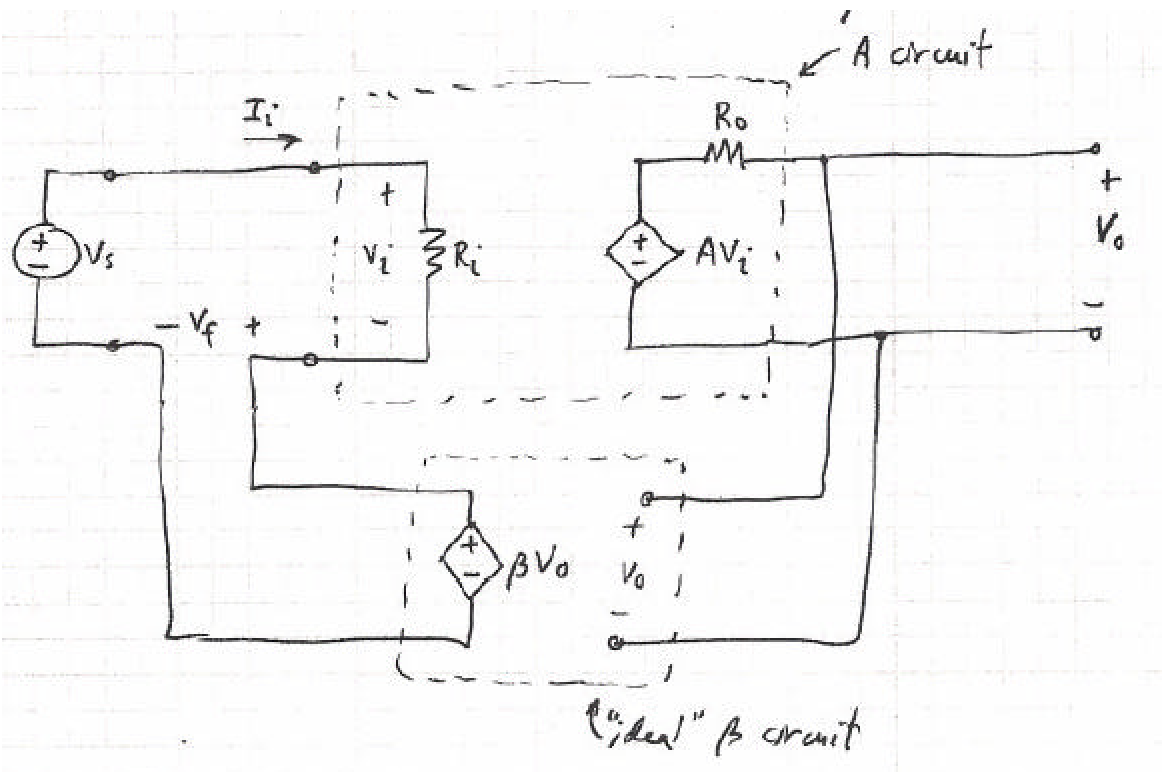
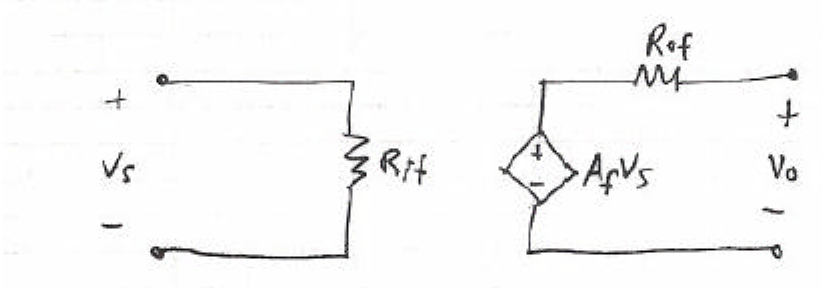
FEEDBACK/STABILITY

Detailed look at series-shunt feedback:



Equivalent circuit:



$\mathbf{A_f = 1/(1+A}$b$\mathbf{)}$

$\mathbf{R_{if}}$**:**

$$R_{if} \equiv \frac{V_s}{I_i} = \frac{V_s}{V_i/R_i} = R_i \frac{V_s}{V_i} = R_i \frac{V_i + V_f}{V_i} = R_i \frac{V_i + \beta A V_i}{V_i}$$

$V_f = \beta Vo = \beta AV_i$

=> $\mathbf{R_{if} = R_i(1+A}b\mathbf{)}$ *This increase in input resistance is desirable

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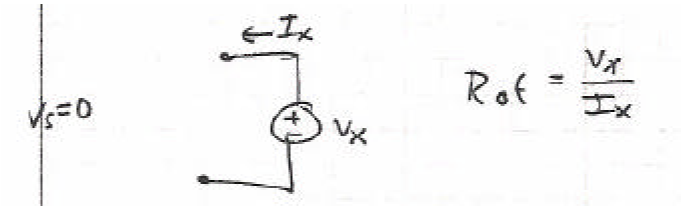
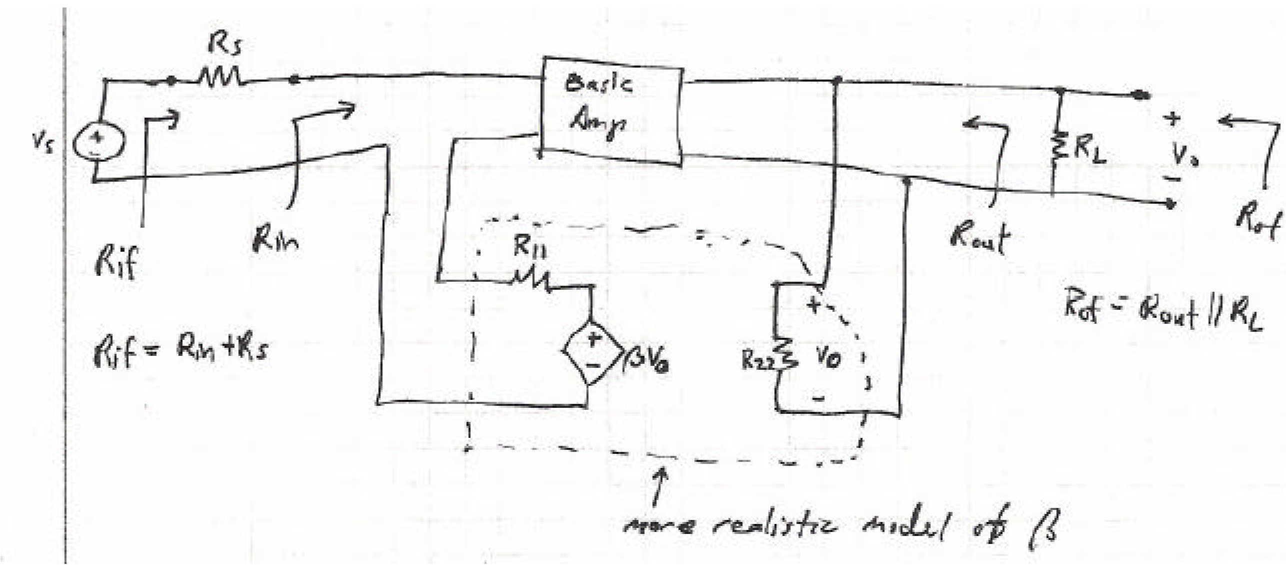
R_{of}:

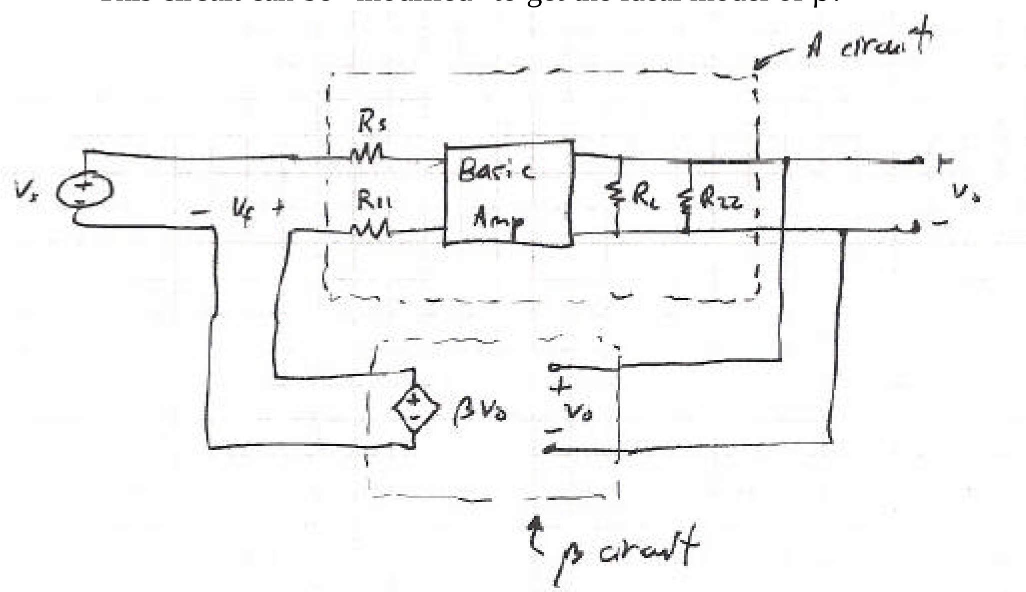


Series-shunt feedback:

- Nonideal situation for feedback:



- This circuit can be “modified” to get the ideal model of β:



- Need to find R_{11}, R_{22}, and β for different topologies
  - Series-shunt feedback:

FEEDBACK/STABILITY

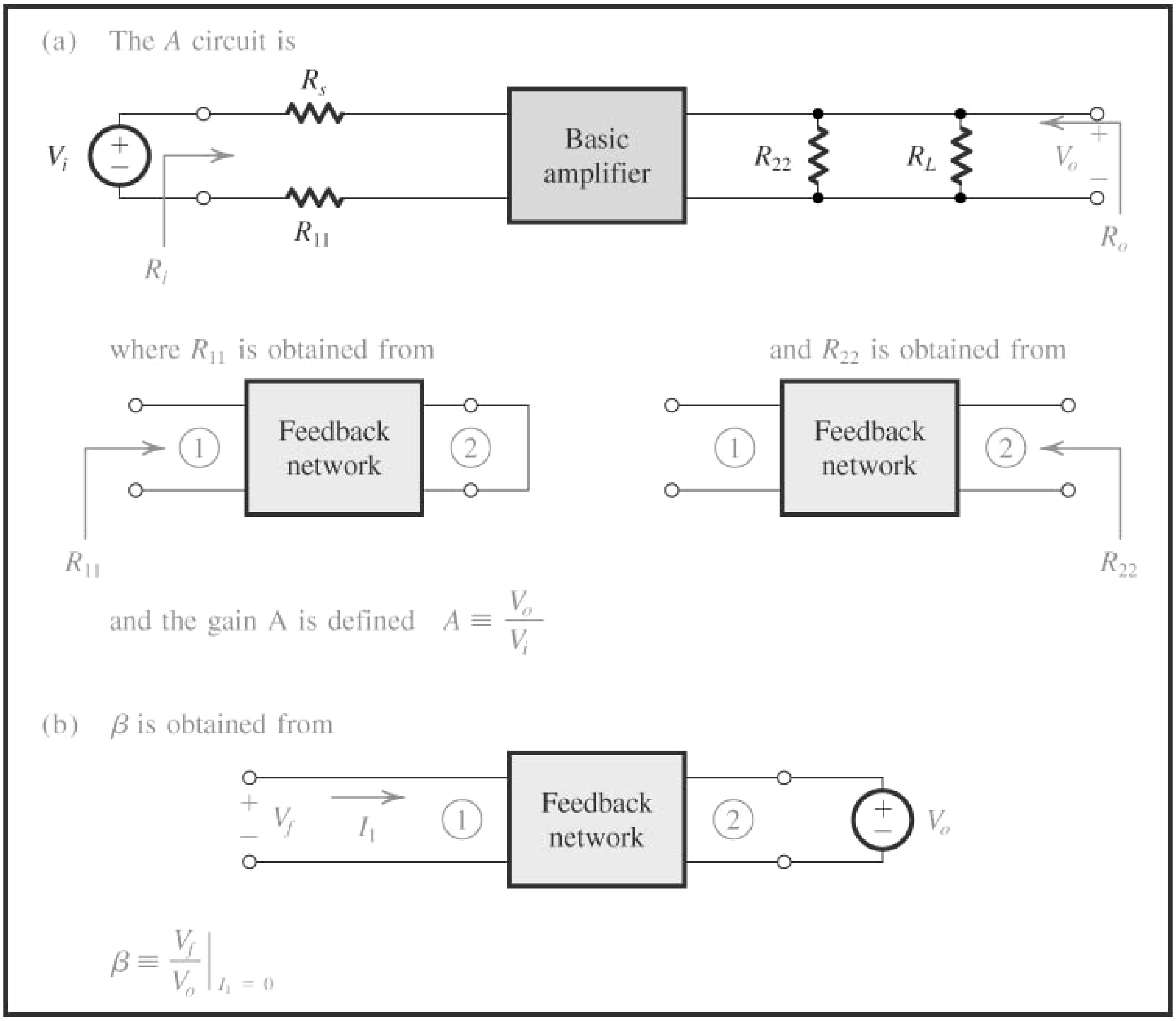
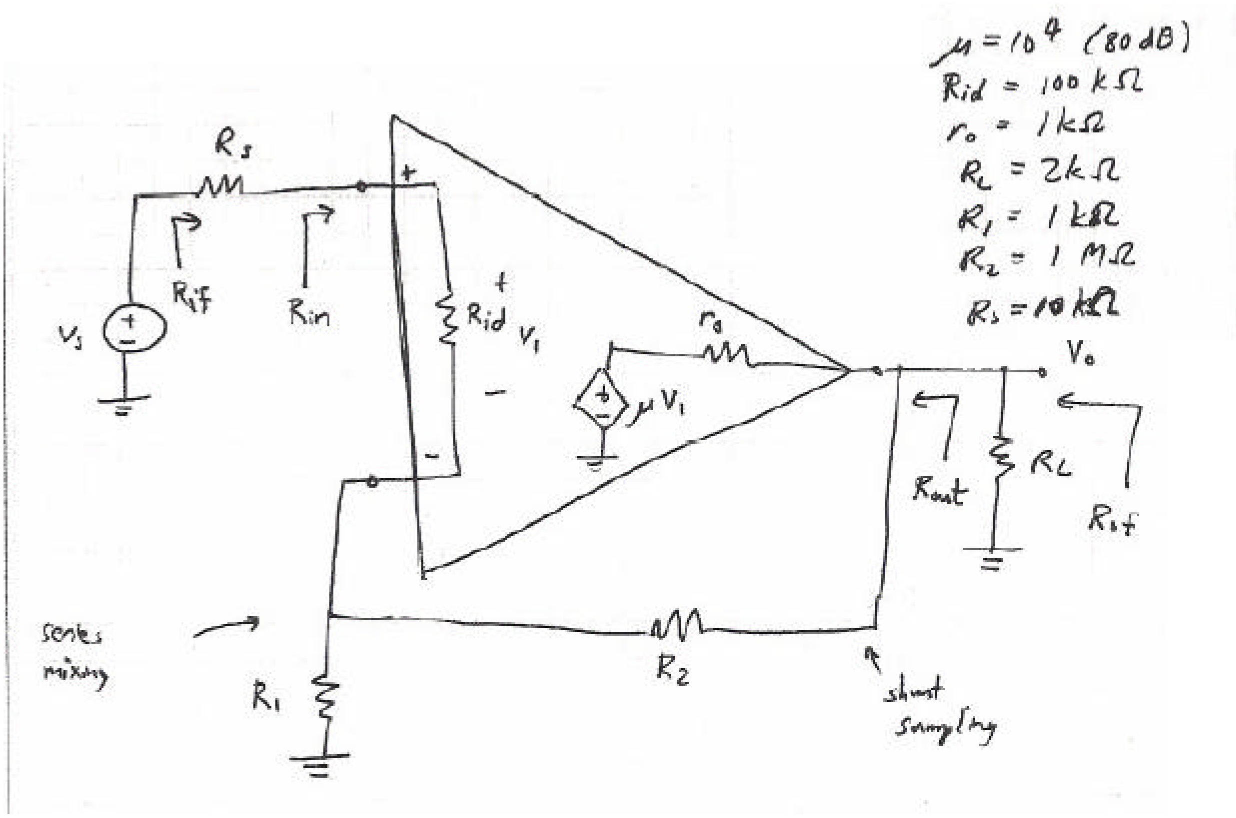


Fig. 8.11 (book)

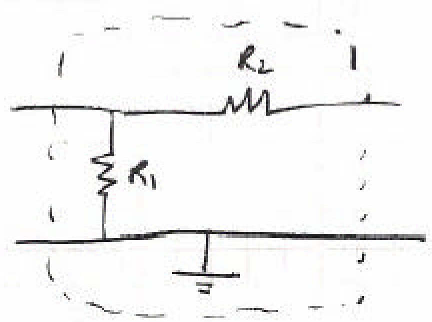
NOTE: The modified circuit will be different for each feedback topology:
See Figs. 8.15, 8.16, 8.18, 8.20, 8.22, 8.24
See Table 8.1 for a summary

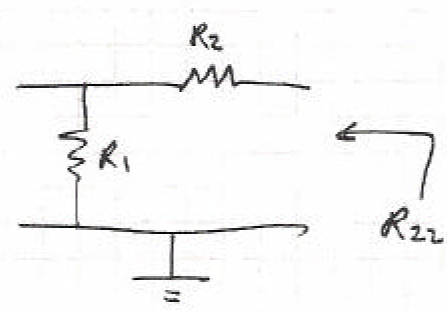
FEEDBACK/STABILITY

Example 8.1:



Feedback network:





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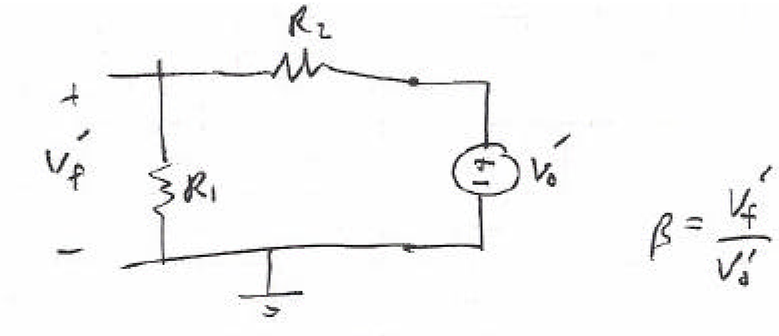
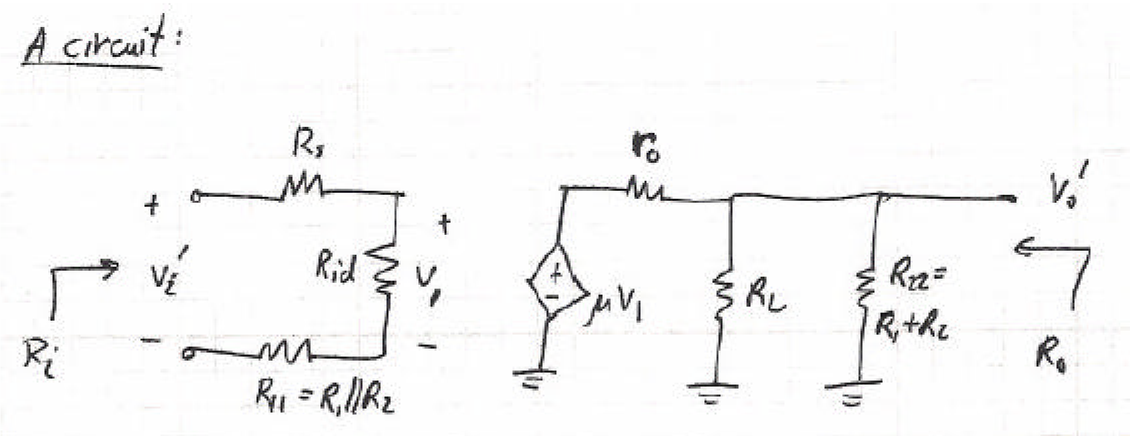




Stability:

- Negative feedback is stable, why?
- All positive feedback is unstable – leads to oscillations

$$A_f(jw) = \frac{A(jw)}{1 + A(jw)b(jw)}$$

Case 1: $|A(jw)b(jw)| < 1$

Case 2: $|A(jw)b(jw)| = 1$

Case 3: $|A(jw)b(jw)| > 1$

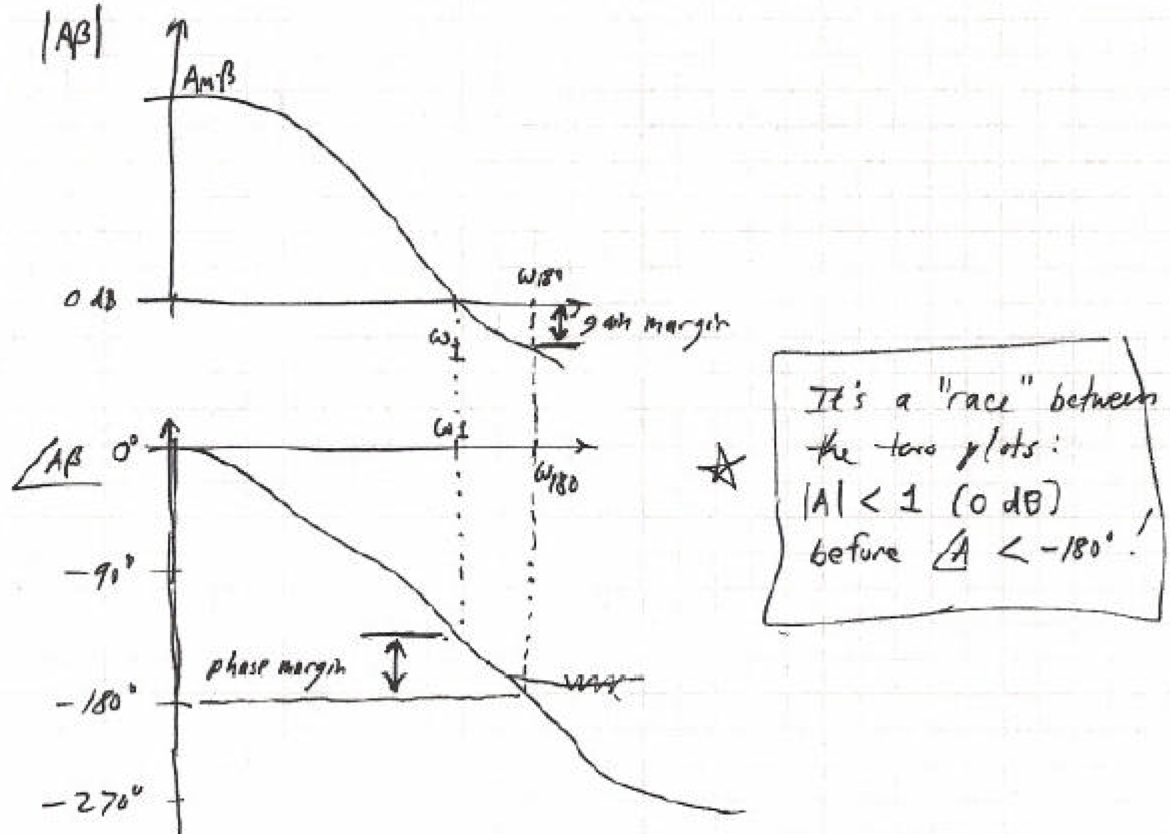
FEEDBACK/STABILITY

Definitions:

Oscillator=>

Gain margin=>

Phase margin=>



Rule of thumb: Phase margin should be at least 45°
... at least 60° to be safe.

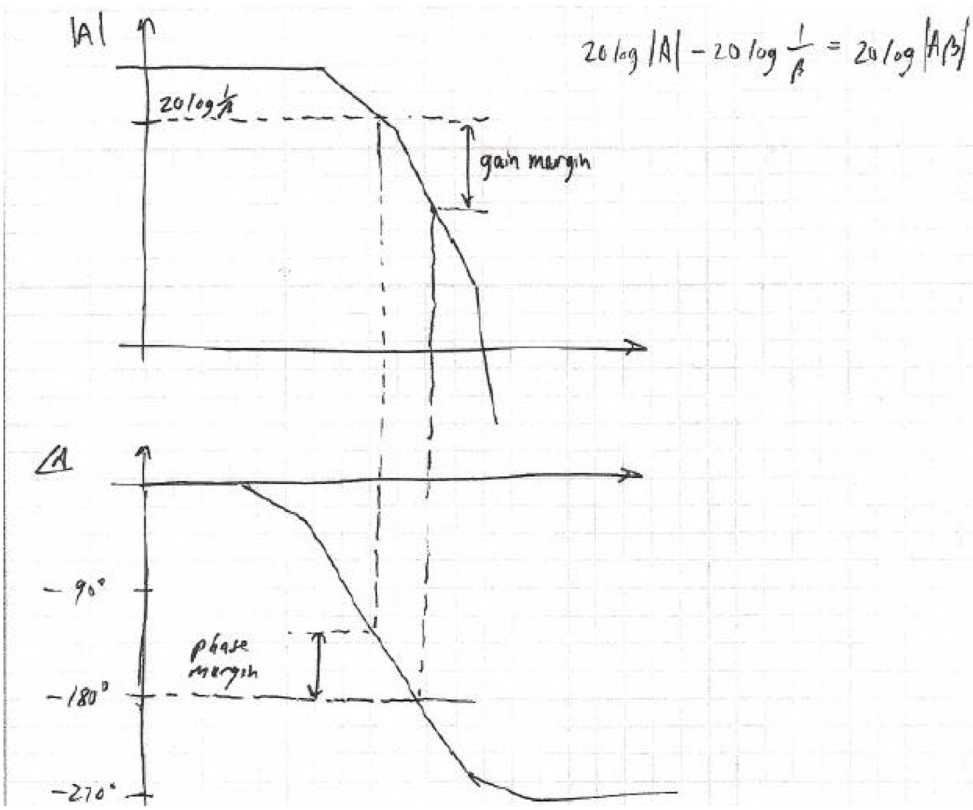
FEEDBACK/STABILITY

Instead of making Bode plot for loop gain, we can use the Bode plot of just A:

Step 1. Draw magnitude plot for A

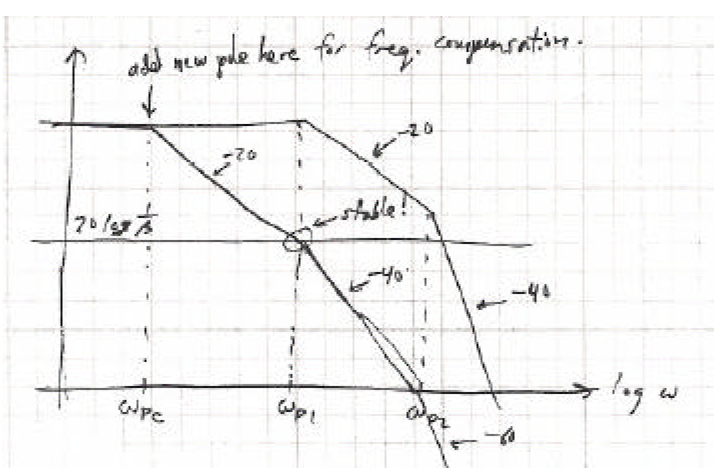
Step 2. Draw a line for 20 log ($1/\beta$)

Step 3. Can measure gain margin and phase margin from this plot:



Frequency Compensation:

- Add a pole so that 20 log (1/b) intersects |A| line at -20dB/dec. What is phase after 1st pole?
- Add pole $p_c < p_1, p_2, \ldots$ so p_1 becomes 2nd pole.



Tradeoff?

FEEDBACK/STABILITY

Method:

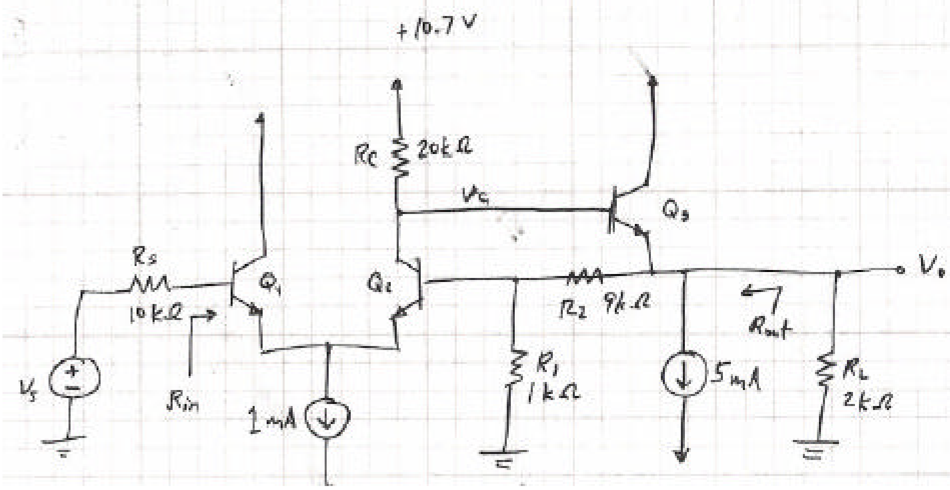
Step 1. Draw magnitude Bode plot of |A| and straight line at 20 log (1/β)

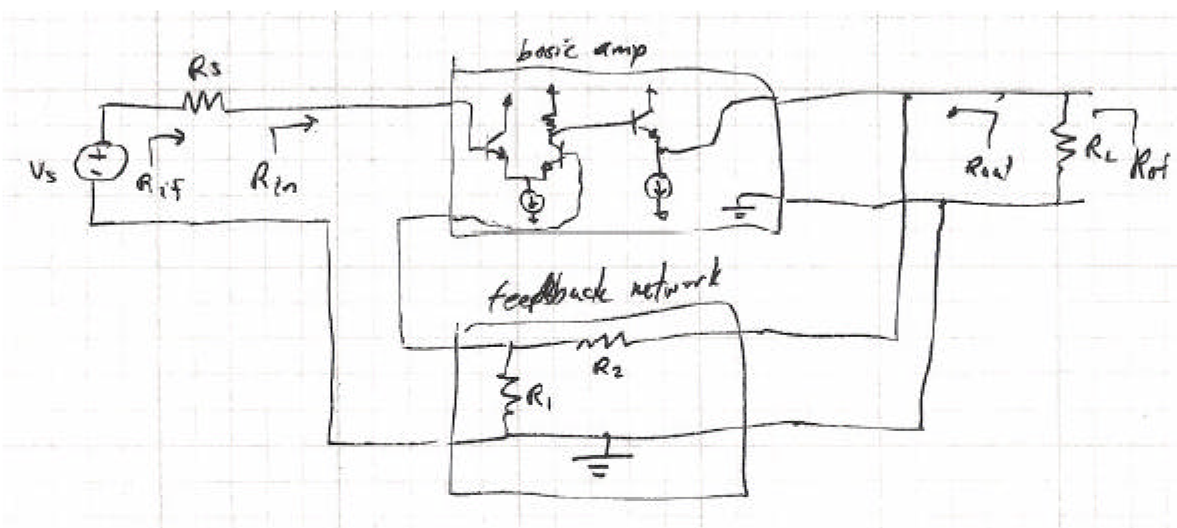
Step 2. Mark point at first pole freq. on 20 log (1/β) line

Step 3. Trace a line from the point in Step 2 backwards at a slope of -20dB/dec.

Step 4. Note where this line intersects |A| curve and determine this frequency as the new pole.

Example: Exercise 8.5 β=100, series-shunt feedback, A, β, A_f, R_{in}, and R_{out}.





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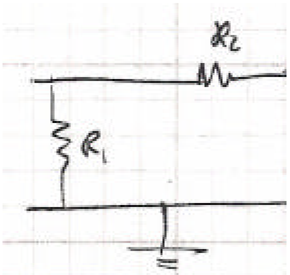
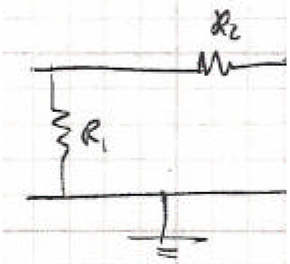
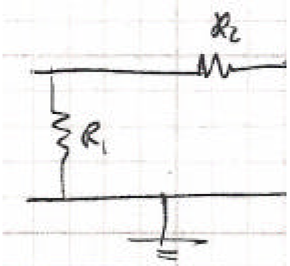
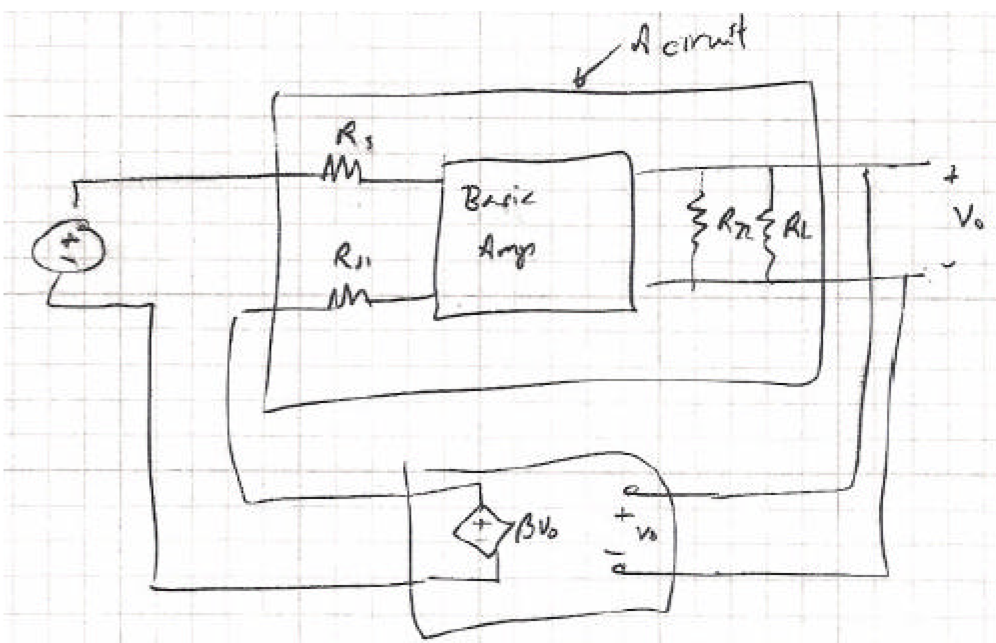


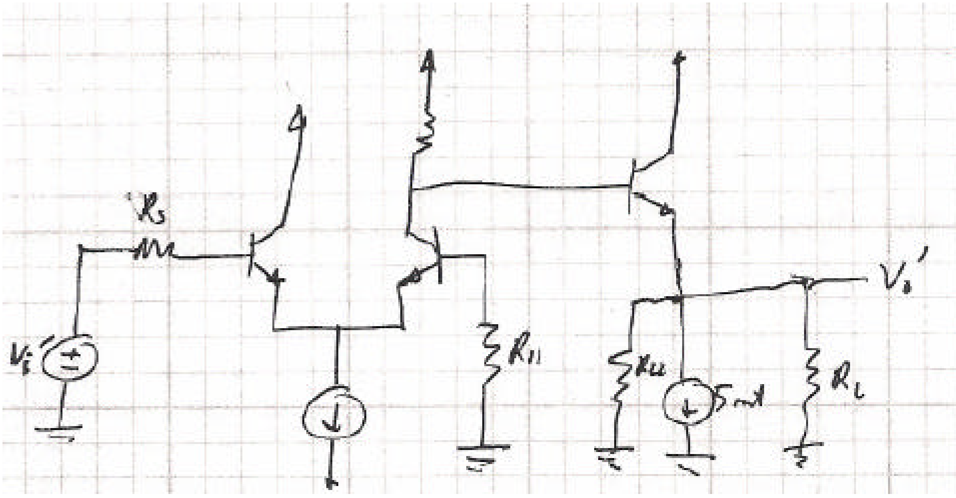




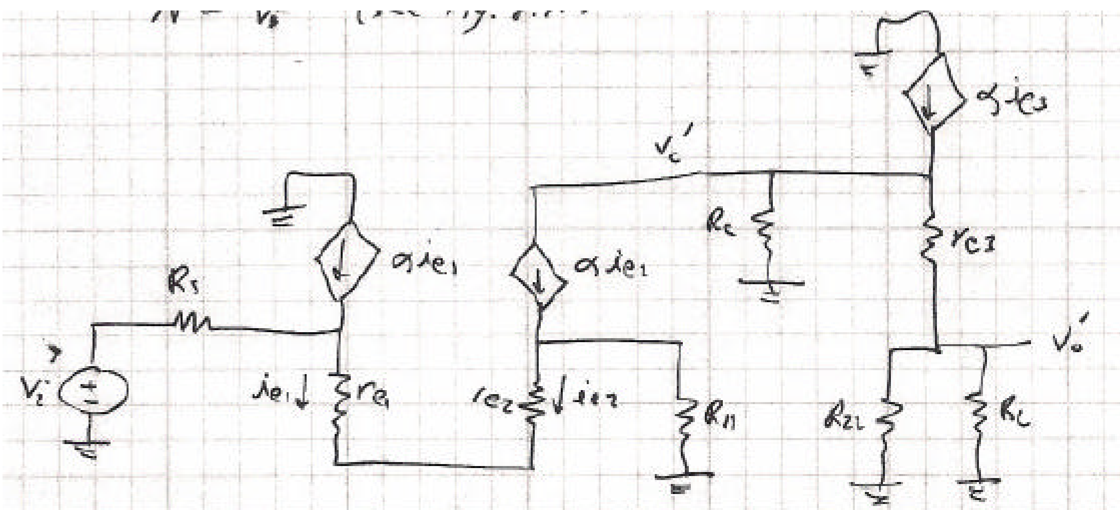


FEEDBACK/STABILITY

A circuit:



A = Vo'/Vi'



$$i_{c1} = -i_{e2} = \frac{V_i'}{\frac{R_s}{\beta+1} + r_{e1} + r_{e2} + \frac{R_{11}}{\beta+1}}$$

$$V_c' = -\alpha i_{e2}\left\{R_C \,\|\, \left[(\beta+1)\left[r_{e3} + (R_{22} \| R_L)\right]\right]\right\}$$

$$\frac{V_c'}{V_i'} = -\frac{\alpha\left[R_C \,\|\, (\beta+1)(r_{e3} + R_{22} \| R_L)\right]}{r_{e1} + r_{e2} + \frac{R_s + R_{11}}{\beta+1}} = -\frac{0.99\,(20k\Omega \,\|\, 169k\Omega)}{100\,\Omega + 108\,\Omega} = -85.1 \text{ V/V}$$

$$\frac{V_o'}{V_c'} = \frac{R_{22} \| R_L}{R_{22} \| R_L + r_{e3}} \approx 1 \qquad A = \frac{V_o'}{V_i'} = -85.1 \text{ V/V}$$

$r_{e3} \approx 5\Omega$

FEEDBACK/STABILITY