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Improvement in Power Quality Using Dual Boost Converter

Mrs.Sindhuja.G[1], Mrs. Anita. I. Patil[2]
[1]Department of Electrical and Electronics Engineering, Don Bosco Institute of Technology, Bangalore, India
Email :sindhujagraj09@gmail.com
[2]Department of Electrical and Electronics Engineering, Don Bosco Institute of Technology, Bangalore, India
Email :mrs.anitaravi@gmail.com

***Abstract*—In this paper, a circuit for power factor correction by implementing two boost converters arranged in parallel is developed. Initially, the work involves simulation of nonlinear load and corresponding waveforms. Later boost converter and dual boost converter has been implemented in the circuit to improve power quality. Also comparison between the boost and dual boost converter has been presented. The main objective is to improve the input current waveform. Simulation work is carried out using MATLAB Simulink environment.**

***Keywords*—Boost converter, PFC, PMBLDCM, PI controller, THD**

I. Introduction

Brush Less DC (BLDC) motors are widely used in industries such as appliances, consumer, automotive, medical, aerospace, industrial automation Equipment and Instrumentation. Permanent Magnet Brush Less (PMBL) motors belong to three-phase synchronous motor family and can be categorized as Permanent Magnet Synchronous Motor (PMSM) and PMBLDCM. The PMSM uses continuous rotor position feedback for supplying sinusoidal voltages and currents to the motor with sinusoidal back EMF, so that the interaction with sinusoidal currents produces constant torque with very low ripple. PMBL machines are best suited for position control and medium size industrial drive because of their excellent dynamic capability, reduced losses and high torque and weight ratio. [5]
Various Power Factor Correction (PFC) techniques are employed to overcome power quality problems out of which the boost converter topology has been extensively used in various ac/dc and dc/dc applications. PFC is necessary in order to comply the recent international standards, such as IEC-1000-3-2 and IEEE-519. The basic boost topology does not provide a high boost factor. This has led to many proposed topologies such as the tapped- inductor boost, cascaded boost and interleaved boost converters. [8]

II. Power Factor And THD

Harmonic distortion is divided into voltage distortion and current distortion. Any voltage distortion will results in a corresponding current distortion assuming the source impedance very low. On the other hand, current distortion results in voltage distortion only to the extent that the source impedance provides common

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coupling impedance. The effects of harmonic currents from nonlinear loads are not widely understood, due to the low impedance of most power systems. The power system can generally absorb significant amounts of harmonic current without converting these to unacceptable voltage distortion levels. Harmonic distortion can be caused by the utility or by the load. Harmonic power factor is related to harmonic distortion. [9]

III. BLDC MOTOR OPERATION WITH INVERTER

Basically it is an electronic motor and requires a three-phase inverter in the front end as shown in Fig. 1. In self-control mode the inverter acts like an electronic commutator that receives the switching logical pulse from the absolute position sensors. The drive is also known as an electronic commutated motor. [5]

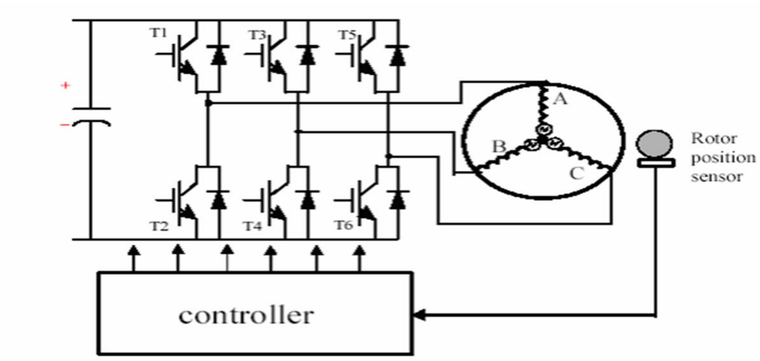

Figure 1. Brushless dc motor drive system

Schematic diagram of a three level voltage source inverter fed PMBLDC motor with PFC full bridge converter is shown in Fig.1.This is a closed loop control circuit using 3 Hall Sensors. MOSFETs are used as switching devices here. For very slow, medium, fast and accurate speed response, quick recovery of the set speed is important keeping insensitiveness to the parameter variations. In order to achieve high performance, many conventional control schemes are employed. At present the conventional PI controller handles these control issues. Moreover conventional PI controller is very sensitive to step change of command speed, parameter variation and load disturbances.

IV. SIMULATION AND RESULTS

To improve the performance of BLDC motor, by reducing THD to improve the power factor, simulations has been performed in MATLAB/Simulink Version 7.9. The performance of BLDC motor is analysed under three cases.

- **Case 1 :**
  PMBLDC Motor without power factor correction controller
- **Case 2 :**
  PMBLDC Motor with power factor correction controller using boost converter
- **Case 3 :**
  PMBLDC Motor with power factor correction controller using dual boost converter

Case 1: PMBLDC Motor without power factor correction controller

Fig.2 shows that this circuit consists of two groups of diodes: top group and bottom group . It is easy to see the operation of each group of diodes. The current i_d flows continuously through one diode of the top group and one diode in the bottom group.
The circuit is simulated using Simulink and input current waveform is plotted in graph as shown in Fig.3. The input current waveform consists of Total Harmonic Distortion. Fast Fourier Transform (FFT) analysis is done to get the value of THD. Fig.4 shows THD of input current and THD percentage is 81.42. High THD will effect the equipments connected.

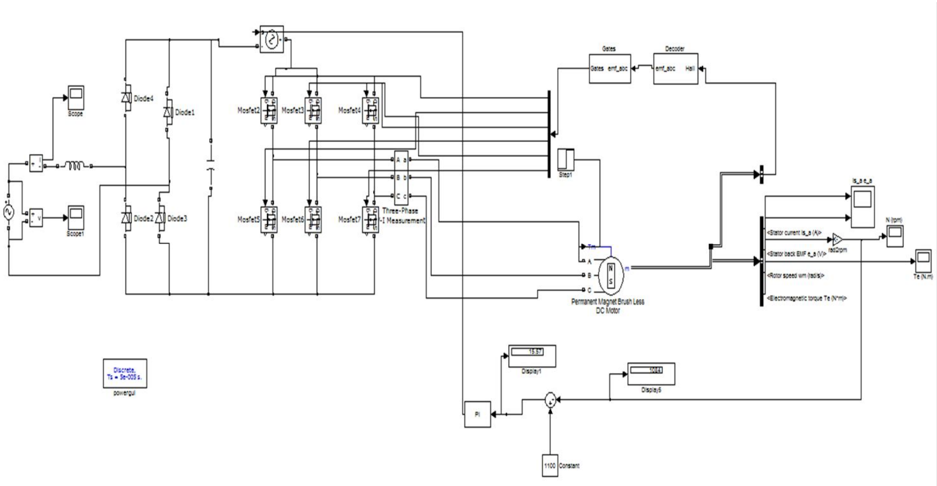

Figure 2. PMBLDC Motor without Power Factor Correction controller

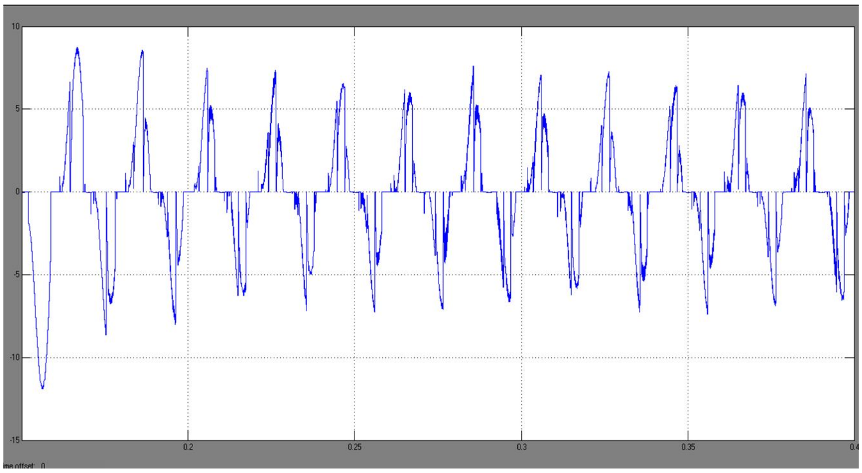

Figure 3. Input current waveform

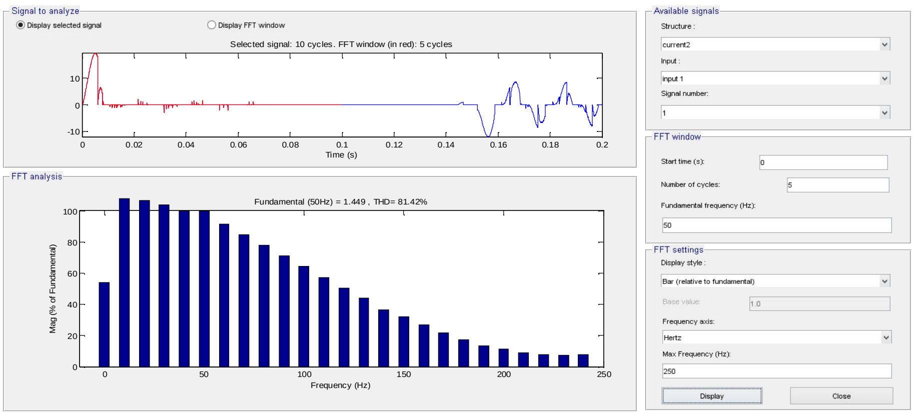

Figure 4. FFT analysis window

Case 2: PMBLDC Motor with PFC controller using Boost Converter

In this circuit, a boost converter is added as a PFC controller and is simulated using Simulink and input current waveform is plotted in graph, shown in the Fig.6. It is clear from Fig.7 that the THD of input current wave form is reduced from 81.42% to 11.47%. The reduction of THD is due to the addition of boost converter in the circuit as PFC controller.

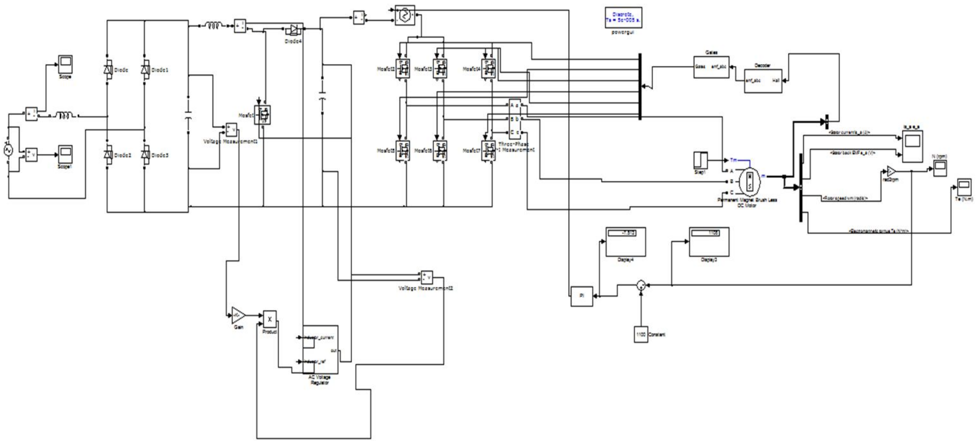

Figure 5. PMBLDC motor with PFC controller using boost converter

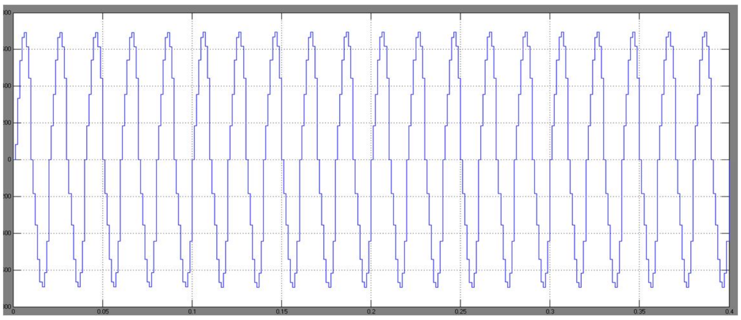

Figure 6. Input current waveform

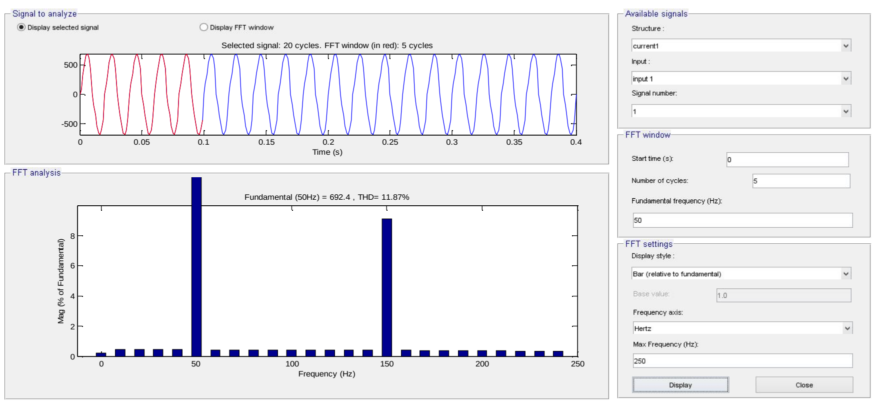

Figure 7. FFT analysis window

Case 3: PMBLDC Motor with PFC controller using Dual Boost Converter

Fig.8. shows the proposed topology. The top & bottom inductors have the same values, the diodes are the same type. Each inductor has its own switch and thus is similar with the paralleling of two single/classic converters. When the MOSFETS are in ON state, the proposed topology transfers energy from the dc source into the inductors. Here, the current divides and equal currents are flowing through top inductor & Mosfet and bottom inductor & Mosfet. Input current waveform is plotted in graph as shown in the Fig.9.

From FFT analysis of input current waveform shown in Fig.10, THD percentage is reduced further from 11.87% to 7.89% using this model. Due to the addition of dual boost converter as PFC controller, further reduction in THD is observed.

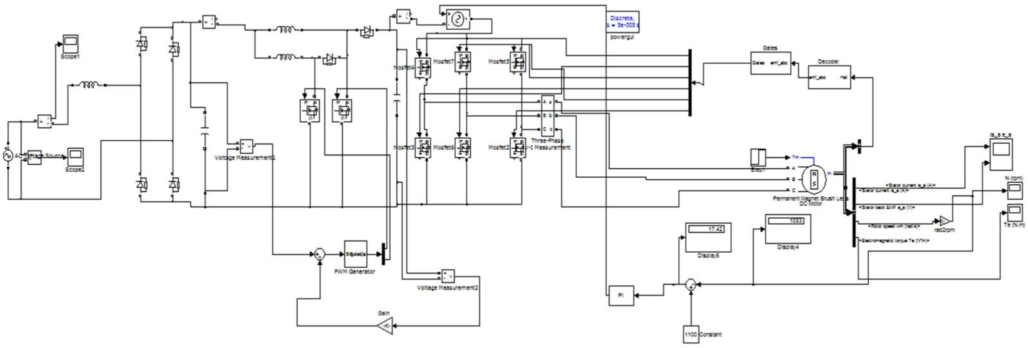

Figure 8. PMBLDC motor with PFC controller using dual boost converter

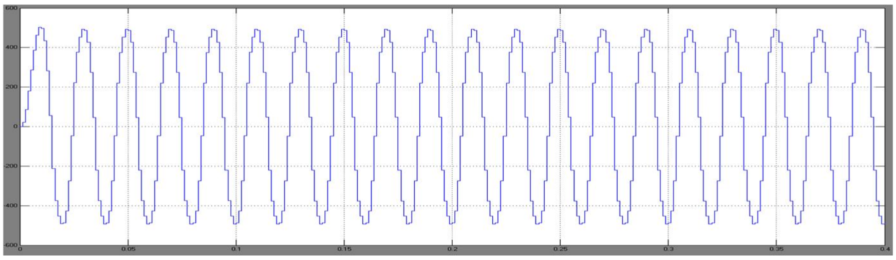

Figure 9. Input current waveform

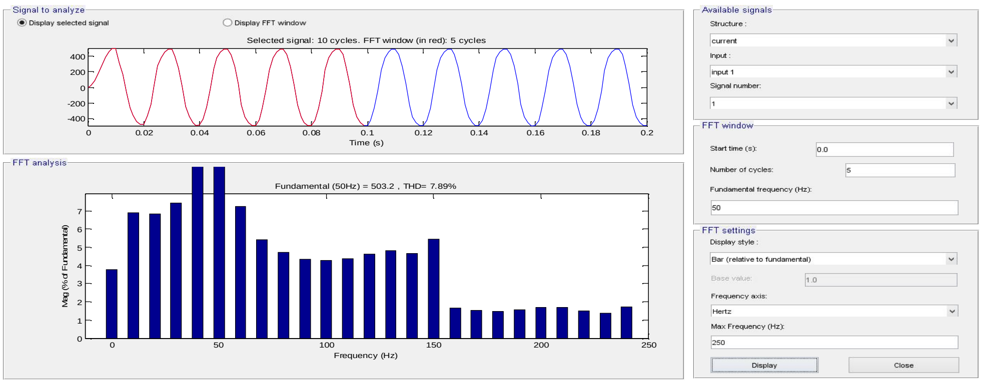

Figure 10. FFT analysis window

The results are tabulated as follows:

TABLE

	INPUT POWER FACTOR	THD
Case 1	0.7755	81.4%
Case 2	0.993	11.87%
Case 3	0.997	7.89%

V. CONCLUSION

Simulations were initially done for elementary rectifier circuits without employing any PFC circuit. The changes in the input current waveform were observed and studied. A PFC circuit having a parallel boost converter was designed. The control strategy was based on average current mode control due to its relative advantages over voltage mode control and peak current mode control. Calculation of power factor was done for the purpose of comparison and to validate the improvement in power factor and THD (for three different cases discussed. In case 2, the power factor has improved from 0.7755 to 0.993 and THD has reduced from 81.4% to 11.87%. Also in case 2, power factor has improved further from 0.993 to 0.997 and reduction of THD is from 11.87% to 7.89%.

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