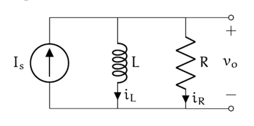
can.exe Exercises for Chapter can

Exercise can.mad

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 $i_L(0) = 0$.

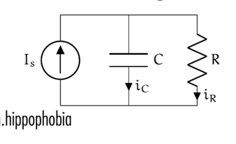
(a) Write the elemental, KCL, and KVL equations.
(b) Write the differential equation for $i_L(t)$ arranged in the standard form and identify the time constant τ.
(c) Solve the differential equation for $i_L(t)$ and use the solution to find the output voltage $v_o(t)$.



Exercise can.theocratically

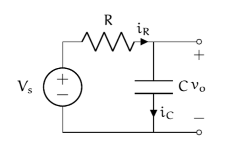
Use the diagram below to answer the following questions and imperatives. Let $I_s = A_0$, where $A_0 \in \mathbb{R}$ is a known constant. Perform a full circuit analysis, including the transient response. The initial capacitor voltage is $v_C(0) = v_{C0}$, a known constant.

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



Exercise can.hippophobia

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 $v_C(t)$.



Elemental Eq's

$V_R = i_R R$ $\qquad V_o = V_c$

$\frac{dV_c}{dt} = \frac{1}{C} i_c$ $\qquad V_s = A \sin wt$

KCL $i_R = i_c$

KVL $V_s = V_R + V_c$

$$\frac{dV_c}{dt} = \frac{1}{C} i_R = \frac{1}{RC} V_R = \frac{1}{RC}(V_s - V_c)$$

$$\frac{dV_c}{dt} + \frac{1}{RC} V_c = \frac{1}{RC} A \sin(wt)$$

$$\lambda + \frac{1}{RC} = 0 \Rightarrow \lambda = \frac{-1}{RC}$$

$$V_{cp} = C_1 e^{-t/RC}$$

$$V_{ch} = K_1 \sin(wt) + K_2 \cos(wt)$$

$$\frac{dV_{ch}}{dt} = K_1 w \cos(wt) - K_2 w \sin(wt)$$

$$K_1 w \cos(wt) - K_2 w \sin(wt) + \frac{1}{RC}(K_1 \sin(wt) + K_2 \cos(wt)) = \frac{A \sin(wt)}{RC}$$

$$K_1 w \cos(wt) + \frac{K_2}{RC} \cos(wt) = 0 \Rightarrow K_1 w + \frac{K_2}{RC} = 0$$

$$-K_2 w + \frac{K_1}{RC} = \frac{A}{RC}$$

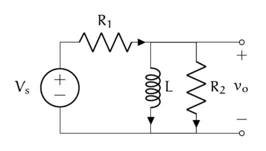
$$V_c = C_1 e^{-t/RC} + K_1 \sin(wt) + K_2 \cos(wt)$$

$$V_c(0) = V_{c0}$$

$$V_{c0} = C_1 + K_2 \Rightarrow C_1 = V_{c0} - K_2$$

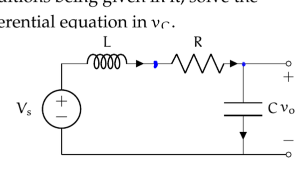
Exercise can.fruitarianism

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.gastrolobium

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.



$V_c = V_o$

KCL

$i_L = i_R \qquad i_R = i_c \qquad i_L = i_c$

KVL

$$V_s = V_L + V_R + V_c \Rightarrow V_L = V_s - V_R - V_c$$

Elemental Eq's

$V_R = i_R R$

$$\frac{dV_c}{dt} = \frac{1}{C} i_c \Rightarrow \frac{d^2V_c}{dt^2} = \frac{1}{C}\frac{di_c}{dt} = \frac{1}{C}\frac{di_L}{dt}$$

$$\frac{di_L}{dt} = \frac{1}{L} V_L = \frac{1}{L}(V_s - V_R - V_c) = \frac{1}{L}(V_s - i_R R - V_c) = \frac{1}{L}(V_s - i_L R - V_c)$$

$$\frac{d^2V_c}{dt^2} = \frac{1}{LC}(V_s - i_L R - V_c) = \frac{1}{LC}(V_s - i_c R - V_c) = \frac{1}{LC}\left(V_s - RC\frac{dV_c}{dt} - V_c\right)$$

$$\frac{d^2V_c}{dt^2} + \frac{R}{L}\frac{dV_c}{dt} + \frac{1}{LC} V_c = \frac{1}{LC} V_s = 0$$

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

assume $\lambda = \lambda_1, \lambda_2 \qquad \lambda_1 \neq \lambda_2$

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

$$V_c(0) = 5 \qquad \left.\frac{dV_c}{dt}\right|_{t=0} = 0$$

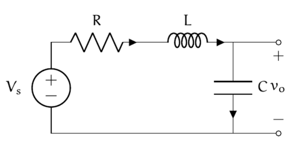
$$V_c(0) = C_1 + C_2 = 5$$

$$\frac{dV_c}{dt} = C_1 \lambda_1 e^{\lambda_1 t} + C_2 \lambda_2 e^{\lambda_2 t}$$

$$\left.\frac{dV_c}{dt}\right|_{t=0} = C_1\lambda_1 + C_2\lambda_2 = 0$$

Exercise can.thyroprivic

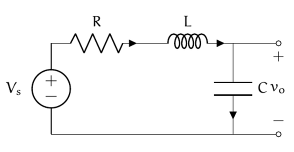
For the circuit diagram below, perform a complete circuit analysis to solve for $v_o(t)$ if $V_s(t) = 3 \sin(10t)$. Let $v_C(t)|_{t=0} = 0$ V and $dv_C/dt|_{t=0} = 0$ V/s be the initial conditions. Assume the characteristic equation has distinct, complex roots. Recommendation: due to the initial conditions 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.



Exercise can.hemogenesis

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



Exercise can.photochromascope

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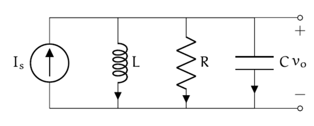
Use the circuit diagram below to answer the following questions and imperatives. Let $I_s = A_0$, where $A_0 > 0$ is a known constant. Perform a full circuit analysis, including the transient response. The initial inductor current is $i_L(0) = 0$ and the initial capacitor voltage is $v_C(0) = 0$. Assume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

(a) Write the elemental, KCL, and KVL equations.
(b) 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.
(c) Convert the initial condition in v_C to a second initial condition in i_L.
(d) 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.



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Steady−state circuit analysis

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.