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Power Factor Improvement in PMBLDC Motor Drive using Bridge Less Ultra Luo Converter

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ABSTRACT:The essential requirements of any motor for electric drive are high efficiency, low maintenance and a high flux density per unit volume. The brushed motors use a core of laminated iron in the rotor, which gives them large rotational inertia that limits the acceleration and deceleration rates of the motor. It is possible to build a brushless motor with very powerful rare earth magnets on the rotor, which minimizes the rotational inertia. Due to declining costs and better performance, brushless motors are gaining in popularity in many applications. The Permanent Magnet Brushless DC motors (PMBLDCM) uses voltage source converter (VSC) with control technique to obtain desired performance and characteristics. In these motors, the Power Factor Correction (PFC) Bridgeless-Luo converter is used to improve the power quality. In this paper, the two converters for BLDC motor drive system are developed a model in MATLAB/SIMULINK and obtained results are shown at the end.

KEYWORDS:PMBLDCM, VSC, PFC, Bridgeless-Luo converter

I. INTRODUCTION

In our daily life, theappliances likerefrigerators, driers, air-conditioners andothersapplicationsmade fromelectricalmotors. Potencyandvalue area unit are main issues in designing and developing low-power applications such as fans,air conditioners, blowers, mixers and different house devices. The improved efficiency inmotor-drivesystems and achieving the desirable characteristics in drive system are one of the important requirements [4].

Due to the lot of demand of these applications along with these converters,thepowerqualityissues were increased. The Power Factor Correction(PFC)converter is a good solution in these applications to improve the power quality[9] to [11].

In PermanentMagnetBrushless DC motors (PMBLDCM) consists ofpermanentmagnets(PMs)ontherotorandpowered through a three-phase voltage source inverter (VSI)which is fed from single-phase AC supply using a power electronic converter like diodebridge rectifier followed by smoothening DC linkcapacitor. The constant torque is exerted by BLDC motor byaconstantcurrentinthestatorwinding wherethe back-emf of the PMBLDCM is proportional tothemotorspeedandthedevelopedtorqueisproportionaltoitsphasecurrent [3]. In the motor, the desired speed can be obtained by changing the terminalvoltage of the motor. The control of VSI is only forelectronic commutation which is based on the rotor position signals of the PMBLDCmotor as show in Fig.1.

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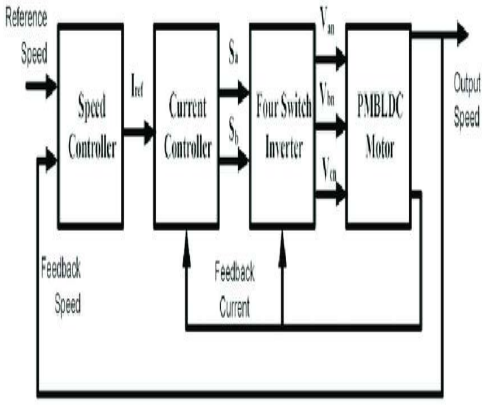

Fig.1.Control diagram of PMBLDC Motor

Due to the lot of demand of these applications along with these converters,thepowerqualityissues were increased. The Power Factor Correction(PFC)converter is a good solution in these applications to improve the power quality. The BL-Luo converter is a Power Factor Correction(PFC)converter which works in Discontinuous Inductor Current Mode (DICM) to act asassociate inherent power issue pre-regulator. The speed of theBLDC motor is controlled by adjusting the DC link voltage of VSIwhich permits voltage supplyallowselectricalconvertertooperateath armonicswitchand therefore has lowswitchlossesinit [4]. In this paper,theperformanceof negative BL-UltraLuo convertor fed BLDC motor drive is analyzed by usingMATLAB/ SIMULINKmodels.

III. PERMANENTMAGNET BLDC MOTORS

The traditionalDCmotorsare equipped with commutator andbrushes which are subjecttowearandrequiremaintenance, so their usage are slowly reduced. The similar functionswereimplemented by solid state switches, brushless motorswere realized without changing the basic action. These motors are known as brushless DC motors. Thebrushlessconfigurationinwhichtherotori nside the stator is that more cross-sectional area is available forthe power or armature winding. At the same time conduction ofheat through the frame is providing greater specific torque. For the same size, theefficiencyislikelytobehigherthatofacomm utatormotorandtheabsenceofbrushfrictionhe lpfurther.

The stator is made up of silicon steelstampingswithslotsinitsinteriorsurface as shown in Fig.2. Theslots areaccommodate with distributed armature winding eitheraclosedoropenedusuallyitisclosed.This windingistobewoundforaspecifiednumberofpo les.Thiswindingissuitablyconnectedtoadcsupp lythroughapowerelectronicswitchingcircuitry (namedaselectronic commutator).Rotor is made of forged steel. Rotor accommodates permanentmagnet. Number of poles of the rotor is the same as that of thestator.Therotorshaftcarriesarotorposition sensor.Thispositionsensor provides information about the position of the shaft at anyinstanttothecontrollerwhichsendssuitabl esignalstotheelectroniccommutator.[1]

[1]

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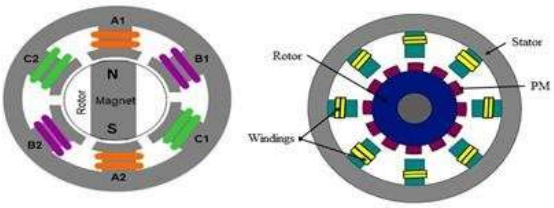

Fig. a. BLDC motor Fig. b. PMSM

Fig.2. Brushless Motors

Comparisonofbrushlessdcmotorrelativetoinductionmotordrives:

- In the same frame, for same cooling, the brushless PM motorwillhavebetterefficiencyandp.fandthereforegreateroutput. The difference may be in the order of 20 – 50% whichishigher.
- Power electronic converter required is similar in topology tothePWMinvertersusedininductionmotor drives.
- Incaseofinductionmotor,operationinthe weakeningmodeis easily achieved providing a constant power capability athighspeedwhichisdifficultinBLPMdc motor.
- PM excitation is viable only in smaller motors usually wellbelow20kwalsosubjecttospeedconstraints,InlargemotorsPMexcitationdoesnotmakesenseduetoweightandcost.

The PMSM and PMBLDC motors have similar construction withpoly-phasestatorwindingsandpermanentmagnetrotors,thedifference being the method of control and the distribution ofwindings. The PMSM motor has sinusoidally distributed statorwindings and the controller tracks sinusoidal reference current.ThePMBLDCmotorisfedwithrectangularvoltagesandthewindings are distributed so as to produce trapezoidal back emf[3].

TheadvantagesofusingbrushlessDCmotorare asfollows,

- High Speed Operation - BLDC motors can operate at speedabove10,000rpmunderloadedandunloadedconditions.
- Responsiveness and quick acceleration - Inner rotor BLDCmotors have low rotor inertia, allowing them to accelerate,decelerate,andreversedirectionquickly.
- HighReliability-BLDCmotorsdonothavebrushes,havelife expectanciesover10,000hours.
- HighPowerDensity-Agoodweight/sizetopowerratio.

IV. PFCBRIDGELESS ULTRA LUO CONVERTER TOPOLOGY

Bridgeless UltraLuoconverterisdesignedforPower Factor Correctionby eliminating the diode bridge rectifier similar to BL-Luoconverter. The lossesassociatedwithitgetdisappearedwitheliminationofdiodebridgerectifier,however,the circuitbecomesmore complex[1].The bridgeless Ultra Luo converter as shown inFig.3

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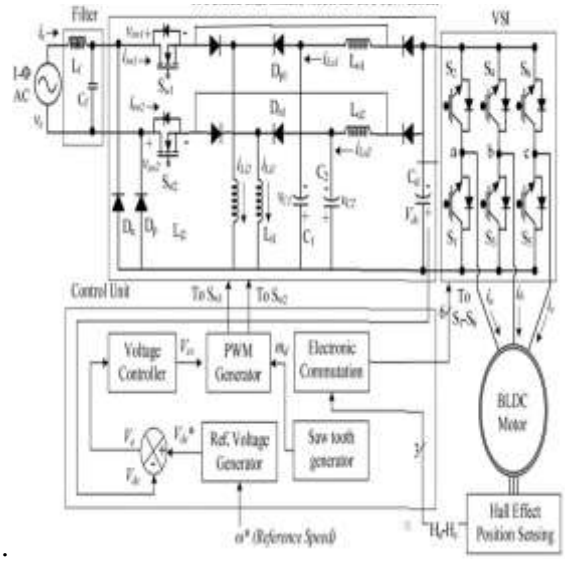

Fig.3. Bridgeless UltraLuoconverter

ModesofOperation:

Thefunctionsofbothrectificationandpowerfactorcorrectionare achieved inPFCBL-UltraLuoconverterwith separatecircuitpathand withseparateswitchesareprovided. So mode of operation during the positive and negativehalfcyclesofsupplyvoltagearedifferentandboth of this havethree separate modes of operations as shown in figure there are 6modesofoperationduringthecompleteswitching cycle.

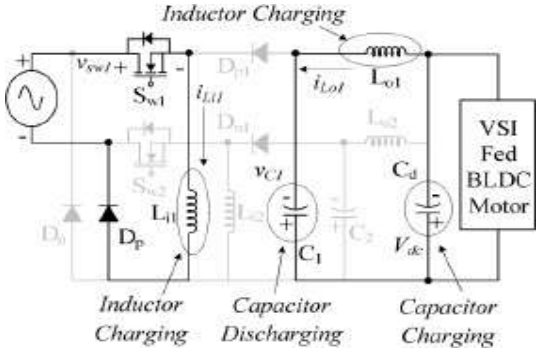

Fig.4.PositivecycleMode-1operation

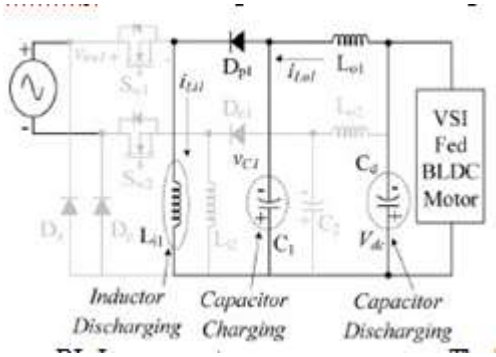

Fig.5PositivecycleMode-2operation

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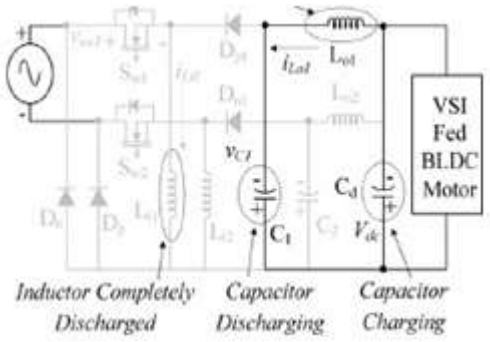

Fig.6PositivecycleMode-3operation

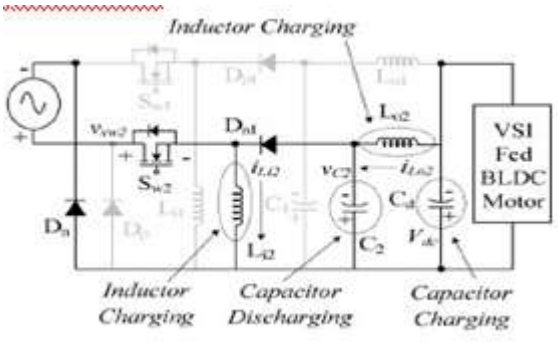

Fig.7. Negative cycle Mode-1 operation

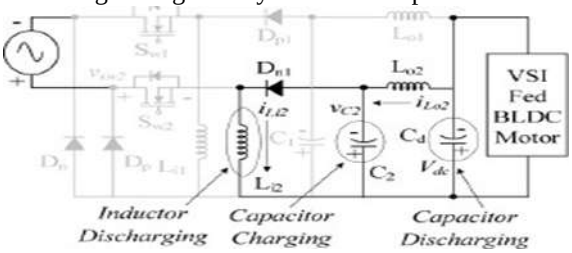

Fig.8NegativecycleMode-2operation

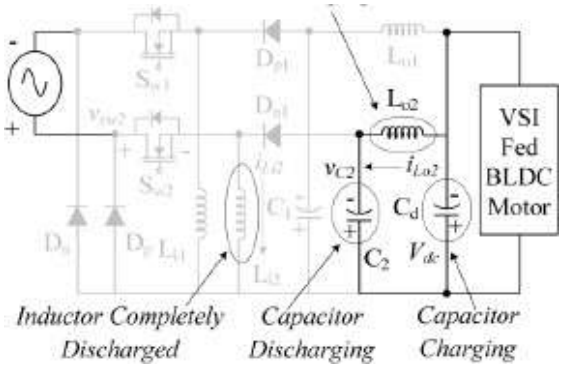

Fig.9NegativecycleMode-3operation

The above figure shows the different modes of operations in positive and negative half cycles of supply voltages. The operation of PFC BL-Luo converter for positive half cycles of supply voltageshown in Fig.4, Fig.5, Fig.6 and the operation for negative half cycles ofsupply voltage shown in Fig.7, Fig.8, Fig.9, respectively. The two different switches operate for a positive and

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negative half cycles of supply voltages in this converter. In the positive half cycle of supply voltage switch Sw1, input inductor Li1 and Output inductor Lo1 and diodes Dp and Dp1 are conduct. In a similar manner, during the negative half cycle of supply voltage switch Sw2, input inductor Li2 and Output inductor Lo2 and diodes Dnand Dn1 conducts [6].

Positive cycle Mode-1 operation: During the positive cycle with the help of switching control circuit when switch Sw1 is turned-on as shown in Fig.4 energy will be stored in the input side inductor (Li1),The amount of energy stored in inductor (Lio) depends upon the current (iL1) flowing through it and theat the same time energy stored in intermediate capacitor (C1) will be transferred to the DC link capacitor (Cd) and the output side inductor (Lio),causing the voltage across intermediate capacitor (VC1) to drop, So this helps to increase the current in output inductor (iLo1) and voltage at the DC link capacitor (Vdc).

Positive cycle Mode-2 operation: During the positive cycle with the help of switching control circuit when switch Sw1 is turned-off as shown in Fig. 4, energy will be transferred from the input side inductor (Li1) the intermediate capacitor (C1) through diode Dp1. The inductor Li1 will discharge current iLi1 till its value reaches zero, causing the voltage across intermediate capacitor (VC1) to rise up. Simultaneously the DC link capacitor (Cd) supplies the required energy to the load; which in effect will result in decrease in voltage Vdc across the DC link capacitor [6].

Positive cycle Mode-3 operation: In this mode of operation input inductor (Li1) will work in discontinuousconduction mode of operation.Which means that there is no energy willbe left in the input inductor (Li1).i.e. current iLi1 becomeszero.At the same time the output inductor (Lo1) and intermediatecapacitor (C1) are discharged; causing the current iniLo1 and voltage VC1 to be reduced.At the same time the DClink voltage Vdc increases in this mode of operation. This 3modes of operation will be cyclically repeated when switchSw1 is turned-on again in next cycle. In a similar manner,for negative half cycle of supply voltage the input inductorsLi2 and output inductors Lo2, diode Dn1 and intermediatecapacitor C2 conduct to achieve a similar operation at negativehalf cycle as well[6].

V. SIMULATION AND RESULTS

The BL-Ultra Luo converter is developed usingMatlab/Simulink software as shownin the Fig.10 and Fig.11. The simulation analysis explains the working of PFC fed Bridgeless-UltraLuo BLDC motor drive The different DC linkVoltages like Vdcmin and Vdcmax are taken.The reference speed whichare taken within this DC voltage range is 1500rpm.Then setting thereference speed separatecontinuous analysis is done using MatLab/ Simulink,Thus inputand output waveforms,THD analysis details and graphical dataof PI controlled speed in rpm values etc are obtained whilesetting different reference speeds.Here, the data obtained forBL-Ultra Luoconverter corresponding to the reference speedkept to be at 2500rpm are shown in the figures Fig.12, Fig.13, Fig.14and Fig.15.

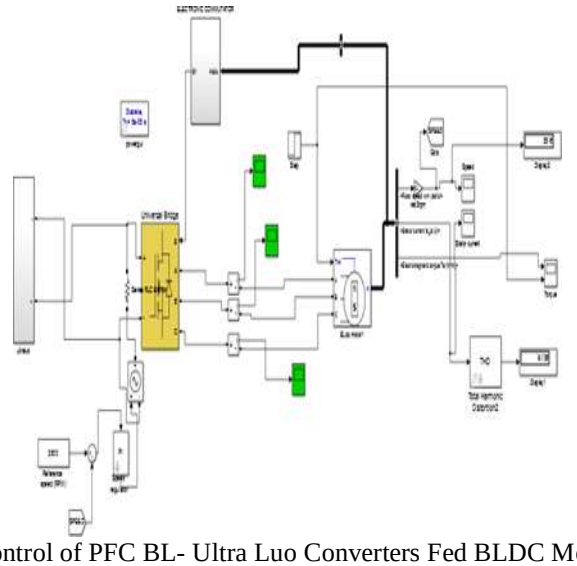

Fig.10. Control of PFC BL- Ultra Luo Converters Fed BLDC Motor Drive

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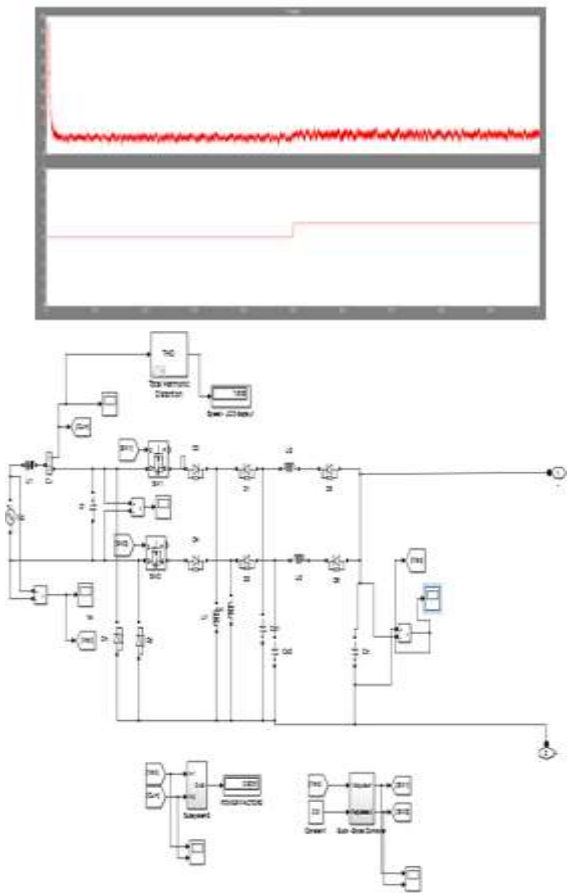

Fig.11. PFCBridgelessUltraLuoconverterSIMULINK

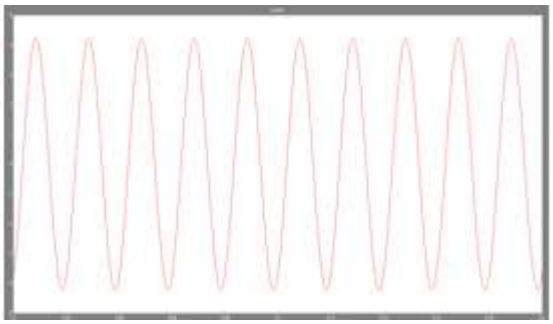

Fig.12. Source Current

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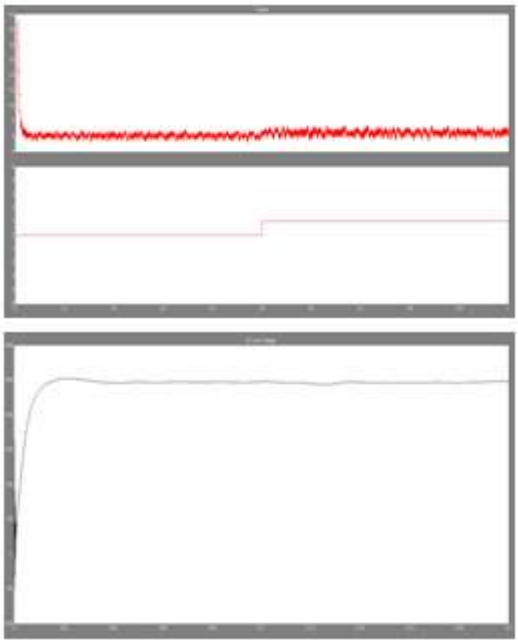

Fig.13. DC link capacitor Voltage
Fig.1 4 (i)MotorTorque(Tm)(ii)LoadTorque(Tl)

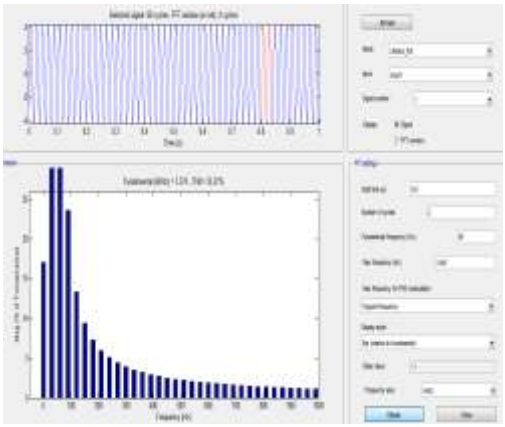

Fig.5.1.2.6 Bridgeless UltraLuo Converter Sourcecurrent &THD

VI. CONCLUSION

The advanced speed control technique along with bridgeless ultra-Luo converter of a PMBLDCM drive isdeveloped whichusesthereferencespeedasanequivalentrefer enceveltageatDC link capacitor. The analysis has done in MATLAB/SIMULINK at a reference speed of 2500rpm correspondingtoBL-UltraLuoconverterasshownintheresults. Theproposedsystemhas good speed control with energy efficientoperation of the drive system in the wide range of speed andinput AC voltage. The proposed converter is having slightly better THDperformance and the power factor correction solution thanBL-Luoconverter.

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