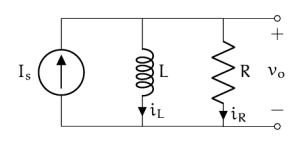


can.exe Exercises for Chapter can

Exercise can.mcd

Use the diagram below to answer the following questions and imperatives. Let $I_s = A_0$, where $A_0 \in \mathbb{R}$ is a known constant. Perform a full circuit analysis, including the transient response. The initial inductor current is $i_L(0) = 0$.

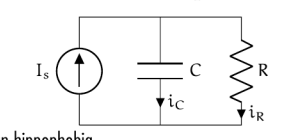
- Write the elemental, KCL, and KVL equations.
- Write the differential equation for $i_L(t)$ arranged in the standard form and identify the time constant τ .
- Solve the differential equation for $i_L(t)$ and use the solution to find the output voltage $v_o(t)$.



Exercise can.theoretically

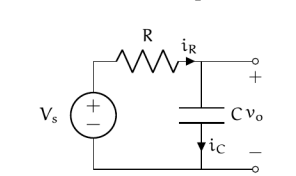
Use the diagram below to answer the following questions and imperatives. Let $I_s = A_0$, where $A_0 \in \mathbb{R}$ is a known constant. Perform a full circuit analysis, including the transient response. The initial capacitor voltage is $v_C(0) = v_{C0}$, a known constant.

- Write the elemental, KCL, and KVL equations.
- Write the differential equation for $v_C(t)$ arranged in the standard form.
- Solve the differential equation for $v_C(t)$.



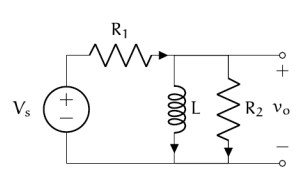
Exercise can.hippohoto

For the RC circuit diagram below, perform a complete circuit analysis to solve for $v_o(t)$ if $V_s(t) = A \sin \omega t$, where $A \in \mathbb{R}$ is a given amplitude and $\omega \in \mathbb{R}$ is a given angular frequency. Let $v_C(t)|_{t=0} = v_{C0}$, where $v_{C0} \in \mathbb{R}$ is a given initial capacitor voltage. Hint: you will need to solve a differential equation for $v_C(t)$.



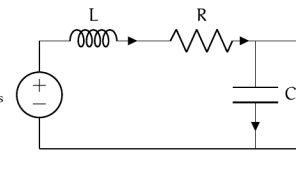
Exercise can.frustration

For the circuit diagram below, perform a complete circuit analysis to solve for $v_o(t)$ if $V_s(t) = A \sin \omega t$, where $A \in \mathbb{R}$ is a given amplitude and $\omega \in \mathbb{R}$ is a given angular frequency. Let $i_L(t)|_{t=0} = 0$ be the initial inductor current. Hint: you will need to solve a differential equation for $i_L(t)$.



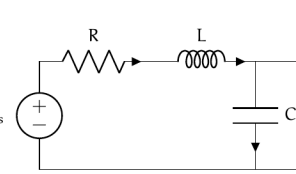
Exercise can.gstobobium

For the circuit diagram below, perform a complete circuit analysis to solve for $v_o(t)$ if $V_s(t) = 0$. Let $v_C(t)|_{t=0} = 5$ V and $dv_C/dt|_{t=0} = 0$ V/s be the initial conditions. Assume the characteristic equation has distinct roots. Recommendation: due to the initial conditions being given in it, solve the differential equation in v_C .



Exercise can.thyopptic

For the circuit diagram below, perform a complete circuit analysis to solve for $v_o(t)$ if $V_s(t) = 3 \sin(10t)$. Let $v_C(t)|_{t=0} = 0$ V and $dv_C/dt|_{t=0} = 0$ V/s be the initial conditions. Assume the characteristic equation has distinct, complex roots. Recommendation: due to the initial conditions being given in it, solve the differential equation in v_C . Also, consider which, if any, of your results from Exercise can. apply and re-use them, if so.



$$E_{lem} + I_s! E_q$$

$$V_R = I_R R$$

$$\frac{dV_C}{dt} = \frac{1}{C} I_C = \frac{1}{C} I_L$$

$$\frac{dI_L}{dt} = \frac{1}{L} V_L$$

$$KCL$$

$$I_R = I_L = I_C$$

$$KVL$$

$$V_S = V_R + V_L + V_C$$

$$V_C = V_S - V_R - V_L$$

$$\frac{d^2 V_C}{dt^2} = \frac{1}{C} \frac{dI_L}{dt}$$

$$= \frac{1}{C} \frac{d}{dt} \left(\frac{1}{L} (V_S - V_R - V_C) \right)$$

$$= \frac{1}{C} \frac{d}{dt} (V_S - I_R R - V_C)$$

$$= \frac{1}{C} \frac{d}{dt} (V_S - I_L R - V_C)$$

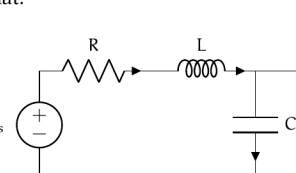
$$= \frac{1}{C} \frac{d}{dt} (V_S - R \frac{dV_C}{dt} - V_C)$$

$$\frac{d^2 V_C}{dt^2} + \frac{R}{L} \frac{dV_C}{dt} + \frac{1}{C} V_C = \frac{1}{C} 3 \sin(10t)$$

$$V_C(0) = 0 \quad \left. \frac{dV_C}{dt} \right|_{t=0} = 0$$

Exercise can.hamogenesis

For the circuit diagram below, solve for $v_o(t)$ if $V_s(t) = A \sin \omega t$, where $A = 2$ V is the given amplitude and $\omega \in \mathbb{R}$ is a given angular frequency. Let $R = 50 \Omega$, $L = 50$ mH, and $C = 200$ nF. Let the circuit have initial conditions $v_C(0) = 1$ V and $i_L(0) = 0$ A. Find the steady-state ratio of the output amplitude to the input amplitude A for $\omega = \{5000, 10000, 50000\}$ rad/s. This circuit is called a low-pass filter—explain why this makes sense. Plot $v_o(t)$ in MATLAB, Python, or Mathematica for $\omega = 400$ rad/s (you think this won't be part of the quiz, but it will be!). Hint: either re-write your system of differential-algebraic equations and initial conditions as a single second-order differential equation with initial conditions in the differential variable or re-write it as a system of two first-order differential equations and solve that.



low-pass filter

$$\lambda^2 + \frac{R}{L} \lambda + \frac{1}{C} = 0$$

$$\lambda = \lambda_1, \lambda_2 \quad \lambda_1 \neq \lambda_2$$

$$V_h = c_1 e^{\lambda_1 t} + c_2 e^{\lambda_2 t}$$

$$V_{sp} = K_1 \sin(\omega t) + K_2 \cos(\omega t)$$

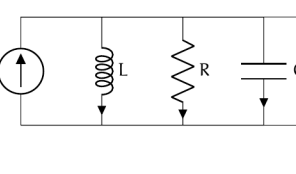
$$\frac{dV_{sp}}{dt} = 10 K_1 \cos(10t) - 10 K_2 \sin(10t)$$

$$\frac{dV_C}{dt} = -100 K_1 \sin(10t) - 100 K_2 \cos(10t)$$

Exercise can.photochrome

Use the circuit diagram below to answer the following questions and imperatives. Let $I_s = A_0$, where $A_0 > 0$ is a known constant. Perform a full circuit analysis, including the transient response. The initial inductor current is $i_L(0) = 0$ and the initial capacitor voltage is $v_C(0) = 0$. Assume the damping ratio $\zeta \in (0, 1)$; i.e. the system is underdamped and the roots of the characteristic equation are complex.

- Write the elemental, KCL, and KVL equations.
- Write the second-order differential equation for $i_L(t)$ arranged in the standard form and identify the natural frequency ω_n and damping ratio ζ .
- Convert the initial condition in v_C to a second initial condition in i_L .
- Solve the differential equation for $i_L(t)$ and use the solution to find the output voltage $v_o(t)$. It is acceptable to use a known solution and to express your solution in terms of ω_n and ζ .



—/20 p.

Steady-state circuit analysis does not require the, at times, lengthy process of solving differential equations. Impedance methods, presented in this chapter, are shortcuts to steady-state analysis. It is important to note that impedance methods do not give information about the transient response.