Chaos in a Transmission Line Circuit

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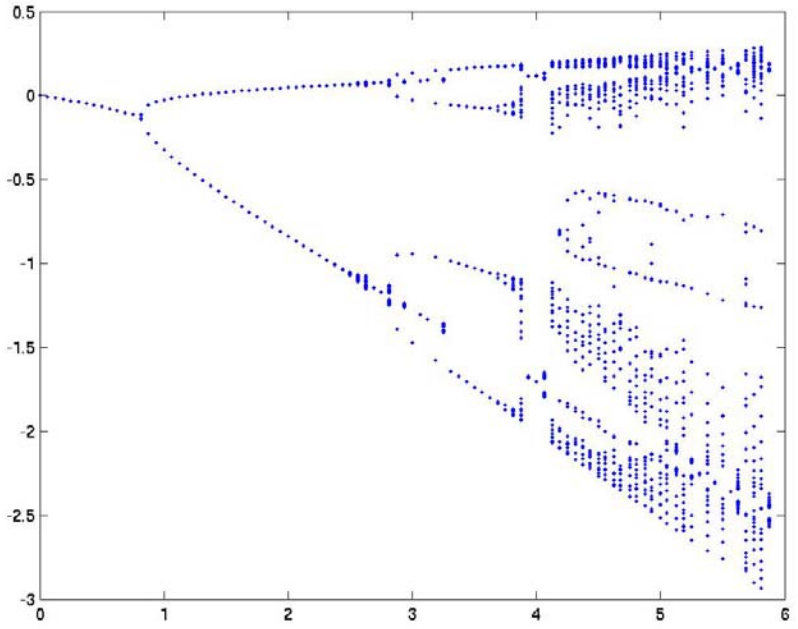

With…
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AND
APPLIED PHYSICS

Our Motivation

- As computer clock times become shorter, circuit connections behave more and more like transmission lines.

Length of device

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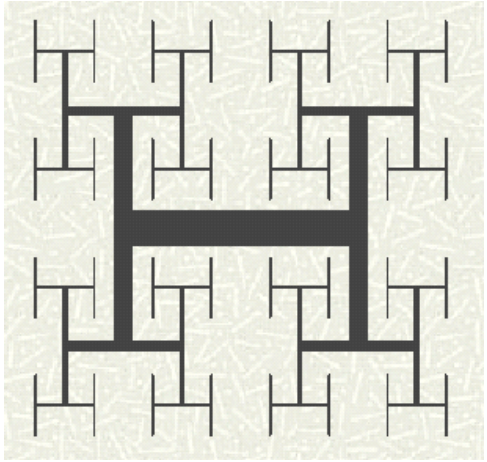
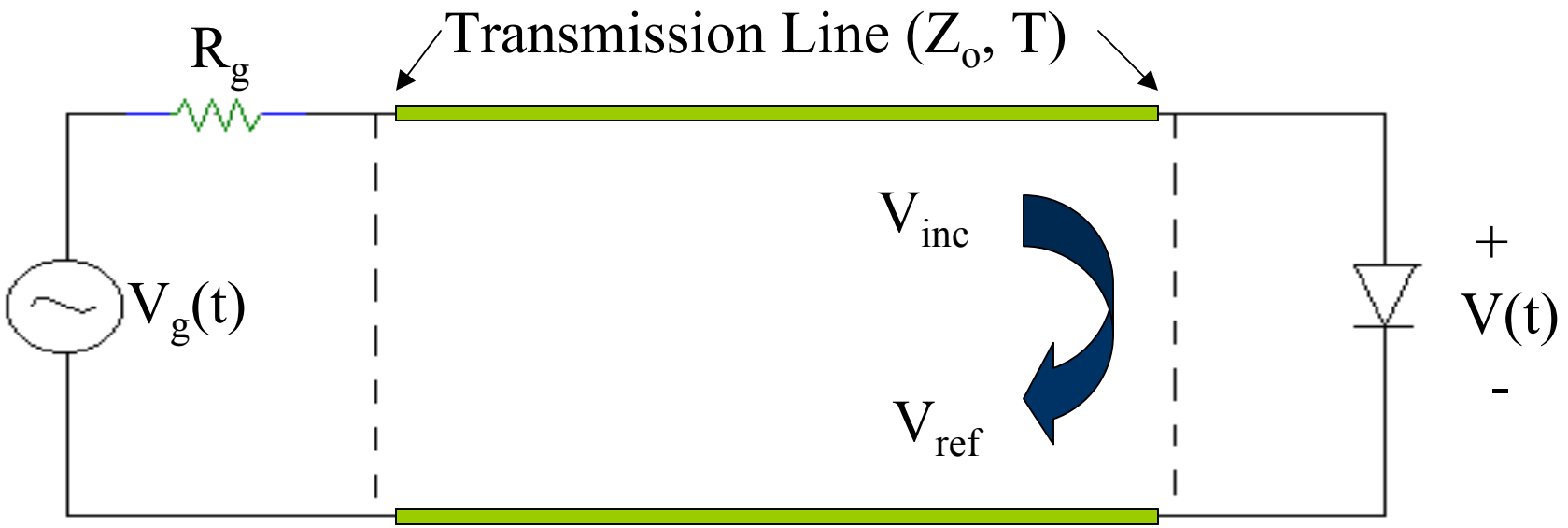
Wavelength of Signal



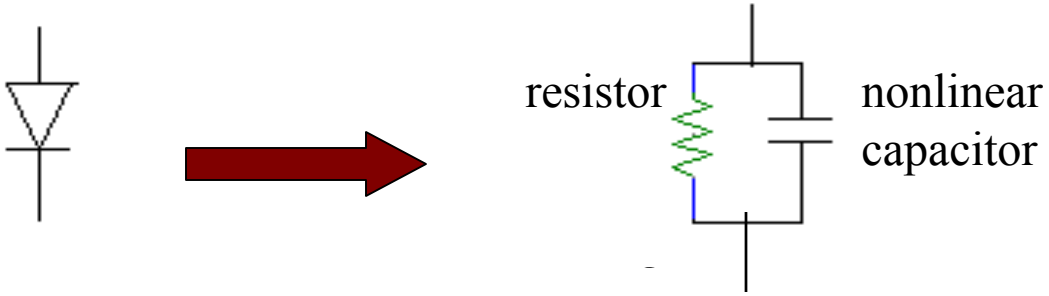
A clock time distribution network in a computer chip

- Theoretical framework needed to complement the experimental project of Professor Steven Anlage with the help of graduate student Anand Banerjee

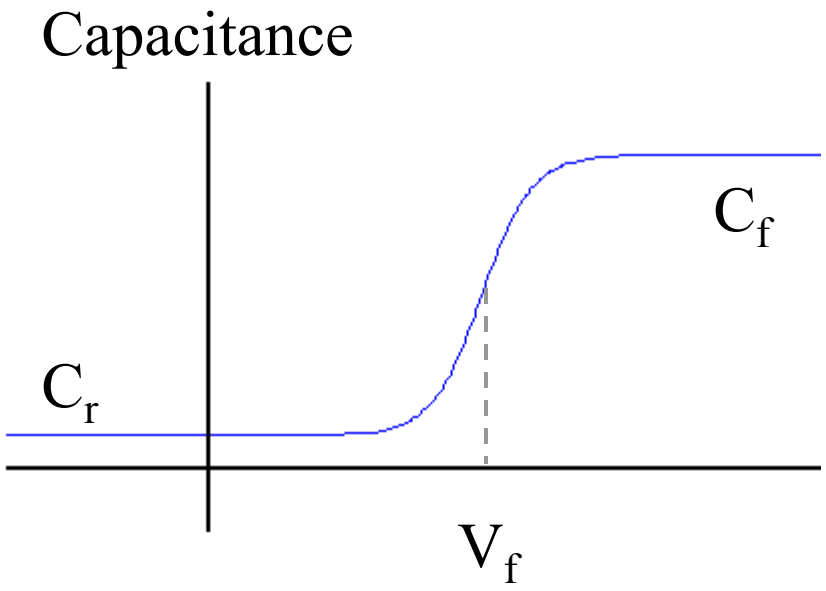
Picture of Circuit



Diode **Model**



Model for Nonlinear Capacitor



$$5 \leq C_f/C_r \leq 1000$$

- By making the capacitance dependent on the voltage, nonlinear effects are introduced into the circuit.

The Delay Differential Equation

Our system is described by a delay differential equation of the form…

$$\frac{d}{dt}V(t) = C_1V(t) + C_2V(t\text{-}2T) + C_3\frac{d}{dt}V(t\text{-}2T) + C_4Vg(t\text{-}T))$$

…where T is the time it takes for a signal to propagate across the length of the transmission line.

- We solved the differential equation using Matlab with Runge-Kutta 4.
- Our program's solutions were verified by comparing them with phasor solutions in the linear case of the capacitor.

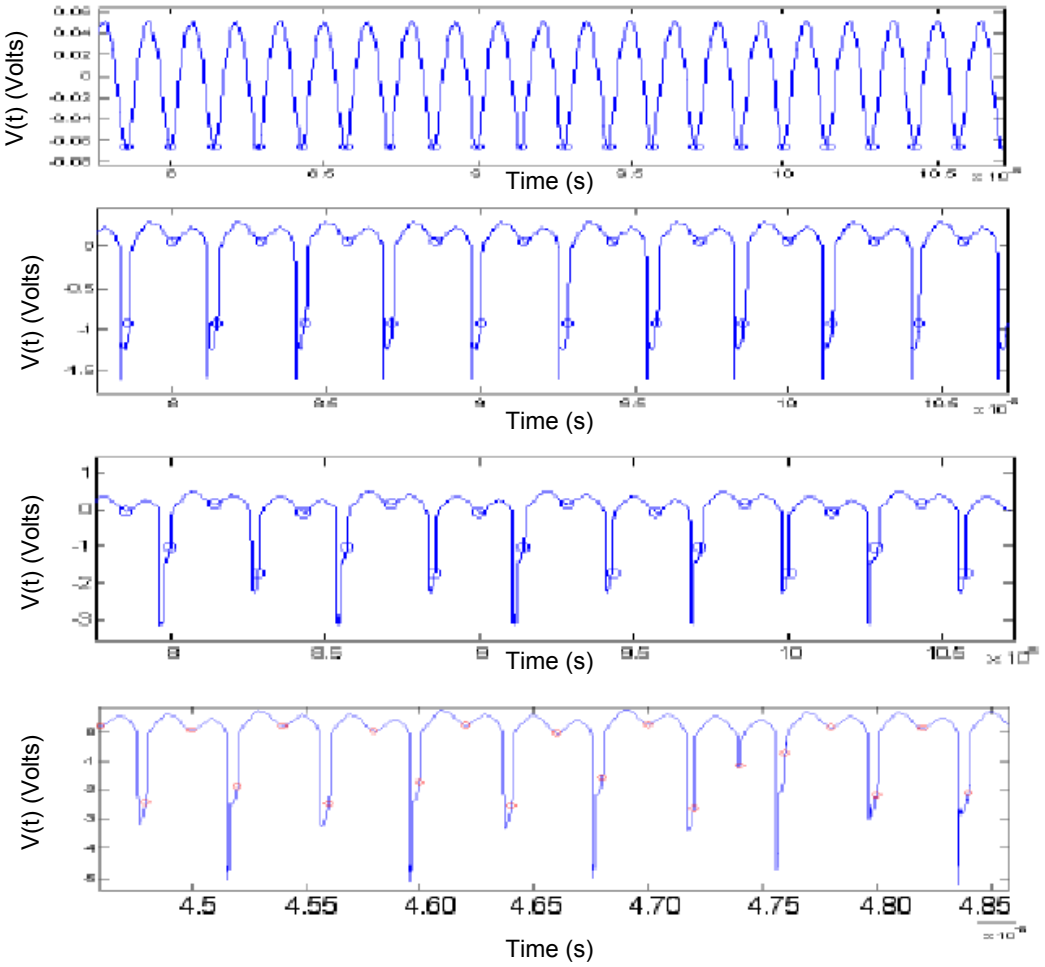
Voltage Wave Forms for Various V_g

V_g = .5 V **Period 1**

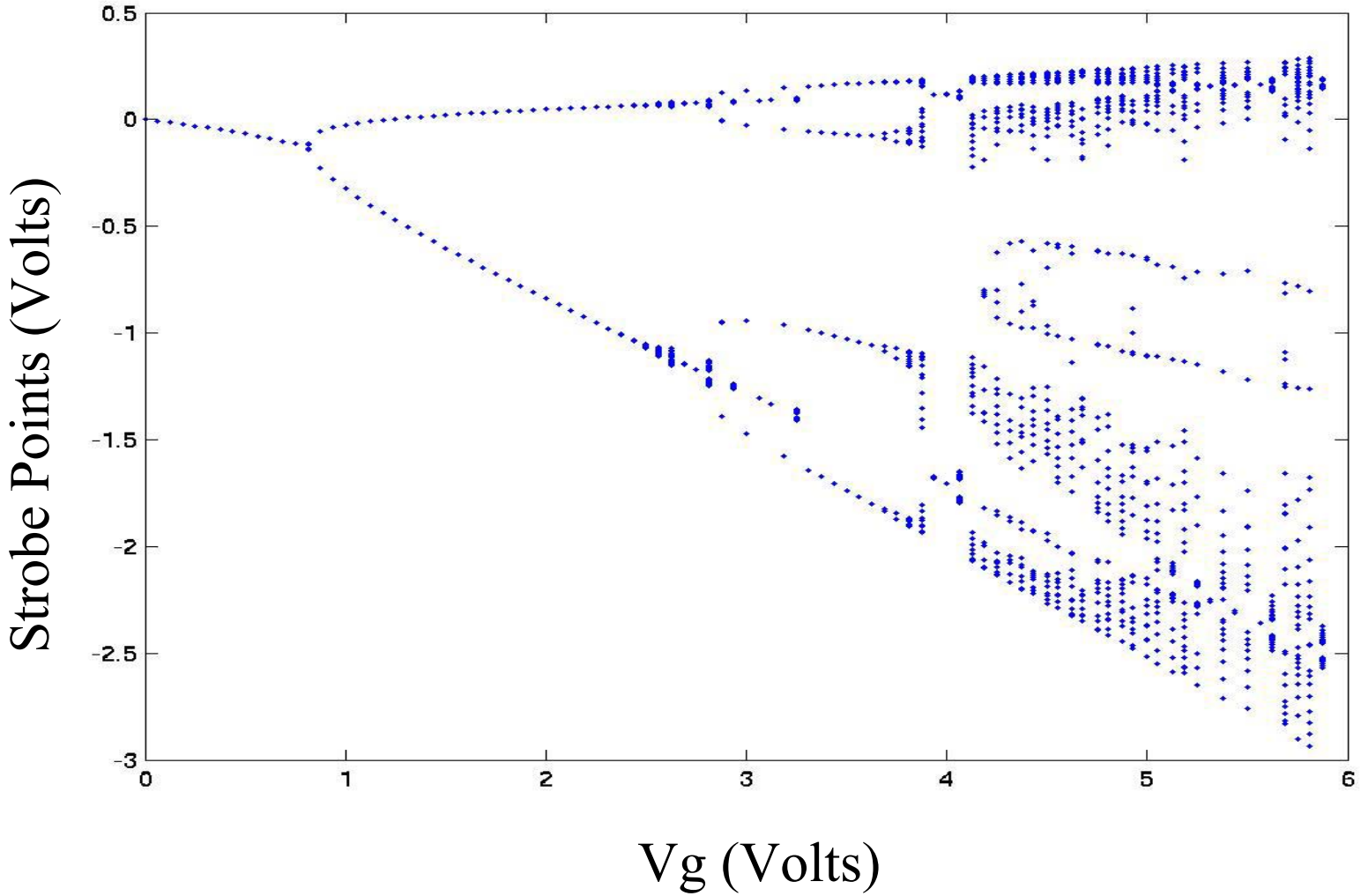
V_g = 2.25 V **Period 2**

V_g = 3.5 V **Period 4**

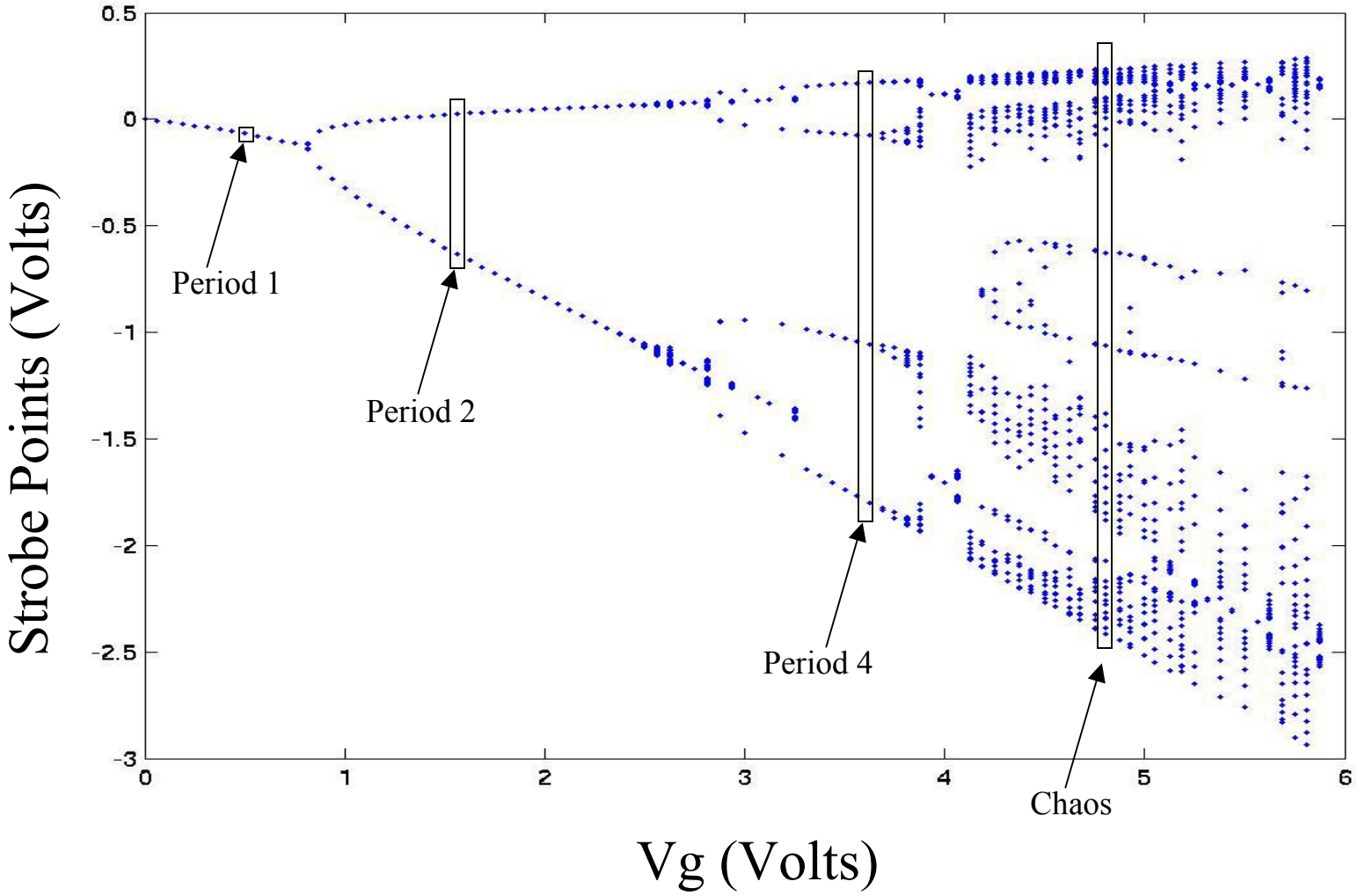
V_g = 5.25 V **Chaos**



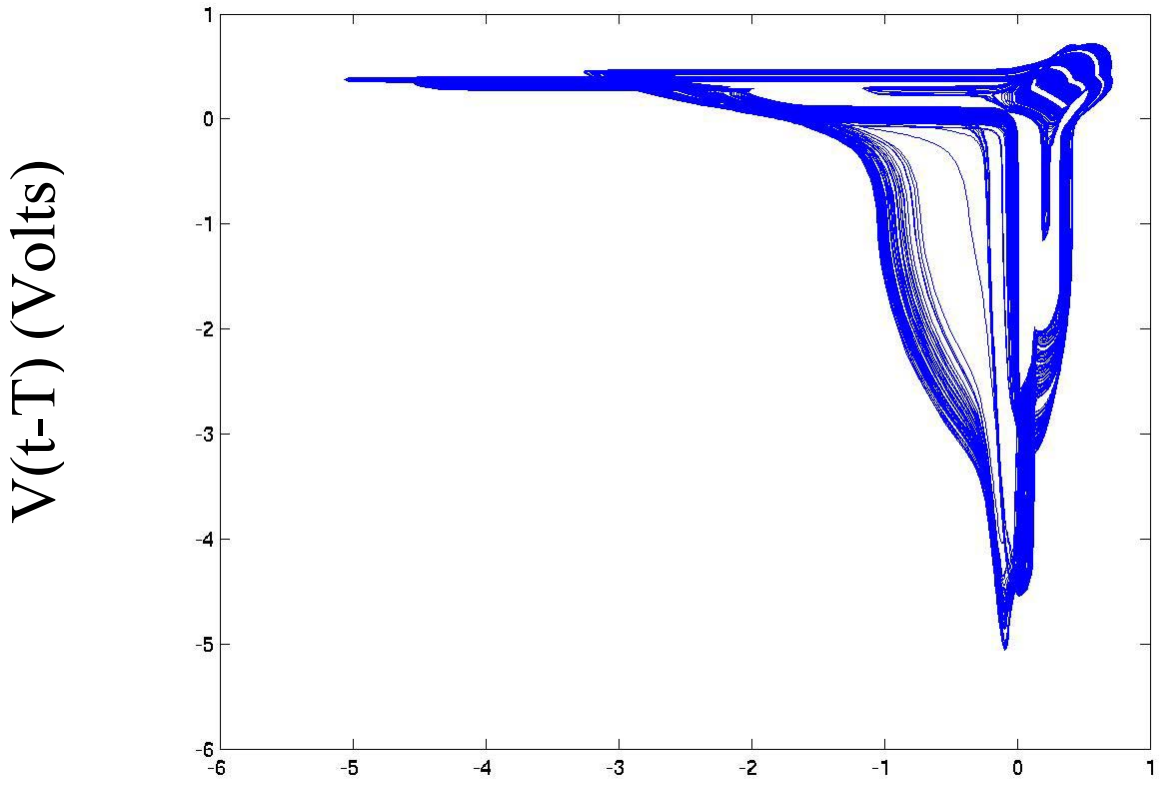
Bifurcation Diagram



Bifurcation Diagram



2D Projection of a Chaotic Orbit



$V_g = 5$ V

Challenges for the Future

- Ten parameters to explore:

$$C_f,\ C_r,\ g,\ Z_o,\ R_g,\ V_g,\ \omega,\ T,\ V_f,\ V_{gap}$$

- Experimental verification of numerical results