The Wilkinson Power Divider

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

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

Note this device is matched at port 1 \(S_{11} = 0\), and we find that magnitude of column 1 is:

\[
|S_{11}|^2 + |S_{21}|^2 + |S_{31}|^2 = 1
\]

Thus, just like the lossless divider, the incident power on port 1 is evenly and efficiently divided between the outputs of port 2 and port 3:

\[
\rho_2^- = |S_{21}|^2 \rho_1^+ = \frac{\rho_1^+}{2} \quad \rho_3^- = |S_{31}|^2 \rho_1^+ = \frac{\rho_1^+}{2}
\]

But now look closer at the scattering matrix. We also note that the ports 2 and 3 of this device are matched!

\[
S_{22} = S_{33} = 0
\]

Likewise, we note that ports 2 and ports 3 are isolated:
\[ S_{23} = S_{32} = 0 \]

→ It's the (nearly) ideal 3dB power divider!!!

**Q:** So just how do we make this Wilkinson power divider?

It looks a lot like a lossless 3dB divider, only with an additional resistor of value \( 2Z_0 \) between ports 2 and 3:

This resistor is the secret to the Wilkinson power divider, and is the reason that it is matched at ports 2 and 3, and the reason that ports 2 and 3 are isolated.

Note however, that the quarter-wave transmission line sections make the Wilkinson power divider a narrow-band device.
Figure 7.12 (p. 322)
Frequency response of an equal-split Wilkinson power divider. Port 1 is the input port; ports 2 and 3 are the output ports.