

## ASSIGNMENT 2

**Due date: Sep 16, 2025 (4 PM)**

When solving circuits given numerical values for components, consider deriving the solution in symbolic form. This way, math errors may be spotted by performing a dimensional analysis on individual terms.

In general, in this and other assignments, certain problems are setup for you to practice technique. If you are asked to approach a problem a certain way, please do so. Marks will not be awarded for a correct answer that was obtained by a means other than what you were asked to execute.

Always indicate units in your answers.

Relevant Class Notes	Assessment Criteria
<b>LTI Systems</b> <b>Electronic Circuits (§ 6-22)</b>  There is also a Circuits Tutorial in the References section if you need more examples on how to solve circuits.	Interpret observations / results. Analyze a problem and obtain a correct result. Apply one or more procedure(s) to a problem. Write a MATLAB script to analyze a problem. Provide short answers to questions.

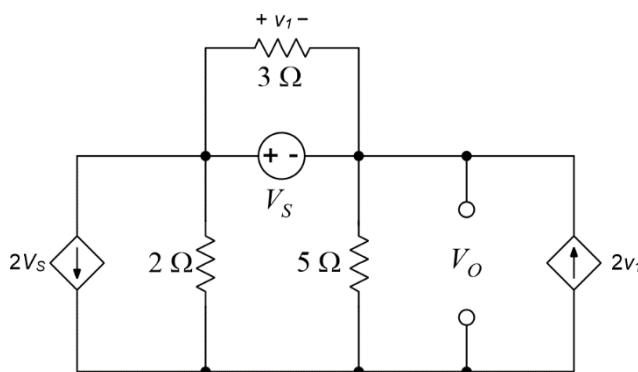
Manage your time. Having problems with the assignment? Discuss them with the instructor!

*Attachment02.zip* accompanies this assignment and contains needed MATLAB files.

### 1.(1/10)

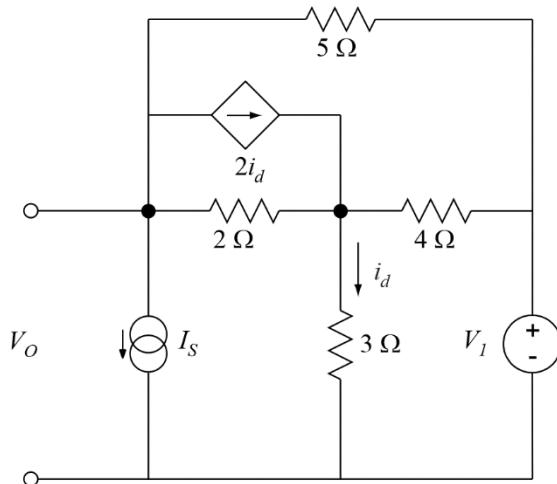
By *inspection*, classify the following systems as either linear or non-linear. Briefly justify your answer.

a)



Where  $V_s$  is the input and  $V_o$  is the output.

b)

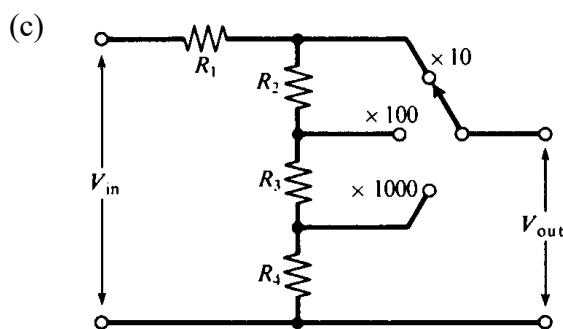
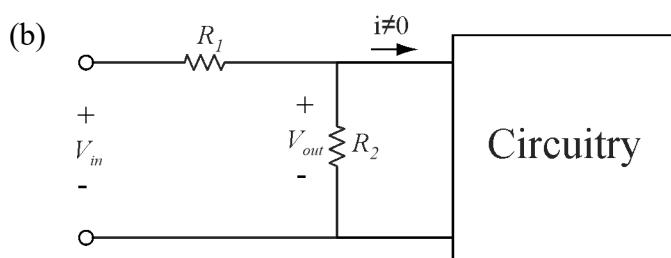
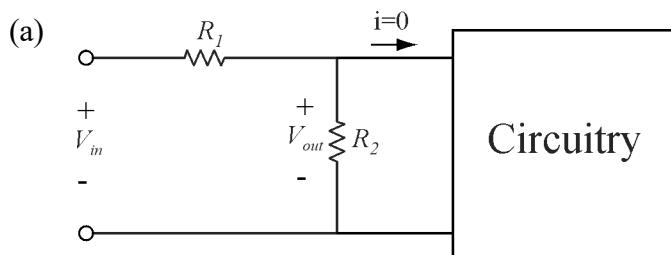


Where  $I_s$  is the input and  $V_o$  is the output.

Tip: Think of Thévenin models of each system and the resulting terms that appear in the driving-point equation (like the resulting voltage when the system is excited by a current source). In particular, how do dependent and independent sources express themselves in said equation?

## 2. (1.5/10)

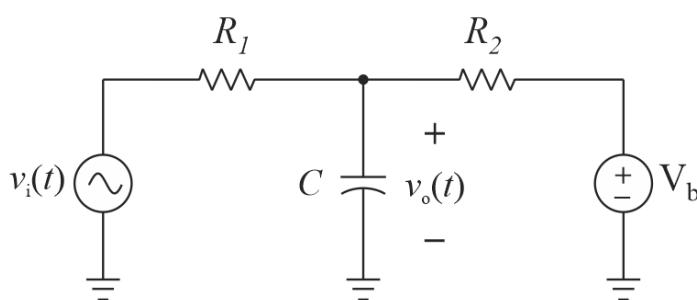
For which of the following scenarios does the voltage-divider equation  $V_{out} = \frac{R_2}{R_2+R_1} \cdot V_{in}$  apply? (Select all that apply. No explanation necessary.)



A switch-selectable voltage divider network.

The tap points provide attenuations of  $\times 10$ ,  $\times 100$ , and  $\times 1000$ . (I.e., gains of 0.1, 0.01, and 0.001, respectively.)

## 3. (3/10)



For the dynamic network shown to the left  $v_o(t)$  is the output;  $v_i(t)$  and  $V_b$  are the inputs. Use the network transform technique and the principle of superposition to solve for the steady-state response when  $v_i(t) = A \cos(\omega t)$  and  $V_b$  is constant.

For full marks you must address the initial condition on the capacitance and cast the portion of the answer relating to the sinusoidal steady-state in terms of a single trigonometric function.

Tips:

- Look over the Laplace Transform properties, especially to handle  $V_b$  correctly.
- The use of superposition allows one to employ the voltage divider rule. For example, when  $V_b = 0$ ,  $C$  and  $R_2$  appear in parallel with each other; the combination is then in series with  $R_1$ :
  - The parallel combination makes one ‘leg’ of the voltage divider topology.

- Alternatively, interchange the position of  $C$  and  $R_2$ , find the Thévenin equivalent of  $R_1$  and  $R_2$ , then apply the voltage divider rule on the Thévenin equivalent circuit and  $C_2$ .
- The technique shown in §17.2.3 in the note on *Electronic Circuits* should prove helpful.
- Circuit symmetry will allow you to write some answers by inspection.

#### 4.(2/10)

Figure 1 shows a circuit that is connected to (or is ‘driving’)  $R_4$ . Conceptually, this can be simplified to the equivalent circuit shown in Figure 2.

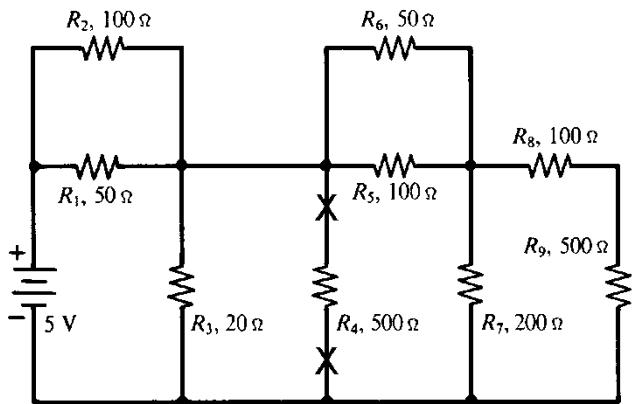


Figure 1. Circuit driving  $R_4$ .

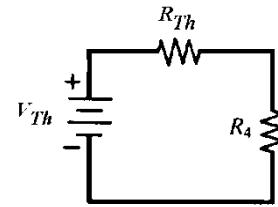
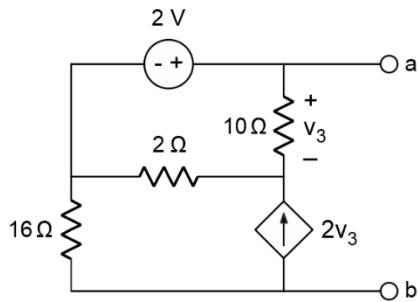


Figure 2. Thévenin equivalent circuit driving  $R_4$ .

a) Find the Thévenin equivalent network driving  $R_4$  by incrementally simplifying the circuitry around  $R_4$  to yield Figure 2. You may use only the voltage divider equation and formulae for parallel and series topologies. (For example,  $R_5$  and  $R_6$  are in parallel with each other....)

- Do not explicitly use KCL or KVL.
- Component values are provided in *Q4.mat*, in *Attachment02.zip*. These may be conveniently loaded by, and used in your script. (In other words, after the component values are loaded just use ‘R1’, ‘R2’, etc.)
- Load the *.mat* file into the MATLAB workspace with the following command: ‘load Q4’.
- Write a MATLAB script to solve for  $V_{Th}$  and  $R_{Th}$ , respecting the constraints of the problem.
- Attach your MATLAB code.
- *rp.m*, provided in *Supporting\_functions.zip*, computes parallel resistance values.

b) Using the Thévenin equivalent network and  $R_4$  (i.e., Figure 2) find the current through  $R_4$  and the resulting power dissipated in the component.

**5. (2.5/10)**

$v_3$  is a controlling variable and must be solved for. Note that it establishes the current direction through the  $10\Omega$  resistance.

a) Using the circuit-solving technique shown in class, write down the system of equations (KVL / KCL) required to determine the Thévenin or Norton equivalent circuits between terminals  $a-b$ .

- Use Method 1 from §22 of the class notes on *Electronic Circuits* and drive the system with a voltage source.
- Do not solve the equations
- Do not use superposition

b) On paper one would solve the system of equations symbolically and parse the result to determine equivalent-model parameters ( $V_{Th}$ ,  $I_N$ ,  $R_{eq}$ ). However, when such a model must be determined for a physical device – or even when using a circuit simulator – there is no symbolic solution. That is virtually the case here.

The function *Q5.p*, in *Assignment02.zip*, computes the driving-point current into  $a$  when a constant arbitrary driving-point voltage is applied at  $a$  with respect to  $b$ . Think of *Q5.p* as an instrument for measuring current.

- Devise the necessary experiment(s) that allow you to use *Q5.p* to determine the Thévenin and Norton equivalent networks. Attach your commented MATLAB code.
- Sketch the two equivalent networks.

c) List two reasons why it is of interest to find the Thévenin or Norton equivalent of circuits. (Brief answers please.)

d) Is it guaranteed that both Thévenin and Norton equivalent circuits exist for an LTI system?

**6. (0.5/10) Bonus**

Report the amount of time spent on this assignment.

**Relevant MATLAB function(s):**

`format` Controls how numbers are displayed in the MATLAB command window. (e.g., `format shorteng`)

`load` Loads data from a MAT-file into the workspace.

For example, including ‘`load Q4.mat`’ in a MATLAB script imports the variables and values stored in the MAT file.

`rp*` Computes the parallel resistance value.

(\*): Supplied in *Supporting\_functions.zip*