Hybrid (H) Parameter

- The third possible set of parameters is known as hybrid parameters or h-parameters.
- The input and output terminal current and voltage can be presented as follow:

$$(V_1, I_2) = f(I_1, V_2)$$

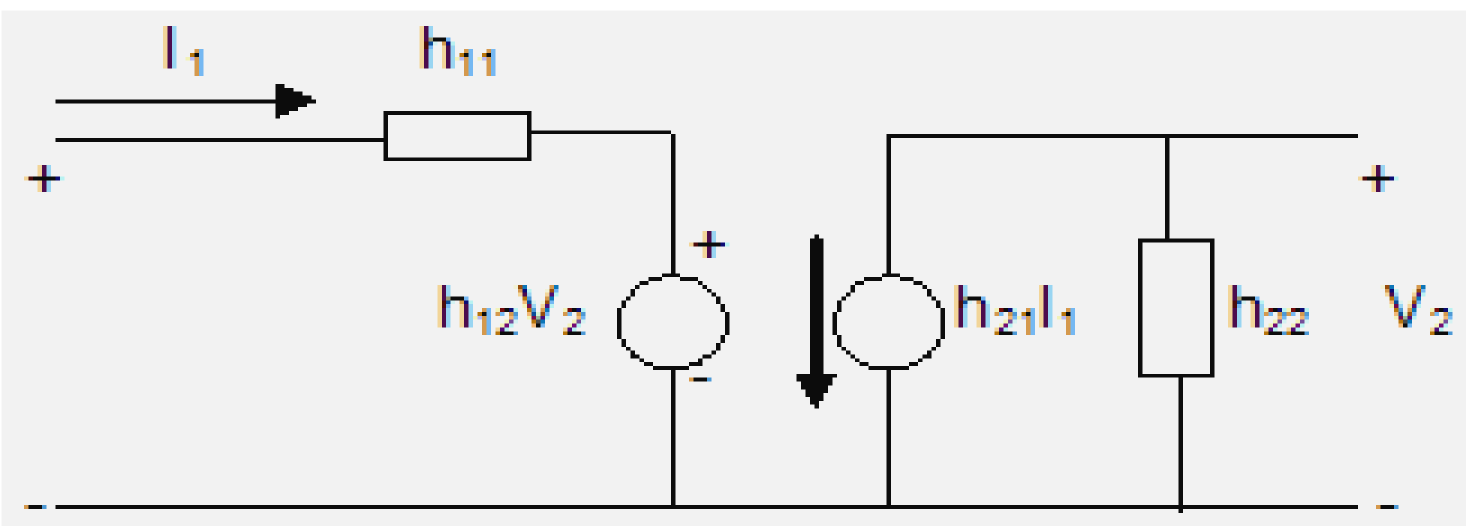
$$\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ V_2 \end{bmatrix}$$

$$V_1 = h_{11} I_1 + h_{12} V_2$$

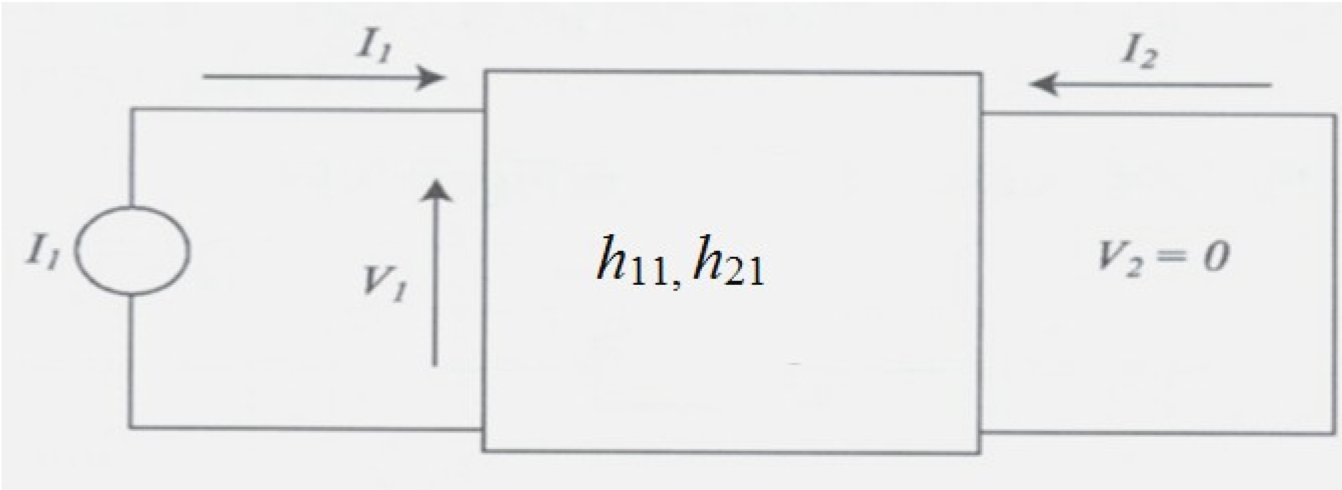
$$I_2 = h_{21} I_1 + h_{22} V_2$$

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

These parameters are very useful in analyzing the transistor compare to the z-parameters and y-parameters.



Case –I Assuming the output of the two port to be short circuit, V_2 =0



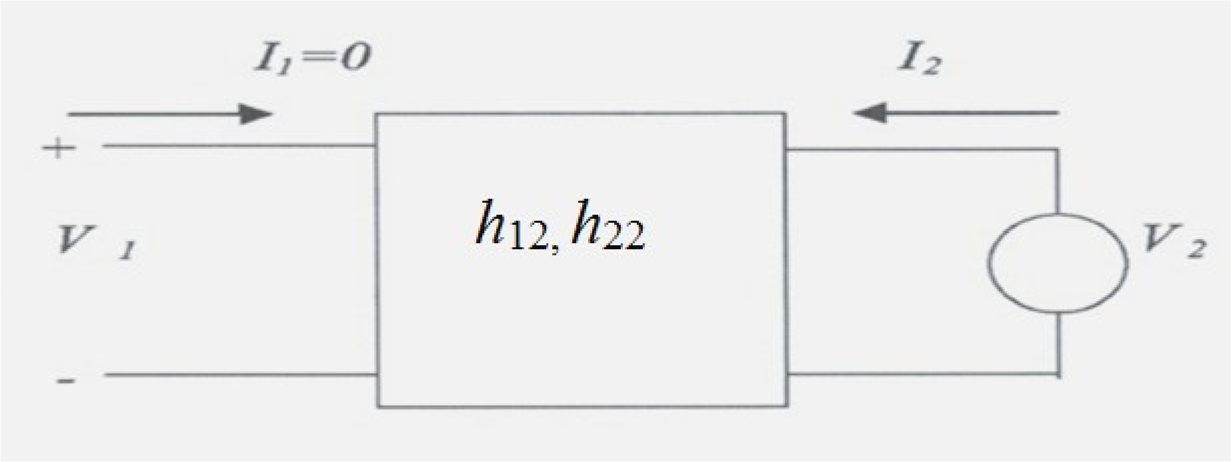
$$h_{11} = \left.\frac{V_1}{I_1}\right|_{V_2=0}$$

short circuit input impedance

$$h_{21} = \left.\frac{I_2}{I_1}\right|_{V_2=0}$$

short circuit forward current gain

Case –II Assuming the input of the same two port to be open circuit, $I_1 = 0$



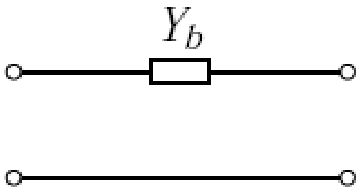
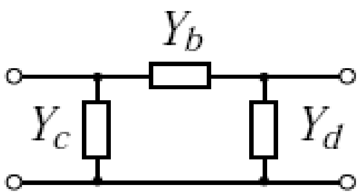
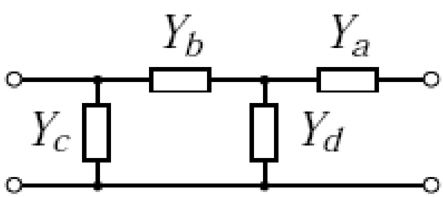
$$h_{12} = \left. \frac{V_1}{V_2} \right|_{I_1=0}$$

open circuit reverse voltage gain

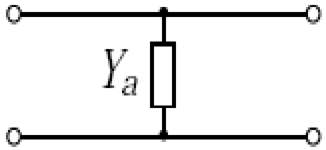
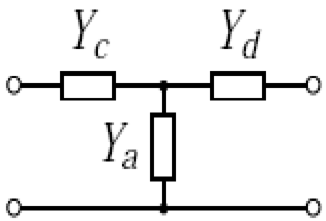
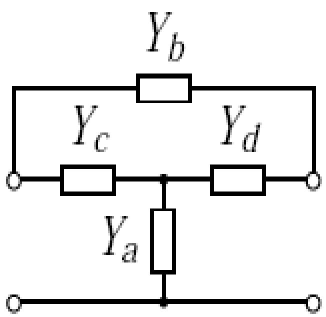
$$h_{22} = \left. \frac{I_2}{V_2} \right|_{I_1=0}$$

open circuit output admittance

Circuit based on π network

	Y	**A**
	$Y_b\begin{bmatrix}1 & -1\\ -1 & 1\end{bmatrix}$	$\begin{bmatrix}1 & \frac{1}{Y_b}\\ 0 & 1\end{bmatrix}$
	$\begin{bmatrix}Y_c & 0\\ 0 & Y_d\end{bmatrix}$	does not exist
	$\begin{bmatrix}Y_b+Y_c & -Y_b\\ -Y_b & Y_b+Y_d\end{bmatrix}$	$\frac{1}{Y_b}\begin{bmatrix}Y_b+Y_d & 1\\ Y_bY_c+Y_bY_d+Y_cY_d & Y_b+Y_c\end{bmatrix}$
	$\frac{1}{Y_a+Y_b+Y_d}\begin{bmatrix}(Y_b+Y_c)(Y_a+Y_d)+Y_bY_c & -Y_aY_b\\ -Y_aY_b & Y_a(Y_b+Y_d)\end{bmatrix}$	$\frac{1}{Y_aY_b}\begin{bmatrix}Y_a(Y_b+Y_d) & Y_a+Y_b+Y_d\\ Y_a(Y_bY_c+Y_bY_d+Y_cY_d) & (Y_b+Y_c)(Y_a+Y_d)+Y_bY_c\end{bmatrix}$

Circuit based on T network

	Y	A
	does not exist	$\begin{bmatrix} 1 & 0 \\ Y_a & 1 \end{bmatrix}$
	$\dfrac{1}{Y_a+Y_c+Y_d}\begin{bmatrix} Y_c(Y_a+Y_d) & -Y_cY_d \\ -Y_cY_d & Y_d(Y_a+Y_c) \end{bmatrix}$	$\dfrac{1}{Y_cY_d}\begin{bmatrix} Y_d(Y_a+Y_c) & Y_a+Y_c+Y_d \\ Y_aY_cY_d & Y_c(Y_a+Y_d) \end{bmatrix}$
	$\dfrac{1}{Y_a+Y_c+Y_d}\begin{bmatrix} (Y_c+Y_b)(Y_a+Y_d)+Y_bY_c & -Y_b(Y_a+Y_c+Y_d)-Y_cY_d \\ -Y_b(Y_a+Y_c+Y_d)-Y_cY_d & (Y_a+Y_c)(Y_b+Y_d)+Y_bY_d \end{bmatrix}$	$\dfrac{1}{Y_b(Y_a+Y_c+Y_d)+Y_cY_d}\begin{bmatrix} (Y_a+Y_c)(Y_b+Y_d)+Y_bY_d & Y_a+Y_c+Y_d \\ Y_a(Y_bY_c+Y_bY_d+Y_cY_d) & (Y_b+Y_c)(Y_a+Y_d)+Y_bY_c \end{bmatrix}$

Y - Parameters into A.BCD parameters

[Y] $(I_1, I_2) = f(V_1, V_2)$

$$[I] = [Y][V]$$

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

$$I_1 = Y_{11}V_1 + Y_{12}V_2 \quad \text{— (1)}$$

$$I_2 = Y_{21}V_1 + Y_{22}V_2 \quad \text{— (2)}$$

[T] or [ABCD] $(V_1, I_1) = f(V_2, -I_2)$

$$V_1 = AV_2 + B(-I_2) \quad \text{— (3)}$$

$$I_1 = CV_2 + D(-I_2) \quad \text{— (4)}$$

Aim is to express A, B, C, D in terms of Y_{11}, Y_{12}, Y_{21} & Y_{22}

Convert 1 & 2 in term of 3 & 4

Equation 2 can be written as

$$V_1 = -\frac{Y_{22}}{Y_{21}} V_2 + \frac{1}{Y_{21}} I_2$$

or $$V_1 = -\frac{Y_{22}}{Y_{21}} V_2 - \frac{1}{Y_{21}}(-I_2) \quad \text{---} (5)$$

Comparing with eq (3) we have

$$\boxed{A = -\frac{Y_{22}}{Y_{21}}} \quad \& \quad \boxed{B = -\frac{1}{Y_{21}}}$$

By eliminating V_1 between eq ① & ② we get

$$I_1 = -\frac{Y_{11}Y_{22} - Y_{12}Y_{21}}{Y_{21}} V_2 - \frac{Y_{11}}{Y_{21}}(-I_2) \text{ --- ⑥}$$

By comparing it with eq (4) we have

$$\boxed{C = -\frac{Y_{11}Y_{22} - Y_{12}Y_{21}}{Y_{21}}} \quad \& \quad \boxed{D = -\frac{Y_{11}}{Y_{21}}}$$

Similarly we can get [Y] in terms of [A B C D]

RELATIONSHIPS BETWEEN PARAMETER SETS (Contd)

'Z' parameters in terms of 'Y' parameters

$$(V_1, V_2) = f(I_1, I_2)$$

$$\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$$

$$[V] = [Z][I]$$

$$V_1 = Z_{11} I_1 + Z_{12} I_2 \quad \text{— (1)}$$

$$V_2 = Z_{21} I_1 + Z_{22} I_2 \quad \text{— (2)}$$

$$(I_1, I_2) = f(V_1, V_2)$$

$$\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \end{bmatrix}$$

$$[I] = [Y][V]$$

$$I_1 = Y_{11} V_1 + Y_{12} V_2 \quad \text{——} \quad (3)$$

$$I_2 = Y_{21} V_1 + Y_{22} V_2 \quad \text{——} \quad (4)$$

$$[V] = [Z][I]$$

$$[I] = [Y][V]$$

$$[Z]^{-1}[V] = [Z]^{-1}[Z][I]$$

$$= [I]$$

$$[I] = [Z]^{-1}[V]$$

$$= [Y][V]$$

$$\therefore [Y] = [Z]^{-1}$$

$$\begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix} = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix}^{-1}$$

$$I = [Y][V]$$

$$[Y^{-1}][I] = [Y]^{-1}[Y][V]$$

$$[Y^{-1}][I] = [V]$$

$$[Z][I] = [V]$$

$$\therefore [Y]^{-1} = [Z]$$

$$\& \; [Z] = [Y]^{-1}$$

$$\text{or} \quad [Z] = [Y]^{-1}$$

$$\begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix} = \begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix}^{-1}$$

$$(V_1, V_2) = f(I_1, I_2)$$

$$V_1 = Z_{11} I_1 + Z_{12} I_2 \quad \text{---}(1) \quad \times Z_{22}$$

$$V_2 = Z_{21} I_1 + Z_{22} I_2 \quad \text{---}(2) \quad \times Z_{12}$$

$$V_1 Z_{22} = Z_{11} Z_{22} I_1 + Z_{12} Z_{22} I_2$$

$$V_2 Z_{12} = Z_{21} Z_{12} I_1 + Z_{12} Z_{22} I_2$$

$$V_1 Z_{22} - V_2 Z_{12} = I_1 (Z_{11} Z_{22} - Z_{21} Z_{12})$$

$$I_1 = \frac{Z_{22}}{Z_{11} Z_{22} - Z_{12} Z_{21}} V_1 - \frac{Z_{12}}{Z_{11} Z_{22} - Z_{12} Z_{21}} V_2$$

$$I_1 = \frac{Z_{22}}{\Delta Z} V_1 + \frac{-Z_{12}}{\Delta Z} V_2$$

Comparing with eq (3)

$$I_1 = Y_{11} V_1 + Y_{12} V_2$$

$$(I_1, I_2) = f(V_1, V_2)$$

$$I_1 = Y_{11} V_1 + Y_{12} V_2 \quad \text{---}(3)$$

$$I_2 = Y_{21} V_1 + Y_{22} V_2 \quad \text{---}(4)$$

we have

$$Y_{11} = \frac{Z_{22}}{\Delta Z} \quad \text{where } \Delta Z = Z_{11}Z_{22} - Z_{12}Z_{21}$$

$$Y_{12} = -\frac{Z_{12}}{\Delta Z}$$

Similarly by eliminating I_1 between (I) & (II) we get

$$Y_{21} = -\frac{Z_{21}}{\Delta Z}$$

$$Y_{22} = \frac{Z_{22}}{\Delta Z}$$

$$\begin{bmatrix} Y_{11} & Y_{12} \\ Y_{21} & Y_{22} \end{bmatrix} = \begin{bmatrix} \frac{Z_{11}}{\Delta Z} & -\frac{Z_{12}}{\Delta Z} \\ -\frac{Z_{21}}{\Delta Z} & \frac{Z_{22}}{\Delta Z} \end{bmatrix} \text{ or } [Y] = \frac{1}{\Delta Z}\begin{bmatrix} Z_{11} & -Z_{12} \\ -Z_{21} & Z_{22} \end{bmatrix}$$

$$\text{or } [Y] = [Z]^{-1}$$

$$b_{21} = \frac{1}{z_{12}} = -\frac{\Delta y}{y_{12}} = \frac{a_{21}}{\Delta a} = \frac{h_{22}}{h_{12}} = -\frac{g_{11}}{g_{12}}$$

$$b_{22} = \frac{z_{11}}{z_{12}} = \frac{y_{22}}{y_{12}} = \frac{a_{11}}{\Delta a} = \frac{\Delta h}{h_{12}} = -\frac{1}{g_{12}}$$

$$h_{11} = \frac{\Delta z}{z_{22}} = \frac{1}{y_{11}} = \frac{a_{12}}{a_{22}} = \frac{b_{12}}{b_{11}} = \frac{g_{22}}{\Delta g}$$

$$h_{12} = \frac{z_{12}}{z_{22}} = -\frac{y_{12}}{y_{11}} = \frac{\Delta a}{a_{22}} = \frac{1}{b_{11}} = -\frac{g_{12}}{\Delta g}$$

$$h_{21} = -\frac{z_{21}}{z_{22}} = \frac{y_{21}}{y_{11}} = -\frac{1}{a_{22}} = -\frac{\Delta b}{b_{11}} = -\frac{g_{21}}{\Delta g}$$

$$h_{22} = \frac{1}{z_{22}} = \frac{\Delta y}{y_{11}} = \frac{a_{21}}{a_{22}} = \frac{b_{21}}{b_{11}} = \frac{g_{11}}{\Delta g}$$

$$g_{11} = \frac{1}{z_{11}} = \frac{\Delta y}{y_{22}} = \frac{a_{21}}{a_{11}} = \frac{b_{21}}{b_{22}} = \frac{h_{22}}{\Delta h}$$

$$g_{12} = -\frac{z_{12}}{z_{11}} = \frac{y_{12}}{y_{22}} = -\frac{\Delta a}{a_{11}} = -\frac{1}{b_{22}} = -\frac{h_{12}}{\Delta h}$$

$$g_{21} = \frac{z_{21}}{z_{11}} = -\frac{y_{21}}{y_{22}} = \frac{1}{a_{11}} = \frac{\Delta b}{b_{22}} = -\frac{h_{21}}{\Delta h}$$

$$g_{22} = \frac{\Delta z}{z_{11}} = \frac{1}{y_{22}} = \frac{a_{12}}{a_{11}} = \frac{b_{12}}{b_{22}} = \frac{h_{11}}{\Delta h}$$

$$\Delta z = z_{11}z_{22} - z_{12}z_{21}$$

$$\Delta y = y_{11}y_{22} - y_{12}y_{21}$$

$$\Delta a = a_{11}a_{22} - a_{12}a_{21}$$

$$\Delta b = b_{11}b_{22} - b_{12}b_{21}$$

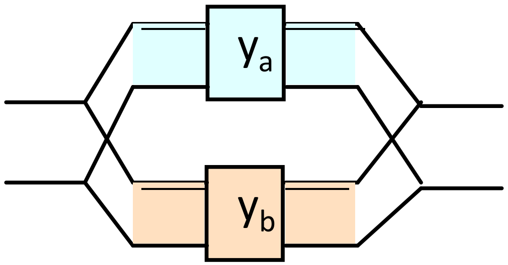
$$\Delta h = h_{11}h_{22} - h_{12}h_{21}$$

$$\Delta g = g_{11}g_{22} - g_{12}g_{21}$$

INTERCONNECTION OF TWO-PORT NETWORKS

Three ways that two ports are interconnected:

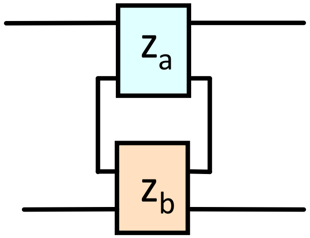
* Parallel



Y parameters

$$[y] = [y_a] + [y_b]$$

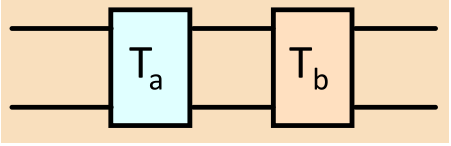
* Series



Z parameters

$$[z] = [z_a] + [z_b]$$

* Cascade

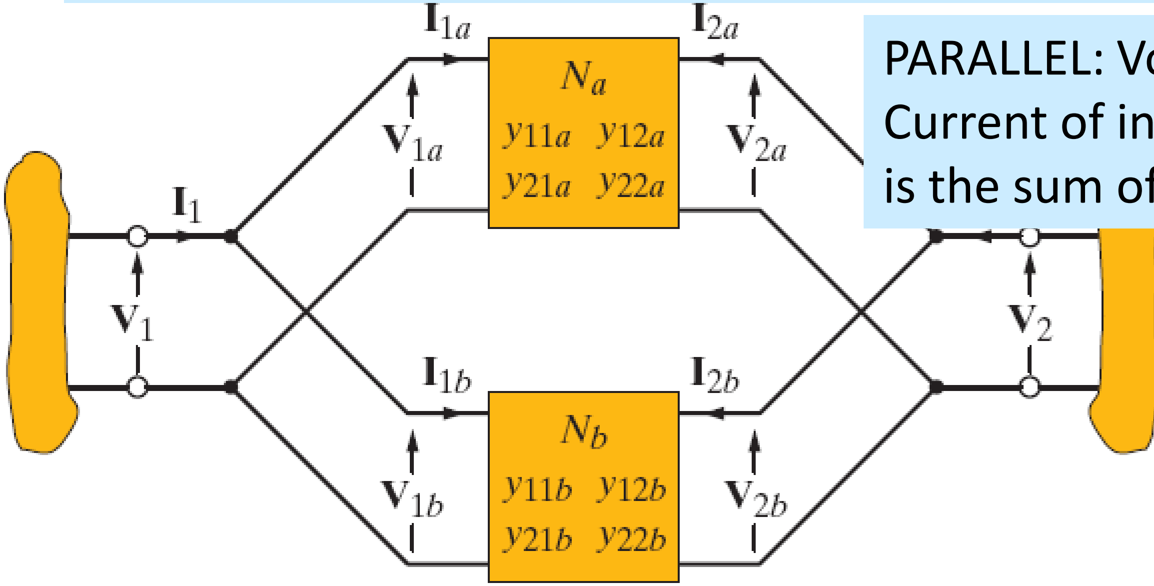


ABCD parameters

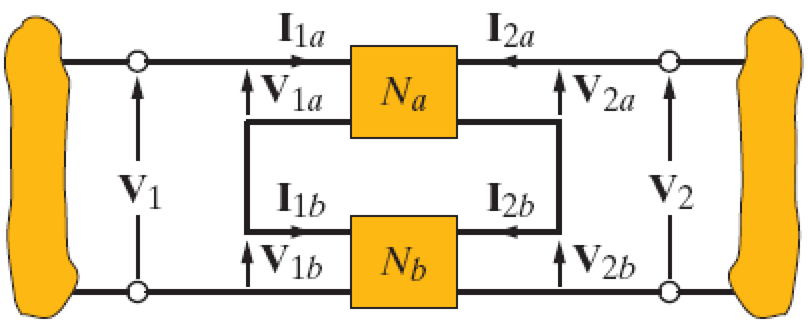
$$[T] = [T_a]\,[T_b]$$

Interconnections permit the description of complex systems in terms of simpler components or subsystems

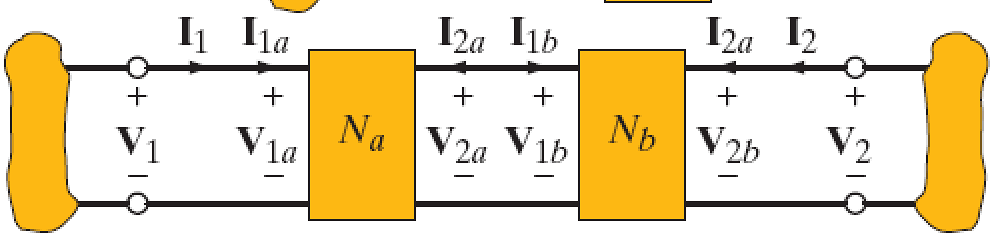
The basic interconnections to be considered are: *parallel, series and cascade*



PARALLEL: Voltages are the same.
Current of interconnection
is the sum of currents

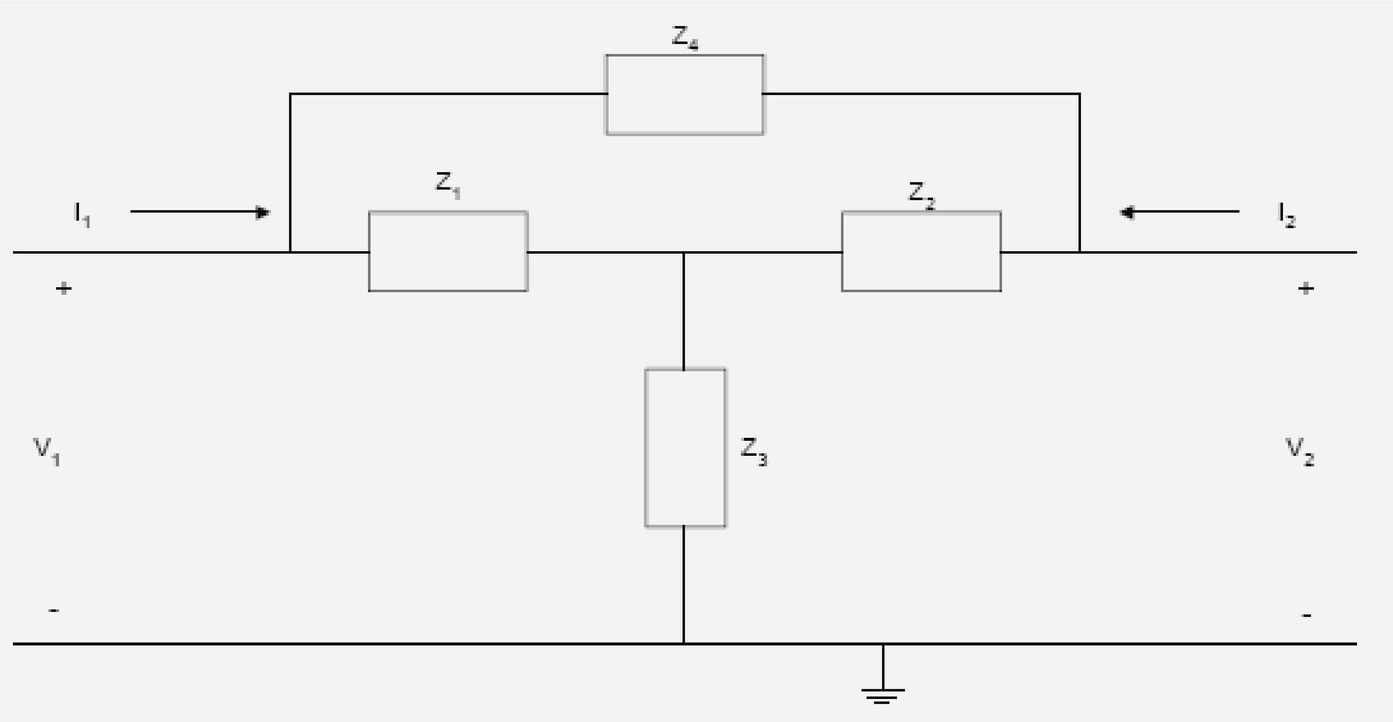


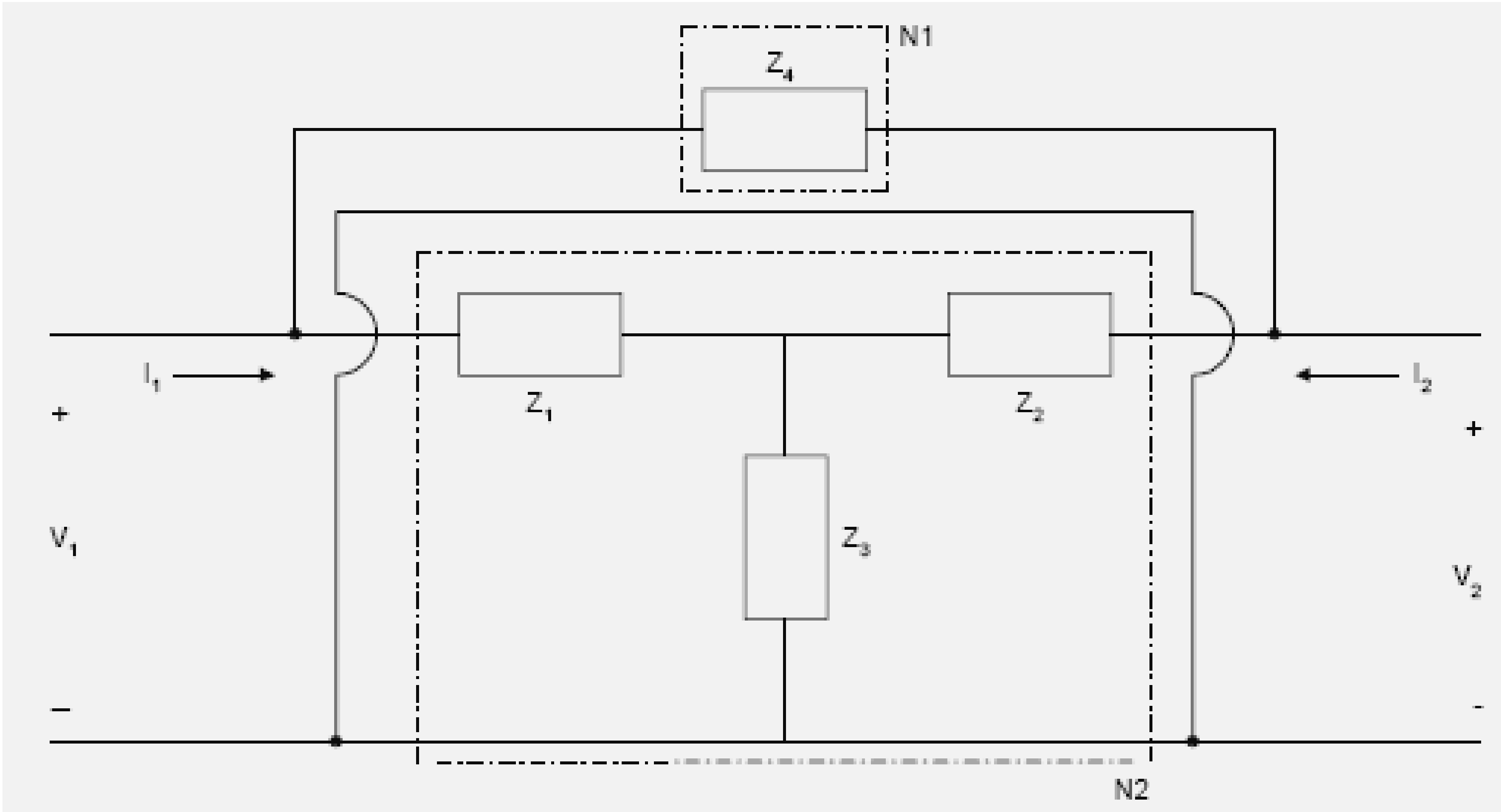
SERIES: Currents are the same.
Voltage of interconnection is the sum
of voltages



CASCADE:
Output of first subsystem
acts as input for the
second

Find the equivalent y-parameters for the bridge T-network





the z-parameters of network N2 are

$$[Z] = \begin{bmatrix} Z_1 + Z_3 & Z_3 \\ Z_3 & Z_2 + Z_3 \end{bmatrix}$$

We can convert the z-parameters to y-parameters

$$y_{11} = \frac{Z_2 + Z_3}{Z_1Z_2 + Z_1Z_3 + Z_2Z_3}$$

$$y_{12} = \frac{-Z_3}{Z_1Z_2 + Z_1Z_3 + Z_2Z_3}$$

$$y_{21} = \frac{-Z_3}{Z_1Z_2 + Z_1Z_3 + Z_2Z_3}$$

$$y_{22} = -\frac{Z_1 + Z_3}{Z_1Z_2 + Z_1Z_3 + Z_2Z_3}$$

$$y_{11} = \frac{1}{Z_4}$$

$$y_{12} = -\frac{1}{Z_4}$$

$$y_{21} = -\frac{1}{Z_4}$$

$$y_{22} = \frac{1}{Z_4}$$

$$y_{11eq} = \frac{1}{Z_4} + \frac{Z_2 + Z_3}{Z_1Z_2 + Z_1Z_3 + Z_2Z_3}$$

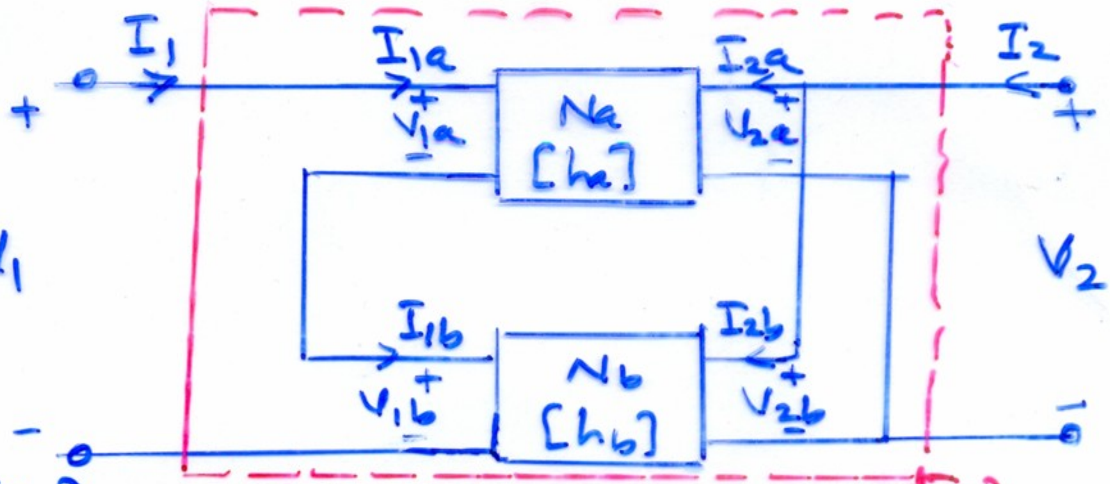
$$y_{12eq} = -\frac{1}{Z_4} - \frac{Z_3}{Z_1Z_2 + Z_1Z_3 + Z_2Z_3}$$

$$y_{21eq} = -\frac{1}{Z_4} - \frac{Z_3}{Z_1Z_2 + Z_1Z_3 + Z_2Z_3}$$

$$y_{22eq} = \frac{1}{Z_4} + \frac{Z_1 + Z_3}{Z_1Z_2 + Z_1Z_3 + Z_2Z_3}$$

SERIES PARALLEL CONNECTION

I/P ports are in Series
O/P Ports are in Parallel



Series - Parallel Connection of Two two-port Networks

$$I_1 = I_{1a} = I_{1b}$$
$$V_1 = V_{1a} + V_{1b}$$
$$V_2 = V_{2a} = V_{2b}$$
$$I_2 = I_{2a} + I_{2b}$$

$$\begin{bmatrix} V_{1b} \\ I_{2b} \end{bmatrix} = \begin{bmatrix} h_{11b} & h_{12b} \\ h_{21b} & h_{22b} \end{bmatrix} \begin{bmatrix} I_{1b} \\ V_{2b} \end{bmatrix}$$

and $$\begin{bmatrix} V_{1a} \\ I_{2a} \end{bmatrix} = \begin{bmatrix} h_{11a} & h_{12a} \\ h_{21a} & h_{22a} \end{bmatrix} \begin{bmatrix} I_{1a} \\ V_{2a} \end{bmatrix}$$

$$\begin{bmatrix} V_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} V_{1a} \\ I_{2a} \end{bmatrix} + \begin{bmatrix} V_{1b} \\ I_{2b} \end{bmatrix} = \begin{bmatrix} h_{11a} & h_{12a} \\ h_{21a} & h_{22a} \end{bmatrix} \begin{bmatrix} I_{1a} \\ V_{2a} \end{bmatrix} + \begin{bmatrix} h_{11b} & h_{12b} \\ h_{21b} & h_{22b} \end{bmatrix} \begin{bmatrix} I_{1b} \\ V_{2b} \end{bmatrix}$$

$$= \begin{bmatrix} h_{11a} & h_{12a} \\ h_{21a} & h_{22a} \end{bmatrix} \begin{bmatrix} I_1 \\ V_2 \end{bmatrix} + \begin{bmatrix} h_{11b} & h_{12b} \\ h_{21b} & h_{22b} \end{bmatrix} \begin{bmatrix} I_1 \\ V_2 \end{bmatrix}$$

$$= \left(\begin{bmatrix} h_{11a} & h_{12a} \\ h_{21a} & h_{22a} \end{bmatrix} + \begin{bmatrix} h_{11b} & h_{12b} \\ h_{21b} & h_{22b} \end{bmatrix} \right) \begin{bmatrix} I_1 \\ V_2 \end{bmatrix}$$

$$= \begin{bmatrix} h_{11a}+h_{11b} & h_{12a}+h_{12b} \\ h_{21a}+h_{21b} & h_{22a}+h_{22b} \end{bmatrix} \begin{bmatrix} I_1 \\ V_2 \end{bmatrix}$$

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

$h_{11} = h_{11a} + h_{11b}$

$h_{12} = h_{12a} + h_{12b}$

$h_{21a} = h_{21a} + h_{21b}$

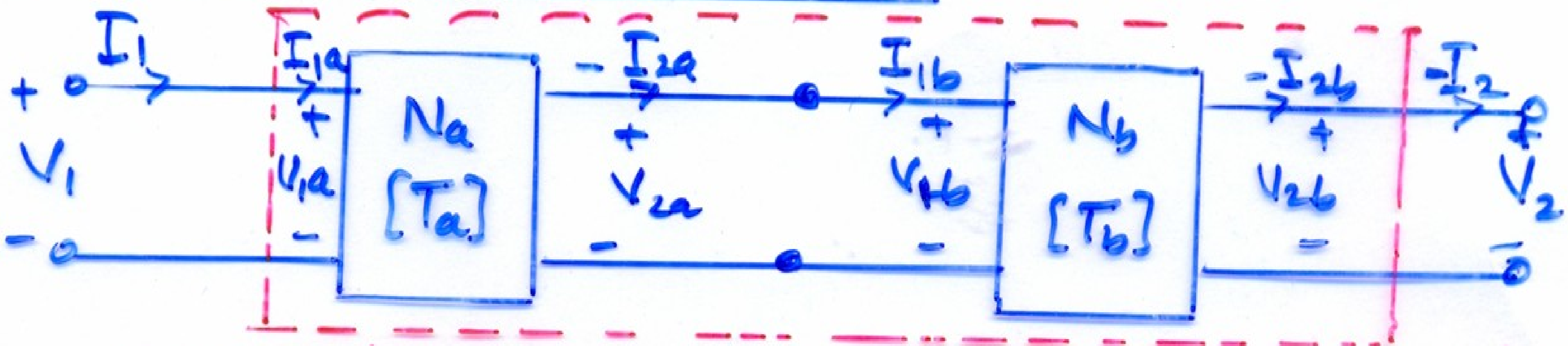
$h_{22} = h_{22a} + h_{22b}$

The overall h-parameter matrix for Series parallel Connected two port networks is simply the sum of h-parameter matrices of each individual two-port network connected in Series parallel.

Parallel-Series $[g] = [g_a] + [g_b]$

* Series-Series or Series $[Z] = [Z_a] + [Z_b]$
* Parallel-Parallel or Parallel $[Y] = [Y_a] + [Y_b]$
* Cascade or Tandem $[T] = [T_a] \times [T_b]$

CASCADE CONNECTIONS



Cascade Connection of Two 2-port Networks

output port of one becomes the input port of the second.

$$\begin{bmatrix} V_{1a} \\ I_{1a} \end{bmatrix} = \begin{bmatrix} A_a & B_a \\ C_a & D_a \end{bmatrix} \begin{bmatrix} V_{2a} \\ -I_{2a} \end{bmatrix} \quad \& \quad \begin{bmatrix} V_{1b} \\ I_{1b} \end{bmatrix} = \begin{bmatrix} A_b & B_b \\ C_b & D_b \end{bmatrix} \begin{bmatrix} V_{2b} \\ -I_{2b} \end{bmatrix}$$

now $\quad I_1 = I_{1a} \qquad -I_{2a} = I_{1b} \qquad I_{2b} = I_2$

$\qquad V_1 = V_{1a} \qquad V_{2a} = V_{1b} \qquad V_{2b} = V_2$

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} V_{1a} \\ I_{1a} \end{bmatrix} = \begin{bmatrix} A_a & B_a \\ C_a & D_a \end{bmatrix} \begin{bmatrix} V_{2a} \\ -I_{2a} \end{bmatrix} = \begin{bmatrix} A_a & B_a \\ C_a & D_a \end{bmatrix} \begin{bmatrix} V_{1b} \\ I_{1b} \end{bmatrix}$$

$$= \begin{bmatrix} A_a & B_a \\ C_a & D_a \end{bmatrix} \begin{bmatrix} A_b & B_b \\ C_b & D_b \end{bmatrix} \begin{bmatrix} V_{2b} \\ -I_{2b} \end{bmatrix}$$

$$= \begin{bmatrix} A_a & B_a \\ C_a & D_a \end{bmatrix} \begin{bmatrix} A_b & B_b \\ C_b & D_b \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$

$$= \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ -I_2 \end{bmatrix}$$

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} A_a & B_a \\ C_a & D_a \end{bmatrix} \begin{bmatrix} A_b & B_b \\ C_b & D_b \end{bmatrix}$$

$$A = A_a A_b + B_a C_b$$
$$B = A_a B_b + B_a D_b$$
$$C = C_a A_b + D_a C_b$$
$$D = C_a B_b + D_a D_b$$

or $[T] = [T_a] \times [T_b]$

The overall T-parameter matrix for cascade connected two-port networks is simply the matrix product of the T-parameter matrices of each individual two port network in cascade.

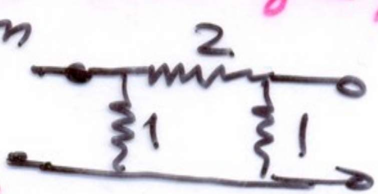
Similarly for inverse transmission T parameters

$$[T'] = [T'_b][T'_a]$$

TWO PORT PARAMETERS

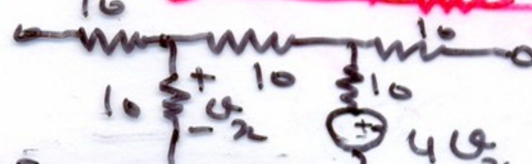
1. Find 'h' parameters in terms of Z-parameters
2. Find Y parameters in terms of Z-parameters
3. Obtain the relationship between Z-parameters & ABCD parameters
4. Two networks are connected in parallel. Find the 'Y' parameters of overall network.
5. Find ABCD parameters in terms of Z-parameters
6. Find Symmetrical & Reciprocal conditions for 'Y' parameters
7. Find ABCD parameters in terms of 'h' parameters
8. Derive equivalent parameters in terms of ABCD parameters for a Cascade Connection of 2-port n/w,

- Two identical sections of n/w shown are connected in parallel. Find 'Y' parameters of resulting n/w.



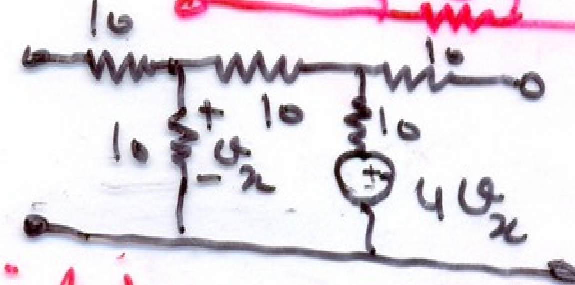
- For the n/w shown find Z-parameters

- Find Z parameters of the network shown



Z-parameters

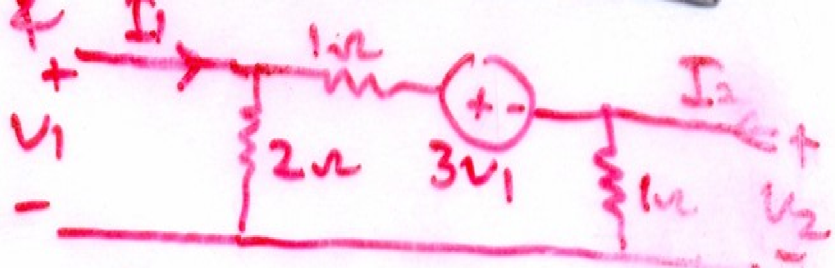
- Find Z parameters of the network shown



- For the n/w shown find hybrid parameters & transmission parameters

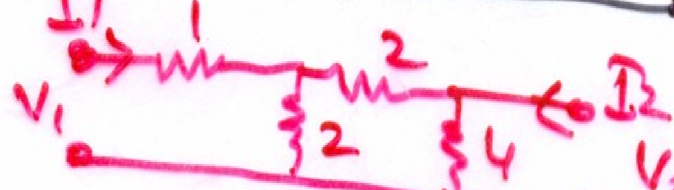
- equivalent T & Π n/ws
circuit shown

- Determine Z-parameters & Y parameters of the n/w shown.



ABCD parameters of the n/w shown

- Find Y-parameters of the n/w shown.



REVISION

- Z - parameters are also called open cct parameters (T/F)
- Y - parameters are also called Short cct parameters
- ABCD parameters are also called Transmission parameters or T-parameters (T/F) (T/F)
- $[Z] = [Y]^{-1}$ (T/F) ; $\begin{bmatrix} V_1 \\ V_2 \end{bmatrix} = [Z] \begin{bmatrix} I_1 \\ I_2 \end{bmatrix}$
- $[Y] = [Z]^{-1}$ (T/F) ;
- $\begin{bmatrix} 2, & 4 \\ 3 & 8 \end{bmatrix}^{-1} = \frac{1}{4} \begin{bmatrix} 8 & -4 \\ -3 & 2 \end{bmatrix}$ [T/F]
- $V_1 = 2 I_1 + 3 I_2$

  $V_2 = 4 I_1 + 8 I_2$

  $Z_{11} =$ $Z_{12} =$

  $Z_{22} =$ $Z_{21} =$

- $V_1 = 3V_2 + 6(-I_2)$

$I_1 = 4V_2 + 5(-I_2)$

$A =$ $B =$

$C =$ $D =$

Home work

Find out Z & Y parameters for which A, B, C, D are known above.

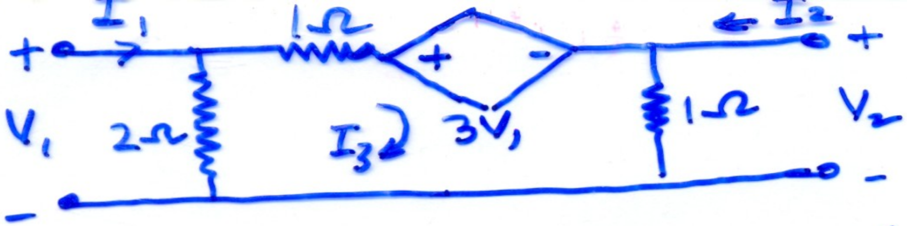
'h' or Hybrid parameters :

CONVERSION OF PARAMETERS [SUMMARY]

$\Delta x = Y_{11} Y_{22} - Y_{12} Y_{21}$

Parameter	In terms of Z	In terms of Y	In terms of T
Z	$\begin{matrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{matrix}$	$\begin{matrix} \frac{Y_{22}}{\Delta Y} & -\frac{Y_{12}}{\Delta Y} \\ -\frac{Y_{21}}{\Delta Y} & \frac{Y_{11}}{\Delta Y} \end{matrix}$	$\begin{matrix} \frac{A}{C} & \frac{\Delta T}{C} \\ \frac{1}{C} & \frac{D}{C} \end{matrix}$
Y	$\begin{matrix} \frac{Z_{22}}{\Delta Z} & -\frac{Z_{12}}{\Delta Z} \\ -\frac{Z_{21}}{\Delta Z} & \frac{Z_{11}}{\Delta Z} \end{matrix}$	$\begin{matrix} Y_{12} & Y_{22} \\ Y_{21} & Y_{22} \end{matrix}$	$\begin{matrix} \frac{D}{B} & -\frac{\Delta T}{B} \\ -\frac{1}{B} & \frac{A}{B} \end{matrix}$
T	$\begin{matrix} \frac{Z_{11}}{Z_{21}} & \frac{\Delta Z}{Z_{21}} \\ \frac{1}{Z_{21}} & \frac{Z_{22}}{Z_{21}} \end{matrix}$	$\begin{matrix} -\frac{Y_{22}}{Y_{21}} & -\frac{1}{Y_{21}} \\ -\frac{\Delta Y}{Y_{21}} & -\frac{Y_{11}}{Y_{21}} \end{matrix}$	$\begin{matrix} A & B \\ C & D \end{matrix}$

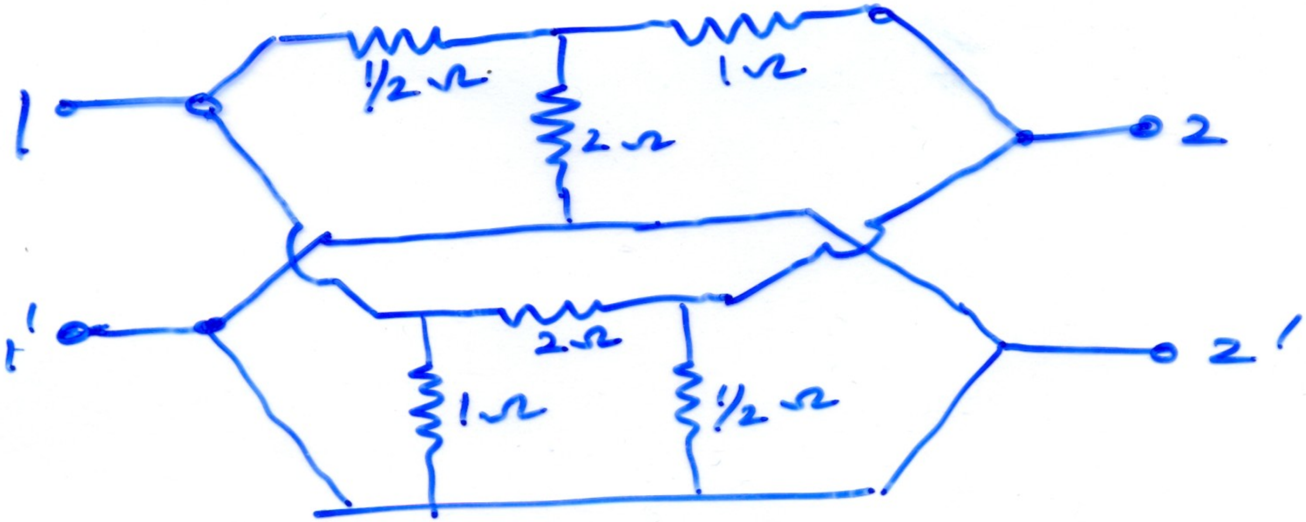
①



Apply KVL in three loops $[Y] = [Z]^{-1} = \begin{bmatrix} -\frac{3}{2} & -1 \\ 2 & 2 \end{bmatrix}$

find Y & Z parameters for above cct

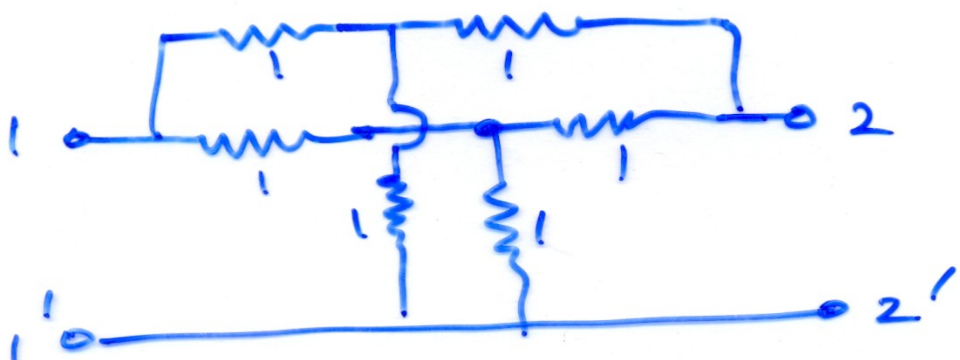
②



Connected in Parallel.

Determine Y parameters

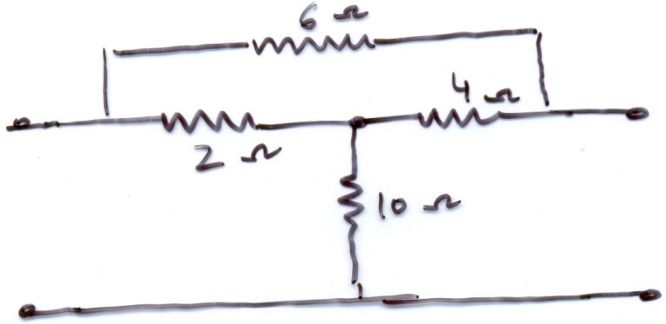
③



$Y_A = [Z_A]^{-1} = \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix}^{-1}$

$Y_A = Y_B.$

$Y = \begin{bmatrix} 4/3 & -2/3 \\ & \end{bmatrix}$



$$[Z] = \begin{bmatrix} \frac{35}{3} & \frac{32}{3} \\ \frac{32}{3} & \frac{38}{3} \end{bmatrix}$$

- Loop method
- Parallel networks
- Y-Δ conversion