



Advanced Nano-material Integration in Power Factor Correction Control of Converters for Energy-efficient and Sustainable Operation

M. Nagarajan¹, V. Vanitha¹ and K. Balachander^{2*}

¹Department of Electrical and Electronics Engineering, Faculty of Engineering, Karpagam Academy of Higher Education, Coimbatore, TN, India

²Department of Electrical and Electronics Engineering, Sri Ramakrishna Engineering College, Coimbatore, TN, India

Received: 17.10.2025 Accepted: 01.12.2025 Published: 30.12.2025

*kaybe.ind@gmail.com



ABSTRACT

The growing demand for energy-efficient and environmentally sustainable power conversion systems has emphasized the importance of power factor correction (PFC) techniques in modern electronic and renewable energy applications. This work explores the implementation and performance evaluation of PFC control strategies in widely utilized DC–DC converter topologies, namely Boost, Ćuk, and SEPIC converters. These converters are extensively adopted in power electronic systems for their capability to maintain stable output voltage despite fluctuations in input supply and load variations. While the conventional Boost converter is often favored for PFC because of its structural simplicity and satisfactory efficiency, topologies such as Ćuk and SEPIC offer enhanced voltage conversion flexibility and superior dynamic response, making them attractive alternatives in advanced energy systems. In this study, the converters are modeled and simulated using MATLAB/Simulink to assess their performance under different operating conditions. The analysis focuses on critical parameters such as output voltage regulation, conversion efficiency, input current harmonic distortion, and overall power quality. A key contribution of this work is the integration of nano-material-based components, which not only improve switching characteristics and thermal stability but also contribute to reduced losses and longer device lifetime, thereby promoting environmental sustainability. The comparative results demonstrate that, when integrated with nano-material enhancements, DC–DC converters with PFC control can achieve near-unity power factor, minimized total harmonic distortion, and improved system efficiency. These attributes make them well-suited for applications in renewable energy systems, smart grids, and environmentally conscious electronic devices. Ultimately, this study provides a comprehensive assessment of Boost, Ćuk, and SEPIC converters for sustainable energy conversion, highlighting their role in addressing global energy challenges while aligning with environmental and technological advancements.

Keywords: Power factor correction; Converter; Nano material; Boost; Ćuk; Sepic.

1. INTRODUCTION

The integration of nano-materials in power converter topologies has led to significant improvements in performance and reliability. Nano-structured magnetic cores enhance inductor and transformer efficiency by reducing core losses and enabling compact designs. Advanced nano-composite capacitors offer higher energy density, better thermal stability, and longer lifespan compared to conventional materials. Heat dissipation is improved through nano-coatings and thermal interface materials, which enhance converter durability under high power operation. Furthermore, nanomaterial-based semiconductors enable faster switching, lower conduction losses, and higher power density, making converters more efficient and environmentally sustainable.

1.1 Importance of Power Factor Correction (PFC) Control

Power factor adjustment is widely used and required for electrical grid network. It decreases system reactive power flow, which raises system rated power while minimizing line harmonic components and loss (Gazafrudi *et al.* 2015; Haghbin *et al.* 2013; Erickson and Maksimovic, 2001). Boost converters are the most widely used power factor correction circuit topologies today. On the other hand, some server power applications, handheld devices, and consumer appliances (Huai *et al.* 2014; Stevens *et al.* 2002) require a reduced DC input voltage for the main ac supply. To comply with harmonic regulations, a PFC controller for input is commonly included within the AC-DC supply with transformer isolation, in compliance with IEC 1000-3-2 (Wen *et al.* 2012). There are three approaches that may be used to meet the above guidelines. Due to the size; the resulting converter is extremely huge, heavy, and contains low-frequency inductors and capacitors (Wang *et al.* 2011).

However, adding a second switching converter makes using active PFC more expensive and difficult for the full two-stage converter (Kai *et al.* 2012). So, single-stage power-factor-corrected (SSPFC) converters have emerged. Numerous research works on SSPFC converters have been published, mainly on low-power AC–DC flyback and forward converters (Sun *et al.* 2015). However, research on higher power AC–DC single-stage full-bridge converters has proven to be more difficult, resulting in far fewer publications (Serban *et al.* 2015; Ohnuma *et al.* 2015).

In some single-stage AC–DC full-bridge current-fed converters, a boost inductor connected to the full-bridge circuit's input has been suggested (Sun *et al.* 2016). The lack of an energy-storage capacitor across the primary-side DC bus can result in severe voltage overshoots and ringing across the DC bus, despite the fact that they can achieve input power factors that are close to unity. It results in a substantial 120-Hz ripple in the output voltage, which restricts their applications.

It has been proven that boost, buck-boost, and Ćuk converters operating in discontinuous-inductor-current mode (DICM) are capable of intrinsic power factor correction (Singh *et al.* 2003; Garcia *et al.* 2003). They are suitable for low-power applications because of their simple control circuitry. These converters imply that further filtering might be required.

The effectiveness of a fourth order DC–DC Ćuk converter has been proposed by (Kuo and Chen, 1998; Sainz *et al.* 2012). The advantage is that the output voltage can be changed, but with inverted polarity. A DC–DC single ended primary inductance converter (SEPIC) with continuous conduction mode is applied in this study for PFC to address the flaws of the previous mentioned DC–DC converters. The DC–DC SEPIC is a popular topology since both input and output inductors are present. Its suitability for PFC operations is improved by its characteristics (Mariscotti *et al.* 2011).

1.2 Emergence of Nano-materials in Power Electronics

Recent advancements in nano-material science have opened new possibilities in the field of power electronics. Nano-materials exhibit unique electrical, magnetic, and thermal characteristics due to their high surface-area-to-volume ratio and quantum-scale effects. These properties make them highly suitable for improving the efficiency, reliability, and sustainability of converter systems. When integrated into magnetic cores, capacitor dielectrics, and conductor coatings, nano-materials can:

- Enhance magnetic permeability and reduce core losses.

- Increase thermal conductivity for improved heat dissipation.
- Lower electrical resistivity, improving current flow.
- Minimize switching and conduction losses in high-frequency operation.

1.3 Nano-ferrites for Inductive Energy Storage

Nano-ferrite materials such as NiFe_2O_4 , $\text{MnZnFe}_2\text{O}_4$, and CoFe_2O_4 are increasingly used in inductor and transformer cores due to their low coercivity and high electrical resistivity. The nano-scale particle size minimizes eddy current losses and improves magnetic flux density. When applied in boost and SEPIC converters, nano-ferrite cores enable faster transient response and reduced magnetic saturation, thereby improving PFC performance and converter stability.

1.4 Graphene and Carbon Nanotube (CNT) Composites in Conductors

Graphene and CNT composites are emerging as superior conductor materials due to their exceptional electrical conductivity and thermal resilience. Integrating graphene-based coatings in switching devices or bus bars reduces resistive losses and enhances current-carrying capability. Moreover, CNT-embedded copper or aluminum conductors offer lower skin-effect losses at high frequencies, which is beneficial for high-frequency PFC converters operating under wide load variations.

1.5 Metal Oxide Nanoparticles for Dielectric Enhancement

The incorporation of metal oxide nanoparticles such as TiO_2 , Al_2O_3 , and SiO_2 into capacitor dielectrics improves the dielectric strength, energy density, and thermal reliability of PFC circuits. Nano-oxide films provide uniform charge distribution and enhanced breakdown voltage, reducing stress on switching devices. This results in better harmonic suppression and higher energy storage efficiency within the converter's DC link.

1.6 Role of Nano-coatings in Thermal and Environmental Stability

Thermal management is a crucial factor affecting converter lifespan and efficiency. Nano-coatings such as AlN , BN , and ZnO thin films act as thermal interfaces that reduce hotspot formation and enhance heat dissipation. In PFC converters, nano-coatings improve temperature uniformity, reducing the degradation of magnetic and semiconductor components. Moreover, these coatings provide corrosion resistance and environmental durability, aligning with green energy and sustainability goals.

2. POWER CONVERTER TOPOLOGIES

This section presents the modelling of different DC-DC power converter topologies. The modelling parameters are used to analyze the converter performance at the different input condition and duty cycles (Balachander *et al.* 2020).

2.1 Boost Converter

A boost converter's output signal is always higher than the input source voltage. Fig. 1 shows the circuit for a traditional boost converter (Ramakrishnan and Balachander, 2025).

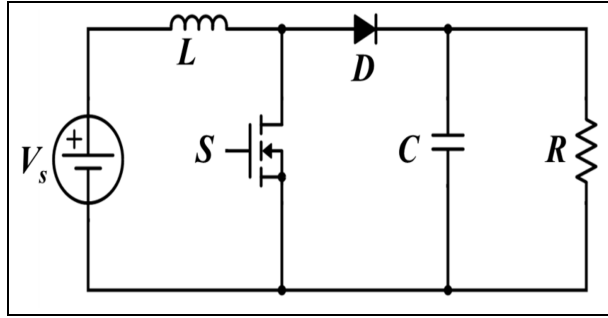


Fig. 1: Boost converter circuit

When the switch is activated, it simulates a short-circuit, which ought to present the current with zero resistance. All current travels through the switch when it is activated before returning to the DC input source. Suppose the switch is on for the T_{ON} period and off for the T_{OFF} time. The overall switching time is then shown as follows.

$$T = T_{ON} + T_{OFF} \quad \dots (1)$$

Where $T=1/f_s$, and f_s is the switching frequency

For boost converter,

$$\text{Duty cycle } D = \frac{T_{ON}}{T} \text{ and}$$

Applying KVL under steady-state operation of boost converter

$$V_S = V_L \quad \dots (2)$$

$$V_S = L \frac{di_L}{dt} \quad \dots (3)$$

$$\frac{di_L}{dt} = \frac{V_S}{L} \quad \dots (4)$$

$$\frac{\Delta i_L}{\Delta t} = \frac{V_S}{L} \quad \dots (5)$$

When the switch is closed for a time $T_{ON} = DT$, then $\Delta t = DT$.

Therefore,

$$\Delta i_L = \frac{V_S}{L} DT \quad \dots (6)$$

By applying KVL under T_{OFF} will produce

$$V_S = V_L + V_o \quad \dots (7)$$

$$V_L = V_S - V_o \quad \dots (8)$$

$$L \frac{di_L}{dt} = V_S - V_o \quad \dots (9)$$

$$\frac{di_L}{dt} = \frac{V_S - V_o}{L} \quad \dots (10)$$

$$\frac{\Delta i_L}{\Delta t} = \frac{V_S - V_o}{L} \quad \dots (11)$$

At open condition, $T_{OFF} = (1-D) T$, then $\Delta t = (1-D) T$.

Therefore,

$$\Delta i_L = \frac{V_S - V_o}{L} (1-D) T \quad \dots (12)$$

It has previously been proven that the net change in inductor current throughout any single full cycle is zero.

$$\frac{V_S}{L} DT = \frac{V_S - V_o}{L} (1-D) T \quad \dots (13)$$

$$\frac{V_o}{V_S} = \frac{1}{(1-D)} \quad \dots (14)$$

Here, the terminal voltage of the boost converter always depends on the turn-off time of the power semiconductor switch. Hence, by controlling the duty cycle, particularly controlling the turn-off time using proper duty cycle, tuning circuit will improve the overall performance of the converter circuit (Etier *et al.* 2022).

2.2 Ćuk Converter

The boost converter and the buck converter are cascaded to generate the Ćuk converter. Fig. 2 depicts the Ćuk converter's structural layout.

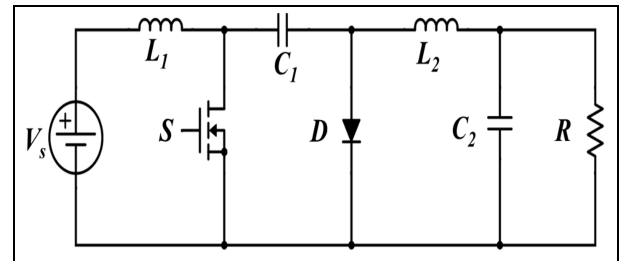


Fig. 2: Ćuk converter circuit

At S is ON condition, the circuit will be reduced using KVL as follows

$$V_S = V_{L1} \quad \dots (15)$$

$$V_S = L_1 \frac{di_{L1}}{dt} \quad \dots (16)$$

$$\frac{di_{L1}}{dt} = \frac{V_S}{L_1} \quad \dots (17)$$

$$\frac{\Delta i_{L1}}{\Delta t} = \frac{V_S}{L_1} \quad \dots (18)$$

When the switch is closed for a time $T_{ON} = DT$, then $\Delta t = DT$.

Therefore,

$$\Delta i_{L1} = \frac{V_S}{L_1} DT \quad \dots (19)$$

For inductor L_2

$$V_{C1} + V_{L2} + V_o = 0 \quad \dots (20)$$

$$\frac{di_{L2}}{dt} = -\frac{(V_{C1} + V_o)}{L_1} \quad \dots (21)$$

If the polarities of the V_{C1} and V_{C2} are reversed in the loop under consideration and the current must increase, the current must increase in the opposite direction of the expected direction.

When switch S is off, the circuit will reduced to the configuration

$$-V_S + V_{L1} + V_{C1} = 0 \quad \dots (22)$$

$$\frac{di_{L1}}{dt} = -\frac{(V_{C1} - V_S)}{L_1} \quad \dots (23)$$

For inductor L_2

$$V_{L2} - V_{C2} = 0 \quad \dots (24)$$

$$\frac{di_{L2}}{dt} = \frac{V_{C2}}{L_1} \quad \dots (25)$$

By using current balance equation

$$V_o = \frac{V_S D}{(1-D)} \quad \dots (26)$$

$$\frac{V_o}{V_S} = \frac{D}{(1-D)} \quad \dots (27)$$

The Ćuk converter's voltage output throughout this case is influenced by the power semiconductor switch's on and off times.

2.3 SEPIC Converter

A DC-DC converter architecture known as SEPIC produces a positive controlled output voltage

from an input voltage that varies from above to below the output voltage.

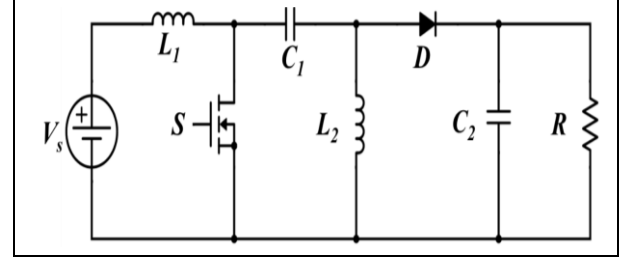


Fig. 3: SEPIC converter circuit

In Fig. 3, when switch S is on, the circuit will be reduced using KVL as follows

$$V_S = V_{L1} \quad \dots (28)$$

$$V_S = L_1 \frac{di_{L1}}{dt} \quad \dots (29)$$

$$\frac{di_{L1}}{dt} = \frac{V_S}{L_1} \quad \dots (30)$$

$$\frac{\Delta i_{L1}}{\Delta t} = \frac{V_S}{L_1} \quad \dots (31)$$

To determine i_{L2} , apply KVL between the first capacitor and the second inductor, which yields the following.

$$V_{C1} = V_{L2} \quad \dots (32)$$

$$V_{C1} = L_2 \frac{di_{L2}}{dt} \quad \dots (33)$$

$$\frac{di_{L2}}{dt} = \frac{V_{C1}}{L_2} \quad \dots (34)$$

When the switch S is OFF,

$$V_{L1} = V_S + V_{C1} + V_{C2} \quad \dots (35)$$

$$L_1 \frac{di_{L1}}{dt} = V_S + V_{C1} + V_{C2} \quad \dots (36)$$

$$\frac{di_{L1}}{dt} = \frac{V_S + V_{C1} + V_{C2}}{L_1} \quad \dots (37)$$

In output loop

$$V_{C2} - V_{L2} = 0 \quad \dots (38)$$

$$V_{L2} = V_{C2} \quad \dots (39)$$

$$L_2 \frac{di_{L2}}{dt} = V_{C2} \quad \dots (40)$$

$$\frac{di_{L2}}{dt} = \frac{V_{C2}}{L_2} \quad \dots (41)$$

$$V_o = \frac{V_S D}{(1-D)} \quad \dots (42)$$

$$\frac{V_o}{V_s} = \frac{D}{(1-D)} \quad \dots (43)$$

Similar to the output voltage of the Ćuk converter, output of SEPIC converter is also dependent on both the turn-on and off time of the power semiconductor switch.

3. POWER FACTOR CORRECTION CONTROL SCHEMES

It is a measure of how much electricity from the grid is being used. Power factor is the mathematical ratio of the real power to the apparent power and it ranges from 0 to 1.

$$PF = \cos\phi \quad \dots (44)$$

Here, $\cos\phi$ represents the displacement factor between voltage and current. In power factor correction schemes, the displacement factor is compensated. For the non-linear loads with sinusoidal input voltage and line-current the power factor is expressed as

$$PF = \frac{V_{rms} \cdot I_{rms1}}{V_{rms} \cdot I_{rms}} \cos\phi \quad \dots (45)$$

$$PF = \frac{I_{rms1}}{I_{rms}} \cos\phi \quad \dots (46)$$

$$PF = K_p \cos\phi \quad \dots (47)$$

where K_p indicates the harmonic content of the current associated with the fundamental. As a result, the PF is proportional to both harmonic content and displacement factor.

$$THD = \frac{\sqrt{\sum_{n=2}^{\infty} I_{rms,n}^2}}{I_{rms}} \quad \dots (48)$$

where n is the n^{th} order of the harmonic current and

$$K_p = \frac{1}{\sqrt{1+THD^2}} \quad \dots (49)$$

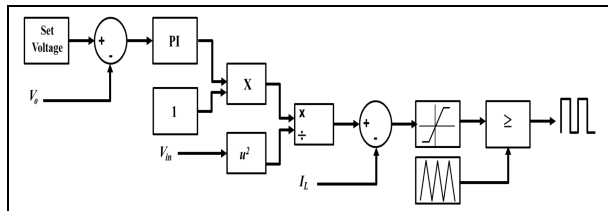


Fig. 4: Closed-loop PFC control circuit

A lower THD corresponds to a higher K_p leading to an improved power factor. The proposed closed-loop PFC control circuit, shown in Fig. 4, effectively reduces the harmonic content in the line current. The integration of nano-material-based passive components, such as nano-coated inductors and

capacitors, further minimizes losses and improves harmonic suppression, contributing to enhanced energy efficiency and environmental sustainability.

3.1 PID Controller

The basic qualities of a proportional, integral, and derivative controller are combined in a PID controller. The proportional control action changes the input is proportionate to the control error. The integral control action changes the input to make it proportionate to the integrated error. The controller's derivative action adjusts the input based on the derivative of the variable that may be regulated. The total controller action is the sum of the contributions of these three terms.

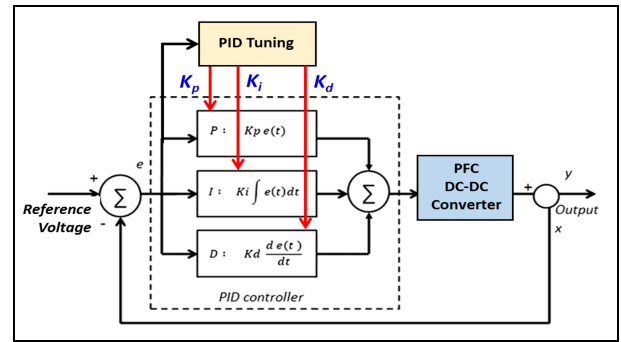


Fig. 5: PID control structure for power factor correction converter

Fig. 5 is a simplified block diagram of a plant. This is handled by a PID controller. A PID controller's output, which is the processed error signal, may be expressed as follows:

Table 1. Comparison of PID tuning methods

Schemes	K_p	K_i	K_d	T_s (sec)	T_r (sec)	%POS
ZN	1.754	1.01	0.2784	2.23	0.53	5.92
IMC	0.1793	0.1313	0.0435	6.96	1.93	7.26
PID	2.459	1.789	0.2141	1.66	0.38	11.2

Table 1 compares the tuning approaches based on ZN and IMC to the standard PID controller and displays the step-response characteristics. The findings reveal that the PID controller is very successful at keeping system stable by enhancing the system's phase and gain margins.

4. RESULTS AND DISCUSSION

In this work, the MATLAB simulation model of Boost, Ćuk and SEPIC converters are developed and system parameters are analyzed. The results are discussed as follows.

4.1 Boost Converter

In boost converter, the input supply is taken from the alternating current source, which is converted into DC using diode bridge rectifier, the non-linear output voltage is fed to the converter circuit. The PFC controller is implemented to measure the changes in the rectifier output voltage and current and duty cycle is adjusted to maintain the power factor near to unity.

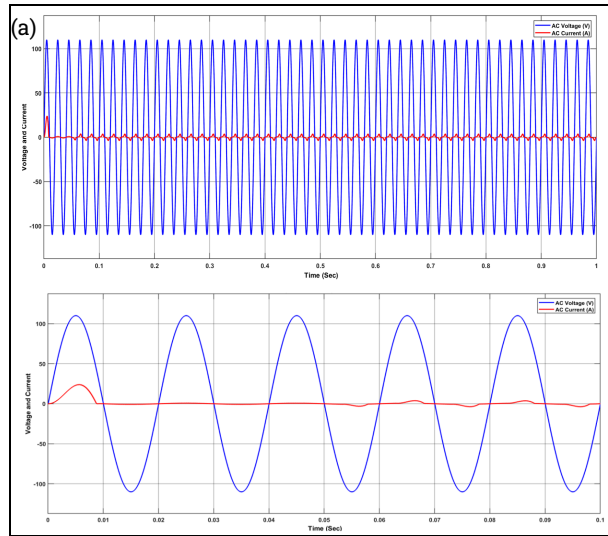


Fig. 6: Boost Converter (a) Alternating supply voltage and current waveforms for 0 to 1 sec and (b) Alternating supply voltage and current waveforms for 0 to 0.1 sec

The power factor is determined by analysing the waveforms of the voltage and current on the AC source side. A power factor of 0.9638 is shown in Fig. 6.

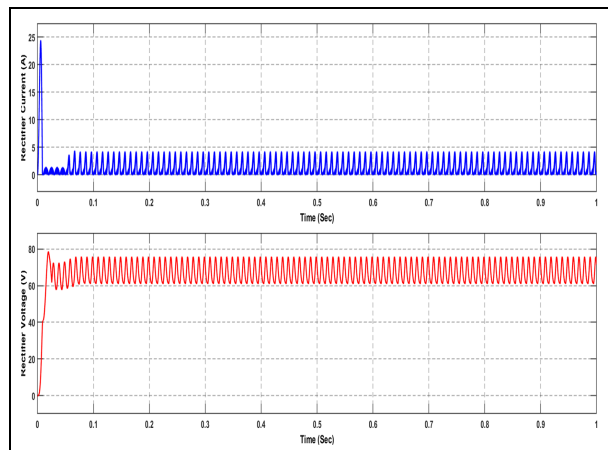


Fig. 7: Rectifier voltage and current waveform at source side of boost converter

The voltage and current magnitudes of rectifier output to the Boost Converter is presented in Fig. 7. It has the higher ripple and the corresponding inductor current and capacitor ripple voltages are presented in Fig. 8.

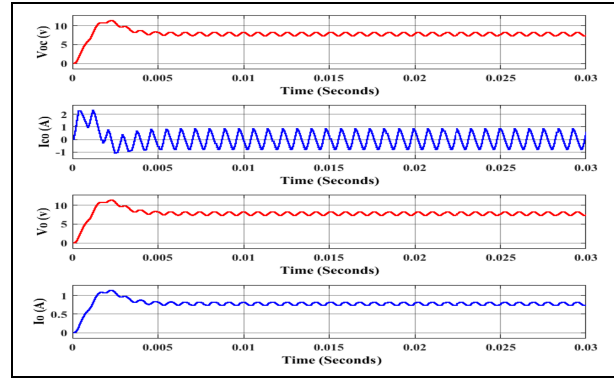


Fig. 8: Boost converter current and voltage waveform for inductor and capacitor

Fig. 9 shows the oscillations in the rectifier output voltage and current and it should be considered for the PFC at source.

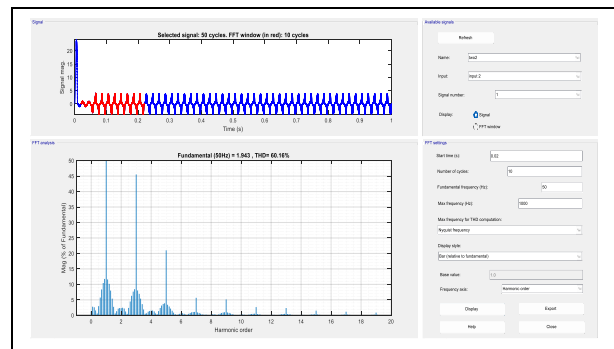


Fig. 9: Current THD of boost converter

The THD level at the AC source side current is measured and it has been found as 60.16 % as illustrated in Fig. 9 and it can be reduced to the standard level by implementing a novel converter and PWM Control schemes

4.2 Ćuk Converter

This section examines and shows the waveforms of the current and voltage output of a Ćuk converter at the load and source sides.

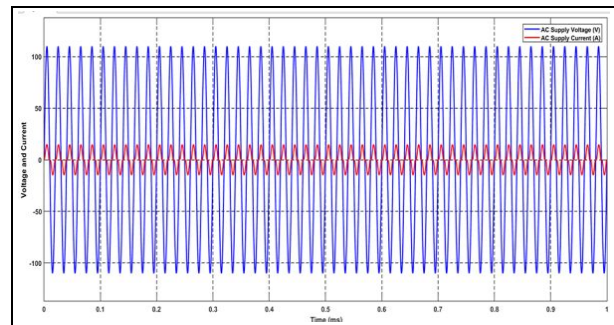


Fig. 10: Ćuk converter

(a) AC voltage and current waveform 0 to 1 sec

(b) AC voltage and current waveforms for 0 to 0.1 sec

In order to measure the power factor, the waveforms of the voltage and current on the AC source side are studied with Ćuk converter. It has been determined that the power factor is 0.9723 as shown in Fig. 10.

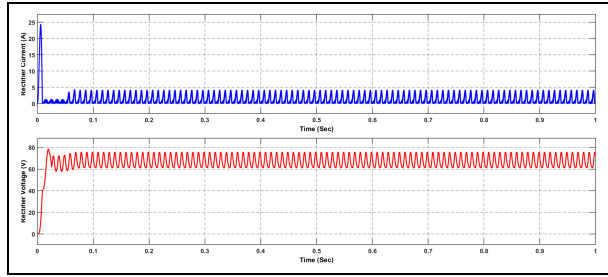


Fig. 11: Ćuk converter voltage and current waveform at the source side

Fig. 11 illustrates the magnitudes of the voltage and current at the rectifier's output, which is connected to the Ćuk Converter. It has the highest ripple, and the ripple voltages that correspond to the inductor current and capacitor ripple current are shown in Fig. 12.

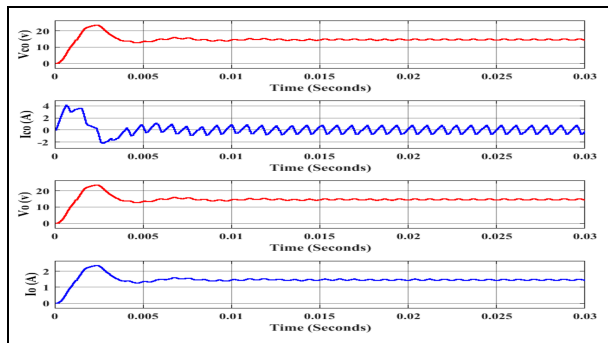


Fig. 12: Ćuk converter inductor and capacitor current and voltage waveforms

Fig. 12 shows the fluctuations in the current and voltage output of the rectifier; the PFC at the source should take this into account.

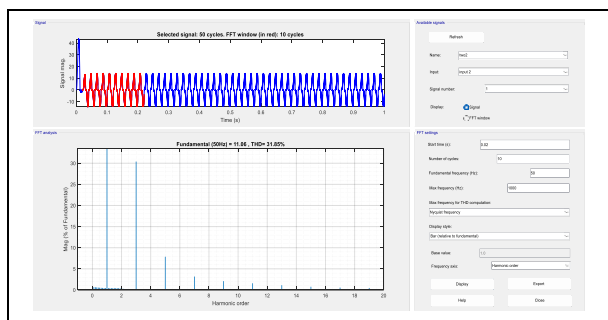


Fig. 13: Current THD of Ćuk converter

Fig.13 shows measurement of the THD level at the AC source side current. The THD level at the AC source side current has been tested, and it has been found to be 31.85%. The THD level may be decreased to the standard level by using new converters and PWM control methods.

4.3 SEPIC Converter

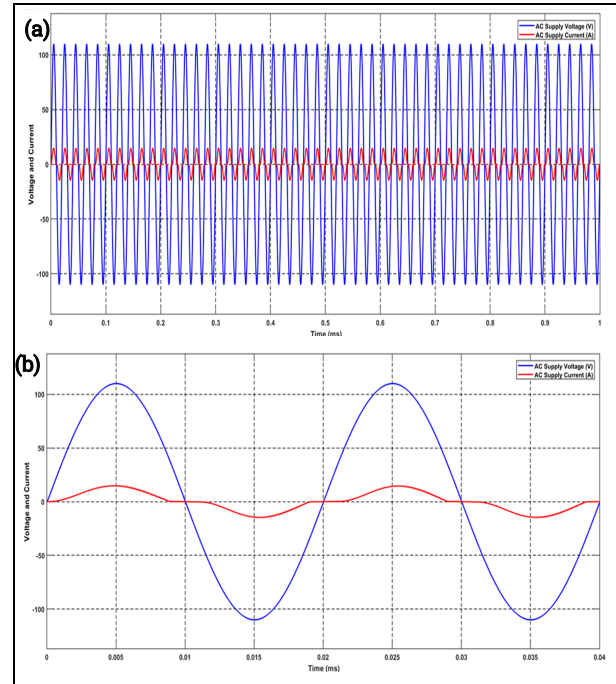


Fig. 14: SEPIC converter (a) Alternating supply voltage and current waveforms for 0 to 1 sec and (b) Alternating supply voltage and current waveforms for 0 to 0.1 sec

The waveforms of the voltage and current on the AC source side are analysed using a SEPIC converter in order to facilitate the calculation of the power factor. From Fig. 10, it has been found that the power factor is 0.9931.

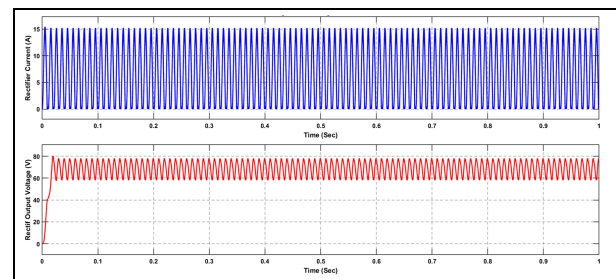


Fig. 15: Rectifier voltage and current waveform at the source side of boost converter

The magnitudes of the voltage and current at the rectifier's output, which is coupled to the Ćuk Converter, are shown in Fig. 15. It has the most ripple parameters, and the ripple voltages that correspond to the ripple

currents of the inductor and the capacitor are shown in Fig. 16.

A measurement of the THD level was taken at the AC source side current as shown in Fig. 17. The THD level at supply current was measured, and the results showed that it was 30.98%. By using modern converters and PWM Control techniques, the THD level may be reduced to the level that is considered to be standard. The performance comparison of the PFC based DC-DC converters are presented in Table 2.

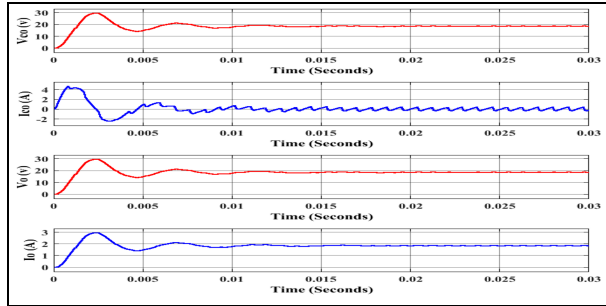


Fig. 16: Inductor current and voltage and capacitor output voltage and current of SEPIC converter

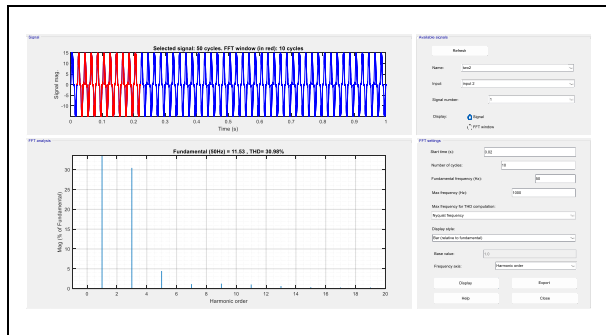


Fig. 17: Current THD of SEPIC converter

When the bridgeless and bridge converter topologies are compared, and PFC control is more effective in the control of Ćuk converter compared with traditional Boost and SEPIC converter topologies.

Table 2. Performance comparison of PFC based DC-DC power converters

Parameter	Boost		Ćuk		SEPIC	
	With Bridge	Bridgeless	With Bridge	Bridgeless	With Bridge	Bridgeless
Voltage Ripple	18.3 V	5.3 V	1	1.3 V	3.0 V	1.7 V
Current Ripple	15.2 A	4.89 A	11.1 A	1.8 A	12.3 A	2.1 A
THD	62.3 %	48 %	39.2 %	31.89	36.2%	30.98 %
Power Factor	0.8372	0.9638	0.7323	0.9723	0.8432	0.9931

5. CONCLUSION

The present work has investigated the effectiveness of PFC in three prominent DC-DC converter topologies: Boost, Ćuk, and SEPIC. Using MATLAB/Simulink models with closed-loop control, the converters were analyzed in terms of voltage regulation, efficiency, and input current quality. The results show that while the Boost converter remains a simple and reliable choice for PFC, the Ćuk and SEPIC converters exhibit superior dynamic response and extended voltage conversion ability. In particular, the SEPIC topology demonstrated a near-unity power factor (0.9931) with significantly reduced harmonic distortion, highlighting its potential for power quality improvement in demanding applications.

An additional contribution of this work is the exploration of nano-material integration in converter components. The use of nano-structured cores, high-density capacitors, and advanced semiconductor materials improved switching performance, reduced losses, and enhanced thermal stability. These improvements not only increase the operational efficiency of converters but also contribute to environmentally sustainable design by minimizing energy wastage and extending component life.

Overall, the findings confirm that PFC-enabled DC-DC converters, when supported by nano-material technologies, can deliver high efficiency, reduced harmonic pollution, and reliable operation. Such systems are well-suited for renewable energy integration, electric vehicle charging, and smart grid applications where environmental sustainability and energy efficiency are critical requirements. Future research may include hardware validation and the application of intelligent control techniques to further optimize performance.

FUNDING

This research received no specific grant from any funding agency in the public, commercial, or not-forprofit sectors.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

COPYRIGHT

This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC-BY) license (<http://creativecommons.org/licenses/by/4.0/>).



REFERENCES

- Balachander, K., Amudha, A., Ramkumar, G. S., Emayavaramban, G., Divyapriya, S., Nagaveni, P., Design and analysis of modified CUK converter for electric hybrid vehicle, *Mater. Today. Proc.*, 45, 1691–1695(2020).
<https://doi.org/10.1016/j.matpr.2020.08.566>
- Erickson, R. W. and Maksimovic, D., Fundamentals of Power Electronics, 2nd ed., *Springer*, 2001.
<https://doi.org/10.1007/b100747>
- Etier, I., Balachander, K., Kavitha, G., Sureshkumaar, G. and Kannan, N., Design and Performance Assessment of SEPIC Converter for the Grid-Connected PV System, *2022 3rd Int. Conf. Smart Electron. Commun. (ICOSEC)*, 235–244(2022).
<https://doi.org/10.1109/ICOSEC54921.2022.9951911>
- Garcia, O., Cobos, J. A., Prieto, R., Alou, P. and Uceda, J., Single-Phase Power Factor Correction: A Survey, *IEEE Trans. Power Electron.*, 18(3), 749–755(2003).
<https://doi.org/10.1109/TPEL.2003.810856>
- Gazafrudi, S. M. M., Langerudy, A. T., Fuchs, E. F. and Al-Haddad, K., Power quality issues in railway electrification: A comprehensive perspective, *IEEE Trans. Ind. Electron.*, 62(5), 3081–3090(2015).
<https://doi.org/10.1109/TIE.2014.2386794>
- Huai and Blaabjerg, Reliability of capacitors for DC-link applications in power electronic converters—An overview, *IEEE Trans. Ind. Appl.*, 50(5), 3569–3578(2014).
<https://doi.org/10.1109/TIA.2014.2308357>
- Haghbin, S., Lundmark, S., Alakula, M. and Carlson, O., Grid-connected integrated battery chargers in vehicle applications: Review and new solution, *IEEE Trans. Ind. Electron.*, 60(2), 459–473(2013).
<https://doi.org/10.1109/TIE.2012.2187414>
- Kai, Y., Ruan, X., Mao, X. and Ye, Z., Reducing storage capacitor of a DCM boost PFC converter, *IEEE Trans. Power Electron.*, 27(1), 151–160(2012).
<https://doi.org/10.1109/TPEL.2011.2105507>
- Kuo, H. Y. and Chen, T. H., Rigorous evaluation of the voltage unbalance due to high-speed railway demands, *IEEE Trans. Veh. Technol.*, 47(4), 1385–1389(1998).
<https://doi.org/10.1109/25.728533>
- Mariscotti, A., Direct measurement of power quality over railway networks with results of a 16.7-Hz network, *IEEE Trans. Instrum. Meas.*, 60(5), 1604–1612(2011).
<https://doi.org/10.1109/TIM.2010.2089170>
- Ohnuma, Y., Orikawa, K. and Itoh, J. I., A single-phase current-source PV inverter with power decoupling capability using an active buffer, *IEEE Trans. Ind. Appl.*, 51(1), 531–538(2015).
<https://doi.org/10.1109/TIA.2014.2347312>
- Ramakrishnan, A. and Balachander, K., Performance Analysis of Electric Vehicle Battery Management System using Interleaved Converter Topologies, *2025 5th Int. Conf. Trends in Mater. Sci. Inventive Mater. (ICTMIM)*, XXXX, 26–31(2025).
<https://doi.org/10.1109/ICTMIM65579.2025.10988183>
- Sainz, L., Monjo, L., Riera, S. and Pedra, J., Study of the Steinmetz circuit influence on ac traction system resonance, *IEEE Trans. Power Delivery*, 27(4), 2295–2303(2012).
<https://doi.org/10.1109/TPWRD.2012.2211084>
- Serban, I., Power decoupling method for single-phase H-bridge inverters with no additional power electronics, *IEEE Trans. Ind. Electron.*, 62(8), 4805–4813(2015).
<https://doi.org/10.1109/TIE.2015.2399274>
- 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.*, 50(5), 962–981(2003).
<https://doi.org/10.1109/TIE.2003.817609>
- Stevens, J. L., Shaffer, J. S. and Vandenham, J. T., The service life of large aluminum electrolytic capacitors: Effects of construction and application, *IEEE Trans. Ind. Appl.*, 38(5), 1441–1446(2002).
<https://doi.org/10.1109/TIA.2002.802922>
- Sun, Y., Liu, Y., Su, M., Li, X. and Yang, J., Active power decoupling method for single-phase current-source rectifier with no additional active switches, *IEEE Trans. Power Electron.*, 31(8), 5644–5653(2016).
<https://doi.org/10.1109/TPEL.2015.2494742>
- Sun, Y., Liu, Y., Su, M., Xiong, W. and Yang, J., Review of active power decoupling topologies in single-phase systems, *IEEE Trans. Power Electron.*, 31(7), 4778–4794(2015).
<https://doi.org/10.1109/TPEL.2015.2477882>
- Wang, R., Fei, W., Boroyevich, D., Burgos, R., Lai, R., Ning, P. and Rajashekara, K., A high power density single-phase PWM rectifier with active ripple energy storage, *IEEE Trans. Power Electron.*, 26(5), 1430–1443(2011).
<https://doi.org/10.1109/TPEL.2010.2090670>
- Wen, H., Xiao, W., Wen, X. and Armstrong, P., Analysis and evaluation of DC-link capacitors for high-power-density electric vehicle drive systems, *IEEE Trans. Veh. Technol.*, 61(7), 2950–2964(2012).
<https://doi.org/10.1109/TVT.2012.2206082>