

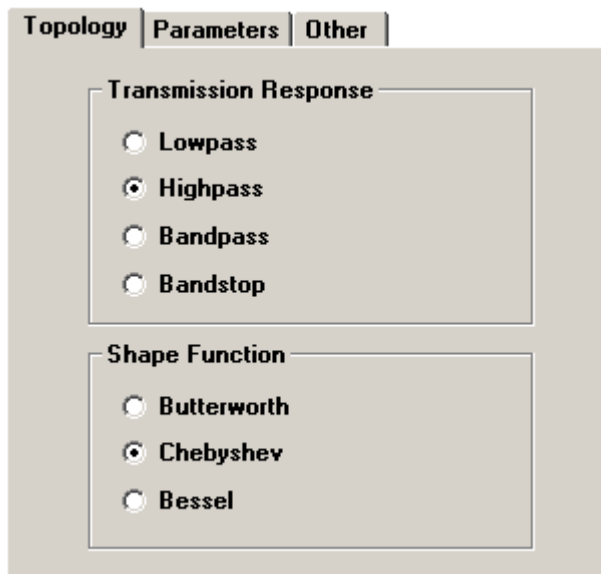
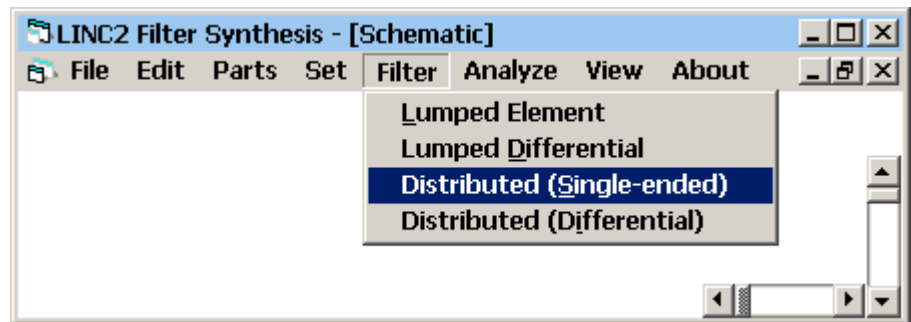
Designing Microwave Distributed Filters with LINC2- Single-Ended Highpass Distributed Filter Design Example

The LINC2 filter design module can synthesize filters for each of the basic transmission responses (lowpass, highpass, bandpass and bandstop). Each of these can be shaped according to Chebyshev, Butterworth, or Bessel shape functions. All of these options can be applied to four basic kinds of filters: Lumped Single-Ended, Lumped Differential, Single-Ended Distributed, and Differential Distributed. The LINC2 filter program generates “live” schematics that can be edited, simulated, tuned, optimized or saved to a disk file.

The following example outlines the design of a 9th order Chebyshev highpass distributed filter with a cutoff frequency of 1000 MHz.

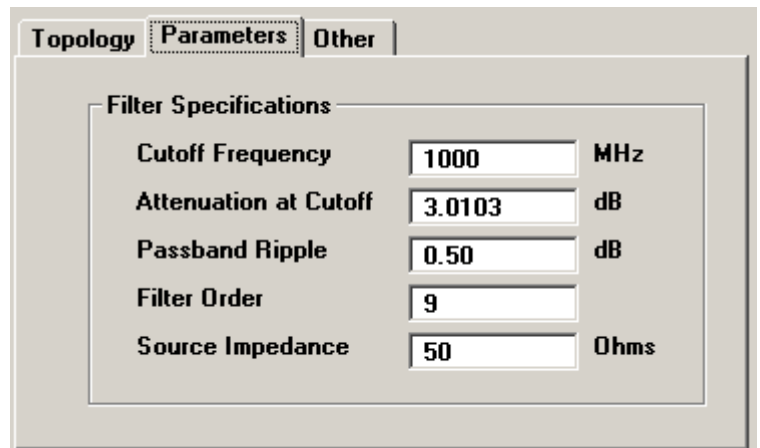
Start the LINC2 program and select “Tools | Filter Design” from the main menu.

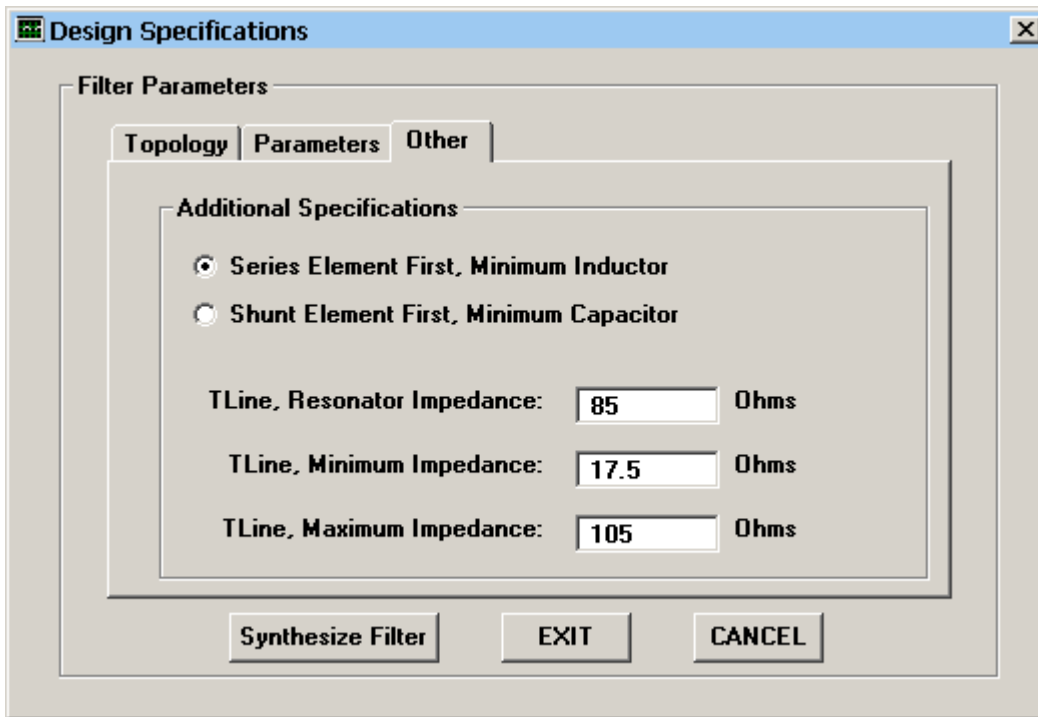
Select “Distributed (Single-ended)” from the “Filter” menu.



Next, select the type of filter and its shape function. For this example, a Chebyshev highpass filter was selected.

Click the “Parameters” tab and fill in the following design parameters: -3 dB cutoff frequency at 1000 MHz, 0.5 dB of passband ripple, port impedances of 50 ohms and a filter order of 9.

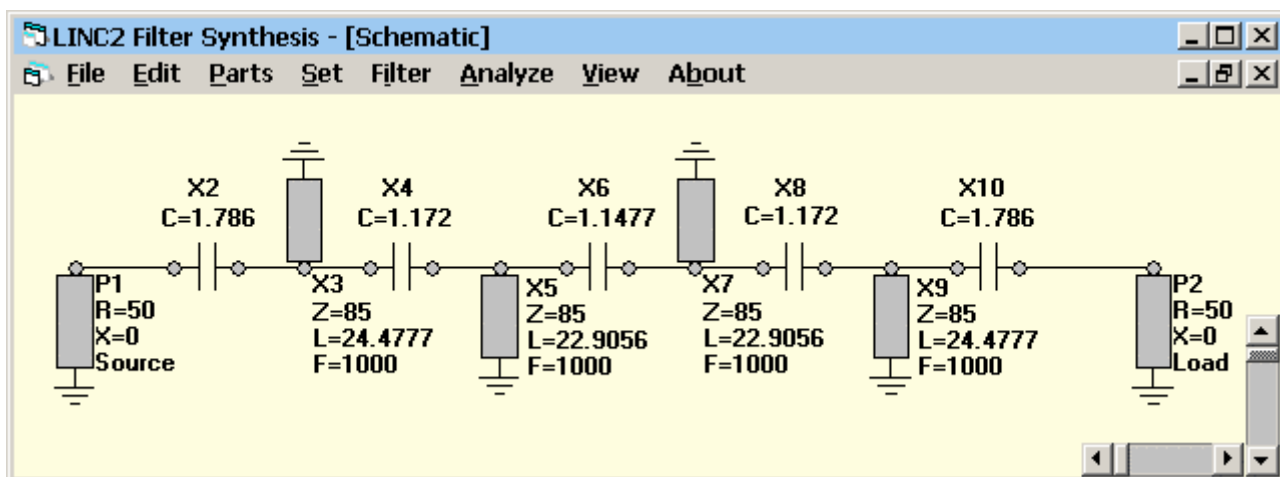




Click the “**Other**” tab and fill in the other parameters related to the type of filter selected. In this case, 85 ohms is entered for the transmission line resonator impedance.

The other parameters are left in their default states.

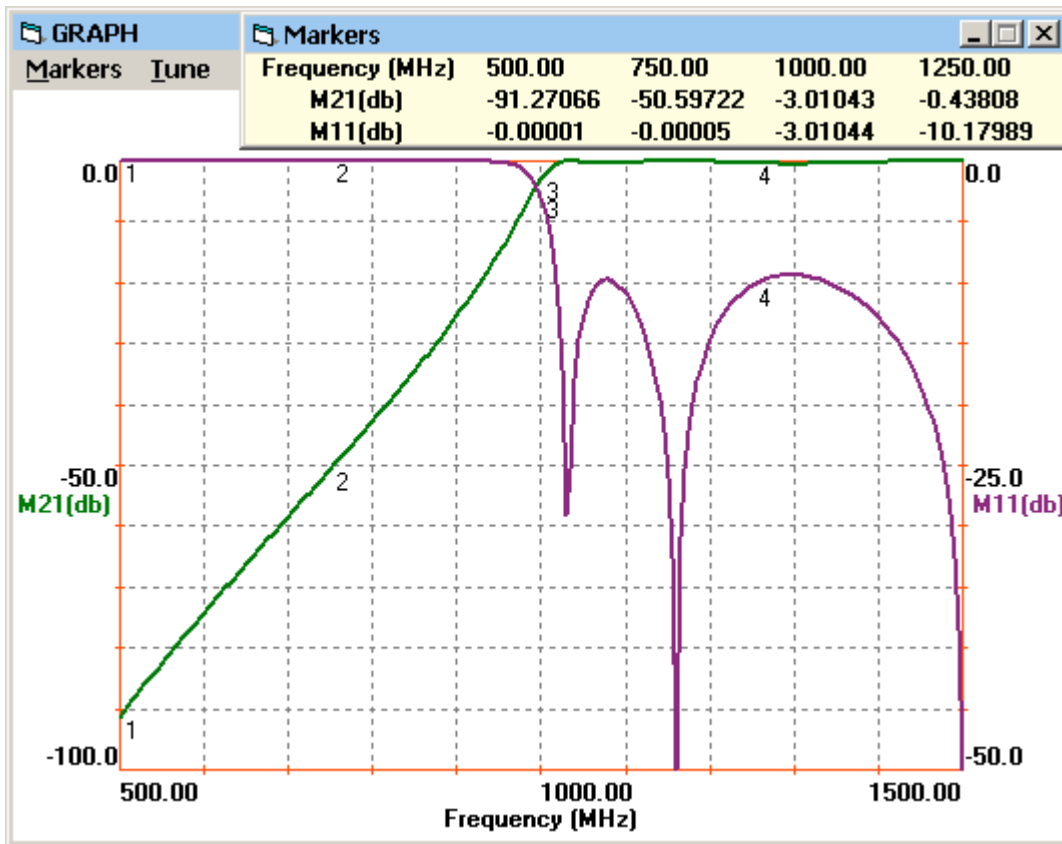
Click the “**Synthesize Filter**” button to generate the filter schematic below:



The short circuit transmission line stubs are automatically placed with orientations that alternate up and down to eliminate unwanted coupling between the lines.

At this point, all the transmission lines are ideal. Each line is modeled by its electrical parameters (characteristic impedance, electrical length and the frequency at which the electrical length is determined). LINC2 FILTER can automatically convert all of the electrical (transmission line models) to physical lines (microstrip or stripline) in one step.

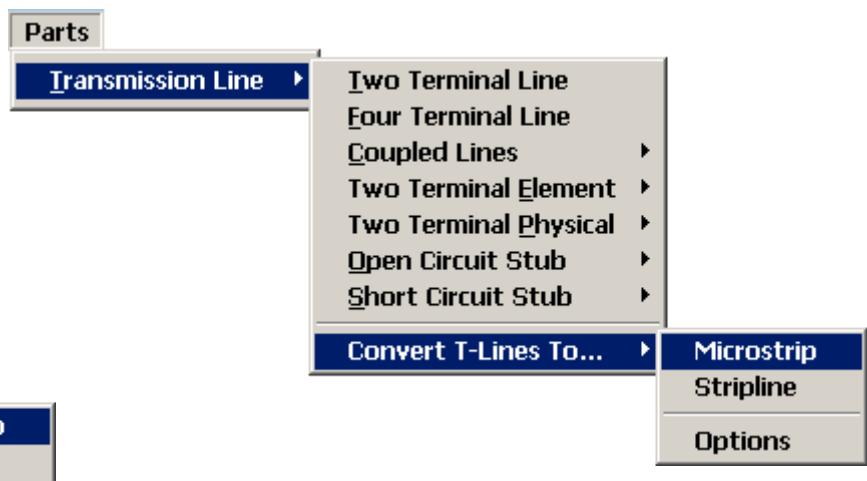
However, first we will run a simulation on the “ideal” filter schematic for comparison. To simulate the filter schematic as is, simply click “**Analyze**” in the main menu bar (above). Clicking “**Set | Output...**” allows for setting up the vertical scales and plot options prior to simulation. The plot options can also be changed after a simulation is run by selecting “**View | Set Options**” from the main menu bar. Close any open plot windows before changing the View Options. Then selecting “**View | Plot**” will display the changes. In this case, the plot of the ideal 9th order highpass filter will look like the graph below:



The graph indicates that the 3 dB cutoff frequency occurs exactly at 1000 MHz as designed. The passband ripple is also 0.5 dB as predicted.

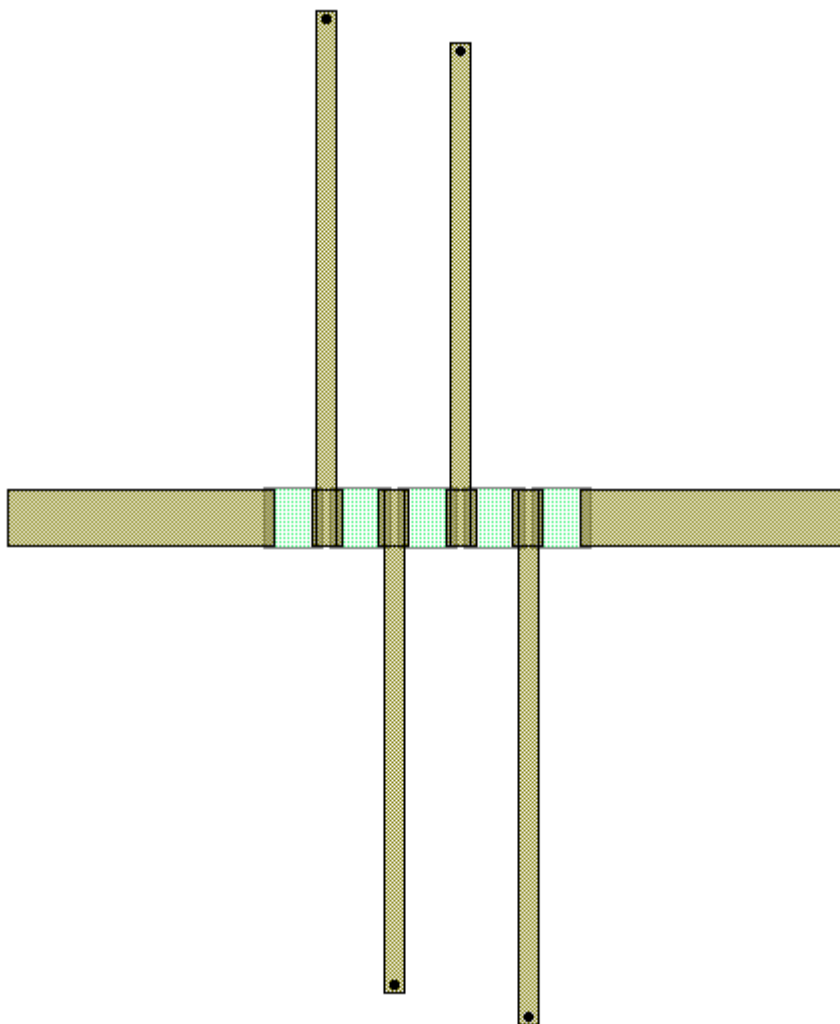
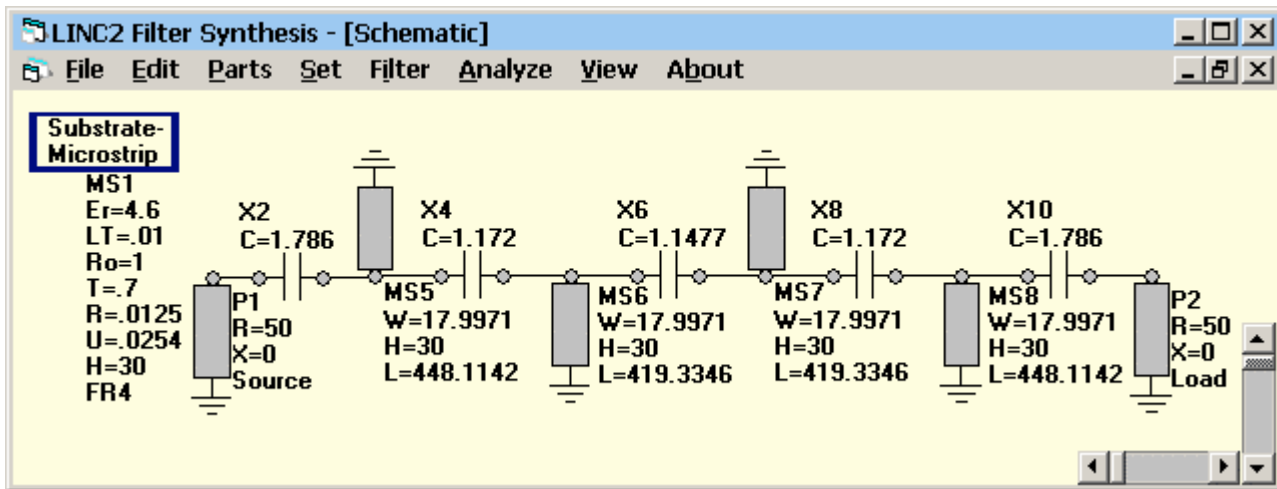
As previously mentioned, all of the electrical (transmission line models) can be automatically converted to physical lines (microstrip or stripline) in one step.

The conversion to microstrip can be found in the “Parts” menu under “Transmission Line | Convert T-Lines To... | Microstrip”.



For convenience, a shortcut to this menu can be found in the main menu bar under “Auto”.

Selecting “Convert T-Lines To... | Microstrip” converts all the ideal transmission lines to microstrip. The schematic of the microstrip filter is show below. With physical dimensions of width, Length and substrate height, all of the information for constructing the filter is provided.



The physical layout is shown here below the schematic (left). 50 ohm microstrip lines connect the filter to its input and output ports to the left and right of the filter.

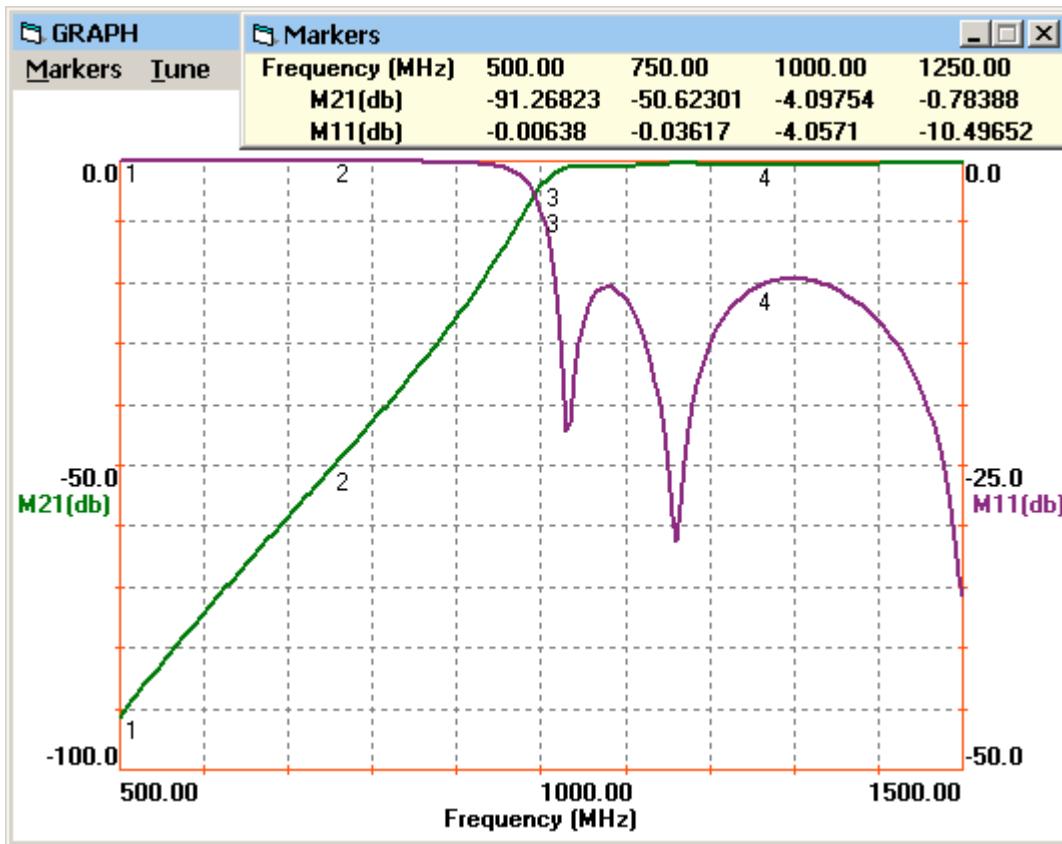
The positions of 5 ATC 100A chip capacitors are shown between the vertical stubs (shorted transmission lines).

Click “**Analyze**” to run a simulation of the physical (microstrip) filter schematic.

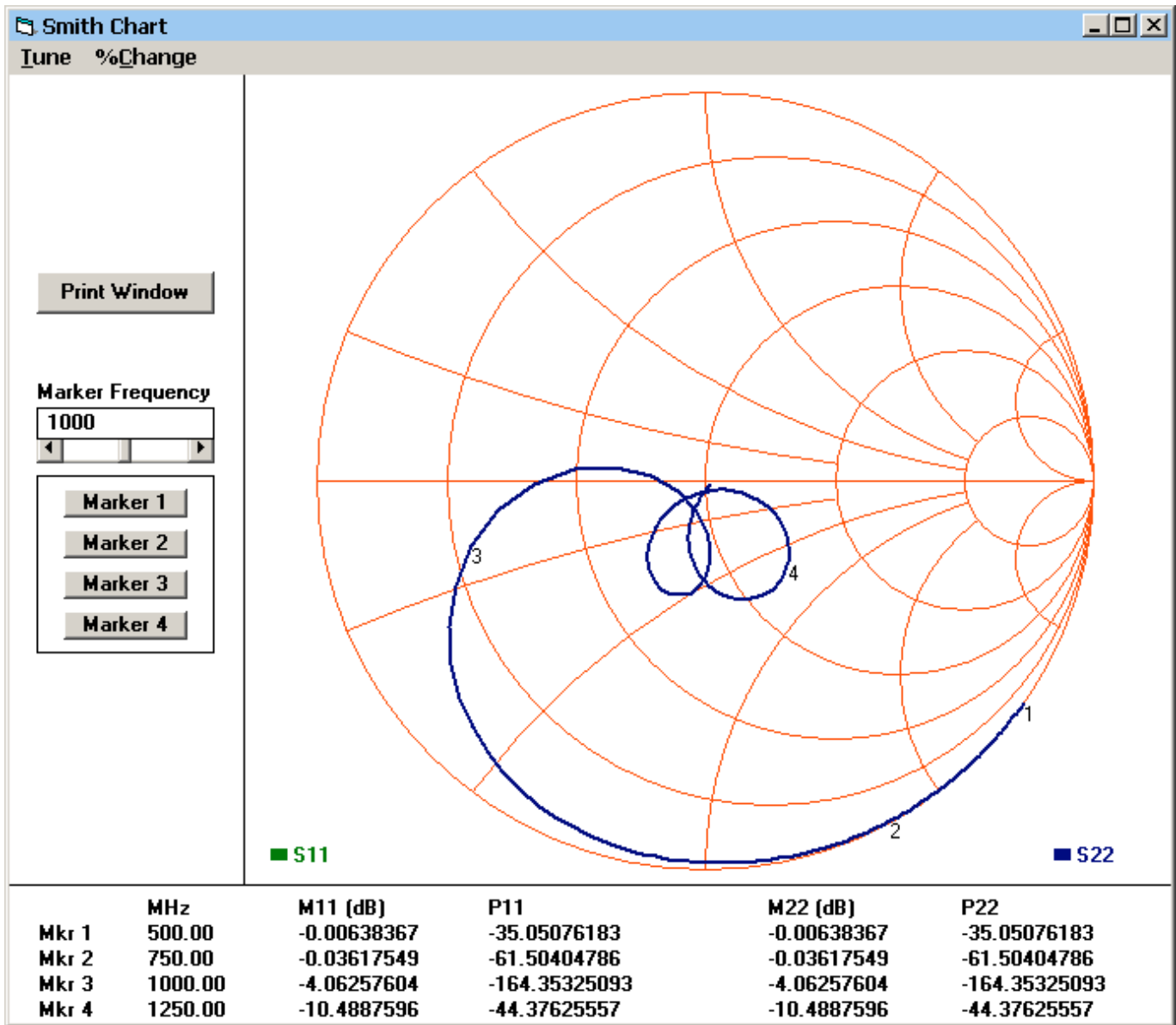
The resulting graph below shows that an additional 1 dB of insertion loss occurs at 1000 MHz. This can be viewed as an upward shift of a few MHz in the cutoff frequency.

The rejection in the stopband at 750 MHz (25% below the cutoff frequency) remains the same at 50.6 dB.

The program accurately models the loss due to the physical microstrip and substrate material. Except for a fraction of a dB in additional insertion loss and a slight shift in the cutoff frequency, all of the filter’s parameters have held up extremely well after the conversion to microstrip. The program will also compute the losses in the capacitors used. However, these 1 to 2 pF Hi-Q capacitors operating at 1000 MHz have Qs between 300 and 400, and the effect due to capacitor loss is relatively insignificant.



The log magnitude of S21 and S11 (M21 and M11 in dB) are plotted in the graph above for the physical microstrip highpass filter. S11 and S22 are plotted on the Smith Chart below. S11 and S22 are identical and therefore the plot of S22 overlays S11.



$M11[\text{dB}] = 20 \text{ Log}(|S11|)$ and $M22[\text{dB}] = 20 \text{ Log}(|S22|)$ are plotted above for the physical microstrip highpass filter.

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