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Subject: High Frequency Effects

In this lab, non-ideal component behavior was demonstrated by showing how the component varied with frequency. A resistor was used to show this, and non-ideal behavior was clearly seen. We took many measurements to determine the parasitic inductance in a wire using a resonance circuit, and also using direct measurement.

Appendix 1: Tabulated Impedance Measurements

Appendix 2: Plot of Frequency Response

Appendix 3: Sketch of Frequency Response with 2.1mH inductor

The inductance between connections causes the frequency response to be shifted, as well as the other characteristic things normal inductors do such as giving a positive phase to the overall impedance. This inductance also effects the frequency response by making the resonant frequency less than it normally is. For very high frequencies, the inductance becomes very high and dominates the frequency response of the circuit, so for a high-speed digital circuit, it would mostly be inductive.

High Frequency Effects *(continued)*

From the lab it was seen that even a resistor had parasitic features, and changed with frequency, especially for high frequencies, due to the parasitic inductance that was present. Even an inductor itself has a parasitic inductance that makes it unreliable for extremely high frequencies (megahertz frequencies), because the parasitic inductance becomes really large. Other real components also probably have a parasitic inductance making them act like a non-real component at high frequencies.

Appendix 1 - Tabulated Impedance Measurements

High Frequency Effects

Frequency:	***50 W resistor:***	***Lead wire:***	***Combination:***
500 MHz	47.6 ∠ .8°	3.48 ∠ 78.8°	47.9 ∠ 4.4°
2 MHz	47.9 ∠ .6°	13.56 ∠ 86.1°	50.2 ∠ 14.8°
10 MHz	48.2 ∠ 4.2°	71.3 ∠ 88.6°	88.8 ∠ 50.8°
20 MHz	49.3 ∠ 8.5°	183.5 ∠ 86.2°	193.8 ∠ 58.5°
40 MHz	53.4 ∠ 16.2°	1.461 k ∠ 71.5°	976 ∠ 24°

When inductance equals resistance of load, at ∠45°, f =7.875 MHz *and* 37.39 MHz

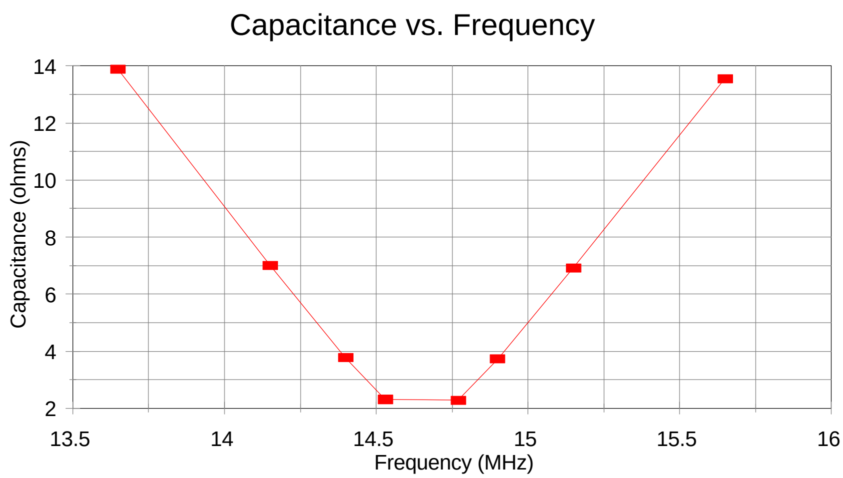
In lead wire, $Z_{eq}=j\omega L+R$. When ∠90°, $|Z_{eq}|=\omega L$.

Therefore, $\mathbf{L}=|Z_{eq}|/2*\pi*f$ = **1.1 μH**

Appendix 2 - Plot of Frequency Response

High Frequency Effects

Capacitor's Measured Value: ***95.1 pF***



Resonance frequency in an RLC circuit:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

$$L = \frac{1}{(2\pi f)^2 C} = \frac{1}{(95.1p)[2\pi(14.65M)]^2} = 1.24\mu H$$

$$halfpowerfrequency = \frac{\sqrt{2}R}{4\pi L} \pm \frac{\sqrt{2R^2 + \frac{4L}{C}}}{4\pi L}$$

*% Difference = 100% * (1.24 μH – 1.135 μH)/ 1.135 μH =* ***9.36%***

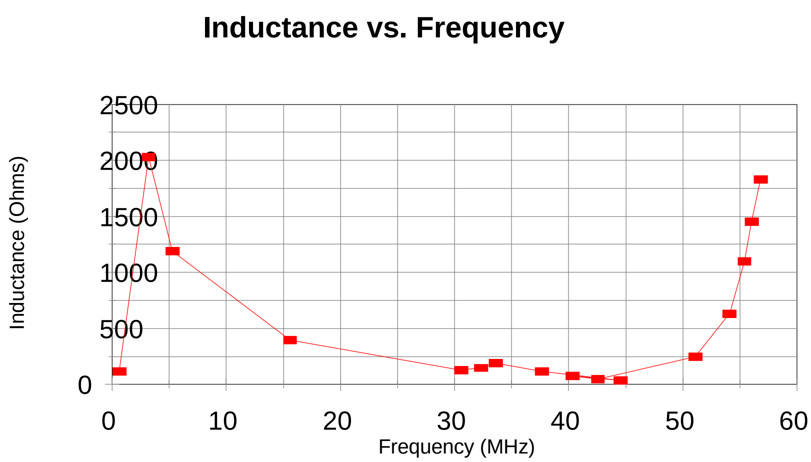
Upper frequency: ***14.7 MHz****; Lower frequency:* ***14.5 Mhz***

Bandwidth = Upper – Lower = ***.2 Mhz***

$R_{calculated}$: ***2.28 Ω***

Appendix 3 - Sketch of Frequency Response with 2.1mH inductor

High Frequency Effects



Resonant Frequencies:

f=669 kHz, 44.54 MHz, and 56.75 Mhz