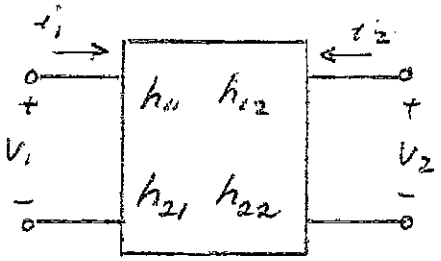
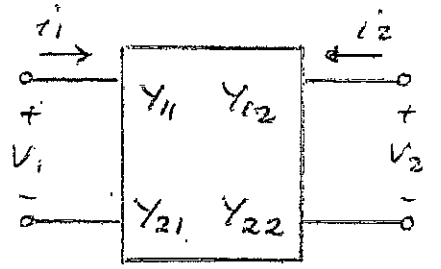
2-Port Matrices

Def Hybrid Matrix



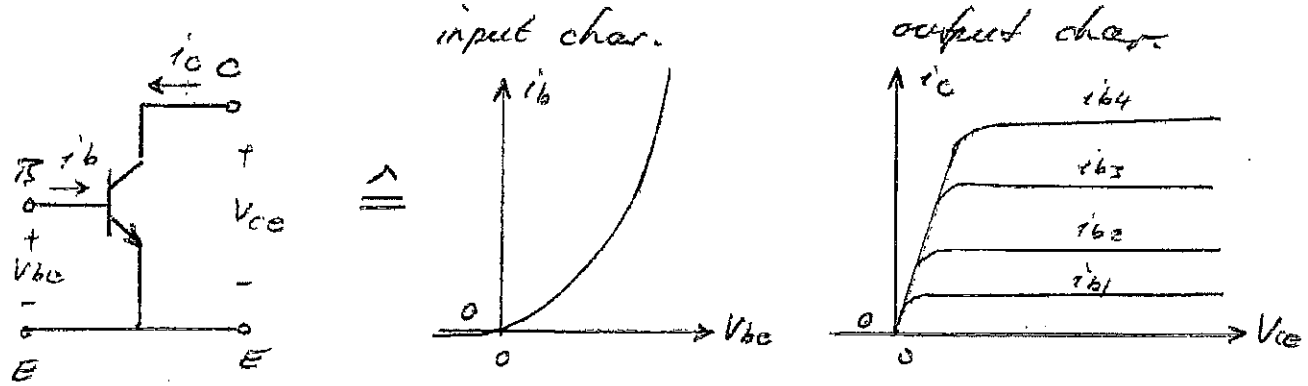
$$\begin{Vmatrix} V_1 \\ i_2 \end{Vmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} i_1 \\ V_2 \end{bmatrix} \Bigg\|$$

Def Admittance Matrix



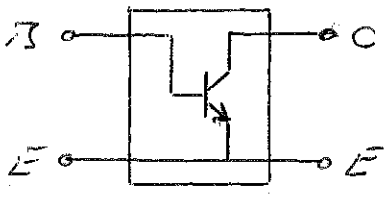
$$\begin{Vmatrix} i_1 \\ i_2 \end{Vmatrix} = \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} \Bigg\|$$

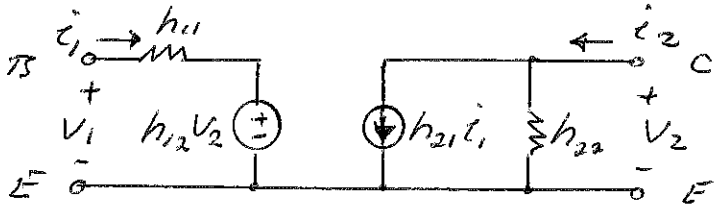
Alternatively, a two port can be described by its input and output v-i characteristics. For example, a BJT with the emitter as the common terminal possesses the following input and output characteristics:



BJT [H]-Parameter Representation

a) CE Configuration





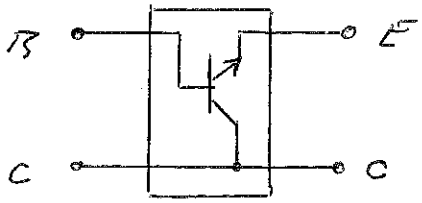
$$g_m = \frac{I_C}{V_T}$$

$$g_o = \frac{I_C}{V_A}$$

$$h_{11e} \cong \frac{\beta}{g_m} \qquad h_{12e} \cong 0$$

$$h_{21e} = \beta \qquad h_{22e} = g_o$$

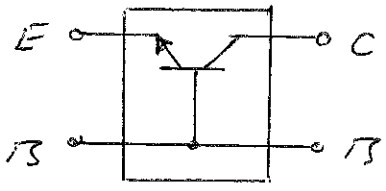
b) CC Configuration (Emitter Follower)



$$h_{11c} \cong \frac{\beta}{g_m} \qquad h_{12c} \cong 1$$

$$h_{21c} = -(1+\beta) \qquad h_{22c} = g_o$$

c) CB Configuration



$$h_{11b} \cong \frac{\alpha}{g_m} \qquad h_{12b} \cong 0$$

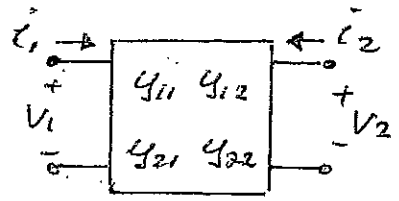
$$h_{21b} = -\alpha \qquad h_{22b} \cong \frac{g_o}{1+\beta}$$

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

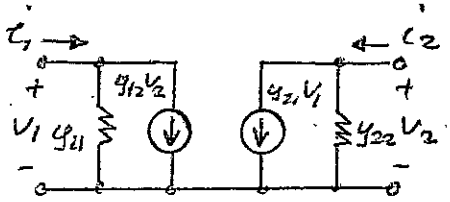
$$\begin{bmatrix} V_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \cdot \begin{bmatrix} i_1 \\ V_2 \end{bmatrix}$$

FET [Y]-Parameter Representation

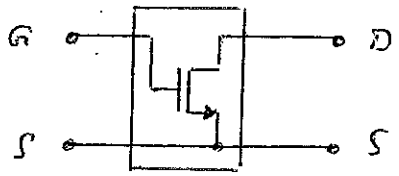
Definition



$$i_1 = y_{11} V_1 + y_{12} V_2$$
$$i_2 = y_{21} V_1 + y_{22} V_2$$



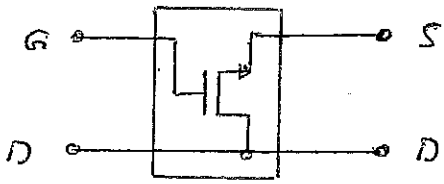
a) CS Configuration



$$y_{11_S} \cong 0 \qquad y_{12_S} \cong 0$$
$$y_{21_S} = g_m \qquad y_{22_S} = g_o$$

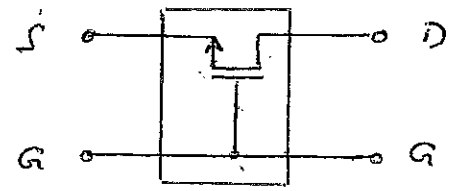
MOSFET $\quad g_m = \sqrt{2\mu C_{ox} \frac{W}{L} I_D}\,; \quad g_o = \lambda I_D$

b) CD Configuration (Source Follower)



$$y_{11_d} \cong 0 \qquad y_{12_d} \cong 0$$
$$y_{21_d} \cong -g_m \qquad y_{22_d} \cong g_m + g_o$$

c) CG Configuration



$$y_{11_g} = g_m + g_o \qquad y_{12_g} = -g_o$$
$$y_{21_g} = -g_m - g_o \qquad y_{22_g} = g_o$$

Note: typically $g_m \gg g_o$