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ANN BASED ON LEARNING RULE OF NEURON ACTI-VATION FUNCTION USING ELECTRONIC DEVICES

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Abstract

Artificial Neural Network (ANN) is realized by using analog devices. Analog components such as Junction Field Effect Transistor (JFET) and Operational Amplifier are utilized to construct a simple feed forward artificial neural network. Field Effect Transistor (FET) used as weight function for the neurons to self-regulate the resistance between source and drain. Where the operational amplifier serve two functions: first to sum each inputs of the neuron with its correspondent weights, second function is used as activation function to the neuron. The work conducted using National Instrument (NI) MULTISIM Software version 11. Logic functions are successfully implemented in single layer and two layers feed forward neural network based on the concept of learning rule of neurons. Experiment results showed that analog devices has been realized and implemented to solve simple problems such as OR, AND & XOR (exclusive OR) logic functions based on the concept of Artificial neural network learning rule.

Introduction

ANN is the subject of many fields hoping that one day neural network will have the ability to perform tasks, such that we can emulate some of the flexibility and powerful of human brain by artificial means. Neural networks can supplement the enormous processing power of the Von Neumann digital computer with the ability to make sensible decisions and to learn by ordinary experience. Artificial neural systems function as parallel distributed computing networks, this consider great advantage to conventional computers, which are programmed to perform specific tasks. The advantages of analog hardware implementation over the digital are high speed, low power consumption and compact in size. However analog computational hardware has its own drawback and limitations [1].The publication on hardware implementation of neural network from literature is as follows. Artificial neural networks in hardware: A survey of two decades of progress [2]. Implementation of Hopfield Neural Network Using Double Gate MOSFET [3]. Analysis of Analog Neural Network Model with CMOS Multipliers [4].This paper show the implementation and realization of neural network using simple analog devices such as FET transistor and operational amplifiers, these component were design to function as OR, AND & XOR logic functions. Using MULTISIM software environment. The work has been segmented into three sections first weight realization, second summation of these weight and third the activation function.

Artificial Neural Structure

ANNs are computational devices whose conception has been motivated by our current knowledge of biological nervous systems. ANN are configure in layers each has a number of neurons which have the ability to perform parallel computation in a very short response time for tasks that involve real time simultaneous processing of several signals [5]. The transmission of signals in biological neurons through synapses is a complex chemical process in which specific transmitter substances are released from the sending side of the synapse. The goal is to raise or lower the electrical potential inside the body of the receiving cell. Then if this potential reaches a threshold, the neuron fires otherwise not. According to McCulloch Pitts artificial neuron model shown in figure (1).

The ANN has N input, denote x1,x2,…,xn each input has its associated weight denoted by w1,w2,..,wn. These input and weight are multiplied with each other and then summed to produce (a), this variable pass through activation function called (f) which will determine whether or not the neuron will fire. It is given by the formula:

$$a = \sum_{j=1}^{n} (wj\ xj) \quad -------(1)$$

$$Output = f(a) \quad -------(2)$$

Where the activation function could be any function such as a threshold, linear, ramp or sigmoid [6].

FET transistor as a weight function

Field Effect Transistors (FETs) utilize as a conductive channel between source and drain whose resistance is controlled by an applied potential on the V_{gs} (gate source voltage).The working principle of FET is changing the magnitude of the reverse bias on the gate modulates the cross sec-

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tion of the channel. In order to emulate the resistance of the channel V_{ds} (drain source voltage) for various values of V_{gs} identify the transistor work in the linear region shown in figure (2).

The resistance Rds (drain source resistor) of P-Channel FET transistor is used as weight function for the artificial neural network in equation number (2) [7].

Operational amplifier as neuron summer

Operational amplifier (LM324) considers one of the most useful and widely used components in analog electronics. The summing amplifier shown in figure (3) is used to sum all the input of the neuron in the equation (1) above according to the formula [8]:

$$Vout = -Rf \sum_{j=1}^{n} \frac{V_j}{R_j} \quad -------(3)$$

Operational amplifier as activation function

Operational amplifier (LM324) is use as a decision maker whether or not the neuron gives an output in two states on and off. Base on the equation below the design circuit will give in output if the voltage equal or above the threshold shown in figure (4). Figure (5) present the ratio of input/output mapping of the activation function.

$$out = On \quad if\ a \geq 0.6\ V \quad -------(4a)$$
$$out = Off \quad if\ a < 0.6\ V \quad -------(4b)$$

Result and Discussion

ANN has been realized to preform logic function such as OR, AND & XOR logic functions, with two bipolar input where (1) present on state and (-1) present off state. The author has chosen bipolar since it's hard to represent physical quantity such as voltage by binary representation. JFET transistor used to evaluate the weight of the neuron by the resistance of Rds in the linear region as a function of voltage applied.in order to sum the input signal operational amplifier used to as a summer shown in equation (3), as well as used as inverter and a threshold function to the neurons. OR & AND logic functions where implemented using single layer feed forward neural network since they are linearly separable but not in the case of XOR two layer feed forward neural network. All logic functions OR, AND & XOR are implemented using MULTISIM 11 software successfully as in figure (6), figure (7) and figure (8) for OR, AND & XOR respectively. The result of experiment is shown in table (1).

Conclusion

ANN has been realized and implemented successfully by using analog components of electronic devices such as FET transistor as a weight function for the neuron based on the applied voltage. Also operational amplifier used as summer, invertor and threshold activation function. The new design fulfills the function of simple logic functions of artificial neural network. The work showed that with these simple and an expensive devices and their analog nature could be used to preform functions in correspondence with McCullough Pitts neurons. Using these components on a large scale may lead to implement more complicated function to solve real life problems.

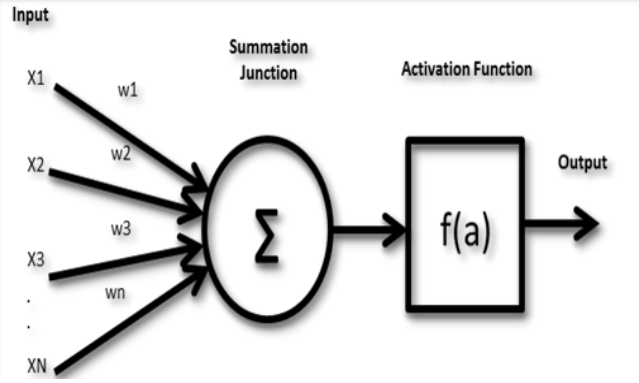

Figure 1. Structural Diagram of a Neuron

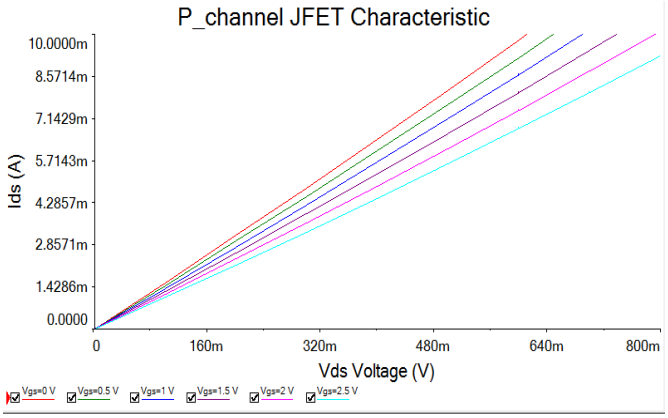

Figure 2. P-channel FET transistor characteristic

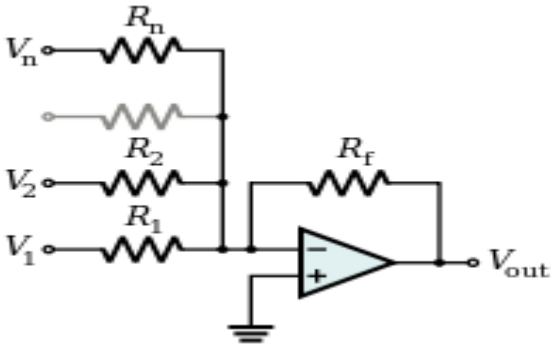

Figure 3.Summing Amplifier

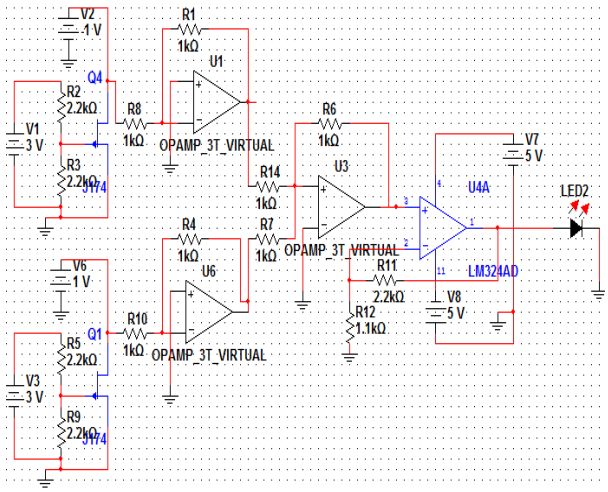

Figure 6.Logic OR Function

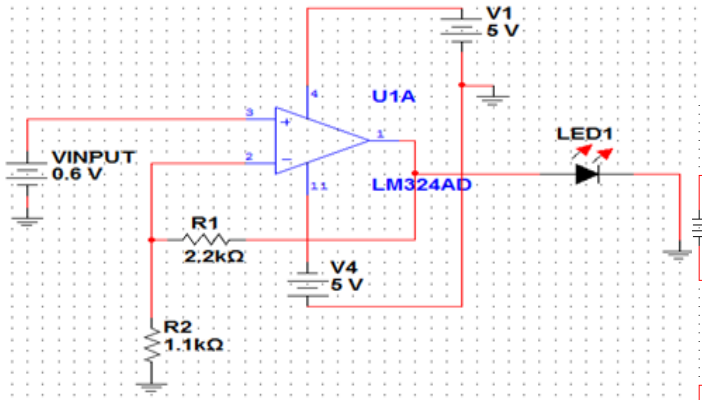

Figure 4.Schematic of Activation Function

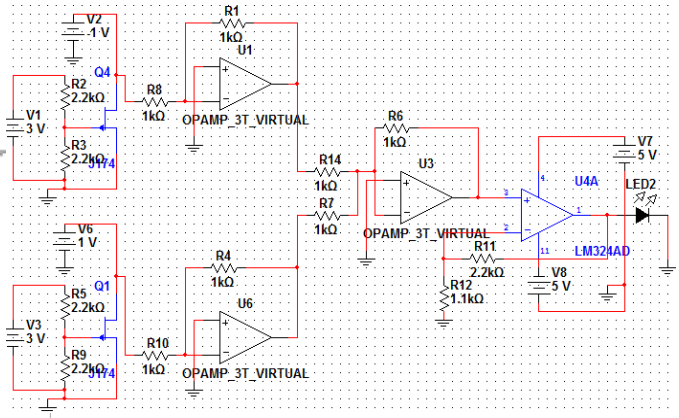

Figure 7.Logic AND Function

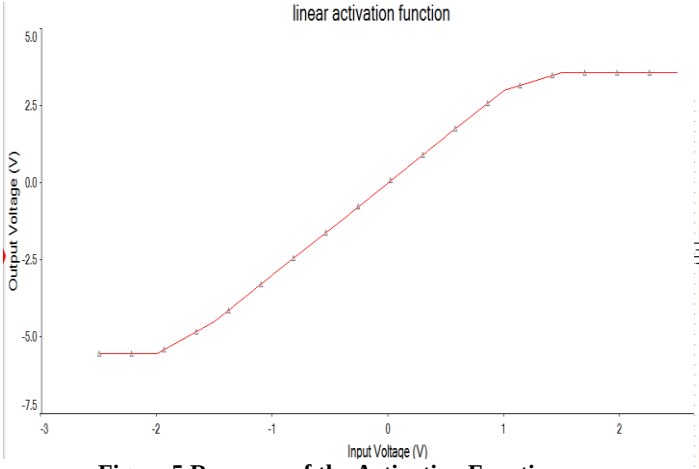

Figure 5.Response of the Activation Function

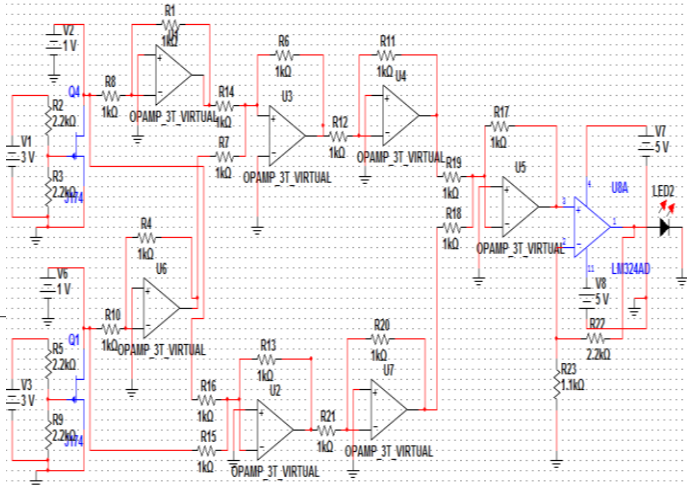

Figure 8.Logic XOR Function

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Table (1) result of experiment

Truth Table of ANN Logic Function

Input1	*Input2*	*OR*	*AND*	*XOR*
1	1	On	On	Off
1	-1	On	Off	On
-1	1	On	Off	On
-1	-1	Off	Off	Off

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