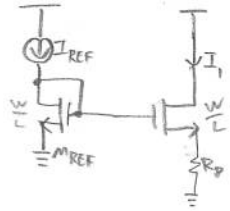
ECEn 340 Sect 001 | 9.49 | Benjamin Bergeson | 1

Homework 12 | 11: ~~1~~ 1, 4, 16, 20, 24, 26

9.49

Find R_p $\quad I_1 = I_{REF}/2$



$V_{GS,REF} = \sqrt{\dfrac{2 I_{REF}}{\mu C_{ox} \frac{W}{L}}} + V_{TH} \qquad V_{GS1} = V_{GS,REF} - I_1 R_p$

$V_{GS1} = V_{TH} + \sqrt{\dfrac{2 I_{REF}}{\mu C_{ox}\frac{W}{L}}} - I_1 R_p = V_{TH} + \sqrt{\dfrac{2 I_{REF}}{\mu C_{ox}\frac{W}{L}}} - \dfrac{I_{REF}}{2} R_p$

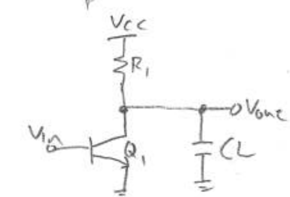
$I_1 = \frac{1}{2}\mu C_{ox}\frac{W}{L}\left(\sqrt{\dfrac{2I_{REF}}{\mu C_{ox}\frac{W}{L}}} - \dfrac{I_{REF}}{2}R_p\right)^2 = \dfrac{I_{REF}}{2} \qquad \sqrt{\dfrac{I_{REF}}{\mu C_{ox}\frac{W}{L}}} = \sqrt{\dfrac{2I_{REF}}{\mu C_{ox}\frac{W}{L}}} - \dfrac{I_{REF}}{2}R_p$

$\dfrac{I_{REF}}{2}R_p = \sqrt{\dfrac{2I_{REF}}{\mu C_{ox}\frac{W}{L}}} - \sqrt{\dfrac{I_{REF}}{\mu C_{ox}\frac{W}{L}}} \qquad \boxed{R_p = \dfrac{2}{I_{REF}}\left(\sqrt{\dfrac{2I_{REF}}{\mu C_{ox}\frac{W}{L}}} - \sqrt{\dfrac{I_{REF}}{\mu C_{ox}\frac{W}{L}}}\right)}$

No, I_1 will not change if V_{TH} changes by ΔV because the mirror remains constant.

11.1

−3 dB Bandwidth 1 GHz $C_L = 2\,pF$ $\quad$ What is maximum gain with power dissipation of 2 mW $\quad V_{CC} = 2.5\,V$



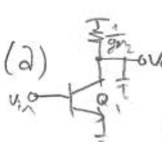
$I_C \cdot V_{CC} = 2\,mW$

$1\,GHz = \dfrac{1}{R_1 C_L}$ $\qquad I_C = 0.0008 = 0.8\,mA$

$R_1 = 500\,\Omega$ $\qquad \boxed{Gain = \dfrac{-I_C}{V_T}R_1 = -15.3846}$

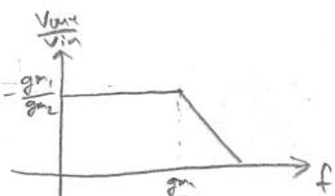
11.4

(a)

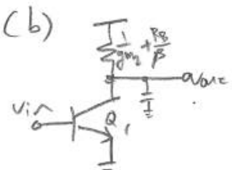


$\omega_{p1} = \dfrac{gm_2}{C_L}$

$Gain = \dfrac{-gm_1}{gm_2}$

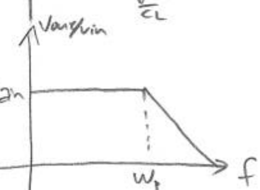


(b)

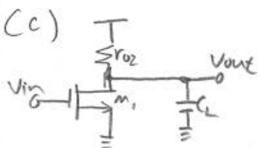


$Gain = -gm_1\left(\dfrac{1}{gm_2} + \dfrac{R_B}{\beta}\right) = Gain$

$\omega_p = \dfrac{1}{\left(\frac{1}{gm_2} + \frac{R_B}{\beta}\right)C_L}$

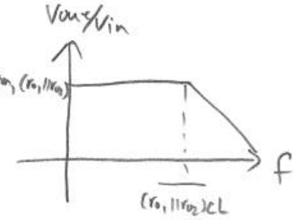


(c)

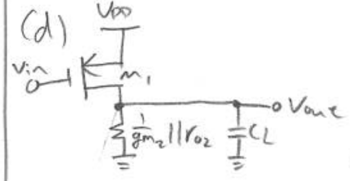


$Gain = \dfrac{-gm_1 r_{o1} r_{o2}}{r_{o2} + r_{o1}} = -gm_1(r_{o1} \| r_{o2})$

$\omega_p = \dfrac{1}{(r_{o1} \| r_{o2})C_L}$

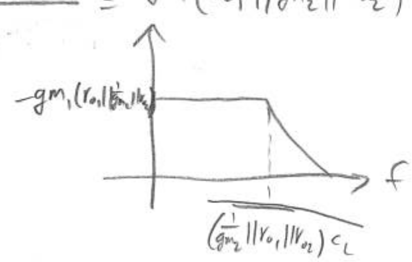


(d)



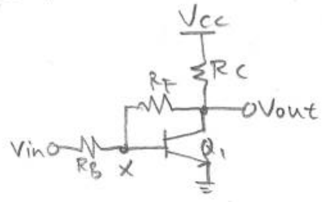
$Gain = \dfrac{-gm_1 r_{o1}\left(\frac{1}{gm_2} \| r_{o2}\right)}{\left(\frac{1}{gm_2} \| r_{o2}\right) + r_{o1}} = -gm_1\left(r_{o1} \| \frac{1}{gm_2} \| r_{o2}\right)$

$\omega_p = \dfrac{1}{\left(\frac{1}{gm_2} \| r_{o1} \| r_{o2}\right)C_L}$

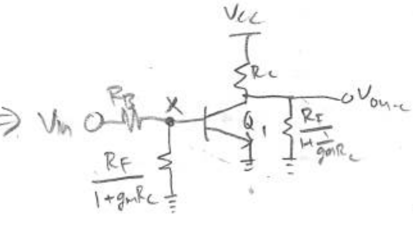


11.16 $V_A = \infty$ $\quad \frac{V_{out}}{V_x} = -g_m R_C$

$$\text{Gain} = \frac{-g_m R_C}{1 + g_m R_E + \frac{R_B}{r_\pi}}$$

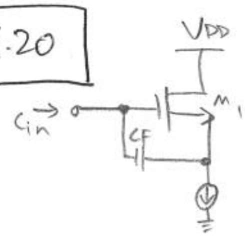


$\Rightarrow$



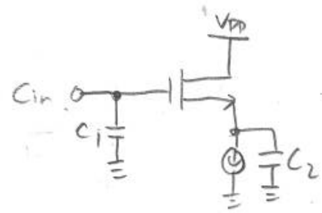
$$\boxed{\text{Gain} = \frac{-g_{m1}\left(R_C \,\|\, \frac{R_F}{1+\frac{1}{g_m R_C}}\right)}{1 + \frac{1}{r_\pi}\left(R_B \,\|\, \frac{R_F}{1+g_m R_C}\right)}}$$

11.20



Assume $\lambda > 0$

$$\text{Gain} = \frac{g_{m1} r_{o1} R_S}{R_S + r_{o1} + g_{m1} r_{o1} R_S} = -g_m r_o$$



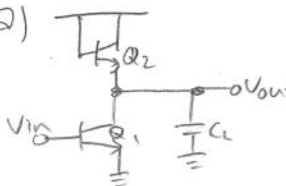
$C_1 = (1 + A_v) C_F = (1 - g_m r_o) C_F$

$C_2 = (1 + \frac{1}{A_v}) C_F = (1 - \frac{1}{g_m r_o}) C_F$

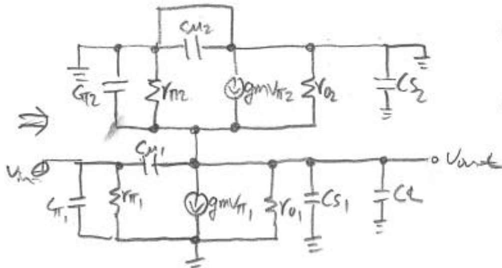
If $\lambda \to 0$ $\quad r_o \to \infty$

$$\boxed{C_{in} = (1 - g_m r_o) C_F}$$

11.24 (a)



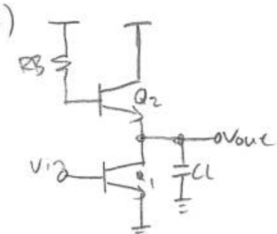
$\Rightarrow$



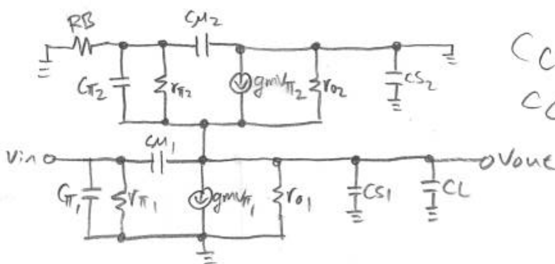
$C_{\pi 2} \,\|\, C_{S1} \,\|\, C_L$

$C_{\mu 2}$ & C_{S2} are grounded.

(b)



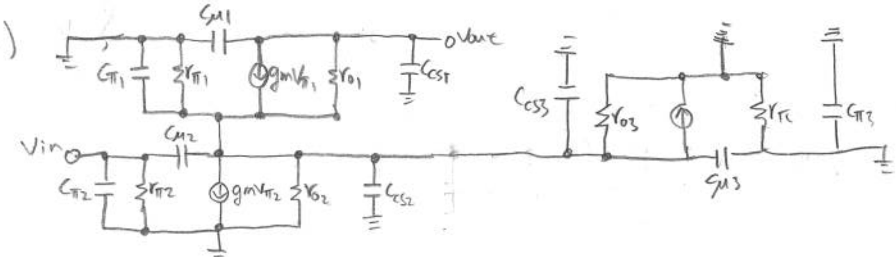
$\Rightarrow$



C_{CS2} is grounded

$C_{CS1} \,\|\, C_L$

(c)

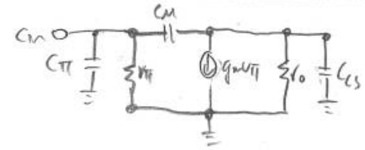


$C_{\pi 2} \,\|\, C_{CS1} \,\|\, C_{CS3} \,\|\, C_{\mu 3}$

$C_{\mu 2} \,\|\, C_{CS2}$

$C_{\pi 3}$ is grounded

11.26 11.49



$$Z_{in} = \frac{1}{\left[\left(C_\pi + (1+g_m R_D) C_\mu\right) s\right]} \parallel r_\pi$$

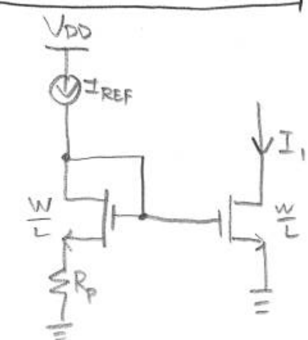
$$\frac{I_{out}}{I_{in}} = \frac{g_m r_\pi}{1 + r_\pi\left[\left(\left(C_\pi + (1+g_m R_D)\right) C_\mu\right) s\right]} \qquad I_{out} = g_m I_{in} Z_{in} \qquad = \frac{\beta}{1 + r_\pi\left[\left(C_\pi + (1+g_m R_D) C_\mu\right) s\right]}$$

$$@\ \omega_T = 2\pi f_T \qquad \frac{\beta}{\sqrt{1 + r_\pi^2\left[\left(C_\pi + (1+g_m R_D) C_\mu\right)^2 \omega_T^2\right]}} = 1$$

$$\beta^2 - 1 = r_\pi^2\left[\left(C_\pi + (1+g_m R_D) C_\mu\right)^2 \omega_T^2\right] \qquad \frac{\beta^2 - 1}{r_\pi^2} = \left(C_\pi + (1+g_m R_D) C_\mu\right)^2 \omega_T^2$$

$$\frac{\beta^2 - 1}{r_\pi^2\left(C_\pi + (1+g_m R_D) C_\mu\right)^2} = \omega_T^2 \qquad \boxed{\omega_T = \frac{\sqrt{\beta^2 - 1}}{r_\pi\left(C_\pi + (1+g_m R_D) C_\mu\right)}}$$

Create A Problem



Determine R_P so that $I_1 = 9 I_{REF}$

$$V_{GS1} = \sqrt{\frac{2 I_1}{\mu_n C_{ox} \frac{W}{L}}} + V_{TH} = \sqrt{\frac{9 I_{REF}}{\mu_n C_{ox} \frac{W}{L}}} + V_{TH} = 3\sqrt{\frac{I_{REF}}{\mu_n C_{ox} \frac{W}{L}}} + V_{TH}$$

$$I_{REF} = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)\left(V_{GS,REF} - V_{TH}\right)^2$$

$$= \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)\left(V_{GS1} - I_{REF}R_P - V_{TH}\right)^2$$

$$I_{REF} = \frac{1}{2}\mu_n C_{ox}\left(\frac{W}{L}\right)\left(3\sqrt{\frac{I_{REF}}{\mu_n C_{ox}\frac{W}{L}}} - I_{REF}R_P\right)^2$$

$$\sqrt{\frac{2 I_{REF}}{\mu_n C_{ox}\frac{W}{L}}} = 3\sqrt{\frac{I_{REF}}{\mu_n C_{ox}\frac{W}{L}}} - I_{REF}R_P \qquad I_{REF}R_P = 3\sqrt{\frac{I_{REF}}{\mu_n C_{ox}\frac{W}{L}}} - \sqrt{\frac{2 I_{REF}}{\mu_n C_{ox}\frac{W}{L}}}$$

$$I_{REF}R_P = (3 - \sqrt{2})\sqrt{\frac{I_{REF}}{\mu_n C_{ox}\frac{W}{L}}} \qquad \boxed{R_P = \frac{(3-\sqrt{2})}{\sqrt{I_{REF}\,\mu_n C_{ox}\frac{W}{L}}} \quad A} \qquad \frac{(3-\sqrt{2})}{\sqrt{2 I_{REF}\,\mu_n C_{ox}\frac{W}{L}}} \quad D$$

$$\frac{(\sqrt{3}-\sqrt{2})}{\sqrt{I_{REF}\,\mu_n C_{ox}\frac{W}{L}}} \quad B$$

$$\frac{1}{\sqrt{I_{REF}\,\mu_n C_{ox}\frac{W}{L}}} \quad C$$