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Design and energy function determination of a memristor-coupled circuit representing a two-dimensional chaotic map

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Model and Scheme

A 2D chaotic map is built using an open-loop modulation coupling method.

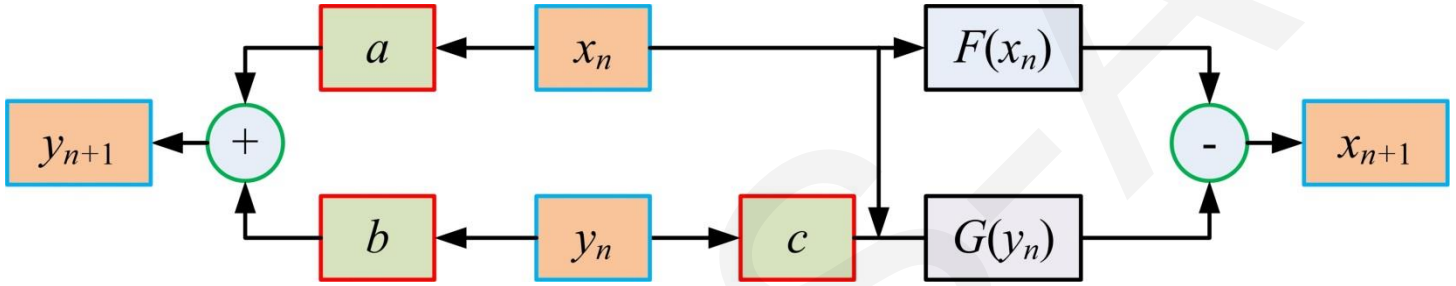

Fig.1 Structural diagram of an open-loop modulation coupling method.

$$\begin{cases} x_{n+1} = F(x_n) - cx_n G(y_n), \\ y_{n+1} = by_n + ax_n, \end{cases} \tag{1}$$

$$\begin{cases} x_{n+1} = \mu_1 x_n - \mu_2 x_n^2 - cx_n y_n, \\ y_{n+1} = by_n + ax_n. \end{cases} \tag{2}$$

The structural diagram of an open-loop modulation coupling system in Fig. 1 is expressed as Eq.(1), and then a 2D map system is described by Eq.(2).

Model and Scheme

A 2D chaotic map is expressed by applying two different memristor-coupled circuits.

$$\begin{cases} x_{n+1} = \mu_1 x_n - \mu_2 x_n^2 - c x_n y_n, \\ y_{n+1} = b y_n + a x_n. \end{cases} \tag{2}$$

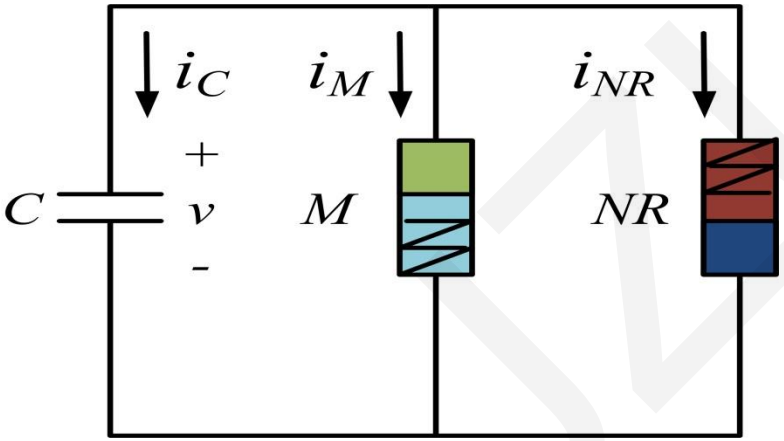

Fig.2 Magnetic flux-controlled memristor circuit without an inductor.

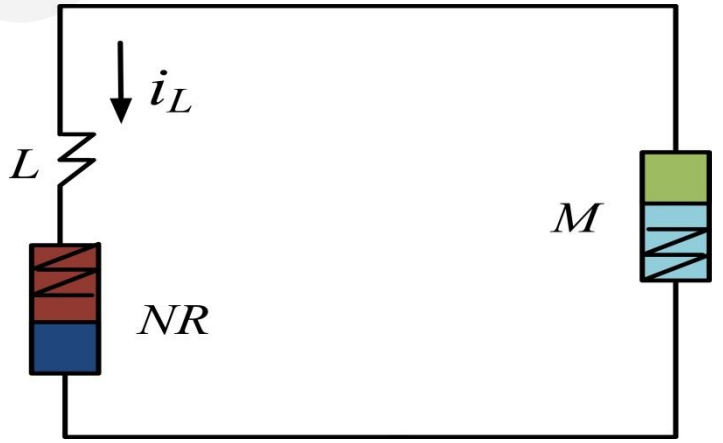

Fig.2 Charge-controlled memristor circuit without an inductor.

Model and Scheme

Energy function of a 2D chaotic map is approached

$$\begin{cases} x_{n+1} = \mu_1 x_n - \mu_2 x_n^2 - c x_n y_n, \\ y_{n+1} = b y_n + a x_n. \end{cases} \tag{2}$$



$$H_{n+1} = \frac{1}{2} x_n^2 + \frac{1}{2} c y_n^2 x_n. \tag{3}$$

The energy function presented in Eq. (3) of the chaotic map given in Eq. (2) is defined through the memristor-coupled circuits shown in Figs. 2 and 3.

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Conclusions

- A 2D chaotic map was built using an open-loop modulation coupling method.
- 2D chaotic map can be implemented experimentally using two distinct memristor-coupled circuits.
- Higher-order terms in any 2D chaotic system can be equivalently realized using a nonlinear resistor, while nonlinear cross terms and linear coupling between variables can be effectively represented by a memristor.
- The dimensional consistency of dimensionless equations can be restored through appropriate combinations of capacitance and resistance, or inductance and resistance.
- Energy function associated with a chaotic map system can be derived from its corresponding memristor-coupled circuit configurations.