CALIFORNIA STATE SCIENCE FAIR
2003 PROJECT SUMMARY

Name(s)
Elizabeth L. Llanes

Project Number
J0717

Project Title
A Random Walk Down Chaos Street

Abstract

Objectives/Goals
This project shows that it is possible to predict the onset of chaos in an electrical circuit, an example of a nonlinear dynamic system. It was hypothesized that if the first and second period doublings (or bifurcations) were measured, then it would be possible to predict the onset of chaos in an electrical circuit.

Methods/Materials
To conduct the experiment, a resistor, an inductor, and a diode were connected in series on a breadboard. Then, a waveform function generator was connected across the resistor and the diode as the input for the circuit. An oscilloscope was connected across the inductor and diode to monitor the output of the circuit. The waveform function generator was set to produce sine waves at 1.75 MHz, at a peak-to-peak voltage swing of 0.1 Volts. The peak-to-peak voltage was increased until the first and second bifurcations and chaos were achieved, and those voltage values were recorded. The above procedure was repeated for 3 different types of diodes.

Results
The measured versus the predicted voltage value for the onset of chaos for the 1N4004 diode had a 5.45% error and for the 1N4005 diode had a 3.99% error. The 1N4004 and 1N4005 diodes had a high enough capacitance to produce chaos in the electrical circuit. Capacitance, in combination with inductance, contributes to the generation of chaos in the electrical circuit. The values of capacitance and inductance define the critical frequency of the circuit. If the critical period (the reciprocal of the critical frequency) of the circuit is about the same value as the reverse recovery period of the diode, the diode will cause bifurcations and, eventually, chaos to occur in the circuit. The 1N4001 diode, however, only produced the first bifurcation. The reason that this diode did not produce further bifurcations or chaos was because the capacitance of the diode was low.

Conclusions/Discussion
The predicted versus the actual voltage value for the point of chaos in the electrical circuit had a small error for the 1N4004 and 1N4005 diodes. Due to a low capacitance, the 1N4001 diode did not produce a second bifurcation or chaos. Because the percentage error between the predicted versus the measured value for the onset of chaos was small, the results prove the hypothesis. It is possible to predict the onset of chaos in an electrical circuit if the first and second bifurcations are measured.

Summary Statement
This project shows that it is possible to predict the onset of chaos in an electrical circuit (an example of a nonlinear dynamic system) if the first and second period doublings (or bifurcations) are measured.

Help Received
My father helped me understand some of the math used in chaos theory. Teradyne Inc. allowed me to use an oscilloscope.