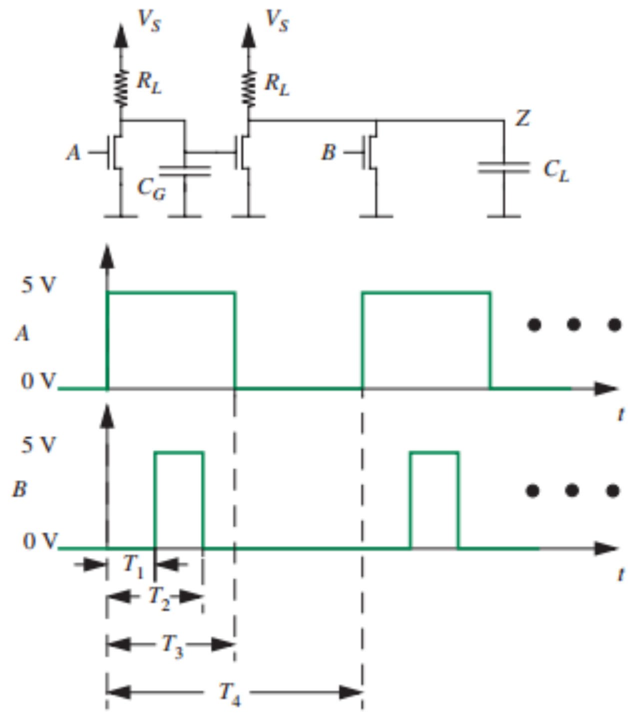
EE2210 Electric Circuits **Spring 2018**

Practice problems for Lecture 8 – Lecture 10

1. This problem examines the power dissipated by a small digital logic circuit. The circuit comprises a series-connected inverter and NOR gate as shown in the following figure. The circuit has two inputs, A and B, and one output, Z. The inputs are assumed to be periodic with period T_4 as shown in the following figure. Assume that RON for each MOSFET is zero.



a) Sketch and clearly label the waveform for the output Z for $0 \leq t \leq T_4$. In doing so, assume that C_G and C_L are both zero.

b) Derive the time-average static power consumed by the circuit in terms of V_S, R_L, T_1, T_2, T_3, and T_4. Here, time-average power is defined as the total energy dissipated by the gate during the period $0 \leq t \leq T_4$ divided by T_4.

c) Now assume that C_G and C_L are nonzero. Derive the time-average dynamic power consumed by the circuit in terms of V_S, R_L, C_G, C_L, T_1, T_2, T_3, and T_4. In doing so, assume that the circuit-time constants are all much smaller than T_1, $T_2 - T_1$, $T_3 - T_2$, and $T_4 - T_3$.

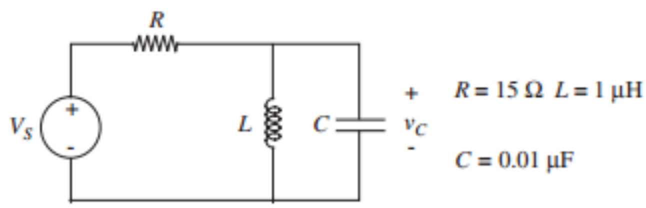
d) Evaluate the time-average static and dynamic powers for V_S = 5 V, R_L = 10 kΩ, C_G = 100 fF, C_L = 1 pF, T_1 = 100 ns, T_2 = 200 ns, T_3 = 300 ns, and T_4 = 600 ns.

e) What is the amount of energy consumed by the circuit in 1 minute for the parameters in part (d)?

f) By what percentage does the total time-average power consumption drop if the power supply voltage V_S drops by 30%?

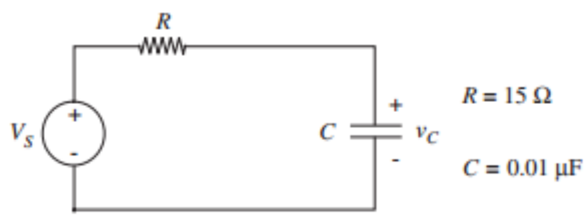
2.

a) Is the zero input response of the circuit shown in the following figure under-damped, overdamped, or critically-damped?



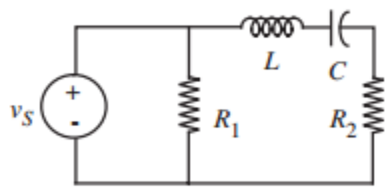
b) What is the form of the zero input response (v_C) for the same circuit in part (a)? Make a rough sketch.

c) Compare the envelope of the zero input response with the rate of decay of the zero input response of the RC circuit in the following figure.



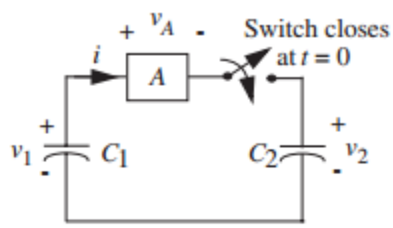
3. Is the zero-input response of the circuit in the following figure under-damped, over-damped, or critically-damped? (Provide some kind of justification for your answer, either a calculation or a sentence of explanation.)

L = 1 μH C = 0.01 μF and $R_1 = R_2$ = 15Ω



4. Capacitor C_1 has an initial voltage $v_1(0)$ = V. Capacitor C_2 is initially uncharged, $v_2(0)$

= 0. The voltage across element A tends to zero as time tends to infinity. At time t = 0, the switch is closed. Refer to the following figure.



a) Compute the initial charge of the system.

b) Find the voltage across both capacitors a long time after the switch has been closed. Remember that the total charge of the system must be conserved.

c) Find the energy stored in the system after a long time.

d) Find the ratio of final stored energy to initial energy. Where did the rest of the energy go?

e) Assume element A is a resistor R. Find its voltage or current, and from that, find out the energy lost in it.

f) Find the ratio of lost energy to initial energy. Is it what you expected? Does it depend on R?

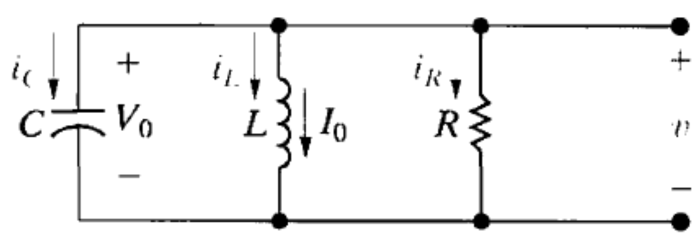
g) What would happen if an inductor was placed in series with R? Sketch the behavior of the current. (No calculations are needed.)

5. The circuit elements in the following circuit are R = 200Ω, C = 200nF, and L = 50mH. The initial inductor current is -45mA, and the initial capacitor voltage is 15V.

a) Calculate the initial current in each branch of the circuit.

b) Find v(t) for $t \geq 0$.

c) Find $i_L(t)$ for $t \geq 0$.

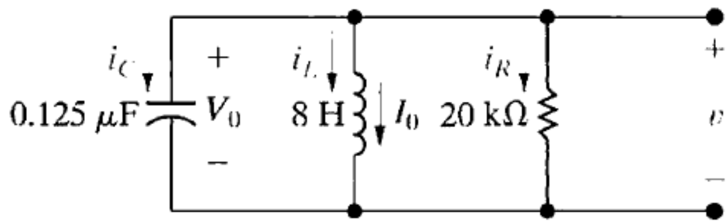


6.

a) For the following circuit, find the value of R that results in a critically damped voltage response.

b) Calculate v(t) for $t \geq 0$.

c) Plot v(t) versus t for $0 \leq t \leq 7ms$.



7. The 0.1μF capacitor in the following circuit is charged to 100V. At t = 0, the capacitor is discharged through a series combination of a 100mH inductor and a 560Ω resistor.

a) Find i(t) for $t \geq 0$.

b) Find $v_C(t)$ for $t \geq 0$.