An AC/DC PFC Converter with Active Soft Switching Technique

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ABSTRACT

This paper proposes an AC-DC converter with the application of active type soft switching techniques. Boost converter with active snubber is used to achieve power factor correction. Boost converter main switch uses Zero Voltage Transition switching for turn on and Zero Current Transition switching for turn off. The active snubber auxiliary switch uses Zero Current Switching for both turn on and turn off. Since all the switches of the proposed circuit are soft switched, overall component stress has been greatly reduced and the output DC voltage is expected to have low ripples. A small amount of auxiliary switch current is made to flow to the output side by the help of coupling inductor. The proposed circuit is simulated using MATLAB Simulink. All the related waveforms are shown for the reference. The power factor is measured as 0.99 showing that the input current and input voltage is in phase with each other. The PFC circuit has very less number of components with smaller size and can be controlled easily at a wide line and load range.

Keywords: Active Snubber, Boost Converter, Current Stress, Power Factor, Voltage Stress

INTRODUCTION

In applications like photovoltaic power systems, fuel cells, battery storage systems, adjustable speed drives, uninterrupted power supplies, telecommunication systems and switch mode power supplies AC-DC converters are used extensively. They are composed of diodes and thyristors to provide DC power to the DC loads (João Paulo et al., 2005; Jayakumar & Ajeesh, 2012). These power electronic devices are able to deliver a power of more than 10 KW when operated at higher switching frequencies. During the conversion from AC power to DC power, there will be a production of large amount of harmonics in the input current waveform. Due to its nonlinear characteristics, the electronic devices will draw a high peak discontinuous non sinusoidal line current without a smooth sinusoidal current with lot of harmonics. These harmonics will flow through the electricity grid and also in to the equipment connected to it (Mohammad Marvi & Ali Fotowat-Ahmady 2012; Kai Yao et al., 2012; Hussain Athab & Dylan Dah-Chuan Lu, 2010; Bhim Singh, 2003).

When current with harmonics are injected in to the utility due the connection of these power electronic devices, it results in the distortion of voltage levels, noises, electromagnetic interference problems, losses and generation of heat in transformers, AC machines, transmission cables and all the other equipment connected to the grid.

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resulting in their failure and reduction of amount of energy that can be provided by the line. The neutral conductors may get overheated ending with the tripping of protective relays. Line current harmonics produce electrical resonances in the power system with insulation failures. In addition, it also brings high switching losses and makes the converter performance poor with reduced efficiency. The amount of harmonics injected by a single electronic equipment may be small but when more equipment connected to a single grid it will have serious effects as it reduces the quality of power with poor power factor (Ram Mohan, Vijaya Kumar & Raghava Reddy, 2008).

To overcome all these drawbacks and to meet the international standards there is a need of reducing harmonics present in the input current waveform which is called as the power factor correction techniques (Velumurugan, Sekar & Jojina anna Varghese, 2013). The amounts of harmonic current possible in AC line as per the international regulations have enlightened the research for power factor correction methods.

**NEED FOR POWER FACTOR CORRECTION**

Power factor is the ratio of real power to apparent power both measured in Watts. From the voltage and current waveforms it can also be inferred as the phase shift between them. Power factor correction is shaping the input current of AC main synchronized with input AC voltage increasing the rectifier’s conduction angle. This is done to increase the amount of real power from the mains and to remove the harmonics present in the input current (Ahmad Mousavi & Gerry Moschopoulos, 2014; Chongming Qiao & Keyue Ma Smedley, 2001). In older days, inductors and capacitors were used with low EMI but with reduced efficiency and increased component stress (Mishra, Ramteke & Suryawanshi, 2012). A lower capacitance can be added to the output capacitor but it will create ripples at the output voltage. Many researches have been developed in the area of power factor correction during recent years since electronic equipment with PFC converters are necessary to meet the standard and regulations involving harmonics.

For power factor correction either buck converter or boost converter topology can be used. In buck converter the output available voltage is less than the applied input voltage. So it can provide only less increase in the input current quality even when filters are added to the input side. From medium to high power level boost converter topology is well suitable for correcting the power factor at the front end as it has some advantages like inductor in series leads to low current ripple, grounded resistor, small input inductor, simple circuit and good efficiency (Yungtaek Jang, Dave Dillman & Milan Jovanović, 2004; Yungtaek Jang, Milan Jovanovic, Kung-Hui Fang & Yu-Ming Chang, 2006; Sridevi, 2013; Muthuramalingam & Himavathi, 2009). Boost converter gives an output voltage greater than the input voltage. Power factor correction can be achieved automatically by the presence of inductor in the boost converter circuit as it helps in maintaining the waveform shape of the input current. Due to this the power factor is maintained near unity with a low input current THD value, low ripples in the output voltage waveform and poor efficiency (Nihan Altintas et al., 2014; Colin Clark et al., 2014; Pritam Das et al., 2014; Marcos Alonso et al., 2013; Zhiliang Zhang et al., 2013; Fei Yang, Xinbo Ruan & Zhihong Ye, 2014).

When the boost converter semiconductor components are made to turn on and off hardly, problems like conduction and switching losses occur (Anjan Kumar Sahoo, Sarika Kalra & Nitin Singh; Oscar García et al., 2003). Conduction losses are due to the flow of current through a switching device in on state with some voltage drop on the device. The amount of conduction loss in a converter is the sum of individual on state losses of switch. To reduce the conduction loss there are two interrelated approaches either the number of switches in power path has to be reduced or average current flowing through the switch has to be reduced.
Optimal Training of Artificial Neural Networks to Forecast Power System State Variables
Victor Kurbatsky, Denis Sidorov, Nikita Tomin and Vadim Spiryaev (2014).