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A Novel bridgeless SEPIC Converter for Power Factor Correction

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Abstract

In this paper, a new Power Factor Correction controlling technique using bridgeless SEPIC (single-ended primary induction) AC-DC converter with fuzzy control is proposed. The converter design has single switching device of MOFET, to reduce switching losses. This design also has Voltage and Current loop controlling technique to improve the Power Factor and output Voltage. Fuzzy logic controllersetup also improves the controller responses in this circuit. The output voltage depends on the switching frequency of the MOSFET. This proposed converter produces low conduction loss, low total harmonic reduction and high power factor reaching near-unity. This converter circuit is simulated with universal input voltage of 190V - 220V DC output Voltage connected to resistive load. All the simulation work is done using MATLAB – Simulink.

*Keywords:*PFC; PI controller; BLSEPIC;Current controller; THD;Power Factor;Voltage controller

1. Introduction

Recently, power quality of the AC system has become a great challenge due to the heavy increase in Power electronic devices [1], [2]. The current flowing through power semi converter devices from the main, resulting in a

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high Total Harmonic Distortion (THD) and low Power Factor (PF) [3],[4]. The Power factor correction (PFC) plays an essential role in eliminating input power loss. Input power loss may emanate from input current harmonics. A PFC places the input current in phase with input voltage waveforms. When Power Factor is 1.0, the input Current is perfectly in phase with the input Voltage

Single-Ended Primary Inductance Converter (SEPIC) is a AC-DC buck-boost Rectifier that provides an output Voltage that changes from above to below the output Voltage [5], [6]. The output of this converter is positive, hence this is recommended in applications such as battery chargers, fan, Air-conditioners, motor drive and home appliances. The SEPIC has two separate inductors, making the power-supply entirely vast.

Bridgeless PFC topologies are currently gaining increasing interests. Generally, bridgeless PFC converters suffer from the difficulty of implementation of control circuit because of 2 switch, but a bridgeless topology can reduce conduction losses from rectifying bridges; thus, overall system efficiency can increased. In addition, a bridgeless topology has the advantage of total harmonic distortion (THD) decreasing from input diode reduction [7], [8].

More than that, due to strict needed things of improved power quality at input AC mains several standards been developed and are enforced on the consumers such increases cost, size, weight, and losses in the system [9]. These issues can be avoided utilizing newly developed single-stage improved power quality-DC converters; a new bridgeless SEPIC topology is explained in this paper. Unlike the boost, the SEPIC and bridgeless SEPIC converters have many several benefits in PFC applications, such as easier implementation of transformer isolation, input surge current limitation during start up and full-load conditions, lower input current ripple, and less electromagnetic interference.

2. Operation of the SEPIC Converter

2.1. Basic Circuit Diagram of SEPIC

The single ended primary inductance converter (SEPIC) is a DC to DC converter allowing the electrical voltage at it output to be greater than, less than or equal to its input. The SEPIC converter contains inductors L1 and L2, single MOSFET (S1), capacitor C1, diode D and output capacitor C2 and the circuit is shown in Fig 1.

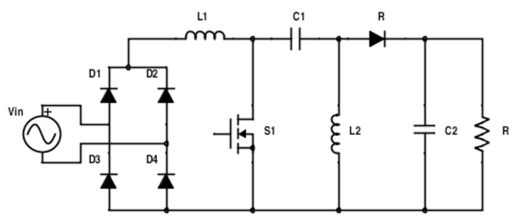


Fig 1:Basic SEPIC circuit

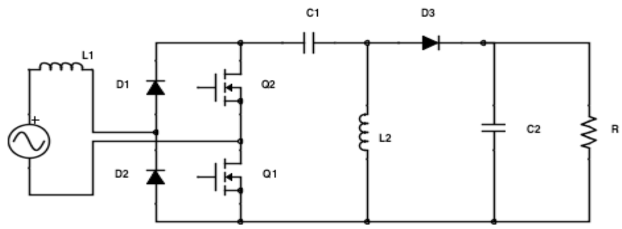


Fig 2:Basic Bridgeless SEPIC Circuit

2.2. Basic Circuit Diagram of Bridgeless SEPIC

The basic single stage Bridgeless SEPIC circuit is shown in Fig 2. In this system, there are two MOSFET switch replacing diode bridge rectifiers, which helps to reduce high conduction losses. But the controller circuit is complex to implement. And the size of the system too high. The circuit diagram of Bridgeless SEPIC is shown in Fig 2**.**

2.3. Design Calculation of Bridgeless SEPIC Converter Circuit

The fundamental operation of the SEPIC converter is, at the point when the switch S1 is turned on, the inductance L1 is charged, in the meantime the inductance L2 reads energy from the capacitance C2.The output

Capacitance Co supplies the load. At the point when the MOSFET switch S1 is turned off, L1 charges C1 and also supplies the current to load. L2 is connected to the load.

$Vo = Vin * D / (1-D)$ (1)

$D = (1 + VD) / (Vin + Vout + VD)$ (2)

$L1 = L2 = D * Vin / \{fs(\Delta I\ L1)\}$ (3)

$C2 >= (Iout * D) / Vripple * 0.5\ fs$ (4)

$Voltage\ error = Vref - Vo$ (5)

$I\ ref = Vref - Vo) / r(t) * \sin\omega t$ (6)

Using the equation (1),(2),(3),(4),(5) and (6) ,the SEPIC Converter is designed for a constant link voltage Vout =60V , Vin= 195 V to 230V, I=2.5A, L1=L2=L=156µH , C1=171µF, C2=33µF and fsw=10KHZ.

3. Operation of Proposed Bridgeless SEPIC Converter

3.1. Propose System circuit diagram

The Proposed system Bridgeless SEPIC circuit is shown in Fig 3. In this proposed system, there is single MOSFET switch replacing the two MOSFETs, which helps to reduce high conduction loss and reduce the size of the converter. In this proposed to reduce the complexity of controller circuit. The closed loop of Bridgeless SEPIC converter circuit shown in Fig 4. In this system has two loop control method. One is outer layer (voltage control) and another one is inner layer (current control).voltage control is used to control the output voltage. The current control is used to improve the power factor. In this output Voltage is compared with reference Voltage, then divided with r (t) and then multiply with sinωt. This reference current is compared with input inductance current. And this signal given to fuzzy logic controller, generate the PWM plus using comparator.

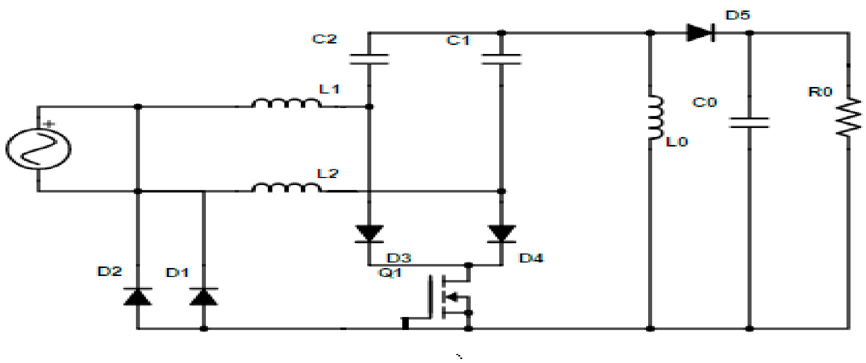


Fig 3 : Proposed system BRIDGELESS SEPIC circuit

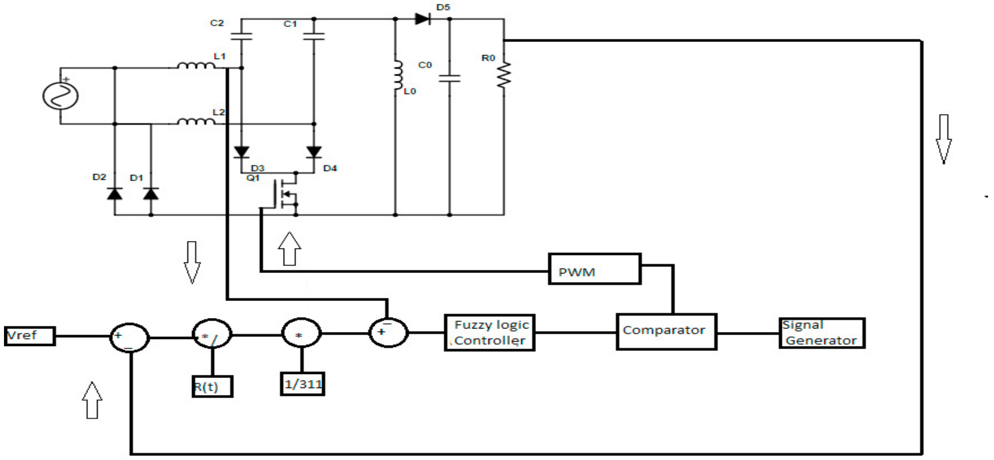


Fig 4 : Closed loop Control ofProposed system BRIDGELESS SEPIC circuit

3.2. Modes of Operation of Bridgeless SEPIC

Fig 5 shows the OFF state diagram for switch Q1, in which switch is off and the diode D1 is ON. Inductor L1charges the capacitance C2 and provides the load current. The Inductor Lois connected to load: it charges the output capacitance Co and provides the load current. Fig 6 shows the ONstate diagram for switch Q1, in whichswitch Q1 is ON andthe diode D1 is on. Inductor L1 charges the capacitor C 1 andprovidestheload current. The Inductor L2 is connected to the load: it chargesthe outputcapacitorCo and providestheload current.

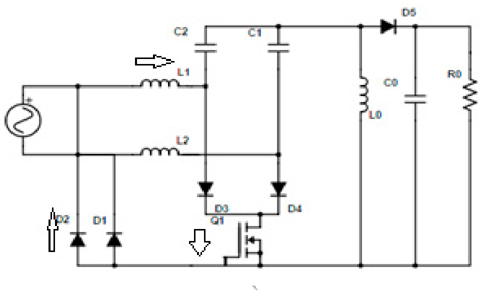


Fig 5 : Switch Q1(ON-state)

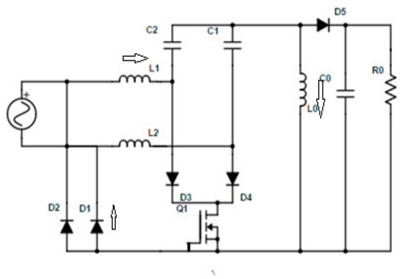


Fig 6 : Switch Q1(OFF-state)

3.3. Simulation circuit diagram of Proposed system

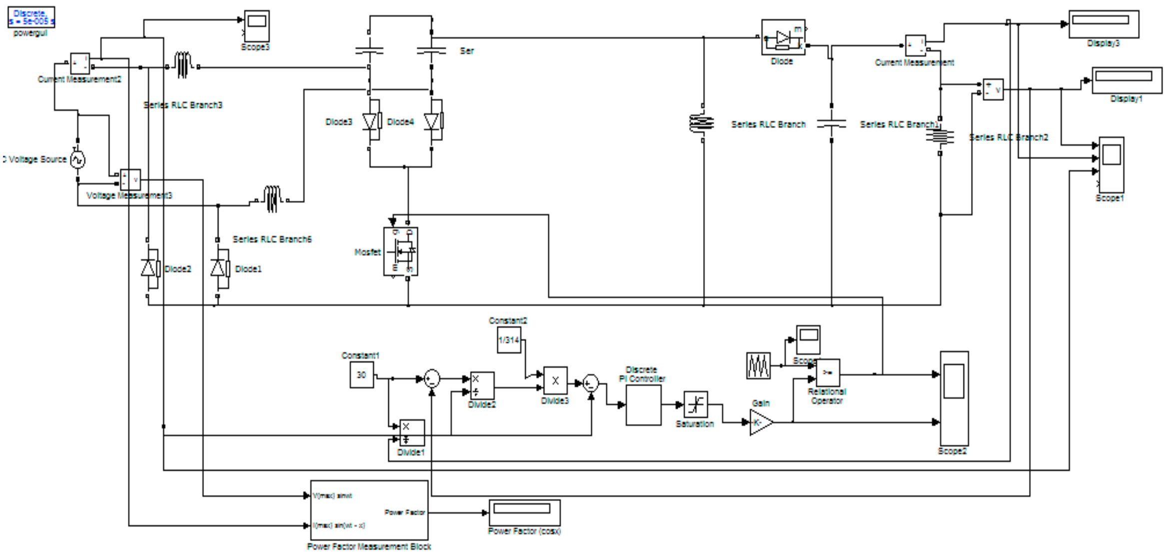


Fig 6 : matlab simulation diagram

3.4. Fuzzy Logic Controller

The Fuzzy Logic controller is designed to improve performance of control behaviour of the convertersystem in load and parameter variations. The proposed fuzzy logic controller is shown in Fig 7.

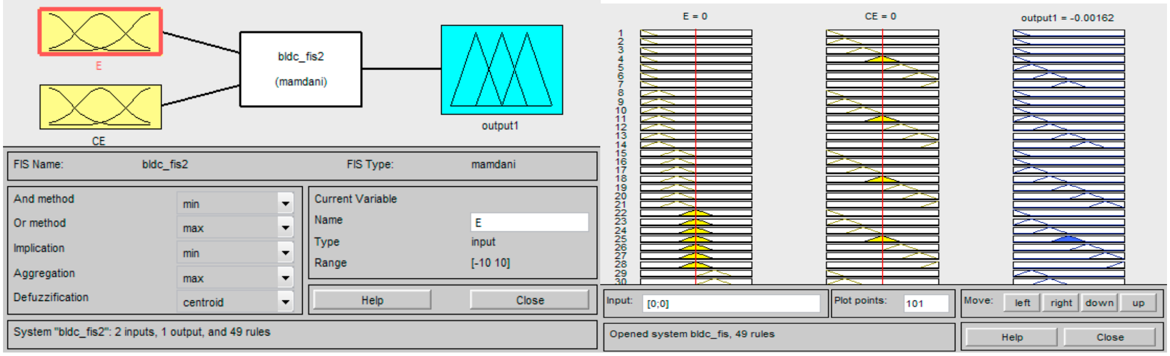
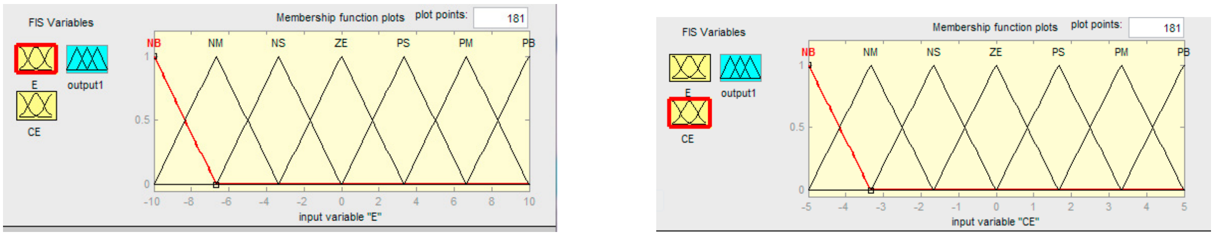
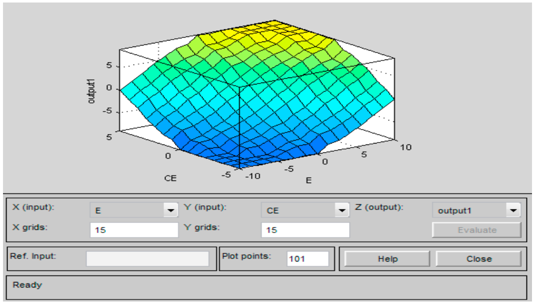


Fig 7: Fuzzy Logic Controller

Fuzzification is the first part inside the controller which reads input data and converts to degrees of membership functions. The input membership function is shown in Fig 8(a).Input membership functionThe second part of the fuzzy controller is fuzzy reference which contains knowledge base and decision making rules. It is a process to formulate the mapping from the given input to an output based on decision making rules. There are two types of fuzzy inference namely Mandani-type and Sugeno-type. In this paper, Mandani type is selected. The below Table list the fuzzy rules. The Fuzzy surface viewer is shown in Fig 8(b).



(a) Input membership function



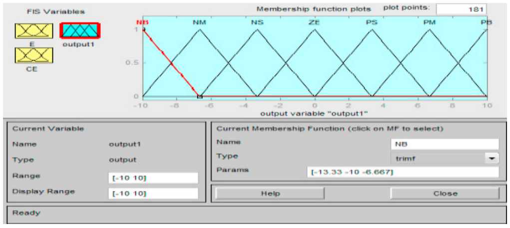


Fig 8 (b): Surface Viewer

Table.1: Formingthe Fuzzy rule use these condition

e \ ce	NB	NM	NS	ZE	PS	PM	PB
NB	PB	PB	PB	PB	PM	PS	ZE
NM	PB	PB	PB	PM	PS	ZE	NS
NS	PB	PB	PM	PS	ZE	NS	NM
ZE	PB	PM	ZE	NS	NM	NB	NM
PS	PM	PS	ZE	NS	NM	NB	NB
PM	NS	ZE	NS	NM	NB	NB	NB
PB	ZE	NS	NM	NB	NB	NB	NB

Using the Table1, this proposed system Fuzzy logic rules are formed and consented Fuzzy controller for Bridgeless SEPIC Converter and generate the PWM pluses using relational operator. In this PWM pluses has given to MOSFET.

3.5. Output waveform of Proposed system

The simulation waveform shown in Fig9.Input Current wave form show in Fig9(a) and zoom picture shown in Fig9(b).The Output voltage waveform is shown in Fig10(a).The Output current waveform is shown in Fig 10(b)and zoom picture in Fig(c).the Table 2 show the proposed Bridgeless SEPIC is compared with normal Bridgeless SEPIC converter.

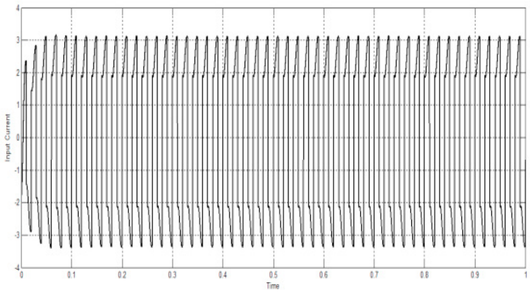


Fig 9(a): Input Current waveform

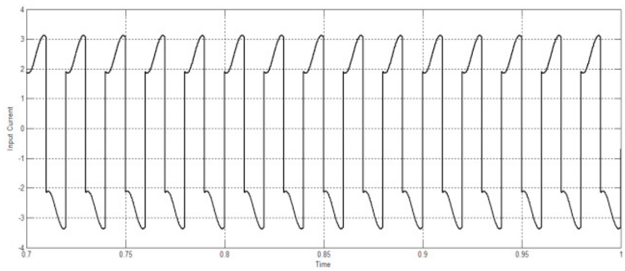
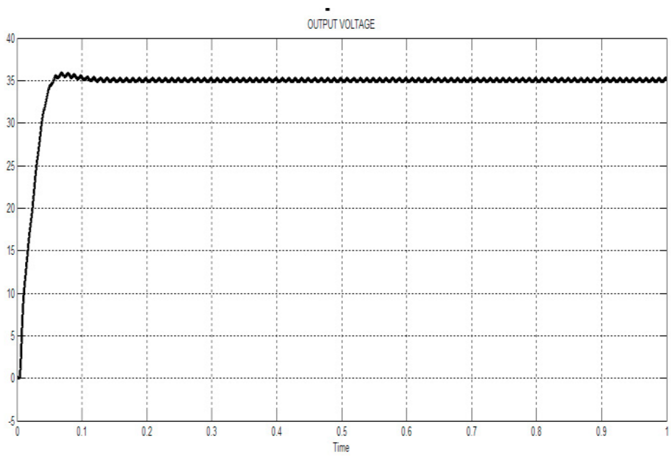
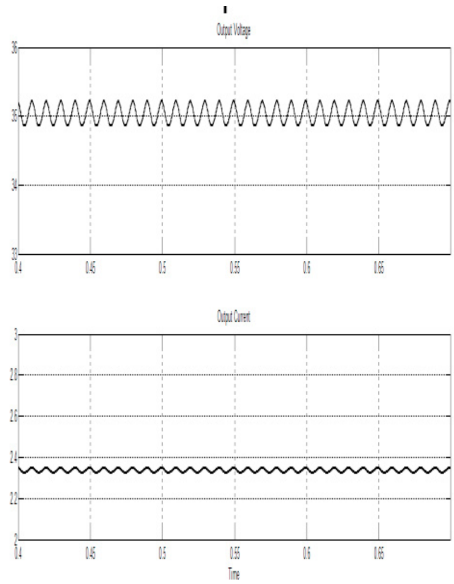


Fig9(b): Input current zoom waveform





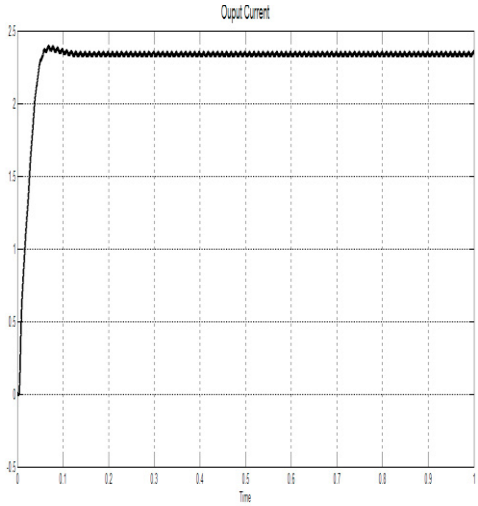


Fig 10(a): Output voltage of proposed system
Fig 10(b): Voltage and Current ripple
Fig 10(c): Output current wave form

Table 2. Comparison of Proposed Bridgeless SEPIC Converter.

An example of a column heading	Bridgeless SEPIC	Proposed Bridgeless SEPIC
No.of switches	2	1
No.of components	less	Less
Power Factor	0.91	0.998
THD	34.15	14.7
Current Ripple	0.3A	0.05A
Voltage Ripple	2V	0.8V
Cost	Medium	Less

3.1. Reading of Proposed Bridgeless Sepic Converter

In this system is simulated using MATLAB / Simulink. The input voltage is changed from 190V to 230V (normal supply voltage) and the power factor, output voltage, output current readings are taken and tabulated in Table 3the tabulated.Values are clearly showing, the power factor is maintained near-unity with less voltage and current ripple.The table showing SEPIC converter output is maintained around 35V DC.

Table 3. Various Input Voltage Performance of Proposed system.

Input Voltage (V)	Output Voltage(v)	Power Factor	Output Current
230V	35.5V	0.997	2.7A
225V	35.4V	0.998	2.6A
220V	35.2V	0.998	2.6A
215V	35V	0.998	2.6A
210V	35V	0.997	2.5A
205V	34.9V	0.997	2.5A
200V	34.9V	0.996	2.55A
195V	34.8V	0.996	2.45A
190V	34.8V	0.994	2.45A

4. Conclusion

In this paper a new Bridgeless SEPIC converter with Fuzzy controller has been proposed for low Voltage house hold applications. The topology for power factor correction has been derived from the traditional single stage AC-DC rectifier adopting single MOSFET switch in the middle. With the advanced voltage and current controlling technique, significant improvement of input power factor is verified at low duty cycles and achieved input power factor of 0.997.The Proposed system has been verified with MATLAB Simulink and the results are compared with traditional Bridgeless SEPIC. The main advantage of the Bridgeless SEPIC Converter is proved as, power factor reaching near-unity with low Voltage stress, low Total Harmonic Distortion under input voltage variations.

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