Ryerson University

Department of Electrical, Computer, & Biomedical Engineering
Faculty of Engineering & Architectural Science

ELE 202
Electric Circuit Analysis
LAB COVER PAGE for Part I submission.

Lab #:	7	Lab Title:	Sinusoidal Steady-State Response of Simple R-C and R-L Circuits

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Section #:	11
Submission date and time:	4/12/2023 - 15:00
Due date and time:	4/12/2023 - 15:00

Document submission for Part I:

- A completed and signed "COVER PAGE – **Part I**" has to be included with your submission. The report will not be graded if the signed cover page is not included.
- Your completed handwritten pages of **Section 4.0** should be scanned (via a scanner or phone images), together with the required MultiSIM images. **Note:** *MultiSIM results must be generated using the Department's licensed version of MultiSIM, and the captured screenshots should show your name (at the center-top) and the timestamp (at the bottom-right corner of your screen).*
- Collate and create a ***.pdf*** or ***.docx*** file of the above, and upload it via D2L **any time prior to the start of your scheduled lab**. Upload instructions are provided on D2L.

Zero marks will be assigned for the entire lab if this Part I is not submitted prior to your scheduled lab.

**By signing above, you attest that you have contributed to this submission and confirm that all work you have contributed to this submission is your own work. Any suspicion of copying or plagiarism in this work will result in an investigation of Academic Misconduct and may result in a "0" on the work, an "F" in the course, or possibly more severe penalties, as well as a Disciplinary Notice on your academic record under the Student Code of Academic Conduct, which can be found online at: www.ryerson.ca/senate/current/pol60.pdf.*

4.0 PRE-LAB: ASSIGNMENT

(a) *R-C Circuit S-S-S Frequency Response*

(i) Referring to the **R-C** circuit shown in **Figure 2.0a**, assume the circuit is operating in the steady-state. For a sinusoidal signal source of $v(t) = V_m\cos(\omega t + 0^o)$, determine the expressions for the circuit impedance, **Z**; the magnitude, $\|Z\|$; the phase-angle, Θ_Z^o and the magnitude, $\|I_Z\|$.

Pre-Lab workspace

Xc = 1 / wL

Z = sqrt(R62 + Xc^2)

|Z| = 1 / wc

Angle = arctan(Xc / R) & |I2| = V / sqrt(R^2 + Xc^2)

(ii) For the circuit in **Figure 2.0a**: If $v(t) = 10\cos(\omega t + 0^o)$ volts, **R** = 510 **Ω**, and **C** = 0.22 **μF**; use your derived expressions to determine the magnitude $\|Z\|$; the phase-angle, Θ_Z^o and the magnitude, $\|I_Z\|$ for *each* frequency, **f** listed in below **Table 2.0**.
Recall: $\omega = 2\pi f$; and 1**k**Hz = 10^3Hz = **1000**Hz.

frequency, f (kHz)	magnitude, $\|I_Z\|$ (mA)	magnitude, $\|Z\|$ (kΩ)	phase-angle, Θ_Z^o (degrees)
0.1	19.606	7.2342	0.8127
0.5	19.608	1.44686	0.1625
1.0	19.608	0.72343	0.0813
5.0	19.608	0.14469	0.0163
10.0	19.608	0.07234	0.0081
50.0	19.608	0.01447	0.0016
200.0	19.608	0.00362	0.0004

Table 2.0: Theoretical frequency response data-points for the R-C circuit of Figure 2.0a.

(iii) For the values of $v(t) = 10\cos(\omega t + 0^o)$ volts, **R** = 510 **Ω**, and **C** = 0.22 **μF**, construct and simulate the circuit of **Figure 2.0b** on MultiSIM. Use the following procedures to set up the circuit for proper measurements: -

1. For the source-signal, set the function generator (**FG**) for a sinusoidal output with an initial frequency of **0.1**kHz and **20**V_{P-P} voltage (i.e. V_m =**10** volts peak-amplitude), connect it to the circuit and display the waveform directly on **CH-1** of the MultiSIM Oscilloscope. Display at least two complete waveform cycles.
Note: *For proper operation, the **FG**, Oscilloscope and the circuit must share a **common reference point** (or ground) as depicted in **Figure 2.0b**.*

2. To monitor the current, $I_Z(t)$ [= $V_R(t)$/**R**], the corresponding voltage, $V_R(t)$ across the resistor, **R** is connected to **CH-2**.

3. For **each** frequency, **f** listed in **Table 2.1**, capture the Oscilloscope screen image, and then measure and record the corresponding magnitude (i.e. peak voltage) of the sinusoidal signal observed in **CH-1** and **CH-2**, respectively. Also record the time-difference value, Δ**t** to facilitate phase-measurement => **Note:** *As was practised in* **Lab #5**, *one way to measure the phase difference between **CH-1** and **CH-2** waveforms is to position the **vertical cursors** between the two adjacent peaks of the respective sinusoidal waveforms in order to reliably measure the time-difference, Δ**t**. The equation $\Theta = 2\pi f \times \Delta t$ (radians) or $\Theta = 2\pi(1/T) \times \Delta t$ (radians) can be used to calculate the phase-difference in radians. You will need to convert Θ (radians) to degrees, noting that π radians = 180°.*

- Copy and paste a screenshot showing one MultiSIM readings on the circuit. Include the MultiSIM circuit file (**.ms14**) in your Pre-Lab submission.

- All screenshots should show your name printed on the center-top of the MultiSIM screen and the timestamp at the bottom-lower corner.

frequency, f (kHz)	Results measured from MultiSIM			Calculated from the results		
	$\|V_{CH-1}\|$ (volt)	$\|V_{CH-2}\|$ (volt)	Δt (µSec.)	$\|I_Z\|$ (mA)	$\|Z\|$ (kΩ)	$\Theta_Z{}^o$ (degree)
0.1	9.998	0.0372	2500	19.602	7.234	0.8127
0.5	9.987	1.273	375	19.582	1.447	0.1625
1.0	9.986	3.577	156.25	19.580	0.723	0.0813
5.0	9.986	9.099	6.25	19.580	0.147	0.0163
10.0	9.962	8.657	0.844	19.533	0.072	0.0081
50.0	9.870	9.550	0.6614	19.533	0.014	0.0016
200.0	9.986	9.919	0	19.580	0.004	0.0004

Table 2.1: MultiSIM frequency response data-points for the R-C circuit of **Figure 2.0a**.

4. From the above results recorded in **Table 2.1** for each frequency, **f;** determine the corresponding values for the magnitudes $\|Z\|$ and $\|I_Z\|$; the phase-angle, $\Theta_Z{}^o$. Compare these results with your corresponding theoretical values in **Table 2.0**. Provide explanations below for any deviations between the theoretical and MultSIM results.

Pre-Lab workspace

Looking at the values between the two tables, the phase angle remains the same since only the Xc and R values are considered. Even |Z| values stay the same, but I rounded to3 decimal places for table 2.1 this time.

Now for |I2|, there are actual small changes in the values but still close to the original values; this is due to minute difference between the voltages as well as he Xc value being rounded off to 3 decimal places.

Regardless, they were small changes that produced similar results.

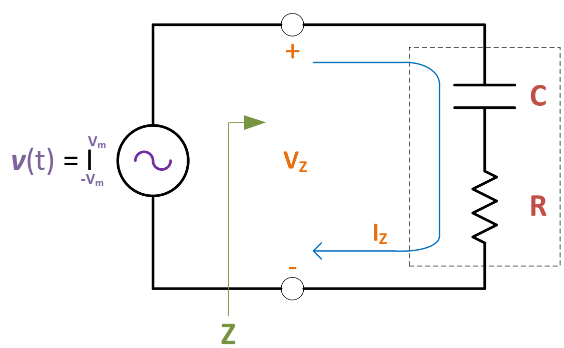

Figure 2.0a: R-C circuit with sinusoidal AC source

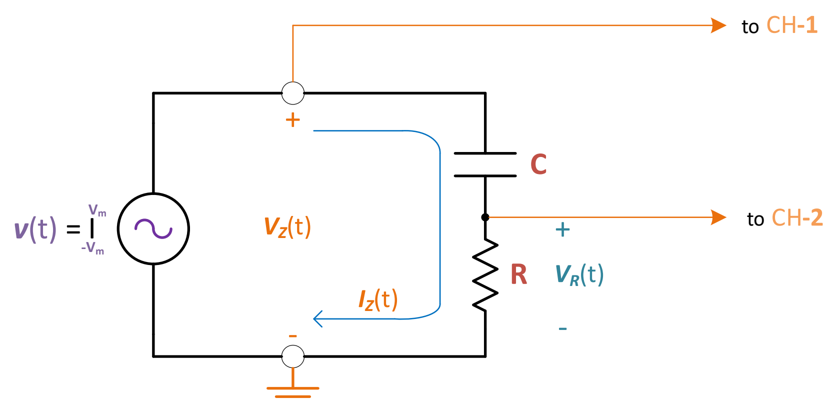

Figure 2.0b: R-C circuit with sinusoidal AC source and measurement connections.

(b) *R-L Circuit S-S-S Frequency Response*

(i) Referring to the **R-L** circuit shown in **Figure 3.0a**, assume the circuit is operating in the steady-state. For a sinusoidal signal source of ***v*(t)** = V_m**cos(ωt** + 0º), determine the expressions for the circuit impedance, **Z**; the magnitude, ‖**Z**‖; the phase-angle, Θ_Zº and the magnitude, ‖I_Z‖ .

Pre-Lab workspace

Xl = wL

Z^2 = R^2 + Xl^2

|Z| = wL

Angle = arctan(Xl/R) & |I2| = V / (sqrt(R^2 + Xl^2))

For the circuit in **Figure 3.0a**: If ***v*(t)** = 10**cos(ωt** + 0º) volts, **R** = 510 **Ω**, and **L** = 4.7 **mH**; use your derived expressions to determine the magnitude ‖**Z**‖; the phase-angle, Θ_Zº and the magnitude, ‖I_Z‖ at *each* frequency, **f** listed in below **Table 3.0**.
Recall: **ω** = 2π**f**; and 1**k**Hz = **10**³Hz = **1000**Hz.

frequency, f (kHz)	**magnitude, ‖I_Z‖** (mA)	**magnitude, ‖Z‖** (kΩ)	**phase-angle, Θ_Zº** (degrees)
0.1	19.608	0.00295	0.000331
0.5	19.608	0.01477	0.001659
1.0	19.608	0.02953	0.003318
5.0	19.608	0.14765	0.016588
10.0	19.608	0.29531	0.033176
50.0	19.608	1.47655	0.165882
200.0	19.607	5.90619	0.663499

Table 3.0: Theoretical frequency response data-points for the R-L circuit of Figure 3.0a.

(ii) For the values of ***v*(t)** =10**cos(ωt** + 0º) volts, **R** = 510 **Ω**, and **L** = 4.7 **mH**, construct and simulate the circuit of **Figure 3.0b** on MultiSIM. Use the following procedures to set up the circuit for proper measurements: -

1. For the source-signal, set the function generator (**FG**) for a sinusoidal output with an initial frequency of **0.1**kHz and **20**V_{P-P} voltage (i.e. V_m =**10** volts peak-amplitude), connect it to the circuit and display the waveform directly on **CH-1** (or CH-A) of the MultiSIM Oscilloscope. Display at least two complete waveform cycles.

Note: *For proper operation, the* ***FG****, Oscilloscope and the circuit must share a* ***common reference point*** *(or ground) as depicted in* ***Figure 3.0b****.*

2. To monitor the current, $I_Z(t)$ [= $V_R(t)$/**R**], the corresponding voltage, $V_R(t)$ across the resistor, **R** is connected to **CH-2** (or CH-B) of the MultiSIM Oscilloscope

3. For **each** frequency, **f** listed in **Table 2.1**, capture the Oscilloscope screen image, and then measure and record the corresponding magnitude (i.e. peak voltage) of the sinusoidal signal observed in **CH-1** and **CH-2**, respectively. Also record the time-difference value, Δ**t** to facilitate phase-measurement => **Note:** *As was practised in* **Lab #5**, *one way to measure the phase difference between* ***CH-1*** *and* ***CH-2*** *waveforms is to position the* ***vertical cursors*** *(or traces) between the two adjacent peaks of the respective sinusoidal waveforms in order to reliably measure the time-difference,* Δt. *The equation* $\Theta = 2\pi f \times \Delta t$ *(radians) or* $\Theta = 2\pi(1/T) \times \Delta t$ *(radians) can be used to calculate the phase-difference in radians. You will need to convert* Θ *(radians) to degrees, noting that* π *radians = 180º.*

- Copy and paste a screenshot showing one MultiSIM readings on the circuit. Include the MultiSIM circuit file (**.ms14**) in your Pre-Lab submission.
- All screenshots should show your name printed on the center-top of the MultiSIM screen and the timestamp at the bottom-lower corner.

frequency, f (kHz)	Results measured from MultiSIM			Calculated from the results		
	$\|V_{CH-1}\|$ (volt)	$\|V_{CH-2}\|$ (volt)	Δt (μSec.)	$\|I_Z\|$ (mA)	$\|Z\|$ (kΩ)	Θ_z^o (degree)
0.1	9.984	9.987	0	19.576	0.00295	0.000331
0.5	9.998	9.984	0	19.604	0.01477	0.001659
1.0	10.00	9.966	0	19.608	0.02953	0.003318
5.0	9.982	9.056	12.5	19.573	0.14765	0.016588
10.0	9.986	7.548	4.375	19.580	0.29531	0.033176
50.0	9.986	2.718	3.75	19.580	1.47655	0.165882
200.0	9.986	0.776	1.094	19.579	5.90619	0.66349

Table 3.1: MultiSIM frequency response data-points for the R-L circuit of Figure 3.0b.

4. From the above results recorded in **Table 3.1** for each frequency, **f;** determine the corresponding values for the magnitudes $\|Z\|$ and $\|I_Z\|$; the phase-angle, Θ_z^o. Compare these results with your corresponding theoretical values in **Table 3.0**. Provide explanations below for any deviations between the theoretical and MultSIM results.

Pre-Lab workspace

Looking at the values between the two tables, like with the RC circuit, while Angle at Z and |Z| remains the same, it is |IZ| that slightly differs from each other. Again, this slight difference in values is from the difference of voltages, but this time I decided to keep the Xl value exactly the same.

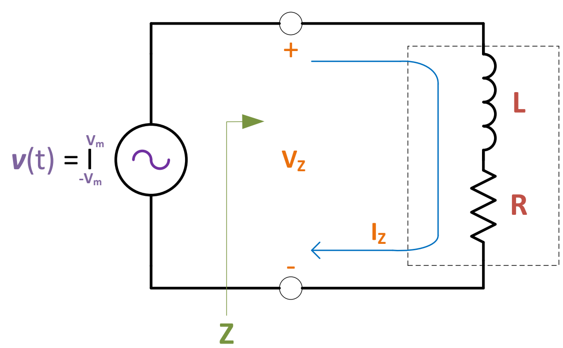

Figure 3.0a: R-L circuit with sinusoidal AC source

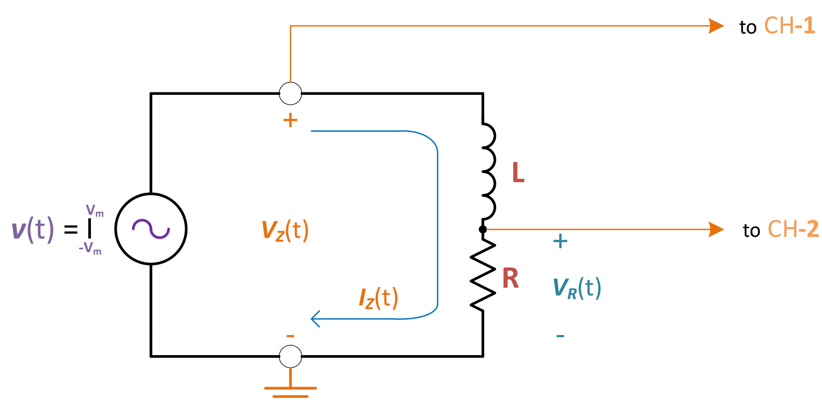

Figure 3.0b: R-L circuit with sinusoidal AC source and measurement connections.