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THE COMPARATIVE ANALYSIS OF AC-DC BOOST PFC CONVERTER BASED ON PWM AND HYSTERESIS CURRENT CONTROL TECHNIQUES

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Abstract—*This paper presents various current control techniques of an ac-dc boost converter to obtain nearest unity power factor (UPF). Single phase high power factor rectification is the most frequently accomplished using a dual boost converter. This converter reshapes distorted input current waveform to approximate a sinusoidal current that is in phase with the input voltage. There are several current control techniques for achieving a sinusoidal input current waveform with low distortion. Two typical techniques for power factor correction (PFC) are pulse width mode control (PWMC) and hysteresis current mode control (HCMC) is very useful for power factor correction. These control techniques are evaluated based on control strategy, circuit components, and total harmonic distortion of input current. The single phase ac-dc dual boost converter is operated in continuous conduction mode (CCM). Both control techniques are simulated in Matlab/Simulink program.*

Keywords: *PWMC, HCMC, Total harmonic distortion, Dual boost converter.*

1. INTRODUCTION

Various techniques are used for the power factor correction applications and controlling. The single phase active PFC techniques are used via two methods. One of them is single stage methods and other is two stage methods: single stage method is used for low power level applications. Eg: lead acid battery charging system. Therefore two stage methods is used for high power level applications e.g.: lithium-ion battery charging, which is very high power rating comparison to lead acid battery. In the two stage topology, first stage is PFC rectification where it rectifies the input ac voltage and transfer to a dc link. At the same time, PFC is also improved.

Dual boost converter has been used for high current applications to minimize device current rating and inductor size by interleaved the switching device and inductors. The inductor size is reduced by a quarter for the same current ripple. This is a main advantage as inductor size can severely constrain the design of high current PFC converters. The most popular topology in PFC is the dual boost topology, shown in Fig.1 together with two switching gate pulse controller.

A diode rectifier effects the ac/dc conversion, while the controller operates the switch in such a way to properly

Shape the input current i_g according to its reference. The output capacitor absorbs the input power pulsation, Allowing a small ripple of the output voltage V_o.

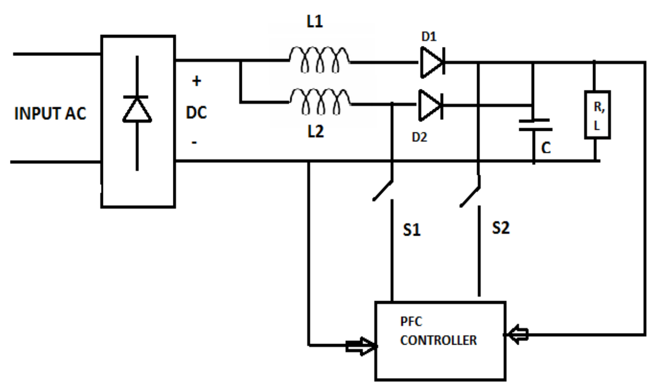

Fig. 1: Basic dual boost PFC controller schematic diagram

The purpose of parallel boost converter is to avoid twice power process in two stage scheme. Two converters can be connected in parallel to form the interleaved PFC scheme. Here, power form the ac main to the load flows through the two parallel scheme. The main path is a rectifier, in which power is not processed twice for PFC. whereas the other path processes the input power twice for PFC purpose. To achieve both unity power factor and tight output voltage regulation. Only the difference between the input power and output power needs to be processed twice. Therefore high power efficiency can be obtained.[3]

2. FEATURES OF PARALLEL BOOST CONVERTER:

Assume both the main switches (S1 & S2) are operates in the same frequency:

The S1 and S2 are turn on with zero voltage transition and turn off with zero current transition. This dual boost converter is operates in high switching frequency. The interleaved boost converter is simply two boost converters in parallel operating 180° out of phase. The input current is the sum of the two inductor currents I_{L1} and I_{L2}. Because the inductor's ripple currents are out of phase, they tend to cancel each other and reduce the input ripple current caused by the boost inductors [4]. The best input inductor ripple current cancellation occurs at 50 percent duty cycle. The output capacitor current is the sum of the two diode currents ($I_1 + I_2$) less the dc output current. Interleaving reduces the output capacitor ripple current as a function of duty cycle. As the duty cycle approaches 0 percent, 50 percent and 100 percent duty cycle, the sum of the two diode currents approaches dc[4].At these points, the output capacitor only has to filter the inductor ripple current.[4]

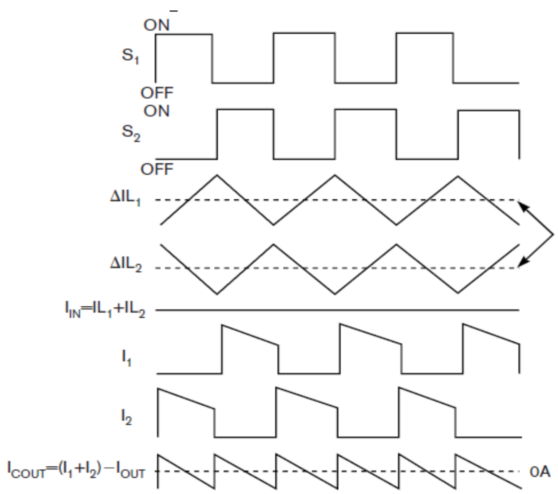

Fig. Switch signals for switches S_1 and S_2.

3. CONTROL STRATEGY FOR PFC:

Various control strategy is used for power factor correction is as follows:

Voltage mode control

Current mode control

4. CURRENT MODE CONTROL TECHNIQUES

Current mode control uses the load current as feedback to regulate the output voltage. In this approach there is direct control over the load current whereas output voltage is controlled indirectly, hence it is called "current-mode control". Different current control techniques are usually used for controlling the PFC converters. The various current mode control schemes are- average current control, peak current control, hysteresis control, borderline control, valley current control, emulated current control.

In this section, several known methods of PWM and HCMC techniques are discussed to enable the input current to be synchronized with the fundamental component of the input voltage. The parameters used in controllers to generate the gate signals of the switches are; input voltage, input current and output voltage. There are two loops in the software. The inner loop is responsible for controlling the shape of the inductor current and the outer loop controls the output voltage and keeps it constant at the pre-defined reference value. In outer loop, the output voltage level is scaled and compared with the given reference.

5. PWM CURRENT CONTROL TECHNIQUE

Discontinuous current PWM control scheme is shown in Fig. 5.7 and it eliminates the internal current control loop to operate the switch at constant on time and switching frequency. This control technique causes some harmonic distortion in the line current with the boost PFC, but allows unity power when it is used with converter topologies like Flyback, Cuk and Sepic with the converter operating in "Discontinuous conduction mode" (DCM) [10].

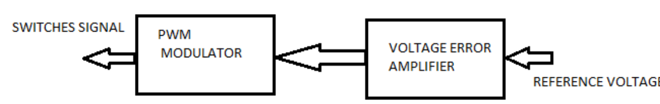

Fig. 2: PFC controller for Discontinuous current PWM control scheme.

6. SIMULATION AND RESULT

PWM CURRENT CONTROL TECHNIQUE

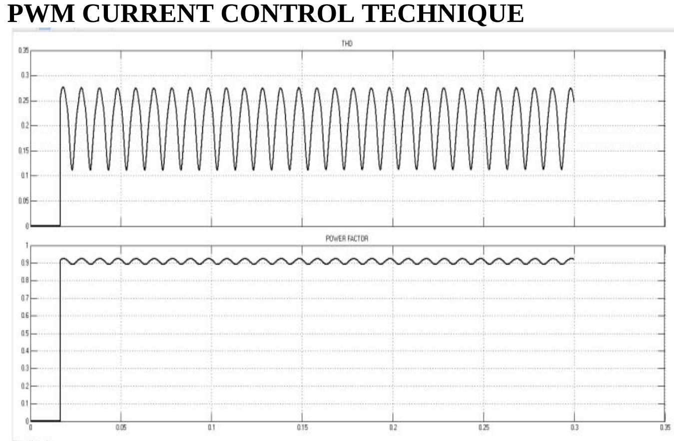

Fig. 3: Simulation result with PWM current control technique

THD = 2.48%

Power Factor = 0.9197

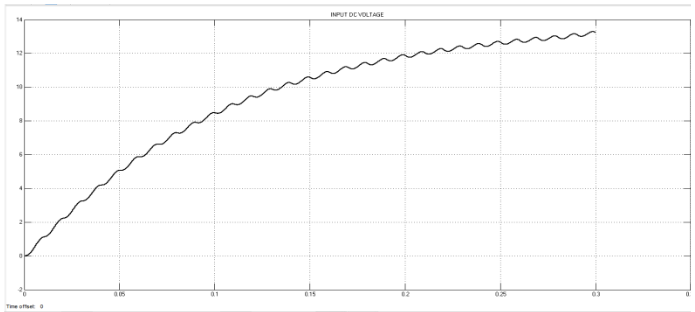

Fig. 4: Waveform of rectified dc input (13.22 Volt)

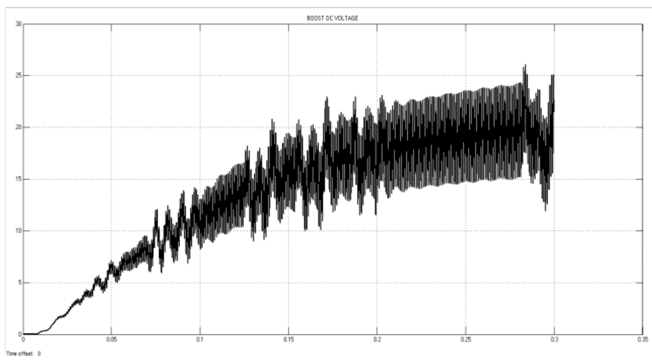

Fig. 5: waveform of boost dc voltage (22.66 volt)

7. HYSTERESIS CURRENT MODE CONTROL TECHNIQUE

There are two distinct states of the hysteresis comparator as shown in Fig. :

1. When the actual inductor current (i_L) goes above the reference current (i_{ref}) by the comparator hysteresis band, the Current ramp goes down by changing the comparator state to make the boost converter switch off.

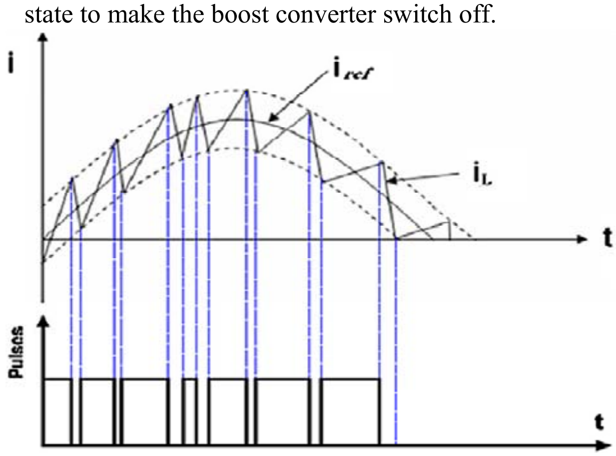

Fig. 6: Rectified current (i_L), reference current (i_{ref}) waveforms and pulses of Dual boost PFC with hysteresis control.

2. When the actual current goes below the reference current by the comparator hysteresis band, the current ramp goes up by changing the comparator state again to make the boost converter switch on.

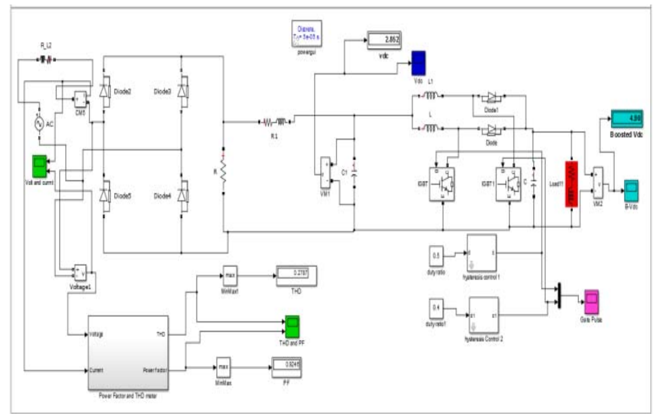

Fig. 7: Simulation in hysteresis current control technique

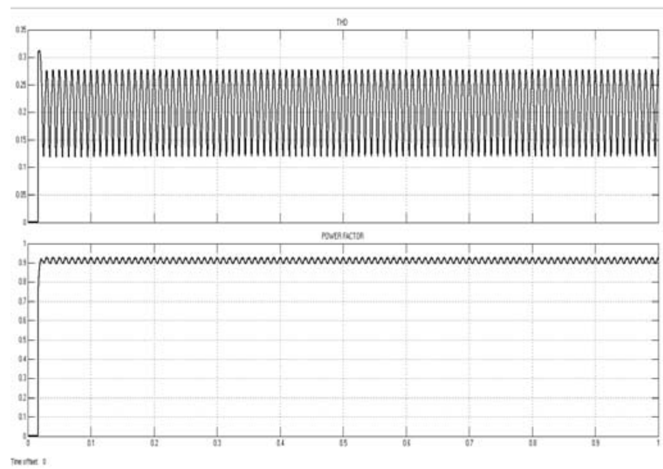

Fig. 8: THD and power factor wave form

THD =2.78 %

PF = 0.9311

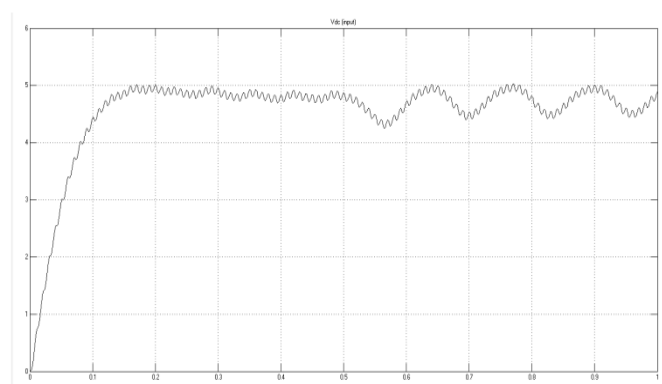

Fig. 9: Waveform of rectified dc input (4.88 Volt)

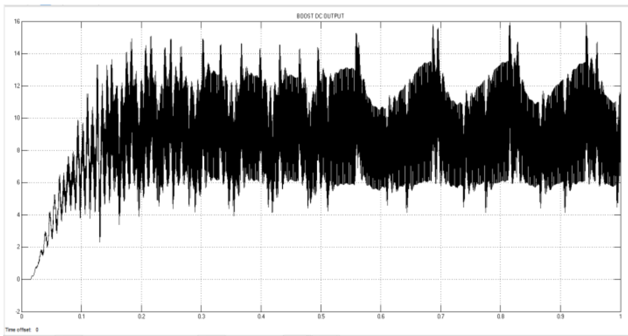

Fig. 10: Waveform of boost dc voltage (10.44 volt)

Table 1: Simulation Parameter for PWM current control technique

Parameter	Rating
Input Voltage	200 V (peak)
Input Frequency	50 Hz
Rectified DC	13.24 volt
Boost dc	22.66 volt
Load(R,L)	0.8Ω, 2e-3 mH
Boost inductor(L1&L)	2.5e-3
Power factor	0.91

Table 2: Simulation Parameter for hysteresis current control technique

Parameter	Rating
Input Voltage	200 V (peak)
Rectified DC	4.88 volt
Boost dc	10.44 volt
Load(R,L)	0.8Ω, 2e-3Mh
Boost inductor(L1&L)	2.5e-3 Mh
Power Factor	0.9311

8. RESULTS AND CONCLUSION:

In this paper, PWM technique gives power factor 0.9197 and HCMC technique gives power factor is 0.9311. And respectively gives THD is 2.48 % and 2.78%. Power factor is improved in HCMC method so we can say that hysteresis current control technique is better than PWMC technique.

The main objective of this paper was to improve the power factor with dual boost converter using PWMC and HCMC methods. Simulations were initially done for conventional dual boost converter

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Bharat Singh received the B.Tech Degree in Electrical & Electronics Engineering from shree ganpati institute of technology, Ghaziabad, UP which is affiliated to UPTU Lucknow in 2010. M.Tech will complete from Krishna institute of engineering & technology Ghaziabad, U.P in 2015.

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