

The Wilkinson Power Divider

The **Wilkinson power divider** is a 3-port device with a scattering matrix of:

$$\bar{\bar{S}} = \begin{bmatrix} 0 & -j/\sqrt{2} & -j/\sqrt{2} \\ -j/\sqrt{2} & 0 & 0 \\ -j/\sqrt{2} & 0 & 0 \end{bmatrix}$$

Note this device is **matched**, but it is **lossy**. What makes this device interesting is the behavior of **port 1** (i.e., column 1).

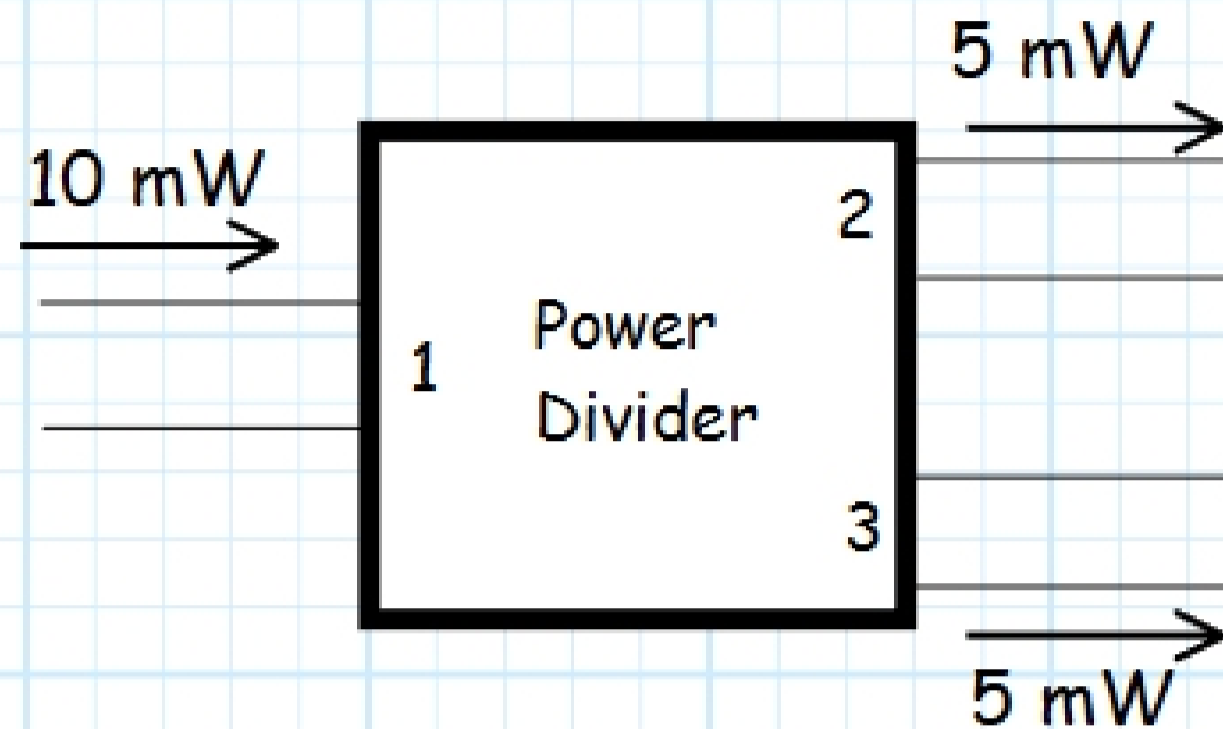
Say that a signal (P_1^+) is incident on port 1 **only**. Provided that all ports are all terminated in matched loads, we find of course that **no power** is reflected at port 1:

$$P_1^- = |S_{11}|^2 P_1^+ = 0$$

Instead, all the incident power is **evenly divided** between the outputs of port 2 and port 3:

$$P_2^- = |S_{21}|^2 P_1^+ = \frac{P_1^+}{2} \quad P_3^- = |S_{31}|^2 P_1^+ = \frac{P_1^+}{2}$$

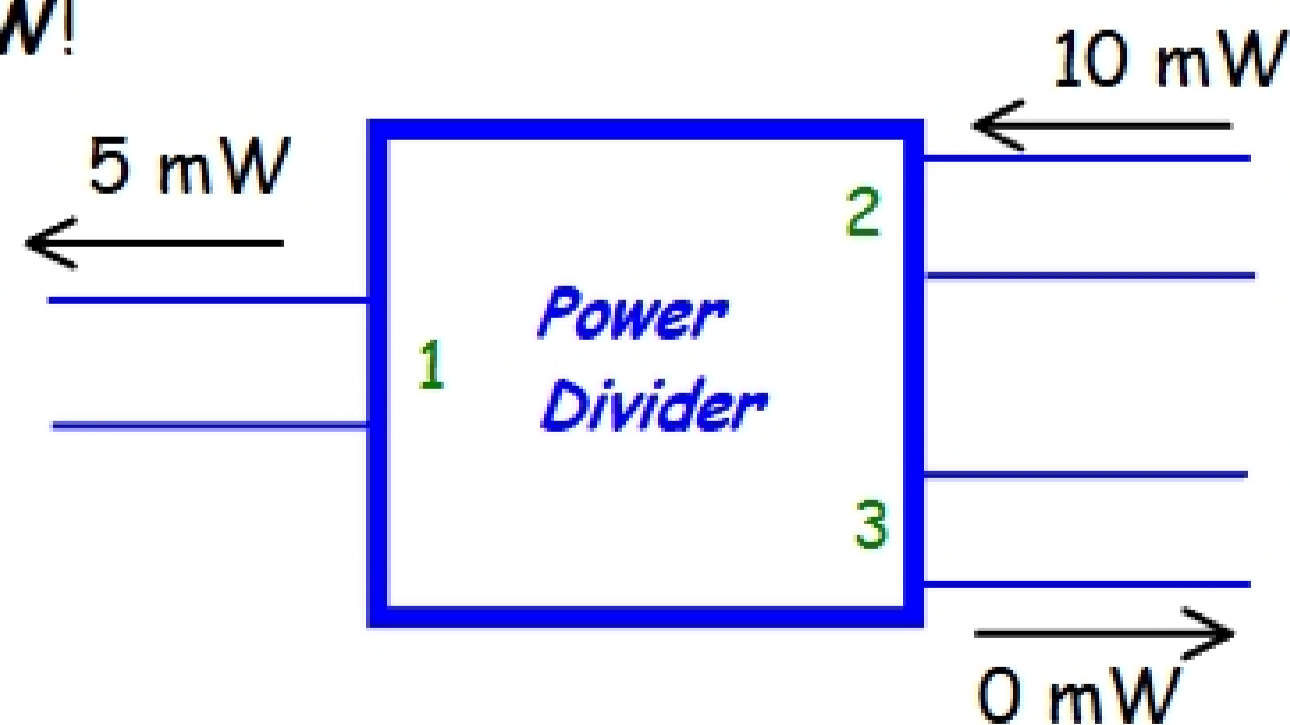
In other words, if 10 mW of signal power flows into port 1, then 5 mW will flow out of ports 2 and 3.



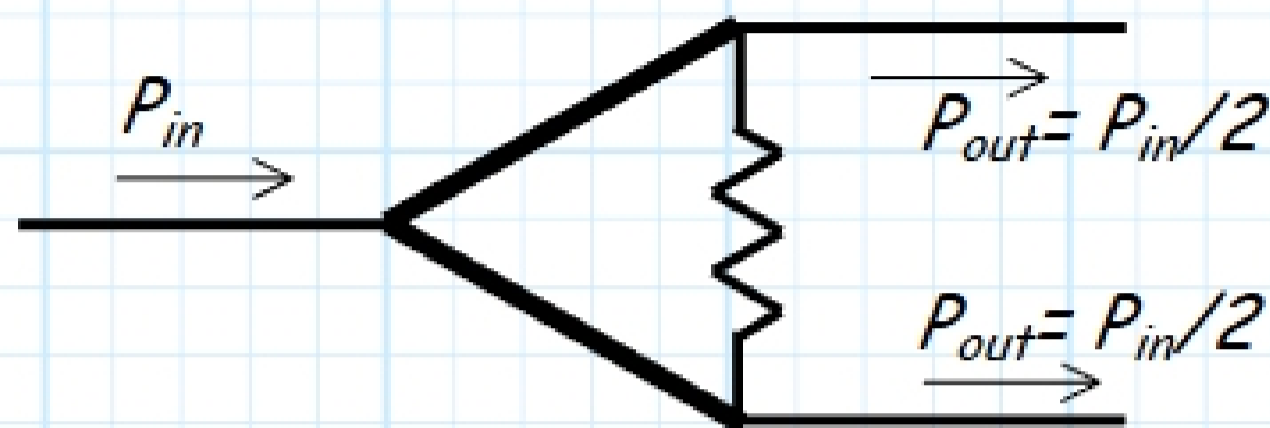
Q: *Hey! This device appears to be lossless! I thought you said it is lossy?*

A: Yes, from the standpoint of port 1, it **does** appear to be lossless. That is why the Wilkinson power divider is **so useful**.

However, the device is **clearly** lossy, as if we put 10 mW in either port 2 or port 3, then 5 mW will leave port 1, but **no power** will leave the other port—we've **lost 5mW!**



The **Wilkinson power divider** is therefore a useful device for **dividing** signal power into two **equal** parts. **No** power is lost, either due to **reflection** at the input port or **absorption** by the device!



The Wilkinson Power Divider

We often refer to this device as a **3 dB power divider**, as:

$$10 \log_{10} \left[\frac{P_{out}}{P_{in}} \right] = 10 \log_{10} \left[\frac{1}{2} \right] = -3 \text{ dB}$$

