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An Review of Power Factor Correction in SRM Drives Using Bridgeless Converters

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Abstract

This paper deals with a comparative analysis of various converter topologies for Power Factor Correction (PFC) in switched reluctance motor drives. Hence a power factor corrected converter required for obtaining the improved PQ at the AC mains for an inverter fed SRM drive has been analyzed. The SRM when fed by a DBR with a high value of DC-link capacitor results in highly distorted supply current and a poor power factor. A new bidirectional bridgeless LUO converter is used. The bridgeless LUO converter is a mixture of two dc-dc converters with one or two semiconductor switches in the current flowing path thereby reducing the current stresses in the active and passive switches. Circuit efficiency is further improved as compared to conventional Converters. LUO converters are new series of DC/DC Converters that have very low ripple of voltage and current and have output wave with high quality, high transfer voltage gain and high power density.

Keywords: *power quality (PQ), power factor correction (PFC), bridgeless converters, LUO converter, switched reluctance motor (SRM)*

1. Introduction

The SRM are becoming popular in many low and medium power applications. Switched Reluctance Motors (SRM) have intrinsic advantages such as simple structure with non-winding construction in rotor side, high tolerance, robustness, low cost with no permanent magnet in the structure and it operate in high temperatures or in intense temperature variations [1]. The SRM is an electric machine it converts the reluctance torque into mechanical power. In SRM, both the rotor and stator enclose a structure of projected-pole, due to projected poles it produce a high output torque. Hence it is also known as an electronically commutated motor. The disadvantages of this type of motor are the pulsating nature of their torque and they can be acoustically noisy [1].

Power quality problems have become important issues in these motors due to the recommended limits of harmonics in supply current by various international power quality standards such as the International Electro technical Commission (IEC) 61000-3-2 [1]. So the power factor correction has led the circuit designers to look closely at all sections of the circuit and develop possible lower loss alternatives. One section that contributes significantly to the losses is the input bridge rectifier. As a result, the alternatives to eliminate the diode bridge or convert it into a dual-use circuit have been explored for many years. This removal/adaptation of Diode Bridge brings about its own set of challenges.

2. Types of Bridgeless Converters

Bridgeless converters are becoming more popular in order to increase the power factor at the ac mains. The distinguishing characteristic of a bridgeless PFC converter is that it eliminates the need for a diode bridge at the input. This decreases power losses that usually occur in a diode bridge and, as a result, improves overall system efficiency with comparable cost savings. Power Factor Correction rectifiers are used to improve the rectifier power density and to reduce noise emissions via soft switching techniques or coupled magnetic topologies [1].

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2.1. Bridgeless Boost Converter

Figure 1 shows the Bridgeless Boost Converters. A bridgeless boost rectifier with low transference losses and reduced diode reverse-recovery troubles is projected for power-factor correction**.**

Similar as predictable Boost Rectifier output voltage is superior than the peak output voltage, Continuous input current, eliminates input filter, Pulsed output current increases output voltage ripple, Output voltage is always greater than input voltage, Lack of galvanic remoteness, large start up in rush currents.

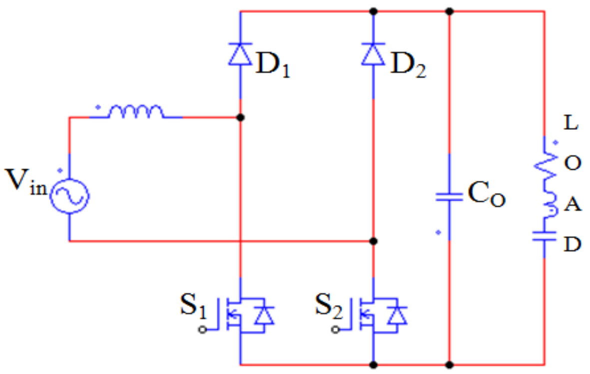

Figure 1. Bridgeless Boost Converter

For low voltage applications such as telecommunication, computer industry an additional converter (or) an isolation transformer is required to step down the voltage [2]. Boost PFC converter generates a high voltage stress (>1000V) in the wide input voltage range of adaptable electronic Components, especially in high voltage input condition.Therefore, it is very complex to choose the components and energy storage space capacitor of later stage secluded converter over buck boost converter [3].

2.2. Bridgeless Buck-Boost Converter

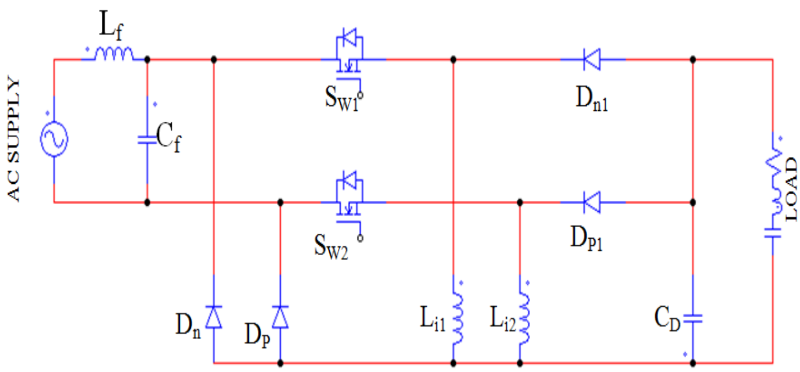

Figure 2. Bridgeless Buck-Boost Converter

Figure 2 shows the Bridgeless Buck-Boost Converter. Advantages of a buck - boost converter are Continuous output current results in lesser output voltage ripple, Pulsed input current, requires input filter, Pulsed output current increases output voltage ripple, Output voltage can be either smaller or greater than input voltage [4].

2.3. Bridgeless CUK Converter

Figure 3 shows the Bridgeless CUK Converter. CUK converter is actually the cascade combination of a boost and a buck converter. CUK converter is one such converter. It has the following advantages. Continuous input current, Continuous output current, Output voltage can be either greater or less than input voltage.

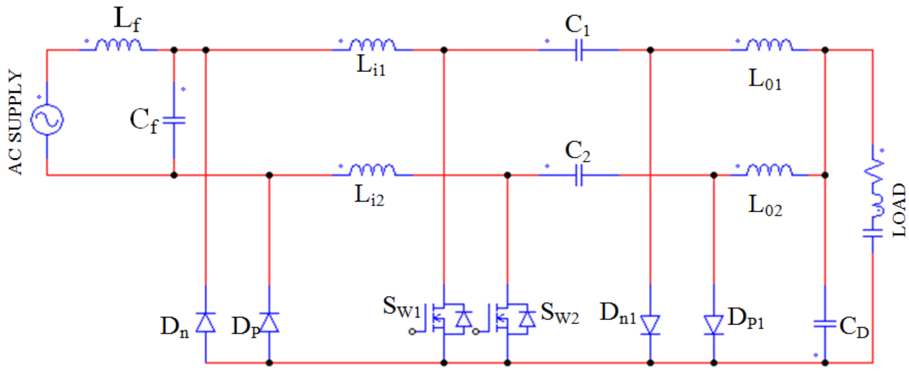

Figure 3. Bridgeless CUK Converter

The bridgeless Cuk converter operating in a DICM gives an inherent PFC and requires a simple voltage follower approach for the voltage control and requirement of low size of heat sink for the switches [5-6].

2.4. Bridgeless SEPIC Converter

Figure 4 shows the Bridgeless SEPIC Converter. The SEPIC officially stands for "Single-Ended Primary Inductance Converter". However, the unofficial explanation is more expressive: "Secondary Polarity Inverted Cuk". At any given instant, three semiconductor devices exist in the power flow path [7].

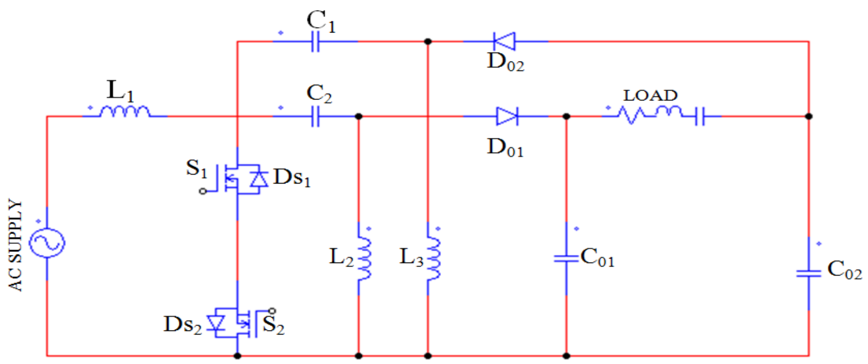

Figure 4. Bridgeless SEPIC Converter

Also, special design of the dc-side inductor is necessary to carry the dc current as well as high-frequency ripple current. This converter has three extra passive elements which contribute to the volume and weight of the converter. Another main problem with this converter is that it doubles the output voltage which significantly increases the size of output filter [8].

2.5. Bridgeless ZETA Converter

Figure 5 shows the Bridgeless ZETA Converter. The benefits of the ZETA converter over the SEPIC converter include lower output-voltage ripple and easier compensation. The ripple current in the load is greater for Cuk and ZETA converters than SEPIC. The drawbacks are the requirements for a higher input-voltage ripple, a much larger flying capacitor [9-10].

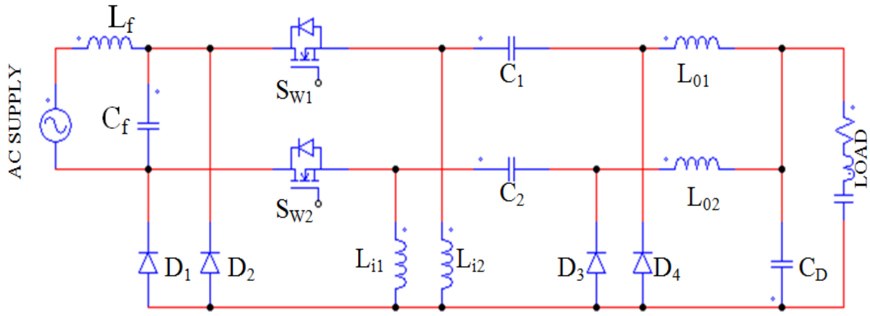

Figure 5. Bridgeless ZETA Converter

2.6. Bridgeless LUO Converter

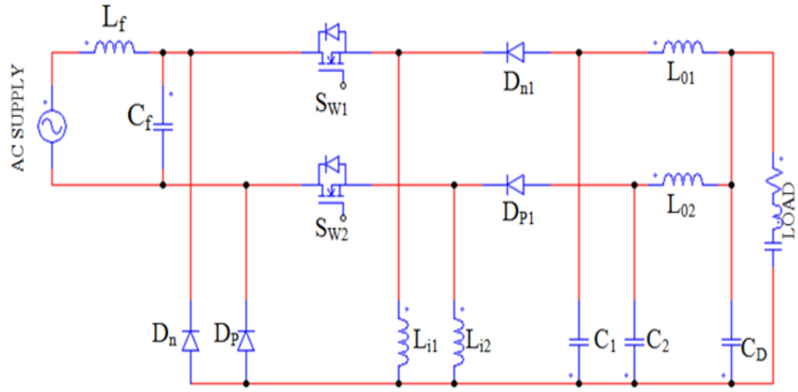

Figure 6. Bridgeless LUO Converter

The BL-LUO retains all the advantages of the conventional converter system such as small size, high power density and micro power consumption and at the same time adds some additional benefits such as, low or no inrush current; improve resistance to failure switching and EMI distortions, relatively simple start-up, voltage and current ripple is less in output, it is a bidirectional converter etc [11].

In the current study, the developed Bridgeless luo converter has been shown to be capable of providing a topology tha reduces the output ripple and parasitic effects. Using this method stable and ripple free output is obtained.

CONVERTERS NAME	NO.OF DEVICES				SUITABILITY FOR SRM DRIVE	LINE CURRENT WAVEFORM	POWER LEVEL
	Switch	Diode	Inductor	Capacitor			
BL-BOOST	2	2	1	1	No	Good	Low to Medium
BL-BUCK BOOST	2	4	2	1	No	Excellent	Low to Medium
BL-CUK	2	4	4	3	Yes	Poor	Low to Medium
BL-SEPIC	2	2	2	4	Yes	Poor	Low to Medium
BL-ZETA	2	4	4	3	Yes	Poor	Low to Medium
BL-LUO	2	4	4	3	Yes	Excellent	Medium to High

All the Bridgeless converters have at least one of the following Drawbacks: 1) High components count, 2) Components are not fully utilized over whole ac-line cycle, 3) Complex control, 4) Dc output voltage is always higher than the peak input voltage, 5) Input–output galvanic isolation cannot be easily implemented, and 6) Due to floating ground, some topologies require additional diodes and/or capacitors to minimize EMI.

4. Conclusion

Comparative analysis of different types of Bridgeless converter topologies for power factor correction in SRM drives has been discussed. For elevated power SRM drives BL-LUO converter is for the most part suitable. It gives the high efficiency output, reduced torque ripples and good speed response for the SRM drives when compared to the conventional PFC converters.

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