Middle-East Journal of Scientific Research 24 (3): 972-979, 2016
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2016.24.03.23108

Performance Improvement of Single Power Conversion Using AC to DC Converter with High Power Factor and Reduced Current Harmonics by Using Window Enable Control Method

S. Prakash and G.R.P. Lakshmi

Sathyabama University, Chennai, India

Abstract: In this paper a single power conversion ac– dc converter with high power factor and reduce the current harmonics. Many topologies are developed for dc-dc converter. In that Non isolation based converter is simple and low cost. To improve the performance and provide better isolation will go for isolated power supply topology. The proposed converter is combined a full- bridge diode rectifier and series resonant active clamp dc-dc converter. This paper proposes a window enable control method without any power factor correction circuit to obtain high power factor. In This paper proposed fly back converter based dc-dc converter with output side voltage doubler. This voltage doubler removes the reverse recovery problem of the output diode. More over, it provides the zero-voltage turn – on switching of the switches. The circuit is controlled by using window enabling technique (WET). This control technique is used to improve the input power factor and reduce the input current harmonics. This circuit is simulated using MATLAB/ SIMULINK. The proposed converter provides maximum power factor and maximum%THD. The performance parameters of the conventional and proposed method is compared and verified. Thus the proposed control system has high performance compared to conventional control method.

Key words: Fly back topology · Single power conversion · Voltage doubler · Active clamp circuit · Series resonant circuit

INTRODUCTION

Generally the ac-dc converters circuit is capable of converting an alternative voltage range into a dc voltage range this canbe achieved as rectification process. It consists of high frequency dc-dc converter, dc link capacitor and full bridge diode rectifier. The ac power source is required for powering major appliances but almost all electronic circuits require a steady dc supply. Simple bridge rectifier circuit converts the ac input into stepped a lower value of voltage. Ac supply is passed through a rectifier circuit to remove the negative cycle of the ac waveform. The resulting signal is then filtered to get the dc output. In this high frequency dc-dc converters absorbs the energy from the ac line because dc link voltage is lower than the rectified line voltage. These kinds of converters have highly input distortion current because of the%THD is low. To solve the harmonic pollution caused by ac- dc converters [1, 2] because of large reduction of harmonics and low power factor. Here then pfc of ac-dc converter circuits has been proposed and developed. This benefits in saving of electricity costs and by reducing or eliminating reactive power charges and reduce the losses. The pfc ac-dc converters can be implemented by using two power–processing levels. The pfc at input stage is used to obtain high power factor at maintaining a constant dc link voltages. Most pfc circuits employ the boost converter [3-5]. These conventional boost converters has the conventional input stage for a single phase power supply operates and filtered with large electrolytic capacitors and rectifying the ac line voltage. This process results in a large harmonic content and more input distortion current and the result of power factor becomes very poor. Then the reduction of input current harmonics and operation of high power factor. It is important requirement for good power supplies. This conventional boost topology used for pfc applications. The output stage, which is high frequency dc-dc converters gives a desired output. These two power processing stages

Corresponding Author: S. Prakash, Sathyabama University, Chennai, India.

require control circuit consists of gate driver and those controllers. The pfc ac-dc converters [6], can be divided into two types namely Two stage ac-dc converters [7] and Single stage ac-dc converters with the irrespective control circuits. However the two stage ac-dc converters has power losses and manufacturing cost is high and to reduce the size and cost, stages the single stage ac-dc converters have been proposed and developed. The idea of pfc of input stage and high frequency dc-dc converters are simplified by sharing the common switches of the pfc controller. Because of that pfc switch and its gate drives can be eliminated. Most of the single stage ac- dc converters are used in low power applications. The single switch dc-dc converters such as fly back or forward converters [8]. The output stage, which is high frequency dc-dc converters gives a desired output. These two power processing stages require control circuit consists of gate driver and those controllers. The pfc ac-dc converters [6], can be divided into two types namely Two stage ac-dc converters [7] and Single stage ac-dc converters with the irrespective control circuits. However the two stage ac-dc converters has power losses and manufacturing cost is high and to reduce the size and cost, stages the single stage ac-dc converters have been proposed and developed. The idea of pfc of input stage and high frequency dc-dc converters are simplified by sharing the common switches of the pfc controller. Because of that pfc switch and its gate drives can be eliminated. Most of the single stage ac- dc converters are used in low power applications. The single switch dc-dc converters such as fly back or forward converters [8] are used in both ac/dc and dc/dc conversion with galvanic isolation between input and any outputs. Galvanic isolation means an isolation transformer used to prevent the current flow. These converters are low cost, simple and also they have hard switching operation because of this operation switching power losses are very high. This is the drawbacks of single stage ac-dc converters. This single stage ac-dc converter based on the asymmetrical pulse width modulation half bridge converter have been proposed [9]. They have the ZVS operation because of this operation they have low switching losses. However, in this single stage ac-dc converters have high voltage stress and low power factor in comparison with the two stage ac-dc converter. The pfc circuit used in the single stage ac-dc converter requires the dc link electrolytic capacitors and inductors which has the high cost and large size. To solve these problems, the dc link electrolytic capacitor should be removed from the circuit and non electrolytic capacitors such as either film capacitors or

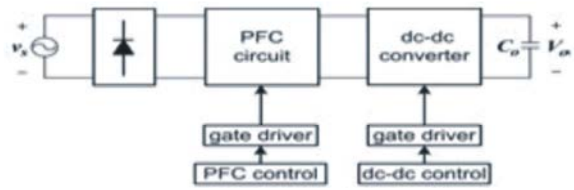

Fig. 1(a): The conventional PFC converters with the proposed converter.

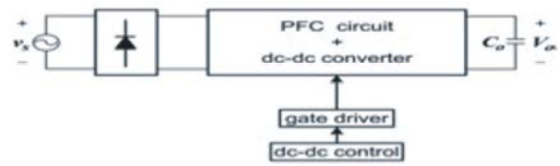

Fig. 1(b): Singlestageconverter

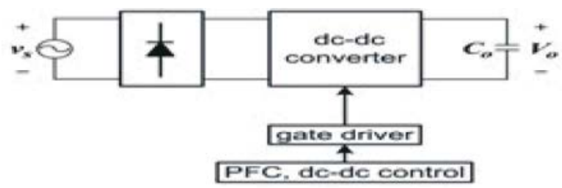

Fig. 1(c): Single power conversion

ceramic capacitors can be used instead of electrolytic capacitors [10, 11]. This capacitors are mostly applied to single switch pfc ac-dc converters. The pfc ac-dc converters are attractive in low cost and low power applications like light emitting diode power supply. Fig 1(a) shows the diagram of two stage dc- dc converters which consists of full- bridge diode rectifier, a pfc circuit and control circuit for that pfc circuit. A high frequency dc-dc converter and control circuit for the output control. It has two stage ac-dc converter with two power processing stages with their respective control circuits.

The Fig 1(b) shows the single stage ac-dc converter which has only one circuit thus, output voltage is easily regulated by controller. However the single stage ac-dc converter has the high voltage stress and low power factor in comparison with two stage ac-dc converter.

Fig. 1(c) shows the diagram of single power conversion converter which consists of full-bridge diode rectifier and high frequency dc-dc converter. But in this circuit it has no pfc circuit, however it requires control algorithm for both pfc & output control and also a large ac second harmonic ripple component reflected at the output voltage in comparison with two and single stage ac-dc converters because it has no dc link electrolytic capacitors and inductors. So it provides simple structure, low cost and low voltage stress. Therefore the single power conversion is preferred. Fig. 1 (d) shows the proposed single power conversion with window enable

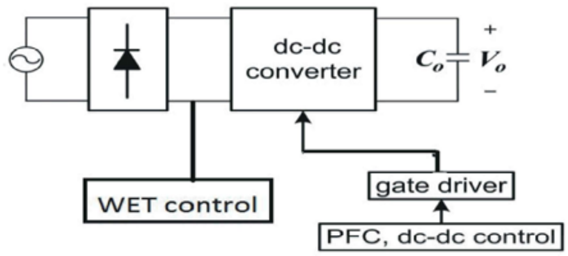

Fig. 1(d): Single power conversion converter with proposed window enable technique method.

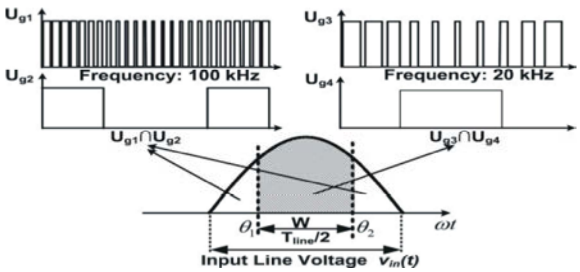

Fig. 1(e): Principle of wec

control method. This control method is used mainly to reduce the switching losses and conduction losses in the input side.

Principle of WEC: The Fig. 1(e) shows the window enable control method which is introduced to reduce the switching losses and conduction losses.

In Fig 1(e) the ac wave form of one window is shown. Most of the power is transferred in the middle area of the half line cycle, Where the input voltage is higher. The lower switching is used in this area to reduce the switching losses and conduction losses. In other area of half line cycle less power is transferred and switching loss is smaller [12]. The main objective of this paper is the performance improvement of single power conversion ac-dc converter with high power factor and reduced harmonic currents. The proposed converter has a full bridge diode rectifier and series resonant active clamp circuit. Due to the high frequency dc-dc converter, the proposed converter provides low voltage stress, low cost and simple structure. To obtain high power factor and reduced harmonic content window enable control method is proposed. Also the active clamp circuit clamps the surge voltage of the switches and recycles the energy stored in leakage inductance of the transformer. It provides the ZVS operation of the switches. It removes the reverse recovery problem of the output diodes by using ZCS operation. The design guidelines for the proposed converter are discussed and experimental results were obtained to show the performance of the proposed converter.

Conventional System

Operation of the Conventional System: Fig. 2 shows the circuit diagram of conventional system. It consists of two

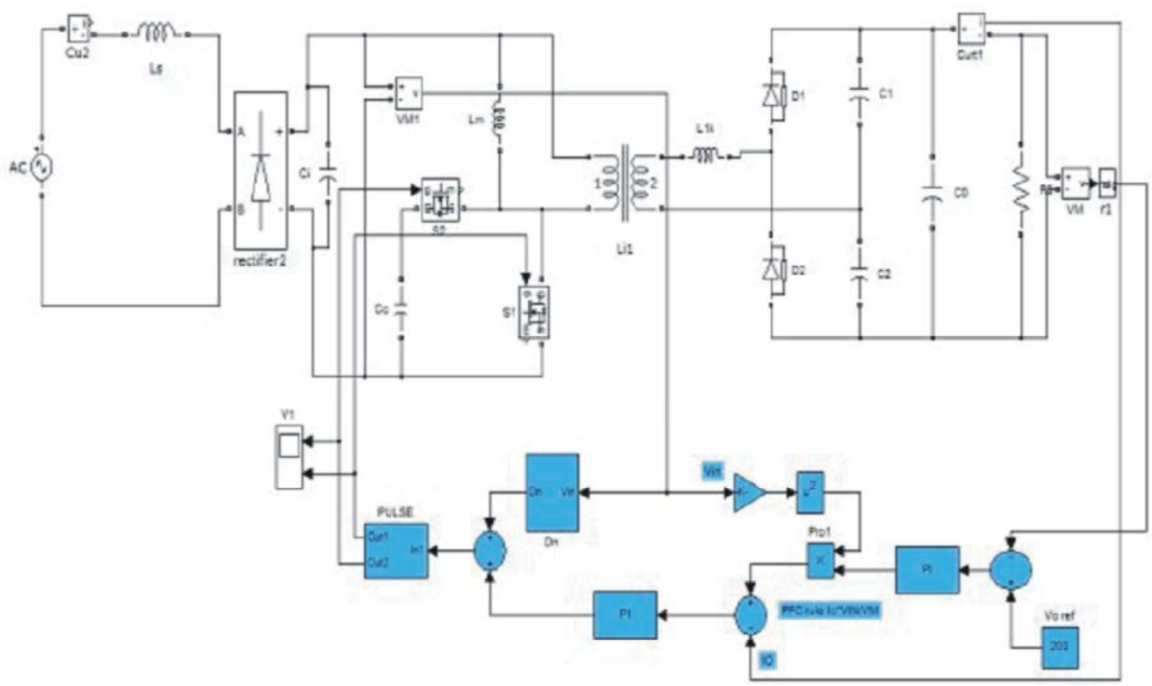

Fig. 2: Circuit diagram of conventional system

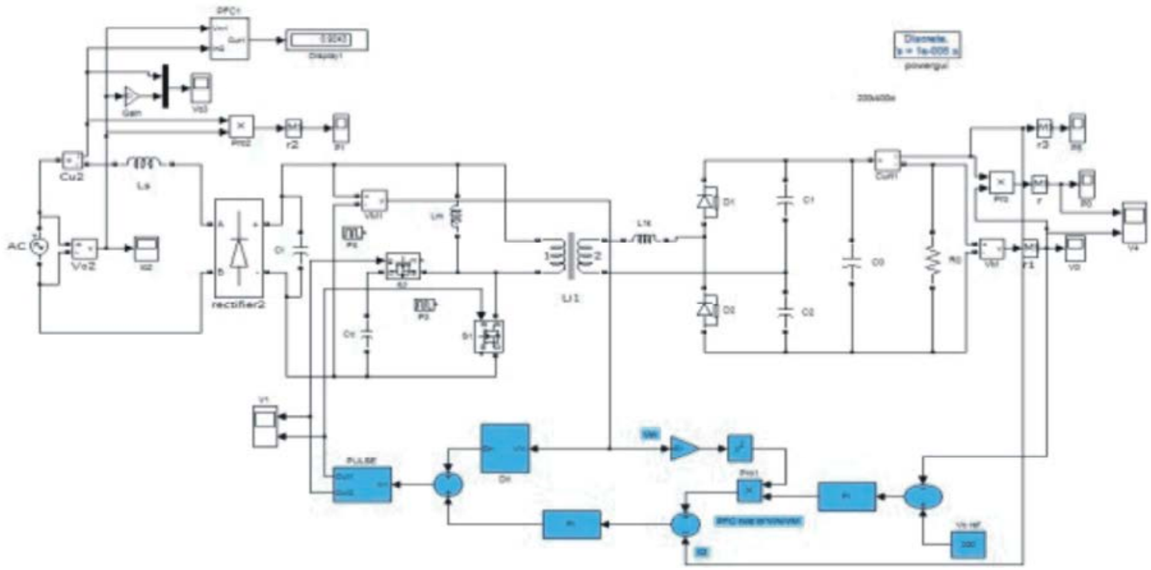

Fig. 2(a): Simulation diagram of conventional system

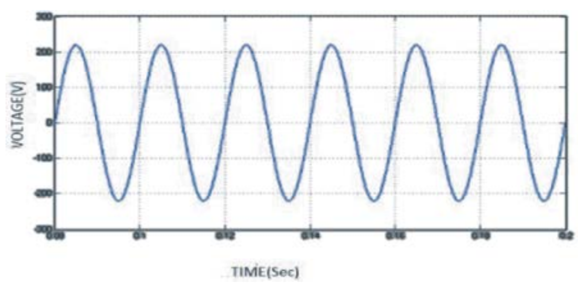

Fig. 2(b): Ac input voltage waveform

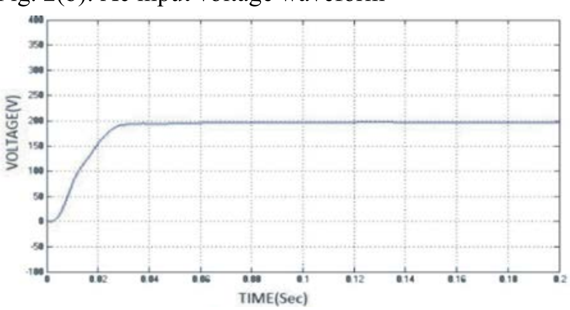

Fig. 2(c): Output voltage waveform

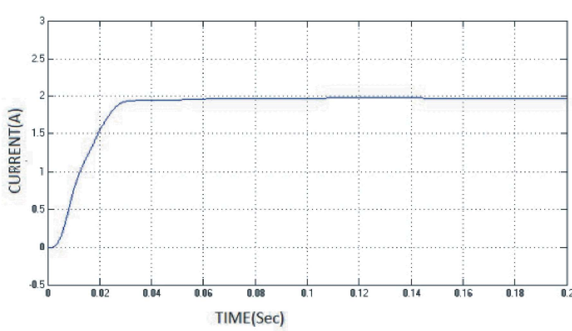

Fig. 2(d): Output current waveform

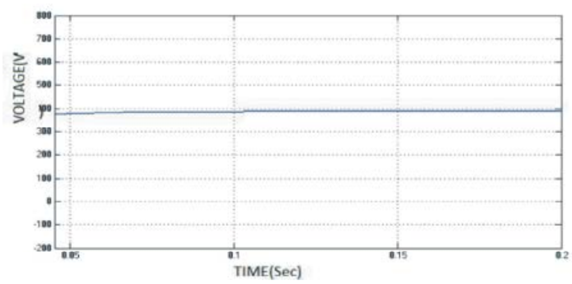

Fig. 2(e): Output power waveform

parts namely the power circuit and control circuit. In this conventional converter the high frequency dc-dc converter with an active-clamp circuit and a series-resonant circuit across the transformer are used.

The active clamp circuit consists of two switches, namely the main switch s1 and auxiliary switch s2 and also the clamp capacitor (Cc) which is used for filtering purpose. The main switchs1 is modulated with duty ratio D and the auxiliary switch s2 is complementary to s1 with a short dead time. The active clamp circuit serves to clamp the voltage spike across 1 and to recycle the energy stored in leakage inductance of the transformer. Here the two switches s1 and s2 combines to form ZVS operation. On the other side in the series resonant circuit it combines mainly the secondary transformer leakage inductance and resonant capacitors C1 & C2 and the output diodes D1&D2 are form a ZCS operation. It is used to turn off the device at the level of zero current. Figure 2(a) shows the simulation diagram of conventional system.

The results of conventional system are shown in Figure 2(b),2(c), 2(d), 2(e) and 2(f).

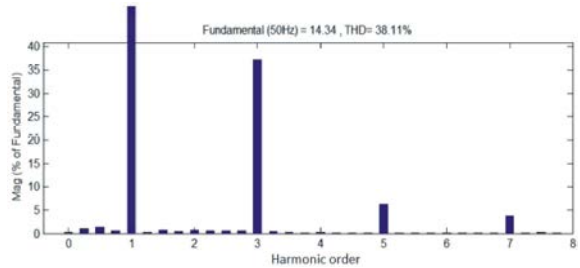

Fig. 2(f): %THD of conventional system waveform

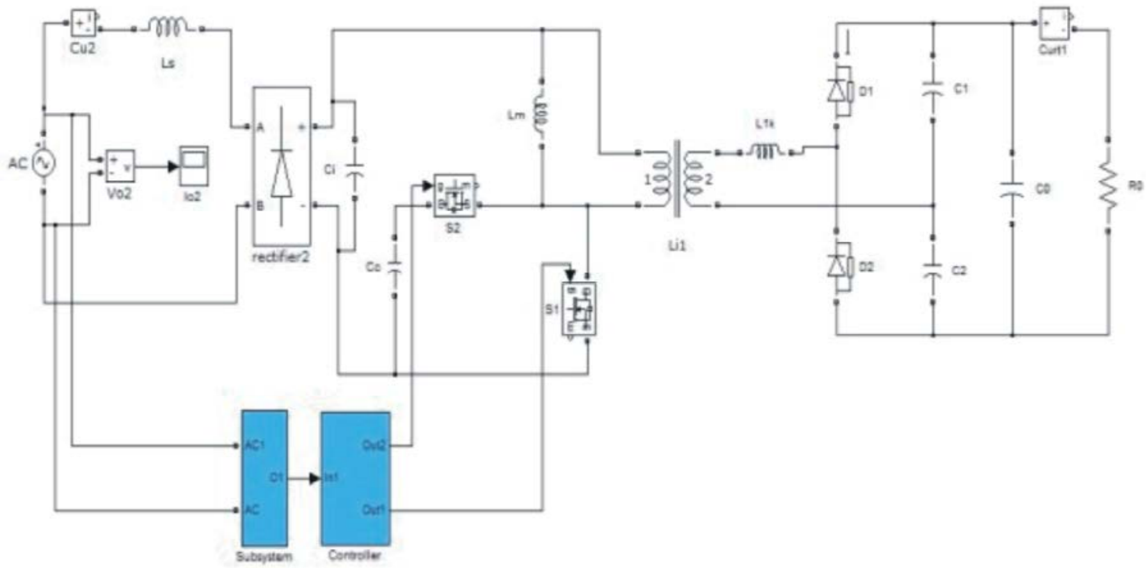

Fig. 3: Circuit diagram of single power ac-dc converter

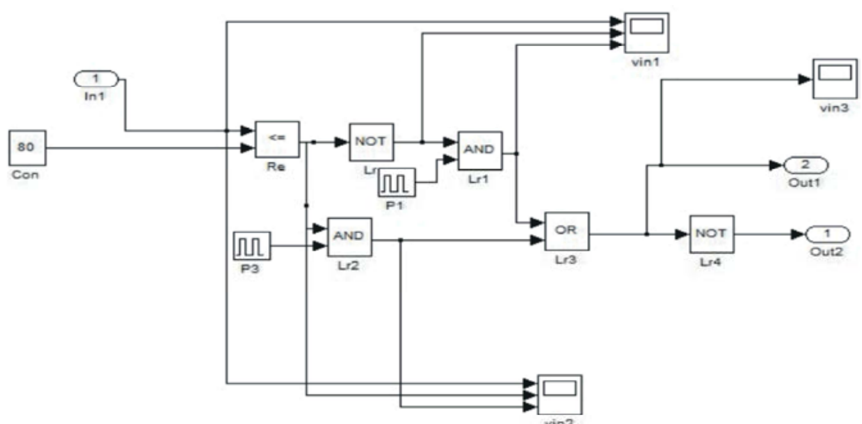

Fig. 3(a): Block diagram of window enable control

Figure 3 shows the proposed system. It consists of the power circuit and control circuit. Power circuit is common for both conventional and proposed systems. In the control circuit the control technique used is window enable control technique.

The Fig 3(a) shows the block diagram of proposed window enable control method. In this method the input rectified unidirectional dc voltage is taken for gating window enabling control signal. The signal is compared with the constant voltage it is giving the center window of the unidirectional pulse. This pulse is inverted then will get the center window of the unidirectional signal. The corner window signal and very high frequency signal is given to AND gate. This AND gate generate very high frequency modulated signal. The center window signal and high frequency signal is given to another AND gate.

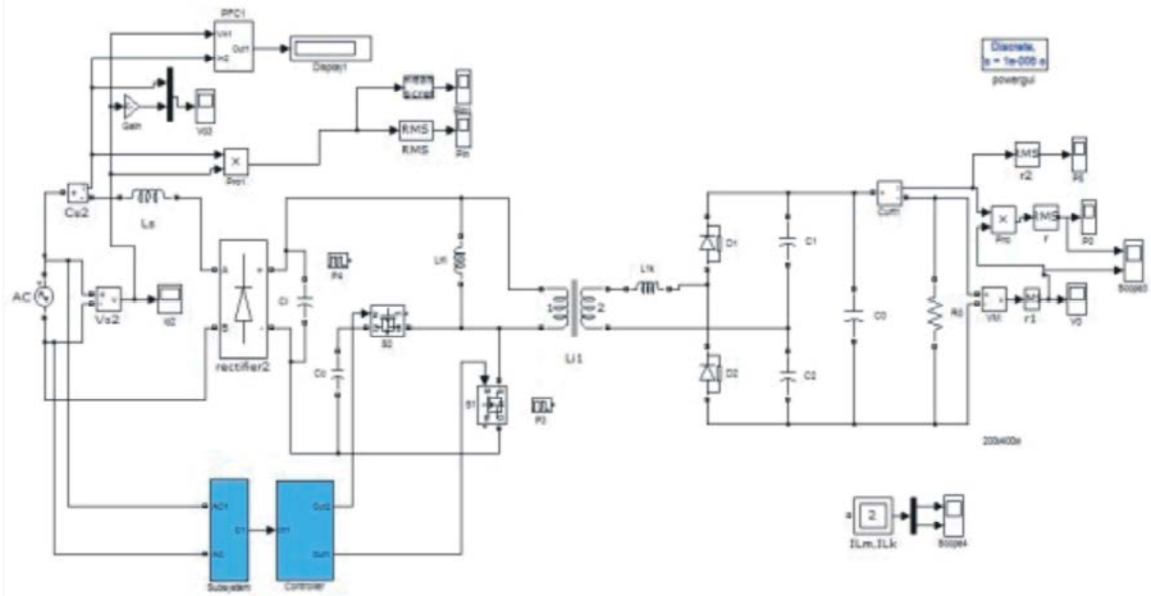

Fig. 3(b): Simulation circuit of proposed system

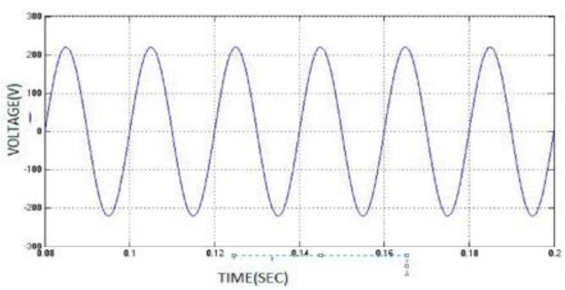

Fig. 3(c): Ac input voltage waveform

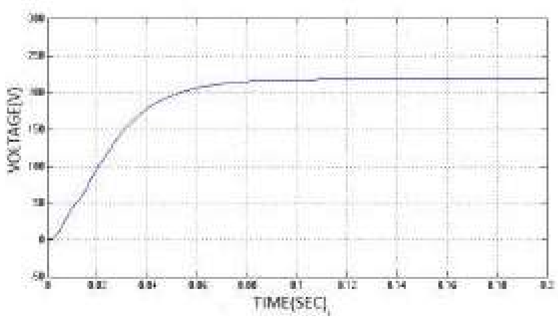

Fig. 3(d): Output voltage waveform

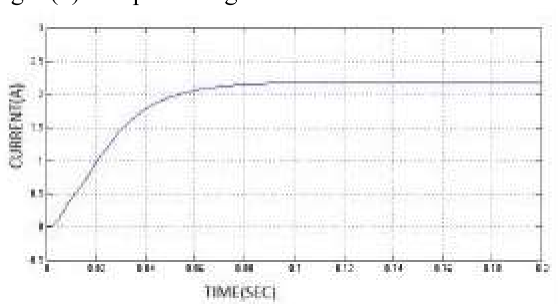

Fig. 3(e): Output current waveform

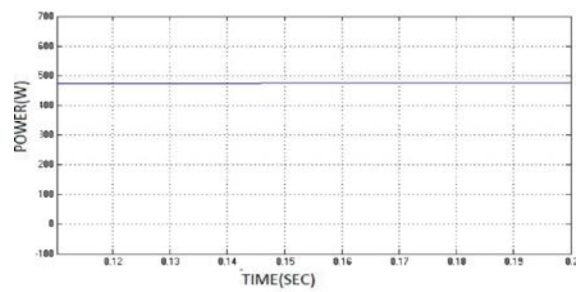

Fig. 3(f): Output power waveform

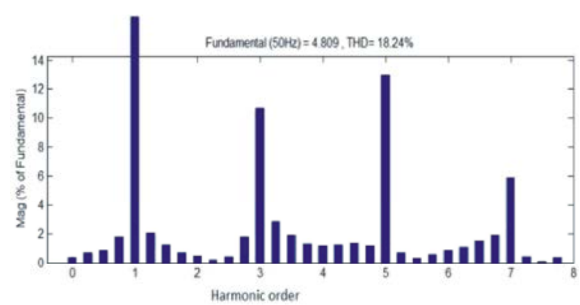

Fig. 3(g): %THD of proposed system

This AND gate generate modulated high frequency center window signal. The center modulated window signal and center modulated high frequency signal is added with the help of OR gate, combined pulse is given to MOSFET or controlling the output and input power factor.

Figure 3(b) shows the simulation diagram of proposed system. The results of proposed system are shown in Figure 3(c), 3 (d), 3(e), 3(f) and 3(g).

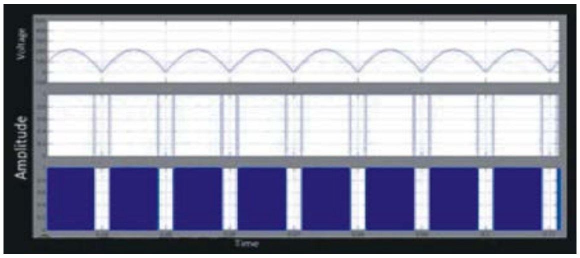

Fig. 4: Waveform of non inverted switching pulses

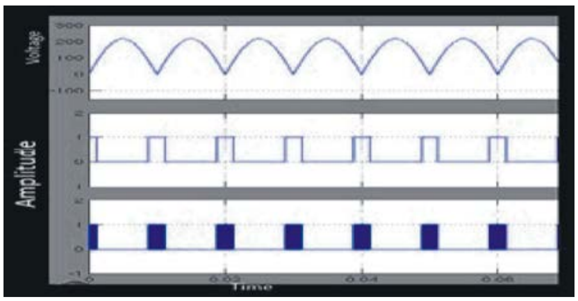

Fig. 4(a): Waveform of inverted switching pulses

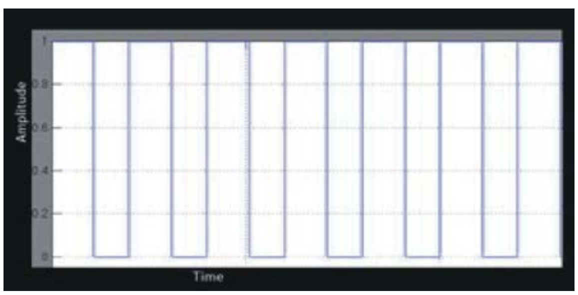

Fig. 4(b): Waveform of inverted and non inverted switching pulses

Table 1:

Sl. No	Parameters	Conventional system	Proposed system
1	Input voltage	220	220
2	Output voltage	200	218
3	Output power	400	474
4	Power factor	0.9243	1
5	%THD	38.21%	18.24%

The result of window enable control block is as shown in Figure 4, 4(a) and 4(b).

Comparison of Results: The comparison of results of conventional and proposed system is shown in Table 1

CONCLUSION

The window enable control method and single power conversion are used in this paper to improve the power factor and reduce the current harmonics. The proposed converter has mainly fly-back converter Also, the proposed converter provides the improved structure, low cost, low voltage stress by the single power conversion without a PFC circuit. Therefore, the proposed converter is suitable for lower power applications. The proposed converter has low line current harmonics, low% THD and the power factor of unity by using window enable control for both PFC and power control.

REFERENCES

1. Singh, B., B.N. Singh, A. Chandra, K. Al-Haddad, A. Pandey and D.P. Kothari, 2003. A review of single-phase improved power quality AC–DC converters, IEEE Trans. Ind. Electron., 50(5): 962-981.
2. Singh, B., B.N. Singh, A. Chandra, K. Al-Haddad, A. Pandey and D.P. Kothari, 2004. A review of three-phase improved power quality ac-converters, IEEE Trans. Ind. Electron., 51(3): 641-660.
3. Skim, H., M.H. Rye, J.W. Beak and J.H. Jung, 2013. High-efficiency isolated bidirectional AC-DC converter for a DC distribution system, IEEETrans. Power Electron., 28(4): 1642-1654.
4. Arias, M., D.G. Lamar, J. Sebastian, D. Balocco and A.A. Diallo, 2013. High efficiency LED driver without electrolytic capacitor for street lighting, IEEE Trans. Ind. Appl., 49(1): 127-137.
5. Qian, C. and K.M. Smedley, 2000. A topology survey of single-stage power factor corrector with a boost type input-current shaper, in Proc. IEEE Appl. Power Electron. Conf. (APEC), pp: 460-467.
6. Figuerido, J.P.M., F.L. Tofili and B.L.A. Silva, 2010. A review of single-phase PFC topologies based on the boost converter, in Proc. IEEE Int.Conf. Ind. Appl., Sao Paulo, Brazil, pp: 1-6.
7. Yao, K., X. Ruan, X. Mao and Z. Ye, 2012. Reducing storage capacitor of a DCM boost PFC converter, IEEE Trans. Power Electron., 27(1): 151-160.
8. Yang, F., X. Ruan, Y. Yang and Z. Ye, 2011. Interleaved critical current mode boost PFC converter with coupled inductor, IEEE Trans. Power Electron., 26(9): 2404-2413.
9. Kwon, J.M., W.Y. Choi and B.H. Kwon, 2005. High-performance plasma display panel sustain power supply, in Proc. IEE Elect. Power Appl., 152: 1381-1388.
10. Lee K.Y., and Andy S. Lai, 2009. Novel circuit design for two-stage ac/dc Converterto meet standby power regulations, IET Power Electron, 2(6): 625-634.

11. Lu, D.D.C.L., H.H.C. Iu and V. Pjevalica, 2008. A single-stage ac/dc Converterwith high power factor, regulated bus voltage and output voltage, IEEE Trans. PowerElectron., 23(1): 218-228.
12. Skim, T., G.B. Koo, G.W. Moon and M.J. Youn, 2006. A single-stage power Factor correction ac/dc converter based on zero voltage switching full bridge topology with two series-connected transformers, IEEE Trans.Power Electron., 21(1): 89-97.