RECONFIGURABLE ANTENNA USING FPGA AND NEURAL NETWORK

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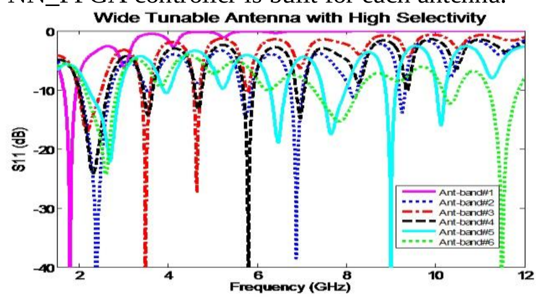
Abstract: The advantages of both neural network and FPGA are numerous but the use of FPGA in reconfigurable antennas are used to control their configuration. Basically neural network determines how software simulations is done in the Reconfigurable antenna which is embedded on FPGA, this work show a new approach of modelling reconfigurable antenna using neural network ,here we can use Matlab ,a code which is written to generate any reconfigurable system by providing any input /output data of antenna.

I. INTRODUCTION

The technology of design and use of FPGA in reconfigurable antenna using neuron network have responded well in the ever increasing needs of antenna bandwidth. The advanatages of reconfigurable antenna are numerous but are limited by the method of controlling their configuration. This dissertation proposes to utilize the advantages of both Neural Network(NN) and Field programmable Gate Arrays(FPGA) to overcome this dilemma as they have many advantages as they are very attractive in military and commercial applications where it is dynamically reconfigured to transmit or receive multiple frequency bands. Neural networks are cosiderably emerged as a powerful technique for modelling general input/output relationship. It have been applied to many problems since they first itroduced, including, pattern recognition, handwritten charcter recognition, financial and economic modelling, and next generation computing models. we have highly reconfigurable system in real time controller that thinks exactly same as the system it models. The "brain" is connected to the antenna and becomes the decision maker in antenna reconfiguration or switching. Due to complex like structure their numerical modelling poses serious computational challenges therefore accurate modelling of physical phenomena of these structures are much important. Different types of reconfigurable with different reconfigurability are simulated and are modelled. Neuron Network models show great match with measured antenna data. NN_FPGA controller is built for each antenna.



II. CONCEPT OF NEURON NETWORK

Neuron network, due to high speed computational capability, can be employed with reconfigurable antennas to achieve reconfigurability in real time, and to avoid coputational complexities involved in the analyzing reconfigurable antennas. Neural Network is a highly interconnected network of information-processing elements that mimics the connectivity and functioning of human brain. Neural networks provides some insight into the way the human brain works.

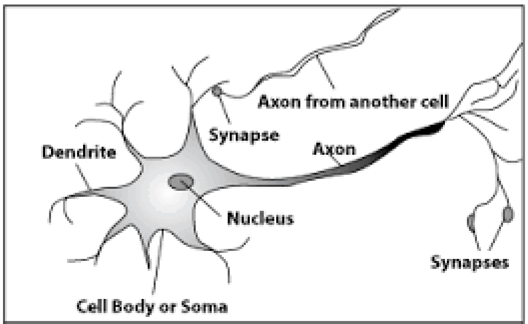


Figure 1: A Biological Neuron

The basic element in the NN is the neuron. A biological neural network as shown in the figure is a nerve cell with all of its processes. Neuron have three main parts the central body, called the soma, and two different types of branched, treelike structures that extend from the soma, called dendrites and axons. In a form of electrical impulses information from other neurons enters the dendrites at connection points called synapses. The information flows from the dendrites to the soma, where it processed. The output signal is then sent down the axon to the synapses of other neurons.

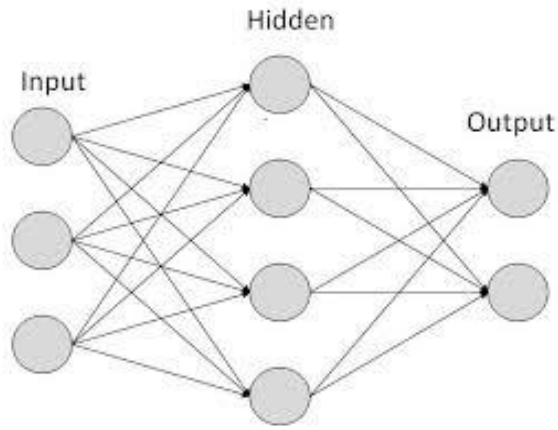


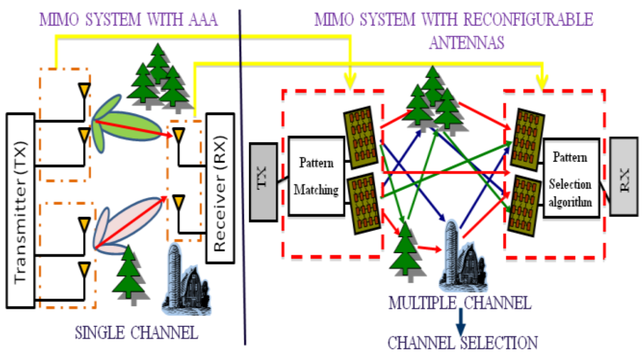
Fig-3 Artificial neural topology

2.1 Dissertation contributions

This work proposes to utilize the advanatages of both Neural Networks(NN)and Field programmable Gate Arrays(FPGA) to overcome this problem. Neural Networks, due to their high speed computational capability, can be employed with reconfigurable antennas to achieve reconfigurability in real time, and to avoid the computational complexities involoved in analyzing reconfigurable antennas. Neural Networks models rely on massive parallel computations. Thus, the high speed operation in real time applications can be achieved only in NNs are implemented using parallel hardware architecture. Neuron Networks modelling on FPGA preserves the parallel architecture of the neurons within layers and allows flexibility in reconfiguration.

III. INTRODUCTION TO RECONFIGURABLE ANTENNA

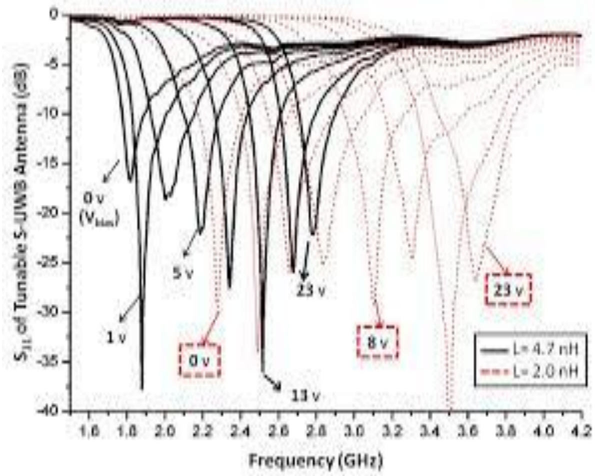
3.1 operation of reconfigurable antenna in general: Antenna are critical components of communications and radar systems. Different types of antennas have developed during the past 50years in both wireless communications and radar sysstems. These varieties include dipoles/monopoles, loop antennas, slot/horn antennas, reflector antennas, and frequency independent antennas. Each category posseses inherent benifits and detriments that make them more or less suitable for particular operations. When faced with the new system design, engineers change and adapt these basic antennas, using theoretical knowledge and general design guidelines as starting points to develop new structures that often produce acceptable results.



3.2 Reconfigurability capacity

Reconfigurability is the capacity to change an individual radiator's fundamental operating charcterstics through electrical, mechanical, or other means. Thus, under this defination, the traditional phasing of signals between elements in an array to achieve beam forming and beam steering does not make the antenna "reconfigurable" because the antenna's basic operating charcterstics reamain unchanged in this case. Neverthless, the choice of an antenna from the families mentioned above also impose restrictions on the overall system performance that arises because the antenna characteristics are fixed.

3.3 Operating frequency: Reconfigurable antennas should be able to alter their operating frequencies, impedance bandwidths, polarizations, and radiation patterns independently to accommodate changing operating requirements. However, the development of these antennas poses significant challenges to both antenna and system designers. These challenges lie not only in desiered levels of antenna fuctionality but also in integrating this fuctionality into complete systems to arrive at efficient and cost effective solutions. As in many case of techonology development,most of the cost will not come from antenna but the surrounding technologies that enable reconfigurability.



Frequency respose: Traditional charcterization of any antenna requires two types of information: the input impedance charcterstics over frequency (typically called frequency respose) and the radiation charcterstics and (or radiation pattern).Usually frequency response is considered to be the first because without a resonable input impedance match, a transmitting system may suffer from severe reflections that could damage other components and waste power, whereas receiving systems will suffer from reduced sensitivity and require additional signal amplifications. Once an antenna's frequency response is known,the radiation pattern is examined. This chapter briefly reviews both the frequency and radiation charcterstics of antennas that can be manipulated through reconfiguration of physical and material parameters.

IV. MATHEMATICAL MODEL OF NEURON

Neuron is the information processing unit in a neural network.The mathematical part represent basic for building neural networks.

Fig. 4.1- Neuron model

As shown in Figure 4.1, a neuron has three main components:

1. Synaptic links, which is characterized by the synaptic weights ( ). Each input signal ( ) is multiplied by the synaptic weight ( ).
2. Adder, for adding up the input signals, weighted by synaptic weights.
3. Activation function, for limiting the amplitude of neurons output to some finite
limit.

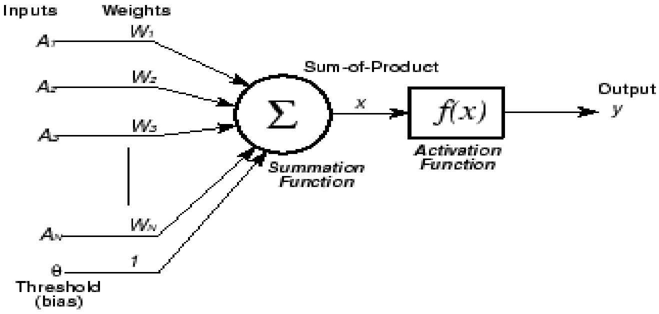


Fig4-Neuron model

4.1-NN-FPGA CONTROLLER DESIGN:

Implementing a neural network in reconfigurable architectutres like FPGA is an efficient way to calculate weights and network topologies. Network parameters are mapped into a hardware structure that improves the perfomance and the efficiency. The size of the implemented NN is limited by the block RAM capacity of the FPGA board. The size of a NN is the amount of neurons synaptic weights available. Number of synaptic weight connections available for FPGA board.

4.2. NN modelling for FPGA procedure: The controller design starts in building and training a neural network model for the antenna using Matlab and XSG, then, Xilinx ISE, the model is sent to an FPGA board.T he whole process can be summarizing in the following steps:

1.Measured antenna S11 data are collected, sampled, and normalized.

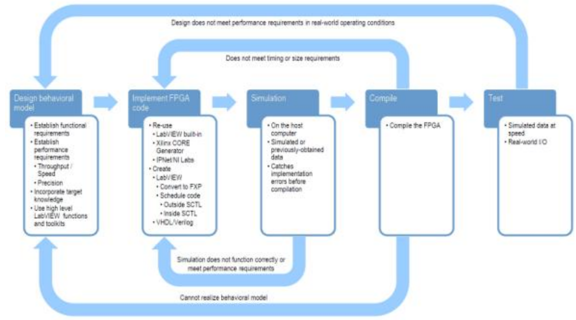
2.Matlab m-code is written to build for the NN using XSG blocks.

3.A Matlab simulink model is built for the NN using XSG blocks.

4.VHDL code for the design is generated using Xilinx system Generator.

5.The VHDL code is sent to the ISE, where it synthesized, implemented, and sent to the FPGA board.

6.FPGA board output is connected to the antenna input.



V. EXAMPLES SIMULATION AND RESULTS

The designed NN-FPGA controller is applied to different reconfigurable antennas. For each antenna, a different NN-FPGA model is built and analyzed. Simulations were done using Matlab R2009a and the xilinix system generator 12.1 on an Intel core duo T5450 computer with 2GB and 32-bit windows 7.FPGA board used was the Xilinx ML403.

5.1 EXAMPLE 1: Reconfigurable Filter Antenna - A reconfigurable filter is an antenna that is tuned based on the integration of a reconfigurable filter in the antenna feeding line. It changes the operating frequency without incorporating without active components in the antenna radiating surface .This can be implemented by integrating a reconfigurable band-pass filter within the feeding line of the antenna .Thus the antenna is able to tune its frequency based on the filter's operation. The filter structure consists of a dual sided Vivaldi antenna which is a wideband structure. It is fed via a 50ohms micro strip line which corresponds to a width of 5mm.The antenna is made frequency reconfigurable by incorporating a band pass filter in the antenna microstrip feeding line.

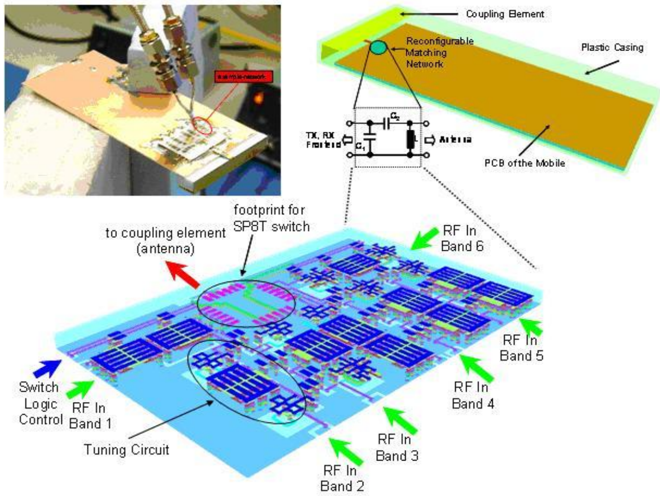


Fig. Reconfigurable antenna

5.2 EXAMPLE 2: Microstrip Patch Antenna.

As an example, a Neural Network modelling of a reconfigurable microstrip antenna is presented. This antenna has 2 side slots.1 switch bridge over each slot to achieve return loss tunning when activated and deactivated. By adjusting the status of the switches, the resonance frequency can be varied, thus achieving frequency reconfigurability.

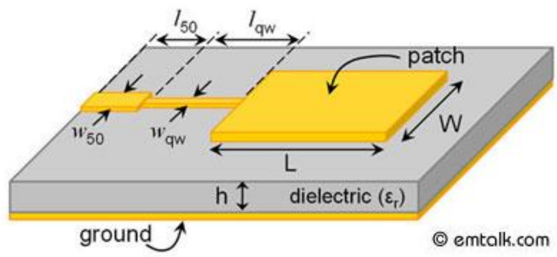


Fig-Microstrip Patch antenna

VI. CONCLUSION

In this paper, a detailed study about the different types of reconfigurable antennas was presented. The study was based on the different reconfiguration techniques used to obtain the required reconfigurability. Reconfigurable antennas were mainly divided into electrically, optically, physically, and smart-material-based tunable structures. A comparison between the different techniques used to implement like FPGA and neural network.

REFERENCES

List and number all bibliographical references in 9- point Times, single-spaced, at the end of your paper. When referenced in the text, enclose the citation number in square brackets.

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