CHAPTER 10.7
ATTENUATORS

Arthur B. Williams, Fred, J. Taylor

ATTENUATOR NETWORK DESIGN

Attenuators are passive circuits that introduce a fixed power loss between a source and load while matching impedances. The power loss is independent of the direction of power flow. Figure 10.7.1 shows *T*, Π, and bridged-*T* networks. The first two are unbalanced and unsymmetrical, unless $Z_L = Z_S$. In this case, $Z_1 = Z_2$, and the network is symmetrical. To build an unbalanced network, divide Z_1 and Z_2 by 2, and put half of each element in each series arm. The bridged-*T* shown is only for symmetrical networks.

These design equations are valid for resistive and complex impedances.

$$\begin{aligned} Z_S &= \text{source impedance} \\ Z_L &= \text{load impedance} \\ A &= \text{ratio of available power to desired load power (dB)} = 10^{B/10} \\ B &= 10 \log A \\ \theta &= 1/2 \ln A = 1/2 \ln 10^{B/10} \end{aligned} \tag{1}$$

As an example, design an attenuator to match a 75-Ω source to a 300-Ω load and to introduce a 14.0-dB loss. Use a *T* section. In terms of Eq. (1),

$$Z_s = 75\ \Omega \qquad Z_L = 300\ \Omega \qquad B = 14.0\ \text{dB} \qquad A = 25.12$$

$$\theta = 1.612 \qquad Z_3 = 62.34\ \Omega \qquad Z_1 = 18.88\ \Omega \qquad Z_2 = 262.54\ \Omega$$

Figure 10.7.2 shows the network.

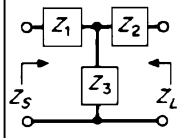
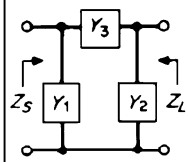
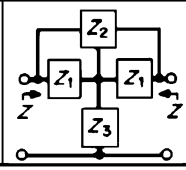
Circuit name	Circuit diagram	Equations
T-Network		$Z_3=\sqrt{Z_s Z_L}/\sinh\theta=\frac{2\sqrt{Z_s Z_L \cdot A}}{A-1}$ $Z_1=Z_s\coth\theta-Z_3=Z_s\left(\frac{A+1}{A-1}\right)-Z_3$ $Z_2=Z_L\coth\theta-Z_3=Z_L\left(\frac{A+1}{A-1}\right)-Z_3$
π-Network		$Y_3=\frac{1}{\sqrt{Z_s Z_L}\sinh\theta}$ $=\frac{2}{A-1}\sqrt{\frac{A}{Z_s Z_L}}$ $Y_1=\frac{\tanh\theta}{Z_s}-Y_3=\frac{1}{Z_s}\left(\frac{A+1}{A-1}\right)-Y_3$ $Y_2=\frac{\tanh\theta}{Z_L}-Y_3=\frac{1}{Z_L}\left(\frac{A+1}{A-1}\right)-Y_3$
Bridged-T		$Z_1=Z$ $Z_2=Z(A-1)$ $Z_3=\frac{Z}{A-1}$

FIGURE 10.7.1 Attenuator networks and equations.

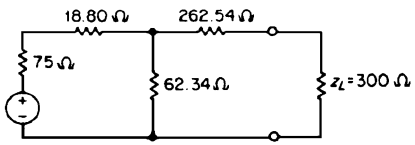


FIGURE 10.7.2 A 14.0-dB attenuator between a 75-Ω source and a 300-Ω load.