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Development and Implementation of Shunt Field Converter for Synchronous Motor

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Abstract

Background/Objectives: This paper deals with the design and implementation of Shunt Field Converter for Synchronous Motor. **Methods/Statistical Analysis:** This converter topology is developed to improve the performance of the motor and to reduce the total power loss. **Findings:** The RCD snubber is used to suppress the high voltage spike which occurs on the collector of the IGBT during turn ON and turn OFF period of the switch. **Applications:** The designed converter can be used for all types of reluctance motor.

Keywords: Full Pitch Winding, Flux Reversal, Synchronous Motor, Shunt Field Converter

1. Introduction

A special type of synchronous motor which works on the reluctance principle is shown in Figure 1. The excitation (Field) and load (Armature) winding both are present in the stator having equal number of turns. The excitation winding is triggered by dc supply and the load winding is excited by pulsated DC through power electronic converter[1]. The excitation winding is distributed winding and load winding is bifilar winding. Therefore, to influence the performance of the machine the power electronic converter has to be analysed. The shunt field converter shown in Figure 2 is used for the analysis and estimate the performance of the synchronous motor.

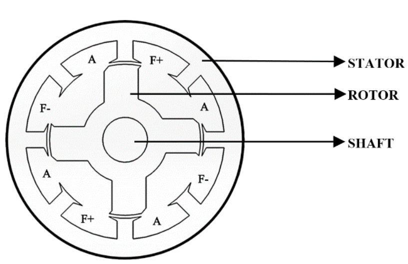

Figure 1. CAD model of synchronous motor.

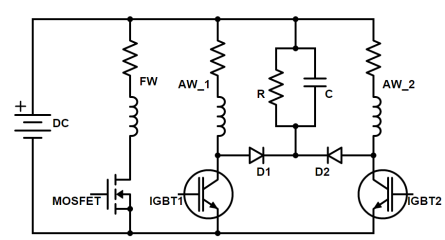

Figure 2. Shunt field converter.

2. Converter Description

The shunt field converter has three switches for the control of current in excitation and load winding. The Excitation winding is controlled by the MOSFET and Load Winding is controlled by IGBT. The MOSFET is switched at high frequency to control the current in excitation winding and the frequency of the load winding switches is varied accordingly to the speed requirement of the motor[2,3]. RCD snubber is provided across the load winding to provide regenerative operation which improves the overall efficiency of the drive system. Table 1 shows the technical specifications of the Shunt Field Converter which is designed for Synchronous Motor

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Table 1. Converter specifications

S.No.	Parameter	Rating
1	Input Voltage (V_{in})	24 V
2	Input Current (I_{in})	6 A
3	Output Power (P_o)	70 W
4	Switching Frequency (F)	100 Hz
5	Duty cycle Ratio (α)	0.5

3. Specifications

4. Modes of Operation

The power converter for DSRM works on two different modes of operation.

4.1 Mode – 1

During this mode the IGBT_1 is switched on, which in turn excites the load Winding (AW1) and makes it align towards the energized stator poles[4-6]. When IGBT1 is turned off, the stored energy in the load winding gets dissipated through the RC network through the freewheeling diode D1 provided which can be inferred from Figure 3.

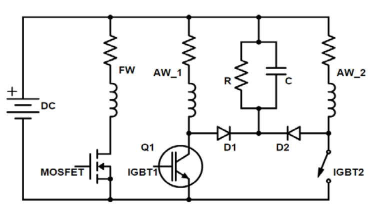

Figure 3. Mode – 1 equivalent circuit diagram.

4.2 Mode – 2

During this mode the IGBT2 is switched on, the load winding (AW2) is excited by the DC supply. The excited load winding (AW2) aligns itself to the energized stator poles. In post process of this mode, the stored energy in the AW2 gets dissipated by the RC network through freewheeling diode D2 which can be inferred from Figure 4.

During Mode – 1 and Mode – 2 the MOSFET provided in series with the excitation winding is switched at high frequency to control the current and to provide better efficient field excitation.

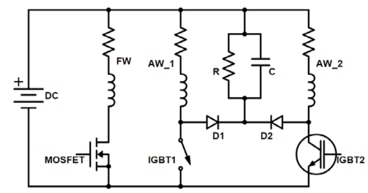

Figure 4. Mode – 2 equivalent circuit diagram.

5. Simulation Results

Figure 5 and Figure 6 shows the simulation results of the converter. The simulation results in Figure 5 show the voltage across the Excitation winding and current through the Excitation winding. The simulation results in Figure 6 show the Gate-Emitter Voltage of the IGBT-1, voltage across the Load Winding-1 and Current through the Load Winding-1.

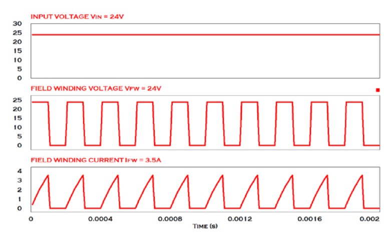

Figure 5. Input voltage, excitation winding voltage, excitation winding current.

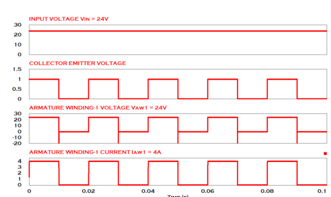

Figure 6. Input voltage, load winding-1 voltage, load winding-1 current.

6. Hardware Results

Figure 7 shows the hardware results of the shunt field converter in which channel 1 is input voltage, channel 2 is the excitation winding voltage and channel 3 is voltage across the bifilar armature (load) winding and channel 4 is the current the load winding of the bifilar winding.

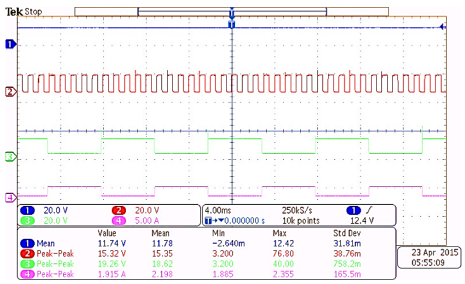

Figure 7. Input voltage, excitation winding voltage, load winding-1 voltage, load winding-1 current.

7. Efficiency Plot

The maximum efficiency obtained by the drive system is 74.27% at rated load condition, which is inferred from Figure 8.

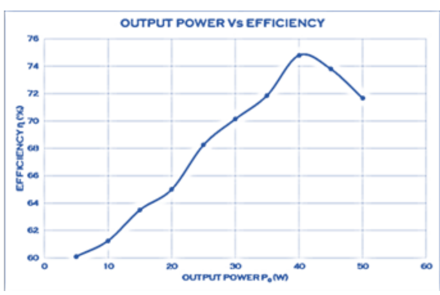

Figure 8. Efficiency plot of the converter at different load conditions.

8. Conclusion

The Shunt field converter has been developed and tested for various load conditions. The performance of the converter has been observed and converter has functioned as per the expectation. Having RCD network across the armature of the motor the efficiency has been increased by 4.1% when compared to converter without RCD network.

9. References

1. Pollock H, Pollock C, Walter RT, Gorti BV. Low Cost, high power density, flux-switching machines and drives for power tools. Proceeding IEEE Industry Applications Society Annual Meeting; 2003 Oct 3. p. 1451-7.
2. Li Y, Li S, Yang Y, Sarlioglu B. Analysis of flux switching permanent magnet machine design for high-speed applications. Proceeding IEEE Energy Conversion Congress and Expo (ECCE); 2014 Sep. p. 302–9.
3. Pollock PH, Barron R, Coles JR, Moule D, Court A, Sutton R. Flux-switching motors for automotive applications. IEEE Transactions on Industry Applications. 2006 Sep-Oct; 42(5):1177-84.
4. ChengM, ChauK T, Chan CC, Sun Q. Control and operation of a new 8/6-pole doubly salient permanent magnet motor drive. IEEE Transactions on Industry Applications.2003 Sep-Oct; 39(5):1363-71.
5. Pollock BM. Comparison of the acoustic noise of a flux switching and a switched reluctance drive. IEEE Transactions on Industry Applications. 2003 May–Jun; 39(3):826–34.
6. Cheng M, Chau KT, Chan CC. Design and analysis of a new doubly salient permanent magnet motor. IEEE Transactions on Magnetics. 2001 Jul; 37(4):3012-20.