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ECEN203 Analogue Circuits and Systems
Lab 4
SPICE 2

3. Resonance Frequency.

3.1 RLC Transfer Function

$$\frac{Vo}{Vi} = \frac{R}{R+jwL + \frac{1}{jwC}}$$

$$= \frac{R}{R+jwL - \frac{j}{wC}}$$

$$\frac{Vo}{Vi} = \frac{R}{R+j(wL - \frac{1}{wC})}$$

3.2 Resonance Frequency

At resonance $w_0 \ : \ wL = \frac{1}{wC}$

$$w_0 L = \frac{1}{w_0 C}$$

$$w_0{}^2 LC = 1$$

$$w_0 = \sqrt{\frac{1}{LC}} \quad \Rightarrow \quad f_0 = \frac{1}{2\pi\sqrt{LC}}$$

*With L = 220mH **and** C = 47nF the expected resonant frequency is :* ***f_0 = 1565Hz***

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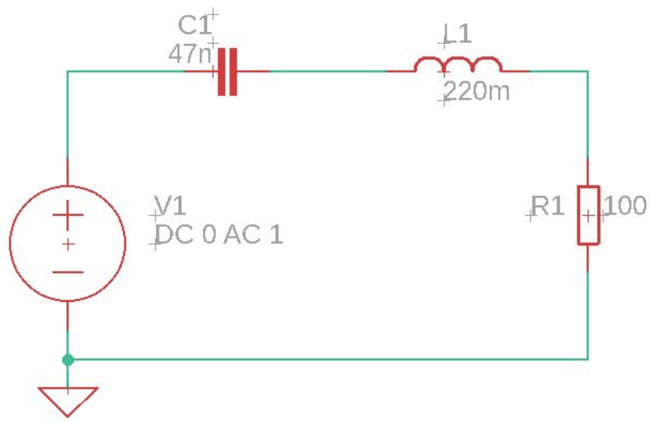
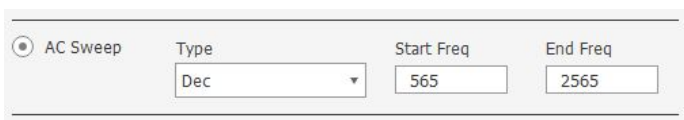
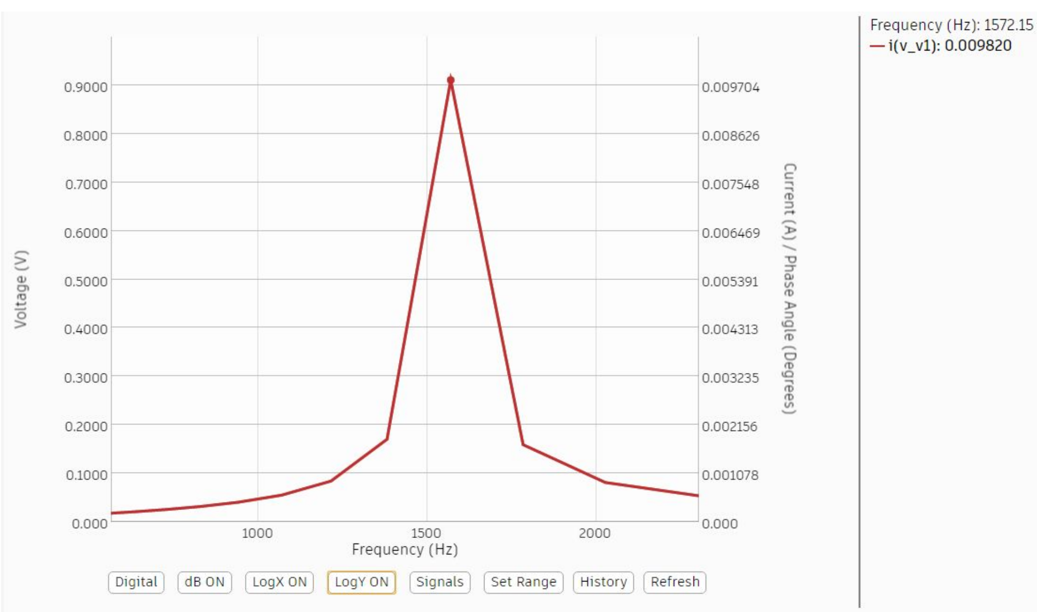
3.2 Simulation



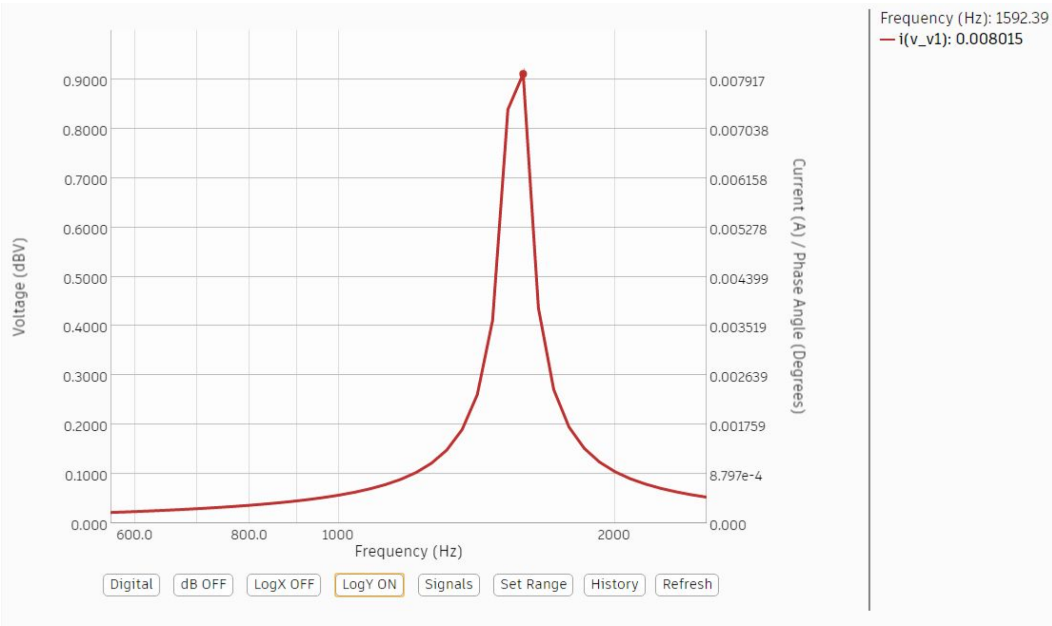


Initial circuit setup, AC sweep, enveloped around expected resonance.



6 decades, 3 points per decade.

Gave f_0 of around 1570, but lacks any detail of surrounding behavior

<table>
<tr>
<td>
</td>
<td>10 points per decade

Shows more detailed behavior, but sampling overshoots f_0, showing 1592</td>
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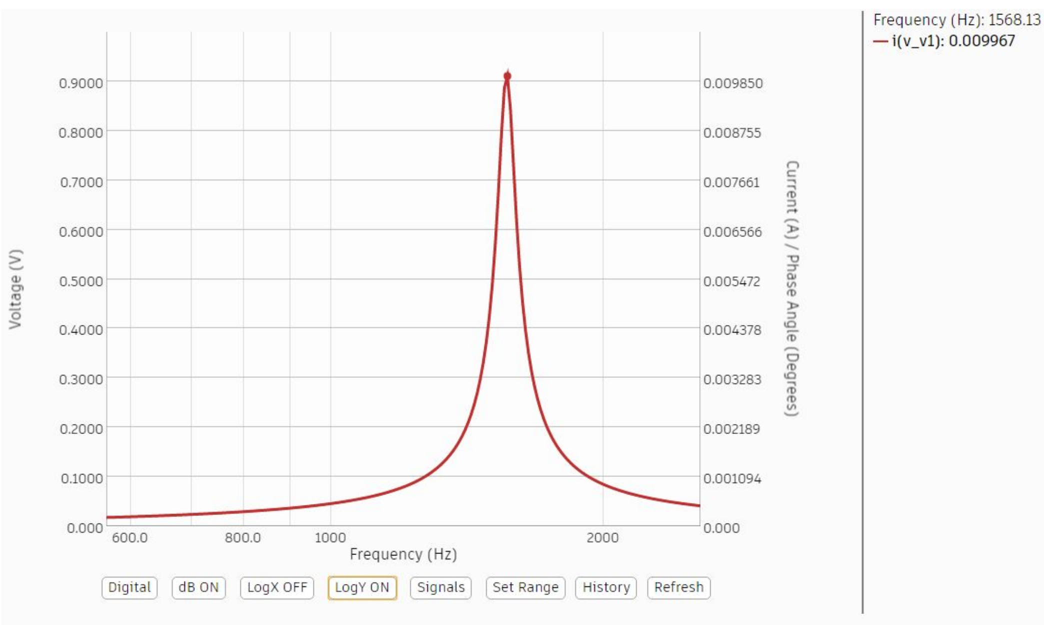
<td>
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<td>50 points per decade, shows good detail and quite accurate $f_{0.}$ This sampling rate is adequate but increasing further would be of benefit.</td>
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4. Q Factor

4.1 Quality calc and measurements

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}} \Rightarrow \frac{1}{100}\sqrt{\frac{220\times10^{-3}}{47\times10^{-9}}} = 21.6$$

Measured from sim: such that

Q = f0 / f1-f2, → Q = 1563 / 1603 - 1527
Q = 20.56

This is quite close, showing adequate representation.

4.2 Varying Q → R1

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}\ ,\ R = \frac{\sqrt{\frac{L}{C}}}{Q}$$

$Q = 0.25$ $R = \frac{\sqrt{\frac{L}{C}}}{0.25}$ $R = 8654\Omega$	$Q = 0.5$ $R = \frac{\sqrt{\frac{L}{C}}}{0.5}$ $R = 4327\Omega$	$Q = 0.707$ $R = \frac{\sqrt{\frac{L}{C}}}{0.707}$ $R = 3060\Omega$	$Q = 1$ $R = \frac{\sqrt{\frac{L}{C}}}{1}$ $R = 2163\Omega$	$Q = 10$ $R = \frac{\sqrt{\frac{L}{C}}}{10}$ $R = 216\Omega$

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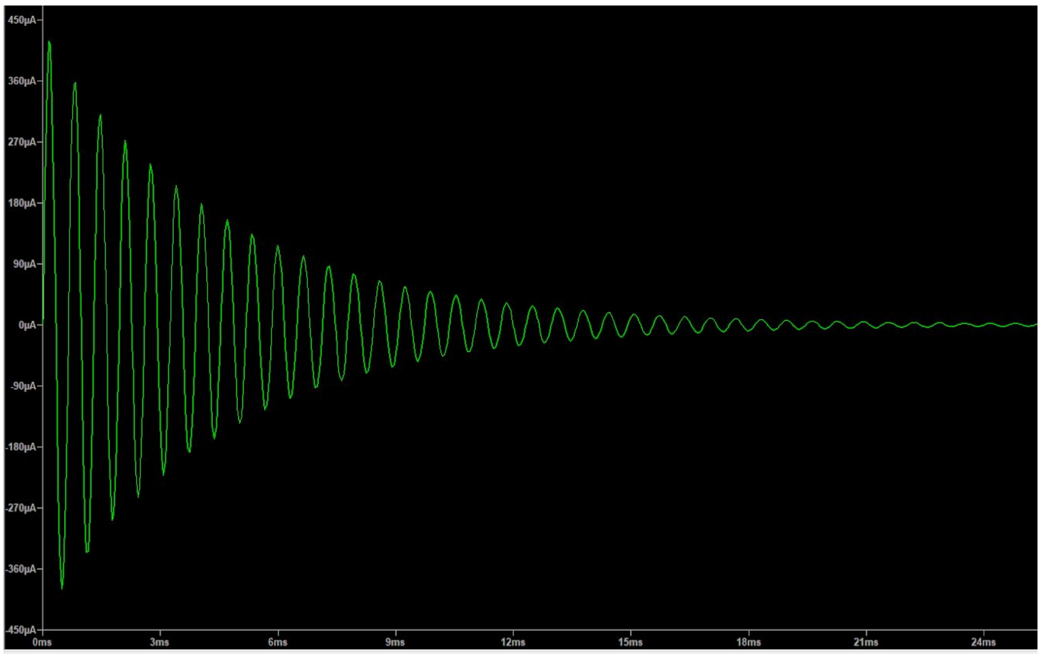
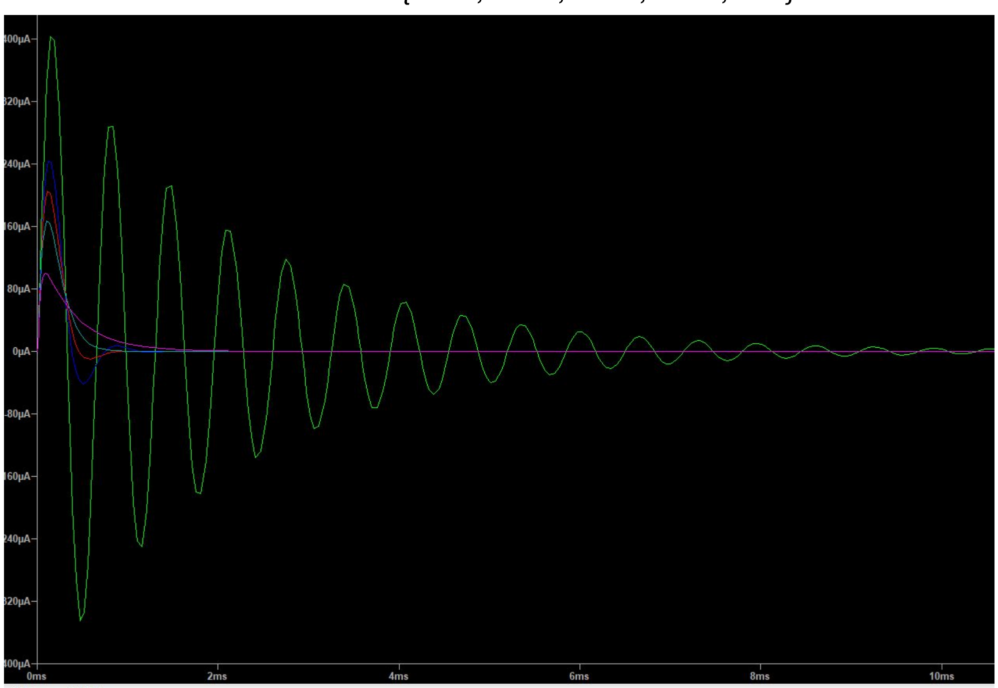
4.2 Transient analysis: R = 100; {R} from section above

R = 100



Transient R list {8654, 4327, 3060, 2163, 216}



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4.3 What is the effect of increasing Q on the transient response of your circuit?

Increasing the Q value results in less energy dissipation, ie less dampening so circuit oscillations continue for a longer time. With underdamped systems exchanging energy between its reactive components and overdamped systems dissipating that energy too quickly.

Overdamped systems specifically have a higher real energy consumption rate, and asymmetrically approach origin.

Underdamped likewise have a lower rate and oscillate around origin.

5. Parameter sensitivity to component variations in resonant circuits