ECE 3041 Lecture Exam No. 2 Spring 2012

FRIDAY MARCH 16, 2012 4-5 PM   GTID 9 ______________

Name ___Key___

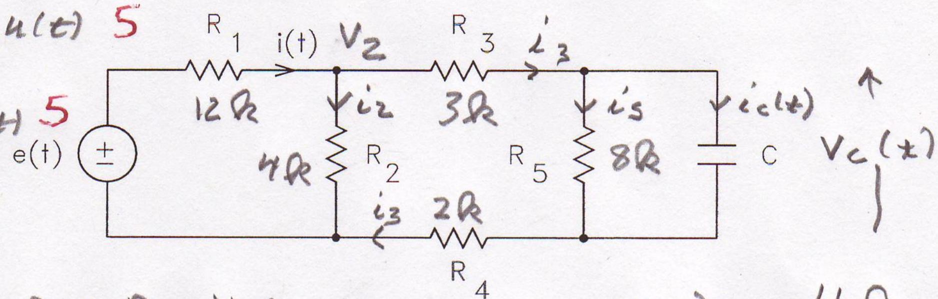
Instructions. Totally Closed Book and Note. Calculator Permitted. Four Equally Weighted Problems. All Work Must Be Shown for Credit.

1. What is the current $i(t)$ in the circuit shown below when $t = 3.22\,\text{ms}$? The source voltage is $e(t) = 30u(t)\,\text{V}$. The component values are: $R_1 = 12\,\text{k}\Omega$, $R_2 = 4\,\text{k}\Omega$, $R_3 = 3\,\text{k}\Omega$, $R_4 = 2\,\text{k}\Omega$, $R_5 = 8\,\text{k}\Omega$, and $C = 0.68\,\mu\text{F}$.

$v_c(t) = E[1 - e^{-\frac{t}{\tau}}]u(t)$ 5

$i_c(t) = \frac{E}{R} e^{-\frac{t}{\tau}} u(t)$ 5

$\tau = RC$



$\tau = 2.72\,\text{ms}$ $\quad R = R_5 \| (R_3 + R_1 \| R_2 + R_4) = 4\,\text{k}$ $\quad E_0 = 30$

$$E = E_0 \frac{R_2 \| (R_3 + R_4 + R_5)}{R_1 + R_2 \| (R_3 + R_4 + R_5)} \frac{R_5}{R_3 + R_4 + R_5} = 3.75$$

@ $t = 3.22\,\text{ms}$ $\quad v_c = 6.09\left[1 - e^{-\frac{3.22}{2.72}}\right] = 2.6\,\text{V}$

$$i_c = \frac{6.09}{4} e^{-\frac{3.22}{2.72}} = 0.287\,\text{mA}$$

$i_5 = \frac{V_c}{8} = 0.325\,\text{mA}$ $\quad i_3 = i_5 + i_c = 0.612\,\text{mA}$

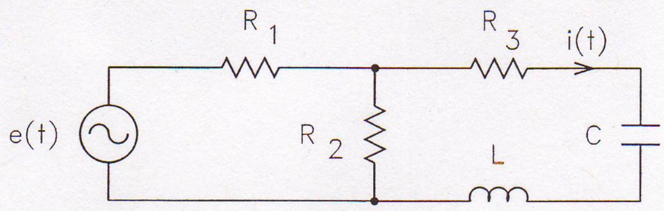
$v_2 = i_3(R_3 + R_4) + V_c = 5.66$ $\quad i_2 = \frac{V_2}{4} = 1.42\,\text{mA}$

$i = i_2 + i_3 = 2.03\,\text{mA}$

$i(t) =$ ___2.03 mA___ 10

5 try

2. In the circuit shown below, what is the resonant frequency, quality factor, and half-power bandwidth for the capacitor current, $i(t)$. The voltage source is $e(t) = 20\sqrt{2}\cos(\omega t)$ V. The component values are: $R_1 = 24\,\Omega$, $R_2 = 12\ \Omega$, $R_3 = 16\,\Omega$, $L = 3\,\text{mH}$, and $C = 100\,\text{nF}$.



$$f_o = \frac{1}{2\pi\sqrt{LC}} = 9.1888149\ \text{kHz}$$

$$R = R_3 + R_2 \parallel R_1 = 16 + 12\parallel 24 = 24\,\Omega$$

$$Q = \frac{\omega_o L}{R} = 7.2169$$

$$\Delta f = \frac{f_o}{Q} = 1.2732395\ \text{kHz}$$

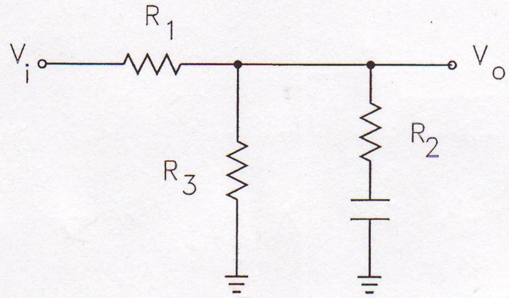
5 $f_o =$ 9.19 kHz

5 $\Delta f =$ 1.27 kHz

5 $Q =$ 7.22

10 try

3. Determine the complex transfer function $\bar{T}(s)$ for the circuit shown below. Specify it as a function of the complex frequency varible, s, and the symbols for the resistors and capacitor. Express it as a ratio of two polynomials in s. Plot the magnitude of the complex transfer function $\bar{T}(j\omega)$ in decibels as a function of the frequency f of the source as f varies from 1 Hz to 1 MHz. The component values are $R_1 = 22\,\text{k}\Omega$, $R_2 = 2\,\text{k}\Omega$, $R_3 = 470\,\text{k}\Omega$, and $C = 2\,\text{nF}$. Use the numerical values given for the resistors and capacitors for the plot. Find the high and low frequency gain in dB and the pole and zero frequencies in Hertz if applicable.



4 $T(s) = K \dfrac{1 + s\tau_z}{1 + s\tau_p} = \dfrac{R_3}{R_1 + R_3} \dfrac{1 + sR_2C}{1 + s[R_2 + R_1 \| R_3]C}$

4 $|T(0)|_{dB} = 20\log_{10}\left|\dfrac{R_3}{R_1+R_3}\right| = -0.397\ \text{dB}$

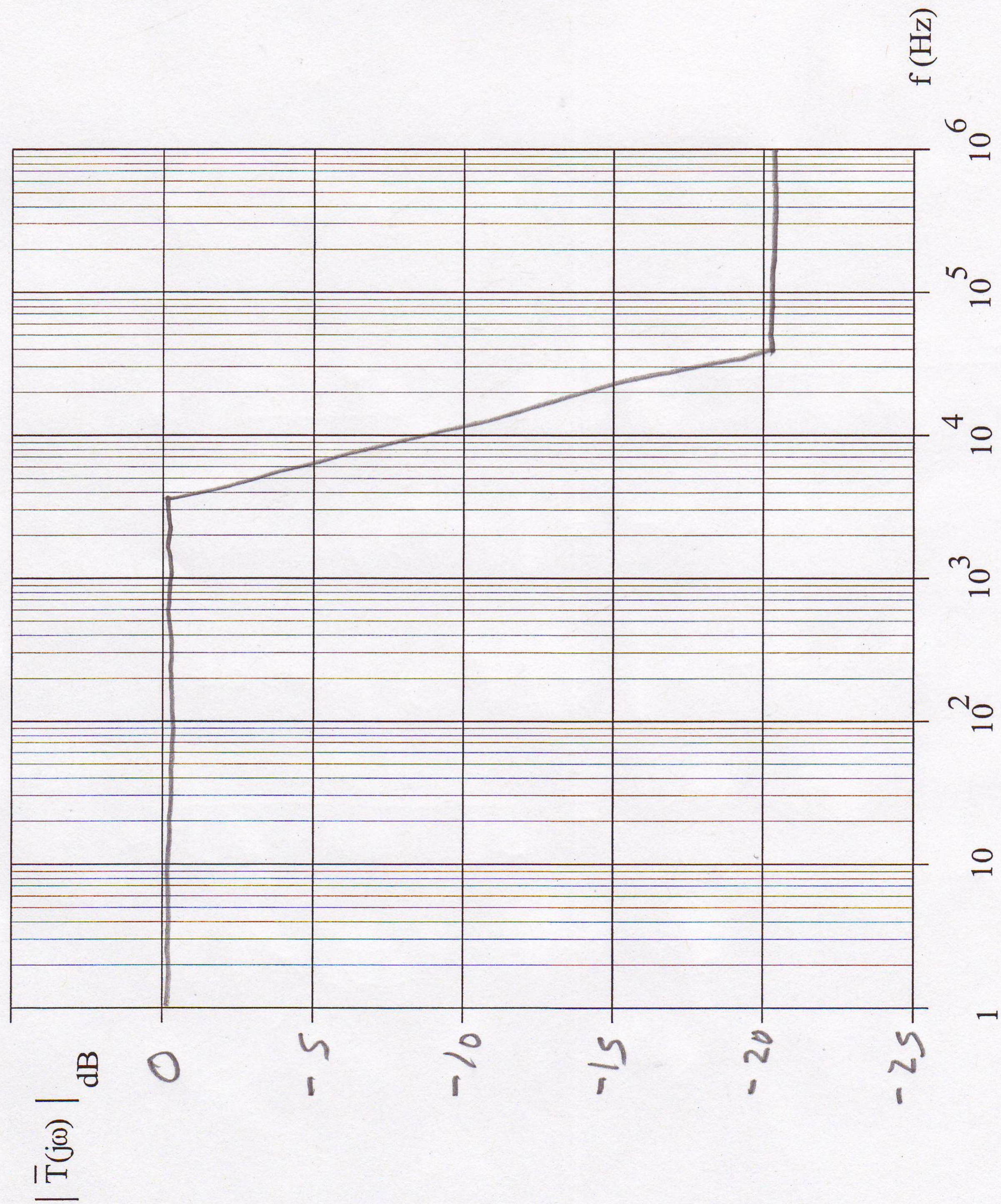
4 $|T(\infty)|_{dB} = 20\log_{10}\left|\dfrac{R_2 \| R_3}{R_1 + R_2 \| R_3}\right| = -21.6\ \text{dB}$

4 $f_p = \dfrac{1}{2\pi[R_2 + R_1 \| R_3]C} = 3.46\ \text{kHz}$

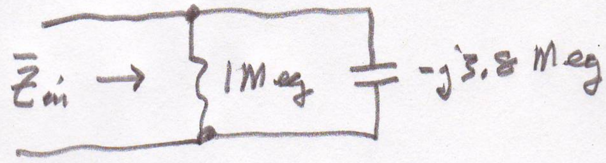
4 $f_z = \dfrac{1}{2\pi R_2 C} = 39.8\ \text{kHz}$

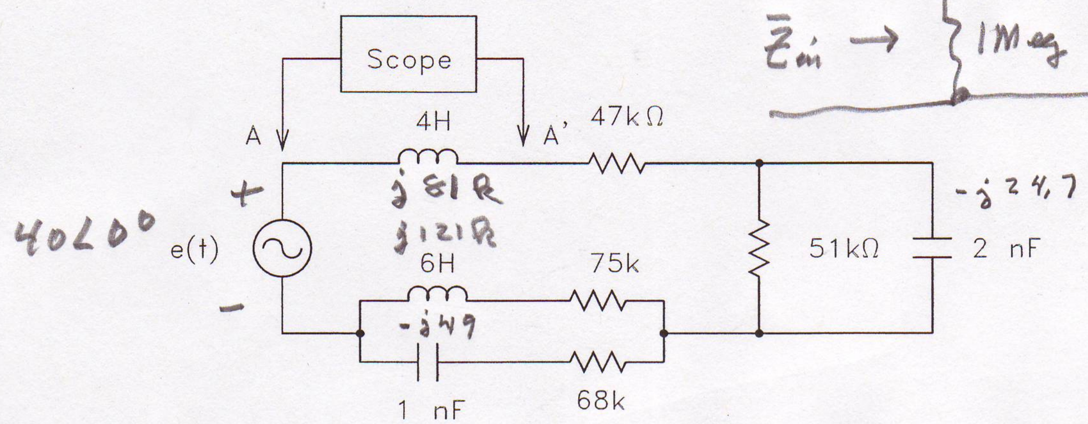
~~slope~~
bp 1
bz 1
|T(0)|dB 1
|T(∞)|dB 1
shape 1

5



4. In the circuit shown below a **Tektronix 3012B** oscilloscope (which has an input impedance which can be characterized by a $1\,\mathrm{M\Omega}$ resistor in parallel with a $13\,\mathrm{pF}$ capacitor) is being used to measure the voltage $\overline{V}_{AA'}$.The frequency of the sinusoidal source, $e(t) = 40\sqrt{2}\cos\omega t\,\mathrm{V}$, is $f = 3.22\,\mathrm{kHz}$. Determine the percentage error due to oscilloscope loading in measuring the rms magnitude of this voltage. Use rms phasors in the calculations and express any complex answer in polar form with the angel specified in degrees. As an intermediate step in the solution determine the input impedance of the oscilloscope, $\overline{Z}_{in}$, and the Thévenin equivalent circuit with respect to the oscilloscope, $\overline{E}_{th}$ and $\overline{Z}_{th}$.





let $\overline{Z}_1 = 47 + 51 \,||\, (-j24.7) + (75 + j121) \,||\, (68 - j49) = 134\angle -11.1^\circ\,\mathrm{k\Omega}$

$$\overline{E}_{th} = 40\,\frac{j81}{j81 + \overline{Z}_1} = 22.7\angle 67.2^\circ\,\mathrm{V}$$

$$\overline{Z}_{th} = j81 \,||\, \overline{Z}_1 = 76.1\angle 56.1^\circ\,\mathrm{k\Omega}$$

$$\overline{Z}_{in} = 1{,}000 \,||\, (-j3{,}802) = 967\angle -14.7^\circ\,\mathrm{k\Omega}$$

$$\%\ error = 100\left[\frac{1}{\left|1 + \frac{\overline{Z}_{th}}{\overline{Z}_{in}}\right|} - 1\right] = -2.77\%$$

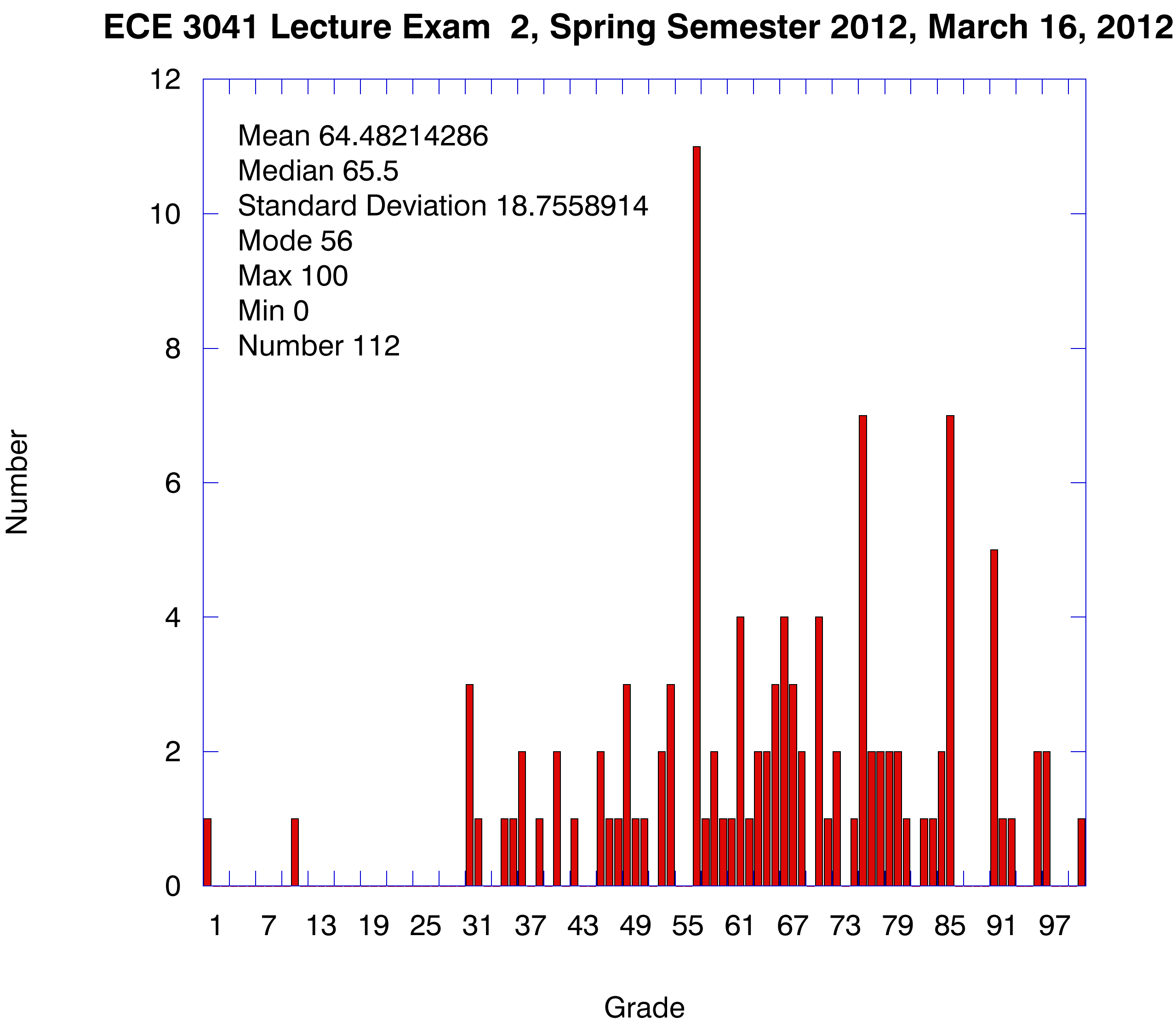
5 $\overline{Z}_{in} =$ $967\angle -14.7^\circ\,\mathrm{k\Omega}$

5 $\overline{E}_{th} =$ $22.7\angle 67.20\,\mathrm{V}$

5 $\overline{Z}_{th} =$ $76.1\angle 56.1^\circ\,\mathrm{k\Omega}$

5 $\%\ error =$ -2.77%

5 try


ECE 3041 Lecture Exam 2, Spring Semester 2012, March 16, 2012
Mean 64.48214286
Median 65.5
Standard Deviation 18.7558914
Mode 56
Max 100
Min 0
Number 112
Number
Grade
0
2
4
6
8
10
12
1
7
13
19
25
31
37
43
49
55
61
67
73
79
85
91
97