ENGR 065 Circuit Theory

Laboratory 9

Transient Responses of Second Order RLC Circuits

Objectives

- Observe the transient responses of RLC circuits.
- Learn how R, L, and C affect the circuit behaviors.

Equipment and components

- A desk computer
- PSPICE software

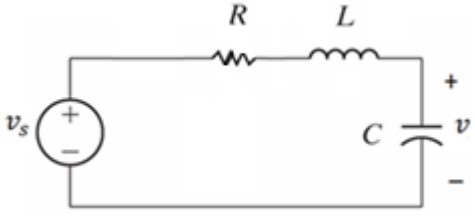
Preliminary

- **Read the lecture slides of "Inverse Laplace Transform and RC, RL, and RLC Circuits".**
- Find the voltage across a capacitor in each circuit. Find Neper frequency α, and resonant (radian) frequency $\omega_0$and damping factor $\frac{\alpha}{\omega_0}$ for each circuit.
- Find the resistance of the resistor with which each circuit response (the voltage) is overdamped, underdamped, and critically damped.

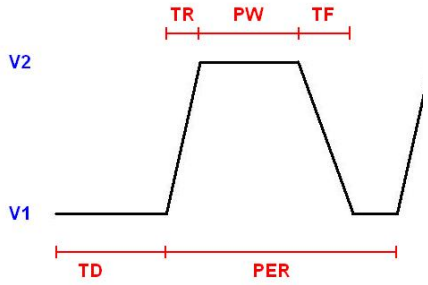
Procedure

The Series RLC circuit

1. Open PSpice and build the circuit shown below. Set $L = 10\,mH, C = 0.01\,\mu F, and\ R = 10\,k\Omega$. v_s is a pulse voltage source.



2. Select VPULSE from Part box. The definitions of each parameters in VPULSE are shown below. Set $V_1 = 0, V_2 = 10, TR = TF = TD = 0, PW = 1\ ms, and\ PER = 2\ ms$.

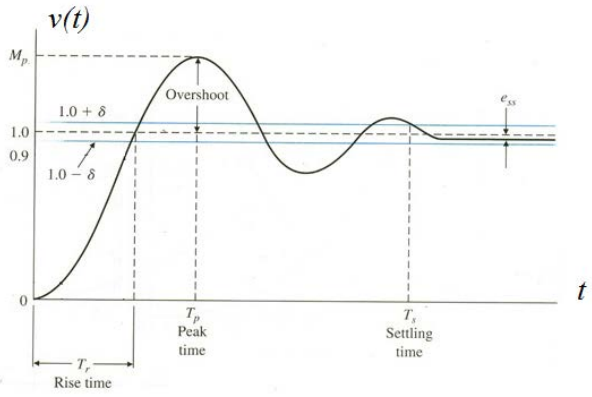


3. If R = 10 kΩ. What type of response do you obtain for the voltage?
4. Calculate R to obtain a critical response. What is the value of R when the circuit has the critically damped response.
5. Set R to 500 Ω. What type of response do you obtain for the voltage?
6. Measure the four major specifications that define the response of a second order system/circuit.

    1) **The rise time (T_r)** is used to measure the swiftness of the circuit, which is defined as the time required reaching 90% of the reference input (the source).
    2) **The overshoot (PO)** is used to measure the closeness of the response to the reference in terms of %. It is calculated as:

    PO = ((M_p – final value)/final value)*100

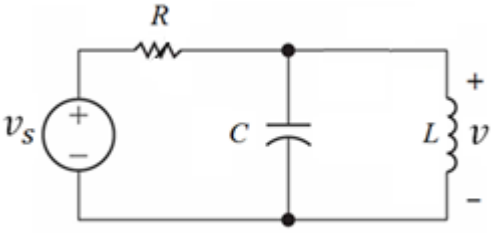
    3) **The peak time (T_p)** measures the time taken to reach the maximum response.
    4) **The settling time (T_s)** is the time required for the circuit to settle within a certain percentage of the reference input ($\pm\delta$). Here, we choose $\boldsymbol{\delta = 5\%}$.



Note: for critically and overdamped responses, only the rise time (T_r) is required to measure.

The parallel RLC circuit

1. Construct the circuit shown below in PSPICE.



2. Set $L = 10\ mH, C = 0.01\ \mu F, and\ R = 10\ k\Omega$.
3. Set the source to be a square pulse and use the same parameters as described for the series RLC circuit.
4. If R = 10 kΩ. What type of response do you obtain for the voltage?
5. Find the value of R to result in a critically damped response.
6. Set R to be 200 Ω. Observe the voltage response.
7. Compare the responses of the two circuits, explain why they are different for three different responses.

Questions and conclusions

- Summarize your findings and explanations in response to the questions given in this lab.