HW #8 Sol'n

1. $V_{BB} = 2V_T \ln\left(\frac{I_Q}{I_S}\right) = 2(25m)\ln\left(\frac{1m}{1\times10^{-14}}\right) = 1.27V$

Let I_{C_1} also $= 2mA$

If $I_{Bias} = 3mA$

then $I_R = 1mA$

$\therefore R_1 + R_2 = \frac{V_{BB}}{I_R} = \frac{1.27}{1m} = 1.27K\Omega$

for Q_1: $V_{BE1} = V_T \ln\left(\frac{2m}{1\times10^{-14}}\right) = 0.65V$

$R_1 = \frac{0.65}{1m} \cong \boxed{651\Omega}$

$R_2 = 1.27k - 651 = \boxed{619\Omega}$

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2. $P_D = 60W$ at $40°C$, $T_{Jmax} = 120°C$

(a.) $\theta_{JC} = \frac{T_J - T_C}{P_D} = \frac{120-40}{60} = +1.33°C/W$

$\theta_{CS} = 0.5°C/W \Rightarrow T_J - T_S = (\theta_{JC} + \theta_{CS})P_D$

$\therefore T_S = 120 - (1.33+0.5)30 = \boxed{65.1°C}$

(b.) $T_S - T_A = \theta_{SA} \cdot P_D$

$65.1 - 30 = \theta_{SA} \cdot 30 \Rightarrow \theta_{SA} = \boxed{+1.17°C/W}$

c. $\frac{4.5°C/W/cm}{1.17°C/W} \cong \boxed{3.9cm}$

3. (9.1)

$V_{Icm}(max) \leq V_{DD} - |V_{tp}| - |V_{ov1}| - |V_{ov5}|$

$\leq 2.5 - .7 - .3 - .3 = \boxed{+1.2V}$

$V_{Icm}(min) \geq -V_{SS} + V_{ov3} + V_{tn} - |V_{tp}|$

$\geq -2.5 + 0.3 + 0.7 - 0.7 = \boxed{-2.2V}$

$-V_{SS} + V_{ov6} \leq V_O \leq V_{DD} - |V_{ov7}|$

$-2.5 + 0.3 \leq V_O \leq 2.5 - 0.3$

$\boxed{-2.2 \leq V_O \leq 2.2V}$

(9.2) $A = A_1 \cdot A_2 = G_{m1}(r_{o2} \| r_{o4})\, G_{m2}(r_{o6} \| r_{o7})$

$r_{o7} = \frac{V_{AP} = 20V/\mu m \cdot 0.8\mu m}{I_0 = 0.4m} = 40K$, $r_{o6} = \frac{25V/\mu m \cdot 0.8\mu m}{I_0 = 0.4m} = 50K\Omega$

$r_{o7} \| r_{o6} = 22.2K\Omega$

$g_{m1} = G_{m1}$ ← has 0.4m/2 current through it so

$\frac{2I_D}{V_{ov}} = g_{m1} = \frac{2\left(\frac{0.4m}{2}\right)}{V_{ov} = 0.25} = 1.6m\ A/V$

$G_{m2} = g_{m6} = \frac{2(0.4m)}{0.25} = 3.2m\ A/V$

$\therefore A_v = 1.6m \left[\underbrace{\frac{(20V/\mu m \cdot 0.8\mu)}{(0.4m/2)}}_{80K} \,\Big\|\, \underbrace{\frac{(25V/\mu m \cdot 0.8\mu m)}{(0.4m/2)}}_{100K} \right] (3.2m)(22.2K)$

$A_1 = 1.6m(44.4K) = \boxed{71.04 V/V}$

$A_2 = 3.2m(22.2K) = \boxed{71.04 V/V}$

$A_v = (71.04)(71.04) = \boxed{5047 V/V}$

#3. (cont.)

9.2

$R_o = r_{o7} \| r_{o6} = \boxed{22.2k\Omega}$

For a unity gain amplifier $\Rightarrow \beta = 1$

$$\therefore R_{of} = \frac{R_o}{(1+A\beta)} = \frac{22.2k}{(1+5047)} \cong \boxed{4.4\Omega}$$

4. Exercise 9.3

(a) $f_t = \frac{G_{m1}}{2\pi C_c} \Rightarrow 100M = \frac{1m}{2\pi C_c}$

$\therefore C_c = \boxed{1.6pF}$

$A_1 = -G_{m1} \cdot (r_{o2} \| r_{o4}) = -1m\left(\frac{100k}{2}\right) = -50$

$A_2 = -G_{m2}\,(r_{o6} \| r_{o7}) = -2m\left(\frac{40k}{2}\right) = -40$

$A_v = -50(-40) = +2{,}000\ V/V$

$f_t = |A_v| \cdot f_{p3dB} \Rightarrow f_{3dB} = \frac{100M}{2{,}000} = \boxed{50KHZ}$

(b) $R = \frac{1}{G_{m2}} = \frac{1}{2m} = \boxed{500\Omega}$

(c) $f_{p2} \approx \frac{G_{m2}}{2\pi C_2} = \frac{2m}{2\pi \cdot 1p} \cong \boxed{318\ MHz}$

$\Theta = \tan^{-1} f_t/f_p = \tan^{-1}\left(\frac{100M}{318M}\right) \cong \boxed{17.5^\circ}$

$pm = 90 - \Theta = \boxed{72.6^\circ}$