print | close

Back to Basics: Impedance Matching (Part 2)

Electronic Design
Lou Frenzel
Louis E. Frenzel
Thu, 2012-03-01 11:57

During impedance matching, a specific electronic load (R_L) is made to match a generator output impedance (R_g) for maximum power transfer. The need arises in virtually all electronic circuits, especially in RF circuit design.

"Back to Basics: Impedance Matching (Part 1)" discusses the use of a transformer as a basic way to match impedance. This article will introduce the L-network, which is a simple inductor-capacitor (LC) circuit that can be used to match a wide range of impedances in RF circuits.

Table of Contents

L-Network Applications And Configurations

The primary applications of L-networks involve impedance matching in RF circuits, transmitters, and receivers. L-networks are useful in matching one amplifier output to the input of a following stage. Another use is matching an antenna impedance to a transmitter output or a receiver input. Any RF circuit application covering a narrow frequency range is a candidate for an L-network.

Related

Back to Basics: Impedance Matching (Part 1)

Back to Basics: Impedance Matching (Part 3)

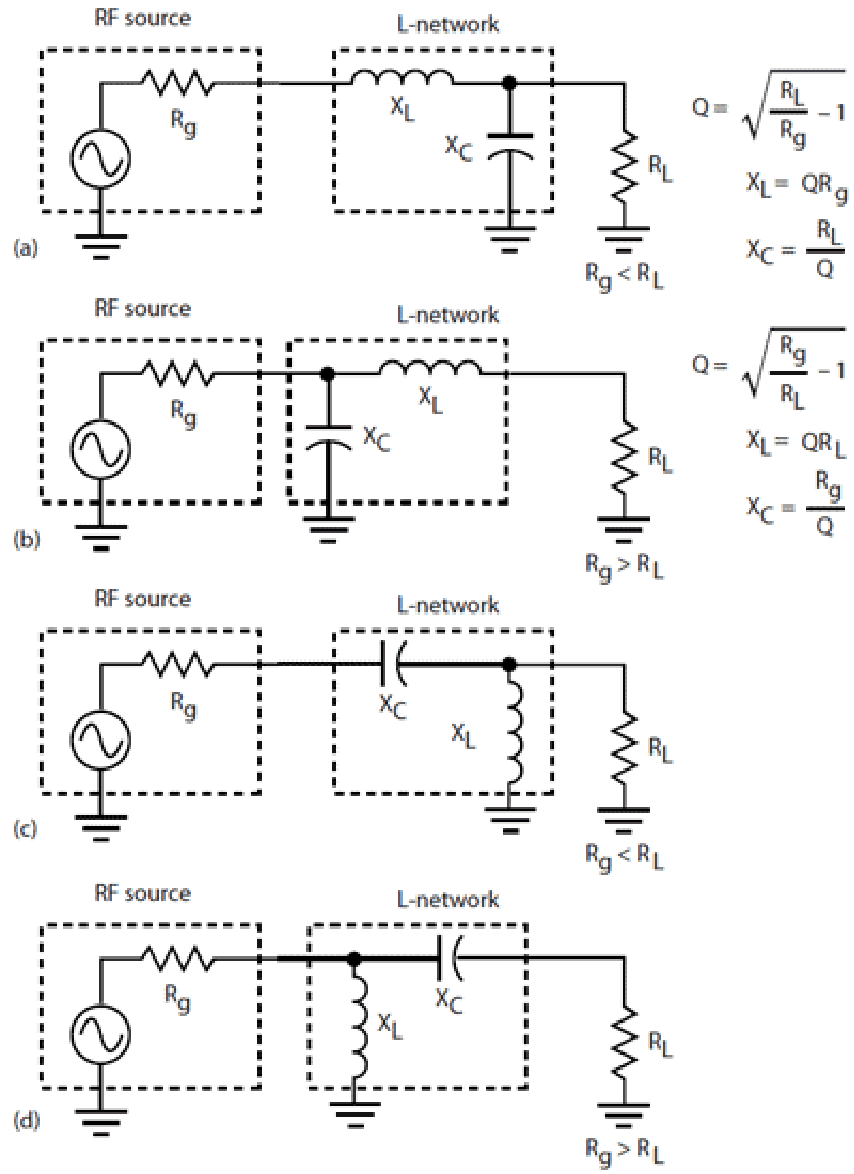
Welcome To Antennas 101

Back To Amp Camp

There are four basic versions of the L-network, with two low-pass versions and two high-pass versions *(Fig. 1)*. The low-pass versions are probably the most widely used since they attenuate harmonics, noise, and

DOCKET ALARM
Find authenticated court documents without watermarks at docketalarm.com.

relative sizes of the driving generator output impedance and load impedance.



1. There are four basic L-network configurations. The network to be used depends on the relationship of the generator and load impedance values. Those in (a) and (b) are low-pass circuits, and those in (c) and (d) are high-pass versions.

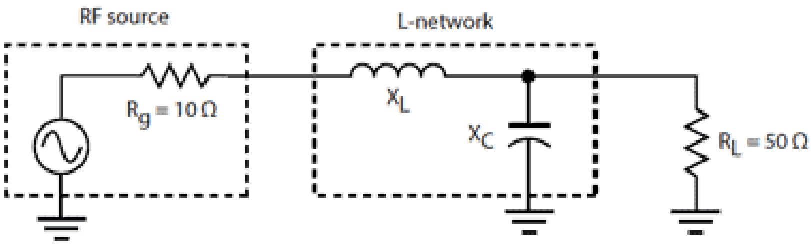
The impedances that are being matched determine the Q of the circuit, which cannot be specified or controlled. If it is essential to control Q and bandwidth, a T or π-network is a better choice. These choices will be covered in a subsequent article.

While the L-network is very versatile, it may not fit every need. There are limits to the range of impedances that it can match. In some instances, the calculated values of inductance or capacitance may be too large or small to be practical for a given frequency range. This problem can sometimes be overcome by switching from a low-pass version to a high-pass version or vice versa.

Design Example #1

The goal is to match the output impedance of a low-power RF transistor amplifier to a 50-output load, and 50 Ω is a universal standard for most receiver, transmitter, and RF circuits. Most power amplifiers have a low output impedance, typically less than 50 Ω.

DOCKET ALARM
Find authenticated court documents without watermarks at docketalarm.com.



2. The RF source is a transistor amplifier with an output impedance of 10 Ω that is to be matched to 50-Ω output impedance load. The L-network with a parallel output capacitor is used.

Figure 2 shows the desired circuit. Assume an amplifier output (generator) impedance of 10 Ω at a frequency of 76 MHz. Calculate the needed inductor and capacitor values using the formulas given in Figure 1a:

$Q = \sqrt{[(R_L/R_g) - 1]}$

$Q = \sqrt{[(50/10) - 1]} = \sqrt{[(5) - 1]} = \sqrt{4} = 2$

$X_L = QR_g = 2(10) = 20\ \Omega$

$L = X_L/2\pi f$

$L = 20/[2(3.14)(76 \times 10^6)]$

$L = 42\ nH$

$X_C = R_L/Q$

$X_C = 50/2 = 25\ \Omega$

$C = 1/2\pi f X_C$

$C = 1/[2(3.14)(76 \times 10^6)(25)]$

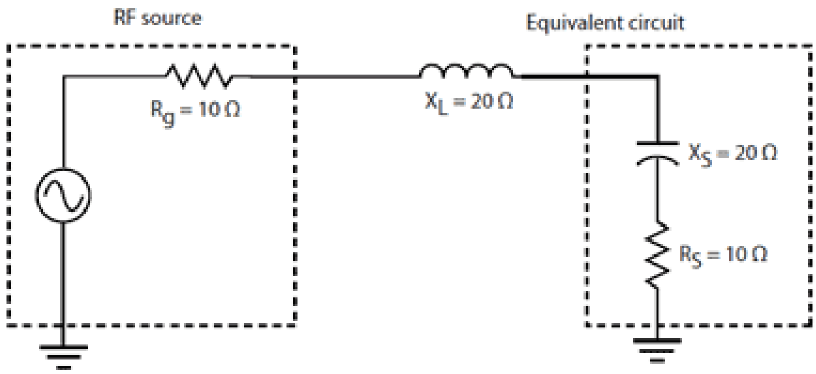
$C = 83.8\ pF$

This solution omits any output impedance reactance such as transistor amplifier output capacitance or inductance and any load reactance that could be shunt capacitance or series inductance. When these factors are known, the computed values can be compensated.

The bandwidth (BW) of the circuit is relatively wide given the low Q of 2:

$BW = f/Q = 76 \times 10^6/2 = 38 \times 10^6 = 38\ MHz$

DOCKET ALARM
Find authenticated court documents without watermarks at docketalarm.com.



3. The equivalent circuit of the network in Figure 2 is a simple series RLC network where the reactances cancel and the source and load impedances match.

You can see how this matching network functions by converting the parallel combination of the 50-Ω resistive load and the 25-Ω capacitive reactance into its series equivalent *(Fig. 3)*:

$$R_S = R_p/(Q^2 + 1)$$

$$R_S = 50/(2^2 + 1) = 10\ \Omega$$

$$X_S = X_p/\backslash\backslash[(Q^2 + 1)Q^2\backslash\backslash]$$

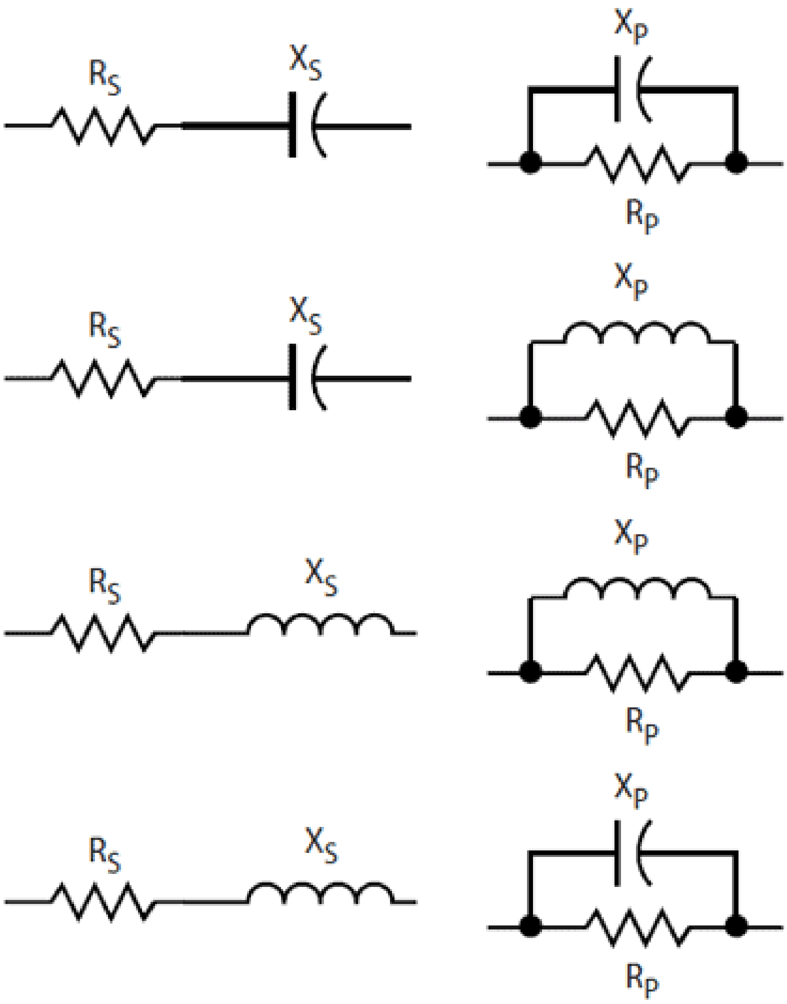
$$X_S = 25/(5/4) = 25/1.25 = 20\ \Omega$$

Note how the series equivalent capacitive reactance equals and cancels the series inductive reactance. Also the series equivalent load of 10 Ω matches the generator resistance for maximum power transfer.

Parallel And Series Circuit Equivalents

Sometimes it's necessary to convert a series RC or RL circuit into an equivalent parallel RC or RL circuit or vice versa. Such conversions are useful in RLC circuit analysis and design *(Fig. 4)*.

DOCKET ALARM
Find authenticated court documents without watermarks at docketalarm.com.



4. These are all the possible practical series and parallel RC and RL circuit equivalents. The text provides the calculations for R_S, R_P, X_S, and X_P.

These equivalents also can help explain how the L-networks and other impedance-matching circuits work. The designations are:

R_s = series resistance

R_p = parallel resistance

X_s = series reactance

X_p = parallel reactance

The conversion formulas are:

$R_s = R_p/(Q^2 + 1)$

$X_s = X_p$/\\[Q^2 + 1)Q^2\\]

DOCKET ALARM
Find authenticated court documents without watermarks at docketalarm.com.

DOCKET ALARM

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts

Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips

Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.

WHAT WILL YOU BUILD? | **sales@docketalarm.com** | **1-866-77-FASTCASE**

fastcase®
Smarter legal research.