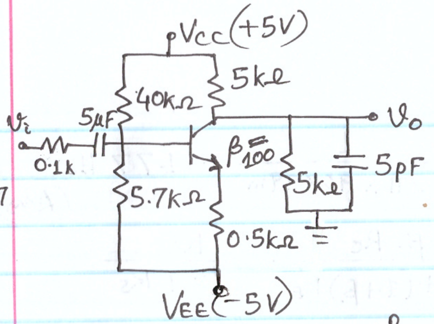
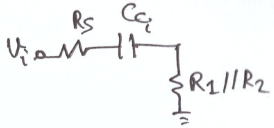
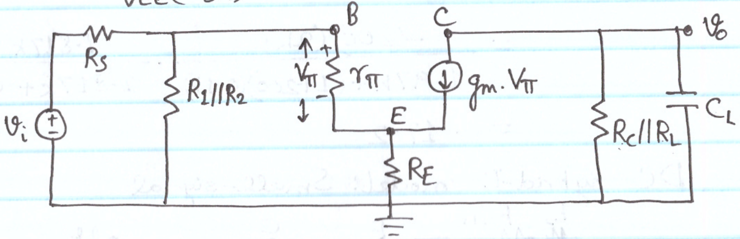
15.
Ex7.7





Find: I_C, hybrid-π model parameters, f_{BW} & corner frequencies.

Solⁿ.



$$R_{TH} = \frac{R_1 R_2}{R_1+R_2} = \frac{40k \cdot 5.7k}{40k+5.7k} = 5k\Omega$$

$$V_{TH} = \frac{R_2}{R_1+R_2} \cdot [V_{CC} - V_{EE}] = \frac{5.7k}{40k+5.7k} \cdot 10 = -3.752V$$

$$I_{Bq} = \frac{V_{TH} - V_{BEon} - V_{EE}}{R_{TH} + (1+\beta) R_E} = \frac{-3.752 - 0.7 + 5}{5k + (1+100) \cdot 0.5k}$$

$$= 9.86\ \mu A$$

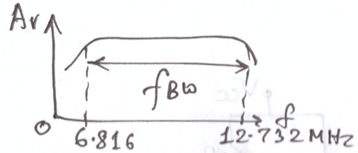
$$I_{cq} = \beta \cdot I_{Bq} = 100 \times 9.86\mu = 986\ \mu A \quad \text{(Ans)}$$

$$g_m = \frac{I_{cq}}{V_T} = \frac{986\mu}{0.026} = 37.925\ mA/V \quad \text{(Ans)}$$

$$r_\pi = \frac{\beta \cdot V_T}{I_{cq}} = \frac{100 \times 0.026}{986\mu} = 2.637k\Omega \quad \text{(Ans)}$$

$$\tau_L = (R_C // R_L)\, C_L = \frac{5k \cdot 5k}{5k+5k} \cdot 5pF = 12.5\ ns$$

$$R_i = r_\pi + (1+\beta) R_E = 2.637k + (1+100) 0.5k$$
$$= 53.137\ k\Omega$$



$$\tau_S = (R_i // R_{TH} + R_S)\, C_C = \left(\frac{53.137k \cdot 5k}{53.137k + 5k} + 0.1k\right) \cdot 5\mu$$

$$= 23.349\ ms$$

$$\therefore f_L = \frac{1}{2\pi \tau_S} = \frac{1}{2\pi \times 23.349m} = 6.816\ Hz \quad \text{(Ans)}$$

$$\therefore f_H = \frac{1}{2\pi \tau_L} = \frac{1}{2\pi \times 12.5n} = 12.732\ MHz \quad \text{(Ans)}$$

$$f_{bandwidth} = f_H - f_L \cong 12.732\ MHz \quad \text{(Ans)}$$

Ckt. BW

16. (Ex7.9) A BJT has $\beta_o = 150$, $C_\pi = 2pF$, $C_\mu = 0.3pF$, $I_{cq} = 0.5mA$, find f_β (bandwidth) & f_T (gain-bandwidth product).

Solⁿ. $$r_\pi = \frac{\beta_o \cdot V_T}{I_{cq}} = \frac{150 \times 0.026}{0.5m} = 7.8k\Omega$$

$$f_\beta = \frac{1}{2\pi r_\pi (C_\pi + C_\mu)} = \frac{1}{2\pi \times 7.8k(2p + 0.3p)}$$

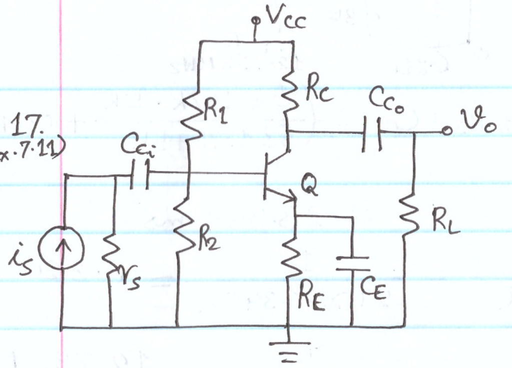
BJT's BW

$$= 8.87\ MHz \quad \text{(Ans)}$$

$$g_m = \frac{I_{cq}}{V_T} = \frac{0.5m}{0.026} = 19.23\ mA/V$$

$$f_T = \frac{g_m}{2\pi (C_\pi + C_\mu)} = \frac{19.23m}{2\pi (2p + 0.3p)} = 1.330\ GHz \quad \text{(Ans)}$$

17. (Ex. 7.11)

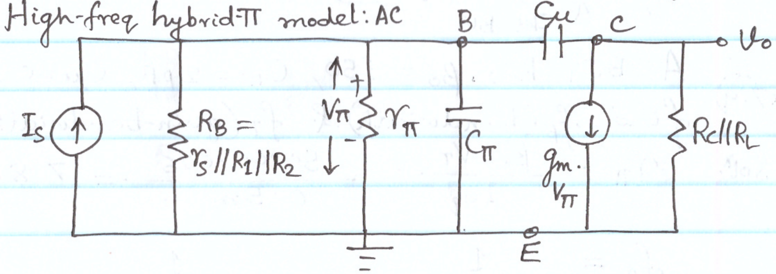


Draw the high-freq hybrid-π ckt.

$R_1 = 200k\Omega$, $R_2 = 220k\Omega$, $R_C = 2.2k\Omega$, $R_E = 1k\Omega$, $r_s = 100k\Omega$, $R_L = 4.7k\Omega$, $V_{CC} = 5V$, $\beta_o = 100$, $V_{BEon} = 0.7V$, $V_A = \infty$, $C_\mu = 2pF$, $C_\pi = 10pF$.

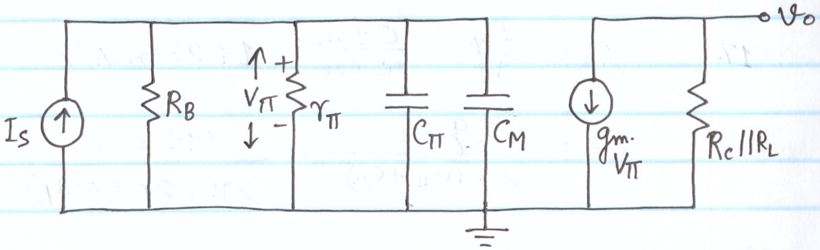
Find: C_M & f_{3db}.

Sol^n. High-freq hybrid-π model: AC



(Note: R_E & C_E are shorted/ignored at high freq.)

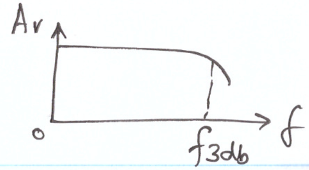
Modified hybrid-π model with C_M (Miller cap.): AC



$$R_{TH} = R_1 // R_2 = 200k // 220k = 104.8\,k\Omega$$

$$V_{TH} = \frac{R_2}{R_1 + R_2} V_{CC} = \frac{220k}{200k + 220k} \cdot 5 = 2.619V$$

$$I_{Bq} = \frac{V_{TH} - V_{BEon}}{R_{TH} + (1+\beta) R_E}$$



$$I_{cq} = \beta \cdot I_{Bq} =$$

$$g_m = \frac{I_{cq}}{V_T} =$$

$$r_\pi = \frac{\beta \cdot V_T}{I_{cq}} =$$

$$C_M = C_\mu [1 + g_m (R_C // R_L)]$$
$$=$$ (Ans)

$$R_B = r_s // R_1 // R_2 =$$

$$f_{3db} = \frac{1}{2\pi (R_B // r_\pi)(C_\pi + C_\mu)}$$

Ckt. BW at high freq. $=$ (Ans)

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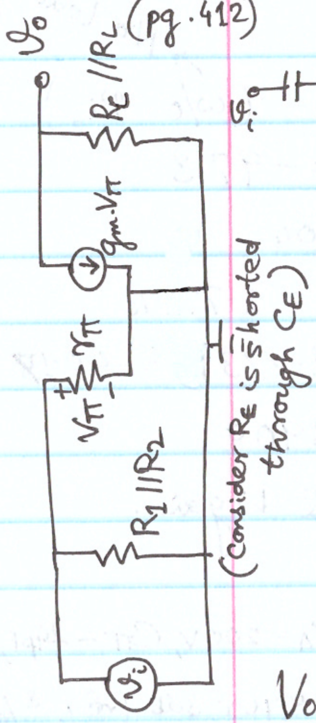

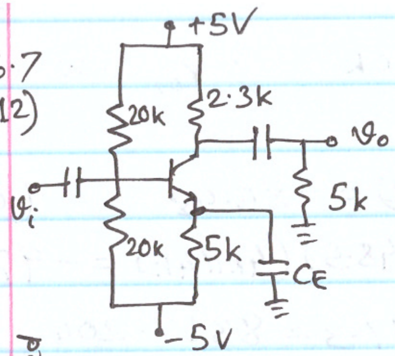

$\beta = 125$, $V_{BEon} = 0.7V$, $V_A = 200V$, Find A_v & R_o

$R_{TH} = R_1 // R_2 = 10k\Omega$

$$I_{Bq} = \frac{0 - 0.7 - (-5)}{10 + (126 \times 5)} = 6.72\,\mu A$$

$$I_{cq} = 125 \times 6.72\,\mu A = 0.84\,mA$$

$$r_\pi = \frac{\beta \cdot V_T}{I_{cq}} = \frac{125 \times 26\,mV}{0.84\,mA} = 3.87\,k\Omega$$

$$g_m = \frac{I_{cq}}{V_T} = \frac{0.84m}{0.026} = 32.3\,mA/V$$

$$r_o = \frac{V_A}{I_{cq}} = \frac{200}{0.84m} = 238\,k\Omega$$

$V_o = -g_m \cdot V_\pi (r_o // R_c // R_L)$ & $V_\pi = V_i$

$$\therefore A_v = \frac{V_o}{V_i} = -g_m (r_o // R_c // R_L) = -(32.3)(238k // 2.3k // 5k)$$
$$= -50.5 \quad \text{(Ans)}$$

$R_o = r_o // R_c = 238k // 2.3k = 2.28\,k\Omega$ (Ans)

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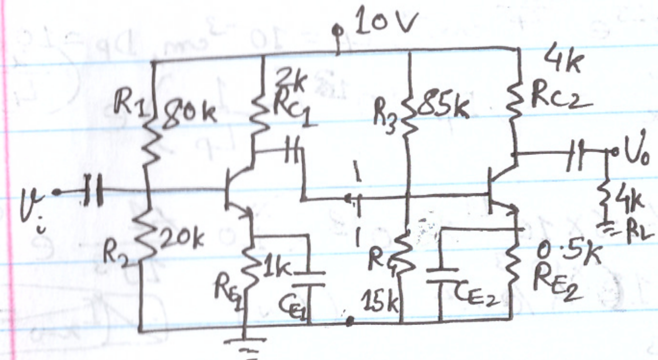

$\beta = 100$, $V_A = \infty$, Find Av. while considering loading

$V_{TH1} = (80k \,||\, 20k)\frac{V_{cc}}{} = 16k \times 10 = 2V$

$I_{B1} = \frac{2 - 0.7}{16 + (101)(1k)} = 0.0111\ mA$

$I_{C1} = 100 \times 0.0111m = 1.11\ mA$

$g_{m1} = \frac{I_{cq}}{V_T} = \frac{1.111m}{26m} = 42.74\ mA/V$

$r_{\pi_1} = \frac{\beta \cdot V_T}{I_{cq}} = \frac{100 \times 26m}{1.11m} = 2.34k$

$r_{o1} = \frac{V_A}{I_{cq}} = \frac{\infty}{1.11m} = \infty$

$V_{TH2} = (85k \,||\, 15k)\ \cancel{V}_{cc} = 1.5V$

$R_{TH2} = R_3 \,||\, R_4 = 12.75k.$

$I_{B2} = \frac{1.5 - 0.7}{12.75k + \underbrace{(101)(0.5)}_{(1+\beta)R_E}}$; $I_{C2} = 1.265mA$; $g_{m2} = \frac{1.265m}{0.026} = 48.65mA/V$

$r_{\pi_2} = \frac{100 \times (0.026)}{1.265m} = 2.06k$; $r_{o2} = \infty$

$A_{v1} = -g_{m1} R_{C1} = -(42.7)(2) = -85.48$ (w/o Ri_2) No loading

$A_{v2} = -g_{m2}(R_{C2} \,||\, R_L) = -(48.5)(4k \,||\, 4k) = -97.3$

$A_v = A_{v1} \cdot A_{v2} = 85.48 \times 97.3 = 8317.204$

$Ri_2 = R_3 \,||\, R_4 \,||\, r_{\pi 2} = 15k \,||\, 85k \,||\, 2.06k = 1.773k$

$A_{v1}' = -g_m (R_{C1} \,||\, Ri_2) = -(42.7)(2k \,||\, 1.773k) = -40.17$

$\therefore\ A_v' = A_{v1}' \cdot A_{v2} = 40.17 \times 97.3 = 3909$

$\therefore$ Loading of stage 2 reduces overall V-gain.