

A Review on Single-Phase Boost Converter PFC Techniques

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ABSTRACT: Image DC system is wide area application system and continuously spreading their area of interest in the conventional energy sectors that indicate a wide requirement of the AC to DC converter modules. AC to DC converter module or any Electronic module affects the system performance because of their nonlinear component characteristics. This paper contains the study of the particularly selected six boost converters that are suitable for the power factor correction (PFC) application. This paper consist a sufficient comparative study of the converters that is for the selection of the particular converter in the particular application.

KEYWORDS: Ac-dc converter, boost converter, harmonics, power factor correction.

I. INTRODUCTION

Major effects on power quality contains source side Current harmonics, distortion in voltage waveform, rippled DC output at load side, large size of filters and poor power factor toward source side. This irresponsible power quality nature has to be rectified and for that purpose the Power quality improvement devices such as Power Factor Correction (PFC) components are the modern choice. Passive or Active power factor correction techniques can be use to reduce harmonic content and to improve the power factor of the supply. Passive PFC technique provide robust solution with the LC filter use but also rise the Converter size, weight and volume but cost is still less compare to Active PFC technique. And also the passive filters show the irresponsible behavior for Load power factor variation which is not a problem for the Active power factor correction converters. Besides this the Active PFC method is the more efficient solution by solid-state switches with the passive elements such as resistors, inductors and capacitors. Input current drawn by low power requirement meets the proposed international standards such as IEC 61000-3-2 and IEEE Std 519 by the use of these suitable PFC converters. Boost PFC operating at the continuous conduction mode (CCM) is the popular choice for medium and high power applications because input current for continuous mode boost converter operation gives low Electromagnetic Interference (EMI) instead of other converter techniques like Buck or Buck-Boost converters. Selection of the converter for the particular application is not a simple task and for that some points have to be consider like Robustness, power density, efficiency, cost and complexity.

A lot of boost techniques have been identified in the previous years that greatly enhanced the converter efficiency as well as the converter performance by constraining the power quality system variables within the proposed standard range (W.Y. Choi *et al*, 2007; J.M. Kwon *et al*, 2008) also improve input current waveform, minimized EMI, and reduced size of magnetic and high robustness. This review paper is based on the sincere study of previous and recent study papers and literature of the.

II. PFC BOOST TOPOLOGY CLASSIFICATION

Boost converter based PFC techniques can be classified as shown in the fig. 1

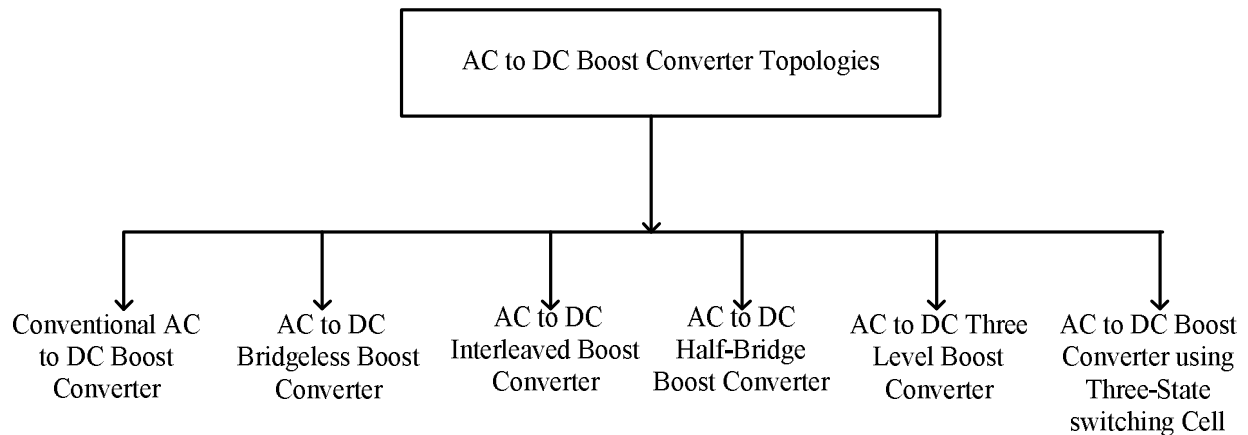


Figure 1 Boost converter based PFC techniques classifications

PFC topology categorized into Conventional, bridgeless, interleaved, half bridge, full bridge, three level boost, three state switching. This can be further categorized based on the performance improvement techniques such as the Schottky diode implementation and/or Mosfet switch preference etc.

A. Conventional AC-DC Boost Converter

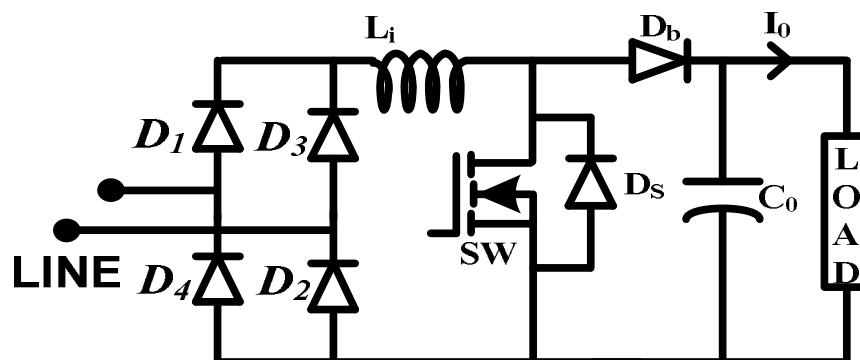


Figure 2 conventional Boost converters Topology

Boost topology is very simple and allow low-distorted input currents, with almost unity power factor using different dedicated control techniques. As the switching frequency, the output diode operated in high voltage provides the significant reverse-recovery loss in a hard switching boost converter. The reverse recovery problem of the output diode affects the switching devices in the form of additional turn-on loss. Development of Schottky diode improves the system performance to the great extent by reducing the conduction losses and increase converter efficiency. Sic is the costly material as compare to the silicon based products.

B. AC-DC Bridgeless Boost Converter

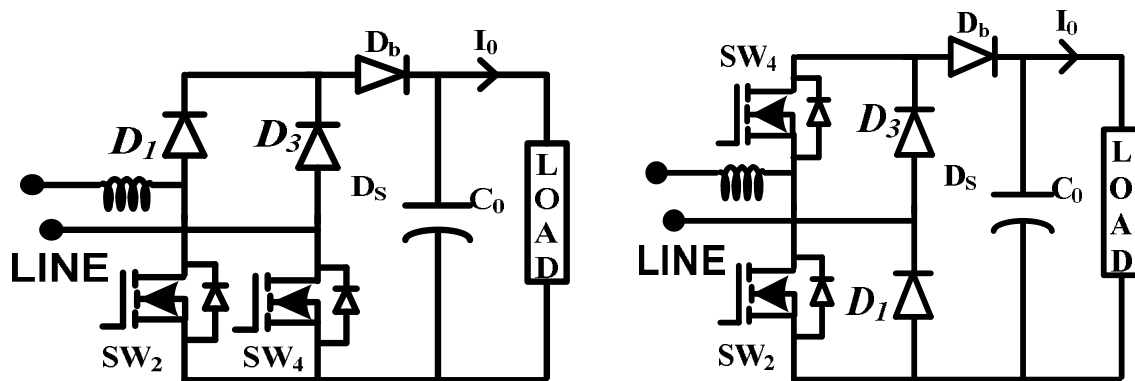


Figure 3 Bridgeless Boost converter Topology (Symmetrical and Asymmetrical)

Figure 3 showing two configuration of the Bridgeless Boost converter such as Symmetrical and the Asymmetrical Boost converter techniques. Both topologies have their own specification and the particular area of applications. Although the asymmetric arrangement given in the figure also affect the system by rise in cost, Complexity because of the inclusion of two active switches but the complexity is less in case of the Symmetric arrangement circuitry because of the symmetry present in the circuitry. Although the above circuit also provides the short circuit current protection. The Reverse recovery problem is the headache for the given circuitry although by preferring a coupled inductor and additional diodes this problem also can be remove(W.Y. Choi *et al*, 2007).

C. AC-DC Interleaved Boost Converter

Interleaving technique is the big hand for the filter size reduction in the converter arrangement this is because of the frequency doubling and the reduced Ripple in the supply waveforms (Y. Jang *et al*, 2007). An interleaving system therefore reduces size of filters and ultimately reduces the cost of the filter. This also achieve saving in the Energy storage devices and indicate improved power conversion possibilities with good level Efficiency.

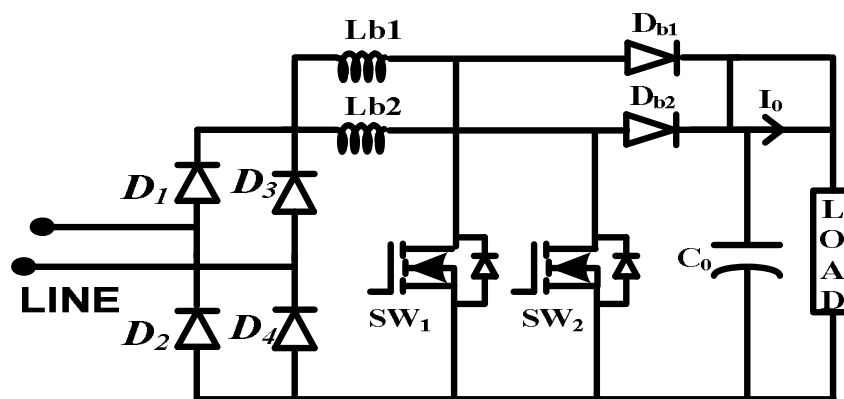


Figure 4 interleaved AC-DC Boost converters Topology

Ultimately the Interleaving technique can be used to raise the conversion efficiency and the power conversion density as well as to alleviate the ripple amplitudes (B. A. Miwa *et al*, 1992).

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Vol. 6, Issue 8, August 2017

D. AC-DC Half-Bridge Boost Converter Topology

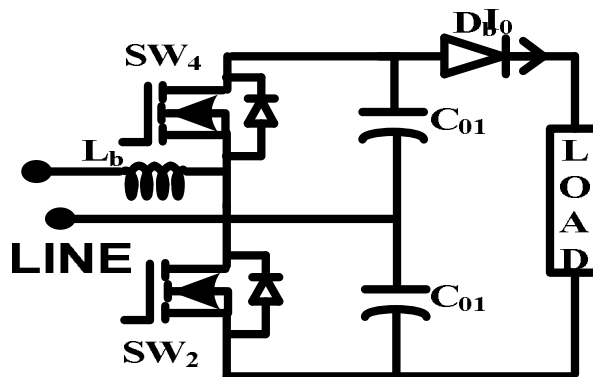


Figure 5 AC-DC Half-Bridge Boost converters Topology

Use of capacitor splitter is to split the direct current link system and if compare with the conventional boost converter thus converter provide the improved performances because of the higher output voltage gain. Although the voltage regulation also affect the system by high voltage stress on the converter components. But if consider the operation for the 127 V then 620 V is the output voltage and is the acceptable parameter.

E. AC-DC Full-Bridge Boost Converter Topology

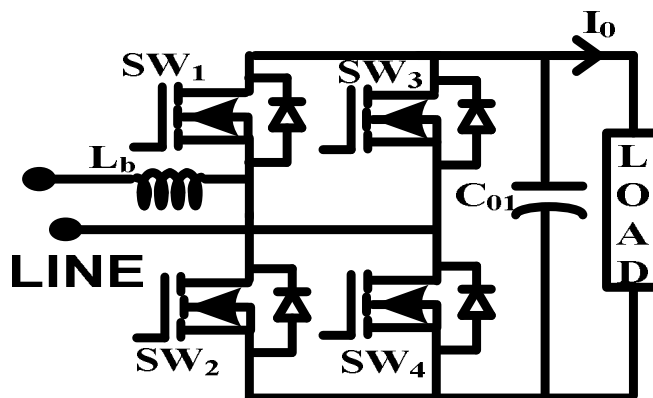


Figure 5 AC-DC Full-Bridge Boost converters Topology

The problems present in the Half-bridge converter system is overcome by this Full-bridge boost converter arrangement topology. Although the arrangement is capable to handle the high voltage level and high power but the drawback is in form of the high cost and complexity in the system.

F. AC-DC Three-Level Boost Converter Topology

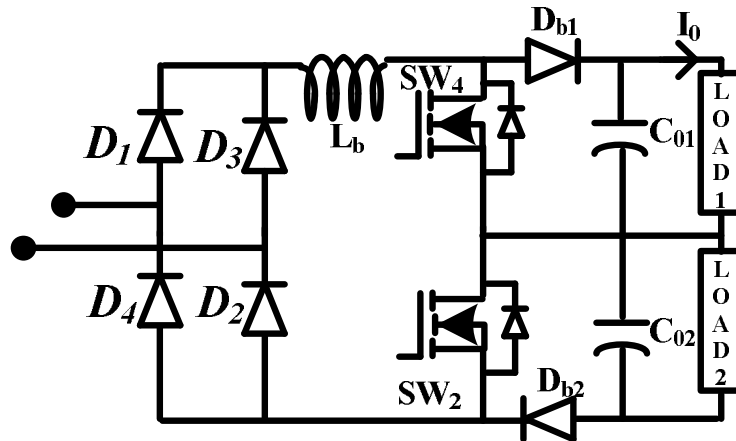


Figure 6 AC-DC three level Boost converters Topology (Bridge)

For the practical application point of view as the arrangement contain two active switches and suitable to handle high power therefore it is prefer for the 400 V or above applications. The low device voltage rating also an advantage for the high power uses.

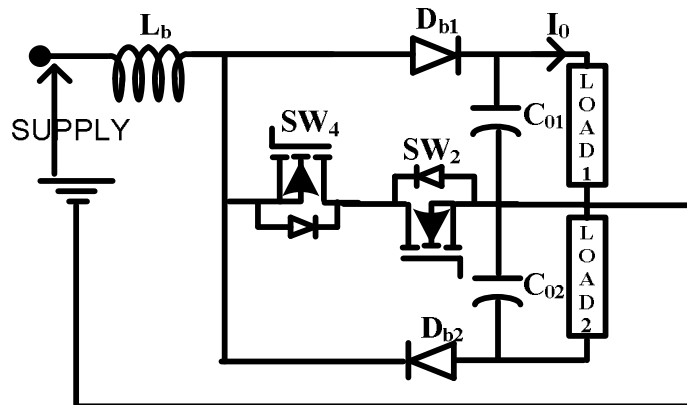


Figure 7 AC-DC three level Boost converters Topology (Bridgeless)

The current ripple frequency is high (approx double) in case of three level and interleave technique that reduces the Inductor size for the filter application (M.T. Zhang *et al.*, 1995) this shows that 3 level boost topology is far better than the conventional boost topology. In the Bridgeless 3 level boost arrangement one boost operate during positive cycle and another one with the negative cycle. Reduced semiconductor devices, diode bridge elimination reduce conduction losses and the advantage of the 3 level boost with bridge is also include in the 3 level boost without bridge such as High voltage gain and the reduced voltage across the switches.

G. AC-DC Three-state switching Boost Converter Topology

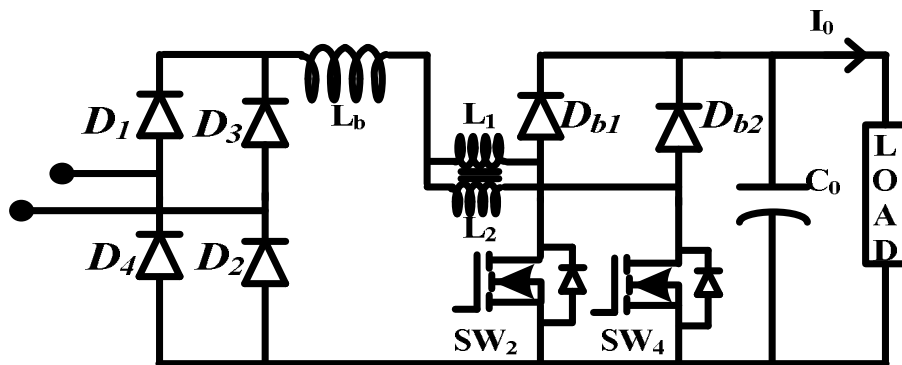


Figure 8 AC-DC three level Boost converters Topology (Bridge)

When a center tapped transformer is used for the two separate PWM device connection then this provides present the 3-state switching cells (G. V. Bascope *et al*, 2000) that in combination with boost converter provide PFC operation capability. The difference between the interleaving technique and the 3 state cell technique is that in case of interleaving technique each interleaved technique contains with the inductor per cell whereas for the 3-state cell it uses auto transformer. Because of the bridge rectifier along with the autotransformer raises the considerable conduction losses. Complete topology is discussed in (G. V. Bascope *et al*, 2004). Instead of figure 3 arrangement there are also some modified techniques such as modified 3-state switching technique and voltage double 3-state switching technique etc, these modified converter further improves the power quality and supply waveforms.

III. COMPARATIVE STUDY

- I. *Based on Size of Boost Inductor:* The current ripple frequency is high (approx double) in case of three level and interleaved technique that reduces the inductor size for the filter application therefore interleaved boost type using half of conventional boost inductor size similarly voltage-doubler three state boost converter is using inductor of 1/16th of conventional boost type.
- II. *Based on Active Switch quantity:* Voltage-doubler three state boost converter having maximum number of active switches (4), whereas the conventional boost having 1 active switch and remain all converters contains 2 active switches.
- III. *Based on Diode Bridge presence:* only conventional boost and interleaved boost having bridge rectifier arrangement whereas all other boost techniques shown in this paper are bridgeless.
- IV. *Based on Boost Inductor:* Specially interleaved technique contains the two boost inductors and all others are with 1 boost inductor.

IV. CONCLUSION

This paper contains the classification and the comparative study of the PFC based boost converter topologies from the conventional topology to the three-state boost topology for the easy converter selection. Although this paper doesn't contain a wide study of the PFC based AC to DC converter topologies and also the content of this paper can be dynamically changes based on the recent researches on the boost converter area but this can be the very helpful for the engineers and researchers to study all PFC based boost converter topologies in the same paper only.

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Vol. 6, Issue 8, August 2017

REFERENCES

- [1] W. Y. Choi, J. Kwon, E. H. Kim, J. J. Lee, and B. H. Kwon, "Bridgeless boost rectifier with low conduction losses and reduced diode reverse-recovery problems," *IEEE Trans. Ind. Electron.*, vol. 54, no. 2, pp. 769–780, April 2007.
- [2] J. M. Kwon, W. Y. Choi, and B. H. Kwon, "Cost-effective boost converter with reverse-recovery reduction and power factor correction," *IEEE Trans. Ind. Electron.*, vol. 55, no. 1, pp. 471–473, Jan. 2008.
- [3] Y. Jang and M. M. Jovanovic, "Interleaved boost converter with intrinsic voltage-doubler characteristic for universal-line PFC front end," *IEEE Trans. Power Electron.*, vol. 22, no. 4, pp. 1394–1401, July 2007.
- [4] B. A. Miwa, D. M. Otten, and M. E. Schlecht, "High efficiency power factor correction using interleaving techniques," in Proc. *IEEE Applied Power Electronics Conference and Exposition*, 1992, pp. 557–568.
- [5] M. T. Zhang, Y. Jiang, F. C. Lee, and M. M. Jovanovic, "Single-phase three-level boost power factor correction converters," in Proc. *Applied Power Electronics Conference and Exposition*, 1995, vol. 1, pp. 434–439.
- [6] G. V. T. Bascopé and I. Barbi, "Generation of a family of non-isolated DC-DC PWM converters using new three-state switching cell," in Proc. *IEEE Power Electronics Specialists Conference*, 2000, vol. 2, pp. 858–863.
- [7] F. L. Tofoli, E. A. A. Coelho, L. C. de Freitas, V. J. Farias, and J. B. Vieira Jr., "Proposal of a soft-switching single-phase three-level rectifier," *IEEE Trans. Ind. Electron.*, vol. 55, no. 1, pp. 107–113, Jan. 2008.
- [8] L. Rossetto, G. Spiazzi, and P. Tenti, "Control techniques for power factor correction converters," in Proc. *Power Electronics, Motion Control (PEMC)*, September 1994, pp. 1310–1318.
- [9] K. M. Smedley and S. Cúk, "One-cycle control of switching converters," *IEEE Trans. Power. Electron.*, vol. 10, no. 6, pp. 625–633, Nov. 1995.
- [10] D. Borgonovo, J. P. Remor, I. Barbi, and A. J. Perin, "A self-controlled power factor correction single-phase boost pre-regulator," in Proc. *IEEE 36th Power Electronics Specialists Conference (PESC '05)*, 2005, pp. 2351–2357.
- [11] R. Martinez and P. N. Enjeti, "A high-performance single-phase rectifier with input power factor correction," *IEEE Trans. Power Electron.*, vol. 11, no. 2, pp. 311–317, Mar. 1996.
- [12] J. W. Lim and B. H. Kwon, "A power factor controller for single-phase PWM rectifiers," *IEEE Trans. Ind. Electron.*, vol. 46, no. 5, pp. 1035–1037, Oct. 1999.
- [13] W.-Y. Choi, J.-M. Kwon, E.-H. Kim, J.-J. Lee, and B.-H. Kwon, "Bridgeless boost rectifier with low conduction losses and reduced diode reverse-recovery problems," *IEEE Trans. Power Electron.*, vol. 54, no. 2, pp. 1406–1415, April 2007.
- [14] B. Su and Z. Lu, "An interleaved totem-pole boost bridgeless rectifier with reduced reverse recovery problems for power factor correction," *IEEE Trans. Power Electron.*, vol. 25, no. 6, pp. 769–780, June 2010.
- [15] D. J. Perreault and J. G. Kassakian, "Distributed interleaving of paralleled power converters," *IEEE Trans. Circuits and Systems I: Fundamental Theory Application*, vol. 44, no. 8, pp. 728–734, Aug. 1997.