Motion control - Fault diagnosis in Machines using VHDL

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Abstract- The machines which have become a part of present day life, even in some cases it overcome human working ways. So for there is major concern in functioning of motor drives because a minute faulty function of motor may lead to drastic damage in working environment. Thus before entering into the fault diagnosis of induction motor the speed control is an important aspect. The speed control in induction motor can be done using SVPWM technique. From the past several years, much progress has been made in Artificial Intelligence (AI) technology. Simplified models of neural processing in the brain have been viewed as artificial intelligence in neural networks. It's an inexpensive, reliable and non-invasive Artificial Neural Network (ANN) based fault diagnosis. Multilayer Perceptron (MLP) is to be used in this paper because the input data contain continuous feature. The fault diagnosis in induction motor using AI technology can be done without resuming the function of induction motor an advantage of this approach compared with other techniques for fault diagnosis[1]. This paper presents the new technique relevant to the design method of artificial intelligence based on VHDL hardware description language and FPGA implementation. The simulation results are obtained from XILINX 12.2 software.

Keywords: ai, svpwm, ann, svm, mlp, vhdl, fpga.

I. Introduction

In the past few years most of the methods are based on knowledge of status equation for fully or partially controlled systems. However status equation can't be easily obtained. Therefore we go for a smart control method with self-learning capability for better control performance. Thus here in this paper induction motor fault diagnosis and its motion control are going to be delt. Our design users Neural Network for its amazing effect which traditional controllers cannot achieve, when the system involved in an uncertain, time varying or non-linear status. The speed control of induction motor is the main process to be undergone before fault diagnosis is performed. The speed of the motor is of major concern in detection of fault. The speed control and fault diagnosis are performed in comparative manner [1]. The speed control of induction motor is performed by space vector pulse width modulation (SVPWM). Thus three level voltage fed PWM inverter, which shows popularity in industrial drive application. The output voltage waveform which is generated by multilevel inverter. It can be generated at low switching frequency with high efficiency and low distortion. This is the reason why large voltage between the series device is easily shared. The space vector PWM technique is very popular which results in higher magnitude of fundamental output voltage available. The SVPWM is an advanced computation-intensive PWM method and it's the best among all other PWM method as it functions at variable frequency drive applications [2].

II Speed Control of motor

A voltage source inverter type Space vector pulse width modulation for controlling the speed of the induction motor is performed. The pulse width modulation in which several pulse are produced in each half cycle but width of each pulse is not same as in case of multiple pulse width modulation however the width of each pulse is varied in accordance with the amplitude of the sine wave reference voltage. The Space Vector Modulation (SVM) is normally implemented using the direct method. The space Vector is an algorithm for the control of PWM. The principle behind SVPWM is that voltage vector which is to be approximated by using three adjacent vectors. To drive a 3phase AC powered motor at varying speed we require alternate current waveform which can be generated using SVM. Thus Fig 1 shows the SVPWM wave model in response to the sinusoidal input wave. The SVPWM is generated mainly based upon the positive and negative cycles of the sinusoidal wave. The space vector diagram which consist 8 vectors these vectors are given as input to the IGBT inverter through which the speed of the induction motor is controlled. Taking into consideration of these 8 vectors among which 6 vectors starting from V001 to V110 is for supplying signal to Switch ON the transistors present in the IGBT inverter.

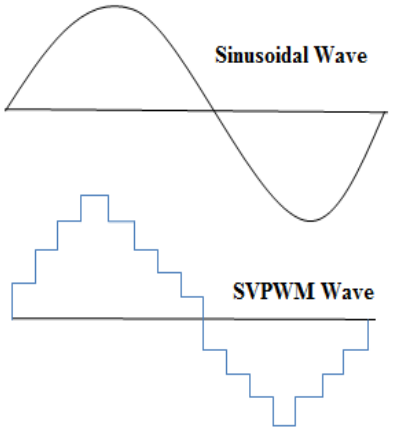

Fig.1 Sinusoidal PWM Modulation

Thus with appropriate SVPWM signals a vector is produced. The vector transit smoothly between the 6 sectors and provide line to line voltages. The line voltages are passed as input to transistors in the inverter. Thus the IGBT inverter makes the induction motor to run. Other than the above said 6 vectors there are two null vectors V000 to V111 which provide 0v (i.e.) IGBT stop generating pulse which in turn stop the motion of induction motor.[3] These null vectors are due to short of transistors. There are two series of transistors in IGBT inverter of these either the upper end or lower end transistor may get shorted which leads to null vector.

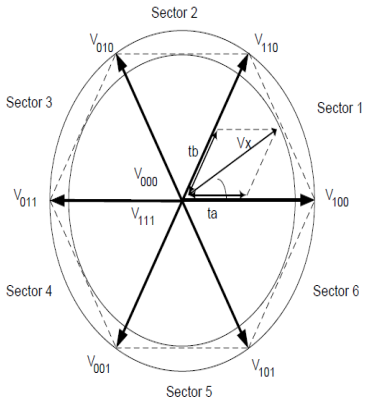

Fig 2 SVPWM Vector Diagram

Upper End Transistors = T1,T3,T5
Lower End Transistors = T2,T4,T6.

Based upon the inverter bridge configuration the six transistor combination has eight permissible switching states as said before which is given in the following table I with vector values of each states are also incorporated. In this there are 8 states and the devices that are in on condition are represented in ON DEVICS and their corresponding space voltage vectors are represented as V_{000} to V_{111}. In this from state 1 to state 6 the transistors are in ON condition alternatively. Whereas the state0 and state1 in which either the upper end transistors or the lower end transistors are in ON condition. The other end of the transistors are OFF which produces null vectors and the IGBT stop generating pulse thus induction stop functioning particularly in this two vector states.

Table I Inverter Switching States

States	on Devices	Spacevoltagevector
0	T2 T4 T6	V000
1	T1 T4 T6	V100
2	T1 T3 T6	V110
3	T3 T2 T6	V010
4	T2 T3 T5	V011
5	T2 T4 T5	V001
6	T1 T4 T5	V101
7	T1 T3 T5	V111

III Fault Diagnosis

A. Neural Networks

For the past several years there is a progressive development in the field of Neural Networks. Neural network is a network of biological neurons. These neural networks are classified into biological neural networks and artificial neural network [4]. A biological neural network is a population of physical interconnected neurons. An artificial neural network is the mathematical or computational model inspired by the structure & function of biological Neural networks "Adaptive System". Thus the ANN is also termed to be as Artificial intelligence (AI). AI is the intelligence of machine and branch of computer science. Simply to say AI is the science of making computer to do things by its own as like human. We go for AI because without any external learning source it can't make *any intelligent response*.

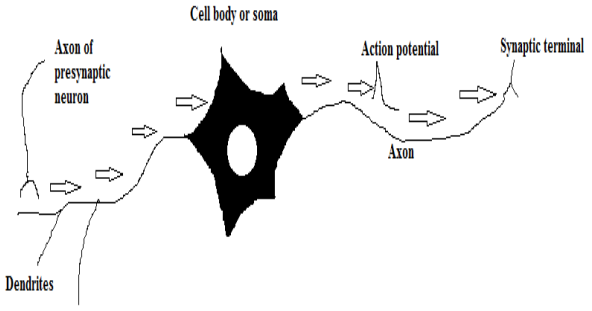

Fig.3 A Neuron

The neurons architecture in which we choose multiply and accumulate structure for neurons. In which single multiplier and accumulators are present [5]. Multiplier in which one input is from previous layer neuron and the other is from the corresponding weighted ROM. The multiplier is 8bit multiplier results in 16 bit product. The weighted ROM whose inputs are address and clock. Neuron has its own individual weight storage ROM. Next to the multiplier is the accumulator where the multiplied values are summed, with the help of clock signals these process are synchronised. The accumulator is of 16 bit wide. The accumulator enable signal which enable accumulator function and out enable signal for 3state outputs. ANN consists of 3 layers input unit connected to hidden unit which is connected to output unit. The activity of input unit represents raw information that is fed into the network. The function of each hidden unit is determined by the activity of input unit and weights on the connection between the inputs and the hidden units. The behaviour of output units depends on the activity of hidden unit and weight between the hidden and output unit. The architecture consists of 20 input nodes with 2 hidden nodes and 1 output node. In the upcoming architecture where the sigmoid activation functions is used. In that the tansig for hidden nodes f(n) and the logsig for output node in g(a). One of the most frequently used activation function is hyperbolic tangent (tanh) sigmoid function referred as tansig in matlab.

B. Multilayer Perceptron Algorithm

The following discussion is about Multilayer Perceptron Algorithm (MLP). MLP which consist of three layers input, hidden and output layer. The input layer which posse's n linear neurons. These neurons receive inputs in vector format from which the MLP starts its operation. Along with these input vector an additional bias neuron are also given as input to the hidden layer which produce signal+1.[6] Thus the hidden layer which posses q sigmoidal neurons to receive input from the input layer and teh output layer which posses p sigmoidal neurons to receive signal from the hidden layer. The network mainly functioning of Data shift and approximate the function. By which the learning problem can be executed.

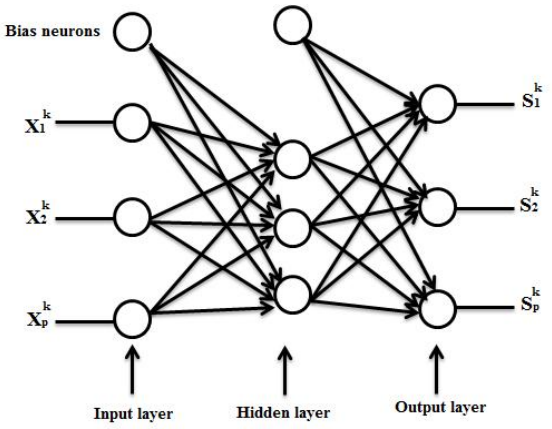

Fig.4 Architecture of Feed forward Neural Network

Once the experiment setup starts it operation each and every input values are passed into the MLP block [7]. The MLP algorithm which compares the input voltage with the reference values and if there is any mismatch in the reference value it will be termed as stator fault occurred in the transcript window in modelsim. Similarly for rotor fault and voltage flow control are exposed in the transcript window.

C. FPGA Implementation

The choice of VHDL is mainly because of its ease of operation, flexibility, and definitive output, to be more precise with one design description many design architecture can be included.[8] The implementation of FPGA in research which reduce the cost of experimentation and increasing the performance. So far concerned the software implementation of neural network into FPGA is discussed but it's not advisable. There are some modifications in the neural network structure and its function mapping has to be done before hardware implementation of the neural network.

IV RESULTS

The simulated outputs are as follows which shows output of sinusoidal wave based on the positive and negative cycles of the sinusoidal output the SVPWM pulses are generated. Thus it shows IGBT switching for functioning of induction motor. Thus following this is the stator fault, rotor fault and voltage flow control of induction motor are given

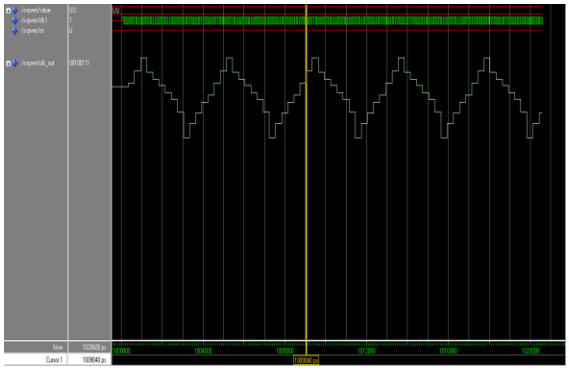

Fig.6 SVPWM Output

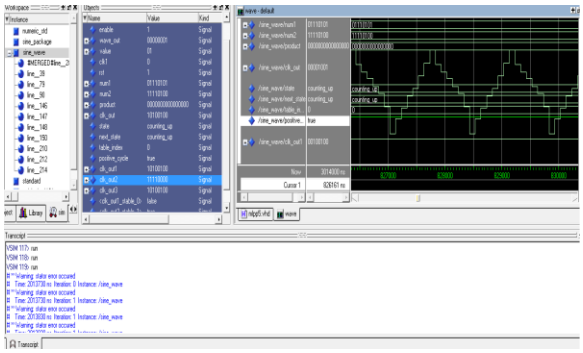

Fig.7 SVPWM with Stator Fault using MLP

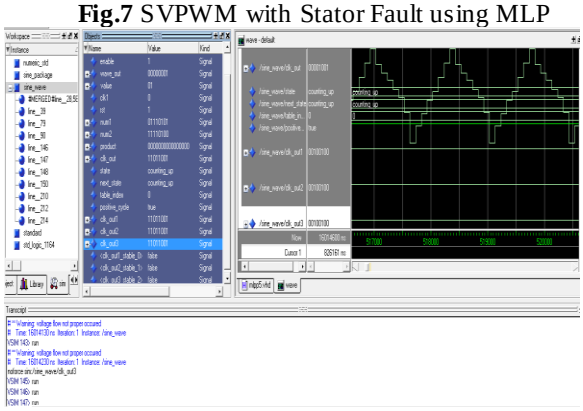

Fig 8. SVPWM with Voltage Flow problem using MLP

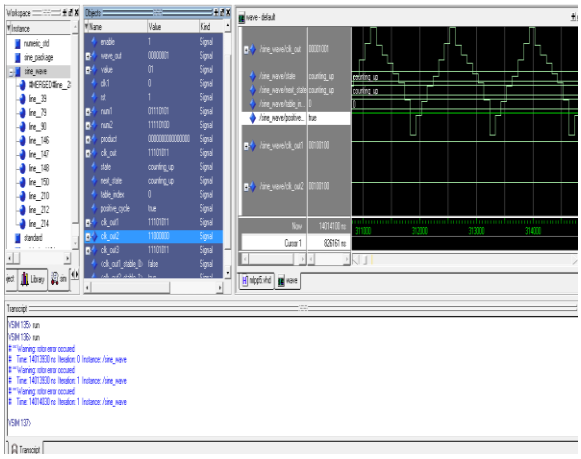

Fig.9 SVPWM with Rotor Fault using MLP

V. Conclusion

Thus the above given techniques for fault diagnosis in induction motor which shows many advantages compared to all other existing method. This is briefly presented over in this paper based on reference works from different authors. The future enhancement is using Back Propagation Network (BPN) fault diagnosis in induction motor is performed and the efficiency between these two algorithms and which one is best suited for fault diagnosis have to be found.

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