1. Shown below is a single stage common emitter amplifier with a unipolar power supply using a 2N3904 NPN BJT as the active device. It is specified that $V^+ = 15\, \text{V}$, $C_1 = C_2 = C_B = 300\, \mu\text{F}$, $R_C = 5.1\, \text{k}\Omega$, $R_E1 = 2\, \text{k}\Omega$, and $R_L = 27\, \text{k}\Omega$. Design the circuit so that the dc collector current is $1.1\, \text{mA}$ and the magnitude of the small-signal midband voltage gain is 7.3. For the design calculations assume that the base-to-emitter dc voltage drop is $0.65\, \text{V}$, the dc current in $R_{E1}$ is $11I_B$, $\beta = 322$, and the Early voltage is infinity. Assume that the thermal voltage is $25.9\, \text{mV}$. Determine the values of the resistors $R_{B1}$, $R_{B2}$, and $R_{E2}$ to satisfy the design criteria.

\[
\alpha = \frac{\beta}{\beta + 1} = 0.997
\]

\[
I_C = 1.1\, \text{mA}
\]

\[
I_E = \frac{I_C}{\alpha} = 1.103\, \text{mA}
\]

\[
e = \frac{V_T}{I_E} = 23.473\, \Omega
\]

\[
V_E = I_E R_{E1} = 2.207\, \text{V}
\]

\[
V_B = V_E + V_{BE} = 2.357\, \text{V}
\]

\[
I_B = \frac{I_C}{\beta} = 3.416\, \mu\text{A}
\]

\[
I_{B1} = 11I_B = 35.578\, \text{mA}
\]

\[
I_{B2} = I_E + I_{B1} = 12I_B = 40.997\, \text{mA}
\]

\[
R_{E1} = \frac{V_B}{I_{B1}} = 76.025\, \text{k}\Omega
\]

\[
R_{E2} = \frac{V^+ - V_B}{I_{B2}} = 296.22\, \text{k}\Omega
\]

\[
A_V = -\alpha \frac{R_{E2}R_L}{R_{E1}R_{E2}} = -7.3 \Rightarrow R_{E2} = 782.301
\]

<table>
<thead>
<tr>
<th>$R_{B1}$</th>
<th>$R_{B2}$</th>
<th>$R_{E2}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>76kΩ</td>
<td>296kΩ</td>
<td>782Ω</td>
</tr>
</tbody>
</table>

\[\text{10 tns}\]

\[5\, 5\, 5\]
2. In the circuit shown below determine the currents $I_1$, $I_2$, $I_7$, $I_L$ and the voltage $V_o$. The resistors are $R_1 = 4 \, \text{k} \Omega$, $R_2 = 16 \, \text{k} \Omega$, and $R_L = 2 \, \text{k} \Omega$. The sources are dc voltage with $E_1 = 10 \, \text{V}$ and $E_2 = 12 \, \text{V}$. Assume that the op amp is ideal. The voltages are referenced to ground.

\begin{align*}
I_1 &= \frac{E_1}{R_1 + R_2} = \frac{10}{4 + 16} = 0.5 \, \text{mA} \\
V_+ &= \frac{R_2}{R_1 + R_2} E_1 = \frac{16}{4 + 16} = 8 \, \text{V} = V_- \\
I_2 &= \frac{E_2 - V_-}{R_1} = \frac{12 - 8}{4} = 1 \, \text{mA} = I_5 \\
V_0 &= \frac{R_2}{R_1} [V_1 - V_2] = \frac{16}{4} (10 - 12) = -8 \, \text{V} \\
I_L &= \frac{V_0}{R_L} = \frac{-8}{2} = -4 \, \text{mA} \\
I_7 &= I_L - I_5 = -4 - 1 = -5 \, \text{mA}
\end{align*}

<table>
<thead>
<tr>
<th>$I_1$</th>
<th>$I_2$</th>
<th>$I_7$</th>
<th>$I_L$</th>
<th>$V_0$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 mA</td>
<td>1 mA</td>
<td>-5 mA</td>
<td>-4 mA</td>
<td>-8 V</td>
</tr>
</tbody>
</table>

S. Try
3. The op amp in the circuit shown below is ideal. Determine $I_1, I_2, I_4$, and $V_o$. The voltage source is $E = 10\, \text{V}$. The parameter values are: $R_1 = 2\, \text{k}\Omega$, $R_2 = 2\, \text{k}\Omega$, $R_3 = 5\, \text{k}\Omega$, $R_4 = 1\, \text{k}\Omega$, and $R_L = 10\, \text{k}\Omega$.

$I_1 = \frac{E}{R_1} = \frac{10}{2} = 5\, \text{mA}$

$I_2 = -I_1 = -5\, \text{mA}$

$V_c = -E \frac{R_2}{R_1} = -10 \frac{2}{2} = -10\, \text{V}$

$I_3 = \frac{V_c}{R_3} = -10 \frac{5}{2} = -2\, \text{mA}$

$I_4 = -(I_2 + I_3) = -(-5 - 2) = 7\, \text{mA}$

$V_o = V_c - R_4 I_4 = -10 - 1 \times 7 = -17\, \text{V}$

<table>
<thead>
<tr>
<th>$I_1$</th>
<th>$I_2$</th>
<th>$I_4$</th>
<th>$V_o$</th>
</tr>
</thead>
<tbody>
<tr>
<td>5, \text{mA}</td>
<td>-5, \text{mA}</td>
<td>7, \text{mA}</td>
<td>-17, \text{V}</td>
</tr>
</tbody>
</table>
4. Determine the complex transfer function $\mathcal{T}(s) = \frac{V_o}{V_i}$ for the circuit shown below as a ratio of two polynomials in the complex frequency variable $s$. Specify it as a function of the complex frequency, $s$, and the symbols for the resistors and capacitor (not the numerical values). Plot the magnitude of the complex transfer function $\mathcal{T}(j\omega)$ in decibels as a function of the frequency $\omega$ of the source as $\omega$ varies from 1 Hz to 1 MHz. If applicable, determine the pole and zero frequencies in Hertz and the high and low frequency gains in decibels. Assume that the op amp is ideal. Use as the numerical values for the resistors and capacitors: $R_1 = 10\,k\Omega$, $R_2 = 1\,k\Omega$, $R_3 = 150\,k\Omega$, $R_F = 470\,k\Omega$, and $C = 1\,nF$.

\[
\mathcal{T}(s) = \frac{1 + \frac{R_2}{R_1 + R_2}}{1 + \frac{R_F}{R_1 + R_2}} = \frac{1 + \frac{R_F}{R_1 + R_2}}{1 + \frac{R_F}{R_1 + R_2}} \frac{1 + \frac{R_F}{R_1 + R_2}}{1 + 2 \left[\frac{R_2 + R_1 + R_2}{R_1 + R_2}\right] C}
\]

4. $f_p = \frac{2\pi \left[\frac{R_2 + R_1 + R_2}{R_1 + R_2}\right] C}{2\pi (R_2 + R_3) C} = 153\,Hz$

4. $f_z = \frac{2\pi (R_2 + R_3) C}{2\pi (R_2 + R_3) C} = 105\,Hz$

4. $|\mathcal{T}(j0)|_{dB} = 20 \log_{10} \left| \frac{R_F}{R_1 + R_2} \right| = 9.36\,dB$

4. $|\mathcal{T}(j\infty)|_{dB} = 20 \log_{10} \left| \frac{R_F}{R_1 + R_2 + R_3} \right| = 32.6\,dB$
1. Shown below is a single stage common emitter amplifier with a unipolar power supply using a 2N3904 BFN 112 as the active device. It is specified that $V_{CC} = 15\text{V}$.

Junction forward voltage drop $V_T = 0.7\text{V}$, and the circuit is designed so that $R_1$ and $R_2$ are chosen such that $R_1 = R_2 = 10\text{k}\Omega$. Assume a gain at high frequency.

- Comment on the shape of the graph.

- Identify the frequency $f_p$.

- Identify the cutoff frequency $f_3$.

- Plot $|T(\omega)|\text{dB}$ and $T(\infty)\text{dB}$.
ECE 3042 Lecture Exam 1 Feb 22, 2013 Spring

Average 66.54545455
Median 72
Standard Deviation 22.44710955
Max 100
Min 28
Number 11