122 **6**

(a)

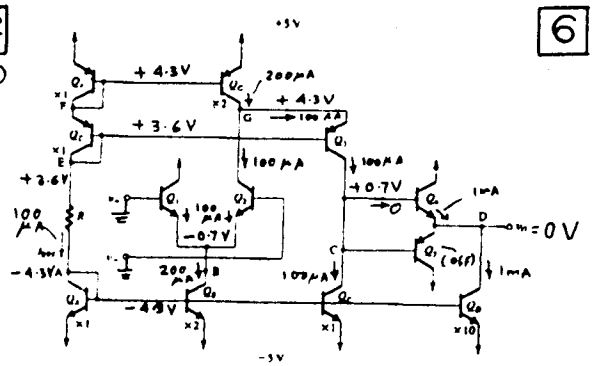


FIG P6.122 DC Analysis

$$R = \frac{3.6 - (-4.3)}{100\ \mu A} = \underline{79\ k\Omega}$$

Node voltages: $V_A = \underline{-4.3\ V}$, $V_B = \underline{-0.7\ V}$,
$V_C = \underline{+0.7\ V}$, $V_D = \underline{0\ V}$, $V_E = \underline{+3.6\ V}$,
$V_F = \underline{+4.3\ V}$, $V_G = \underline{+4.3\ V}$

(b)

Transistor	I_C (mA)	g_m (mA/V)	r_o (MΩ)
Q_1	0.1	4	2
Q_2	0.1	4	2
Q_3	0.1	4	2
Q_4	1.0	40	0.2

(b) Contd'

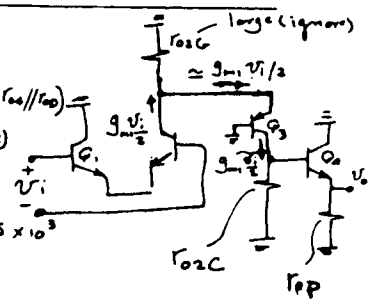
Transistor	I_C (mA)	g_m (mA/V)	r_o MΩ
Q_5	0	0	∞
Q_A	0.1		
Q_B	0.2		
Q_C	0.1	. . . . .	2
Q_D	1.0	. . . . .	0.2
Q_E	0.1		
Q_F	0.1		
Q_G	0.2	. . . . .	1

(c) Total resistance at collector Q_3

$\simeq \beta_3 r_{o3} // r_{oc} // [(\beta_4+1)(r_{o4} // r_{oD})$

$= 100 \times 2 // 2 // 101(0.2 // 0.2)$

$= 1.65\ M\Omega$



$\frac{v_{c3}}{v_i} = +g_{m1} \times \frac{1}{2} \times 1.65 \times 10^3$

$= 3300\ V/V$

$\frac{v_o}{v_{c3}} \simeq 1$

Thus, $\frac{v_o}{v_i} \simeq 3300\ V/V$ (polarity correct)

(d) $R_{in} = 2 r_{\pi 1}$

$= 2 \times \frac{100}{4} = \underline{50\ k\Omega}$

$R_{out} = r_{oD} // r_{o4} // \left[r_{e4} + \frac{r_{o2C} // \beta_3 r_{o3}}{\beta + 1} \right]$

$= 0.2 // 0.2 // \left[25 \times 10^{-6} + \frac{2 // 100 \times 2}{101} \right]$

$\simeq \underline{16.4\ k\Omega}$

(e) $v_{ICM}|_{min} = -4.3 - 0.4 + 0.7 = \underline{-4\ V}$

$v_{ICM}|_{max} = V_G + 0.4 = \underline{+4.7\ V}$

(f) The voltage at the base of Q_4 can rise to V_{B3} (V_E) + 0.4 = +4 V (before Q_3 saturating). Thus v_o can go up to $\underline{+3.3\ V}$

The voltage at the output can go down to $V_{Base\ of\ Q_D} + 0.4 = V_A + 0.4$

$= -4.3 - 0.4 = \underline{-4.7\ V}$

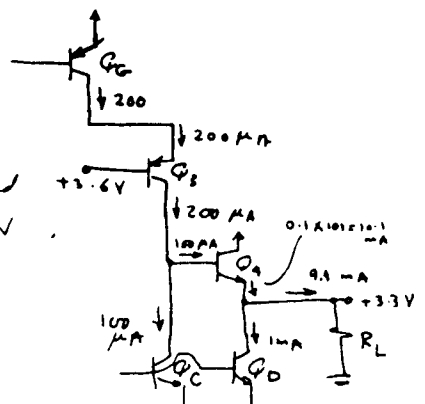
Thus the linear range at the output is $\underline{-4.7\ V \text{ to } +3.3\ V}$

(g) At the positive limit of v_o, i.e. $v_o = +3.3\ V$ and Q_2 just cut off

$R_L = \frac{3.3\ V}{9.1\ mA}$

$= \underline{363\ \Omega}$

(This is the minimum allowed R_L for +3.3 V output)



At the negative limit of v_o, i.e. $v_o = -3.3\ V$ and Q_1 has cut off. Q_3 also will be cut off, and Q_4 will cut off.

Thus

$R_L = \frac{4.7}{11.1\ mA}$

$= \underline{423\ \Omega}$

This is the minimum allowed R_L for a −4.7 V output.