Monostage High Powerfactor AC-DC Converter

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***Abstract*— This paper describes a single stage AC-DC converter with high power factor. The diode-capacitor type of rectifier cause low power factor because of its nonlinearity. PFC serves to smooth out power drawn and regulates the output voltage. High power factor at the input is assured by operating the buck-boost converter at discontinuous conduction mode of operation. With same operation on both cycle and detailed designed circuit parameter, zero- voltage switching on all the active switches of the converter can be retained to achieve good efficiency. This gives soft switching condition which increases the efficiency of the system and reduces the switching power losses. The buck boost converter and the filter circuit are used to re-shape the input current waveform so as to be in phase with input voltage waveform. The design, analysis, simulation and hardware realization of the AC-DC converter with soft switching.**

***Keywords*-Buck-boost converter, full-bridge resonant converter, power factor correction (PFC), zero-voltage switching(ZVS).**

I. INTRODUCTION

Power factor (PF) is the cosine of the angular difference between voltage and current. It is calculated as PF = cosϕ = cos (Vs^Is). It can vary between zero and one depending on the type of load. If the supply voltage and current are in-phase with each other, then the power factor of the circuit (cosϕ) is
unity. The power electronic switching devices introduce distortion into the system. As a result, the power factor gets lowered.

The diode bridge rectifier with capacitive filter is used as the fundamental block of many power electronics converters. Due to its non-linear nature, non-sinusoidal current is drawn from the utility and harmonics are injected into the utility lines. The injected current has lower order of harmonics and causes voltage distortion and poor power factor at input AC mains. This causes slow varying ripples at DC output load resulting in lower efficiency and larger size of AC and DC filters [2]. These converters are required to operate with high switching frequencies due to demand for small filter size and high power density. High-switching frequency operation results in higher switching losses, increased electromagnetic interference (EMI), noise and reduced converter efficiency [3]. To overcome these drawbacks, the switches of buck-boost converter are operated with zero voltage and zero current switching. High-switching frequency with SS provides low switching stress and losses, high-power density, less volume and lowered ratings for the components, high reliability and efficiency.

To improve the efficiency, a large number of soft switching technique including resonant circuits have been proposed [4]-[7]. But these converters increase the number of switches and stages in power conversion circuit thus complicating the sequence of switching operation, excessive voltage and current stresses, and also narrower line and load ranges[8],[9].

This paper describes a single stage AC-DC converter with high power factor. For high power application power handling capacity is increased so full bridge resonant converter is adopted which is combined with two Buck-boost type PFC circuits. Two active power switches act as a PFC circuits Therefore, power handing capacity increased. A high power factor at the input line is achieved by operating the PFCs at discontinuous conduction mode. The output voltage is regulated by controlling the

ON/OFF time of switches present in buck-boost converter. The higher order harmonics are eliminated by using low pass filter, which reduce the size of filter and increases the power factor. Here soft switching can be obtained by using a new partial resonant converter. The higher order harmonics are eliminated by using low pass filter, which reduce the size of filter and increases the power factor. Here soft switching can be obtained by using a full bridge resonant converter. The proposed system has the advantage of less components and less switching losses.

II. PROPOSED CIRCUIT CONFIGURATION

A single stage ac-dc converter is integrated with PFCs as shown in the figure 1.The diodes (D9-D12) represents the intrinsic body diodes of the MOSFETs. A series resonant circuit and a transformer T_1 form the load resonant circuits. (PFC1 and PFC2) to make the sine wave sinusoidal and in phase with the input line voltage. PFC1 and PFC2 operating simultaneously at both positive half cycle and negative half cycle of the input line. A small low pass filter is used to remove the high frequency component at the input.

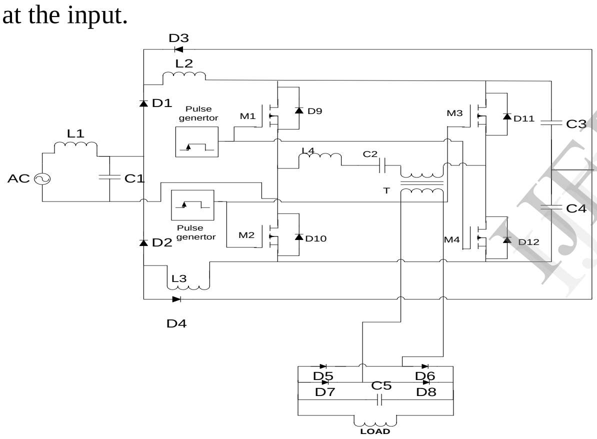


Figure 1: Single stage high power factor converter

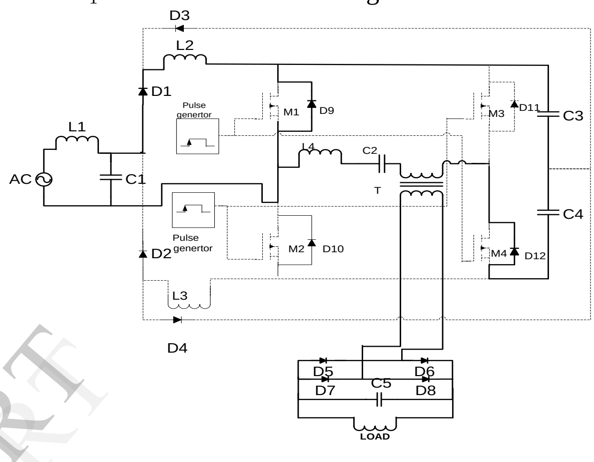
III. CIRCUIT OPERATION

There are four switches, namely $M_{1.}$, M2,M3,and M_4 are controlled by four gating signals,namely,$V_{gs}1$,$V_{gs}2$,$V_{gs}3$, and $V_{gs}4$ respectively. Gating signal $V_{gs}1$and $V_{gs}4$ and gating signals $V_{gs}2$ and $V_{gs}3$ forms two voltage waveforms. The gated signals have equal and same waveform. M_1 and M_4 is turned on, M_2 and M_3 is turned off simultaneously and vice versa, each gated signals has a duty ratio of 0.5.

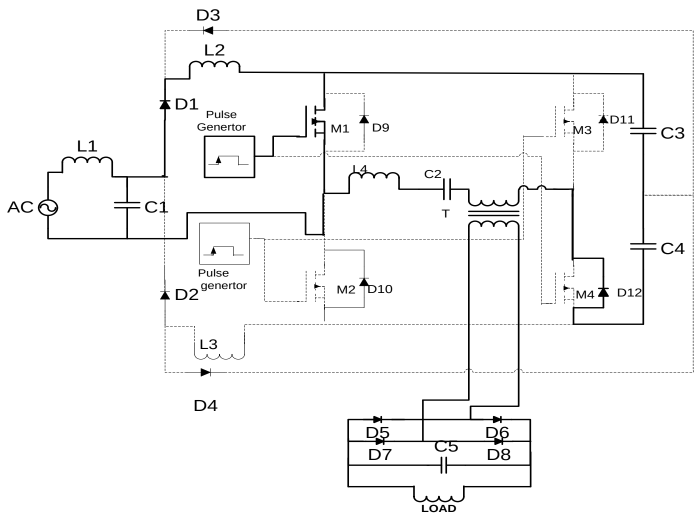
Since the circuit operates equally, the operation of the negative half cycle of the line voltage are equal to positive half cycle, except for inductor and power factor correction circuit .Hence the circuit is analyzed for positive half cycle only. The circuit operation divided into seven modes of operation with respect to conducting switches. Each modes are explained below.

A. *MODE I*

This mode begins at when turning off the MOSFETs (M_2 and M_3), since the load current i_r is negative at the switching off time. The diodes (D_9 and D_{12}) are forced to freewheel $i_{r.}$The drain to sources voltage ($V_{ds}2$ and $V_{ds}3$) of M_2 and M_3 are combined to -0.7 v. The voltage across the resonant circuit is equal to dc-link voltage $V_{dc}3$ and $V_{dc}4$.After some time gating signal are given to MOSFETs (M_1 and M_4) but there are still in off condition. The voltage in the reactive component L_1 is equal to the line voltage. The inductor current I_{p1} increases linearly from zero. Then M_1 is turned on at zero voltage.

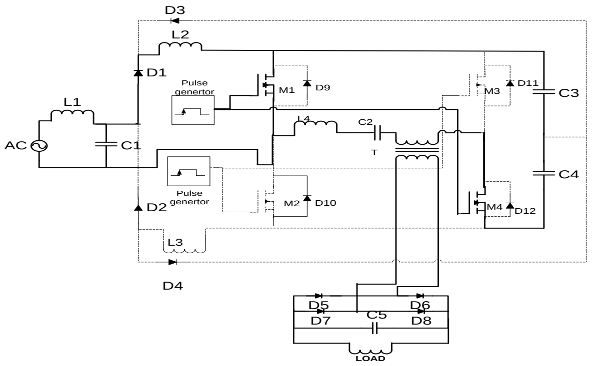


B. *MODE II*



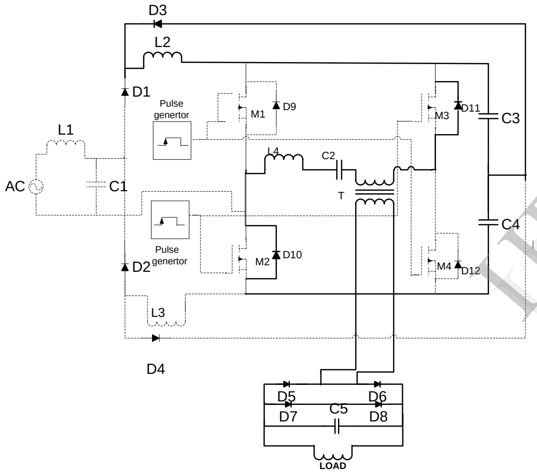
During this mode, i_r is still negative.small part of I_P1 flow through M_1, but it is equal to i_r which flows to D_{12}. This mode will end at when I_r passes zero and becomes positive,then M_4 turned on approximately at zero voltage

C. MODE III



During this mode, M_1 and M_4 are kept at ON state. Since the line voltage keeps applying on inductor L_1, i_{p1} increases continuously and flows through switch M_1, current i_r is positive and flows through switches M_1 and M_4.

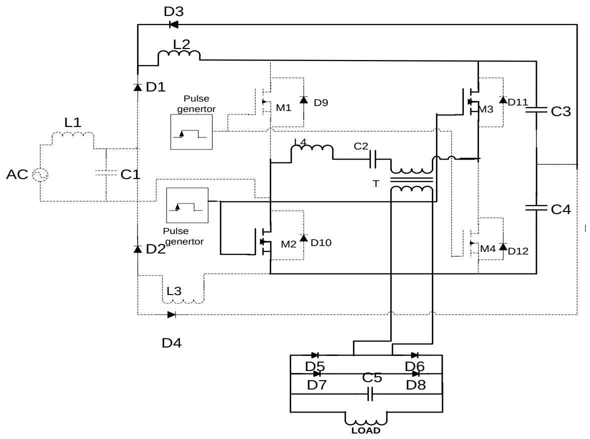
D. MODE IV



This mode begins when M_1 and M_4 are turned off. At the switching off instant ,i_{p1} reaches its peak and i_r is positive. Current i_r will freewheel through D_{10} and D_{11} to charge the capacitor. Then diode D_5 is reverse biased and i_{p1} will flow through diode D_7 to charge the capacitor. The voltage across L_1 is $-V_{dc1}$, therefore,i_{p1} starts to decrease linearly.

Since the peak of i_{p1} is proportional to the rectifier input voltage, the duration for i_{p1}.

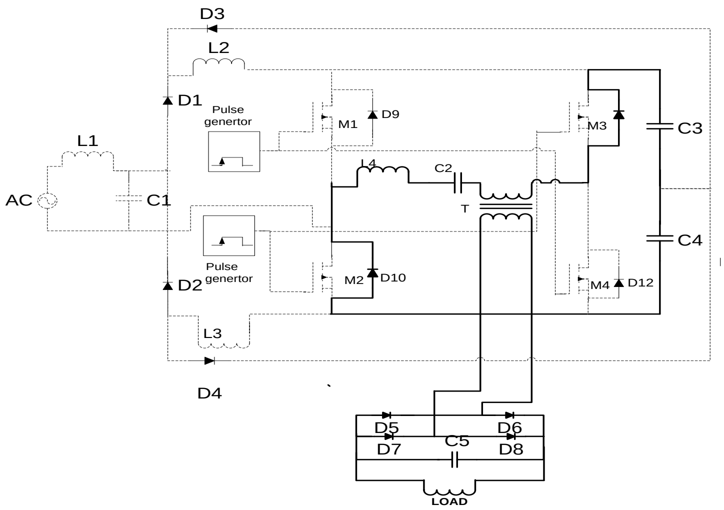
E. MODE V



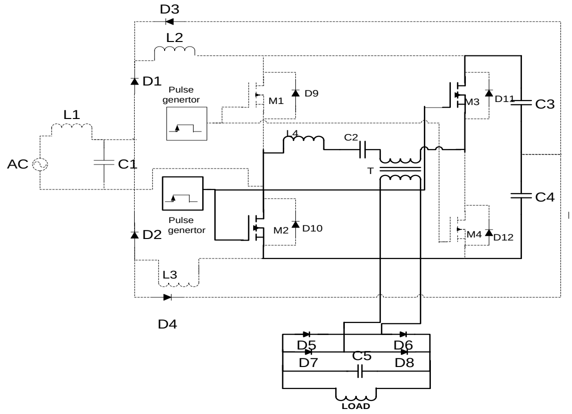
When the rectified input voltage is at high level, the peak value of i_{p1} is high. On this condition, i_r declines to zero before i_{p1} does. When i_r resonates to pass zero, the circuit operation enters mode 5. At this instant, D_2 and D_3 turn off naturally ,and M_2 and M_3 are turned on at nearly zero voltage to carry i_r.

F. MODE VI

When the rectified input voltage is at low level, the peak of ip1 is small and declines to zero before ir resonates to zero. The circuit operation will enter mode 6 when ip1 decreases to zero. In this mode ends D3 is off and ir keep flowing through D10 and D11. This mode ends at the time when ir resonates to zero. Then,M2 andM4 are turned at zero voltage to carry ir .



G. MODE VII



During this mode, i_r is negative and flows through M_2 and M_3. The capacitor supply energy to the load resonant circuit, then both the switching devices are turned off.

IV. RESULTS

The simulation result of proposed converter was analysed by MATLAB/Simulink Software. Fig. 1 shows the input voltage and current waveform of the proposed converter

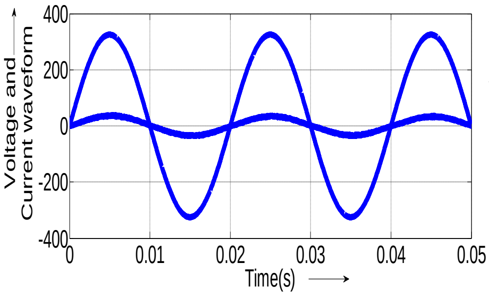


Fig. 1 Input voltage and current waveform

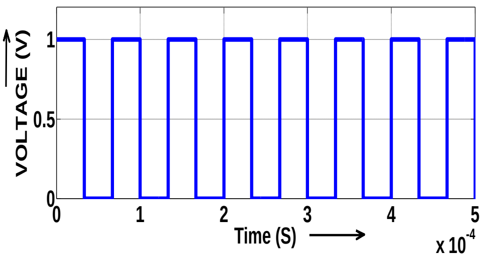


Fig. 2 Gate pulses for switches M1 & M4

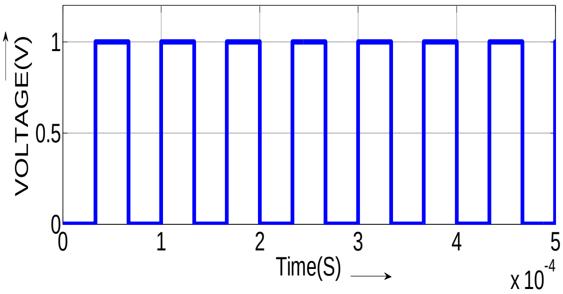


Fig. 3 Gate pulses for switches M_2 & M_3

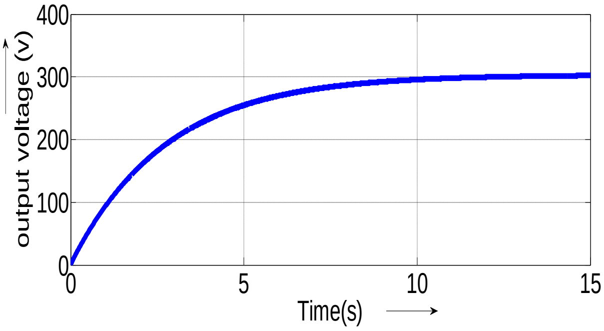


Fig. 4 output voltage of the proposed converter

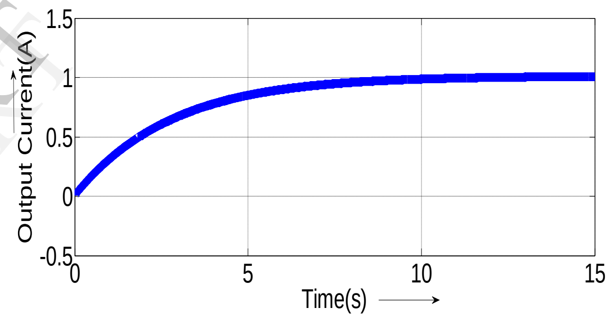


Fig. 5 Output current of the proposed converter

Fig. 1 shows the input voltage is sinusoidal and the input current is also in phase with each other and the power factor the proposed circuit is 0.99 for the given inductive load.

Fig. 2 and Fig. 3 shows the gate pulses for the switches whenever the gate pulses is given switches will in the on condition whenever the gate pulses is not given the switches will in the off condition.

Fig 4 shows the output voltage of the proposed converter. The output voltage of the proposed converter is 300V for the given switching sequence. The output voltage waveform stabilizes after 10 seconds

Fig 5 shows the output current of the proposed converter.The output current of the proposed converter is 1A the output current waveform stabilizes after 10 seconds.

V. CONCLUSION

The power factor of the AC-DC converter has been improved by using power factor correction circuit and filter. In this project, comparative results of voltage regulation of AC-DC converter with load conditions and the power factor correction also realized in MATLAB environment. The switching power losses and stresses has been minimized due to soft switching technique.

VI. REFERENCES

[1]Hung-Liang cheng, Yao-Ching Hsieh, and Chi-Sean Lin, "A Novel Single-Stage High-Power Factor AC/DC Converter Featuring High Circuit Efficiency," *IEEE Trans. Ind. Electron*., vol.58, no.2, pp.524-532, Feb.2011.

[2]Burak Akin and Haci Bodur, "A New Single-Phase Soft-Switching Power Factor Correction Converter," *IEEE Trans. Power Electron*., vol.26, no.2, pp. 436-443, Feb.2011.

[3]W.Huang and Moschopoulos, "A new family of zero voltage transition PWM converters with dual active auxiliary circuits," *IEEE Trans. Power Electron.*, vol.21,no.2, pp.370-379,Mar.2006.

[4] W. Guo, and P. K. Jain, "A low frequency ac to high frequency ac inverter with build-in power factor correction and soft-switching", *IEEE Trans. Power Electron*., Vol. 19, No. 2, pp. 430-442, March 2004.

[5] W. J. Lee, S. W. Choi, C. E. kim, and G. W. Moon, "A new PWM-controlled quasi-resonant converter for a high efficiency PDP sustaining power module", *IEEE Trans. Power Electron*., Vol. 7, No. 1, pp. 28-37, Jan. 2007.

[6] Singh B, Singh B.N, Chandra A, Al-Haddad K, Pandey A, and Kothari D.P, "A review of single-phase improved power quality AC– DC converters," *IEEE Trans. Ind. Electron*., vol. 50, no. 5, pp. 962–982, Oct. 2003.

[7] Jung-Goo Cho, Chang-Yong Jeong, Hong-Sik Lee, and Geun-Hie Rim, "Novel Zero-Voltage-Transition Current-Fed Full-Bridge PWM Converter for Single-Stage Power Factor Correction," *IEEE Trans. Power Electron*., vol.13, no.6, pp. 1005-1012, Nov1998.

[8] G.Hua, E.X.Yang, y.Jiang, and F.C.Lee, "Novel Zero-current-transition PWM Converters," *IEEE Trans. Power Electron*., vol.9, pp.601-606, Nov.1994.

[9]K.M.Smith and K.M.Smedley, "Properties and Synthesis of Passive Lossless Soft-Switching PWM Converters," *IEEE Trans. Power Electron*., vol.14, pp.890-899, Sept.1999.

[10]Singh K, Al-Haddad K, and Chandra A, "A review of active filters for power quality improvement," *IEEE Trans. Ind. Electron*., vol. 46, no. 5, pp. 960–971, Oct. 1999.

[11] Singh B, Singh B.N, Chandra A, Al-Haddad K, Pandey A, and Kothari D.P, "A review of single-phase improved power quality AC– DC converters," *IEEE Trans. Ind. Electron*., vol. 50, no. 5, pp. 962–982, Oct. 2003.

[12] Jong-Jae Lee, Jung-Min Kwon, Eung-Ho Kim, Woo-Young Choi, and Bong- Hwan Kwon, "Single-Stage Single-Switch PFC Flyback Convert Using a Synchronous Rectifier," *IEEE Trans. Ind. Electron.*, vol.55, no.3, pp 1352- 1365, Mar.2008.

[13] E. H. Kim and B. H. Kwon, "Zero-voltage- and zero-current-switching full-bridge converter with secondary resonance," IEEE Trans. Ind Electron., vol. 57, no. 3, pp. 1017–1025, Mar. 2010.