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Direct Torque Controlled SVPWM Fed Induction Motor Drive using ANFIS System for Improved Performance

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Abstract: In this article a right away torsion svpwm fed induction motor drive controlled by neuro-fuzzy system is planned. during this topology the artificial Neural Network (ANN) accustomed estimate the appropriate inputs to regulate the system And mathematical logic Controller wont to evaluating the system inputs in terms of logic variables Back propagation coaching formula is wide used techniques in artificial neural network and is additionally extremely popular optimisation task find an best weight sets throughout the coaching method. However, traditional back propagation algorithms have some drawbacks reminiscent of obtaining stuck in native minimum and slow speed of convergence. This analysis planned AN improved Levenberg Marquardt (LM) primarily based back propagation (BP) trained algorithmic rule for quick and improved convergence speed of the hybrid neural networks learning technique. simulation results are given to demonstrate the engaging performance of the projected ANFIS primarily based DTC speed management of the induction motor.

Keywords: Adaptive Neuro-Fuzzy Inference System (ANFIS), fuzzy logic (FL), neural network (NN), Levenberg Marquardt back propagation, membership functions (MFs).

I. INTRODUCTION

Technological innovations in soft computing aim to take advantage of tolerance for impreciseness and have brought automation capabilities to new levels of applications [2]. method management is a vital application of any trade for dominant the complicated system parameter and to supply low value resolution. Soft computing techniques will take care of type of environmental and stability connected uncertainties applications. These techniques carries with it mathematical logic (FL), neural network (NN) and genetic algorithms (GA) methodologies to style state-of-art intelligent systems starting from laptop assisted diagnosing, laptop assisted recognition or in medical aid unit . In methodically, the management techniques supported fuzzy modeling or fuzzy identification was initial consistently introduced by Takagi and Sugeno, has found various applications in fuzzy management for diagnosing, decision-making and solve issues supported data processing. However, there are some basic aspects of this approach that ar in would like of higher understanding. a lot of specifically, the dearth of ordinary style procedure and optimisation method to rework human information or expertise into rule base and therefore the information base of the fuzzy reasoning system [1]. a unique category of neuro-fuzzy design referred to as adjustive Neuro-Fuzzy reasoning System (ANFIS) with final aim to elucidate fuzzy reasoning system via learning and has been wide used to represent or approximate a system. adjustive systems will be delineated by constructing a collection of fuzzy if-then rules that represent native linear input-output relations of the system. of these methodologies work along and supply versatile data capabilities from one type to a different to handle real world ambiguous things. it's been tried that Takagi-Sugeno fuzzy systems with affine terms will swimmingly approximate any nonlinear functions to any such accuracy at intervals any compact set, that provides a theoretical foundation for mistreatment T-S fuzzy model to represent complicated system roughly [1].

A. Neural Network

Neural networks build use of nodes and weighted connections. This fulfills the necessity not to write rules for input. However, the system fails to elucidate the explanation for exploitation the info in a very specific manner. Simulation studies shows that the self-organizing method of coaching the neural network during which it's n't given any religious residence data regarding the classes it is needed to spot, capable of extracting acceptable data from computer file so as to supply clusters that correspond to category. what is

more it needs solely a little proportion of obtainable information to coach the network. Neural Networks are wide helpful for modeling advanced databases of medical data and to resolve non-linear applied math modeling issues. coaching of neural network-based systems may be done by victimisation numerical information and fuzzy rules may be extracted from neural networks. These networks are trained so as to optimize performance of network in estimating output for specific input.

Back propagation coaching algorithmic rule, a preferred approach used with information adjusts weight of associate degree ANN to reduce a value perform. The ANN maintains correct classification rates and permits an oversized reduction in quality of the systems. the utilization of the weight-elimination price perform is tolerably to beat the network learning issues.

A controller could be a device that controls every & each operation within the system creating choices [7]. From the system purpose of read, it's conveyance stability to the system once there's a disturbance, therefore safeguarding the instrumentation from additional damages. it's going to be hardware primarily based } controller or a computer code based controller or a mixture of each. during this section, the event of the management strategy for management of assorted parameters of the induction machine corresponding to the speed, flux, torque, and voltage, current is bestowed victimisation the ideas of ANFIS management theme, the diagram of that is shown within the Fig.1.

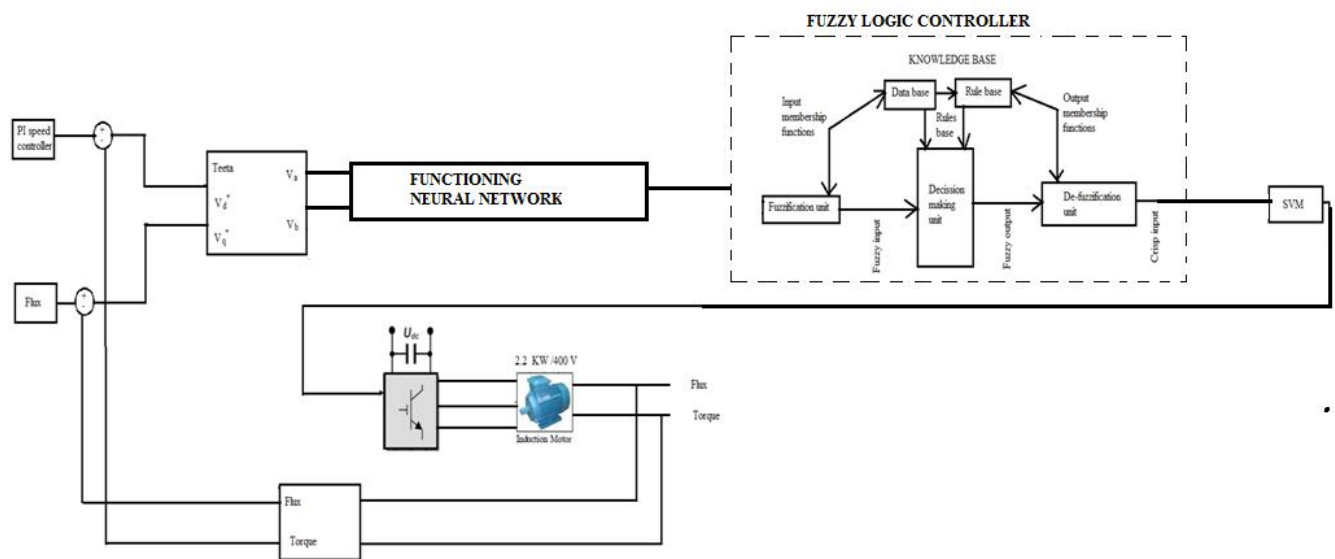


Fig 1 Basic Block diagram of the ANFIS control scheme of the IM

B. Adaptive Neuro Fuzzy Inference System

Jang in 1993 planned design and learning algorithms that is combination of mathematical logic with neural networks for drawing reasoning [2]. it's a model that's practiced in constructing input-output mapping accurately supported each human information exploitation information within the type of fuzzy if-then rules and preset input output information pairs. The adaptive-network-based fuzzy reasoning system maps computer file exploitation input membership functions (MFs) with its associated parameters, then through output MFs to conclude outputs. The initial membership functions and rules for the fuzzy reasoning system will be calculated by using human skilled information regarding the target system to be modelled. ANFIS will then refine the fuzzy if-then rules and membership functions for instance the input-output behaviour of a complex system.

Multi-layer adaptive network-based fuzzy illation design consists of altogether 5 layers to implement completely different node functions to be told and tune parameters during a FIS employing a hybrid learning mode. The hybrid learning algorithmic program permits characteristic parameters of Sugeno-type fuzzy illation systems. It applies a mixture of the least-squares methodology and therefore the back-propagation gradient descent methodology for coaching FIS membership operate parameters to follow a given coaching information set.

Figure two shows entire system design consists of 5 layers, particularly fuzzy layer, product layer, normalized layer, de-fuzzy layer and output layer. Hybrid neuro system may be a powerful framework for handling sensible categoryfication issues and is in a position to make class boundaries that cut back its misclassification rates. throughout the aerial, with fastened premise parameters, the smallest amount square error estimation approach is used to update the resultant parameters and to pass the errors to the backward pass..

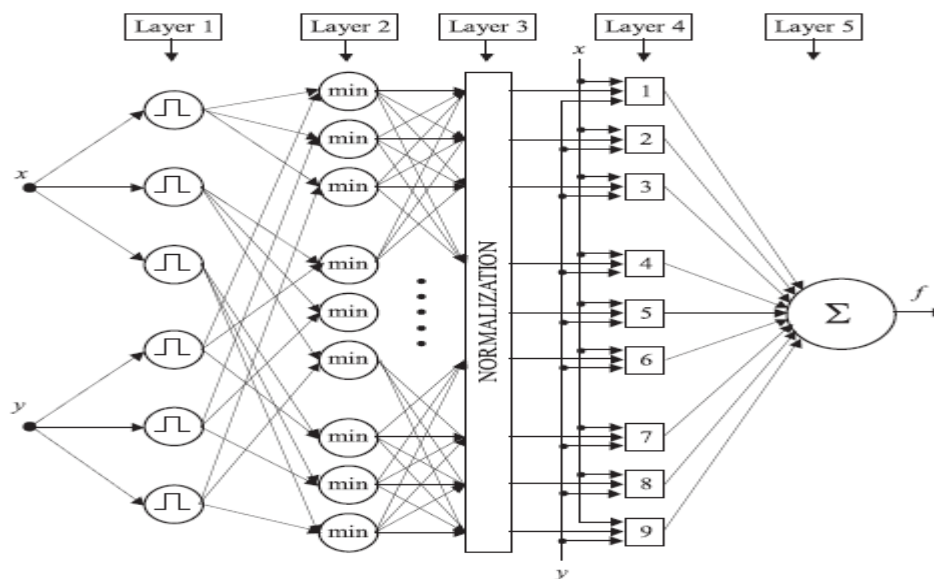


Fig 2 Two-input NF controller structure

Figure three shows the adaptive NF reasoning system structure projected in [3.4], it's composed of 5 purposeful blocks (rule base, database, a choice creating unit, a fuzzification interface and a defuzzification interface) that area unit generated using 5 network layers.

The ANFIS structure will be tuned mechanically by a least-square estimation (for output membership functions) and a back propagation algorithmic rule (for output and input membership functions). The block of the projected self-tuned direct torsion neuro-fuzzy controller (DTNFC) for a voltage supply PWM electrical converter fed induction motor is given in Fig. 1. the interior structure of the NFC is shown in Fig.2. [5] The fuzzy reasoning commonly employed in ANFIS is initial order Sugeno fuzzy model due to its simplicity, high interpretability, and procedure potency, built- in best and adaptive techniques.

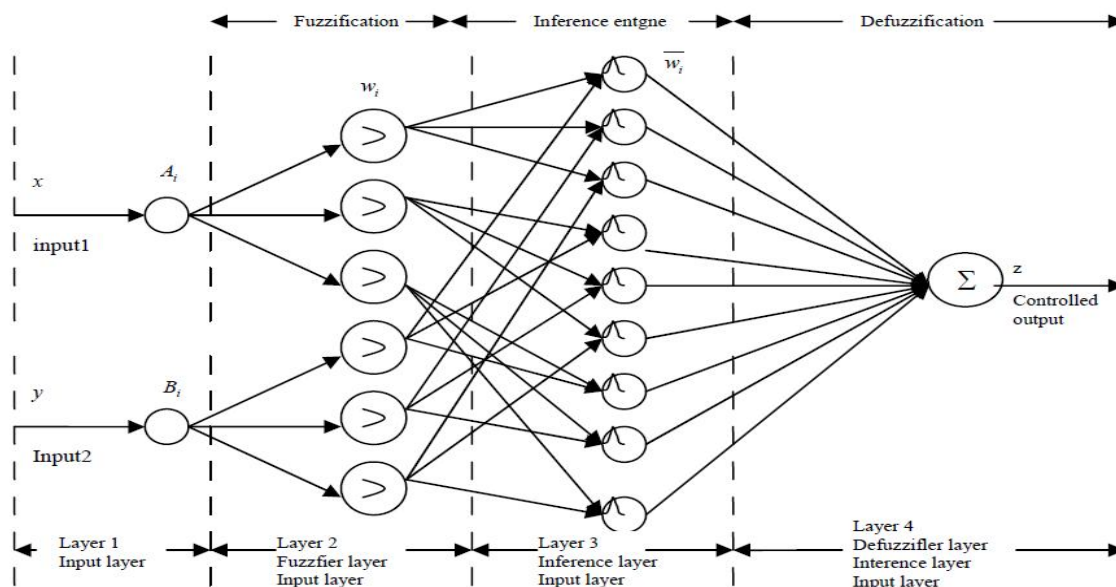


Fig 3 Adaptive neuro fuzzy structure

Among many FIS models, the Sugeno fuzzy model is the most widely applied one for its high interpretability and computational efficiency, and built-in optimal and adaptive techniques. For a first order Sugeno fuzzy model, a common rule set with two fuzzy if-then rules can be expressed as:

Rule 1: if x is A_1 and y is B_1 , then $z_1 = p_1x + q_1y + r_1$

Rule 2: if x is A_2 and y is B_2 , then $z_2 = p_2x + q_2y + r_2$

where A_i and B_i are the fuzzy sets in the antecedent, and p_i , q_i and r_i are the design parameters that are determined during the training process.

Layer 1: Every node in this layer contains member-ship function

$$o_i^1 = \mu_{A_i}(x), i = 1, 2 \quad \text{————— (1)}$$

$$o_i^1 = \mu_{B_i}(y), i = 3, 4 \quad \text{————— (2)}$$

where μ_{A_i} and μ_{B_i} can adopt any fuzzy membership function (MF).

Layer 2: This layer chooses the minimum value of two input weights.

$$o_i^2 = w_i = \mu_{A_i}(x) \mu_{B_i}(y), i = 1, 2 \quad \text{————— (3)}$$

Layer 3: Every node of these layers calculates the weight, which is normalized.

$$o_i^3 = \overline{w_i} = \frac{w_i}{w_1 + w_2}, i = 1, 2 \quad \text{————— (4)}$$

Where $\overline{w_i}$ is referred to as the normalized firing strengths.

Layer 4: This layer includes linear functions, which are functions of the input signals.

$$o_i^4 = \overline{w_i} z_i = \overline{w_i} (p_i x + q_i y + r_i), i = 1, 2 \quad \text{————— (5)}$$

where W_i is the output of layer 3, and $\{p_i, q_i, r_i\}$ is the parameter set. The parameters in this layer are referred to as the consequent parameters.

Layer 5: This layer sums all the incoming signals

$$o_i^5 = \sum_{i=1}^2 \overline{w_i} z_i = \frac{w_1 z_1 + w_2 z_2}{w_1 + w_2} \quad \text{————— (6)}$$

The output z in Figure 7.2 can be rewritten as:

$$z = \left(\overline{w_1} x\right) p_1 + \left(\overline{w_1} y\right) q_1 + \left(\overline{w_1}\right) r_1 + \left(\overline{w_2} x\right) p_2 + \left(\overline{w_2} y\right) q_2 + \left(\overline{w_2}\right) r_2 \quad \text{————— (7)}$$

C. Applications of Neuro Fuzzy Systems

- 1) *NFS in Student Modelling*: Modeling Neuro fuzzy applications in instructional field have gotten a lot of and a lot of widespread throughout the last decade (2002–2012) which is why abundant relevant analysis has been conducted. Neuro fuzzy system encompasses a wide selection of applications within the instructional field and new directions are perpetually given in instructional analysis.[5] student modeling consists of 2 components: the coed model and the diagnostic module. the coed model is one amongst the components of associate degree intelligent tutoring system (ITS) that provides an outline of student connected info like his knowledge level, skills or maybe preferences whereas identification is that the inference process which {ends up|which ends} within the end updates of the coed model. Student modeling includes student classification, watching students' actions, process intelligent learning surroundings (ILE), assessing students' information, evaluating students in intelligent tutoring system, modeling students in net primarily based ITS etc
- 2) *NFS in financial System*: An financial system is outlined as a company wherever a person, country or space makes, distributes, consumes, buys or sells services and merchandise. this sort of system encompasses a direct impact on various governments and additionally on public activities. NFS is applied in various field of financial system like state economic, stock exchange, toll assortment, gas atmospheric phenomenon, energy consumption, electrical load forecasting, value prediction, provide chain management etc.[6]

- 3) *NFS in foretelling and Prediction*: Forecasting and prediction is that the method to predict future events and conditions and will be key decision-making parts for management in commission organizations. The term ‘forecasting’ is usually reserved for estimates of values at bound specific future times, whereas the term prediction is employed for a lot of general estimates of values over a protracted amount of times
- 4) *NFS in electrical and physics system*: System Impact of electrical and physics system in our everyday life is increasing day by day. As a result, a lot of relevant analysis are conducted during this field since last decade. Electrical systems disagree round the world each in voltage and fewer critically frequency. it's accustomed connect one or a lot of items of kit to or a part of a structure and designed to supply a service like heat or electricity or water or disposal [6]. Electronic systems square measure groupings of electronic circuits and elements that concentrate on the upper abstraction level issues initial and foremost, accustomed accomplish one or a lot of advanced functions. each electrical and physics systems enhance the general operation and additionally improve the operator’ safety, through numerous safety circuits and applied ways. a number of the applications enforced by NFS within the field of electrical and physics system square measure thermal method, electrical drives, transformer currents, circuit theory, power grid, servo system and signal process

D. Simulink Diagram

Below figure shows the Matlab/simulink implementation of the proposed system shown in Fig 1

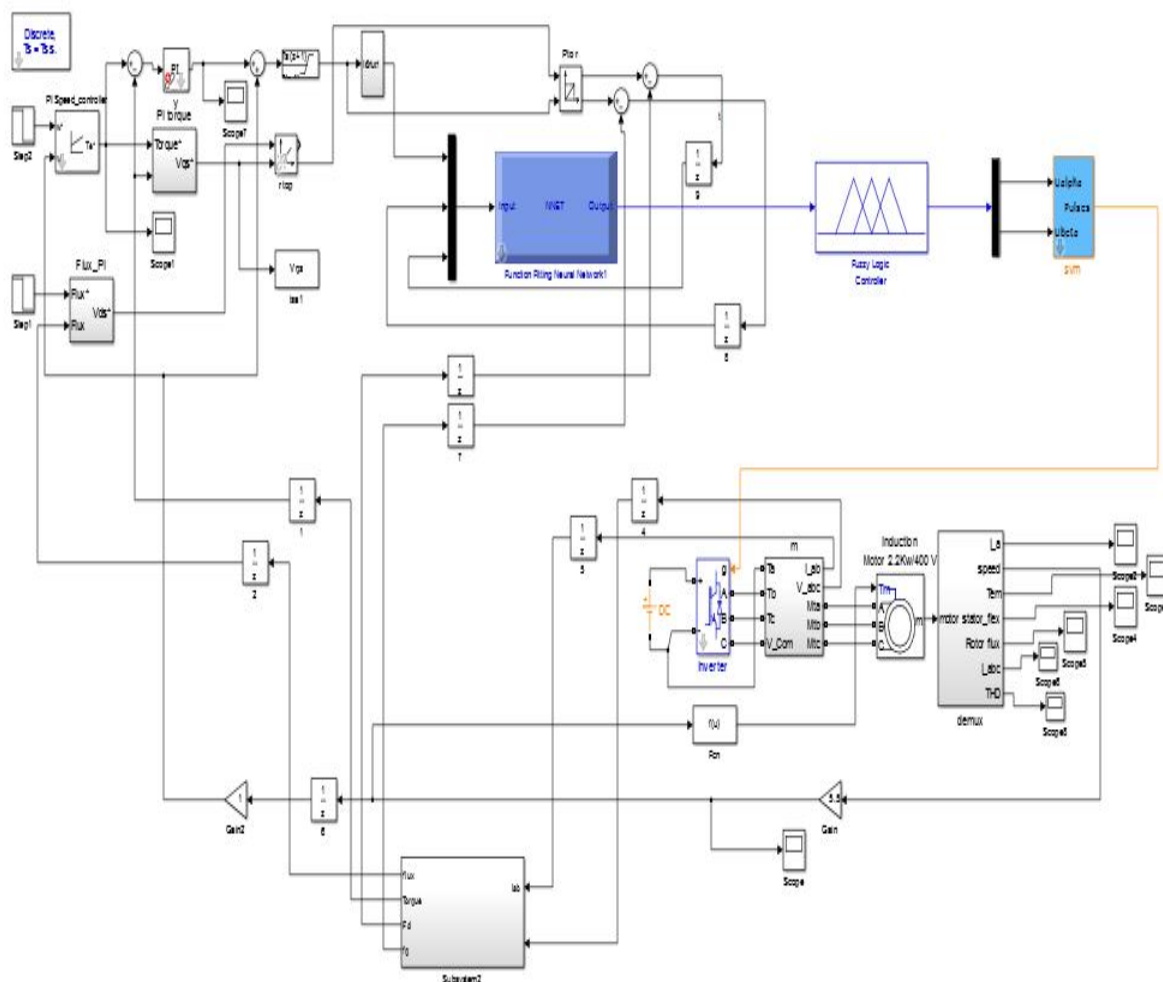


Fig 4 Simulink model of proposed system

II. RESULTS

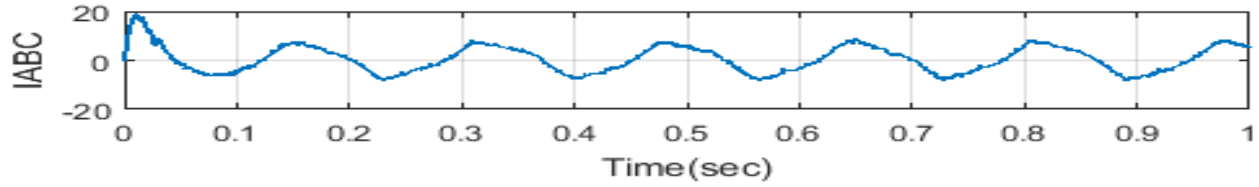


Fig 5 Stator current of the ANFIS system (PROPOSED MODEL)

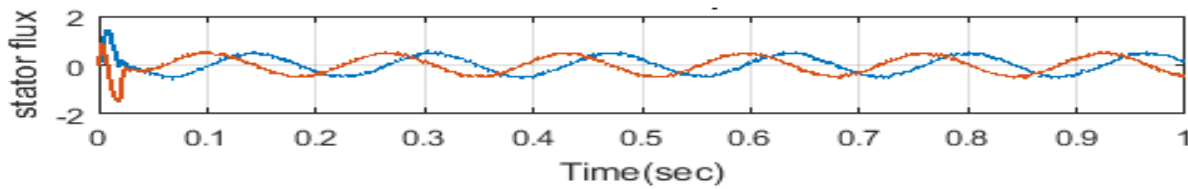


Fig 6 Rotor flux of the ANFIS system (PROPOSED MODEL)

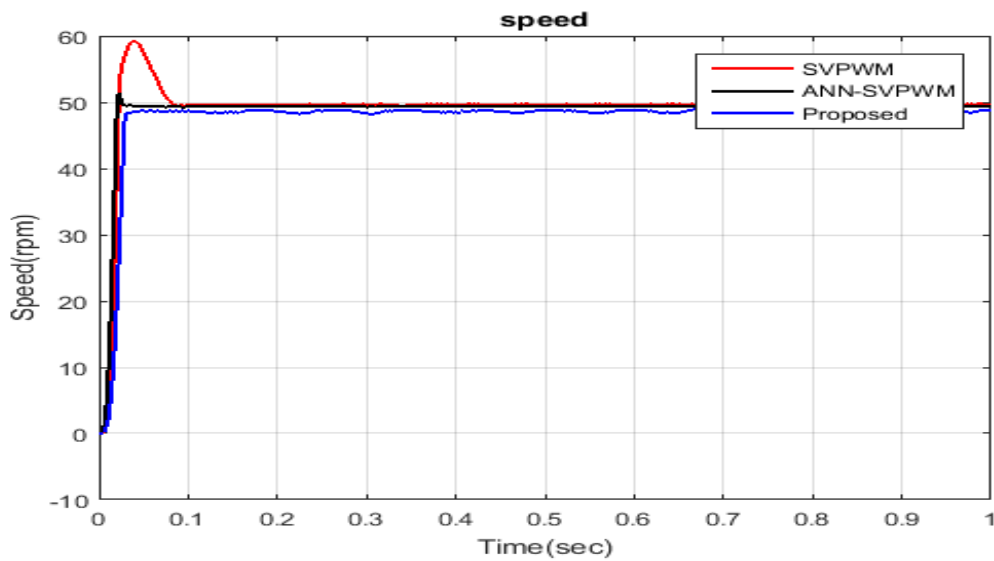


Fig 7 Comparison of speed for SVPWM, ANN-SVPWM and ANFIS(Proposed model)

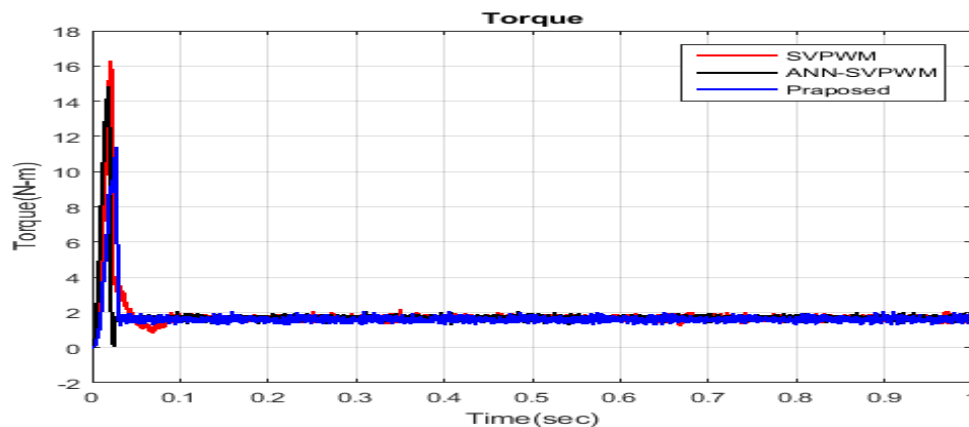


Fig 8 Comparison of speed for SVPWM, ANN-SVPWM and ANFIS(Proposed model)

III.CONCLUSION

The ANFIS (PROPOSED) technique describes a unique category of neuro-fuzzy design known as adaptive Neuro-Fuzzy logical thinking System with final aim to elucidate fuzzy logical thinking system via learning and has been wide used to represent or approximate a system. adaptive systems may be represented by constructing a collection of fuzzy if-then rules that represent native linear input-output relations of the system. of these methodologies work along and supply versatile data capabilities from one type to a different to handle reality ambiguous things. it's been evidenced that Takagi-Sugeno fuzzy systems with affine terms will swimmingly approximate any nonlinear functions to any specified accuracy inside any compact set, that provides a theoretical foundation for mistreatment T-S fuzzy model to represent advanced system roughly. planned results has been compared with the results of SVPWM fed DTC, and ANN fed DTC Induction Motor Drive.

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