Boosting Input Voltage and Improving PF Using PFC Circuit

Prof.D.B.Madihalli, Prof.V.M.Chougala and Prof.D.M.Kumbhar

Abstract - DC to DC converters are electronic devices used whenever we want to change DC electrical power efficiently from one voltage level to another. Electrical and electronic equipment is designed to operate on standard supply voltage .When the supply voltage is constantly too high or too low, the equipment fails to operate at maximum efficiency. So we need of boost converter to change the level of voltage from low to high in some applications. There are two types in boost converter. They are single boost and dual boost converter. We are applying same dc input voltage from bridge rectifier to both boost converters. Then we get different voltages for both boost converters from hardware model. But it should be Vo>Vi and dual boost output voltage should be greater than single boost output voltage.

If a electrical device has a Power Factor is less than 1, that means more total input current must be supplied for a given output power dissipation and a more powerful source is required to deliver the required output power. So reducing lifetime of the device and its performance will not good. Hence, there is a continuous need for power factor improvement and reduction of line current harmonics. This work is carried out in MATLAB Simulink Environment. By measuring real power, reactive power and calculating apparent power, we get improved Power Factor and Total Harmonic Distortion of both single and dual boost converters using MATLAB Simulink Environment.

The aim of this project to develop a circuit for Power Factor Correction by implementing two boost converters arranged in parallel to boost the input voltage, improve the PF of device and current quality for reducing current harmonics & switching losses.

Key words - Single Boost converter, Dual Boost converter, Bridge Rectifier, Power Factor Meter.

I. INTRODUCTION

DC to DC converters are electronic devices used whenever we want to change DC electrical power efficiently from one voltage level to another. They are needed because unlike AC, DC cannot simply be stepped up or down using a transformer. In many ways, a DC to DC converter is the DC equivalent of a transformer. Typical applications of DC to DC converters are, where 1.5V from a single cell must be stepped up to 5V or more to operate electronic circuitry, where 6V or 9V DC must be stepped up to 500V DC or more to provide an insulation testing voltage, where 12V DC must be stepped up to 40V or more to run a car amplifiers circuitry, where 12V DC must be stepped up to 650V DC or more as part of a DC to AC sine wave inverter. We want to perform the conversion with the highest possible efficiency. Most modern DC to DC converters operate at a relatively high frequency compared with the 50-60Hz of the AC power mains. when use a high frequency, this allows the use of smaller inductors, transformers and capacitors in order to handle the same power level and this in turn allows a reduction in both the size and material cost of the converters.

With the widespread deployment of electronic equipment in our society, rectifier harmonics have become significant and measurable problems. Most power electronics equipment including Drives use rectifiers at the input. Uncontrolled rectifiers are used as front -end converters in SMPSs, VFDs, DC power supplies, and some UPSs. Controlled rectifiers are used in variable speed DC drives, DC power plants, induction heating and welding furnace control. When using rectifier circuit, voltage distortion is occur due to communication notches and voltage clamping. So conventional AC rectification is thus a very inefficient process resulting in waveform distortion of the current drawn from the mains. This produces a large spectrum of harmonic signals that may interfere with other equipment. Thus there is a need for high-quality rectifiers which operate with high power factor, high efficiency and reduced generation of harmonics. So we use boost converter with control systems that regulate the ac input current waveform. This boost converter is used as Power Factor Correction circuit. A boost converter is known for its characteristic to amplify or increase the input voltage. The increment of input voltage is being controlled by a switch and a diode instead of a transformer which is widely used in electronic design. The switch and the diode will act by conducting and breaking the flow of current through the circuit and with the additional usage of inductor, it will be able to increase the voltage across the circuit. The inductor characteristic is an element that is able to store energy inside it by charging current through it and also be able to reuse the energy to act as a source in the circuit. A basic circuit of boost converter only is able to increase the voltage without controlling it and maintain its output voltage even with disturbances. This can be done by creating a feedback circuit and applying it into the boost converter circuit using only in simulation part.[1]

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II. BLOCK DIAGRAM

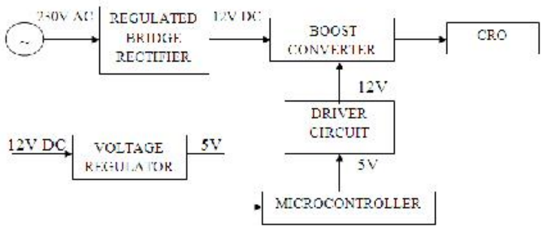

Fig1: Block Diagram of the project

Because of the growing use of computers and electronics equipment, the number of rectifiers connected to the utility grid increasing rapidly and as such they produce non-sinusoidal input current due to non-linear characteristics, thus injecting line current harmonics. The power factor of the system reduces and the adverse effects are already well-known. A high frequency active PFCs shapes input current as close as possible to a sinusoidal waveform i.e. in phase with the input voltage and thus nearly unity power factor. Any DC-DC converter can be used for this purpose as in this project we prefer to use boost converter considering some merits of continuity in input current. A suitable control topology will be adopted which will shape the input current and thus exhibits inherent PFC properties.

III. CIRCUIT DIAGRAM

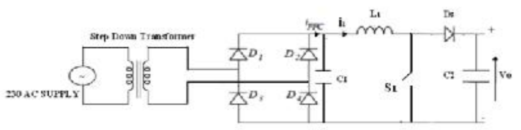

Fig 2: Single boost converter

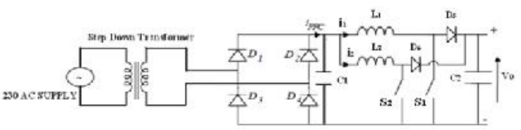

Fig 3:Dual boost converter

The most common example is boosting 208 volts to 230 volts usually to operate a 230 volt motor such as an air conditioner compressor from a 208 volt supply line. Electrical and electronic equipment is designed to operate on standard supply voltage. When the supply voltage is constantly too high or too low the equipment fails to operate at maximum efficiency. A boost converter is a simple and economical for correcting this off-standard voltage. Boosting 208V to 230V or 240V and vice versa for commercial and industrial air conditioning systems, boosting 110V to 120V and 240V to 277V for lighting systems, voltage correction for heating systems and induction motors of all types. Many applications exist where supply voltages are constantly above or below normal.[2]

IV. APPLICATIONS

- It is used in Regulated dc power supplies that are switched mode dc power supplies. So it provides higher energy efficiency.
- It is used in power supplies for low voltage circuit in T V Set.
- It is used in power supply for controllers of switching loads such as stepper motor drives.
- It is used in power supply for critical medical equipments.
- It is used in Computers, Battery Chargers, Battery operated electric vehicles.

V. POWER FACTOR

Power Factor gives a measure of how effective the real power utilization of the system is. It is a figure of merit that measures how effectively power is transmitted between a source and load network.

$$\text{Power Factor} = \frac{\text{Real power}}{\text{Apparent power}} = \frac{P}{S} \quad (1)$$

Real power is the actual capacity of the electrical power source to power the equipment it is connected to. Apparent power is the product of the current and voltage within a circuit. Reactive loads such as inductors and capacitors have energy storage within the load producing a time difference between the current and voltage wave forms. The stored energy returns to the source and is not available to power the load, hence apparent power. If the circuit is inductive, the current lags behind the voltage and power factor is referred to as lagging. However, in a capacitive circuit, current leads the voltage and the power factor is said to be leading.[1]

In a linear system, the load draws purely sinusoidal current and voltage, the current and voltage, hence the power factor is determined only by the phase difference between voltage and current. For purely sinusoidal voltage and current, the ideal definition is applied as: PF = cos ø. Where, cos ø is the displacement factor of the voltage and current.

VI. ADVANTAGES OF HIGH PF

- Reduce the distortion of voltage and current waveform.
- Reduce the switching and conduction losses.
- Increases the efficiency and lifetime of the device.
- Improve the performance of the device.

VII. PURPOSE OF PFC

Low power factor means poor electrical efficiency**.** The lower the power factor, the higher the apparent power drawn from the distribution network. When low power factor is not corrected, the utility must provide the non-working reactive power, in addition to the working active power. This results in the use of larger generators, transformers, bus bars, cables and other distribution systems devices, which would otherwise be unnecessary. As the utility's capital expenditures and operating costs are going to be higher, they are going to pass these higher expenses down the line to industrial users in the form of power factor penalties.

It is a technique of counteracting the undesirable effects of electric loads that create a power factor less than 1.When an electric load has a pf lower than 1, the apparent power delivered to the load is greater than the real power which the load consumes. Only the real power is capable of doing work, but the apparent power determines the amount of power that flows into the load, combining both active and reactive components. In power systems , wasted energy capacity, also known as poor power factor. It can result in poor reliability, safety problems and higher energy costs. The lower the power factor, the less economically the system operates. So for these reasons, power factor correction is necessary.[3]

Power factor correction circuit is to minimize the input current waveform distortion and make it in phase with the voltage one.

VIII. HARDWARE MODEL

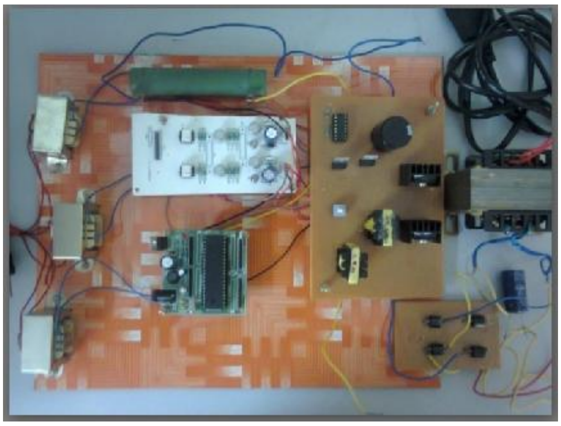

Fig 4: Hardware Model

IX. RESULT ANALYSIS

1) *HARDWARE PART*

In this, first we are calculating theoretical output voltage. Then comparing with practical output voltage from hardware model. All most both output voltages should nearly equal. Here output voltage of dual boost converter is more than single boost converter.

I)THEORITICAL RESULTS

$$Vo = \frac{Vi}{1-D}$$

Where, $D = \text{duty cycle} = \frac{Ton}{Ts} = \frac{Ton}{Ton+Toff}$

Vi = 12V, Fs = 1kHZ then Ts = 1msec, assume Ton = 0.5msec

$$D = \frac{Ton}{Ts} = D = \frac{0.5}{1} = 0.5$$

$$Vo = \frac{12}{1-0.5} = 24V \text{ (For single boost converter)}$$

$$Vo = 2 * \frac{Vi}{1-D} = 2*24V = 48V \text{ (For dual boost converter)}$$

II) PRACTICAL RESULTS

SN	Vi DC (V)	SINGLE BOOST CONVERTER		DUAL BOOST CONVERTER	
		THEORITICAL (Vo) DC	PRACTICAL (Vo) DC	THEORITICAL (Vo) DC	PRACTICAL (Vo) DC
1	12	24V	32V	48V	36V

Table 1 : Hardware Results

2)*SOFTWARE PART*

SN	SINGLE BOOST CONVERTER						
	Vi AC (V)	Vo DC (V)	REAL POWER (P) (WATT)	REACTIVE POWER (Q) (VAR)	APPARENT POWER (S) $\sqrt{P^2+Q^2}$	PF % $\frac{P}{S}$	THD (%)
1	230	271.3	100K	50K	111.8KW	89.4	43.74

Table II : Software Results of single boost converter

SN	DUAL BOOST CONVERTER						
	Vi AC (V)	Vo DC (V)	REAL POWER (P) (WATT)	REACTIVE POWER (Q) (VAR)	APPARENT POWER (S) $\sqrt{P^2+Q^2}$	PF (%) $\frac{P}{S}$	THD (%)
1	230	304.6	150K	62.5K	162.5KW	92.3	42.90

Table III : Software Results of dual boost converter

X. COCLUSION AND FUTURE SCOPE

CONCLUSION

The main objective of the project has been to boost the input voltage at the output stage, that is (Vo > Vi) by dual boost converter circuit and improve the input Power Factor with simultaneous reduction of input current harmonics using that same circuit. A PFC circuit having a parallel boost converter i.e. two boost converters arranged in parallel was designed. In hardware, output voltage has boosted from 32V dc in single boost circuit to 36Vdc in dual boost converter when input voltage is 12Vdc for both circuit. In software, the power factor has improved from 89.44 % in a single boost circuit to 92.30% in a circuit employing a parallel boost converter for Power Factor Correction & reduction of total harmonic distortion from 43.74% to 42.90 %.

FUTURE SCOPE

In this project, it is noticed that the Power Factor is better and THD is less for Dual Boost Converter Circuit.

- This can be further improved by using PI and Fuzzy Controllers.
- For further improvement, we can introduce predictive control strategy in which the active filtering approach can be utilized so as to further reduce the current ripples and switching losses. The switches can be made to be work under soft-switching condition.

REFERENCES

[1] P. Vijaya Prasuna, J.V.G. Rama Rao, Ch. M. Lakshmi / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 2, Issue4, July-August 2012, pp.2368-2376

[2] Hussain S. Athab, IEEE Member, P. K. Shadhu Khan, senior IEEE Member, A Cost Effective Method of Reducing Total Harmonic Distortion (THD) in Single-Phase Boost Rectifier 1-4244-0645-5/07/$20.00©2007 IEEE.

[3] Tiago Kommers Jappe & Samir Ahmad Mussa, Federal University of Santa Catarina, INEP-Power Electronics Institute, lorian´opolis, SC, Brazil, Current control techniques applied in PFC boost converter at instantaneous power interruption - 978-1-4244-4649-0/09/$25.00 ©2009 IEEE.

[4] Yasunobu Suzuki, Toru Teshima Isao Sugawara Akira Takeuchi, Experimental Studies on Active and Passive PFC Circuits, 0-78'03-3996-7/97/ $1 0.0001 997 I EEE.

[5] Paul Nosike Ekemezie, Design Of A Power Factor Correction AC-DC Converter, P. N. Ekemezie is with the Department of Electronic Engineering, University of Swaziland, Private Bag 4, Kwaluseni, M201, Swaziland, 1-4244-0987-X/07/$25.00 ©2007 IEEE.

[6] N.Vishwanathan, Dr. V.Ramanarayanan Power Electronics Group, Dept. of Electrical Engineering, Indian Institute of Science, Bangalore -- 560 012, India., Average Current Mode Control of High Voltage DC Power Supply for Pulsed Load Application 0-7803-7420-7/02/$17.00 © 2002 IEEE.