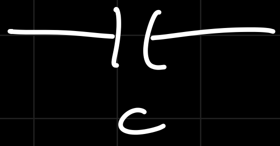
Lecture → Tut



DC → $w = 0$

$X_C = \frac{1}{wC} = \infty$ OC

AC → $w >>>$

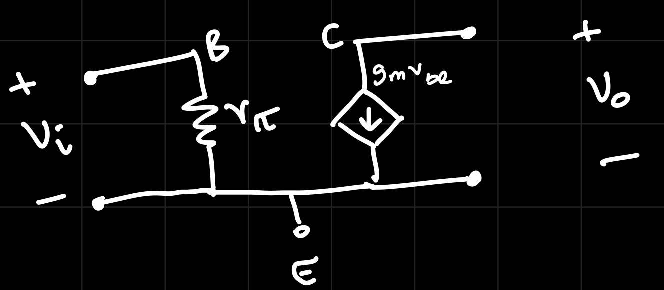
$X_C = \frac{1}{wC} = 0$ SC

all the params bias Base, collector and emitter current by using DC analysis. Also, the Q point of the transistor calculated by DC Analysis

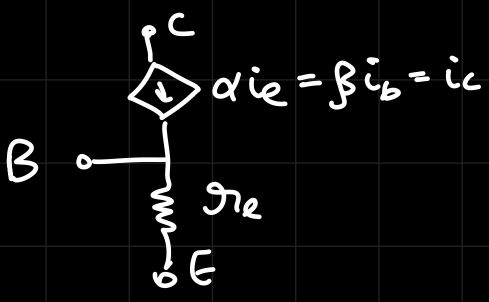
The input impedance, output impedance and the gain of the BJT calculated by AC analysis

we have 2 imp methods to solve the BJT under AC analysis

(a) π model



(b) T model



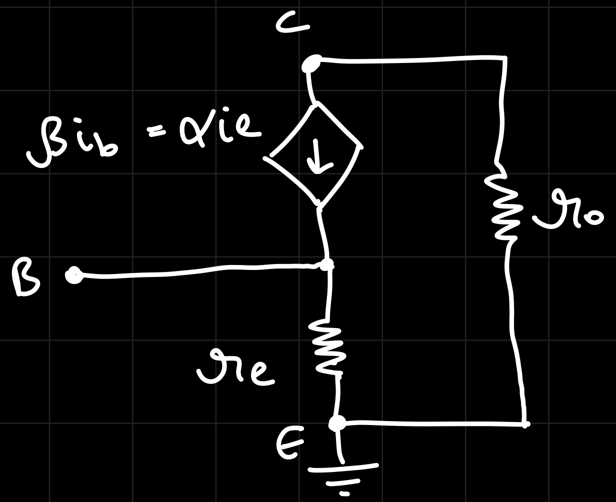
if early effect voltage given then consider r_o in π model

$$r_\pi = (\beta+1)\, r_e$$

$$r_\pi \simeq \beta r_e$$

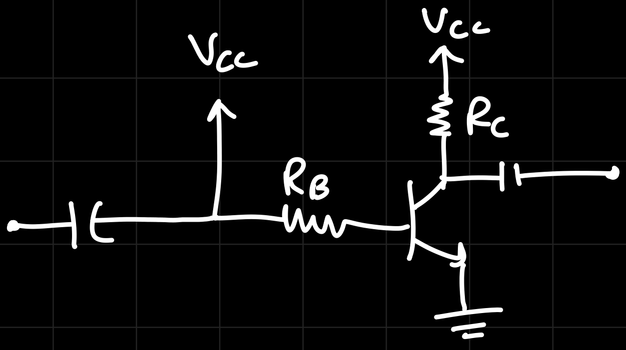
$$r_e = \frac{V_T}{I_E}$$ thermal voltage

$$V_T = 25/26\,mV$$



Q) for a given BJT configuration, determine the Z_{in}, Z_{out}, A_v

Note : we only use π model if there is a capacitor



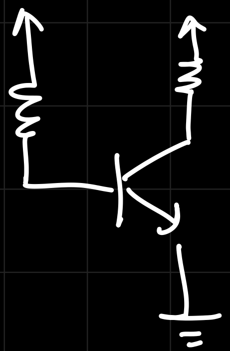
Fixed Bias

DC analysis

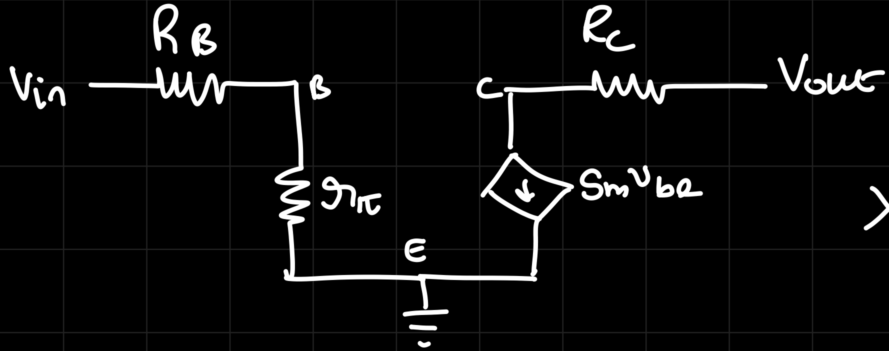
$I_C = \beta I_B + (\beta+1) I_{CBO}$

↓

leakage current



no Rc so, we use π model



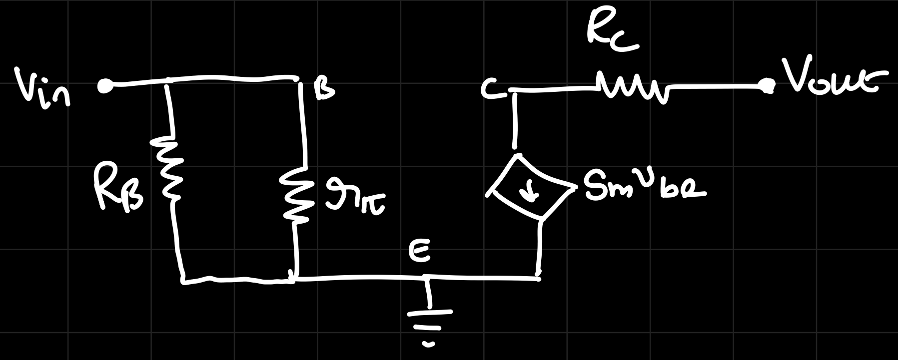
X

$V_{out} = -g_m v_{be} R_C$

$$V_{BE} = \frac{r_\pi}{r_\pi + R_B} V_{in}$$

$$\frac{V_{out}}{V_{in}} = -\frac{I_C}{\cancel{V_T}} \times \frac{\cancel{V_T}/I_B}{V_T/I_B + R_B}$$

X



$$V_{out} = -g_m v_{be} \cdot R_C$$

$$V_{BE} = \left(\frac{r_\pi}{r_\pi + R_B} \right) V_{in}$$

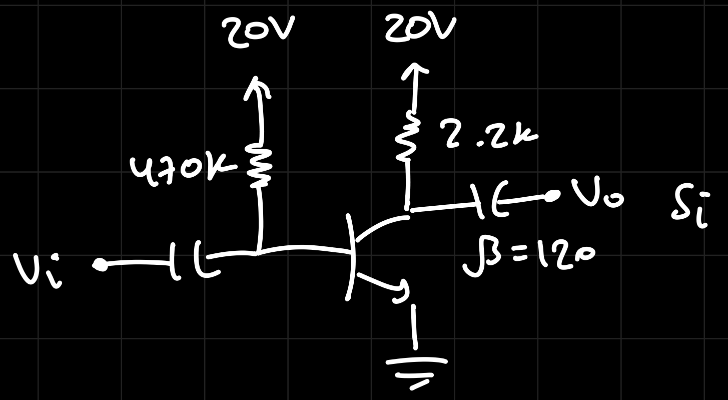
$$\frac{V_{out}}{V_{in}} = -g_m R_C \left(\frac{r_\pi}{r_\pi + R_B} \right)$$

$$Z_{in} = r_\pi \parallel R_B$$

$$Z_{out} = R_C$$

if r_o given $\rightarrow$ $Z_{out} = R_C \parallel r_o$

Q) calculate Z_{in}, Z_{out}, A_v, Q point



$$-20 + 470k(I_B) + 0.7 = 0$$

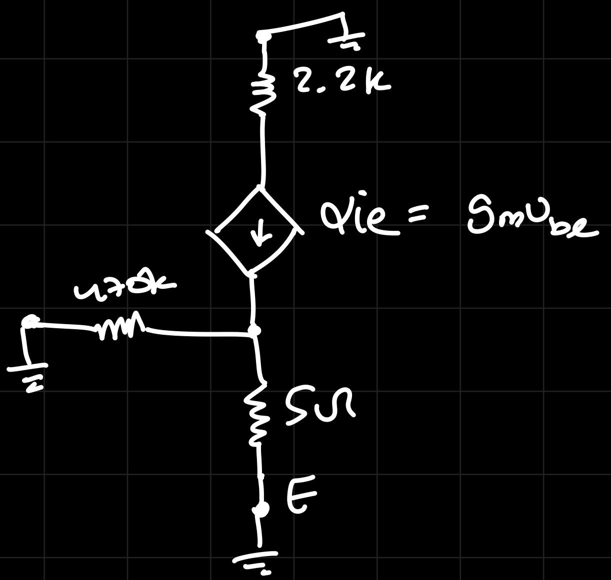
$$I_B = 19.3/470k = 41\,\mu A$$

$I_C = 4.92mA$, $I_E = 4.96mA$

$$-20 + 2.2(4.92) + V_{CE} = 0$$

$$V_{CE} = 20 - 10.824 = 9.176V$$

$$r_e = \frac{V_T}{I_E} = \frac{25m}{4.96m} = \sim 5\Omega$$

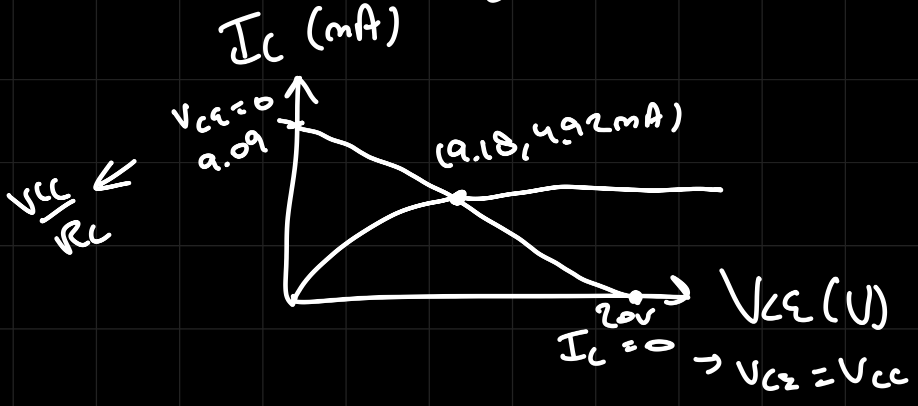


$Q(9.18V, 4.92mA)$

$$-V_{CC} + I_C R_C + V_{CE} = 0$$

$$I_C = -\frac{1}{R_C}V_{CE} + \frac{1}{R_C}V_{CC}$$

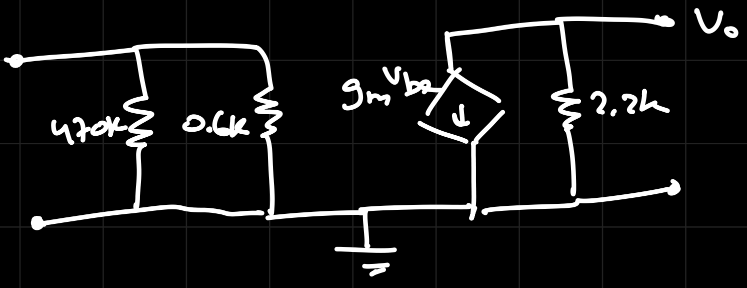
$$y = mx + c$$



AC analysis → DC remove

$C \rightarrow SC$

π model



$$r_\pi = \frac{V_T}{I_B} = \frac{25}{41} K = 0.6k$$

$$V_o = -\frac{2.2k}{8} V_{be}$$

$$V_{be} = Vin(470k \,//\, 0.6k)$$

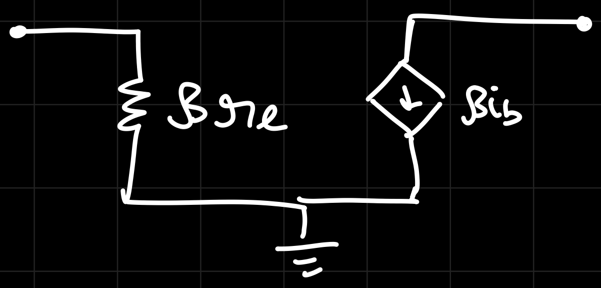
$$\frac{V_o}{Vin} =$$

$$V_o = -\beta i_b R_C$$

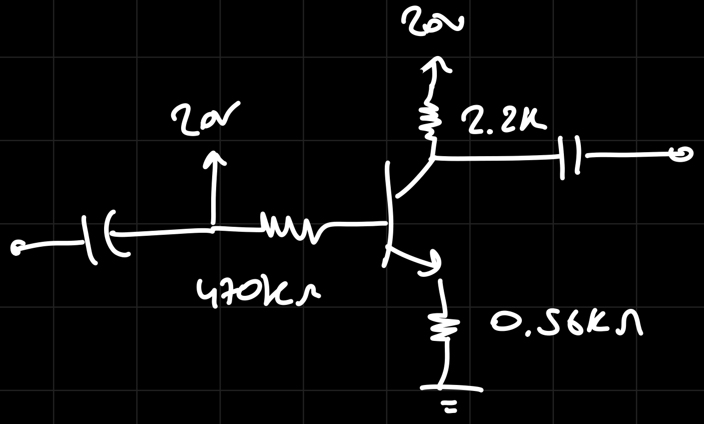
$$i_b = \frac{v_i}{\beta r_e}$$

$$Av = -\frac{\cancel{\beta}}{\cancel{\beta} r_e} R_C = -\frac{R_C}{r_e} = -40V/V$$

repeat all the params in the above numerical considering $r_o = 50K\Omega$ (early effect impedance)



g) find Z_{in}, Z_{out}, A_v



$-20 + 470k(I_B) + 0.7 + 560 I_E = 0$

If Re exists → T model
else π model

$$-20 + 470k(I_B) + 0.7 + 560 I_E = 0$$

$$I_B(470k + 67.76k) = 19.3$$

$$I_B = 35.8 \mu A$$

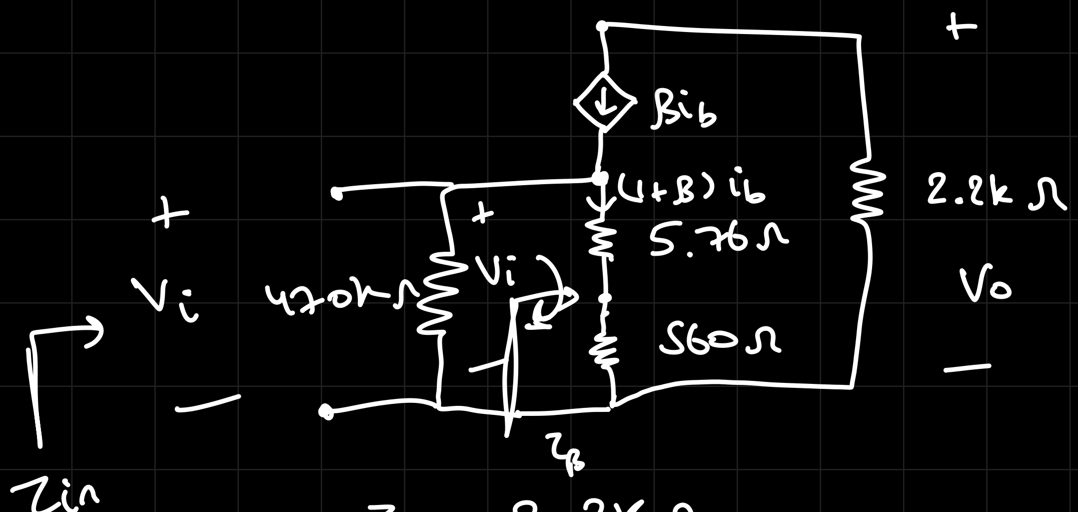
$$I_E = 4.34 mA$$

$$I_C = 4.298 mA$$

$$-20 + 9.45 + V_{CE} + 2.43 = 0$$

$$V_{CE} = 8.12V$$

$$r_e = \frac{V_T}{I_E} = \frac{25}{4.34} = 5.76\Omega$$



$$Z_o = 2.2K\Omega$$

$$Z_{in} = 470k \parallel 565.76\Omega$$

$$= \frac{470 \times 565}{470.565} = 564.32\Omega$$

$$KVL \rightarrow \quad -V_i + (1+\beta) i_b \times (R_e + r_e) = 0$$

$$\Rightarrow V_i = (1+\beta) i_b (R_e + r_e)$$

$$Z_b = \frac{V_i}{i_b} = (1+\beta)(R_e + r_e)$$

$$= (121)(565.76) = 68.45 K\Omega$$

$$Z_{in} = R_B \parallel Z_B = 59.7 K\Omega$$

$$V_i = (1+\beta) i_b (R_e + r_e)$$

$$V_o = -i_c R_c$$

$$= -\beta i_b R_c$$

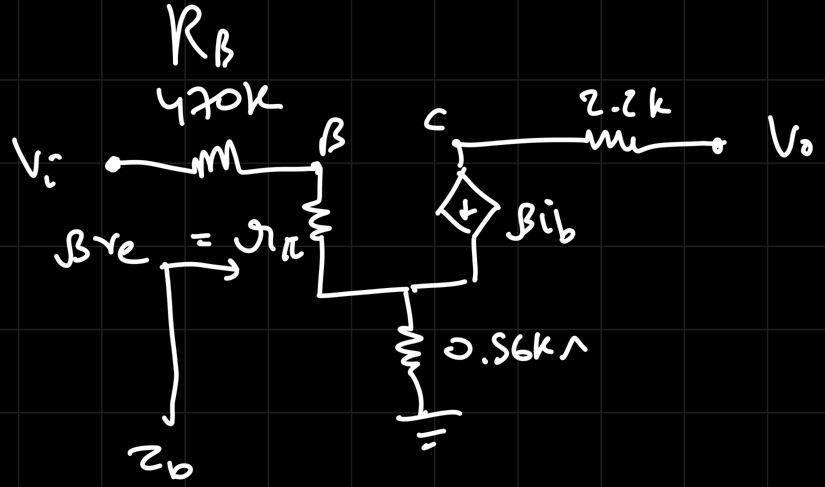
$$= -\beta R_c \left(\frac{V_i}{(1+\beta)(R_e + r_e)} \right)$$

assme $\beta \simeq \beta + 1$

$$A_v = \frac{-R_c}{R_e + r_e} = \frac{-2.2k}{565.76} = -3.8 \text{ V/V}$$

g) now do with π model

$$r_\pi = \frac{V_T}{I_B} = \frac{25}{35.8m} = 700\,\Omega$$



$$V_o = -\beta i_b \cdot R_C$$

$$\times \left\{ i_b = \frac{V_i}{\beta r_e + 0.56k} \right\} \quad V_i = i_b \beta r_e + (1+\beta) R_E\, i_b$$

$$\times \left\{ \frac{V_o}{V_i} = \frac{-\beta R_C}{\beta r_e + 0.56k} = \frac{-2.2k(120)}{5.76(120) + 560} \right.$$

$$= \frac{-264}{1.25} = -211.2$$

$$V_i = i_b (r_e + R_E)\beta \Rightarrow \beta \simeq 1+\beta$$

$$\frac{V_o}{V_i} = \frac{-R_C}{r_e + R_E} = -3.8\,V/V \quad \text{Same} \checkmark$$

$$Z_b = \frac{V_i}{i_b} = (r_e + R_E)\beta$$

$$= 67.87\,k\Omega$$

$$Z_{in} = R_B \,||\, Z_b = 59.32\,k\Omega$$

$$Z_o = R_C$$