# ELEC 2501 Final Exam, Dec. 14th , 2020

## Instructions (READ!!!!!)

1) The exam will last 1.5hours.
2) This is a closed book exam.
3) Show all work.
4) Your solutions to all problems must fit on six one sided 8 ½ X 11 sheets of paper or less.
5) Place a large and very obvious BOX around your final answer for each question.
6) Solutions MUST be uploaded within 15mins after the exam ends to be counted.
7) There are eight questions. Each is worth equal marks.

## Formulas that might be useful:

$$\omega = 2\pi f,\ T = \frac{1}{f},\quad \sqrt{\frac{1}{T_2 - T_1}\int_{T_1}^{T_2}(f(t))^2 dt}\ ,\ i(t) = \frac{dq(t)}{dt}\quad ,\quad v = \frac{dw}{dq}, p(t) = v(t)\cdot i(t),\ \ v = iR,$$

$$\sum_{j=1}^{N} i_j(t) = 0,\ \sum_{j=1}^{N} v_j(t) = 0\ ,\ \frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_N},\ R_S = R_1 + R_2 + \cdots + R_N$$

$$R_a = \frac{R_1 R_2}{R_1 + R_2 + R_3} R_b = \frac{R_2 R_3}{R_1 + R_2 + R_3} R_c = \frac{R_1 R_3}{R_1 + R_2 + R_3}$$

$$R_1 = \frac{R_a R_b + R_b R_c + R_c R_a}{R_b} R_2 = \frac{R_a R_b + R_b R_c + R_c R_a}{R_c}\ R_3 = \frac{R_a R_b + R_b R_c + R_c R_a}{R_a}$$

$$C = \frac{\epsilon \cdot A}{d}, i = C\frac{dv}{dt}, E(t) = \frac{1}{2}Cv^2(t), \frac{1}{C_S} = \sum_{i=1}^{N}\frac{1}{C_i} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots + \frac{1}{C_N}, C_P = \sum_{i=1}^{N} C_i$$

$$v(t) = L\frac{di(t)}{dt}, E(t) = \frac{1}{2}Li^2(t), L_S = \sum_{i=1}^{N} L_i, \frac{1}{L_P} = \sum_{i=1}^{N}\frac{1}{L_i} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \cdots + \frac{1}{L_N}$$

$$x(t) = K_1 + K_2 e^{\frac{-t}{\tau}}, \tau = RC, \tau = \frac{L}{R}$$

$$Z = R, Z = j\omega L, Z = \frac{1}{j\omega C}, Z_S = Z_1 + Z_2 + \cdots + Z_N, \frac{1}{Z_P} = \frac{1}{Z_1} + \frac{1}{Z_2} + \cdots + \frac{1}{Z_N}, Y = \frac{1}{Z},$$

$$Y_P = Y_1 + Y_2 + \cdots + Y_N,\quad \frac{1}{Y_S} = \frac{1}{Y_1} + \frac{1}{Y_2} + \cdots + \frac{1}{Y_N}$$

$$\omega_o = \frac{1}{\sqrt{LC}}, Q = \frac{\omega_o L}{R} = \frac{1}{\omega_o CR} = \frac{1}{R}\sqrt{\frac{L}{C}}, \omega_{LO} = \omega_o\left[\frac{-1}{2Q} + \sqrt{\left(\frac{1}{2Q}\right)^2 + 1}\right] \omega_{HI} = \omega_o\left[\frac{1}{2Q} + \sqrt{\left(\frac{1}{2Q}\right)^2 + 1}\right]$$

$$BW = \omega_{HI} - \omega_{LO} = \frac{\omega_o}{Q}, \omega_{HI}\cdot\omega_{LO} = {\omega_o}^2, Q = 2\pi\frac{\omega_S}{\omega_D},\ \omega_r = \sqrt{\frac{1}{LC} - \left(\frac{R}{L}\right)^2}$$

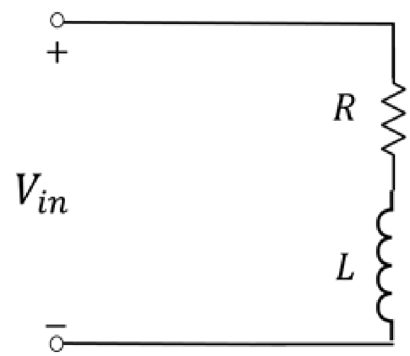
$$P = \frac{V_M I_M}{2}\cos(\theta_v - \theta_i) = V_{RMS} I_{RMS}\cos(\theta_v - \theta_i),\ PF = \cos(\theta_v - \theta_i) = \cos(\theta_{Z_L}) = \cos(-\theta_{Z_L}),$$

$$S = V_{RMS} {I_{RMS}}^*\ ,\ \frac{i_1}{i_2} = \frac{v_2}{v_1} = \frac{N_2}{N_1}\ , Z_p = \left(\frac{N_p}{N_s}\right)^2 Z_s$$

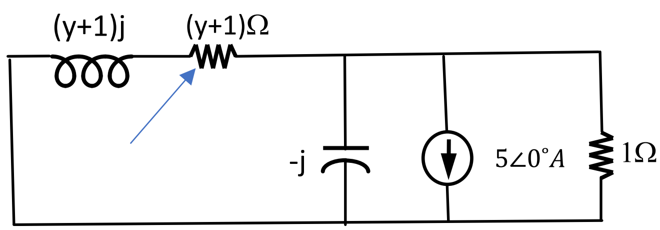
1)

You are asked to design a high-pass filter using a single resistor and a single Inductor. The design asks for an output voltage of $9\ V$ when $V_{in}$ corresponds to an $18\ V$ sinusoid with frequency of $1XY\ kHz$.
Here, XY are the last 2 digits of your student number. Ex. If your last two digits are 75 then the frequency is $175kHz$.

What element (R or L) should you be measuring the voltage across? What is the time constant for this circuit?



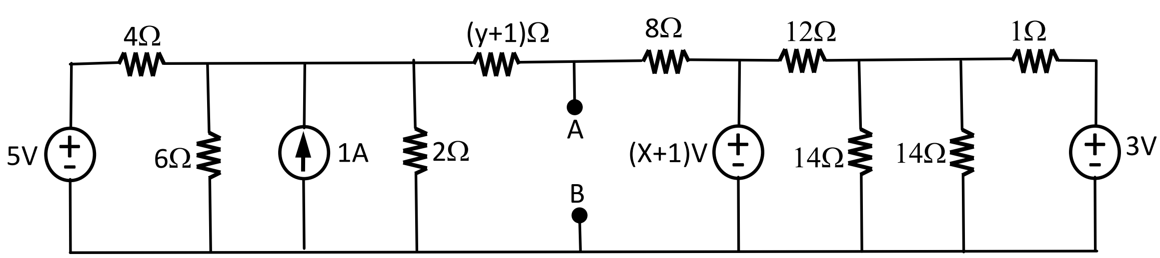

2) Determine the average power supplied to the resistor being identified by the arrow. Note that $Y$ is the last digit of your student number.




3) Sketch the bode plot (magnitude vs frequency) for the following function. Label clearly key amplitudes and frequencies on your graph. Note that x is the last digit of your student number.

$$G_V(j\omega) = \frac{(10x + j\omega)}{(j\omega + 5 - 5j)(j\omega + 5 + 5j)(\frac{j\omega}{1000} + 1)}$$

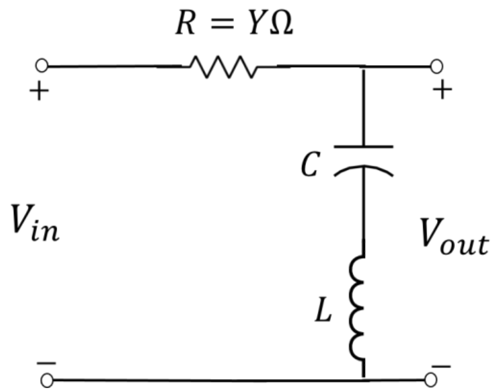
4) Find the Norton equivalent circuit between nodes A and B. Note that xy are the last two digits of your student number.



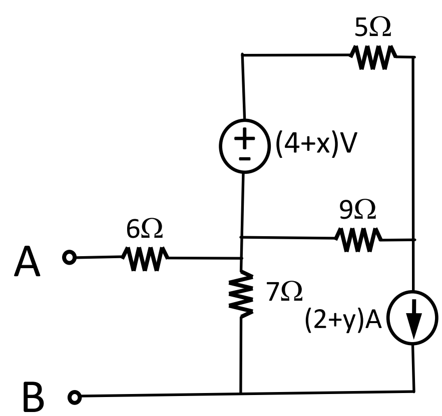
5)

In the circuit shown, when starting from $\omega = 0$, the transfer function is <u>first</u> found to be $|G(j\omega)| = 1/\sqrt{2}$ at $\omega = 8000\ rad/s$. The Q factor for the RLC resonator is $Q = 80$. In the circuit, Y is the last digit of your student number, if your student number ends in zero then $\mathrm{R} = 10\Omega$.

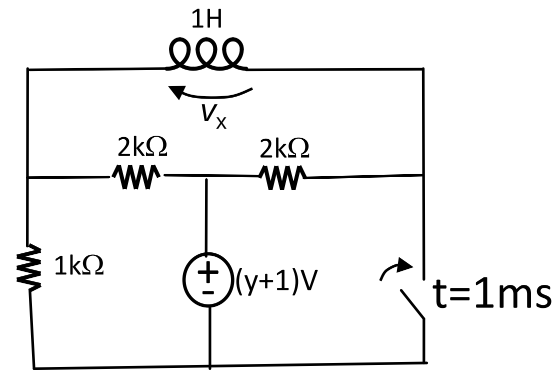
At what frequency will $V_{out}$ be a minimum? What frequency other than $\omega = 8000\ rad/s$ will you find $|G(j\omega)| = 1/\sqrt{2}$ ?




6) What value of resistor connected between nodes A and B will lead to the maximum power transfer? What power will be transferred under this condition? Note that xy are the last two digits of your student number.



7) Find Vx as a function of time and plot it. Note at time t =1ms the switch is closed. Note that y is the last digit of your student number.




8)

Find $V_X$ in the circuit below. Note that $Y$ is the last digit of your student number so for example if your student number ends with a 0, then the voltage source is $10\ \angle 0°\ V$