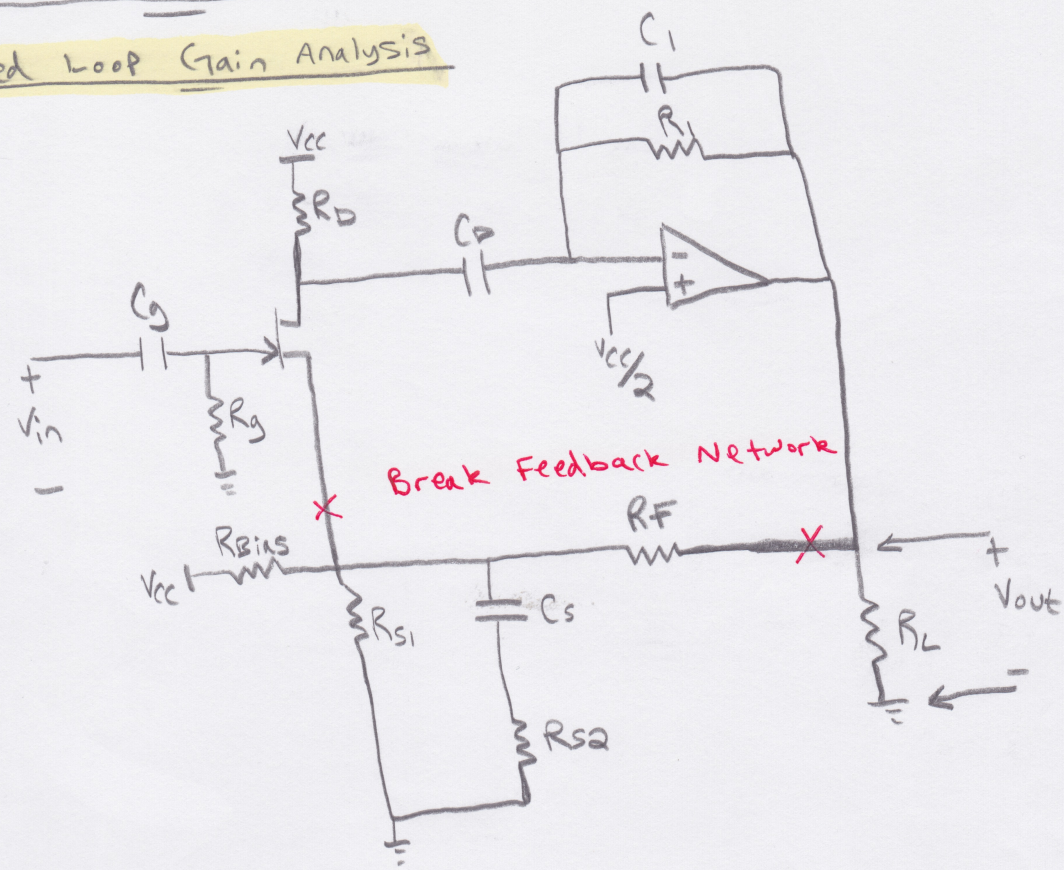
# JFE Pre-Amp Circuit

## Closed Loop Gain Analysis

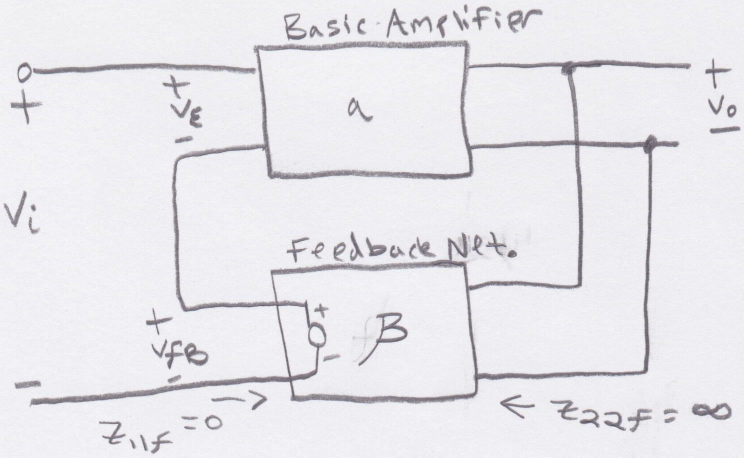



Kill all DC sources and make gnd, For AC Analysis

From Gray and Meyer 5th Edition Page 557

### Series - Shunt Feedback

Suppose it is required to design a feedback amplifier that stabilizes a voltage transfer function. That is, a given input voltage should produce a well defined proportional output voltage. This will require sampling the output voltage and feeding back a proportional voltage for comparison with the incoming voltage.



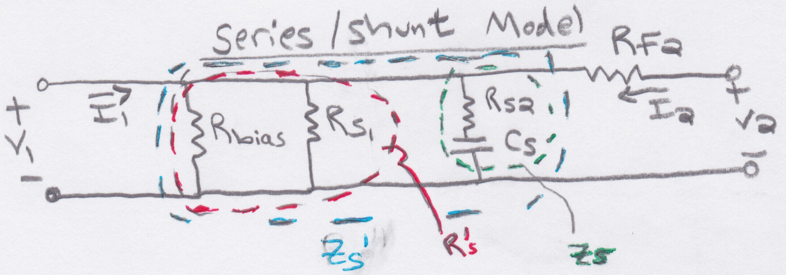

Series - shunt feedback

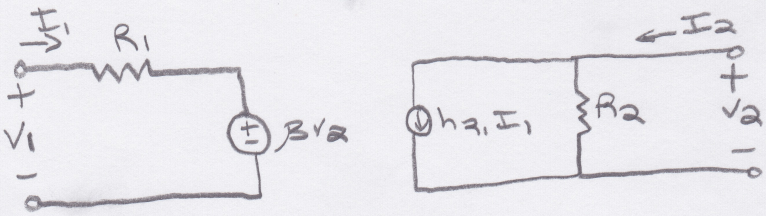
The β feedback Network shunts the output of the basic amplifier to sample $V_o$. The feedback voltage $V_{FB}$ is connected in series with the input to allow comparison with $V_i$

The signal $V_E$ is the difference between $V_i$ and $V_{FB}$ and is fed to the basic Amplifier.

## Two-Port For $\beta$

### Series/Shunt Model




### Eq's From Model

- $V_1 = I_1 R_1 + \beta V_2$
- $I_2 = \dfrac{V_2}{R_2} + h_{21} I_1$
- $R_1 = \left.\dfrac{V_1}{I_1}\right|_{V_2=0} = Z_s' \,//\, R_F$
- $R_2 = \left.\dfrac{V_2}{I_2}\right|_{I_1=0} = R_F + Z_s'$
- $\beta = \left.\dfrac{V_1}{V_2}\right|_{I_1=0} = \dfrac{Z_s'}{Z_s' + R_F}$
- $\dfrac{1}{\beta} = 1 + \dfrac{R_F}{Z_s'}$

**Example** If

- $R_{bias} = 2.5k\Omega$
- $R_1 = 100\Omega$
- $R_{s2} = 10\Omega$
- $C_2 = 1mF$
- $R_F = 10k$

$$R_S' = R_{bias} \parallel R_{S1} = \frac{2.5k\Omega \cdot 100}{2.5k\Omega + 100} = 96\Omega$$

$$Z_S' = [R_{bias} \parallel R_{S1}] \parallel \left[R_{S2} + \frac{1}{sC_2}\right] = \frac{96\Omega \cdot \left[10\Omega + \frac{1}{s1m}\right]}{96\Omega + 10\Omega + \frac{1}{s1m}}$$

$$Z_S' = \frac{960 + \frac{9600}{s}}{106 + \frac{1000}{s}} = \frac{960[s + 10]}{106[s + 9.434]}$$

$$\therefore \beta = \frac{\left[\frac{960[s+10]}{106[s+9.434]}\right]}{\frac{960[s+10]}{106[s+9.434]} + 10k}$$

$$\frac{1}{\beta} = \frac{\frac{960[s+10]}{106[s+9.434]} + 10k}{\frac{960[s+10]}{106[s+9.434]}}$$

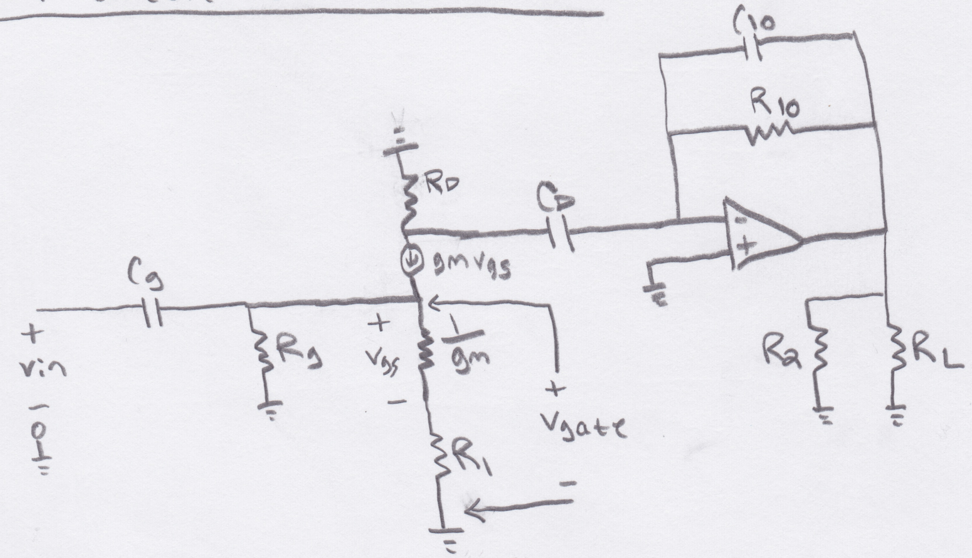
$$\frac{1}{\beta} = \frac{10k}{\frac{960[s+10]}{106[s+9.434]}} + 1$$

$$\frac{1}{\beta} = 1 + \frac{106[s+9.434] \cdot 10k}{960[s+10]}$$

$$\frac{1}{\beta} = 105.168 \frac{V}{V} \text{ or } 40.4376 \text{ dB } @ s \approx 0 \text{ Hz}$$

$$\frac{1}{\beta} = 1104.55 \; V/V \text{ or } 60.86 \text{ dB } @ s \approx 1 \text{kHz}$$

## A-Circuit (Gain circuit)




$$\frac{V_{gate}}{\frac{1}{g_m} + R_1} = g_m V_{gs}$$

$$V_{gate} = \frac{V_{in} \cdot [R_1 + \frac{1}{g_m}] // R_g}{[R_1 + \frac{1}{g_m}] // R_g + \frac{1}{sC_g}}$$

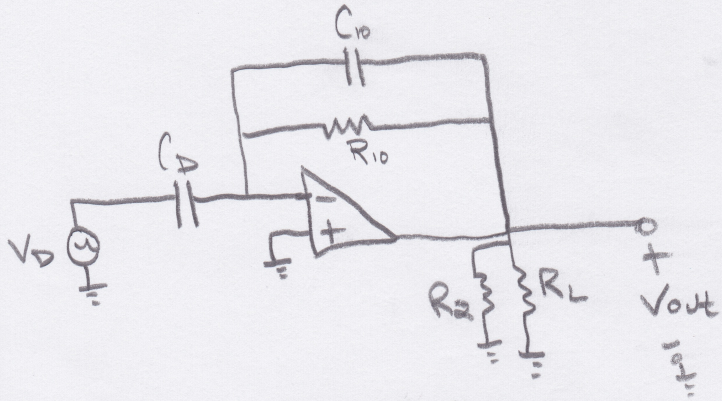
$$g_m V_{gs} = \frac{\left[\frac{V_{in} \cdot [R_1 + \frac{1}{g_m}] // R_g}{[R_1 + \frac{1}{g_m}] // R_g + \frac{1}{sC_g}}\right]}{[R_1 + \frac{1}{g_m}]}$$

if $R_g >> [\frac{1}{g_m} + R_1]$

$$g_m V_{gs} = \frac{V_{in}}{[R_1 + \frac{1}{g_m}] + \frac{1}{sC_g}}$$

# Equations without Rg

$$V_D = -g_m V_{gs} \cdot R_D // Z_{C_D} = \frac{-V_{in} \quad R_D // Z_{C_D}}{\left[R_1 + \frac{1}{g_m}\right] + \frac{1}{sC_g}}$$

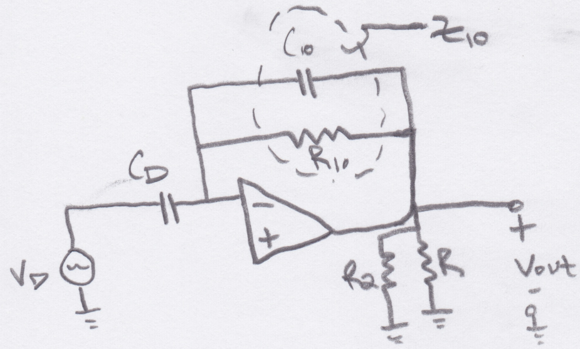



$$V_{out} = -V_D \frac{\left[Z_{C10} // R_{10}\right]}{Z_{C_D}} = -\left[\frac{-V_{in} \cdot R_D // Z_{C_D}}{\left[R_1 + \frac{1}{g_m}\right] + \frac{1}{sC_g}}\right] \cdot \frac{\left[Z_{C10} // R_{10}\right]}{Z_{C_D}}$$

$$A_{v1} = \frac{V_{out}}{V_{in}} = \frac{R_D // Z_{C_D}}{\left[R_1 + \frac{1}{g_m}\right] + Z_{C_g}} \cdot \frac{\left[Z_{10} // R_{10}\right]}{Z_{C_D}}$$

## Equations With $R_g$

$$V_D = -g_m V_{gs} \cdot R_D // Z_{CD} = -\frac{\left[\dfrac{v_{in} \cdot \left[R_1 + \frac{1}{g_m}\right] // R_g}{\left[R_1 + \frac{1}{g_m}\right] // R_g + \frac{1}{sC_g}}\right]}{\left[R_1 + \frac{1}{g_m}\right]} \cdot R_D // Z_D$$




$$V_{out} = -V_D \cdot \frac{\left[Z_{C10} // R_{10}\right]}{Z_{CD}}$$

$$\frac{V_{out}}{V_{in}} = \frac{\dfrac{\left[R_1 + \frac{1}{g_m}\right] // R_g}{\left[R_1 + \frac{1}{g_m}\right] // R_g + \frac{1}{sC_g}}}{\left[R_1 + \frac{1}{g_m}\right]} \cdot R_D // Z_{CD} \cdot \frac{\left[Z_{C10} // R_{10}\right]}{Z_{CD}}$$

($\left[R_1 + \frac{1}{g_m}\right] // R_g$ = $R_{in}$; $R_D // Z_{CD}$ = $Z_D$; $Z_{C10} // R_{10}$ = $Z_{10}$; $R_1 + \frac{1}{g_m}$ = $R_1$prime)

$$A_{01} = \frac{V_{out}}{V_{in}} = \frac{R_{in} \cdot Z_D}{(R_{in} + Z_{Cg}) R_{1prime}} \cdot \frac{Z_{10}}{Z_{CD}}$$

$$A_{CL} = \frac{A_{01}}{1 + A_{01}\beta}$$ Plug into MatLab