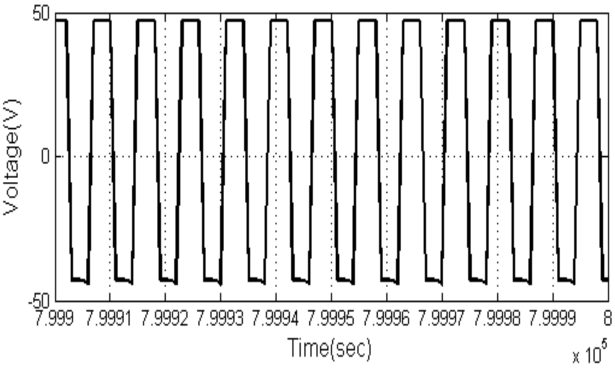

Fig. 16: Transformer 1 primary Voltage

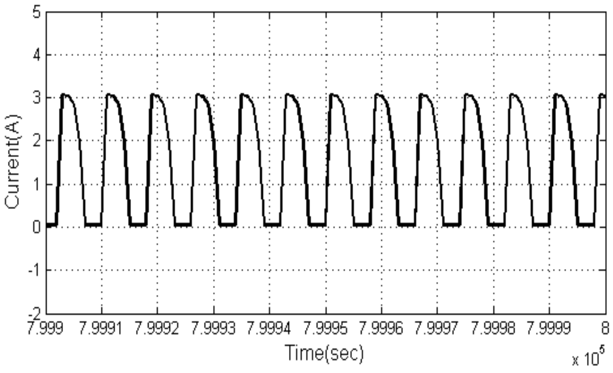

Fig. 17: Transformer 1 Primary Current

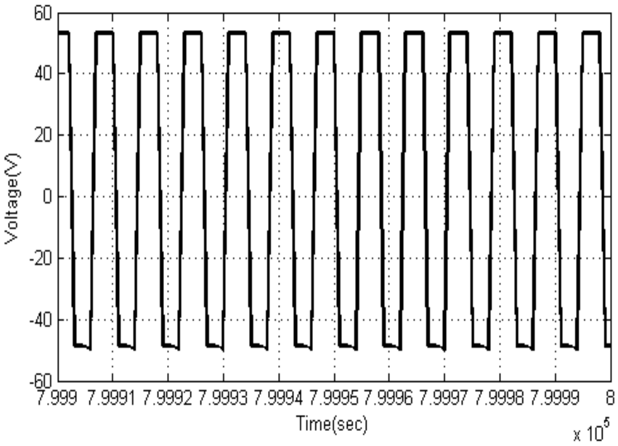

Fig. 18: Transformer 2 secondary Voltage

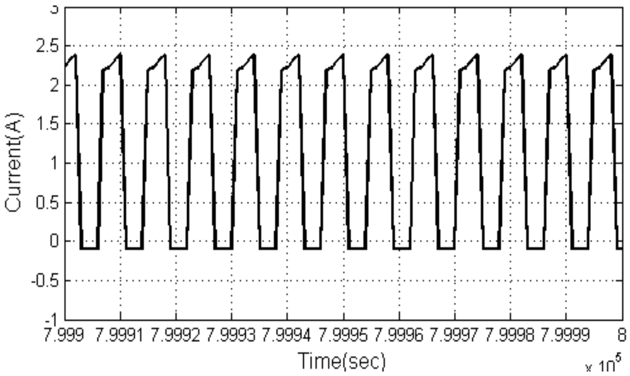

Fig. 19: Transformer 2Secondary Current

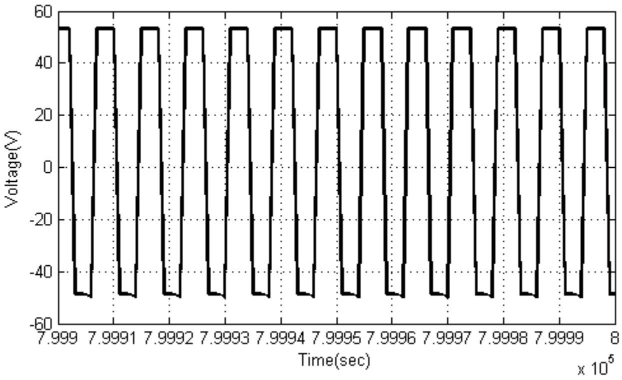

Fig. 20: Transformer 1 Secondary Voltage

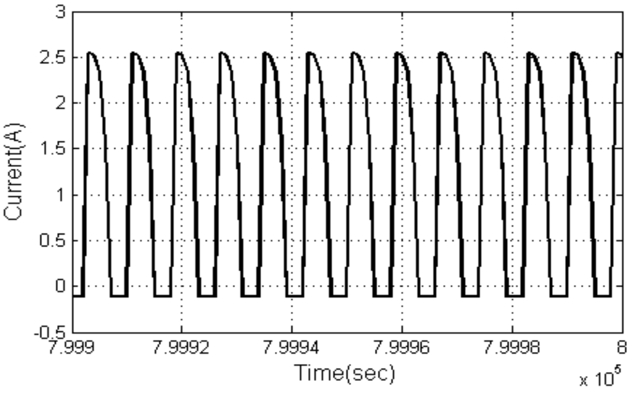

Fig. 21: Transformer 1 Secondary Current

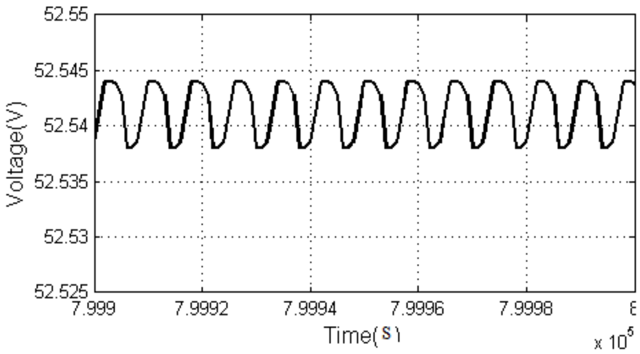

Fig. 22: Capacitor C1 Voltage

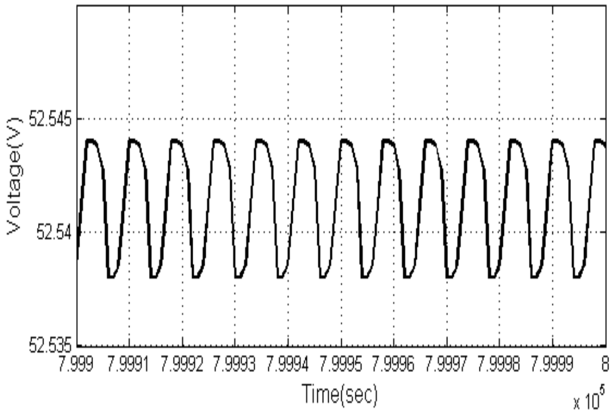

Fig. 23: Capacitor C2 Voltage

IV. CONCLUSION

In this paper Design Procedure and Circuit Analysis of IBPFC has been proposed. The IBPFC has a reasonable efficiency of 95%, when operated in CCM mode. The major advantage of this converter is the Switching Stress is Reducing, high reliability and high power transfer efficiency. The model has been simulated with input supply voltage of 24V and output voltage 50V transformerT1 and 50V transformerT2, 100W power and 100 KHz frequency.

This paper can be further extended by connecting the IBPFC with non-dissipative snubber circuit to reduce the voltage spike an switches and to recover leakage energy hence the voltage stress on the switches reduced and the performance of the system is improved.

When IBPFC used with QSC (Quasi Switched Capacitor) create a soft switching helps in increase of efficiency and more reliability of the converter and then the overall system.

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