UNIVERSITY ☺F P☺RTLAND
Sch☺☺l ☺f Engineering

EE 301
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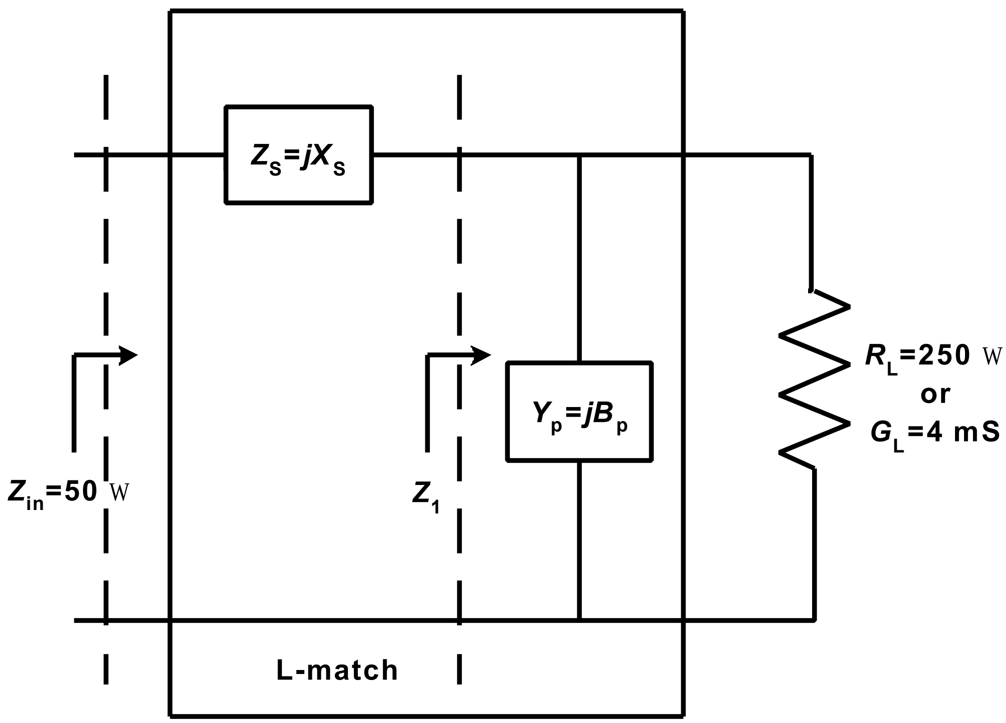
EE 301/Handout # 14
(Monday, March 29, 2004)

L-Matching Network Design

Design Example: Design the L-matching network shown in the figure below to match a purely resistive load with impedance Z_L = 250 Ω to a purely resistive impedance Z_{in} = 50 Ω at 1 MHz. (Note that the L-matching network consists of only reactive elements.)



Solution: Combining the admittances $Y_L = Z_L^{-1} = G_L$ and Y_p in parallel ($Y_1 = Y_L + Y_p$) and impedances $Z_1 = Y_1^{-1}$ and Z_S in series ($Z_{in} = Z_1 + Z_S$) yields

$$\underbrace{\left(\frac{1}{Y_L + Y_p}\right)}_{Z_1} + Z_S = \left(\frac{1}{4\times 10^{-3} + jB_p}\right) + jX_S = Z_{in} = 50\,\Omega$$

Using complex conjugate multiplication, this equation can be rewritten as

$$\frac{4\times10^{-3}-jB_p}{\left(4\times10^{-3}\right)^2+B_p^2}+jX_S=\underbrace{\frac{4\times10^{-3}}{\left(4\times10^{-3}\right)^2+B_p^2}}_{\text{Real part}}+j\underbrace{\left(X_S-\frac{B_p}{\left(4\times10^{-3}\right)^2+B_p^2}\right)}_{\text{Imaginary part}}=50$$

Equating the real parts of the left- and right-hand sides of this equation, one can solve for B_p, the susceptance value of the parallel element of the L-matching network, as

$$\frac{4\times10^{-3}}{\left(4\times10^{-3}\right)^2+B_p^2}=50\rightarrow B_p=\pm8\times10^{-3}\ \text{S}$$

The two values found for B_p lead to two different designs. When $B_p=8\times10^{-3}>0$, the parallel element of the L-matching network is a capacitor with value that can be calculated at the design frequency $f=1\,\text{MHz}$ as

$$\omega C_p=2\pi(10^6)C_p=8\times10^{-3}\rightarrow C_p\cong1.27\,\text{nF}\quad\leftarrow\text{Design \#1}$$

Similarly, when $B_p=-8\times10^{-3}<0$, the parallel element of the L-matching network is an inductor with value that can be obtained as

$$-\frac{1}{\omega L_p}=-\frac{1}{2\pi(10^6)L_p}=-8\times10^{-3}\rightarrow L_p\cong20\,\mu\text{H}\quad\leftarrow\text{Design \#2}$$

Equating the imaginary parts and substituting the value of B_p obtained above, one can compute the reactance value of the series element of the L-matching network as

$$X_S-\frac{B_p}{\left(4\times10^{-3}\right)^2+B_p^2}=0\rightarrow X_S=\pm100\,\Omega$$

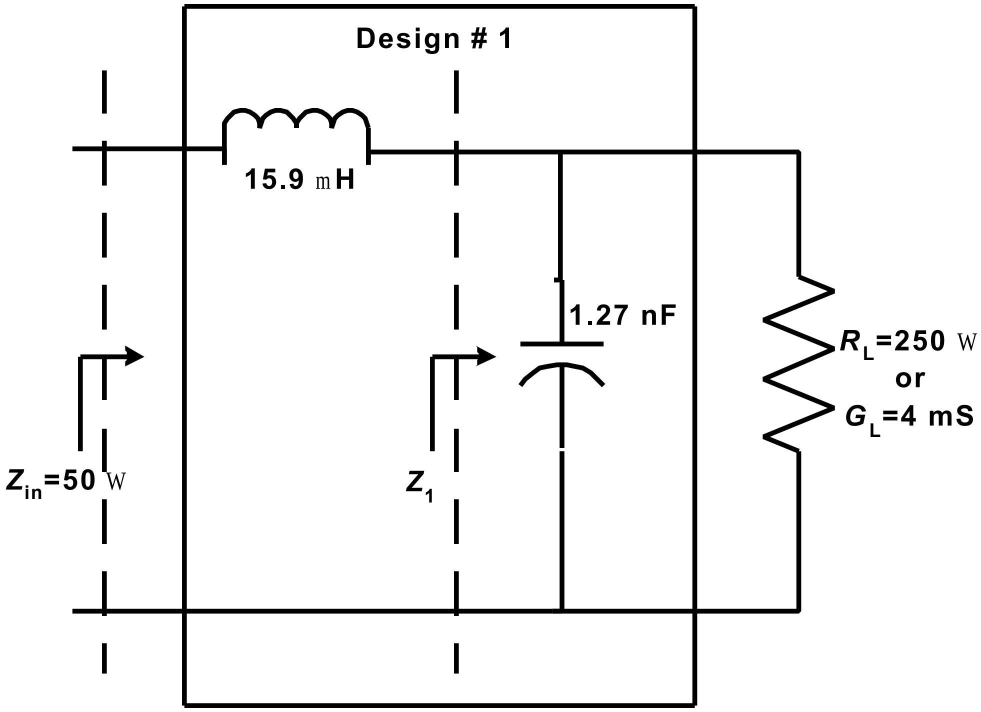
$B_p=8\times10^{-3}>0$ leads to $X_S=100>0$, in which case the series element of the L-matching network is an inductor with value given by

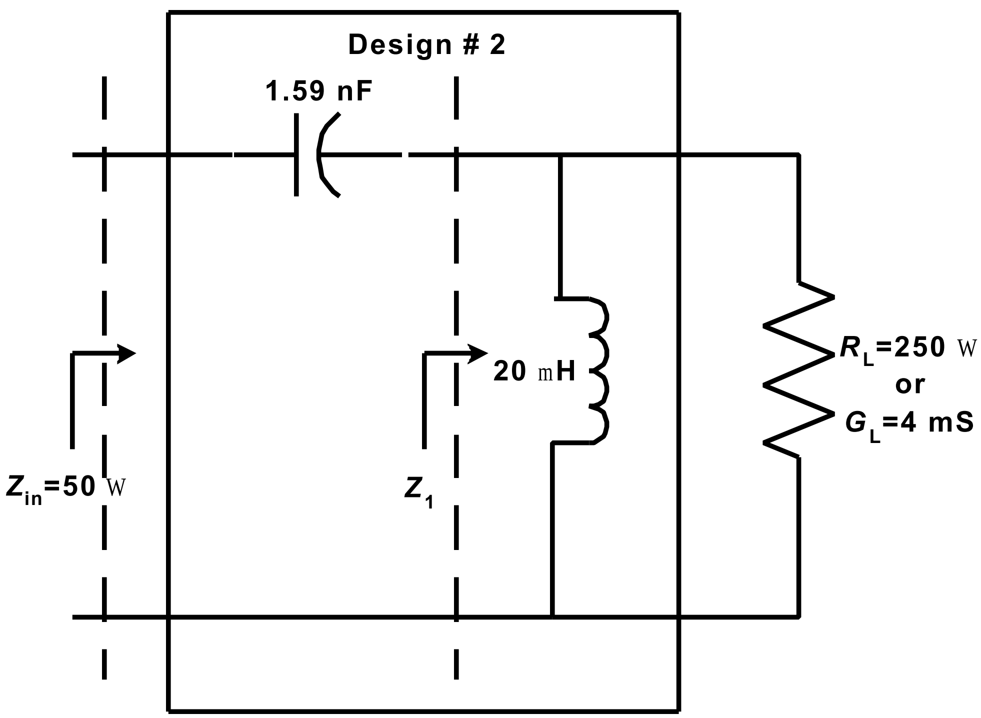
$$\omega L_S=2\pi(10^6)L_S=100\rightarrow L_S\cong15.9\,\mu\text{H}\quad\leftarrow\text{Design \#1}$$

Similarly, $B_p=-8\times10^{-3}<0$ leads to $X_S=-100<0$, in which case the series element of the L-matching network is a capacitor with a value given by

$$-\frac{1}{\omega C_S}=-\frac{1}{2\pi(10^6)C_S}=-100\rightarrow C_S\cong1.59\,\text{nF}\quad\leftarrow\text{Design \#2}$$

The two L-matching networks designed are summarized as shown on the next page. One interesting question that comes to mind is "Is the L-matching network symmetric?" That is instead of converting 250 Ω impedance into 50 Ω impedance, if we wanted to convert 50 Ω impedance into 250 Ω impedance, can we use the L-matching networks we already designed to achieve this goal? And if so, how do we connect the circuit? Do we simply change the places of the 250 Ω and the 50 Ω? Will this work?


Design # 1
15.9 mH
1.27 nF
R_L=250 W
or
G_L=4 mS
Z_{in}=50 W
Z_1


Design # 2
1.59 nF
20 mH
R_L=250 W
or
G_L=4 mS
Z_{in}=50 W
Z_1