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Review: "Implementation of Feedforward and Feedback Neural Network for Signal Processing Using Analog VLSI Technology"

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ABSTRACT
Main focus of project is on implementation of Neural Network Architecture (NNA) with on chip learning on Analog VLSI Technology for signal processing application. In the proposed paper the analog components like Gilbert Cell Multiplier (GCM), Neuron Activation Function (NAF) are used to implement artificial NNA. Analog components used comprises of multiplier, adder and tan sigmoidal function circuit using MOS transistor. This Neural Architecture is trained using Back Propagation (BP) Algorithm in analog domain with new techniques of weight storage. Layout design and verification of above design is carried out using VLSI Backend Microwind 3.1 software Tool. The technology used to design layout is 32 nm CMOS Technology.
Keywords **–** Analog VLSI Technology, Back Propagation Algorithm, Gilbert Cell Multiplier, Neural Network Architecture, Neuron Activation Function

I. Introduction

Artificial Neural Networks are used to derive meaning from complex and imprecise data and it is also used in signal processing application. Therefore the main focus is on implementation of Feedforward and Feedback Neural Network using a very advance 32 nm CMOS Technology and the VLSI Backend Microwind 3.1 software Tool. This will be more useful than the previous technologies as time of execution, area and power requirement of circuit will be reduced and efficiency of system will increase due to use of 32 nm CMOS technology.

1.1 Neural Network

In this neural network we used a neuron, this neuron itself is a simple processing unit which has an associated weight for each input to strengthen it and produces an output. The working of neuron is to add together all the inputs and calculating an output to be passed on. The neural architecture is trained using back propagation algorithm and also it is a feed forward network. The designed neuron is suitable for both analog and digital applications. The proposed neural architecture is capable of performing operations like sine wave learning, amplification and frequency multiplication and can also be used for analog signal processing activities.
Figure can be expressed mathematically as,

$$a = f(P1W1+P2W2+P3W3+Bias)$$

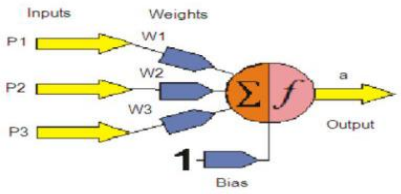

Fig.1 Neural Network

When a set of single layer neurons are connected with each other it forms a multiple layer neurons, as shown in the figure. Fig.2 shows that weights w11 to w16 are used to connect the inputs v1 and v2 to the neuron in the hidden layer. Then weights w21 to w23 transferred the output of hidden layer to the output layer. The final output is a21.

The inputs to the neuron v1 and v2 as shown in Fig. 2 are multiplied by the weight matrix. The resultant output is summed up and passed through an NAF.

The output of the activation function is then passes to the next layer for further processing. Blocks to be used are Multiplier block, Adders, NAF block with derivative.

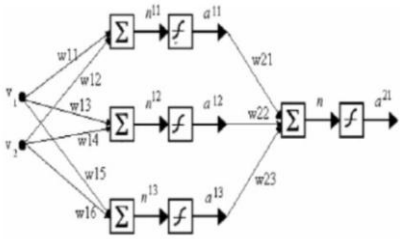

Fig.2 Layered structure of Neural Network

II. Design Architecture of Basic Components

2.1 Multiplier Block and Adder Block

Gilbert cell is used as multiplier and adders. It is only component which act as both adder and multiplier. The output of the Gilbert cell is in the form of current. The node of the Gilbert cell connecting the respective outputs act as adder itself. The schematic and layout is drawn using VLSI Backend Microwind 3.1 Software Tool and technology used to draw layout is 32 nm CMOS technology. Simulation Results are also drawn by VLSI Backend Microwind 3.1 Software Tool.

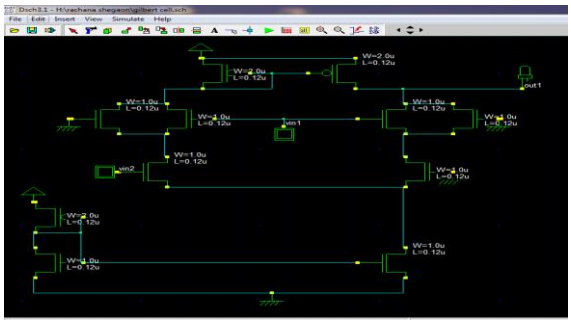

Fig.3 Schematic of Gilbert Cell

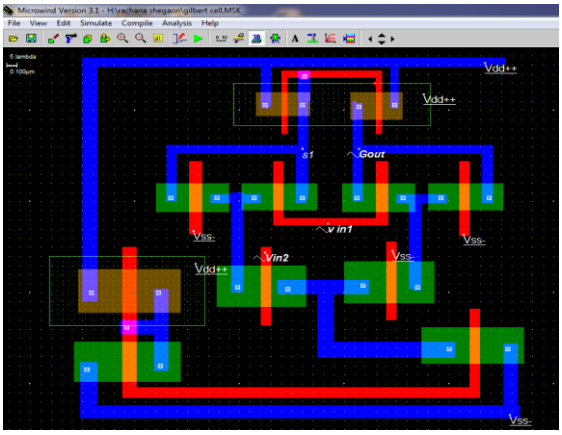

Fig.4 Layout of Gilbert Cell

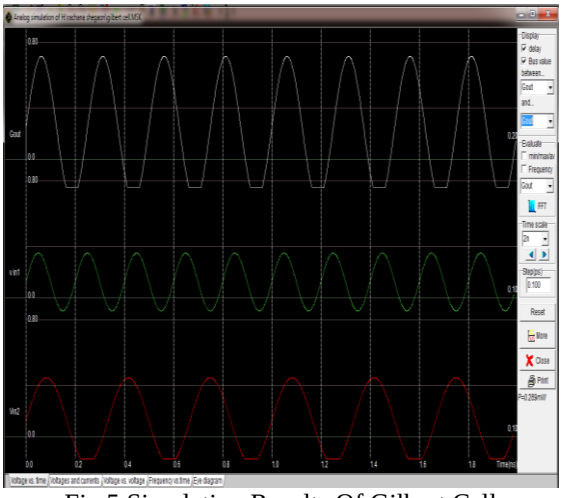

Fig.5 Simulation Results Of Gilbert Cell

2.2 Neuron Activation Function (NAF)

The designed activation function is tan sigmoid. The proposed design is actually a differential amplifier modified for differential output. Same circuit is capable of producing output of the activation function and the differentiation of the activation function.

Here two designs are considered for NAF

1. Differential amplifier as NAF
2. Modified differential amplifier as NAF with differentiation output.

The schematic and layout is drawn using VLSI Backend Microwind 3.1 Software Tool and technology used to draw layout is 32 nm CMOS technology. Simulation Results are also drawn by VLSI Backend Microwind 3.1 Software Tool.

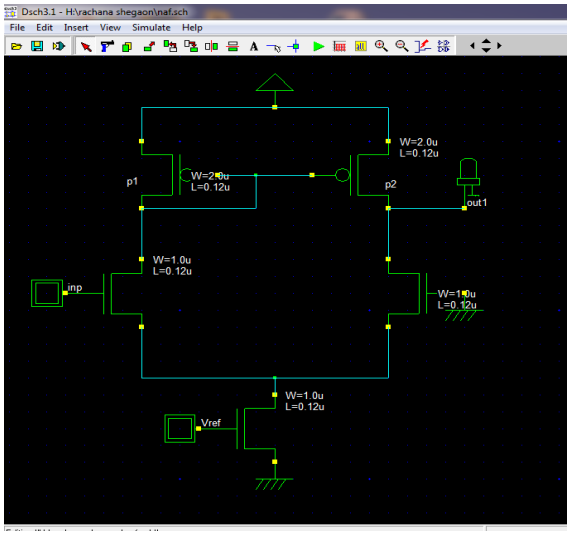

Fig.6 Schematic of NAF

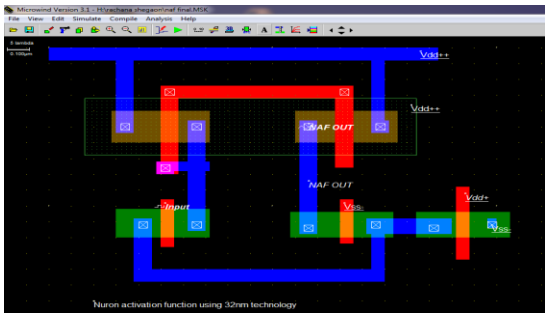

Fig.7 Layout of NAF

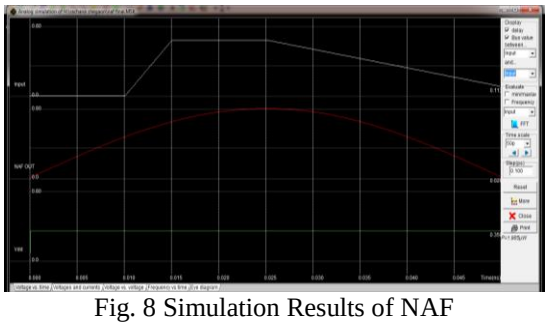

Fig. 8 Simulation Results of NAF

III. Implementation of Neural Architecture using Analog Blocks

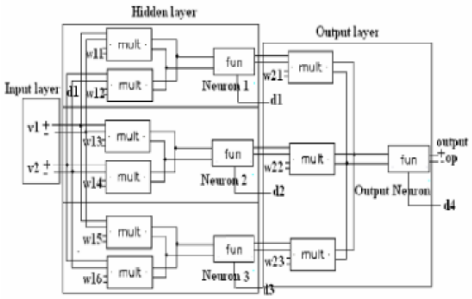

Fig.9 Realisation of Neural Architecture using Analog Blocks

Fig.9 shows exactaly how the neural architecture of fig.2 is implemented using analog components. The input layer is the input to the 2:3:1 neuron.The hidden layer is connected to the input layer by weights in the first layer named as w1i. The output layer is connected to input layer through weights w2j. The op is the output of 2:3:1 neuron.

IV. Expected Layout of Feedforward Neural Network

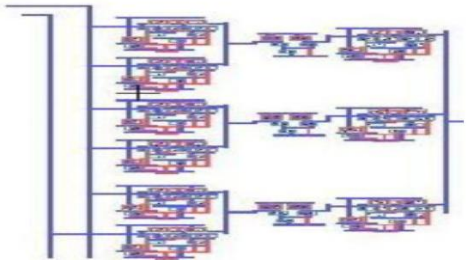

Fig.10 Expected Layout of Feedforward Neural Network

V. Expected Layout of Feedback Neural Network

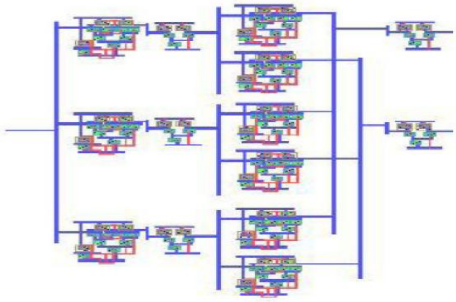

Fig.11 Expected Layout of Feedback Neural Network

Layout in Fig.10 and Fig.11 is taken using Tanner EDA 14.1 tool from reference paper [2]. In this project we will use VLSI Backend Microwind 3.1 software Tool and 32 nm CMOS Technology to draw the layout of both Feedforward and Feedback Neural Network.

VI. Expected Combined Architecture

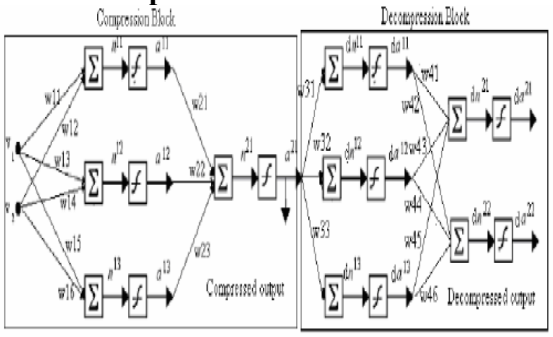

Fig.12 Expected combined architecture

VII. Expected Combined Layout

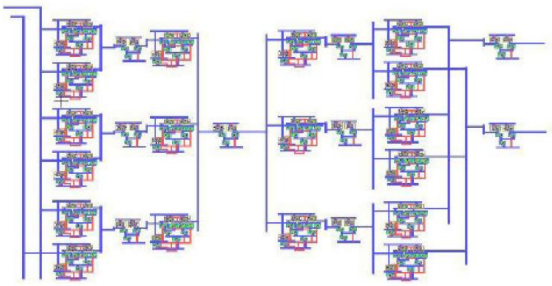

Fig.13 Expected combined layout

Layout in Fig.13 is taken using Tanner EDA 14.1 tool from reference paper [2]. In this project we will use VLSI Backend Microwind 3.1 software Tool to draw the layout of both Feedforward and Feedback Neural Network with 32 nm CMOS Technology.

VIII. Back Propagation Algorithm

Backpropagation method is the most common method of training of artificial neural network so as to minimize objective function. It is the generalization of delta rule and mainly used for feedforward network. The Backpropagation is understand by dividing it into two phases. The first phase is the propagation and second is weight update.

8.1 Propagation

a) Forward propagation of training pattern input through the neural network in order to generate the propagation output activation.
b) Backword propagation of the propagations output activations through the neural network using the training patterns target in order to generate the deltas of all outputs and the hidden neurons.

8.2 Weight Update

a) For each weight synapse it multiply its output delta and the input activation to get the gradient of the weight.

b) Bring the weight in opposite direction of the gradient by subtracting a ratio of it from the weight.

The ratio influences the speed and the quality of learning and it is called learning rate. The sign of the gradient of weight indicates where the error is increasing, that is why the weight must be updated in the opposite direction. This phases goes on repeating until the performance is of the network is of satisfactory.

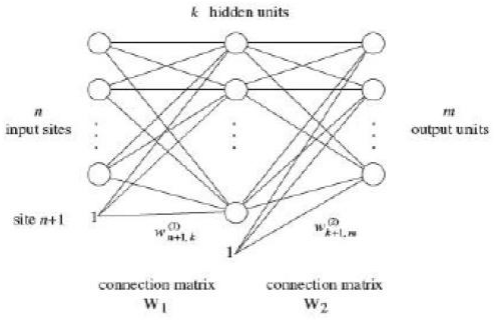

Fig.14 Notation for three-layered network

There are (n + 1) × k weights between input sites and hidden units and (k +1)×m between hidden and output units. Let W1 denote the (n+1)×k matrix with component wij $^{(1)}$ at the i-th row and the j-th column. Similarly let W2 denote the (k + 1) × m matrix with components wij$^{(2)}$ ij. We use an over lined notation to emphasize that the last row of both matrices corresponds to the biases of the computing units. The matrix of weights without this last row will be needed in the back propagation step. The n-dimensional input vector = (o1, . . . , on) is extended, transforming it to o = (o1, . . . , on, 1). The excitation net j of the j-th hidden unit is given by:

$$o_j^{(1)} = s\left(\sum_{i=1}^{n+1} w_{ij}^{(1)}\,\hat{o}_i\right)$$

The activation function is a sigmoid and the output Oj$^{(1)}$ of this unit is thus

$$net_j = \sum_{i=1}^{n+1} w_{ij}^{(1)}\,\hat{o}_i.$$

After choosing the weights of the network randomly, the back propagation algorithm is used to compute the necessary corrections. The algorithm can be decomposed in the following four steps:
(i) Feed-forward computation
(ii) Back propagation to the output layer
(iii) Back propagation to the hidden layer
(iv) Weight updates

The algorithm is stopped when the value of the error function has become sufficiently small.

IX. Expected Results

As shown in Fig.12, analog inputs v1 and v2 should recover back exactly at the last stage of proposed system. After successful implementation of this architecture, it can also be used for signal processing application. The developed ANN should reduce the power consumption and area of circuit and should increase efficiency.

X. Conclusion

Neural network has remarkable ability to derive meaning from complicated or imprecise data and can be used to extract patterns and to detect trends that are too complex to be noticed by either humans or other computer techniques. Due to its adaptive learning, self-organization, real time operations and fault tolerance via redundant information coding properties it can be used in Modeling and Diagnosing the Cardiovascular System and in Electronic noses which has several potential applications in telemedicine. Another application developed was Instant Physician which represents the best diagnosis and treatment.

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