Live Demonstration: mNET: A Visually Rich Memristor Crossbar Simulator

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***Abstract*—A flexible, versatile, and visually rich memristor crossbar simulator is presented in this paper. The system is represented by a Python graphical user interface (GUI) and memristor simulator engine which can instantiate crossbars of any size made out of any available memristor model. This system serves as an education tool, allowing the user to experiment with memristors in a crossbar configuration.**

I. Introduction

Since their theoretical inception more than 40 years ago [1], memristors have made great strides towards technological maturity. Crossbar configurations of memristors emerge as promising architectures for performing a wide range of operations, from multiply-accumulate engines, to playing the role of electronic synapses in artificial neural networks [2], to neural activity detectors [3]. From a research perspective, it is important to have the right tools to first visualise and scrutinise the behaviour of extracted memristor models, and to observe model behaviour in crossbar configurations of devices for the purpose of preparing larger scale experiments. From an educational perspective, having an easy-to-use memristor simulation platform offers students freedom to explore, supporting faster understanding of complex physical phenomena present in solid-state devices.

II. Demonstration Setup

The setup consists of a laptop which runs the mNET GUI (Fig. 1a), written in Python and utilising the pyQT native display library. The simulator has the option of selecting a memristor model which will be used to instantiate the subsequent test crossbar. Any memristor model, as long as it is written in Python as a special class, can be utilised by the mNET. The simulation is performed by solving the chosen models' coupled differential equations per a pre-determined time step (in this case, 100ns). The mNET GUI is an adaptation of a previously built instrumentation control interface [4].

III. Visitor Experience

The visitor can instantiate a crossbar of any size with a range of memristor models. The main model will be a variation of [6]. The GUI gives the possibility of selecting any memristor in the crossbar and then performing: single and full array READs, manual memristor WRITEs (implemented by manual pulsing), I-V curve tracing, endurance measurements, set a specific cross-point to a pre-selected resistance value, or converge the full array to a specific value matrix via voltage pulsing, which emulates learning in the context of memristor-based artificial neural networks (Fig. 1b). Additionally, the visitor can witness first hand the prevalent issue of sneak-paths which translates in WRITE-disturb operations on inactive word- and bit-line devices. The visitor experience will be augmented by rich visualisation tools embedded in the GUI, easily accessible only a click away.

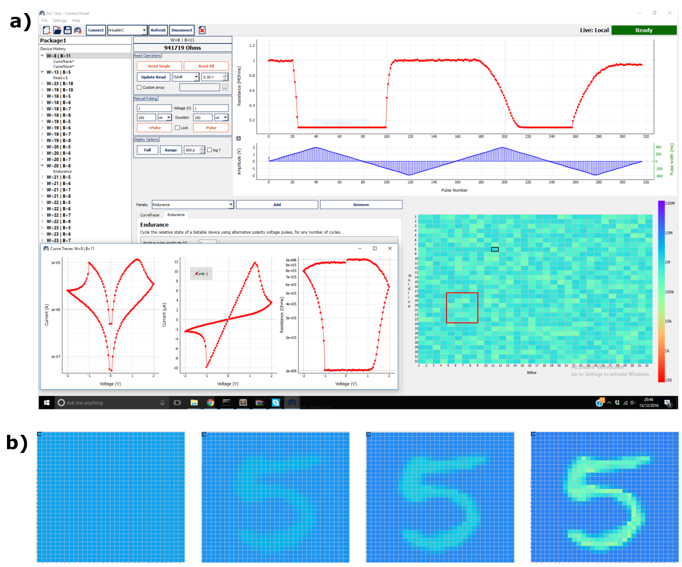

Fig. 1. mNET GUI. a) mNET dashboard showing memristor crossbar model device pulsing history and inset of an I-V measurement graph. The GUI handles live display of measurements on any memristor model. b) Illustration of a gradual full crossbar programming of memristor resistive states following one image from the MNIST dataset [5].

References

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