Chaos in Electronics

There are two parts to this project: the Lorenz attractor and the system $\dddot{x} = A\ddot{x} - \dot{x} + |x| - 1$. If you have extra time, feel free to explore one of the many additional chaotic circuits described in the literature!

1. The Lorenz Attractor

- Build the circuit shown at https://www.chaotic-circuits.com/wp-content/uploads/2015/04/Build-a-Lorenz-Attractor.pdf. It is not necessary to use the specified op amp package (LF412). 741s work fine, though be aware that the 741 pinout is different from the pinout shown for the LF412.
- Observe the Lorenz attractor for the given values of s, r, and b.
- Try a few different values of C to observe the effect.
- Figure out how to modify your circuit to vary r.
- Vary r and observe at least three regimes: r at which there are two stationary solutions, r at which the trajectory is an attractor, and r at which there is stable periodic motion. Record the value of r at which each transition takes place. Record the values of some of the stationary solutions observed for selected values of r.
- Do the op amps saturate for certain r?

In your lab report:

- Clearly and thoroughly explain how the circuit implements the Lorenz equations. Hint: you must convert from voltages to dimensionless variables.
- Explain the role of C in light of your observations.
- Compare the theoretical and observed values of r marking the transitions between the different regimes.
- Compare the theoretical and observed stationary solutions for selected values of r.
- Explain the saturation of the op amps that you should have observed at certain r.

2. $\dddot{x} = A\ddot{x} - \dot{x} + |x| - 1$

- Build the circuit described by Shaik and Mandal, "Chaos from Jerk Circuit" (https://www.ias.ac.in/article/fulltext/reso/015/03/0257-0267). The variable resistor should vary from about 1.5k to 2.5k. The breadboard voltage sources are not nearly good (low output impedance) enough for the specified 1 V supply. You must either use an external voltage source or an op amp follower after the breadboard source.
- Observe the period doubling. Record the **a** value at each transition. Use both X-Y mode and V vs. t mode to understand the meaning of period doubling.

In your lab report:

- Clearly and thoroughly explain how the circuit implements the governing equation.
- Compare the theoretical and experimental **a** values at which transitions occur.