

6. A CE amplifier with transistor parameters $\beta = 100$, $V_{BE} = 0.7V$ is shown in figure 3 [10]

- Calculate the DC parameters I_{BQ} and I_{CQ}
- Calculate the hybrid π model parameters r_π and gm
- Calculate the lower cut-off frequency due to C_{C1} , C_{C2} , and C_E
- Calculate the overall lower cut-off frequency of the circuit
- Calculate the mid-band voltage gain in dB
- Plot the frequency response of the circuit

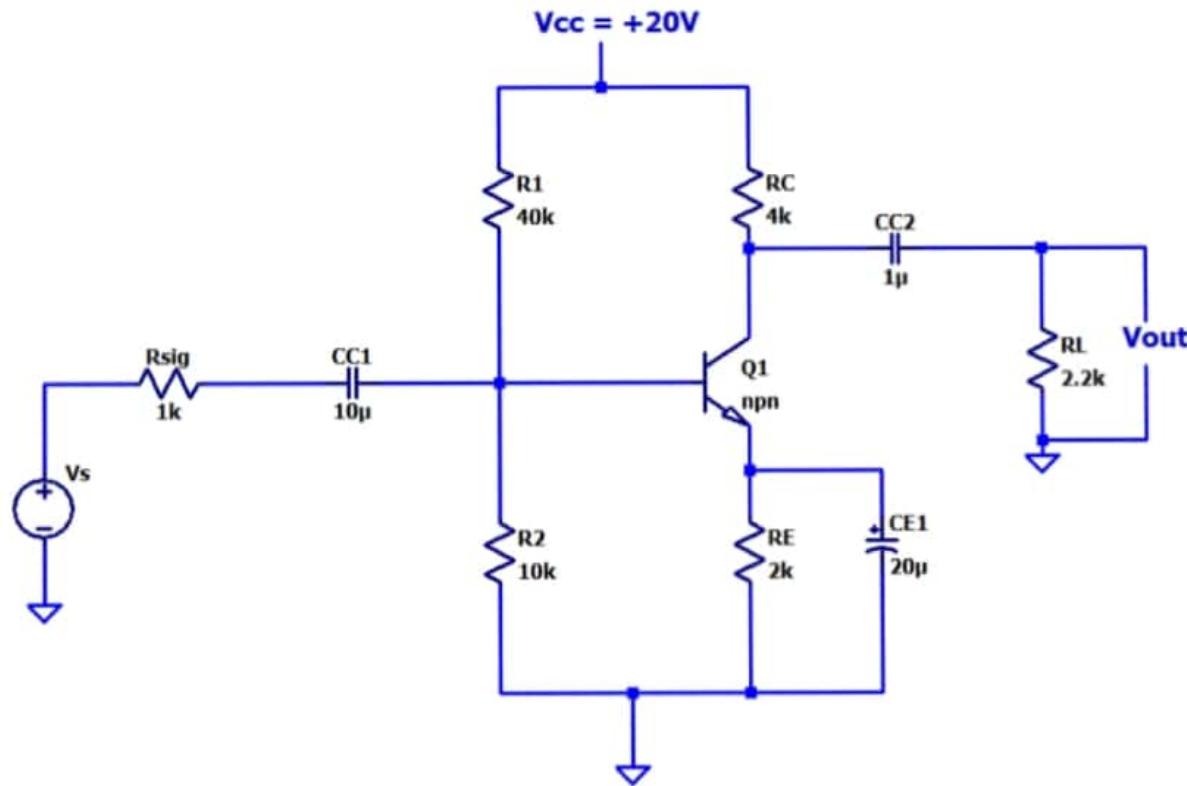
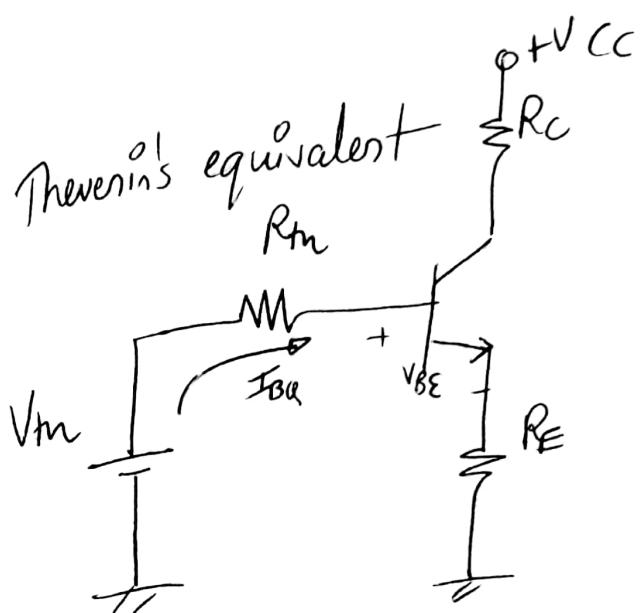
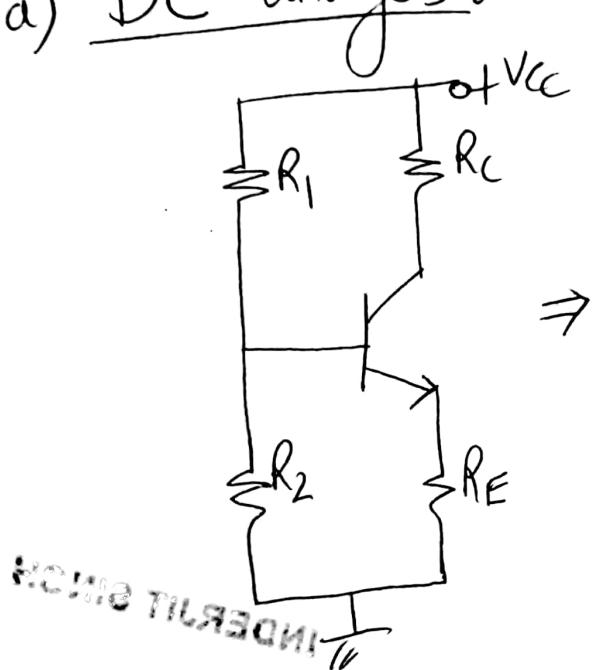


Figure 3: Question 6

Sol: - find:- f_{LCC_1} , f_{LCC_2} , f_{LCE}

a) DC analysis :-



$$V_{th} = \frac{R_2}{R_1 + R_2} \times V_{cc} = 4V$$

$$R_m = R_1 || R_2 = 8k\Omega \quad V_{BE} = 0.7V$$

$$I_{BQ} = \frac{V_{th} - V_{BE}}{R_{th} + (1+\beta)R_E} = \frac{(4+0.7)V}{8k + 101 \times 2k\Omega}$$

$$I_{BQ} = 15.71 \mu A$$

$$I_{CQ} = \beta I_{BQ} = 1.571 mA$$

Small slg parameters

$$\gamma_{II} = \frac{\beta V_T}{I_{CQ}} = \frac{100 \times 26mV}{1.571mA} = 1.655 k\Omega$$

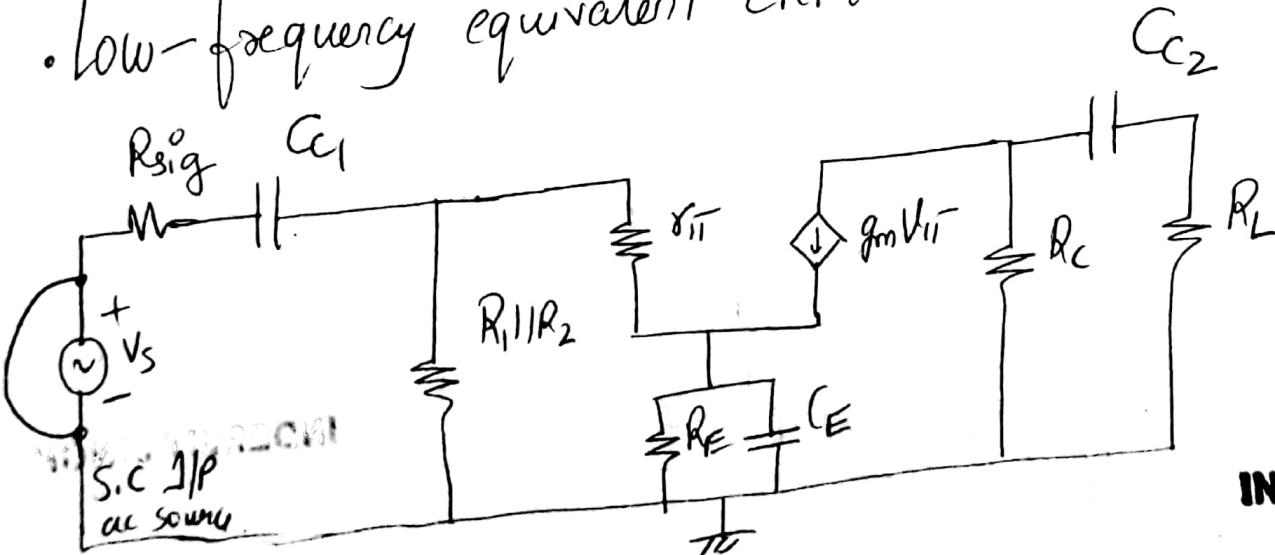
$$g_m = \frac{I_{CQ}}{V_T} = 60.42 \frac{mA}{V}$$

$$V_T = 26mV$$

$$\gamma_0 = \frac{VA}{I_{CQ}}$$

Not given so assume
 $\gamma_0 = \infty$

Low-frequency equivalent ckt:-



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$$f_{L_{C_1}} = \frac{1}{2\pi (R_{\text{sig}} + R_i) C_1}$$

$$C_1 = 10\mu F ; R_{\text{sig}} = 1k\Omega$$

$$R_i^o = R_1 || R_2 || \gamma_{II} = (40k || 10k) || 1.655k = 8k || 1.655k$$

$$R_i^o = 1.37k\Omega$$

$$f_{L_{C_1}} = \frac{1}{2\pi (1.37k + 1k\Omega) 10\mu F} = 6.71 \text{ Hz}$$

$$f_{L_{C_2}} = \frac{1}{2\pi (R_o + R_L) C_2}$$

$$R_o = R_c = 4k\Omega ; C_2 = 1\mu F , R_L = 2.2k\Omega$$

$$f_{L_{C_2}} = \frac{1}{2\pi (4k\Omega + 2.2k\Omega) 1\mu F} = 25.67 \text{ Hz}$$

$$f_{L_{CE}} = \frac{1}{2\pi R_{\text{eq}} C_E} ; C_E = 20\mu F$$

$$\text{Req } R_{\text{eq}} = R_E \parallel \left(\frac{R_{\text{sig}} || R_1 || R_2 + \gamma_{II}}{\beta} \right)$$

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$$R_{eq} = 2K\Omega \parallel \left(\frac{1K\Omega || 8K\Omega + 1.655K\Omega}{100} \right)$$

$$= 2K\Omega \parallel \left(\frac{888.88 + 1.655K\Omega}{100} \right)$$

$$= 2K\Omega \parallel 25.438$$

$$R_{eq} = 25.118 \Omega$$

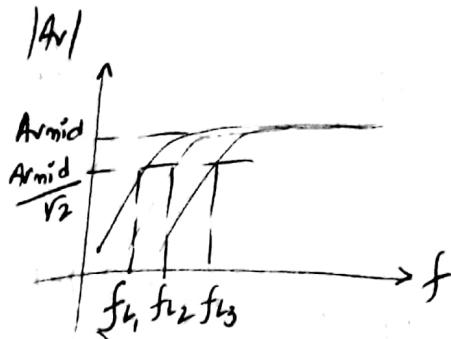
$$f_{LCE} = \frac{1}{2\pi \times (25.118) \times 20\mu F} = \underline{316.81 \text{ Hz}}$$

Since, $f_{LCE} = \underline{316.81 \text{ Hz}}$ is the largest among f_{LC_1} & f_{LC_2} , it is the lower-cut-off frequency of the amplifier. (Bypass capacitor C_E is determining the lower-cut-off freqn of the amp)

$f_L = 316.81 \text{ Hz}$

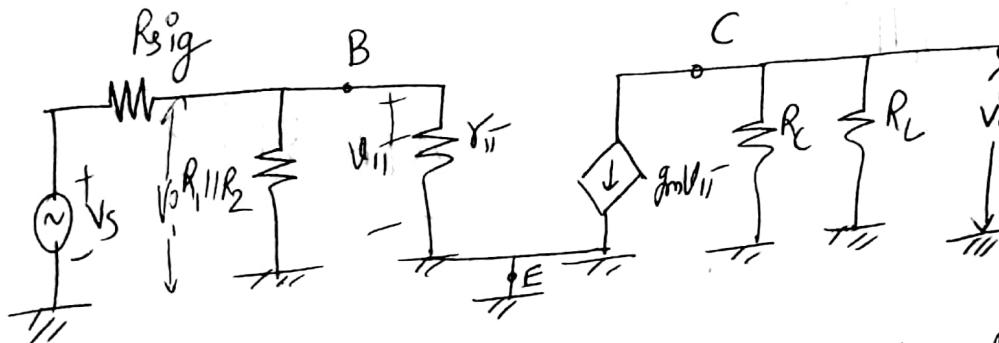
Frequency Response:-

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$A_{V_{mid}}$ (Mid-band gain):-

Consider (mid-freq) AC equivalent ckt :-



$$\frac{V_o}{V_i} = \frac{-g_m V_{ii} (R_C || R_L)}{V_{ii}} ; \quad V_i = V_{ii}$$

$$\frac{V_o}{V_i} = -g_m (R_C || R_L)$$

$$A_{V_{mid}} = -60.42 \text{ mA} (4K || 2.2K) = -60.42 \text{ mA} (1.42 \text{ mK})$$

$$A_{V_{mid}} = -85.75 \quad \text{--- voltage gain w/o considering source resistance}$$

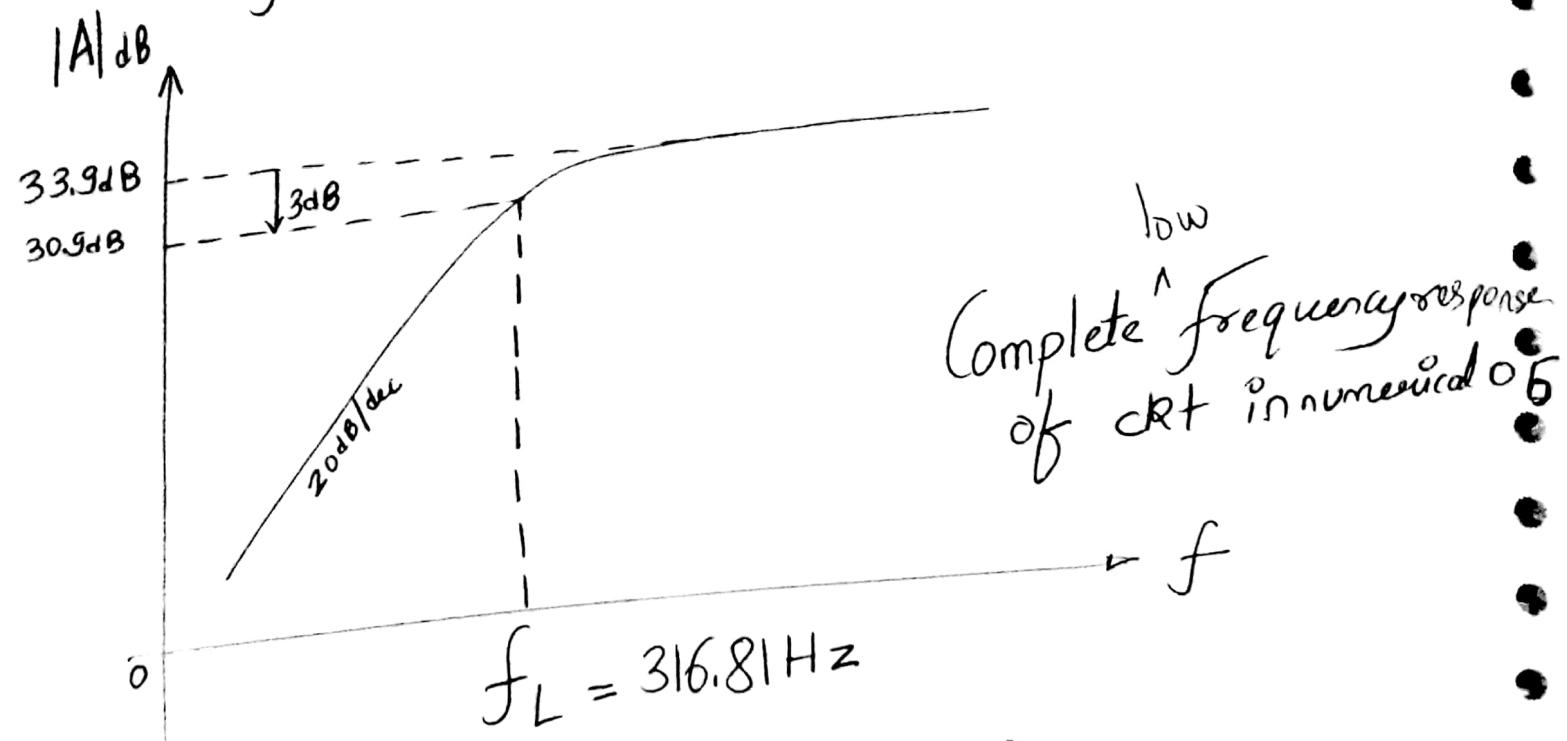
$$\text{Av}_{mid \text{ with } R_{sig}} \Rightarrow \frac{V_o}{V_s} = \frac{V_o}{V_i} \times \frac{V_i}{V_s} \\ = -85.75 \times 0.88$$

$$\Rightarrow V_i = \frac{1.37 \text{ K } R_{sig}}{R_1 || R_2 || Y_{ii}} V_s$$

$$\frac{V_i}{V_s} = \frac{8 \text{ K } || Y_{ii}}{1.37 \text{ K } || 8 \text{ K } + 1 \text{ K }} = 0.8$$

$$A_{V_{mid \text{ with } R_{sig}}} = -78.46 = -49.56 \quad \text{--- voltage of ampl with source resistance } R_{sig}$$

$$|A_{V_{mid}}|_{\text{big}} = 20 \log_{10} (49.56) = \underline{\underline{33.9 \text{ dB}}}$$



Answers: $I_{BQ} = 15.7\mu A$ $I_{CQ} = 1.57mA$ $r_\pi = 1.65k\Omega$ $g_m = 60.4mA/V$
 $f_{LCC1} = 6.71Hz$ $f_{LCC2} = 25.67Hz$ $f_{LCE} = 316.8Hz$ $f_L = 316.8Hz$
 $A_{VMID} = 33.9dB$