On the Necessary and Sufficient Conditions for Small-Signal Voltage Gain in a First-Order Analogue Electrical Cell with a NbO_x Threshold Switch

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As experimentally demonstrated by Brown et. al. [1], small-signal voltage gain may be extracted across the output port of a metallic transmission line, when the underlying Lanthanum cobaltite (LaCoO3) substrate is poised within the stable portion of the *Local Activity* domain [2], also known as *Edge of Chaos* (EOC). A system on the EOC is "elevated" to an *excitable state*, hidden behind its polarization point, which explains why it may take tiny changes to the conditions, it nominally operates, to push it away from the quiescent condition, inducing the emergence of spatio-temporal phenomena across the physical medium it is integrated into [3,4,5]. A system may solve problems more efficiently when it operates on the EOC [6] or some of its constitutive elements do [7]. Taking inspiration from the scientific breakthrough from Brown et al. [1], we recurred to basic concepts from Control Theory to determine the necessary and sufficient conditions, which allow small-signal voltage amplification across at least one of the two output ports of a circuit composed of a source, generating a sine-wave of relatively-small amplitude and suitable offset, a resistor, and a NbOx threshold switch [8]. Remarkably, as one essential requisite, the volatile memristor must operate as a source of infinitesimal energy about the respective bias point. However, when this is the case, local voltage gain may be extracted across the resistor if and only if the frequency of the input sine wave keeps below a critical frequency associated to the resistive output port. Small-signal voltage amplification across the memristor occurs only for certain choices of the offset-resistor pair, responsible for poising the threshold switch on a Negative Differential Resistance (NDR) bias point, and, once again, it is only possible up to a critical frequency associated to the memristive output port.
More details on the theoretical analysis, unveiling the mechanisms behind small-signal voltage amplification in the three-element analogue electrical cell, shall be provided in the talk.

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