EE201 Circuit Theory
KAIST, Fall 2013

Dec. 20, 2013

학번(ID):_____ 이름(Name):_____

Final Exam (2.5 hours) Assume all initial conditions are zero unless otherwise noted.

1. [Phasor and Complex numbers] [**15pts**]

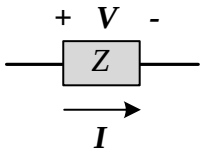
(a) Suppose $v(t) = \cos(10^3 t + 30^o)$. Let's represent this signal as $\mathbf{V} = 1\angle 0^o$. If $\mathbf{I} = 0.5\angle 45^o$, then what is $i(t)$? [2pts]

(b) Suppose $v(t) = \cos(10^3 t + 30^o)$. Let's represent this signal as $\mathbf{V} = 1 + j$. If $\mathbf{I} = 1 - j$, then what is $i(t)$? [2pts]

(c) Suppose $v(t) = \cos(10^3 t + 30^o)$ and $i(t) = \cos(2\times 10^3 t + 60^o)$. If $v(t)$ is represented as $\mathbf{V} = 1\angle 30^o$, then what is $\mathbf{I}$? [2pts]

For (e) ~ (g), consider the below circuit.

(d) Suppose V=1+j and I=1–j. What is the average power consumption? [2pts]



(e) Suppose V=1+j and Z = 1–j. In order to calculate the power consumption of the Z, which should be done? [2pts]

① $P_Z = \mathrm{Re}\left\{\frac{V \cdot V}{Z}\right\}$ ② $P_Z = \mathrm{Re}\left\{\frac{V \cdot V^*}{Z}\right\}$ ③ $P_Z = \mathrm{Re}\left\{\frac{V \cdot V^*}{Z^*}\right\}$

(f) Choose all that can be derived from (f). (Assuming that you chose the correct answer in (f).) [2pts]

① Average power ② Instantaneous power ③ Apparent power ④ Complex power

2. Consider the below RLC Circuit **[21pts]**

(a) Choose the circuits that have the same natural response. [3pts]

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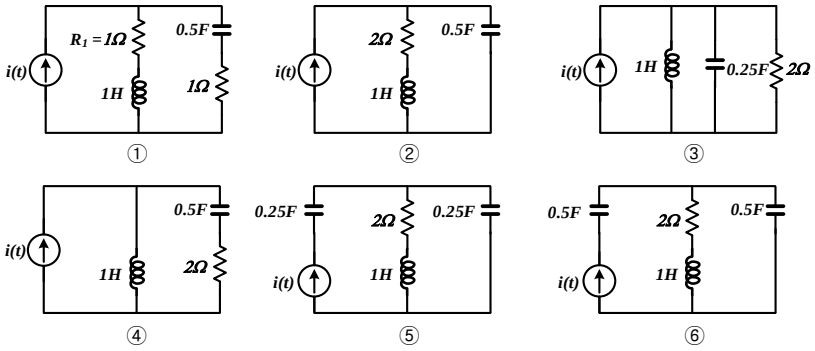


For (b) ~ (d), consider the circuit shown in ①, and suppose *i(t) = 3u(-t) + 5u(t)*.

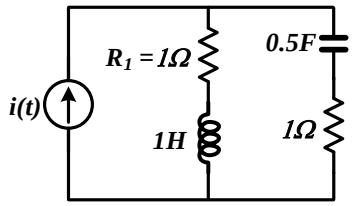
(b) Please write down a differential equation that describes the natural response of the circuit. [3pts]

(c) Please write down a general solution for the above differential equation. [2pts]

(d) Find the initial values. Fill in the table below. [6pts]

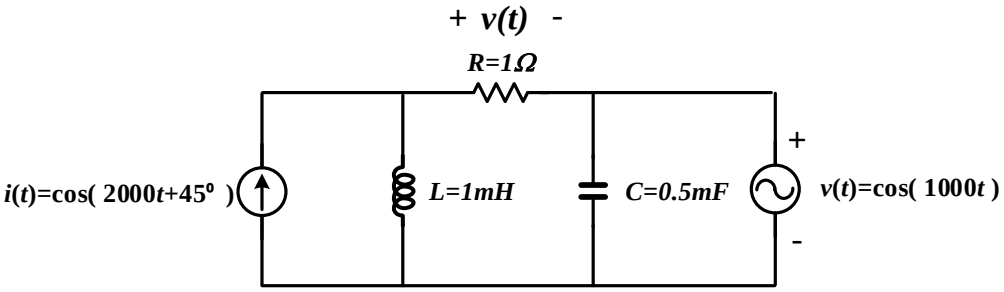
$v_{R1}(0^+)$	$v_L(0^+)$	$v_C(0^+)$	$i_{R1}(0^+)$	$i_L(0^+)$	$i_C(0^+)$
$\frac{dv_{R1}}{dt}(0^+)$	$\frac{dv_L}{dt}(0^+)$	$\frac{dv_C}{dt}(0^+)$	$\frac{di_{R1}}{dt}(0^+)$	$\frac{di_L}{dt}(0^+)$	$\frac{di_C}{dt}(0^+)$

(e) Find $v_c(t)$ for t>0 [4pts]



(f) Change the value of C so that the circuit has critically damped response. [3pts]

3. Suppose the below circuit is in the steady-state condition. [10pts]

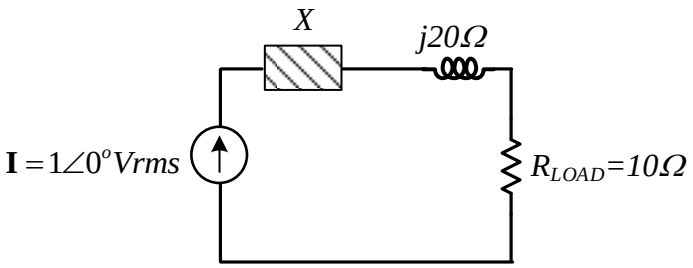


(a) Find the steady-state time-domain voltage across the resistor v(t). [6pts] (Use the function $\tan^{-1}(\ )$ if necessary.)

(b) What is the average power dissipated in the resistor R? [4pts]

4. Consider the circuit below. [17pts]

(a) Determine the value of the reactive device, ***X***, so that the power factor (PF) is 0.8. Give your answer in complex domain. [5pts]



(b) If the AC source is at 100 rad/s and PF is 0.8 *lagging*, find the type and value of the device ***X***. [4pts]

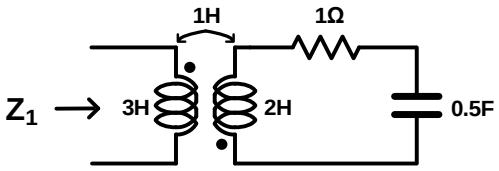
(c) By increasing the PF, P_{Load}/P_{SRC} is (increased, decreased, stays the same), where P_{load} is the average power dissipation at the load resistor and P_{SRC} is the average power dissipation at the source. [2pts] (1pt deducted if incorrect)

(d) What is the maximum value of PF? [1pts]

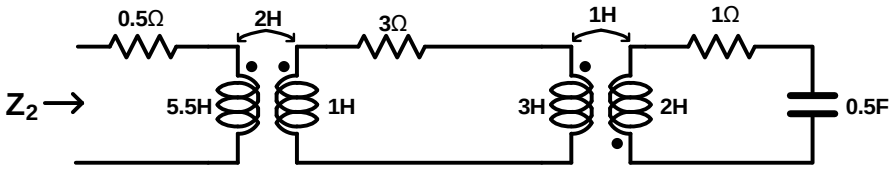
(e) Why is it necessary to increase the PF? (Do not be vague.) [3pts]

5. Mutual inductance. [14pts]

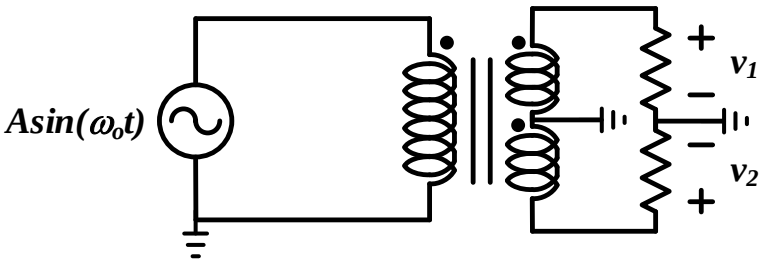
(a) Find the impedance $\mathbf{Z}_1$. Assume ω = 1 rad/s. [3pts]



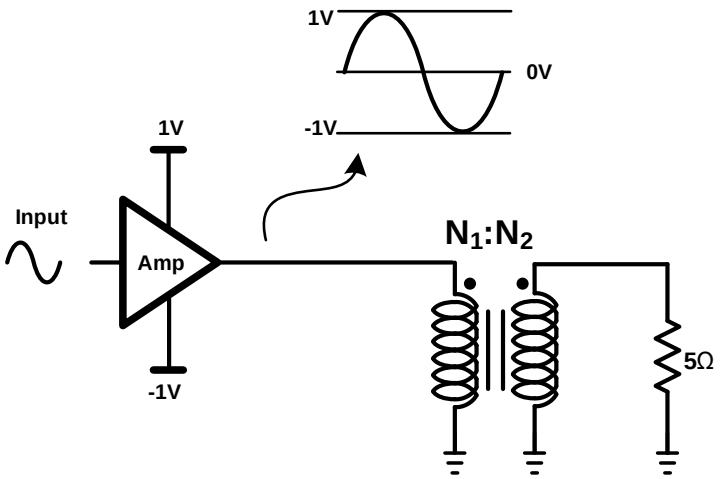
(b) Find the impedance $\mathbf{Z}_2$. Assume ω = 1 rad/s. [4pts]



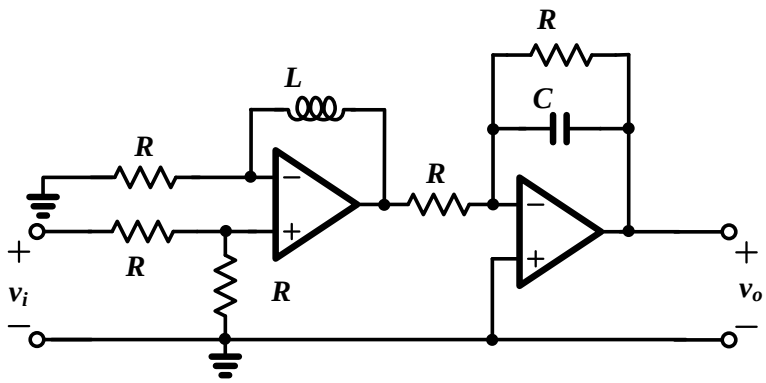
(c) Draw the waveform of v_1 and v_2. [3pts]



(d) Suppose we have an amplifier shown below, whose output voltage is limited by the supply voltages of ±1V. Your job is to determine the ratio N_1:N_2 of the ideal transformer shown below, such that the average power delivered to the load is 10W for a sinusoidal output. [4pts]

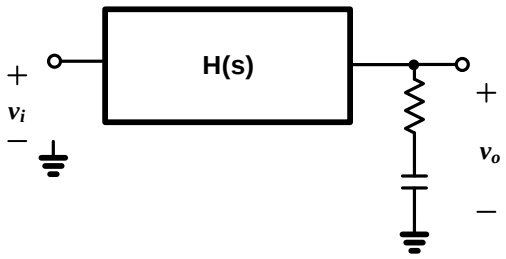


6. Analyze the below circuit in s-domain. [10pts]



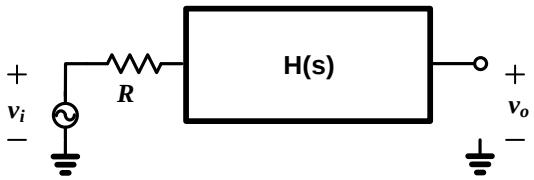
(a) What is the transfer function from v_i to v_o? Express your answer in s-domain. [5pts]

(b) Suppose there is a load at the output as shown below. As frequency is increased, how different will the gain be different from the original circuit. [2pts] (1pt deducted if incorrect)



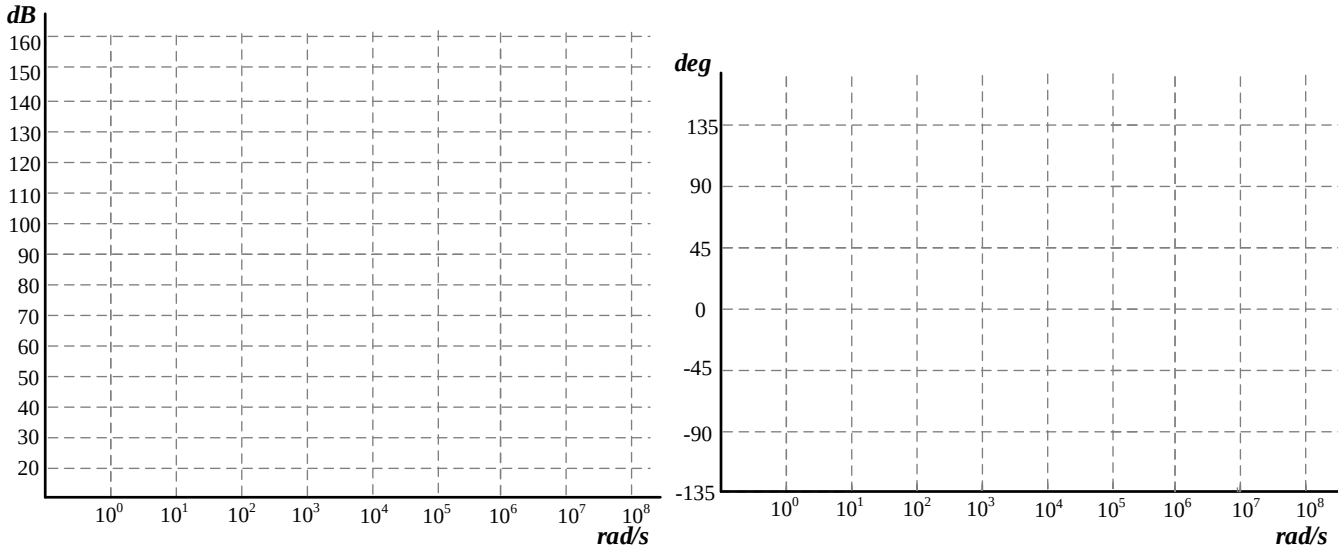
① Gain will be smaller. ② Gain will be larger. ③ Gain will stay the same.

(c) What is the output voltage when the below voltage source is added. Express your answer in s-domain. [3pts]

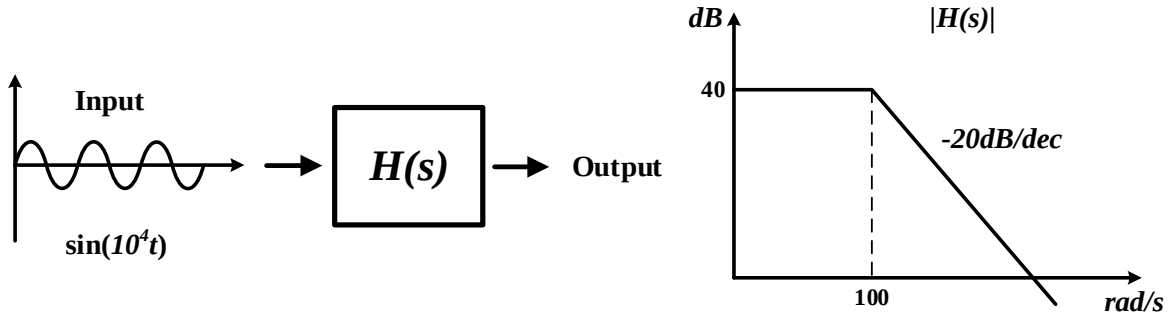


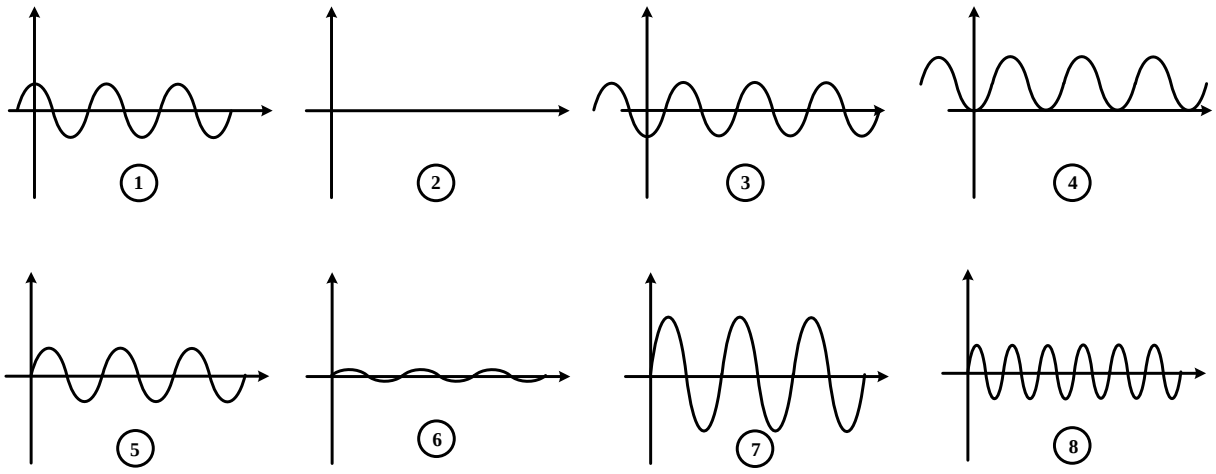
7. $H(s) = \dfrac{100s(1+\frac{s}{10^6})}{(1+\frac{s}{10^3})^2}$

(a) Draw the asymptotic Bode plots of magnitude and phase of H(s). [6pts]

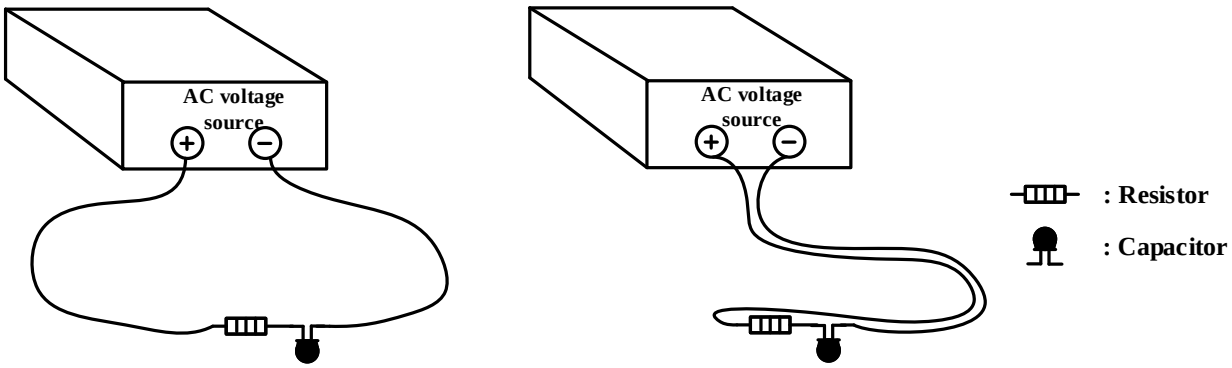


(b) Suppose H(s) that is the transfer function of circuit has the following magnitude Bode plot. If an input of $\sin(10^4 t)$ is applied to H(s), choose which of the below response is achieved. [2pts]





8. Consider the below experiment where AC voltage source of $\sin(\omega_o t)$ is applied. Assume that both circuits have identical input source, resistor, capacitor, and wire length.



(a) Explain the difference between the two circuits from the circuit perspective. [4pts]

(b) In the above circuit, can you think about a case when KCL does not hold? Please explain. [4pts]

#1	#2	#3	#4	#5	#6	#7	#8	Total
/12	/21	/10	/17	/14	/10	/8	/8	/100