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6/2/14

Engr 12L

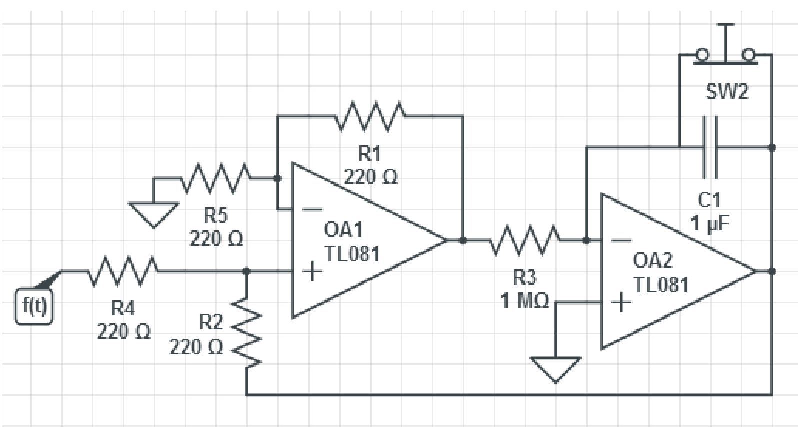
Final Project: Analog Computer

I decided to build the analog computer for my final project. One of the main reasons I decided on this project was the idea that a circuit could solve a differential equation. I always struggled with differentiation and the belief that I could build a circuit which could do the same work in less time was intriguing to me. I was also interested in putting my new knowledge of circuit building to the test.

The circuit that I built will solve a first degree differential equation using two op-amps. One of the op-amps is an inverting op-amp, which is used as the integrator. The other op-amp is a non-inverting summing op-amp, which combines the results of the integration to the original function to create the differential equation. This allows you to solve a basic first order differential

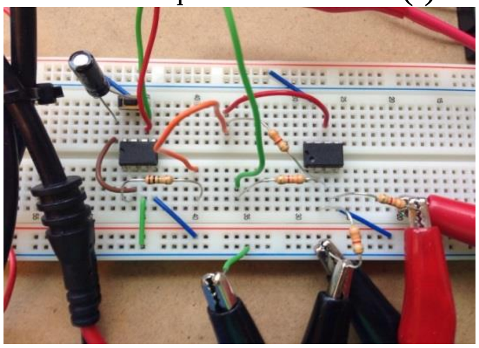
Parts List

Resistors	220 Ω x 4 1 MΩ x 1
Capacitors	1 µF x 1
Push Button Switch	1
Op-Amps	2

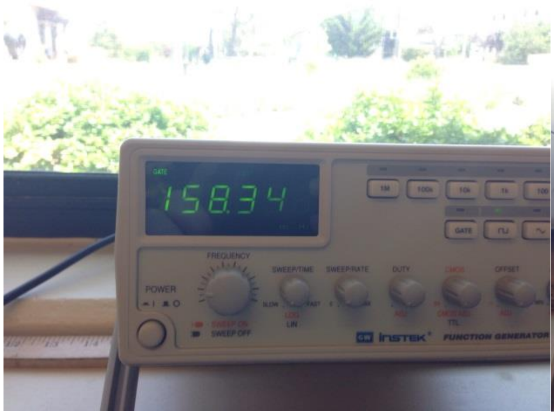


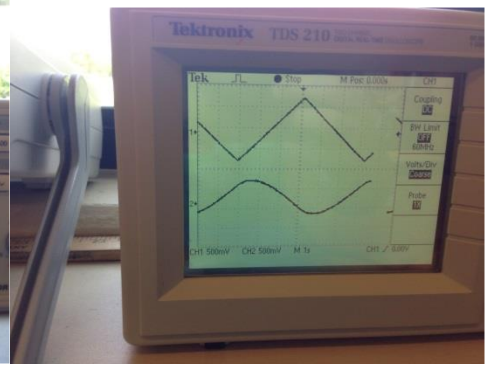
This configuration solves the equation: Y+Y'+F(t) = 0, where F(t) is the input function. The op-amp on the left is for non-inverting summing, while the op-amp on the right is the inverting integrator. The push button that is placed after the inverting op-amp is very important. As the equation continues to integrate, it slowly integrates part of the DC element, which gets larger the longer that the integrator runs. The button "resets" that constant part back to zero when it becomes too large.

When the circuit is built, it will look more like this. The op-amp on the left is the integrator and the one on the right is the summing op-amp. The original function F(t) is sent into the summing op-amp along with the output of the integrating op-amp, which creates the differential equation $Y+Y'+F(t) = 0$

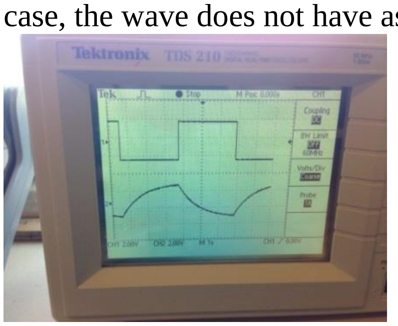


The very first time that I turned on the integrator, the input used was a triangular wave, which resulted in this waveform. The top wave is the input function, which is a wave that had a frequency of 158 mHz. The bottom wave is the solution to the differential equation.

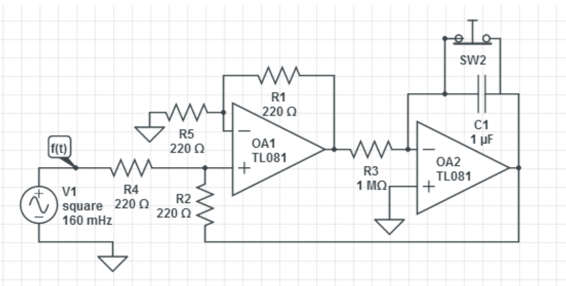


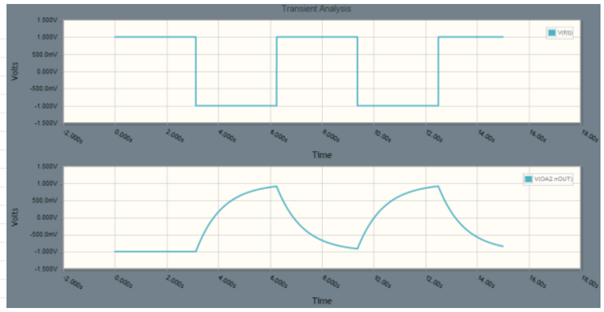


The wave on the bottom looks slightly different when a square wave is the input. In this case, the wave does not have as smooth a curve as when the triangle wave was the input.

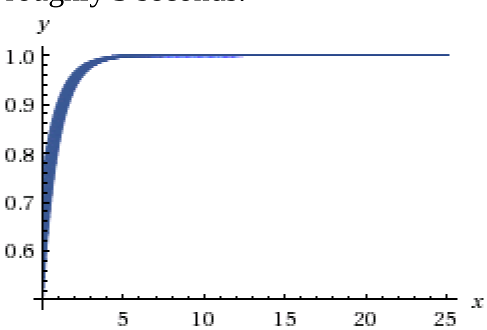


When a square wave source was added to the Circuit Lab schematic, the schematic took on this form. The graph from a time domain sweep shows that the circuit correctly solved the differential equation.





When a step response is run through the circuit, the differential equation creates an image like this. The equation y(x) = c_1*e^-x + 1 forms a curve that quickly increases, then tapers off at roughly 3 seconds.



(sampling $y(0)$)

$$y(x) = c_1\, e^{-x} + 1$$

This project has helped me to understand how the physical construction of circuits works. It also helped me understand how useful circuits can be in solving numerous problems that would normally take more time. Overall, this project has opened up new ideas and paths that I hope to eventually explore.