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A Review of Bridgeless Operation Topology in Power Factor Correction – A Literature Review

J.Stanly Jones[1], Dr.S.Sutha[2]
[1, 2] *Department of Electrical and Electronics Engineering, University college of Engineering, Dindigul.*

Abstract: In power electronics field, the bridgeless rectifier has increased the interest in power factor correction. In this paper review of the Bridgeless DC-DC converters topology, and controlling process are expressed at this paper, this review article is very useful to the researchers for find out the relevant references in the field of improvement of bridgeless rectifier topology and power factor, The main advantages is found.
Index Terms: Power Factor Correction (PFC), Controllers, ac/dc converters,

I. INTRODUCTION

Designing Power Factor Correction (PFC) into modern switched mode power supplies (SMPS) has evolved over the past few years due to introduction of the many new controllers. Today it is possible to design a variety of PFC circuits with different mode of operation,

A. Definition:

Power factor is defined as the ratio of real power to apparent power

$$\text{Power Factor} = \frac{\text{Real Power}}{\text{Apparent Power}}$$

Where the real power is the average, over a cycle, of the instantaneous product of current and voltage, and the apparent power is the product of the RMS value of current times the RMS value of voltage. If the both current and voltage are sinusoidal in phase, the power factor is in 1.0 [1].A bridgeless PFC converter based on novel hybrid switching method. Eliminates the full bridge rectifier altogether. The true single-stage power processing results in many advantages over conventional two stages, bridge-type PFC Converters. True Bridgeless PFC converter achieves over 98% Efficiency, almost 0.999 power factor. And bridgeless schemes used to the low-output voltage applications, such as telecommunication or computer industry,

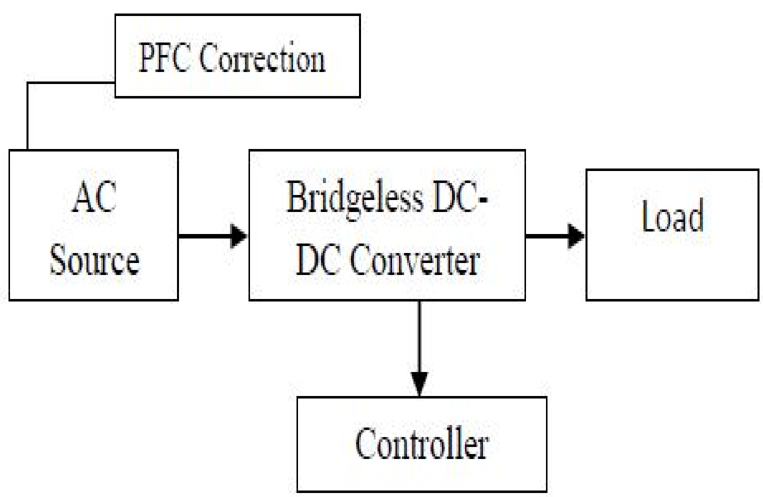

Fig 1. Block diagram of the common bridgeless PFC rectifier structure.

In general common bridgeless PFC rectifier is shown in the figure, in this paper several bridgeless converters with power factor correction, some of the controller's schemes are focusing in this review paper.

II. BRIDGELESS RECTIFIER AND CONTROL SYSTEMS

ZCT-PFC and ZVT-PFC Bridgeless topology presented in the [2], [3]. These are the conventional bridgeless topology to improve the efficiency and power factor, that the conventional topology reduced the voltage stress, in [3] SEPIC conventional topology is introduced in this paper; input rectifier is combined with conventional SEPIC topology to reduce the conduction losses. That the conventional converter operating in the CCM method [3],[4],In [4] the new topology introduced such as HRPWM ZVS AC-DC PFC converter for battery chargers purposes, these ZVS converter reduces [4],[5] the switching losses and Electromagnetic interference, the proposed circuit ZVT bridgeless topology [5] can operating at high switching frequencies, and almost improve the efficiency and power density. The classic bridgeless schemes are introduced in the [6] current flows through one diode with the power MOSFET in this topology, to reduce the common mode noise [6],[7], reduced the harmonics, switching loss is also reduced.

The conduction losses reduced and efficiency are improved in the isolated [8] dual boost bridgeless topology and switching losses reduced in the flexible bridgeless boost PFC [9]. In [10] active PFC technique of the boost bridgeless introduced, in this paper improve PF and operating in CCM mode, in which the conduction losses reduced. Current distortion reducing in the control [11] architecture topology of the bridgeless scheme, this is operating at CCM (Continuous Conduction Mode). In power correction field the SEPIC [12],[23] DC-DC converter is more flexible to have the result, this converter operating in the DCM method; the efficiency and high power factor improved [12],[3]. In [3] soft switching technique to reduced the switching loss, Isolated SEPIC configuration introduced in this paper, in which CCM/DCM mixed methods are operating and current stress is reduced in this topology in which ZVS can active for all switching converter [13]. After SEPIC bridgeless topology for BLDC motor reduced the conduction losses, the switching losses in the VSI, which problem can be minimized by an electronic commutation of BLDCM [14]. The dual mode operation bridgeless topology is introduced in this paper, this is the low power application, it reduced the conduction [15],[16] losses and operating at the DCM method, in which the zero current turn off in output diodes simply the zero current turn on in switches [15]. Another bridgeless topology introduced the voltage multiplier in which semi soft switching function and the current stress These are the PI chart for percentage of the bridgeless topology of the DC-DC converter. The boost converter performed 30% in this bridgeless topology, SEPIC converter 20% involved in this bridgeless topology and CUK,LUO,ZETA converters performed 22% at last the new topology of the novelty performed 18% of this bridgeless schemes is reduced [16].

The Bipolar gain step-up converter topology introduced in [17] these are operating in Discontinuous mode, it can be useful to the zero-current turn-off of the output diode, switching and reverse recovery losses are reduced. The another classical DC-DC CUK converter introduced in the bridgeless scheme, it is used to the low output applications in which conduction losses are reduced, it is operating in the DCM method.[18].The bridgeless and conventional operation in this paper [19] ,this circuit operating at the Continuous Conduction Mode also reduced the conduction losses. Quasi Z-source bridgeless PFC scheme is introduced in this paper In which the conduction losses caused by isolated PFC converter, so efficiency and PF is improved, and also conduction losses is reduced [20],[21],[23]. The new bridgeless hybrid resonant ac-dc PFC boost converter operating in CCM method, in which converter switches operating in PWM technique[21]. The new recent DC-DC converter LUO bridgeless scheme is introduced in this topology for BLDC motor it can be operating in the DICM (Discontinuous Inductor Current Mode) and also switching losses reduced in this paper [22]. Commonly bridgeless topologies make use of buck, boost, CUK and SEPIC converters. In [24] this paper bridgeless zeta converter controlling one cycle method introduced in this paper. Power losses issues are reduced in this topology [25], in this process mainly MOSFET used to reverse recovery problems of reducing the switches, this rectifier name 3 level power factor correction rectifier. The both bridgeless boost converter operating in the parallel this type of converter known as the bridgeless boost interleaved converter. Harmonics reduced and improve the PF. The Bridgeless topology processing in maximum of the DC-DC converter, but this review section we take some of the research paper for our survey. Main bridgeless scheme of the rectifier basic diagram is shown in the below.

A. Block diagrams

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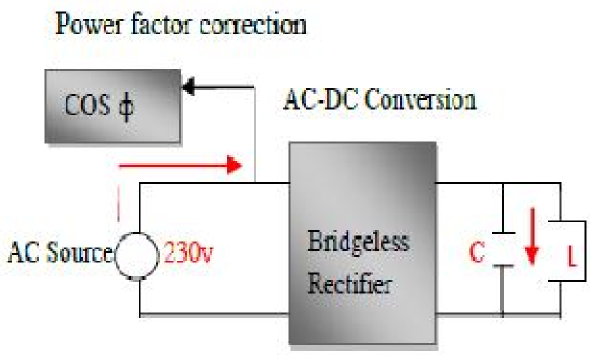
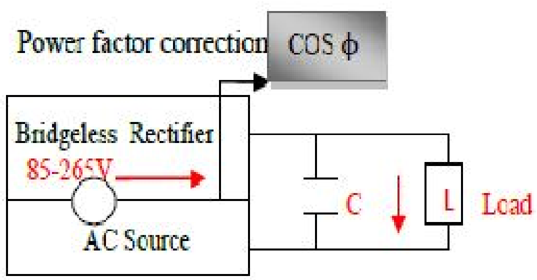
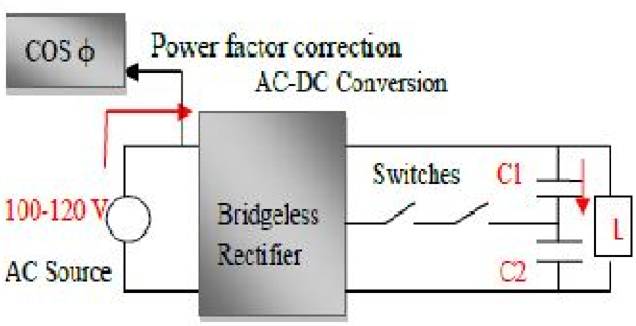
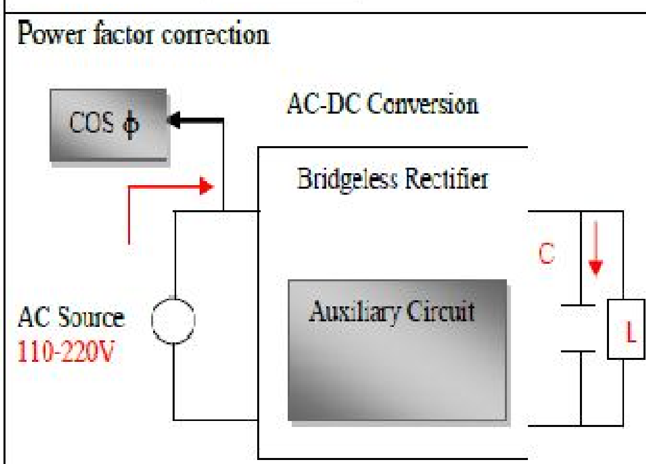
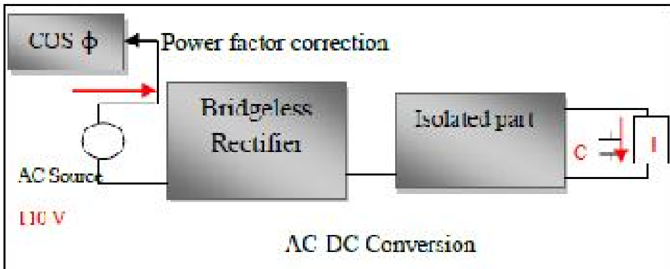
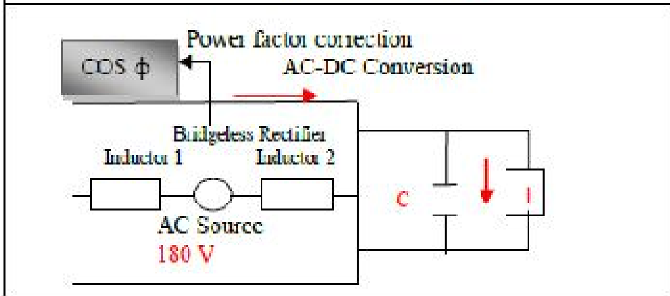
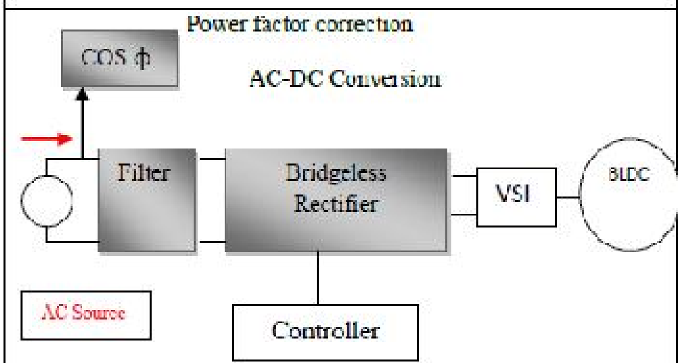
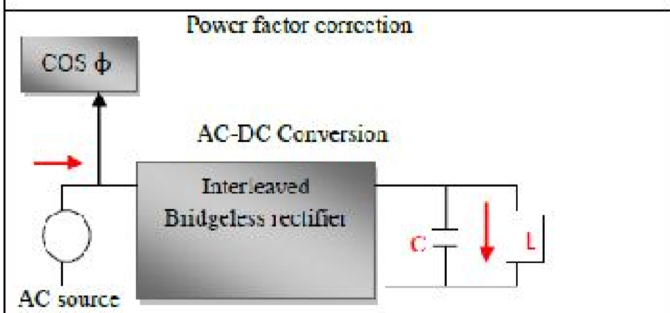
Block Diagram Of the Bridgeless Rectifier	Type of DC-DC Converter	Solved Issues
	Boost Converter	Common mode noise and harmonics, Switching losses are reduced .
	A hybrid resonant pulse-width modulation (HRPWM) bridgeless ac-dc power factor correction (PFC) boost converter	The start-up inrush current is reduced, The reverse recovery problems are eliminates.
	. The proposed flexible mode bridgeless boost PFC rectifier.	Switching loss is reduced, Common mode noise is reduced and Extra cost is reduced.
	ZVT Bridgeless SEPIC	Conduction losses is reduced, Operating in Continuous Conduction Mode (CCM),

	Bridgeless active-clamp power factor correction isolated SEPIC converter	Current stress is reduced, Conduction losses is reduced and Improve efficiency.
	Bridgeless CUK PFC	Conduction losses are reduced and Operating in DCM mode.
	LUO Converter	Switching losses is reduced, Improve power quality, Operating in DICM (Discontinuous Inductor Current Mode)
	Interleaved Boost Converter	The high frequency input ripple current is reduced, reduced the conduction losses, and reduced the high frequency ripple

III. CONTROL SYSTEMS:

Generally in control systems which are used for controlling processes or machines. Many controlling process used in the power factor correction bridgeless topology but some of controlling systems are discussed in this review paper, these details are given in the below.

A. PI Control Technique:

PI controller used for the steady state error elimination from P Controller, it has negative impact, in which speed of the system is not an issue, and it cannot decrease the rise time and eliminate the oscillations. These type of the controller achieved following papers [3],[10],[17].

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1) *Block diagram of the PI controller:* The block diagram of the PI controller is the given in the below.

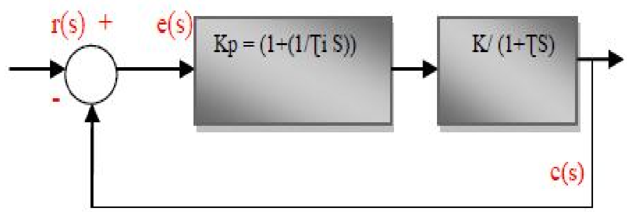


Fig. 2. Propositional – Integral Controller Block

B. PWM Technique

Pulse – Width Modulation (PWM) technique used for transformation techniques, it is mainly used to power supply of the electrical or electronics devices. In battery chargers and power factor correction techniques, the PWM techniques are needed. This control technique achieved in the following papers [2],[8],[18],[19],[21].

1) Block diagram of the PWM controller: The block diagram of the PWM controller is the given in the below.

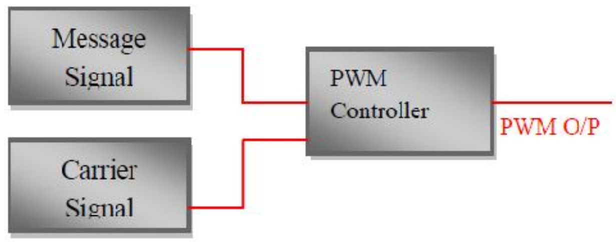


Fig. 3. PWM technique block

C. Soft Switching Technique

In soft switching technique basically consist of two methods such as ZVS (Zero Voltage Transition and ZCS (Zero Current Transition). MOSFET's is important to the ZVT techniques and also IGBT important for ZVS techniques to reduces the current problems and IGBT used for high power applications simply MOSFET switches used for high- frequency applications. These types of the techniques achieved following papers [2],[3],[4],[5],[13]

1) *Block diagram of the Soft Switching Technique:* The block diagram of the Soft Switching Technique is the given in the below.

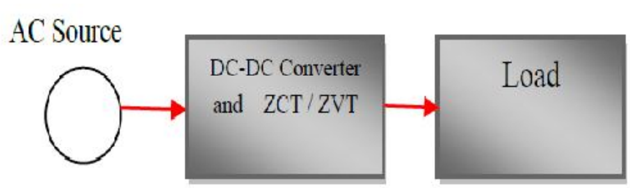
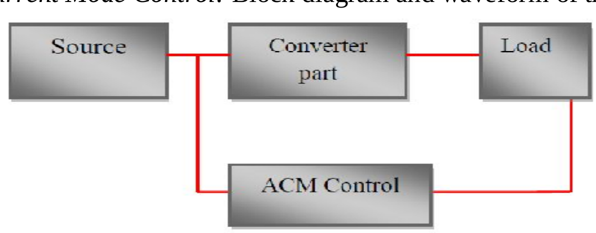


Fig. 4. Soft Switching Technique block

D. Average Current Mode control

The Average current mode control techniques importantly used in high PF preregulators. it can be achieved the low harmonics and that controllers achieved immunity of the noise. It can be used to achieve in any circuit branch, in circuit branch the current can be control and sense by the average current mode control.

1) *Block diagram of the Average Current Mode Control:* Block diagram and waveform of the ACM control is given in the below.



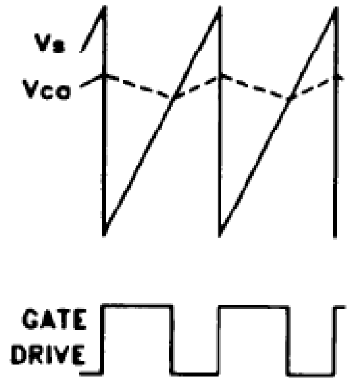


Fig.5. ACM control block and wave form

These are the power factor bridgeless topology control systems, this control systems achieved in this topology, However the another type of the control schemes are used in topologies are voltage followers controls, one cycle control, feasible control schemes and duty cycle control are successfully achieved in bridgeless topology of the power factor correction such this control topology verified in the following papers [22],[15],[24],[26],[16].

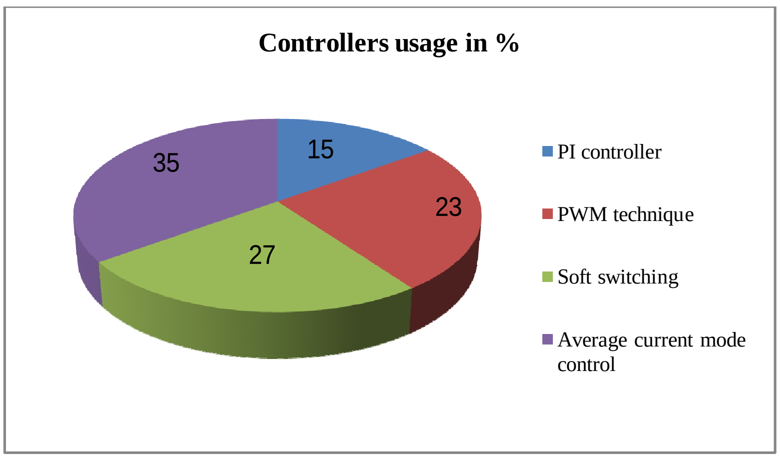


Fig. 6. Controller's usage percentage based on our reference

From our chart, 35% percentage ACM control method used n the power factor correction topology, and 25% percentage soft switching technique , PWM technique can be used to these bridgeless topology, at last the PI controller utilized only 15% in this power factor correction that operation how to utilized by researchers detail review given in the below.

IV. POWER FACTOR AHIEVED IN BRIDGELESS TOPOLOGY

In bridgeless rectifier, the power factor will be improved and maintained properly and has two types such as Passive approach and active approach.

A. Passive approach:

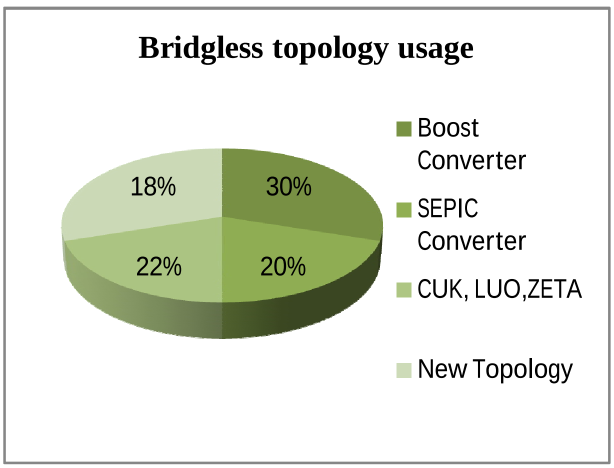
In passive approach has ac lines in between L-C filter inserted, this approach haven't high power factor, and simple structure but it has bulky size, weight components, if connected one filter to eliminate the particular type of the harmonics.

B. Active approach

In the power factor correction field, the researchers used the active approach topology because DC-DC converter employed and high frequency achieved so the sinusoidal is possible, in this approach has more advantages over the passive approach because it has small size, low harmonics, small size and weight. Hence, the unity power factor achieved by active approach. The power factor improved table are shown in the below.

TABLE I: POWER FACTOR IN BRIDGELESS RECTIFIER

DC-DC converter	Reference Paper No	Power factor achieved
Boost Converter	[6 to11-26]	0.91 to 0.99
SEPIC Converter	[3-12 to 16-19]	0.9 to 0.99
Soft Switching	[2-4-5]	0.95 to 0.96
CUK Converter	18	0.98
LUO and ZETA	[22-24]	0.9 to 0.97
New Topologies	[17-20-21-23-25]	Almost 0.9



These are the PI chart for percentage of the bridgeless topology of the DC-DC converter. The boost converter performed 30% in this bridgeless topology, SEPIC converter 20% involved in this bridgeless topology and CUK,LUO,ZETA converters performed 22% at last the new topology of the novelty performed 18% of this bridgeless schemes.

V. CONCULSION

A review of this paper described the Bridgeless DC-DC converter, block diagram of the rectifiers, how to controllers achieved in these methods and power factor improvements are explained. Recent days the classic converters are performed but in future main new topologies of controllers and converters will involve in these research fields by researchers. Therefore, today topologies might not be used tomorrow. The next level new concept of the literature review is continuing another way.

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