

# **A Review of Improve the Power Factor Using Sliding Mode Controller for Three Phase Boost Rectifier Circuit**

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## **ABSTRACT**

*In the modern world the efficient conversion of power is the most important problem. At the starting diode rectifier is used improve the shape of the line current. It is simple and rugged technique but in this technique power factor cannot be highly improved and output voltage is not controllable. To overcome this drawback three phase AC/DC boost converter used for improvement of power factor correction, reduced harmonics distortion at input and regulated dc output. Three phase boost rectifier are increasingly used for industrial application such as ups battery charger, motor drives etc. But there is problem of power factor correction for class of three phase ac/dc power converter. Many scheme and solution are available for improvement of power factor and power quality of converter and it is now possible to implement new and improved control algorithm to provide fast dynamic perormance of converter such as sliding mode, fuzzy logic, PI, controller etc So in this paper studied the different technique for improvement of power factor for boost ac/dc power converter and select the controller for boost converter.*

**Keywords:** Boost converters, various controller technique, power factor correction

## **1.INTRODUCTION**

Power factor improvement is the important aspects in the field of AC/DC conversion because the efficient conversion of power is the important problem in the modern word. the unity valve of power factor converter does not introduced any distortion to the energy source and maximize the performance of power conversion.

At the starting diode rectifier is used improve the shape of the line current. It is simple and rugged technique but in this technique power factor cannot be highly improved and output voltage is not controllable [3]. To overcome this drawback three phase boost converter is used. Three phase AC/DC conversion of electrical power is widely use in many system. The design modification and improve quality converters in domestic, commercial and industrial environment has made of three phase converter to improve the quality of converters. [9] But now a days three boost type three phase rectifiers are very useful in industrial application such as variable speed drive ,power supplies ,uninterruptible power supplies(UPS), dc motor drives AC drives, HVDC transmission, power supplies for telecommunication equipmentary environment and so on. Because there is few advantages of boost rectifier as compared to other rectifier such as high power density, High efficiency, improvement of power quality at input and output [9]. Hence boost converter are mainly used in various system. But there is some problems occurs such as circuit parameters are expected to be non-constant while the load could vary. The introduced methods of of indirect output voltage regulation allow the evading of non-minimum phase phenomenon.

In this paper manyschemes and solution are used for field of power factor correction. Some of them are used for reduction of harmonics distortion of the input current by taking into account compensating for the parasitic capacitance of rewardingelements or adjusting the switching frequency. Many processors have been developed to give direct PWM outputs with fast algorithms [13]. This algorithm provides for improvement of fast dynamic performance and improves the power quality of converters. To overcome the disadvantages of boost converters different hardware topology and control methods are discussed in this paper such as starting with proportional

integral (PI), sliding mode controller, fuzzy logic controller, Dynamic response controller, PI Controller, an adaptive passivity based control the different methods are used for control of these converter.

The objectives of this to improve the power factor of converts using different controller technique. And study the various controller techniques such as fuzzy logic controller, sliding mode controller, PI controller, dynamic evaluation controller etc. for improvement of dynamic response and improvement of power factor near to unity.

## 2.LITERATURE SURVEY

In the literature survey, I have studied about modelling of 3-ph AC/DC converter and to get unity value of power factor different nonlinear control technique are studied

A.R.Prasad al[4] is proposed the active power factor correction technique for three phase diode rectifiers to improve the power factor at fixed switching frequency and shows the active input power factor correction use to regulated dc voltages. Schaeffe *et.al.*[8] explained power factor correction (PFC) for a full bridge 3-phase AC/DC boost power converter. The purpose of this paper is to design and study the effectiveness of the traditional sliding mode controllers (SMC) and second order sliding mode (SOSM) controllers that convert AC power into DC power at a desired voltage level in a 3-phase AC/DC boost power converter while driving the power factor to a unity level. Y.Shtssel *al.c*[9] understanding the problem of power factor correction a full-bridge 3-phase AC/DC converter hardware topology is designed and used for efficient power conversion with high values of power factor. The sliding mode control drives the output voltage to the desired dc level in the presence of external disturbances and internal parameter uncertainties while providing a value of power factor that is close to unity (greater than 97%). sliding mode observers are engaged to estimate variation in load and phase resistances-subject of real-time adjustment in the control law. Yu Wang *et.al.*[12] introduced the topology of Three-Phase PWM Voltage Source Rectifier (VSR). Then the mathematical models in three-phase static and two-phase rotary coordinate system are rebuilt. Based on that theory and the voltage-oriented vector control's idea, a dual-channel closed loop control strategy with current-inner-loop and voltage-outer-loop. Active power channel is aim to make DC side voltage remain steady, and reactive power channel can regulate power factor by set current q-axis component reference. In order to prove that voltage-outer-loop is necessary, the paper builds a comparative model without a voltage loop. Kada Hartani *et.al.*[13] proposed the space vector pulse width modulation (SVPWM) control scheme for three-phase voltage source PWM rectifier. The proposed control can stabilize the minimum of the systems storage function at the desired equilibrium point determined by unity power factor and sinusoidal current on the AC side, and constant output voltage on the DC side.

B Singh al[14] show the review of three phase improved power quality controller has been carried out to explore a board perspective on their different configuration to researchers study the different IPQC for improvement of power quality not only input mains but also dc output. A. Levant[15] has introduced universal finite-time-convergent controller is developed capable to control the output of any uncertain single-input-single-output system with a known permanent relative degree  $r$ . the tracking error zero. Escobar al[17] developed the passivity based control scheme for the feedback regulation of a class of switched power converters commonly address as power factor precompensators. H Komurcugil al c[20] discussed a technique for 3-phase pulse width modulation (PWM) AC/DC voltage source converter with the control laws proposed so far is not only unstable against large signal disturbances, but also has the problem that its stability depends on the circuit parameters such as the DC output capacitance. This paper describes a new control law based on

Lyapunov's stability theory. It is shown that the converter can be stabilized globally for handling large-signal disturbances. The resulting closed-loop system not only guarantees a sufficient stability region (independent of the circuit parameters) in the state space, but also exhibits good transient response both in the rectifying and regenerating stability region (independent of the circuit parameters) in the state space, but also exhibits good transient response both in the rectifying and regenerating modes.

## 3.NEED OF BOOST CONVERTER.

There are numbers of procedures for the power factor correction [2]. But mainly, it categorized into methods as; "Passive method" and "Active method". In passive method diode rectifiers are used but this rectifiers has some drawback such as power factor cannot be highly improved and output voltage is not controllable. hence we used active method to overcome this drawback. In this method boost rectifier is used to overcome this drawback such as reduced the harmonics current, high power factor. Nowadays this type of three phase rectifiers are mostly used as are placement of a conventional diode rectifier to provide unity power factor, reduced THD at ac mains, and constant-regulated dc output voltage even under fluctuations of ac voltage and dc load[22].

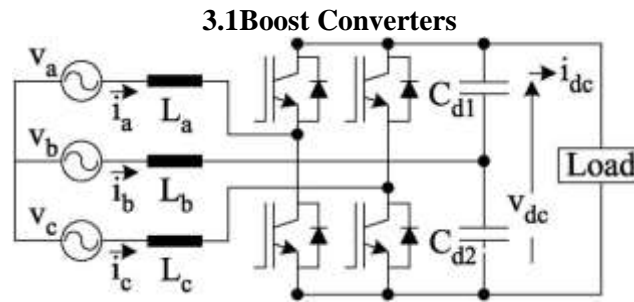


Fig 3.1 Four-switch bidirectional boost converter.

Fig. 3.1 shows the circuit diagrams of the bidirectional converters. The closed-loop control of dc-bus voltage decides the amplitude of supply currents, which are in phase with ac mains voltages. To design a mathematical model, it is assumed that the AC voltage is a balanced three-phase supply, switch is ideal and lossless, and filter is linear. The circuit consists of three main parts, storage elements, bi-directional switches, and RC filter. The Inductors are the energy storage elements used for higher output DC voltages that could be obtained by rectifier. The IGBTs with anti-parallel diode make the needed switches. The switches are bidirectional because when the switches are closed, they short the diode, therefore current can flow in either direction. The output is an RC filter which is used for smoothing and reducing the output variations to a dc voltage level[9]. there are many advantages such as high power density, high efficiency, improve power quality etc. hence it is used in various applications such as ups, battery charger HVDC transmission, PS.

### 3.1.1 Advantages of Circuits with PFC:

1. The cost saving factor like the electrical loads (SMPS, Electronic ballast unit or other electrical load) become much simpler.
2. Because of the smaller RMS current with PFC, it permits to use small, much cost effective mains rectifiers to the manufacturer of electrical load.
3. The input voltage for the DC electrical load becomes stable and regulated. Indeed, the AC-DC system becomes operates on wide-range power supply because of PFC.

But there is some drawback of boost converter the main concerns in controlling the output voltage of boost converter is keep output voltage in desirable value under the variations of load. So controller is used for boost converter for improve power factor[22].

## 4. VARIOUS CONTROLLER TECHNIQUES

Some of the problem occurred in three phase boost ac/dc converter to overcome this problem controllers are connects for improving the power factor close to unity. The controller algorithms provides for improvement of fast dynamic performance and improve the power quality of converters. To overcome the disadvantages of converters different hardware topology and control methods are discussed such as starting with proportional integral (PI), peak current controller, sliding mode controller, fuzzy logic controller, dynamic evaluation controller, an adaptive passivity based control the different methods are as followed[13].

### 4.1. Proportional Integral (PI)

Two control strategies proportional and integral are combined to get proportional integral (PI) controller. In this controller the integral term in PI controller causes steady state error to reduce to zero. Due to lack of derivative term system becomes steadier in steady state operation; also it is less effective to real and fast changes in state, so system will be slower as compared to other controller. To achieve the power balance between the AC-source side and DC-load side of the AC/DC converter, a proportional integral voltage controller is used to obtain the amplitude of the line current commands. The proportional plus integral (PI) is probably the most commonly used controller in the industry that arguably the PI controller is the simplest practical controller that provides integral action which required in many process control applications for asymptotic tracking of set point commands[24].

### 4.2. Peak Current Control Method

Peak current control method is taken as a standard strategy in the industry for the boost AC-DC PFC converter, The switch turns on with a constant frequency and it can turn off up hill inductor current reaches a level

set by the outer loop. Therefore, instant over-current switch protection is easier, but there is very noise sensitive control.

#### **Advantages**

- 1) Fixed switching frequency
- 2) Only the switch current must be sensed, which can be accomplished by a current transformer, thus avoiding the losses due to sensing resistor.
- 4) Current error amplifier and its compensation network are not required
- 5) Improved reliability and increased speed response because of the instantaneous
- 6) pulse-by-pulse current limit, i.e. the possibility of true switch current limiting

#### **Disadvantages**

- 1) Presence of subharmonic oscillations, at duty cycle exceeding 0.5, so a compensating ramp is required.
- 2) Input current distortion which increases at high line voltages and light load and is worsened by the presence of the compensation ramp
- 3) Control more sensitive to commutation noises.

### **4.3. Fuzzy logic controller**

Fuzzy logic is regularly in combination with genetic algorithms and neural networks, has been successfully applied in numerous electrical drive problems such as the control of dc and ac drives and the tuning of state observers. Their use in power electronics, instead, with the exception of some applications to dc/dc converters, aiming to improve tuning procedures or to simplify implementation issues, is rather limited. In fact, only a few attempts have been carried out proposing fuzzy-logic-based proportional–integral (PI) current controllers and fuzzy-logic-based modulators for three-phase converters[15,25].

### **4.4. Dynamic Evaluation Controlled method.**

The principle of the Dynamic Evolution Control technique is, “The Error State, i.e., the difference between the output system and the reference input must be reduced to zero”, without loss of generality. The elementary idea is the minimization of State Error by driving the state error to follow the definite track, which ensure the Null condition of Error State in increase of time. The target of the controller is to monitor the dynamic characteristic of the system to work on the governing equation. The evolution track can be a function of a linear path or of an exponential path. For the Boost PFC converter, the linear evolution path is chosen for the controller[23].

### **4.5. Adaptive passivity based controller**

A passivity-based control scheme for the feedback regulation of a class of switched power converters commonly addressed as power factor precompensators. In such applications, aside from load voltage regulation to a prespecified constant level, a vital additional control objective consists in keeping the input power factor close to unity. By forcing the converter input current to follow a sinusoidal reference signal which is in phase with the supplied voltage, one may approximately satisfy both control objectives within a single power stage. A further complication in our design is to consider the output load, usually modeled by a resistance, as unknown. Experimental results are furnished for assessing the performance of the proposed feedback controllaw[16].

### **4.6. Sliding mode controller**

Sliding mode controller maintains stability and provide consistence performance. In general the function of switching control law is to drive nonlinear plant’s state trajectory onto a pre-specified surface and to maintain plant’s state trajectory for subsequent time. The surface is known as switching surface which defines rules for proper switching. This surface is also called sliding surface. Feedback path has one gain when plant trajectory is above the surface and a different gain when trajectory is below the surface. Conventional controls such as stabilization, regulation, tracking can be obtained by proper design of sliding surface.[8,9]

#### **Advantages**

- 1) Low sensitivity to plant parameter uncertainty
- 2) Greatly reduced-order modeling of plant dynamics
- 3) Finite-time convergence (due to discontinuous control law)
- 4) Stability even for large line and load variations
- 5) Robustness
- 6) Good dynamic response
- 7) Simple implementation.

AC/DC system	Power factor	THD (%)
Without filter & converter(diode rectifier)	0.9396	99.94
Peak Current Control Method	0.996	1.26
PI Controller	0.9909	0.73
Fuzzy logic controller	0.999	3.17
Dynamic Evolution Controller	0.998	1.83
Adaptive passivity based controller	0.999	8.50
Sliding mode controller	0.999	0.53

Table 1:- PF and THD of AC-DC System Operating in Different Control Method [24,15,25,23,16,8]

The Table 1 explains about the obtained power factor and THD for the Boost PFC converter with Load, operating with different control schemes. It shows the various ranges of PF and THD to various controller. From these table sliding mode controller is has near about unity power factor and total harmonics distortion is less. hence in these techniques the sliding mode controller is more suitable for controller for improvement of power factor of boost converter.

### 5. CONCLUSION

This paper presents the survey of different technique for improvement of power factor close to unity and solves the problem of efficient conversion of power. For the improvement of power factor and fast dynamic performance of the three phase boost converter different new technology are discussed in this paper and with the help of new technique controller we can improve the dynamic response and improve the dc out put voltages of converter. So after studied the all technique and discover the sliding mode controller having power factor near to unity and less THD so select sliding mode controller for three phase ac/dc boost converter for improvement of power factor.

### REFERENCES

[1] M. H. Rashid, Power Electronics: “Circuits, Devices and Applications (3rd Edition), Prentice Hall”, 2003.  
 N. Mohan, et al. Power Electronics: Converters, Applications, and Design. New York: NY, USA, John Wiley & Sons, Inc., 1995.

[3] G. G. A.W. Green, J.T. Boys, “3-phase voltage source reversible rectifier”, Proc. Inst. Elect. Eng. 1988. [4] A. R. Prasad, Phoivos D. Ziogas, and Stefanos Manias, “An Active Power Factor Correction Technique for Three-phase Diode Rectifiers”, IEEE transactions on Power Electronics, vol. 6 (1991).

[5] V. Utkin, J. Gulder, and M. Shijun, “Sliding Mode Control in Electromechanical Systems”, 2nd Edition, Taylor and Francis, 1999.

[6] C. Edwards and S. Spurgeon, “Sliding Mode Control”. Bristol, PA: Taylor & Francis, 1998.

[7] S.-C. Tan, Y. M. Lai, C. K. Tse, L. Martinez-Salamero, and C.-K. Wu, “A fast-response Sliding-mode controller for boost-type converters with a wide range of operating conditions”, IEEE Trans. Ind. Electron., vol. 54, no. 6, pp. 3276–3286, Dec. 2007

[8] R. Schaeffer, Y. Steele, S. Baev, and H. Biglari, “3-Phase AC/DC Boost Converter Power Factor Control via Traditional and Second Order Sliding Modes”, 2010 American Control Conference Marriott Waterfront, Baltimore, MD, USA June 30-July 02, 2010.

[9] Yuri Shtessel, Senior Member, IEEE, Simon Bae, Member, IEEE, and Haik Biglari, Senior Member, IEEE, “Unity Power Factor Control in Three-Phase AC/DC Boost Converter Using Sliding Modes”, IEEE TRANSACTION ON INDUSTRIAL ELECTRONICS, VOL. 55, NO. 11 NOVEMBER 2008..

[10] A. Lazaro, A. Barrado, M. Sanz, V. Salas, and E. Olias, “New power factor correction AC-DC converter with reduced storage capacitor voltage,” IEEE Trans. Ind. Electron., vol. 54, no. 1, pp. 384–397, Feb. 2007. Wang Jiuhe, Yin Hongren, Zhang Jinlong\*, and Li Huade\*, “Study on Power Decoupling Control of Three Phase Voltage Source PWM Rectifiers”, 1-4244-0449-5/06/\$20.00 C 2006 IEEE.

[11] Yu WANG, Yanbo CHE, K.W.E CHENG, “Research on Control Strategy for Three-Phase PWM Voltage Source Rectifier”, 2009 3rd International Conference on Power Electronics Systems and Applications.

- [12] Kada HARTANI, Yahia MILOUD, "Control Strategy for Three Phase Voltage Source PWM Rectifier Based on the Space Vector Modulation", Digital Object Identifier 10.4316/AECE.2010.03010.
- [13] B. Singh, B.N. Singh, A. Chandra, K. Al-Haddad, A. Pandey, D.P. Kothari, "A Review of Three-phase Improved Power Quality AC/DC Converters", IEEE TRANS. IND. ELECTRON VOL 51, (2004).
- [14] A. Levant, "Higher order sliding modes, differentiation and output feedback Control", Int.J.Control, Vol. 76(2003), Nos.9/10, pp. 924-941.
- [15] C. Cecati, A. Dell'Aquila, A. Lecce, and M. Iserè, "Implementation issues of a fuzzy- Logic-based three-phase active rectifier employing only voltage sensors", Industrial Electronics, IEEE Transactions on, vol. 52, no. 2, pp. 378– 385, April 2005.
- [16] G. Escobar, D. Chevreau, R. Ortega, and E. Mendes, "An adaptive passivity-based controller for a unity power factor rectifier", Control Systems Technology, IEEE Transactions on, vol. 9, no. 4, pp. 637 –644, July 2001.
- [17] G. Escobar, "A passivity based-sliding mode control approach for the regulation of power factor precompensators",
- [18] B. Yin, R. Oruganti, S. Panda, and A. Bhat, "Control of a three-phase pwm rectifier based on a dual single-input single-output linear model," in Power Electronics and Drives Systems, 2005. PEDS 2005. International Conference on, vol. 1, 0-0 2005, pp. 456 –461.
- [19] H. Komurcugil and O. Kukrer, "Lyapunov-based control for three phase pwa/c dc Voltage-source converters," Power Electronics, IEEE Transactions on, vol. 13, no. 5, pp. 801–813, 1998.38
- [20] M. E. Elbuluk, G. C. Verghese, and D. E. Cameron, "Nonlinear control of switching power converters" , vol. 5, no. 4, pp. 601–617, 1989.
- [21] Y. Shtessel, A. Zinober, and I. Shkolnikov, "Sliding mode control of boost and buck-boost power converters using the dynamic sliding manifold," Int. J. Robust Nonlinear Control, vol. 13, no. 14, pp. 1285–1298, 2003.
- [22] S.-C. Tan, Y. M. Lai, C. K. Tse, L. Martinez-Salamero, and C.-K. Wu, "A fast-response sliding-mode controller for boost-type converters with a wide range of operating conditions," IEEE Trans. Ind. Electron., vol. 54, no. pp 3276–3286, Dec. 2007.
- [23] A.S. Samosir, A.H.M Yatim, "Dynamic Evolution Control of Bidirectional DC-DC Converter for Interfacing Ultracapacitor Energy Storage to Fuel Cell Electric Vehicle System", AUPEC, Dec. 2008
- [24] Mitulkumar R. Dave, K.C. Dave, "Analysis of Boost Converter Using PI Control Algorithms", International Journal of Engineering Trends and Technology- Volume 3 Issue 2- 2012
- [25] P. Kripakaran, J. Sathishkumar, R.G. Krishna, "Power Factor Correction Using Fuzzy Logic Control", IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) e-ISSN: 2278-1676, p-ISSN: 2320-3331, Volume 9, Issue 1 Ver. III (Jan. 2014), PP 11-20 www.iosrjournals.org