Department of Electrical and Electronic Engineering

Summer 2022

EEE 204: Numerical Techniques in Engineering

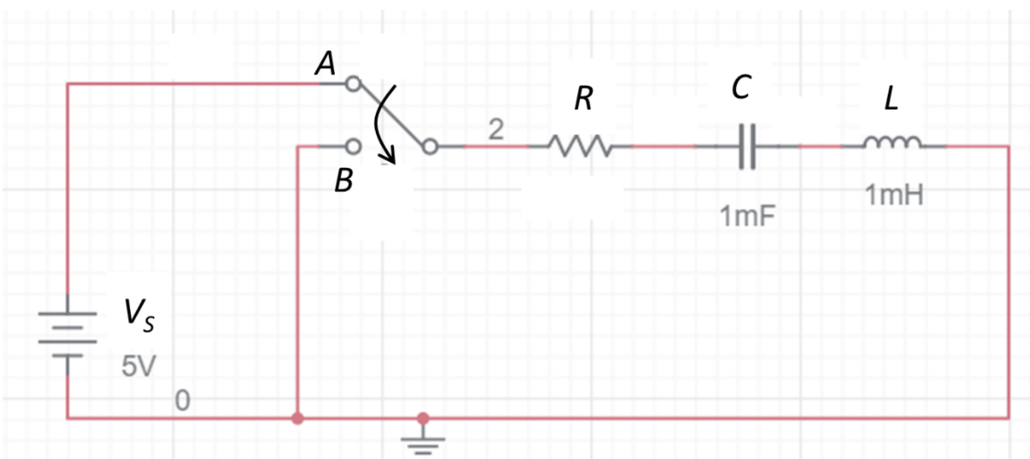
Section (1)

Mid-2 Project

Total marks: 35. Rubrics for assessment given in a separate file.

Instructions:

1. Deadline: Aug. 18, 2022 (submission of report + online submission + viva)
2. You can discuss with TA or instructor.
3. Students who copy will either withdraw the course or be sent to disciplinary committee.



The circuit was kept at position A for a long time. Then it switches from A to B at time $t = 0$ triggering a transient response of voltage and current before reaching steady values. The goal of this project is to analyze the transient behavior of the system. The current $i(t)$ through the circuit at $t = 0$ is $i(0) = 0$ mA, and at $t = 50$ ms is $i(50\text{ms}) = 132.56$ mA. The circuit parameters are: $V_S = 5$ V, $R = 0.1\Omega, L = 1\text{mH}, C = 1\text{mF}$.

1. Setting up the equations:
    a. Appropriately mark the directions (arrows and $+/-$) of i, v_R, v_L, v_C in the circuit.
    b. Find the differential equation for the system and also write its boundary conditions.
    c. Then derive the difference equation along with appropriate coefficient values.
    d. Write the system equations in a matrix forms including the boundary conditions.

2. In MATLAB, write a code to solve the differential equation (for now you can set $n = 1000$).
3. The exact solution can be found as follows:

$$\alpha = \frac{R}{2L} \text{ and } \omega_0 = \frac{1}{\sqrt{LC}}$$

$$s1 = -\alpha + \sqrt{\alpha^2 - \omega_0^2} \text{ and } s2 = -\alpha - \sqrt{\alpha^2 - \omega_0^2}$$

$$A = -\frac{V_S}{L(s1 - s2)}$$

$$i_{exact}(t) = A\exp(s1\, t) - A\exp(s2\, t)$$

4. Find and plot the following:
    a. Voltage across the inductor $v_L(t)$. [Hint: how is i related to v_L?]
    b. Instantaneous power $P_R(t)$ dissipated in the resistor.
    c. Instantaneous power absorbed by the inductor P_L vs t.
5. Visualizations and plots:
    a. Plot the numerically solved i vs t for $n = 100$. Also plot the exact solution in the same plot. What is the amount of error $E_n = \sqrt{\sum e_i^2/n}$?
    b. Plot the numerically solved v_L vs t for $n = 100$.
    c. Plot the numerically solved P_R vs t for $n = 100$. Also plot the exact solution in the same plot.
    d. Repeat a, b, c for $n = 200, 500, 1000, 5000$. [$n = 5000$ may take couple of minutes to run].
    e. Comment on the accuracy of the solution for different n. Does the accuracy improve with n? Why?
6. Find and plot E_n vs n for $n =$ [75:25:1000 2000 3500 5000]. (You may need to write another code with a loop for n). Comment on the accuracy/error.

Bonuses:

1. First three students to complete [**Bonus 2pts**]
2. If you choose to do a higher difficulty level problem-set [**Bonus 3pts**]