Name: ______________________________ (please print)

Signature: ___________________________

ECE 3455
Quiz #3
Summer 2010

Quiz duration: 30 minutes

1. You may have one 8 ½ x 11 in. "crib" sheet, written on both sides, during the quiz. You may have any calculator you choose, but no computers. No other notes or materials will be allowed.
2. Show all work necessary to complete the problem on these pages. A solution without the work shown will receive no credit.
3. Show units in intermediate and final results, and in figures.
4. If your work is sloppy or difficult to follow, points will be subtracted.

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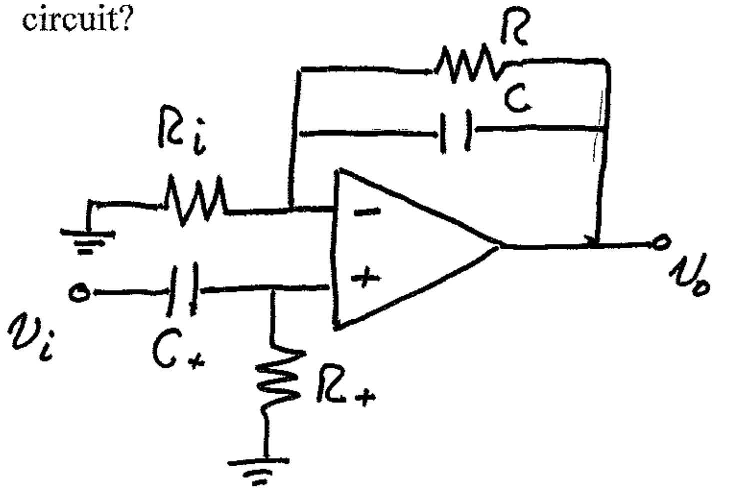
For the circuit below, do the following.

i. Find the transfer function $T(\omega) = V_o/V_i$. Express your answer algebraically, i.e., do not substitute numerical values yet.

ii. Find the frequencies at which breakpoints occur. (Now you can substitute numbers.)

iii. The *3 dB bandwidth* is defined as the range of frequencies over which $|T(\omega)|$ is within 3 dB of the maximum value. What is the 3 dB bandwidth of this circuit?



$C_+ = 1\ \mu F$

$R_+ = 4.7\ k\Omega$

$C = 0.1\ \mu F$

$R = 10\ k\Omega$

$R_i = 1\ k\Omega$

$$R \parallel 1/j\omega C = \frac{R}{1+j\omega CR}$$

i)

$$\frac{\bar{V}_+}{\bar{V}_i} = \frac{R_+}{R_+ + 1/j\omega C_+} = \frac{j\omega C_+R_+}{1+j\omega C_+R_+}$$

$$\frac{\bar{V}_o}{\bar{V}_+} = 1 + \frac{R/R_i}{1+j\omega CR} \Rightarrow T(\omega) = \frac{j\omega C_+R_+}{1+j\omega C_+R_+}\left(1+\frac{R/R_i}{1+j\omega CR}\right)$$

ii)

$$1+\frac{R/R_i}{1+j\omega CR} = \frac{1+j\omega CR + R/R_i}{1+j\omega CR} = \frac{(1+R/R_i) + j\omega CR}{1+j\omega CR}$$

Breakpoints occur where imaginary and real parts of terms like $(a+jb)$ are equal. So...

Room for Extra Work

We have poles at $1/C_+R_+$ and $1/CR$

We have a zero at 0 and another at

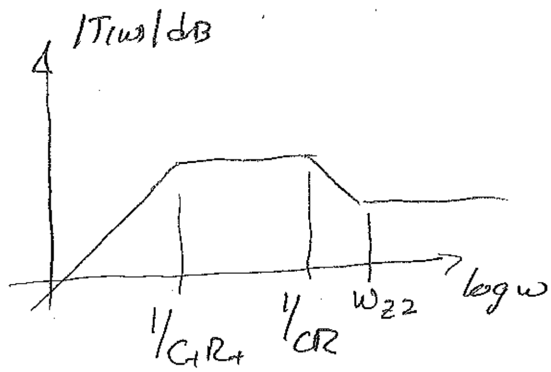
$$1 + R/R_i = \omega_{z2} CR$$

$$\Rightarrow \omega_{z2} = \frac{1 + R/R_i}{CR} = \frac{1 + 10^4/10^3}{(10^{-7})(10^4)} = 1.1 \times 10^4 \text{ rad/s}$$

So $p_1 = 1/C_+R_+ = 213$ rad/s $\quad p_2 = 1/CR = 10^3$ rad/s

$z_1 = 0$ rad/s $\quad z_2 = 1.1 \times 10^4$ rad/s

iii) A rough sketch of the magnitude Bode plot is:

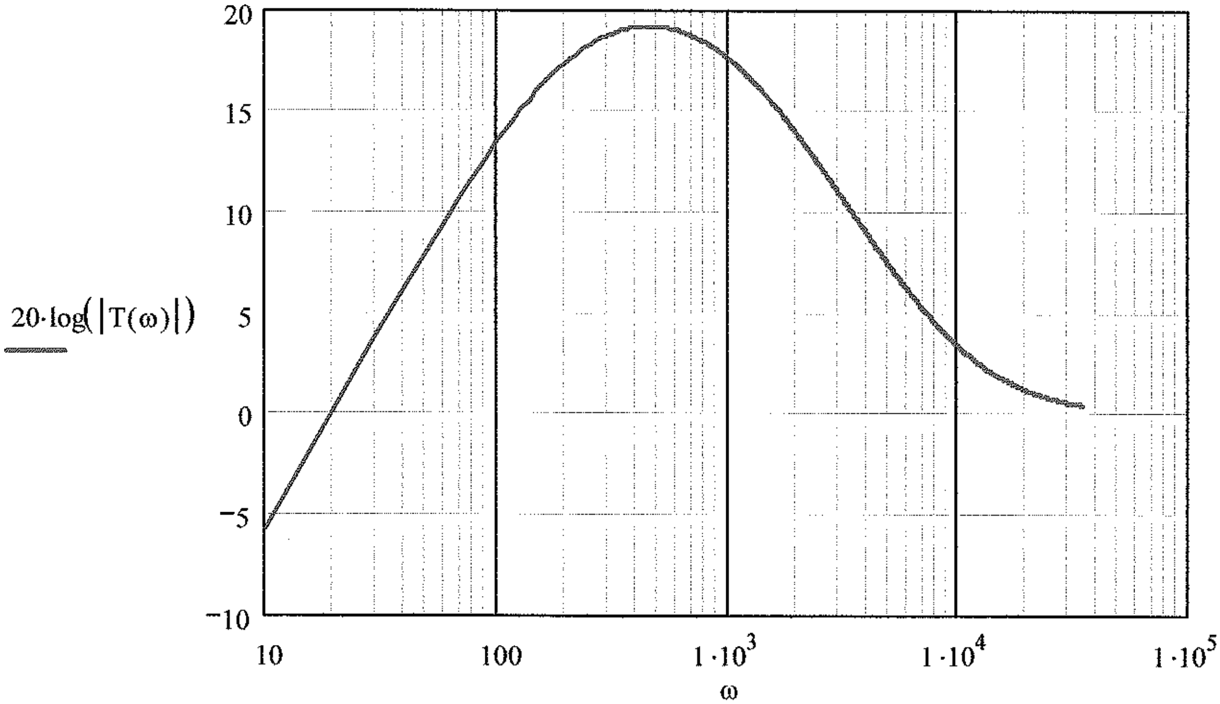


(MathCad plot is on next page)

There was no requirement to make a plot, but it does make clear that

$$\omega_{3dB} = 1/CR - 1/C_+R_+ \simeq 800 \text{ rad/s}$$

(Recall that the breakpoints are in fact the frequencies at which the straight line approximation is 3dB from the "true" value.)



20
15
10
5
0
−5
−10
20·log(|T(ω)|)
10
100
1·10^3
1·10^4
1·10^5
ω