Response to “Pinched Hysteresis Loops is the Fingerprint of Memristive Devices”

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Abstract— **This is a short response to a recent paper by Kim et al. [1] which correctly notes that the zero-crossing pinched hysteresis loop of a memristor or memristive system must hold for all amplitudes, for all frequencies, and for all initial conditions, of any periodic testing waveform, such as sinusoidal or triangular signals, which assumes both positive and negative values over each period of the waveform. An example is noted from the literature indicating that TiO_2 memory resistors might not be considered either memristors or memristive systems given this constraint.**

Keywords- non-linear dynamic systems, memresistor, RRAM, ReRAM

1) Initially, it is noted that the paper by Kim et al. [1] appears to be missing the basic point of my paper [2]. My point was that there are non-memristive dynamic systems that also demonstrate pinched hysteresis under some conditions. Arguing that my examples do not fall into the category of memristive systems actually supports my position rather than contradicting it. Zero-crossing pinched hysteresis is a property of memristors but it is also a property of other dynamic systems which are neither memristors nor memristive systems which my paper proves.

2) Secondly, it is noted that I provided 15 examples in my paper. I agree that Kim et al. makes a good point that for my first three examples the zero-crossing pinched hysteresis effect does not hold under variation in amplitude, initial conditions, and frequencies. However, Kim et al. has ignored several of my more generalized examples which do exhibit amplitude and initial condition invariance of the zero-crossing pinched hysteresis effect. See examples 7-9 and 14 of [2].

3) Thirdly, there is experimental evidence that for real materials the zero-crossing pinched hysteresis effect does not hold under variation in amplitude, initial conditions, or frequencies. For example, the reader is referred to Fig. 1a of Argall’s 1968 paper on the memory resistance effects of thin film TiO_2 [3]. Fig. 1a of Argall illustrates that under some conditions (probably during electroformation processes) the zero-crossing pinched hysteresis does not occur. Thus the physics of TiO_2 memory resistors may not be concordant with the formal definition of memristors or memristive systems. Any paper claiming to have found an example of a physical memristor or memristive system needs to show experimental results for different amplitudes and frequencies and compare them with what would be expected from a memristor or memristive systems model. Otherwise the term “memristor” should not be considered a scientific term but rather a term related to propaganda.

4) Fourthly, it is noted that Hyongsuk Kim (the first listed author of [1]) is a co-inventor (along with Leon Chua) in a pending US Patent Application [4] claiming a method of implementing memristor memory. Therefore Kim may have a financial interest in trying to discredit anyone who questions whether all forms of resistance memory (ReRAM, phase change memory, MRAM) are memristors.

5) In conclusion, it is noted that Kim et al. does not adequately address the main point of my paper. There is currently no strong scientific evidence that either the memristor or the memristive systems model of Chua is the correct model for TiO_2 memory resistors or any other type of memory resistor. I have shown in [2] that it is possible to generate zero-crossing pinched hysteresis curves using other dynamic systems models. It is very

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possible that HP's so-called memristor models may be predicated on the contingent affirmation of a false reality. It is my position [5] that the unquestioned acceptance of the Chua-HP memristor model is representative of a systemic failure of the scientific community vis-à-vis the scientific method.

It is suggested that *memresistor* be used as a more generic term to refer to any 2-terminal device exhibiting a memory resistance effect in order to distinguish from the original "4th fundamental circuit element" memristor definition relating electric charge and magnetic flux linkage.

REFERENCES

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