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ORIGINAL ARTICLE

Parameters estimation of squirrel-cage induction motors using ANN and ANFIS

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Abstract In the transient behavior analysis of a squirrel-cage induction motor, the parameters of the single-cage and double-cage models are studied. These parameters are usually hard to obtain. This paper presents two new methods to predict the induction motor parameters in the single-cage and double-cage models based on artificial neural network (ANN) and adaptive neuro-fuzzy inference system (ANFIS). For this purpose, the experimental data (manufacturer data) of 20 induction motors with the different power are used. The experimental data are including of the starting torque and current, maximum torque, full load sleep, efficiency, rated active power and reactive power. The obtained results from the proposed ANN and ANFIS models are compared with each other and with the experimental data, which show a good agreement between the predicted values and the experimental data. But the proposed ANFIS model is more accurate than the proposed ANN model.

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1. Introduction

Induction motors especially the squirrel-cage motors have the advantages such as less necessity to repair and control, higher reliability, more efficiency and low price and size. The induction motors can be considered as the industry's motive motor [1]. To study and simulate the induction motors' behaviors, the starting details and the transient state faults should be considered. Therefore, for this purpose the induction motor parameters should be estimated by high precision [2]. The parameters estimation of the induction motor is an important topic in the electric drive literatures because the controller performance depends on the accuracy of the motor parameters used by the control algorithm [3–5]. The squirrel-cage type induction motors are usually modeled with single-cage and double-cage models. The parameters of these models can be obtained by two methods [6]:

1. With the information of the full load test, the maximum torque and current [7–9].
2. With the information of the no-load test and the locker-rotor test.

Nowadays, the various methods have been presented to estimate the parameters in the induction motors by the researchers [8–11]. In one of these methods, the transient stator current has been used to identify the parameters of an electromechanical mode of the induction motor. In [12], a new

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Table 1 Manufacturer data of induction motors (U = 400 V, f = 50 Hz).

P (KW)	$\mathrm{Cos}\rho_{FL}$	T_M/T_{FL}	T_{ST}/T_{FL}	I_{ST}/I_{FL}	ω_{FL} (r/min)	η_{FL}
500	0.87	2.7	2.3	6.5	992	0.966
400	0.82	2.6	2.1	6.5	742	0.962
355	0.87	2.7	2.2	6.8	1486	0.967
250	0.8	3	2.2	7.3	991	0.91
200	0.87	2.7	2.7	7	1488	0.962
160	0.86	2.7	2.4	7	1487	0.96
110	0.86	3	2	7.6	2982	0.955
90	0.86	2.7	2.2	6.8	1480	0.94
75	0.86	2.4	2.1	6.3	1482	0.947
45	0.81	2.3	2.1	6	740	0.92
37	0.86	3.1	2.5	7	1475	0.929
30	0.88	2.7	2.3	6	2940	0.91
19	0.84	3.2	2.7	6.9	1460	0.905
15	0.92	2.9	2.2	6.6	2910	0.904
11	0.9	3.1	2.2	7	2945	0.91
8	0.74	2.5	2.1	4.6	960	0.86
315	0.84	3	2	7.3	991	0.962
132	0.86	3	2.7	7.2	1486	0.955
55	0.82	2.4	2.2	6	738	0.931
22	0.77	2.9	2.8	5.5	975	0.908

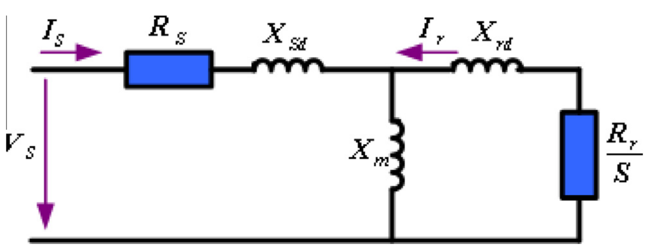

Figure 1 Single-cage induction motor steady state model.

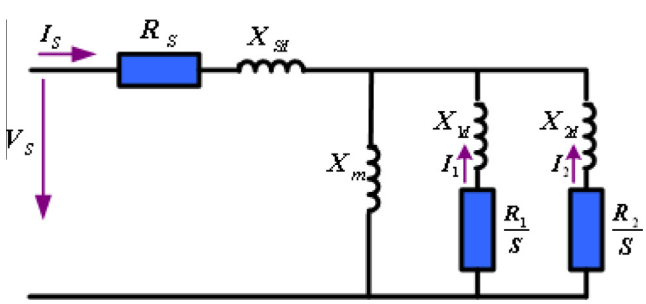

Figure 2 Double-cage induction motor steady state model.

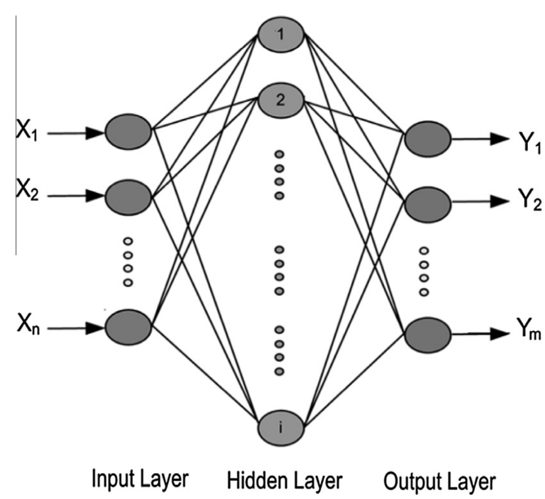

Figure 3 MLP structure.

method for determination of the steady-state equivalent circuit parameters of the wound-rotor induction motors has been presented using the experimental data from the starting transient measurements. Also, a new parameters determination method for squirrel-cage induction motors has been presented in [13] based on the instantaneous electrical power and the mechanical speed measured in a free acceleration test. In [14], the implementation of an adaptive neuro fuzzy inference system (ANFIS) technique to control the speed of the induction motor has been proposed and compared it with the PI and fuzzy controllers. In [15] a Takagi–Sugeno neuro-fuzzy inference system for direct torque and stator reactive power control has been applied to a doubly fed induction motor. In this case, the control variables (d-axis and q-axis rotor voltages) have been determined through a control system. More recently, authors have developed a two-step approach for parameters identification of induction motor form a nonlinear model including the magnetic saturation [16,17]. In [18], a new method to estimate the electrical parameters in a three-phase induction motor equivalent circuit has been presented using the genetic algorithm (GA). Also, in [19] the artificial bee colony (ABC) algorithm has been proposed and compared with the various recently methods for the parameters estimation of the induction motors. The shuffled frog-leaping algorithm has been introduced in [20] for the parameters estimation of a double-cage asynchronous machine using the standard manufacturer data. In these works, the induction motor parameters have been obtained from a relatively poor initial guess,

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