Name: Key ID #

100 / 100

Q1) [35 points]

For the amplifier circuit shown, neglect r_o,.

(a) Drive an expression for the **midband voltage gain (V_{out}/V_{sig})**. 9

(b) Drive an expression for the **low and high frequency poles**. 16

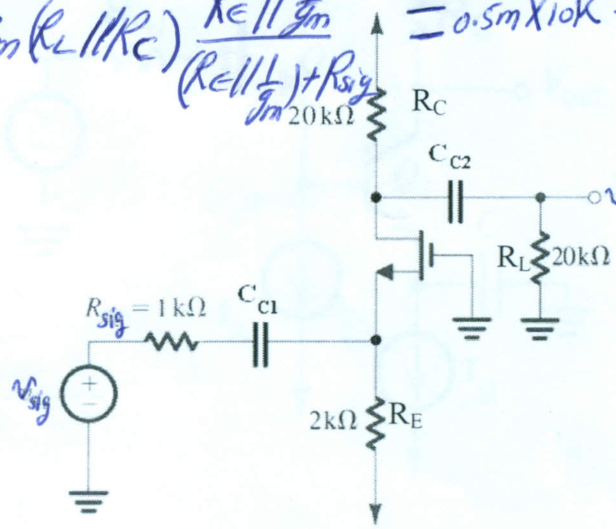
(c) Find the amplifier transfer function T(s)= $V_{out}(s)/V_{sig}(s)$. 4

Given that g_m=0.5mA/V, C_{C1}= C_{C2}=1μF, C_{gs}=1pF and C_{gd}=0.5pF

Find the values of :

- ω_L and ω_H and the bandwidth **BW**. 4
- Voltage gain= **(V_{out}/V_{sig})** 2

a) $A_M = \dfrac{R_E \| \frac{1}{g_m}}{(R_E \| \frac{1}{g_m}) + R_{sig}} \cdot \dfrac{R_L \| R_C}{\frac{1}{g_m}} = g_m (R_L \| R_C) \dfrac{R_E \| \frac{1}{g_m}}{(R_E \| \frac{1}{g_m}) + R_{sig}} = 0.5m \times 10K \, \frac{1}{2} = 2.5 \, V/V$



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b) Low freq. poles:

$$\omega_{C_{C1}} = \frac{1}{(R_{sig} + R_E \| \frac{1}{g_m}) C_{C1}}$$

$$\omega_{C_{C2}} = \frac{1}{C_{C2} (R_C + R_L)}$$

High freq. poles: $\omega_{C_{gs}} = \dfrac{1}{C_{gs} (R_{sig} \| R_E \| \frac{1}{g_m})}$

$$\omega_{C_{gd}} = \frac{1}{C_{gd} (R_C \| R_L)}$$

$$T(s) = A_M \frac{s}{s + \omega_H} \cdot \frac{1}{1 + \frac{s}{\omega_L}}$$

where $\omega_H = \dfrac{1}{\tau_{C_{gs}} + \tau_{C_{gd}}}$; $\omega_L \simeq \omega_{C_{C1}} = 500 \, rad/sec$

$= \dfrac{1}{5 \times 10^{-10} + 5 \times 10^{-9}} = 1.818 \times 10^{8} \, rad/sec \Rightarrow BW = \omega_H - \omega_L$

$\simeq \omega_H$

Q2) [35 points]

For the amplifier circuit shown below,

(d) Drive an expression for the **midband voltage gain** $A_M = V_{out}/V_{sig}$. 10

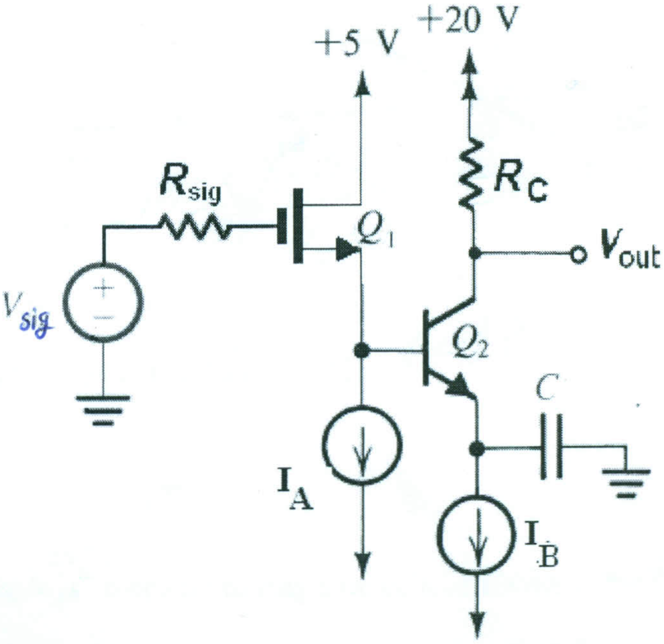
(e) Drive an expression for the **low corner frequency** ω_L. 5

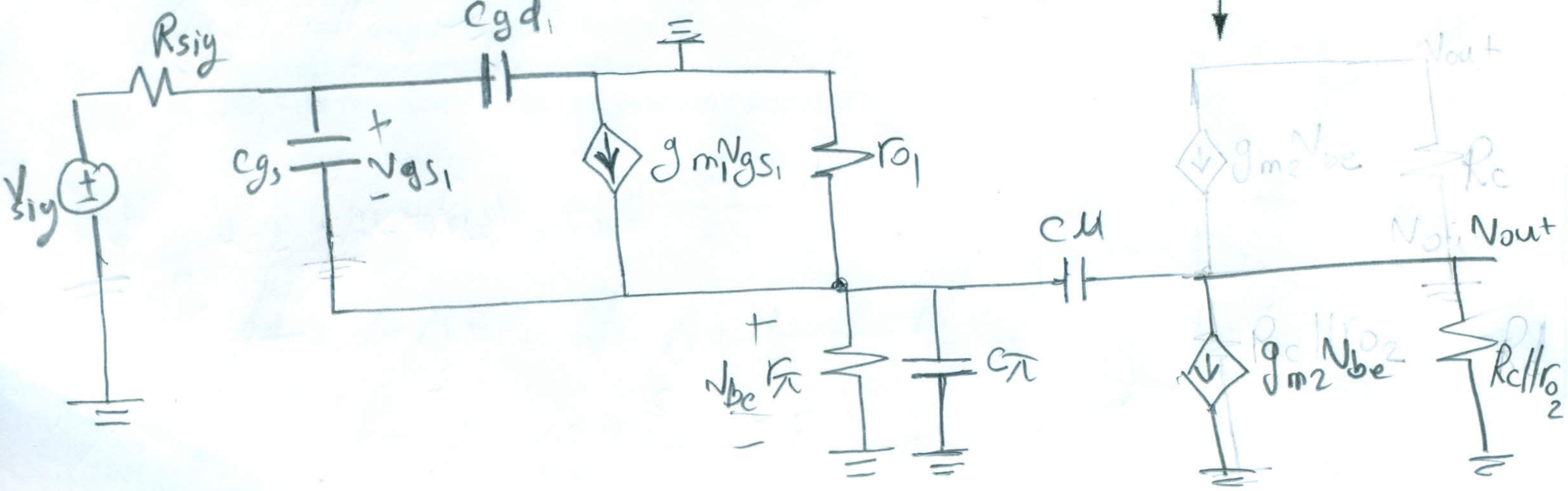
(f) Drive an exprsion for the upper corner frequency ω_H 20

d) $$A_M = \frac{r_{\pi 2} \| r_{o1}}{r_{o1} \| r_{\pi 2} + \frac{1}{g_{m1}}} \left[-g_{m2} (R_C \| r_{o2}) \right]$$

e) $$\omega_L = \frac{1}{C \left(r_e + \frac{1/g_{m1} \| r_{o1}}{(\beta + 1)} \right)}$$

f) $\omega_H = ??$





$$\omega_{cgd} = \frac{1}{C_{gd} R_{sig}}$$,
$$\omega_{ceq} = \frac{1}{\left[C_\pi + C_\mu (1 + g_{m2} R_C \| r_{o2}) \right] (r_\pi \| \frac{1}{g_{m1}} \| r_{o1})}$$

$$\omega_{cgs} = \frac{1}{C_{gs} \frac{R_{sig} + r_{o1} \| r_\pi}{1 + g_{m1} (r_{o1} \| r_\pi)}}$$

$$\omega_{c2} = \frac{1}{C_\mu \left(1 + \frac{1}{g_{m2} R_C \| r_{o2}}\right) (R_C \| r_{o2})}$$

$$\omega_H = \frac{1}{\tau_{cgd} + \tau_{cgs} + \tau_{ceq} + \tau_{c2}}$$

Q3) [30 points]

a) Sketch Bode plots for the **magnitude** of the transfer function and **estimate the gain** in dB at 10^5 rad/s

$$T(s) = \frac{10s}{(1+s/10^2)(1+s/10^5)}$$

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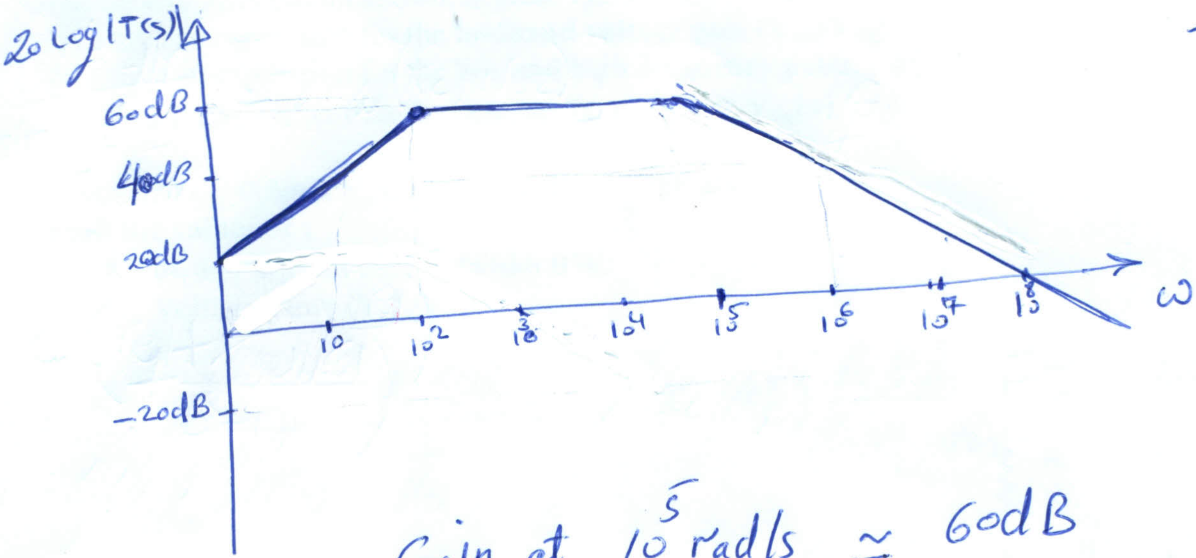

Gain at 10^5 rad/s $\simeq$ 60dB

b) Non-inverting amplifier with gain of 30v/v employs an opamp having a dc gain of 100dB and unity-gain frequency of 10MHz, **find :**

i. The 3-dB frequency of the opamp.

ii. The 3-dB frequency of the non-inverting amplifier

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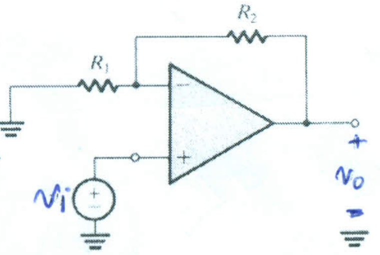
(i) For opamp $\omega_b = \frac{\omega_T}{A_o}$



$f_T = 10$ MHZ & $A_o = 100\text{dB} = 10^5$ V/V

$$f_b = \frac{f_T}{A_o} = \frac{10\,\text{MHz}}{10^5} = 100\ \text{Hz}$$

(ii) for the closed loop sys.

$$f_{b_{CL}} = \frac{f_T}{A_{CL}} = \frac{10\,\text{MHz}}{30} = 333.33\ \text{KHz}$$