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Improve the Power Factor Based Switch Mode Power Supply Application Using Bridgeless LUO Converter

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ABSTRACT: Multiple outputs Switched Mode Power Supplies (SMPSs) for personal computers (PCs) normally explain graphically extreme bad power quality such as total harmonic distortion(THD) of the input current being more than 80%, power factor being lower below 0.7 and output voltage regulation being very poor. So, they break forcibly limits of harmonic emissions set by international power quality standards. The performance of the LUO Converter is evaluated in three different types of operating conditions to select the best operating condition for the proposed Switch mode power supply system and its output that is fed to the second stage of isolated half-bridge Converter. The performance of the proposed SMPS in simulation system is established on the MATLAB/ SIMULINK software. Final and the test results are found to be in line with the simulated performance under varying input voltages and loading conditions and all the results demonstrate its enhanced performance.

KEYWORDS: Harmonic distortion, smps application (Personal Computer), Power Factor improvement, BL LUO Converter, tap changing transformer, neural network, multiple outputs.

I. INTRODUCTION

The growth of electronics types of equipment has increased that the average home has a lot of electronic devices such as computers, low energy lighting, televisions, and battery chargers their peripherals etc. These electronic devices have rectification circuits, which is the major reason for causing harmonic distortion. Most applications consist of ac-dc power Converters and need the output dc voltage to be regulated with good steady-state as well as transient performance.

The quality of the power supply thereby affecting the performance of other loads connected to it, which also leads to cause other relevant problems. The waveform of current is non-sinusoidal, very peaky, and highly distorted power factor (PF) is around 0.48. At full load, the total harmonic distortion (THD) of ac input mains current is 83.5%. Due to these issues, the improved power quality SMPSs is extensively researched. This is most expected to draw a sinusoidal input current at a high Power Factor. Improvement in power quality also results in high reliability and to get better efficiency. To achieve an improvement in power quality, PF correction (PFC) circuits are employed in these SMPSs. Because, if more electronic SMPSs devices are connected in a short area, the PQ get to suffer. Active power factor correction alludes to the mode of increasing PF by using active electronic circuits with a self-regulating system that command the shape of the drawn current. High-frequency switching techniques, i.e. voltage lift technique have been used to shape the input current waveform successfully.

Multiple output DC-DC Converters, especially in the personal computer, are desirable for a variety of applications to reduce the number of power supplies, complexity, space and cost than a large number of single output Converters. To make amends for this, in the present work, a DC-DC voltage lift Converter is used with power factor correction (PFC) circuit.

Among various types of power conversion, DC-DC LUO converter conversion has greater importance. DC-DC conversion can be reliably performed using LUO Converter. LUO Converters is one of the simplest forms of DC/DC Converters which operates on voltage lift technique.

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It allows controlled energy transfer from unregulated source to the regulated output voltage. Improvement in power quality also results in better efficiency. This paper deals with the development of bridgeless rectifier based multiple outputs SMPS especially power applications. In proposed designed for low two stages multiple output switched mode power supply bridgeless LUO Converter is operating for both positive as well as negative cycle as a first stage a half bridge inverter connected to the tap changing transformer is used for isolation and to get multiple outputs.

II. CONFIGURATION OF PROPOSED MODEL USING BL LUO CONVERTER BASED MULTIPLE-OUTPUT SMPS

Fig.1. describes the block diagram of the proposed system. In the present, a personal computer (PCs) plays a vital role and an essential part of our day to day activities from education to official works. Switched Mode Power Supply (SMPS) is the main part of the computer that converts ac to multiple numbers of dc voltages to supply the power to different parts of the PC. It contains dc-dc Converter to achieve multiple dc output voltages of different ratings. The charging and discharging of the capacitor, which makes the high crest factor; highly distorted waveform, these breaks forcibly the limits of international power quality (PQ) standards. The neutral current of the distribution system is increased if this Personal Computer (PCs)

is used in large numbers which create the serious problems like overloading the neutral conductor, noise, de-rating of the transformer, voltage waveform distortion.

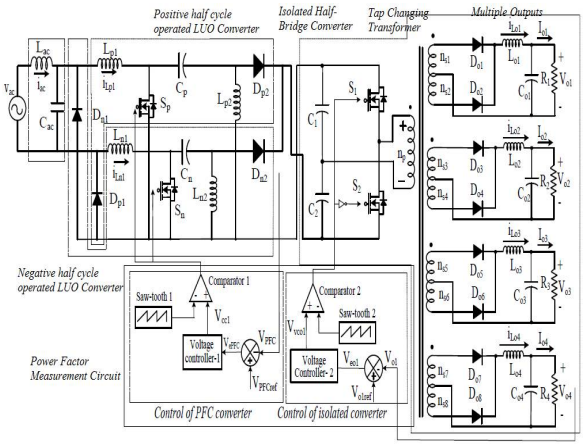

Fig.1. Schematic diagram of Proposed Bridgeless LUO converter based multiple output switch mode power supply

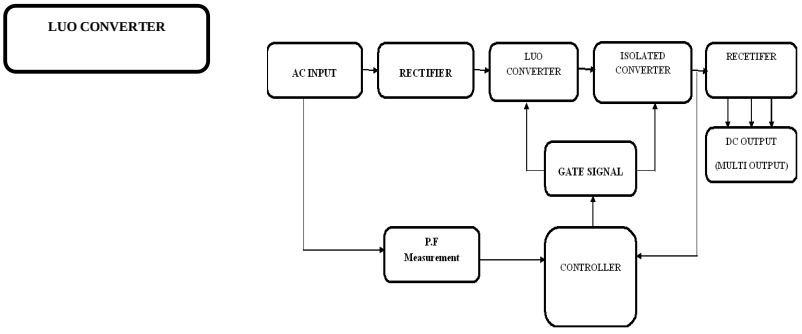

Fig.2. Proposed Block Diagram

Switched Mode Power Supply (SMPS) is a required for completing the whole part of the computer. The input ac supply is directly given to the rectifier; which is accompanied by LUO converter, the work of rectifier converts the ac

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input into dc. Simultaneously the input ac supply power factor is measured by power factor measurement circuit. The output of the dc supply is fed to the LUO Converter; it is a dc/dc voltage lift technique. LUO Converter is made up of anti-parallel connection of the capacitors and inductors. It is mostly meant to ensure the current balance and voltage balance. The main similar things are made up of 2 lift, 4 lift, 8 lift LUO Converter etc. The Converter requires voltage lift techniques are different from other existing DC/DC step-up buck-boost Converter and are with simple operation and simple structure. The power factor measurement circuit is installed which gives the gate signal to the LUO Converter when the power factor is getting lag. The dc-dc Converter output is isolated by the isolated half-bridge Converter and the output is twice the input. And the dc output of the dc/dc BL-LUO converter is again converted into ac supply by using an isolated half-bridge converter, which is connected to tap changing transformer. And the multiple outputs is rectified into dc as per the supply needed for personal computer gives the better efficiency and good power quality performance.

III. CONFIGURATION OF BRIDGELESS

LUO CONVERTER

Voltage lift technique is being used due to its simplicity, ease of use and economic nature. The voltage-lift technique can be applied to several series of DC to DC Converters. By employing the technique of voltage has been opened a way in designing high voltage gain dc output. It allows the voltage to be increased in stage by stage process. LUO Converters are one of the easiest forms of DC/DC Converters which operates on the technique of voltage lift. Many series of LUO Converters are available now, which is ranging from elementary 2 lift to 192 lift, but here used for low voltage application. Basically LUO Converters operates in the mode of push and pull state; the voltage level is increased stage by stage. It can be of mainly two types, either switched capacitor type or switched inductor type. The switched capacitor type LUO Converter has no inductors and transformers.

A. Bridgeless-LUO converter

A LUO Converter mostly made up of two series, the first thing is the main series and another one is additional series. The main series includes 2 lift, 4 lift, 8 lift etc and additional series includes 3 lift, 6 lift, 12 lift etc. The following fig.2 indicates the circuit diagram of the BL LUO Converter and the operation during switch on and off. This configuration is the based on switched inductor type LUO Converter. It allows controlled energy transfer from the unregulated source to the regulated output voltage and also enhances the supply voltage.

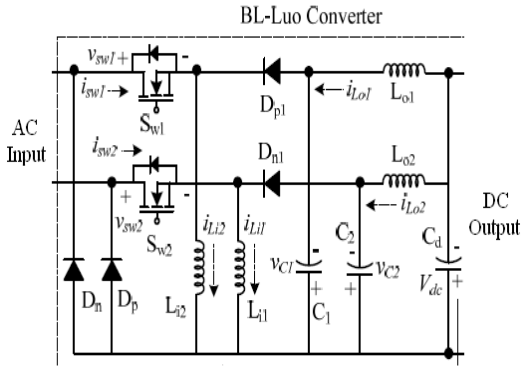

Fig.3. circuit diagram of bridgeless LUO converter

B .Operation of BL LUO converter

The Bridgeless-LUO converter is mainly designed for its operation in discontinues conduction mode to act as a power factor pre-regulator and also indicates. The current in the input inductors is (iLi1 and iLi2) becomes discontinuous in a switching period, the output inductor currents (iLo1 and iLo2) and intermediate capacitor voltage (VC1 and VC2) remain continuous. A converter is designed to control the DC link voltage minimum voltage to maximum dc Voltage. Since the speed is directly proportional to DC link voltage, hence output power is taken as a linear function of the DC link voltage. The output power is corresponding to minimum DC link. It is like a boost converter voltage lift techniques.

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C. Analysis of LUO converter

The inductor current IL2,

$$IL2 = \frac{1-a}{a} \text{IL1} \quad (1)$$

Duty cycle,

$$a = \frac{Ton}{T}$$

Output voltage equation,

$$Vo = \frac{a}{1-a} Vin \quad (2)$$

Average Voltage across the capacitor C1 is,

$$Vc1 = \frac{a}{1-a} Vin \quad (3)$$

Peak to peak inductor current is,

$$\nabla IL1 = \frac{aTVin}{L1} \quad (4)$$

Equation (4) inductor L1 value,

$$L1 = \frac{aTVin}{\nabla IL1} \quad (5)$$

Peak to peak inductor current L2 is,

$$\nabla IL2 = \frac{aTVin}{L2} \quad (6)$$

Equation (6) inductor L2 value,

$$L2 = \frac{aTVin}{\nabla IL2} \quad (7)$$

The charge on the series capacitor (C1) is increases during off period by IL2 (=Io) and it is decreases during on period by IL1. The change in the charge on C1 must be zero Peak to peak ripple voltage across the capacitor C1,

$$\nabla VC1 = \frac{1-a}{C1} TI1 \quad (8)$$

Equation (8) C1 value,

$$C1 = \frac{1-a}{\nabla VC1} TI1 \quad (9)$$

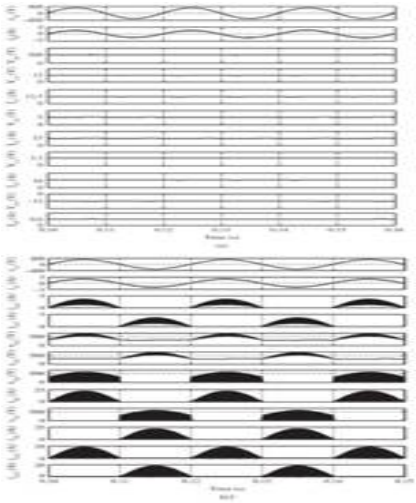

Fig.4. Output waveform of LUO Converter

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Operation of Isolated Half-Bridge Converter

The controlled output dc voltage of the LUO converter is fed to the half-bridge for high- frequency isolation, for voltage scaling, and for obtaining multiple dc output voltages. The operation of the half-bridge in one switching cycle is described in four states. The second and fourth states are similar and occur twice in each switching cycle, as shown in Fig.3 (b). In the first state, the upper switch S1 is turned on; the input current circulates through the primary winding of the HFT to the lower input capacitor C12.

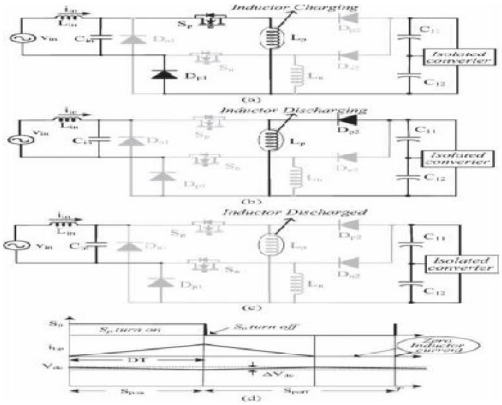

Fig.5. Operating modes for under (a) upper switch Sp is on, (b) upper switch Sp is off, (c) both switch and diode are off, and (d) waveforms in one switching cycle.

Diodes D1, D3, D5, and D7 start conducting, and the inductors associated with the windings start storing energy, as shown in Fig. 5(a). Therefore, inductor currents iL1, iL2, iL3, and iL4 increase, and output filter capacitors Co1, Co2, Co3, and Co4 discharge through the loads. In the second state [Fig. 5(b)], both switches are turned off, and all secondary diodes D1–D8 freewheel the stored energy until the voltage across the HFT becomes zero. Therefore, inductor currents iL1, iL2, iL3, and iL4 start decreasing. In the third state of the switching cycle, The second switch S2 is turned on, and the input current flows through upper capacitor C11 and the primary winding, as shown in Fig.6(c).Associated diodes D2, D4, D6, and D8 are the

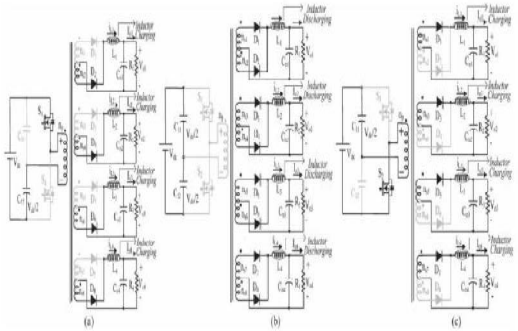

Fig.6. (a) When the first switch S1 is on, (b) when both switches are off, (c) and when the second switch S2 is on.

secondary windings conduct, and inductors L1, L2, L3, and L4 start storing energy. When the energy stored in the inductors reaches maximum values, the switch is turned off. In the last state, all secondary diodes start conducting; this is similar to the second state. The same operating states repeat in each switching cycle.

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IV. POWER FACTOR MEASUREMENT CIRCUIT

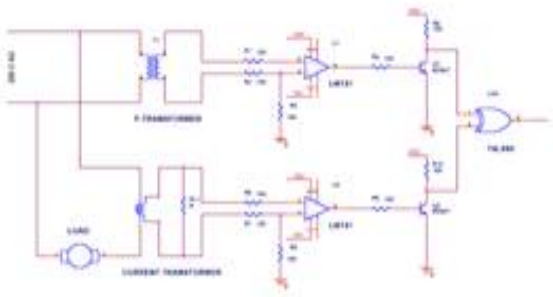

Fig.7. Power Factor Measurement Circuit

Circuit Description

This circuit is designed to find the power factor in the power line. The power line voltage and current are monitored through the potential and current transformer respectively. The potential transformer is used to step down the mains supply voltage to the low voltage level. The voltage level is from 440V AC to 6V AC. Then the output of the transformer is given to Zero Crossing Detector. The current consumed by the load is measured with the help of a current transformer. The current transformer will convert the load current into lower values that current output will be converted into voltage with the help of the shunt resistor. Then the corresponding the AC voltage is given to zero crossing detector. The Zero Crossing Detector is used to convert the sine wave to square wave signal.

The zero crossing detectors are constructed by the operational amplifier LM 741. The inverting and non-inverting input terminals are connected to the potential transformer and current transformer terminals respectively. So the input sine wave signal is converted into square wave signals.

The square signal is in the range of +12v to -12v level. Then the square wave signal is given to base of the BC 547 switching transistor in order to convert the TTL voltage 0 to 5v level. Then the both ZCD's outputs are given to logical XOR gate 74LS86 to find the phase angle difference between the voltage and current. The XOR gate output is given to microcontroller or PC and calculated the power factor with help of software.

V. TAP CHANGING TRANSFORMER

The on load tap changer (OLTC) is used the tapping's connection of the transformer winding while the transformer is energized. The tap changer can be designed as a single unit for a single and three applications with one common neutral point. Depending on the three-phase rating, it might require three separate units, each having its own insulated phases. Tap changers can be located either inside the transformer, main tank or outside in its own compartment. Switching from one position to another has to be performed through an impedance can be either resistor or reactor. In supply system, tap changing has normally to be performed on load so that there is no interruption to supply. The secondary consist of two equal parallel winding which has similar tapping. Under the normal working condition, each secondary winding carried one half of total current.

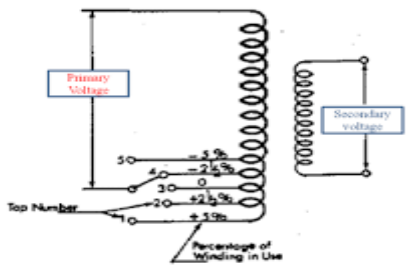

Fig.8. Tap changing transformer

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The pc based tap changer consists of:
1. Voltage sensing unit
2. Main transformer unit
3. Zero crossing detector
4. Reference and logic generation
5. Relay / Static Switched, isolation driver
6. Add-on card interface chip decoding logic
7. Pc
8. Load

Voltage sensing unit:

In this unit a 230 V ac supply is given as input and regulated to 12V supply and it is given to voltage sensing unit which comprises of two amplifiers. In differential mode and it is given to reference and logic generation unit and to the main transformer.

Main transformer unit:

It is most important part of tap changing system. Its rating is 500W but it can withstand load up to.1 KW. Tappings are provided on the primary side of the transformer so that we can get constant voltage irrespective of changes in load. The output of the main transformer is given to load. It gets input from voltage sensing unit and feedback is given to relay/static switches unit.

Zero crossing detector:

ZCD gets input from a main that is 230 V ac supply. It detects the zero point of ac sine wave because at the point both current and voltage is zero (in case of resistive load) its output is given to the ADDON card.

Reference and logic generation:

This unit gets input from the voltage sensing unit. It consists of circuitry which generates binary logic as (00, 01, 10, 11). This binary signal is given to the ADDON card, which is then fed to the computer.

Relay/Static Switches, isolation and driver:

This unit consists of relays and static switches such as TRIAC. TRIAC is a bidirectional device that means it can conduct in both directions. Isolation is provided to reduce the unwanted noise signal. This unit is connected with the tapping of the main transformer. This unit is also connected to the ADDON card.

ADDON card interface chip decoding logic:

ADDON card plays a very important role in connecting our hardware with software. It consists of four IC's namely magnitude comparator, buffer, peripheral interface 8055 IC, AND gate IC. This unit gets signals from zero crossing detector reference and logic generation. It gives a signal to the relay and static switches. This ADDON card is inserted into the PC.

Personal Computer:

It is any personal computer having ISA slot in it so that we can insert ADDON card on that computer generally it is P1 or P2 pc. The supply voltage required in the personal computer is $\pm$12V, $\pm$5V. It is changed according to the requirement

Load:

It may be any load bank, from where we can vary the load. The computers are the low voltage application. The luo converters may be used in high voltage application like drives etc.

VI. NEURAL NETWORK

For the innovation and development of better control systems, the design and implementation of intelligent systems have become an essential factor. In such a situation, the implementation of artificial neural networks gives solutions to the questions that linear systems are not able to solve.

The artificial neural network is a replication of our human brain. The understanding, recognizing, classifying, clustering, error detection and correction is the sixth sense of human brain and this capability is incorporated with the help of the artificial neural network. This is an emulation of the biological neural system. The neural network can be said to resemble human brain in following the below-mentioned things.

- It acquires knowledge through learning. The knowledge is stored within inter-neuron connection strengths known as synaptic weights. The artificial neural network is capable of representing both the linear and non-linear relationships.

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It is having the ability to learn these relationships directly from the data being modeled. Hence, a neural network can be implemented in the following case

- Algorithmic solution cannot be formulated.
- More samples of the required behavior are available.

VII.MATLAB/SIMULATION RESULTS

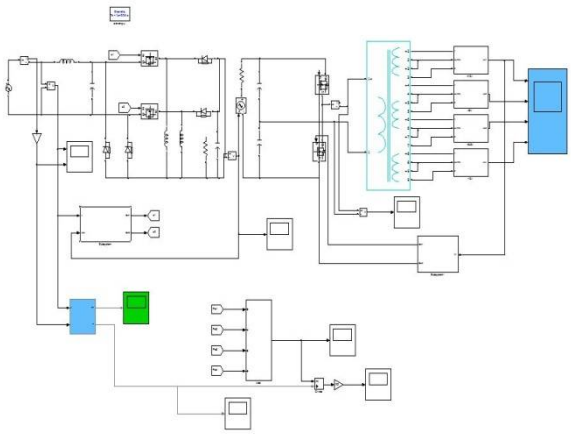

Fig.9.Matlab/simulation of bridgeless-LUO converter-based multiple-output SMPS

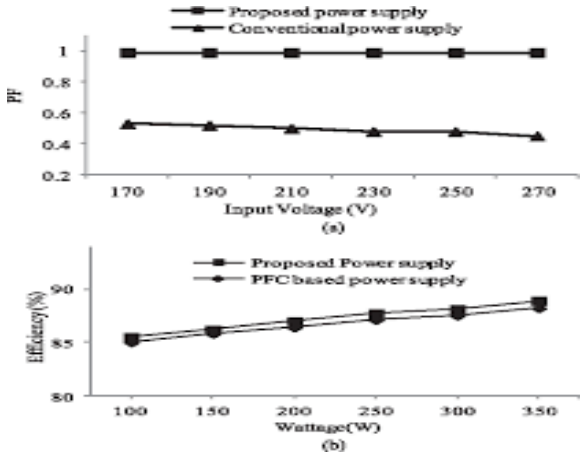

Fig.10. Power factor and efficiency output line indication of proposed LUO Converter

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VIII. RESULT ANAYSIS

Table.1. Duty cycle analysis of LUO Converter

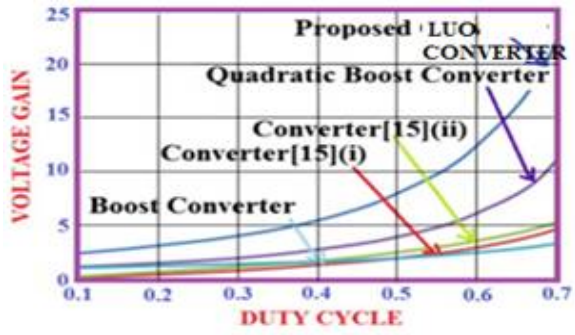

Fig.11. Curve representation of advanced LUO Converter

Configuration	Diode	Capacitor	Inductor	Switch	Half cycle conduction
Bridgeless Buck-boost Converter	4	3	1	3	8
Bridgeless Cuk Converter	3	2	3	2	8
Bridgeless SEPIC	2	4	3	2	10
LUO converter	4	2	2	2	6

According to the result analysis, the half cycle conduction is reduced when it is compared to the other existing system. In the fig.10 the power factor (PF) is maintained nearly 0.8 or 0.9 and the percentage of efficiency is increased simultaneously.

Simulation outputs

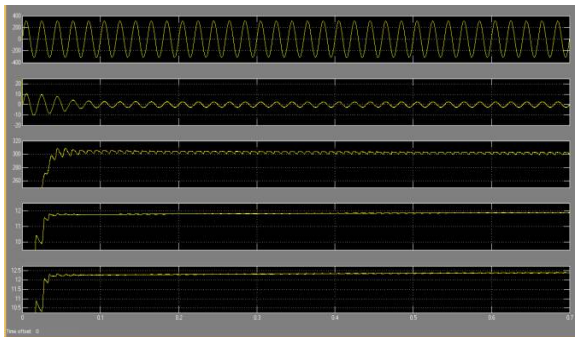

Fig.12. Simulation waveform of input voltage, input current, LUO Converter output voltage, half-bridge output voltages, and currents.

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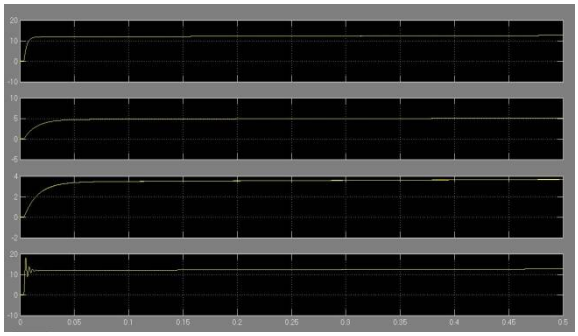

Fig.13.Simulation waveform of multiple output smps ±12V, ±5V

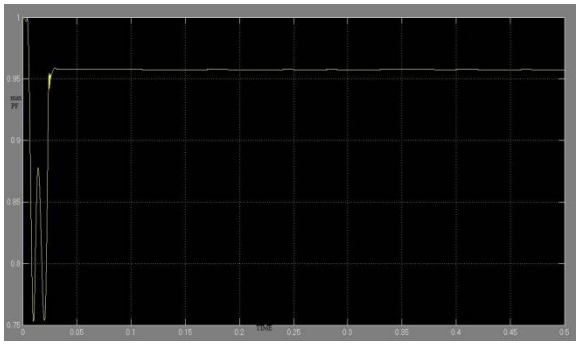

Fig.14.Simulation waveform of maintaining power factor (PF) up to 0.96

IX. CONCLUSION

A bridgeless LUO Converter based power supply has been proposed here to mitigate the power quality problems prevalent in any conventional computer power supply and also for multiple outputs. The proposed power supply is able to operate satisfactorily under wide variations in input voltages and loads. The design and simulation of the proposed power supply are initially carried to demonstrate its improved performance. Further, a laboratory prototype is built and experiments are conducted on this prototype. Test results obtained are found to be in line with the simulated performance. They confirm the truth that the power quality problems are mitigated and hence, the proposed circuit can be recommended the solution for computers and other similar appliances.

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