Journal of Computational Intelligence and Secure Systems of Artificial Intelligence
Volume 01, Issue 01, May 2025
www.jcissai.com

AC-DC Converter Using a Single Stage Single Phase Active Power Factor Corrected CUK Topology

Suresh Nair
Department of Electronics and Communication Engineering, GIET University, Orissa
Corresponding Author: sureshnairece@gmail.com

To Cite this Article
Samuel Jack, "AC-DC Converter Using a Single Stage Single Phase Active Power Factor Corrected CUK Topology", Journal of Computational Intelligence and Secure Systems of Artificial Intelligence, Vol. 01, Issue 01, May 2025, pp:13-16.

Abstract*: This work is cantered in the analysis of a near loop Cuk PFC converter. The buck or buck-boost converter continuously presents a discontinuous input current profile regardless of input line voltage or output load conditions. The boost converter also suffers from the strains that appear across the power electronics apparatus associated with high voltage. Cuk converter Input current behaves like the boost converters one. The output voltage is regulated through power factor correction (PFC) as well as inner and outer voltage control loops. It presents lower THD on input current dependent on the variable input voltage and load on the output side, a power factor very close to one, and better output voltage regulation in the AC-DC converter for different input/output scenarios. This work provides a comparative performance of open loop Cuk rectifiers, close loop Cuk rectifiers, and standard diode rectifiers. An algorithm is developed and simulated, designing a near loop Cuk rectifier within a digital environment.*

Keywords*: PWM, digital algorithm, Cuk topology, PI control, inner current loop, Outer voltage loop*

I. Introduction

The importance of computers and telecommunication devices is growing for modern society. Environment-friendly technological practices are responsible for the sudden popularity of electric vehicles. The key part of this device is its DC power supply, that is often obtained from an AC-DC converter. Among the concerns with these AC-DC converters are, for instance, efficiency, input power factor, total harmonic distortion of input current, regulated output voltage, among others. The most frequent low budget, power supply is an uncontrolled diode bridge rectifier such as the one in figure 1, followed by L-C smoothing filters. An uncontrolled DC filter capacitor charge, charging at the input of the rectifier, produces the waveform of Figure 2, that shows a 50Hz pulsed ac current [11-13].

The source side is where most of the power quality problems such as low power factor, high input current total harmonic distortion (THD) (see Fig. 3), transformer burning out because of overheating, harmonic pollution of the grid [1]–[2], etc that may lead to electrical devices damage/failure due to grid disturbance. Several methods exist to combat harmonic pollution within the electrical system, and others are being researched [12]. As seen in figure 4, when varying input voltage and load, the open loop Cuk converter exhibits a poor power factor, low efficiency, limited control of the output voltages, and a high input current THD.

This type of research in any case indicates a duty cycle Cuk converter for output voltage and input current control to obtain sinusoidal AC mains current, and modulation of the output voltage tolerances since line voltage and load do vary. Fixed frequency is chosen because it is more easily implemented than hysteresis control.

II. AC DC Converter Based on Closed Loop CUK Converter

Figure 5 shows the suggested close loop Cuk regulator-based AC-DC converter. Here, the control mode is Average Current Mode. The average value of the current signal used to regulate the output voltage is altered with Average Current Mode control. If the input voltage is decreased, the voltage feed forward compensator's output rises; if the input voltage is increased, the output falls. After measuring and comparing the actual output DC voltage against a reference voltage, the proportional integral controller will handle the voltage error. The output of the proportional integral controller is multiplied by the input rectified voltage and the output of the voltage feed forward compensator to provide the reference current that is in phase with the rectified input. The real current is pushed to the reference current by means of a current error compensator. PC-I compares the output with a sawtooth wave after receiving the difference between the real current and the reference current in order to produce the necessary PWM signal [13].

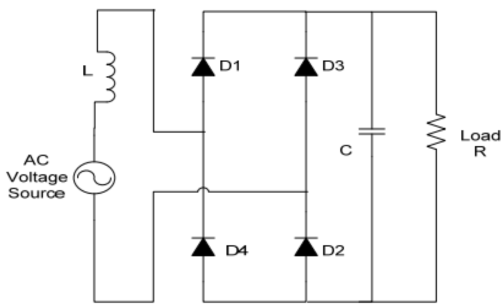


Fig 1: Normal diode rectifier

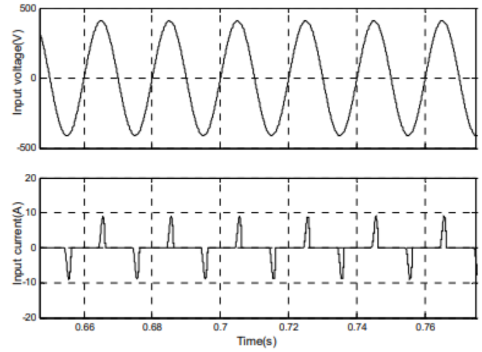


Fig 2: Input voltage and input current for 400Ω load resistance

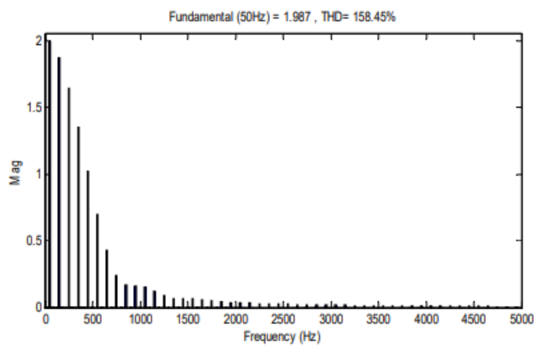


Fig 3: Input current THD for 400Ω load resistance

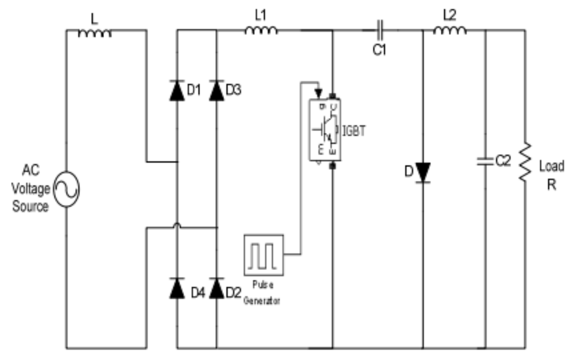


Fig 4: Open loop Cuk rectifier

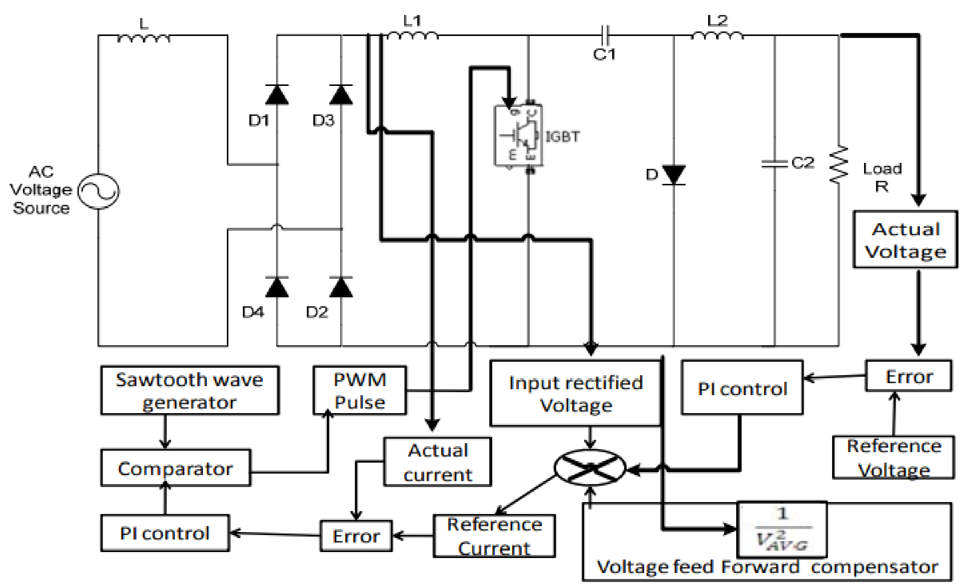


Fig 5: Proposed close loop Cuk rectifier

III. Close Loop CUK Regulator in Digital Domain

A bridge rectifier, power MOSFET switch, inductors, capacitors, and a diode arranged in the Cuk topology are among the fundamental parts needed to create the hardware needed for the suggested closed-loop Cuk-based AC-DC converter [12]. A microcontroller or DSP unit, which uses an algorithm based on PI or PWM to control the output voltage, often provides closed-loop control as shown in figure 6. Real-time feedback is provided via current and voltage sensors to guarantee stability and improved performance. The MOSFET is properly switched using a gate driver circuit. The design prioritizes high power factor, low ripple, and efficient power conversion, which makes it ideal for applications requiring steady, well-regulated DC from an AC source [11-13].

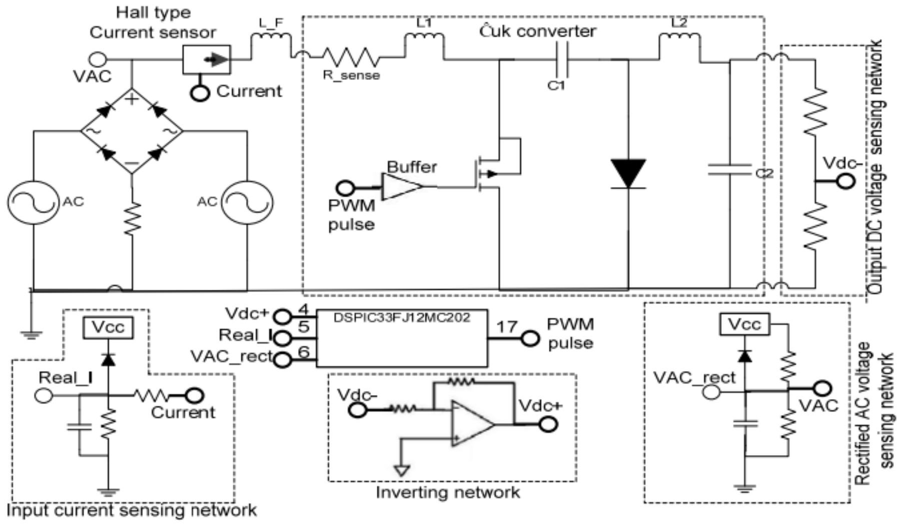


Fig 6: Circuit diagram for close loop Cuk rectifier

IV. Simulation Results

The topology of Cuk An efficient tool for simulating and analyzing Cuk converter performance under various operating situations is the Simulink model. To efficiently run the output voltage, engineers can model, test, and optimize control methods like PI or PWM controllers using Simulink. The main parts of the model, which enable the observation of energy transfer and transient behavior, include inductors, capacitors, a switching device, and a diode. It makes it possible to evaluate performance in both discontinuous and continuous conduction modes. Simulink's versatility and MATLAB integration enable it to be used as a tool for converter efficiency optimization and design verification for theoretical designs prior to hardware implementation as shown in figure 7 to 10.

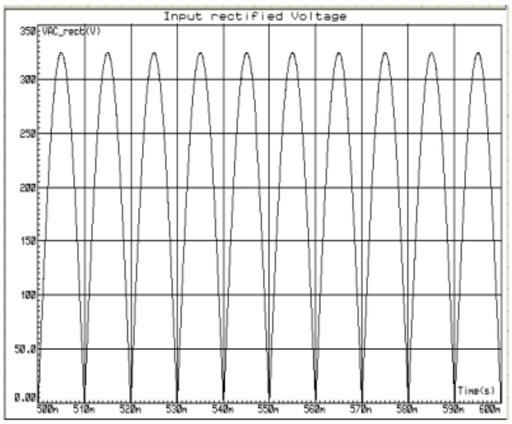


Fig 7: 325V (peak) input rectified voltage

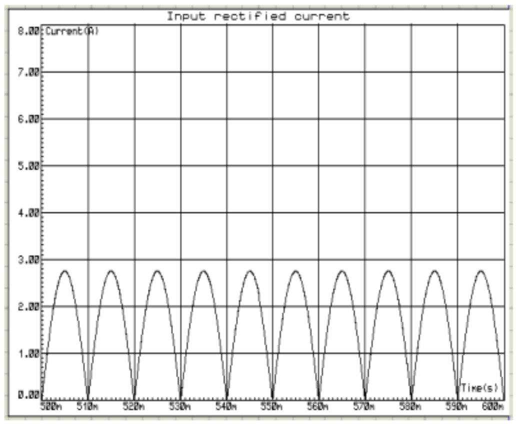
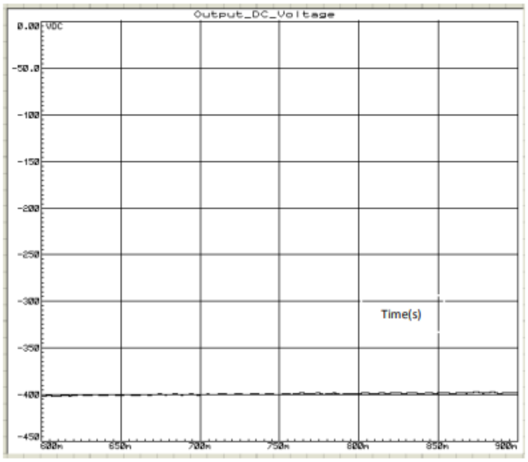


Fig 8: input rectified current for 400Ω load



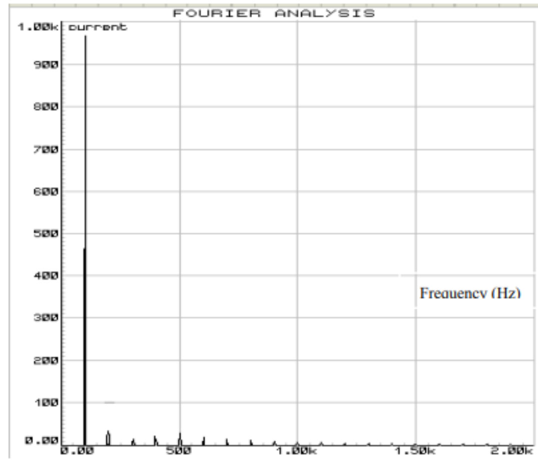


Fig 9: Output voltage for 400Ω load   Fig 10: FFT component of input rectified current for 400Ω load

V. Conclusion

In conclusion, the Cuk topology-based AC-DC converter provides a sizeable, effective solution for powering application with continuous input and output currents and electronic interference. Thanks to its ability to offer both step-up and step-down voltage regulation and enhanced power factor as well as low output voltage ripple, this is suitable for a wide range of industrial as well as consumer electronics. The application for a single inductor-capacitor means of energy transfer guarantees high efficiency and stable performance. Generally, distinct features of the Cuk converter make it a reliable and versatile option for modern AC-DC control systems in which high Cuk efficiency and Cuk stability are necessary [13].

References

[1] Zixin Li, Yaohua Li, Ping Wang, Hai bin Zhu, Cong wei Liu and Wei Xu. Control of Three-Phase Boost-Type PWM Rectifier in Stationary Frame under Unbalanced Input Voltage. IEEE Trans. On Power Electronics. 2010; 25(10): 2521-2530.

[2] Thomas Nussbaumer, Johann W Kolar. Comparison of 3-Phase Wide Output Voltage Range PWM Rectifiers. IEEE Transaction on Power electronics. 2007; 54(6): 3422-3425.

[3] H Azizi, A Vahedi. Performance Analysis of Direct Power Controlled PWM Rectifier under Disturbed AC Line Voltage. ICREPQ'05. Zaragoza- Spain Serial. 2005; 244: 1-6.

[4] Chie Lee and Yadav Kumar. "An Matrix Converter using Array System in Power Electronics in Communication Systems". Springer Conference in Hindustan University, Chennai, VOL. 2, NO. 3, March 2009

[5] Saritha, Srikanth, Subhakar and Sunitha, "A Process control system in Industrial Applications using Thyristors in power electronics for PMSG",". Elsevier 2011. China, 7 – 9, January 2012.

[6] Niharika, Lakshman Reddy and Shanchie, "A Novel of MIMO concepts in wireless relay networks in Space Time and Space Frequency in achieve diversity", " IEEE Conference Proceedings on Innovative Research in Communication Systems (IRCS), International Conference. vol. 2, pp. 67 – 75, January. 2010

[7] John Diesel, Shang Chee and Cooper Lee, "Standalone Grid system for On and OFF modes Using Renewable energy sources using PMMC Technology', "Springer Proceedings on Green Energy on World environmental Day", IEEE conference proceedings held at Madras University, on the 20tt Century. pp.10-19, 2020