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The elusive memristor: properties of basic electrical circuits.

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Summary: We present an introduction to and a tutorial on the properties of the recently discovered ideal circuit element, a memristor. By definition, a memristor M relates the charge q and the magnetic flux ϕ in a circuit and complements a resistor R , a capacitor C and an inductor L as an ingredient of ideal electrical circuits. The properties of these three elements and their circuits are a part of the standard curricula. The existence of the memristor as the fourth ideal circuit element was predicted in 1971 based on symmetry arguments, but was clearly experimentally demonstrated just last year. We present the properties of a single memristor, memristors in series and parallel, as well as ideal memristor-capacitor (MC), memristor-inductor (ML) and memristor-capacitor-inductor (MCL) circuits. We find that the memristor has hysteretic current-voltage characteristics. We show that the ideal MC (ML) circuit undergoes non-exponential charge (current) decay with two time scales and that by switching the polarity of the capacitor, an ideal MCL circuit can be tuned from overdamped to underdamped. We present simple models which show that these unusual properties are closely related to the memristor's internal dynamics. This tutorial complements the pedagogy of ideal circuit elements (R, C and L) and the properties of their circuits, and is aimed at undergraduate physics and electrical engineering students.

Classification: M55

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