Ele.II summer15 mt3 Name:	SurName:	Number:

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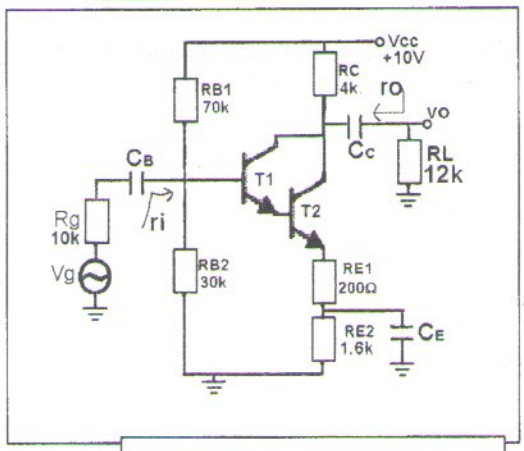
P1 $V_{BE1}=V_{BE2}=0.6V$, $\beta_{F1}=\beta_{F2}=100$, $V_T=25mV$ are given for the Transistors in the figure.



P1a) Find I_{E2Q}.(2p)

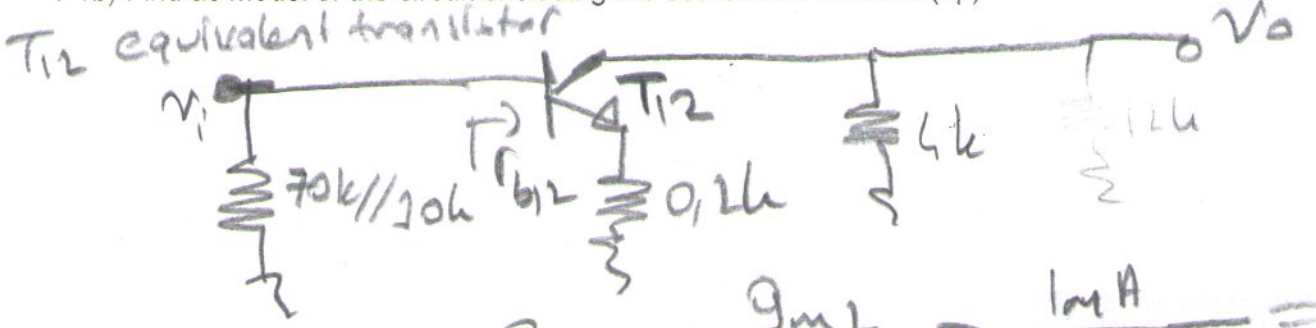
$V_{B12}=\frac{2}{10}\cdot 10=2V$

$V_{E22}=2-2\cdot 0,6V=1,8V$

$I_{E2Q}=\frac{1,8V}{1,6k+0,2k}=1mA\cong I_{C2Q}$

Answer-1a
$I_{E2Q}=$ 1mA

P1b) Find ac model of the circuit excluding the source and the load.(3p)



$g_{m12}=\frac{g_{m2}}{2}=\frac{1mA}{2.25mV}=\frac{1}{50}S$

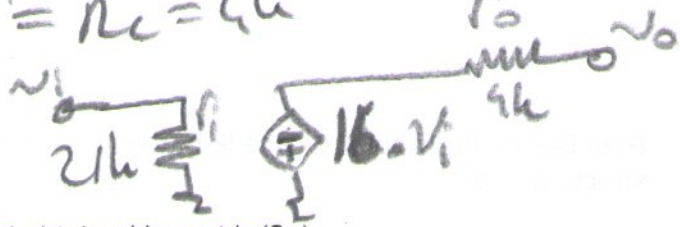
$\beta_{F12}=\beta_{F1}\cdot\beta_{F2}=10^4$

$\frac{v_o}{v_i}=\frac{-g_{m12}\cdot(4k//12k)}{1+g_{m12}\cdot 0,2k}=\frac{-60}{5}=-16$

$r_i\cong 10k//70k//r_{b12}\cong 2k$

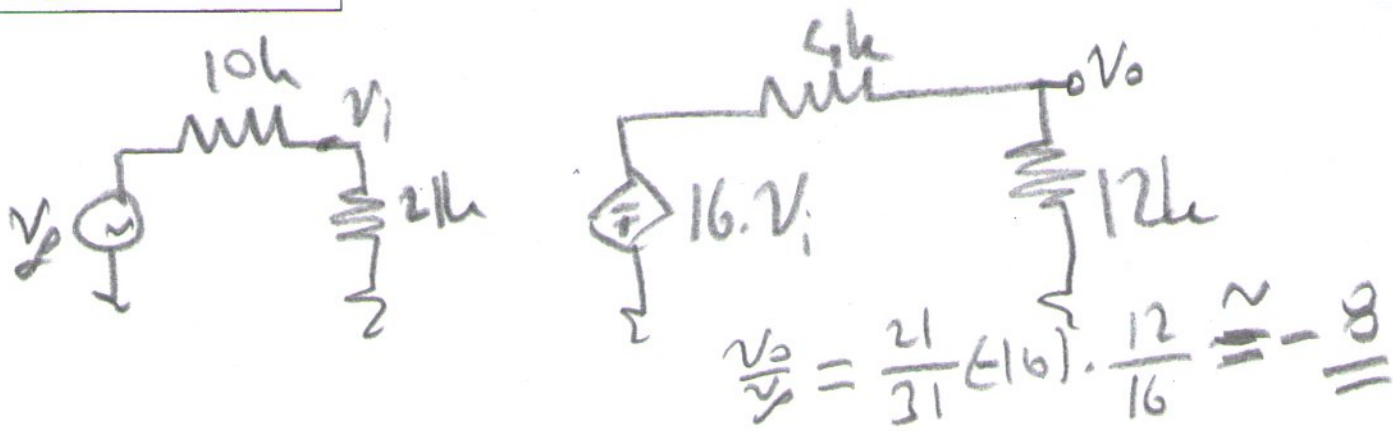
$r_{b12}=\beta_{F12}\cdot\left(\frac{1}{g_{m12}}+0,2k\right)=2,5M$

$r_o\cong R_C=4k$



P1c) Find ac gain of the circuit (vo/vg) by using the ac model obtained in part b.(2p)

Answer-1c
(vo/vg)=

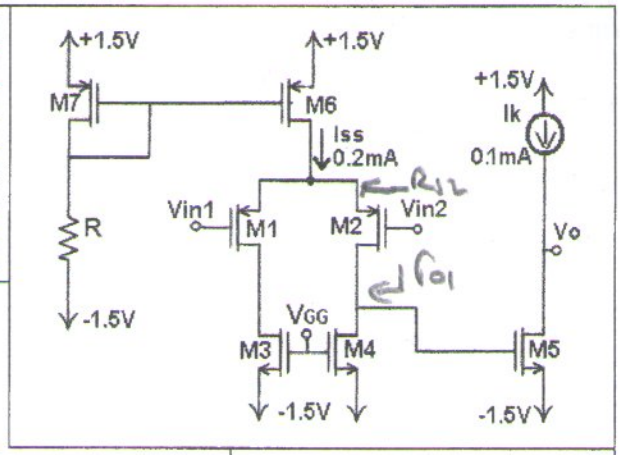


$\frac{v_o}{v_g}=\frac{21}{31}(-16)\cdot\frac{12}{16}\cong -8$

P2 For the MOSFETs in the figure, $k_p'=\mu_p c_{ox}=40\mu A/V^2$, $k_n'=\mu_n c_{ox}=80\mu A/V^2$, $V_{An}= V_{Ap} =40V$, $V_{Th,p}= -0.8V$, $V_{Th,n}= 0.6V$ are given. Vin1=Vin2=0 for DC case.

P2a) Find the differential gain of the circuit {vo/(vin1-vin2)}.(4p)

	L(um)	W(um)
M1	0.7	28
M2	0.7	28
M3	0.7	7
M4	0.7	7
M5	0.7	7
M6	0.7	7
M7	0.7	7



$\frac{v_{d2}}{v_{id}} = \frac{g_{m1}(r_{o1})}{2}$

$r_{o1} = r_{o4} // r_{o2}$ $\quad r_{o4} = r_{ds4} = \frac{40}{0,1m} = 400k$

$r_{o2} = r_{ds2}(1+g_{m2}R_{s2}) + R_{s2}$ ($r_{ds2} \to 400k$, $g_{m2} \to 0,56mS$)

$R_{s2} \cong \frac{1}{g_{m1}} = \frac{1}{\sqrt{2 \cdot \frac{28}{0,7} \cdot 40\mu \cdot 0,1m}} = 1/0,56mS$

$r_{o2} = 800k$

$\frac{v_{d2}}{v_{id}} = \frac{0,56mS \cdot 270k}{2} \cong 75$

$\frac{v_o}{v_{d2}} = \frac{-g_{ms} \cdot r_{ds5}}{1} = \frac{-\sqrt{2 \cdot 10 \cdot 80\mu \cdot 0,1m} \cdot 400k}{L} = -0,4m \cdot 400k = -160$

$\frac{v_o}{v_{id}} = 75 \cdot (-160) = -12000$

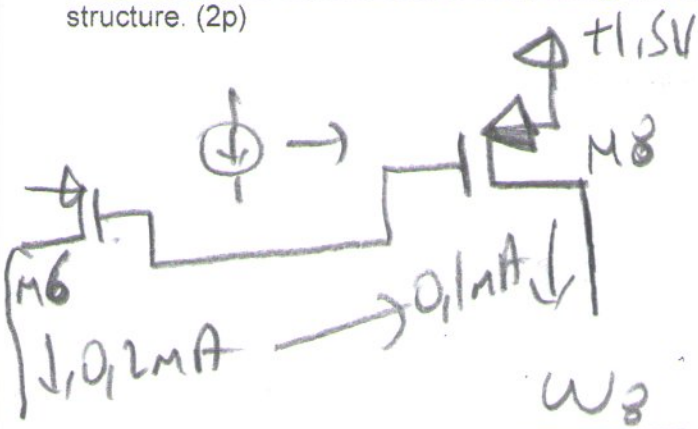
Answer-2a
(vo/(vin1-vin2)= -12000

P2b) Find CMRR of the circuit. (2p)

Answer-2b
CMRR=

$CMRR = g_{m1} \cdot R_{ss} = g_{m1} \cdot r_{ds6} = 0,56mS \cdot 200k = 112 \cong 41dB$

P2c) Design the current source Ik by using one transistor operating together with the current mirror structure. (2p)



$\frac{I_{D8}}{I_{D6}} = \frac{1}{2}$ $\quad \left(I_{D8} = \frac{I_{D6}}{2}\right)$

$\frac{W_8}{L_8} = \frac{1}{2}\frac{W_6}{L_6} = \frac{7/2}{0,7} = \frac{3,5}{0,7}$