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DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING
EECE 311 – Electronic Circuits (Section 2)
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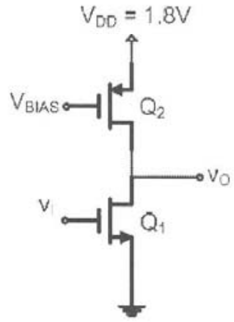
HOMEWORK 2

1. Common Source Amplifier



a) P = 1mW and V_{DD} = 1.8V

$\Rightarrow I_{DD} = \dfrac{P}{V_{DD}} = 0.556\ mA$

$r_{O1} = \dfrac{V_{An}}{I} = 9\ K\Omega, \qquad r_{O2} = \dfrac{|V_{Ap}|}{I} = 7.2\ K\Omega$

$|A_{V1}| = g_{m1}(r_{O1}//\ r_{O2}) \Rightarrow g_{m1} = 2.5\ mA/V$

$but\ g_{m1} = \dfrac{2I}{V_{OV1}} \Rightarrow V_{OV1} = 0.444\ V$

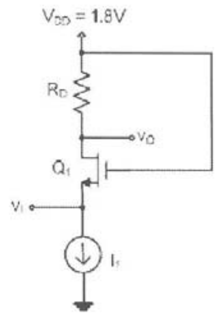
$I = \frac{1}{2}k_n'\left(\dfrac{W}{L}\right)_1 (V_{OV1})^2 \quad in\ Q_1$

$\Rightarrow \left(\dfrac{W}{L}\right)_1 = 18.75$

b) $I = \frac{1}{2}k_p'\left(\frac{W}{L}\right)_2 (V_{OV2})^2 \quad in\ Q_2 \Rightarrow V_{OV2} = 0.316\ V$

$but\ V_{OV2} = V_{DD} - V_{bias} - |V_{tp}| \Rightarrow V_{bias} = 0.984\ V$

2. Common Gate Amplifier



P = 2mW and V_{DD} = 1.8V

$\Rightarrow I_{DD} = I_1 = \dfrac{P}{V_{DD}} = 1.111\ mA$

Using the small signal model we have:

$R_i = \dfrac{v_i}{i_i} = \dfrac{v_i}{g_m v_i} \Rightarrow g_m = \dfrac{1}{R_i} = 0.02\dfrac{A}{V}$

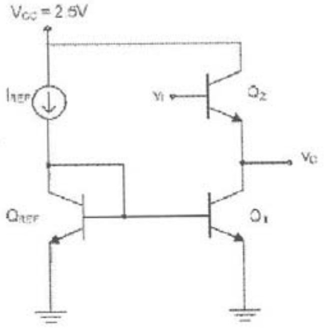
$A_v = \dfrac{v_o}{v_i} = \dfrac{g_m v_i R_D}{v_i} \Rightarrow R_D = 250\ \Omega$

$but\ g_m = \dfrac{2I_1}{V_{OV}} \Rightarrow V_{OV} = 0.111\ V$

$I_1 = \frac{1}{2}k_n'\left(\dfrac{W}{L}\right)(V_{OV})^2$

$\Rightarrow \left(\dfrac{W}{L}\right) = 600.1$

3. Emitter Follower



P = 3mW and V_{CC} = 2.5V

$$\Rightarrow I_{CC} = \frac{P}{V_{CC}} = 1.2\ mA$$

$$since\ we\ neglect\ base - width\ modulation\ no\ r_o$$

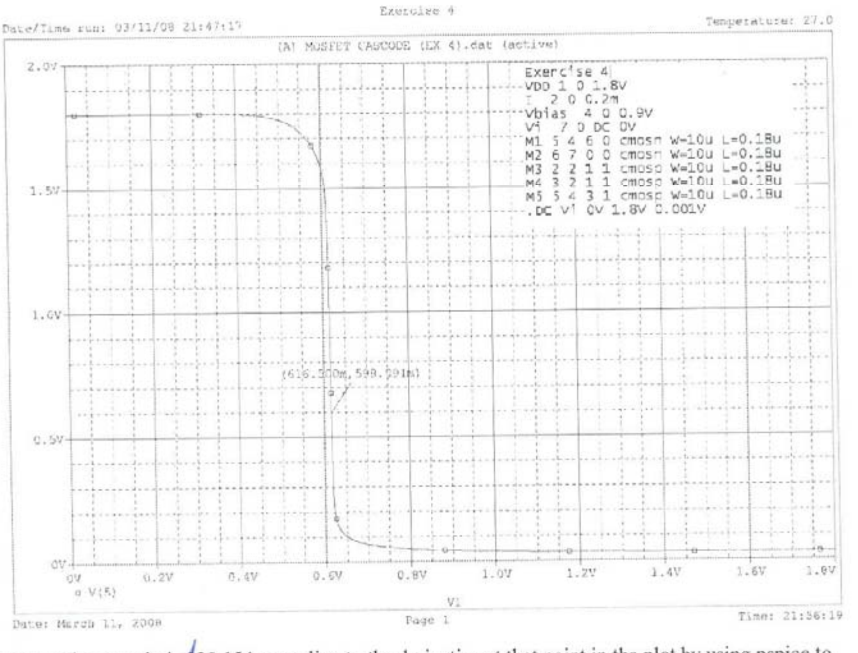
$$\Rightarrow in\ Q_2: R_o = r_e = \frac{V_T}{I_E} \Rightarrow I_E = I_C = 0.5\ mA$$

$$since\ B -> \infty$$

$$\Rightarrow I_{REF} = I_{CC} - I_E = 0.7\ mA$$

$$\frac{A_{E1}}{A_{EREF}} = \frac{I_E}{I_{REF}} = 0.714$$

4. MOSFET Cascode

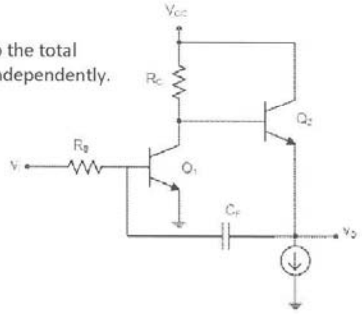


The maximum gain is ~~229.154~~ 129.154 according to the derivative at that point in the plot by using pspice to calculate the maximum slope of the plot.

more accurately it's 129

When the bias changes by ± 20mV, the gain drops to less than 10.

5. Miller's Theorem



The two BJT's in this circuit are cascaded, so the total gain is the product of the gain of each BJT independently.

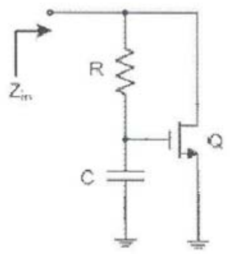
$\Rightarrow K = -g_{m1}R_c \times 1$
by Miller's theorem we can seperate
C_F in to 2 different capacitors, one on the side of the input and one on the input.
At the input: $C_{in} = C_F(1-K)$
At the output: $C_{out} = C_F\left(1-\frac{1}{K}\right)$
The resistance seen by C_{in} is:
$R_{Cin} = (R_B//r_{\pi 1})$
The resistance seen by C_{out}: Replace Cout by a current source I_x having voltage V_x

$$R_{Cout} = \frac{V_x}{I_x} = \frac{r_{\pi 2} + R_C}{1 + g_m r_{\pi 2}}$$

$$\Rightarrow \textit{the pole at the input is: } \frac{1}{R_{Cin}C_{in}} = \frac{1}{(R_B//r_{\pi 1})C_F(1+g_{m1}R_c)}$$

$$\Rightarrow \textit{the pole at the input is: } \frac{1}{R_{Cout}C_{out}} = \frac{1 + g_m r_{\pi 2}}{(r_{\pi 2} + R_C)C_F\left(1 + \frac{1}{g_{m1}R_c}\right)}$$

6. Active Inductor



To find Zin we add a voltage source Vx with a current Ix, and then: $Z_{in} = \frac{V_x}{I_x}$, In small signal analysis the MOSFET becomes a dependent current source = $g_m v_{gs}$ with Vgs being the voltage across the capacitor C.

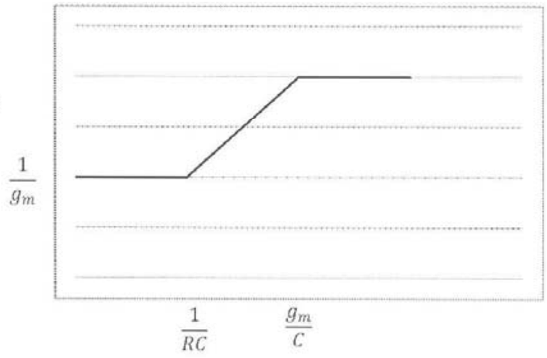
$$V_{gs} = \frac{V_x}{sC\left(R + \frac{1}{sC}\right)} = \frac{V_x}{1 + sRC}$$

$$I_x = \frac{V_x}{\left(R + \frac{1}{sC}\right)} + g_m V_{gs} = \frac{g_m + sC}{1 + sRC}V_x$$

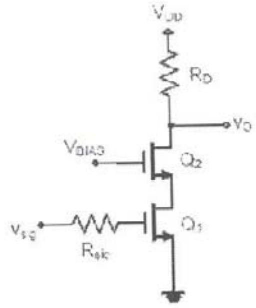
$$\Rightarrow \frac{V_x}{I_x} = \frac{1}{g_m} \times \frac{1 + sRC}{1 + \frac{sC}{g_m}}$$

- The Bode Plot of Zin ~~represents~~ approximates the Bode plot of an inductor.

Between $\omega = \frac{1}{RC}$ and $\omega = \frac{g_m}{C}$



7. Cascode Frequency Response



$I_D = \frac{1}{2} k_n' \left(\frac{W}{L}\right) (V_{OV})^2$

$\Rightarrow \left(\frac{W}{L}\right) = 250 \ \Rightarrow \mathrm{W} = 45\mu\mathrm{m}$

$\Rightarrow \ C_{gs} = 64.8\, fF \ \Rightarrow \ C_{gd} = 9\, fF$

$g_m = \frac{2I_D}{V_{OV}} = 5\frac{mA}{V}$

The gain of Q1 is -1

So by Miller's we can approximate Cgd1 in to 2 capacitors

On the side of the input: Cgdin = 9fF x 2~~// Cgdout~~

$\omega_{in} = \frac{1}{R_{sig}\left(C_{gdin} + C_{gs}\right)}, \Rightarrow R_{sig} = 384.43\, \Omega$

At the output :

$f_{P_{out}} = \frac{1}{2\pi\, C_{gd}\, R_D} \ \Rightarrow \ R_D = 1.768\ k\Omega$

Voltage Gain $= -g_{m_2} R_D$ since gain of Q_1 is -1

$= -5m \times 1.768 = -8.84$ V/V