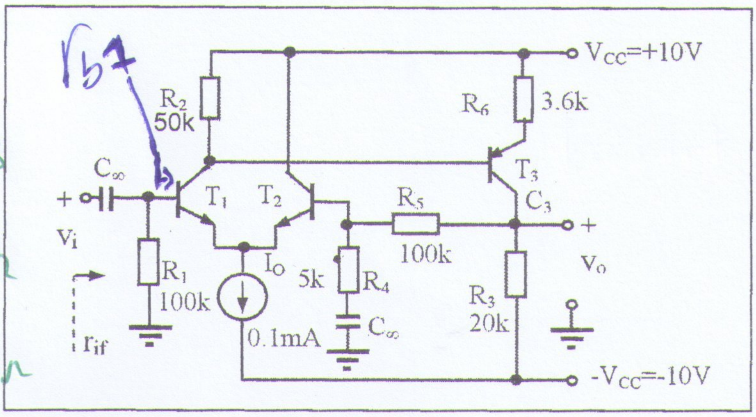
Analog Electronic Circuits_Summer19_Final- **Name:** **Number:**

P1 For the transistors in the figure, $|V_{BE}| \approx 0.7V$, $V_T = 25mV$, $\beta_{F1} = \beta_{F2} = 200$ and $\beta_{F3} = 500$ are given. In DC case, $V_{C3} = 0V$ and $I_{R5} << I_{R3}$.

P1a- Find mid-band gain of the loaded circuit in open-loop case.



$g_{m1} = g_{m2} = \frac{0{,}05mA}{25mV} = \frac{1}{500} = 2mS$

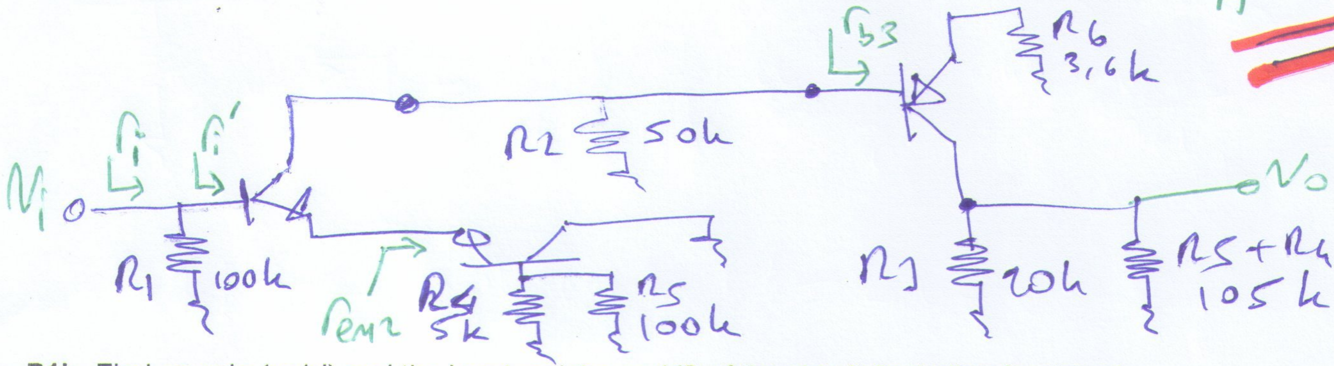
$r_{em2} = \frac{1}{g_{m2}} + \frac{R_4}{\beta_{F2}} \cong \frac{1}{g_{m2}} = 500\Omega$

$r_{b3} = \beta_{F3}\left(\frac{1}{g_{m3}} + R_6\right) \cong 1{,}8MEG\Omega$

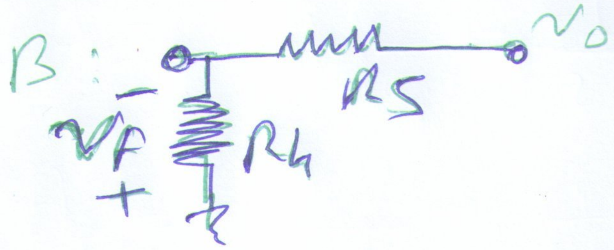
$r_i' = r_{b1}' = \beta_{F1}\left(\frac{1}{g_{m1}} + r_{em2}\right) \cong 200k$

$A = \frac{v_{c1}}{v_i} \cdot \frac{v_o}{v_{b3}} = \frac{-g_{m1} \cdot (R_2 // r_{b3})}{1 + g_{m1} \cdot r_{em2}} \cdot \frac{-g_{m3} \cdot (R_3 // (R_5 + R_4))}{1 + g_{m3} \cdot R_6} \cong (-50) \cdot (-4{,}6)$

$A = 230$



P1b- Find ac gain (vo/vi) and the input resistance (rif) of the circuit (including feedback).



$\beta = \frac{v_f}{v_o} = \frac{-R_4}{R_4 + R_5} = -\frac{1}{21}$

$A = 460$

$1 - \beta A = 1 + \frac{460}{21} \cong 12$

$A_f = \frac{A}{1 - \beta A} = \frac{230}{1 + \frac{230}{21}} \cong 19 = A_f$

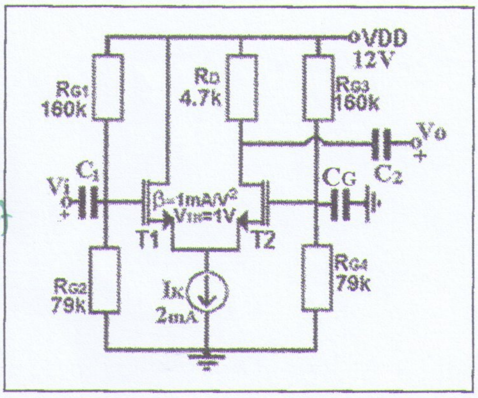
$r_{if} = R_1 // r_{b1} = R_1 // (1 - \beta A) r_{b1}'$

$r_{if} = 100k // (12 \times 200k)$

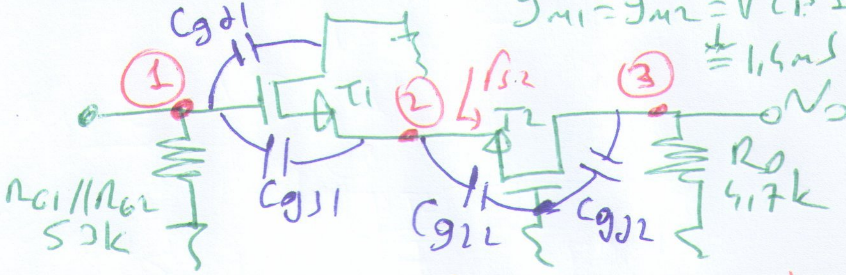
$r_{if} \cong 100k$

Analog Electronic Circuits_Summer19_Final- **Name:** **Number:**

P2- For the MOS transistors in the figure β=1mA/V^2, V_{TH}=1V, $V_A=\infty$, C_{gs}=100pF and C_{dg}=5pF are given. To the input, a voltage-pulse source is applied. The pulse source includes a resisitance of 10k.
Find the rise time of the signal at the output of the circuit (vo).
(C1, C2 and CG large capacitors.)



$g_{m1} = g_{m2} = \sqrt{2\beta I_D} \cong 1{,}4\,mS$ ~~1mA~~



$$\frac{v_{s1}}{v_{g1}} = \frac{g_{m1} \cdot r_{s2}}{1 + g_{m1} r_{s2}} = \frac{g_{m1} \cdot (1/g_{m2})}{1 + g_{m1}(1/g_{m2})} = \frac{1}{2}$$

source resistance

$$C_{1eq} = C_{gd1} + C_{gs1}\left(1 - \frac{v_{s1}}{v_{g1}}\right) = 55\,pF \qquad R_{1eq} \cong R_{G1} // R_{G2} // 10k \cong 8{,}5k$$

$$C_{2eq} = C_{gs1}\left(1 - \frac{1}{\frac{v_{s1}}{v_{g1}}}\right) + C_{gs2} \cong 0 \qquad R_{3eq} \cong R_{C1} \cong 4{,}7k \qquad \boxed{f_{ust} \cong \frac{w_{H1}}{2\pi}}$$

$$C_{3eq} = C_{gd2} = 5\,pF$$

$$w_{H1} = \frac{1}{C_{eq1} R_{eq1}} = 2M \xrightarrow{\text{dominant}} t_r = \frac{0{,}35}{f_{ust}} \cong 1\mu s$$

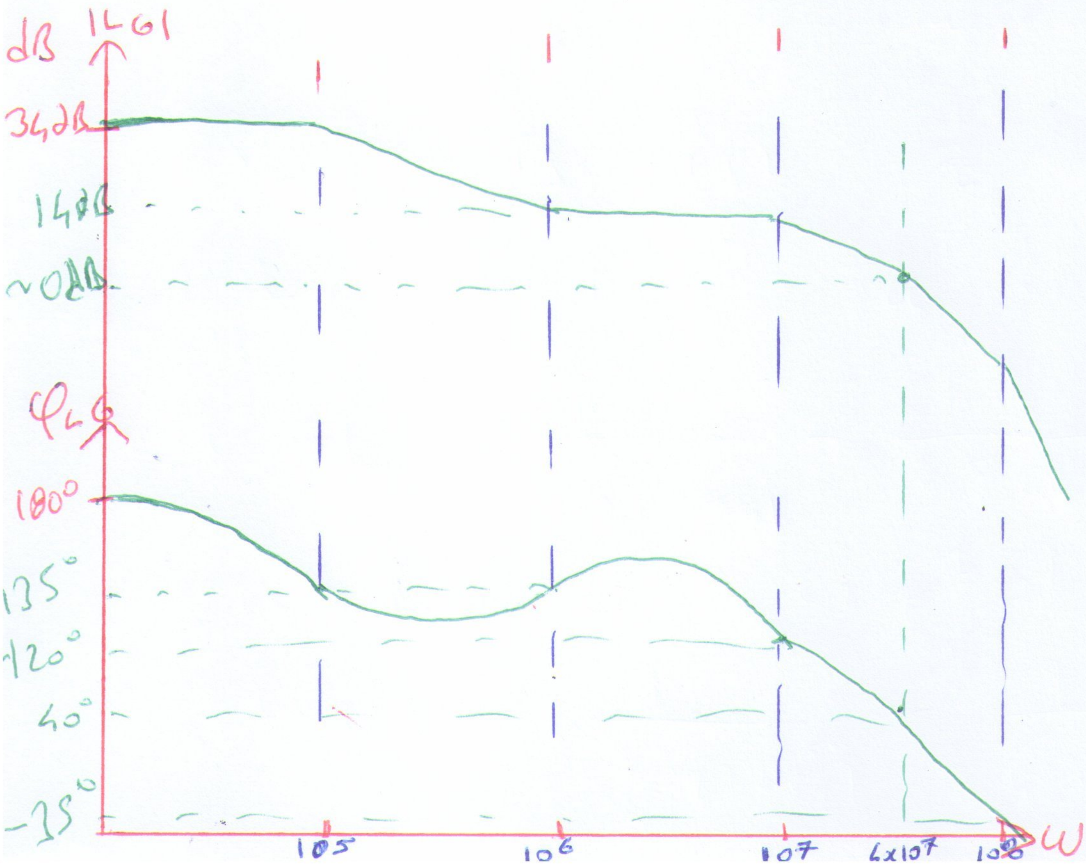
$$w_{H3} = \frac{1}{C_{eq3} R_{eq3}} = 43M$$

P3- For a circuit including feedback, the loop gain is given as

$$LG = \frac{-2x10^{23}(S + 10^6)}{(S + 10^5)(S + 10^7)(S + 4x10^7)(S + 10^8)}$$

Find the phase margin by using Bode characteristics and determine if the circuit is stable or not.

$$LG_0 = \frac{-2 \cdot 10^{23} \cdot 10^6}{10^5 \cdot 10^7 \cdot 4 \cdot 10^7 \cdot 10^8} = -50 \rightarrow 180^\circ, \ \sim 34dB$$



$|LG| = 0\,dB$

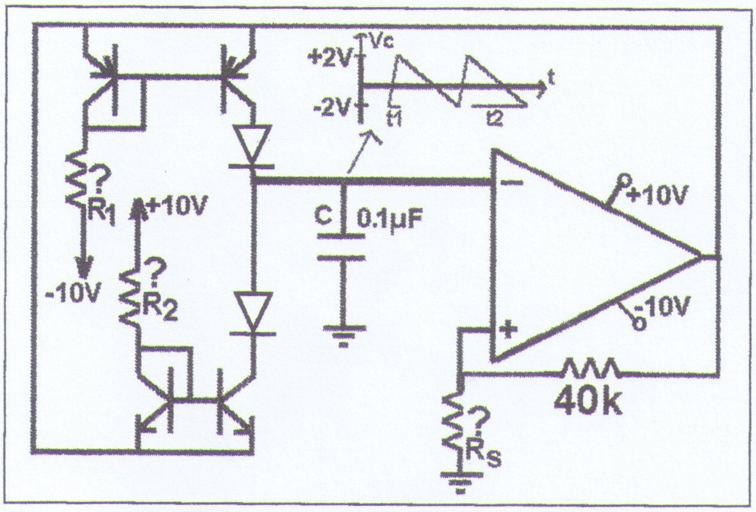
$\downarrow$

$\varphi_0 \cong 40^\circ = PM$

Circuit is stable.

Analog Electronic Circuits_Summer19_Final- **Name:** **Number:**

P4- Vc(t) is a triangle signal which has a peak to peak value of 4V, T= t1+t2=1mSn, and rise-fall ratio (t1/ t2) is 1/9. Find R1, R2 and Rs. (V_{BE}=0.7V)



$V_{H} = 2-(-2) = 4V$

$\downarrow$

$= 2\dfrac{R_s}{R_s+40k}\cdot 10V$

$\downarrow$

$R_s = 10k$ //

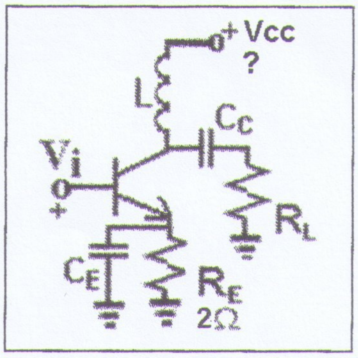
$C\cdot\dfrac{\Delta V_C}{\Delta t_1} = 0{,}1\mu F\cdot\dfrac{4V}{0{,}1mSn} = 4mA = I_{Charge}$

$C\cdot\dfrac{\Delta V_C}{\Delta t_2} = 0{,}1\mu F\dfrac{4V}{0{,}9mSn} = \dfrac{4}{9}mA = I_{Discharge}$

$I_{Charge} = \dfrac{20-|V_{BE}|}{R_1} = 4mA \rightarrow R_1 \cong 4{,}8k$

$I_{Discharge} = \dfrac{20-|V_{BE}|}{R_2} = \dfrac{4}{9}mA \rightarrow R_2 \cong 43k$

P5 The design targets of the power amplifier circuit in the figure:
The load value (RL) is 100Ω and the maximum output power is 2W.
a) Find the appropriate Vcc value.(V_{CEsat}=0.3V)



$V_{RLmax} = V_{CC} - V_{CEsat} - V_{EQ}$

$P_{Lmax} = I_{CQ}^2\cdot R_L\cdot\dfrac{1}{2} \rightarrow I_{CQ} = 0{,}2\underline{\underline{A}}$

$V_{EQ} = I_{CQ}\cdot R_E = 0{,}4V$

$V_{RLmax} = I_{CQ}\cdot R_L = 20 = V_{CC} - 0{,}3 - 0{,}4 \Rightarrow V_{CC} = 20{,}7V$

b) Find the maximum power value dissipated on the transistor.(6P)

$P_{Tr_{Max}} = I_{CQ}\cdot V_{CEQ}$

$\downarrow$

$= I_{CQ}\cdot(V_{CC} - V_{EQ}) = 4{,}06W$

$\downarrow$

$= P_{DC} \cong 4W$

$\downarrow$

$= 2\times P_{RLmax}$