ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 9, Issue, 02, pp.47144-47148, February, 2017

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

POWER FACTOR IMPROVEMENT USING DC-DC CONVERTER IN BLDC MOTOR DRIVES

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ARTICLE INFO

Article History:
Received 23rd November, 2016
Received in revised form
20th December, 2016
Accepted 09th January, 2017
Published online 28th February, 2017

Key words:

Power Quality (PQ),
Power Factor Correction (PFC),
Bridgeless converters,
Cuk Converter,
Bridgeless isolated cuk converter,
Brushless dc motor (BLDC).

ABSTRACT

This paper deals about the Power Factor Correction (PFC) in Brushless motor drives by comparing various DC-DC converter. Power factor corrected converter is essential to improve the Power quality (PQ). Speed control is done by Voltage Source inverter (VSI). In order to reduce conduction loss and number of components, diode bridge rectifier is eliminated. It is used to operate in DICM mode. The Brushless DC motor is fed by bridge rectifier with a elevated rate of DC-link capacitor. It consequences in extremely pulled supply current and a poor power factor. To achieve power factor near to unity is used to new bidirectional bridgeless isolated CUK converter. When compared to conventional Converters Circuit efficiency is further improved.

Citation: Vignesh, L. and Kaliappan, S. 2017. "Power factor improvement using dc-dc converter in BLDC motor drive", *International Journal of Current Research*, 9, (02), 47144-47148.

INTRODUCTION

Brushless DC motors are recommended for an many applications due to the absence of mechanical commutator. It causes less need maintenance and low EMI problem. Brushless DC motor is more energy efficient than brushed DC-motors. The Brushless DC motor is smaller because its body has less heat to dissipate. It is applicable in many household appliances. Some of the advantages such as reduced size, higher efficiency, no voltage drop across brushes, low electric noise (Singh, 2013). BLDC motor consists no of brushes and commutator. Rotor consists of Permanent Magnet, where stator consists of number of windings. So the current direction of the conductor on the stator controlled electronically. Hall sensor is used to determine the position during commutation. Rotor position depends on the accurate position with stator. It has semiconductor switches to turn the stator winding on and off at appropriate time. Switches current from winding to winding forcing the rotor to turn by varying pulse motor is rotated (Vashist Bist, 2013). Electronically commutated motors are different from other motors like brushless DC motors.In brush-type motors, commutation is done with a commutator and brushes. In brushless motor with an electronically commutated, it is achieved by switching electronics.

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It obtains information on the position of the rotor by means of sensors with the help of microprocessor. Electronic commutation is achieved by using an three phase voltage source inverter (VSI) (Sahid, 2011). BLDC motor is connected after the diode bridge rectifier (DBR) and DC link capacitor. When DC link voltage is higher than the supply voltage .It draws current only for a small duration. Therefore, peaky current is strained from the AC supply, it has elevated rate of harmonics which lead to deprived power factor (PF) (Bist and Singh, 2014). Power factor correction (PFC) converters are used to improve power factor.

The requirement of sensor plays major role in determining overall cost of the system. There are two mode of operation such as Continuous inductor current mode (CICM) and discontinuous inductor current mode (DICM) (Bhim Singh and Vashist Bist, 2015). In the entire switching period the current in inductance remains continuous. In CICM, or continuous conduction mode (CCM), whereas the current becomes discontinuous in DICM or DCM mode. 2-Voltage and 1-Current sensors are required in CCM mode and it has lower current stress. In DICM single voltage sensor is required. It has low voltage stress and cost is low (Yie-Tone Chen, 2013). In conventional method cuk converter is used for power quality improvement at AC supply. It maintains constant DC link voltage. High switching loss is occurred so the bridgeless configuration is introduced.

Bridgeless Converter

Types of Bridgeless converter: Bridgeless means Diode Bridge is eliminated at frontend. It reduces the number of semiconductor components. Switching loss and power losses is reduced. It usually occurs in a diode bridge and as a result overall system efficiency is improved. The occurrence of two semiconductors switches in the current path through out interval it consequence in a smaller amount conduction losses (Jang and Jovanovic, 2009).

B. Bridgeless Boost converter: Figure 1 shows the Bridgeless Boost Converters. Abridgeless boost converter with low common mode noise is presented in this paper. The numbers of components are condensed by the magnetic components such as transformer and inductor on same core. Bridgeless power factor correction (PFC) circuit topologies are used to maximize the power supply efficiency and conduction loss is reduced and the number of semiconductor components in the current path is condensed. By replace a couple of bridge rectifiers and employ an boost inductor is implemented. In bridgeless type, one rectifier is get rid of from the contour path reduce the conduction loss. The further type works mutually in continuous conduction mode (CCM) and discontinuous conduction mode (DCM). This figure 1 utilizes the totem-pole collection in the reverse recovery performance of the anti-parallel diode. It can work only in DCM mode .It makes CCM operation impractical. High common-mode noise produced in realistic application is vulnerable by a lofty frequency switching. This implementations does not bear from the lofty noise problem (Jang and Jovanovic, 2009). Bridgeless boost rectifier has several realistic problems. It has elevated output voltage than the crest input voltage, deficient in galvanic isolation and elevated initiate and inrush currents. An extra converter or isolation transformer is necessary for small output voltage purpose, for instance telecommunication or computer to step-down the voltage. Three semiconductors in current transmission path throughout all switching cycle is still suffers (Abbas, 2012).

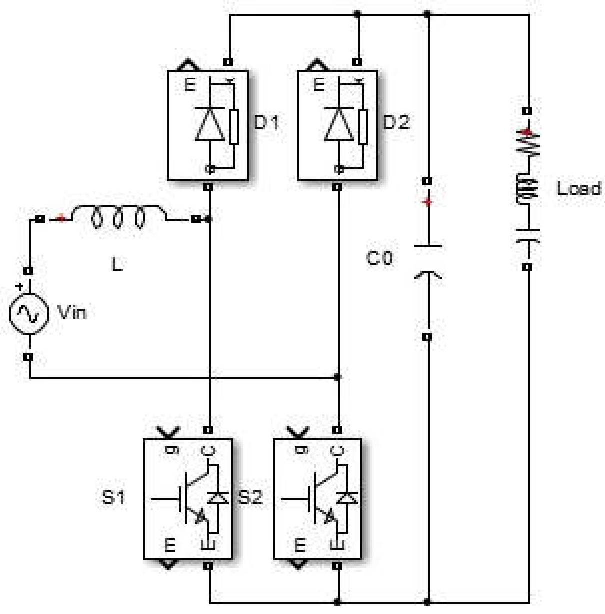

Fig 1. Bridgeless Boost Converter

Bridgeless Buck-Boost Converter: Figure 2 shows the Bridgeless Buck-Boost Converter. This converter is considered to work in DICM to offer natural PFC at AC supply. Rate of BLDC motor is prohibited by single voltage sensor. The commutation of motor provides a compact switching losses and frequency switching is specified by means of this commutation. In BL configuration eradication of the diode bridge rectifier diminish the conduction losses related in it. Figure 2. Bridgeless Buck Boost Converter Due to the usage of a smaller amount of apparatus and a single switch single stage PFC converter has high effectiveness when evaluate to two stage converters. The ranking of the apparatus used in the converter create a serious concern since it straight affects the modes of converter. Two modes are continuous conduction mode (CCM) and discontinuous conduction mode (DCM). The current or the voltage in the inductor remains uninterrupted in CCM mode [2] .It Sense dc linkage voltage and supply voltage. Single voltage sensor is needed for DCM. Hence, for low-power applications DCM mode is preferred. Bridgeless Buck –Boost converter has pulsed input current and hence it require input filter. It has peak input current in power component. Power transient response makes it less efficient (Vashist Bist and Bhim Singh, 2014).

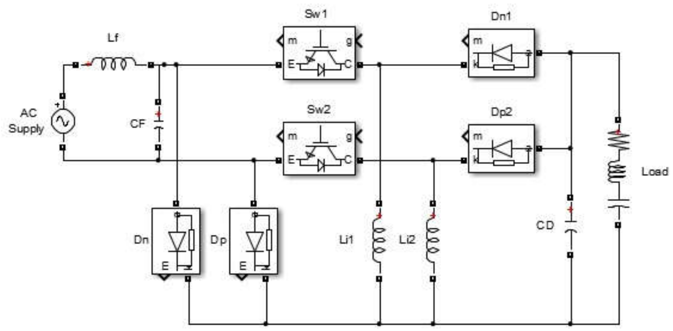

Fig. 2. Bridgeless Buck – Boost Converter

Bridgeless SEPIC Converter: Figure 3 shows the Bridgeless SEPIC Converter. In bridgeless sepic converter extraordinary intend of dc side inductor is required to bear dc current and elevated rate of wrinkle current. It requires three additional passive element. It adds the amount and mass of converter.It twice the output voltage and amount of output filter is increased. While working in Continuous conduction mode Voltage and current loop is necessary for usual PFC converters. When the converter function in discontinuous conduction mode the power circuit is easy and current loop is not necessary for the proposed converter. In Buck converter offline small voltage power provisions is chosen to have worse output than the input voltage. On the other hand, the buck converter has irregular input current and a further passive filter is used to filter the current. To determine this trouble, single ended primary inductor converter (SEPIC) and Cuk converters is used. Control circuit is necessary in CCM mode, but in DCM, converter can work at permanent duty cycle to accurate the input power factor (PF) [11]. In the power flow path three semiconductor devices is already exist. To bear the dc current and high-frequency wrinkle current a unique design of dc-side inductor inessential. The bridgeless rectifier is projected to conquer these problems. Therefore to contour input current towards the sinusoidal waveform additional passive filter is needed. The converter is working in DCM due to the continuous input current. Three additional passive elements of this converter have add the mass and volume of converter. It twice the output voltage and volume of output filter is increased. Bridgeless EPIC converter is establishing to conquer these limits while compared to conservative SEPIC PFC. However the converter has no supplementary elements.

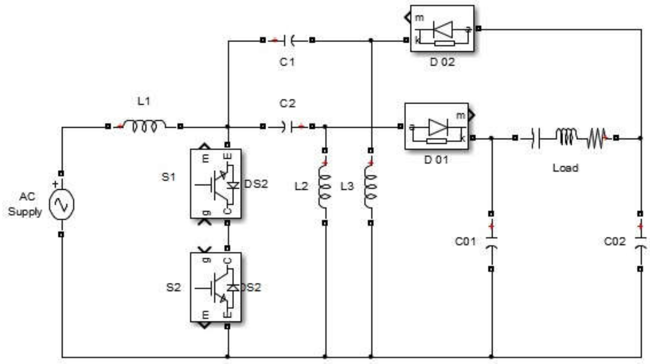

Fig. 3. Bridgeless SEPIC Converter

Bridgeless ZETA Converter: Figure 4 shows the Bridgeless ZETA Converter. Single voltage sensor is used for devious voltage. PWM (Pulse Width Modulation) is the method used conventionally. VSI is novel scheme for calculating the speed and voltage. In BL-Zeta converter voltage follower technique is used in favour of voltage control which is operating in DCM (Discontinuous Conduction Mode). The concert of projected drive for a various choice of speed and voltage is satisfactory. Switches stresses and heat sink design are also analysed for their selection. To progress the power quality of BLDC it cannot be used for feeding. Boost converter with two stages is mostly chosen to work in DCM mode and for voltage control a buck-boost converter has been generally used. Two independent controls is essential or two stages. Owing to multiple stages losses is increased Figure 4. Bridgeless ZETA Converter to overcome these disadvantages PFC converters with single stage is utilized for voltage control. Stresses in voltage and current is take place across the switch. Stresses across the switch is low in CCM mode but current multiplier approach is complex and two-voltage sensor and one-current sensor totally three sensors are required. Voltage follower approach for DCM mode is simple.

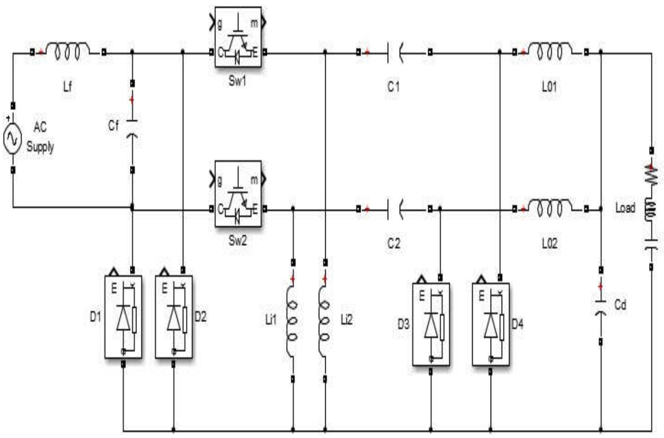

Fig. 4. Bridgeless ZETA Converter

Single voltage sensor is required but higher stresses occur across the switch. For a low power rating DCM mode is preferred. It limits stresses across the switch, whereas for high power ratings CCM mode is used. Generally two switches are accomplished alternatively for positive and negative half cycle. Power Factor Correction of Zeta converter is extensively used for diverse applications. For the improvement of BLDC motor Bridgeless configuration in Zeta converter is still unexplored in low cost. BL-Zeta converter with reduced sensor is offered. High efficiency is achieved by reduced switching and conduction losses. In the front end converter suitable rating of MOSFET (Metal Oxide Semiconductor Field Effect Transistors) is used. Whereas for low frequency operation IGBT (Insulated Gate Bipolar Transistors) are used in VSI. Therefore switches and heat sink are selected. Commutation of BLDC motor electronically is achieved with fundamental frequency switching. Due to ringing high voltage stress is caused by the resonance (Vashist Bist, 2013).

Bridgeless CUK Converter: Figure 5 shows the Bridgeless CUK Converter. CUK converter in fact is a grouping of buck and boost converter. The process during each sub-interval is discussed. Current Injected Equivalent Circuit Approach (CIECA) is a new technique that represents the minute and bulky indicator. Power factor correction (PFC) circuit produces more unusual concern for the earlier period. Due to its capacity switch-mode power supply (SMPS) draws energy from the mains efficiently. Two diode rectifiers are conduct repeatedly in usual converter but in bridgeless converter one diode rectifier is conduct, particularly in trigger state. Efficiency of the converter is enhanced by soft-switching technique and reducing the energy loss in all component. Though, in Boost converter output voltage intensity is elevated for all time than the input voltage. The voltage intensity is about 50V or additional for a general PFC converter, whereas the majority of the electronic applications control at 5V to 50V DC for all time. To decrease intensity of voltage another cuk converter is introduce. Thus the converter is proficient to offer inferior voltage at output (Mahdavi, 2012).

A latest bridgeless Cuk converter is projected. Foremost compensation of Cuk converter has prominent feature ofinput and output current. The main cause to validate the position of inductance at the input and output of converteris that these two currents would never be turned OFF suddenly. During each phase the amount of input diode is fewer compare to usual Cuk Converter. For instance in any case two diode is perform for normal bridgeless PFC. In this converter one diode is conduct at all instance. The amount of apparatus used to extend the converter is further when compare to the other Cuk converter types. It is because of two Cuk converters are subsisting throughout the half-line period. Advantages of this converter such as continuous input and output current. For voltage control voltage follower approach is used. Output voltage can be either superior or fewer than input voltage. It defends against the inrush current taking place at initial or surplus current. It has worse current ripple. Fewer range of heat sink is used for the witch. Non isolated converter cannot withstand high voltage. It create unwanted current loop problem. It suppresses electrical noise (Mahdavi, 2012).

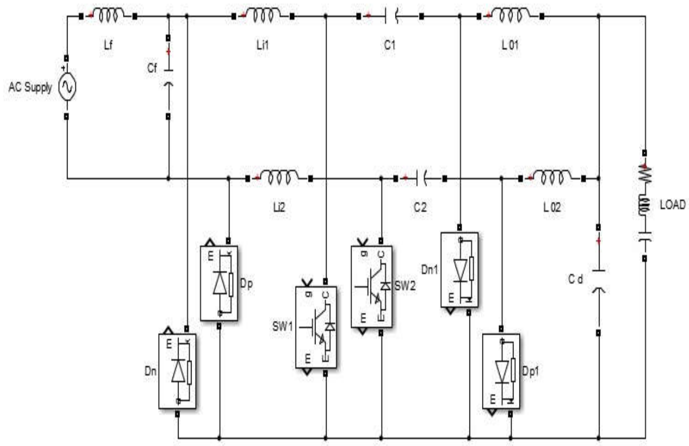

Fig. 5. Bridgeless CUK Converter

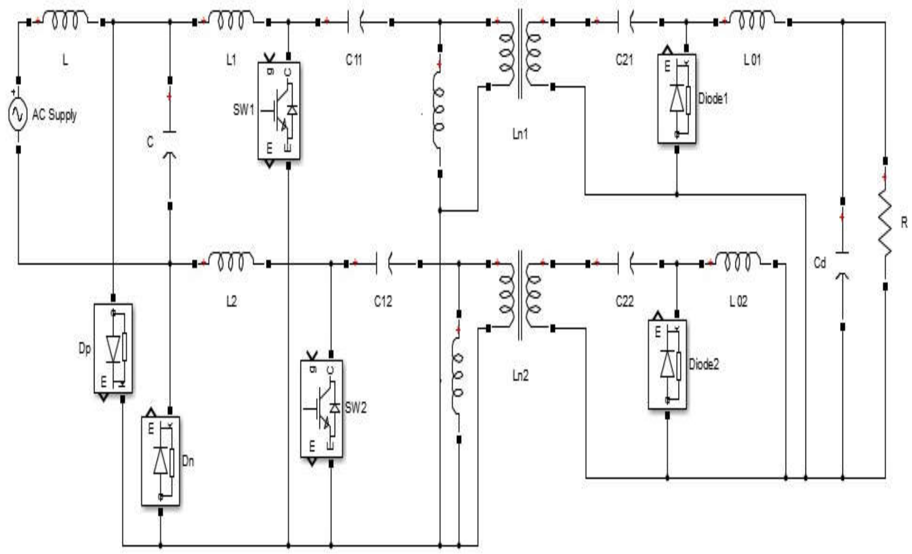

Fig. 6. Bridgeless Isolated Cuk Converter

Table 1. Comparative analysis of bridgeless pfc converter topologies

Converter Topology	Component Count					Stability	Isolation
	SW	*D*	*L*	*C*	*Total*		
BL – BUCK	2	4	2	2	10	NO	NO
BL – BOOST	2	2	1	1	6	NO	NO
BL – BUCK BOOST	3	4	1	3	11	YES	NO
BL – CUK TYPE 1	2	3	3	3	11	YES	NO
BL – CUK TYPE 2	2	2	3	4	11	YES	NO
BL – CUK TYPE 3	2	3	3	2	10	YES	NO
BL – ISLOATED CUK	2	4	4	4	14	YES	YES

Bridgeless ISOLATED CUK converter: Bridgeless isolated cuk converter means there is an electrical isolation and no electron flow between two circuits. It withstands high voltage between windings. It prevent unwanted current loop (Dakshina Murthy-Bellur, 2011). Isolation between electrical system prevent current flow. They do not conduct directly. High frequency isolation is present in this isolation transformer. It is bidirectional and it eliminates losses and corono free operation. It withstands high vibration and voltage (Dominik Bortis, 2013). Energy can be exchanged between the section by means of inductance, capacitance or electromagnetic waves. It is used for safety, preventing accidental current from reaching ground through person body. Bridgeless isolatedcuk converter is used for wind, solar, fuel, hybrid vehicles, industrial drives and transportation (Mohd Rodhi Sahid, 2010). Comparative analysis of different types of Bridgeless topologies for PFC in BLDC drives is shown in Table 1.

Bridgeless isolated Cuk converter has the following advantages:

- There is an electrical isolation and no electron flow between two circuits.
- It withstands high voltage between windings.
- It prevent unwanted current loop.
- Isolation between electrical systems prevents current flow. They do not conduct directly. High frequency isolation is present in this isolation transformer. It is bidirectional and it eliminates losses and corono free operation.
- It withstands high vibration and voltage.
- Energy can be exchanged between the sections by means of inductance, capacitance or electromagnetic waves.
- It is used for safety, preventing accidental current from reaching ground through person body stability and isolation is more in Bridgeless isolated cukconverter when compare to other converter.

Conclusion

Comparative analysis of different types of Bridgeless topologies for PFC in BLDC drives has been discussed. Bridgeless isolated cuk converter is most suitable. It gives the high efficiency output, power factor near to unity, reduced torque ripples and good speed response for the BLDC drives while compare to the conventional PFC converters.

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