

Name: \_\_\_\_\_ (please print)

Signature: \_\_\_\_\_

ECE 3355  
Quiz 2  
February 13, 2020

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.

\_\_\_\_\_ ~~120~~ 25

Room for Extra Work

The transfer function  $T(\omega)$  for a certain amplifier is shown below. It is known that the magnitude of the transfer function at very large values of  $\omega$  is 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.

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

- a) Find the value of  $K$ , assuming it is a real number.
- b) Using the paper provided on the next page, draw the straight-line approximation to the **magnitude** Bode plot for this transfer function.

This image shows a full-page grid of graph paper. The grid is composed of 7 columns and 25 rows. The columns are divided into four vertical sections: the first section is 2 columns wide, the second is 2 columns wide, the third is 2 columns wide, and the fourth is 1 column wide. The rows are organized into groups: the first 5 rows of each section are separated by a single line, the next 5 rows by a double line, the next 5 rows by a single line, and the final 5 rows by a double line. This layout is typical of graph paper used for technical drawing or engineering.

The transfer function  $T(\omega)$  for a certain amplifier is shown below. It is known that the magnitude of the transfer function at very large values of  $\omega$  is 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.

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

- a) Find the value of  $K$ , assuming it is a real number.  
 b) Using the paper provided on the next page, draw the straight-line approximation to the **magnitude** Bode plot for this transfer function.

a) For  $\omega \rightarrow \infty$ ,  $T(\omega) \rightarrow K \cdot \frac{(j\omega) (j\omega R_4C_4)^2}{(j\omega R_2C_2)^2 \cdot (3j\omega)}$

$$= K \cdot \frac{(R_4C_4)^2}{(R_2C_2)^2 \cdot 3} = 3K$$

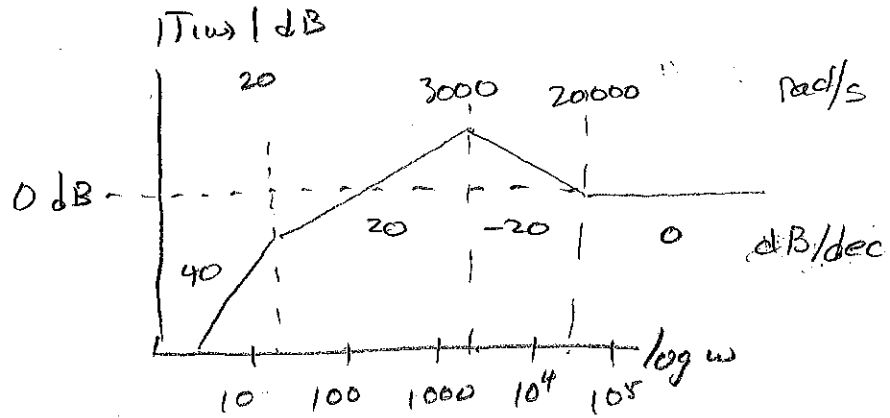
+6

Since  $|T(\omega \rightarrow \infty)| = 0$  dB,  $3K = 1 \Rightarrow \boxed{K = 1/3}$

b) Zeros:  $0, 0, 1/R_1C_1 = 0, 0, 20000$  rad/s +3  
 poles:  $\frac{1}{3R_3C_3}, \frac{1}{R_2C_2}, \frac{1}{R_2C_2} = 20, 3000, 3000$  rad/s +3

So we have a double zero at 0  $\Rightarrow +40$  dB/dec  
 and a double pole at 3000 rad/s  $\Rightarrow -40$  dB/dec  
 at those breakpoints.

Rough sketch:



More careful drawing is on graph paper.

If we re-write  $T(s)$  by multiplying and dividing by  $\frac{R_1 C_1}{R_2 C_3}$ , we get

$$T(s) = K \frac{R_2 C_3}{R_1 C_1} \cdot \frac{(1 + j\omega C_1 R_1)(j\omega C_4 R_4)^2}{(1 + j\omega C_2 R_2)^2 (1 + j\omega C_3 R_3)}$$

If in addition we lump  $R_2 C_3 / R_1 C_1$  into the constant  $K$ , we have

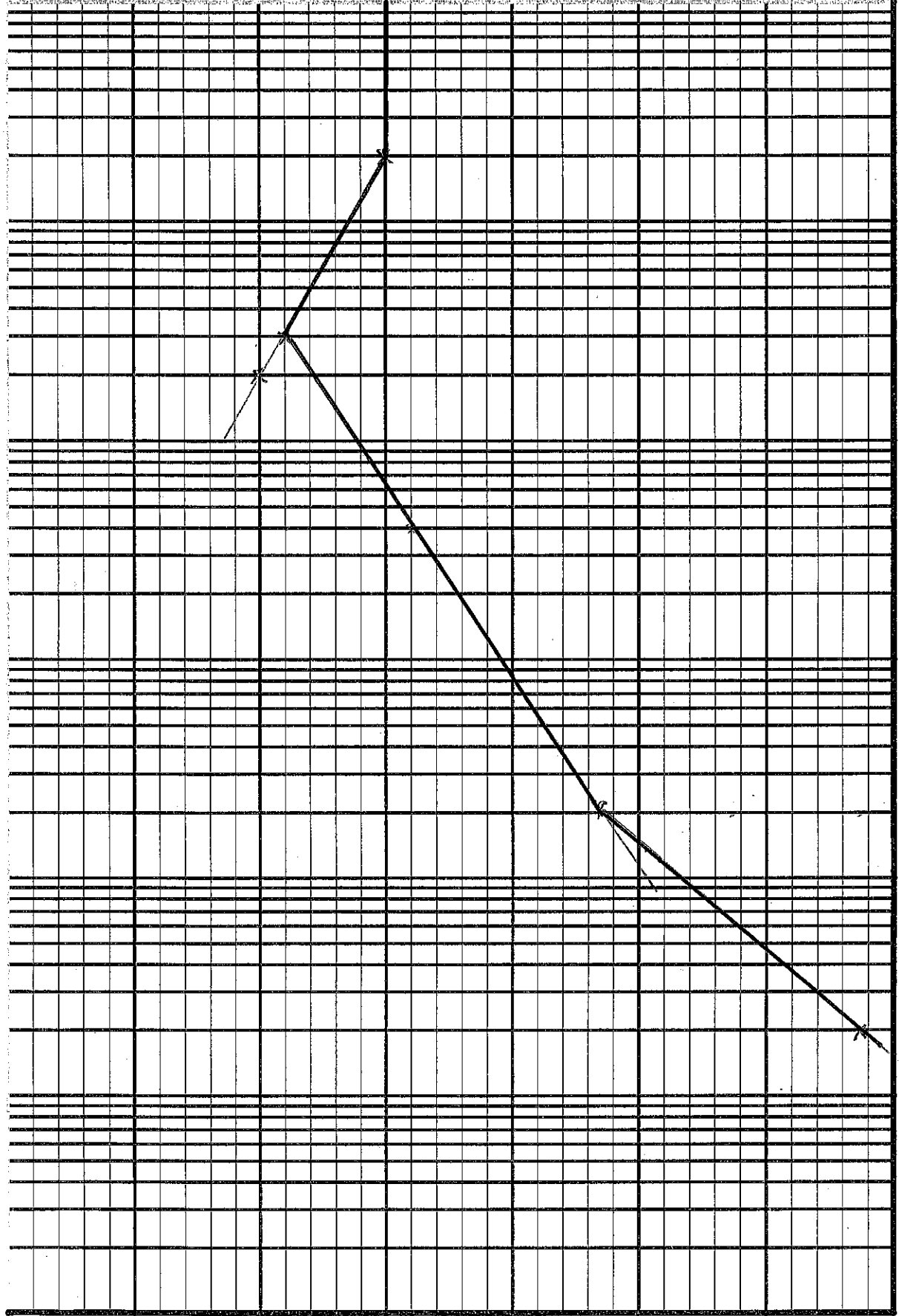
$$T(s) = K' \frac{(1 + j\omega C_1 R_1)(j\omega C_4 R_4)^2}{(1 + j\omega C_2 R_2)^2 (1 + j\omega C_3 R_3)}$$

In this case,  $K'$  works out to 111.1.

+1

$|T(\omega)|$  dB

+2 +1 +2 +1 +2 +1 +2 +1 +2 +1



+1

$\omega$  (rad/s)

10000

1000

100

10

1