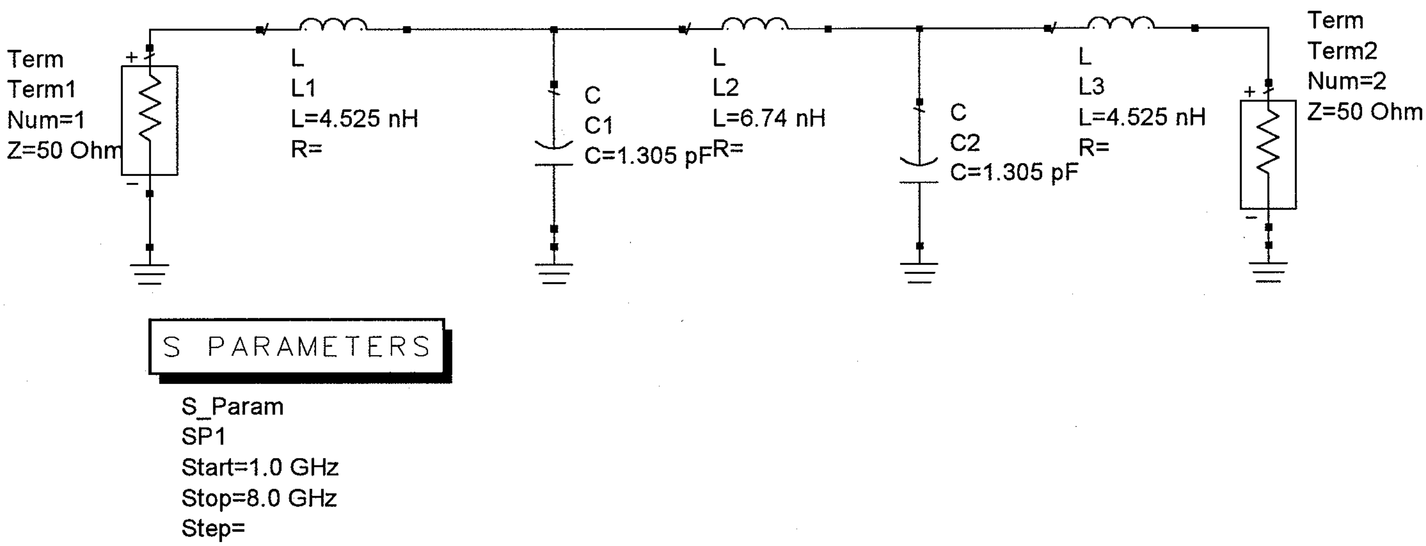
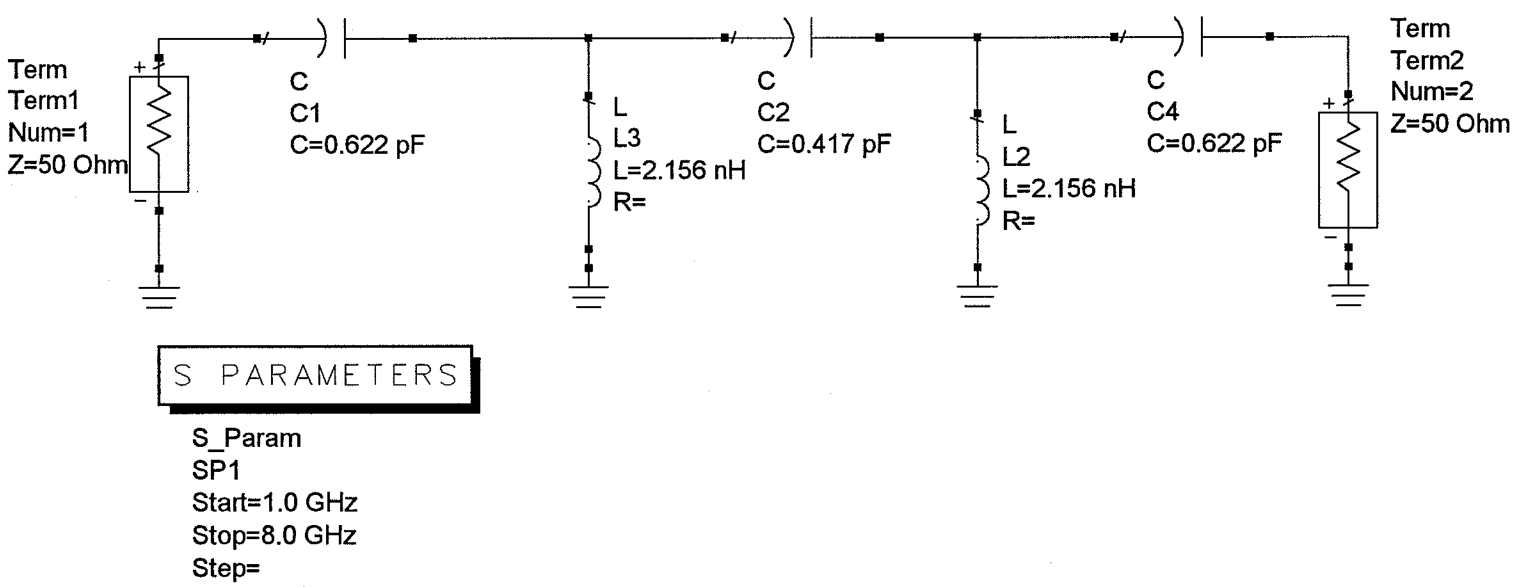
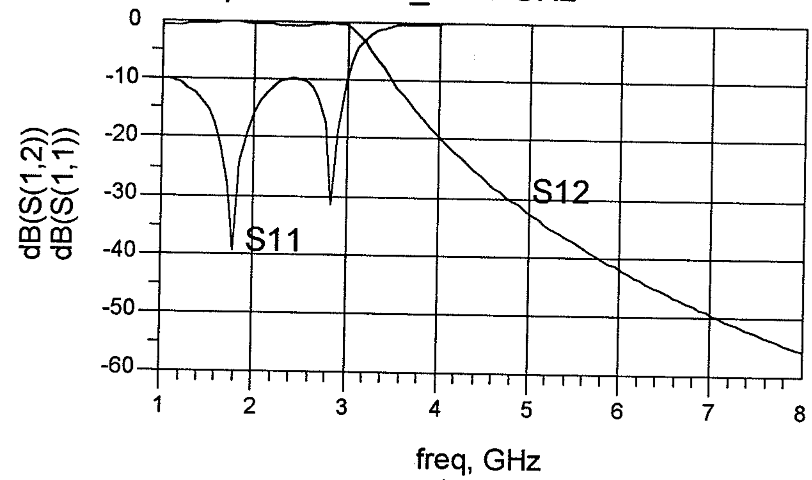
low-pass Filter



'Transformed' high-pass Filter

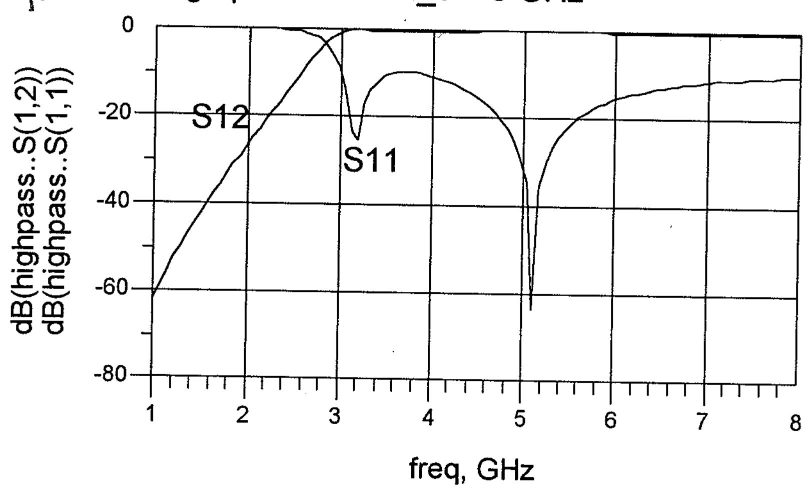


Low pass **filter** f_c = 3 GHz



Calculated S-parameters for Low-Pass Filter of p. 14

'Transformed' High pass **filter** f_c = 3 GHz

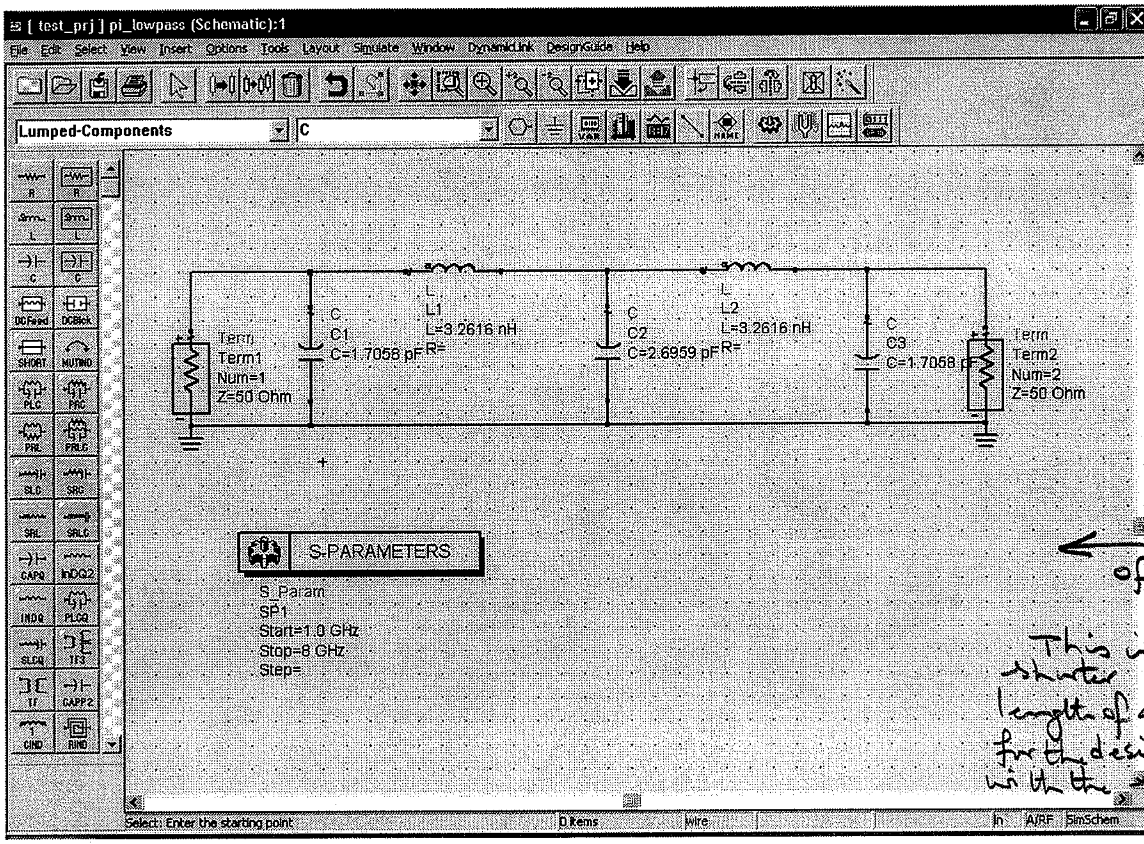


For 'transformed' high-pass filter of p. 14

Alternative Design for the N = 5, 0.5 dB low-pass Filter on p. 8-15

Prototype beginning with a shunt element (Fig. 8.25 a) rather than with a series element (Fig. 8.25 b) used previously on p. 17

Low-pass π-section filter, f_c = 3 GHz

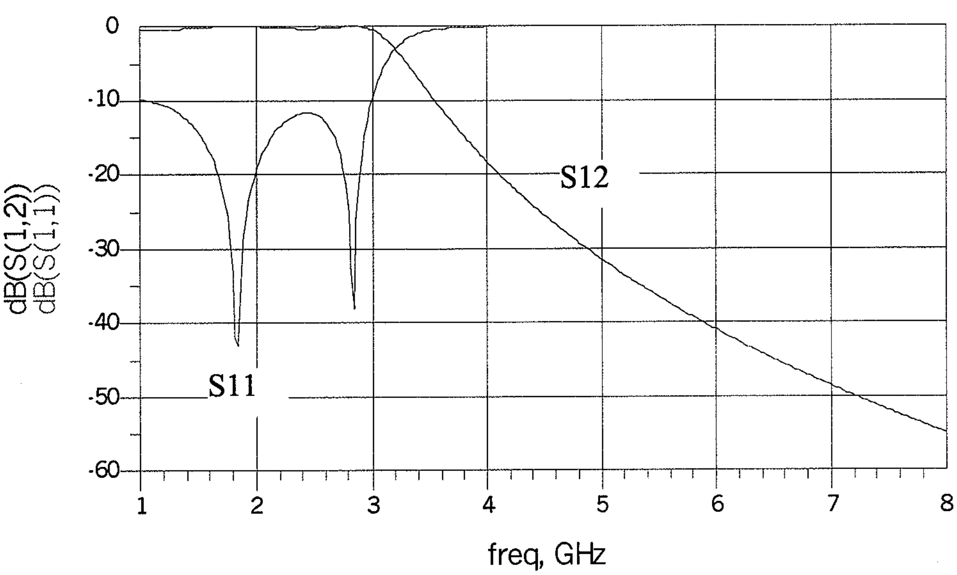


Assume $L_l = 0.5\ \frac{nH}{mm}$

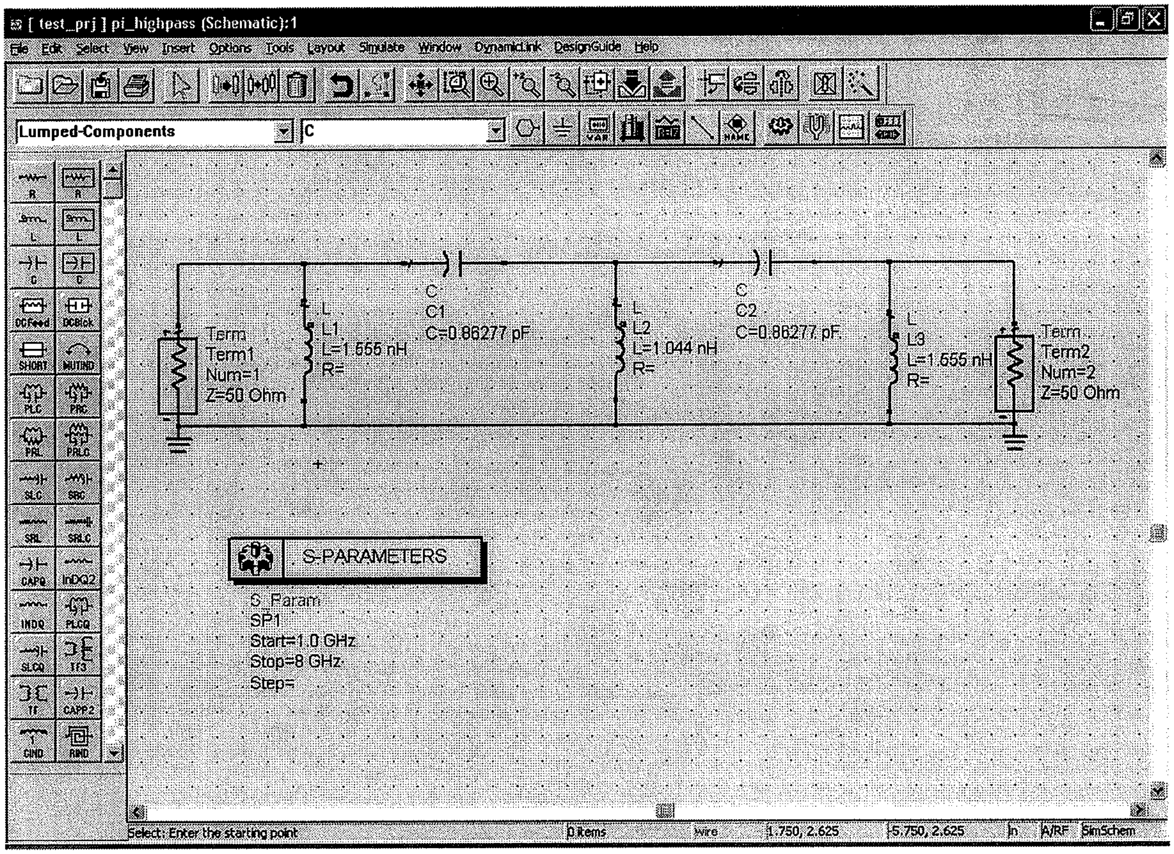
$C_l = 0.3\ \frac{pF}{mm}$

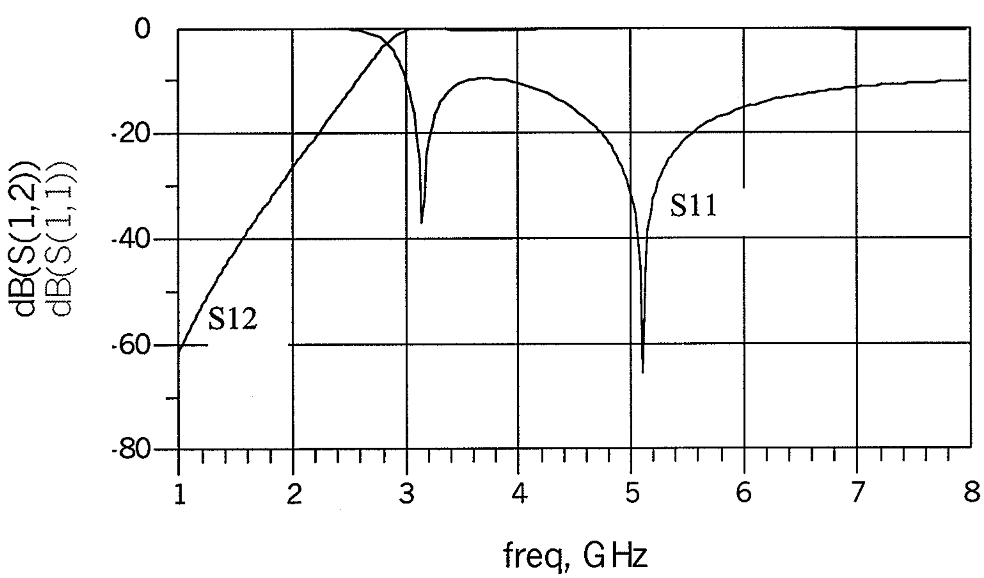
← Total length of the filter ≃ 33.4 mm

This is somewhat shorter than the required length of 40.3 mm for the design beginning with the series element on p. 17 of the Notes.



High-pass π-section filter, $f_c = 3$ GHz





pp. 401–405 Text

Bandpass Filter Design by Transformation from a Low-pass Filter (8-24)

Define $\Delta = \frac{\omega_2 - \omega_1}{\omega_0}$ (8.72)

See Table 8.6 p. 404

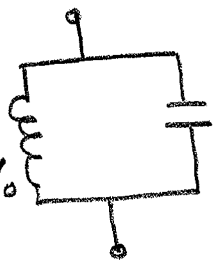
Low pass | **Bandpass**

$g_K = \frac{\omega L}{Z_0}$ L

$\frac{g_K Z_0}{\omega_0 \Delta}$ ← dimensions of inductance

$\frac{\Delta}{\omega_0 g_K Z_0}$ ← dimensions of C

$g_K = \frac{\omega C}{Y_0}$ C



dimensions of L → $\frac{\Delta}{\omega_0 g_K Y_0}$

$\frac{g_K Y_0}{\omega_0 \Delta}$ ← dimensions of C

Ex. 8.4 Bandpass Filter Design
p. 404 Text

0.5 dB equal-ripple filter ; $N = 3$; $f_0 = 1\ GHz$; $\Delta = 0.1$

$Z_0 = 50\ \Omega$

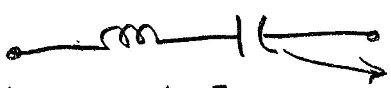
From Table 8.4 for N = 3 (for a low-pass filter)

$g_1 = 1.5963$ (inductance)

$g_2 = 1.0967$ (capacitance)

$g_3 = 1.5963$ (inductance)

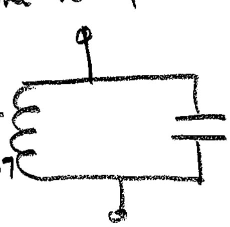
for bandpass filter, the inductance g_1 can be replaced by ($g_1 = 1.5963$)



$L = \frac{1.5963 \times 50}{2\pi \times 10^9 \times 0.1} = 127.0\ nH$

$C = \Delta / (\omega_0 g_K Z_0) = \frac{0.1}{2\pi \times 10^9 \times 1.5963 \times 50} = 0.199\ pF$

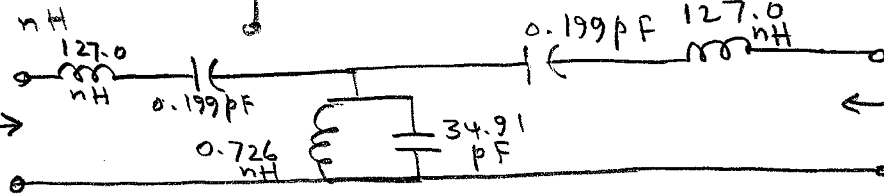
The capacitance C of the low pass filter ($g_K = 1.0967$) can be replaced by



$L = \frac{\Delta}{\omega_0 g_K \frac{1}{50}} = \frac{5}{2\pi \times 10^9 \times 1.0967} = 0.726\ nH$

$C = \frac{g_K Y_0}{\omega_0 \Delta} = \frac{1.0967 \times \frac{1}{50}}{2\pi \times 10^9 \times 0.1} = 34.91\ pF$

From Fig. 8.32



Ex. 8.6 Stepped-Impedance Filter Design
p. 414

From Table 8.3, for N=6 maximally flat response lowpass filter, the elements required are:

$$g_1 = 0.517, \quad g_2 = 1.414, \quad g_3 = 1.932 \quad (1)$$
$$g_4 = 1.932, \quad g_5 = 1.414, \quad g_6 = 0.517$$
$$g_7 = 1.0$$

From p. 12 of these notes

$$C_\ell = \frac{1}{v_p Z_\ell} \quad (2a) \qquad L_\ell = \frac{Z_h}{v_p} \quad (2b)$$

Thus if a capacitor element is used for the filter, say g_1

$$g_1 = \frac{\omega_c C}{Y_0} = \omega_c C Z_0 \quad (3)$$

length of the microstripline needed to get the needed capacitance (from Eqs. 2a, 3)

$$\ell = \frac{C}{C_\ell} = \left(\frac{g_1}{\omega_c Z_0}\right) v_p Z_\ell = \frac{g_1}{\beta_c}\frac{Z_\ell}{Z_0} \quad (4)$$

where $\beta_c = \omega_c / v_p$

Thus $\beta_c \ell = g_1 \dfrac{Z_\ell}{Z_0}$ for capacitive sections (5)

Similarly for inductive elements say g_2

$$g_2 = \frac{\omega_c L}{Z_0} \quad (6)$$

$$\ell = \frac{L}{L_\ell} = \left(\frac{g_2 Z_0}{\omega_c}\right)\left(\frac{v_p}{Z_h}\right) \quad (7)$$

$$\beta_c \ell = g_2 \frac{Z_0}{Z_h}$$

For Ex. 8.6 the text selects $Z_0 = 50\,\Omega$, $Z_\ell = 20\,\Omega$, $Z_h = 120\,\Omega$

C_1: $\beta_c \ell_1 = g_1 \dfrac{20}{50} = 0.517 \times \dfrac{20}{50} = 0.2068$ rad $\Rightarrow 11.8^\circ$

L_2: $\beta_c \ell_2 = g_2 \dfrac{50}{120} = 1.414 \times \dfrac{50}{120} = 0.589$ rad $\Rightarrow 33.8^\circ$

C_3: $\beta_c \ell_3 = g_3 \dfrac{20}{50} = 1.932 \times \dfrac{20}{50} = 0.773$ rad $\Rightarrow 44.3^\circ$

L_4: $\beta_c \ell_4 = g_4 \dfrac{50}{120} = 1.932 \times \dfrac{50}{120} = 0.805$ rad $\Rightarrow 46.1^\circ$

C_5: $\beta_c \ell_5 = g_5 \times \dfrac{20}{50} = 1.414 \times \dfrac{20}{50} = 0.5656$ rad $\Rightarrow 32.4^\circ$

L_6: $\beta_c \ell_6 = g_6 \dfrac{50}{120} = 0.517 \times \dfrac{50}{120} = 0.2154$ rad $\Rightarrow 12.3^\circ$

Total length of filter $= 180.7^\circ \simeq \lambda_g/2$

8.7 Design of a Coupled Line Bandpass filter (pp. 416 – 426)

See Ex. 8.7 pp. 425, 426

Step 1 Determine g_n for the prototype low pass filter

from Table 8.3 for a maximally flat LP filter

from Table 8.4 for an equal-ripple or Chebyshev LP filter (a faster attenuation for stop band)

Step 2 Eqs 8.121 a – c p. 425

determine admittance inverter constants $J_1, J_2, \ldots J_{N+1}$

This helps in determining $Z_0 J_1, Z_0 J_2 \ldots Z_0 J_{N+1}$

Step 3 Determine Z_{oe}, Z_{oo} for various sections (Eqs. 8.108 a, b p. 421

$$Z_{oe} = Z_0\left[1 + JZ_0 + (JZ_0)^2\right] \quad (8.108\ a)$$

$$Z_{oo} = Z_0\left[1 - JZ_0 + (JZ_0)^2\right] \quad (8.108\ b)$$

Step 4 Determine C_n from Eq. 7.81 and Z_{on} from Eq. 7.77

$$C_n = \frac{Z_{oe} - Z_{oo}}{Z_{oe} + Z_{oo}} \quad (7.81)$$

$$Z_{on} = \sqrt{Z_{oe} Z_{oo}} \quad (7.77)$$

The spacings and widths to use for the various coupled sections are then given from Figs. 7.29 or 7.30, as appropriate.