Assignment 4

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A

RL Circuit

The original equation for the RL Circuit is:

$$E(t) = Ri(t) + Li'(t)$$

To get the state space for the simulation, we start by defining a differential equation:

$$i(t) = x(t)$$

If we differentiate both sides, we get

$$i'(t) = x'(t)$$

Which can be expanded to

$$\frac{E(t) - Ri(t)}{L} = x'(t)$$

So,

$$\frac{E(t) - Rx(t)}{L} = x'(t)$$

We substitute this into the state space vector. Below is the MATLAB code used in this simulation.

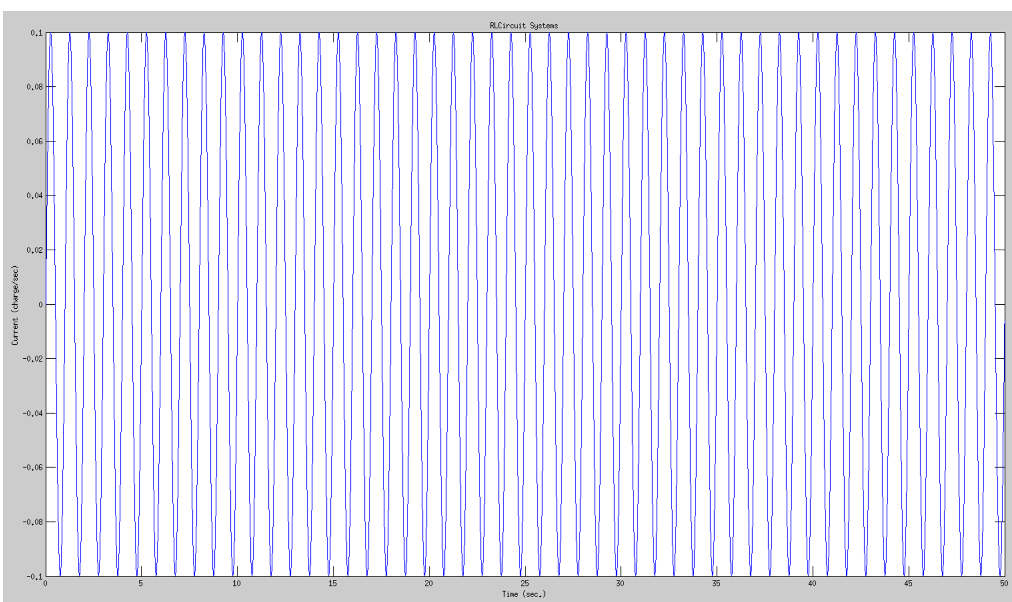
```
% RLCircuit.m

function dx = RLDamper(t, x, w, r, l)
% Generates the RL Circuit equation sin(wt) = ri(t) + li'(t)
% t is the time
% x is the current
% w is the frequency in rad/sec
% r is the resistance
% l is the inductance

xd1 = (sin(w*t) - r*x(1)) / l % first order derivative

dx = [xd1];

end

% solver.m

clc; clear all; close all;
```

```
% Solve the RLCircuit function under different conditions

% Parameters
r = 10 % resistance
l = 0.1; % inductance
w= 4*r/l; % frequency
t_max = 5; % simulation time = 5s

x_0 = 0; % initial current

X_0 = [x_0];

[t,y] = ode45(@RLCircuit, [0, t_max], X_0, [], w, r, l);

plot(t, y(:,1));
xlabel('Time (sec.)');
ylabel('Current (charge/sec)');
title('RLCircuit Systems');
```

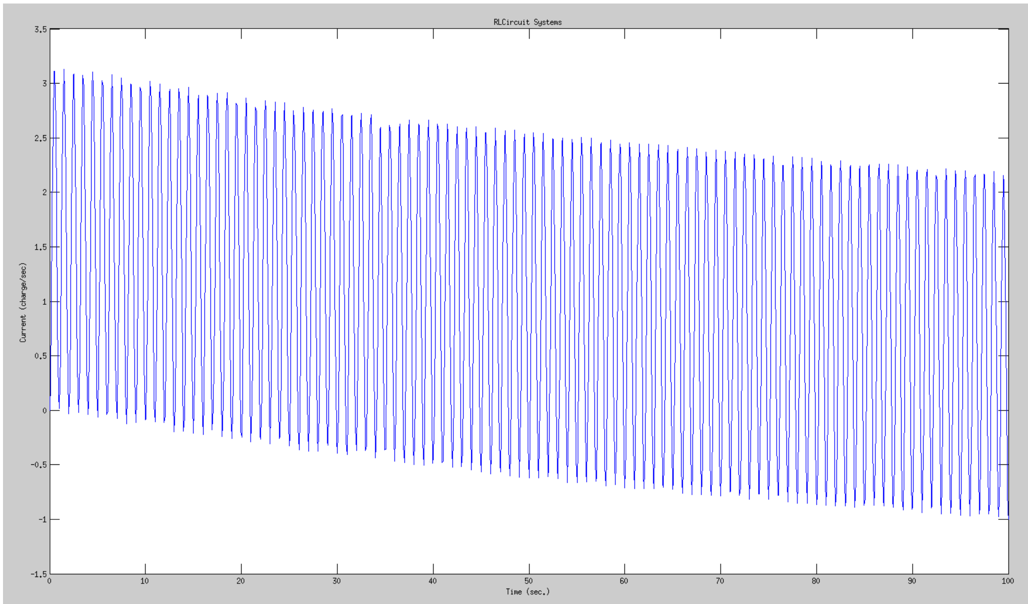
B

RL Circuit

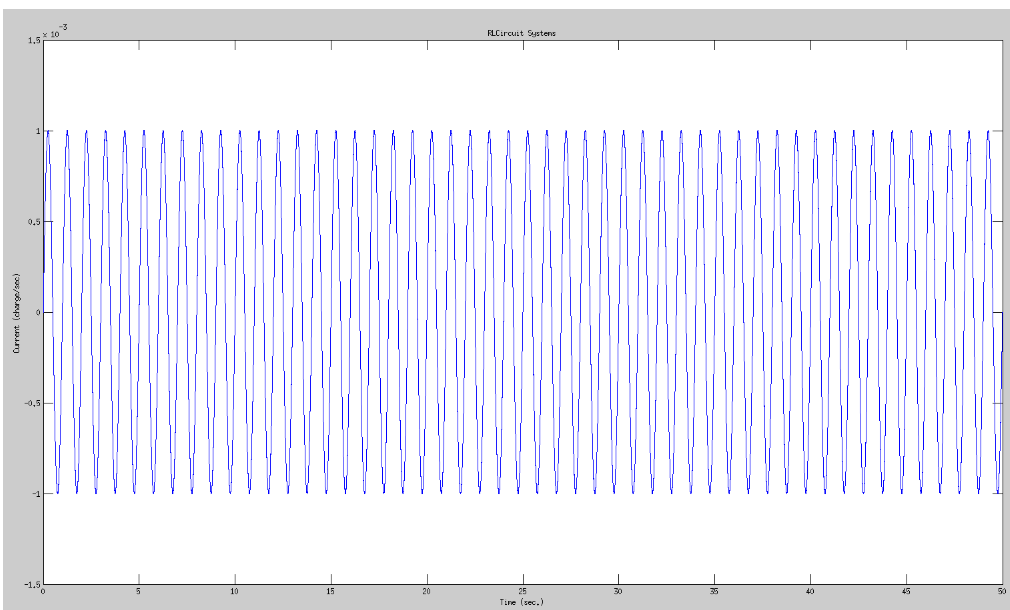
We initially start off with the following graph, using initial conditions $R = 10$, $L = 0.1$, and $w = 2\pi$.



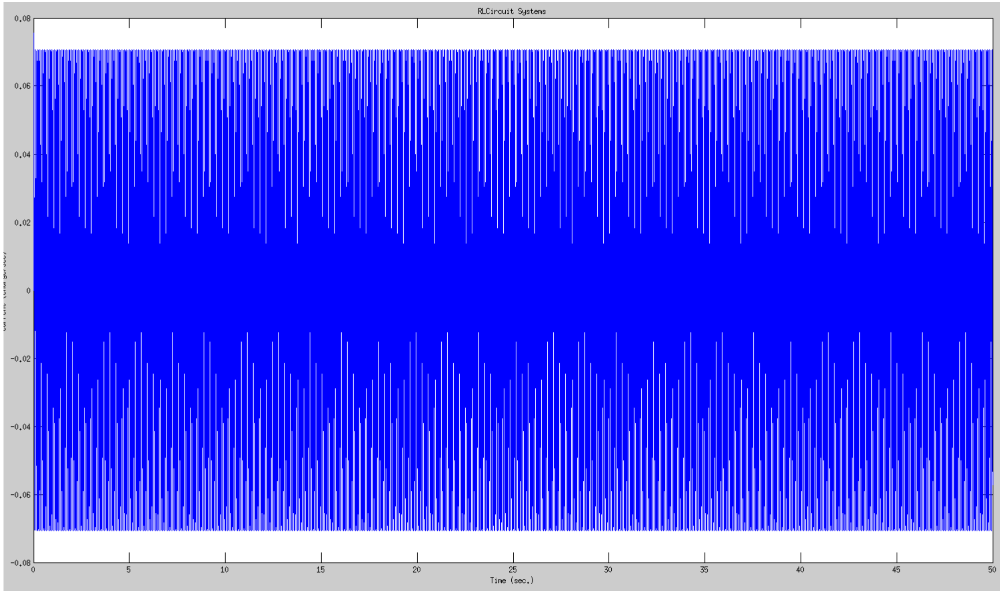
Next we decrease the resistance such that $R = 0.001$.



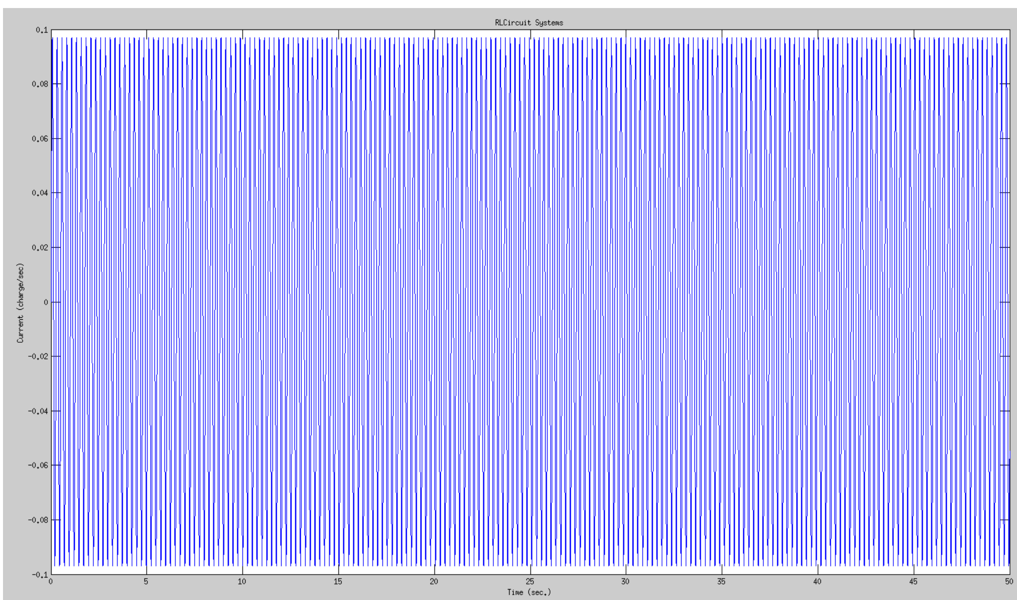
From this graph, we can see that the amplitude of the current is increased from below 0.1 to above 1.5. This makes sense, because the lower the resistance of the circuit, the higher the current can be for a given voltage. Next we increase the resistance such that $R = 1000$.



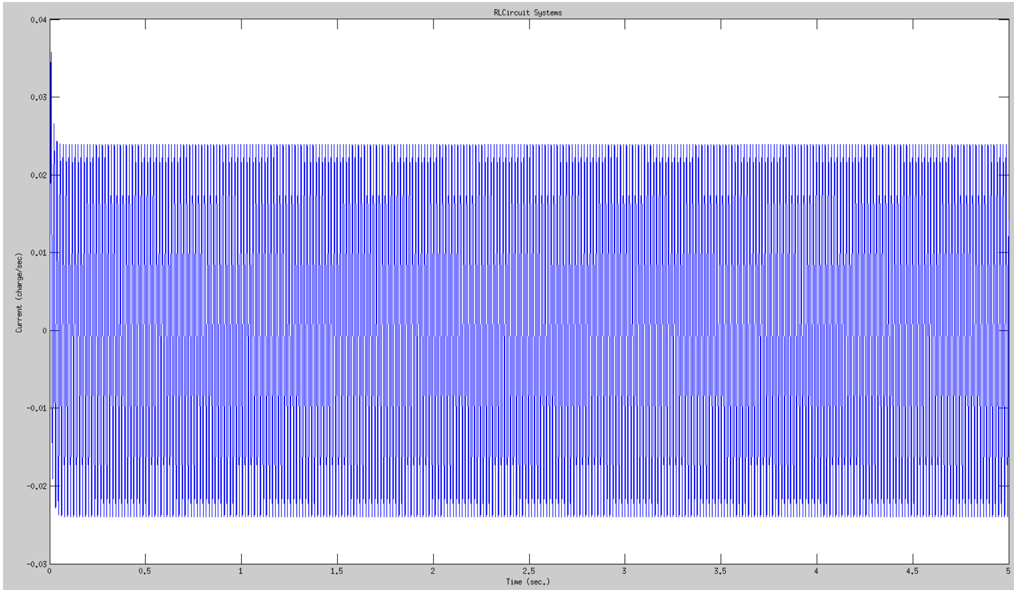
We get a really small amplitude, as the resistance is very high. This also makes sense, because Ohm's law dictates that as resistance increases, current should decrease. Next, we set the resistance back to $R = 10$ and vary the frequency, starting at the baseline of $w = R/L$.



In this graph, you can see that beating occurs, as there are multiple layers of sinusoidal waves. Next, we lower the frequency down to $w = 0.25R/L$.



Beating still occurs, but the important fact is that the amplitude of the current has increased. Next, we increase the frequency to $w = 4R/L$.



Beating, again, still occurs, but we can see that increasing the frequency has decreased the amplitude of the wave.

C

RL Circuit

This circuit could be used in a subwoofer, because it seems to be able to amplify lower frequencies while de-amplifying higher frequencies. A subwoofer is designed for lower frequency sounds, so having the circuit able to trim out the unwanted higher frequency noises would make it very suitable for use in a subwoofer.