

## Design Project #3: Low Pass Filters

### PROJECT SCOPE

Design a **low-pass** filter with the following specifications:

<i>Order</i>	3
<i>Cutoff frequency</i>	2.0 GHz
<i>Source and Load Impedance</i>	50 $\Omega$
<i>Filter Type</i>	Chebyshev (0.5 dB ripple)

Design this filter using **3 methods**:

- With lumped elements, using two series inductors and one shunt capacitor
- With shunt stubs (i.e., Richard's Transformation and Kuroda's Identities).
- Using stepped impedance transmission lines, with  $Z_0^l = 15\Omega$  and  $Z_0^h = 200\Omega$ .

### PROJECT TASKS:

- Determine design values for each of the three designs. Show clearly your design steps, and specify all relevant parameters for each

design. Specify transmission line lengths assuming TEM propagation and  $\epsilon_r = 4.0$ .

2) For each method, plot  $|S_{21}|$  in linear scale and  $|S_{21}|^2$  in log scale, from 0 GHz to 10 GHz.

**Q1:** *Do these results indicate that your designs are correct? Explain why you think so.*

3) From these plots, determine the insertion loss of each filter design at 1, 3, 4 and 7 GHz.

**Q2:** *Compare these values between the different filter designs. Some of these values are close to the same for each design, while some values are quite different. Explain why this is so.*

4) For each design, plot  $S_{11}$  on a **Smith Chart** over the same frequencies of 0 to 10 GHz.

**Q3:** *For what frequencies is the curve on the Smith chart nearest the center? Explain why this is so.*

5) For each method, plot the **phase** of  $S_{21}$  from 0 GHz to 10 GHz.

**Q4:** *Do these filters appear to be linear phase filters? Explain why you think they are or are not.*

6) Change the impedance of the "TERM" element to  $100 \Omega$  for the input (port 1) element, and change the impedance of "TERM" element to  $25 \Omega$  for the output (port 2) element.

Now replot  $|S_{21}|$ , in both linear and log scale, from 0 GHz to 10 GHz.

**Q5:** *Compare these plots to the results of task 2. Explain **why** they are not the same.*

### ADS INFORMATION

You will need two "TERM" elements, as well as inductors "L" capacitors "C" and ideal transmission line lengths "TLIN".

### PROJECT REPORT

The same as project 1.

### PROJECT GRADING

The same as project 1.