Adaptive Bacterial Foraging Optimization Based Tuning of Optimal PI Speed Controller for PMSM Drive

Ravi Kumar Jatoth[1] and A. Rajasekhar[2]

[1] Department of Electronics and Communication Engineering,
National Institute of Technology, Warangal-506004, Andhra Pradesh, India
[2] Department of Electrical and Electronics Engineering,
National Institute of Technology, Warangal-506004, Andhra Pradesh, India
ravikumar@nitw.ac.in, boni.simulator@gmail.com
http://www.nitw.ac.in

Abstract. Speed regulation with conventional PI regulator reduces the speed control precision because of disturbances in Motor and load characteristics, leading to poor performance of whole system. The values so obtained may not give satisfactory results for a wide range of speed. This paper implements, a new tuning algorithm based on the foraging behavior of E-coli Bacteria with an adaptive chemotaxis step, to optimize the coefficients of "Proportional-Integral" (PI) speed controller in a Vector-Controlled Permanent Magnet Synchronous Motor (PMSM) Drive. Through the computer simulations, it is observed that dynamic response of Adaptive bacterial foraging PI (ABF-PI) controller is quite satisfactory. It has good dynamic and static characteristics like low peak overshoot, low Steady state error and less settling time. The ABF technique is compared with "Gradient descent search" method and basic "Bacterial Foraging" Algorithm. The performances of these methods are studied thoroughly using "ITAE" criterion. Simulations are implemented using Industrial Standard MATLAB/SIMULINK.

Keywords: Permanent Magnet Synchronous Motor, PI speed controller, gradient descent, bacterial foraging, adaptive chemotaxis, ITAE.

1 Introduction

According to recent studies, with the advancement of Control theories, Power Electronics, Micro electronics in connection with new motor design and magnetic materials since 1980's electrical (A.C) drives are making tremendous impact in the area of variable speed control systems [1,2]. Among A.C drives newly developed Permanent Magnet Synchronous Motors with high energy permanent magnet materials like "Neodymium Iron Boron" ("Nd-Fe-B") provide fast dynamics and compatibility with the applications if they are controlled properly.

PMSM's are commonly used for applications like actuators, machine tools and robotics. This is due to some of its advantages, features such as high power-density, efficiency, reduced volume and weight, low noise and robustness [3].

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Now-a-days vector control technique has made it possible to apply the PMSM's in high-performance industrial applications where only D.C motor drives were previously available. In order to make the most of a motor performance, a very effective control system is needed. Although many possible solutions are available, eg., adaptive, intelligent control [4,5], PI based control system scheme still remains the more widely adopted solution because of the fact that although simple, a PI based control allows achieving of very high performances when optimally designed [6].

The PI controller has been widely used in industry due to its low steady state error and less maintenance cost [7]. However finding out the parameters K_p, K_i of controller is not any easy task because of motor dynamics and Load parameters. To get the controller parameters "Trail and Error" solution is very complex and doesn't guarantee optimal solution. So for finding optimal PI parameters, bio inspired tuning methods are used to tune the controller. In this paper a new algorithm based on the foraging behavior of bacteria with an adaptive chemotactic step is been used to optimize the K_p and K_i gains of PI controller. The basic BF optimization technique is proposed by "K.M.Passino" [8]. This paper also presents the tuning of PI speed controller with "Gradient Descent search" method,"Bacterial Foraging Optimization Algorithm" and compared with "Adaptive Bacterial Foraging Optimization algorithm" .

2 Permanent Magnet Synchronous Motor

2.1 Structure of PMSM

PMSM with approximately sinusoidal back electromotive force can be broadly categorized in to two types 1) Interior Permanent Magnet Motors (IPMSM) 2) Surface mounted Permanent Magnet Motors (SPM). In this paper we considered "SPM" . In this motor magnets are mounted on the surface.

Because the incremental permeability of magnets is 1.02-1.20 relative to external fields, the magnets have high reluctance and SPM can be considered to have large and effective uniform air gap. This property makes saliency negligible. Thus *q-axis* inductance of motor is equal to *d-axis* inductance i.e., $L_q = L_d$. As a result magnetic torque only can be produced by the motor which arises from the

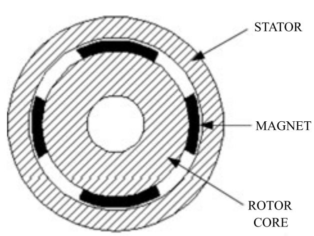

Fig. 1. Structure of Permanent Magnet Synchronous Motor [10]