1

(a) Transistor parameters are:

$$r_\pi = \frac{\beta_o}{g_m} = 200 \times 52 = 10.4\,k\Omega$$

$$\tau_T = \frac{1}{2\pi f_T} = 318\ ps$$

$$C_\pi + C_\mu = g_m \tau_T = \frac{1}{52} \times 318 = 6.12\,pF$$

$$\therefore C_\pi = 6.1 - 0.3 = 5.8\,pF$$

$$C_M = (1 + g_m R_L) C_\mu$$

$$= \left(1 + \frac{3000}{52}\right) \times 0.3 = 17.6\,pF$$

In (7.12)

$$f_{-3dB} = \frac{1}{2\pi} \frac{5000 + 300 + 10400}{(5000 + 300) \times 10400} \frac{10^{12}}{5.8 + 17.6}$$

$$= 1.94\,MHz$$

(b) From (7.27)

$$P_2 = -\left(\frac{1}{R_L C_\mu} + \frac{1}{R C_\pi} + \frac{1}{R_L C_\pi} + \omega_T\right)$$

$$R = (R_S + r_b) \,//\, r_\pi$$

$$= 5300 \,//\, 10400 = 3511\,\Omega$$

$$\therefore P_2 = -\left(\frac{10^{12}}{3000 \times 0.3} + \frac{10^{12}}{3511 \times 5.8} + \frac{10^{12}}{3000 \times 5.8} + 2\pi \times 500 \times 10^6\right)$$

$$= -43.6 \times 10^8\ rad/sec$$

$$= -693\,MHz$$

#2

$C_\pi + C_\mu = \frac{g_m}{2\pi f_T} = \frac{1}{2\pi \times 26 \times 500 \times 10^6}$

$= 12.2\ pF$ at $I_C = 1mA$

$\therefore C_\pi = 11.8\ pF$

$r_\pi = \frac{\beta}{g_m} = 2.6\ k\Omega$, $r_o = \infty$

(a) For each circuit

$\frac{v_o}{v_i} = -\frac{r_\pi}{r_\pi + R_s} g_m R_L$

$= -\frac{2.6}{2.6+5} \frac{3000}{26} = -39.5$

(b) Common Emitter

$R_{\pi o} = r_\pi \parallel R_S = 2.6 \parallel 5 = 1.71\ k\Omega$

$R_{\mu o} = R_{\pi o} + R_L + g_m R_L R_{\pi o}$

$= 1.71 + 3 + \frac{3000}{26} \times 1.71$

$= 202\ k\Omega$

$C_\pi R_{\pi o} = 11.8 \times 1.71 = 20.2 ns$

$C_\mu R_{\mu o} = 0.4 \times 202 = 80.8\ ns$

$C_{cs} R_L = 1 \times 3 = 3\ ns$

$\therefore \Sigma T_o = 20.2 + 80.8 + 3 = 104\ ns$

$\therefore f_{-3dB} = \frac{1}{2\pi \Sigma T_o} = 1.53\ MHz$

Cascode

$C_{\pi 1} R_{\pi o1} = 20.2\ ns$

$R_{\mu o1} = R_{\pi o1} + R_{L1} + g_{m1} R_{L1} R_{\pi o1}$

$R_{L1} = \frac{1}{g_{m2}} = 26\ \Omega$

$\therefore R_{\mu o1} = 1.71 + 0.026 + \frac{1}{26} \times 26 \times 1.71$

$= 3.45\ k\Omega$

$\therefore C_{\mu 1} R_{\mu o1} = 0.4 \times 3.45 = 1.38\ ns$

$C_{cs1} R_{L1} = 1 \times 0.026 = 0.026\ ns$

$R_{\pi o2} = \frac{1}{g_{m2}} = 26\ \Omega$

$\therefore C_{\pi 2} R_{\pi o2} = 11.8 \times 0.026 = 0.31\ ns$

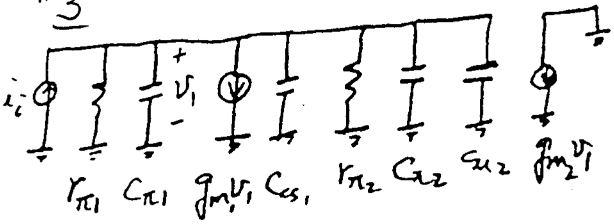
$(C_{\mu 2} + C_{cs2}) R_{L2} = 1.4 \times 3 = 4.2 ns$

$\therefore \Sigma T_o = 20.2 + 1.38 + 0.03 + 0.31$
$+ 4.2 = 26.1\ ns$

$\therefore f_{-3dB} = 6.1\ MHz$

This is 4 times higher than the common-emitter stage. because Miller effect in $Q_1$ is eliminated.

#3




$v_1 = i_i \left( r_{\pi 1} \parallel \frac{1}{g_{m1}} \parallel r_{\pi 2} \right)$

$r_{\pi 1} = \frac{\beta}{g_{m1}} = 200 \times 26 = 5.2 k\Omega$

$\frac{1}{g_{m1}} = 26\ \Omega$

$r_{\pi 2} = \frac{\beta}{g_m} = 200 \times \frac{26}{4} = 1.3 k\Omega$

$\therefore v_1 = i_i \times 25.37\ \Omega$

$i_o = g_{m2} v_1 = \frac{4}{26} v_1$

$\therefore \frac{i_o}{i_i} = \frac{4}{26} \times 25.37 = 3.90$

For $Q_1$ $C_b = \tau_F g_{m1}$
$= 0.2 \times \frac{1}{26} \times 10^{-9} = 7.7 PF$

$\therefore C_{\pi 1} = 8.7\ PF$

For $Q_2$ $C_b = 0.2 \times \frac{4}{26} \times 10^{-9} = 30.8\ pF$

$\therefore C_{\pi 2} = 34.8\ PF$

Total Shunt C

$= C_{\pi 1} + C_{cs1} + C_{\pi 2} + C_{\mu 2}$

$= 8.7 + 1 + 34.8 + 0.8 = 45.3\ pF$

$r_{\pi 1} \parallel \frac{1}{g_{m1}} \parallel r_{\pi 2} = 25.4\ \Omega$

$\therefore$ Time constant $= 45.3 \times 25.4 = 1.15 ns$

$\therefore f_{-3dB} = 138\ MHz$

4. a) $$\frac{V_a}{V_{in}} = -\frac{Z_F}{1k\Omega} = -\frac{\dfrac{200k\Omega}{1+s(200k)(500p)}}{1k\Omega}$$

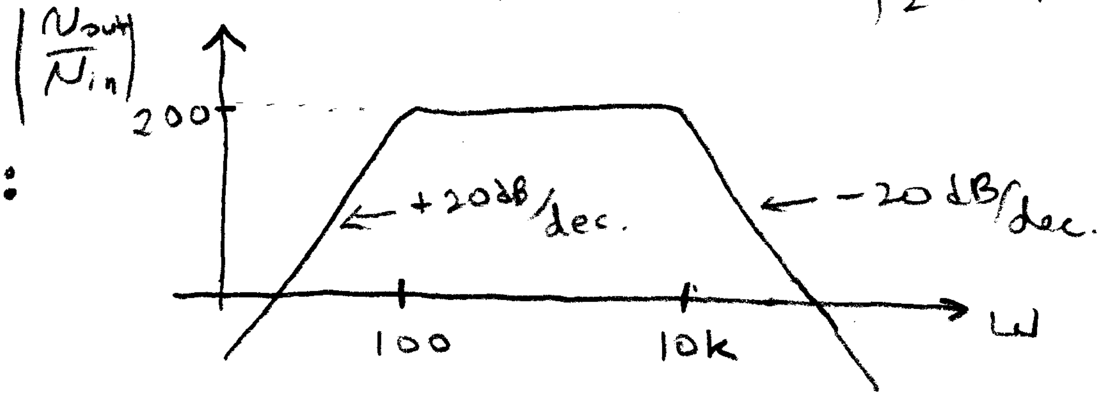
$$= -200 \cdot \frac{1}{1+\frac{s}{10k}}$$

b) $$\frac{V_{out}}{V_{IN}} = \frac{V_a}{V_{in}} \cdot \frac{10k}{10k + \frac{1}{s \cdot 1\mu}} = \frac{\frac{s}{100}}{1+\frac{s}{100}} \cdot \frac{V_a}{V_{in}}$$

$$= -200 \frac{\frac{s}{100}}{\left(1+\frac{s}{10k}\right)\left(1+\frac{s}{100}\right)}$$

$z = DC = 0 \qquad p_1 = -100 \qquad p_2 = -10k$

b) $s = j\omega$:




c) Now $1k\Omega \rightarrow Z = 1k\Omega + \frac{1}{s(25\mu)}$

$$\frac{V_a}{V_{IN}} = -\frac{\dfrac{200k}{1+s(200k)(500p)}}{1k + \dfrac{1}{s(25\mu)}} \cdot \frac{\frac{s}{100}}{1+\frac{s}{100}}$$

$$= -200 \cdot \left(\frac{1}{1+\frac{s}{10k}}\right) \cdot \left(\frac{\frac{s}{40}}{1+\frac{s}{40}}\right)\left(\frac{\frac{s}{100}}{1+\frac{s}{100}}\right)$$

two zeros @ $z = 0 \quad p_1 = -40 \quad p_2 = -100 \quad p_3 = -10k$