LEC-5Peng/BJT

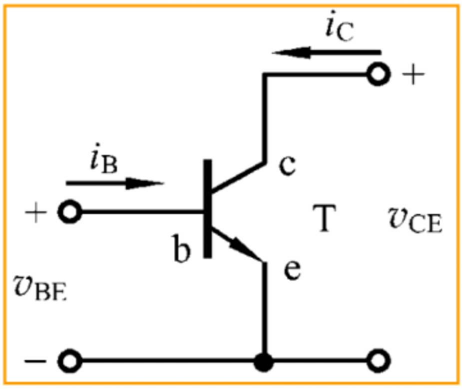
Thursday, 23 May 2024 11.20

$$i_C = I_S\left(e^{(\upsilon_{BE}/V_T)} - 1\right) = \frac{A_E q D_n n_i^2}{N_B W_B}\left(e^{(\upsilon_{BE}/V_T)} - 1\right)$$

$$\approx \frac{A_E q D_n n_i^2}{N_B W_B} e^{(\upsilon_{BE}/V_T)}$$

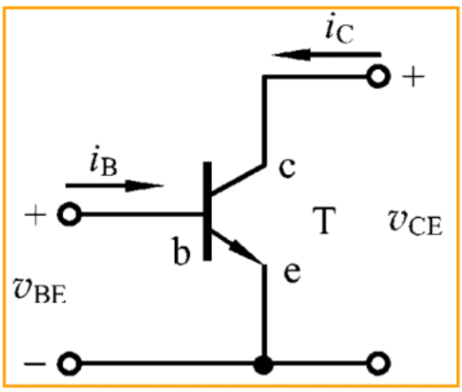
$$i_B = \left(\frac{A_E q D_p n_i^2}{N_D L_p} + \frac{A_E q W n_i^2}{2\tau_b N_A}\right)\left(e^{\left(\upsilon_{BE}/V_T\right)} - 1\right)$$

$$\approx \left(\frac{A_E q D_p n_i^2}{N_D L_p} + \frac{A_E q W n_i^2}{2\tau_b N_A}\right) e^{\left(\upsilon_{BE}/V_T\right)}$$



Current gain $\boxed{\beta = \dfrac{i_C}{i_B}}$

$$i_B = \frac{i_C}{\beta} = \frac{I_S\left(e^{(\upsilon_{BE}/V_T)} - 1\right)}{\beta} = \left(\frac{I_S}{\beta}\right)\left(e^{(\upsilon_{BE}/V_T)} - 1\right)$$



According to KCL:

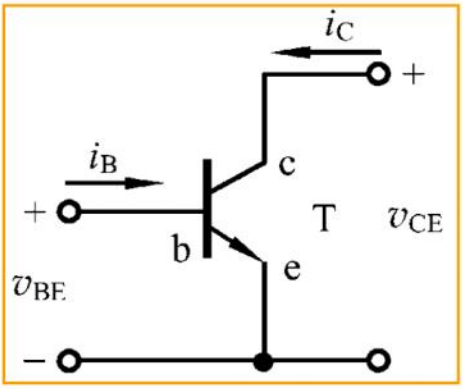
$$i_E = i_B + i_C = \frac{i_C}{\beta} + i_C$$

$$= \frac{\beta + 1}{\beta} i_C$$

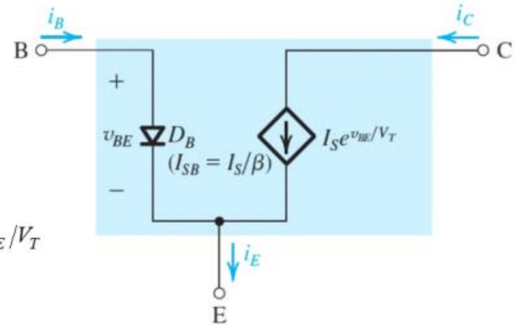
$$= \frac{\beta + 1}{\beta} I_S\left(e^{(\upsilon_{BE}/V_T)} - 1\right)$$

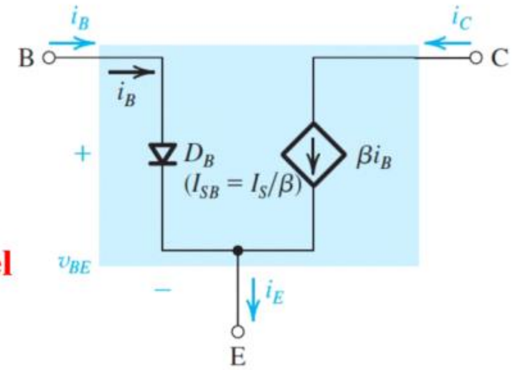
$$\alpha = \frac{i_C}{i_E} \Rightarrow \alpha = \frac{\beta}{\beta + 1} \quad \text{or} \quad \beta = \frac{\alpha}{1 - \alpha}$$

Simple bipolar transistor model



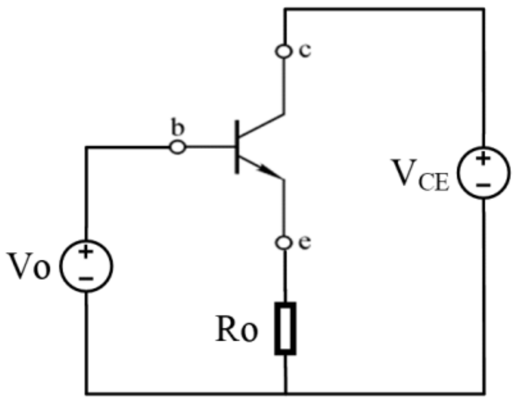
$$i_B = \frac{i_C}{\beta} = \frac{i_S}{\beta} e^{v_{BE}/V_T}$$

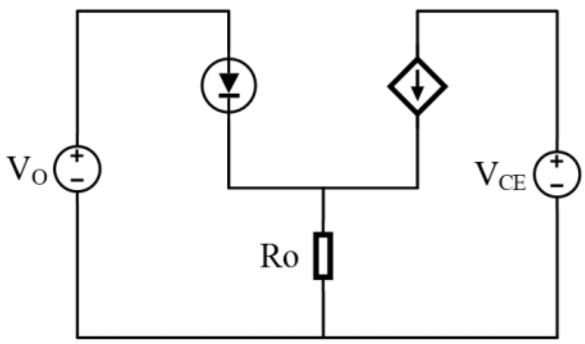




Application of a simple bipolar transistor model

Application of a simple bipolar transistor model





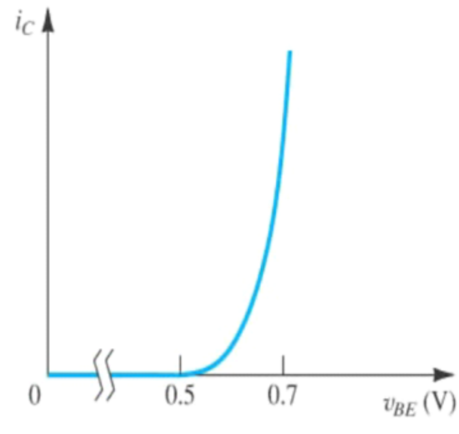
Vo = 5V, V_{CE} = 12V, Ro = 100 Ω

$$I_S = 5\times10^{-16} A$$

$$V_o = V_{BE} + R_o \cdot I_E \approx V_T \ln\frac{I_C}{I_S} + R_o \cdot I_C$$

Concept of transconductance:

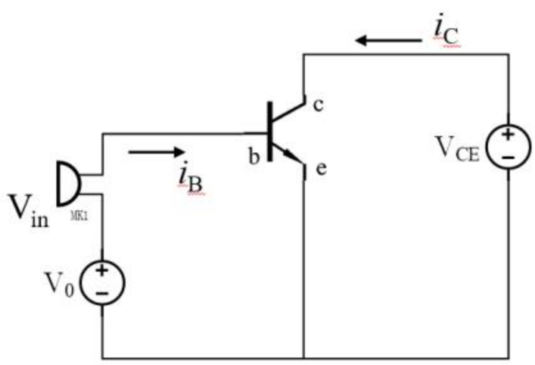
Concept of transconductance:



$$g_m = \frac{\Delta i_c}{\Delta \upsilon_{BE}} = \frac{di_c}{d\upsilon_{BE}}$$

$$i_c = I_S e^{\upsilon_{BE}/V_T}$$

$$g_m = \frac{d}{d\upsilon_{BE}}\left(I_S e^{\upsilon_{BE}/V_T}\right) = \frac{I_S}{V_T} e^{\upsilon_{BE}/V_T} = \frac{i_c}{V_T}$$



$$V_{in} = V_m \sin \omega t$$

$$i_C = I_S e^{\left(\frac{V_0+V_{in}}{V_T}\right)} = I_S e^{\left(\frac{V_0}{V_T}\right)} \cdot e^{\left(\frac{V_m \sin \omega t}{V_T}\right)}$$

$$= I_{CO} \cdot e^{\left(\frac{V_m \sin \omega t}{V_T}\right)} \boxed{\approx} I_{CO} \cdot \left(1 + \frac{V_m \sin \omega t}{V_T}\right)$$

$$= I_{CO} + \frac{I_{CO}}{V_T} V_m \sin \omega t$$

$$= I_{CO} + g_m V_m \sin \omega t$$

Blackboard Notes for lecture - 2

slide 6:

To figure out the component over V_{be}, we need to find out the relationship between i_b and V_{be} in this circuit branch.

slide 7:

we know that:

$$i_B = \frac{i_c}{\beta} = \frac{I_s}{\beta}\exp(V_{BE}/V_T)$$

therefore, the component over V_{be} is a PN diode.

slide 13:

when a small perturbation is added in the input side:

$V_{in} = V_m \sin\omega t$, then

$$I_c = I_s \exp((V_o + V_{in})/V_T) = \underline{I_s \exp(V_o/V_T)} \cdot \exp\left(\frac{V_m \sin\omega t}{V_T}\right)$$

$$= I_{co} \cdot \exp\left(\frac{V_m \sin\omega t}{V_T}\right)$$

$$\approx I_{co} \cdot \left(1 + \frac{V_m \sin\omega t}{V_T}\right)$$

we use an approximation here: $e^x \approx 1 + x$, when $x << 1$

$$= I_{co} + \frac{I_{co}}{V_T} V_m \sin\omega t$$

$$= I_{co} + g_m V_m \sin\omega t$$

$$= \underline{I_{co} + g_m V_{in}}$$

1. A bipolar transistor has a collector current of 1mA and $I_S = 5 \times 10^{-16}$ A, how much is V_{BE}? If β = 50, how much is base current?

① $i_c = 1\,mA$, $I_s = 5 \times 10^{-16}\,A$, $V_T = 26\,mV$

$V_{BE} = \ln\left(\frac{I_C}{I_S}\right) \cdot V_T$

$i_c = I_s \exp\frac{V_{BE}}{V_T}$

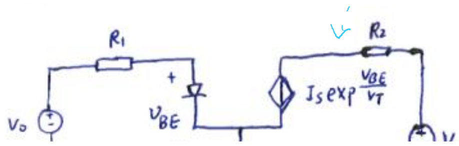
This is big NONO

$V_{BE} = \boxed{5 \times 778\,m\,V} = 3.89\,V$

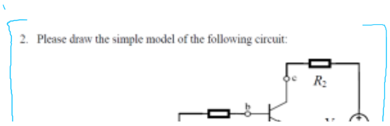
svaret her er forkert

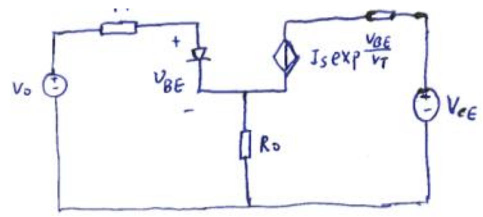
$i_b = \frac{i_c}{\beta} = \frac{1\,mA}{50} = 20\,\mu A$

② simple model:

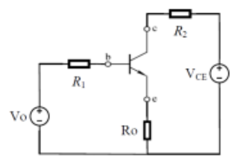


This is the ex


2. Please draw the simple model of the following circuit:



2. Please draw the simple model of the following circuit:



3. If Vo = 5 V, Ro = 100 Ω, V_{CE} = 12 V, R_1 = 200 Ω, R_2 = 100 Ω, β = 50, please calculate collector current? (Just give the final formula, not need to calculate the exact value).

③ $V_o = 5V$. $R_o = 100\Omega$, $V_{CE} = 12V$. $R_1 = 200\,\Omega$, $R_2 = 100\Omega$. $\beta : 50$, $I_S : 5 \times 10^{-16} A$

$i_C \approx i_E$

$$V_o = \overbrace{R_1 \cdot i_B}^{\text{input}} + v_{BE} + \overbrace{R_o \cdot i_E}^{\text{output}} = R_1 \cdot i_B + \underbrace{V_T \cdot \ln \frac{i_C}{I_S}}_{v_{BE}} + R_o \cdot i_E$$

? ?

$$V_o = R_1 \cdot \frac{i_C}{\beta} + V_T \cdot \ln \frac{i_C}{I_S} + R_o \cdot i_C$$

Og så her fra kan man isolere for I_C og det er jo så det jeg gerne vil have

$$V_0 = R_1 \cdot \frac{i_C}{\beta} + V_T \ln\left(\frac{i_C}{I_S}\right) + R_o \cdot i_C$$

$$\hookrightarrow i_C = \sim + \sim + \sim$$