EXAMPLE 2:

Band-stop Filter Design Using Stubs and coupled lines

Design a low-pass filter for fabrication using microstrip lines.
The specifications are:

- cutoff frequency;
  fc1 = 2.9 GHz
  fc2 = 3.1 Ghz
- Stop frequency: fs = 2.95 GHz
- IL = 15 dB @ fs
- Impedance of 50 Ω
- 0.2 dB equal-ripple characteristic.
- Er = 9.8
- Thickness of dielectric = 25 mill

Solution

Start up the rf & microwave toolbox and select the band-stop filter tool.

Then select, from the menu, filter type Chebyshev and normalized LC-values as output.
Fill in the filter specifications and tab the Calculate button.

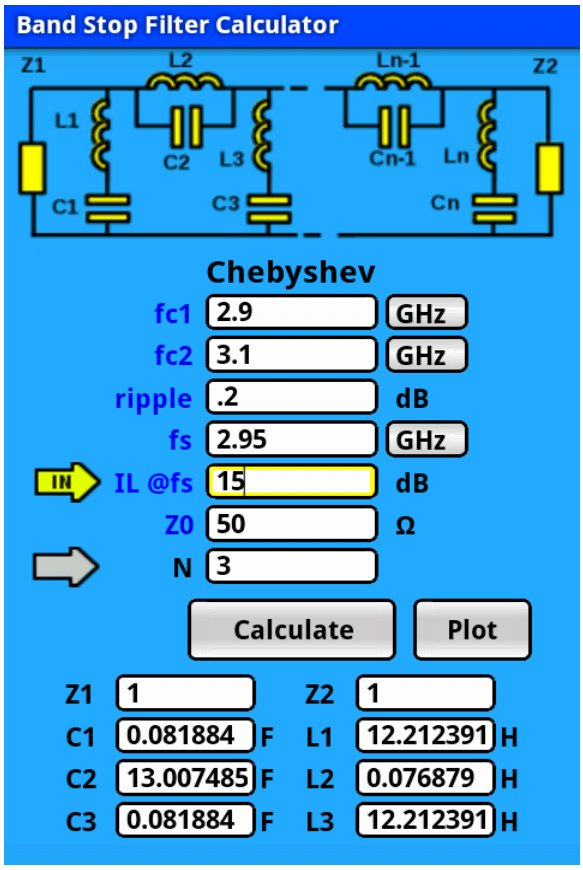

Figure 1: Band-stop filter calculator dialog

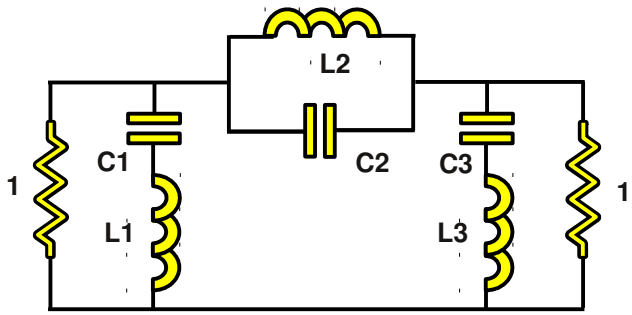

Figure 2: Band-stop prototype filter

The normalized band-stop prototype element values are:

L1 = 12.2124
C1 = 0.0819
L2 = 0.0769
C2 = 13.0075
L3 = 12.2124
C3 = 0.0819

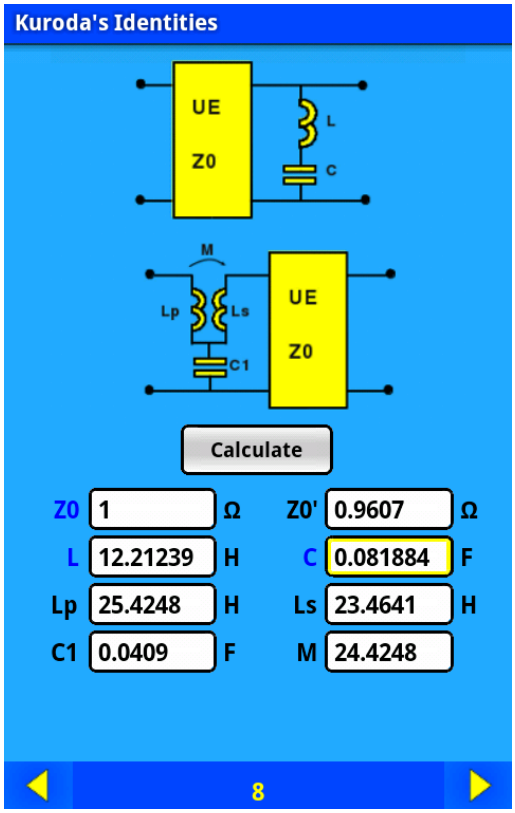

Figure 3: Kuroda's Identities dialog

We will use Kuroda's identity nr 8 to convert the shunt LC elements into Brune sections.
Select tool Filter Design and the tab button Kuroda's Identities.
Fill in the values for Z0 (Zin, Zout) and L (L1,L3)

After using Kuroda's identities we getting the circuit of Figure 4.

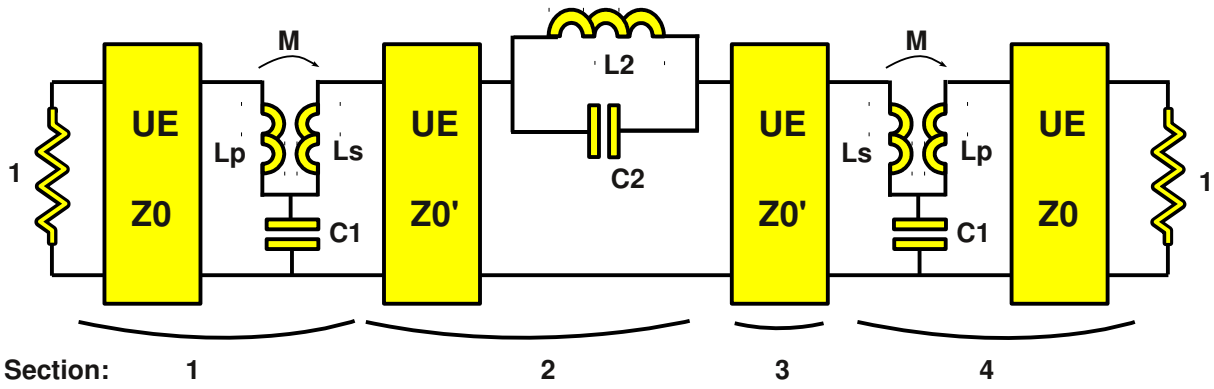

Figure 4: Band-stop filter after using Kuroda's Identities

Z0 = 1
Z0' = 0.9607
C1 = 0.0409
C2 = 13.0075
L2 = 0.0769
Lp = 25.4224
Ls = 23.4617
M = 24.4224

Now we will use coupled line equivalent circuit nr 12 and 14 to convert the lumped elements into coupled line sections with shunt stubs.
According to Richard's transformation all lengths for coupled line and stubs are λ/8.
(The frequency at which the lines are λ/8 is equal to √(2.9*3.1) = 2.9983 Ghz)

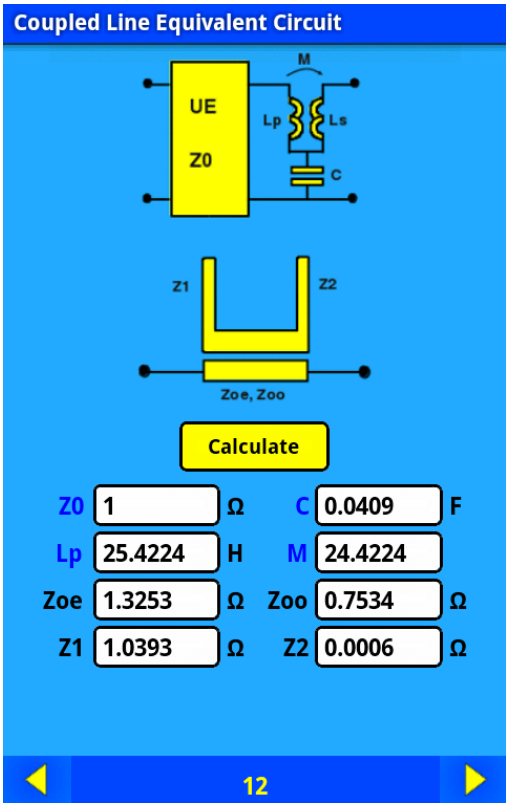

Figure 5: Series and shunt equivalent circuit nr 12 dialog

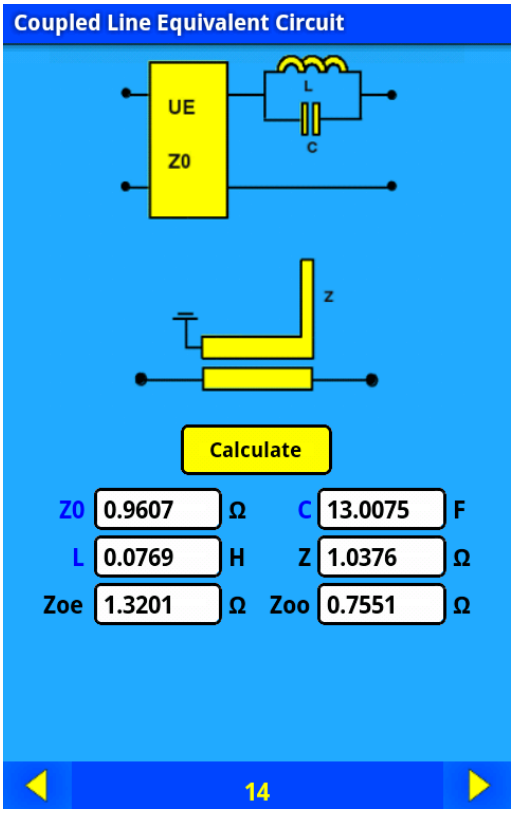

Figure 6: Series and shunt equivalent circuit nr14 dialog

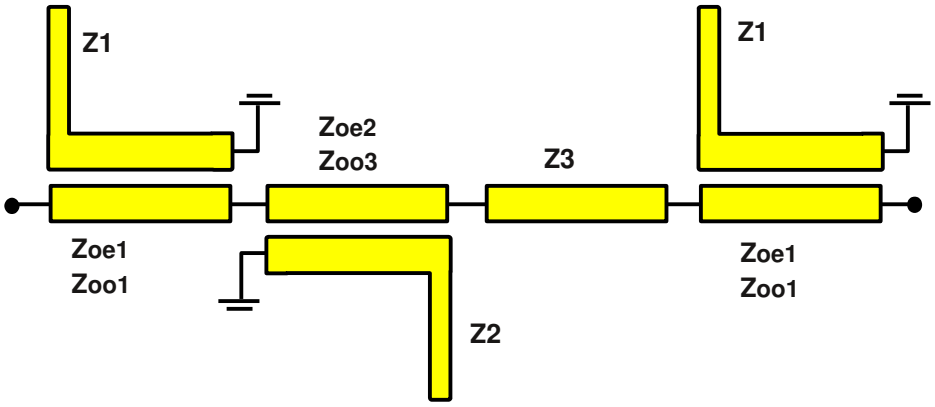

Figure 7: Band-stop filter using transmission lines. All lengths are λ/8 @fo

	Normalized values (Z0 = 1)	***De-Normalized values (Z0 = 50Ω)***
Z1	*1.0393*	*51.97*
Z2	*0.9604*	*48.02*
Z3	*1.0376*	*51.88*
Zoe1	*1.3252*	*66.26*
Zoo1	*0.7534*	37.67
Zoe2	*1.3201*	*66.01*
Zoo2	*0.7551*	37.76

Next step is to convert the ideal transmission lines to microstrip lines.
Select tool Microstrip Calculator and fill in the values for Er (9.8) and substrate height (25 mil).
Fill in a phase of 45 deg (λ/8) and F is the center frequency (2.9983 Ghz)
Leave all other parameters to default.

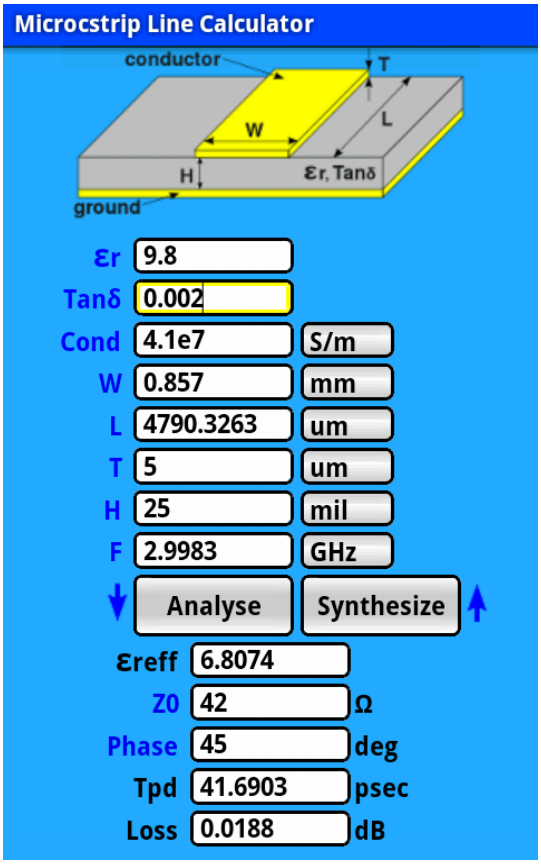

Figure 9: Microstrip line calculator dialog

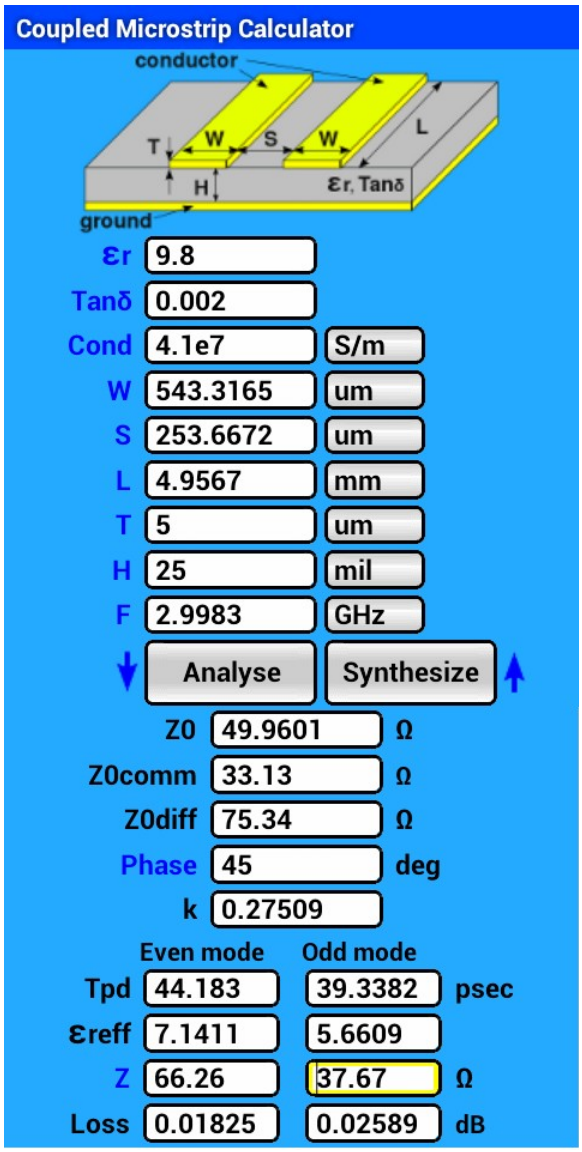

Figure 8: Coupled microstrip calculator dialog

Fill in the desired impedance of the transmission lines and synthesize the width an length of the microstrip lines.

Next step is to convert the coupled line sections to microstrip lines.
Select tool Coupled Microstrip Calculator (Figure 8) and fill in the values for Er (9.8) and substrate height (25 mil).
Fill in a phase of 45 deg (λ/8) and F is fo=√(fc1*fc2) = 2.9983 Ghz
Leave all other parameters to default.

Then set the synthesize mode to **Z odd & even**.
Fill in the desired Z even and Z odd impedance and synthesize the width (W), length (L) and the gap (S).

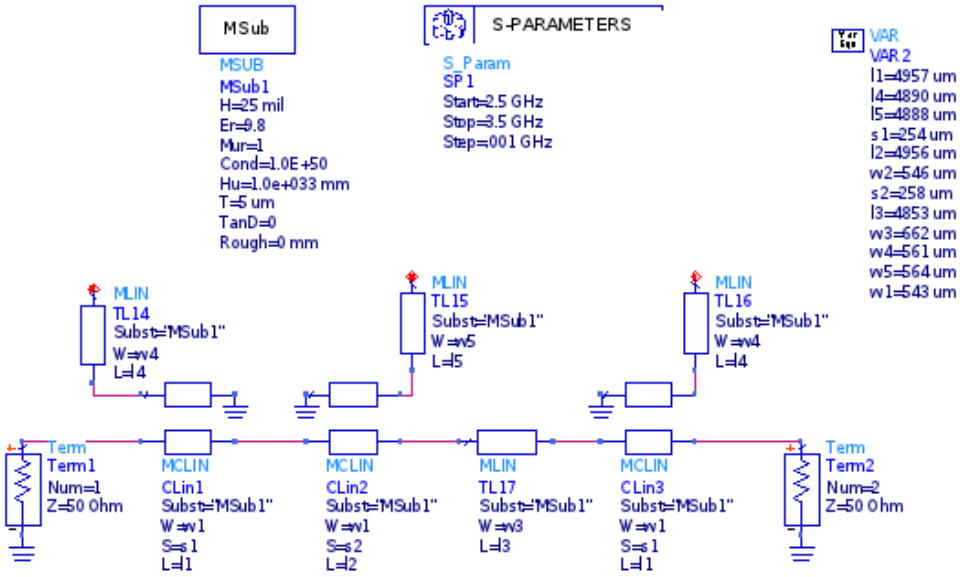

Figure 10: ADS circuit of the microstrip band-stop filter

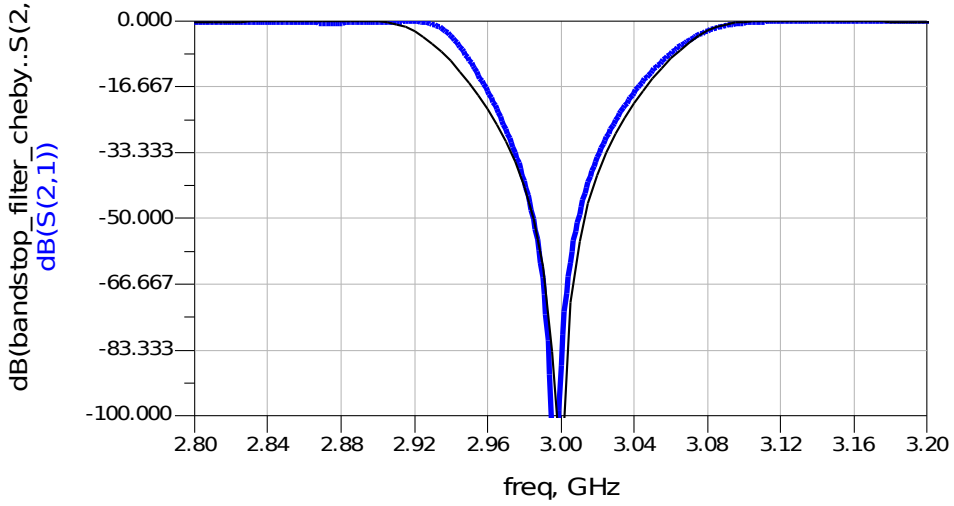

*Figure 11: ADS simulation of the band-stop filter. **Blue**: Using microstrip lines. **Black**: Lumped circuit.*