Name: ______________________________ (please print)

Signature: ___________________________

ECE 3455
Quiz 2
February 24, 2009

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.

________________/20

The transfer function T(ω) for a certain amplifier is shown below. It is known that the magnitude of the transfer function at ω = 300 rad/sec is approximately 0 dB.

We are given that $R_1C_1 = 5 \times 10^{-5}$ s; $R_2C_2 = 3.333 \times 10^{-4}$ s; $R_3C_3 = 0.01667$ s; and $R_4C_4 = 10^{-3}$ s.

$$T(\omega) = K\frac{\left(\dfrac{1}{R_1C_1}+j\omega\right)(j\omega R_4C_4)^2}{(1+j\omega R_2C_2)^2\left(\dfrac{1}{R_3C_3}+3j\omega\right)}$$

Using the paper provided on the next page, draw the straight-line approximation to the **magnitude** Bode plot for this transfer function.

We will need to find a way to set the vertical scale based on the fact that $|T(\omega = 300 \text{ rad/s})| = 0$ dB.

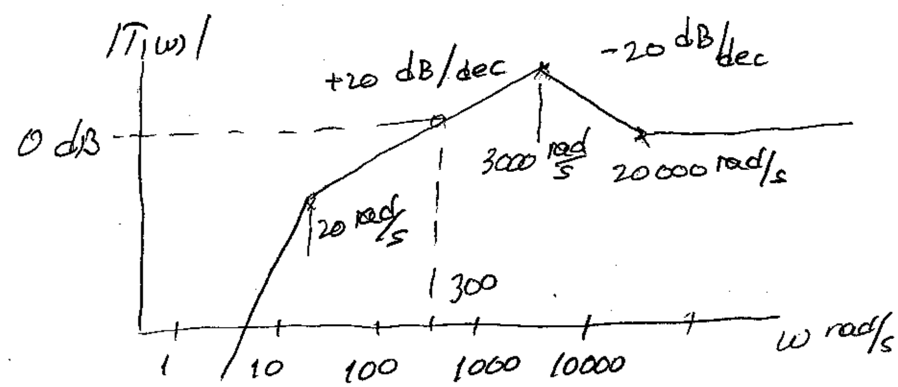
First we find poles and zeros.

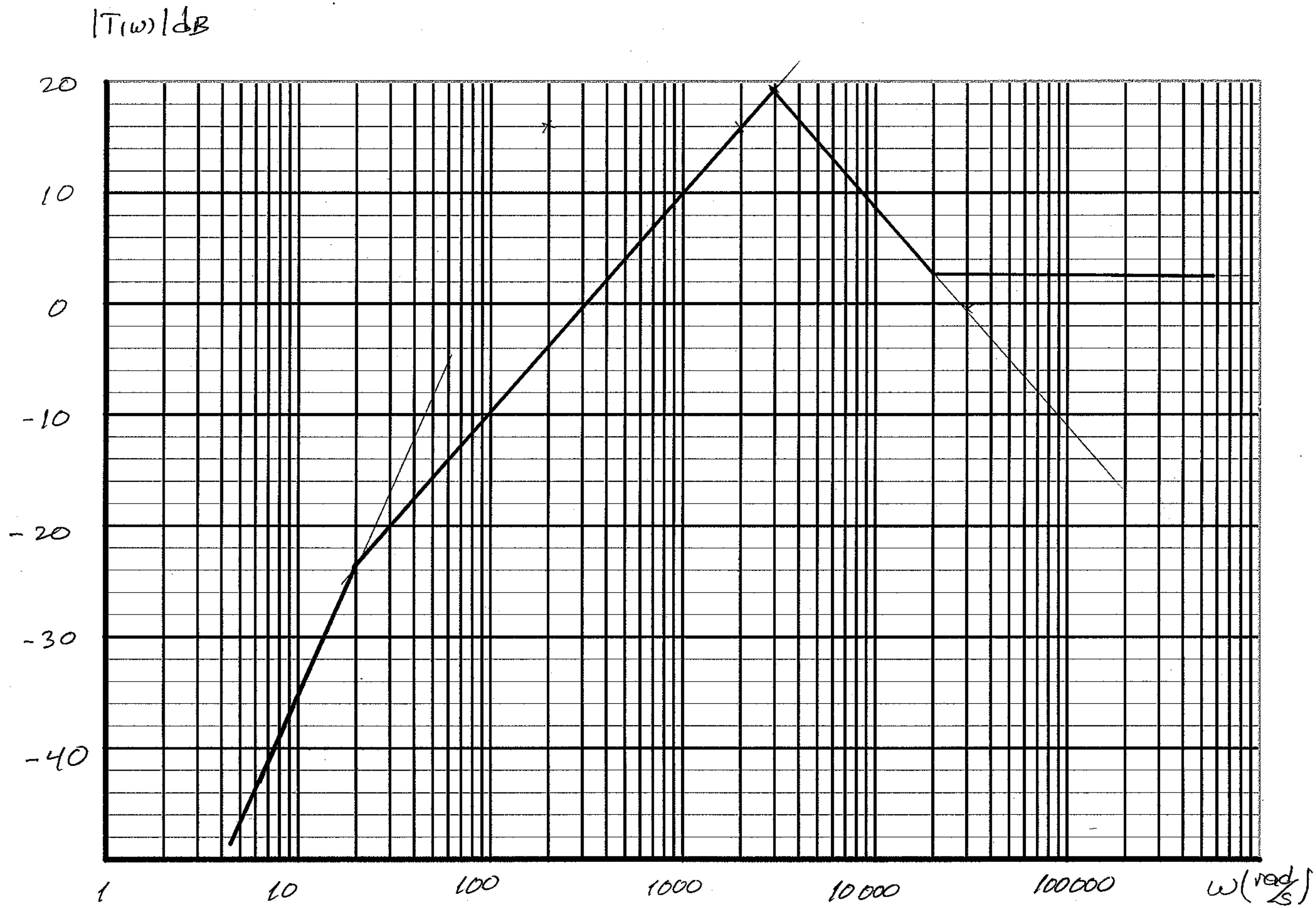
$\omega_{z1} = 0$ rad/s (double zero) $\quad \omega_{z2} = 1/R_1C_1 = 20000$ rad/s

$\omega_{p1} = 1/R_2C_2 = 3000$ rad/s (double pole)

$3\omega_{p2} = 1/R_3C_3 \Rightarrow \omega_{p2} = \dfrac{1}{3R_3C_3} = 20$ rad/s.

So a rough plot looks like the following:





|T(ω)| dB
20
10
0
-10
-20
-30
-40
1
10
100
1000
10 000
100000
ω(rad/s)

How should we set the vertical scale? We could estimate the range we need, based on our rough plot. Alternatively we could calculate K and find $|T(\omega)|$ at a couple of points. We will do both.

- Estimate vertical scale:

We have a slope of +20 dB/dec from 20 rad/s to 3000 rad/s, which is approximately 2 decades. So that region of the graph runs through a bit more than 40 dB, with 0 dB approx. in the middle ($\omega = 300$ rad/s), i.e. −20 dB to +20 dB. Below 20 rad/s we have a drop of 40 dB/dec. To account for that we'll include another −20 dB on our scale. So we will use −40 dB to +20 dB.

- Find K: We have 0 dB → $|T(\omega)| = 1$ at $\omega = 300$ rad/s

$$\Rightarrow \quad 1 = \left| K \cdot \frac{(20000 + j300)(j300 \times 10^{-3})^2}{(1 + j300 \times 3.33 \times 10^{-4})^2 (60 + 3j300)} \right|$$

$$1 = K \cdot 2 \quad \Rightarrow \quad K = 0.5$$

With this we have $|T(\omega = 10 \text{ rad/s})| = -36$ dB

$|T(\omega = 100000 \text{ rad/s})| \cong 4$ dB

$|T(\omega = 3000 \text{ rad/s})| \cong 15$ dB

So our estimate was about right.