COMPARATIVE STUDY OF POWER FACTOR CORRECTION TECHNIQUES FOR AC/DC CONVERTER

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ABSTRACT: In this paper, three generalized topologies of single stage circuits such as Boost converter, Buck converter & Quasi active power factor correction (PFC) converter circuits are designed and their performance comparison is presented. Converters connected to the mains have the potential of injecting current harmonics that may cause voltage distortion. These harmonics can be significantly reduced if the input power factor is corrected by shaping the input current so that it is sinusoidal and in phase with the supply voltage. In the proposed quasi active PFC system, the power factor is drastically improved by using an auxiliary winding coupled to the transformer of a cascade dc/dc fly back converter. The proposed converter is presented and compared with boost, buck converter for different loads and inputs.
Keywords: AC/DC converters, power factor correction (PFC), single stage, Fly back converter, total harmonic distortion (THD)

I. INTRODUCTION

Unity power factor and better output voltage regulation can be achieved with the very well known two stage in fig 1.

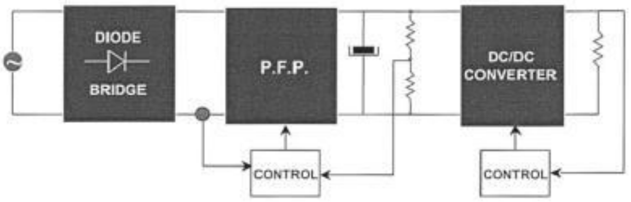


Fig.1 Two stage ac-dc converter

The two-stage scheme results in high power factor and fast response output voltage by using two independent controllers and optimized power stages. Single-stage PFC converters meet the regulatory requirements regarding the input current harmonics, but they do not improve the power factor and reduce the THD as much as their conventional two-stage counterpart. In order to reduce the cost, the single-stage approach if hardware is implemented, this integrates the PFC stage with a dc/dc converter into one stage and has been elaborated and implemented [1-8]. To overcome the disadvantages of the single-stage scheme, many converters with input current shaping have been presented in which a high frequency ac voltage source (dither signal) is connected in series with the rectified input voltage in order to shape the input current .In this circuit, the dc/dc cell operates in DCM so that a series of discontinuous pulses is used to shape the input inductor current and the PFC is achieved. Boost converter, Buck converter & quasi active power factor correction (PFC) converter circuits are designed and their performance comparison is presented. Some of these circuits are practical but others are too complex to be worth changing. Although unity power factor is the ideal objective, it is not necessary for meeting the Regulations. For example, both IEEE 519 and IEC 1000-3-2, allow the presence of harmonics in the line current [4-5]. This fact has lead to propose solutions that obtain some advantages over the two stage approach. The purpose of this project is to classify and compare several single stage converters proposed for the ac–dc conversion with power factor correction, having the two stage approach as a reference and focusing the study in the low power range.

II. POWER FACTOR CORRECTIONTECHNIQUE

2.1 Buck converter for power factor correction

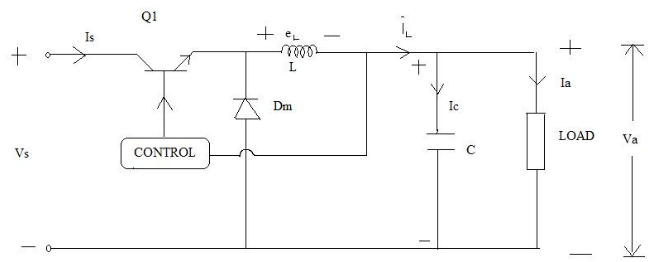


Fig 2 Buck converter

It requires only one transistor and is simple load current. But, the input current is discontinuous and a smoothing input filter is required. Buck converter provides one polarity of output voltage and unidirectional output current. In systems such as universal line AC-DC converters it is very difficult to improve power factor where high efficiency is required throughout the entire line. A Power Factor Correction circuit using Boost Converter possesses 1% to 3% lower efficiency at 100 Volts than that at 230 Volts. This is due to increased input current that produces higher losses in semiconductors and input filters. Also the high output voltage of Boost Converter in 380-400 Volts range has a detrimental effect on its switching losses and on the size and efficiency of the isolation transformer. The above drawbacks of Boost Converter in Power Factor Correction circuit can be overcome by using Buck Converter with output voltage in 135 Volts range which has higher efficiency throughout the line. Also the lower input voltage to the DC-DC output stage can now be operated with lower voltage rated semiconductors, optimized loss and size of isolation transformer and better performance.

2.2 Boost converter for power factor correction

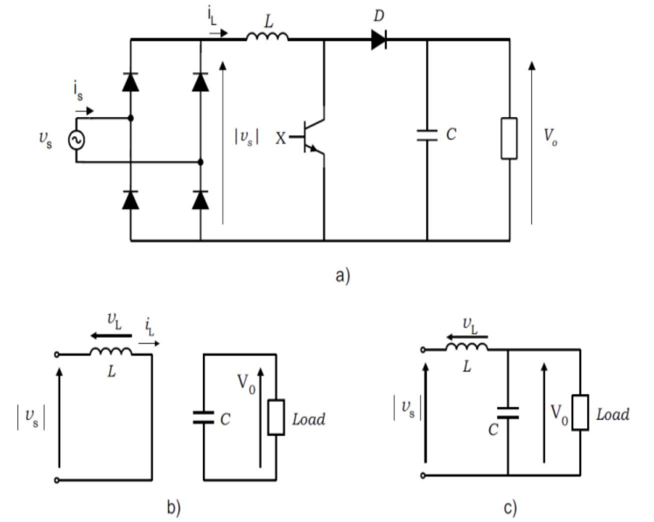


Fig 4. Boost converter

The input current is (t) is controlled by changing the conduction state of transistor. By switching the transistor with appropriate firing pulse sequence, the waveform of the input current can be controlled to follow a sinusoidal reference, as can be observed in the positive half wave in Fig.5(a,b). This figure shows the reference inductor current iLref , the inductor current iL, and the gate drive signal x for transistor. Transistor is ON when x = 1 and it is OFF when x =0. The ON and OFF state of the transistor produces an increase and decrease in the inductor current iL.

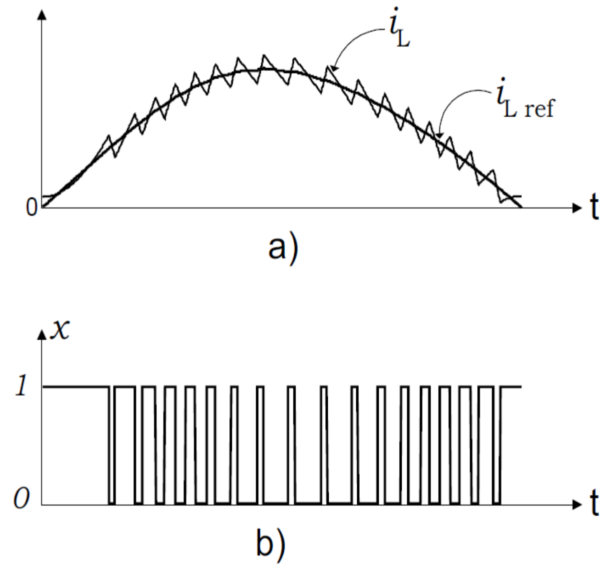
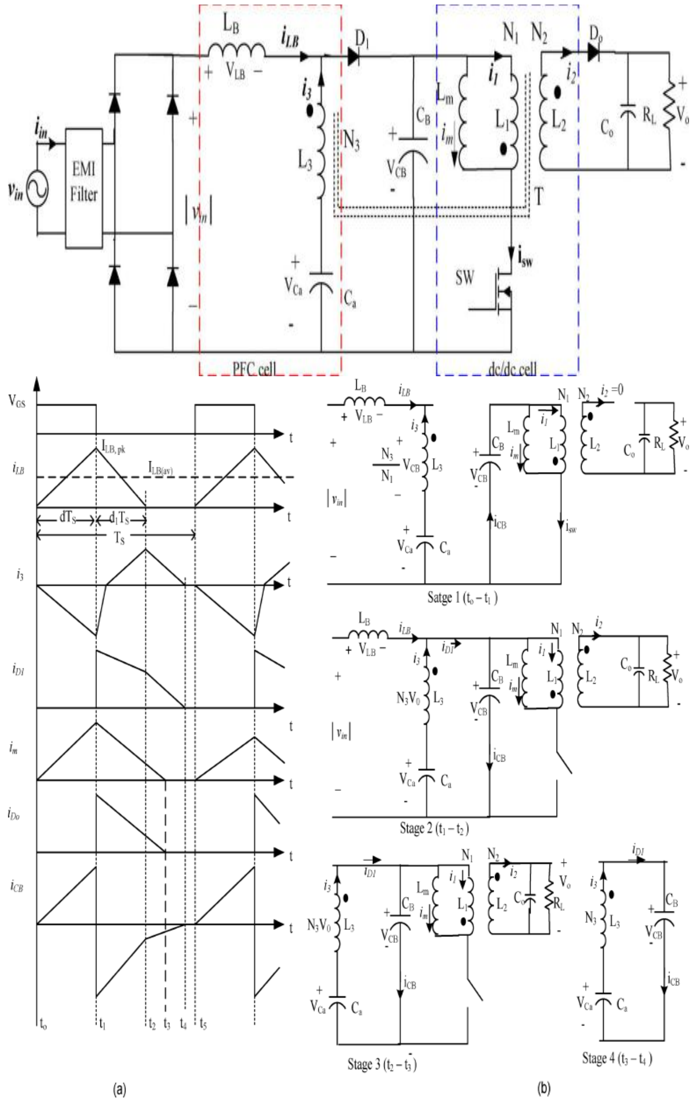


Fig 5 Behavior of inductor current
(a) Waveforms, (b) Transistor T gate drive signal x

III. PROPOSED QUASI ACTIVE TECHNIQUE

Quasi-active PFC cell is formed by connecting the energy buffer (LB) and an auxiliary winding (LA) coupled to the transformer of the dc/dc cell, between the input rectifier and the low-frequency filter capacitor used in conventional power converter. The input inductor operates in DCM such that a lower THD of the input current can be achieved [1]



Stage 1 (to − t1):

When the switch (SW) is turned on at t = to, diodes D1 and Do are OFF, therefore, the dc-bus voltage VCB is applied to the magnetizing inductor Lm, which causes the magnetizing current to linearly increases. This current can be expressed as

$$i_m = \frac{V_{CB}}{L_m}(t_0 - t_1) \tag{1}$$

And since diode D1 is OFF, the input inductor L B is charged by input voltage, therefore, the inductor current iLB is linearly increased from zero since it is assumed that the PFC cell operates in DCM.

This current can be expressed as

$$i_{LB} = \frac{|V_{in}| + \left(\frac{N_3}{N_1}\right)V_{CB} - V_{Ca}}{L_B}(t_0 - t_1) \tag{2}$$

Where, Vin = Vm| sin θ| is the rectified input voltage, (to − t1) = dTS is the ON-time of the switch (SW), LB is the boost inductor and N1, N3 are the primary and auxiliary turns ratio, respectively.

At this stage, iLB = −i3 and the capacitor Ca is in the charging mode. On the other hand, Do is reversed biased and there is no current flow through the secondary winding. Since the transformer is assumed ideal, based on Ampere's law, it has

N1i1 + N2i2 − N3iLB = 0 Where i2 = 0 at this stage therefore,

$$i_1 = \frac{N_3}{N_1} . i_{LB} \quad (3)$$

$$i_m = i_{CB} - i_1 = i_{CB} + \frac{N_3}{N_1} i_3 \quad (4)$$

Therefore, from (4) it can be seen that the magnetizing current im is supplied by the discharging current from the dc bus capacitor CB and the current i3 which is equal to input current iLB at this stage. The current through the main switch (SW) is given by

$$i_{SW} = i_{CB} = i_m - \frac{N_3}{N_1} i_3 = i_m + \frac{N_3}{N_1} i_{LB}$$

Therefore, the current stress of the switch can be reduced by selecting the turn's ratio (N3/N1), which is designed to be less than 1 to ensure proper operation of the transformer. Compared to the single-stage BIFRED converter, the switch current is given by

iSW = im + iLB (6)

Obviously, the proposed circuit has less switch current stress, therefore, the conduction loss and switching losses are reduced, and the efficiency is improved correspondingly. This stage ends when the switch is turned off at t = t1.

IV. COMPARATIVE ANALYSIS

	Buck converter	Boost converter	Proposed technique
Power factor	Less improved	Moderately improved	Highly improved
Efficiency	70%	70-75%	90%
THD of input current	25-30%	>20%	<20%
Semiconductor	1 transistor 1 diode 1 inductor	3 diode 1 bridge 1 switch	2 diode Switch bridge

V. ACKNOWLEDGEMENT

This paper studies the comparative analysis of the three converters. And help us to understand that quasi active technique is the excellent technique to improve the power factor, efficiency, THD of input current can be controlled more as compare to the buck and boot converter.

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