UNIVERSITI TEKNOLOGI MARA

SPEED SENSORLESS CONTROL OF PERMANENT MAGNET SYNCHRONOUS MOTOR USING MODEL REFERENCE ADAPTIVE SYSTEM AND ARTIFICIAL NEURAL NETWORK

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ABSTRACT

Permanent magnet synchronous motor (PMSM) have been applied in a variety of industrial applications which require fast dynamic response and accurate control over wide speed range. There are two (2) methods for controlling the PMSM which are sensor-based and sensorless-based methods. Sensorless-based method is preferable as it overcome the problems of sensor-based method such as costly, require more installation space and influenced by surroundings such as harsh environment and high temperature. Model reference adaptive system (MRAS) is effective for accurate control of speed and position for the PMSM in sensorless-based method. However, conventional adaptation scheme such as PI controller reduce the estimation accuracy for speed and position of the PMSM. The purpose of this study is to improve the accuracy of speed and position estimation of the PMSM by using speed sensorless control. A new adaptation scheme using hybrid multilayer perceptron (HMLP) network and particle swarm optimization (PSO) algorithm called HMLP-PSO controller is introduced in the MRAS for speed sensorless control of PMSM. First, the field oriented control (FOC) is modelled and validated using sensor-based method to ensure its ability in controlling the PMSM. Then, the MRAS is modelled and HMLP network is used for its adaptation scheme. This study introduced a new method to train the HMLP network using PSO algorithm. The algorithm is used to find the best weights and biases in the HMLP network in order to minimize the error between the reference and adjustable currents. The performance of HMLP-PSO controller is evaluated in term of transient response, steady state response and overall response when certain conditions are applied. In this study, eight (8) different conditions have been selected to evaluate the performance of the proposed controller by manipulating the speed region and motor load of the PMSM. To benchmark its performance, the HMLP-PSO controller is evaluated against two different controllers namely MLP and PI controller. To ensure a fair comparison, both controllers are also trained by using the PSO algorithm. Overall, MRAS using HMLP-PSO controller outperformed the MLP-PSO and PI-PSO controllers in six (6) out of eight (8) conditions. The results proved that HMLP-PSO controller able to improve the accuracy of speed and position estimation of the PMSM.

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CHAPTER ONE
INTRODUCTION

1.1 Research Background

An electrical motor is an electrical machine that converts electrical energy into mechanical energy. The motor can be powered by direct current (DC) source called DC motor or by alternating current (AC) source called AC motor. During the past 30 years, direct current (DC) motor drives have been over take by the alternating current (AC) electrical drive. The drive was evolved positively and become dominant in variable-frequency drive applications because of development of power electronic, digital signal processors (DSPs), and computer-aided design technologies. Nowadays, many types of AC motor have been developed to fulfil the demand of industrial application such as induction motor (IM), permanent magnet synchronous motor (PMSM) and switched reluctance machines (SRM).

Among the dramatic growth of AC electrical drives, the PMSM have been used in many application such as electric home appliance [1], [2], electric transportation appliance [3], [4], and industrial automation [5]. This motor has been widely used due to its small size and volume, high energy efficiency reliable operation, simple structure and high power density [6], [7].

With the continuous reduction in the cost of permanent magnet material and the development of control techniques, PMSM have become more attractive and competitive [8]. The continuous in reduction of material cost also reduced the overall installation and maintenance of the motor. Moreover, the world now more concern about energy crisis, where renewable energy can create large demand of PMSM technologies for energy conversion appliance and electric-drive vehicles [9].

1.2 Permanent Magnet Synchronous Motor

The permanent magnet synchronous motor (PMSM) and the brushless dc motor (BDCM) have many similarities where both machine consist of permanent magnet at the rotor and require alternating current to produce constant torque [10], [11]. The different between these two machines is PMSM has sinusoidal back