1. This is a parallel voltage configuration.

The small-signal model needed to find $a$ is:

$$I_s = \frac{V_2}{1k}$$

$$R_{FL1} = \frac{1}{y_{21}}$$

$R_{FL1}, R_{FL2}$ account for loading effects of the feedback network.

The feedback network is:

$$\frac{I_2}{\frac{71}{10k} \text{ pF}} \text{ to } I_2$$

$$V_1 \frac{1}{\frac{1}{10k}} \text{ to } V_2$$

$$y_{11} = \frac{I_1}{V_1} \bigg|_{V_2 = 0} = \frac{1}{9.7k}$$

$$y_{22} = \frac{I_2}{V_2} \bigg|_{V_1 = 0} = \frac{1}{13.2k}$$

$$y_{12} = \frac{I_1}{V_2} \bigg|_{V_1 = 0} = y_{22} \left( \frac{I_1}{I_2} \right) = \frac{1}{13.2k} \left( \frac{-10k}{9.7k} \right) = f$$
1) \( \alpha = \left. \frac{V_o}{I_s} \right|_{I_{58} = 0} = (2)(1k) = 2k = 2 \times 10^3 \)  
\( = (2)(851)(76.5) = 12.99 \times 10^3 \)

\( f = \gamma_{12} = 51.5 \times 10^{-4} \)

2) Series current network uses 2 parameters, so we need to find \( z_{12} = f \).

\( z_{12} = \left. \frac{V_1}{I_2} \right|_{I_1 = 0} = \left( \frac{1}{2} \right)(1k) = 333 \)

3) Current divider

[Diagram with Bode plots showing frequency response in dB and phase]
4) Phase margin - Find \( \omega_1 \) such that 
\[ 20 \log |T(j\omega)| = 0 \text{dB}. \]
Then 
\[ \text{phase margin} = 180 + \angle T(j\omega). \]
If the result is positive the system is considered stable and
if the result is negative the system is considered unstable.

Gain margin - Find \( \omega_2 \) such that 
\[ |T(j\omega)| = 180^\circ. \] Then the gain
margin is 
\[ -20 \log |T(j\omega)|. \]
If the result is positive the system is considered stable and
if the result is negative the system is considered unstable.

5) \[ V_{11} = \left. \frac{I_1}{V_1} \right|_{V_2=0} = \frac{1}{390 + (1k) + 500} = \frac{1}{723} \]
\[ V_{12} = \left. \frac{I_2}{V_2} \right|_{V_1=0} = \frac{1}{500 + (1k) + 390} = \frac{1}{780.5} \]
5' cont. \[ y_{21} = \frac{I_2}{V_2} \bigg|_{V_1=0} = \frac{I_2}{V_2} \left( \frac{I_1}{I_2} \right) = \frac{1}{7805} \left( \frac{-1k}{139D} \right) = -921.7 \times 10^{-6} \]

\[ y_{21} = \frac{I_2}{V_1} \bigg|_{V_1=0} = \frac{I_1}{V_1} \left( \frac{I_1}{I_2} \right) = \frac{1}{723} \left( \frac{-1k}{139D} \right) = -922 \times 10^{-6} \]

6) This is a parallel voltage configuration.

The small-signal model needed to find a is:

\[ I_{22} = -\frac{V_2}{660} \]

\[ RF_1, RF_2 \text{ account for loading effects of the feedback network.} \]

The feedback network is:

\[ \frac{I_2}{V_2} = \frac{-1k}{10k} + \frac{1}{10k} + \frac{1}{10k} \]

\[ y_{11} = \frac{I_1}{V_1} \bigg|_{V_2=0} = \frac{1}{10k} \quad y_{22} = \frac{I_2}{V_2} \bigg|_{V_1=0} = \frac{1}{10k} \]

\[ y_{12} = \frac{I_1}{V_2} \bigg|_{V_1=0} = \frac{-1}{10k} = f \]
\[ a = \left. \frac{\frac{v_o}{i_s}}{i_s} \right|_{i_{f_b} = 0} = \begin{pmatrix} -2 \\ 1 \end{pmatrix} \begin{pmatrix} 1k \parallel 10k \parallel 10k \\ 600 \parallel 333 \parallel 10k \parallel 1k \parallel 1k \parallel 1k \parallel 1K \end{pmatrix} \]

\[ = (-2)(1\parallel 7.7)(833.3) \]

\[ = -2.4 \times 10^3 \]

\[ f = -10^{-8} \]

7) This is a parallel current configuration. The small-signal model needed to find \( a \) is:

[Diagram of the circuit configuration]

\[ i_s \]

\[ (\frac{v_o}{i_s}) \]

\[ = \frac{v_o}{i_s} \approx I_o \]

\[ \frac{v_o}{10k} \]

\[ \frac{v_o}{1k} \]

\[ \frac{v_o}{1k} \]

\[ \frac{v_o}{1k} \]

\[ \frac{v_o}{1k} \]
The feedback network is:

\[ \frac{10k^2}{V_1} + \frac{1}{100k^2} + \frac{1}{V_2} \]

For the parallel current configuration we use a parameter. For this case,

\[ g_{21} = \frac{V_1}{I_1} \bigg|_{I_2=0} = \frac{1}{10.1k} \]

\[ g_{22} = \frac{V_2}{I_2} \bigg|_{V_1=0} = \left(10k, 1100\right) = 991.2 \]

\[ g_{12} = \frac{I_1}{I_2} \bigg|_{V_1=0} = -\frac{100}{10.1k} \]

Use Table to find the relevant gain expressions.

2nd stage is CE w/ RE feedback, so

\[ A_{012} = \frac{-g_{m2} R_{e2} || R_e}{1 + g_{m2} R_{e2}} = \frac{-2(1k, 110k)}{1 + 2(99)} \]

\[ = -8.74 \]
\[ R_i = R_{BE} \left[ \frac{1}{R_x} + \left( \frac{1}{R_{E2}} \right) R_{E2} \right] = 99 \]

1st stage is CE, so

\[ AV_{i1} = -g_m \left( \frac{R_c}{R_{i1}} \right) = -2 (1k \Omega) \]

\[ = -18 \]

So, \( AV_{i\text{total}} = AV_{i1} = 15.75 \]

But \( a = \frac{I_{10}}{I_S} \bigg|_{I_{10} = 0} = \left( \frac{V_o}{R_L} \right) \left( \frac{R_2 || R_{E2}}{R_1} \right) \)

\[ R_{i1} = 500 \Omega \frac{10}{1k \Omega} 150 = 82.7 \Omega \]

So, \( a = 15.75 \left( \frac{1k \Omega}{909} \right) = 13.2 \)

\[ f = g_{12} = -9.9 \times 10^{-3} \]
8) This is a series voltage configuration.

The small-signal model needed to find $a$ is:

The feedback network is:

Express in $h$-parameters

$V_1 = h_{11} i_1 + h_{12} V_2$

$i_2 = h_{21} i_1 + h_{22} V_2$
(cont.) \( h_{u_1} = \frac{\dot{V}_1}{i_1}, \quad \text{if} \quad V_2 = 0 = (100)(10k) = 99.2 \)

\( h_{i_2} = \frac{i_2}{V_2}, \quad \text{if} \quad i_1 = 0 = \frac{1}{10.1k} \)

\( h_{i_2} = \frac{V_i}{V_2}, \quad \text{if} \quad i_1 = 0 = \frac{100}{10.1k} \)

2nd stage is CE w/Re feedback

\( A_{u_{i_2}} = \frac{g_m (R_{e_{11}} R_{e_{11}} / h_{i_2})}{1 + g_m R_{e_2}} = \frac{-166.8}{21} = -7.94 \)

\( R_{i_2} = \frac{R_{e_{11}} [r_{i_2} + (1 + \beta_2) R_{e_2}]}{99.2} \)

1st stage is CE, so

\( A_{u_{i_1}} = \frac{g_m (R_{e_{11}} / R_{i_2})}{1 + g_m h_{i_1}} = \frac{-18.02}{20.8} = -0.86 \)

So, \( A_{v_{\text{total}}} = A_{u_{i_1}} A_{v_{i_2}} \)

\( A_{v_{s'}} = \frac{V_s'}{V_s} = \frac{R_{i_1}}{R_{i_1} + R_{s'}} \frac{A_{v_{\text{total}}}}{10.5k A_{v_{\text{total}}} + 0.9} = 6.82 \)

In this case \( s = A_{v_{s'}} = \frac{V_s}{V_s'} \)

\( R_{i_1} = \left[ r_{i_1} + (1 + \beta_1) (h_{i_1}) \right] = 10.5k \)

\( f = h_{i_2} = \frac{100}{10.1k} = .099 \)

\( \Rightarrow A = \frac{a}{1 + af} = 6.39 \)
a) $PM = -50^\circ$ so the amplifier is unstable.

b) From the above graphs it is apparent that we need to lower the lowest frequency pole to $100 \text{rad}/\text{sec}$ for $PM = 45^\circ$.

From $\omega_s = 10^5(1 - 1.98 \times 10^9 C_e) = 10^2$

we obtain $C_e \approx 50 \mu F$
a) $PM = 60^\circ$ so the amplifier is unstable.

b) From the above graphs it is apparent that we need to lower the lowest frequency pole to 100 rad/sec. for $PM = 95^\circ$. From $w_1 = 10^5(1 - 19.98 \times 10^9 C_c) = 10^2$ we obtain $C_c \approx 50 \mu F$. 
Assuming the transistor $Q_3$ begins to just conduct at $V_{BE} = 0.65V$, then the 100uA flows mostly through $R_1$ and $R_2$. In that case

$$R_1 = R_2 = \frac{0.65}{10^{-4}} = 6.5 \text{ k}\Omega$$

The average power to the load of 50W implies

$$\frac{1}{2} \frac{V_{max}^2}{8} = 50,$$

or

$$V_{max} = \sqrt{800} = 28.3V$$

Assuming a saturation voltage of .2V for $Q_1$ and $Q_2$, $V_{CC} = V_{EE} \geq 28.5V$

If $I_S = 10^{-13}A$ for $Q_1$ and $Q_2$ then

$$I_{COA} = I_{CQ} = 10^{-13} e^{\frac{0.65}{0.026}} = 7.2 \text{ mA}$$
12) For this problem use a 120 VAC transformer.

Neglecting the resistive voltage drop of the secondary winding

\[ V_{\text{sec}}^{\text{pk}} = 12.6 \left( \frac{\sqrt{2}}{2} \right) = 17.8 \text{V} \]

\[ V_{\text{rop}}^{\text{pk}} = 17.8 - 1.4 = 16.4 \text{V} \]

Assume forward voltage drop of .7V for diodes

Using the equation \( I = \frac{C \Delta V}{\Delta t} \) we can estimate \( C \) from \( \frac{I \Delta t}{\Delta V} = C = 8300 \mu F \)

\( \text{Vripple}=1 \)
13) Series regulator example:
Generate 10V from 20V, using a 2.7V reference voltage, with 1mA current for the divider network, and current limiting at 1A. 10mA is needed for the zener diode. Assume $V_f = 0.7V$.

\[ R_2 = \frac{2.7}{.001} = 2.7k\Omega \]
\[ R_1 = 7.3k\Omega \]
\[ I_C = (1 + \frac{R_1}{2.7k}) \cdot 2.7 \]

14) See web pages mentioned on announcement page.