EEEN203 Lab 7 - Transformers

Part 1. Voltage and Current measurements

Calculated turns ratio:

Primary side resistance

Secondary side resistance

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:

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:

Which is very close.

Calculated resistance in primary:

(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):

Power dissipated across resistor

Difference:

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 |

Chart

Description automatically generated

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 |

Chart, line chart

Description automatically generated

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 |

Chart, line chart

Description automatically generated

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 |

Chart, line chart

Description automatically generated

Comparing Frequency Response of transformer with no load vs capacitor load

Chart, line chart

Description automatically generated(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: . Since 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.