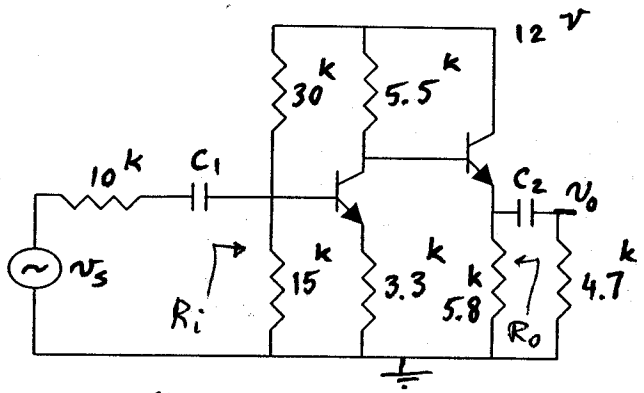
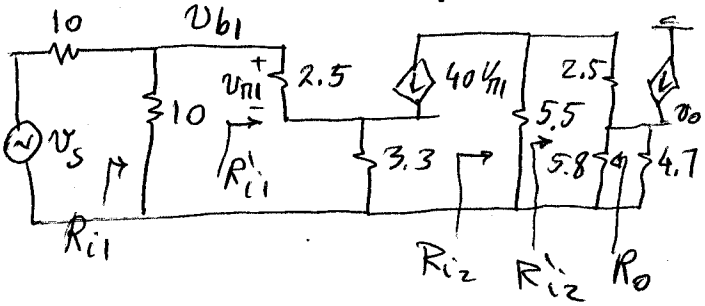
4-30 points) In the 2 stage amplifier shown,
$r_{\pi 1} = r_{\pi 2} = 2.5$ Kohms , $g_{m1} = g_{m2} = 40$ ms.
, V_A=infinity and beta1=beta2=100. Find:

a) The voltage gain Av=Vo/Vs.
b) The input and output resistance.
c) The maximum voltage swing of the output Vo and input Vs.



c_1 and c_2 are short for ac signals



Solution : $R'_{i1} = r_{\pi 1} + (1+\beta)3.3 = 335.8$ kΩ

$R_{i1} = 10 \,//\, 335.8 = 9.71$ kΩ

(a) $R'_{i2} = 2.5 + 101\,(5.8 \,//\, 4.7) = 272.4$ kΩ

$R_{i2} = 5.5 \,//\, 272.4 = 5.4$ kΩ

$$\frac{v_{b1}}{v_s} = \frac{R_{i1}}{R_s + R_{i1}} = \frac{9.71}{10 + 9.71} = 0.49 \qquad \frac{v_{\pi 1}}{v_{b1}} = \frac{r_{\pi 1}}{R'_{i1}} = \frac{2.5}{335.8} = 7.44 \times 10^{-3}$$

$$\frac{v_{b2}}{v_{\pi 1}} = -g_m R_{i2} = -40 \times 5.4 = -216 \qquad \frac{v_o}{v_{b2}} = \frac{(5.8 \,//\, 4.7)101}{R'_{i2}} = 0.95$$

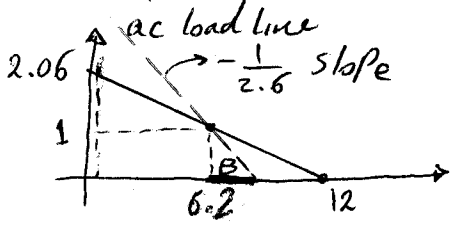
$$A_V = \frac{v_o}{v_s} = \frac{v_{b1}}{v_s} \times \frac{v_{\pi 1}}{v_{b1}} \times \frac{v_{b2}}{v_{\pi 1}} \times \frac{v_o}{v_{b2}} = -0.75 = \text{Voltage gain } [V/V]$$

(b) $R_i = R_{i1} = 9.71\,[k\Omega] \qquad R_o = 5.8 \,//\, \frac{r_{\pi 2} + R_{c1}}{1+\beta} = 5.8 \,//\, 80\,k\Omega = 79\,[\Omega]$

(c) slope of the DC load line $\frac{-1}{R_{E2}} = \frac{-1}{5.8}$

$V_{CE} = V_{cc} - R_{E2} I_C$

slope of the ac load line $\frac{-1}{5.8 \,//\, 4.7} = -\frac{1}{2.6}$



maximum output swing = $1 \times 2.6 = 2.6$ V

$V_o(max) = 2.6\,[V]$ Peak

$V_s(max) = \frac{2.6}{0.75} = 3.46$ V

The I_{CQ2} is obtaind from

$$g_m = \frac{I_{CQ}}{V_T} \qquad 40\,\text{mV} = \frac{I_{CQ}}{25\,\text{mV}}$$

$I_{CQ} = 1$ mA $\quad V_{CE} = 12 - 5.8 \times 1 = 6.2$