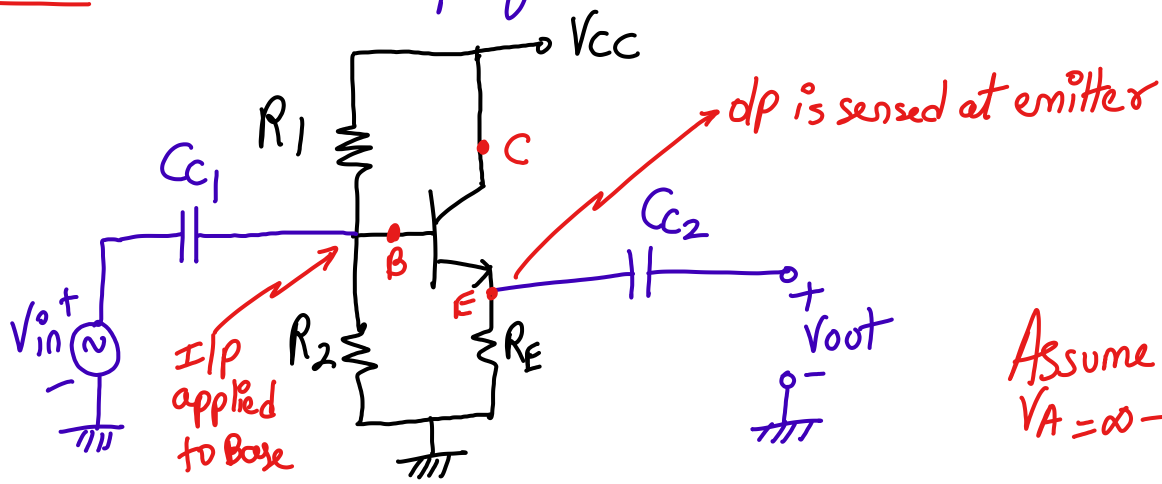
AEC lec 13 16/8/23

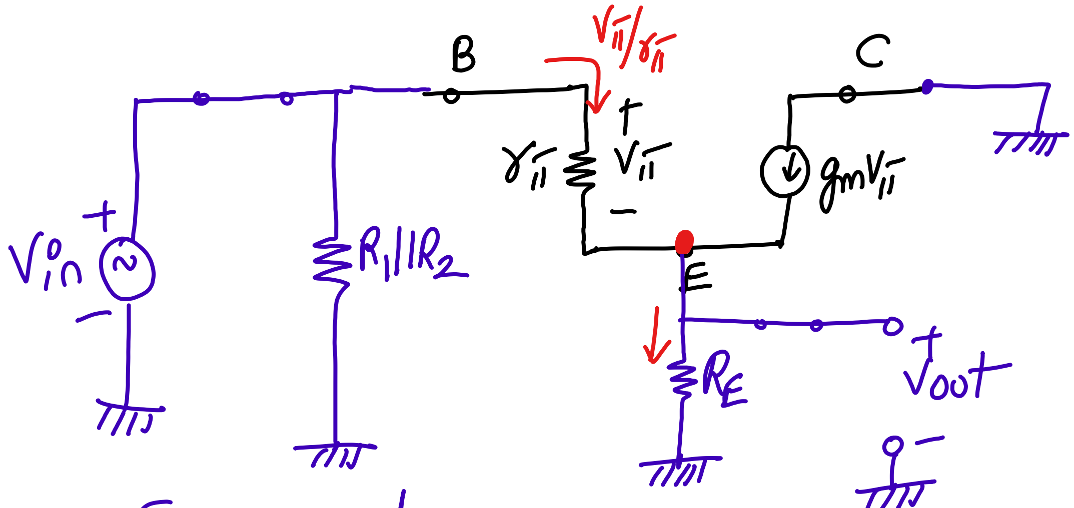
Module 1.3 : Hybrid-π model, 1) CE ampl^r (A_v, R_{in}, R_{out})
2) CE ampl^r w/o C_E (—||—)
3) —||— Numerical: A_v, R_{in}, R_{out}
4) CB ampl^r (A_v, R_{in}, R_{out}), Numerical

Common collector amplifier:



Assume
$V_A = \infty \rightarrow r_o = \infty$

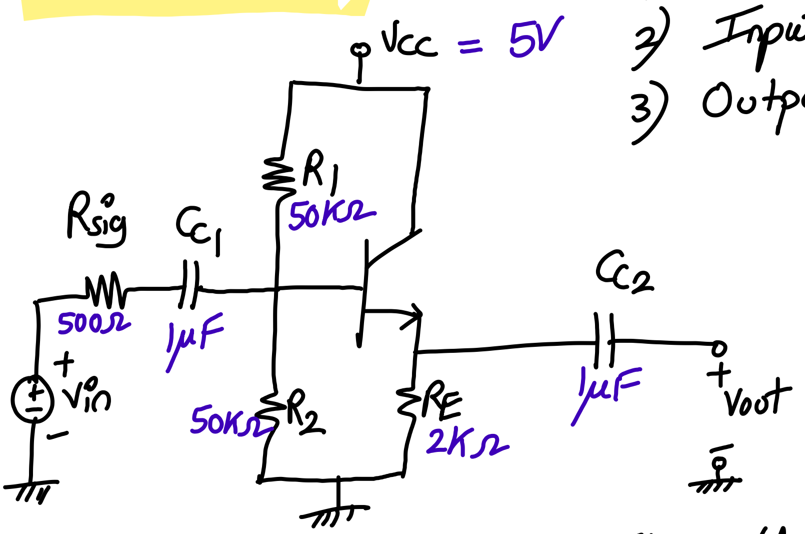
A_v ✓
R_{in} ✓
R_{out} ✓



Small-signal equivalent ckt for CC ampl^r

For Av, Rin and Rout derivations are given in AEC Lec 13 markings.pdf

Numerical 14: Determine 1) Small-slg voltage gain
2) Input resistance
3) Output resistance



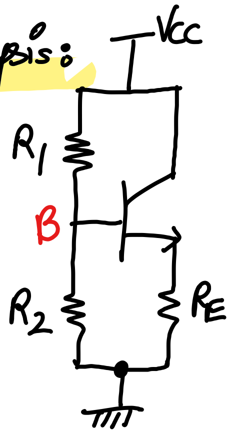
$\beta = 100$

$V_A = 80V$

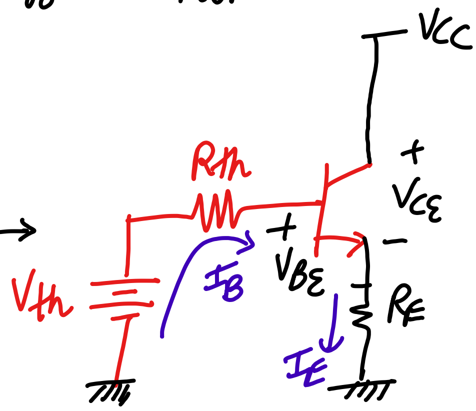
$V_{BE(on)} = 0.7V$

Solution: ① $I_{CQ} \longrightarrow$ ② r_π, g_m, r_o $\longrightarrow$ ③ A_v, R_{in}, R_{out}

② DC analysis:



$\longrightarrow$



$$V_{th} = \frac{R_2}{R_1+R_2} V_{CC} = \underline{2.5V}$$

$$R_{th} = R_1 \| R_2 = \underline{25K\Omega}$$

Apply KVL to B-E loop, $V_{th} - I_B R_{th} - V_{BE} - (1+\beta) I_B R_E = 0$

$$I_{BQ} = \frac{\overset{2.5V}{V_{th}} - \overset{0.7V}{V_{BE}}}{\underset{25K}{R_{th}} + \underbrace{(1+\beta)}_{101} \underset{2K}{R_E}} = 7.93\mu A$$

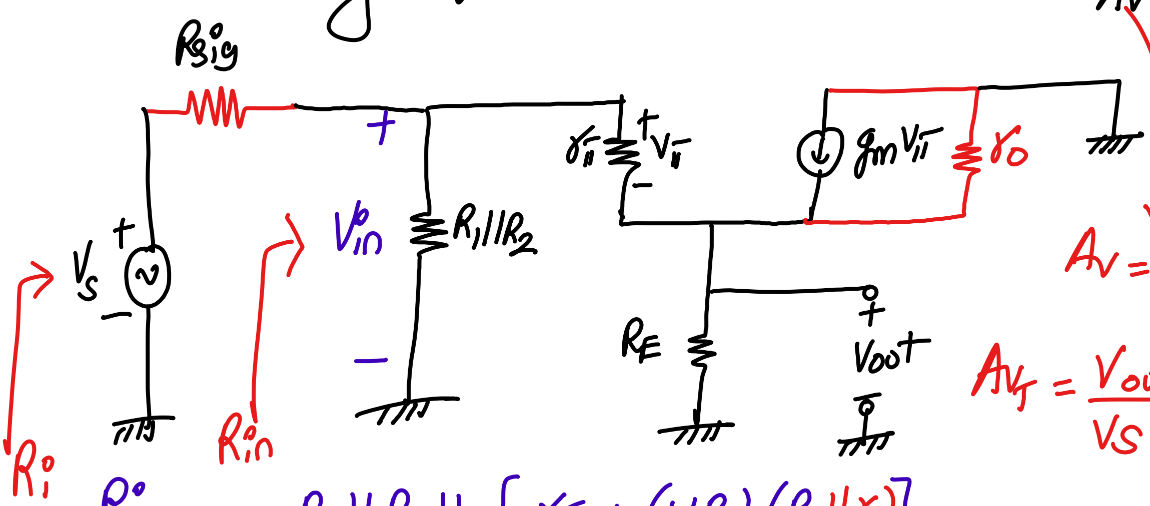
$$I_{CQ} = \beta I_{BQ} = 100 \times 7.93\mu A = 0.793mA$$

② $$g_m = \frac{I_{CQ}}{V_T} = \frac{0.793\times10^{-3}}{26\times10^{-3}} = \underline{30.5 \frac{mA}{V}} \qquad V_T = 26mV$$

$$r_\pi = \frac{\beta}{g_m} = \frac{100\times10^3}{30.5} = \underline{3.279K\Omega}$$

$$r_o = \frac{V_A}{I_{CQ}} = \frac{80}{0.793\times10^{-3}} = \underline{100.88K\Omega}$$

③ Small-sig equivalent ckt:



$$A_V = \frac{(R_E \| r_o)}{\frac{1}{g_m} + (R_E \| r_o)}$$

$$A_V = \frac{V_{out}}{V_{in}}$$

$$A_{V_T} = \frac{V_{out}}{V_S} = \frac{V_{out}}{V_{in}} \frac{V_{in}}{V_S}$$

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

$$r_o \| R_E = 100.88K \| 2K = 1.96K\Omega$$

$$r_\pi + (1+\beta)(r_o \| R_E) = 201.24K\Omega$$

$$R_1 \| R_2 \| 201.24K\Omega = 25K\Omega \| 201.24K = \underline{22.24K\Omega} \ (R_{in})$$

$$R_i = R_{sig} + R_{in} = 500\Omega + 22.24K\Omega = \underline{22.74K\Omega}$$

$$R_{out} = \frac{1}{g_m} \| R_E \| r_o \qquad \frac{1}{g_m} = \frac{1}{30.5 \times 10^{-3}} = 32.78$$

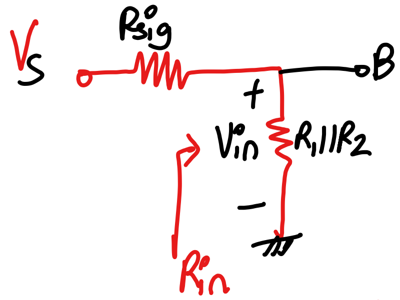
$$R_{out} = 32.78 \| 2K \| 100.88K\Omega$$

$$\boxed{R_{out} = 32.24\Omega} \quad \text{"Low"}$$

$$A_{V_T} = \frac{V_{out}}{V_s} = \frac{V_{out}}{V_{in}} \frac{V_{in}}{V_s} \rightarrow \frac{V_{out}}{V_{in}} = A_V = \frac{(R_E \| r_o)}{\frac{1}{g_m} + (R_E \| r_o)}$$

$$R_E \| r_o = 2K \| 100.88K$$

$$R_E \| r_o = 1.96K\Omega$$



$$\rightarrow A_V = \frac{V_{out}}{V_{in}} = \frac{1.96K}{32.78 + 1.96K}$$

$$\underline{A_V = 0.9835}$$

$$\frac{V_{in}}{V_s} = \frac{R_{in}}{R_{in} + R_{sig}}$$

$$\frac{V_{in}}{V_s} = \frac{22.24K}{22.24K + 500} = \underline{0.978}$$

$$A_{V_T} = \frac{V_{in}}{V_s} \times A_V = 0.978 \times 0.9835$$

$$\boxed{A_{V_T} = 0.962}$$

—x—

CE, CB, CC amplifier comparison is given in AEC Lec 13_markings.pdf

24, 25, 30, 11, 72, 16,
67, 85, 97, 50, 54, 61,
41, 42, 69, 46, 58, 80,
78, 100