EEEN203 Lab 7 - Transformers

Part 1. Voltage and Current measurements

Calculated turns ratio:

Primary side resistance $R \approx 75\ \Omega$ $\qquad V_{rms} = 2.72$

Secondary side resistance $R \approx 1.2\ \Omega$ $\qquad V_{rms} = 0.203$

$$\frac{V_1}{V_2} = \frac{2.72}{0.203} = 13.3990$$

V2 phase relative to V1 measured using the oscilloscope: 180

- This phase shift is expected to due to Lenz's law, which states the direction of an induced current is opposite to the field that induces it

Current Ratio:

$V_{1k} \approx 2.14\ V_{rms}$ $\qquad I_1 = \frac{2.14}{1000} = 2.14 \times 10^{-3}$

$V_{10} \approx 0.2108\ V_{rms}$ $\qquad I_2 = \frac{0.210}{10} = 0.02108$

$$\frac{I_2}{I_1} = \frac{0.02108}{2.14 \times 10^{-3}} = 9.850$$

$$13.3990 - 9.850 = 3.549\ diff$$

The actual turns ratio of the inductor as indicated on the datasheet is around 11.456. When taking the difference, dividing by two, adding to the lower, we get:

$$\frac{3.549}{2} + 9.850 = 11.6245$$

Which is very close.

Calculated resistance in primary:

$$V_T = 5 - 2.14 = 2.86\ V_{rms}$$

$$R = \frac{V}{I_1} = \frac{2.86}{2.14 \times 10^{-3}} = 1336.4485\ \Omega$$

(This is way higher than what was recorded in the multimeter, and I am probably doing something wrong)

Power dissipated

Power given by function generator (RMS):

$$P_{rms} = V_{rms} I_1 = 5 \times 2.14 \times 10^{-3} = 10.7 \times 10^{-3}\ W$$

Power dissipated across resistor

$$P_{rms} = V_{rms} I_1 = 2.14 \times 2.14 \times 10^{-3} = 4.578 \times 10^{-3}\ W$$

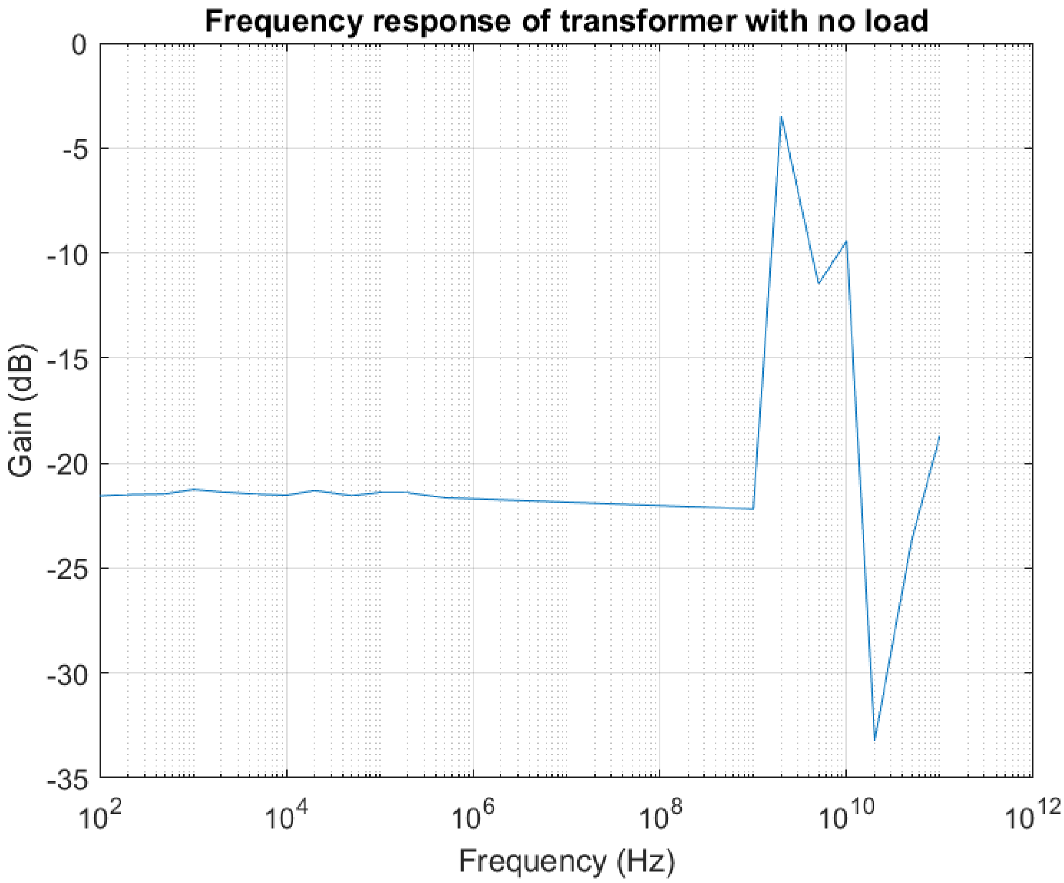
Difference:

$$10.7 - 4.578 = 6.122\ mW$$

An ideal transformer would have no real resistance and be purely inductive impedance – therefore all the power dissipated will be across the resistor. The fact that there is a difference shows that the transformer used is non-ideal and has resistances from the wire used to create it

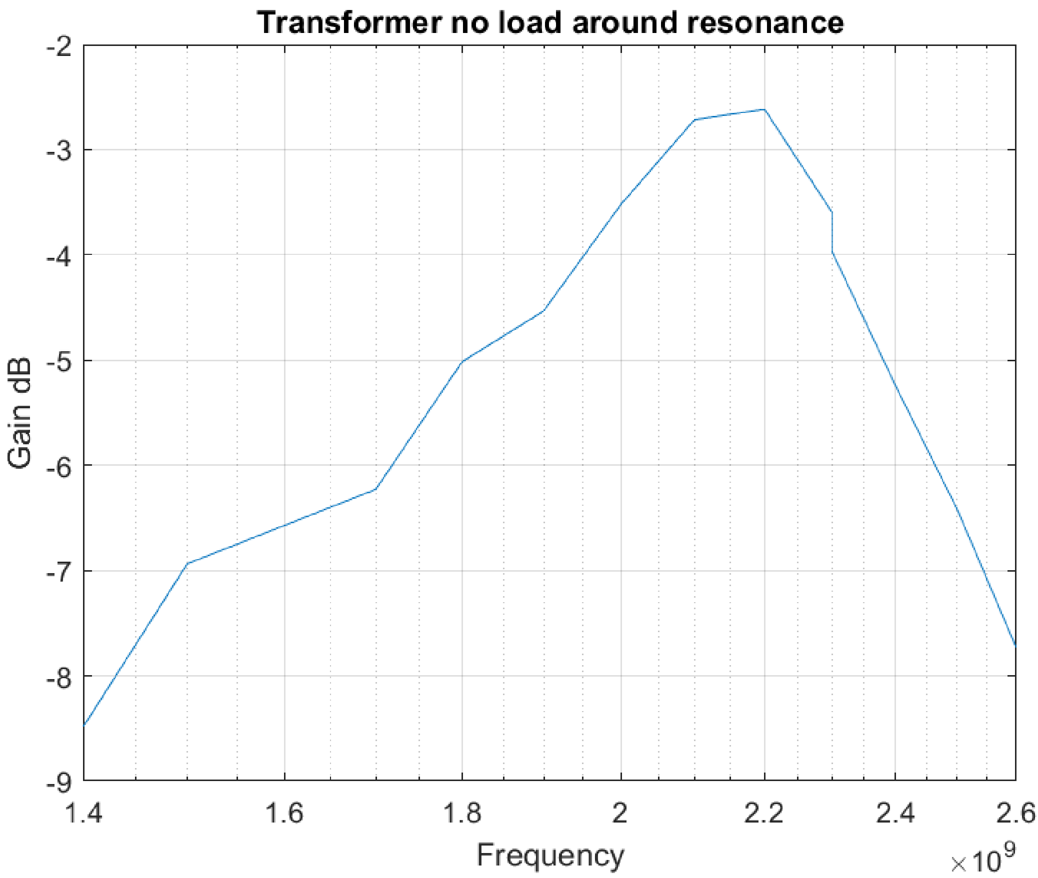
Part 2: Frequency Response from 100 Hz – 1MHz, 10 Vpp

F [Hz]	V1	V2	Phase
100	7.28	608mV	-174
200	8.08	680mV	-177
500	8.72	736mV	-178
1 K	8.88	768mV	-179
2 K	9.28	792mV	-179
5 K	9.68	816mV	-180
10 K	9.92	832mV	-180
20 K	10	860mV	179
50 K	9.80	820mV	180
100 K	9.40	800mV	178
200 K	8.00	680mV	178
500 K	4.60	380mV	177
1 M	2.16	168mV	30.8
2 M	1.04	696mV	105
5 M	1.44	384mV	19.3
10 M	1.02	344 mV	-155
20 M	1.10	24 mV	-78.4
50 M	1.40	92.0mV	-43.2
100 M	1.24	144 mV	134



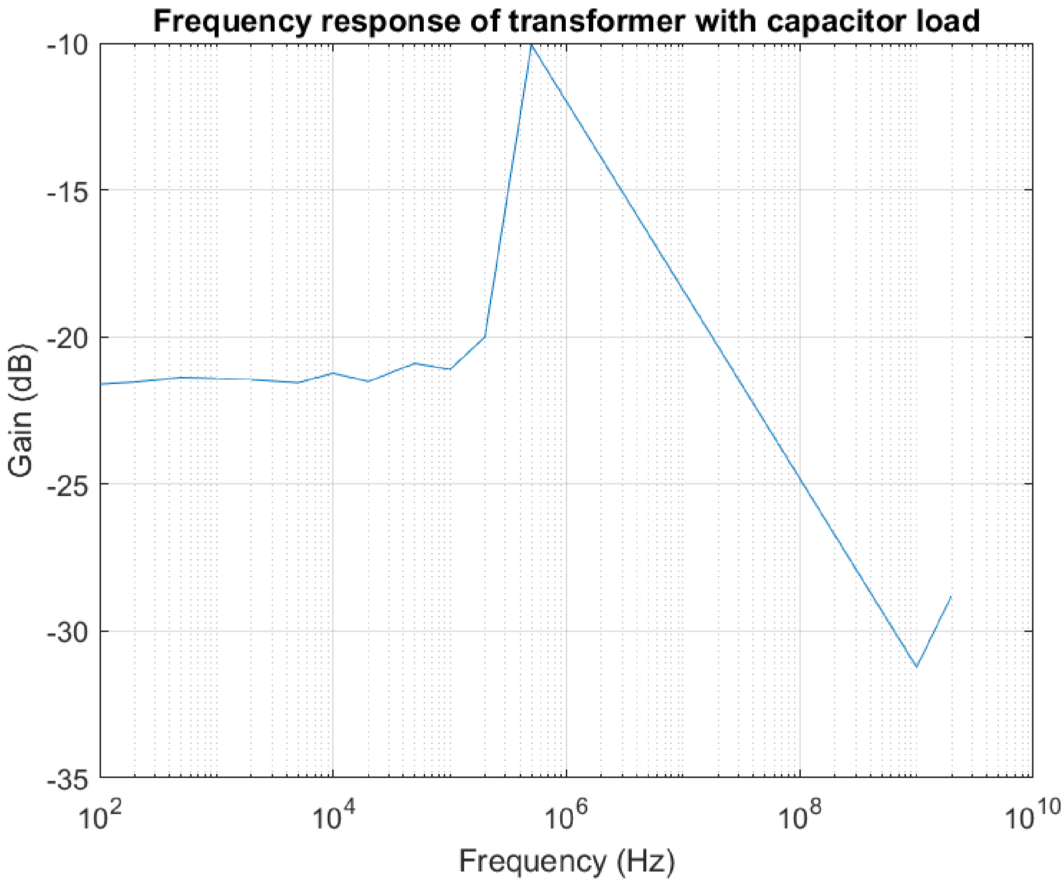
Resonance frequency: Voltage starts peaking between at 2 MHz

1.4 M	1.36	512mV	-157
1.5 M	1.36	612mV	-174
1.6 M	1.36	664mV	171
1.7 M	1.24	696mV	157
1.8 M	1.20	712mV	143
1.9 M	1.08	720mV	123
2 M	1.04	768mV	108
2.1 M	1.00	740mV	94.3
2.2 M	1.04	688mV	73.7
2.3 M	1.06	672mV	62.0
2.4 M	1.20	656mV	48.6
2.5 M	1.34	640mV	44.1
2.6 M	1.52	624mV	34.0



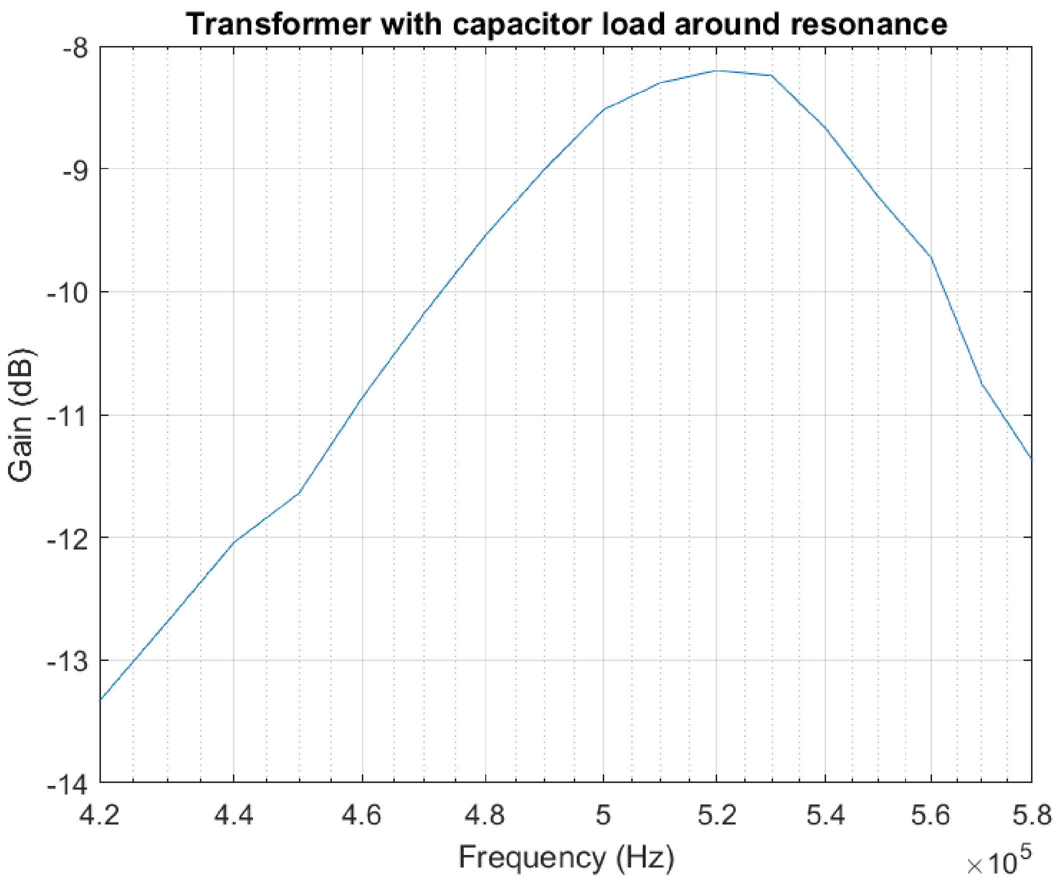
Part 3: Transformer Resonance with Capacitive Load

F [Hz]	V1	V2	Phase
100	7.12	592mV	-174
200	7.92	664mV	-177
500	8.72	744mV	-179
1 K	9.04	768mV	-179
2 K	9.36	792mV	-179
5 K	9.76	816mV	-180
10 K	10.6	920mV	-180
20 K	10.0	840mV	179
50 K	10.2	920mV	179
100 K	10.0	880mV	-180
200 K	8.40	840mV	179
500 K	4.40	1.38	115
1 M	2.04	56.0 mV	52.8
2 M	1.32	48.0mV	-17.1

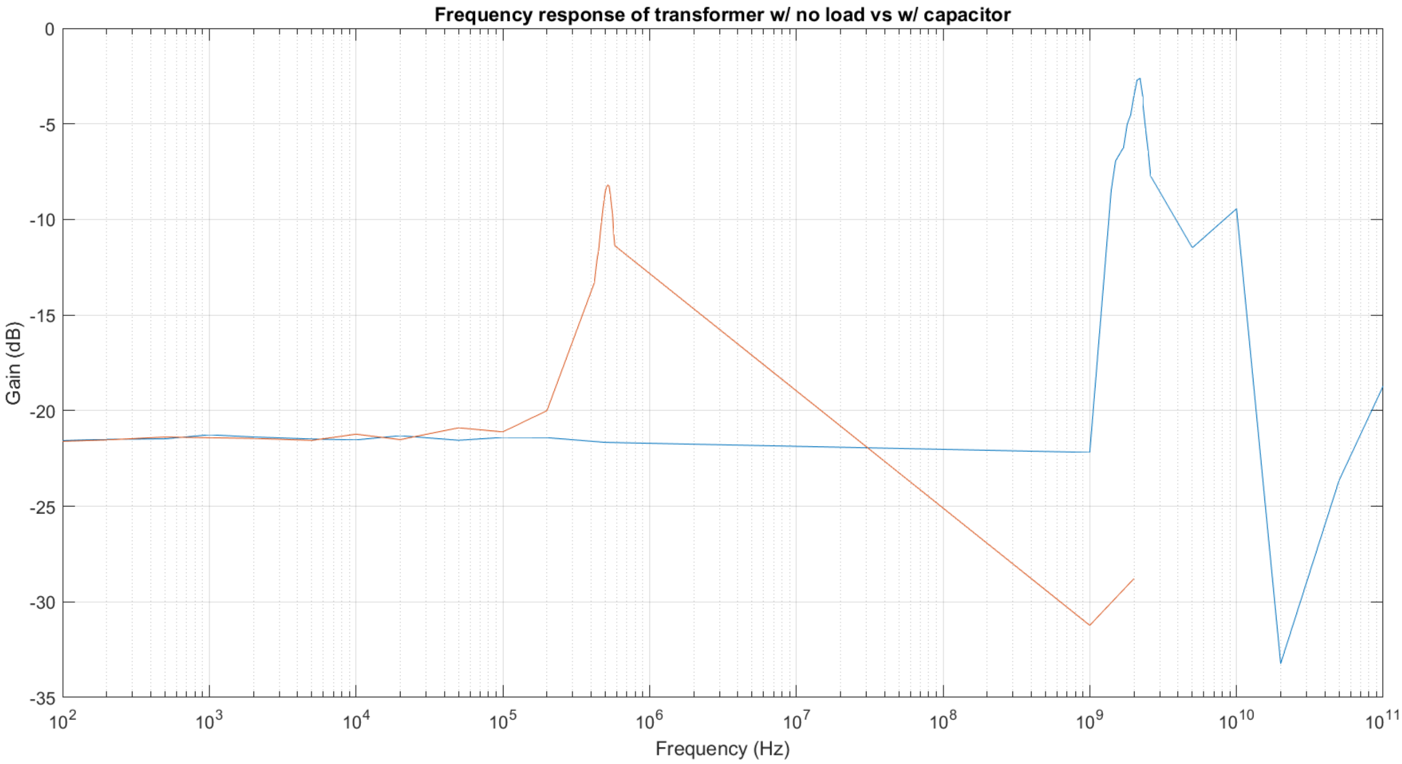


Resonance Frequency: Voltage peaking around 500k

420 K	4.64	1.00	159
430 K	4.48	1.04	154
440 K	4.32	1.08	154
450 K	4.24	1.11	155
460 K	4.12	1.18	147
470 K	4.00	1.24	142
480K	3.84	1.28	134
490 K	3.72	1.32	130
500 K	3.68	1.38	120
510 K	3.64	1.40	112
520 K	3.65	1.42	104
530 K	3.72	1.44	93.1
540 K	3.80	1.40	84.1
550 K	3.88	1.34	75.2
560 K	3.92	1.28	67.5
570 K	4.00	1.16	61.4
580 K	4.00	1.08	55.1



Comparing Frequency Response of transformer with no load vs capacitor load (Resonant frequency graphs added)



The frequency responses are similar, with both acting as a bandpass filter. But adding a capacitor load drastically reduces the resonant frequency of the circuit. This can be explained through the equation for the resonant frequency: $\omega_0 = \frac{1}{\sqrt{LC}}$. Since ω_0 and capacitance are inversely proportional to each other, adding a physical capacitance overrides whatever tiny capacitances created from the transformer wires and potentially the breadboard.