Available online at www.sciencedirect.com
ScienceDirect
Journal of Electrical Systems and Information Technology xxx (2017) xxx–xxx
www.elsevier.com/locate/jesit

Vibration analysis including stator, rotor, housing and dynamic response analysis of Flux Reversal Generator

Q1 B. Vidhya *, K.N. Srinivas

Q2 *Department of Electrical and Electronics Engineering, B. S. Abdur Rahman Crescent University, Chennai 600048, India*

Received 26 August 2015; received in revised form 12 April 2017; accepted 3 February 2018

Abstract

This paper attempts to present numerical solution for the vibration analysis of a Flux Reversal Generator (FRG). A three-dimensional finite-element modal analysis (3-D FEA) methodology has been used for this purpose. Vibrations induced due to mechanical and unbalanced reasons have been analyzed. The 3-D modal analysis undertaken identifies the vibrations caused in every part of FRG (stator, shaft, end shields, bearings, and housing), which has been systematically documented. Modal frequencies and the respective speeds which are to be skipped immediately in order to operate the machine always in a safer acoustic zone have been identified and tabulated. To fine tune this, a harmonic analysis has been performed. Up to 10,000 Hz has been considered and frequencies (and proportional speeds) such as 1500 Hz, 1488.62 Hz and 1568.78 have identified as the speeds to be avoided. Apart from frequently reported modal analysis on electrical machines, this 3-D vibration analysis for FRG considering every part of the machine will be helpful to examine the vibration in the machine as a whole. This forms the claim of the paper.

Keywords: Flux Reversal Generator; Modal analysis; Finite element method; Harmonic response; Frequency domain analysis

1. Introduction

1.1. Flux reversal machines (FRM)

FR machine is developed by combining the advantages of SRM (simple construction, fault tolerance, mechanical robustness) and DSPMM (high energy magnets placed in a stator back iron). It is a doubly salient machine. It has a stator with even number of projecting poles. Each stator pole has a concentrated field winding on its pole body and

* Corresponding author.
E-mail addresses: vidhya_eee_phd_2013@bsauniv.ac.in (V. B.), knsrinivas@bsauniv.ac.in (S. K.N.).
Peer review under the responsibility of Electronics Research Institute (ERI).

ELSEVIER Production and hosting by Elsevier

https://doi.org/10.1016/j.jesit.2018.02.004

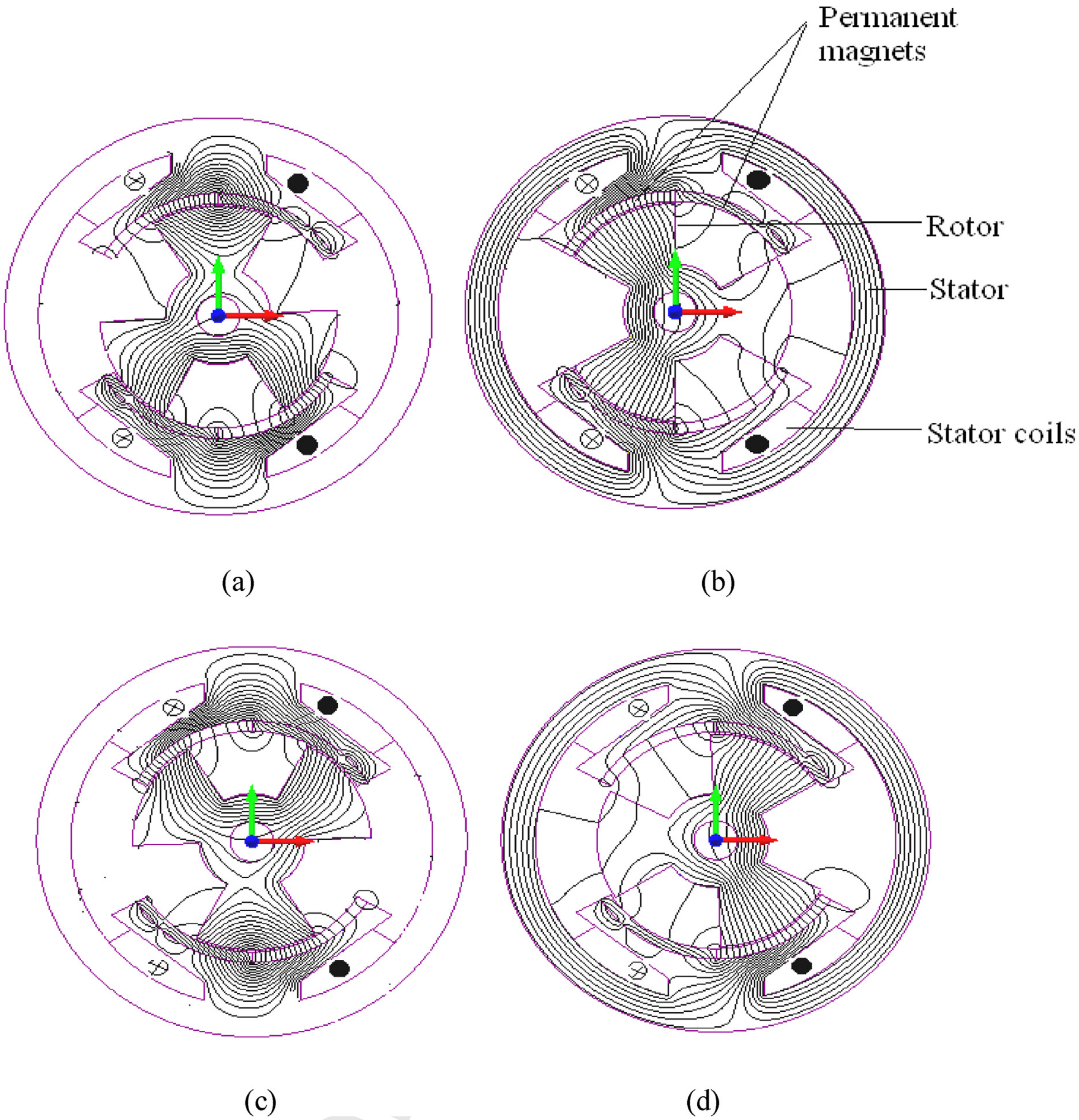

Fig. 1. Operation of flux reversal machine: (a and c) flux does not link field winding. (b and d) Flux has a closed path through the yoke and has flux linkage.

oppositely polarized permanent magnets (PM) on its pole face. Rotor of the machine too has even number of projecting poles, but without any kind windings on it. The principle of operation of FRG is simple. On the stator pole-rotor pole aligned position there is no flux linkage with the stator field winding, as the flux set up circulates completely within each stator pole around PMs. This is the equilibrium position in which there is no flux linkage (or MMF). When the rotor pole overlaps other magnets, after moving certain amount of degrees of rotation, the flux will start to pass through the phase coil, ultimately reaching maximum/minimum. In these positions, flux linkage flux linkage (or MMF) occur. This produces the useful torque for the FR machine (Deodhar et al., 1997).

This is depicted in Fig. 1. Fig. 1(a) and (c) shows two equilibrium positions in the course of the rotor's rotation in CCW direction. There will be no MMF in these positions. Fig. 1(b) shows the displacement of rotor after 30° and Fig. 1(d) shows the same after a further 30° + 30°, that is 60° displacement of the rotor. These are the rotor positions at