# DESIGN NOTES

Impedance Matching With LC Networks

This month's columns includes more information on LCR circuits, provided by Ain Rehmann. The circuits described first are L-networks, consisting of one series and one shunt reactance. These networks are practical for matching a wide range of impedances in narrowband applications. They are commonly used for antenna matching, amplifier matching, and for matching to the inputs and/or outputs of passive circuits such as crystal and ceramic bandpass filters.

The two topologies detailed here include one inductor and one capacitor. Although not presented here, L-networks with two capacitors and two inductors are

$$Q = \sqrt{(R1/R2 - 1)}$$
$$\omega C1 = Q/R1$$
$$\omega L2 = Q/R2$$

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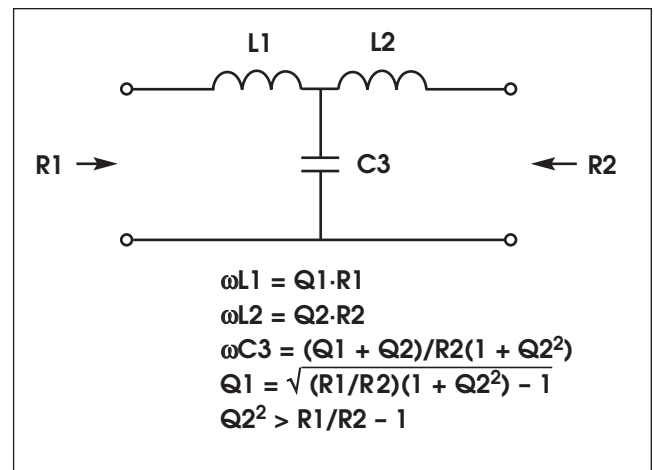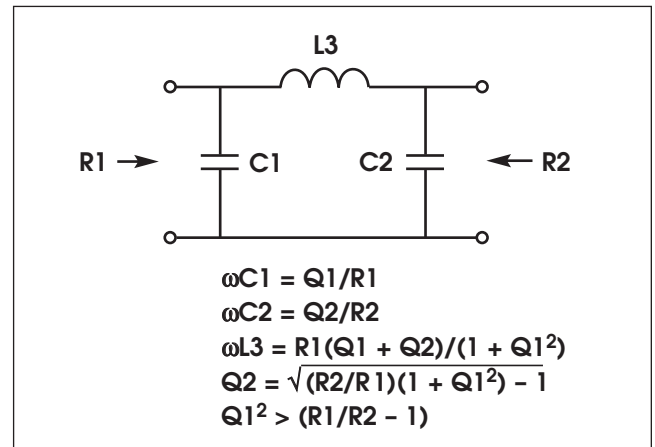$$\omega L1 = R1/Q$$
$$\omega C2 = 1/Q \cdot R2$$
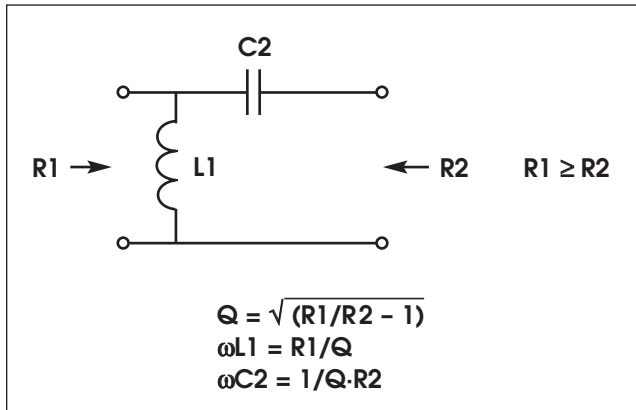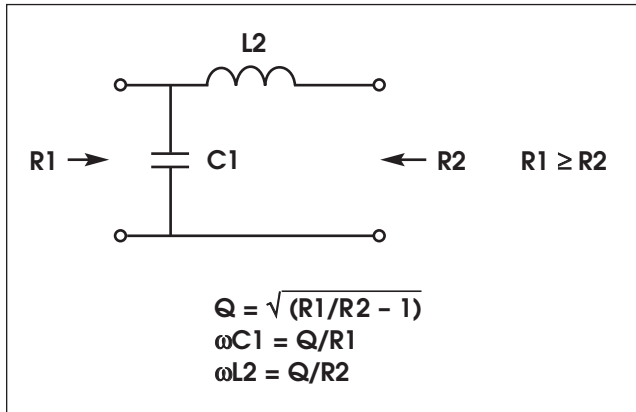
also legitimate choices.

Note that the formulas are for resistive load matching only. Reactive loads are accommodated by incorporating them into the series reactance. For example, in the top configuration with a series inductance, the complex load is R2 ±jX. If the reactance is inductive, that inductance can be subtracted from the value of L2. Thus, $X_{L2new} = X_{L2old} - |X_{load}|$.

A capacitive reactance can be incorporated into the

network by adding an equal value of inductive reactance to L2, so that $X_{L2new} = X_{L2old} + |X_{load}|$.

Three-element matching networks are also commonly used for impedance matching. With an additional degree of freedom in component value selection, these networks are more flexible when matching reactive loads. Below are two possible topologies, a "Pi" or "π" network, and a "Tee" or "T" network. Of course, they are named for the shapes of their circuit diagrams.

$$\omega C1 = Q1/R1$$
$$\omega C2 = Q2/R2$$
$$\omega L3 = R1(Q1 + Q2)/(1 + Q1^2)$$
$$Q2 = \sqrt{(R2/R1)(1 + Q1^2) - 1}$$
$$Q1^2 > (R1/R2 - 1)$$

$$\omega L1 = Q1 \cdot R1$$
$$\omega L2 = Q2 \cdot R2$$
$$\omega C3 = (Q1 + Q2)/R2(1 + Q2^2)$$
$$Q1 = \sqrt{(R1/R2)(1 + Q2^2) - 1}$$
$$Q2^2 > R1/R2 - 1$$

Additional topologies are possible, with inductors or capacitors in each position. These two are shown as examples. Readers are referred to texts on matching networks for additional information.

It should be noted that the Tee and Pi networks may be designed with phase shift as a parameter. Different design equations will apply. This approach is commonly used in broadcast transmitting arrays; a good source of information is any past edition of the *NAB Engineering Handbook*.