

## 2-Way Equal Power Divider

For a lossless network:

$$|S_{11}|^2 + |S_{21}|^2 + |S_{31}|^2 = 1 \quad (1)$$

$$|S_{12}|^2 + |S_{22}|^2 + |S_{32}|^2 = 1 \quad (2)$$

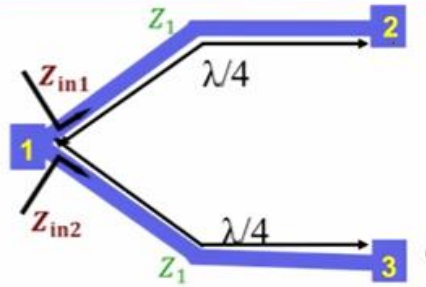
$$|S_{13}|^2 + |S_{23}|^2 + |S_{33}|^2 = 1 \quad (3)$$

For  $|S_{11}| = 0$ ,  $Z_{in} = Z_0 = 50\Omega$

$$Z_{in1} = Z_{in2} = 100\Omega; Z_{in1} = \frac{|Z_1|^2}{Z_L} \rightarrow |Z_1|^2 = Z_{in1} * Z_L \rightarrow |Z_1| = 70.7\Omega$$

For equal power division and loss-less network:

$$S_{21} = S_{31} = -\frac{j}{\sqrt{2}} = S_{12} = S_{13} \quad (4)$$



If signal transmission considered from port 1 to port 2 then path difference ( $\lambda/4$ ) causes phase difference ( $\beta * \lambda/4 = 2\pi/\lambda * \lambda/4 = \pi/2$ ) which can be replaced by 'j' and (-) sign indicates phase delay.

(0+ j1 ...90 degree)

## 2-Way Power Divider (contd.)

$$Z_{L12} = 100 || 50 = \frac{100}{3}\Omega$$

$$\rightarrow Z_{in12} = \frac{|Z_1|^2}{Z_{L12}} = \frac{(50\sqrt{2})^2}{100/3} = 150\Omega$$

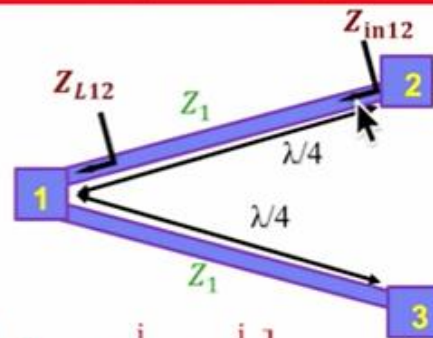
$$S_{22} = \Gamma_2 = \frac{Z_{in12} - Z_0}{Z_{in12} + Z_0} = \frac{1}{2}$$

$$S_{22} = S_{33} = 1/2$$

Using eqs. (2) and (4)

$$\rightarrow |S_{32}| = 1/2 = |S_{23}|$$

$$\rightarrow S_{32} = -1/2 = S_{23}$$

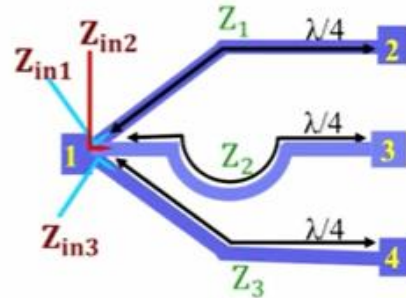
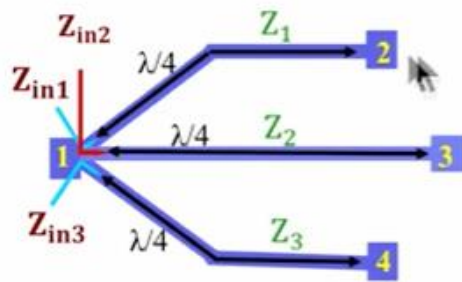


$$[S] = \begin{bmatrix} 0 & -\frac{j}{\sqrt{2}} & -\frac{j}{\sqrt{2}} \\ -\frac{j}{\sqrt{2}} & \frac{1}{2} & -\frac{1}{2} \\ -\frac{j}{\sqrt{2}} & -\frac{1}{2} & \frac{1}{2} \end{bmatrix}$$

If signal transmission considered from port 2 to port 3 then path difference ( $\lambda/4 + \lambda/4$ ) causes phase difference ( $\beta * 2\lambda/4 = 2\pi/\lambda * 2\lambda/4 = \pi$ , 180 degree) which can be replaced by '-1' and (-) sign indicates phase delay.

Good power divider but a not good power combiner.

### 3 Way Equal Power Divider



$$Z_{in1} = Z_{in2} = Z_{in3} = 150\Omega$$

$$\rightarrow Z_{in1} = \frac{|Z_1|^2}{Z_L}$$

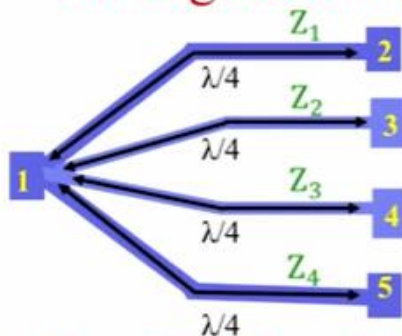
$$\rightarrow |Z_1|^2 = Z_{in1} * Z_L \Rightarrow Z_1 = 50\sqrt{3}$$

$$Z_1 = Z_2 = Z_3 = 50\sqrt{3}\Omega = 86.6\Omega$$

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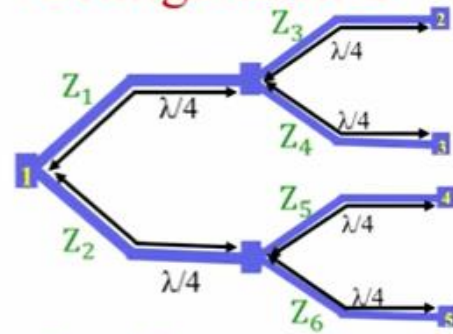
### 4-Way Power Divider

Configuration-1



$$Z_1 = Z_2 = Z_3 = Z_4 = 100\Omega$$

Configuration-2

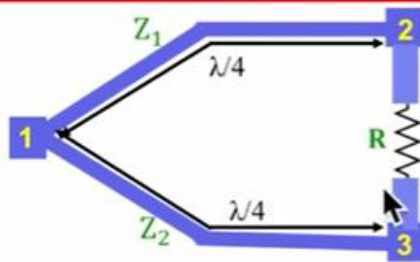


$$Z_1 = Z_2 = \dots = Z_6 = Z$$

Theoretically any value of  $Z$  can be chosen but best choice of  $Z$  is  $50\sqrt{2}\Omega = 70.7\Omega$  for broad bandwidth.



## 2-Way Equal Power Divider with Resistor



$$Z_1 = Z_2 = 50\sqrt{2} \Omega$$

R is isolation resistor and its value is calculated using even and odd mode analysis.  $R = 2Z_0 = 100\Omega$

Use of isolation resistor makes

$$S_{22} = S_{33} = S_{23} = S_{32} = 0$$

$$[S] = \begin{bmatrix} 0 & -\frac{j}{\sqrt{2}} & -\frac{j}{\sqrt{2}} \\ -\frac{j}{\sqrt{2}} & 0 & 0 \\ -\frac{j}{\sqrt{2}} & 0 & 0 \end{bmatrix}$$

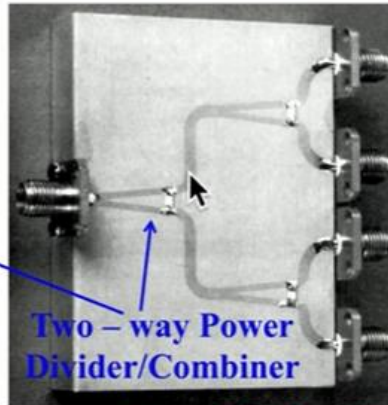
Consider input at port 2 then no output from port 3-, Reason: there are two path from port 2 and 3- one directly from 2 to 3 but practically the distance between port 2 and 3 are very loss causes 0 degree phase difference- another path 2 to 1 then 1 to 3 causes 180 degree phase difference due to  $2 * \lambda/4$  path difference- so the signal mixed are out of phase causes 0 output.

While considering power combiner donot look at the terms of S matrix isolated because while considering signal transmission between two port third is considered as matched, whereas in power combiner signal applied simultaneously in two ports- signal applied in two port should be same in phase.

# Power Divider/Combiner



Two – way  
Power Divider



Two – way Power  
Divider/Combiner

Four – way Power Divider/Combiner

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## 2-Way Unequal Power Divider

For  $|S_{11}| = 0$ ,  $Z_{in} = Z_0 = 50\Omega = Z_{in1} \parallel Z_{in2}$

$$Z_{in1} = \frac{|Z_1|^2}{Z_0} \text{ and } Z_{in2} = \frac{|Z_2|^2}{Z_0}$$

$$\rightarrow Z_1 = \sqrt{Z_{in1} * Z_0} \text{ and } Z_2 = \sqrt{Z_{in2} * Z_0}$$

$$P_1 = \frac{V_0^2}{2Z_0}; P_2 = \frac{V_0^2}{2Z_{in1}} = x P_1 = x \frac{V_0^2}{2Z_0}$$

$$\Rightarrow Z_{in1} = \frac{Z_0}{x} = \frac{Z_1^2}{Z_0} \Rightarrow Z_1 = \frac{Z_0}{\sqrt{x}}$$

$$P_3 = \frac{V_0^2}{2Z_{in2}} = (1-x)P_1 \Rightarrow Z_{in2} = \frac{Z_0}{1-x} = \frac{Z_2^2}{Z_0} \Rightarrow Z_2 = \frac{Z_0}{\sqrt{1-x}}$$

Desired:  $P_2 = 1/4 P_1$  and  $P_3 = 3/4 P_1 \Rightarrow Z_1 = 100 \Omega$  and  $Z_2 = 57.7 \Omega$

