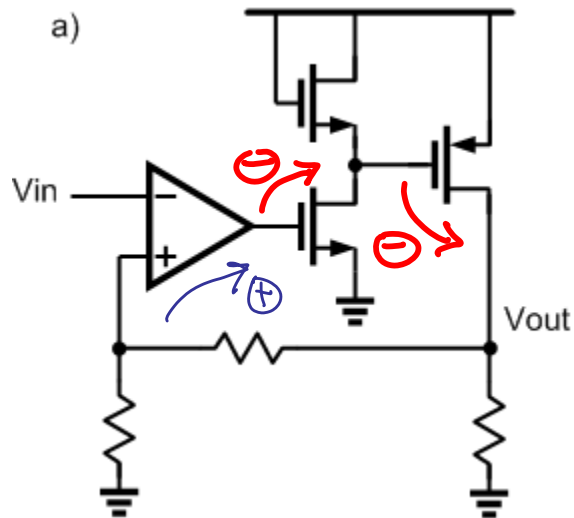


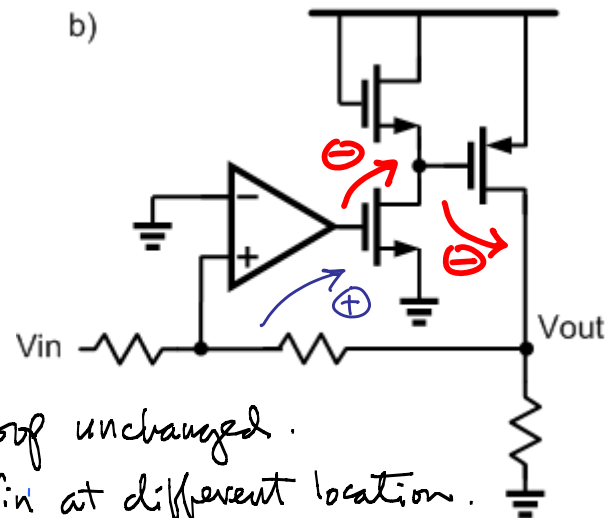
ECE323

Homework 5

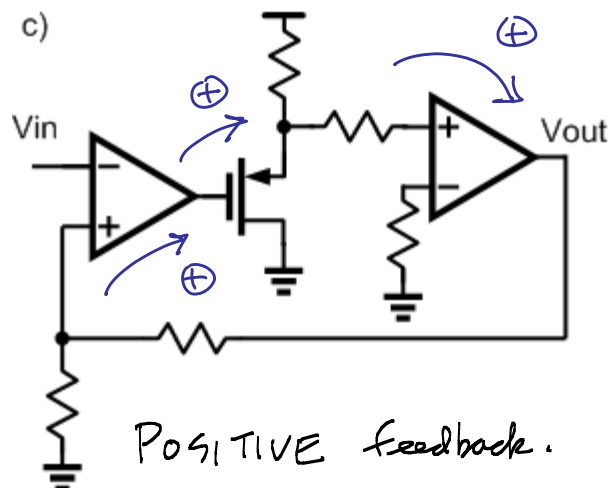
1. Determine the polarity of the feedback circuits shown below.



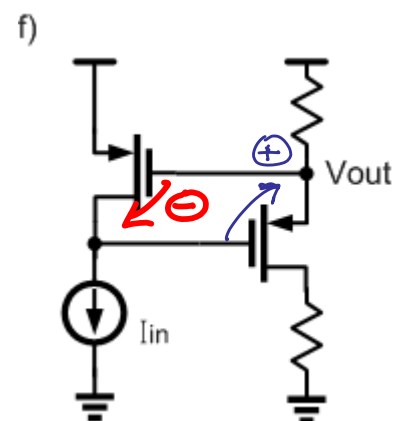
Net POSITIVE feedback.



Loop unchanged.
Vin at different location.
POSITIVE feedback.

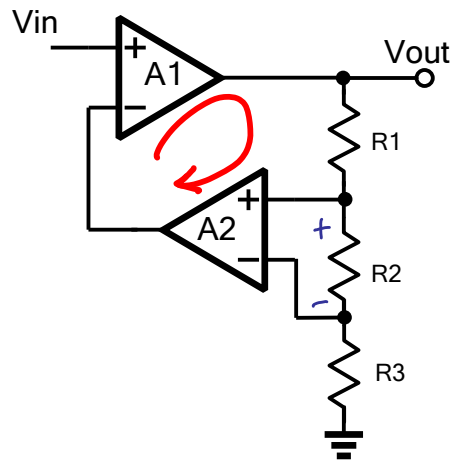


POSITIVE feedback.



NEGATIVE feedback.

2. Compute the closed loop gain of the circuit shown below. Assume opamps have finite gain of A1, A2, but are otherwise ideal.



Forward path = A_1

$$\text{Loop} = -\frac{R_2}{R_1 + R_2 + R_3} A_2 A_1$$



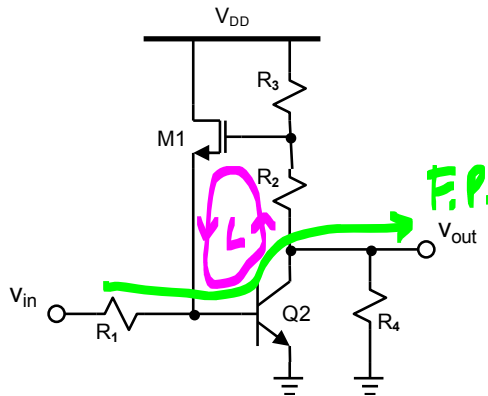
$$\frac{V_{out}}{V_{in}} = \frac{A_1}{1 + \frac{A_1 A_2 R_2}{R_1 + R_2 + R_3}}$$

3. In problem 2, assume opamp A1 has a transfer function $H_{OL}(s) = \frac{A1}{1 + s/\omega_p}$, determine the closed loop -3dB bandwidth.

$$\frac{V_{out}}{V_{in}} = \frac{\frac{A1}{\left(1 + \frac{s}{\omega_p}\right)}}{1 + \frac{R2 A1 A2}{(R1 + R2 + R3) \left(1 + \frac{s}{\omega_p}\right)}} = \frac{\frac{A1}{1 + \frac{A1 A2 R2}{R1 + R2 + R3}}}{1 + \frac{s}{\omega_p \left(1 + \frac{A1 A2 R2}{R1 + R2 + R3}\right)}}$$

closed loop pole is
at higher frequency
(related to loop gain)

4. Find the input-to-output small-signal gain.

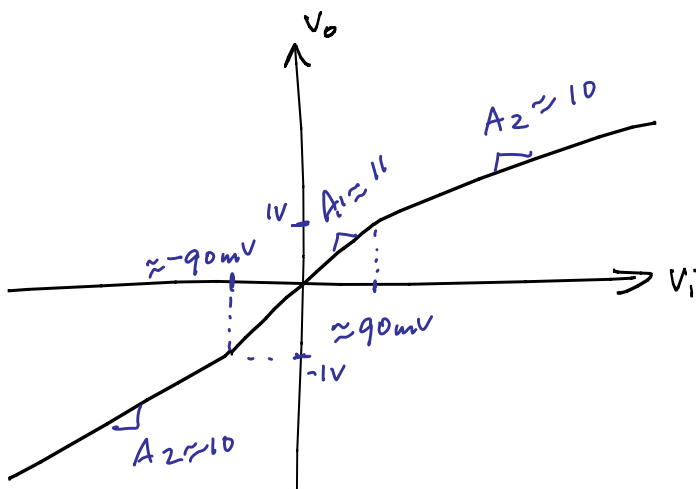
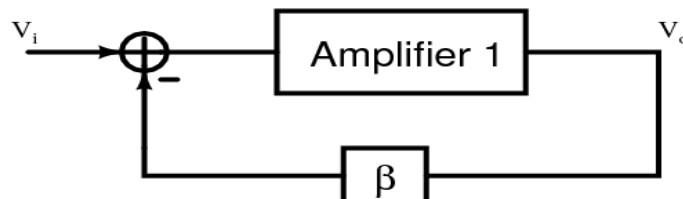
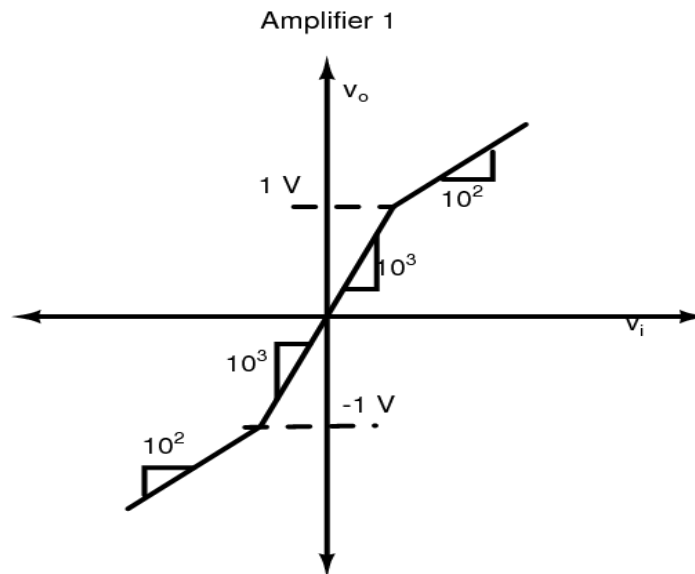


$$\text{gain} = \frac{\text{F.P.}}{1 - L}$$

$$\text{F.P.} = - \frac{r_{\pi 2} \parallel \frac{1}{g_{m1}}}{R_1 + (r_{\pi 2} \parallel \frac{1}{g_{m1}})} g_{m2} [(R_2 + R_3) \parallel R_4]$$

$$L = - g_{m2} [(R_2 + R_3) \parallel R_4] \frac{R_3}{R_2 + R_3} \frac{(R_1 \parallel r_{\pi 2})}{\frac{1}{g_{m1}} + (R_1 \parallel r_{\pi 2})}$$

5. A realistic amplifier can be modeled by the following non-linear transfer function. For this amplifier, the open-loop gain changes from 1000 to 100 for output voltage larger than 1 V. Find the feedback factor (β) to be used in the closed loop amplifier shown below such that, the closed loop gain varies only by 10%, when the output voltage is above and below 1V. What is the transfer characteristic of the resulting closed-loop feedback amplifier?

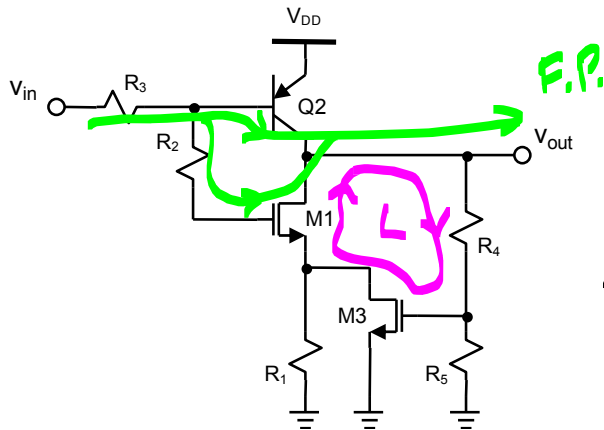


$$A_1 = \frac{1000}{1 + 1000 \cdot \beta} \quad A_2 = \frac{100}{1 + 100 \cdot \beta}$$

$$\text{set } A_1 = (1.1) A_2$$

* Setting $A_1(0.9) = A_2$ also o.k.
 → Will lead to a slightly different answer.

6. Find the input-to-output small-signal gain.



$$\text{gain} = \frac{\text{F.P.}}{1 - L}$$

$$\text{F.P.} = \frac{-r_{\pi 2}}{R_3 + r_{\pi 2}} \left(g_{m2} + \frac{g_{m1}}{1 + g_{m1} R_1} \right) (R_4 + R_5)$$

$$L = -g_{m3} \left(R_1 \parallel \frac{1}{g_{m1}} \right) g_{m1} \cdot R_5$$