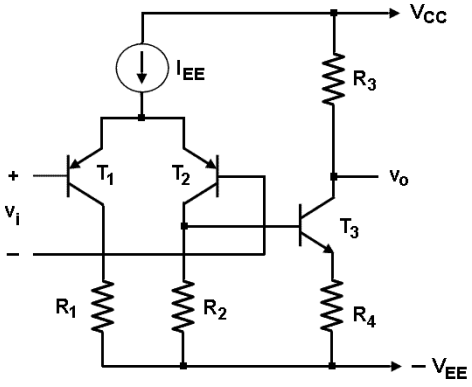
$V_{CC}=V_{EE}=10$ V, $I_{EE}=2$ mA, $R_1=R_2=8$ kΩ, $R_3=4$ kΩ, $R_4=3.3$ kΩ, $V_T=26$ mV, $|V_{BE}|=0.6$ V, $\beta_F=200$, $r_{ce}=50$k olarak verilmektedir.

a) $V_{B1}=V_{B2}=0$. Find I_C and V_O (DC values).

b) $I_{EE}=2$ mA. Design the current source.

c) Find CMRR after the design of the current source (part b)

d) Find the ac model of the circuit.

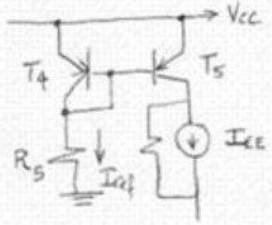


a) $I_{C1}=I_{C2}\cong \frac{I_{EE}}{2}=1$ mA

$R_2 I_{C2}=V_{BE3}+R_4 I_{E3}$

$8.1=0,6+3,3.I_{E3}$ $\quad I_{E3}=2,24$ mA $\cong I_{C3}$

b) **PNP transistors should be used for the current source structure.**



$I_{EE}=2$ mA için;

$I_{EE}=\frac{1}{1+\frac{2}{\beta_F}} I_{ref}=\frac{1}{1+\frac{2}{200}} I_{ref}$

$I_{ref}\cong 2$ mA

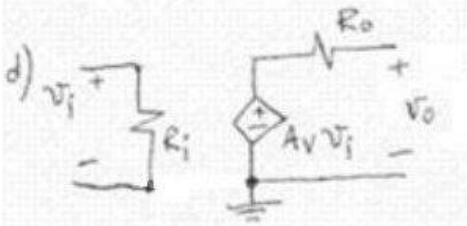
$R_5=\frac{V_{CC}-V_{EB4}}{I_{ref}}=\frac{10-0,6}{2.10^{-3}}=4,7k\Omega$

$R_0=r_{05}=\frac{1}{h_{oe}}=\frac{1}{2.10^{-6}}=50k\Omega$

c) $CMRR=20.\log\left|gm\,Ro\right|=66dB$

$r_{e1}=\frac{V_T}{I_{E1}}=\frac{26}{1}=26\Omega$ $\quad =1/gm$

d)



$$A_V = \frac{v_o}{v_{b3}} \cdot \frac{v_{b3}}{v_{in}}$$

$$= \left(-\frac{R_3 // r_{e3}}{r_{e3} + R_4}\right)\left(\frac{R_2 // R_{i3}}{2 r_{e1}}\right)$$

$$r_{e3} = \frac{V_T}{I_{E3}} = \frac{26}{2{,}24} = 11{,}6\ \Omega$$

$$R_{i3} = \beta_F (r_{e3} + R_4) = 200\,(11{,}6 + 3300) = 662{,}32\ k\Omega$$

$$A_V = \left(-\frac{4.10^3 // 50.10^3}{11{,}6 + 3300}\right)\left(\frac{8.10^3 // 662{,}32.10^3}{2..26}\right)$$

$$= (-1{,}12)(152)$$

$$= -170{,}24$$

$$R_i = 2\beta_F r_{e1} = 2.200.26 = 10{,}4\ k\Omega$$

$$R_o = R_o' // R_3 \qquad R_o' = \frac{1}{h_{ie}} \frac{\beta_F (R_4 + r_{e3}) + R_2}{\beta_F r_{e3} + R_4 + R_2}$$

$$= 50.10^3 . \frac{200\,(3300 + 11{,}6) + 8.10^3}{200.11{,}6 + 3300 + 8.10^3}$$

$$= 50.10^3 . (49{,}2)$$

$$\simeq 2{,}5\ M\Omega$$