

The fourth circuit element

Arising from: D. B. Strukov, G. S. Snider, D. R. Stewart & R. S. Williams *Nature* **453**, 80–83 (2008)

In 1971, Chua suggested¹ that there should in principle exist a circuit element linking electrical charge, q , and magnetic flux, φ . Strukov *et al.*² claim recently to have found such a link. However, here I point out that Chua's suggestion was in fact preceded by experimental evidence^{3–5} for magneto-electric effects whereby magnetic and electrical signals are interconverted. When the stimulus is magnetic and the response is electrical, the linear magneto-electric coupling constant⁵, α , is typically reported as dP/dH , where P represents the electrical polarization and H represents the applied magnetic field. The coupling constant could equally be presented as $dq/d\varphi$ if divided by the permeability of free space.

In making their claim, Strukov *et al.* therefore overlook the magneto-electric literature. In magneto-electric systems, the link arises explicitly and through a simple geometry, whereas Strukov *et al.* consider a system in which magnetic signals are neither applied nor measured. Moreover, some magneto-electric systems display nonlinear coupling^{6,7}, which is necessary but not sufficient for memristance^{1,2}.

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