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Direct Torque Control of Induction Motor: Multilevel inverter with Space Vector Modulation and Neural networks

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ABSTRACT: An Intelligence Direct Torque Control (DTC) of induction motor using multilevel inverter with space vector modulation is proposed in this paper. The novelty of the proposed intelligence technique is an Artificial Neural Network (ANN), which is utilized for the DTC of the induction motor. Here, ANN has been trained by using the target parameters like reference quadrature and direct axis voltage with the corresponding input parameters change in motor torque and flux. The change in motor torque and flux parameters are identified by using the multilevel inverter output voltage and current. The back propagation process is used for the training process of the ANN. By using the ANN outputs, the Space Vector Modulation (SVM) technique develops the control pulses for the multilevel inverter. Then the proposed intelligence technique is implemented in the MATLAB/simulink platform and the effectiveness is analyzed by comparing with the different case studies. The comparison results demonstrate the superiority of the proposed approach and confirm its potential to solve the problem.

KEYWORDS: DTC, SVM, ANN, Induction motor, Multilevel inverter

I. INTRODUCTION

At present, a control method known as Direct Torque Control (DTC) was established with various method to control the induction motor torque and flux [1]. DTC is layout to afford fast and robust reactions of the drive even below low frequency operation of power electronics [2]. It is a combination of the FOC and direct self control (DSC) methods [3]. By using a switching vector look-up table, the basic concept of DTC of induction-motor drives is to control both stator flux-linkage and electromagnetic torque of the machine concurrently [4] [5]. It is described by the deficiency of PI regulators, coordinate transformations, current regulators and PWM signals generators [6]. The DTC has been put into operation by using either variable switching frequency or constant sampling techniques [7]. Compared with a vector control scheme, DTC provides identical dynamic performance with simpler controller architecture [8].

The classical DTC technique is in terms of hysteresis-loop controller with single vector switching table. Its switching frequency differs with speed and load torque, which can bring out high torque pulsation particularly in low speed due to the low switching frequency, which greatly restricts its application [9][10]. Common disadvantages of conventional DTC are high torque ripple and slow transient response to the step changes in torque during start-up [11]. Therefore, intelligent methods are used such as Artificial Neural Networks (ANN), Fuzzy Logic (FL) and Sliding mode control (SMC) theory [12][13]. Majority of them are concerned with enhancement of the flux and torque estimator and combined operation of DTC with a space vector-modulation (SVM) technique [14].

This paper illustrated an Intelligence Direct Torque Control (DTC) of induction motor using multilevel inverter with space vector modulation. The uniqueness of the illustrated intelligence method is an Artificial Neural Network (ANN) is made use of the DTC of the induction motor. Here, ANN has been trained using the target parameters such as reference quadrature and direct axis voltage with their subsequent input parameters altered in motor torque and flux. The change in motor torque and flux parameters are recognized by using the multilevel inverter output voltage and

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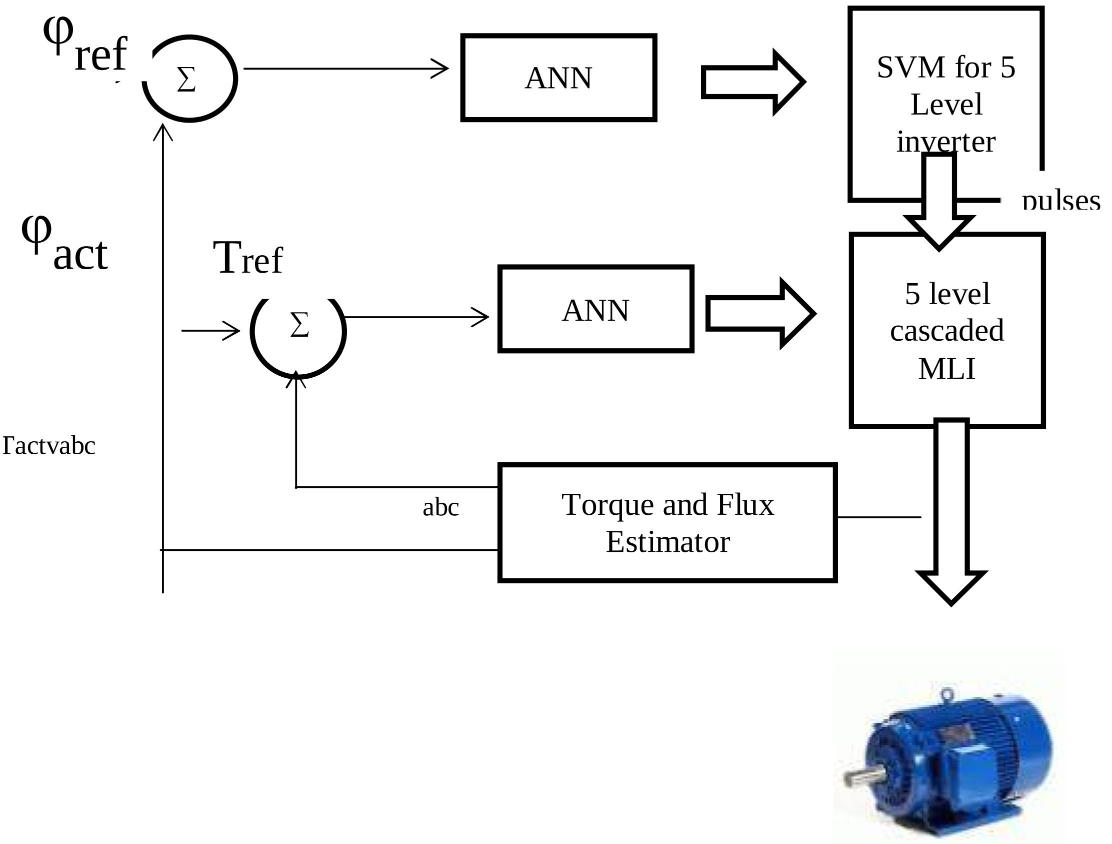
current. The back propagation method is used for the training process of the ANN. By using the ANN outputs the Space Vector Modulation (SVM) technique improves the control pulses for the multilevel inverter. Then the proposed intelligence method is implemented in the MATLAB/simulink platform and the effectiveness is evaluated by comparing with the various case studies i.e., **Case 1:** Here, the torque controller has been continuing with the proposed ANN stage 1 controller but the flux controller is dropped the ANN stage 2 controllers. **Case 2:** during which the torque controller has been dropped at the ANN stage 1 controller but the flux controller is allowed with the ANN stage 2 controllers and **PI Controller** : In this section described about the 5 level inverter DTC scheme with normal proportional integral (PI) controller results.

II. PROPOSED CONTROL METHOD

Traditionally, the speed of IM is often controlled, by various techniques. The available techniques can't be adoptive for unknown load and parameter variations.So,the accuracy of the model and the speed of the system are affected. IN this system we have explained about the ANN based DTC of an induction motor. Here the control model has induction motor with the supply of MLI.The MLI eradicates the disturbance present in the induction motor supply voltage. The induction motor input parameters like voltage Vabc and current Iabc are utilized for the calculations of the flux and the torque estimation.The estimated Flux and torque is verified with the reference values i.e.,reference torque flux. The error is determined for both the torque and flux. Then both the error values are allowed as input of the proposed artificial intelligence technique ANN. From the proposed technique, the flux equivalent reference direct axis voltage and the torque equivalent reference quadrature axis voltage are evaluated as illustrated in fig(1).Depending on the reference direct axis and quadrature axis voltage, the SVM generates the switching pulses of the multilevel inverter.



Fig(1) Structure of Proposed Control Technique

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III. ARTIFICIAL NEURAL NETWORKS

The neural network is one of the artificial intelligence (AI) techniques which workings are based on the training and testing process. Here the reference quadratic and direct axis voltage can be identified by the ANN technique, which works on the basis of a machine learning approach that models a human brain and consists of a number of artificial neurons. The presented neurons have the interior connections and each neuron in ANN receives a number of inputs, depending on the activation functions of the ANN results in the output level of the neuron.Here, the ANN's performance is divided into two stages, which is explained in the following.

ANN Stage 1: Evaluation of referencequadrature axis voltage V_q^* with the help of input parameter change in torque ${}_{\Delta T}$.

ANN Stage 2: Evaluation of reference directaxis voltage V_d^* with the help of input parameter change in flux $\Delta\phi$.

This section describes the combined structure of both the stages of ANN. In general ANN consists of three layers like input layer, hidden layer and output layer as shown in fig(2). The change in motor torque${}_{\Delta T}$ and change in flux $\Delta\phi$ is given as the input layer. The target output is known as the reference quadrature and direct axis volatager(k). The inputs of the network are denoted $[(\Delta T_1 , \Delta\phi_1), (\Delta T_2 , \Delta\phi_2) \quad (\Delta T_n , \Delta\phi_n)]$ the outputs of the network are denoted as $r(k) = [(V_q^* ,V_d^*)^1 , (V_q^* ,V_d^*)^2 \quad (V_q^* ,V_d^*)^n]$. This network is trained by back propagation training algorithm. The back – propagation algorithm is one of the most famour algorithm to train a feed forward network. The The back propagation training algorithm is divided into two phases that are named as propagation and weight update. The back propogation algorithm divide into two phases that are named as propagation and weight update The Simulation results for induction motor speed, torque and stator flux for different case.

IV. RESULTS AND DISCUSSIONS

The proposed mutual method is implemented in MATLAB/simulink 7.10.0 (R2012a) platform, 4GB RAM and Intel(R) core(TM) i5. Then the proposed method effectiveness is analyzed by comparing the different technique and different case studies, i.e., case 1 and case 2.harmonic analysis for PI controller, case 1,case 2and proposed shown in fig(6),fig(7),fig(8)and fig(9) respectively ,which shows the rise in fundamental for proposed compared to other cases. In the proposed method, the ANN is utilized for the DTC of the induction motor. The input parameters of the ANN like change in flux and torque has been identified by using the motor input voltage and current. Depending on the dataset the ANN was trained effectively with the target of reference quadrature axis and direct axis voltage. The structure of the proposed method in the MATLAB platform is described. The implementation parameters for proposed control technique are listed in table 1.

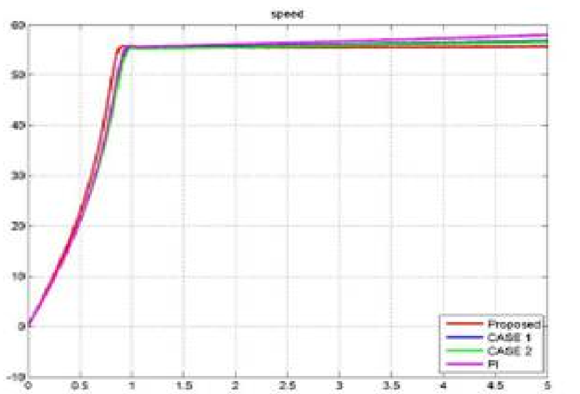

Fig.3 Induction Motor Speed for different cases

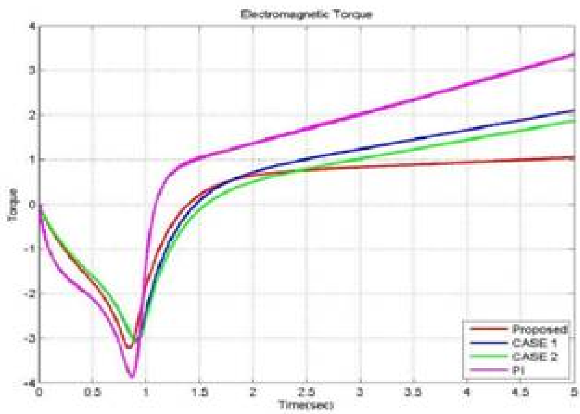

Fig.4 Induction motor Torque for different cases

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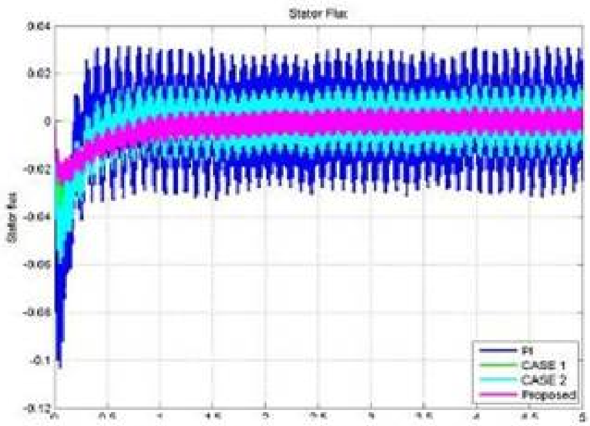

Fig.5 Induction motor Stator Flux for Different cases

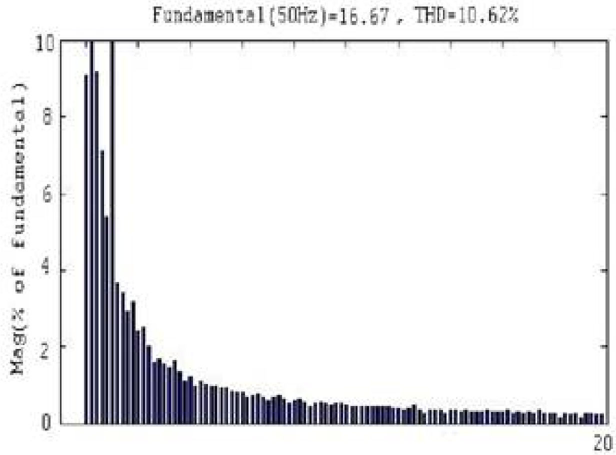

Fig.6 Harmonic Analysis for DTC with PI Controller

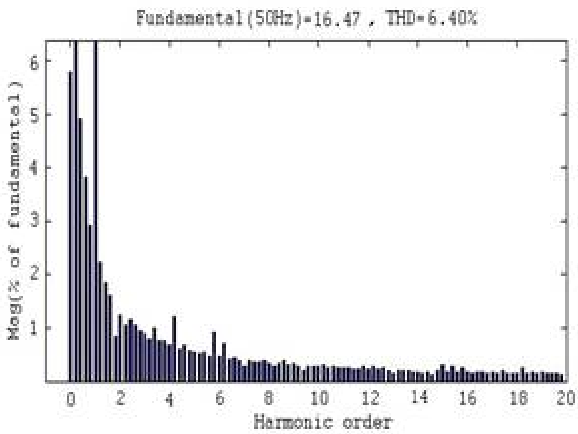

Fig.7 Harmonic Analysis for DTC with Case 1

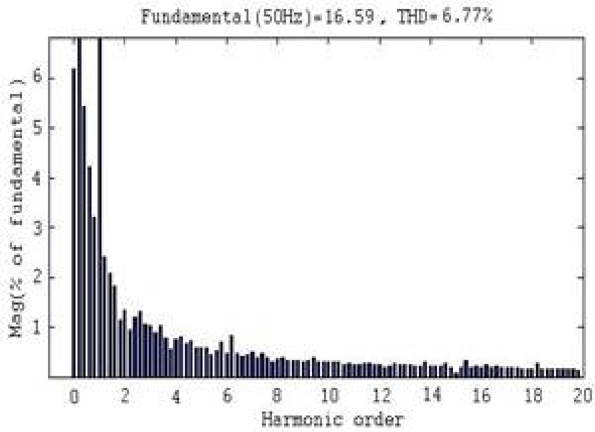

Fig.8 Harmonic Analysis for DTC with Case 2

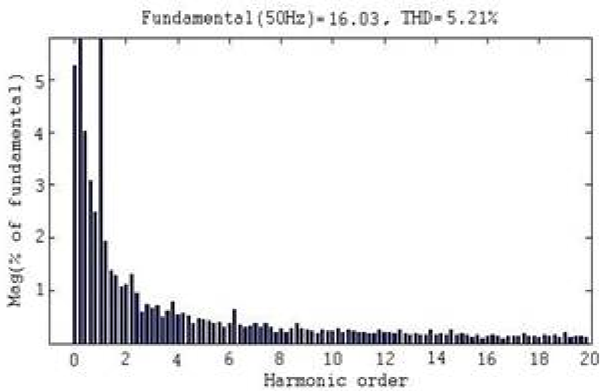

Fig.9 Harmonic Analysis for DTC with Proposed method

Parameters	Values
Nominal power	40MVA
Rated voltage	400 V
Rated frequency	50Hz
Pole pairs	2
Stator resistance	3.67 Ω
Stator inductance	0.0269 H
Rotor resistance	2.1 Ω
Rotor inductance	0.0269 H
Mutual inductance	0.0354H

Table.1 Implementation parameters for proposed Control technique of fig (1)

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V. CONCLUSION

This paper explains an Intelligence Direct Torque Control (DTC) of induction motor using 5-level inverter with space vector modulation. Here the ANN is utilized for the DTC of the induction motor. The reference quadrature axis and direct axis voltage is assumed as the target of the ANN with the corresponding input parameters like the change in torque and change in flux. Depending on these dataset, the ANN has been trained using the back propagation algorithm. Then the proposed system performance has been validated through the simulations. The effectiveness of the proposed method has been analyzed by different case studies and different techniques. From the results analysis, we could justify that the proposed intelligence technique has an improved dynamic performance, smaller motor torque, reduced flux ripple and lower THD, which is competent over the other techniques

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