Artificial Neural Network Based Speed and Torque Control of Three Phase Induction Motor

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Abstract: ***Direct Torque Control (DTC) of Induction Motor drive has quick torque response without complex orientation transformation and inner loop current control. DTC has some drawbacks, such as the torque and flux ripple. The control scheme performance relies on the accurate selection of the switching voltage vector. This proposed simple structured neural network based new identification method for flux position estimation, sector selection and stator voltage vector selection for induction motors using direct torque control (DTC) method. The ANN based speed controller has been introduced to achieve good dynamic performance of induction motor drive. The Levenberg-Marquardt back-propagation technique has been used to train the neural network. Proposed simple structured network facilitates a short training and processing times. The stator flux is estimated by using the modified integration with amplitude limiter algorithms to overcome drawbacks of pure integrator. The conventional flux position estimator, sector selector and stator voltage vector selector based modified direct torque control (MDTC) scheme compared with the proposed scheme and the results are validated through both by simulation and experimentation.***

Keywords: ANN based speed controller, direct torque control (DTC), flux position estimator.

1. Introduction

The induction motor is very popular in variable speed drives due to its well known advantages of simple construction, ruggedness, and inexpensive and available at all power ratings. Progress in the field of power electronics and microelectronics enables the application of induction motors for high-performance drives where traditionally only DC motors were applied. Thanks to sophisticate control methods, induction motor drives offer the same control capabilities as high performance four quadrant DC drives. A major revolution in the area of induction motor control was invention of field-oriented control (FOC).

In vector control methods, it is necessary to determine correctly the orientation of the rotor flux vector, lack of which leads to poor response of the drive. The main drawback of FOC scheme is the complexity. The new technique was developed to find out different solutions for the induction motor torque control, reducing the complexity of FOC schemes known as Direct Torque control (DTC).

The ANNs are capable of learning the desired mapping between the inputs and outputs signals of the system without knowing the exact mathematical model of the system. Since the ANNs do not use the mathematical model of the system, the same. The ANNs are excellent estimators in non linear systems [6] - [8]. Various ANN based control strategies have been developed for direct torque control induction motor drive to overcome the scheme drawback. In this project, neural network flux position estimation, sector selection and switching vector selection scheme proposed, and ANN based speed controller used to reduce the current ripple by regulating the switching frequency, are proposed. Total harmonic distortion (THD) of the stator current analysis has been also presented in this work.

2. Experimental Methodology

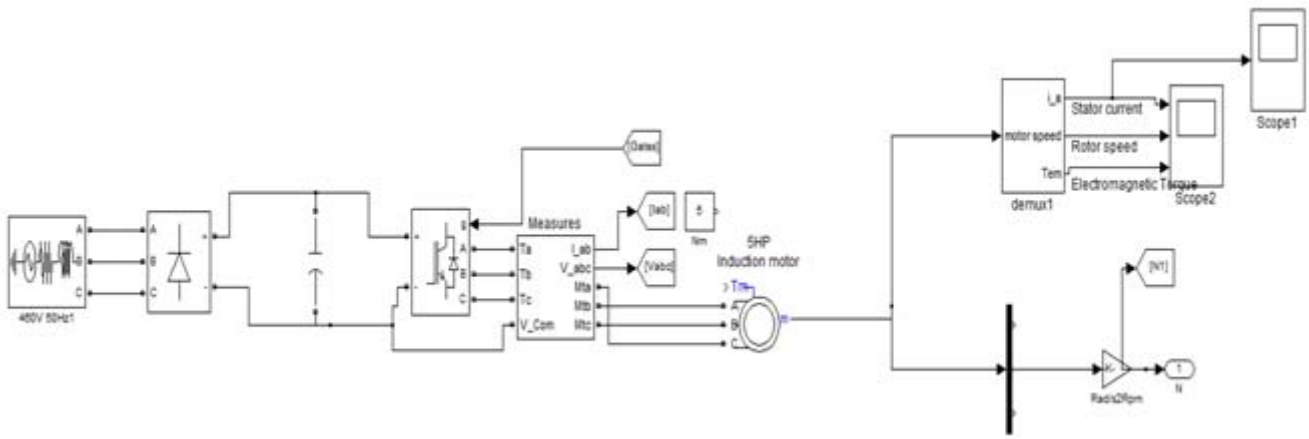

Figure 1: I controller under operation in control of speed and torque of 3 phase induction motor

The speed and torque control of three phase induction motor using PI controller is shown in figure which gives the simulated output of Speed and Torque and the obtained speed and torque consists of fluctuations and ripples. The supply is given to the motor through converter and inverter to vary the input voltage according to the requirement, then its connected to the measuring circuit where it measures the input parameters. After supply is given to the motor, the

speed and torque of the motor is controlled using the PI controller, before that the Flux and Torque of the motor is separated using DTC principle.

3. Results and Discussions

The results of simulation obtained in this work are for the induction motor of 5HP and The machine model is implemented for modified DTC using PI controller and the entire drive scheme along with flux determination block has been modeled for proposed ANN based DTC scheme using Matlab /Simulink. The Neural Network gives almost the same output pattern for the same or nearby values of input. This tendency of the neural networks which approximates the output for new input data is the reason for which they are used as intelligent systems. An Artificial Neural Network based control scheme has been proposed for arriving at the most suitable flux value, given the speed and torque requirement at any operating point of the drive so that the losses are minimized and the efficiency of the drive is improved. From the results obtained, it is evident that when the machine operates with the flux value determined by the ANN, it yields an improved efficiency conditions.

A .**Dynamics of a DTC based induction motor drive with PI controller**

Under this case the following waveforms are shown below

a) The Stator current to the motor

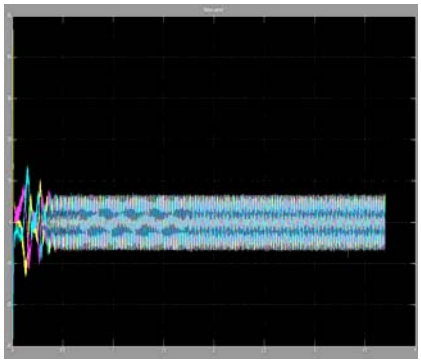

Figure 2: Stator current to the motor

b) The Speed curve of the motor

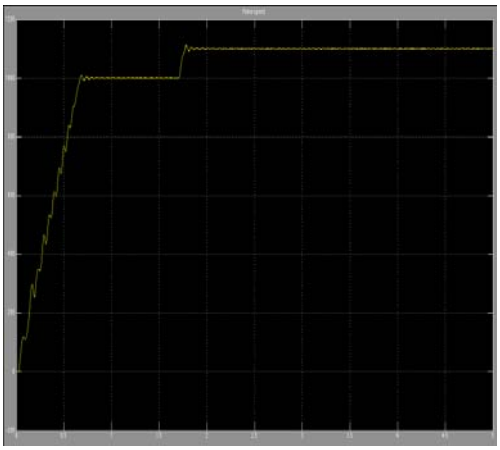

Figure 3: Speed of the motor

c) The Electromagnetic torque at the output side

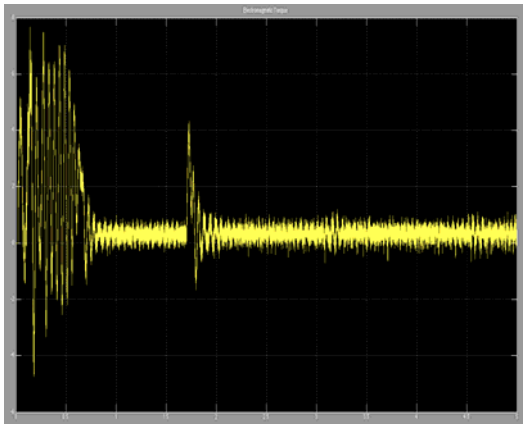

Figure 4: Electromagnetic torque of the motor

B. In the below shown simulink model, the control of three phase induction motor is done using ANN.

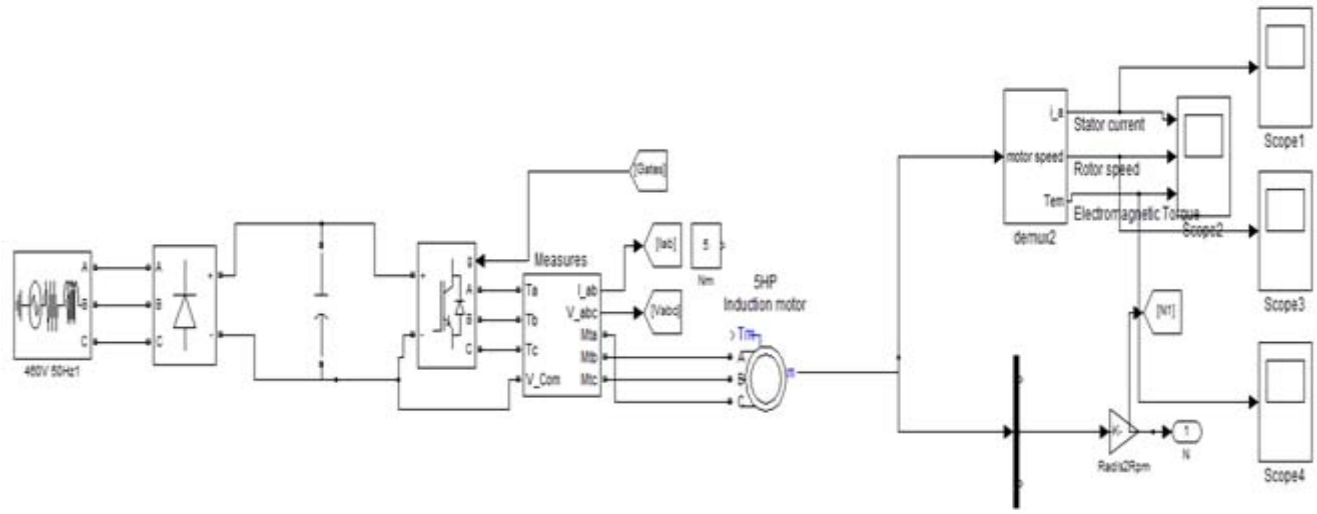

Figure 5: Simulink model with ANN

Figure Shows the speed and torque control of three phase induction motor using Artificial Neural Network with reduction in fluctuation in speed and torque ripples and improves the quality of control of speed and torque of three phase induction motor. In ANN based control of speed and torque, the control is done by using Neural Network where the error in controlling is less than 0.11% and even it doesn't exceed 0.07%. Thus effective control can be achieved using Artificial Neural Network.

Under this case the following waveform are shown below

a) The Speed curve of the motor

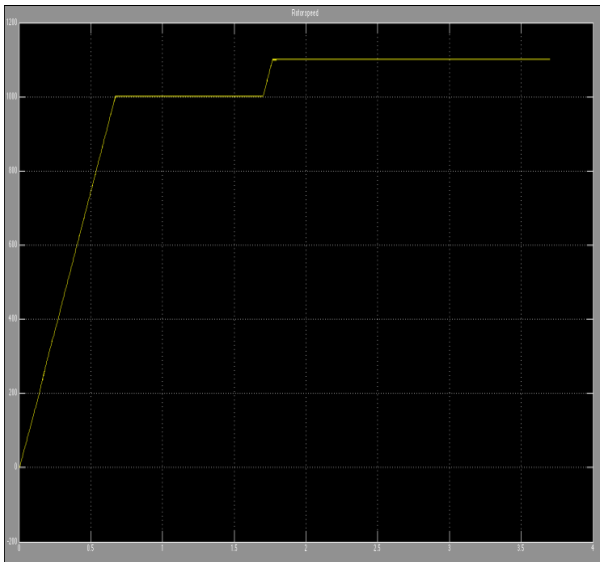

Figure 6: Speed of the motor

b) The Electromagnetic torque at the output side

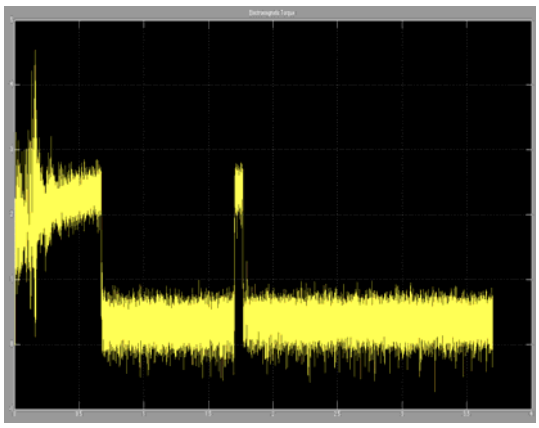

Figure 7: Electromagnetic torque of the motor

Digital signal processor implementation of a neural network induction motor controller performing field oriented control is presented in this project. Experimental test results confirm that two stages of training are required to train the neural network, namely, an offline training stage and another stage where experimental data is employed to train the neural network. It is shown that digital signal processor computation time can be reduced, using simple programming methods, thus enabling the digital signal processor to be used for other system requirements with the present generation of digital signal processors, the proposed neural network will require only a small portion of processor resources. It is also shown that the neural network error due to computation approximations is negligible compared to the error caused by the limited number of neurons and any lack of information in the training data.

C .Simulink Model of ANN for speed and torque control

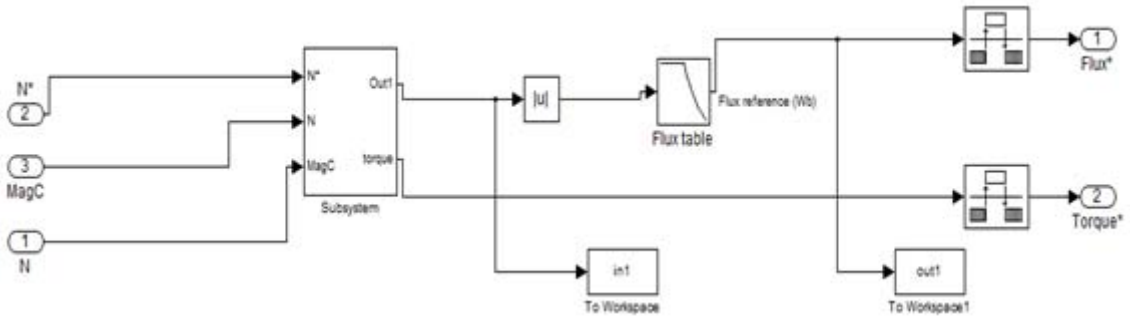

Figure 8: Simulink Model ANN

In Artificial Neural Network based control of speed and torque of three phase induction motor, using artificial neural network, the comparison of reference torque with the actual torque is carried and the error is rectified using ANN and the resultant speed and torque will be effectively rectified. In order to make the experimental validation of the effectiveness of the proposed DTC scheme for torque ripple reduction, a DSP-based induction motor drive system has been built. The experimental setup includes a fully digital controlled IGBT 5kVA Semikron make inverter and a 5hp, 415-V, 50-Hz, four-pole induction motor. It is shown that digital signal processor computation time can be reduced; using simple programming methods, thus enabling the digital signal processor to be used for other system requirements with the present generation of digital signal processors, and the proposed neural network will require only a small portion of processor resources. It is also shown that the neural network error due to computation approximations is negligible compared to the error caused by the limited number of neurons and any lack of information in the training data.

4. Conclusions

In this project a new ANN based speed controller, flux position estimation, sector selection and the switching

voltage vector selection has been proposed for direct torque controlled induction motor drive. The proposed scheme performance is compared with the modified DTC scheme under the steady state and dynamic conditions. According to the simulation and experimental results of a **(**5HP) test motor, amplitude of the stator flux ripple and developed torque ripple are reduced by notable amount with good speed dynamic. The both results support that the ANN based DTC scheme has better performance than modified DTC scheme.

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Author Profile

Manjunath Prasad K P received the BE. degrees in Electrical and Electronic Engineering from P E S College of Engineering in 2010 under Visveswaraya Technological University and During 2011-2013, I joined M. Tech in Ghousia College of Engineering under the Same university and done the project on ANN Based Speed and Torque Control of Three Phase Induction Motor.