L-Network Design Procedure

For maximum power transfer, source and load impedance must have a conjugate match. For many circuits with modest bandwidth requirements, a simple *L-network* comprising two reactive components is the simplest method of achieving that match. This note is a quick review of L-network design.

Figure 1 shows the sequence of steps for matching two impedances, either of which can be considered "source" or "load." Fig. 1a shows only the resistance of these impedances; their reactances will be dealt with later. Most often, one of the impedances is a common system impedance. For this example, we'll assume that R_1 = 50 ohms, then arbitrarily choose R_2 = 10 ohms.

The design process begins with a shunt component (Xp in Fig. 1b) connected in parallel with the higher resistance (R_1). The parallel combination will result in a lower resistance, which we want to be equal to R_2 (10 ohms). Because X_P is reactive, the resulting lower resistance will now have an associated reactance. This is cancelled by the L-network's series reactance X_S, which is the negative of the reactance introduced by X_P. Thus, the series and shunt components are of opposite reactances—a shunt inductor and a series capacitor, or vice versa.

The design calculation starts by determining circuit Q according to the ratio of the two resistances:

$$Q_S = Q_P = \sqrt{\frac{R_P}{R_S} - 1}$$

where R_P is the resistance adjacent to the parallel leg of the network, and R_S is the resistance at the series-connected end. Q may not be negative, so R_P must be the higher of the two resistances. In our example, $R_1 = R_P$ and $R_2 = R_S$. Note that Q is determined by the source and load, not be user-selected as is typical when designing higher order networks.

The calculation continues as follows:

$$Q_S = \frac{|X_S|}{R_S} \quad \text{or,} \quad |X_S| = Q_S R_S$$

$$Q_P = \frac{R_P}{|X_P|} \quad \text{or,} \quad |X_P| = \frac{R_P}{Q_P}$$

where the reactances are given as magnitude only, since X_S and X_P may be either capacitance or inductance, but as noted above, cannot both be the same.

Applying these equations to our example, we find that Q = 2, $|X_S|$ = 20 ohms and $|X_P|$ = 25 ohms. Before assigning a sign to each reactance, let's look at our example with complex impedances at Z_1 and Z_2, as in the circuit of Fig. 1c. Since we assumed a system impedance, let $Z_1 = 50 \pm j0$ ohms (same as R_1). Then let's say that $Z_2 = 10 - j10$ ohms.

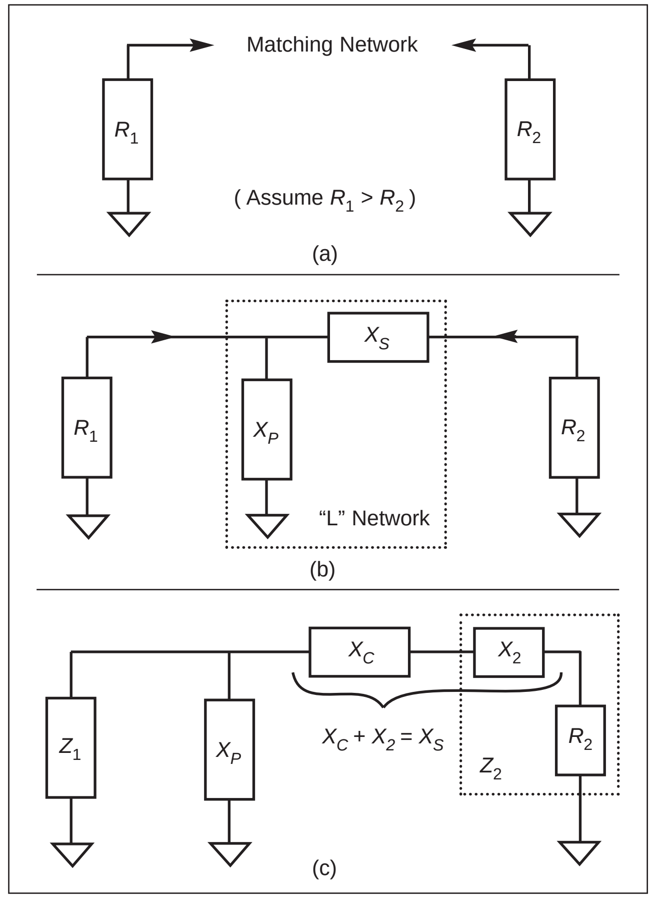

Figure 1 · L-network design sequence.

In Fig. 1c we see that X_S has been split into two parts: X_2 is the reactive part of Z_2, and X_C is the final circuit value that makes X_S equal to the sum of X_C and X_2. We have two choices for the signs of the network reactances, and can examine the effect of each for obtaining practical values of X_C and X_P.

If X_S = +20 ohms, then X_C must be +30 ohms. X_P will be –25 ohms.

If X_S = –20 ohms, then X_C must be –10 ohms. X_P will be +25 ohms.

One common choice is selecting the configuration to enable or block DC continuity. Let's say that Z_2 is a transistor output being matched to a 50 ohm transmission line. Since X_C = –10 ohms, it is a capacitor and will be useful for blocking DC.

Finally, if Z_1 is complex, X_P would be combined with the reactive portion of Z_1 to compute the actual circuit component value, as was done to find X_C.