

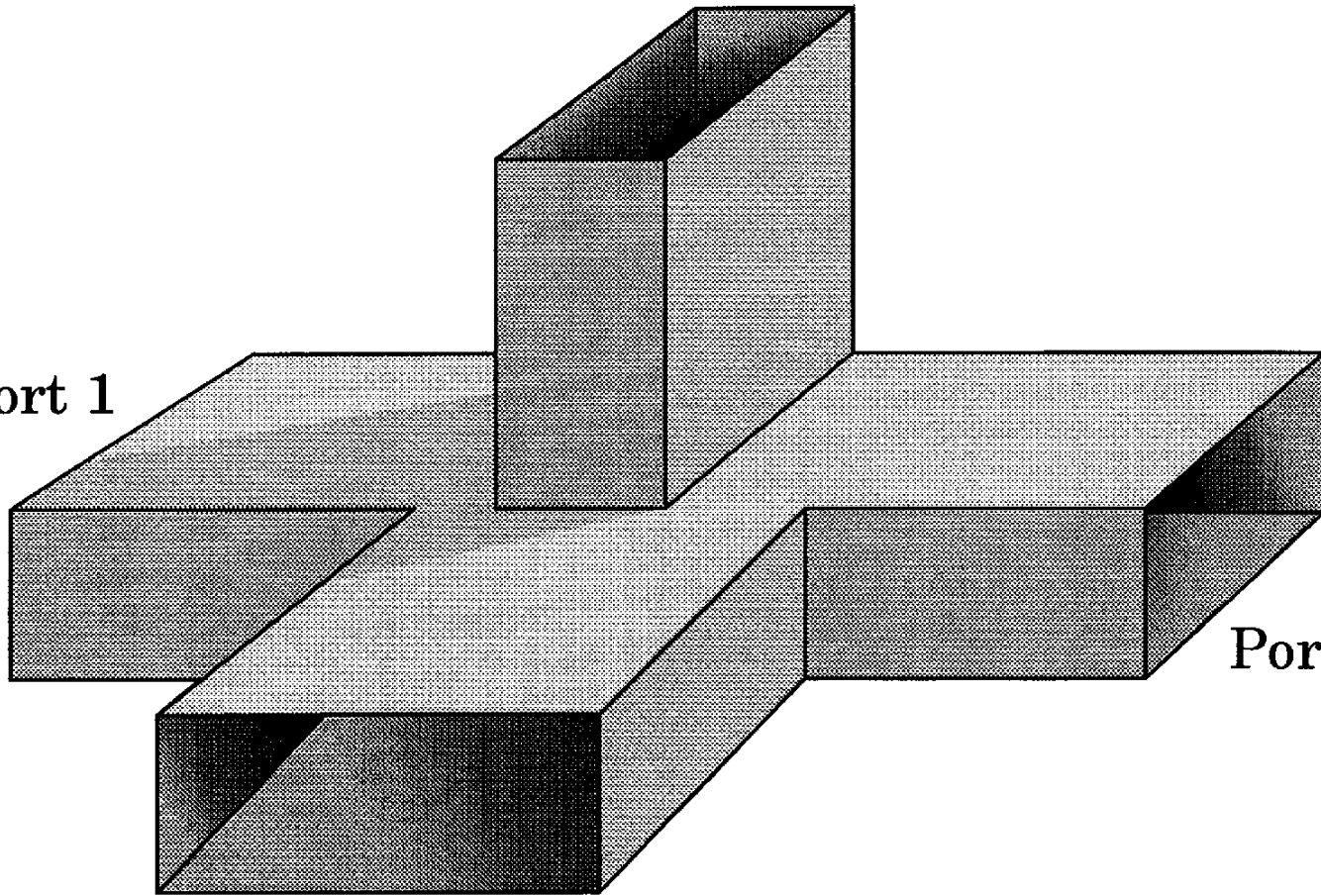
Hybrid Tee

Port 4

Port 1

Port 2

Port 3



$$\begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{21} & S_{22} & S_{23} & S_{24} \\ S_{31} & S_{32} & S_{33} & S_{34} \\ S_{41} & S_{42} & S_{43} & S_{44} \end{bmatrix}$$

$$S_{23} = S_{13}$$

$$S_{24} = -S_{14}$$

$$S_{34} = S_{43} = \mathbf{0}$$

$$\begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{12} & S_{22} & S_{13} & -S_{14} \\ S_{13} & S_{23} & \mathbf{0} & \mathbf{0} \\ S_{14} & -S_{14} & \mathbf{0} & \mathbf{0} \end{bmatrix}$$

$$\begin{bmatrix} S_{11} & S_{12} & S_{13} & S_{14} \\ S_{12} & S_{22} & S_{13} & -S_{14} \\ S_{13} & S_{23} & 0 & 0 \\ S_{14} & -S_{14} & 0 & 0 \end{bmatrix} \begin{bmatrix} S^*_{11} & S^*_{12} & S^*_{13} & S^*_{14} \\ S^*_{12} & S^*_{22} & S^*_{13} & -S^*_{14} \\ S^*_{13} & S^*_{23} & 0 & 0 \\ S^*_{14} & -S^*_{14} & 0 & 0 \end{bmatrix} =$$

$$\begin{bmatrix} 1000 \\ 0100 \\ 0010 \\ 0001 \end{bmatrix}$$

$$|\mathcal{S}_{11}|^2 + |\mathcal{S}_{12}|^2 + |\mathcal{S}_{13}|^2 + |\mathcal{S}_{14}|^2 = 1$$

$$|\mathcal{S}_{12}|^2 + |\mathcal{S}_{22}|^2 + |\mathcal{S}_{13}|^2 + |\mathcal{S}_{14}|^2 = 1$$

$$|\mathcal{S}_{13}|^2 + |\mathcal{S}_{13}|^2 = 1$$

$$|\mathcal{S}_{14}|^2 + |\mathcal{S}_{14}|^2 = 1$$

$$\mathcal{S}_{13} = \frac{1}{\sqrt{2}}$$

$$\mathcal{S}_{14} = \frac{1}{\sqrt{2}}$$

$$\mathcal{S}_{11} = \mathcal{S}_{22} = 0 = \mathcal{S}_{12}$$

$$\begin{bmatrix} 0 & 0 & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ 0 & 0 & \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 & 0 \\ \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 & 0 \end{bmatrix}$$

$$\begin{bmatrix} b_1 \\ b_2 \\ b_3 \\ b_4 \end{bmatrix} = \begin{bmatrix} 0 & 0 & \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \\ 0 & 0 & \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 & 0 \\ \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} & 0 & 0 \end{bmatrix} * \begin{bmatrix} a_1 \\ a_2 \\ a_3 \\ a_4 \end{bmatrix}$$

$$b_1 = \frac{1}{\sqrt{2}} (a_3 + a_4); b_2 = \frac{1}{\sqrt{2}} (a_3 - a_4)$$
$$b_3 = \frac{1}{\sqrt{2}} (a_1 + a_2); b_4 = \frac{1}{\sqrt{2}} (a_1 - a_2)$$

# Case 1

- $a_3 \neq 0, a_1 = a_2 = a_4 = 0$
- $B_1 = a_3/\sqrt{2}; b_2 = a_3/\sqrt{2}, b_3 = b_4 = 0$
- Property of H plane

# Case 2

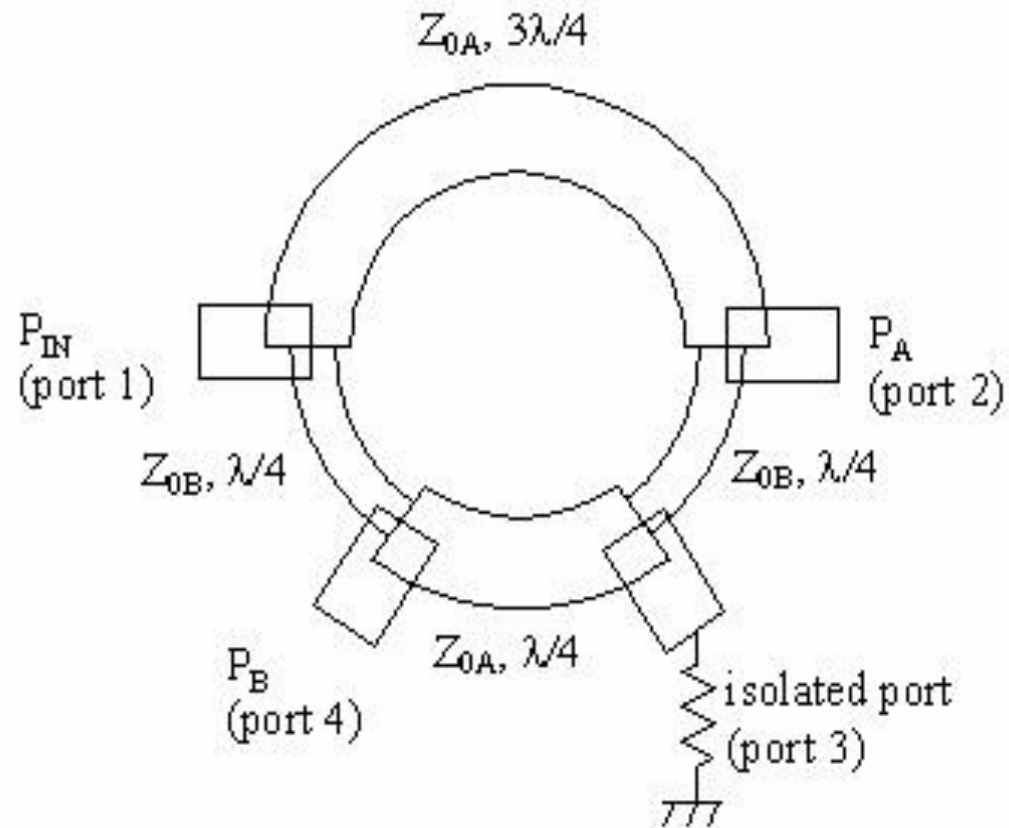
- $A_4 \neq 0, a_1 = a_2 = a_3 = 0$
- $B_1 = a_4/\sqrt{2}; b_2 = -a_4/\sqrt{2}, b_3 = b_4 = 0$
- Case 3
- $a_1 \neq 0, a_2 = a_3 = a_4 = 0$
- $B_1 = 0, b_2 = 0, b_3 = a_1/\sqrt{2}; b_4 = a_1/\sqrt{2}$
- Case 4
- $A_3 = a_4, a_1 = a_2 = 0$
- $B_1 = b_2 = b_4 = 0; b_3 = (2a_1)^{1/\sqrt{2}}$



# Application of Magic Tee

- Measurement of Impedance
- Magic Tee as duplexer
- Magic tee as a mixer

# Rat Race junction



# Rat Race Junction

$$\begin{bmatrix} 0 & S_{12} & 0 & S_{14} \\ S_{12} & 0 & S_{13} & 0 \\ 0 & S_{23} & 0 & S_{34} \\ S_{41} & 0 & S_{43} & 0 \end{bmatrix}$$