Highpass L Matching Network Designer

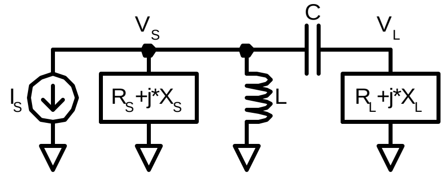

Table of Contents

I. Inputs
II. Calculations
III. Outputs
IV. Copyright Information

▶ useful functions and identities
▶ Units
▶ Constants

Inputs

$Z_S := 200\text{ohm} - j\cdot 50\text{ohm}$ Source impedance

$Z_L := 50\text{ohm} + j\cdot 25\text{ohm}$ Load impedance

$f_{min} := 900\text{MHz}$ Lower edge of band frequency

$f_{max} := 900\text{MHz}$ Upper edge of band frequency

Calculations

The L matching network is only designed to provide maximum power transfer at one frequency. In other words it is a narrow band matching network. Given a band of input frequencies, we set design the matching network for the center of the band.

$$f_c := \frac{f_{min} + f_{max}}{2} \qquad f_c = 900\,\mathrm{MHz}$$

$$f := f_c \qquad \omega_c := 2\cdot\pi\cdot f_c \qquad \omega := 2\cdot\pi\cdot f$$

The first step in synthesizing an impedance matching network is to deimbedd the source and load reactances. Because the matching network consists of a capacitor in series with the load, the load impedance is converted into an equivalent series resistance and capacitance. The equivalent series capacitance and resistance of load impedance are:

$$C_1 := \mathrm{if}\left(\mathrm{Im}(Z_L) = 0\,\mathrm{ohm}, 1000\mathrm{F}, \frac{-1}{\omega\cdot \mathrm{Im}(Z_L)}\right) \qquad C_1 = -7.074\,\mathrm{pF}$$

$$R_S := \mathrm{Re}(Z_L) \qquad R_S = 50\,\Omega$$

Deimbedding the source reactance is a little more difficult, because the impedance is parallel. The calculation is easy to perform by converting the input impedance to an admittance with a complex math processor, such as Mathcad, but is performed here assuming only a real processor is available. The equivalent parallel inductance and resistance of source impedance are:

$$Q_S := \frac{\mathrm{Im}(Z_S)}{\mathrm{Re}(Z_S)} \qquad Q_S = -0.25$$

$$R_p := \left(1 + Q_S^{\,2}\right)\cdot \mathrm{Re}(Z_S) \qquad R_p = 212.5\,\mathrm{ohm}$$

$$L_1 := \mathrm{if}\left(Q_S = 0, 1000\mathrm{H}, \frac{1 + Q_S^{\,2}}{Q_S^{\,2}}\cdot\frac{\mathrm{Im}(Z_S)}{\omega}\right) \qquad L_1 = -150.313\,\mathrm{nH}$$

With the source and load reactances deimbedded, we can synthesize the matching network using the real part of the source and the load. Our goal here is to size the L and the C such that source and the load sees the conjugate of it's impedance looking into the network. A matched network sliced anywhere in the network will have a conjugate impedance looking in either direction.

$$Z_{left} = \overline{Z_{right}}$$

The left side of the matching network consists of a parallel resistance and reactance. This can be expressed in a simplified form with the parallel resistance and the Q of the source.

$$Z_{left} = \frac{1}{\dfrac{1}{R_{left}} + \dfrac{1}{j\cdot L_{left}}} = \frac{1}{G_p + j\cdot B_{left}} = \frac{R_p}{\left(1 + j\cdot Q_{left}\right)}$$

The right side of the matching network consists of a series resistance and reactance. This can be expressed in a simplified form with the series resistance and the Q of the load.

$$\overline{Z_{right}} = R_{right} + \frac{1}{j\cdot C_{right}} = R_S + j\cdot X_{right} = R_S\cdot\left(1 - j\cdot Q_{right}\right)$$

Because the left and right resistances must be equal, and the reactances conjugates of each other, the Q's of the left and right sides must be equal. Setting the left impedance and right conjugate equal to each other, and setting the Q's equal gives the following equality.

$$\frac{R_p}{(1 + j\cdot Q)} = R_S\cdot(1 - j\cdot Q)$$

Solving this expression gives a general expression for the Q of matching network. Note the Q value is fixed by the source and load impedance for the L matching network. For higher order networks, and for equal source and load resistance, the Q of the network may be chosen.

$$Q := \sqrt{\frac{R_P}{R_S} - 1} \qquad Q = 1.803$$

This Q will serve as a lower bound for pi and T matching networks, and as an upper bound for cascaded L matching networks. Note the difference between network Q and component Q. Network Q is usually on the order of zero to three, to reduce sensitivity of the network. Component Q is much higher, typically 10 to 100, to

Given the Q of the left and right half sides of the network, and the effective source and load impedances, we can find the matching network inductance and capacitance without source inductance deembedded

$$C_S := \frac{1}{Q \cdot \omega \cdot R_S} \qquad C_S = 1.962\,\mathrm{pF} \qquad L_p := \frac{R_p}{\omega \cdot Q} \qquad L_p = 20.845\,\mathrm{nH}$$

The final impedance network is found by substracting the source inductance from the matching inductance and the load capacitance from the matching capacitance.

$$C := \mathrm{if}\left(C_1 = C_S, 1000\mathrm{F}, \frac{C_1 \cdot C_S}{C_1 - C_S}\right) \qquad \boxed{C = 1.536\,\mathrm{pF}}$$

$$L := \mathrm{if}\left(L_1 = L_p, 1000\mathrm{H}, \frac{L_p \cdot L_1}{L_1 - L_p}\right) \qquad \boxed{L = 18.306\,\mathrm{nH}}$$

We can check our calculation, by checking to see if the input and output impedances are complex conjugates of each other.

$$Z_i := (j \cdot \omega \cdot L) \parallel \left(Z_L + \frac{1}{j \cdot \omega \cdot C}\right) \qquad Z_i = 200 + 50i\,\mathrm{ohm} \qquad Z_S = 200 - 50i\,\Omega$$

$$Z_o := Z_S \parallel (j \cdot \omega \cdot L) + \frac{1}{j \cdot \omega \cdot C} \qquad Z_o = 50 - 25i\,\mathrm{ohm} \qquad Z_L = 50 + 25i\,\Omega$$

Outputs

$C = 1.536\,\mathrm{pF}$	Load Capacitance (in series with load)
$L = 18.306\,\mathrm{nH}$	Source Inductance (in parallel with source)

Copyright Information