Charakterystyki tranzystora
i jego matematyczny opis (model) zlinearyzowany

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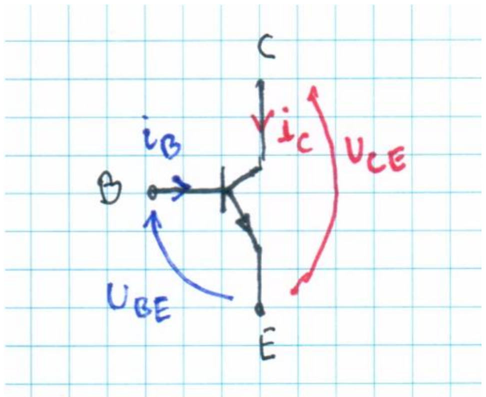
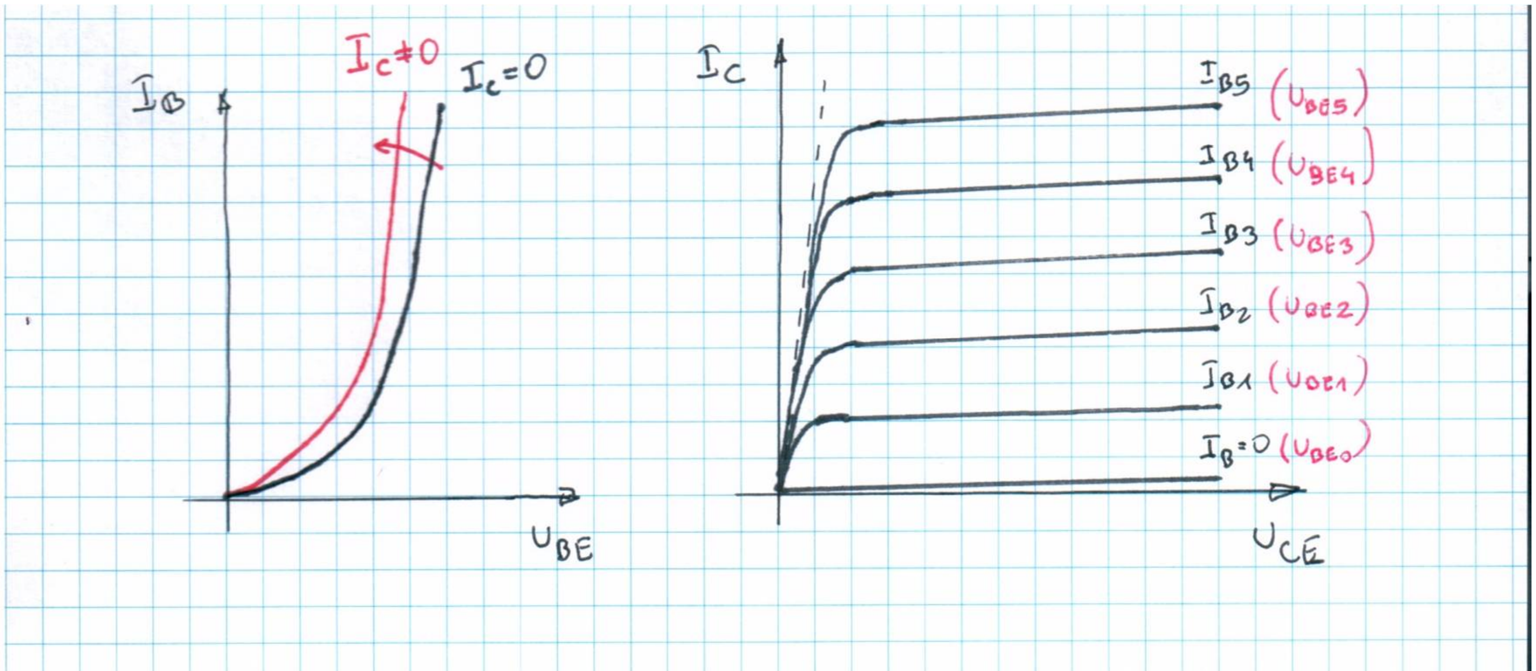
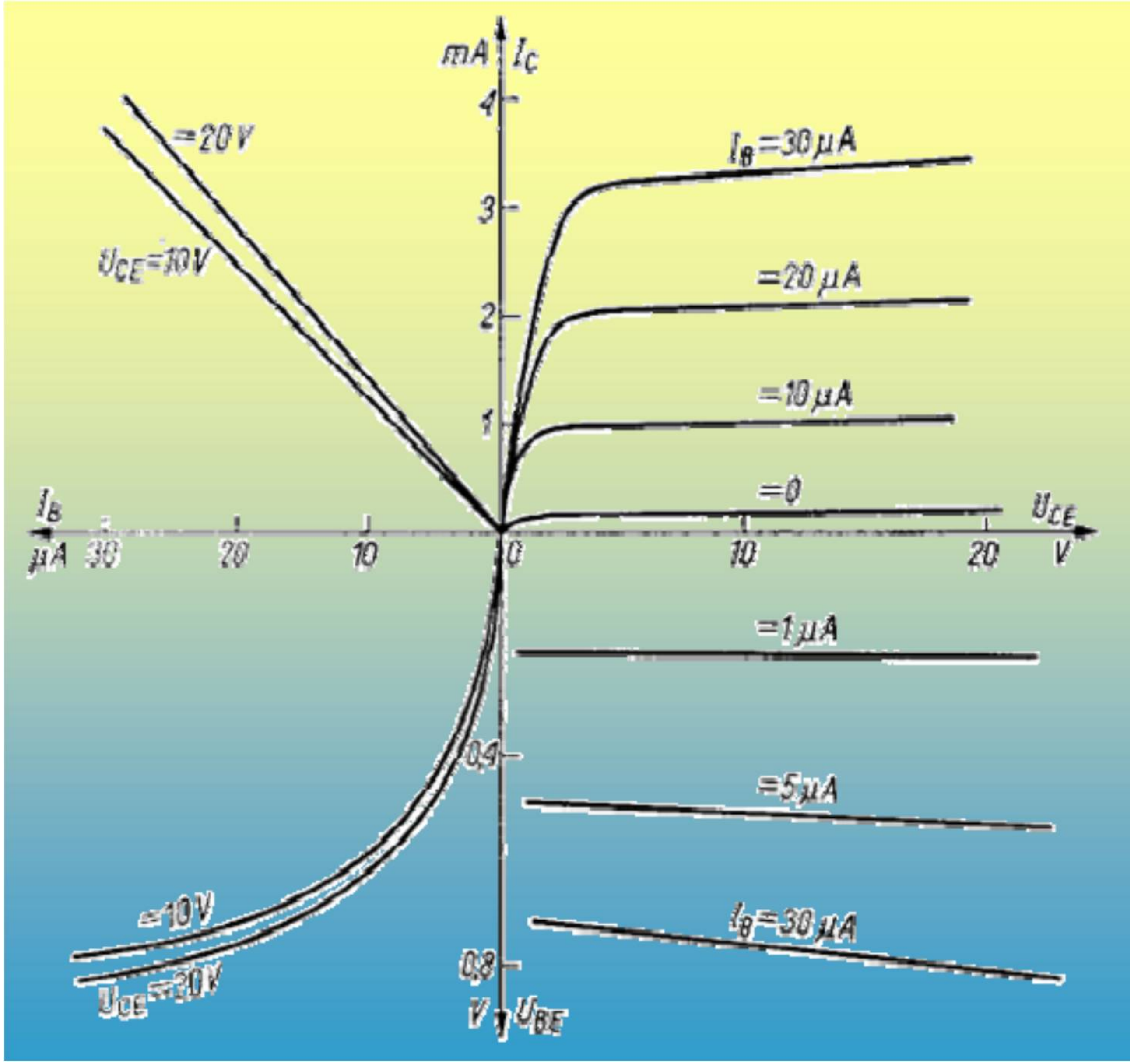


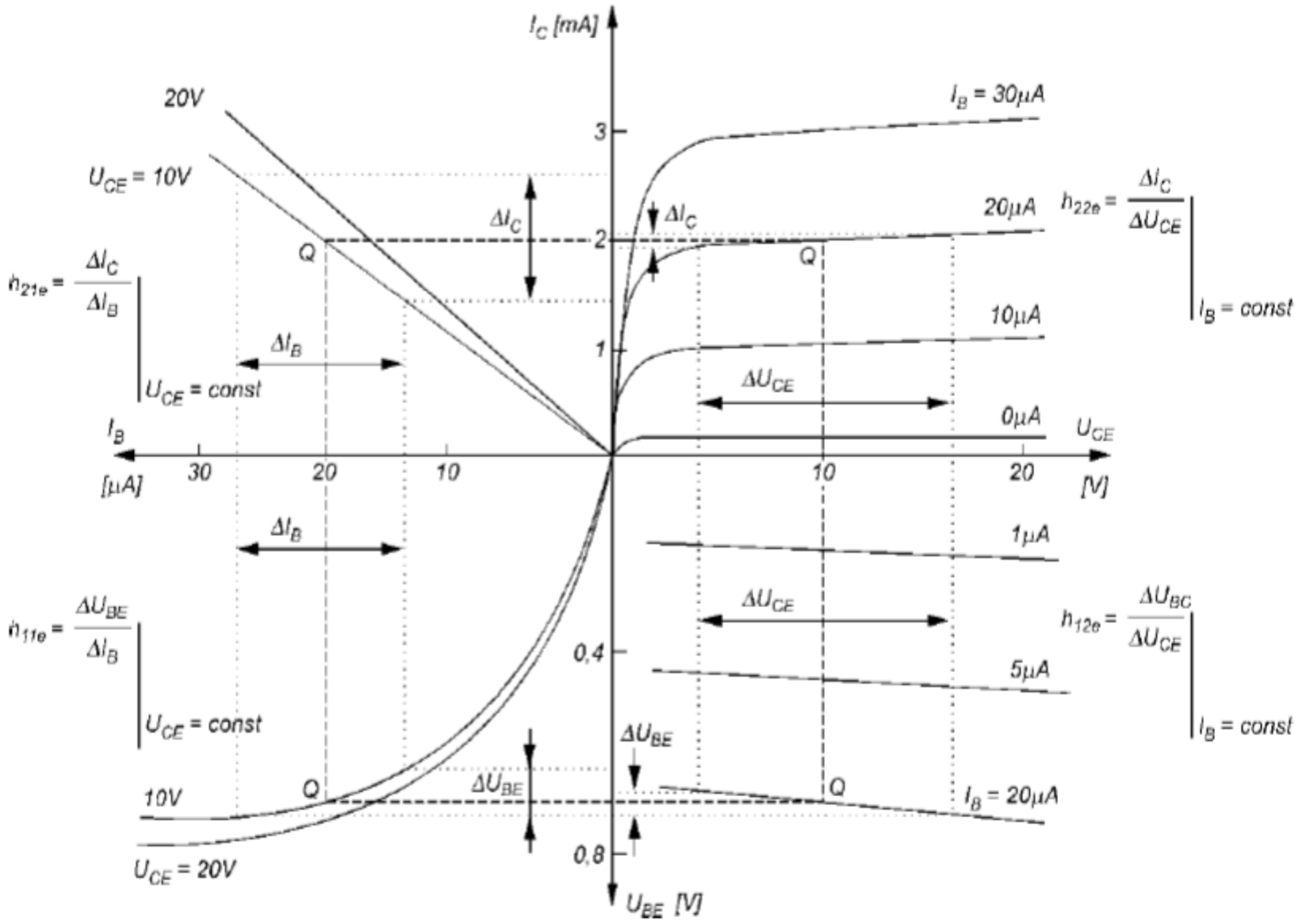
Tranzystor n-p-n (npn)



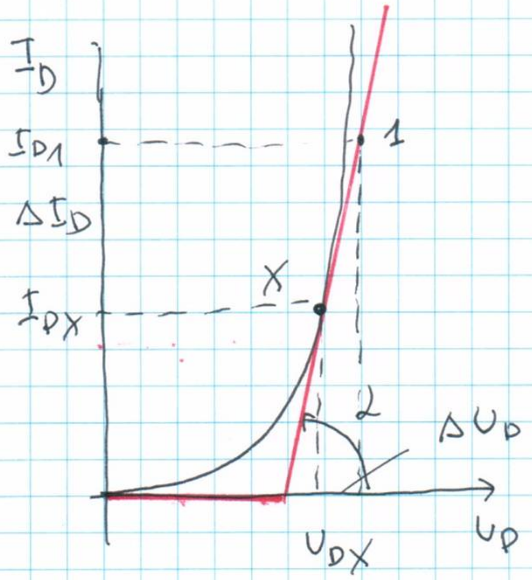
Charakterystyki katalogowe tranzystora



Charakterystyki katalogowe tranzystora



Linearyzacja charakterystyki diody

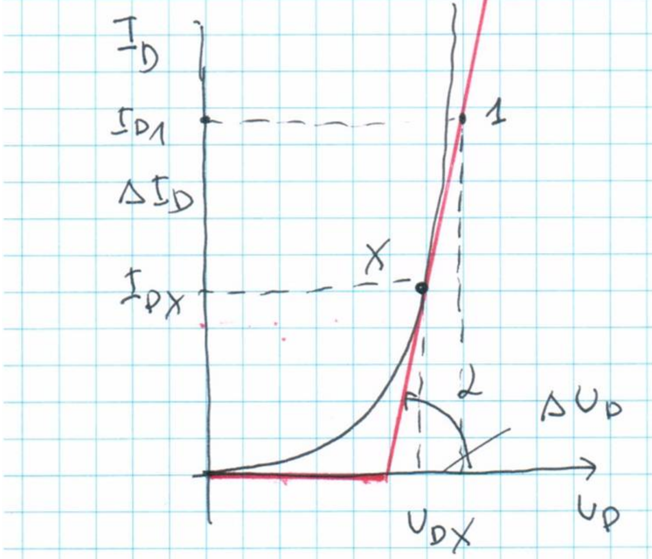


$$I_{D1} = I_{DX} + \Delta I_D = I_{DX} + \Delta U_D \cdot tg\alpha$$

$$tg\alpha = \frac{dI_d}{dU_D}\Big|_X = \frac{1}{r_D}$$

$$I_{D1} = I_{DX} + \frac{\Delta U_D}{r_D}$$

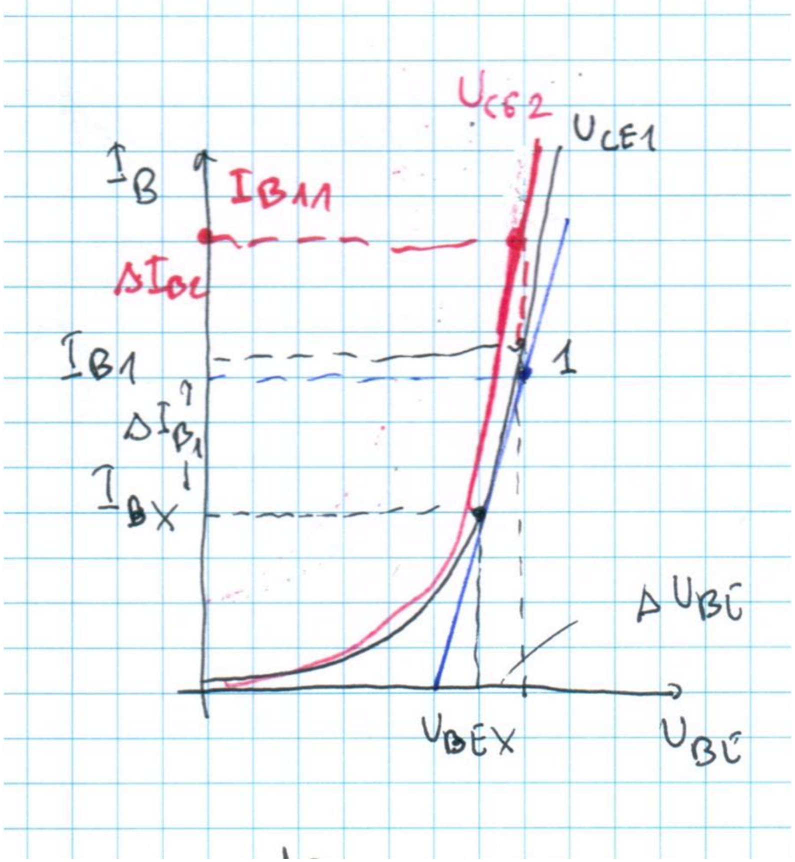
Linearyzacja charakterystyki diody i tranzystora



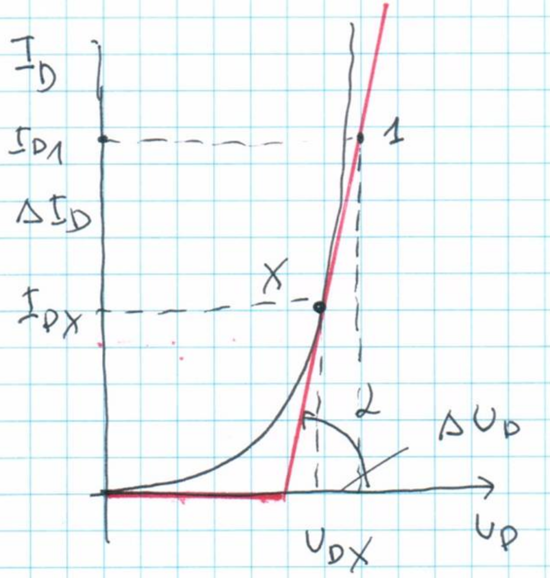
$$I_{D1} = I_{DX} + \Delta I_D = I_{DX} + \Delta U_D \cdot tg\alpha$$

$$tg\alpha = \left.\frac{dI_d}{dU_D}\right|_X = \frac{1}{r_D}$$

$$I_{D1} = I_{DX} + \frac{\Delta U_D}{r_D}$$



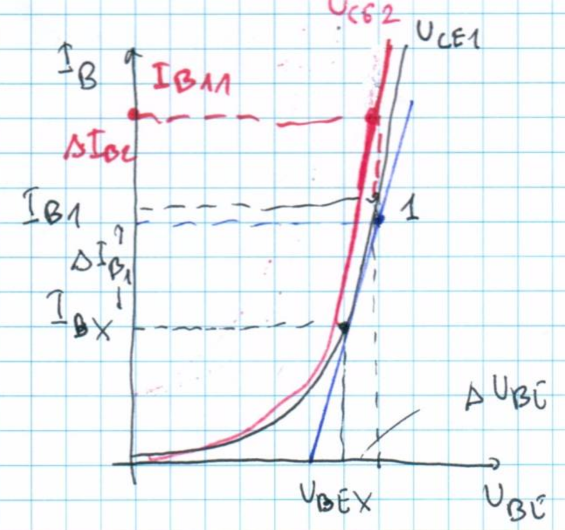
Linearyzacja charakterystyki diody i tranzystora



$I_{D1} = I_{DX} + \Delta I_D = I_{DX} + \Delta U_D \cdot tg\alpha$

$tg\alpha = \left.\frac{dI_D}{dU_D}\right|_X = \frac{1}{r_D}$

$I_{D1} = I_{DX} + \frac{\Delta U_D}{r_D}$



$I_{B1} = I_{BX} + \Delta I_{B1}$

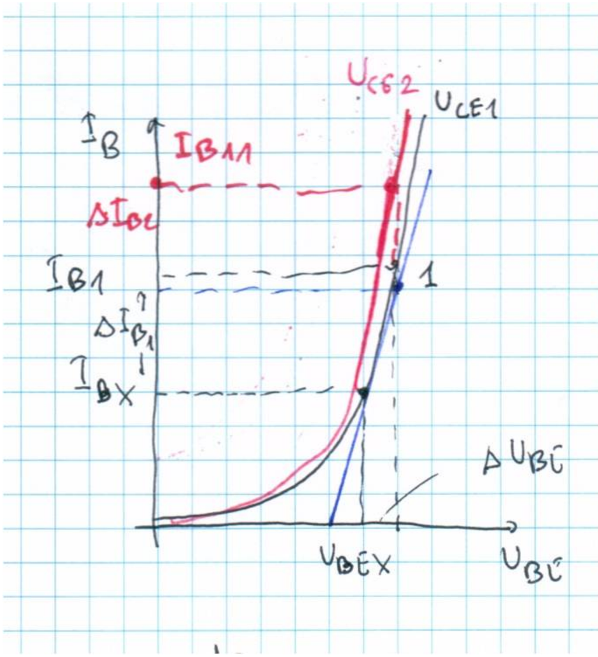
$I_{B1} = I_{BX} + \left.\frac{dI_B}{dU_{BE}}\right|_X \cdot \Delta U_{BE}$

$I_B = f(U_{BE}, U_{CE}) =$

$I_{B11} = I_{BX} + \Delta I_{B1} + \Delta I_{B2}$

$\frac{dI_B}{dU_{BE}} \to \frac{\partial I_B}{\partial U_{BE}}$ $\quad \Delta I_{B1} = \left.\frac{\partial I_B}{\partial U_{BE}}\right|_X \cdot \Delta U_{BE} + \left.\frac{\partial I_B}{\partial U_{CE}}\right|_X \cdot \Delta U_{CE}$

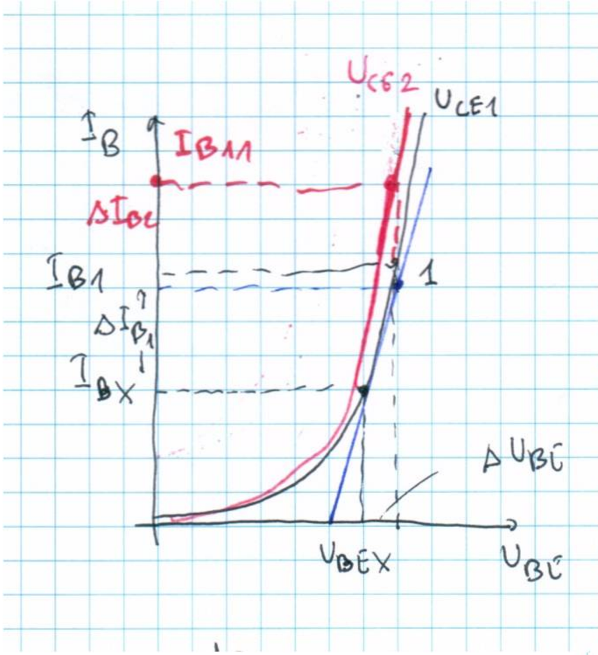
Linearyzacja charakterystyk tranzystora



$$\frac{dI_B}{dU_{BE}} \rightarrow \frac{\partial I_B}{\partial U_{BE}} \qquad \Delta I_{B1} = \frac{\partial I_B}{\partial U_{BE}}\Big|_X \cdot \Delta U_{BE} + \frac{\partial I_B}{\partial U_{CE}}\Big|_X \cdot \Delta U_{CE}$$

$$Y = f(x_1, x_2) \rightarrow Y_X + \Delta Y = Y_X + \frac{\partial f}{\partial x_1} \cdot \Delta x_1 + \frac{\partial f}{\partial x_2} \cdot \Delta x_2 + \dots$$

Linearyzacja charakterystyk tranzystora



$$\frac{dI_B}{dU_{BE}} \rightarrow \frac{\partial I_B}{\partial U_{BE}} \qquad \Delta I_{B1} = \frac{\partial I_B}{\partial U_{BE}}\Big|_X \cdot \Delta U_{BE} + \frac{\partial I_B}{\partial U_{CE}}\Big|_X \cdot \Delta U_{CE}$$

$$y = f(x_1, x_2) \rightarrow y_x + \Delta y = y_x + \frac{\partial f}{\partial x_1} \cdot \Delta x_1 + \frac{\partial f}{\partial x_2} \cdot \Delta x_2 + \ldots$$

uproszczenie

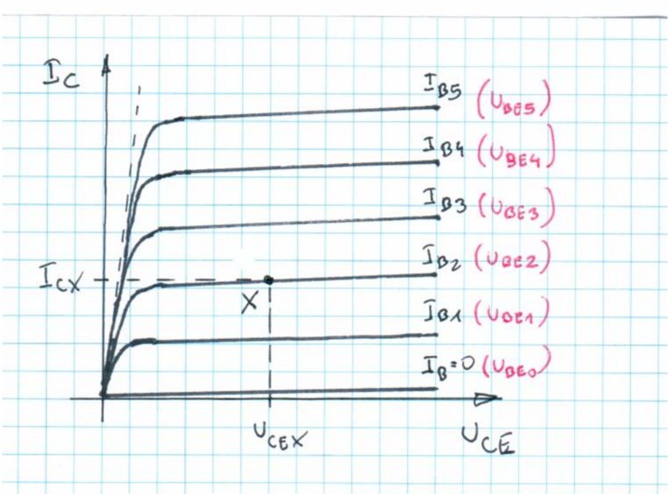
$$\frac{\partial I_B}{\partial U_{CE}} \approx 0$$

$$I_B = I_{BX} + \frac{\partial I_B}{\partial U_{BE}} \cdot \Delta U_{BE}$$

$$\Delta I_B = I_B - I_{BX} = \frac{\partial I_B}{\partial U_{BE}}\Big|_X \Delta U_{BE} \qquad \frac{\partial I_B}{\partial U_{BE}} = \frac{1}{r_{BE}}$$

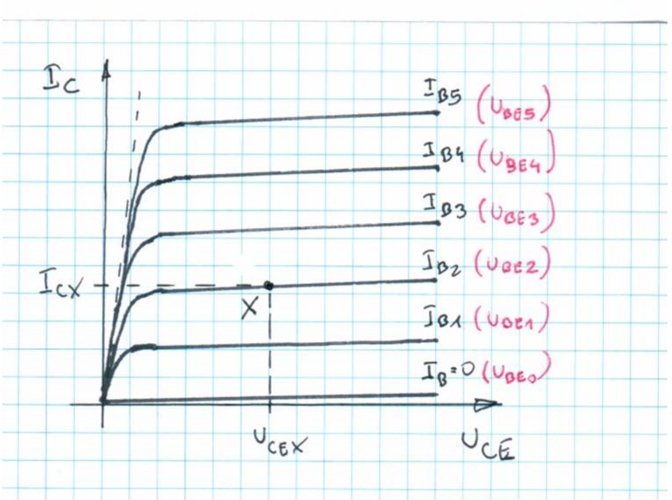
$$\Delta I_B = \frac{1}{r_{BE}} \cdot \Delta U_{BE}$$

Linearyzacja charakterystyk tranzystora

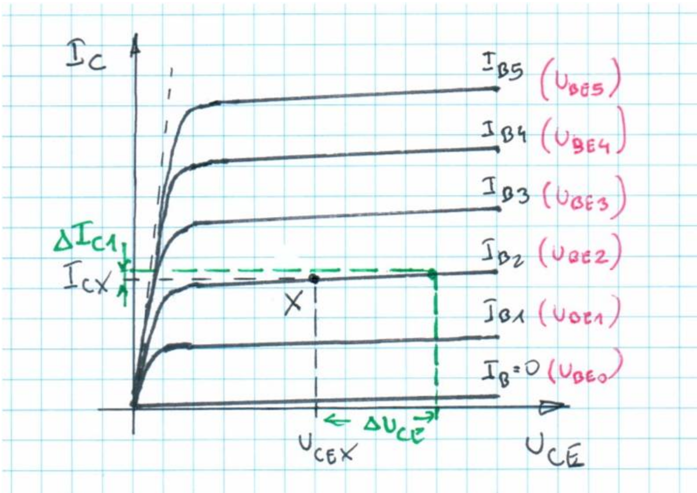


$$I_C = f(U_{BE}, U_{CE})$$

Linearyzacja charakterystyk tranzystora

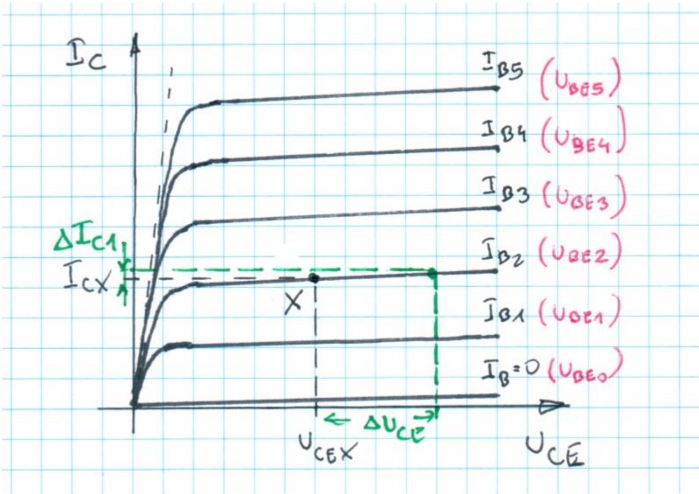


$$I_C = f(U_{BE}, U_{CE})$$



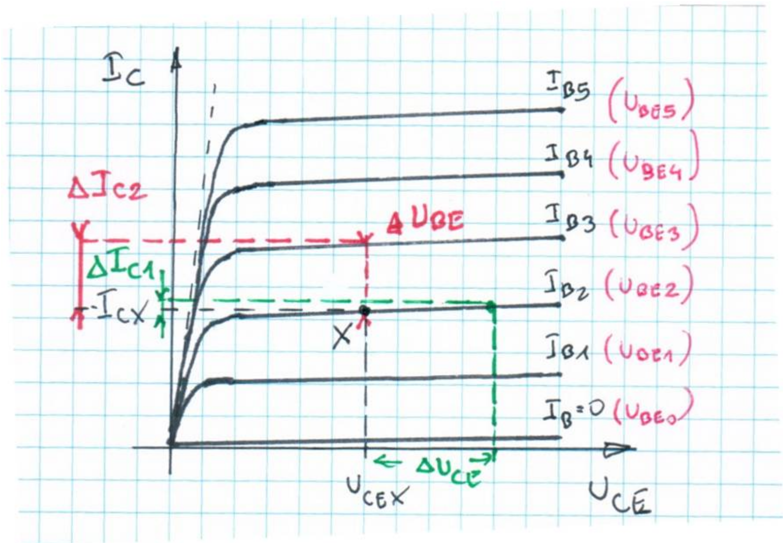
$$\Delta I_{C1} = I_{C1} - I_{CX} = \left.\frac{\partial I_C}{\partial U_{CE}}\right|_X \cdot \Delta U_{CE}$$

Linearyzacja charakterystyk tranzystora



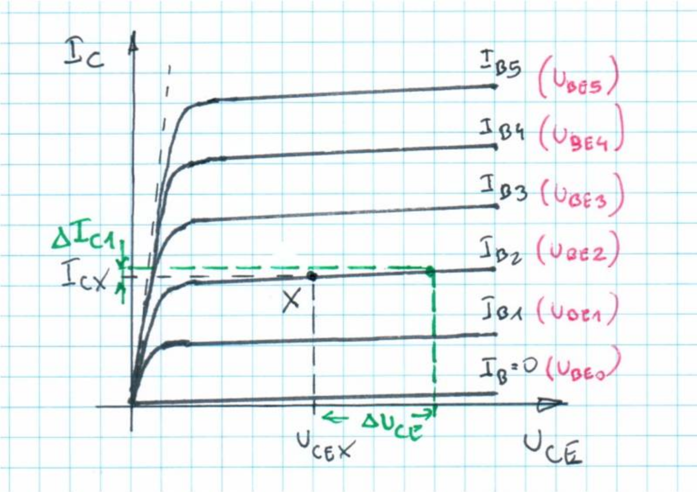
$$I_C = f(U_{BE}, U_{CE})$$

$$\Delta I_{C1} = I_{C1} - I_{CX} = \left.\frac{\partial I_C}{\partial U_{CE}}\right|_X \cdot \Delta U_{CE}$$



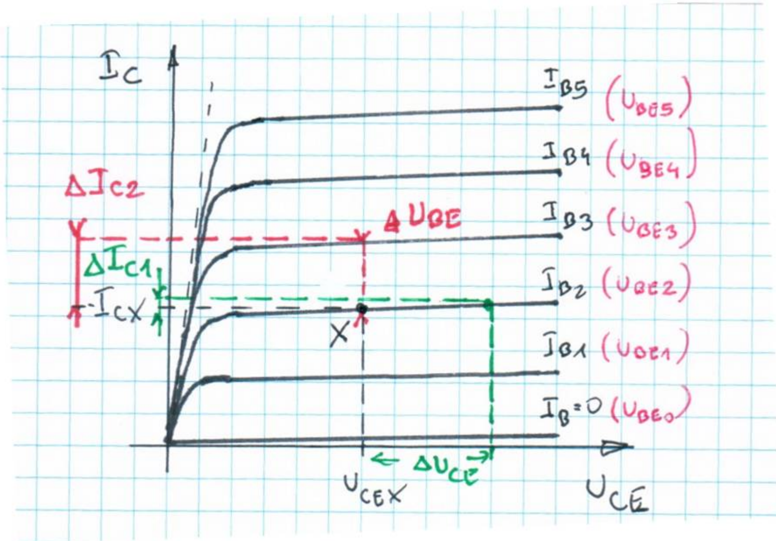
$$\Delta I_{C2} = I_{C2} - I_{CX} = \left.\frac{\partial I_C}{\partial U_{BE}}\right|_X \cdot \Delta U_{BE}$$

Linearyzacja charakterystyk tranzystora



$$I_C = f(U_{BE}, U_{CE})$$

$$\Delta I_{C1} = I_{C1} - I_{CX} = \left.\frac{\partial I_C}{\partial U_{CE}}\right|_X \cdot \Delta U_{CE}$$



$$\Delta I_{C2} = I_{C2} - I_{CX} = \left.\frac{\partial I_C}{\partial U_{BE}}\right|_X \cdot \Delta U_{BE}$$

$$\Delta I_C = \left.\frac{\partial I_C}{\partial U_{BE}}\right|_X \cdot \Delta U_{BE} + \left.\frac{\partial I_C}{\partial U_{CE}}\right|_X \cdot \Delta U_{CE}$$

$$\frac{\partial I_C}{\partial U_{BE}} = g_m \qquad \frac{\partial I_C}{\partial U_{CE}} = \frac{1}{r_{CE}}$$

Linearyzacja charakterystyk tranzystora

Zapis konduktancyjny
(przewodnościowy)

$$\Delta I_B = \frac{1}{r_{BE}} \cdot \Delta U_{BE}$$

$$\Delta I_C = g_m \cdot \Delta U_{BE} + \frac{1}{r_{CE}} \cdot \Delta U_{CE}$$

$$\begin{bmatrix} \Delta I_B \\ \Delta I_C \end{bmatrix} = \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix} \begin{bmatrix} \Delta U_{BE} \\ \Delta U_{CE} \end{bmatrix}$$

$$g_{11} = \frac{1}{r_{BE}} \qquad g_{12} \cong 0$$

$$g_{21} = g_m \qquad g_{22} = \frac{1}{r_{CE}}$$

Linearyzacja charakterystyk tranzystora

Zapis konduktancyjny (przewodnościowy)

$$\Delta I_B = \frac{1}{r_{BE}} \cdot \Delta U_{BE}$$

$$\Delta I_C = g_m \cdot \Delta U_{BE} + \frac{1}{r_{CE}} \cdot \Delta U_{CE}$$

$$\begin{bmatrix} \Delta I_B \\ \Delta I_C \end{bmatrix} = \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix} \begin{bmatrix} \Delta U_{BE} \\ \Delta U_{CE} \end{bmatrix}$$

$$g_{11} = \frac{1}{r_{BE}} \qquad g_{12} \cong 0$$

$$g_{21} = g_m \qquad g_{22} = \frac{1}{r_{CE}}$$

Zapis hybrydowy

$$\Delta U_{BE} = r_{BE} \cdot \Delta I_B$$

$$\Delta I_C = r_{BE}\, g_m \cdot \Delta I_B + \frac{1}{r_{CE}} \cdot \Delta U_{CE}$$

$$\frac{\Delta I_C}{\Delta I_B} = \beta \qquad \Delta I_C = \beta \cdot \Delta I_B \qquad \beta = r_{BE} \cdot g_m$$

$$\Delta U_{BE} = r_{BE} \cdot \Delta I_B$$

$$\Delta I_C = \beta \cdot \Delta I_B + \frac{1}{r_{CE}} \cdot \Delta U_{CE}$$

$$\begin{bmatrix} \Delta U_{BE} \\ \Delta I_C \end{bmatrix} = \begin{bmatrix} h_{11} \cdot \Delta I_B + h_{12} \cdot \Delta U_{CE} \\ h_{21} \cdot \Delta I_B + h_{22} \cdot \Delta U_{CE} \end{bmatrix}$$

$$h_{11} = r_{BE} \qquad h_{12} \cong 0$$

$$h_{21} = \beta \qquad h_{22} = \frac{1}{r_{CE}}$$