# Simulation of Single and Multilayer of Artificial Neural Network using Verilog

**Shreyas J. Patel[1] Rajesh Vasdadiya[2] Shaktivel S.M[3]**
[1]PG Student [2]PG Student [3]Associate Professor
[1,2,3]Department of Electronics and communication Engineering.
[1,2,3] VIT UNIVERSITY, Chennai-600 048 (Chennai-Tamil Nadu-INDIA)

*Abstract* — Artificial neural network play an important role in VLSI circuit to find and diagnosis multiple fault in digital circuit. In this paper, the example of single layer and multi-layer neural network had been discussed secondly implement those structure by using verilog code and same idea must be implement in mat lab for getting number of iteration and verilog code gives us time taken to adjust the weight when error become almost equal to zero. The purposed aim at reducing resource requirement, without much compromises on the speed that neural network can be realized on single chip at lower cost.

*Keywords*:--Neural Network, Verilog, Matlab, architecture

## I. INTRODUCTION

As we know rapid increase in demand of digital circuit and industry need there to launch their product as earlier as possible without sacrificing integrated circuit (IC) quality, so testing of digital circuit in Very Large Scale Integration (VLSI) has become challenge for that it is also very important to develop more powerful algorithms for diagnosis more multiple fault in digital circuit. Diagnosis defines as task of identifying the cause and location of a manifested by some observation behavior. This is often considering being a two stage process: first the fact that fault has occurred must be recognized-this is referred to as fault detection that is general achieved by testing. Secondly the nature and location should be determined such that appropriate remedial action may be initiated. To come across this problem a test engineer has devolved a parallel algorithm knows as ARTIFIAL NEURAL NETWORK. [4]
The application of ANN are expanding because neural network are good at solving problem not just in engineering but in medicine, control system, signal processing ,science etc., because of faster algorithm and faster computer have made it possible to use neural network to solve complex industrial problem that formerly required too much computation. Artificial neural networks (ANN) are parallel algorithms. Their inherent parallelism makes them particularly suited to parallel VLSI implementations.
The idea of neural network based on characteristic of brain function, the brain consist of many highly connected element knows as neuron and this is connected to axon. Even though biological neuron is very slow when compared to electrical circuit, the brain must perform many tasks faster than any computer. ANN work on two network single input neuron network and multi-layer input neuron network.

## II. ALGORITHM

### A. SINGLE LAYER NEURON NETWORK

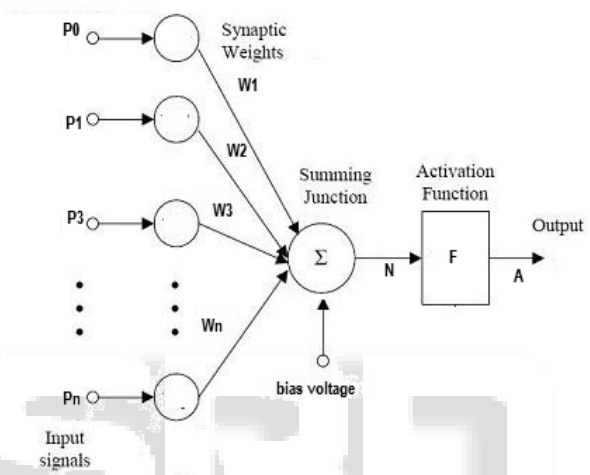


Fig. 1: Single layer Neural network

Above fig-1 shown is single layer neuron network in which there is one input layer where multiple input is being applied and all applied input and one bias voltage are summed at one neuron and at last output is passed through nonlinear activation function that can be sigmoid function, there are many other non-linear activation function hard for those refer [4] For single input equation can be return as

A=F (w1*P1+Bias voltage) (1)

For n number of input the equation-1 can be return [1]

$$A= \sum_{k=0}^{n} Pk * Wk + b \text{ (bias voltage)} \quad (2)$$

Weight in single layer neural network can be adjusted by different algorithm such as supervised learning, unsupervised and reinforcement learning here our example falls under category of supervised learning because to adjust weight automatically we have to find mean square error and tries to minimize the average squared error between network output and targeted value. To minimize those errors we use gradient descent algorithm.[4]

Error= (target out – network output)$^2$ (3)

Weight=weight + alpha*Error*neural network input (4)

Continue adjusting weight from are equation-4 up to Error reach zero here alpha is learning rate which always between 0 and 1. [4]

 

### *B. MULTILAYER NEURAL NETWORK*

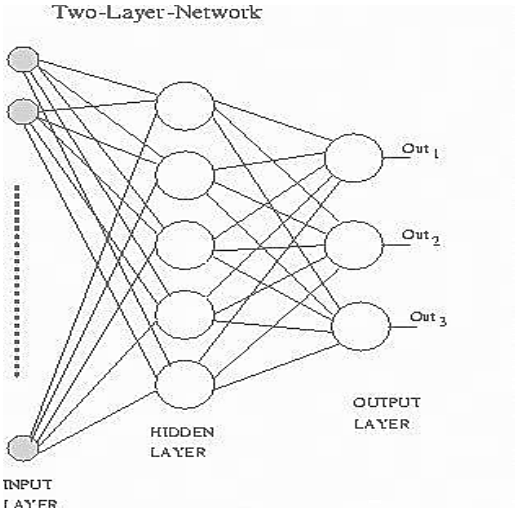


Fig. 2: Multilayer network

From fig-2 Multilayer consists three layer input (I), hidden (j) and output layer (k). To adjust the weight between two different layer automatically in an multi-layer neural network there are so many algorithm but one of advantageous for this network is batch gradient negative that is nothing but back propagation method in which weight are update in direction of negative gradient of the performance. The learning factor is multiplied the negative gradient to determine the changes to weight and bias. The larger the learning rates the bigger step. If the learning rate is made too bigger the algorithm becomes unstable. Back propagation is fastest algorithm than the other technique.

For multilayer neural network we are using sigmoid function [4].where x is your input of any neuron.

$$Y = f(x) = \frac{1}{(1+e^{-x})} \quad (5)$$

$$\text{Error} = (\text{target out} - \text{network output})^2 \quad (6)$$

From equation-6

Wjk = Wjk+ alpha*Δjk*input (input of hidden neuron)

Wij = Wij+ alpha*Δij*input (input of input neuron)

Where

Δjk=error*dE/dWjk and wjk is weight between hidden layer to output layer

Δij=∑wjk* Δjk and wij is weight between input and hidden layer

## III. DESIGN METHODOLOGY/DESIGN DETAILS

Simulation for single layer and multilayer example for And Gate and X-or Gate is given.

### *A. And gate using single neural network*

The single layer neural network first of all weight is being assigned manually and by neural network rule weight is being multiplied by input and summing all input with weight and last neural network output compared to targeted output. if difference is there that is error by using gradient decent algorithm decrease error and at same time weight is being adjusted and when error reach to desired output we can say that our neural network is being trained. In an and gate we had applied two input (1, 0) and w0, w1 are synaptic weigh and b is bias voltage (b is not necessary that depends upon user)[4] these three value are summed together .

How many iteration training algorithm take to reduce error zero that can be seen by implementing the idea or program in mat lab and how many second the algorithm is taking to reduce error approximately up to zero can be observed by implementing your Verilog code in model sim or Xilinx simulator.

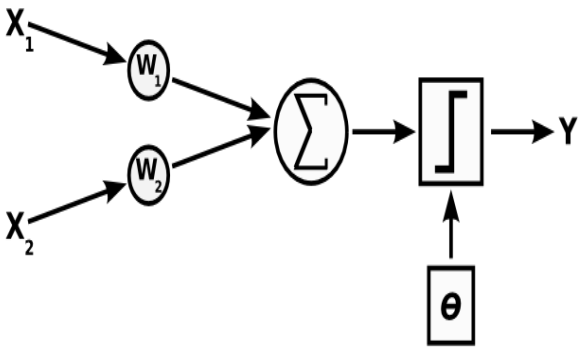


Fig. 3: And gate using single neural network

For example consider you are applying input and weight randomly.

A=1 and B=0;

W0=0.5; W1=0.7;

N=(a*w0+b*w1)

=1 * 0.5 + 0 * 0.7

= 0.5

Error = target output –(desired output)

=-0.5

Here by summing input and weight (eq-3) at last output compare with targeted output, and continuously updating weight as per (eq-4). By using Gradient decent algorithm error will decrease and how much iteration been taken to adjust the weight can be easily seen by mat lab.(fig-4)

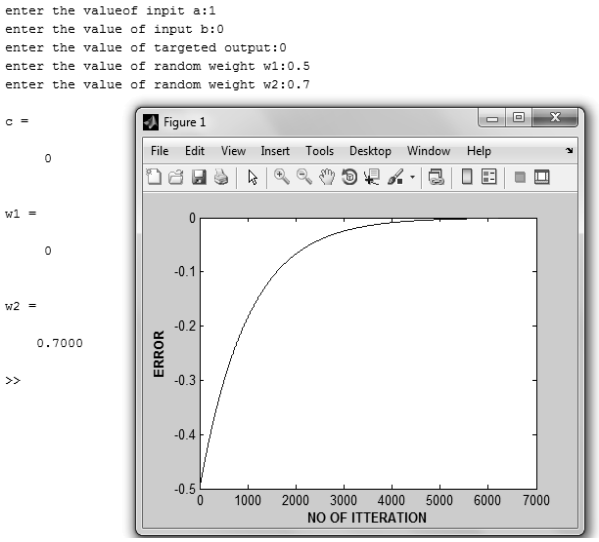


Fig. 4: Calculation of error using gradient decent algorithm

Number of iteration ==7000

Now same algorithm been implemented in model simulator to see how much second take to adjust the weight.

 

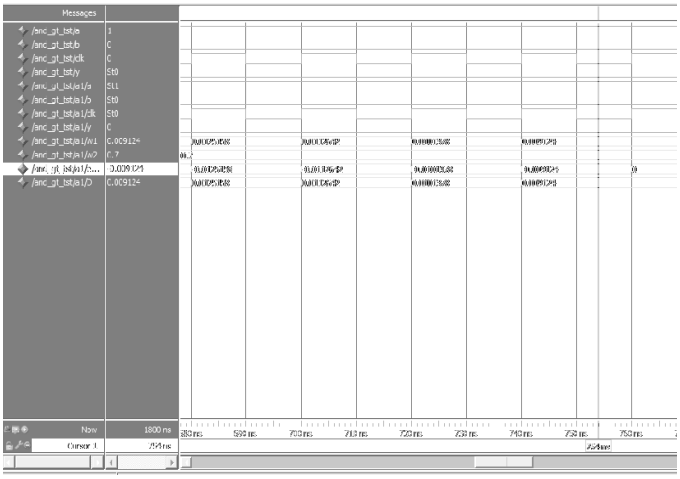

Fig. 5: Calculation of error using Verilog code

Time taken to adjust weight:-754ns

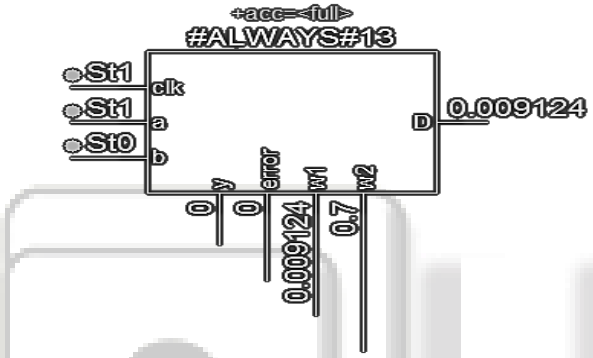


Fig. 6: Dataflow structure

This is weight w1 and w2 value when error is zero can be seen by model simulator.

## IV. MULTILAYER NEURAL NETWORK

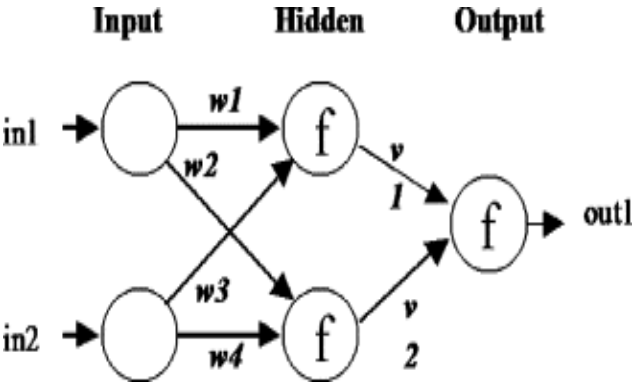


Fig. 6: X-OR gate using multilayer neural network

In an 2-2-1 multilayer there are 2 input neuron,2 hidden neuron and single output,the weight between input and hidden layer is w1,w2,w3,w4 and weight between hidden to output is w5 and w6,here we had used back propagation algorithm the main advantage of this method to reduce number of iterrationand time[3].the simulation result shown below

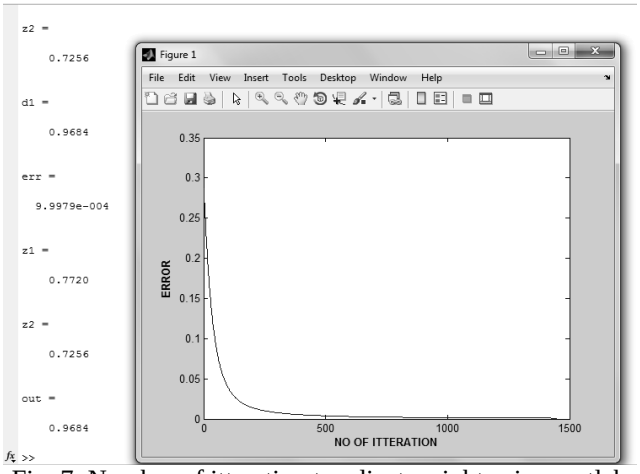


Fig. 7: Number of itteration to adjust weight using matlab

Number of iteration:-1500

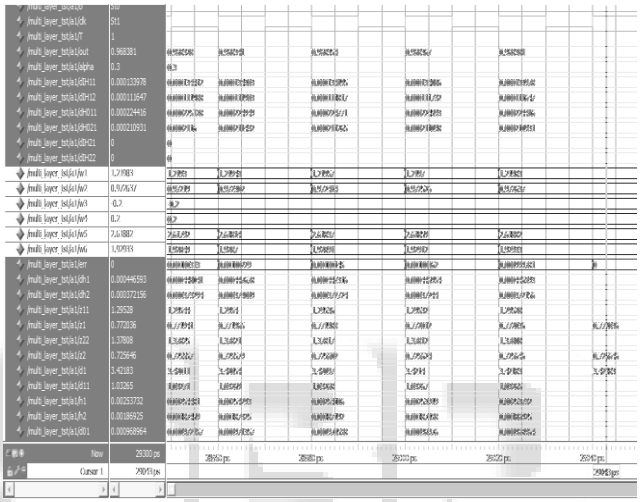

Fig 8: Time taken to adjust weight using verilog

Time taken to adjust weight:-2904ps

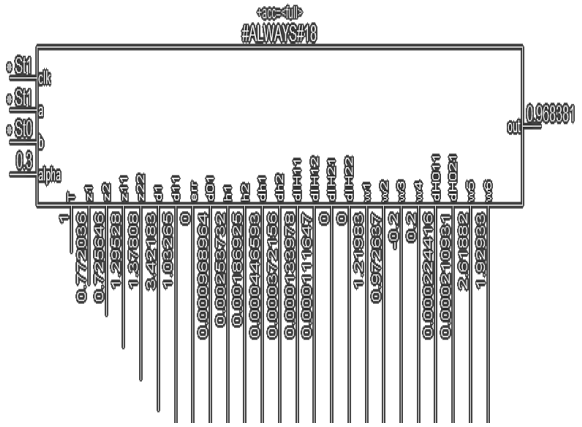


Fig. 9: Dataflow structure

## V. CONCLUSION

All digital circuit consist of universal and logical gate and last step in industry to test those circuit if there is fault again they have to go for some adjustment it will take more time to reach product to market, so if we replace those circuit by neural network maximum time to for finding fault can be minimized.

 

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