THE COGNITIVE MODELS USING OSCILLATORY NEURAL NETS

M. Atasoyu and S. Ozoguz

Abstract**—** Oscillatory neural nets needs energy efficient neurons and synapses in its hardware implementation, as a candidate, Magnetic Tunnel Junctions (MTJ), which are known energy efficient devices [1-3], can be functioning as a neuron or synapse in a neural net**.** In this work, we have proposed a Phase Locked Loop (PLL) based Oscillatory Neural Network (ONN) for binary image recognition. The ONN architecture is proposed and possible design aspects are presented. The response time of the network may be faster with respect to the operating frequencies of the STO.

Keywords**—** *Cognitive, Neuron, PLL, MTJ*

1. INTRODUCTION

THE era of quantum-inspired devices and cognitive brain-based computing, such as pattern recognition applications, has become an interesting area of research. In such a calculation, the basic structure consists of neural networks that mimic the cognitive functions of the brain. These networks are composed of neurons and synapses, known to be energy efficient devices in their hardware implementation, such as MTJ, known to be efficient energy devices [1-3], as well as a neuron. or synapse in a neural network. Many different architectures have been proposed as a neural network [1-6]. However, physically, the phase relationship between neurons and synapses [6] was attracted by a network of neurons, oscillating neural network (ONN), exploiting the synchronous oscillatory behavior of neurons for image segmentation [1.6]. The ONNs were developed [1] and [4-9] in these designs, a neuron modeled as a locked phase (PLL).

In this work, we have proposed a new architecture based on MTJ devices as an oscillator that is a spin torque oscillator (STO) and whose increased phase stability of the PLL using frequency dividers differs from [1].

2. OSCILLATORY NEURAL NETS

STOs is composed of a perpendicular free layer, an in-plane pinned layer, and a barrier layer, as shown in Fig.1. The maximum power of the STO is reported in [10], and we modeled STO in Verilog-AMS by modifying given a model in [12], while capturing the dynamic behavior of an STO via the LLGS equations [11], and the parameters of the STO are taken from [10]. STO is a microwave signal source in a proposed PLL structure. The oscillation gain for different biasing currents is given in Fig.2.

Mesut Atasoyu is with Electrical and Electronics Engineering Faculty Istanbul Technical University, Istanbul, Turkey, (e-mail: matasoyu@itu.edu.tr).

Serdar Ozoguz is with Electrical and Electronics Engineering Faculty Istanbul Technical University, Istanbul, Turkey, (e-mail: ozoguz@itu.edu.tr).

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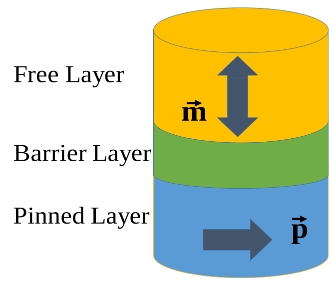

Fig.1. The physical layer structure of STO.

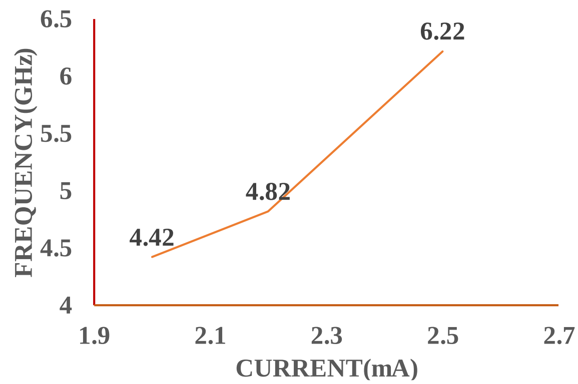

Fig.2. The gain of STO with different biasing currents.

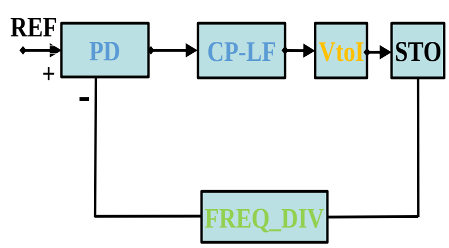

Fig.4. The proposed PLL is as a neuron.

In the proposed PLL, the design comprises a phase-frequency detector, a loop filter, a voltage-current converter and the STO, illustrated in Fig.4. The structure of the neural net proposed in [4,6], illustrated in Fig.5. The main concern is that the image recognition is associated with the synchronization of the neurons [6].

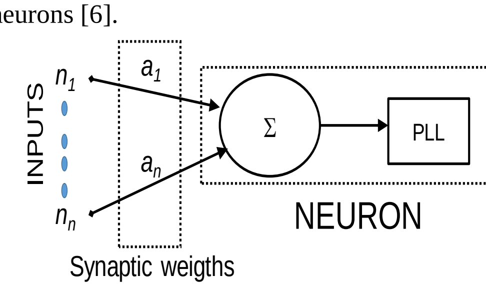

Fig.5. The proposed PLL is as a neuron [4].

3. COGNITIVE PERCEPTION

The ONN architecture project was first proposed by Izhikevich in [4] and the first use of STOs in [1]. The complexity lies in the architecture because each neuron is represented by a single PLL, as shown in Fig.5. To train the synaptic weights of the ONN are applied by a Hebbian learning rule [4]. To test the proposed network, a possible test architecture structure is in Fig.6 and also the possible test images are given in Fig.7a and in Fig.7b, and in the training and identification setup 10x6 three binary images, proposed in [1,5], can also be used.

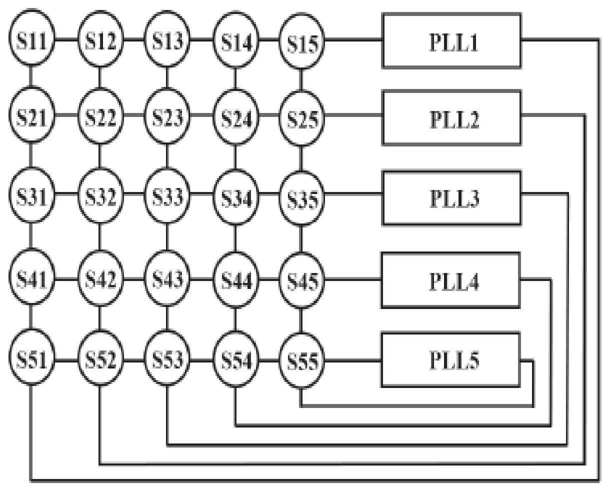

Fig.6. The ONN architecture [1].

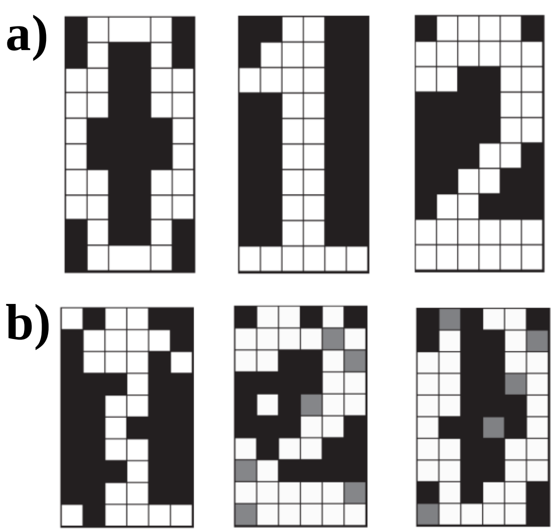

Fig.7. a) Training data and b) distorted image for the recognition [1].

4. CONCLUSIONS

In this work, we have proposed a PLL based ONN for binary image recognition. The ONN architecture is proposed and possible design aspects are presented. The response time of the network may be faster with respect to the operating frequencies of the STO.

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BIOGRAPHIES

Mesut Atasoyu received MSc. diploma in Electronic Engineering from the Istanbul Technical University in 2014,. His research interests are analog and digital vlsi systems and cognitive computing.

Serdar Ozoguz received his BSEE, MSEE and PhD degrees in Electronics Engineering from Istanbul TechnicalUniversity in 1991, 1993 and 2000 respectively. Since 2009, he is working as a full professor in Istanbul Technical University. His research interests include analog circuit design, chaotic circuits and chaos applications. Serdar Ozoguz has become a recipient of the Young Scientist Award of the Scientific and Technical Research Council of Turkey in 2004 and the Outstanding Young Scientist Award of the Turkish Academy of Sciences in 2002.