# Active Power Factor Correction Technology Based on Boost Circuit

Jiaqi Hao

School of Energy Systems, Lappeenranta University of Technology, Lahti, 15140, Finland
`Jiaqi.Hao@student.lut.fi`

**Abstract.** Power Factor Correction (PFC) technology is a key means to improve system energy efficiency. This paper conducts a systematic review and analysis of Boost-type active power factor correction technology. Firstly, it sorts out the topological structure and working principle of Boost-type PFC, and expounds its advantages in improving power factor and suppressing harmonics in single-phase AC/DC converters. Subsequently, it focuses on elaborating typical strategies such as average current model control (ACMC), peak current model control (PCMC), and sliding mode control (SMC), analyzes the principles and characteristics of these three strategies, and compares their application scenarios, advantages, and disadvantages. The analysis results show that average current model control performs well in terms of steady-state performance and harmonic suppression, but the controller is relatively complex; peak current model control is simple to implement and has a fast response speed, but its anti-noise capability is weak and the harmonics are slightly higher; sliding mode control has strong robustness and is suitable for complex scenarios, but its design is relatively complex. On this basis, the development trend of Boost-type PFC control strategies is summarized, and suggestions and reference ideas are put forward on how to further improve the accuracy in the future.

**Keywords:** Boost Circuit, Active Power Factor Correction, Control Strategy.

## 1 Introduction

In the power systems of modern society, non-linear electronic loads are widely used, leading to problems such as reduced power factor, intensified grid harmonics, and decreased efficiency of electric energy utilization. These problems not only increase the pressure on the power grid but also interfere with the normal operation of sensitive equipment. Therefore, Power Factor Correction (PFC) technology is an important means to improve the power factor of power electronic equipment, optimize the waveform of the input power grid, and enhance power quality.

Power factor correction technology is widely applied in various types of single-phase AC-DC converters. Compared with passive PFC, active PFC has advantages such as flexible control, high power factor, and strong adaptability Among them, the Boost topology is widely applied due to its characteristics such as simple circuit structure, mature control strategy, and suitability for small and medium power ranges, for example,

S. Zhang (ed.), *Proceedings of the 2025 International Conference on Electronics, Electrical and Grid Technology (ICEEGT 2025)*, Advances in Engineering Research 292,
https://doi.org/10.2991/978-94-6463-986-5_88

in fields like LEDs and electric vehicles. In recent years, a large number of studies have also been conducted on Boost-type PFC. In terms of control strategies, Louganski and Lai introduced zero-phase distortion compensation on the basis of the traditional average current control, which can improve the distortion of the input current and enhance the dynamic response performance [1]; at the same time, Ren and Liu analyzed the PFC boost converter using the DMC model, which provides sufficient theoretical basis for the operational stability and performance of such converters in subsequent applications [2]. These studies indicate that although the research methods have different focuses, they all provide an important theoretical and methodological foundation for the development of Boost-type PFC technology.

Different control strategies exhibit significant differences in different scenarios, such as in terms of stability, dynamic performance, and other aspects. This paper will focus on Boost-type PFC technology, systematically sort out its basic structure and working principle, focus on analyzing its mainstream control strategies, and conduct comparative discussions to provide references for related research.

## 2 Equations and mathematics

The Boost-type active power factor correction circuit is a unidirectional AC-DC conversion structure built based on a boost converter. Its main goal is to stabilize the input voltage while making the input current waveform consistent with the input voltage waveform, thereby making the power factor close to 1. The circuit is mainly composed of a rectifier bridge, a Boost boost unit (inductor, power switch, diode), a filter capacitor, and a controller, as shown in Figure 1.

During operation, when the switch is turned on, the inductor stores energy, and the input current flows through the switch; when the switch is turned off, the energy stored in the inductor is released, supplying power to the output capacitor and the load through the diode, and the inductor current decreases to achieve boost conversion. The controller adjusts the switching tube to control the input current waveform, making the current waveform consistent with the voltage waveform to achieve power factor correction.

This structure is widely applied due to its simple structure, strong boosting capability, and suitability for small and medium-power devices, and it is the mainstream choice in the current PFC field [3].

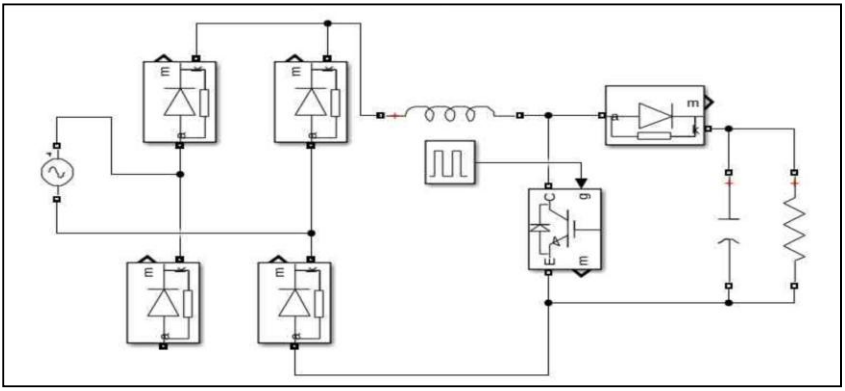

**Fig. 1**.Typical Topology of Boost-type Active Power Factor Correction Circuit

## 3 Development and Optimization of Control Strategies

Control strategy is the core of the design of Boost-type PFC systems. Currently, mainstream control methods include average current model control, peak current model control, and sliding mode control. The following will analyze these three control strategies in detail.

### 3.1 Average Current Mode Control (ACMC)

Average current model control is one of the most widely used control methods in Boost-type PFC. It is a control strategy based on a dual closed-loop structure. The voltage outer loop samples the output voltage and compares it with the set value to generate a current reference. The current inner loop samples the inductor current in real-time and compares it with the reference value, then controls the PWM duty cycle of the switching tube so that the inductor current value is consistent with the reference value, thereby making the voltage and current waveforms consistent. This method is relatively reliable in terms of steady state and has strong resistance to external disturbances, but it is relatively complex to implement in practical applications, and high-precision sampling needs to be ensured.

As the mainstream method for Boost-type PFC, the theoretical basis of average current control has been systematically expounded in the classic textbook by Erickson and Maksimovic [4]. In related research, Louganski and Lai proposed a generalized average current mode control method. In experiments, they attempted to introduce zero-phase distortion compensation, which effectively alleviated input current distortion, improved the dynamic performance of the system, and also provided a reference for studying stability under weak current conditions [1]. In engineering applications, Xu Rui et al. combined Boost PFC with LLC, which can reduce the circuit volume and losses while maintaining a high power factor, providing a new idea for future development [5]. A comparison of these studies shows that average current control has obvious advantages in terms of steady state and harmonic suppression, but it has higher requirements in terms of sampling accuracy and controller complexity.

### 3.2 Peak Current Mode Control (PCMC)

Peak current control is a common current control strategy in Boost-type PFC and DC-DC converters. In each switching cycle, it monitors the inductor current in real time, and once the current reaches the preset reference value, the switch is turned off immediately. This method features a simple structure, low control implementation cost, and the ability to quickly respond to load changes while maintaining stable output voltage, thus being suitable for embedded platforms with limited hardware resources.

Wu Jixia et al. proposed a practical design scheme for LED lighting driver power supplies, which extends the service life of bulbs on the basis of simplifying the circuit and reducing costs [6]. On the other hand, Ren and Liu analyzed this control method from the perspective of nonlinear dynamics and found that the PFC circuit under PCMC is prone to instability under light load conditions and improper parameters. They also provided the stable parameter range, which offers theoretical data for the design and control of PFC [2]. Fang constructed a unified theoretical model that can analyze the stability of various current control strategies [7]. Based on these studies, it can be found that peak current control is more suitable for low-power scenarios, while improvements are still needed in terms of stability and harmonic performance.

### 3.3 Sliding Mode Control (SMC)

Sliding mode control is a typical nonlinear control strategy. Its control idea is to pre-design a sliding mode surface, then restrict the system state to the sliding mode surface, making the system operate near the sliding mode surface, thereby achieving a fast and stable response. Compared with traditional linear control methods, SMC has stronger adaptability to load mutations, grid disturbances, and other conditions.

Through a series of experiments conducted by Shi Dianzheng et al. on the DSP platform by combining sliding mode control with Boost-type PFC, it can be observed that the sliding mode method can still maintain low harmonic distortion and a high power factor under disturbances [8]. On the other hand, Michel et al. proposed a model-free sliding mode control method, whose advantage is that it can still achieve rapid current tracking under conditions of system parameter changes and external disturbances [9]. In general, the prominent advantages of sliding mode control lie in its robustness and dynamic response, while improvements are still needed in terms of design complexity and chattering issues.

Table 1 presents common Boost-type PFC control strategies. Firstly, average current model control, with a control structure of dual closed-loop average strategy, features good steady-state performance and low harmonic distortion, but it has the disadvantages of a complex controller and the need for high-precision sampling, making it suitable for industrial occasions with high requirements for power quality. Secondly, peak current model control has a simple structure and fast response, but its drawbacks include weak anti-noise capability and slightly higher harmonics, which makes it suitable for low-power devices such as LED driver power supplies. Finally, sliding mode control is a nonlinear control method; its advantages are strong robustness and excellent dynamic performance, while its disadvantage is complex design, and it is more suitable for electric vehicle charging modules.

**Table 1.** Comparison of Different Boost-Type PFC Control Strategies

| **Control Strategy** | **Control Structure** | **Advantages** | **Disadvantages** | **Application Scenarios** |
|---|---|---|---|---|
| ACMC | Dual Closed-Loop Average Strategy | Good Steady-State Performance, Low THD, Strong Anti-Interference Capability | Complex Controller, Requiring High-Precision Sampling | Industrial-Grade AC-DC Power Supplies, Servers |
| PCMC | Peak Current Detection Control | Simple Control, Fast Response | Weak Anti-Noise Capability, Slightly Higher Harmonics | LED Drivers, Small Chargers |
| Control Strategy | Control Structure | Advantages | Disadvantages | Application Scenarios |

## 4 Existing problems and development

Although Boost-type active power factor correction control technology has been widely applied in single-phase AC/DC converters and mature control strategies such as average current model control, peak current model control, and sliding mode control have been developed, there are still some problems that need to be solved urgently. Firstly, average current model control has high requirements for current sampling accuracy and controllers, which will increase hardware costs and the complexity of controller design. Although the peak current model control has a simple structure and fast response, it is more sensitive to noise and prone to subharmonic oscillations, which will affect the stability of the system. While sliding mode control has strong anti-interference capability and dynamic response performance, it is prone to chattering and has a complex design. Overall, there are still problems in the existing control strategies regarding the balance between performance, design complexity, and cost control.

The future development trends mainly focus on three aspects: first, making the system more intelligent and automated by introducing fuzzy control or other advanced control methods, enabling the controller to automatically optimize parameters under different conditions to improve the robustness and adaptability of the system [10]. Second, achieving greater digitization by means of digital control platforms such as DSP or FPGA to achieve higher control accuracy, increase response speed, and implement more complex algorithms; third, moving towards high-frequency operation by applying new semiconductor devices such as SiC and GaN to reduce controller losses and improve frequency and efficiency.

## 5 Conclusion

This paper summarizes Boost-type active power factor correction technology, introduces its basic structure and working principle, and focuses on analyzing the principles and performance characteristics of three typical control strategies: average current model control, peak current model control, and sliding mode control. The research shows that different control methods have their own advantages and disadvantages in terms of steady-state accuracy, dynamic response, and robustness, and different control strategies should be selected according to different application scenarios.

Finally, the shortcomings of current research are summarized and prospects are put forward. Future research can make control algorithms more intelligent by combining them with artificial intelligence; utilize digital platforms and apply new semiconductor devices. Boost-type PFC still has broad application prospects in fields such as smart grids and vehicles. By continuously updating and optimizing control strategies, it will play a greater role in the future.

## References

1. K. P. Louganski, J. Lai, Generalized average-current-mode control of single-phase AC-DC boost converters. Ph.D. thesis, Virginia Tech (2007).
2. H.-P. Ren, D. Liu, Bifurcation behaviours of peak current model controlled PFC boost converter. Chinese Physics B **14**(7), 1352–1358 (2005).
3. H. Lan, W. Zhang, W. Huang, Research and simulation of constant frequency sliding mode variable structure control of BOOST converter. Electrical Measurement & Instrumentation **7**, 82–85 (2008).
4. Y. Chu, L. Ding, D. Chen et al., Simulation and experiment of boost-type active power factor correction circuits. Journal of Mechanics and Electronics **34**(3), 61–64 (2016).
5. X. Gao, T. Liu, An implementation method for average current model control of a Boost PFC circuit. Power Supply Technology **46**(2), 104–107 (2022).
6. M. Rashid, M. Ali, Z. Khan, Adaptive average current model control for boost PFC converters under grid frequency variation. IEEE Transactions on Power Electronics **34**(8), 7342–7353 (2019).
7. J. Wu, H. Zhang, Design of a practical boost-type active power factor correction circuit. Technology Innovation **5**, 41–44 (2024).
8. W. H. Chung, S. Z. Li, L. C. Lu, A digital peak current-mode control PFC with bifurcation control, in Applied Mechanics and Materials (2025).
9. C.-C. Fang, Unified subharmonic oscillation conditions for peak or average current mode control. (2013).
10. D. Shi, A. Liu, H. Zhou et al., Design of digital control system for boost-type PFC converter based on full-order sliding mode. Mechanical Design and Manufacturing Engineering **48**(10), 71–74 (2019).
11. L. Michel, W. Michiels, X. Boucher, Model-free control of nonlinear power converters. (2013).