Information Technology University, Lahore, Pakistan

Electrical Network Analysis (EE-241)

Assignment # 1, Spring 2021

Submission Deadline: Wednesday April 07, 2021 Maximum Marks: 100

- Late submissions will not be graded.
- Scan your hand-written assignment and submit on the Google Classroom in the given space.
- This Assignment will be conducted under the rules and guidelines of the ITU Honour Code and no cheating will be tolerated (i.e. no discussion about the Assignment with other students, no plagiarism at all). Each student must be able to justify his/her work.

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1. Consider the following unit-step functions:
   - $f(t) = 5u(t-1)$
   - $g(t) = 3u(-t) + 5$
   - $h(t) = 4u(1-t) + 2u(t+2)$
   - $i(t) = tu(2-t)$
   - $j(t) = u(t) - u(t-0.5) + u(t-1) - u(t-1.5) + u(t-2) - u(t-2.5)$
   - $k(t) = 3u(t) - 2u(-t) + 0.8u(1-t)$
   - $l(t) = 3 - u(2-t) - 2u(t)$

   (a) Evaluate the function $f(t)$ at $t = -3, 0$ and $+3$. [3]

   (b) Evaluate the functions $h(t)$ at $t = 0$ and $+2$. [2]

   (c) Evaluate the function $k(t)$ at $t = 0.8$. [1]

   (d) Sketch all the function over the range $-3 \leq t \leq 3$: [14]

2. (a) The resistor in the circuit of Figure 1 has been included to model the dielectric layer separating the plates of the 3.1 nF capacitor, and has a value of 55 MΩ. The capacitor is storing 200 mJ of energy just prior to $t = 0$.

   i. Write an expression for $v(t)$ valid for $t \geq 0$. [4]

   ii. Compute the energy remaining in the capacitor at $t = 170$ ms. [2]

   iii. Graph $v(t)$ over the range of $0 < t < 850$ ms, and identify the value of $v(t)$ when $t = 2\tau$. [4]

   (b) The resistor in the circuit of Figure 1 has a value of 1 Ω and is connected to a 22 mF capacitor. The capacitor dielectric has infinite resistance, and the device is storing 891 mJ of energy just prior to $t = 0$.

   i. Write an expression for $v(t)$ valid for $t \geq 0$. [2]

   ii. Compute the energy remaining in the capacitor at $t = 11$ ms and 33 ms. [2]

   iii. If it is determined that the capacitor dielectric is much leakier than expected, having a resistance as low as 100 kΩ, repeat parts (a) and (b). [4]

   (c) Calculate the time constant of the circuit depicted in Figure 1 if C = 10 mF and R is equal to $(i).1\,\Omega (ii).100\,\Omega$ [2]

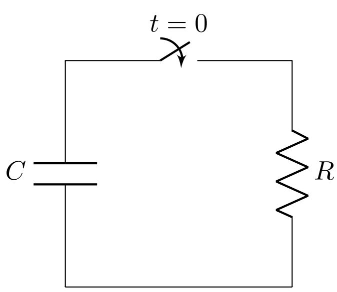

Figure 1: Circuit for problem 2

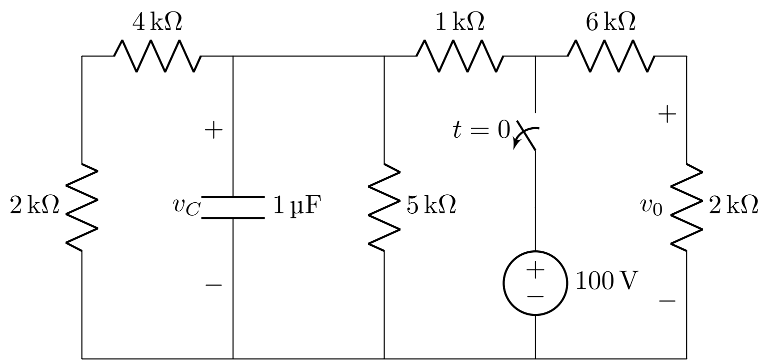

Figure 2: Circuit for problem 3a

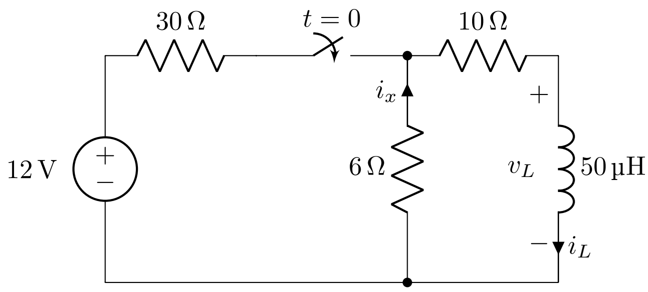

Figure 3: Circuit for problem 3b

3. (a) Determine $v_C(t)$ and $v_o(t)$ as labeled in the circuit represented by Figure 2 for t equal to 0^-, 0^+, 10 ms and 12 ms. [8]
   (b) For the circuit of Figure 3, determine i_x, i_L and v_L at $t = 0^-$ and at $t = 0^+$. [6]
   (c) For the circuit shown in Figure 4, determine $v_C(0^-)$, $v_C(0^+)$, τ and $v_C(3\,\text{ms})$. [6]

4. (a) With reference to the simple circuit depicted in Figure 5, compute $i(t)$ for $t = 0^-$, 0^+, 2^-, 2^+, 4 ms. [5]
   (b) Plot the current $i(t)$ in Figure 6 if $R = 10\,\Omega$ and then for $R = 1\,\Omega$. In which case does the inductor (temporarity) store the most energy? Explain. [5]
   (c) Obtain an expression for i_1 as indicated in Figure 7 that is valid for all values of t. [10]

5. (a) The circuit in Figure 8 contains two switches that always move in perfect synchronization. However, when switch A opens, switch B closes, and vice versa. Switch A is initially open, while switch B is initially closed; they change positions every 40 ms. Using the bottom node as the reference node, determine the voltage across the capacitor at t equal to [10]
      i. 0^-
      ii. 0^+
      iii. 40^- ms
      iv. 40^+ ms
      v. 50 ms
   (b) In the circuit of Figure 8, when switch A opens, switch B closes, and vice versa. Switch A is initially open, while switch B is initially closed; they change positions every 400 ms. Determine the energy in the capacitor at t equal to [10]
      i. 0^-
      ii. 0^+
      iii. 200 ms
      iv. 400^- ms
      v. 400^+ ms
      vi. 700 ms

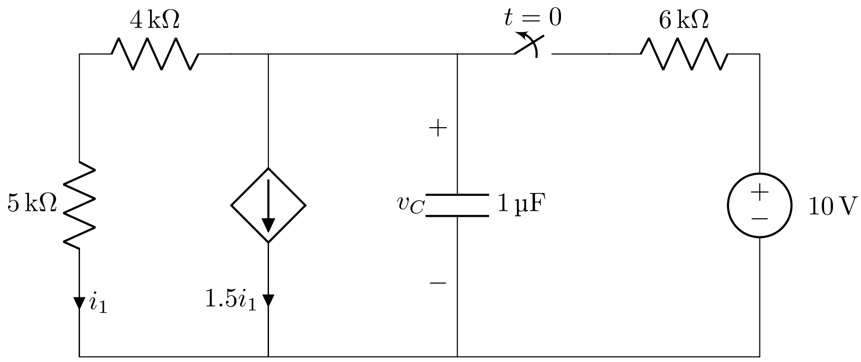

Figure 4: Circuit for problem 3c

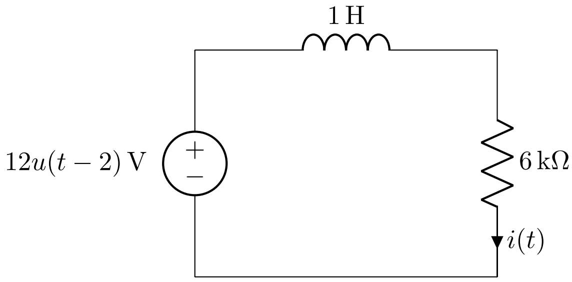

Figure 5: Circuit for problem 4a

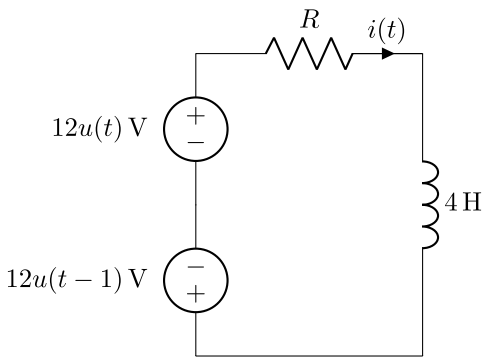

Figure 6: Circuit for problem 4b

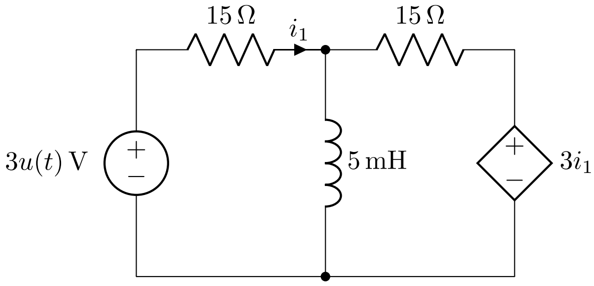

Figure 7: Circuit for problem 4c

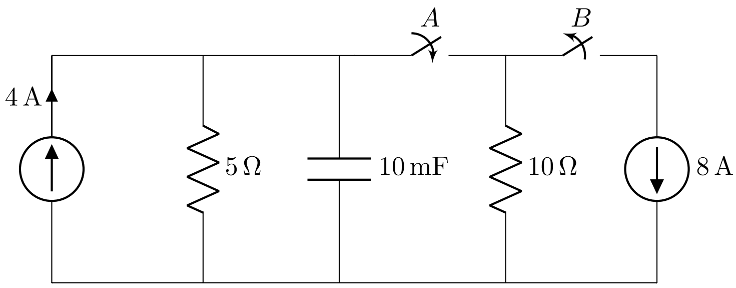

Figure 8: Circuit for problem 5