Electronics II, Spring 2016 Exam1 Solution 2016/3/25

#1

(a) $R_{TH} = (0.1)(1+\beta)R_E = (0.1)(121)(4) = 48.4\,\text{k}\Omega$

$$I_{BQ} = \frac{I_{EQ}}{1+\beta} = \frac{1.5}{121} = 0.012397\ \text{mA}$$

$$V_{TH} = I_{BQ}R_{TH} + V_{BE}(on) + I_{EQ}R_E = \frac{1}{R_1}\cdot R_{TH}\cdot V_{CC}$$

so $\frac{1}{R_1}(48.4)(12) = (0.012397)(48.4) + 0.7 + (1.5)(4)$

which yields $R_1 = 79.6\,\text{k}\Omega$ and $R_2 = 124\,\text{k}\Omega$

(b) $I_{CQ} = \left(\frac{120}{121}\right)(1.5) = 1.488\,\text{mA}$

$$r_\pi = \frac{(120)(0.026)}{1.488} = 2.097\,\text{k}\Omega, \quad r_o = \frac{50}{1.488} = 33.6\,\text{k}\Omega$$

$$A_\upsilon = \frac{(1+\beta)(r_o \| R_E \| R_L)}{r_\pi + (1+\beta)(r_o \| R_E \| R_L)}$$

Now $r_o \| R_E \| R_L = 33.6 \| 4 \| 4 = 1.888\,\text{k}\Omega$

$$A_\upsilon = \frac{(121)(1.888)}{2.097 + (121)(1.888)} = 0.991$$

(c) $R_o = R_E \| r_o \left\| \frac{r_\pi}{1+\beta} = 4 \right\| 33.6 \left\| \frac{2.097}{121} \Rightarrow R_o = 17.25\,\Omega \right.$

(d) $$f_L = \frac{1}{2\pi(R_o + R_L)C_{C2}} = \frac{1}{2\pi(17.25+4000)(2\times10^{-6})}$$

$f_L = 19.8\ \text{Hz}$

#2

$$V_{GS} + I_D R_S = 5$$

$$I_D = \frac{5 - V_{GS}}{R_S} = K_n \left(V_{GS} - V_{TN}\right)^2$$

$$5 - V_{GS} = (3)(10)\left(V^2{}_{GS} - 2V_{GS} + 1\right)$$

$$30V^2{}_{GS} - 59V_{GS} + 25 = 0$$

$$V_{GS} = \frac{59 \pm \sqrt{(59)^2 - 4(30)(25)}}{2(30)} \Rightarrow V_{GS} = 1.349\,\text{V}$$

$$g_m = 2K_n \left(V_{GS} - V_{TN}\right) = 2(3)(1.35 - 1)$$

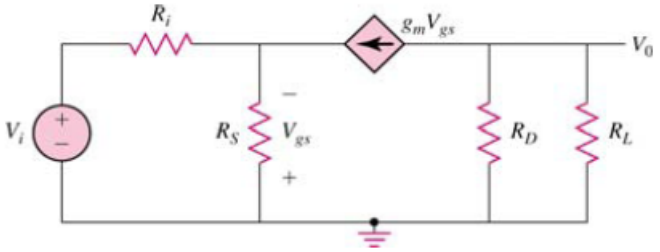
$$g_m = 2.093\ mA/V$$

On the output:

$$\tau_{P\mu} = \left(R_D \| R_L\right) C_{gdT} = \left(5 \| 4\right) \times 10^3 \times \left(4 \times 10^{-12}\right)$$

$$\tau_{P\mu} = 8.89 \times 10^{-9}\ \text{s}$$

$$f_{P\mu} = \frac{1}{2\pi \tau_{P\mu}} \Rightarrow f_{P\mu} = 17.9\ \text{MHz}$$



$$V_0 = -g_m V_{gs} \left(R_D \| R_L\right)$$

$$g_m V_{gs} + \frac{V_{gs}}{R_S} + \frac{V_i - \left(-V_{gs}\right)}{R_S} = 0$$

$$V_{gs}\left(g_m + \frac{1}{R_S} + \frac{1}{R_i}\right) = -\frac{V_i}{R_i}$$

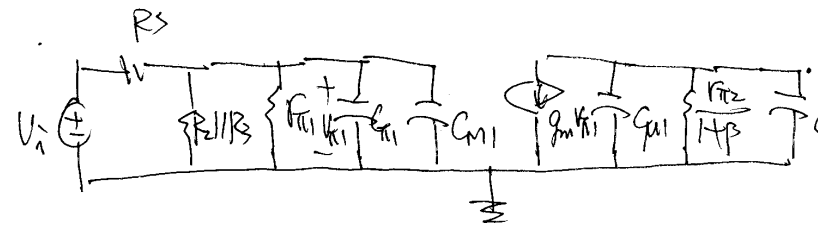
$$V_{gs}\left(2.093 + \frac{1}{10} + \frac{1}{2}\right) = -\frac{V_i}{2}$$

$$V_{gs} = (0.1857) V_i$$

$$A_v = \frac{V_0}{V_i} = (2.093)(0.1857)\left(5 \| 4\right)$$

$$\underline{A_v = 0.864}$$

5.

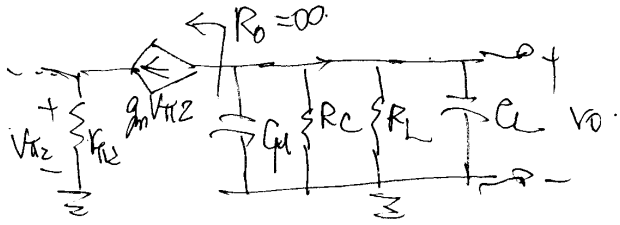


(a) $C_{M1}=C_{\mu1}\left(1+\frac{g_{m2}r_{\pi2}}{1+\beta}\right)=2C_{\mu1}$.

$\tau_{\pi1}=(R_s//R_2//R_3//r_{\pi1})\cdot(C_{\pi1}+C_{M1})$

$f_{H\pi}=\frac{1}{2\pi(R_s//R_2//R_3//r_{\pi1})(C_{\pi1}+2C_{\mu1})}$ ※

$r_{\pi1}=\frac{I_{CQ}}{V_T}$, $C_{\pi1}=C_\pi$, $C_{\mu1}=C_\mu$.



$\tau_M=(R_C//R_L)(C_M+C_L)$

$f_{HM}=\frac{1}{2\pi\tau_M}=\frac{1}{2\pi(R_C//R_L)(C_M+C_L)}$ ※.

(b) $V_o=-g_m(R_C//R_L)\cdot V_{\pi2}$

$=-g_m(R_C//R_L)\cdot\frac{g_{m1}r_{\pi2}}{1+\beta}V_{\pi1}$

$=-g_m(R_C//R_L)\cdot\frac{R_2//R_3//r_\pi}{R_2//R_3//r_\pi+R_S}V_i$.

A_V.

$r_\pi=120\times\frac{0.026}{1.2}$

$\approx 3K$.

(c) ① $C_L\to 0$.

$f_{HX}=\frac{10^9}{2\pi\cdot(6.1//20.5//28.3//3)(12+4)}$

$=\frac{10^9}{2\times3.14\times0.096\times16}=103.67MHz$.

$f_{HM}=\frac{10^9}{2\pi\times(5\parallel10)\times2}=\frac{10^9}{2\times3.14\times3.33\times2}=23.9MHz$ (dominant)

② $C_L=15pF$

$f_{HM}=\frac{10^9}{2\pi\times3.33\times17}=2.8MHz$ (dominant).