Power Factor Corrected by Buck-Boost Converter Employing PWM Technique

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Abstract: **The usage of power electronic system has expended to new and wide application range that include residential commercial aerospace and traction system and SMPS. The current drawn by power semiconductor converters devices from the line is distorted resulting in THD and low P.F. Hence there is a continuous need for power factor improvement and reduction of line current harmonics. This paper aims to develop a circuit for converting AC-DC and correction of power factor by using active PFC circuit and to improve the power quality.**

Single phase AC-DC converter has high frequency isolation are implemented in buck, boost, buck-boost configuration with improvement the power factor and power quality in terms of reducing the harmonics of input current.

The paper propose the circuit confirmation, control mechanics and simulation results for the single phase AC-DC converter.Single phase ac-dc converter will achieve variable output dc voltage. High frequency isolation will be achieved using ferrite transformer. We use employed PWM technology here so that power factor at mains is closed to unity.

Keywords: AC-DC converter, High frequency isolation transformer,Power factor correction,PWM, Buck-Boost converter.

I. INTRODUCTION

Depending upon the voltage level require at the consumer side, the ac main voltage is connected into dc power to feed variety of loads through the single phase ac-dc converter, classified into buck, boost, buck-boost converter to improve the power quality at ac mains and dc loads. These converters are implemented using high frequency transformer isolation with single or multiple converters such as buck, boost, and buck-boost topologies. One of the major reasons to develop the ac-dc converter is the availability of high frequency with switching devices like MOSFET which has the high switching capability with negligible losses.

AC-DC converter is most widely used now these days but we face many problems like low power factor, low poor quality, low efficiency, reduce power factor, large size of capacitor filters. Now we have to overcome the problem of the power factor and power quality so we make a new single stage AC-DC converter mainly used to improve the power quality and power factor correction.Based on the high frequency transformer isolation the converter design is classified into nine different converters such as single phase buck, boost, buck-boost ac-dc converter.In this paper we make a buck-boost type unity power factor converter based on high frequency isolation.We made AC-DC converter with high frequency transformer isolation are developed in the range of several watts to several KW for the application of DC power in computer power supplies, UPS, battery charger, induction heater, electronic ballast etc. The above mentioned application of power supplies is used to develop the power quality of low value of total harmonic distortion, and peak factor, high power factor, low value of EMI and RFI at ac mains are regulated and to reduce the ripple components and stabilize the dc voltage under varying loads. This type of converter is controlled by the different control method as, buck-boost topologies with high frequency transformer isolation.All the simulation work is carried out in MATLAB – Simulink

II. TYPES OF ELECTRONIC CIRCUITS

For the control of electric power or power conditioning, the conversion of electric power from one form to another is necessary and the switching characteristics of the power devices permit these conversion. [2] A converter may be considered as a switching matrix. The power electronics circuits can be classified into six types:

1. Diode rectifier
2. AC-DC converter (controlled rectifier)
3. AC-AC converter (ac voltage controllers)
4. DC-DC converter (dc choppers)
5. DC-AC converter (inverters)
6. Static switches

The devices in the following converters are used to illustrate the basic principles only. The switching action of a converter can be performed by more than one device. The choice of particular devices depends on the voltage, current, and speed requirement of the convert.[7]

1. *Diode rectifier*

A diode rectifier circuit converts ac voltage into a fixed dc voltage and is shown in fig 1. the input voltage to the rectifier V_i could be either single phase or three phase.[1]

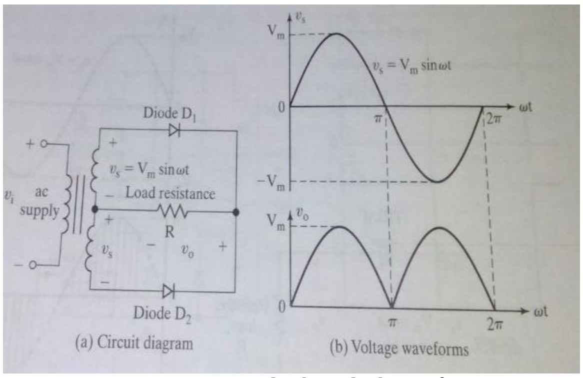

Fig 1: single phase diode rectifier

2. *AC-DC converters*

A single phase converter with two natural commutated thyristors is shown in fig 2. The average value of the output voltage $v_o$can be controlled by varying the conduction time of thyristors or firing delay angle, Ø. The input could be a single or three phase source. These converters are also known as controlled rectifiers.

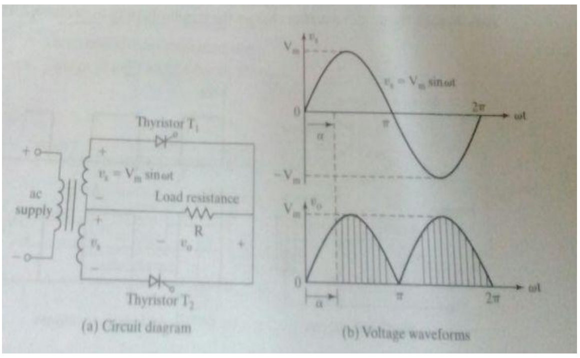

Fig 2:single phase ac-dc converter

3. *AC-AC converter*

These converters are used to obtain a variable ac output voltage $v_o$from a fixed ac source and a single phase converter with a TRIAC is shown in fig 3. The output voltage is controlled by varying the conduction time of a TRIAC or firing delay angle, Ø. These types of converter are also known as ac voltage controllers.[5]

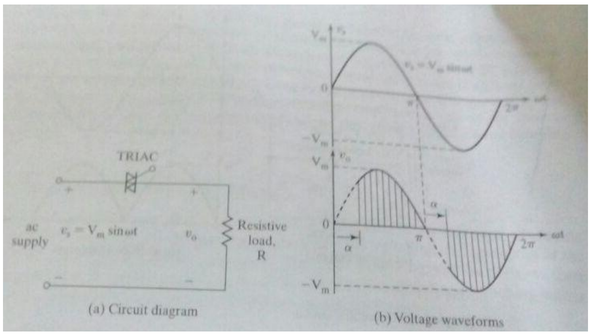

Fig 3:single phase ac-ac converter

4. *DC-DC converters*

A dc-dc converter is also known as a chopper, or switching regulator and a transistor chopper is shown in fig 4. the average output voltage $v_o$is controlled by varying the conduction time t, of transistor Q1. If T is the chopping period, the t1=ØT. Ø is called as the duty cycle of the chopper.

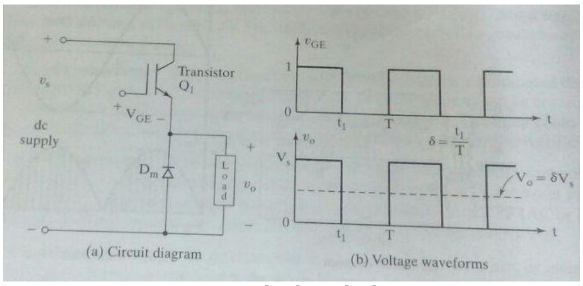

Fig 4: single phase dc-dc converter

5. *DC-AC converter*

A dc-ac converter is also known as an inverter. A single phase transistor inverter is shown in fig 5. Iftransistors m1 and m2 conduct for one half of a period and m3 and m4 conduct for the other half, the output voltage is of the alternating form. The output voltage can be controlled by varying the conduction time of transistors

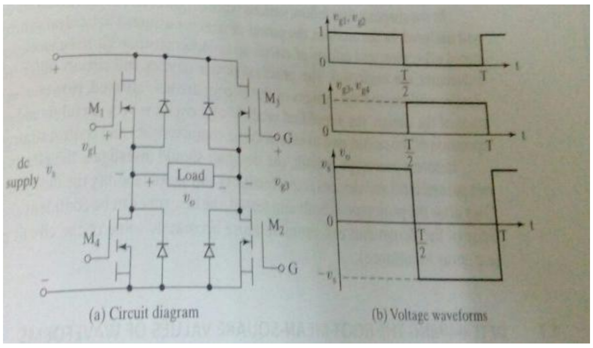

Fig 5: single phase dc-ac converter

V. POWER FACTOR CORRECTION

Power factor correction is the method of improving the power factor of a system by using suitable devices. The objective of power factor correction circuits is to make the input to a power supply behave like purely resistive or a resistor [4]. When the ratio between the current andvoltageis a constant then the input will be resistive so the power factor will be 1.0. When the ratio between current and voltageis other than one due to the presence of non-linear loads, the input will contain harmonic distortion,[4]phase displacement and thus the power factor gets degraded.

$$PF=power/(V_{rms}*I_{rms})=WATTS/V.A\ldots(1)$$

P is the real input power and Vrms and Irms are the root mean square (RMS) voltage and current of the load. Disadvantages of having Low power factor.

1) Poor voltage regulation and large voltage drop
2) Low efficiency
3) Large line loss
4) Penalty from electrical department
5) Drags more current

IV. HARMONIC REDUCTION

The output voltage contains even harmonics over a frequency spectrum. Some application require either a fixed or a variable output voltage, but certain harmonics are undesirable in reducing certain effects such as harmonic torque and heating in motors, interferences, and oscillations.

Phase displacement equation indicates that the *n*th harmonic can be eliminated by a proper choice of displacement angle Ø if

$$\cos n\text{Ø}=0$$

Or

$$\text{Ø}=90^o/n$$

V. MODULATION TECHNIQUES

The modulation technique used in a PWM signal generator should satisfy a number ofnecessities including, the frequency of the fundamental generated signal component should be varied within a wide range, the amplitude of the underlyingcomponent should be controllable with high resolution and the generated signal should have a low overall harmonic content. A modulation technique, which satisfies these requirements, was selected for execution. It is a modification of the popular triangular modulation technique.[3] The PWM signal in each phase of the output is formed when a reference signal, a sine wave of a desired frequency is compared with a timing signal a triangular wave of higher frequency. In order to better the harmonic contents of the resultant PWM signal, thetiming waves andreference have to be synchronized.

Because of advances in solid state power devices,switching power converters and microprocessors are used in industrial application to convert and deliver their required energy to the motor or load. Pulse width modulation signals are pulse trains with fixed magnitude, frequency and variable pulse width. There is one pulse of fixed magnitude in every PWM period. So, the width of the pulses changes from pulse to pulse according to a modulating signal. When a PWM signal is applied to the gate of a power transistor, it causes the turn off and turns on intervals of the transistor to change from one PWM period to another PWM period according to the same modulating signal.[2] The frequency of a PWM signal must be much higher than that of the fundamental frequency, the modulating signals such that the energy delivered to the motor and its load depends mostly on the modulating signal.

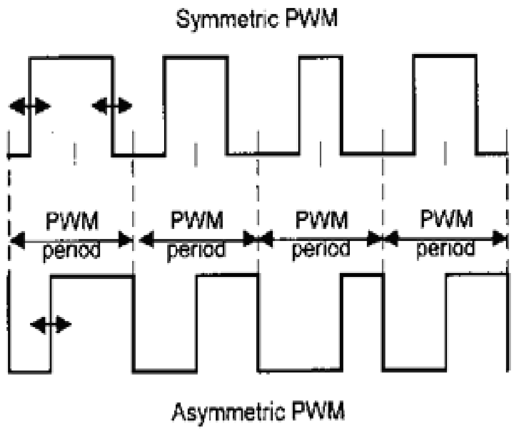

Fig-6: Symmetric and Asymmetric PWM Signals

Fig.-6 shows two types of PWM signals, symmetric and asymmetric. The pulses of an asymmetric PWM signal always have the same side aligned with one end of each PWM period. It has been shown that symmetric PWM signals generate fewer harmonics in the output currents and voltages. The pulses of a symmetric PWM signal are always, symmetric with respect to the centre of each PWM period. This literature is considers three popular PWM techniques, for the mostly used three phase voltage source power inverter applications. This is the most popular method of controlling the output voltage and this method is termed as Pulse Width Modulation (PWM) Control.[1] The advantages possessed by PWM techniques are Easy to implement and control, Lower power dissipation, No temperature variation and aging-caused drifting or degradation in linearity, Compatible with today's digital micro-processors, the output voltage control can be obtained without any additional components and with the method, lower order harmonics can be eliminated or minimized along with its output voltage control. As higher order harmonics can be filtered easily the filtering requirements are minimized. The main disadvantage of this method is that SCRs are expensive as they, must possess low turn-on and turn-off times.

VI. SWITCHING REGULATED

DC converters can be used a switching-mode regulators to convert a dc voltage, normally unregulated, to regulated dc output voltage. There are three basic topologies of switching regulators:

1) Buck regulators (step down)
2) Boost regulator (step up)
3) Buck-Boost regulator (step up/down)
4) Cuck regulator

1) Buck regulators

In a buck regulator, the average output voltage is less than the input voltage.

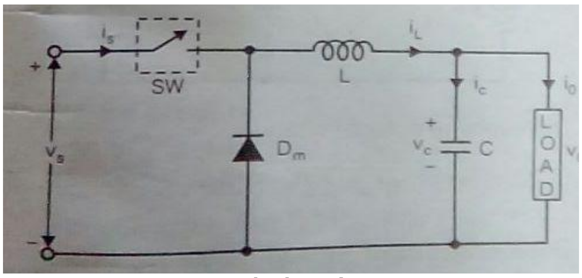

Fig 7:buck regulator

The average output voltage

$$V=\varnothing Vs$$

Where Ø =duty cycle

Assuming a lossless current. The average current

$$Is=\varnothing I$$

2) Boost regulators

In boost regulator, the output voltage is greater than the input voltage.

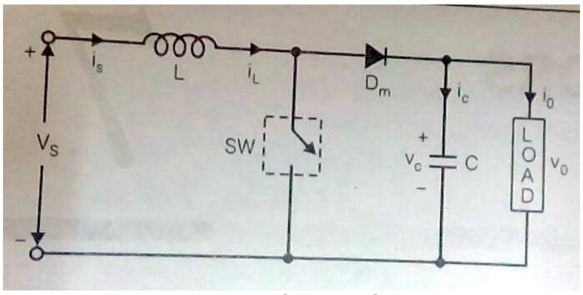

Fig 8:boost regulator

The average output voltage

$$V=V_s/(1-\varnothing)$$

The average input current

$$I_s=Ia/(1-\varnothing)$$

3) Buck-Boost regulator

A buck-boost regulator provides an output voltage that may be less than or greater than the input voltage.

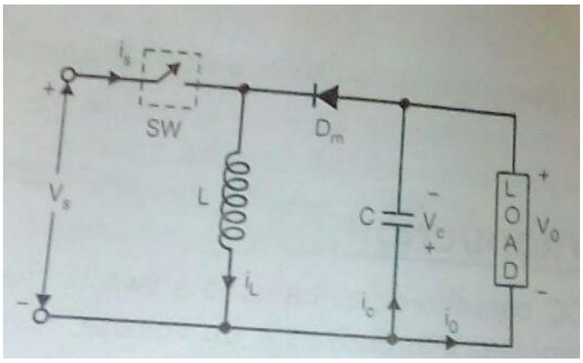

Fig 9:buck-boost regulator

The average output voltage

$$V=V_s\varnothing/(1-\varnothing)$$

The average input current

$$I_s=Ia\varnothing/(1-\varnothing)$$

VII. CONTROL PRINCIPLE

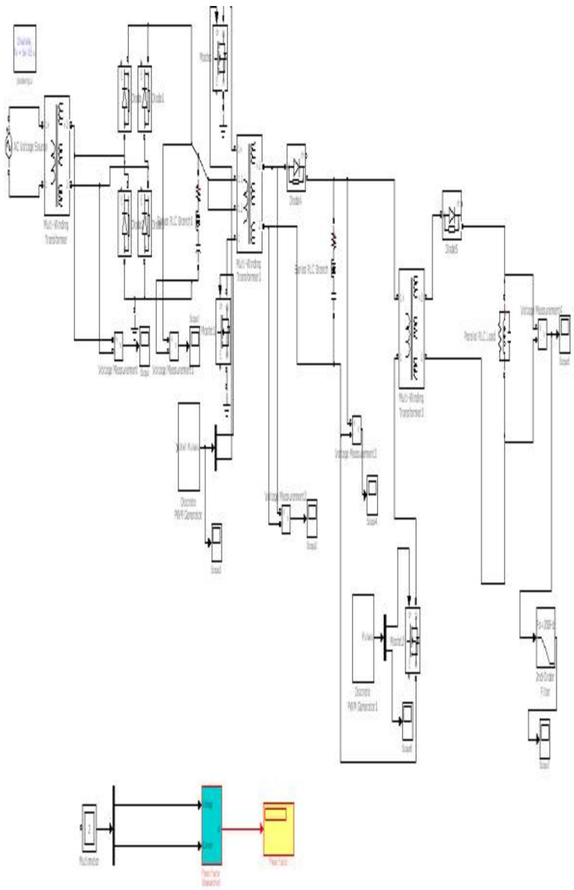

Fig 10: circuit diagram

Development of a single phase AC to DC power supply achieving high power factor and thus high efficiency also.

VIII. RESULT

Here in the output result we have waveforms of step down ac signal, unregulated dc, PWM signal for up converter, high frequency ac voltage, and filtered dc, PWM for down converter then final dc output and passing that by LPF.

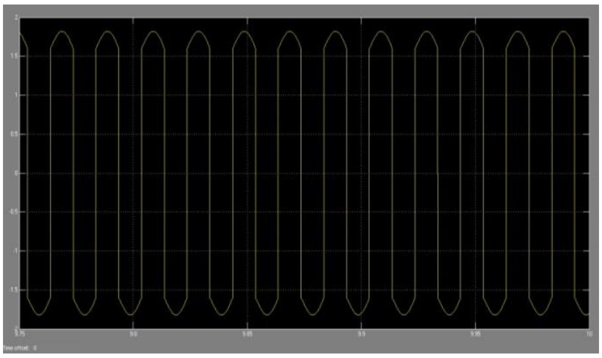

Fig 11: Step down ac signal

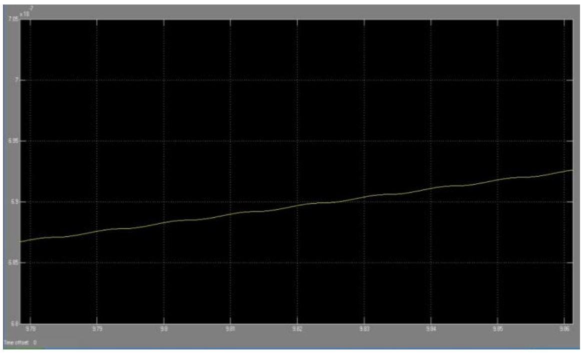

Fig 12: Unregulated dc

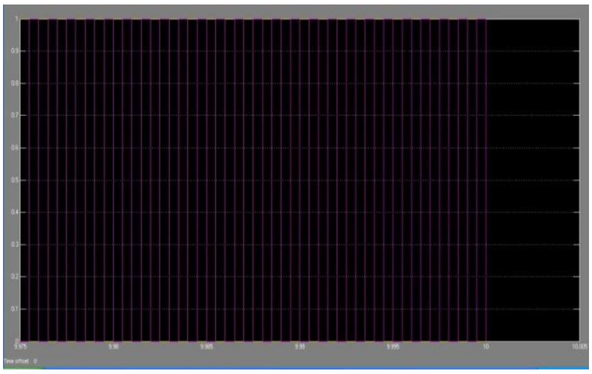

Fig13: PWM signal for up converter

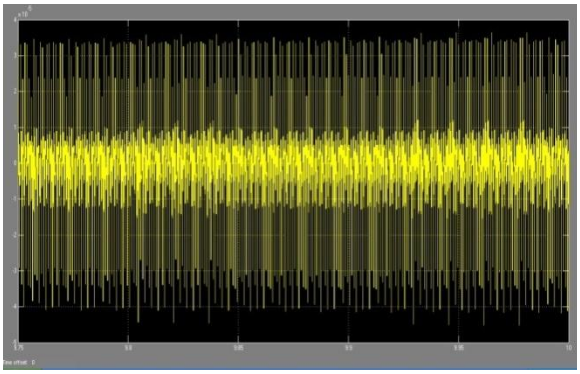

Fig 14: High frequency ac high voltage

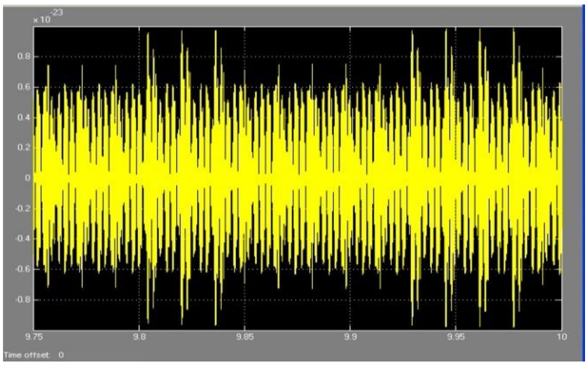

Fig 15: Filtered dc

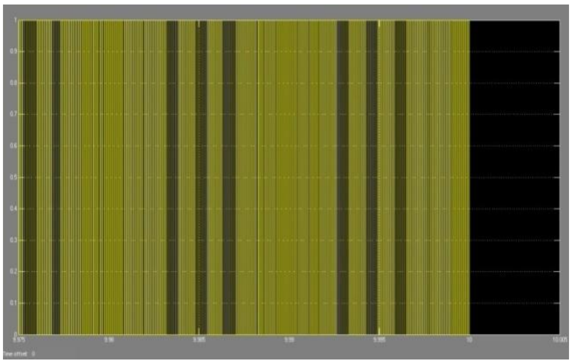

Fig 16: PWM for down converter

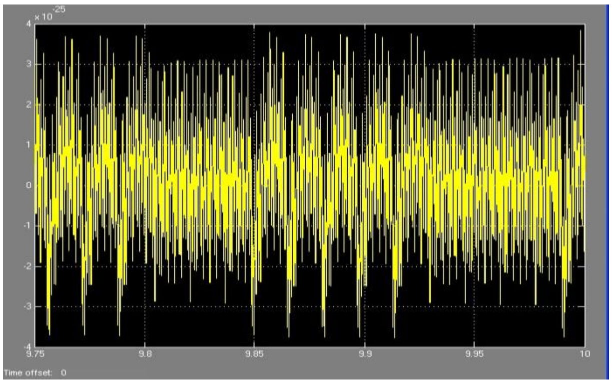

Fig 17: Final dc outputConverter

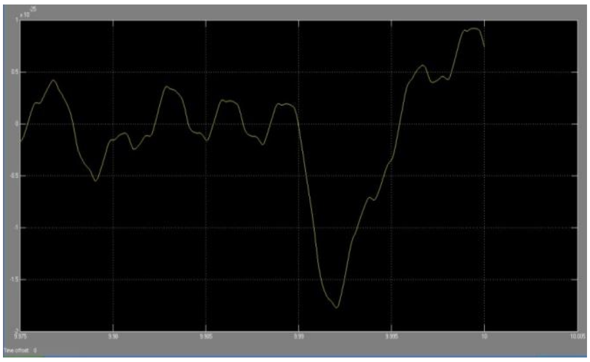

Fig 18: Final dc output after low pass filter

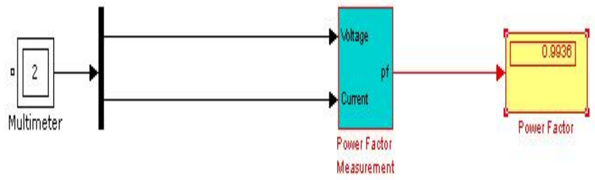

Fig 19: Final power factor

IX. CONCLUSION

The intended work has been done. We implemented this concept on software. In software, 20-30 watts power was used. Power factor closed to 0.95 in final stage. In final stage we used PWM generator by time varying signal we modulate this. By this we achieved DC modulated signal in software.

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