Design And Implementation of Single Stage Bridgeless Ac to Dc Pfc Converter with Low THD for Ups Charging System

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Abstract - This study introduces a design and implementation of a single-stage bridgeless AC-DC power factor correction (PFC) converter for uninterruptible power supply (UPS) battery charging system. Traditional AC-DC converters typically employ a diode bridge rectifier followed by a DC-DC converter, which results in significant conduction losses and poor power quality due to high total harmonic distortion (THD). To address these limitations, a bridgeless topology is adopted to eliminate the diode bridge, thereby reducing conduction losses and improving efficiency. the proposed converter integrates power factor correction within a single-stage topology, simplifying the control mechanism and reducing component count. A suitable control strategy, typically employing average current mode control or voltage feedback loop, is implemented to ensure near-unity power factor and to maintain output voltage regulation under varying load and input conditions. Simulation and experimental results validate the effectiveness of the proposed design, demonstrating improved efficiency. The converter achieves efficient energy transfer with enhanced thermal performance, making it highly suitable for UPS battery charging systems where high reliability, power quality, and energy efficiency are critical.

***Key Words*:** Uninterruptible power supply (UPS), Single stage AC to DC converter, Sepic converter, PFC.

1.INTRODUCTION

Uninterruptible Power Supply **(UPS)** systems play a crucial role in ensuring power continuity for critical applications such as data centers, medical equipment, and communication infrastructure. Central to the efficient operation of a UPS is its charging system, which must convert alternating current (AC) from the grid into regulated direct current (DC) to charge the batteries reliably and efficiently. However, conventional AC-DC converters used in these systems typically rely on full-bridge rectifiers followed by power factor correction (PFC) and DC-DC conversion stages, which can introduce significant power losses, high component count, and elevated Total Harmonic Distortion (THD).To address these challenges, this project focuses on the design and implementation of a single-stage bridgeless AC-DC PFC converter aimed at reducing conduction losses, improving overall efficiency, and minimizing THD. By eliminating the input diode bridge and integrating power factor correction into a single-stage topology, the proposed design offers superior performance in terms of both energy efficiency and power quality. The bridgeless topology inherently reduces the number of conducting semiconductor devices in the current path during each half cycle, leading to lower conduction losses. Additionally, the single-stage configuration streamlines the power conversion process, reducing the component count and improving system reliability. Incorporating power factor correction in the design ensures compliance with international power quality standards by achieving near-unity power factor and significantly reducing harmonic content in the input current.

This report presents the theoretical analysis, design methodology, simulation, and hardware implementation of the proposed converter. Key performance metrics such as power factor, efficiency, and voltage regulation are evaluated and compared against conventional designs. The goal is to demonstrate a compact, efficient, and low-THD solution suitable for modern UPS battery charging systems.

OBJECTIVE

A Bridgeless AC to DC Converter (often referred to as a Bridgeless Rectifier) is a type of AC to DC converter that eliminates the need for a bridge rectifier by utilizing the two diodes in the AC input. This helps in reducing conduction losses, increasing efficiency, and lowering THD. Uninterruptible Power Supply (UPS) systems play a critical role in providing backup power during outages, ensuring uninterrupted operation of essential electronic devices. A key component of any UPS system is its battery charging unit, which must operate efficiently under a wide range of input conditions. This report presents the design and implementation of a **bridgeless SEPIC (Single-Ended Primary Inductor Converter)**, optimized for UPS battery charging applications. Unlike conventional SEPIC converters, the bridgeless topology eliminates the need for an input diode bridge, thereby reducing conduction losses and improving overall efficiency. The proposed converter offers the ability to step up or stepdown voltage as needed, providing a regulated output suitable for charging batteries while maintaining power factor correction. The design includes simulation, hardware implementation, and performance evaluation to validate its suitability for real-world UPS applications.This project focuses on the design and implementation of a SEPIC (Single-Ended Primary-Inductor Converter) topology specifically tailored for use in an Uninterruptible Power Supply (UPS) battery charging system. The converter is intended to provide a stable and efficient charging process under varying input voltage conditions, thereby enhancing the reliability and performance of the UPS system.

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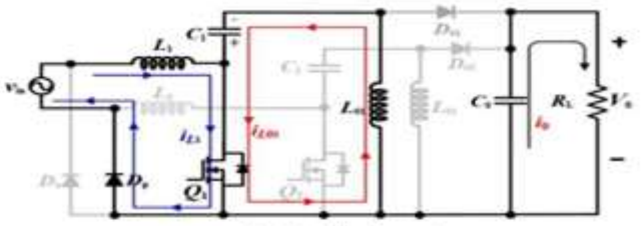
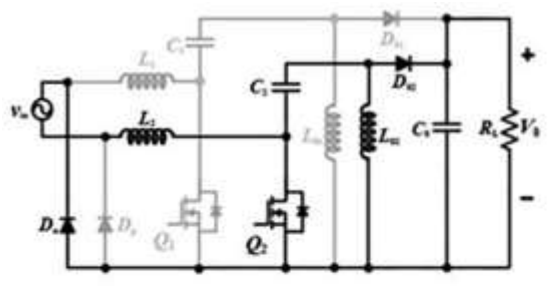
THE PROPOSED AC-DC BRIDGELESS SEPIC CONVERTER



Positive half cycle mode.

MODE 1

The proposed bridgeless SEPIC PFC converter topology provides much better performance than conventional SEPIC PFC converter. When the switch Q1 switched on, output diode D acts as reverse biased. The input inductor L1 gets charge, then output inductor $L2$ and AC input capacitor $C1$ creates a resonant circuit. The voltage of the input inductor will be equal with the rectified AC voltage Vac. Input capacitor voltage and output inductor voltage are also equal to Vac during this first mode of operation.



Negative half cycle mode.

MODE 2

In the second mode operation, The Q1switch is turned off, then the diode D is forward biased and $L1$, $C1$, $L2$ creates a loop. The load is directly connected to the inductors during in second mode, which will discharge them during the mode of operation.

DESIGN OF BRIDGELESS SEPIC CONVERTER

Duty cycle

$$\mathbf{D}=\frac{V_{dc}}{(V_{dc}+V_{ac})}$$

$$= \mathbf{0.6} \qquad \mathbf{(1)}$$

Design equation of inductor L,

$$\mathbf{L1=L2} = \frac{Vi}{\Delta_{I_l}\times F_s}\times D$$

$$= 600\mu h \qquad (2)$$

Design equation of capacitor C,

$$\mathbf{C1=C2} = \frac{I_{in}}{V_{r\times 0.5\times f_s}}$$

$$= \mathbf{1}\mu F \qquad (3)$$

$$C0 = \frac{\Delta_{I_l}\times D}{\Delta_{V_1}\times V_D\times F_s}$$

$$= 1\mu F \qquad (4)$$

ANALYSIS OF SIMULATION SEPIC CONVERTER

Two MATLAB-created simulation circuits are presented in this research. Fig. 3 displays the circuit diagram for the first circuit. Two steps are involved in converting the AC supply voltage to DC. a DC–DC converter and a diode bridge rectifier. The PFC bridgeless SEPIC converter utilized with the predefined values. as per the standard determinations. we have the waveforms that we have confirmed with the equipment. The information voltage that we are giving in the reproduction is 24V output that we are getting is at the battery side is 36 V.Figure 1. shows the BLSEPIC circuit, which is the second circuit. Two steps are involved in converting the AC supply voltage to a DC voltage.

In a single stage, the AC supply voltage is transformed into a DC voltage. The voltage of the proposed converter is controlled by the closed-loop control of the PI controller, which compares the output voltage with the reference value and generates an error signal. The error signal is then applied to the PWM generator, which creates the necessary pulse for the MOSFET. The converter has a single switch, and the input side inductance is directly connected to the supply, output side inductance, and capacitance.

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IV. SIMULATION OF PROPOSED SYSTEM

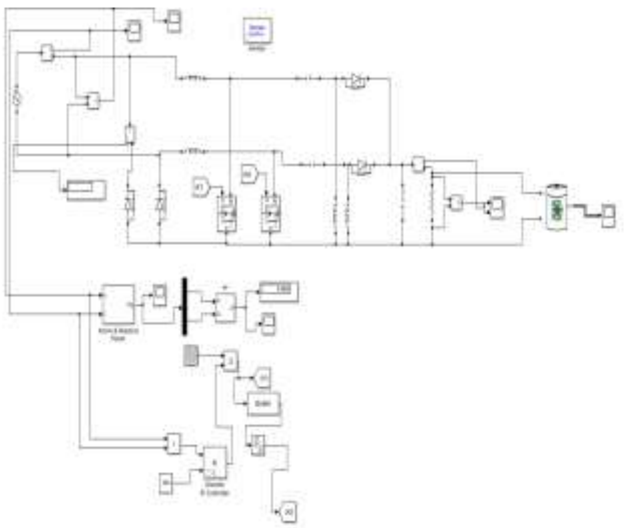


Fig. 3 Simulation circuit of Bridgeless SEPIC converter

SIMULATION PARAMETERS:

SI. No	Parameters	Specification
1.	Input voltage	24V
2.	Switching frequency	50kHz
3.	Inductor	L1, L2 = 600 mH, Lo1, Lo2 =200 mH
4.	Capacitor	C1, C2 = 1 μF , Co =1 μF
5.	Output voltage	36V

BATTERY PARAMETERS:

S.NO	PARAMETERS	SPECIFICATION
1	Battery voltage	36 V
2	Battery capacity	7.5 Ah
3	Full charge voltage	36.5V
4	Discharge voltage	30 V
5	Battery	270 W

SIMULATION RESULTS OF BRIDGELESS CONVERTER

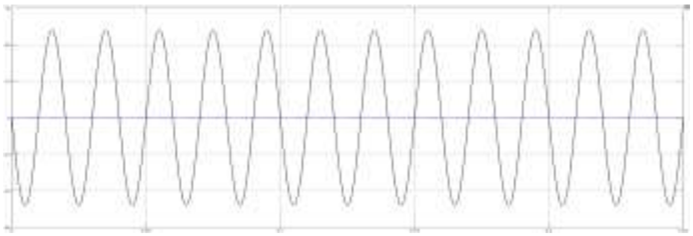
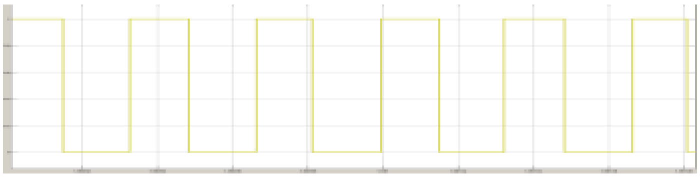
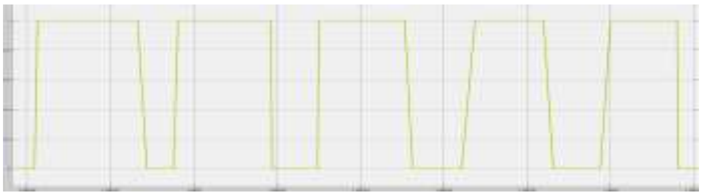


Fig.4 input voltage and current waveform

SIMULATION OUTPUT FOR GATING PULSE



GATE PULSE 1



GATE PULSE 2

PROPOSED BRIDGELESS VOLTAGE AND CURRENT THD WAVEFORM

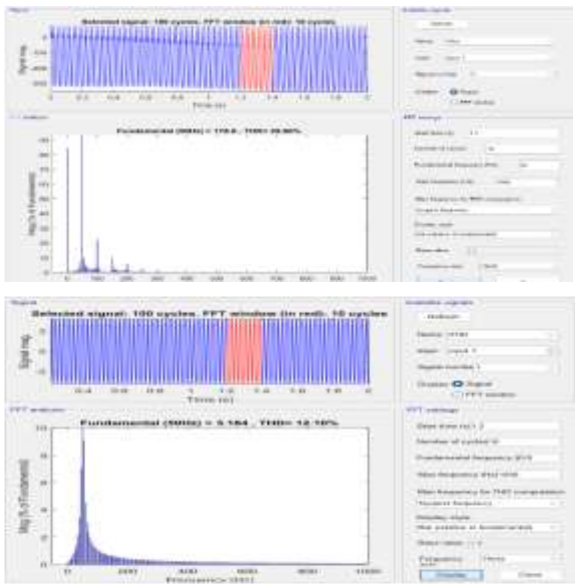


Fig 7 waveform of THD

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PROPOSED BRIDGELESS PFC OUTPUT WAVEFORM

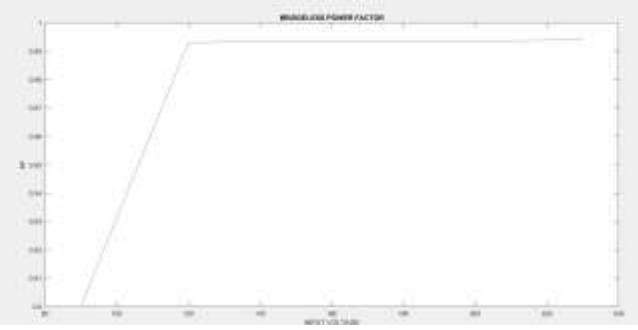

Fig. 8 waveform of bridgeless PFC

HARDWARE IMPLEMENTATION

In hardware we have used the same values as that of the simulation. at the input side we are giving 24 V and we have got the UPS charging output 36 V (Table 2).

BATTERY PARAMETERS LIKE SOC, BATTERY VOLTAGE AND CURRENT

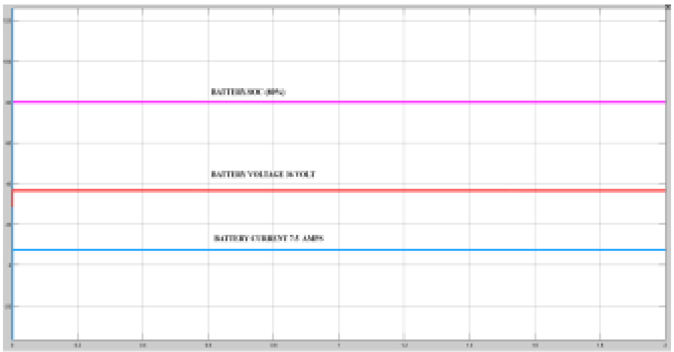

Fig.9 Battery volt and current waveform

The design and implementation of a single-stage bridgeless Power Factor Correction (PFC) converter that eliminates the need for the input diode bridge, thereby reducing conduction losses and improving overall system efficiency. The bridgeless topology is integrated with a power factor correction mechanism, allowing the converter to draw a near-sinusoidal current in phase with the input voltage, significantly reducing input current harmonics. The single-stage design simplifies the converter architecture, minimizing the number of components. This makes it particularly suitable for UPS battery charging applications, where space, reliability, and efficiency are critical factors. Additionally, the proposed converter is designed to achieve low THD and meet the charging requirements of modern lithium-ion batteries used in UPS systems. This report presents the detailed design methodology, simulation analysis, hardware implementation, and performance evaluation of the proposed bridgeless PFC converter. Emphasis is placed on achieving high efficiency, and effective power factor correction.

CIRCUIT IMPLEMENTATION OF HARDWARE

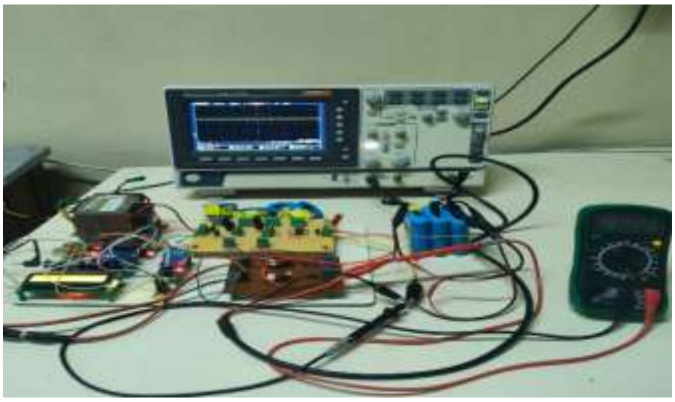

Fig.10 implementation of bridgeless sepic converter

This project focuses on the implementation of a bridgeless AC to DC PFC converter specifically designed for UPS battery charging applications. The bridgeless topology eliminates the conventional diode bridge, thereby reducing conduction losses and improving overall conversion efficiency. Furthermore, by integrating power factor correction directly into the conversion stage, the system draws a near-sinusoidal input current in phase with the supply voltage. the design methodology, component selection, simulation results, and hardware implementation of the bridgeless PFC converter. Special emphasis is placed on evaluating input current harmonics, power factor, conversion efficiency, and the converter's ability to maintain stable charging voltage and current for different battery technologies.

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VI. CONCLUSION

This project successfully demonstrated the design and implementation of a single-stage bridgeless AC to DC power factor correction (PFC) converter tailored for UPS battery charging systems. The bridgeless topology, combined with active PFC control, effectively improved input current quality by minimizing total harmonic distortion (THD) and achieving a near-unity power factor. Experimental results confirmed that the converter delivered a stable 36V DC output with low voltage ripple, and maintained a power factor of 0.72 Additionally, the system achieved high efficiency and due to the reduced conduction losses. The proposed converter meets the critical requirements of UPS systems by ensuring efficient energy conversion, compliance with power quality standards, and reliable charging performance. These results validate the bridgeless PFC architecture as a highly effective solution for compact and energy-efficient power supplies in modern UPS applications.

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