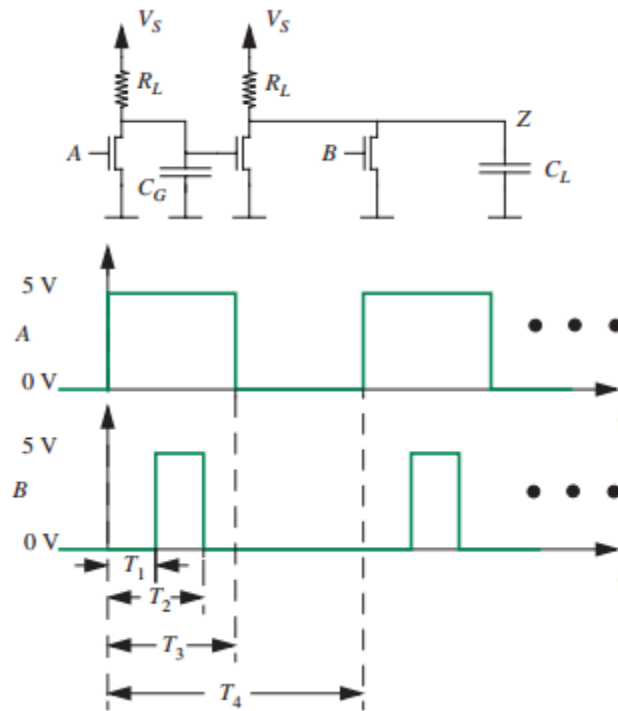


EE2210 Electric Circuits, Spring 2017
Practice problems (Lecture8-Lecture10)

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 R_{ON} for each MOSFET is zero.

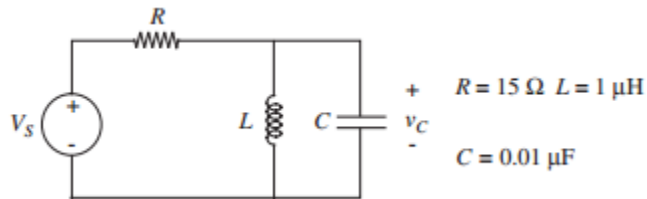


- a) Sketch and clearly label the waveform for the output Z for $0 \leq t \leq T_4$. In doing so, assume that C_G and C_L are both zero.
- b) Derive the time-average static power consumed by the circuit in terms of V_S , R_L , T_1 , T_2 , T_3 , and T_4 . Here, time-average power is defined as the total 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 $T_4 - T_3$.

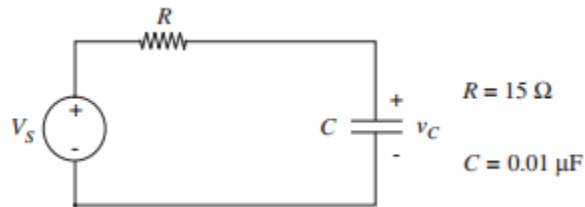
- d) Evaluate the time-average static and dynamic powers for $V_S = 5\text{ V}$, $R_L = 10\text{ k}\Omega$, $C_G = 100\text{ fF}$, $C_L = 1\text{ pF}$, $T_1 = 100\text{ ns}$, $T_2 = 200\text{ ns}$, $T_3 = 300\text{ ns}$, and $T_4 = 600\text{ ns}$.
- e) What is the amount of energy consumed by the circuit 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?

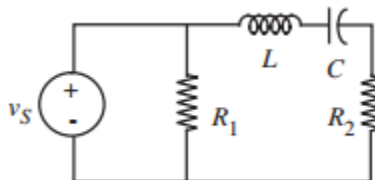


- b) What is the form of the zero input response (v_C) for the same circuit in part (a)? Make a rough sketch.
- c) Compare the envelope of the zero input response with the rate of decay of the zero input response of the RC circuit in the following figure.

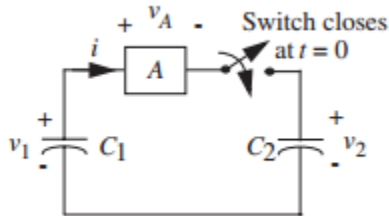


3. Is the zero-input response of the circuit in the following figure under-damped, over-damped, or critically-damped? (Provide some kind of justification for your answer, either a calculation or a sentence of explanation.)

$L = 1\ \mu\text{H}$ $C = 0.01\ \mu\text{F}$ and $R_1 = R_2 = 15\ \Omega$

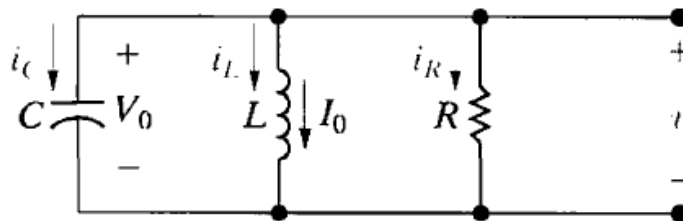


4. Capacitor C_1 has an initial voltage $v_1(0) = V$. Capacitor C_2 is initially uncharged, $v_2(0) = 0$. The voltage across element A tends to zero as time tends to infinity. At time $t = 0$, the switch is closed. Refer to the following figure.



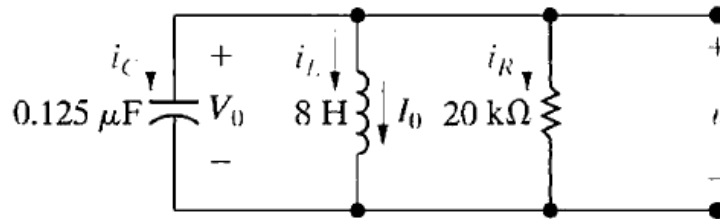
- Compute the initial charge of the system.
 - Find the voltage across both capacitors a long time after the switch has been closed. Remember that the total charge of the system must be conserved.
 - Find the energy stored in the system after a long time.
 - Find the ratio of final stored energy to initial energy. Where did the rest of the energy go?
 - Assume element A is a resistor R . Find its voltage or current, and from that, find out the energy lost in it.
 - Find the ratio of lost energy to initial energy. Is it what you expected? Does it depend on R ?
 - 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 $R = 200\ \Omega$, $C = 200\text{nF}$, and $L = 50\text{mH}$. The initial inductor current is -45mA , and the initial capacitor voltage is 15V .

- Calculate the initial current in each branch of the circuit.
- Find $v(t)$ for $t \geq 0$.
- Find $i_L(t)$ for $t \geq 0$.



6.

- For the following circuit, find the value of R that results in a critically damped voltage response.
- Calculate $v(t)$ for $t \geq 0$.
- Plot $v(t)$ versus t for $0 \leq t \leq 7\text{ms}$.



7. The $0.1 \mu\text{F}$ 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.

- Find $i(t)$ for $t \geq 0$.
- Find $v_C(t)$ for $t \geq 0$.

