University of Victoria

ELEC 250

Linear Circuits I

Lab 4 - Resonance and Power

Instructor:
Dr. Nikitas Dimopoulos

Teaching Assistant:
Zhen Liu

Clayton Kihn V00794569
Yves Senechal V00213837
Tyler Stephen V00812021
A01 - B01

November 24, 2014

University of Victoria

1 Object

This lab will study series resonance as well as the measurement of power in a circuit using a wattmeter.

2 Series Resonance

2.1 Procedure

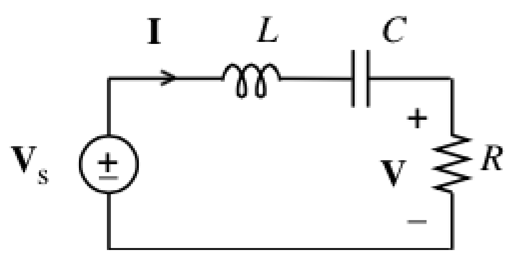

Figure 1: Circuit diagram of resonant RLC circuit
$L = 1.00$ mH, $C = 22$ nF, $R = 43.50\ \Omega$

2.2 Results

Table 2 is located at the end of this report.

find f_0, f_1, f_2, B by interpolating the graph. (hint, using the data table will be the best way to find f_1 and f_2 since we know they occur at $\theta = \pm 45°$)

2.3 Discussion

How do f_0, f_1, f_2, B compare with expected values?

3 Power Measurement

3.1 Procedure

The power factor pf is the ratio of true versus apparent power. A leading pf is achieved in an RC circuit, while a lagging pf is the result of a RL circuit. Two experiments were

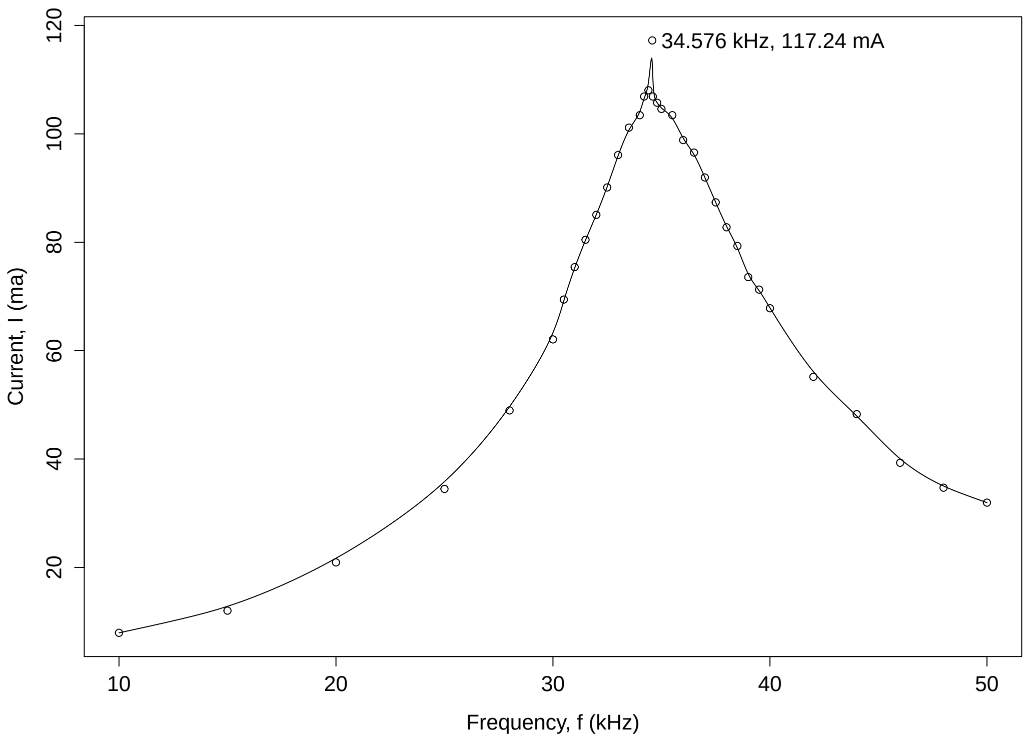

Figure 2: Current through RLC circuit as frequency passes through resonance

performed where a leading and lagging pf were obtained separately. The block diagram in Figure 3 represents the physical setup of the experiment: (a) a high-wattage component board that carries a 200Ω resistor, a $300m$H inductor, and a 10μF capacitor, (b) a variac with an isolation transformer used to reduce the voltage to $50\mathrm{V}_{rms}$, and (c) (not shown) a wattmeter between the isolation transformer and the component board to measure real power. The diagram in Figure 4 represents the electrical RC circuit; the RL circuit is similar with the substitution of and inductor L in place of the capacitor C.

3.2 Results

The first part, a RC circuit was constructed to measure its power consumption. With a 200Ω resistor, a 10μF capacitor, and the voltage set to $49.94\mathrm{V}_{rms}$, the wattmeter measured a current of $151.0m$A with power consumption of 4.55W. A digital multimeter (DMM) placed across the resistor indicated $\mathrm{V}_R = 30.06\mathrm{V}_{rms}$. Using the equation

$$P = \frac{V_R^2}{R} \tag{1}$$

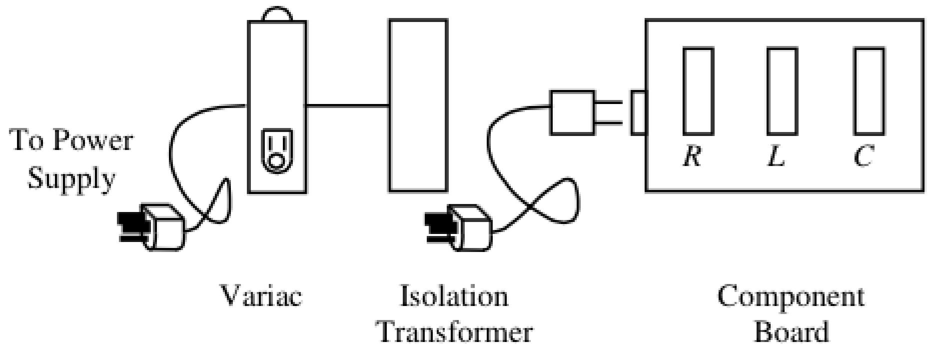

Figure 3: Block diagram of circuit components
$R = 200\ \Omega$, $L = 300\ m\text{H}$, $C = 10\ \mu\text{F}$

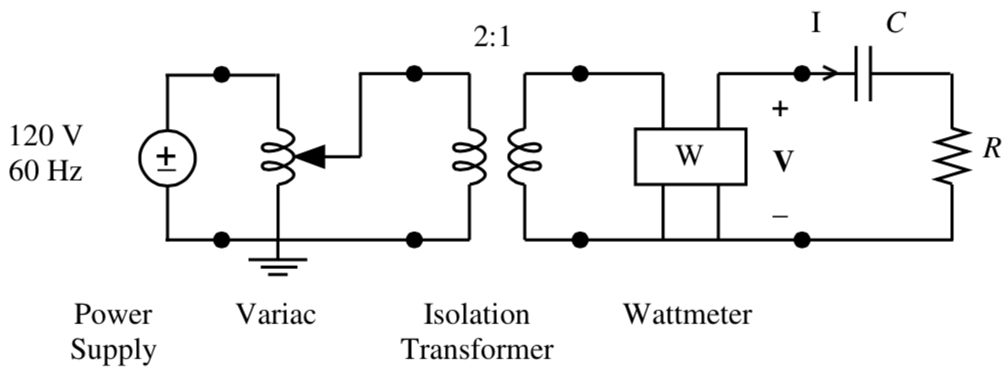

Figure 4: RC pf measurement circuit setup

the true power P is calculated to be 4.52W. Similarly, the apparent power S is calculated using the equation,

$$S = V_{rms} I_{rms} \tag{2}$$

and results to $S = 7.54$VA. The pf can be estimated using

$$pf = \frac{P}{S} \tag{3}$$

which yeilds a power factor of 0.6034. The pf was then be measured to be 0.6019 by the following relationship.

$$pf = \frac{P}{V_{rms} I_{rms}} \tag{4}$$

The relationship of the reactive power Q, true power P, and apparent power S is represented by the following equation, which results in $Q = 6.014$VAR.

$$Q = \sqrt{S^2 - P^2} \tag{5}$$

An RL circuit was constructed for the second part with a 200Ω resistor, a 300 mH inductor, and the voltage set to 50.09V$_{rms}$. The wattmeter in turn measured a current of 181.5mA with power consumption of 7.16W. A digital multimeter (DMM) placed across the resistor indicated V$_R$ = 36.10V$_{rms}$.

Using equation 1, the true power P is expected to be 6.52W. With the relationship of equation 2, the apparent power results in $S = 9.09$VA.

A pf of 0.7876 is estimated using equation 3; however, the pf was measured to be 0.7207 using the relationship of equation 4.

Using equation 5, the reactive power Q results in a value of 5.602VAR.

Circuit	V_{rms} (V)	I_{rms} (mA)	V_R (V)	Q (VAR)	P (W) *measured*	P (W) $\frac{V_R^2}{R}$	pf $\frac{P}{S}$	pf $\frac{V_R}{Vrms}$
RC	49.94	151.0	30.06	6.014	4.55	4.54	0.6034	0.6019
RL	50.09	181.5	36.10	5.602	7.16	6.55	0.7876	0.7207

Table 1: Power measurements in RC and RL circuits

3.3 Discussion

The RC circuit yielded similar power measurement results to those expected. In this circuit the difference between measured and calculated real power P and power factor pf was 0.664% and 0.249% respectively, which is negligible and expected when using non-ideal components.

The RL circuit, however, showed slightly bigger discrepancies. The difference between measured and calculated P and pf was 8.94% and 8.49% respectively. From past experiments, these results can be expected due to the nature of inductors. Heat will increase the internal resistance, which ultimately skews the results.

4 Conclusion

Frequency f (kHz)	Resistor Voltage V_r (V)	Current I (mA)	Phase Shift θ (°)
10.000	0.345	7.931	−85.0
15.000	0.523	12.023	−82.0
20.000	0.910	20.920	−76.0
25.000	1.500	34.483	−69.0
28.000	2.130	48.966	−61.0
30.000	2.700	62.069	−51.5
30.500	3.020	69.425	−47.0
31.000	3.280	75.402	−43.5
31.500	3.500	80.460	−38.0
32.000	3.700	85.057	−34.5
32.500	3.920	90.115	−28.0
33.000	4.180	96.092	−22.0
33.500	4.400	101.149	−15.0
34.000	4.500	103.448	−8.0
34.200	4.650	106.897	−5.0
34.400	4.700	108.046	−2.3
34.576	5.100	117.241	−0.1
34.600	4.650	106.897	0.8
34.800	4.600	105.747	3.8
35.000	4.550	104.598	6.8
35.500	4.500	103.448	13.5
36.000	4.300	98.851	20.0
36.500	4.200	96.552	25.8
37.000	4.000	91.954	31.5
37.500	3.800	87.356	35.7
38.000	3.600	82.759	40.0
38.500	3.450	79.310	43.5
39.000	3.200	73.563	47.2
39.500	3.100	71.264	50.0
40.000	2.950	67.816	53.0
42.000	2.400	55.172	61.0
44.000	2.100	48.276	66.0
46.000	1.710	39.310	69.5
48.000	1.510	34.713	72.0
50.000	1.390	31.954	74.7

Table 2: Change in current through resistor in RLC circuit as source frequency passes through resonance