Build a chaos generator in 5 minutes!

by **Kajnjaps** on May 26, 2016

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Intro: Build a chaos generator in 5 minutes!

The circuit shown is a simple chaotic oscillator that is based on the resistor-capacitor ladder phase shift oscillator. You can use it to show nice pictures (called attractor projections) on your analog oscilloscope in XY mode and impress your friends.

Chaos is defined as long term deterministic and aperiodic behavior, which is bound to a certain region in phase space. What this means is that the circuit oscillates, but not in a regular, repeating fashion. In fact, in theory (ignoring noise) it will never repeat the same path, but it will get arbitrarily close to all points it passes through in phase space.

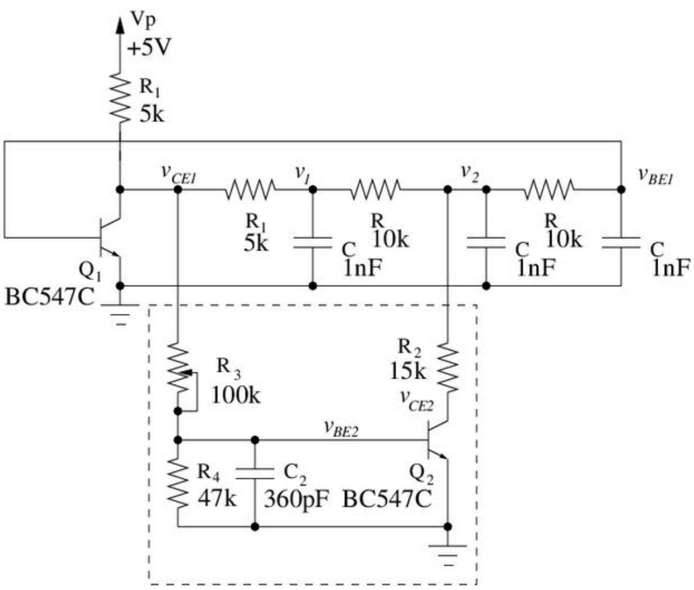
The phase space here is four dimensional, because the circuit has 4 energy storing elements (the capacitors). Specifying the voltages on all these capacitors, fixes the state, and thus the deterministic evolution of the circuit. What we show in the oscilloscope is actually only a 2D projection, of something that goes on in 4D. If all this seems mind boggling: it is.

The circuit can be build using any number of methods, from air-wiring or breadboarding the components to designing a PCB using for example Eagle, so use your imagination. On a breadboard you can slap this together in mere minutes.

As far as the component values go, none are critical. In fact, poking around with the values will change the shape of the attractor (what you see on your oscilloscope) and experimentation with the values and supply voltage is highly recommended.

For the values of the capacitors as shown (C=1nF, C2=360pF) the free running frequency I got was about +-45kHz. Scaling the capacitor values, allows to reach other frequencies.

Compared to many other chaotic oscillators (such as the Chua's circuit), this one does not need inductors (great for those suffering from Helixaphobia), needs only a single supply voltage and no opamps, just plain general purpose transistors. It will work from 3 or 4 Volts up to 15 Volts, although the attractor shapes will change with the supply voltage too.



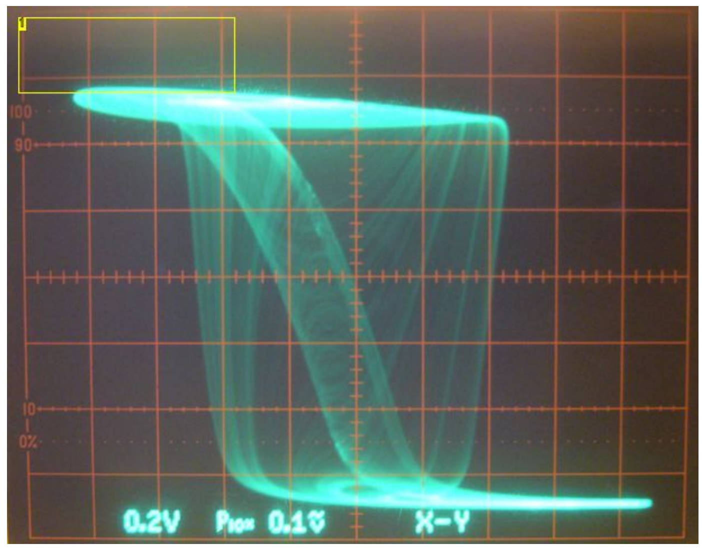


Image Notes
1. x: vce1, y: vce2 at R3=31k

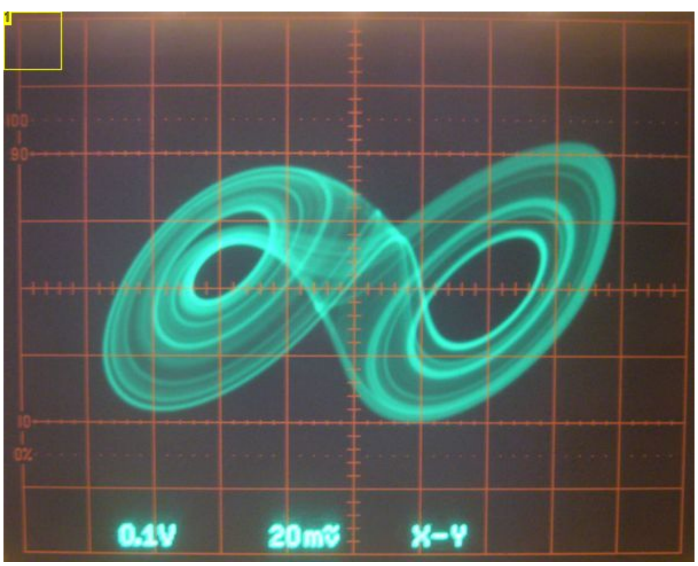


Image Notes
1. x: v1, y: v2 at R3=31k

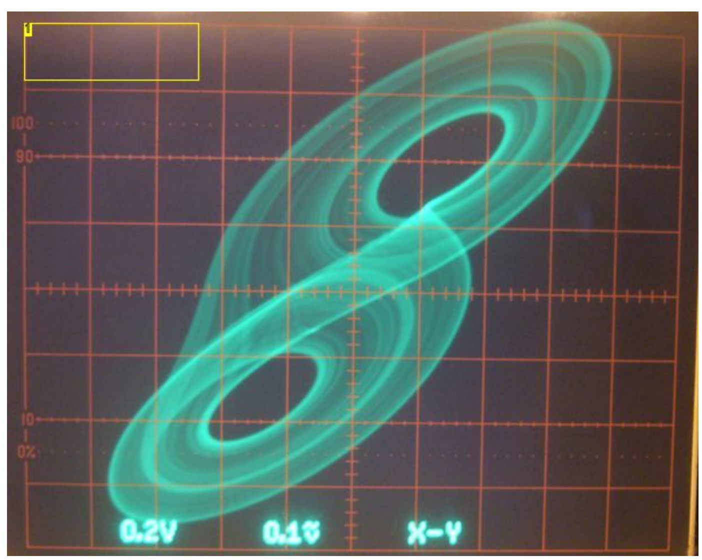


Image Notes
1. x: vce1, y: v1 at R3=31k

Step 1: How does it work?

As long as R3 is very high, Q2 will not conduct and the bottom half of the circuit doesn't interact with the RC ladder. the RC ladder provides 180 degrees of phase shift and Q1, being switched as a common emitter amplifier, gives you another 180 degrees. Together, they fulfill the round-trip condition for oscillation.

This will give you a regular oscillation, as shown in Fig. A (R3=60k, Vp=5V).

Lowering the resistor, Q2 can get some base drive, and thus it will interact with/disturb the exact phase relation in the RC ladder, see Fig. B (R3=40k). This leads to what is called a period doubling.

Still lowering R3, band-shaped chaos is reached, Fig. C (R3=39k). At R3=36.5k, the structure is temporarily periodic again. This is called a periodic window. Lowering R3 still further leads to the attractor of the pictures in step one of this instructable. In the center of the 'eyes' of the attractor, there are unstable equilibria, around which the oscillations grow. The circuit jumps erratically between two states of Q2 conducting or not.

(your mileage will vary with these values, depending on component tolerances and exact values etc..)

Explore and have fun!

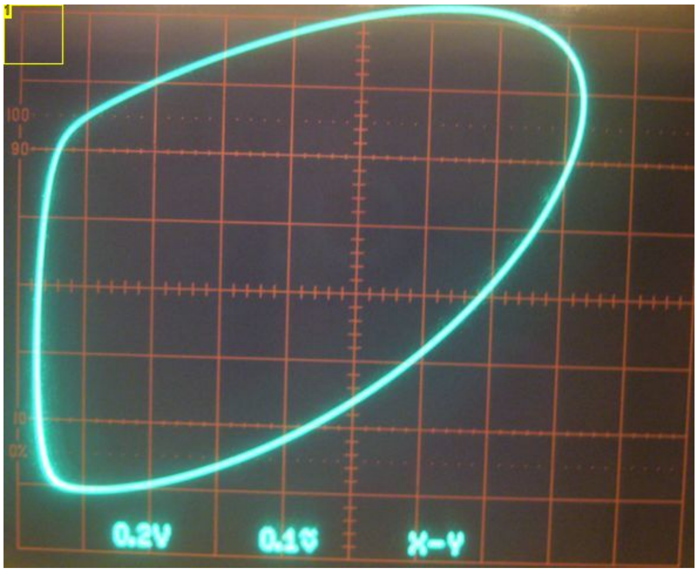


Image Notes
1. Fig A: x: vce1, y: vce2 at R3=60k

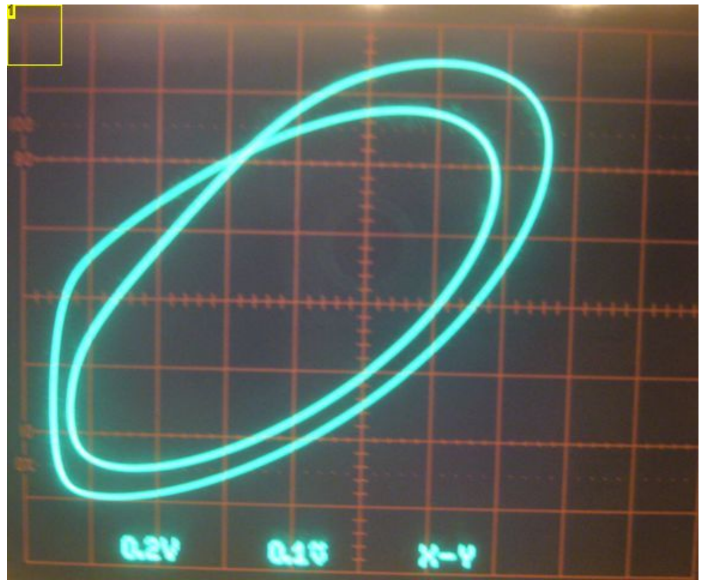


Image Notes
1. Fig B: x: vce1, y: vce2 at R3=40k

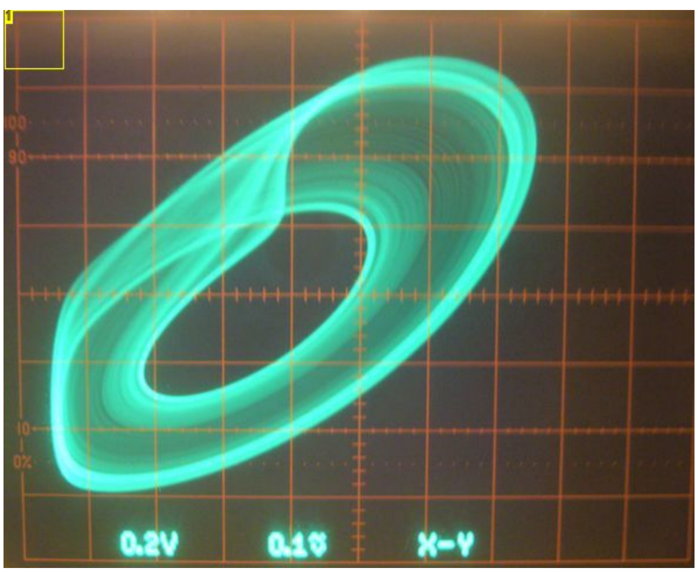


Image Notes
1. Fig C: x: vce1, y: vce2 at R3=39k

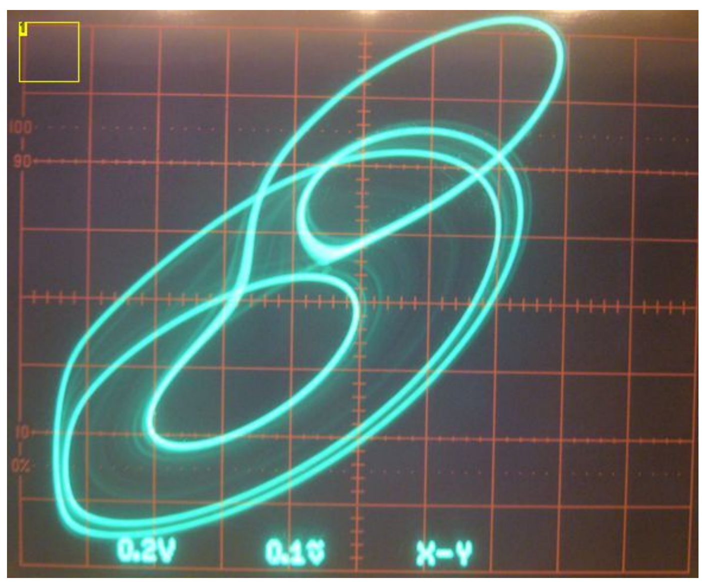


Image Notes
1. Fig D:
x: vce1, y:vce2 at R3=36.5k

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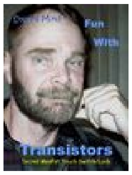

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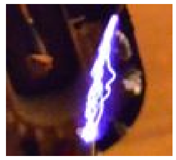

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