EXAMPLE 4-4

Using Fig. 4-10 as a reference, design four different Pi networks to match a 100-ohm source to a 1000-ohm load. Each network must have a loaded Q of 15.

Solution

From Equation 4-4, we can find the virtual resistance we will be matching.

$$R = \frac{R_H}{Q^2 + 1} = \frac{1000}{226} = 4.42 \text{ ohms}$$

To find X_{p2} we have:

$$X_{p2} = \frac{R_p}{Q_p} = \frac{R_L}{Q} = \frac{1000}{15} = 66.7 \text{ ohms}$$

Similarly, to find X_{s2}:

$$X_{s2} = QR_{series} = 15(R) = (15)(4.42) = 66.3 \text{ ohms}$$

This completes the design of the L section on the *load* side of the network. Note that R_{series} in the above equation was substituted for the virtual resistor R, which by definition is in the series arm of the L section.

The Q for the other L network is now defined by the ratio of R_s to R, as per Equation 4-1, where:

$$Q_1 = \sqrt{\frac{R_s}{R} - 1} = \sqrt{\frac{100}{4.42} - 1} = 4.6$$

Notice here that the source resistor is now considered to be in the shunt leg of the L network. Therefore, R_s is defined as R_p, and

$$X_{p1} = \frac{R_p}{Q_1} = \frac{100}{4.6} = 21.7 \text{ ohms}$$

Similarly,

$$X_{s1} = Q_1R_{series} = Q_1R = (4.6)(4.46) = 20.51 \text{ ohms}$$

The actual network design is now complete and is shown in Fig. 4-20. Remember that the virtual resistor (R) is not really in the circuit and, therefore, is not shown. Reactances $-X_{s1}$ and $-X_{s2}$ are now in series and can simply be added together to form a single component.

So far in the design, we have dealt only with reactances and have not yet computed actual component values. This

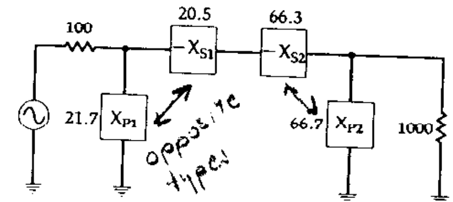

Fig. 4-20. Calculated reactances for Example 4-4.

is because of the need to maintain a general design approach so that four final networks can be generated quickly as per the problem statement.

Notice that X_{p1}, X_{s1}, X_{p2}, and X_{s2} can all be either capacitive or inductive reactances. The only constraint is that X_{p1} and X_{s1} are of opposite types, and X_{p2} and X_{s2} are of opposite types. This yields the four networks of Fig. 4-21 (the source and load have been omitted). Each component in Fig. 4-21 is shown as a reactance (in ohms). Therefore, to perform the transformation from the dual-L to the Pi network, the two series components are merely added if they are alike, and subtracted if the reactances are of opposite type. The final step, of course, is to change each reactance into a component value of capacitance and inductance at the frequency of operation.

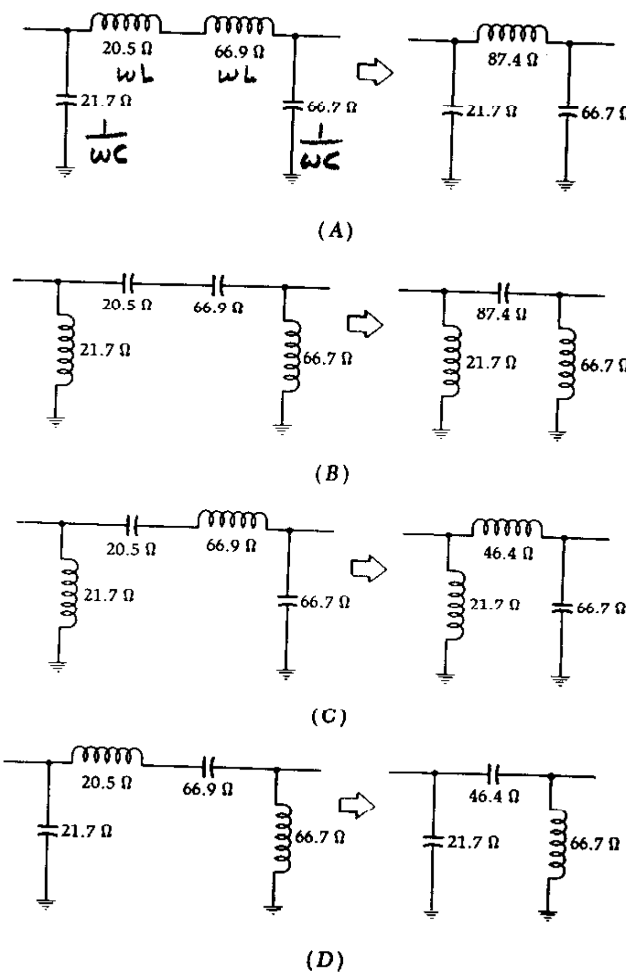

Fig. 4-21. The transformation from double-L to Pi networks.

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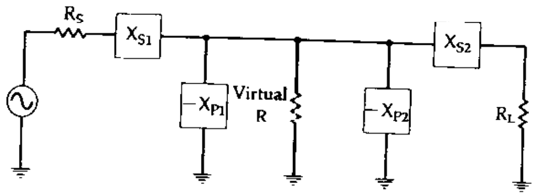

Fig. 4-22. The T network shown as two back-to-back L networks.

where,

$R_{smaller}$ = the smallest terminating resistance,
R_{larger} = the largest terminating resistance,
$R_1, R_2, \ldots R_n$ = virtual resistors.

This is shown in Fig. 4-26.

The design procedure for these wideband matching networks is precisely the same as was given for the previous examples. To design for a specific low Q, simply solve Equation 4-7 for R to find the virtual

EXAMPLE 4-5

Using Fig. 4-22 as a reference, design four different networks to match a 10-ohm source to a 50-ohm load. Each network is to have a loaded Q of 10.

Solution

Using Equation 4-5, we can find the virtual resistance we need for the match.

$$R = R_{small}(Q^2 + 1)$$
$$= 10(101)$$
$$= 1010 \text{ ohms}$$

From Equation 4-2:

$$X_{s1} = QR_s$$
$$= 10(10)$$
$$= 100 \text{ ohms}$$

From Equation 4-3:

$$X_{p1} = \frac{R}{Q}$$
$$= \frac{1010}{10}$$
$$= 101 \text{ ohms}$$

Now, for the L network on the load end, the Q is defined by the virtual resistor and the load resistor. Thus,

$$Q_2 = \sqrt{\frac{R}{R_L} - 1}$$
$$= \sqrt{\frac{1010}{50} - 1}$$
$$= 4.4$$

Therefore,

$$X_{p2} = \frac{R}{Q_2}$$
$$= \frac{1010}{4.4}$$
$$= 230 \text{ ohms}$$
$$X_{s2} = Q_2R_L$$
$$= (4.4)(50)$$
$$= 220 \text{ ohms}$$

The network is now complete and is shown in Fig. 4-23 without the virtual resistor.

The two shunt reactances of Fig. 4-23 can again be combined to form a single element by simply substituting a value that is equal to the combined equivalent parallel reactance of the two.

The four possible T-type networks that can be used for matching the 10-ohm source to the 50-ohm load are shown in Fig. 4-24.

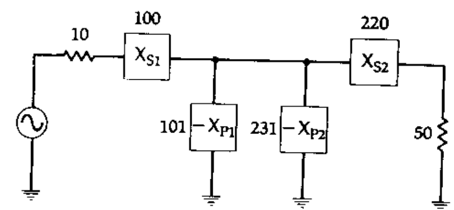

Fig. 4-23. The calculated reactances of Example 4-5.

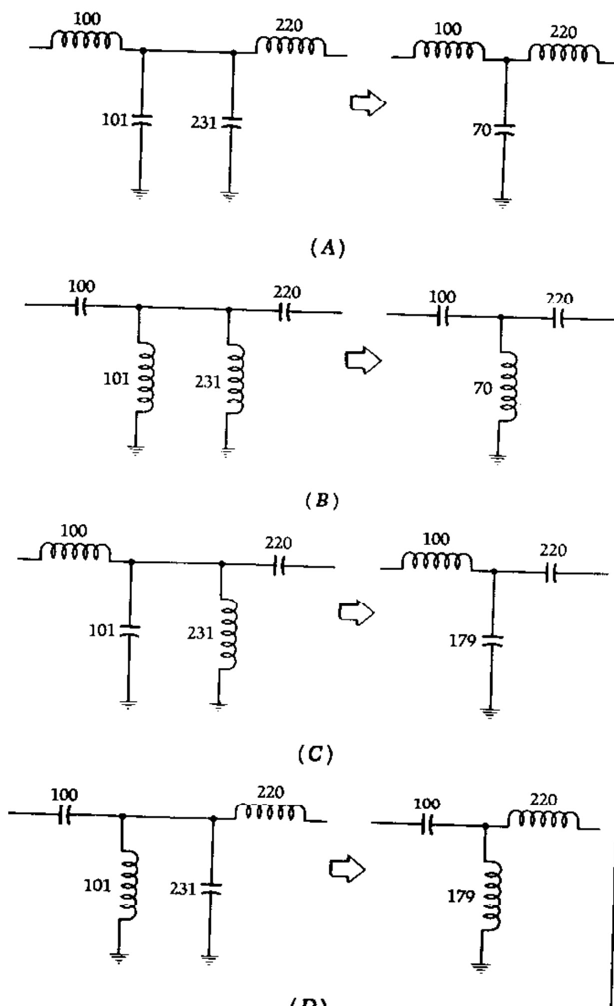

Fig. 4-24. The transformation of circuits from double-L to T-type networks.