EGR 125 Due date: _____
C++ Programming for Engineers
File: N125P2C

# Programming Assignment #2: AC CIRCUIT ANALYSIS

It is useful to be able to generate tables of information involving repeated calculations in engineering. One example of this is where the current is to be calculated (as a function of frequency) for a series RLC electrical circuit.

## Background:

Shown on page 3 is a "series RLC" circuit, consisting of a sinusoidal voltage source, a resistor, an inductor, and a capacitor. The current I in this circuit changes as the frequency of the sinusoidal voltage changes.

R = Resistance in Ohms (Ω)
L = Inductance in Henries (H)
C = Capacitance in Farads (F)
I = Current in Amperes (A)
E = Sinusoidal voltage in Volts (V), at some frequency, f
f = Frequency in Hertz (Hz)

The current, I, can be calculated in the circuit using the following relationships:

$$X_L = \text{inductive reactance} = 2 \cdot \pi \cdot f \cdot L \text{ in ohms } (\Omega)$$

$$X_C = \text{capacitive reactance} = \frac{-1}{2 \cdot \pi \cdot f \cdot C} \text{ in ohms } (\Omega)$$

$$Z = \text{total circuit impedance} = \sqrt{R^2 + (X_L + X_C)^2} \text{ in Ohms } (\Omega)$$

$$I = \text{current} = \frac{E}{Z} \text{ in Amperes (A)}$$

## Program Requirements:

1. The user should be prompted to input the values for E, R, L, C, $f_{initial}$ and $f_{final}$.
   - The value for R should be entered in ohms (for example, the user enters 5000.)
   - The value of E should be entered in volts
   - The value of C should be entered in mF, uF, or nF (then convert it to F). For example, the user enters 10 mF.
   - The value of L should be entered in mH or uH (then convert it to H).
   - The value of $f_{initial}$ should be entered in Hz, kHz, or MHz (then convert it to Hz).

2. Create a table containing values of f, XL, XC, Z, and I for a range of values of f.
   - Use a loop vary f from $f_{initial}$ to the first value of f greater than or equal to $f_{final}$ where f doubles each time through the loop. For example, if $f_{initial}$ = 100 and $f_{final}$ = 1E6, then f = 100, 200, 400, 800, ….. 1638400 (this spacing is common as graphs often place frequency on a log scale).
   - During each pass though the loop call separate functions to calculate XL, XC, and Z.
   - Use at least two additional functions.

- The results should be displayed in a neat, formatted table with headings, units, etc. The value of the current, I, should be printed in mA rather than Amperes. An example of what this table might look like is shown below. The lines in the table are not required.
- Your loop should also determine the maximum value of the current in the table and the corresponding frequency.

3. The output should the table described above, as well as a title or brief explanation of the program, the values of the inputs, and the maximum value of the current and the frequency where I is maximum (include units with all input and output values).
4. The results should display f as an integer; XC, XL, and Z using one digit after the decimal point; and I with 3 digits after the decimal point (as shown below). The numbers should <u>not</u> be printed in scientific notation.
5. Include a loop that will give the user the option of re-running the program.
6. Include loops to allow the user to correct bad inputs. Test for the following:
   - Values entered for R, L, C, and E must be positive.
   - Proper units and prefixes must be used with inputs as described above.
   - $f_{initial} \geq 1$ Hz, $f_{final} \leq$ 1E9 Hz, and $f_{final} > 2*f_{initial}$.

**<u>Example Output Table</u>:** (for R = 5000 Ω, L = 20 mH, C = 0.02 μF, E = 15V, $f_{initial}$ = 100, and $f_{final}$ = 1E6). Note: You might be able to print the ohm (Ω) symbol using the ASCII extended character set (cout << "10M\352"; - to print 10 MΩ).

| Freq (Hz) | XC (Ω) | XL (Ω) | Z (Ω) | I (mA) |
|---|---|---|---|---|
| 100 | -79577.5 | 12.6 | 79721.9 | 0.188 |
| 200 | -40000.5 | 25.1 | 40286.4 | 0.372 |
| . | . | . | . | . |
| . | . | . | . | . |
| . | . | . | . | . |
| 1638400 | -4.9 | 205887.4 | 205943.3 | 0.073 |

**<u>Program Testing</u>:** Print your results and include them with your report for the following two cases:

1) The example shown above.
2) The values shown corresponding to your name in the table on the following page.

**<u>Extra Credit Suggestions</u>:** (up to 10 additional points)

1. Use prefixes to display the values of XC, XL, and Z in the output table as follows:
   if value < 1000 - express in Ohms (Ω)
   if 1000 ≤ value < 1000000 - express in kiloOhms (kΩ)
   if value ≥ 1000000 - express in MegaOhms (MΩ)
2. Express the frequency in Hz, kHz, and MHz (like suggestion 2 above).
3. <u>Instead of</u> suggestion 3 above, use commas in expressing the frequency (e.g., 80,000 instead of 80000).
4. Send the information from your table to a data file and retrieve the data and graph R, XL, XC, and Z versus frequency using Excel.
5. Create and use a library containing all of your functions.
6. Use your imagination!

## Table 1: Input values

| Name | R (Ω) | L (mH) | C (uF) | E (V) | $f_{initial}$ (Hz) | $f_{final}$ (Hz) |
|---|---|---|---|---|---|---|
| Ash | 1000 | 6.33 | 1.0 | 48 | 50 | 1E5 |
| Babcock | 1500 | 1.76 | 0.9 | 47 | 100 | 2E5 |
| Bagley | 2200 | 0.49 | 0.8 | 46 | 200 | 3E5 |
| Barnet | 2700 | 25.3 | 0.01 | 45 | 250 | 4E5 |
| Campbell | 3300 | 3.17 | 0.02 | 44 | 300 | 5E5 |
| Chen | 3900 | 1.58 | 0.01 | 43 | 350 | 8E5 |
| Diop | 4700 | 0.79 | 0.005 | 42 | 400 | 1E6 |
| Harris | 1000 | 3.96 | 0.9 | 41 | 500 | 2E6 |
| Holterhaus | 1500 | 13.2 | 0.8 | 40 | 550 | 3E6 |
| Ivanov | 2200 | 31.7 | 0.01 | 39 | 600 | 4E6 |
| Knust | 2700 | 12.7 | 0.02 | 38 | 650 | 5E6 |
| Lewis | 3300 | 15.8 | 0.01 | 37 | 700 | 8E6 |
| Mann | 3900 | 1.98 | 0.005 | 36 | 750 | 2E6 |
| Mayo | 4700 | 2.53 | 0.002 | 35 | 800 | 3E6 |
| McDougal | 5600 | 12.7 | 0.9 | 34 | 850 | 4E6 |
| McDowell | 5600 | 1.27 | 0.002 | 33 | 450 | 5E6 |
| Noffsinger | 6200 | 7.04 | 0.9 | 32 | 500 | 8E6 |
| Paz | 6800 | 3.96 | 0.4 | 31 | 550 | 4E6 |
| Pham | 8200 | 13.2 | 0.03 | 30 | 600 | 5E6 |
| Quiatchon | 9100 | 31.7 | 0.008 | 29 | 650 | 8E6 |
| Ryser | 8200 | 12.7 | 0.005 | 28 | 700 | 1E7 |
| Tendilla | 6800 | 15.8 | 0.001 | 27 | 750 | 2E7 |
| Tmara | 6200 | 1.98 | 0.002 | 26 | 800 | 3E7 |
| Van Dam | 5600 | 2.53 | 0.001 | 25 | 850 | 4E7 |
| Vanta | 4700 | 12.7 | 0.5 | 24 | 900 | 5E7 |
|  | 3900 | 15.8 | 0.1 | 23 | 950 | 8E7 |

## Series RLC Circuit: