# MANDATORY TASK

## Task 1

**In this task, you create a simple circuit simulator in MATLAB. Assume that an arbitrary in-rest LTI RLC circuit is given. The circuit is characterized by a structure that describes the circuit elements. For example, for the sample circuit of Fig. 1, the describing structure is as follows. Note that the circuit topology can be extracted from the describing structure. Further, remember that the values of the element as well as the phasor of the independent sources are given by the "value" field of the structure. For more information, read the comments accompanied by the sample structure.**

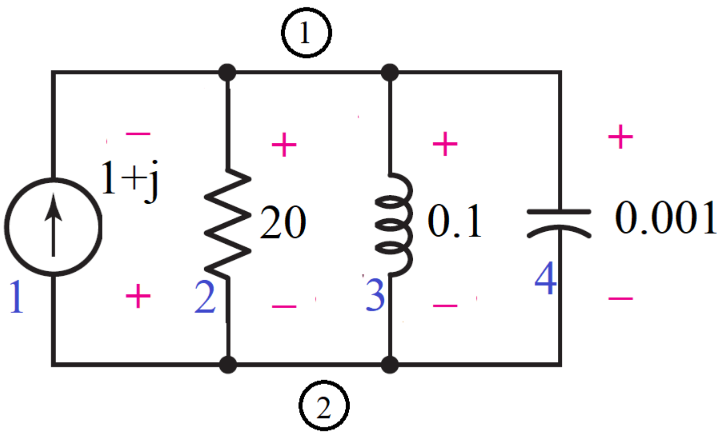


Figure 1: A sample LTI RLC circuit. The node IDs are given is circle while the element IDs are shown in blue.

```
% current source
element(1).id = 1; % element ID number
element(1).posnode = 2; % node ID connected to the element positive terminal
element(1).negnode = 1; % node ID connected to the element negative terminal
element(1).type = 'I'; % can be R (resistor), C (capacitor), L (inductor), V (independent voltage source), I (independent current source)
element(1).value = 1+1i; % value is a real number for R, L, and C elements and is a complex phasor for independent sources
element(1).volres = []; % a complex vector which is filled by element voltage frequency response
element(1).curres = []; % a complex vector which is filled by element current frequency response

% resistor
element(2).id = 2; % element ID number
element(2).posnode = 1; % node ID connected to the element positive terminal
element(2).negnode = 2; % node ID connected to the element negative terminal
element(2).type = 'R'; % can be R (resistor), C (capacitor), L (inductor), V (independent voltage source), I (independent current source)
element(2).value = 20; % value is a real number for R, L, and C elements and is a complex phasor for independent sources
element(2).volres = []; % a complex vector which is filled by element voltage frequency response
element(2).curres = []; % a complex vector which is filled by element current frequency response
```

*Task 1 continued on next page...*

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% inductor
element(3).id = 3; % element ID number
element(3).posnode = 1; % node ID connected to the element positive terminal
element(3).negnode = 2; % node ID connected to the element negative terminal
element(3).type = 'L'; % can be R (resistor), C (capacitor), L (inductor), V (independent voltage source), I (independent current source)
element(3).value = 0.1; % value is a real number for R, L, and C elements and is a complex phasor for independent sources
element(3).volres = []; % a complex vector which is filled by element voltage frequency response
element(3).curres = []; % a complex vector which is filled by element current frequency response

% capacitor
element(4).id = 4; % element ID number
element(4).posnode = 1; % node ID connected to the element positive terminal
element(4).negnode = 2; % node ID connected to the element negative terminal
element(4).type = 'C'; % can be R (resistor), C (capacitor), L (inductor), V (independent voltage source), I (independent current source)
element(4).value = 0.001; % value is a real number for R, L, and C elements and is a complex phasor for independent sources
element(4).volres = []; % a complex vector which is filled by element voltage frequency response
element(4).curres = []; % a complex vector which is filled by element current frequency response
```

*(a) Write a MATLAB function as "[element] = simulator(element, frequency)" that performs AC analysis for a given in-rest LTI RLC circuit over a desired positive frequency range such as* $1:1:1000$*. In fact, the function gets the element structure and frequency range as its inputs, computes the current and voltage frequency responses of the elements, fills the empty response fields of the element structure, and returns the filed element structure. You might use node, mesh, cut-set, or loop analysis for the function implementation. For this part, assume that the input frequency range covers a positive interval and the circuit has no problematic alone independent sources.*

*(b) Now, let the input frequency range include* $0$*. Particularly, it may only be a single* $0:1:0$ *value denoting the DC analysis. Improve your implementation to cover the DC analysis.*

*(c) Now, extend the function to handle the existence of the problematic independent sources.*

*(d) Use the developed simulator to analyze the frequency response of the given sample network in Fig. 1. Use the filled element structure to draw the voltage frequency response of the circuit. Plot the corresponding bode diagrams,*

*(e) Examine your developed simulator for several other circuits and discuss the obtained results.*

*(f) What does happen for your simulator if an exceptional case violating the KCL or KVL rules, such as two parallel voltage sources with different voltage values, occur in the circuit.*

*(g) Prepare a short report and describe your work concisely. Use suitable figures to better describe the developed codes and to make your report more readable and understandable. Attach a copy of the developed codes to your sent report. Make sure to provide descriptive comments for the codes.*

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## BONUS

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*Task 2 continued on next page...*

## Task 2

**You can get extra score by doing the optional tasks listed below.**

*(a) Extend the developed function to cover the existence of linear dependent sources. Plot the frequency response of a circuit having dependent sources using the developed simulator.*

*(b) Extend the developed function to cover the existence of coupled linear inductors and transformers. Plot the frequency response of a coupled circuit using the developed simulator.*

*(c) Improve the implementation to cover the transient analysis. You may need to add new fields to the element structure to include initial conditions and time profiles of independent sources.*

*(d) Return your report by filling the LaTeX template of the project. If you want to add a circuit schematic or a diagram, you can draw it directly using TikZ package, or draw it in a secondary application such as Microsoft Visio and then, import it as a figure. Another option is the website mathcha, where you can draw a desired diagram and receive its corresponding LaTeX code.*