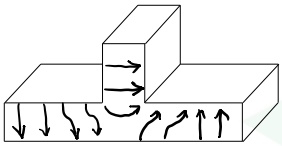
Electromagnetics:
Microwave Engineering

The T-Junction Power Divider

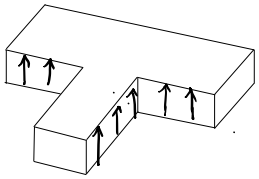
Lecture Outline

- Lossless Divider
- Resistive Divider

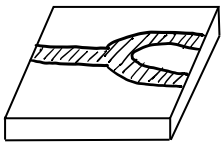
Lossless Divider



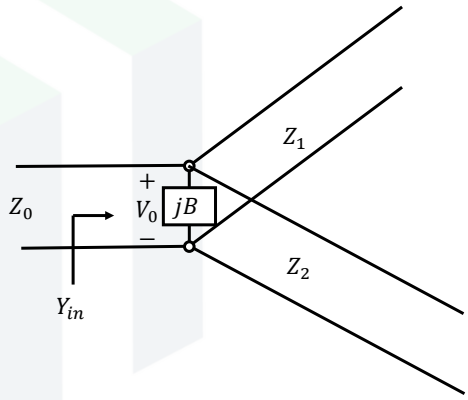
E −plane waveguide



H −plane waveguide



Microstrip Junction Divider



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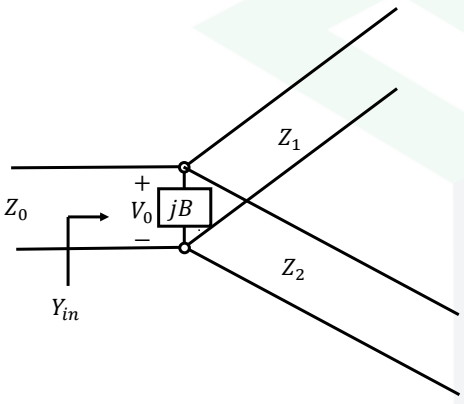
Lossless Divider



In order for the divider to be matched to the input line with characteristic impedance Z_0, we must have

$$Y_{in} = jB + \frac{1}{Z_1} + \frac{1}{Z_2} = \frac{1}{Z_0}$$

Fringing Fields and higher order modes

For the lossless case, $B = 0$, and we have

$$\frac{1}{Z_1} + \frac{1}{Z_2} = \frac{1}{Z_0}$$

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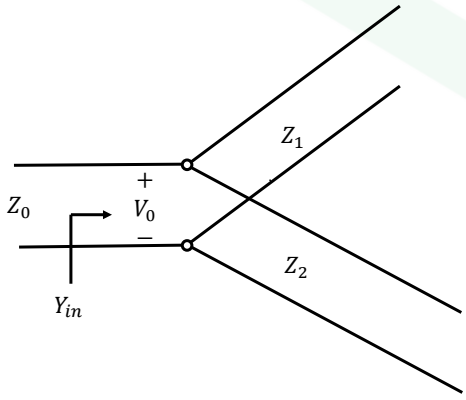
Lossless Divider - Example

A lossless T-junction power divider has a source impedance of $50\ \Omega$. Find the output characteristic impedances so that the output powers are at a 2:1 ratio. Compute the reflection coefficients seen looking into the ports.



Solution:

$$P_{in} = \frac{V_0^2}{2Z_0}$$

The output powers are

$$P_{1out} = \frac{V_0^2}{2Z_1} = \frac{1}{3}P_{in}$$

$$P_{2out} = \frac{V_0^2}{2Z_2} = \frac{2}{3}P_{in}$$

And the resistances are

$$Z_1 = 3Z_0 = 150\ \Omega$$
$$Z_2 = (3/2)Z_0 = 75\ \Omega$$

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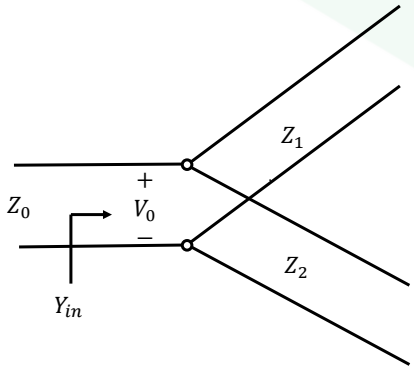
Lossless Divider - Example

A lossless T-junction power divider has a source impedance of $50\ \Omega$. Find the output characteristic impedances so that the output powers are at a 2:1 ratio. Compute the reflection coefficients seen looking into the ports.



Solution:

$$Z_{in} = 75||150 = 50\Omega$$

Looking into the $Z_1 = 150\ \Omega$ output line, the impedance is $30\ \Omega$

Looking into the $Z_2 = 75\ \Omega$ output line, the impedance is $37.5\ \Omega$

The reflection coefficients looking into the ports are

$$\Gamma_1 = \frac{30 - 150}{30 + 150} = -0.667, \qquad \Gamma_2 = \frac{37.5 - 75}{37.5 + 75} = -0.333$$

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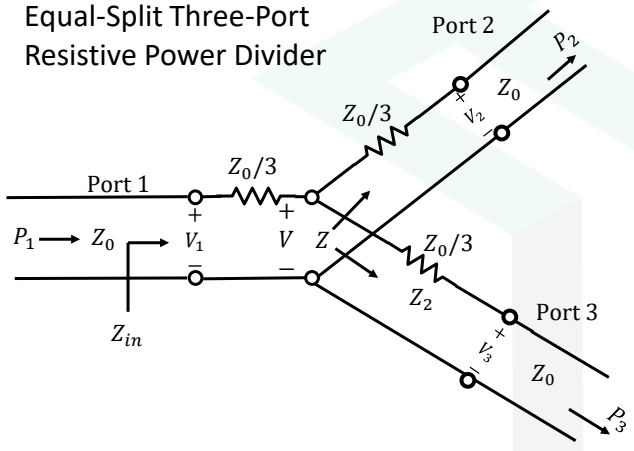
Resistive Divider

Equal-Split Three-Port
Resistive Power Divider



$$Z = Z_0 + \frac{Z_0}{3} = \frac{4}{3}Z_0$$

$$Z_{in} = \frac{Z_0}{3} + \frac{\left(\frac{4}{3}Z_0\right)\left(\frac{4}{3}Z_0\right)}{\left(\frac{4}{3}Z_0 + \frac{4}{3}Z_0\right)} = Z_0$$

$$V = V_1 \frac{2Z_0/3}{Z_0/3 + 2Z_0/3} = \frac{2}{3}V_1$$

$$V_2 = V_3 = V \frac{Z_0}{Z_0 + Z_0/3} = \frac{1}{2}V_1$$

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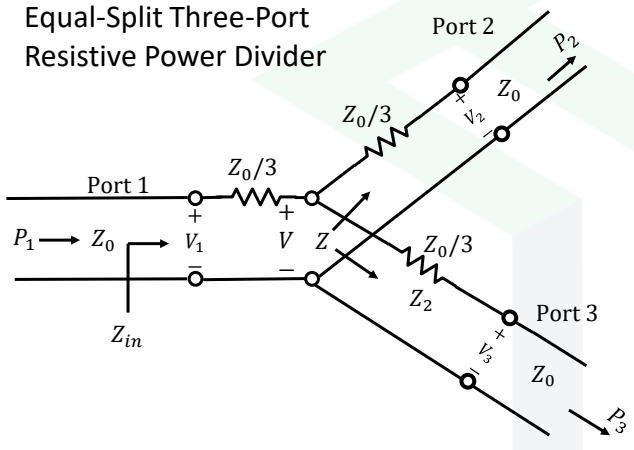
Resistive Divider

Equal-Split Three-Port
Resistive Power Divider



Because the network is symmetric from all three ports the output ports are also matched.

$$S_{11} = S_{22} = S_{33} = 0$$

Since $V_2 = V_3 = 1/2V_1$,

$$S_{21} = S_{31} = S_{23} = 1/2$$

The scattering matrix is written as

$$S = \frac{1}{2}\begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix}$$

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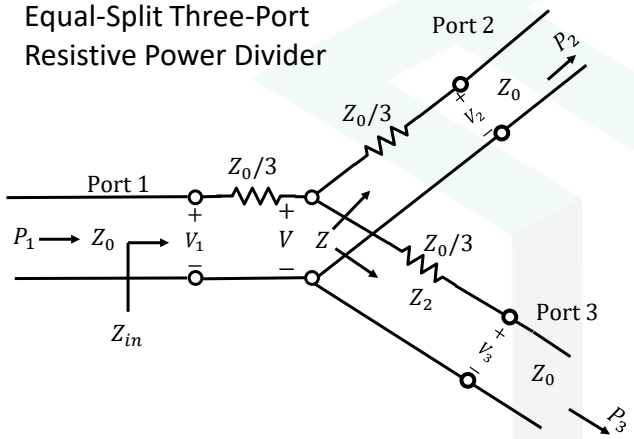
Resistive Divider

Equal-Split Three-Port Resistive Power Divider



The power delivered to the input of the divider is

$$P_{in} = \frac{1}{2}\frac{V_1^2}{Z_0}$$

and the output powers are

$$P_2 = P_3 = \frac{1}{2}\frac{(1/2V_1)^2}{Z_0} = \frac{1}{8}\frac{V_1^2}{Z_0} = \frac{1}{4}P_{in}$$

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