# MODELLING OF A NONLINEAR SWITCHED RELUCTANCE DRIVE BASED ON ARTIFICIAL NEURAL NETWORKS

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***Abstract*** **-** Switched Reluctance Motors (SRMs) are increasingly popular machines in electrical drives, whose performances are directly related to their operating condition. Their dynamic characteristics vary as condition change. Recently, several methods of modelling of the magnetic saturation of SRMs have been proposed. However, the SRM is nonlinear and cannot be adequately described by such models. Artificial Neural Networks (ANNs) may be used to overcome this problem. This paper presents a method which uses backpropagation algorithm to handle one of the modelling problems in an switched reluctance motor. The simulated waveforms of a phase current are compared with those obtained from a real switched reluctance commercial motor. Experimental results have validated the applicability of the proposed method.

## INTRODUCTION

An important characteristic of the SRM drive is its inherent nonlinearity. The inductance of the magnetic circuit is a nonlinear function of both phase current and rotor position. In addition, the system handles energy most efficiently when the energy conversion cycles are made as square as possible, maximising the ratio of energy converted to energy input [12, 13]. This leads a particularly difficult problem because of their complicated magnetic circuit, which operates at varying levels of saturation under operating conditions. Square energy conversion cycles are created by driving the motor into magnetic saturation and bring the energy handling requirements of inverter into closer alignment with the energy conversion characteristics of motor [12, 13]. This can results in reduced switch requirements and energy savings. The recirculated energy in a drive with an applied voltage requires current flow and acts to increase the inverter and motor losses that accompany the current flow. Stephenson and Corda [1] proposed a quite successful method to model the flux linkage as a function of current and rotor position. This method has been modified by several others [2, 3, 4]. Torrey and Lang [5] have also proposed a method to provide analytical expressions for the flux linkage and current for every rotor position within a single summary equation. In contrast to the above methods, there have been many attempts to generate the necessary static magnetisation curves by Finite Element Analysis (FEA) [6]. Recently, the authors have reported an application of ANN for modelling of the magnetic nonlinearity of the magnetisation curves [14].

Artificial Neural Network (ANN) techniques have grown rapidly in recent years. Extensive research has been carried out on the application of artificial intelligence. Artificial Neural Network technology has the potential to accommodate an improved method of determining nonlinear model which is complementary to conventional techniques. NN are alone nonlinear and actual algorithmic relevant set of training examples is required which can be derived from operating plant data.

This paper investigates the use of ANNs for the modelling of the magnetic nonlinearity of the SRM. Since this method does not require any prior information regarding the SRM system apart from the input and output signals, it is quite simple and cost effective. The modelling method in this paper departs significantly from previous modelling method by the authors, in which the magnetisation curves are represented by functions of flux linkage against rotor position, rather than current. In the paper, first, magnetic nonlinearity of the SRM is presented, then ANN approach to the modelling of the SRM is presented. ANN training requirements are discussed next and finally, the models are verified through comparisons with experimentally measured results.

## MAGNETIC NONLINEARITIES OF THE SRM

The first step in modelling the nonlinearities of the SRM is predicting ($\psi/\theta/i$) curves for a given motor. For the experimental motor, these curves are shown in Fig. 1. Although the construction of the SRM is quite simple, it is very difficult to derive a comprehensive mathematical model for the behaviour of the machine. Many attempts have been made by different researchers to overcome this problem. The structure of *Stephenson and Corda method* is that flux linkage is modelled as a function of current,