

Electronics and Instrumentations

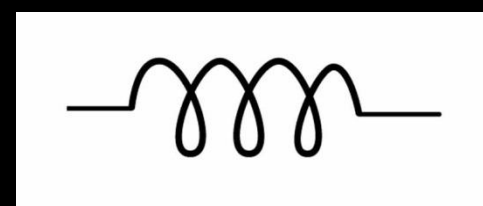
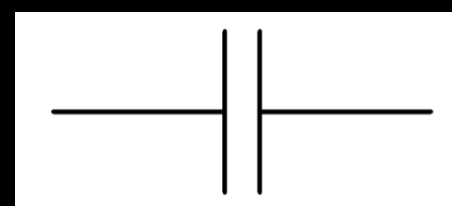
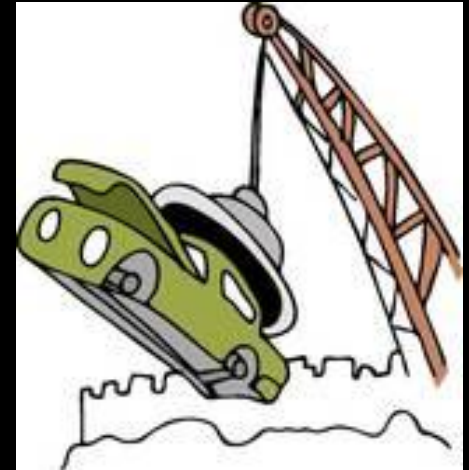
Nonlinear Electronics and Applications

K.THAMILMARAN

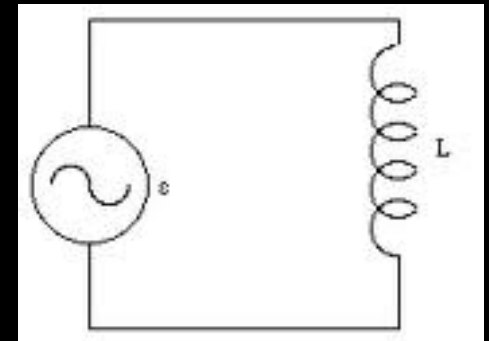
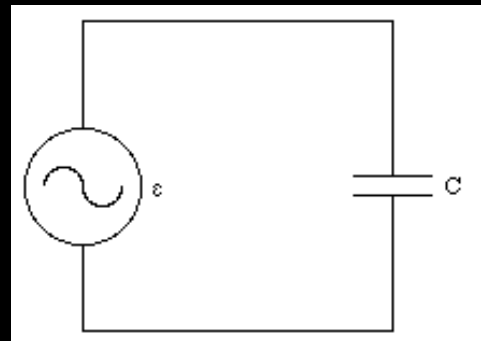
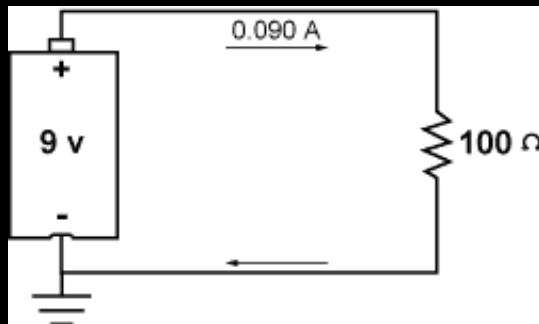
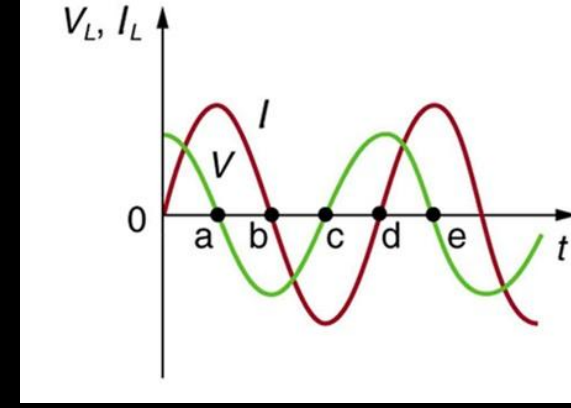
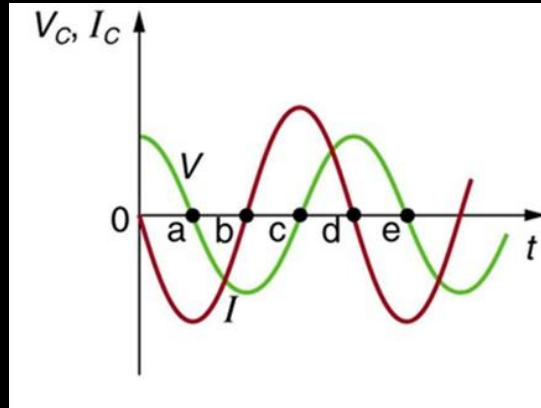
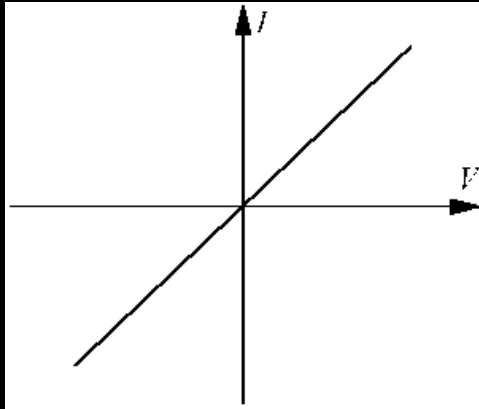


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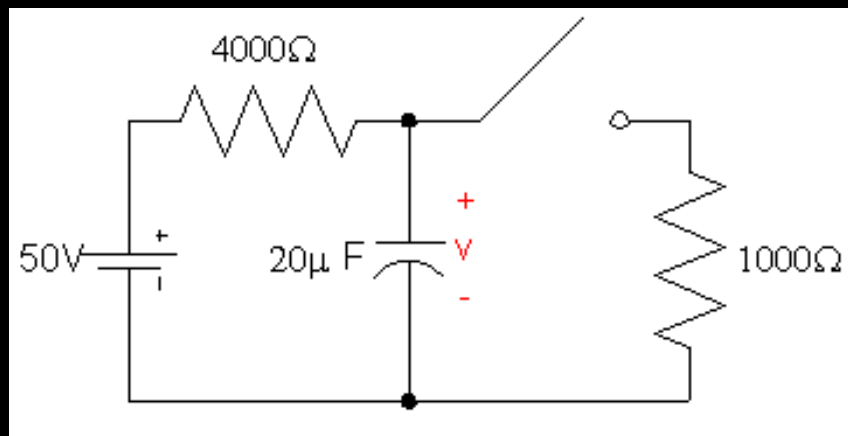
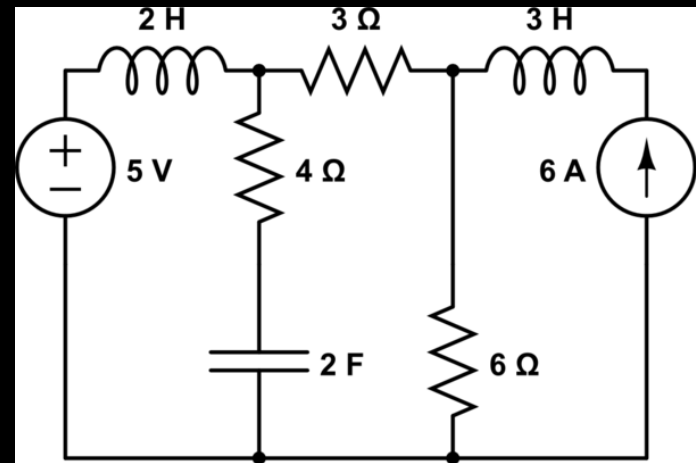
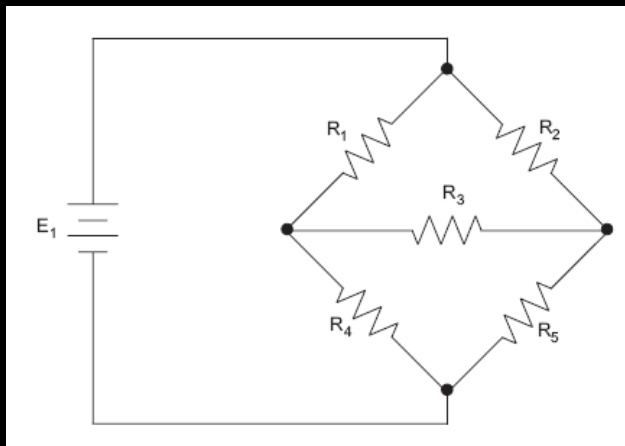
Linear Circuits



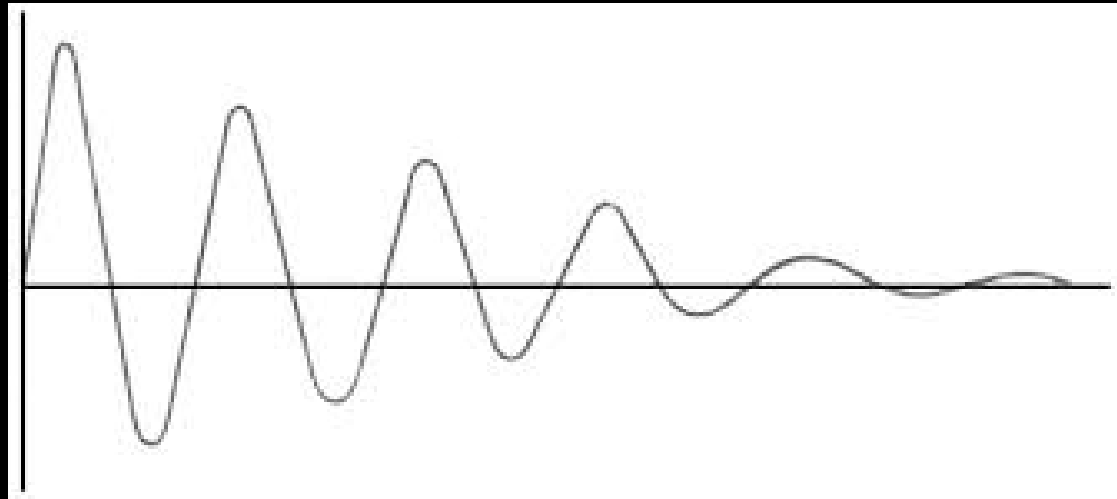
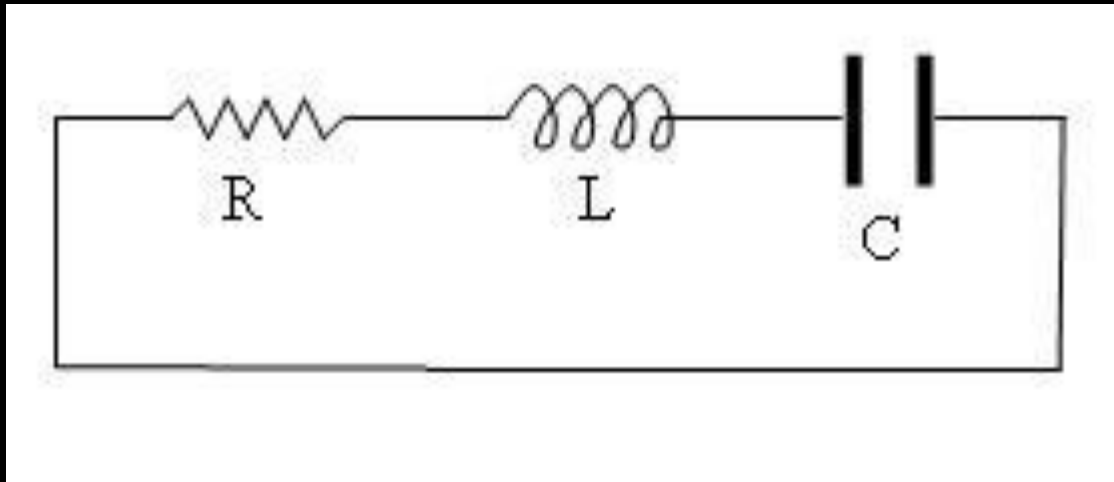
- In linear circuits, voltage is proportional to the current



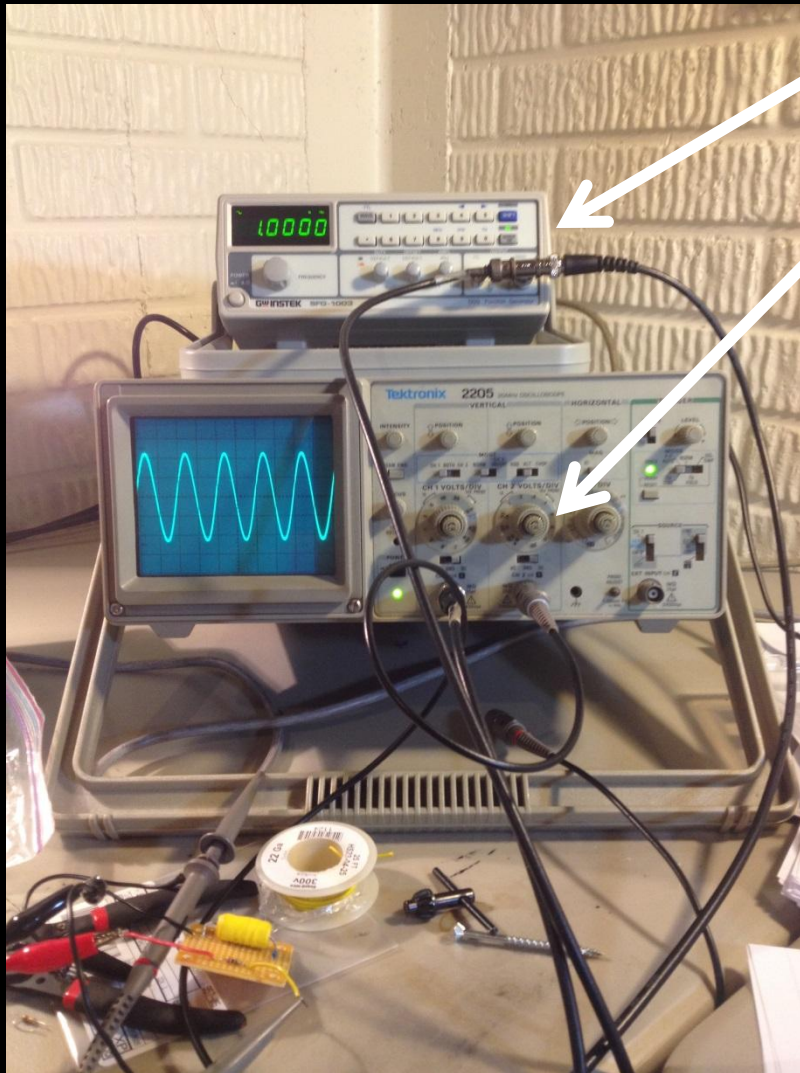
Linear circuit examples



RLC circuit



Equipment



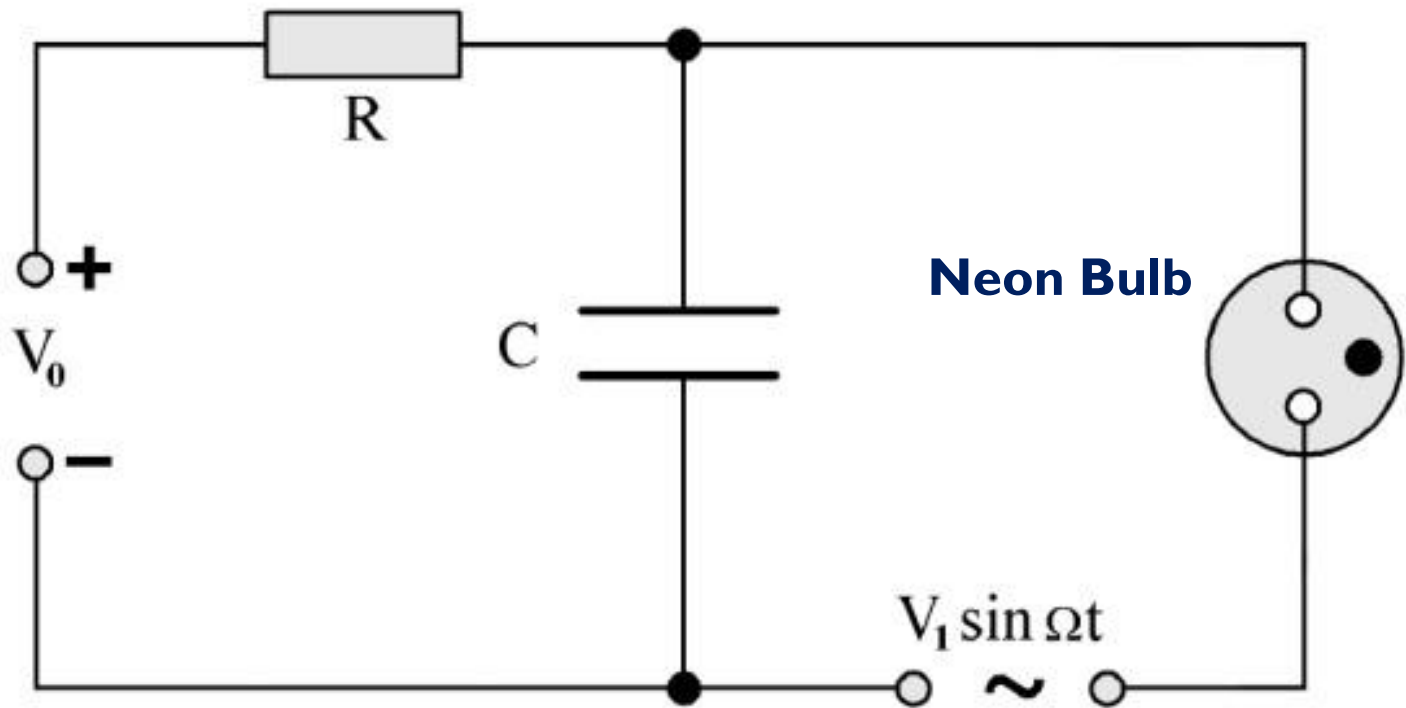
Function Generator

Oscilloscope

Power supply



Van Der Pol Oscillator

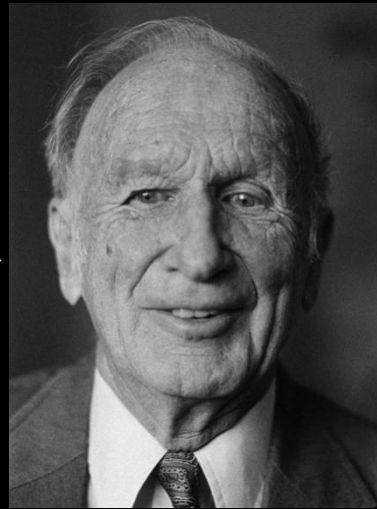


Van Der Pol



1927

Lorenz



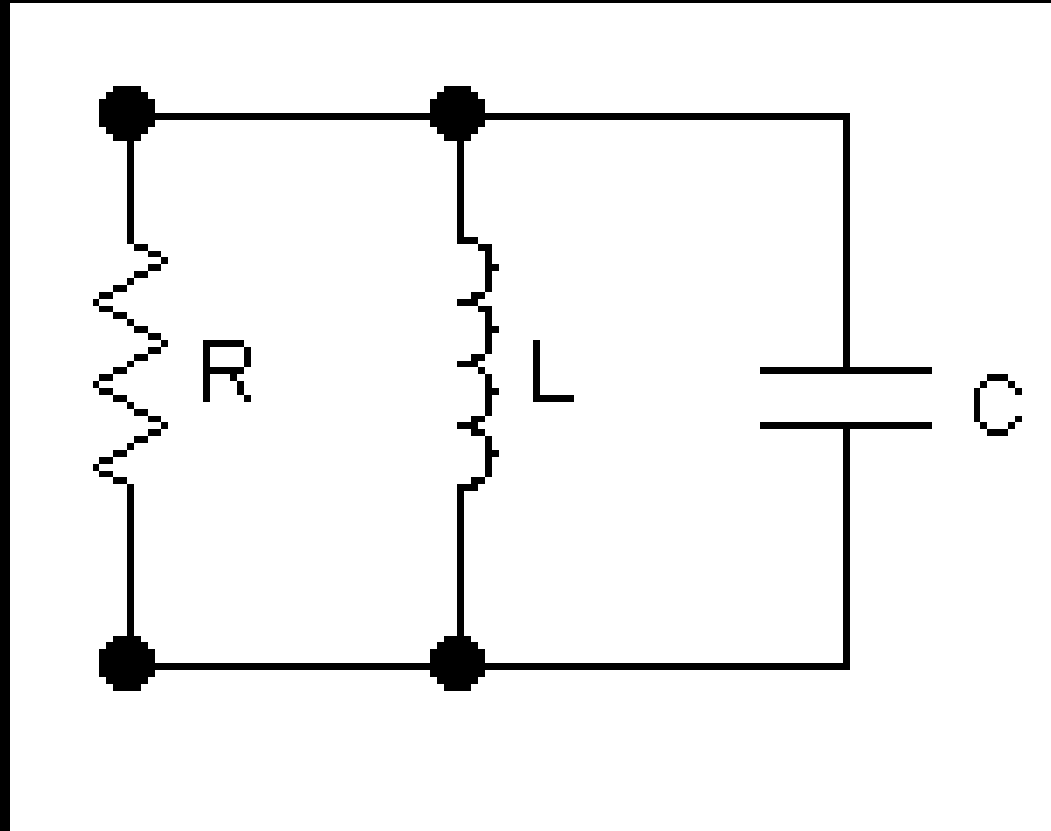
1959

Chua

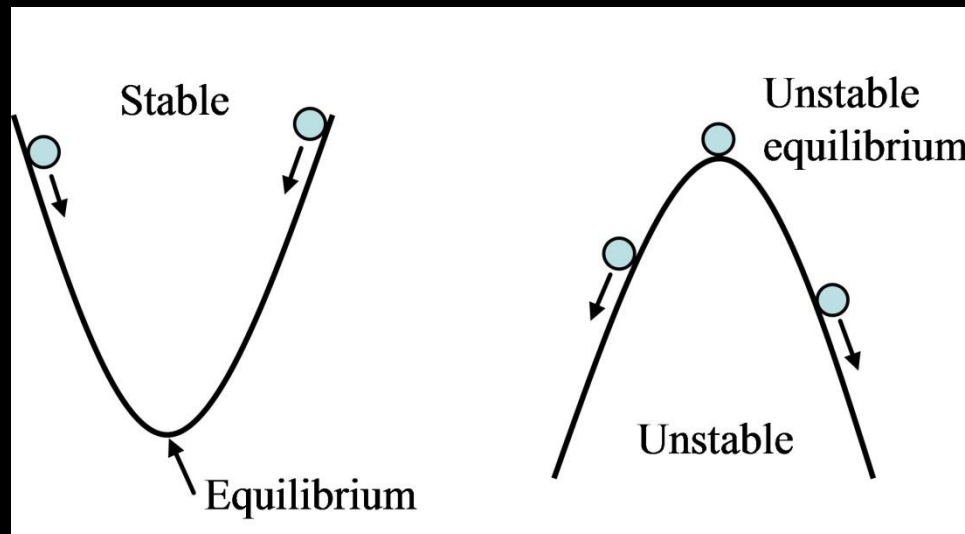
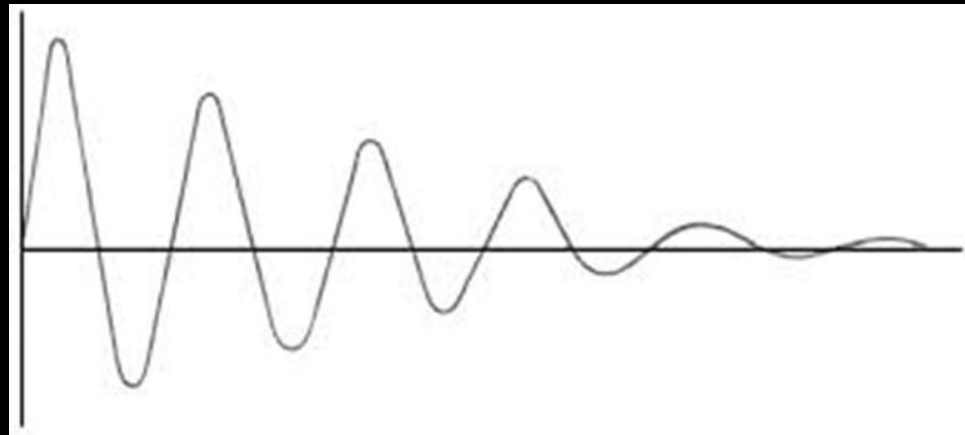


1983

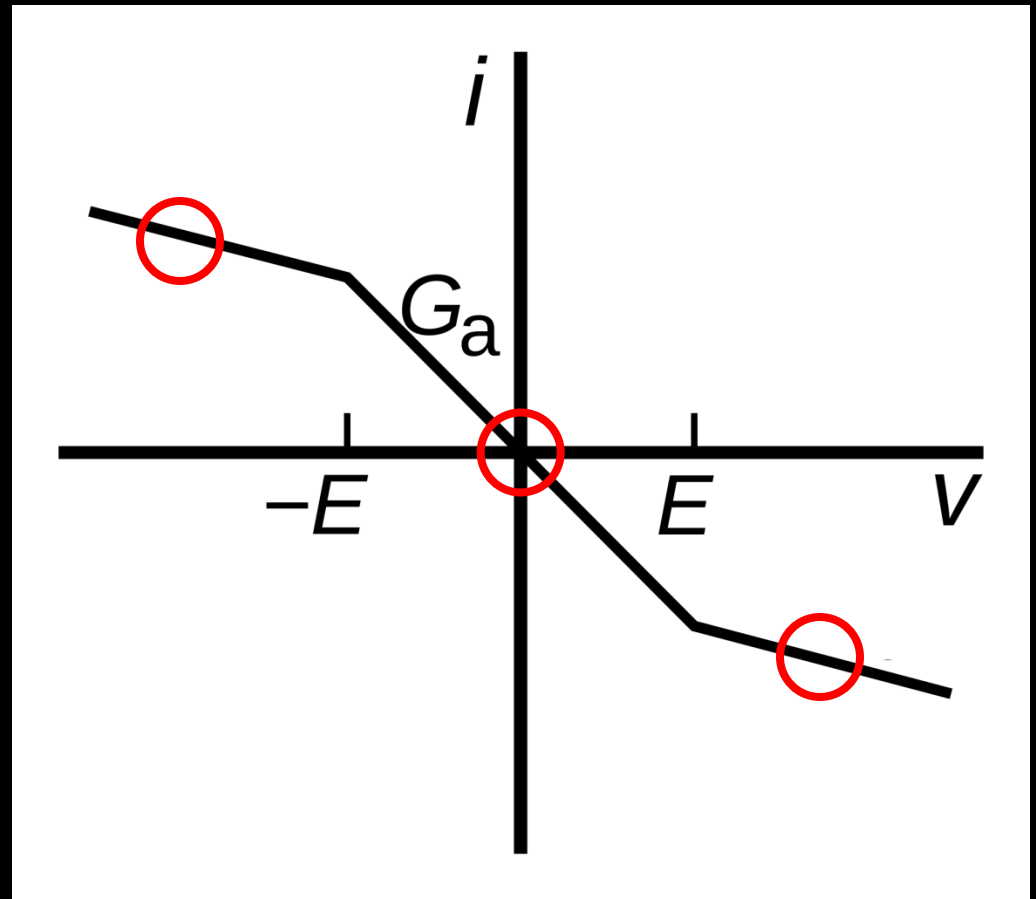
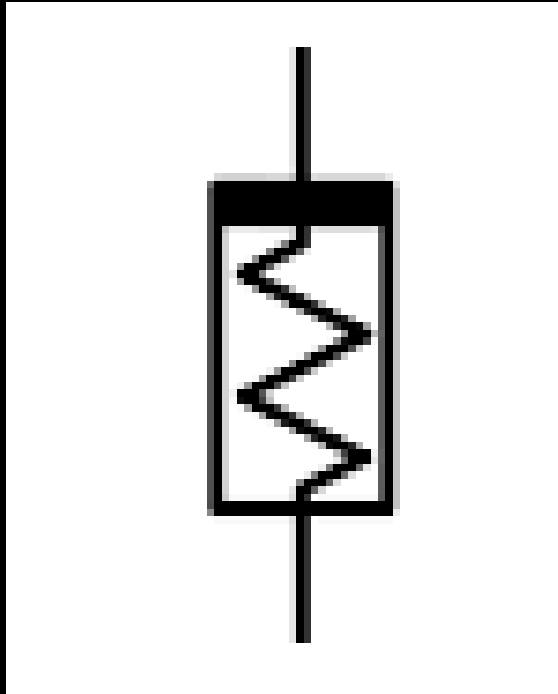
Step 1: RLC circuit (parallel)



- In a RLC circuit, there is one stable equilibrium point at the origin

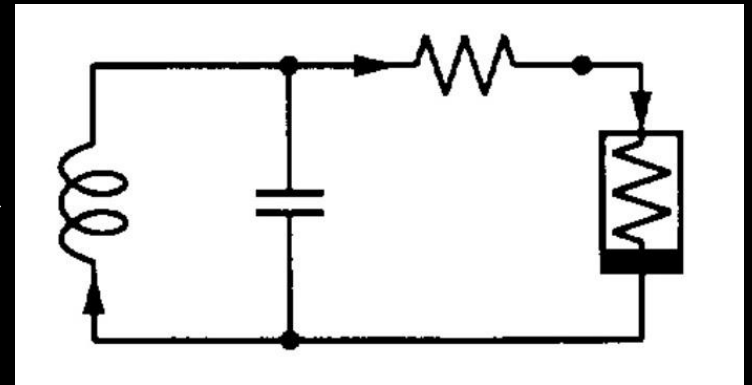
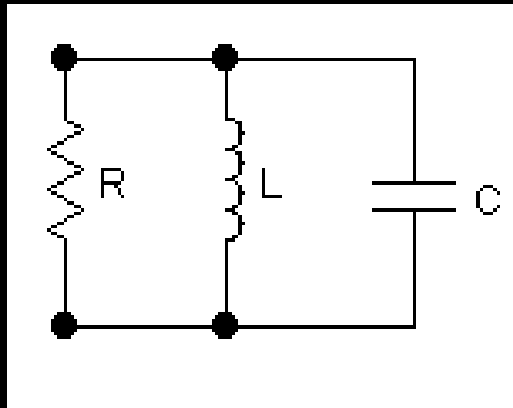


Chua's Nonlinear resistor



3 Equilibrium points (marked red)

Step 2: Nonlinear Resistor



Lorenz System

$$\dot{x} = \sigma(y - x)$$

$$\dot{y} = rx - y - xz$$

$$\dot{z} = xy - bz$$

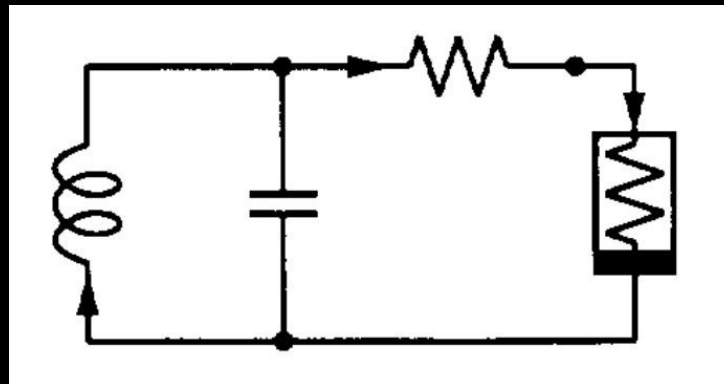
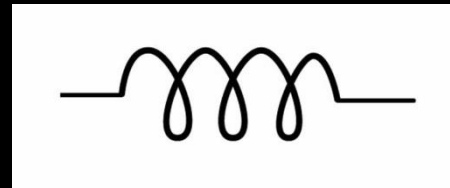
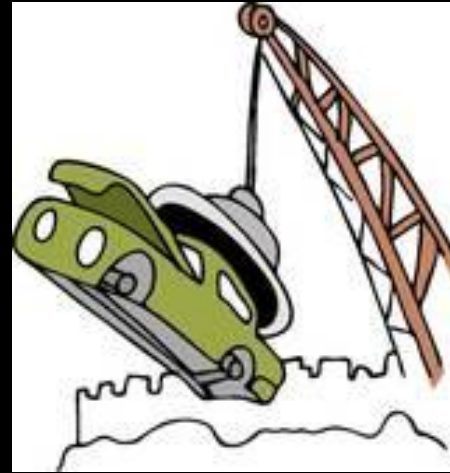
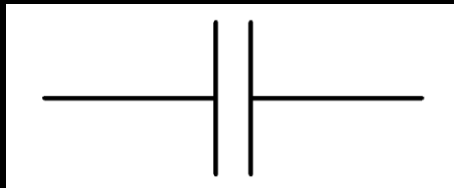
Rossler System

$$\dot{x} = -y - z$$

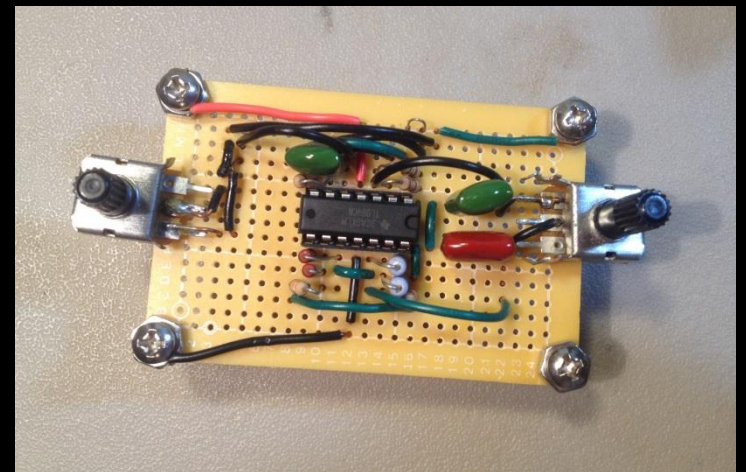
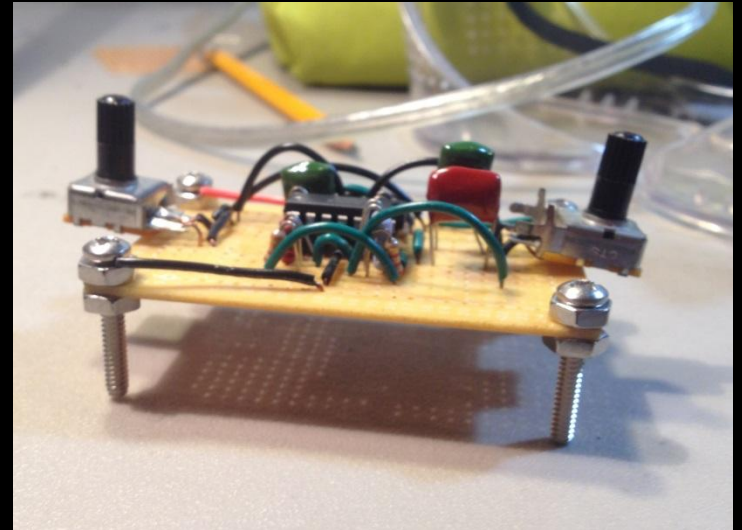
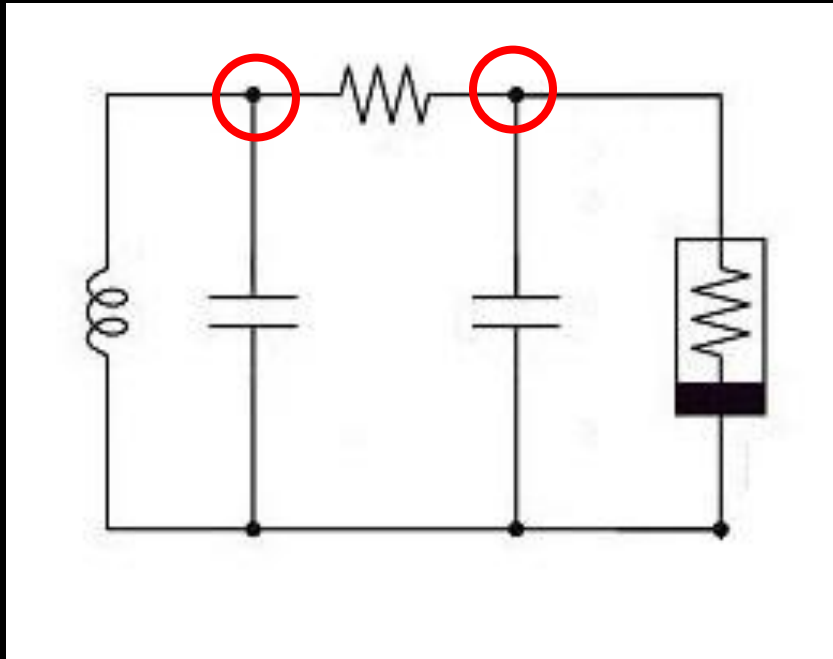
$$\dot{y} = x + ay$$

$$\dot{z} = a + z(x - c)$$

Step 3: Add a third capacitor or inductor

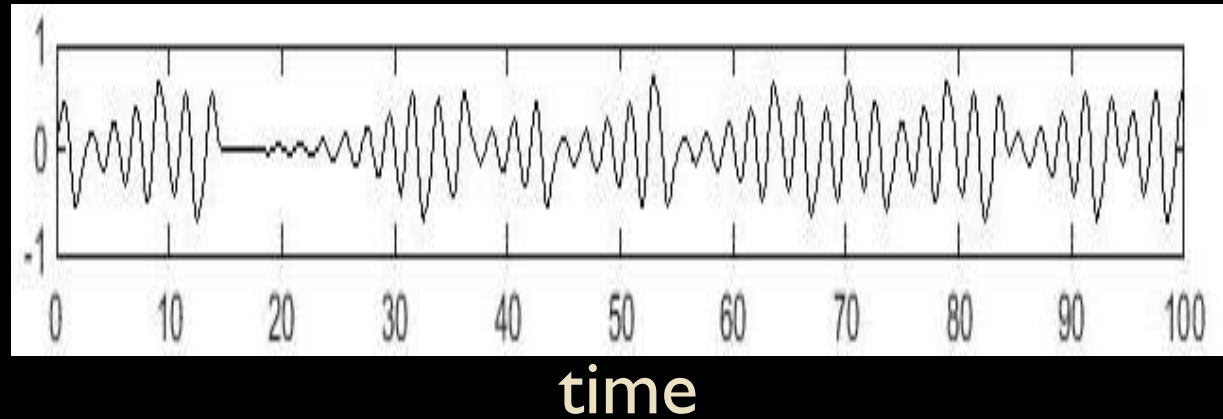


Chua's Circuit

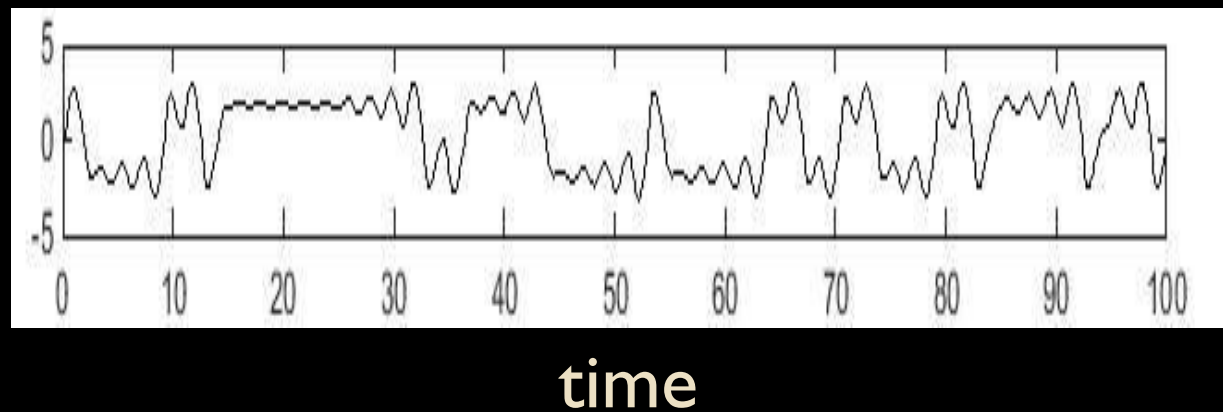


Phase Space: Take the voltage across the capacitors...

Voltage across
capacitor 1

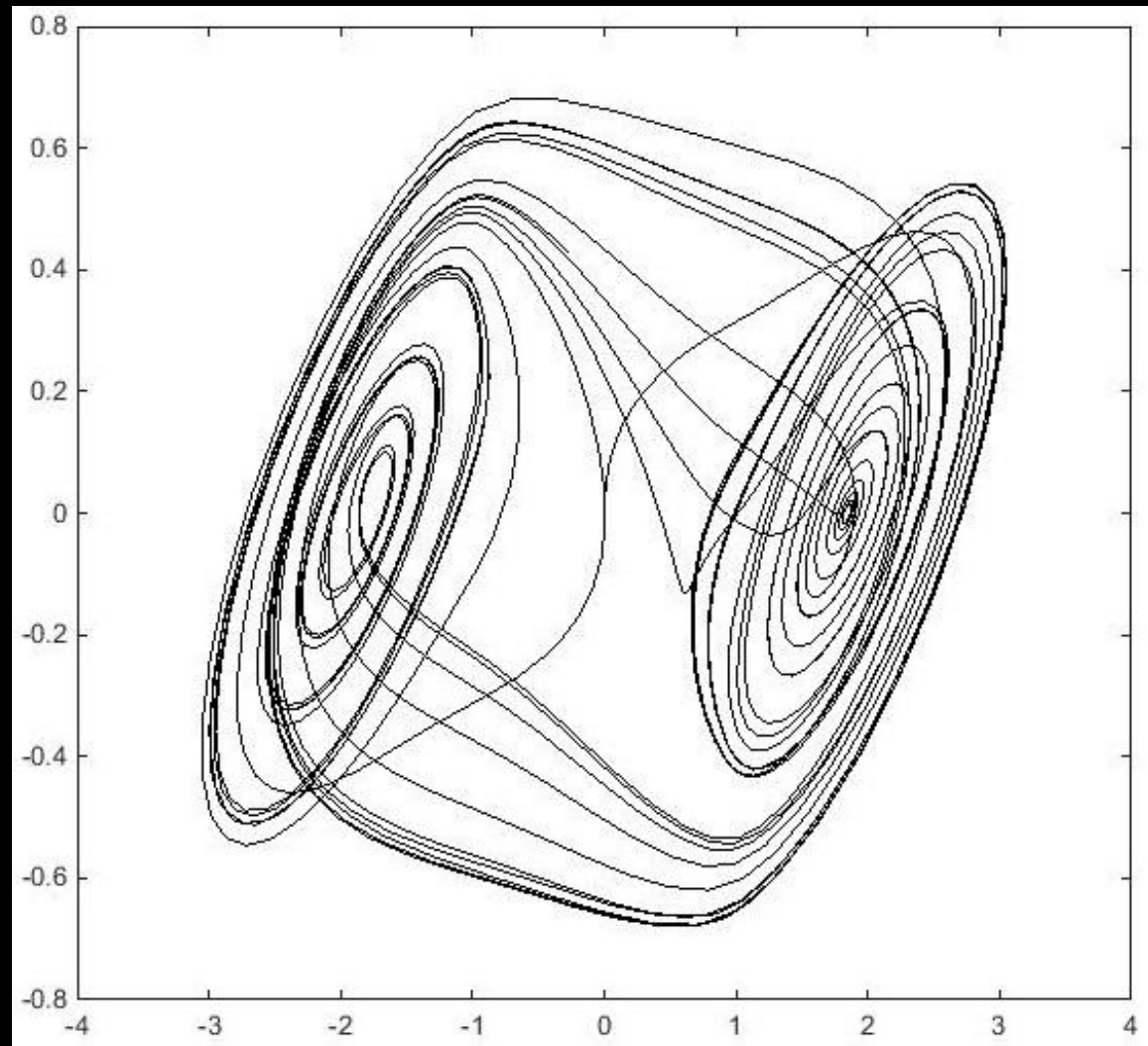


Voltage across
capacitor 2



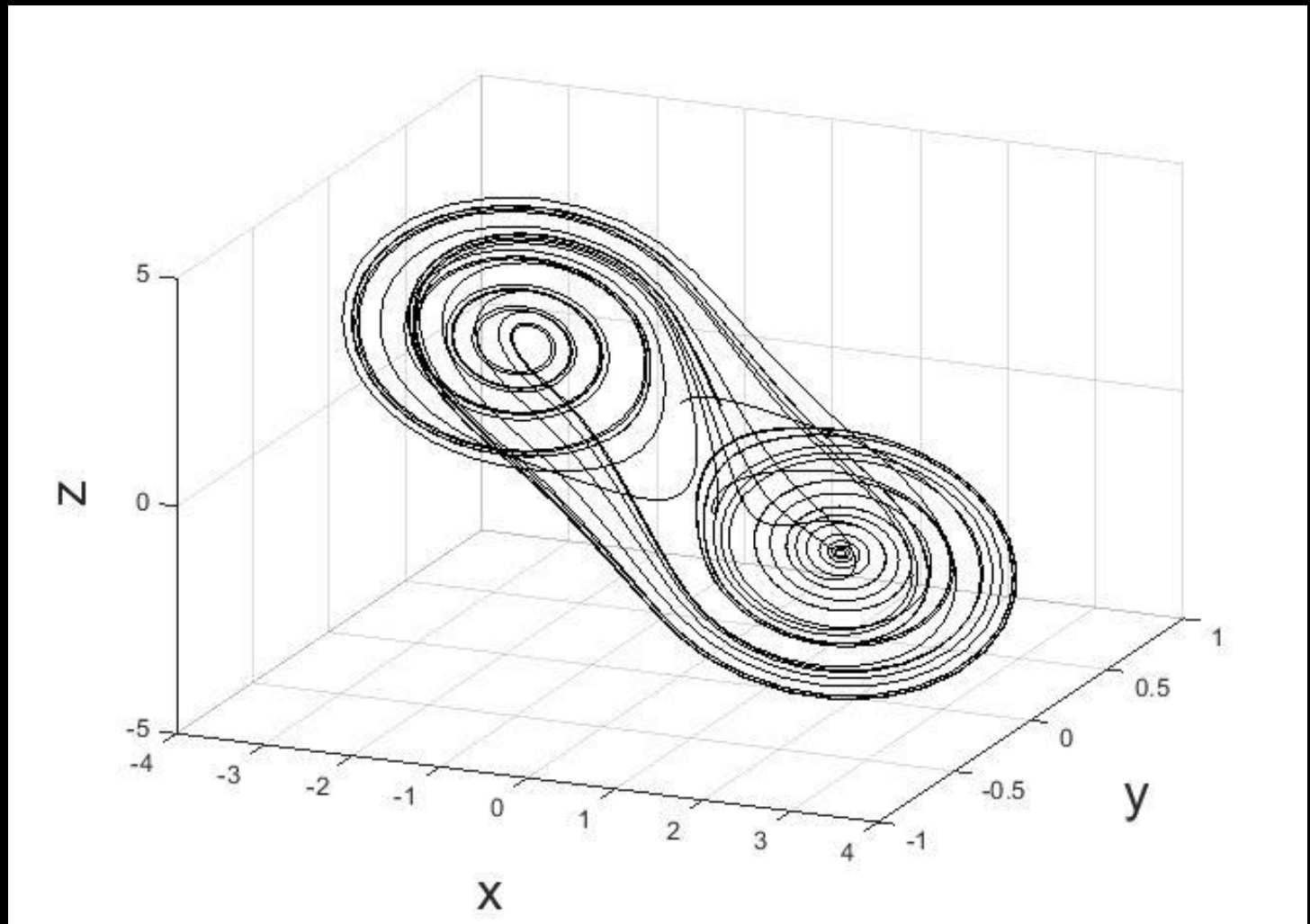
And plot them together!

Voltage
across
capacitor
2

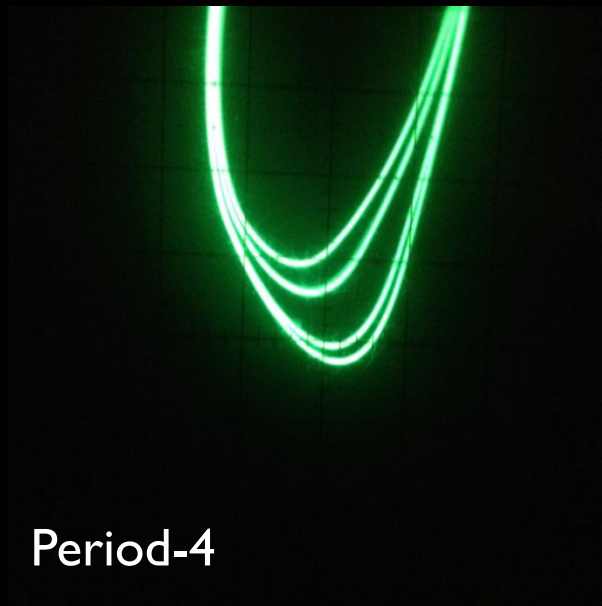
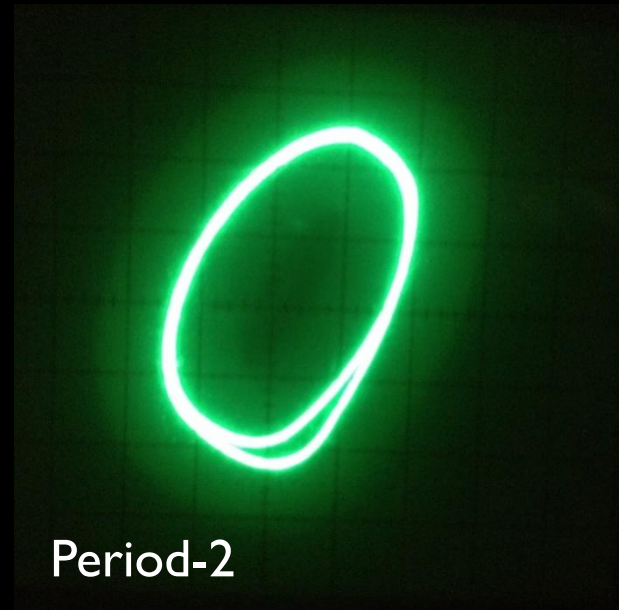
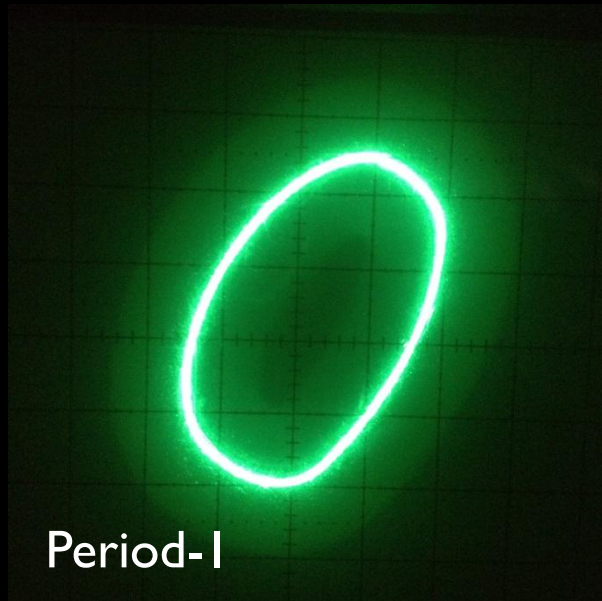


Voltage across capacitor 1

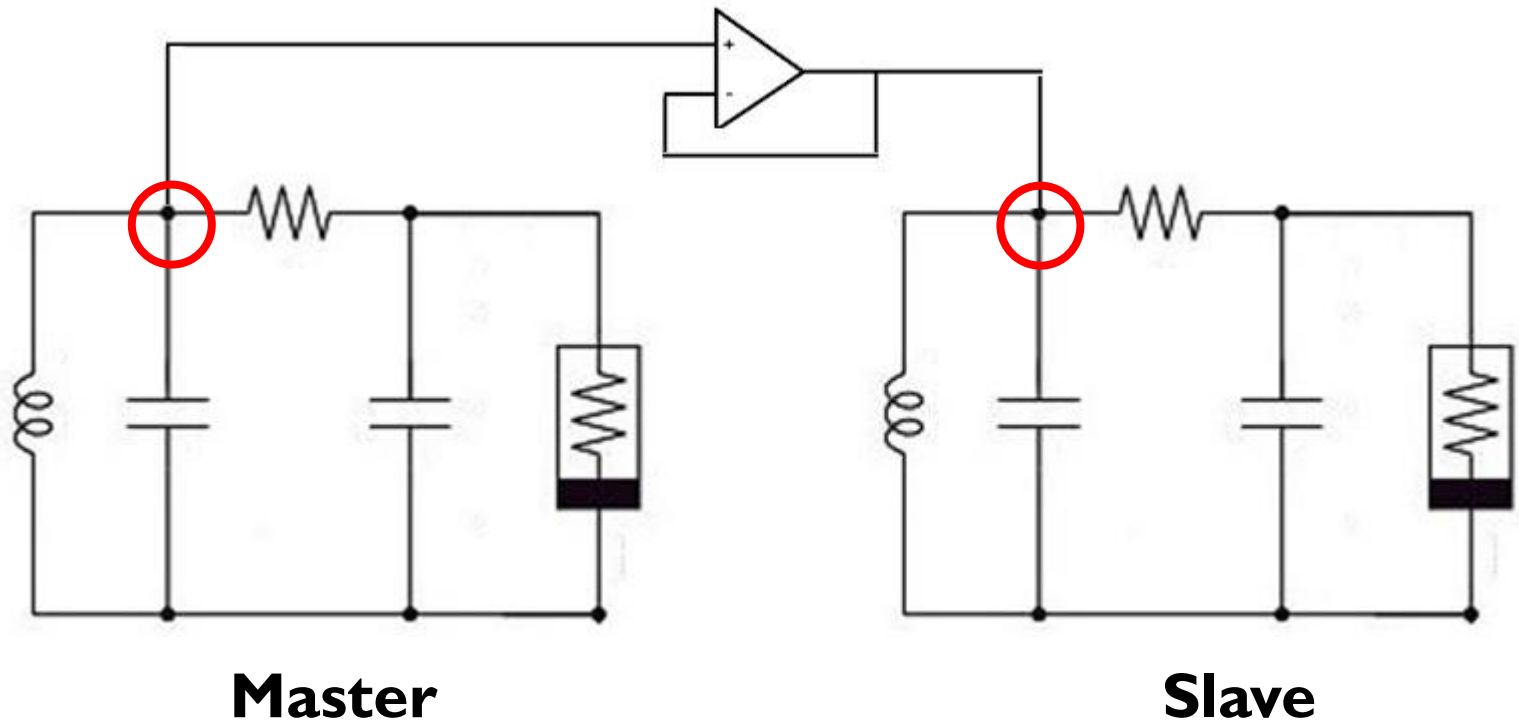
3-D phase space



Period doubling bifurcation

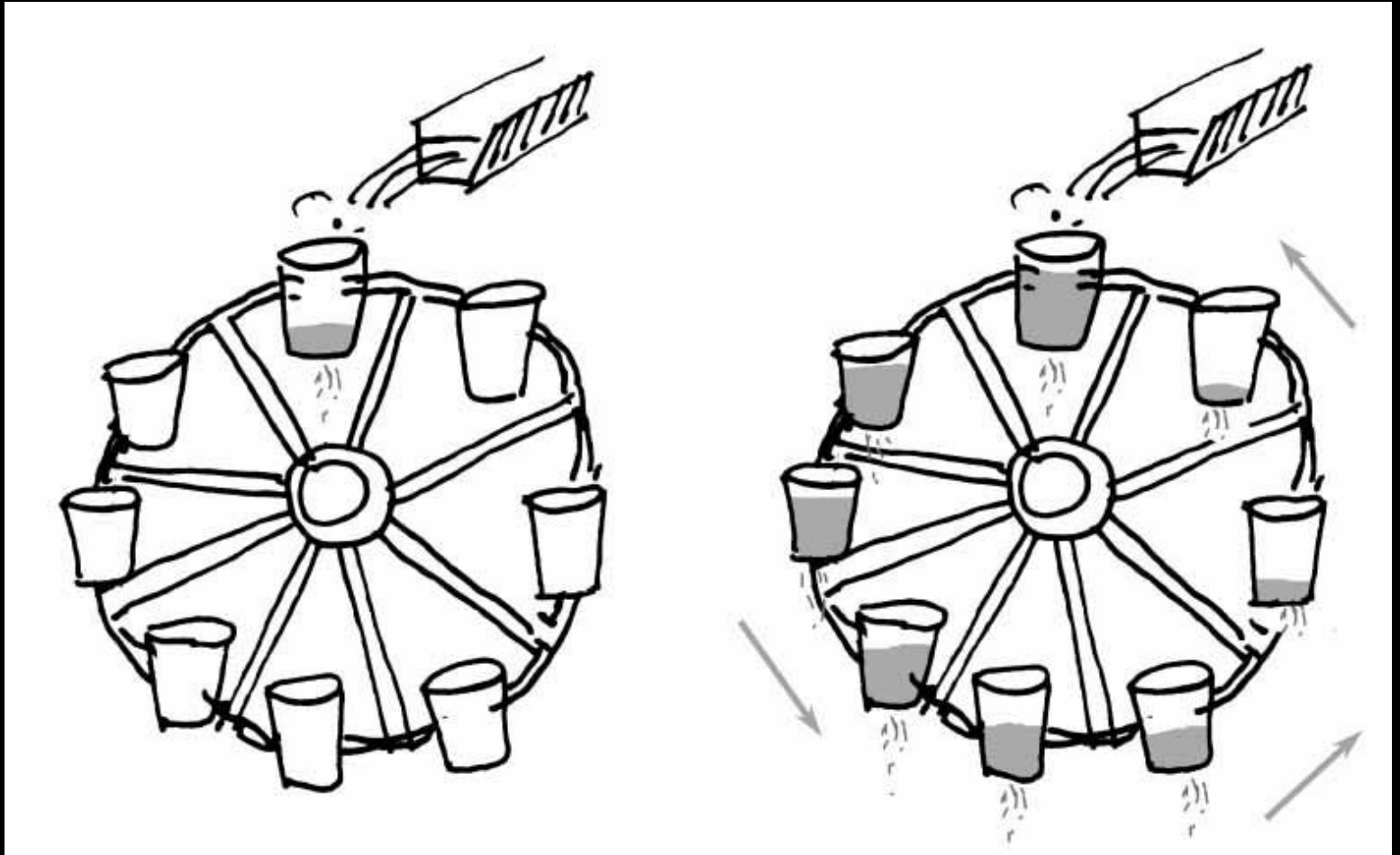


Synchronization of Chua's Circuit



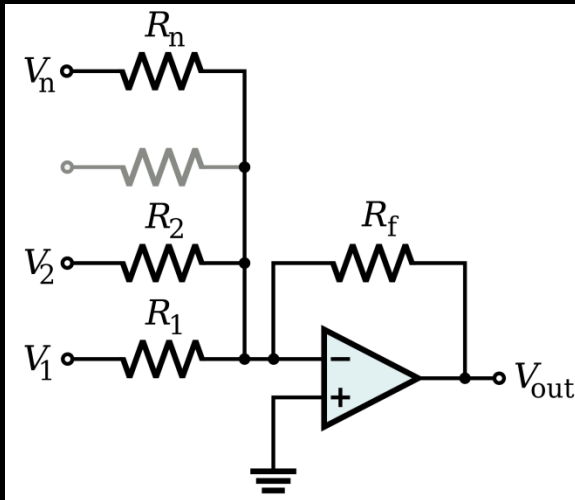
Analog computation

Waterwheel behaving according to Lorenz equations

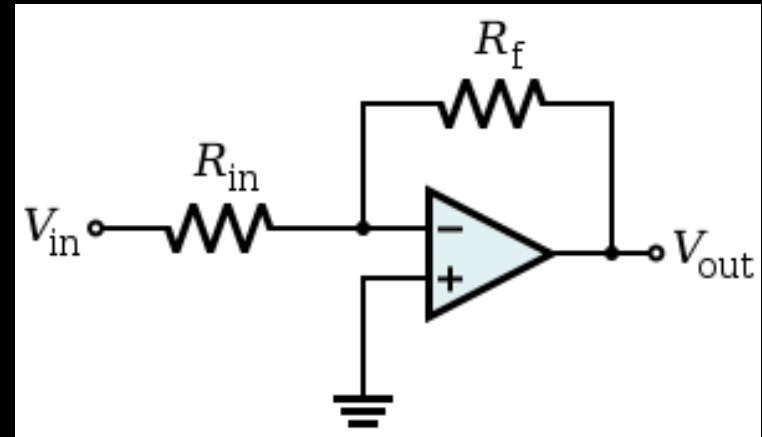


Op amp configurations

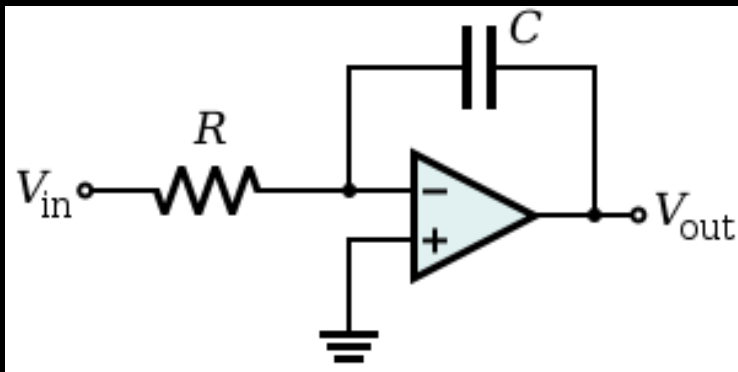
Adder



Inverter

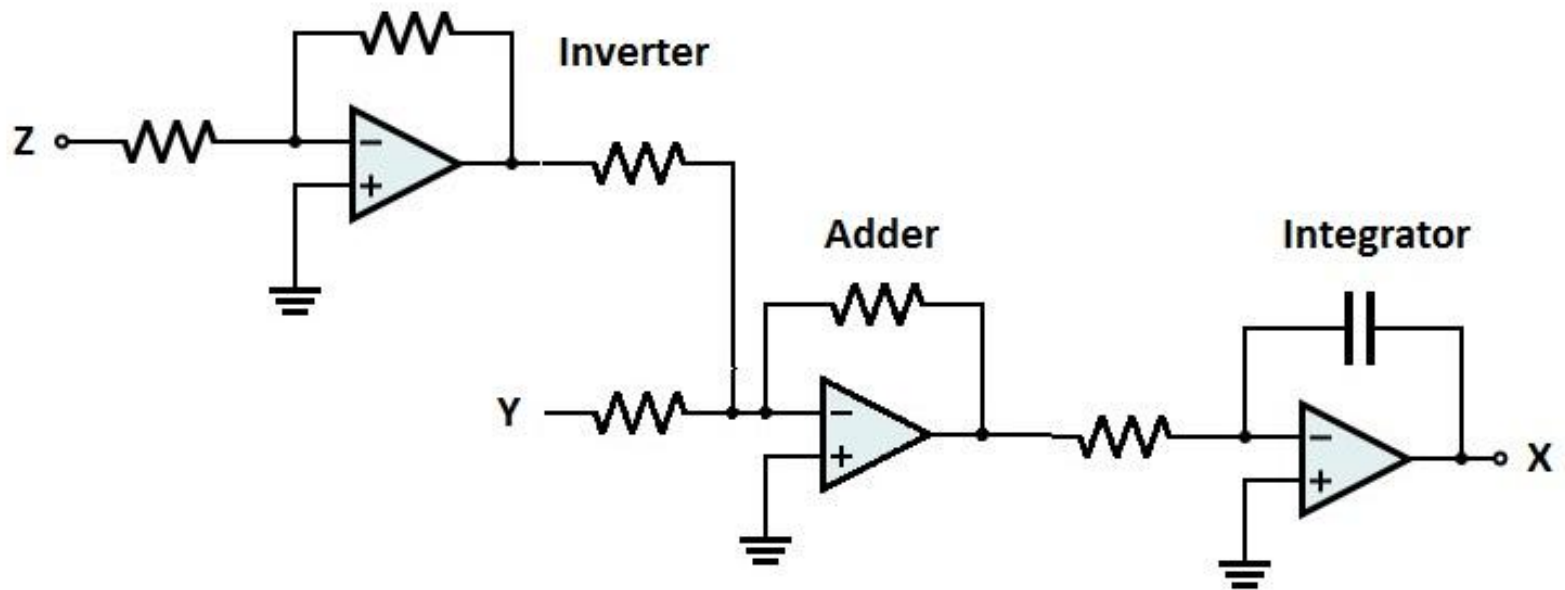


Integrator

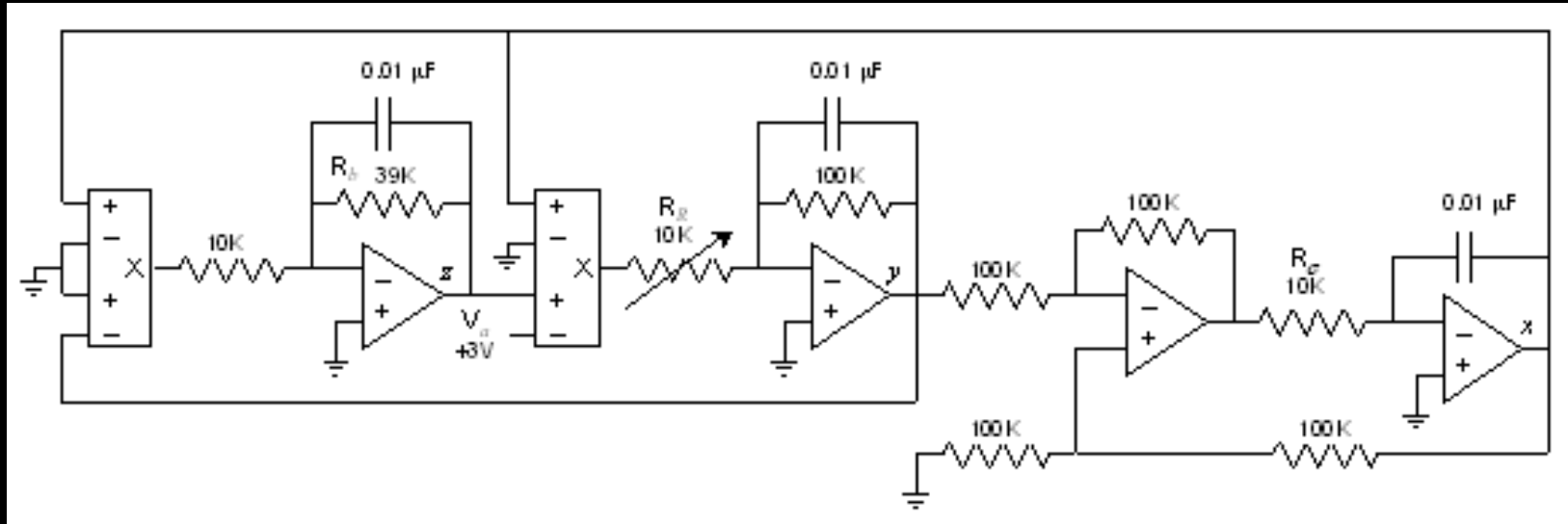


Analog computing example

$$\text{Solve } \dot{x} = y - z$$



Lorenz circuit



$$\dot{x} = \sigma(y - x)$$

$$\dot{y} = rx - y - xz$$

$$\dot{z} = xy - bz$$

Bistability in a Hyperchaotic System with a Line Equilibrium (2014)

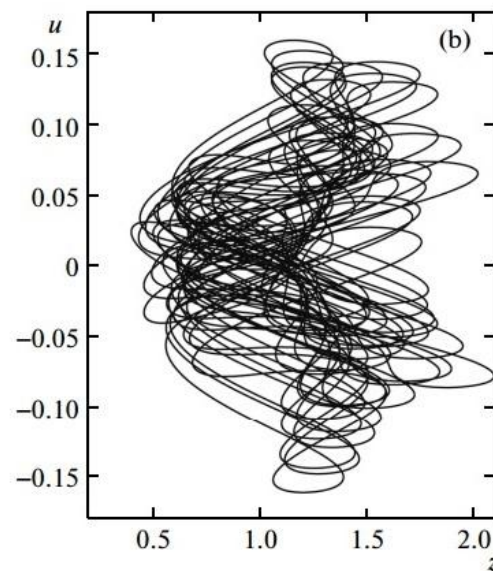
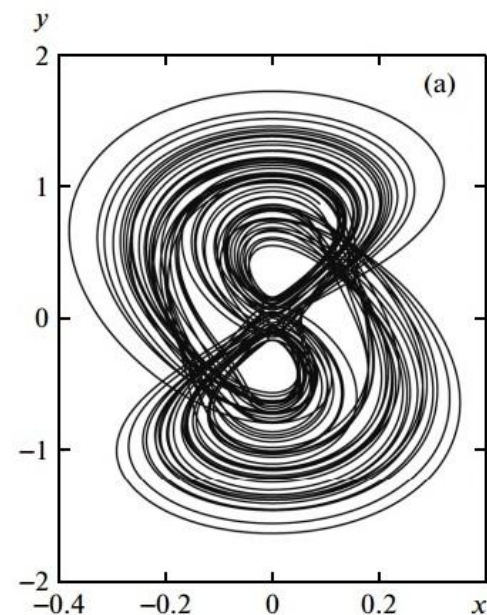
- Coauthors: (C. Li, J.C Sprott, W. Thio,)

$$\dot{x} = y - xz - yz + u$$

$$\dot{y} = a * xz$$

$$\dot{z} = y^2 - b * z^2$$

$$\dot{u} = -c * y$$



A New Piecewise Linear Hyperchaotic Circuit (2014)

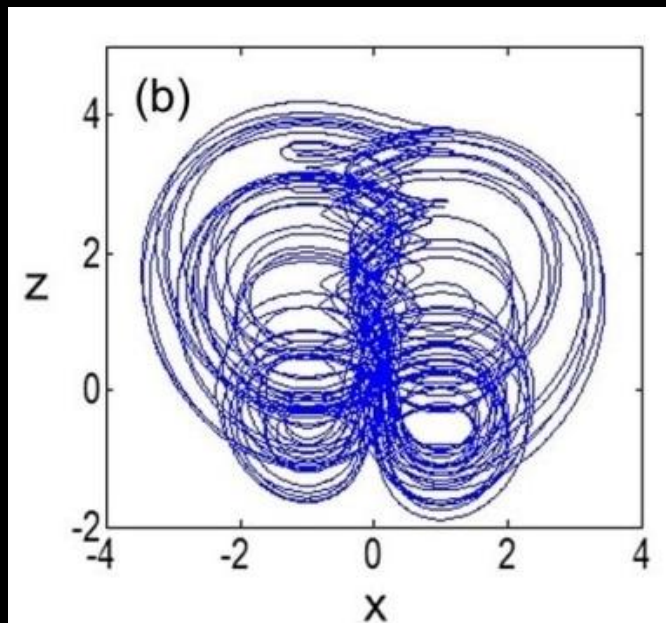
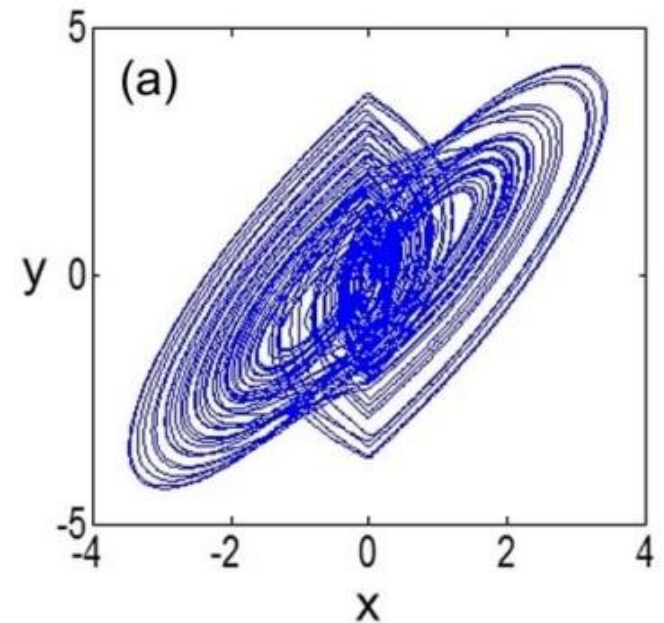
- Coauthors: (C. Li, J.C Sprott, W. Thio, H. Zhu)

$$\dot{x} = y - x$$

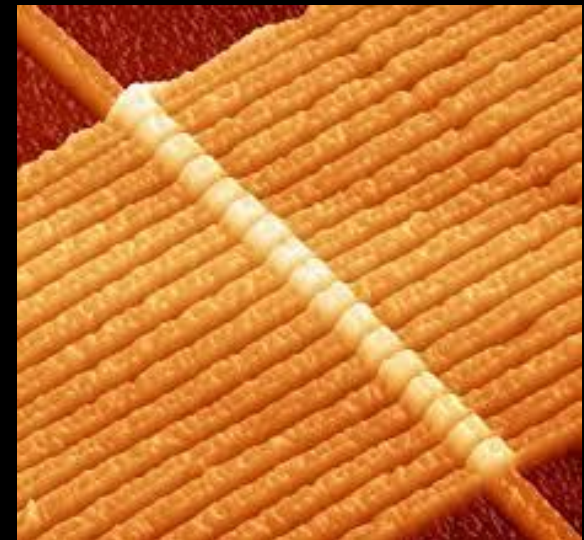
$$\dot{y} = -z * \text{sgn}(x) + u$$

$$\dot{z} = |x| - a$$

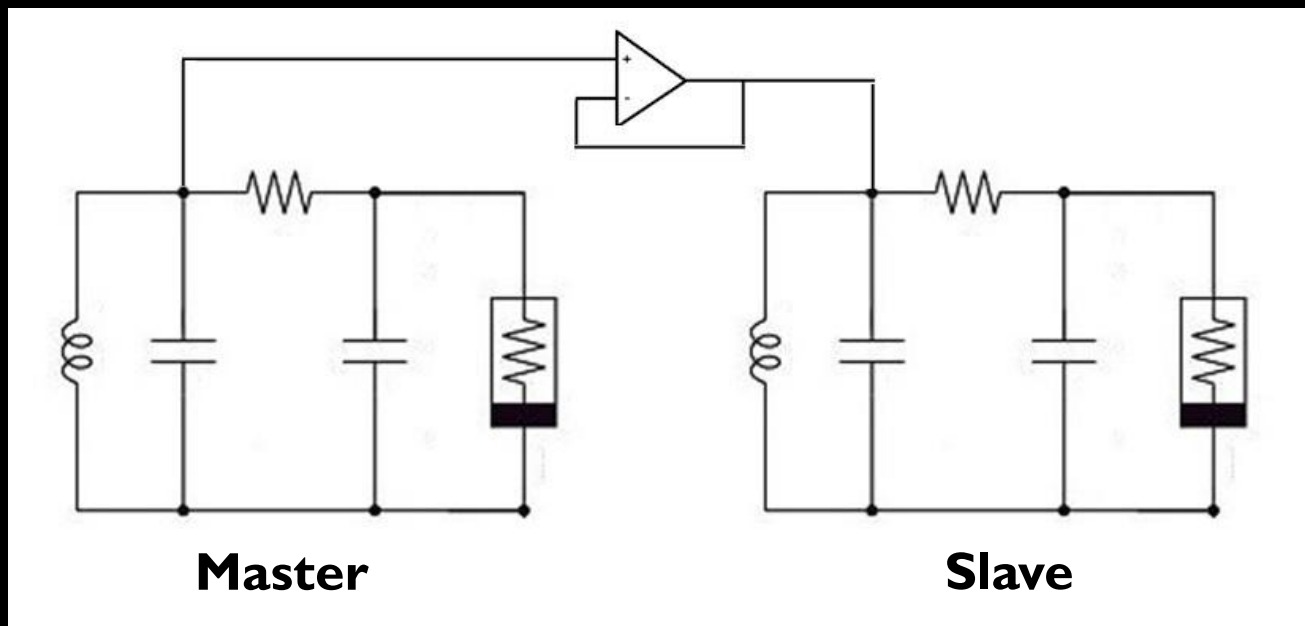
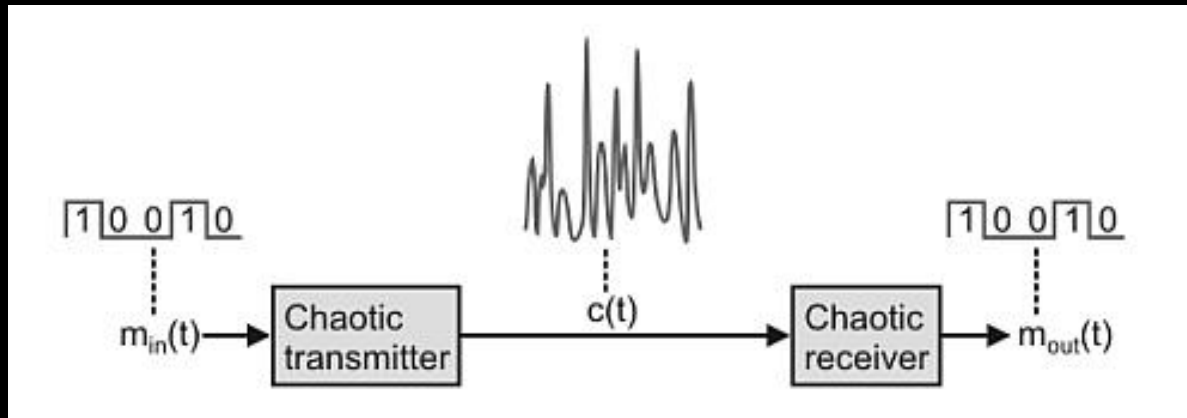
$$\dot{u} = -b * y$$



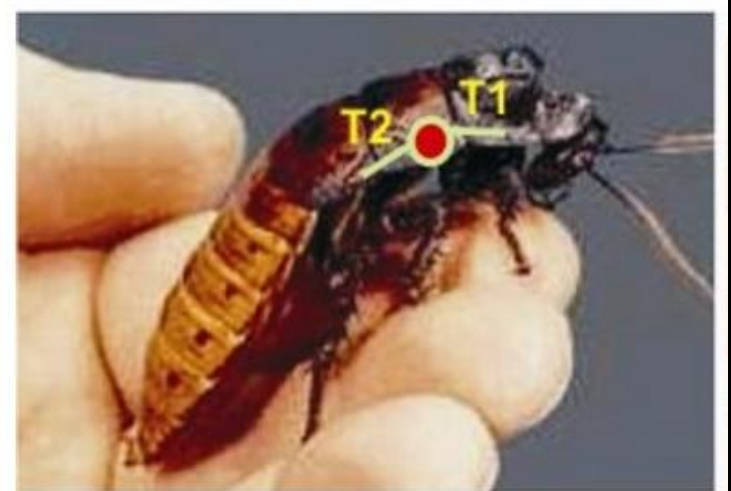
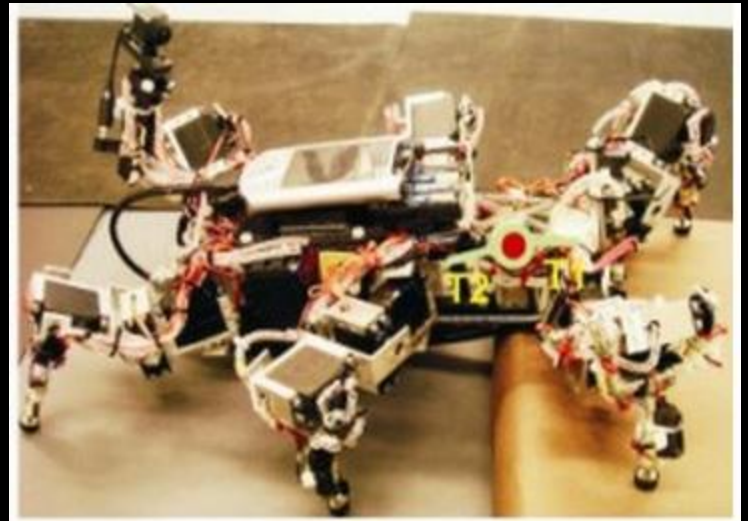
What are the applications?



Secure communications



AMOS-WD06: Cockroach robot using chaos control



Memristors

