$$G = \begin{bmatrix} g_{11} & g_{12} \\ g_{21} & g_{22} \end{bmatrix}$$

$$\begin{cases} I_1 = g_{11} V_1 + g_{12} I_2 \\ V_2 = g_{21} V_1 + g_{22} I_2 \end{cases}$$

$$H = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix}$$

$$\begin{cases} V_1 = h_{11} I_1 + h_{12} V_2 \\ I_2 = h_{21} I_1 + h_{22} V_2 \end{cases}$$

$$ABCD = \begin{bmatrix} A & B \\ C & D \end{bmatrix}$$

$$\begin{cases} V_1 = A V_2 - B I_2 \\ I_1 = C V_2 - D I_2 \end{cases}$$

**(2) $ABCD \rightarrow G$**

$$g_{11} = \frac{I_1}{V_1}\Big|_{I_2=0}$$

$$g_{12} = \frac{I_1}{I_2}\Big|_{V_1=0}$$

$$g_{21} = \frac{V_2}{V_1}\Big|_{I_2=0}$$

$$g_{22} = \frac{V_2}{I_2}\Big|_{V_1=0}$$

$\Rightarrow$ for $I_2=0$: $\begin{cases} V_1 = A V_2 \\ I_1 = C V_2 \end{cases}$ $\Rightarrow$ $g_{11} = \frac{I_1}{V_1}\Big|_{I_2=0} = \frac{C V_2}{A V_2} = \frac{C}{A}$

$$g_{21} = \frac{V_2}{V_1}\Big|_{I_2=0} = \frac{V_2}{A V_2} = \frac{1}{A}$$

$\Rightarrow$ for $V_1=0$: $A V_2 = B I_2$

$$g_{22} = \frac{V_2}{I_2}\Big|_{V_1=0} = \frac{B}{A}$$

$$g_{12} = \frac{I_1}{I_2}\Big|_{V_1=0} = \frac{C V_2 - D I_2}{I_2} = \frac{C(\frac{B}{A} I_2 - D I_2)}{I_2} = \frac{BC - AD}{A}$$

$$\Rightarrow G = \begin{bmatrix} \frac{C}{A} & \frac{BC-AD}{A} \\ \frac{1}{A} & \frac{B}{A} \end{bmatrix}$$

**(1) $ABCD \rightarrow H$**

$$h_{11} = \frac{V_1}{I_1}\Big|_{V_2=0}$$

$$h_{12} = \frac{V_1}{V_2}\Big|_{I_1=0}$$

$$h_{21} = \frac{I_2}{I_1}\Big|_{V_2=0}$$

$$h_{22} = \frac{I_2}{V_2}\Big|_{I_1=0}$$

$$\begin{cases} V_1 = A V_2 - B I_2 \\ I_1 = C V_2 - D I_2 \end{cases}$$

$\Rightarrow$ for $V_2=0$: $\begin{cases} V_1 = -B I_2 \\ I_1 = -D I_2 \end{cases}$ $\Rightarrow$ $h_{11} = \frac{V_1}{I_1}\Big|_{V_2=0} = \frac{-B I_2}{-D I_2} = \frac{B}{D}$

$$h_{21} = \frac{I_2}{I_1}\Big|_{V_2=0} = \frac{I_2}{-D I_2} = -\frac{1}{D}$$

$\Rightarrow$ for $I_1=0$: $C V_2 - D I_2 = 0$

$$\Rightarrow h_{22} = \frac{I_2}{V_2}\Big|_{I_1=0} = \frac{C}{D}$$

$$h_{12} = \frac{V_1}{V_2}\Big|_{I_1=0} = \frac{A V_2 - B I_2}{V_2} = \frac{A V_2 - B(\frac{C}{D}) V_2}{V_2} = \frac{AD - BC}{D}$$

$$\Rightarrow H = \begin{bmatrix} \frac{B}{D} & \frac{AD-BC}{D} \\ -\frac{1}{D} & \frac{C}{D} \end{bmatrix}$$