Ain Shams University
Faculty of Engineering
Electrical power and Machines Department

Dynamic analysis of printed circuit DC motor

By

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B.Sc. Electrical Engineering, Ain Shams University, 2012

A Thesis Submitted in Partial Fulfillment of the Requirement for the Degree of Master of Science in Electrical Engineering

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STATEMENT

This thesis is submitted as partial fulfillment of M.Sc. degree in Electrical Engineering, Faculty of Engineering, Ain Shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or qualification at any other scientific entity.

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ABBREVIATIONS

AFPM	Axial flux Permanent magnet machines
AGC	Automatic Generation Control
ANFIS	Adaptive neuro-fuzzy inference system
Dylab	Discrete Lyapunov equation command MATLAB
FLC	Fuzzy Logic Controller
FLCP	Fuzzy Logic PID Controller
GA	Genetic Algorithm
I	Integral
Lyab	Lyapunov equation command MATLAB
NdfeB	Neodymium magnet
PCBDC	Printed circuit board DC
PCBDCM	Printed circuit board DC Motor
PID	Proportional Integral Derivative
PSO	Particle Swarm Optimization
TLBO	Teaching-Learning-Based Optimization

ABSTRACT

The machines in the industry could be generally classified based on axial and radial field distribution in the airgap. Axial field machines has unique advantages compared to radial gap machines of which slim and short axial length in addition to high power denisty. The axial machines were considered to be the earliest machines however later they were replaced by radial machines. Nowadays the evolution of the axial flux machines was grown enormously due to the urgent needs for a slim compact high power density drive motors that are crucial in many applications like electric cars, robotics, electric bicycles, traction, etc., the axial field machines is an attractive solution for this issue. There are many construction topologies for these machines that are under constant development, the machine could be DC, synchronous multiphase, brushed, brushless, with iron core, coreless with printed stator or printed disc rotor. The presented machine is an axial flux permanent magnet brushed commutated printed circuit rotor DC motor (PCBDCM), it is considered from the family of axial machines. The first objective of the thesis is to study the dynamic performance of this type of motor, this was done by constructing a block diagram of this motor system as well as performing state space modeling, where the simulation program was MATLAB/SIMULINK. There are two presented printed DC motors with different parameters under study the first one is 0.534 KW and the second is 1KW. A comparative study was performed on the two PCB motors and a 3.08KW conventional DC servo motor firstly in open loop then in closed loop using a proportional integral derivative (PID) as a controller. The results of the comparative study show the superior dynamic performance of the PCB motor over the conventional one. The second objective was to test a new controller algorithm which is fuzzy based PID controller (FLCP) on this type of motor in order to greatly improve its dynamic performance for industrial closed loop applications; consequently the PCB motors with this controller could be suggested as reliable candidate for applications that require accurate speed regulation and precise positioning.

Keywords:

Axial flux machines, printed circuit board machines, printed circuit motor, Fuzzy logic controller, Genetics algorithm, MATLAB/SIMULINK, Fuzzy gain scheduling, Adaptive fuzzy logic controller, DC motor

CHAPTER ONE
INTRODUCTION

1.1 General

Seeking of robust, effective and stable drive system is the most critical issue that faces control engineers nowadays in the field of automation technology [1].

DC Motors are used extensively in the automation technology and industrial application due to their outstanding performance and simplicity of their control commands, they are the first choice in applications that require accurate speed regulation as well as precise positioning [2].

Axial flux printed armature machines include various type and technologies they have been widely used in recent years. Their fields of application include motors and generators for hybrid and electric vehicles. [3]

An axial flux permanent magnet (AFPM) motor is different from a radial flux permanent magnet motor because the air-gap flux is along the axial direction and the air gap is in-plane. Because its axial dimension and the armature winding inductance are small AFPM has received increased attention. [3, 4]

Among the main advantages of these machines are the simple construction and maintenance, superior current density achievable, no torque ripple, easy