Comparison of Current Controllers Induction Machine 1 HP based on ANN, Fuzzy, ANFIS and PI

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Abstract: *Induction motors are widely used in industries these days. This is the reason they are manufactured in large numbers. This paper presents the comparative study of Artificial Neural Network (ANN), Fuzzy Control System, Adaptive Neuro-Fuzzy Inference System (ANFIS) and Proportional Integral. These all techniques are applied to AC machine drive to control current spikes. While AC induction motor is operating the load and the parameters varies accordingly, but the provision of desirable control both in transient and steady states must be done. Hence, the control strategy is required as rugged and adaptational. Due to the inability in some regular control methods like PI, PID controllers to work under broad spectrum of operation, the controllers under Artificial Intelligence category like ANN, ANFIS, Fuzzy controller, genetic algorithm and some expert systems are being used widely in the industries. Here, the problem with conventional, fuzzy controller is that the parameters interrelated with membership functions and the rules depend generally on the insight of the experts. The concept of Hybrid controllers is growing these days. To pull through this problem, ANFIS, ANN, Fuzzy Logic Control and PI controllers are put forward in this paper and detail comparison is done.*
Keywords: *Current Controller, ANN, ANFIS, Fuzzy Logic Control, PI Control*

I.   Introduction

Induction motors play an important role in the industries nowadays. With new research and development in power electronics and semiconductor technology, digital electronics industry, control systems; have modified modern-day ac motor drives to undertake thought provoking high efficiency and high performance requirements in the industrial sector. Furthermore, conventional controllers require the exact mathematical model of a system under process. Hence, artificial intelligent controllers acquire value to a greater extent; this is because of non-requirement of exact mathematical model. This proves to be outstanding for managing non-linearity. The unidentified parameters and structure can be easily handled with the artificial intelligence networks. Fuzzy controllers are fully dependent on the membership functions and rules, which are supported by the designer. This paper tries to show the simulation of ANFIS, Fuzzy controller, ANN and PI. The comparison of dynamic performance of induction motor using ANFIS, Fuzzy controller, ANN and PI controllers has been analysed.

a) PI Control Design:

PI control method is the most popular conventional control method utilised in ac motor control design. During the operation of ac motor like induction motor the gain control through conventional Pi control becomes a challenging task due to the utmost uncertainties and variation in the internal parameters. In this paper we are presenting the comparison analysis of all the methods including the conventional PI control and the artificial intelligent controllers like ANN, ANFIS and FLC. It is mainly used to eliminate the steady state error less. Nevertheless, as far as speed is concerned and the overall stability of the system, it doesn't have a positive impact. This controller is mainly used in the system where speed is not an issue. These controllers don't have an ability to predict the future errors of the system it cannot decrease the rise time and eliminate the oscillations.
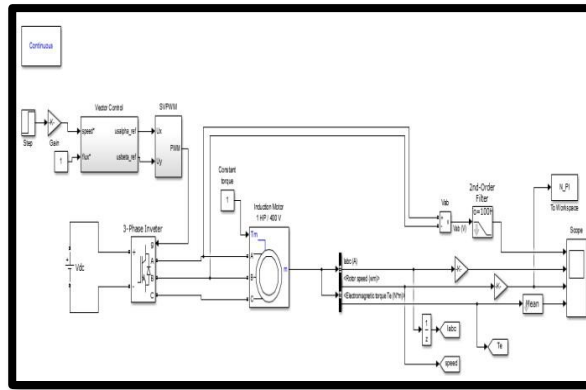

Figure 1. Performance_Comparison_Analysis_of_Indirect_ Vector
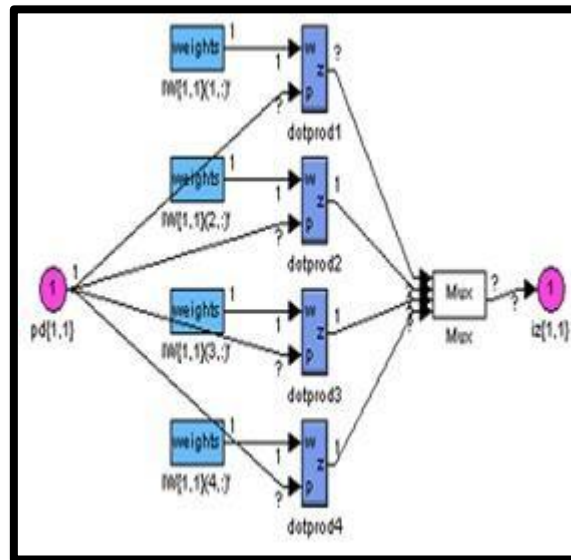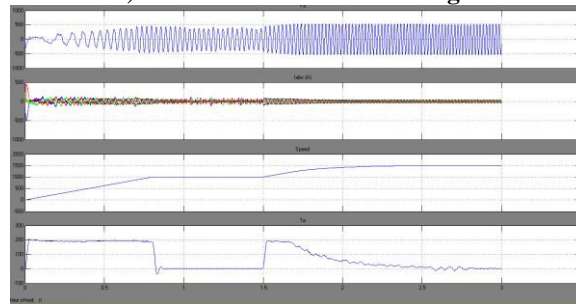
b) Simulation Pi Control Design:

Figure 2. Performance_Comparison_Analysis_of_Indirect_ Vector

II. Artificial Neural Network (ANN)

Artificial Neural Networks (ANN) has an ability to study and upgrade its operation using neural network training. The basic element of the ANN is a neuron which has a summer and an activation function. The mathematical model of a neuron is given by:

$$y = \varphi \sum W_i . X_i + b$$

where $(X_1, X_2…X_N)$ are the input signals of the neuron, $(W_1, W_2…W_N)$ are their corresponding weights and b is bias parameter. φ is a tangent sigmoid function and y is the output signal of the neuron. The ANN can be trained by a learning algorithm which performs the adaptation of weights of the network iteratively until the error between target vectors and the output of the ANN is less than a predefined threshold. There are

several types of learning paradigms like supervised, unsupervised and reinforcement learning. The most important and famous supervised learning algorithm is backpropagation, which consists of a forward and backward action. The forward action has the free parameters of the network as fixed. The input signals are propagated throughout the network from the first to the last layer. The mean square error is computed in the forward phase. In the second step of the backward phase, the error signal is propagated throughout the network in the backward direction so that the control can perform corrections on the free parameters of the network so that the error can be decreased.
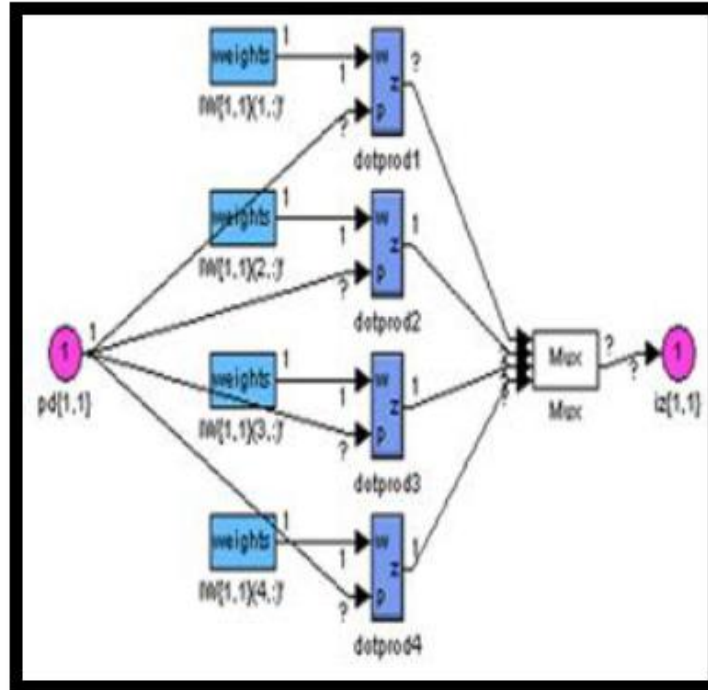

Figure 3. ANN_ weights and dot product block diagram

Figure 3 above shows the dot product of input signal with weights. There are 4 dot products viz. dotprod1, dotprod2, dotprod3 and dotprod4. The 4:1 MUX is used to enable any of the dot product from 4 dotproducts using select lines.
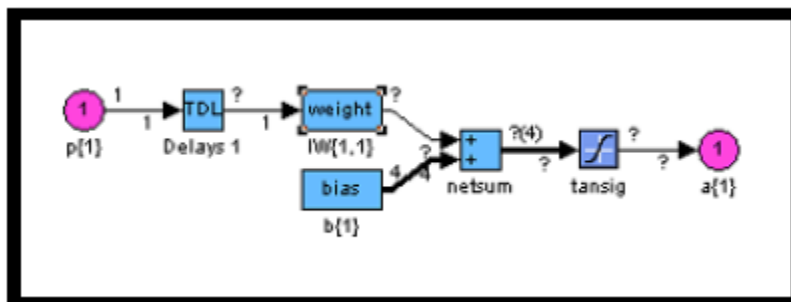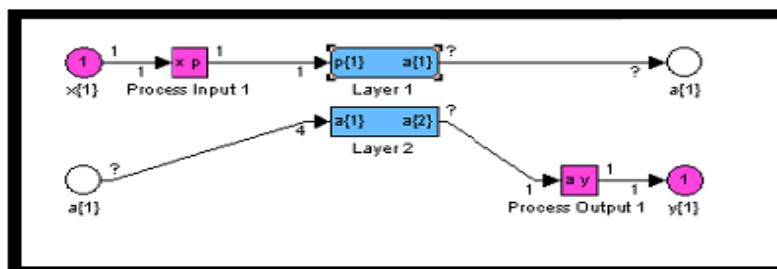

Fig 4. Netsum of Weights and Bias

5.Process Input and Output Block Diagram

Figure 5. above shows the two layers of Artificial Neural Network. X {1} is the process input 1 and a {1} is the output. P {1} is the process input 1 and a {1} is the output of the layer 1.
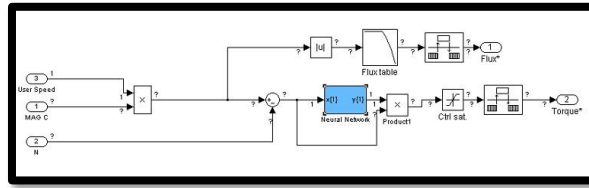

Fig 6.Speed and Torque Block Diagram

III.   Fuzzy Logic Controller (FLC)

PI controller is one of the most commonly used controllers having good robustness. Subsequently, FLC became a well-known controller and has been used as independent or combined with PI to raise the performance of the electric drive. Fuzzy logic is another form of artificial intelligence. Its history and applications are more recent than expert systems. It is always opposed that human being does not use crisp form of logic i.e. 'yes-no' logic, but is often obscure, undefined, uncertain or fuzzy. Based on this concept, Lofty Zadeh, a computer scientist, introduced the 'fuzzy logic' or fuzzy set theory in 1965 that step by step appeared as a domain in AI.

The primary attribute of the fuzzy logic technique is to utilise the fuzzy rule sets and the linguistic representation of a human's knowledge to represent the controlled plant or to build the fuzzy controller. A fuzzy logic controller consists of fuzzification, fuzzy inference with rule base and database, and defuzzification [Intelligent Control of induction motor_D]. Some of the fuzzy-logic controllers designed for induction motor are FOC with fuzzy efficiency optimizer and fuzzy-logic based DSC, a hybrid fuzzy/PI two-stage control scheme is also utilised. Effects of parameter variation, effects of noise in input current are investigated.
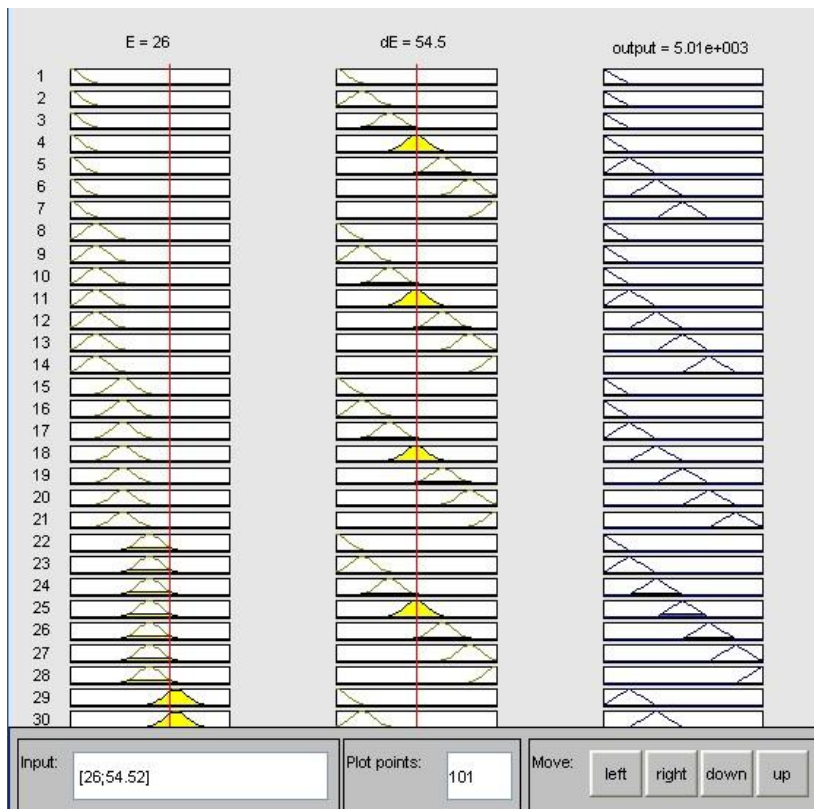
IV.   Fuzzy Logic Controller Simulations:

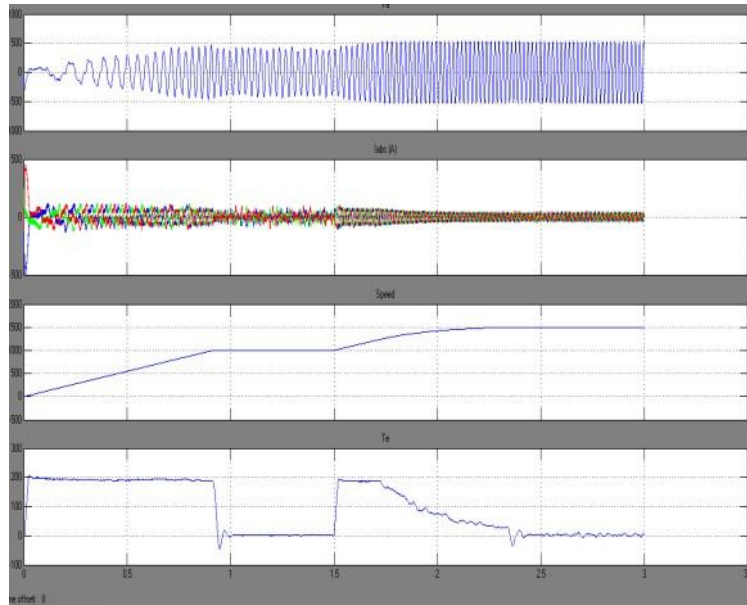**Figure 7. Fuzzy Rule viewer**

Figure 8.Fuzzy Logic Controller – Current, Speed, Torque Waveform Simulation

V. Adaptive Neuro Fuzzy Inference System (ANFIS)

AC induction motors are utilised in large number in industrial and process applications which require high performances. In drive system with high performances the motor current closely follows a specified reference trajectory, regardless of any load disturbances and any model uncertainties. Adaptive Neuro Fuzzy Inference System replaces the draw-backs of Fuzzy Logic Control and Artificial Neural Network [Comparative Analysis for Various Artific.] Adaptive Neuro Fuzzy combines the learning power of neural network with knowledge representation of fuzzy logic. The fusion of Artificial Neural Network (ANN) and Fuzzy Inference Systems (FIS) has an outcome of Neuro Fuzzy Techniques. These techniques now have become popular for solving real world problems. A neuro fuzzy system is trained by a learning algorithm derived from neural network theory.
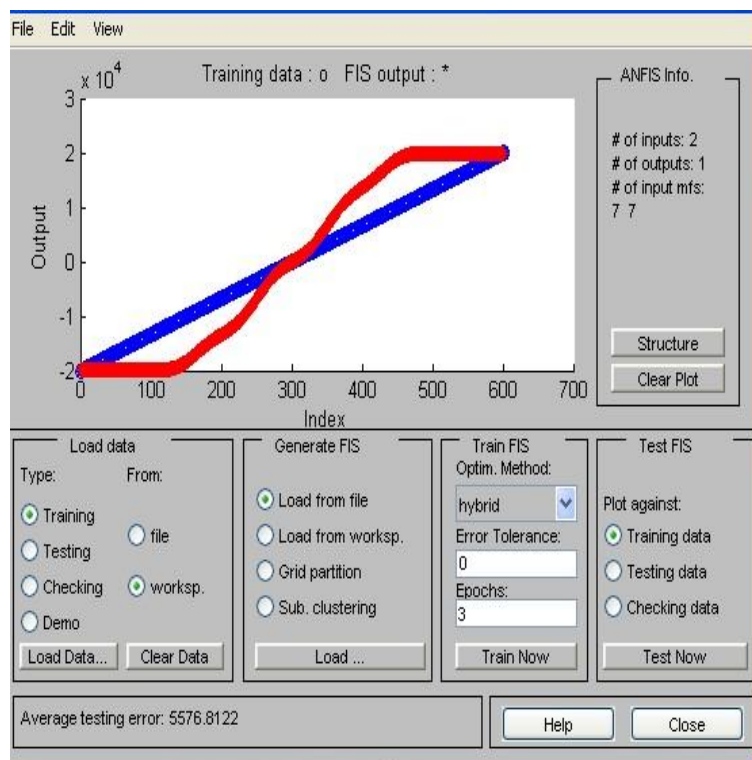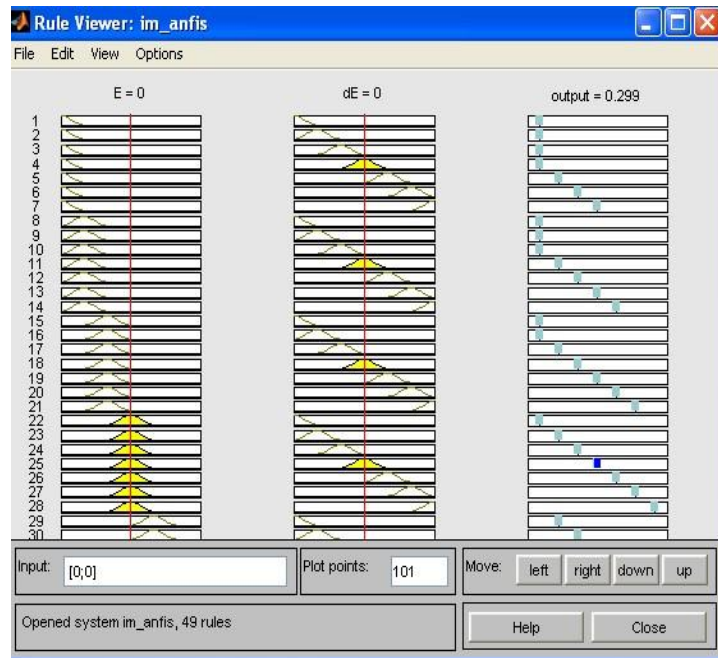

Figure 9. ANFIS Previous versus Trained Values
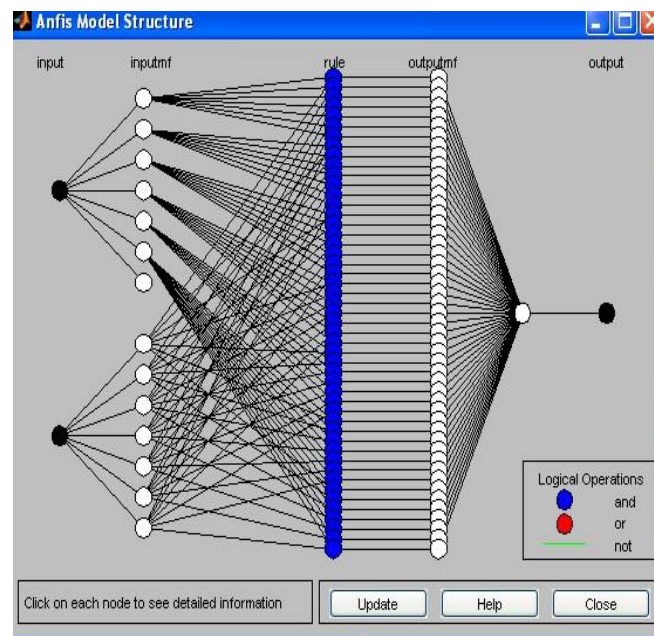
Figure 10. ANFIS Ruleviewer

Figure 11. ANFIS Model Structure

VI. Comparative Analysis

A complete simulation model for induction motor drive including Conventional (PI), Fuzzy Logic Controller (FLC), ANFIS and Artificial Neural Network has been developed. AC machine drive with Fuzzy controller is designed by appropriate improvements of membership functions and Neural network controller designed by matching the weights in order to get simulated results. Adaptive Neuro-Fuzzy Inference System (ANFIS) replaces the draw-backs of Fuzzy Logic Control and Artificial Neural Network. Adaptive Neuro Fuzzy combines the learning power of neural network with knowledge interpretation of Fuzzy Logic. The performance of the artificial intelligent based induction motor drive is analysed at different operating points.The performances of the induction motor will all intelligent controllers are presented in the figures.

VII. Conclusion

A conventional and artificial intelligent based induction motor drive simulations are presented in this paper. The Simulink model are developed for conventional control, artificial intelligent controllers like ANN, ANFIS and FLC. The performance of conventional control induction motor is compared with the proposed artificial intelligence based controllers like FLC, ANN and ANFIS. The results show that the performance of conventional induction motor drive with ANN, ANFIS and FLC are verified to be outstanding to that with conventional controllers. Therefore, by using ANFIS and ANN, the transient response of induction machine has been reinforced to an extraordinary extent and the dynamic response of the same has been made faster. If there is a sudden change in the load, the ANFIS controller reaches its steady state value faster and there are no overshoots as compared to the conventional and Fuzzy controller.

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