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Analysis of DTC-SVM Scheme for Induction Motor Fed with 5-Level Cascaded Multilevel Inverter

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ABSTRACT

Direct Torque Control employing a Voltage Source Inverter (VSI), it is possible to regulate directly the stator flux linkage and the electromagnetic torque by the optimum selection of inverter switching vectors in AC drive systems to obtain high performance torque control. In this Paper, a stage of artificial neural network (ANN) has been employed in the closed loop flux controller for predicting the target parameters. The ANN was trained by adopting the back propogation algorithm and the appropriate pulses for the 5 level cascaded inverter was generated by space vector modulation(SVM). The space vector modulation technique (SVM) is applied to 5 level cascaded inverter control in the proposed DTC-based induction motor drive system, thereby dramatically reducing the total harmonic distortion (THD) and thereby improving the fundamental voltage. Then the model based on space vector modulation is designed to be applied to Induction Motor (IM) with a five-level Inverter and proposes a SIMULINK model based on SVM for Five-level cascaded inverter. The scheme is described clearly and simulation results are reported and demonstrate its effectiveness. The entire control scheme is implemented with Matlab/Simulink.
Keywords : DTC, SVM, ANN, Cascaded Multilevel inverter

1. INTRODUCTION

The high performance electric speed drives needs decoupled torque and flux control [1]. This method is generally afforded through Field oriented control (FOC) or vector control method [2]. The excitation current and load current can be regulated individually by using FOC method. Hence, flux and torque also be separately controlled correspondingly in DC motor [3]. To control pulse-width-modulation in the inverter system, the FOC method needs current controller, coordinate transformation and current regulator [4]. But FOC needs efficient and complex calculation of the decoupling, so it is complex to perform and easily towards by load disturbance and parameter uncertainties [5].

The classical DTC method is based on hysteresis loop controller with single vector switching table. Its switching frequency varies with speed and load torque ,which can bring out high torque pulsation especially in low speed because of the low switching frequency, which greatly limits its application[6][7]. Common disadvantages of conventional DTC are high torque ripple and slow transient response to the step changes in torque during start-up[8]. Therefore intelligent techniques are used like Artificial Neural Networks(ANN),Fuzzy logic and Sliding mode controller(SMC) theory[9][10].most of them are concerned with improvement of the flux and torque estimator and combined operation of DTC with space vector modulation technique.In this paper an Artificial neural Network has been employed in the closed loop flux controller and back propagation algorithm for training the neural networks.

2. BACK PROPAGATION LEARNING ALGORITHM STEPS

Step 1: Initialization of the input layer, hidden layer and output layer weights of the neural network, i.e., change in motor torque ΔT, change in flux $\Delta\phi$ and residual $r(k)$.

Step 2: Learning the network according to the input and the corresponding target.

Step 3: Calculate the back propagation error of the target r_1, r_2 *and* r_k .

$$\left.\begin{aligned} BP^1_{error} &= r_1^{NN(tar)} - r_1^{NN(out)} \\ BP^2_{error} &= r_2^{NN(tar)} - r_2^{NN(out)} \\ BP^k_{error} &= r_k^{NN(tar)} - r_k^{NN(out)} \end{aligned}\right\}$$

Where, $r_k^{NN(tar)}$ is the network target of the k^{th} node and $r_k^{NN(out)}$ is the current output of the network.

Step 4: The current output of the network is determined as follows,

$$\left.\begin{aligned} r_1^{NN(out)} &= \alpha_1 + \sum_{n=1}^{N} w_{2i1}\, r_1^{NN}(n) \\ r_2^{NN(out)} &= \alpha_2 + \sum_{n=1}^{N} w_{2i2}\, r_2^{NN}(n) \\ r_k^{NN(out)} &= \vdots + \sum_{n=1}^{N} w_{knk}\, r_k^{NN}(n) \end{aligned}\right\}$$

Where, α_1, α_2 and α_k are the bias function of the node $1, 2$ *and* k respectively.

$$\left.\begin{aligned} r_1^{NN}(n) &= \frac{1}{1+\exp(-w_{1n1}r_1 - w_{2n1}r_2)} \\ r_2^{NN}(n) &= \frac{1}{1+\exp(-w_{2n2}r_2 - w_{kn2}r_k)} \\ r_k^{NN}(n) &= \frac{1}{1+\exp(-w_{knk}r_k - w_{1nk}r_1)} \end{aligned}\right\}$$

Step 5: The new weights of the each neurons of the network are updated by $w_{new} = w_{old} + \Delta w$. Here, w_{new} is the new weight, w_{old} is the previous weight and Δw is the change of weight of each output. The change of weight is determined as follows:

$$\left.\begin{array}{l} \Delta w_1 = \delta . r_1 . BP^{1}_{error} \\ \Delta w_2 = \delta . r_2 . BP^{2}_{error} \\ \Delta w_k = \delta . r_k . BP^{k}_{error} \end{array}\right\}$$

Where, δ is the learning rate (0.2 to 0.5).

Step 6: Repeat the above steps till the BP_{error} gets minimized $BP_{error} < 0.1$

Once the neural network training process is completed, the network is trained well for the identifying $r(k)$ of the input. Based on the output of the network, the control pulses of the 5-level inverter have been decided by using the SVM technique.

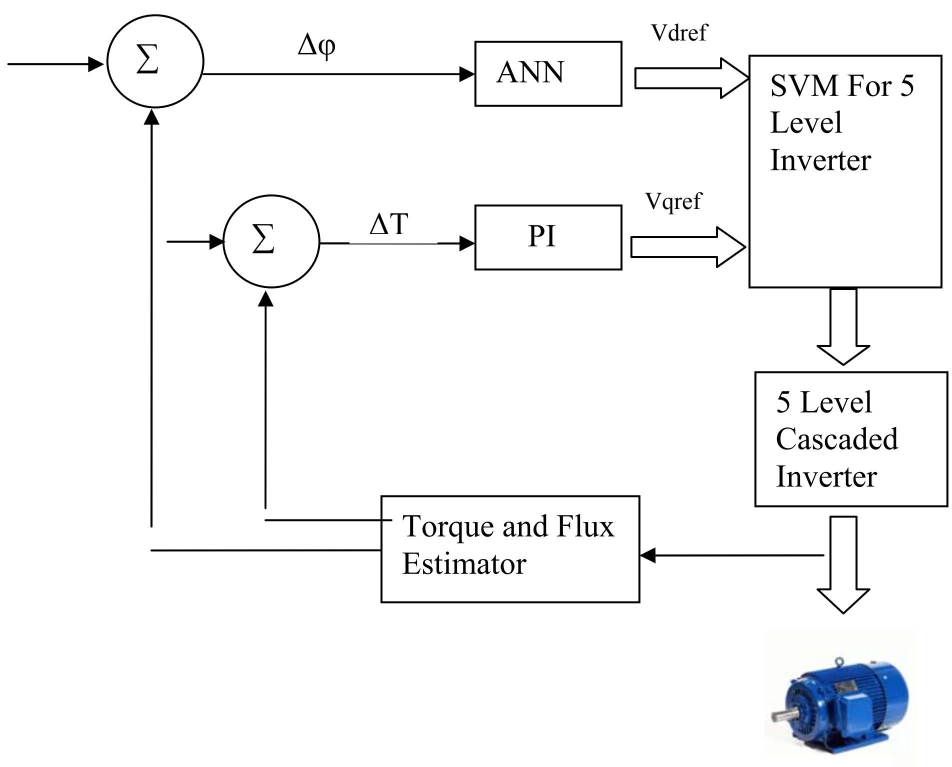

Fig I Structure of Proposed Method

3. RESULTS AND DISCUSSIONS

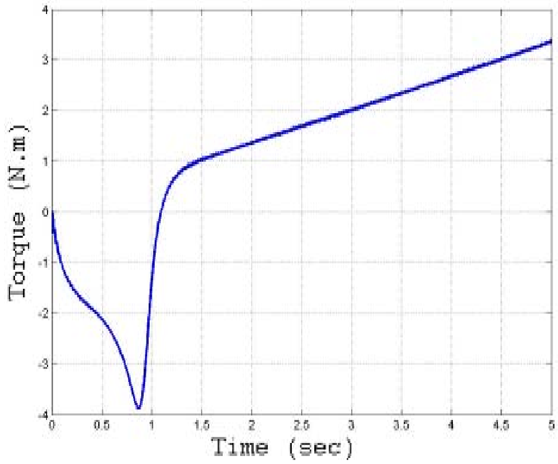

Fig.II Induction motor Torque for

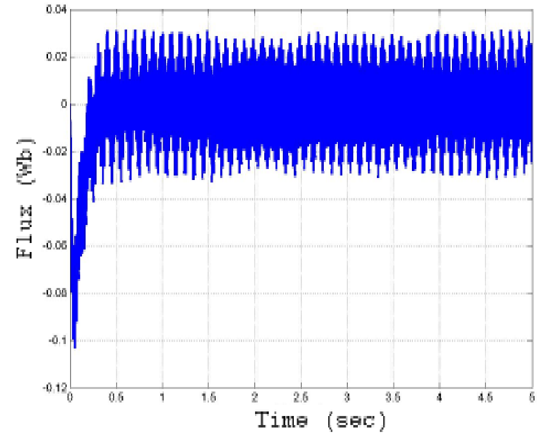

Fig.III Induction motor Stator Flux

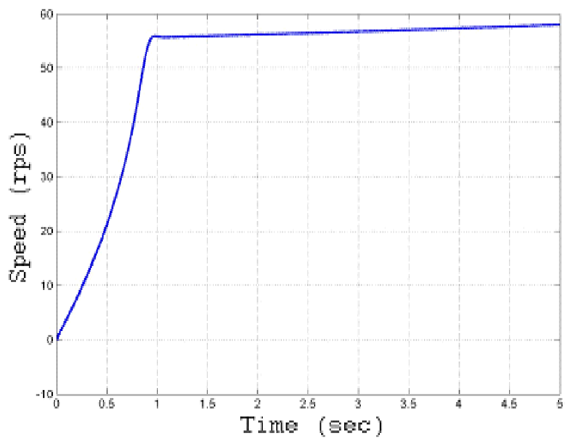

Fig.IV Induction Motor Speed for

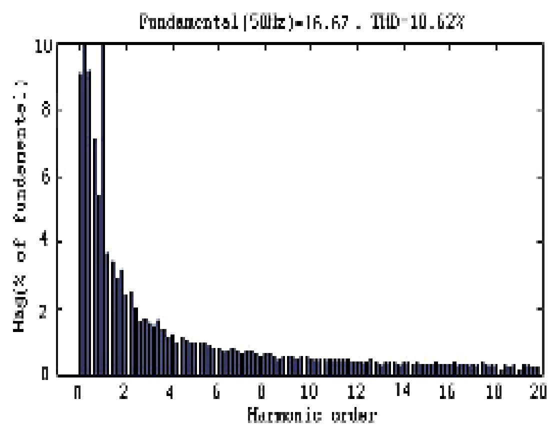

Fig.V Harmonic Analysis for DTC with PI

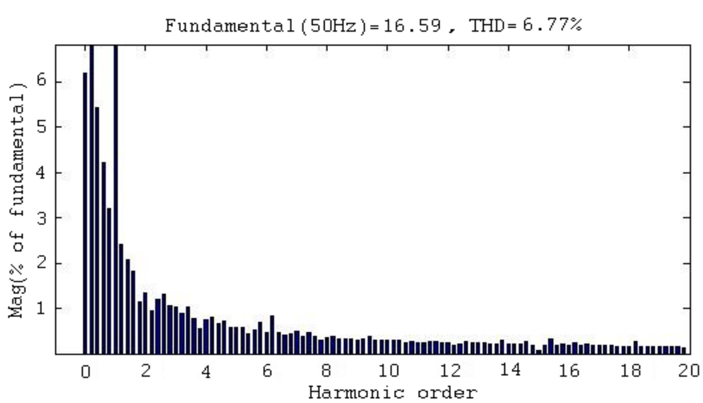

Fig.VI Harmonic Analysis for DTC with Proposed method

4. COMPARATIVE ANALYSIS

	DTC with Normal PI Controller	DTC with proposed method
THD	10.62%	6.77%
Fundamental Voltage	16.67 V	16.59 V
StatorFlux Distortion	+0.07 to -0.07wb	+0.03wb to -0.03wb

5. CONCLUSION

The induction motor speed is analysed with the mentioned supply voltage and current, which is illustrated. It was seen that the rotor speed of the induction motor is measured for 5 seconds and the Total Harmonic Distortion (THD) and the fundamental Voltage has seen considerable improvement with the proposed method i.e, with the ANN in the closed loop flux controller and the normal PI controller in the Closed loop Torque controller. . Depending on these ultimate changes the performance variations of the system has been noticed.

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