

## EXAMPLE 4:

### Low-Pass Filter Design using impedance steps.

Design a low-pass filter for fabrication using microstrip lines.

The specifications are:

- cutoff frequency of 5 GHz
- fifth order
- impedance of  $50 \Omega$
- 0.5 dB equal-ripple characteristic.
- $\epsilon_r = 9.8$
- Thickness of dielectric = 25 mill

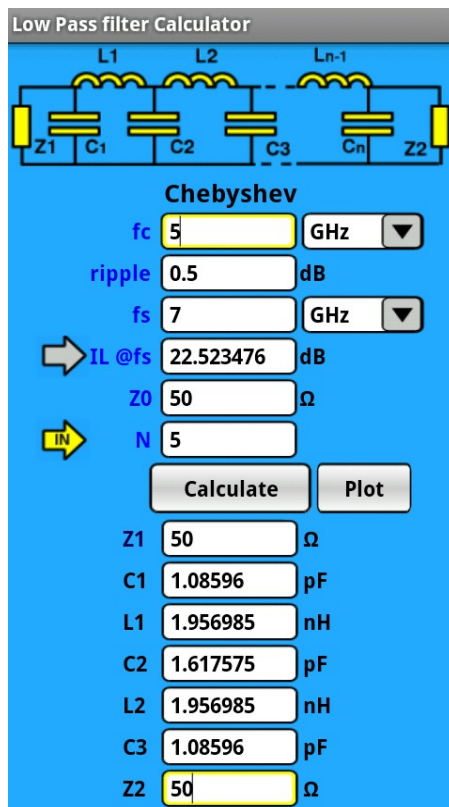
### Solution

Start up the rf & microwave toolbox and select the low pass filter tool.

Then select filter type Chebyshev and g-values as output.

Choose the shunt filter configuration.

Fill in the filter specifications and tab the Calculate button.



Low Pass filter Calculator

Chebyshev

fc 5 GHz

ripple 0.5 dB

fs 7 GHz

IL @fs 22.523476 dB

Z0 50  $\Omega$

N 5

Calculate Plot

Z1 50  $\Omega$

C1 1.08596 pF

L1 1.956985 nH

C2 1.617575 pF

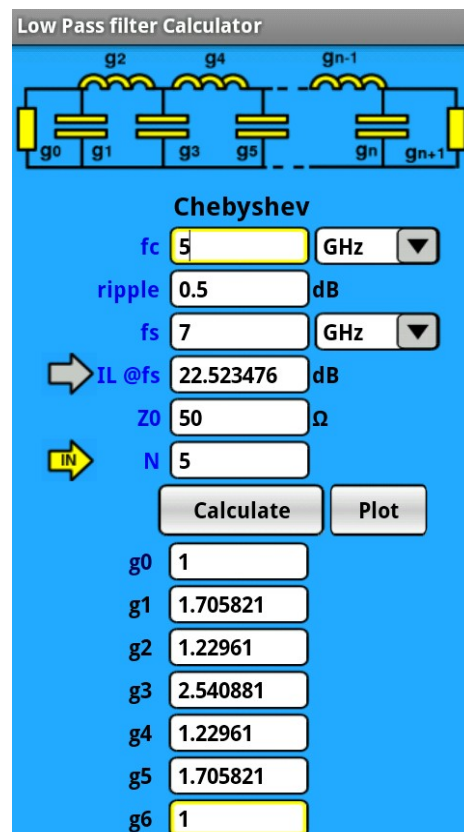
L2 1.956985 nH

C3 1.08596 pF

Z2 50  $\Omega$

The diagram shows a shunt filter configuration with series inductors L1, L2, ..., Ln-1 and shunt capacitors C1, C2, ..., Cn. The input and output impedances are Z1 and Z2.

Figure 1:  $l_c$ -values low pass filter dialog.



Low Pass filter Calculator

Chebyshev

fc 5 GHz

ripple 0.5 dB

fs 7 GHz

IL @fs 22.523476 dB

Z0 50  $\Omega$

N 5

Calculate Plot

g0 1

g1 1.705821

g2 1.22961

g3 2.540881

g4 1.22961

g5 1.705821

g6 1

The diagram shows a shunt filter configuration with shunt capacitors g0, g1, g2, g3, g4, g5, g6 and series inductors g2, g4, gn-1.

Figure 2:  $g$ -values low pass filter dialog

Now select the Stepped Impedance tool and convert the capacitors and inductors to low cq high impedance transmission lines. The best result you get when the Zlow is as low as possible and Zhigh is as high as possible. (This will result in line lengths which are sort as possible.)

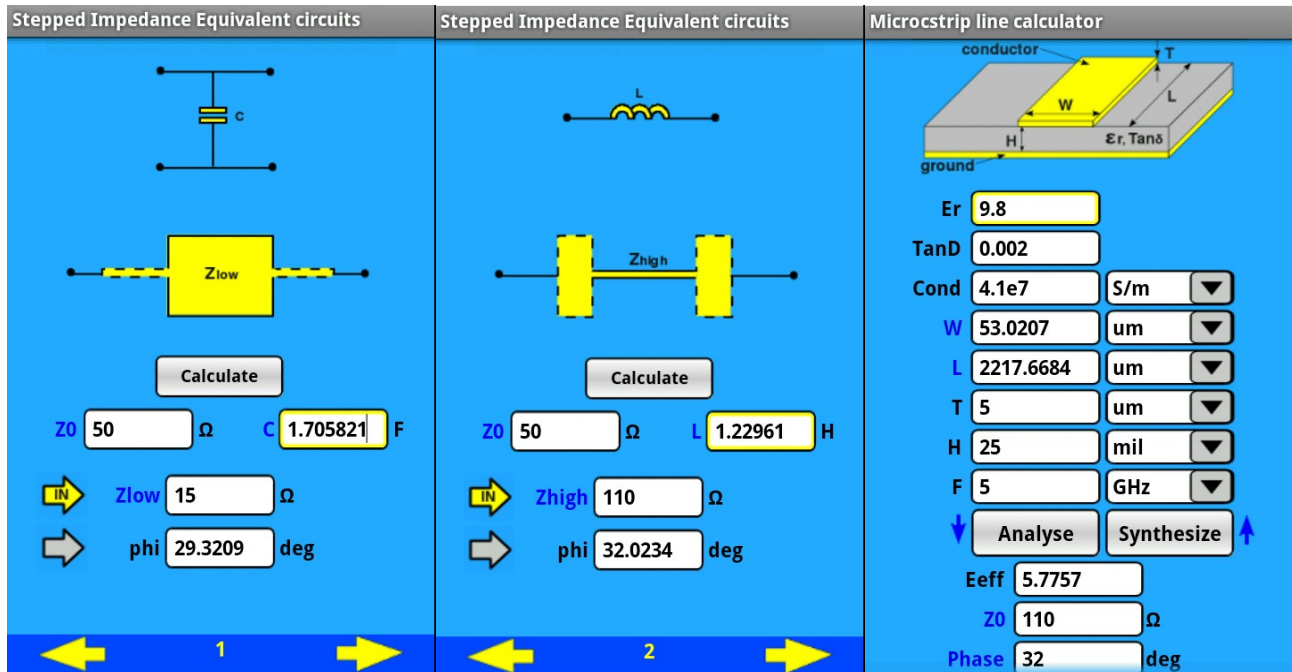


Figure 3: Conversion of C to microstrip with low impedance

Figure 4: Conversion of C to microstrip with high impedance

Figure 5: Calculation of line width and length.

With use of the microstrip calculator the line width and length are calculated.

	Z (Ohm)	Phi (deg)	Width (um)	Length (um)
<b>Z0</b>	50	--	610 um	--
<b>Zlow1</b>	15	29.3	3925	1694
<b>Zlow2</b>	15	43.7	3925	2526
<b>Zhigh</b>	110	32.0	53	2218

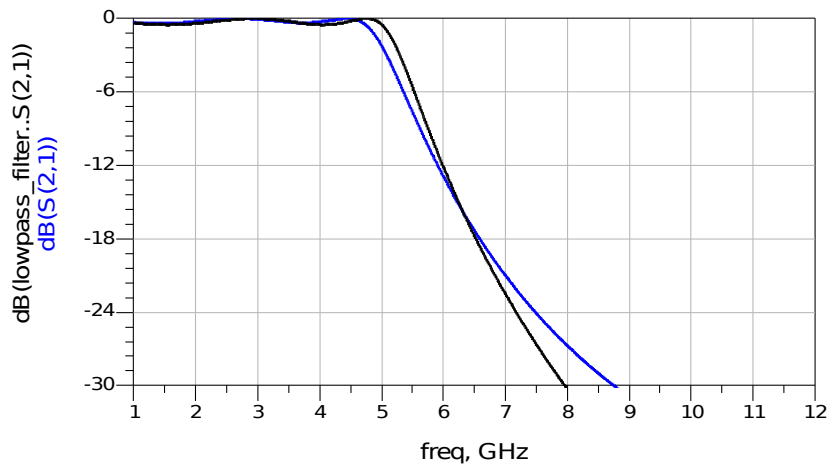


Figure 6 ADS simulation. Black: Prototype filter (lc-values) Blue:Low pass filter using microstrip lines

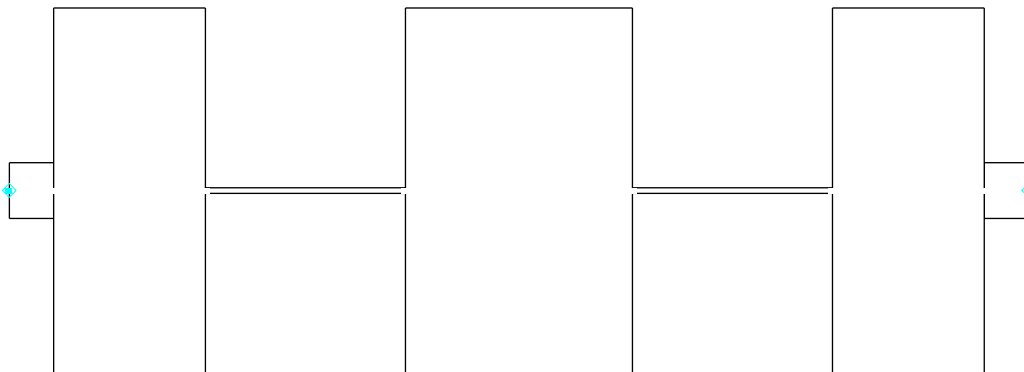


Figure 7 Layout of the low pass filter.