1. What is the current $i(t)$ in the circuit shown below when $t = 7.3 \text{ ms}$? The voltage source is $e(t) = 10 \text{ V}u(t)$ where $u(t)$ is the unit step function. The component values are: $R_1 = 20 \text{ k}\Omega$, $R_2 = 24 \text{ k}\Omega$, $R_3 = 15 \text{ k}\Omega$, and $C = 0.22 \mu\text{F}$.

\[
V_c(t) = E \left[1 - e^{-\frac{t}{\gamma}}\right] u(t)
\]
\[
i_c(t) = E e^{-\frac{t}{\gamma}} u(t)
\]
\[
\gamma = R C = 5.7 \text{ ms}
\]
\[
V_c = E \left[1 - e^{-\frac{t}{\gamma}}\right] = 3.94 \quad i_c = \frac{E}{R} e^{-\frac{t}{\gamma}} = 0.058 \text{ mA}
\]
\[
i_2 = \frac{V_c + R_3 i_c}{R_2} = 0.201 \text{ mA}
\]
\[
i = i_2 + i_c = 0.259 \text{ mA}
\]
\[
i(t) = 0.259 \text{ mA}
\]
2. What is the current $i(t)$ in the circuit shown below when $t = 0.43 \mu s$? The voltage source is $e(t) = 10 V u(t)$, where $u(t)$ is the unit step function. The component values are: $R_1 = 13 k\Omega$, $R_2 = 12 k\Omega$, $R_3 = 6.8 k\Omega$, and $L = 3 mH$.

\[
\begin{align*}
i_L(t) &= I \left[1 - e^{-\frac{t}{\tau}}\right] u(t) \\
v_L(t) &= \frac{I}{G} e^{-\frac{t}{\tau}} u(t) \\
\gamma &= \frac{L}{G} \\
E &= E_0 \frac{R_2}{R_1 + R_2} = 4.8 V \\
R &= R_3 + R_1 || R_2 = 13 k\Omega \\
I &= \frac{E}{R} = 0.368 mA \\
G &= \frac{L}{R} = 76.7 \mu \text{T} \\
R &= R_3 + R_1 || R_2 = 13 k\Omega \\
E &= E_0 \frac{R_2}{R_1 + R_2} = 4.8 V \\
I &= \frac{E}{R} = 0.368 mA \\
\gamma &= \frac{L}{G} = 0.23 \mu s \\
i_L(t) &= I \left[1 - e^{-\frac{t}{\tau}}\right] = 0.311 mA \\
v_L(t) &= \frac{I}{G} e^{-\frac{t}{\tau}} = 0.74 V \\
v_2(t) &= v_L + R_3 i_L = 2.857 V \\
i_Z &= \frac{v_2(t)}{R_2} = 0.238 mA \\
i(t) &= i_L(t) + i_Z = 0.549 mA
\end{align*}
\]

\[i(t) = 0.549 mA\]
3. Determine the complex transfer function $\overline{T}(s)$ for the circuit shown below. Specify it as a function of the complex frequency, $s$, and the symbols for the resistors and capacitor and a the ratio of two polynomials in $s$. Plot the magnitude of the complex transfer function $\overline{T}(j\omega)$ 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 $R_1 = 330 \, k\Omega$, $R_2 = 2 \, k\Omega$, $R_3 = 150 \, k\Omega$, and $C = 10 \, nF$. Use the numerical values given for the resistors and capacitors. If applicable, determine the pole and zero frequencies as well as the high and low frequency gains.

$$H = T(10)$$

$$T(10) = \frac{R_3}{R_1 + R_3}$$

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

$$\therefore s = \frac{1}{\tau_p}$$

$$\overline{T}(s) = \frac{T(\infty)}{1 + \frac{R_3}{R_2 + R_3}} = \frac{1 + \frac{R_2}{R_2 + R_3} \frac{1}{C}}{1 + \frac{R_2}{R_2 + R_3} \frac{1}{C}}$$

$$|\overline{T}(0)|_{dB} = 20 \log_{10} \left| \frac{R_2}{R_1 + R_3} \right| = -10.1 \, dB$$

$$|\overline{T}(\infty)|_{dB} = 20 \log_{10} \left| \frac{R_2 \| R_3}{R_2 \| R_3 + R} \right| = -44.5 \, dB$$

$$f_p = \frac{1}{2\pi \tau_p} = \frac{1}{2\pi \left[ \frac{R_2 + R_1 \| R_3 + R}{C} \right]} = 751 \, Hz$$

$$f_z = \frac{1}{2\pi \tau_z} = \frac{1}{2\pi \left[ \frac{R_2 C}{R_2 + R_3} \right]} = 7.96 \, Hz$$
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 2 each
- **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 [black] wire which is covered with [black] colored insulation, the [white] wire which is covered with [white] colored insulation, and the [green] wire which is covered with [green] colored insulation.
1. What is the current $i(t)$ in the circuit shown below when $t = 7.3\,\text{ms}$? The voltage source is $e(t) = 10\,\text{V}u(t)$ where $u(t)$ is the unit step function. The component values are: $R_1 = 3\,\text{k}\Omega$, $R_2 = 10\,\text{k}\Omega$, $R_3 = 12\,\text{k}\Omega$, and $C = 0.33\,\mu\text{F}$.

\[ R = R_2 + R_1/R_3 = 12.4\,\text{k}\Omega \quad E = E_0 \frac{R_3}{R_1 + R_3} = 8\,\text{V} \]

\[ v_c = E \left[ 1 - e^{-\frac{t}{R_C}} \right] = 6.66\,\text{V} \quad i_c = \frac{E}{R} \, e^{-\frac{t}{R}} = 0.108\,\text{mA} \]

\[ v_3 = v_c + R_2i_c = 7.74\,\text{V} \]

\[ i_3 = \frac{v_3}{R_3} = 0.645\,\text{mA} \]

\[ i = i_c + i_3 = 0.753\,\text{mA} \]

\[ i(t) = 0.753\,\text{mA} \]
2. What is the current \( i(t) \) in the circuit shown below when \( t = 0.43 \mu s \)? The voltage source is \( e(t) = 18 \ V u(t) \) where \( u(t) \) is the unit step function. The component values are: \( R_1 = 39 \ \Omega \), \( R_2 = 13 \ \Omega \), \( R_3 = 30 \ \Omega \), and \( L = 3 \ \text{mH} \).

\[
\begin{align*}
\frac{\gamma}{G} &= G L = 0.1 \ \mu \Omega \\
R &= \frac{R_2}{R_1 + R_3} = 30 \ \Omega \\
G &= \frac{1}{R} = 33.4 \ \mu \Omega \\
E &= E_0 \frac{R_2}{R_1 + R_3} = 16.1 \ V \\
I &= \frac{E}{R} = 0.537 \ mA \\
i_L &= I \left[ 1 - e^{-\frac{t}{\gamma}} \right] = 0.53 \ mA \\
V_L &= \frac{I}{G} e^{-\frac{t}{\gamma}} = 0.22 \ V \\
V_3 &= V_L + R_2 i_L = 7.1 \ V \\
V' &= \frac{V_3}{R_3} \\
i &= i_L + V_3 = 0.767 \ mA \\
i(t) &= 0.767 \ mA
\end{align*}
\]
3. Determine the complex transfer function $\tilde{T}(s)$ for the circuit shown below. Specify it as a function of the complex frequency, $s$, and the symbols for the resistors and capacitor and is the form of the ratio of two polynomials in $s$. Plot the magnitude of the complex transfer function $\tilde{T}(j\omega)$ 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 $R_1 = 10 \, k\Omega$, $R_2 = 330 \, k\Omega$, $R_3 = 1 \, k\Omega$, and $C = 1 \, nF$. Use the numerical values given for the resistors and capacitors. If applicable, determine the pole and zero frequencies as well as the high and low frequency gains.

\[
\tilde{T}(s) = \frac{R_3}{R_1 + R_2 + R_3} \frac{1 + 2 \frac{R_2 C}{s}}{1 + 2 \frac{R_1 + R_2}{s}}
\]

\[
|\tilde{T}(0)|_{dB} = 20 \log_{10} \left| \frac{R_3}{R_1 + R_2 + R_3} \right| = -50.7 \, dB
\]

\[
|\tilde{T}(\infty)|_{dB} = 20 \log_{10} \left| \frac{R_3}{R_1 + R_2} \right| = -20.8 \, dB
\]

\[
f_p = \frac{1}{2\pi R_1 \omega_p} = \frac{1}{2\pi (R_2 || (R_1 + R_3)) C} = 152 \, Hz
\]

\[
f_z = \frac{1}{2\pi R_1 \omega_z} = \frac{1}{2\pi R_2 C} = 482 \, Hz
\]
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  2 each
- 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 **hot** wire which is covered with **black** colored insulation, the **neutral** wire which is covered with **white** colored insulation, and the **ground** which is covered with **green** colored insulation.
ECE 3043 Lecture Exam 1 September 20, 21 2018

Mean 78.48275862
Median 80
Standard Deviation 13.44658863
Mode 90
Mar 100
Min 43
Number 87