Simultaneous amplitude and frequency statistical noise analysis in Chua's circuit.

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Chua's circuit is a non-linear electronic circuit reduced to its minimal components: a parallel LC circuit and a parallel CN circuit, connected by a resistor, N being a piecewise linear negative resistor.

Several theoretical studies and simulations have been realized [1], but only a few works include experimental data on the evolution of the instantaneous frequency and amplitude with the L parameter (value of the inductor).

We have experimentally studied Chua's circuit from a frequency point of view (evolution of the instantaneous frequency with the inductor's value L) and from the point of view of the amplitude (again with the inductor's value L). Using an operational amplifier based simulated inductor [2] whose value is set by a (numerical) variable resistor allowed to completely automate the experiment and gather a large number of data.

The original aspect of our experiment is its ability to analyze the amplitude and the frequency of one and the same period (hence the denomination "instantaneous"): we have developed the electronics necessary to isolate these characteristics on a single period. A comparator and an "AND" gate allow the measurement of the duration of a single period at a given time, while a peak holder circuit (germanium diode and capacitor) is used as an amplitude detector of this same period. An analog to digital converter (12 bits) reads the amplitude while the frequency is recorded (GPIB connection) from a frequency counter. We have taken great care to include enough buffers between Chua's circuit and our probe in order not to disturb the chaotic behavior of the oscillating circuit.

We here present the observed frequency and amplitude bifurcation diagrams, thus validating our data acquisition methods. Our current limitation of not being able to continuously measure the amplitude and frequency (but only being able to measure a randomly chosen period) will be overcome by the realization of our own fast frequency-counter. Our aim is to understand the evolution with time of the frequency noise during the evolution of the oscillator toward a chaotic behavior, and to identify a relation between the evolution of the frequency and of the amplitude depending on the oscillation regime.

References:

[1] R.N. Madan, *Chua's circuit: a paradigm for chaos*, World Scientific Series in Non-linear Science (Series B, vol 1) (1993)

[2] Thomas P. Weldon, *An inductorless double scroll chaotic circuit*, Am. J. Phys **58** (10), October 1990