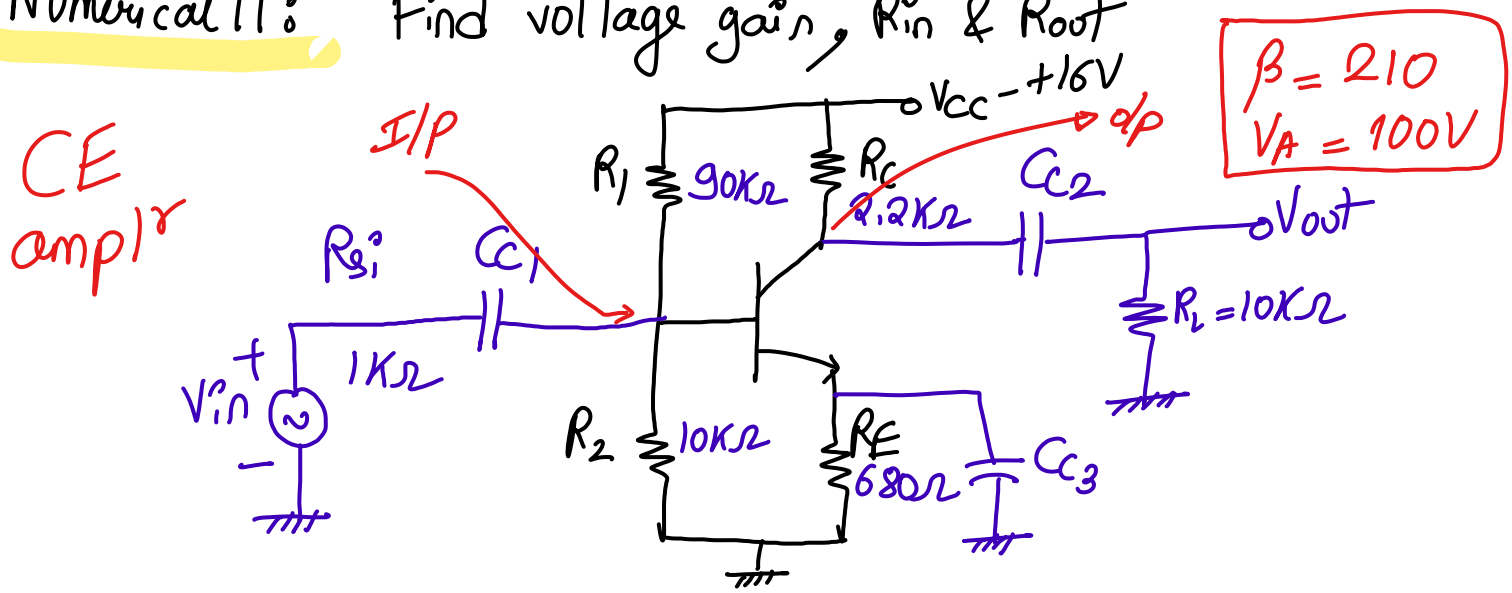
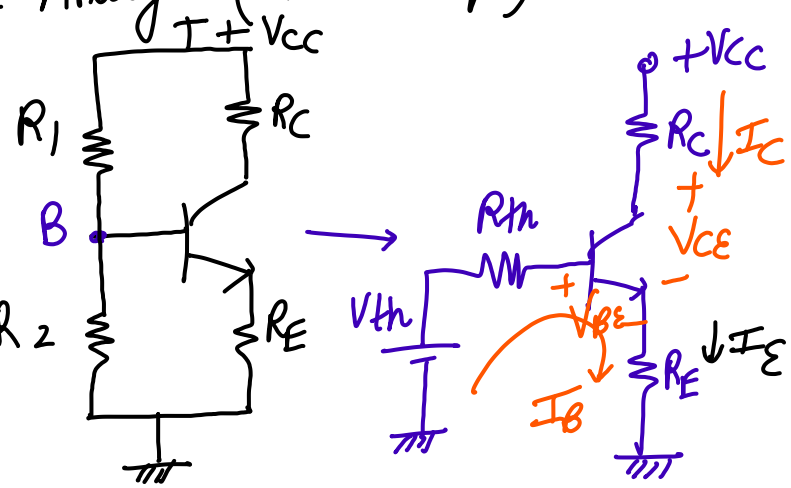
AEC lec 11 10/8/23

Numerical 11: Find voltage gain, R_{in} & R_{out}



Solution:

(1) DC Analysis (o.c all caps) → AIM → I_{CQ} 3



g_m r_π r_o 2m

↓

AC analysis

A_v R_{in} R_{out} 5m

$I_E = (1+\beta) I_B$

$V_{BE} = 0.7V$ (assume)

- KVL to i/p loop (B-E),

$$V_{th} - I_B R_{th} - V_{BE} - (1+\beta) I_B R_E = 0$$

$$I_{BQ} = \frac{V_{th} - V_{BE}}{R_{th} + (1+\beta) R_E}$$

$$V_{th} = \frac{R_2}{R_1 + R_2} V_{CC} = \left(\frac{10}{90+10}\right) \times 16 = \underline{1.6\,V}$$

$$R_{th} = R_1 \| R_2 = 90K \| 10K = \underline{9K\Omega}$$

$$I_{BQ} = \frac{1.6 - 0.7}{9K + 211 \times 680}$$

$$I_{BQ} = \underline{5.9}\ \mu A$$

$$I_{CQ} = \beta I_{BQ} = 210 \times 5.9\mu A = 1.239\ mA$$

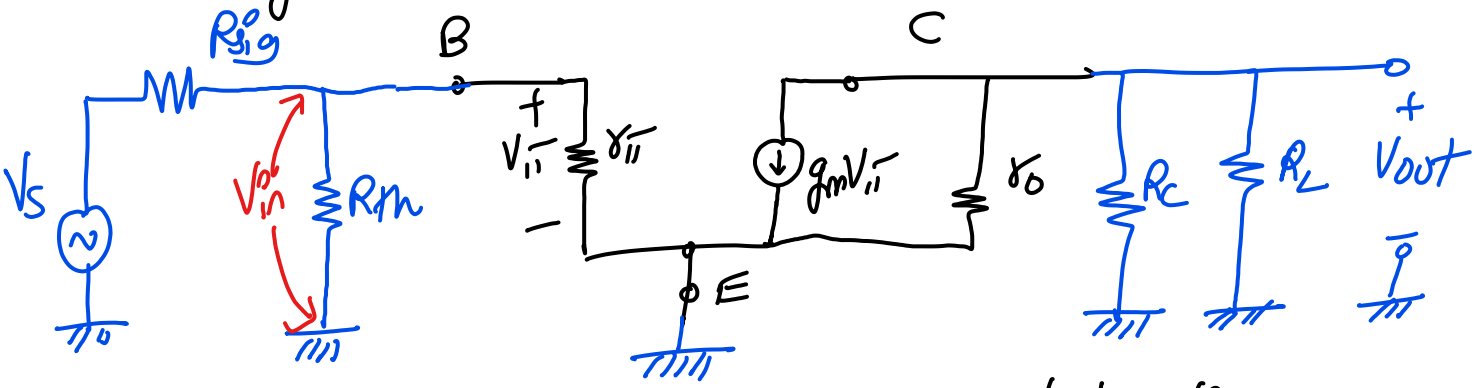
b) Small-signal parameters:- $V_T = 26mV$

$$g_m = \frac{I_{CQ}}{V_T} = \frac{1.239 \times 10^{-3}}{26 \times 10^{-3}} = 47.67\ \frac{mA}{V}$$

$$r_\pi = \frac{\beta}{g_m} = \frac{210}{47.67 \times 10^{-3}} = 4.4K\Omega$$

$$r_o = \frac{V_A}{I_{CQ}} = \frac{100}{1.239 \times 10^{-3}} = 80.68K\Omega$$

c) AC analysis:



a) Voltage gain (A_{VT}): $A_{VT} = \frac{V_{out}}{V_s} = \frac{V_{out}}{V_{in}} \frac{V_{in}}{V_s}$

$$\frac{V_{out}}{V_{in}} = -g_m(r_o \| R_C \| R_L)$$

$$\frac{V_{in}}{V_s} = \left(\frac{R_{th} \| r_\pi}{R_{th} \| r_\pi + R_{sig}}\right)$$

$R_{th} = R_1 \| R_2$

b) Input resistance 'R_{in}': $R_{in} = (R_1 \| R_2 \| r_\pi) + R_{sig}$

$9K\Omega$ $4.4K\Omega$ $1K\Omega$

$$R_{in} = 2.95K\Omega + 1K\Omega = 3.95K\Omega$$

c) Output resistance 'R_{out}': $R_{out} = (r_o \| R_C \| R_L)$

$80.68K$ $2.2K$ $10K\Omega$

$R_{out} = 1.76K\Omega$

4) $\frac{V_{out}}{V_{in}} = -g_m(r_o \| R_C \| R_L) = -47.67\times10^{-3} \times 1.76\times10^{3}$

($r_o \| R_C \| R_L$ = 1.76KΩ)

$$\frac{V_{out}}{V_{in}} = -83.8$$

$$\frac{V_{in}}{V_s} = \frac{R_{th} \| r_\pi}{R_{th} \| r_\pi + R_{sig}} = \frac{2.95K}{2.95K\Omega + 1K\Omega} = 0.746$$

$$A_V = \frac{V_{out}}{V_{in}} \times \frac{V_{in}}{V_s} = -83.89 \times 0.746$$

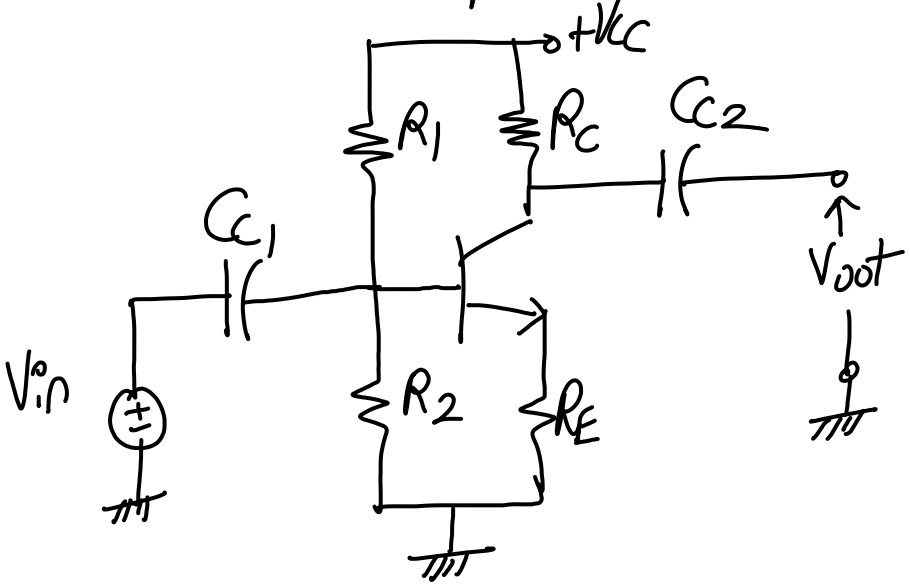
$$A_{V_T} = -62.65$$

→ I/p & o/p are out of phase

2] Degenerated CE amplifier:

(CE amplr with R_E unbypassed)

$r_o = \infty$



$A_V = -g_m(R_C)$

No R_L, No r_o

$$A_V = \frac{V_{out}}{V_{in}} \approx -\frac{R_C}{\frac{1}{g_m} + R_E}$$

(Av have reduced but more stable)

$R_{in} = R_1 \| R_2 \| [r_\pi + (1+\beta) R_E]$ (R_{in} ↑sed)

$R_{out} = R_C$ (R_{out} remains same)

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24, 25, 44, 58, 8, 3, 55, 45,
75, 72, 85, 78, 100, 80, 64, 54

Attendance: AEC lec 11 @ 10/8/23