INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student : **ANANDA Y R**

Roll Number : **186102001**

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Thesis Title: **Design and Analysis of Memelements for Low Power and Area Efficient High Frequency Applications**

Name of Thesis Supervisor(s) : **Dr. Gaurav Trivedi**
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SHORT ABSTRACT

Memristor, memcapacitor, and meminductor are the three types of memory elements (memelements). Memristor is the fourth fundamental circuit element based on the missing relationship between two electrical quantities, the charge (q) and the flux (φ). The memristor is considered one of the most promising nano-devices among those currently being studied for possible use in future electronic systems. The best performance features include fast switching speed, high endurance and data retention, low power consumption, high integration density, and CMOS compatibility. Memristors are being explored as a potential technology to replace CMOS for logic-in-memory systems exploiting memristive nonvolatility. It is one of the prominent characteristic features of the memristor, which effectively solves the so-called memory wall problem in conventional von-Neumann architecture. A memristive device is highly nonlinear and non-volatile, which makes this device is better storage element with greater data density than the existing memory devices. In addition, the memristor exhibits switching capability, which is more relevant for implementing logic gates, a realization of Boolean functions, and system designing, such as arithmetic units like adders, subtractors, multipliers and dividers.

Meminductors and memcapacitors are the two special classes of memelements that exhibit inductive and capacitive behaviour. Memcapacitor is the constitutive relation between the time integral of the charge (TIC) and the flux, and the meminductor is the time integral of the flux (TIF) and the charge. These memelements exhibit a pinched hysteresis loop (PHL), which indicates their nonvolatile behaviour capable of storing the data. Memcapacitors and meminductors are lossless devices and more power efficient than the memristor. The distinctive properties of memelements offer several advantages, such as high scalability and low power consumption, making them suitable for designing high-performance neuromorphic computing, programmable analog ICs, oscillators, filters, amplifiers, process analog information in artificial intelligence (AI) applications, adaptive learning circuits, spiking neural net-works, chaotic oscillators, and several bio-inspired applications. These memelements are expected to be available soon due to the requirement of suitable materials and a new fabrication process. However, emulators are designed by research communities for realizing memelements using available solid-state

electronic devices in designing practical applications. The emulators presented in the literature require more active and passive elements, which increases the hardware complexity with limited operating frequency. It motivated us to propose area and power-efficient emulators capable of operating at high frequency for realizing memelements using a minimum number of off-the-shelf circuit elements.

Further, a very efficient, computationally accurate, highly nonlinear and scalable window functions for linear ion-dopant-drift memristor models are designed. These novel window functions are proposed by incorporating new parameters called Error Parameter (ε_0) and Adaptive constant (A_D), which aid in adjusting the nonlinearity for any variation in applied voltage and frequency. Thus, the proposed window functions help generate expected PHL for a wide range of voltage and frequency operations without distortion and boundary effects compared to other standard window functions reported in the literature.