Test 1 – Model answer

TEST 1 (EEE 241)

1. $W_B = 10\mu m$, $I_C = 0.5mA$

E-B depletion capacitance , $C_{je} = 2pF$

$\tau_F = \frac{W_B^2}{2D_p}$

Neglect C-B capacitance, C_μ.

Diffusion coefficient of minority carrier in B of a pnp transistor is $D_p = 13cm^2/s$

$V_T = 26mV$.

Find f_T ?

Solution

$f_T = \frac{1}{2\pi} \frac{g_m}{C_\pi + C_\mu}$

$C_\pi = C_b + C_{je}$

Base charging capacitance, $C_b = \tau_F g_m$

$\tau_F = \frac{(10\mu m)^2}{2(13cm^2/s)} = \frac{(0.001cm)^2}{26cm^2/s} = 38.4615ns$ (1)

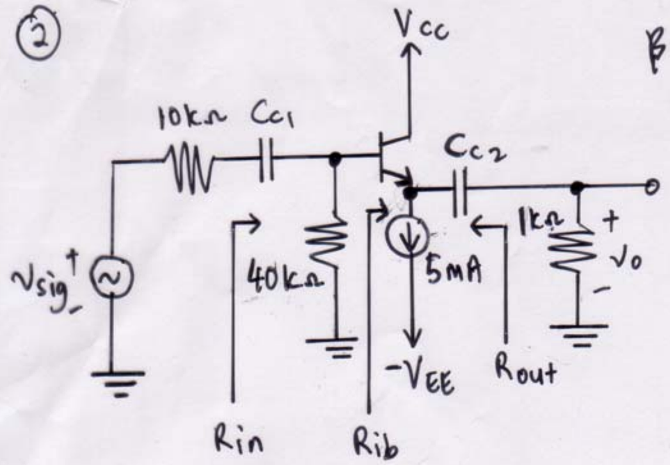
$g_m = \frac{I_C}{V_T} = \frac{0.5mA}{26mV} = 0.0192A/V$ (1)

$\therefore C_b = 38.4615ns \times 0.0192A/V \approx 0.7385nF$ (1)

$f_T = \frac{1}{2\pi} \frac{0.0192A/V}{(0.7385n + 0.002n)F} = 4.1266MHz$

(2)

(2)



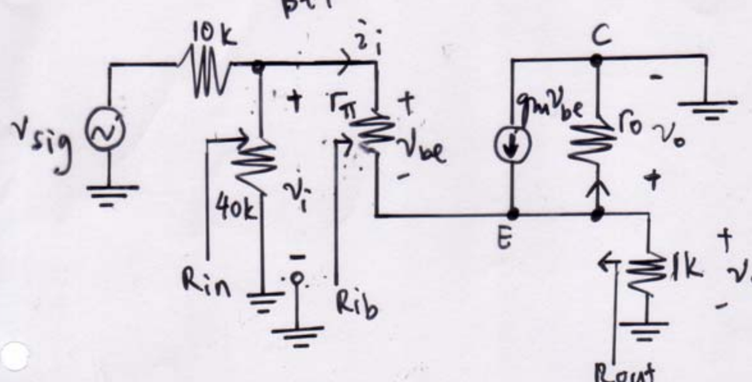
$\beta_F = \beta_o = 100$

$V_A = 100V$

$V_T = 26mV$

$I_E = 5mA$

$I_C = \alpha I_E = \frac{\beta}{\beta+1} I_E = 4.9505\ mA$ (2)



(2)

$R_{ib} = \frac{v_i}{i_i} = \frac{v_{be}+v_o}{i_i} = \frac{(v_{be}+v_o)r_\pi}{v_{be}} = r_\pi + \frac{v_o}{v_{be}} r_\pi$ (2)

KCL at node E, $g_m v_{be} + \frac{v_{be}}{r_\pi} = v_o\left(\frac{1}{r_o} + \frac{1}{1k}\right)$ (2)

$\therefore v_o = \frac{v_{be}\left(g_m + \frac{1}{r_\pi}\right)}{\frac{1}{r_o} + \frac{1}{1k}}$ (1) $g_m = \frac{I_C}{V_T} = \frac{4.9505mA}{26mV}$

$\therefore g_m = 0.1904\ A/V$

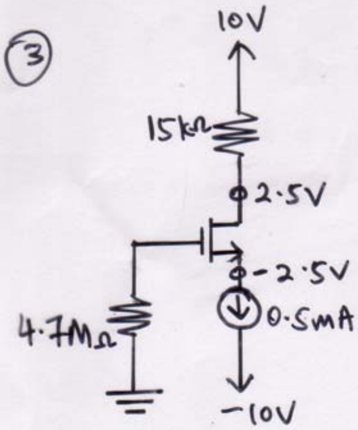
$\therefore R_{ib} = r_\pi + \frac{\left(g_m + \frac{1}{r_\pi}\right) r_\pi}{\frac{1}{r_o} + \frac{1}{1k}} = 96.7615\ k\Omega$ # (2)

(1) $r_o = \frac{V_A}{I_C} = \frac{100V}{4.9505mA} = 20.2k\Omega$

$R_{in} = 40k \,//\, R_{ib} = 28.3008\ k\Omega$ # (2)

(1) $r_\pi = \beta_o / g_m = 525.21\ \Omega$

(3)



Given: $V_t = 1.5V$

$I_D = 0.5mA$

$I_D = \frac{\mu_n C_{ox}}{2} \frac{W}{L} (V_{ov})^2 (1+\lambda V_{DS})$ (1)

$0.5m = \frac{1m}{2} (V_{ov})^2 (1+\lambda V_{DS})$

$\lambda = \frac{1}{75}$ since $V_A = 75V$

$V_{DS} = V_D - V_S = 2.5 + 2.5 = 5V$ (1)

$\therefore V_{ov} = \sqrt{\frac{0.5m \times 2}{1m\left[1+\frac{1}{75}(5)\right]}}$

$= \sqrt{\frac{1}{1.0667}}$

$=$ ~~0.9375~~ 0.9682 V # (1)

$V_{ov} = V_{GS} - V_t$

$V_{GS} = V_{ov} + V_t =$ ~~0.9375~~ 0.9682 V + 1.5V = 2.4~~375~~682 V # (2)

$V_{GS} = V_G - V_S$

$V_S = -2.5$ # (1)

$\therefore V_G = V_{GS} + V_S =$ ~~2.4375~~ 2.4682 − 2.5 = −0.0~~625~~318 V # (2)

$V_D = 2.5V$ # (1)

$g_m = \mu C_{ox} \frac{W}{L} V_{ov}(1+\lambda V_{DS}) = 1m($~~0.9375~~ 0.9682$)(1+\frac{5}{75}) = 1mS$ $= 1.033mS$ # (2)

$r_o = \frac{1}{\lambda I_D} = \frac{75}{0.5m} = 150k\Omega$ # (1)