The Wilkinson Power Divider

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

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

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

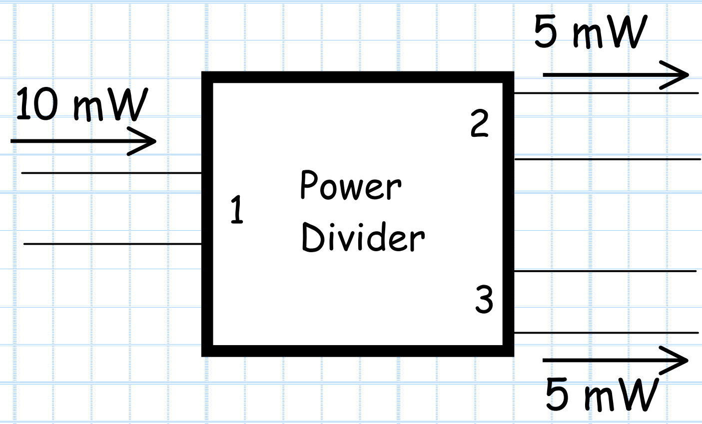
Say that a signal (P_1^+) is incident on port 1 **only**. Provided that all ports are all terminated in matched loads, we find of course that **no power** is reflected at port 1 :

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

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

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

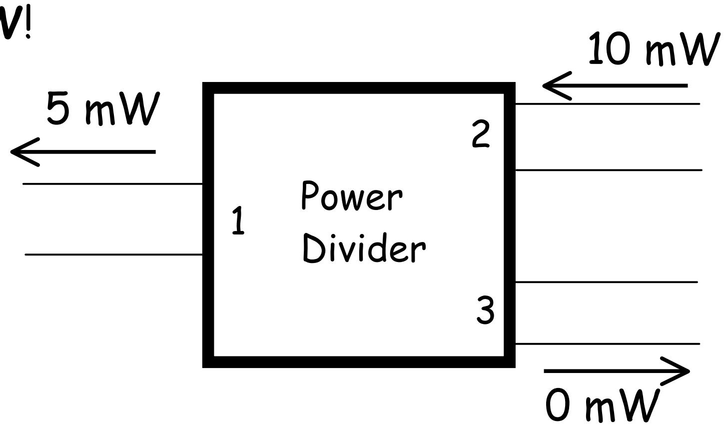
In other words, if 10 mW of signal power flows **into** port 1, then 5 mW will flow **out of** ports 2 and 3.



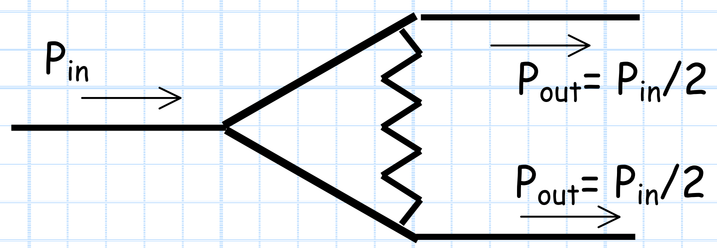
Q: *Hey! This device appears to be* ***lossless****! I thought you said it is* ***lossy****?*

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!



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

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