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Power Factor Correction with An Active Boost Type Converter

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ABSTRACT: This paper extends the application of power factor correction with boost converter. Boost-type power factor correction is the process of power factor correction (PFC) is used to improve power factor of electrical systems by modifying the current waveform. The boost-type PFC encapsulates its fundamental principles and objectives, highlighting its role in enhancing power factor. A low power factor in electrical systems can lead to inefficient energy utilization, increased line losses, and reduced system capacity. Boost-type PFC aims to address these issues by optimizing power factor and enhancing overall energy efficiency. The boost-type PFC circuit typically comprises a boost converter, control loop, and capacitor bank. The boost converter modifies waveform or shape of source current to synchronize with the voltage waveform, minimizing the difference in phase between current and voltage and improving power factor. Implementing boost-type PFC allows electrical systems to achieve a higher power factor, resulting in reduced reactive power, minimized line losses, and improved overall system efficiency. This technique finds wide-ranging applications in various domains, including industrial machinery, power supplies, and renewable energy systems.

KEYWORDS: Conversion of AC-DC, Active power factor correction, Bridge rectifier, Boost type converter.

I. INTRODUCTION

Immense use of electronics devices has now given rise to the need of making power management more flexible, efficient and smart. But Nonlinear current drawn by these power electronics devices affects the quality of power negatively. For improvement of the quality of power of distribution system there are two types of power factor correction methods are available namely as Passive factor correction method and Active power factor correction method. There are some drawbacks of passive power factor correction. So this paper Focuses on Development of power factor correction with correction of power factor with active boost type methodology for DC power supplies.

II. NEED OF PFC IN DC POWER UTILITIES

The concept Most of electronics devices are provided by utility power supplies that operate at 50Hz or 60 Hz, and nearly all of these devices uses or processed through some power converters. Many power supply have a bridge rectifier with a sizable filter capacitor at a input stage. The ac network provides pulses of current to these devices. Fundamental and odd harmonics components are present in the generated periodic discontinuous current[2]. The power distribution systems are hampered by these harmonics. Additionally, the harmonic components of the pulsating current result in additional losses and dielectric stresses in cables and capacitors, which raise peak currents in the windings of transformers as well as in rotating machines and result in unwanted operations of relay, issues with the semiconductor devices' ability to fire, and electromagnetic interference (EMI).

The input rectifier with a capacitive filter circuit pulls pulsing currents from the utility grid in the absence of power factor correction circuits, which results in poor quality of power and very high contents of harmonics that have a negative impact on other users fed from the same grid. Large harmonic loads pollute the electric grid and have an impact on other users who are fed from the same line. Organizations in charge of regulation from all around the world have taken notice of this scenario. The publishing of particular national and international standards (such IEC 1000-3-2, IEC 1000-3-4, and IEEE 519-1992) is one of the most important considerations in resolving this issue and establishing the reliability of the power electronics field. An effective passive filter lowers the current's harmonic content and significantly raises power factor, although it does not totally solve the issue. Active power factor control techniques have so been enhanced. It is widely acknowledged that using an active approach method is the most efficient way to improve the low power factor of electronic power supplies[2].

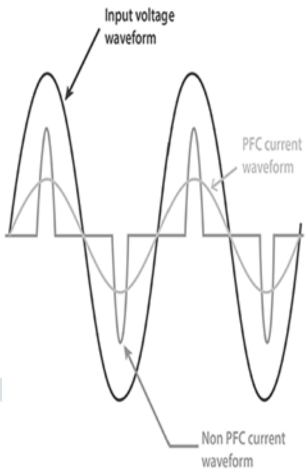


Fig. 1 Input voltage and current with or without PFC.

So, Development of Active power factor correction method. It includes voltage source, rectifier circuit, Boost converter, inductor, and capacitor.

III. OBJECTIVES OF ACTIVE BOOST TYPE PFC SYSTEM

There are some main objectives for developing the boost type PFC system. Which is given as follows:

1. To select correct methodology for the Active Power Factor Correction is simulated and observed.
2. To Analyse the power factor of load Without or with the Active boost type power factor correction.
3. To Analyse difference between the two methods i.e. power factor correction with passive method and also power factor correction with active boost type method.
4. To Analyse effectiveness of power factor correction with active boost type method.
5. Proper utilization of solid states devices which make system more compact and reliable.

Table I. Comparison between Active and passive PFC.

Sr.no	Power factor correction with passive method	Power factor correction with Active method
1	Passive components are used in this PFC method	Active components are used in PFC method
2	Rugged and bulky circuitry	Small components and also light in weight.
3	Cost is less at Low Power	High Power factor almost 0.98 to 0.99
4	It is not possible for universal input range	Active PFC is useful for universal input range.

IV. OPERATION OF BOOST CONVERTER

Boost converter is the type of DC to DC converter also known as step up converter. So it boost output voltage from input voltage. Boost converter mostly used in various application such as in power factor correction, battery charging system. DC power supplies for electronic devices.

Components: I. Voltage source

II. Inductor (L)

III. MOSFET switch

IV. Diode switch

V. Load

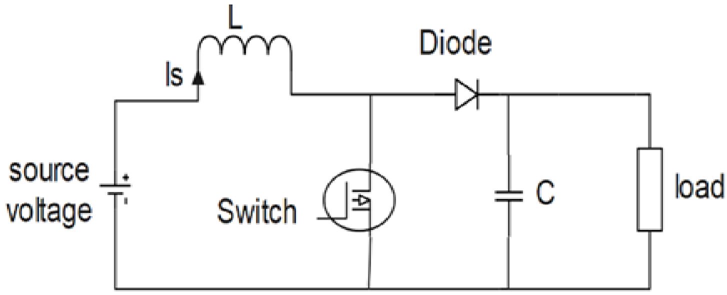


Fig. 2 basic operation of boost converter.

Boost converter circuit need large inductor to be connected in series with the source voltage. MOSFET, IGBT, BJT can use as switches. Thyristor are not used in boost converter as switch because it need extra commutation circuit. Also diode act as another switch and capacitor also need in boost converter which is connected in parallel with the load. This converter is most popular because of high efficiency and compact in size and also having a low cost. Components are same as of a buck converter but locations of components are different. There are two modes of operation.

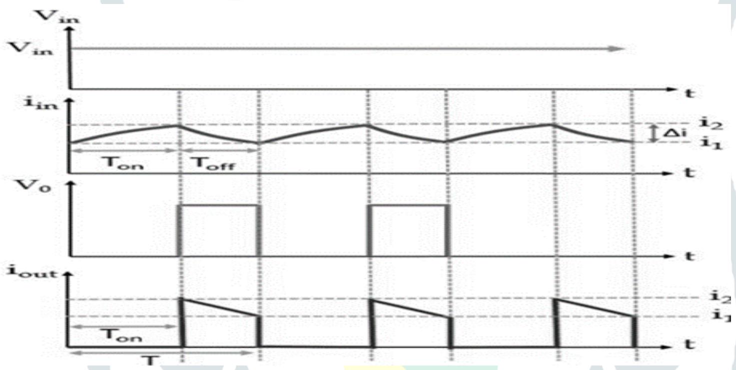


Fig. 3 Waveform of Boost converter.

1st. Mode 1st: switch is closed and Diode is off:

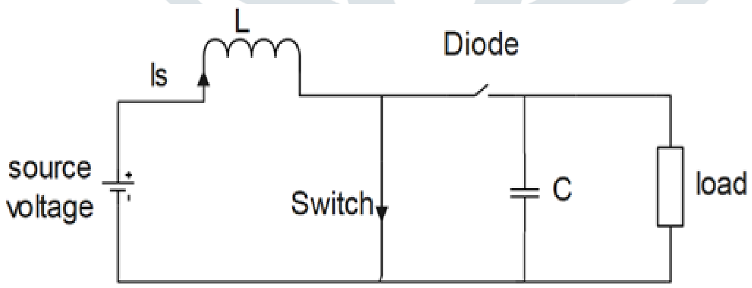


Fig. 4 Switch is closed and diode is off.

Switch is closed in this operation mode i.e. is switch is conduction or operating and diode is in off state that is act as reverse biased. So current flows through inductor and switch allows to pass the current through it and back to voltage source. There are some state variable for above circuit.

a. Input voltage V_{in}

b. Source current Is

c. Inductor current I_L

d. Voltage across capacitor V_c

e. Duty cycle d

By analysis of above circuit, we can conclude the switch is operating for time Ton and switch is not operating for the time Toff so total time T is by combining both the time Ton and Toff.

$$T = T_{on} + T_{off}$$

And we know that frequency of switching is

$$F_{switching} = 1/T$$

So, duty cycle is given by,

$$D = T_{on}/ T$$

If we apply KVL on above mode of operation so we will get,

$$V_{in} = V_L$$

i.e. input voltage is equal to the inductor's voltage. So inductor's voltage can be write

$$V_L = L\ dI_L/ dt$$

So, we can rewrite as,

$$V_{in} = V_L = L\ dI_L/dt$$

From the above equation we can write for change in current will be,

$$I = V_{in}/L.\ dt$$

For, output voltage

$$C\ dV_o/dt = -V_o/R$$

2nd. Mode 2nd Switch is open Diode is conducting:

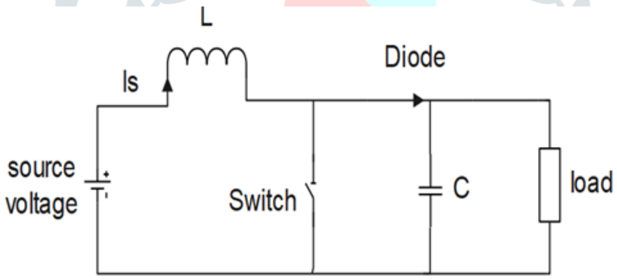


Fig. 5 Switch is open and diode is conducting.

Switch is open in this operation mode i.e. switch is not operating and diode is in forward biased condition means diode is conducting. In this mode of energy the diode which is in forward biased condition and inductor dissipate energy which is stored in previous mode of operation of boost converter. By analysis of above circuit for switch is open and diode is act as a closed switch. If we apply KVL for above circuit then we will get.

$$Vin - VL – Vo = 0$$

So, we can write as,

$$V_{in} – V_o = V_L$$

But we have,

$$V_L = L\ dI_L/dt$$

From above equation we can write as for switch is of

$$L\ dI_L/dt = V_{in} – V_o$$

For output voltage

$$C\ d\ V_o/dt = I_L – V_o/R$$

V. IMPLEMENTATION OF ACTIVE BOOST TYPE PFC

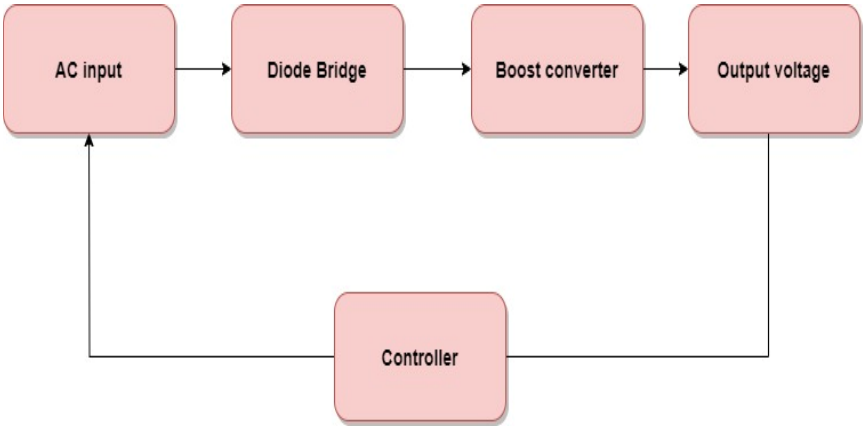


Fig. 6 Block diagram of implementation of boost PFC.

Above fig explain the block diagram of boost type power factor correction. It explains different stages required for Active power factor correction. It needs Ac input voltage source and the diode bridge rectifier. And then boost converter and finally we get output voltage. Also need some controller for controlling the correction of power factor with Active boost type PFC methodology.

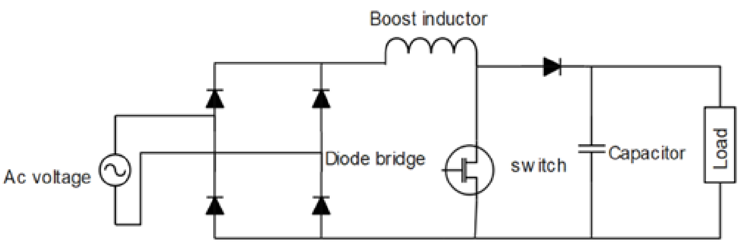


Fig. 7 Circuit diagram of boost type PF.

As we discuss the different stages which is required for Active boost type power factor correction we implemented in this circuit diagram. This circuit diagram consists of AC voltage source and also consist of bridge rectifier, boost inductor, and switch i.e. MOSFET switch and fast recovery diode and circuit along with the control circuit. So boost converter boost the voltage range. Power factor correction with active boost type circuit is Perform two functions.

I. Active boost converter PFC is use to control magnitude of output voltage.

II. And second function is use to control the shape of source current.

As the input source is connected in series with an inductor. because of that it has smooth input current. Due to the boost converter's constant operation during the whole line cycle, there is no distorted input current and current flow continuous [1]. Boost converter perform the operation as per the basic operation of boost converter explains above.

VI. SIMULATION OF ACTIVE BOOST TYPE PFC

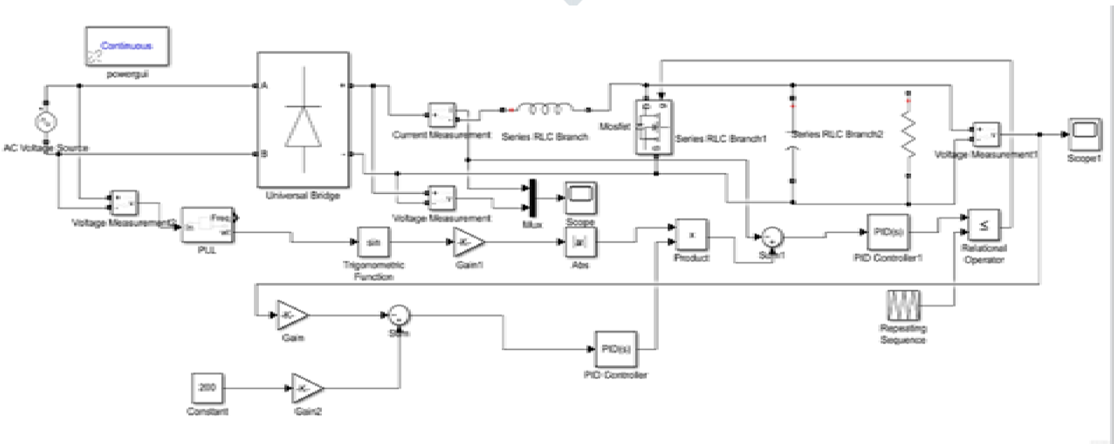


Fig. 8 for simulation of active boost type PFC.

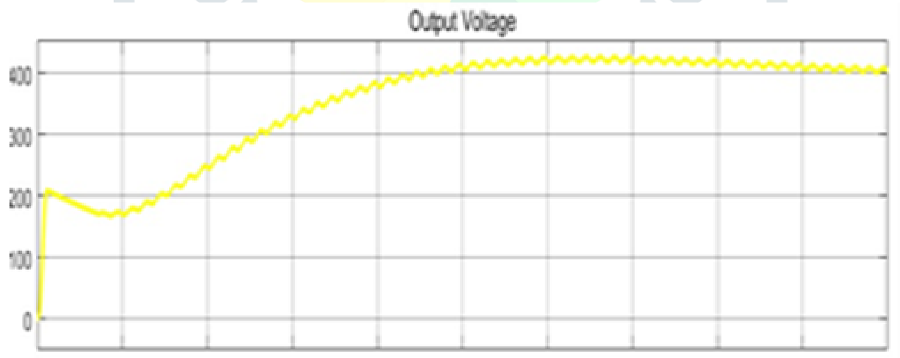
This is the simulation of active boost type PFC with the 400Vdc and analysis of power factor with boost type PFC is expected with 0.98 to 0.99. by using this simulation we can shape the source input and also to control the magnitude of voltage. This simulation used some controller to control the operation of boost type PFC. Simulation uses PID controller relation operator, PLL (phase lock loop) and also different sum blocks and some multipliers and flip-flop is used in this simulation to measure inductor current. By using this simulation we observe different waveform i.e. inductor current. output voltage, output current etc.

A. Specification of simulation of boost type PFC.

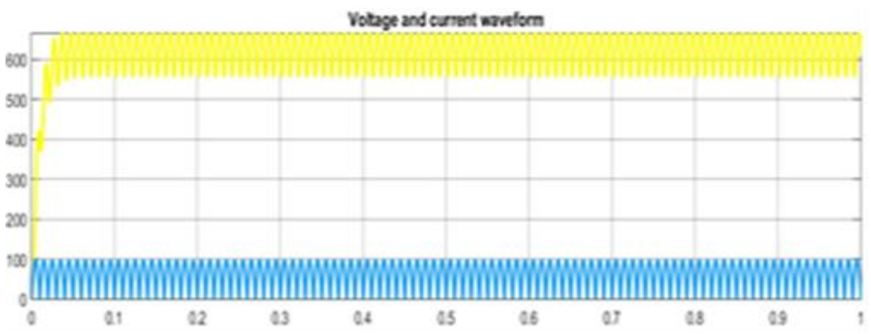
Table: 2 Specification of simulation of boost type PFC.

Sr. no	Parameter	Symbols	Specification
1	Input voltage	V_{in}	100v peak
2	Rated output voltage	V_{out}	400v dc
3	Switching frequency	F_{min}	30 KHZ
4	Efficiency to be expected	H	92%-93%
5	Power factor to be expected	PF	0.98-0.99
6	Output power	Pout	85W

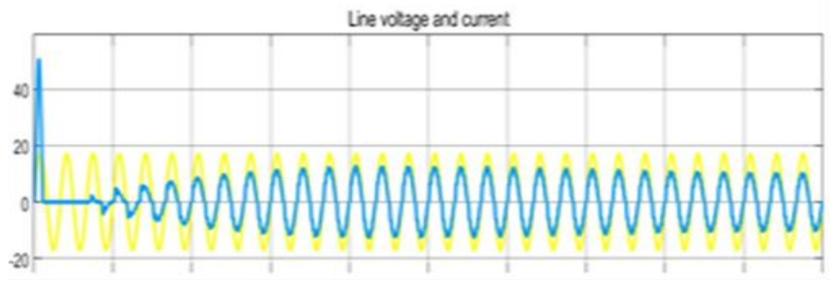
B. Simulation Results and Observation.



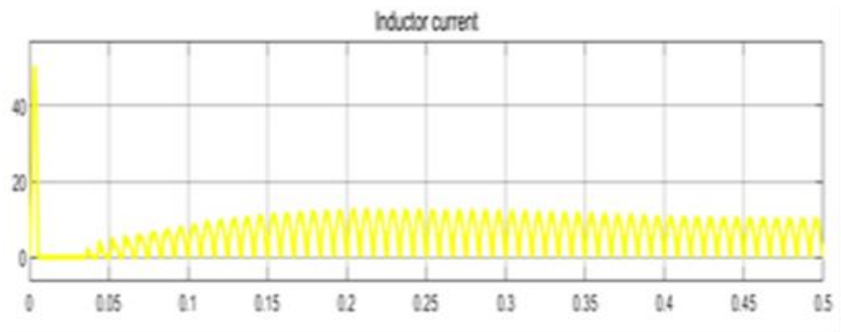
a. DC output voltage.



b. Waveform of current and voltage.



c. Line voltage and current.



d. Inductor current.

Fig. 9 a. voltage of dc output b. waveform of current and voltage c. line voltage and current d. inductor current.

C. Observations from results.

From the simulation of boost type Active power factor correction methodology it is observed that without power factor correction methodology power factor is poor which is feed to the load. But by using the Active boost type PFC power factor is improved to the 0.98 and 0.99. by using the boost type PFC and by some adjusting inductor current it follows the sinusoidal voltage. It is also observed that ripple in the waveform will be decrease as inductor value raise, and current will flow smoothly. but if we increase the value of inductor so that system is become very bulky. As we do not want to make system bulky.

VII. CONCLUSION

This paper explains about the observation and development of Active boost type power factor correction methodology. This methodology is useful for a pf correction of nonlinear dc power supplies. In this paper explanation of need of boost type power factor correction also this paper includes the comparison of Active boost type methodology for correction of power factor and passive methodology for correction of power factor. This simulation module is used improve power factor 0.98-0.99, reduces harmonics. This paper is utilization of new research or development in solid state devices which makes system more reliable and help to improve quality of power.

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