3.24) (a) Since $K = 1.19$ and $\Delta = 0.399, 126.5^\circ$ (i.e., $\Delta < 1$) the BJT is unconditionally stable at 3.5 GHz. Therefore, it can be designed for a simultaneous conjugate match.

(b) From (3.6.5) and (3.6.6): $\Gamma_{Ma} = 0.798 - 146.9^\circ$, $\Gamma_{Mb} = 0.904 - 168^\circ$

From (3.6.10): $G_{2}, \text{max} = 23.06$ or 13.63 dB.

A design for the amplifier at 3.5 GHz is:

(C) $f(GHz)$ | $\lambda | l_1 | l_2 | l_3 | l_4$
--- | --- | --- | --- | --- | ---
$3$ | $\frac{-3}{4}$ | $\frac{1}{2} \lambda_1$ | $0.051 \lambda_1$, $0.368 \lambda_2$, $0.032 \lambda_1$, $0.104 \lambda_1$
$3.5$ | $\frac{5}{12}$ | $\frac{1}{2} \lambda_2$ | $0.057 \lambda_2$, $0.429 \lambda_2$, $0.037 \lambda_3$, $0.121 \lambda_2$
$4$ | $\frac{4}{13}$ | $\frac{1}{2} \lambda_3$ | $0.067 \lambda_3$, $0.49 \lambda_3$, $0.042 \lambda_3$, $0.138 \lambda_3$
Using the Smith chart it is simple to find the values of $\Gamma_L$ and $\Gamma_R$ at $f_1$ and $f_3$. The values of $G_T$ are calculated using (3.2.1). The results are:

<table>
<thead>
<tr>
<th>$f$ (GHz)</th>
<th>$\Gamma_L$</th>
<th>$\Gamma_R$</th>
<th>$G_T$</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>0.8331 118.5°</td>
<td>0.934 182.2°</td>
<td>0.944 or -0.256 dB</td>
</tr>
<tr>
<td>3.5</td>
<td>0.798 166.9°</td>
<td>0.904 168°</td>
<td>23.06 or 13.63 dB</td>
</tr>
<tr>
<td>4</td>
<td>0.749 145.6°</td>
<td>0.878 51.5°</td>
<td>2.257 or 3.54 dB</td>
</tr>
</tbody>
</table>
3.25 (a) The transistor is unconditionally stable \((k=1.033, \Delta = 0.324, -64.8^\circ)\)

with \(g_p = \frac{G_p}{|s_{21}|^2} = \frac{10}{(1.92)^2} = 2.713\), we obtain from (3.7.4) and (3.7.5):

\[ C_p = 0.781 \angle 33.85^\circ \quad \text{and} \quad \gamma_p = 0.214 \]

The \(G_p = 10 \text{dB gain circle} \) is drawn in the Smith chart. Selecting \(\Gamma_L\) at point "A":

\[ \Gamma_L = 0.567 \angle 33.85^\circ \]

Gives

\[ \Gamma_L = \Gamma_{IN}^* = 0.276 \angle 93.33^\circ \]

and

\[ \Gamma_{OUT} = 0.86 \angle -33.85^\circ \]

From (2.8.3): \(|\Gamma_L|^2 = 0\) (since \(\Gamma_L = \Gamma_{IN}^*\))

Hence: \((\text{VSWR})_{IN} = 1\)

From (2.8.6): \(|\Gamma_L| = 0.572\)

Hence: \((\text{VSWR})_{OUT} = \frac{1 + 0.572}{1 - 0.572} = 3.67\)

A design is:

\[ \Gamma_L = 0.567 \angle 33.85^\circ \]

(b) \(G_{P,\text{max}} = G_{T,\text{max}} = 19.08\) or \(12.8\) dB

The \(G_{P,\text{max}}\) gain circle (i.e., a point) occurs at:

\[ g_{P,\text{max}} = \frac{G_{P,\text{max}}}{|s_{21}|^2} = \frac{19.08}{1.92^2} \]

\[ C_{p,\text{max}} = 0.95 \angle 33.8^\circ, \quad \gamma_{p,\text{max}} = 0 \]

Observe (see problem 3.31) that:

\[ \Gamma_{ML} = C_{p,\text{max}} = 0.95 \angle 33.8^\circ \]

And \(\Gamma_L = \Gamma_{IN}^* = 0.73 \angle 33^\circ\) is identical to \(\Gamma_{ML} \).
3.26) For this transistor: \( K = 1.053 \) and \( \Delta = 0.576 -85.4^\circ \). Therefore, it is unconditionally stable.

\[ G_{\text{p, max}} = G_{\text{T, max}} = 77.12 \text{ or } 18.87 \text{ dB} \]

\[ G_p=10 \text{ dB circle}: \frac{1}{G_p} = 0.977, C_p = 0.306 \left(39.45^\circ\right), \gamma_p = 0.693 \]

The \( G_p=10 \text{ dB constant-gain circle} \) is shown in the Smith chart. The \( \Gamma_c \) selected is shown as "A"; \( \Gamma_c = 0.851 \). Then:

\[ \Gamma_c = \Gamma_c^* \]

\[ \left|\Gamma_c^*\right| = 0.851 \]

\( \left|\Gamma_c^*\right| = 0.9 \text{ (VSWR)}_c = 1 \]

\[ \left|\Gamma_c^*\right| = 0.9 \text{ (VSWR)}_c = 1.8 \]

3.27) (a) \( K = 0.53 \), \( \Delta = 0.5241 -142.9^\circ \); it is potentially unstable.

Output stability circle [(3.3.7) and (3.3.8)]:

\[ C_L = 1.47 \left(76.6^\circ\right) \text{ and } \gamma_L = 0.668 \]

\[ G_p=10 \text{ dB constant-gain circle} [(3.7.4) and (3.7.5)]: \]

\[ g_p = 10 \text{ (V)} \]

\[ C_p = 0.41 \left(76.6^\circ\right) \text{ and } \gamma_p = 0.641 \]

(b) The \( G_p=10 \text{ dB gain circle} \) is drawn on the Smith chart. Three values of \( \Gamma_c \) are denoted by "A", "B", and "C". Then,

| \( \Gamma_c \) | \( \Gamma_c^* \) | \( \Gamma_c^* \) | \( \Gamma_c^* \) | \( \left|\Gamma_c^*\right| \text{ (VSWR)}_c = 1 \text{ (VSWR)}_c = 17 \)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;A&quot;</td>
<td>0.59 \text{ (2.43)}</td>
<td>0.687 \text{(10.11)}</td>
<td>0.84 \text{ (70.73)}</td>
<td>1</td>
</tr>
<tr>
<td>&quot;B&quot;</td>
<td>0.24 \text{(2.9)}</td>
<td>0.759 \text{(100.35)}</td>
<td>0.83 \text{ (76.22)}</td>
<td>0.891</td>
</tr>
<tr>
<td>&quot;C&quot;</td>
<td>0.67 \text{(145)}</td>
<td>0.851 \text{(97.7)}</td>
<td>0.84 \text{ (83.74)}</td>
<td>0.889</td>
</tr>
</tbody>
</table>

The 3 values of \( \Gamma_c \) are in the stable region since \( C_L = 1.3 \left(151^\circ\right) \text{ and } \gamma_L = 0.46 \).

(c) For \( G_p=15 \text{ dB} \):

\[ g_p = 10 \cdot 10^{-3} \quad \text{(2.43)^2} \]

\[ G_p=15 \text{ dB circle}: \]

\[ g_p = 10 \text{ (V)} \]

\[ C_p = 0.81 \left(76.6^\circ\right), \gamma_p = 0.402 \]

For \( G_p=20 \text{ dB} \):

\[ g_p = 10 \text{ (V)} \]

\[ C_p = 1.17 \left(76.6^\circ\right), \gamma_p = 0.457 \]

For \( G_p=40 \text{ dB} \):

\[ g_p = 10 \text{ (V)} \]

\[ C_p = 1.46 \left(76.6^\circ\right), \gamma_p = 0.665 \]

The \( G_p=15 \text{ dB}, 20 \text{ dB}, \text{ and } 40 \text{ dB gain circles} \) are also drawn on the Smith chart. The \( G_p=40 \text{ dB circle} \) almost coincides with the output stability circle.
3.29) (a) $K = 1.032$, $\Delta = 1.65 \pm 18.1^\circ$ 

Potential instability

From (3.3.10) to (3.3.16):

**Input Stability Circle**

\[ C_a = 0.285 \pm 161^\circ \]

\[ y_a = 0.65 \]

**Output Stability Circle**

\[ C_l = 0.315 \pm 61.5^\circ \]

\[ y_l = 0.627 \]

(b) From (3.2.3) with $\mu = 0$: (and $\mu = 5$, when $\mu = 0$)

\[ G_p = \frac{|S_{21}|^2}{1-|S_{11}|^2} = \frac{V_+^2}{1-(0.5)^2} = 21.33 \text{ or } 13.3 \text{ dB} \]

(c) $G_p$ can be infinite, because it is potentially unstable. As $\mu$ approaches the stability circle, $G_p \to \infty$.

3.30) From Example 3.8.1: $G_{A_{max}} = 7.66 \text{ dB}$, $\Delta_{A} = 7.66 - 2 = 7.66 \text{ dB}$.

From (3.7.15) and (3.7.16), for the $G_A = 7.66 \text{ dB}$ gain circle:

\[ g_d = \frac{10.766}{(2.3)^2} = 1.103 \]

\[ C_a = 0.503 \pm 40.4^\circ \]

\[ y_a = 0.436 \]

The values of $\Gamma_L$ on the 7.6 dB circle are given by:

\[ \Gamma_L = C_a + y_a e^{i \phi} = 0.503 \pm 40.4^\circ + 0.436 e^{i \phi} \]

Letting $\phi = 0, \pi, \frac{\pi}{2},$ and $\frac{3\pi}{2}$, we obtain the values of $\Gamma_L$ shown in the table. The associated values of $\Gamma_{out}$ are also shown.

For $(\text{VSWR})_{out} = 1.5$ (or $|\Gamma_b| = 0.2$), using (3.8.7) and (3.8.8), the center and radius of the $(\text{VSWR})_{out}$ = 1.5 circle are calculated.

The values of $\Gamma_L$ on the $(\text{VSWR})_{out} = 1.5$ circle are given by:

\[ \Gamma_L = C_v + y_v e^{i \phi} \]

Letting $\phi = 0, \pi, \frac{\pi}{2},$ and $\frac{3\pi}{2}$, four values of $\Gamma_L$ on the $(\text{VSWR})_{out} = 1.5$ circle are calculated, as shown in the table. The associated values of $\Gamma_{in}, \Gamma_{21},$ and $(\text{VSWR})_{out}$ are also shown.
<table>
<thead>
<tr>
<th>$\theta_1$</th>
<th>$\Gamma_{IN}$</th>
<th>$\Gamma_{OUT}$</th>
<th>$\Gamma_{INT}$</th>
<th>$(\text{VSWR})_{OUT}$</th>
<th>$\Gamma_{IN}$</th>
<th>$\Gamma_{INT}$</th>
<th>$(\text{VSWR})_{IN}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0^\circ$</td>
<td>0.881</td>
<td>0.451</td>
<td>0.276</td>
<td>1.745</td>
<td>0.678</td>
<td>0.594</td>
<td>3.95</td>
</tr>
<tr>
<td>$\pi/4$</td>
<td>0.398</td>
<td>0.005</td>
<td>0.2</td>
<td>-1.4</td>
<td>0.539</td>
<td>0.501</td>
<td>3.00</td>
</tr>
<tr>
<td>$\pi$</td>
<td>0.331</td>
<td>0.249</td>
<td>0.368</td>
<td>-35.2</td>
<td>0.539</td>
<td>0.473</td>
<td>2.79</td>
</tr>
<tr>
<td>$3\pi/2$</td>
<td>0.953</td>
<td>0.547</td>
<td>0.54</td>
<td>-17.9</td>
<td>0.666</td>
<td>0.526</td>
<td>3.22</td>
</tr>
</tbody>
</table>
From these calculations it is seen that a design with
\[ \gamma = 0.331 - 99.26^\circ \] and \[ \gamma = 0.368 - 35.2^\circ \] results in \(\text{VSWR} = 2.79\) and \(\text{VSWR} = 1.5\).
3.31 (a) \( K = 1.344 \), \( \Delta = 2.156 \), \(-16.0^\circ\) : Potentially unstable
(b) Output Stability Circle: \( C_L = 0.261 \), \( \gamma_L = -36.3^\circ \)
(c) From (3.6.4) (using the + sign): \( \Gamma_{\text{ML}} = 0.319 \), \(-36.3^\circ\)
(d) \( G_{p_{\min}} = G_{\text{r_{min}}} = 44.82 \) or 16.51 dB

\[
\begin{array}{|c|c|c|}
\hline
G_p & Center & Radius \n\hline
18 dB & \{ C_p = 0.31 \}, -36.3^\circ & 0.234 \n21 dB & \{ C_p = 0.28 \}, -36.3^\circ & 0.34 \n26 dB & \{ C_p = 0.266 \}, -36.3^\circ & 0.39 \n36 dB & \{ C_p = 0.261 \}, -36.3^\circ & 0.407 \n\hline
\end{array}
\]

The 26 dB gain circle, the 36 dB gain circle, and the output stability circle almost coincide.

(f) Input Stability Circle: \( C_d = 0.102 \), \( \gamma_d = 107.4^\circ \)
From (3.6.5) (using the + sign): \( \Gamma_{\text{dL}} = 0.127 \), \( 107.4^\circ \)
(g) \( (\text{VSWR})_{\min} = (\text{VSWR})_{0.44} = 1 \).

3.32 (a) \( K = 1.17 \), \( \Delta = 0.368 \), \( 27.9^\circ \) : Unconditionally stable
\( G_{p_{\max}} = 9.24 \) or 9.66 dB, \( G_o = 9.66 - 1 = 8.66 \) dB

For the \( G_p = 8.66 \) dB circle: \( \sigma_d = 1.388 \), \( C_p = 0.292 \), \( \gamma_p = -29.4^\circ \)

(b) The values of \( \gamma_p \) on the 8.66 dB circle are:
\[ \Gamma_p = C_p + Y_p \gamma_p = 0.292 \cdot 29.4^\circ + 0.466 \]
Letting \( \theta > 0, \pi \), \( \pi \), and \( 3\pi \) we obtain the values of \( \gamma_p \) shown in the table. The associated values of \( \gamma_{\text{dL}} \) are also shown.

For \( (\text{VSWR})_{0.44} = 1.5 \) (or \( \Gamma_{\text{dL}} = 0.2 \)), using (3.8.3) and (3.8.4), the center and radius of the \( (\text{VSWR})_{0.44} = 1.5 \) circle are calculated.
(c) The values of $\Gamma_L$ on the $(\text{VSWR})_{in} = 1.5$ circle are given by $\Gamma_L = C_V + Y_e \exp \theta$. Letting $\theta = 0$ and $\pi$, two values of $\Gamma_L$ on the $(\text{VSWR})_{in} = 1.5$ circle are calculated (see the table). The associated values of $(\text{VSWR})_{out}$, $|\Gamma_n|$, and $(\text{VSWR})_{out}$ are also shown.

| $\Gamma_L$ | $\Gamma_{in}$ | $(\text{VSWR})_{in} = 1.5$ circle | $\Gamma_L$ | $\Gamma_{out}$ | $|\Gamma_n|$ | $(\text{VSWR})_{out}$ |
|-----------|--------------|----------------------------------|-----------|--------------|----------|------------------|
| (\theta = 0) | 0.36 | 0.548 | 0.471 | 0.637 | 0.377 | 0.259 | 0.975 | 2.8 |
| (\theta = \pi/2) | 0.304 | 0.634 | 0.279 | 0.729 | 0.234 | 0.219 | 0.364 | 1.875 |
| (\theta = \pi) | 0.629 | 0.81 | 0.342 | 0.799 | 0.315 | 0.141 | 0.393 | 2.16 |
| (\theta = 3\pi/4) | 0.716 | 0.782 | 0.494 | 0.771 | 0.494 | 0.149 | 0.415 | 2.44 |

From these calculations it is seen that a design with $\Gamma_L = 0.689 \pm 160.8^\circ$ and $\Gamma_n = 0.589 \pm 31.5^\circ$ gives: $G_p = 8.46$ dB, $(\text{VSWR})_{in} = 1.88$, $(\text{VSWR})_{out} = 1.5$.

3.33) (a) From Example 3.7.2, for the $G_p = 10$ dB circle: $C_L = 0.572 \pm 147.2^\circ$, $\gamma_p = 0.473$

From (3.8.9) and (3.8.10), with $C_{co} = C_p$ and $\gamma_{co} = \gamma_p$, we obtain:

$C_e = 1.131 \pm 170.6^\circ$ and $\gamma_e = 0.622$

(b) For $\Gamma_L = 0.1 \pm 197^\circ$, $\Gamma_{in} = 0.52 \pm 179.3^\circ$

$\Gamma_{in} = \Gamma_{in}^{\prime} = 0.52 \pm 179.3^\circ$

Then $(\text{VSWR})_{in} = 1$

For $(\text{VSWR})_{in} = 2$ (or $|\Gamma_{in}| = 0.333$), we obtain from (3.8.3) and (3.8.4):

$C_L = 0.497 \pm 119.3^\circ$, $\gamma_{in} = 0.251$

Diagram: Mapping of the $G_p = 10$ dB circle to the $\Gamma_L = \Gamma_{in}^{\prime}$ plane.
3.34) \( K = 0.924, \Delta = 0.137 \), 139°, potentially unstable

\[ G_{\text{msg}} = \frac{15.1}{15.1} = \frac{8}{0.03} = 266.6 \text{ or } 24.3 \text{ dB} \]

Design for \( G_P = 20 \text{ dB} \) (i.e., 4.3 dB less than \( G_{\text{msg}} \)).

**Output Stability Circle:**

\[ \zeta = 2.26 \left[ \begin{array}{c} 40^\circ \\ 10^\circ \end{array} \right], \quad \gamma = 1.307 \]

\[ G_P = 20 \text{ dB constant gain circle: } (9 \pm \sqrt{150}) \]

\[ \zeta = 0.505 \left( 40^\circ \right), \quad \gamma = 0.519 \]

Values of \( \zeta_n \) on \( G_P = 20 \text{ dB circle: } \)

\[ \zeta = \zeta_n + \gamma e^{j\theta} = 0.505 \left[ \begin{array}{c} 40^\circ \\ j10^\circ \end{array} \right] + 0.519 \left[ \begin{array}{c} 40^\circ \\ j10^\circ \end{array} \right] \]

The table shows two values of \( \zeta_n \) (i.e., \( \theta_1 = \pi \) and \( \theta_2 = \frac{3\pi}{2} \)), the associated values of \( \zeta_n \), \( \zeta_{\text{out}} \), \( \gamma_{\text{out}} \), \( \alpha_{\text{out}} \) and \( \left( \text{VSWR} \right)_{\text{out}} \).

<table>
<thead>
<tr>
<th>( \theta_n )</th>
<th>( \zeta_n )</th>
<th>( \zeta_{\text{out}} )</th>
<th>( \gamma_{\text{out}} )</th>
<th>( \alpha_{\text{out}} )</th>
<th>( \left( \text{VSWR} \right)_{\text{out}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \left( \theta_n = \pi \right) )</td>
<td>0.352 \left[ \begin{array}{c} 11.7^\circ \ 3.4^\circ \end{array} \right]</td>
<td>0.655 \left[ \begin{array}{c} 163.4^\circ \ 1 \end{array} \right]</td>
<td>0.668 \left[ \begin{array}{c} 44.2^\circ \ 1 \end{array} \right]</td>
<td>0.667</td>
<td>30.25</td>
</tr>
<tr>
<td>( \left( \theta_n = \frac{3\pi}{2} \right) )</td>
<td>0.432 \left[ \begin{array}{c} 26.6^\circ \ 1 \end{array} \right]</td>
<td>0.607 \left[ \begin{array}{c} 192.2^\circ \ 1 \end{array} \right]</td>
<td>0.674 \left[ \begin{array}{c} 34.3^\circ \ 1 \end{array} \right]</td>
<td>0.668</td>
<td>30.25</td>
</tr>
</tbody>
</table>

Mapping of the \( G_P = 20 \text{ dB circle to the } \zeta_n \) plane:

\[ \zeta = 0.823 \left[ \begin{array}{c} 175.3^\circ \\ 1 \end{array} \right], \quad \gamma = 0.527 \]

**Input Stability Circle:**

\[ \zeta = 1.65 \left[ \begin{array}{c} 175.3^\circ \\ 1 \end{array} \right], \quad \gamma = 0.679 \]

The values of \( \left( \text{VSWR} \right)_{\text{out}} = 30.25 \)

Show that the output has to be mismatched in order to reduce the gain to 20 dB. The designer can try to reduce \( \left( \text{VSWR} \right)_{\text{out}} \) by relaxing the input VSWR value (say, let \( \left( \text{VSWR} \right)_{\text{in}} = 1.5 \)), as discussed in Example 3.8.2.
$$K = 0.875, \quad \Delta = 0.445 \quad \text{[160, 40]} \quad \text{. Potentially Unstable}$$

$$G_{msg} = \frac{[52, 1]}{[5, 1]} = \frac{3.1}{0.125} = 24.8 \quad \text{or} \quad 13.9 \text{ dB}$$

**Design for** $$G_A = 10 \text{ dB} \quad (\text{i.e.,} \ 39 \text{ dB less than} \ G_{msg})$$

**Input Stability Circle:**

$$\zeta_c = 3.303 \angle 173.2^\circ, \quad \gamma_c = 2.392$$

$$G_A = 10 \text{ dB Constant-Gain Circle:} \quad (q_a = 1.041)$$

$$\zeta_a = 0.296 \angle 173.2^\circ, \quad \gamma_a = 0.73$$

**Values of** $$\Gamma_c$$ **on the** $$G_A = 10 \text{ dB Circle}$$:

$$\Gamma_c = \zeta_c + \gamma_c e^{j\theta} = 0.296 \angle 173.2^\circ + 0.73 e^{j\theta}$$

The table shows two values of $$\Gamma_c$$ (e.g., for $$\theta = 0$$ and $$\theta = \frac{\pi}{2}$$), the associated values of $$\Gamma = \Gamma_{out}$$, $$\Gamma_{in}$$, $$\Gamma_{14}$$, and $$\text{(VSWR)}_{ch}$$.

<table>
<thead>
<tr>
<th>$$\theta$$</th>
<th>$$\Gamma_c$$</th>
<th>$$\text{(VSWR)}_{out}$$</th>
<th>$$\Gamma_{in}$$</th>
<th>$$\Gamma_{14}$$</th>
<th>$$\text{(VSWR)}_{ch}$$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.437 \angle 46^\circ</td>
<td>0.405 \angle 70.8^\circ</td>
<td>1</td>
<td>0.565 \angle 172^\circ</td>
<td>0.802</td>
</tr>
<tr>
<td>$$\frac{\pi}{2}$$</td>
<td>0.755 \angle 112.9^\circ</td>
<td>0.08 \angle 133.8^\circ</td>
<td>1</td>
<td>0.624 \angle 171.9^\circ</td>
<td>0.802</td>
</tr>
</tbody>
</table>

**Mapping of the** $$G_A = 10 \text{ dB Circle}$$ **to the** $$\Gamma = \Gamma_{out}$$ **Plane**:  

$$\zeta_c = 0.646 \angle 130.9^\circ \quad \text{and} \quad \gamma_c = 0.566$$

**Output Stability Circle:**

$$\zeta_c = 9.33 \angle 49.1^\circ, \quad \gamma_c = 10.19$$

The values of $$\text{(VSWR)}_{ch} = 9.1$$ show that the input must be matched in order to reduce the gain to 10 dB. (i.e., $$G_A = 10 \text{ dB}$$). The designer can try to reduce $$\text{(VSWR)}_{ch}$$ by relaxing the output VSWR.
3.36) (a) DC MODEL

(b) \[ V_{TH} = 2.4(9.1) = 4.8 \text{ V} \]
\[ R_{TH} = 4.1 \times 10^3 \text{ k}\Omega = 3.2 \text{ k}\Omega \]
\[ V_{TH} = I_B R_{TH} = 0.7 + I_C R_C \quad (I_C = I_B) \]
\[ I_B = \frac{V_{TH} - 0.7}{R_{TH} + \beta R_C} = 40 \text{ mA} \]
\[ I_C = \beta I_B = 4 \text{ mA} \]
\[ V_{CE} = V_{CE} = I_C (R_C + R_E) = 24 - 4 \times (2.5 + 1) = 10 \text{ V} \]

(c) At 500 MHz the 0.1 \mu F \ (Z_L = 314.2 \Omega) act as short circuits to the AC signal. Thus, RFCs are not needed in series with the 16 \Omega and 2.5 \Omega resistors.

The 100 \mu H inductor \ (Z_L = 314.2 \Omega) impedance is about 10% of the resistance of \( R_L = 4 \text{ k}\Omega \). Thus, a RFC should be used in series with the 4 \text{ k}\Omega resistor.

(d) DC MODEL

\[ Z = \frac{1}{\omega C} = \frac{1}{2 \pi f C} \approx \frac{1}{2 \times 3.14 \times 10^6 \times 0.1 \mu F} = 16.37 \Omega \]
\[ Z_{700 \mu H} = \frac{1}{2 \pi f C} = \frac{1}{2 \times 3.14 \times 10^6 \times 700 \mu F} = 314.2 \Omega \]

Using the ZV chart it is simple to calculate:
\[ R_L = 1.015 + 0.035 \]
\[ R_C = 0.02 \times 65.8 \]

3.37) (a) DC MODEL

(b) \[ 20 = I_C R_C + V_{CE} \]
or \[ R_C = \frac{20 - 10}{I_C} = 2 \text{ k}\Omega \]
\[ V_{CE} = I_B R_B + 0.7 \]
\[ R_B = 10 - 0.7 = 186 \text{ k}\Omega \]

This type of DC bias results in a large value for \( R_B \).

(c) AC MODEL

At \( f = 300 \text{ MHz} \):
\[ Z_{700 \mu H} = 314.2 \Omega \]
\[ Z_{300 \mu F} = 375.4 \Omega \]
\[ Z_{50 \mu F} = 131.9 \Omega \]

Using the ZV Smith chart:

Simple calculations, we obtain:
\[ Z_L = 35.2 + j 55.2 \text{ k}\Omega \] or \( R_L = 0.185 \text{ k}\Omega \)
\[ Z_C = 49.9 + j 1.75 \text{ k}\Omega \] or \( R_C = 0.96 \text{ k}\Omega \)
3.38) Let \( V_{cc} = 20 \, V \), \( R_E = \frac{10\% \, V_{cc}}{I_C} = \frac{0.1(20)}{10 \, \text{m}} = 200 \, \Omega \)

\[ V_{cc} = V_{CE} + I_C (R_c + R_E) \Rightarrow R_c + 200 = \frac{20 - 10}{0.04} = 2.5 \, \text{k}\Omega \text{, or } R_c = 2.3 \, \text{k}\Omega \]

For good beta stability let \( R_{TH} = \frac{0.04 \, R_E}{10} = \frac{100(20)}{10} = 2 \, \text{k}\Omega \)

\[ V_{TH} = I_B R_{TH} + 0.75 + I_C R_E = \frac{4 \, m}{10} (2\, k) + 0.75 + 4 \, m(200) = 1.63 \, V \]

\[ R_1 = R_{TH} \frac{V_{cc}}{V_{TH}} = \frac{2.3 \, k}{1.63} = 28.22 \, \text{k}\Omega \]

\[ R_2 = R_{TH} \frac{1 - V_{TH/V_{cc}}}{1 - (1.63/20)} = 2.5 \, \text{k}\Omega \]

3.39) \( I_{c2} = 10 \, \text{mA} \), let \( I_3 = 20 \, \text{mA} \), then \( I_{c1} = I_3 - I_{c2} = 20 \, \text{mA} - 10 \, \text{mA} = 10 \, \text{mA} \)

\[ R_4 = \frac{0.75}{I_{c1}} = \frac{0.75}{10 \, \text{m}} = 75 \, \text{\mu}\Omega \text{, let } V_{cc} = 20 \, V \]

\[ R_3 = \frac{V_{cc} - V_{CE2}}{I_3} = \frac{20 - 10}{20 \, \text{m}} = 500 \, \Omega \]

For good beta stability let \( I_{R1} = I_{R2} = 20 \, I_{B1} = 20 \, \frac{10 \, \text{mA}}{100} = 2 \, \text{mA} \),

\[ V_{B1} = V_{CE2} - 0.75 = 9.25 \, V \]

\[ R_1 = \frac{V_{cc} - V_{B1}}{I_{R1}} = \frac{20 - 9.25}{2 \, \text{m}} = 5.37 \, \text{k}\Omega \]

\[ R_2 = \frac{V_{B1}}{I_{R2}} = \frac{9.25}{2 \, \text{m}} = 4.63 \, \text{k}\Omega \]