AN ADJUSTABLE-SPEED PFC BRIDGELESS BUCK–BOOST CONVERTER- FED BLDC MOTOR DRIVE

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ABSTRACT: This paper presents a power factor corrected (PFC) bridgeless (BL) buck–boost converter-fed brushless direct current (BLDC) motor drive as a cost-effective solution for low-power applications. o An approach of speed control of the BLDC motor by controlling the dc link voltage of the voltage source inverter (VSI) is used with a single voltage sensor. This facilitates the operation of VSI at fundamental frequency switching by using the electronic commutation of the BLDC motor which offers reduced switching losses. o A BL configuration of the buck–boost converter is proposed which offers the elimination of the diode bridge rectifier, thus reducing the conduction losses associated with it.

o A PFC BL buck–boost converter is designed to operate in discontinuous inductor current mode (DICM) to provide an inherent PFC at ac mains. The performance of the proposed drive is evaluated over a wide range of speed control and varying supply voltages (universal ac mains at 90–265 V) with improved power quality at ac mains. o The obtained power quality indices are within the acceptable limits of international power quality standards such as the IEC 61000-3-2. o The performance of the proposed drive is simulated in MATLAB/Simulink environment, and the obtained results are validated experimentally on a developed prototype of the drive.

Keywords: converter-fed brushless direct current (BLDC), power factor corrected (PFC) bridgeless (BL)

I. INTRODUCTION

❖Efficiency and cost are the major concerns in the development of low-power motor drives targeting household applications such as fans, water pumps, blowers, mixers, etc.

❖The use of the brushless direct current (BLDC) motor in these applications is becoming very common due to features of high efficiency, high flux density per unit volume, low maintenance requirements, and low electromagnetic-interference problems.

❖These BLDC motors are not limited to household applications, but these are suitable for other applications such as medical equipment, transportation, HVAC, motion control, and many industrial tools.

II. Existing system

❖ Power quality problems have become important issues to be considered due to the recommended limits of harmonics in supply current by various international power quality standards such as the International Electrotechnical Commission (IEC) 61000-3-2 .

❖ For class-A equipment (< 600 W, 16 A per phase) which includes household equipment, IEC 61000-3-2 restricts the harmonic current of different order such that the total harmonic distortion (THD) of the supply current should be below 19% .

❖ A BLDC motor when fed by a diode bridge rectifier (DBR) with a high value of dc link capacitor draws peaky current which can lead to a THD of supply current of the order of 65% and power factor as low as 0.8 [8].

❖ Hence, a DBR followed by a power factor corrected (PFC) converter is utilized for improving the power quality at ac mains.

❖ Many topologies of the single-stage PFC converter are reported in the literature which has gained importance because of high efficiency as compared to two-stage PFC converters due to low component count and a single switch for dc link voltage control and PFC operation

III. Proposed system

❖Singh and Singh have proposed a buck– boost converter feeding a BLDC motor based on the concept of constant dc link voltage and PWM-VSI for speed control which has high switching losses.

❖A single-ended primary-inductance converter (SEPIC)-based BLDC motor drive has been proposed by Gopalarathnam and Toliyat but has higher losses in VSI due to PWM switching and a higher number of current and voltage sensors which restricts its applicability in low-cost application.

❖ Singh and Singh have proposed a Cuk converter-fed BLDC motor drive with the concept of variable dc link voltage.

❖ This reduces the switching losses in VSI due to the fundamental switching frequency operation for the electronic commutation of the BLDC motor and to the variation of the speed by controlling the voltage at the dc bus of VSI.

❖ A CCM operation of the Cuk converter has been utilized which requires three sensors and is not encouraged for low cost and low power rating. For further improvement in efficiency, bridgeless (BL) converters are used which allow the elimination of DBR in the front end.

❖A buck–boost converter configuration is best suited among various BL converter topologies for applications requiring a wide range of dc link voltage control (i.e., bucking and boosting mode).

❖Jang and Jovanovic and Huberetal have presented BL buck and boost converters, respectively.

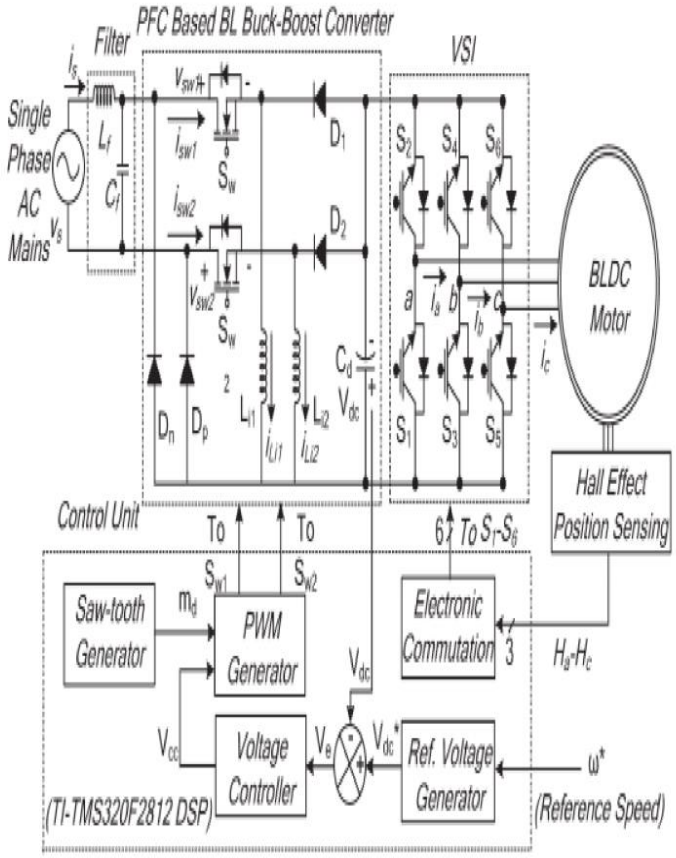
❖These can provide the voltage buck or voltage boost, which limits the operating range of dc link voltage control. Weietal have proposed a BL buck–boost converter but use three switches which is not a costeffective solution. ❖A new family of BL SEPIC and Cuk converters has been reported in the literature but requires a large number of components and has losses associated with it.

COMPARATIVE ANALYSIS OF PROPOSED BL BUCK-BOOST CONVERTER WITH EXISTING TOPOLOGIES

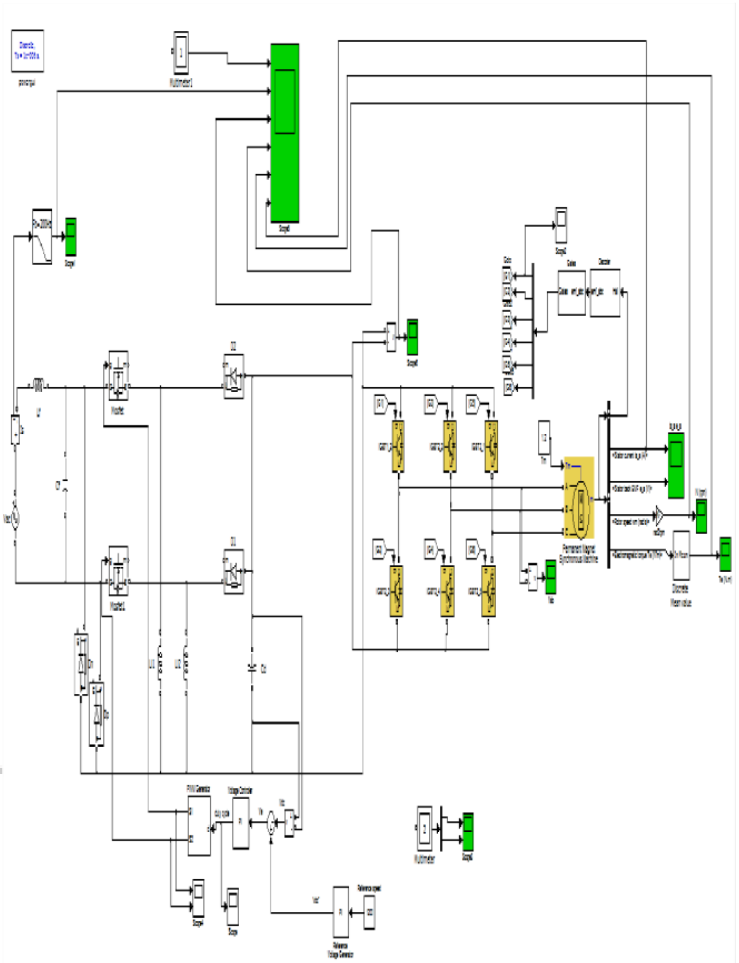
Configuration	No. of Devices					½ Period Cond.	Suit-ability
	S_w	D	L	C	Total		
BL-Buck [13]	2	4	2	2	10	5	No
BL-Boost [14]	2	2	1	1	6	4	No
BL-Boost [15]	2	2	1	2	7	7	No
BL-Buck-Boost [16]	3	4	1	3	11	8	Yes
BL-Cuk T-1 [17, 18]	2	3	3	3	11	7	Yes
BL-Cuk T-2 [17, 18]	2	2	3	4	11	11	Yes
BL-Cuk T-3 [17, 18]	2	4	4	3	13	7	Yes
BL-Cuk [19]	2	3	3	2	10	8	Yes
BL-SEPIC [20]	2	3	1*	3	9	7	Yes
BL-SEPIC [21]	2	3	2	2	9	7	Yes
Proposed	2	4	2	1	9	5	Yes

*- Coupled Inductor

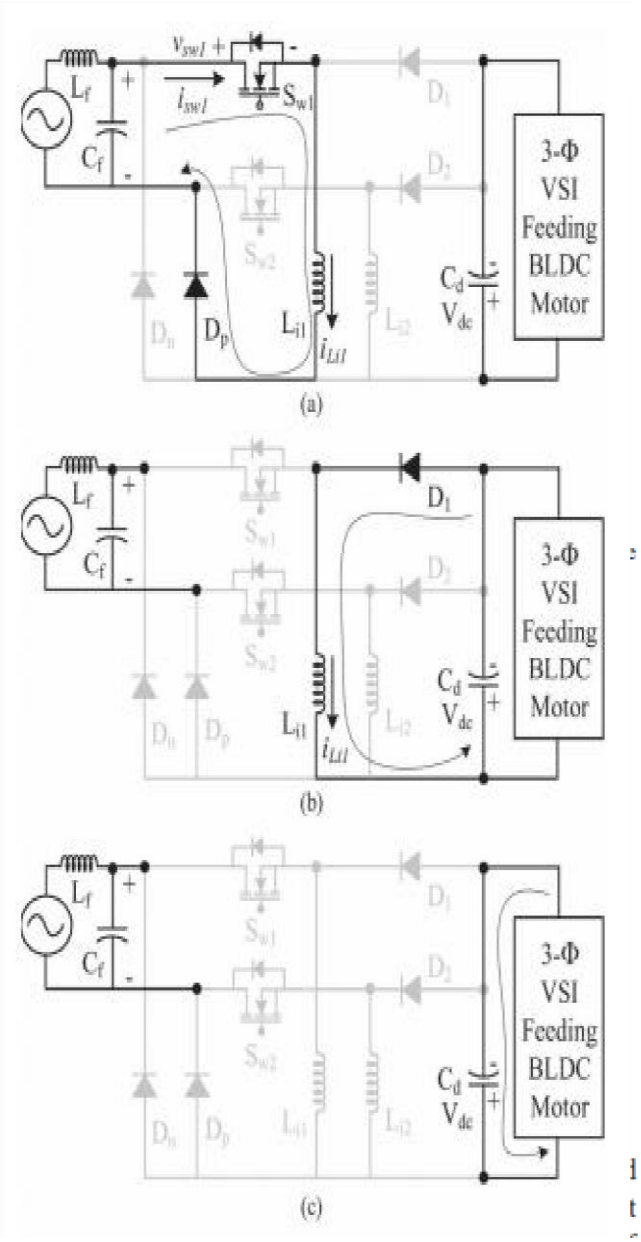
PROPOSED BLDC MOTOR DRIVE WITH FRONT-END BL BUCK-BOOST CONVERTER



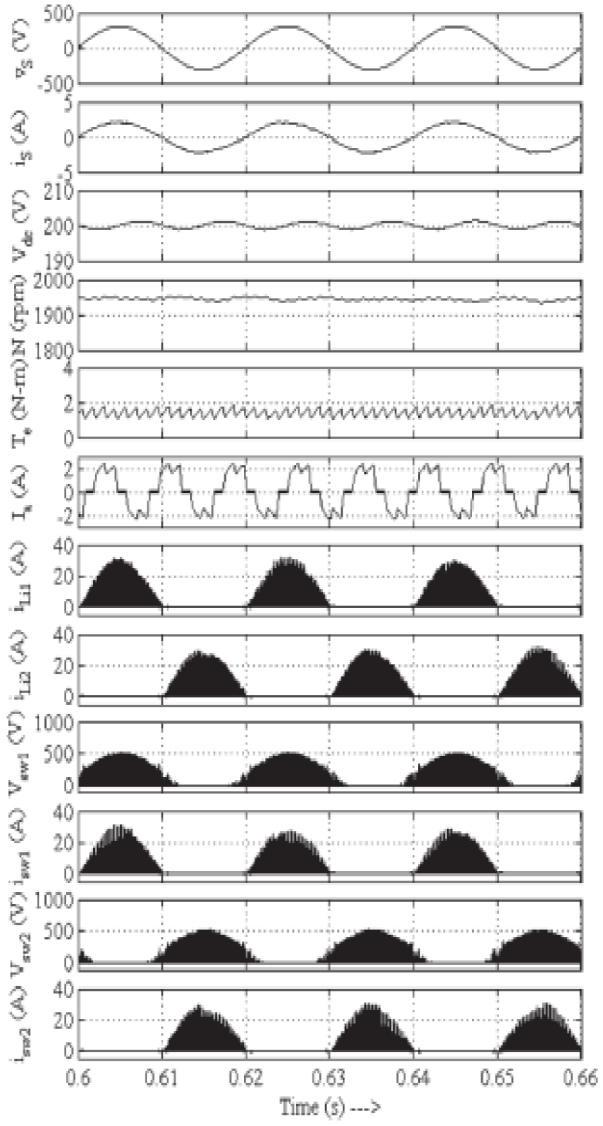
PROPOSED BLDC MOTOR DRIVE WITH FRONT-END BL BUCK-BOOST CONVERTER - MATLAB MODEL



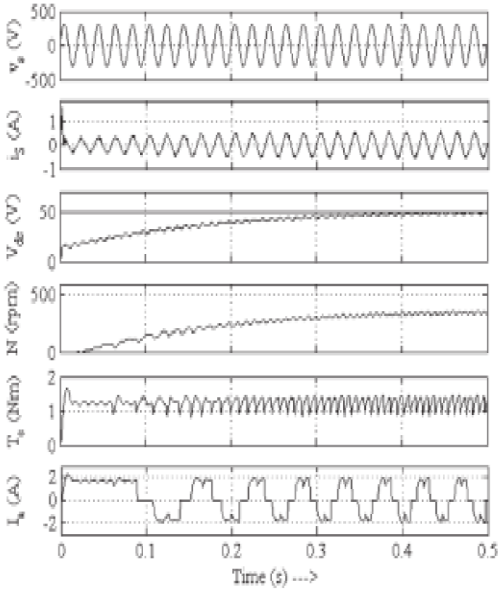
OPERATING PRINCIPLE OF PFC BL BUCK-BOOST CONVERTER



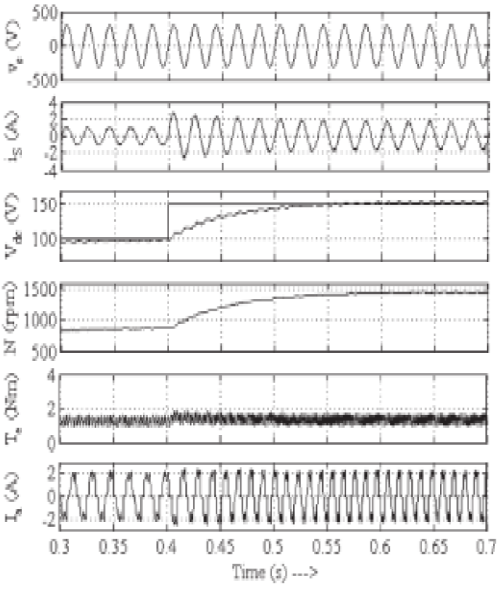
STEADY-STATE PERFORMANCE OF THE PROPOSED BLDC MOTOR DRIVE AT RATED CONDITIONS.



DYNAMIC PERFORMANCE OF PROPOSED BLDC MOTOR DRIVE



(a)



(b)

IV. CONCLUSION

- A PFC BL buck–boost converter-based VSI-fed BLDC motor drive has been proposed targeting low-power applications.
- A new method of speed control has been utilized by controlling the voltage at dc bus and operating the VSI at fundamental frequency for the electronic commutation of the BLDC motor for reducing the switching losses in VSI.
- The front-end BL buck–boost converter has been operated in DICM for achieving an inherent power factor correction at ac mains.
- satisfactory performance has been achieved for speed control and supply voltage variation with power quality indices within the acceptable limits of IEC 61000-3-2. Moreover, voltage and current stresses on the PFC switch have been evaluated for determining the practical application of the proposed scheme.
- Finally, an experimental prototype of the proposed drive has been developed to validate the performance of the proposed BLDC motor drive under speed control with improved power quality at ac mains.
- The proposed scheme has shown satisfactory performance, and it is a recommended solution applicable to low-power BLDC motor drives.

V. REFERENCES

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