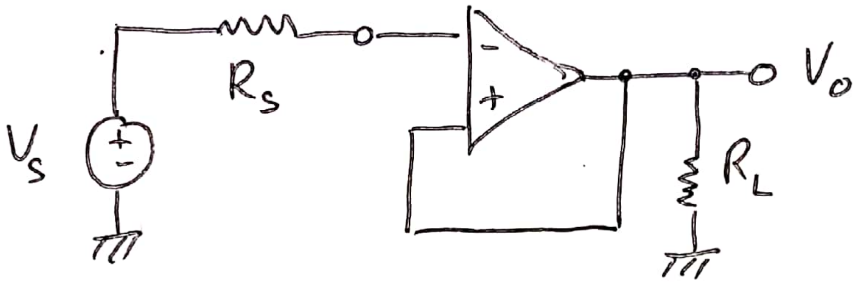
ANALOG ELECTRONICS

Homework #5

Problem 1.



- Open loop gain $A = 1000$. Output voltage fully fedback to the input so $\beta = 1$

$$A_f = \frac{A}{1 + A\beta} = \frac{900}{901} \simeq 0.999$$

- The amount of feedback $= 20 \log (1 + A\beta) \simeq 59 \, dB$
- Output voltage $V_o = V_S A_f = 0.999 \times 1.5 \simeq 1.499$ ✓
- Input voltage $V_i = V_S - V_o \beta = 1 \, mV$
- $A_n = 0.85 A = 765$ ✓ $\Rightarrow A_{f_n} = \frac{A_n}{1 + A_n \beta} \simeq 0.9987$

$$\frac{\Delta A_f}{A_f} = \frac{0.999 - 0.9987}{0.999} \simeq 0.03 \%$$

Problem 2.

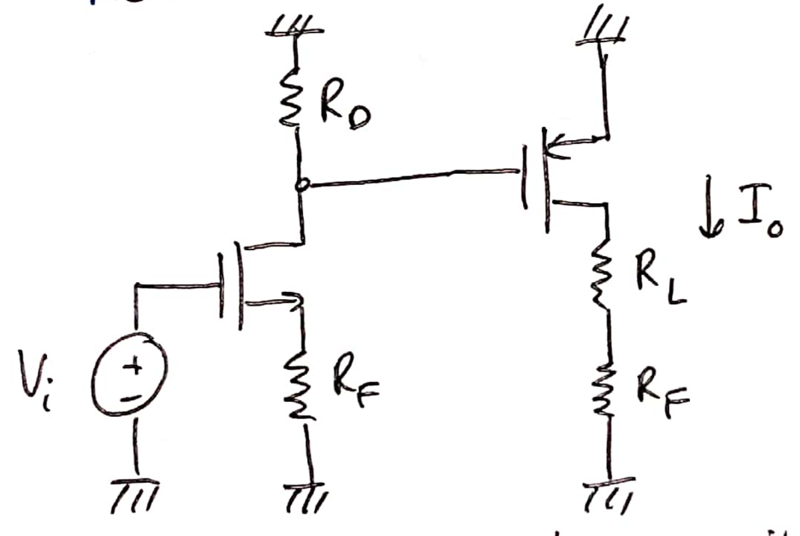
- We have: $\dfrac{A_M}{1+A_M\beta} = 20$

$\Leftrightarrow \dfrac{900}{1+A_M\beta} = 20 \Leftrightarrow 1+A_M\beta = 45$

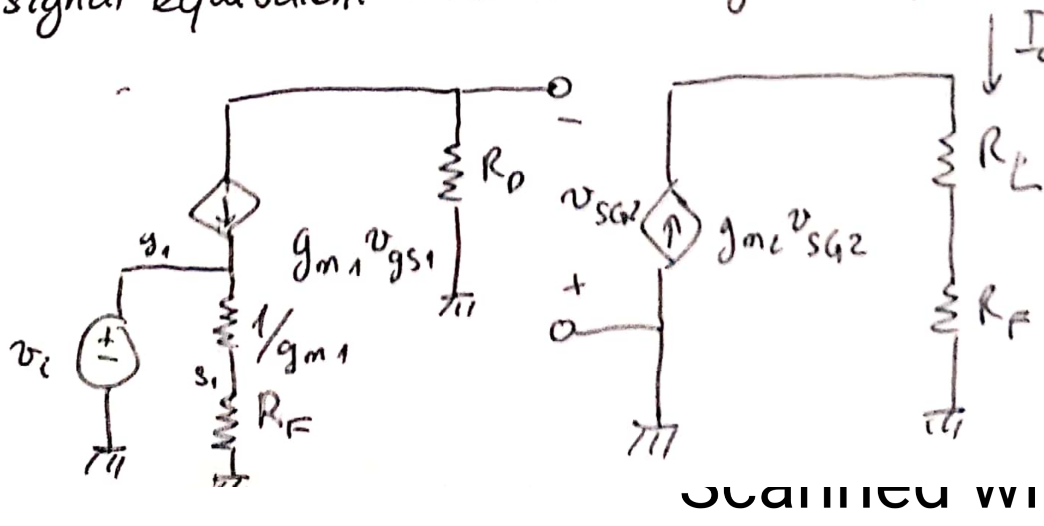
- $f_{Hf} = f_H(1+A_M\beta) = 20 \times 45 = 900\ (kHz)$
- $f_{Lf} = f_L/(1+A_M\beta) = 200/45 \approx 4.44\ (Hz)$

Problem 3.

Redraw the circuit to include R_F in each of the loops



Small signal equivalent circuit: (disregard r_{o1}, r_{o2})



• Open loop gain $A = \frac{I_o}{V_i} = g_{m1} g_{m2} \frac{R_D}{1+g_{m1} R_F}$

$$\left\{ \begin{aligned} \text{, with } I_o &= +g_{m2} V_{SG2} = +g_{m2} (V_{S2} - V_{G2}) \\ &= +g_{m2} \left[0 - (-g_{m1} V_{gs1} R_D) \right] \\ &= g_{m2} g_{m1} V_i \frac{1/g_{m1}}{1/g_{m1} + R_F} R_D \\ &= g_{m1} g_{m2} \frac{V_i R_D}{1 + g_{m1} R_F} \end{aligned} \right.$$

• Feedback gain $\beta = \frac{V_f}{I_o} = R_f$

• Loop gain $A\beta = g_{m1} g_{m2} R_D R_f / 1+g_{m1} R_f = \frac{5^m \times 5^m \times 30^k \times 0.2^k}{1 + 5^m \times 0.2^k} = 75$

• $A_f = \frac{A}{1+A\beta} = \frac{g_{m2} g_{m1} R_D}{1+g_{m1} R_F (1+g_{m2} R_D)}$

$$= \frac{5^m \times 5^m \times 30^k}{1 + 5^m \times 0.2^k (1+5^m \times 30^k)}$$

$$\simeq 0.005 \text{ (A/V)} = 5^{mA/V}$$

• $R_o = r_{o2} + R_L + R_F = 30^k + 1.5^k + 0.2^k = 31.7 (k\Omega)$

• $R_{of} = R_o (1 + A\beta) = 31.7^k (1+75)$

$$\simeq 2.4 \text{ } (M\Omega)$$