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 $t = 1 \text{ ms}$? The voltage source is $e(t) = 15 \text{ V}u(t)$. The component values are: $R_1 = 7.3 \text{ k}\Omega$, $R_2 = 4.3 \text{ k}\Omega$, $R_3 = 11.2 \text{ k}\Omega$, and $C = 0.22 \mu\text{F}$.

\[ V_c(t) = E \left[ 1 - e^{-\frac{t}{\tau}} \right] u(t) \]
\[ i_c(t) = \frac{E}{R} e^{-\frac{t}{\tau}} u(t) \]
\[ \tau = RC \]
\[ E_0 = 15 \text{ V} \]

\[ E = E_0 \frac{R_2}{R_1 + R_2} = 4.161 \text{ V} \]
\[ R = R_1 + R_2 || R_3 = 10.407 \text{ k}\Omega \]
\[ \tau = RC = 2.29 \text{ ms} \]
\[ V_c = E \left[ 1 - e^{-\frac{t}{\tau}} \right] = 1.473 \text{ V} \]
\[ i_c = \frac{E}{R} e^{-\frac{t}{\tau}} = 0.258 \text{ mA} \]
\[ i_2 = \frac{i_c R_1 + V_c}{R_2} = 0.781 \text{ mA} \]
\[ i = i_c + i_2 = 1.039 \text{ mA} \]

\[ i(t) = 1.04 \text{ mA} \]
2. Determine the current \( i(t) \) in the circuit shown below when \( t = 2 \text{ ns} \). The current source \( i_0(t) = 20 \text{ mA} u(t) \). The component values are: \( R_1 = 7.3 \text{ k}\Omega, \ R_2 = 4.3 \text{ k}\Omega, \ R_3 = 11.2 \text{ k}\Omega, \ R_4 = 3.23 \text{ k}\Omega, \) and \( L = 5 \mu\text{H} \).

\[
\begin{align*}
\gamma &= GL \\
E &= \frac{R_4}{R_2 + R_3 + R_4} R_2 = 14.831 \text{ V} \\
R &= R_1 || (R_3 + R_4) = 10.613 \Omega \\
G &= \frac{1}{R} = 94.23 \mu\text{S} \\
\gamma &= GL = 0.471 \text{ nS} \\
I &= \frac{E}{R} = 1.397 \text{ mA} \quad x = 2 \text{ ns} \\
I_L &= I \left[ 1 - e^{-\frac{t}{\gamma}} \right] = 1.377 \text{ mA} \\
V_L &= \frac{I}{G} e^{-\frac{t}{\gamma}} = 0.213 \text{ V} \\
i_2 &= \frac{V_L + R_1 i_L}{R_2} = 2.388 \text{ mA} \\
i &= -(i_2 + i_L) = -3.765 \text{ mA}
\end{align*}
\]

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i(t) = -3.77 \text{ mA}
\]
3. Determine the complex transfer function $T(s)$ for the circuit shown below. Specify it as a function of the complex frequency, $s$, and the symbols for the resistors and capacitor. Plot the magnitude of the complex transfer function $T(j\omega)$ 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 $R_1 = 470 \text{k}\Omega$, $R_2 = 2 \text{k}\Omega$, $R_3 = 1 \text{k}\Omega$, $R_4 = 150 \text{k}\Omega$, and $C = 2 \text{nF}$ Use the numerical values given for the resistors and capacitors. If applicable, determine the pole and zero frequencies in Hertz as well as the high and low frequency gains in decibels.

$$T(\omega) = \frac{\frac{R_3 + R_4}{R_1 + R_2 + R_4}}{\frac{1}{R_3 + R_4}} = 1 + \frac{R_3 + R_4}{R_1}$$

$$T(\infty) = \frac{1}{R_1 + R_2 + R_3 + R_4}$$

$$T(s) = \frac{1 + \frac{R_3 + R_4}{1 + \frac{1}{s}}}{R_1 + R_3 + R_4}$$

$$|T(0)|_{\text{dB}} = -12.3 \text{ dB}$$

$$|T(\infty)|_{\text{dB}} = -941 \text{ dB}$$

$$f_p = \frac{1}{2\pi \left[ \frac{R_2 + R_4}{R_3} \right] C} = 687 \text{ Hz}$$

$$f_z = \frac{1}{2\pi \left[ \frac{R_2 + R_4}{R_3} \right] C} = 26.6 \text{ Hz}$$
4. Indicate with an F (floating) or G (grounded) whether the following laboratory instruments input or output connectors are floating or grounded with respect to the ac power line ground

- F  Keysight 34401A Digital Multimeter
- G  Keysight DSO-X 3012A Oscilloscope
- F  Keysight 3630A Triple Output dc Power Supply
- F  Keysight 33522A Function Generator/Arbitrary Waveform Generator
- F  Fluke/Philips 6303 LCR Meter

The names of the three wires connected to a standard 120 Volt AC outlet are the _______ wire which is covered with _______ colored insulation, the _______ wire which is covered with _______ colored insulation, and the _______ wire which is covered with _______ colored insulation.

2 each
Average 74.15789474
Median 75
Standard Deviation 17.83960375
Mode 90
Max 100
Min 34
Number 19