**Soru 1.**

a) $I_{.2}.R_3 = V_{R1}\frac{R_3}{R_1} \quad V_{R1} = V_T.\ln\left(\frac{I_2.A_{E1}}{I_1.A_{E2}}\right) \qquad I_1.R_2 = I_2.R_3$

$$V_{ref} = V_{EB2} + I_{.2}.R_3 = V_{EB2} + \frac{R_2}{R_1}.V_T.\ln\left(\frac{R_2.A_{E1}}{R_3.A_{E2}}\right) = V_{EB2} + \frac{R_2}{R_1}.V_T.\ln\left(\frac{R_2}{R_3}.m\right)$$

b) m = 10, $V_{BEon}$ = 0.7V, $V_T$ = 26mV , $R_2 = R_3$

$$V_{ref} = V_{EB2} + \frac{R_2}{R_1}.V_T.\ln(m)$$

$$\frac{\partial V_{ref}}{\partial T} = \frac{\partial V_{BE}}{\partial T} + \frac{R_2}{R_1}.\frac{\partial V_T}{\partial T}.\ln(m) = 0$$

$$\frac{R_2}{R_1}. = \frac{-\frac{\partial V_{BE}}{\partial T}}{\frac{\partial V_T}{\partial T}.\ln(m)} = \frac{-2.5mV/^oC}{0.05mV/^oC\ x\ \ln(10)} = 12.78$$

$$V_{ref} = 0.7V + 12.78x26mVx\ln(10) = 1.464V$$

**Soru 2.**

a)

$$SR = \frac{I_O \cdot \omega_1}{g_{mi}} = \omega_1 \cdot \sqrt{\frac{I_O}{\mu.C_{OX}.\left(\frac{W}{L}\right)_1}}$$

$$I_5 = I_O = \frac{SR^2}{\omega_1^2}.\mu.C_{OX}.\left(\frac{W}{L}\right)_1 = \frac{\left(10x10^6\right)^2}{\left(2x\pi\ x\ 5x10^6\right)^2}\ 20x10^{-6}x9 = 18.25\mu A$$

$$C_C = \frac{I_O}{SR} = \frac{18.25\mu A}{10V/\mu sn} = 1.825pF$$

b)

$$\frac{(W/L)_3}{(W/L)_6} = \frac{(W/L)_4}{(W/L)_6} = \frac{1}{2}.\frac{(W/L)_5}{(W/L)_7} = \frac{I_O}{2.I_7}$$

$$\frac{1}{2}.\frac{(W/L)_5}{(W/L)_7} = = \frac{(W/L)_3}{(W/L)_6} = \frac{15}{45} \rightarrow I_7 = \frac{I_O}{2}.\frac{(W/L)_6}{(W/L)_3} = \frac{1}{2} x 18.25\mu A \ x \ 3 = 27.37\mu A$$

$$(W/L)_7 = \frac{1}{2}.(W/L)_5.\frac{(W/L)_6}{(W/L)_3} = \frac{1}{2}.5.3 = 7.5$$

c)

$$K_{V1} = \frac{g_{m1}}{g_{o2} + g_{o4}},\ K_{V2} = -\frac{g_{m6}}{g_{o6} + g_{o7}}$$

$$g_{m1} = g_{m2} = \sqrt{I_5.k_N'.\left[\frac{W}{L}\right]_1} = \sqrt{18.25\mu A \ x \ 20\mu A/V^2 \ x \ 9} = 57\mu A/V$$

$$g_{m6} = \sqrt{2.I_7.k_P'.\left[\frac{W}{L}\right]_6} = \sqrt{2x27.37\mu A \ x \ 10\mu A/V^2 x \ 45} = 156\mu A/V$$

$$g_{o2} + g_{o4} = \frac{1}{2}.I_O.(\lambda_N + \lambda_p) = \frac{1}{2}.18.25\mu A.(0.03V^{-1}) = 0.273\mu A/V$$

$$g_{o6} + g_{o7} = .I_7.(\lambda_N + \lambda_p) = 27.37\mu A \ x \ (0.03V^{-1}) = 0.82\mu A/V$$

$K_{V1} = 209$, $K_{V2} = -190$, $K_d = 39710$

**Soru 3.**

$$K_{V1} = \frac{g_{m1}}{g_{m4}} = \sqrt{\frac{k_N'}{k_P'}.\frac{(W/L)_1}{(W/L)_3}} \rightarrow (W/L)_3 = (W/L)_4 = \frac{k_N'}{k_P'}.\frac{(W/L)_1}{K_{V1}^2} = \frac{20\mu A/V^2}{10\mu A/V^2}.\frac{3}{9} = \frac{2}{3}$$

$$SR = B.\frac{I_A}{C_L + C_{ni}} \rightarrow B.I_A = SR.(C_L + C_{ni}) = 5V/\mu sn \ x \ 50.3pF = 251\mu A$$

$$B = \frac{B.I_A}{I_A} = \frac{251\mu A}{100\mu A} = 2.51$$

$$(W/L)_5 = B.(W/L)_3 = 2.5x\frac{2}{3} = 1.66$$

$$G_m = B.\sqrt{k_n'.I_A.\left(\frac{W}{L}\right)_1} = 2.5x\sqrt{20\mu A/V^2 x100\mu A\ x3} = 194\mu A/V$$

b- baskın olmayan kutba kadar -20dB/dek ile düşmeli. Bunun için

$$f_{nd5} = GBW = \frac{g_{m4}}{2\pi C_{n5}}$$

$$g_{m4} = \sqrt{k_P'.I_A.\left(\frac{W}{L}\right)_4} = \sqrt{10\mu A/V^2 x100\mu A\ x\left(\frac{2}{3}\right)} = 25.81\mu A/V$$

$$f_{nd5} = GBW = \frac{25.81\mu A/V}{2\pi\ x\ 0.3pF} = 13.7MHz$$

$$R_O = \frac{2}{(\lambda_N + \lambda_P).B.I_A} = \frac{2}{0.03V^{-1}x251\mu A} = 265k\Omega$$

$$K_V = G_m.R_O = 194\mu A/V\ \ x\ \ 265k = 51$$

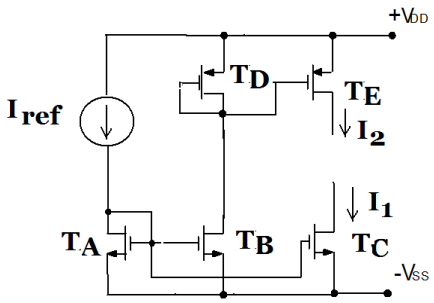
$$f_d = \frac{1}{2\pi R_O(C_{L\min} + C_{n7})} = \frac{GBW}{K_V} = \frac{13.7MHz}{51} = 268kHz$$

$$(C_{L\min} + C_{n7}) = \frac{1}{2\pi R_O.f_d} = \frac{1}{2\pi\ x265k\ x\ 268k} = 2.24pF$$

$$C_{L\min} = 2.24pF$$

**Soru 4.**

a-




$(W/L)_A = (W/L)_B = (W/L)_C$, $(W/L)_D = (W/L)_E$, $I_{ref}$ = 100µA

b- $r_z = \frac{1}{g_{d10} + g_{dI2}} = \frac{1}{g_{d10} + g_{dE}} = \frac{1}{I_2.(\lambda_N + \lambda_p)} = \frac{1}{100\mu A\ x\ (0.03)} = 333k\Omega$