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Engineering

POWER QUALITY IMPROVEMENT IN BL-LANDSMAN CONVERTER BASED BLDC MOTOR DRIVE

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ABSTRACT Power Factor Correction (PFC) system increases the efficiency of power supply, delivering cost savings on electricity Exchanging power supplies without PFC attract current short, high greatness beats. The beats can be smoothed out utilizing dynamic or inactive PFC procedures. This improves the power factor. A Bridgeless (BL) Landsman converter is used for power factor correction in Brushless DC Motor (BLDC) drive. This converter operating in discontinuous inductor current mode (DCIM) and using a single voltage sensor. BLDC motor has many advantages such as high efficiency, it require little maintenance, high energy density. It is used to improve power quality and controlling the speed over wide range. The bridgeless Landsman converter offers low conduction losses due to elimination of diode bridge rectifier at the front end. BL-Landsman converter has low Total Harmonic Distortion and improved power quality is achieved. The obtained power quality indices are within the acceptable limits of IEC 61000-3-2.

KEYWORDS : Power Factor Correction (PFC), Discontinuous inductor current (DCIM), Brushless DC Motor (BLDC)

INTRODUCTION

Power quality improvement in today's world is one of the essential requirement. Power quality refers to the ability of electrical systems to consume the energy supplied to it. Power quality issues including electrical sounds, poor power factor, voltage insecurity and awkwardness sway on the proficiency of electrical hardware. Higher energy usage and cost, Higher support costs, Equipment failure and instability are the some of the consequences including in this.

Now a days control converters have been progressively utilized in the mechanical, business, private, aviation and military condition because of the advantages of high productivity, littler size and weight. The input power factor of converters are reduces and it also injects a certain amount of harmonic current in the utility line when it draw pulsating input current from the utility line. There are harmonic norms such as IEC-61000-3-2 introduced for improving power quality. Power quality can be improved by various PFC schemes [4]. Here, APFC (active power factor converter) are placed in between the bridge rectifier and the load. The motivation behind the PFC circuit is to limit the input current waveform mutilation and make it is stage with voltage. In Bridgeless Landsman converter [1] is used to improve power factor and reduce total harmonic distortion. The addition of an inductor at output which results in low total harmonic distortion [3].

In this Brushless DC motor is preferred due to its high energy density, high efficiency, ruggedness, widespread speed choice and less maintenance. The medical, heating, ventilation, air conditioning, consumer electronics and several others are the major application areas for this motor. Intrinsic issues with mechanical commutator assembly and brushes like as sparking, EMI, tear and wear are eradicated by the use of electronic commutation of BLDCM using a voltage source inverter (VSI) based on hall effect based on position sensing of rotor position.

BRIDGELESS LANDSMAN CONVERTER BASED BLDCM DRIVE

Bridgeless Landsman PFC Converter is used for improve power factor and it also convert AC to DC supply. The block diagram of the system is given in this section.

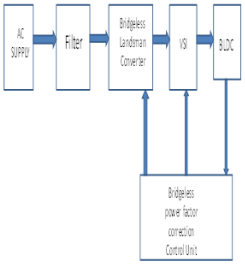


Fig:1 Block diagram of BL-Landsman Converter

CIRCUIT DIAGRAM

Fig: 2 shows the conventional BL-Landsman converter based BLDC drive. In this the DBR is eliminated at the front end of converter, so it reduces switching losses associated with it. This bridgeless converter is designed between the two switches operate for positive and negative half cycles of supply voltage. During the positive half cycle of the supply voltage, the input current flows through switch S_{w1}, inductor L_{i1}, L_{01} and a diode D_p. Similarly, switch S_{w2}, inductors L_{i2}, L_{02} and a diode D_n conduct for a negative half cycle of supply voltage. The current flowing through the input inductors L_{i1} and L_{i2} are discontinuous and the current of output inductors L_{01} and L_{02} and voltage of intermediary capacitors (V_{c1}) and V_{c2} remain continuous during switching cycle.

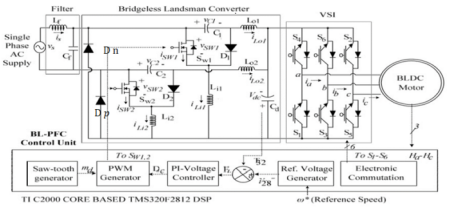


Fig :2 Circuit diagram of BL-Landsman converter

OPERATING PRINCIPLE OF PFC BL- LANDSMAN CONVERTER

Mode 1

When switch S_{w1} is turned on, the input side of inductor L_{i1} charging through the diode, and the input inductor current enhances, where the intermediate capacitor C_1 starts discharging through the switch S_{w1} to charge the dc link capacitor C_d. So the voltage of intermediate capacitor V_{c1} decreases, where the dc link voltage V_{dc} increases.

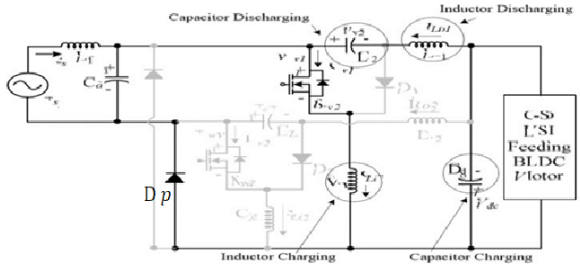


Fig:3 Circuit operation when S_{w1} is On

MODE 2

When switch S_{w1} is turned off, the energy stored in inductor L_{i1} discharges through the diode D_1,as shown in fig: . The current i_{L1} reduces. Intermediate capacitor C_1 starts charging, and voltage V_{c1} goes high., where the dc link capacitor C_d supplies energy to load.

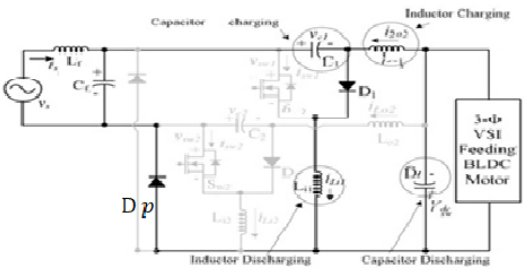


Fig: 4 Circuit operation when S_{w1} is Off

MODE 3

This mode is discontinuous Current mode (DCM) of operation as the current in input inductor L_{i1} is zero. Here the intermediate capacitor is discharging then V_{c1} decreases and the dc link capacitor is charging, where the dc link capacitor C_d supplies energy to the load. The similar behaviour of the converter is obtained for negative half – cycle of supply. An inductor $L_{i2,}$ an intermediate capacitor C_2, an output inductor L_{02} and diodes conducts in same way

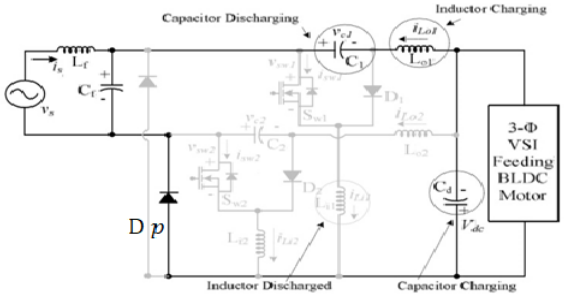


Fig :5 Circuit operation in discontinuous modes

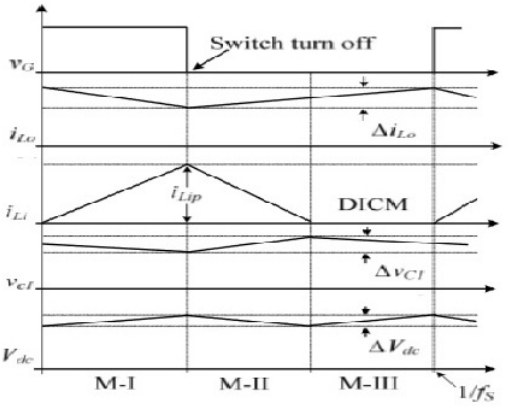


Fig :6 Voltage and current waveforms for different modes of operation

MODELLING OF BL-LANDSMAN CONVERTER

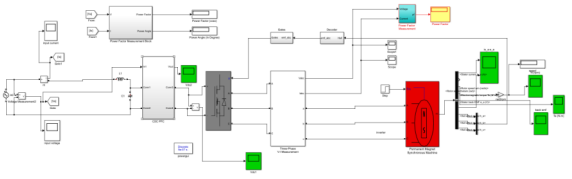


Fig: 7 Simulink model of BL-Landsman converter based BLDC motor Drive The model of BL-Landsman converter developed in MATLAB is given in the Fig 5 by using different parameters of converter which is shown in table 1. It consists of AC supply, LC filter and BL- Landsman converter. This works goes for the advancement of this converter, which offers disposal of DBR at the front end of the converter for reducing the conduction losses associated with it and an inductor is provided at the output , subsequently the total harmonic distortion is also diminish and improved power factor is obtained.

TABLE 1 Parameters of BL- Landsman Converter

Input Inductors, $L_{i1,2}$	486µH
Output Inductors,$L_{01,2}$	3.09mH
IntermediateCapacitors $C_{1,2}$	393.8nF
DC- link Capacitor	2123.1µF
Filter Capacitor,C_f	649.7nF
Filter Inductor,L_f	3.8mH

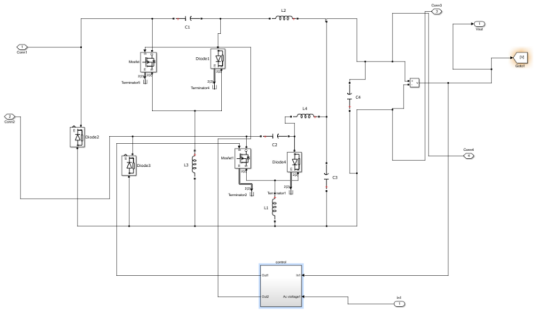


Fig: 8 Simulink model of BL-Landsman converter based BLDC motor Drive

SIMULATION RESULTS OF BL- LANDSMAN CONVERTER

By using MATLAB system, the output waveforms are plotted and below graphs are obtained. The Output voltage of BL Landsman converter is shown in below figure. The output voltage of converter is about 350V

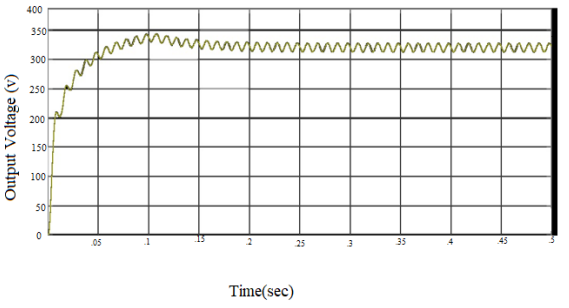
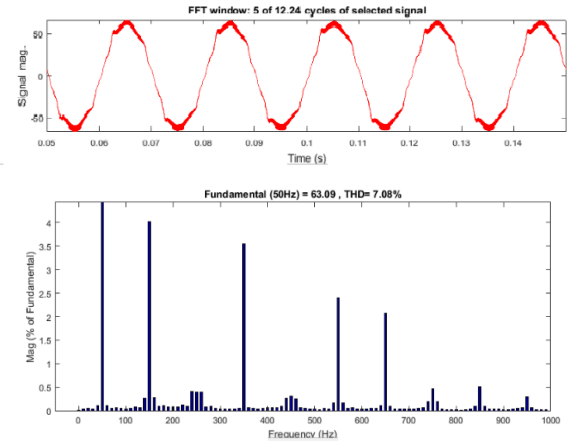


Fig :9 Waveform of output voltage of Landsman converter

THD AND POWER FACTOR OF BL- LANDSMAN CONVERTER

Here, the Fig: 9 shows that total harmonic distortion in BL-Landsman Converter is 7.08 percentage and the power factor is 0.9943.



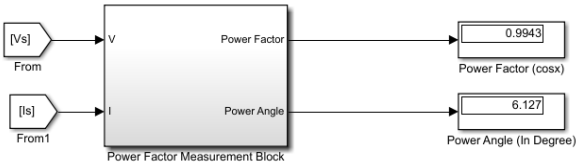


Fig: 10 THD and Power Factor with BL-Landsman converter

MODELLING OF BLDC MOTOR DRIVE SYSTEM

Modelling equations of BLDC motor are given here,

The electrical and mechanical mathematical equations of brushless dc motor are given in this section. The stator voltage equations are:

$$V_a = Ri_a + L\frac{di_a}{dt} + e_a \quad (1)$$

$$V_b = Ri_b + L\frac{di_b}{dt} + e_b \quad (2)$$

$$V_c = Ri_c + L\frac{di_c}{dt} + e_c \quad (3)$$

The equations of back EMF can be given as

$$e_a = K_e \omega_m F(\theta_e) \quad (4)$$

$$e_b = K_e \omega_m F(\theta_e - \frac{2\pi}{3}) \quad (5)$$

$$e_c = K_e \omega_m F(\theta_e + \frac{2\pi}{3}) \quad (6)$$

The equations of torque can be given as

$$T_a = K_t i_a F\theta_e \quad (7)$$

$$T_b = K_t i_b F(\theta_e - \frac{2\pi}{3}) \quad (8)$$

$$T_c = K_t i_b F(\theta_e + \frac{2\pi}{3}) \quad (9)$$

Resultant torque equation is given as

$$T_e = T_a + T_b + T_c \quad (10)$$

Mechanical equation can be derived as

$$T_e - T_l = J\frac{d^2\theta_m}{dt^2} + \beta\frac{d\theta_m}{dt}\theta_e \quad (11)$$

Electrical position and mechanical speed is

$$\theta_e = \frac{p}{2}\theta_m \quad , \quad \omega_m = \frac{d\theta_m}{dt} \quad (12)$$

Current equation can be derived as

$$i_a = \int \left(\frac{1}{3L}\right)[2V_{ab} + V_{bc} - 2E_a + E_b + E_c - 3R_{ia}]$$

$$i_b = \int \left(\frac{1}{3L}\right)[-V_{ab} + V_{bc} + E_a - 2E_b + E_c - 3R_{ib}]$$

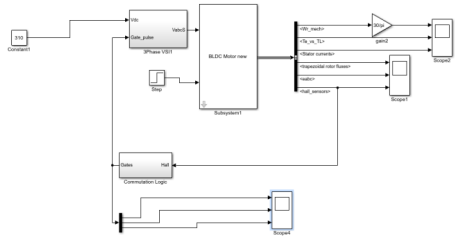


Fig:11 Simulink model of BLDC motor drive

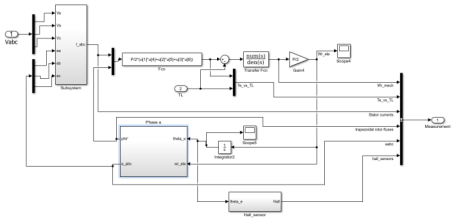


Fig:12 Subsystem of BLDC Motor

RESULTS OF BLDC MOTOR

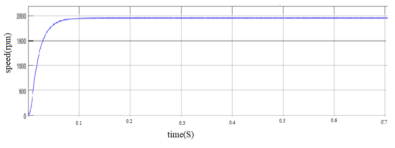


Fig :13 Speed Vs Time

The Fig:13 is a graph plotted between the Speed (rpm) v/s time(s). It shows the result of output speed of BLDC motor increases up to 2000 rpm.

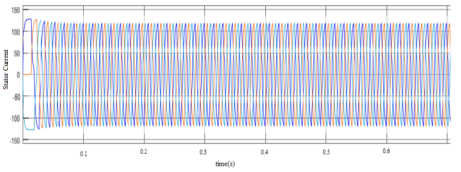


Fig :14 Stator current Vs Time

The Fig: 14 is a graph plotted between the Stator current (A) v/s time(s).It shows the result of stator current of BLDC motor is 125A.

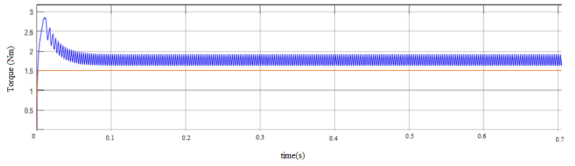


Fig :15 Torque Vs Time

The Fig: 1 is a graph plotted between Torque (N-m) v/s time(s). It shows the result of BLDC motor which have starting torque about 2.8 N-m and it is stable at 1.8 N-m

CONCLUSION

There is an increased use of power electronic devices in the area of electrical machine and drive systems. The use of such devices has resulted in the consumption of current from the ac mains. Due to this harmonic current are increased greatly. The increase in the harmonic current resulted in poor power factor and increased THD content. BL Landsman PFC converter based motor drive has been designed and developed for to produce improved power factor and low THD.

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