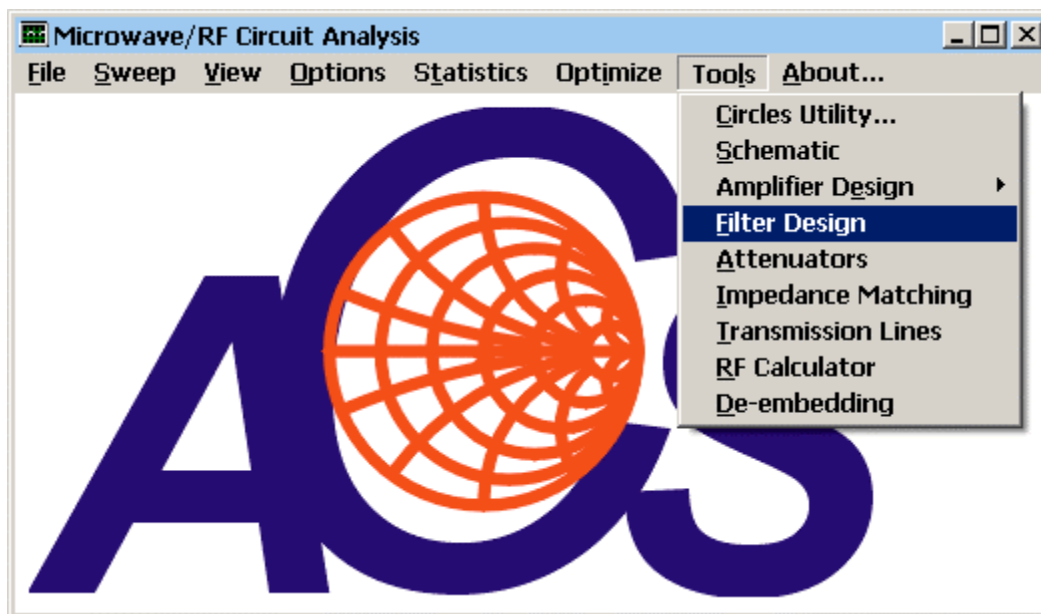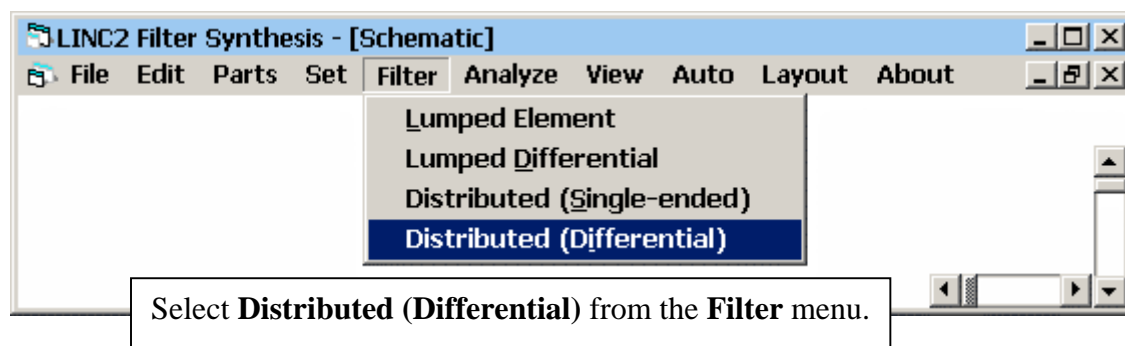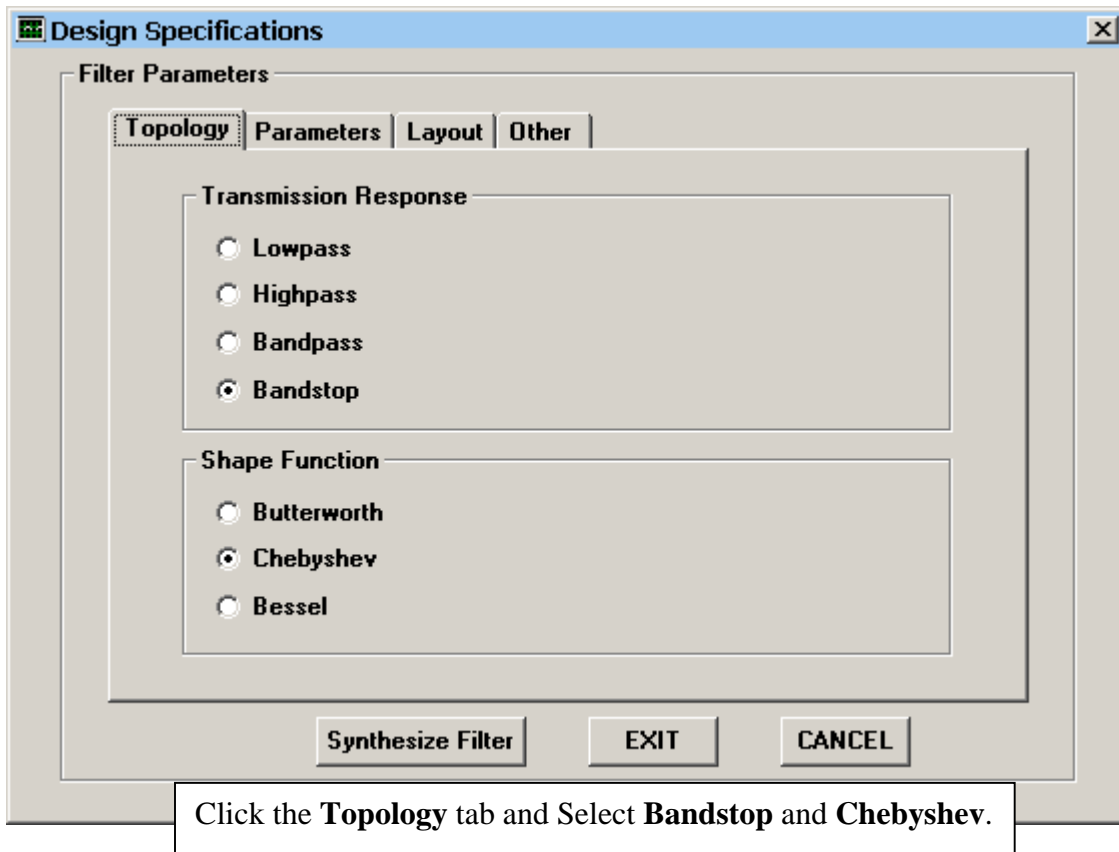# LINC2 FILTER Synthesis

The LINC2 filter synthesis program is started by selecting **Filter Design** from the main LINC2 **Tools** menu as shown above.

The initial filter synthesis process usually generates an ideal electrical schematic. When the schematic (with ideal elements) is converted to a physical layout, non-ideal attributes are often introduced that alter the desired filter characteristics. EM simulation can help the filter designer understand these changes so they can be compensated for in the original design (such as a shift in the frequency specification).

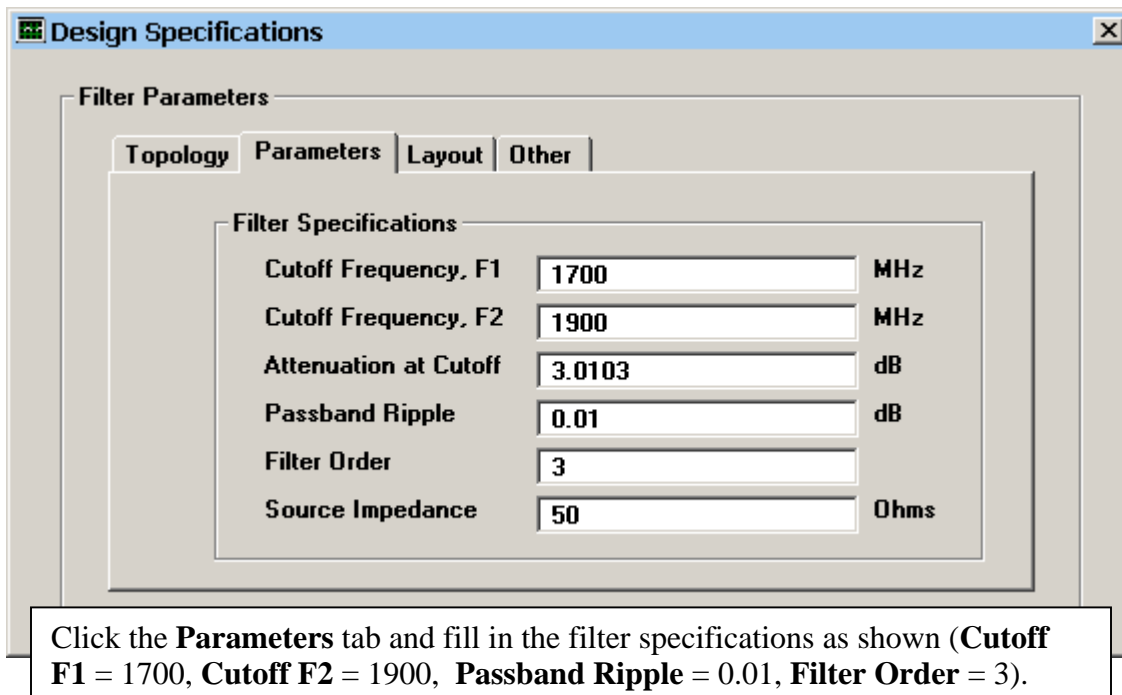The following example will demonstrate how a differential 3rd order distributed Chebyshev bandstop filter (1.7 – 1.9 GHz rejection) can be specified, synthesized, and exported to the Sonnet® EM simulator for analysis in a matter of minutes with only a few menu clicks and keystrokes.
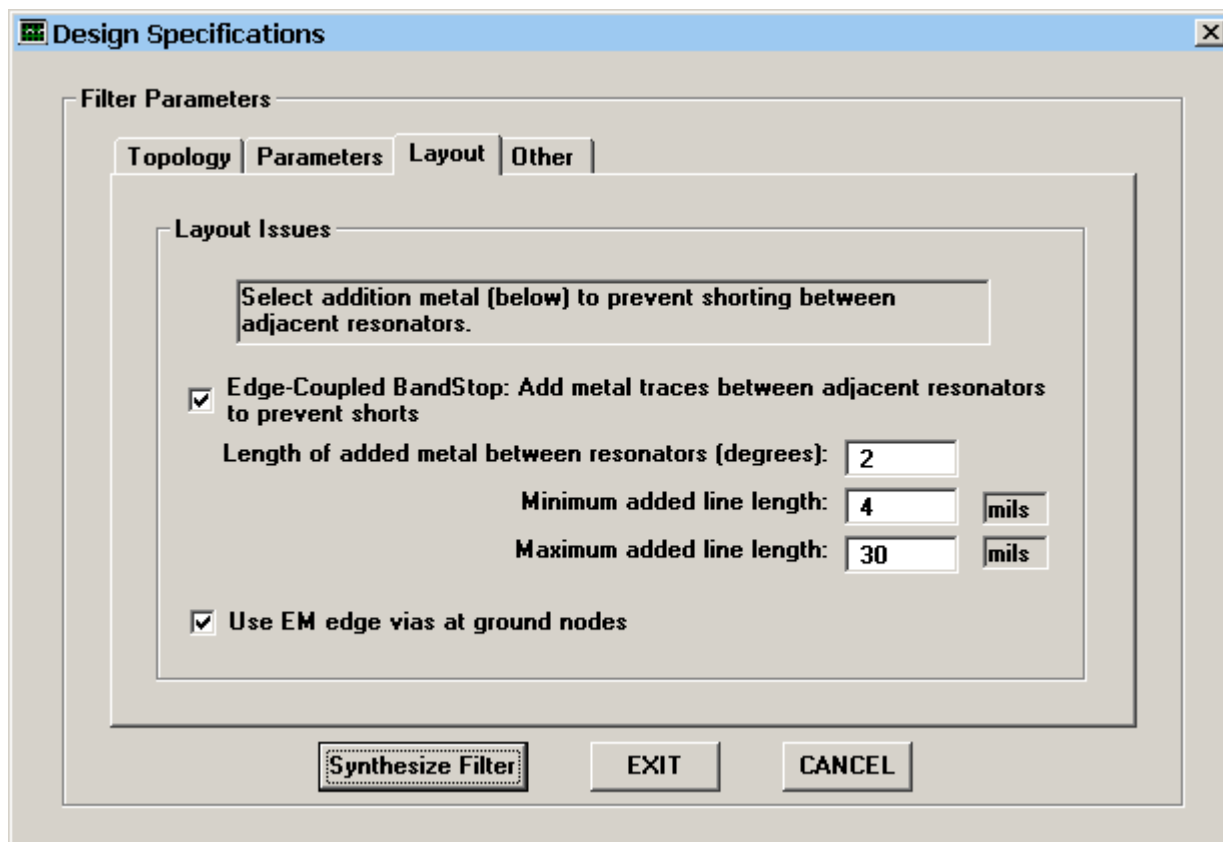

Select **Distributed (Differential)** from the **Filter** menu.

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Click **Topology** and Select **Chebyshev Bandstop**:

Design Specifications

Filter Parameters

| Topology | Parameters | Layout | Other |

Transmission Response

- ○ Lowpass
- ○ Highpass
- ○ Bandpass
- ● Bandstop

Shape Function

- ○ Butterworth
- ● Chebyshev
- ○ Bessel

[Synthesize Filter]   [EXIT]   [CANCEL]

Click the **Topology** tab and Select **Bandstop** and **Chebyshev**.

Enter the detailed filter specifications:

Design Specifications

Filter Parameters

| Topology | Parameters | Layout | Other |

Filter Specifications

Cutoff Frequency, F1	1700	MHz
Cutoff Frequency, F2	1900	MHz
Attenuation at Cutoff	3.0103	dB
Passband Ripple	0.01	dB
Filter Order	3	
Source Impedance	50	Ohms

Click the **Parameters** tab and fill in the filter specifications as shown (**Cutoff F1** = 1700, **Cutoff F2** = 1900, **Passband Ripple** = 0.01, **Filter Order** = 3).

Design Specifications

Filter Parameters

Topology | Parameters | Layout | Other

Layout Issues

Select addition metal (below) to prevent shorting between adjacent resonators.

☑ Edge-Coupled BandStop: Add metal traces between adjacent resonators to prevent shorts

Length of added metal between resonators (degrees): `2`

Minimum added line length: `4` mils

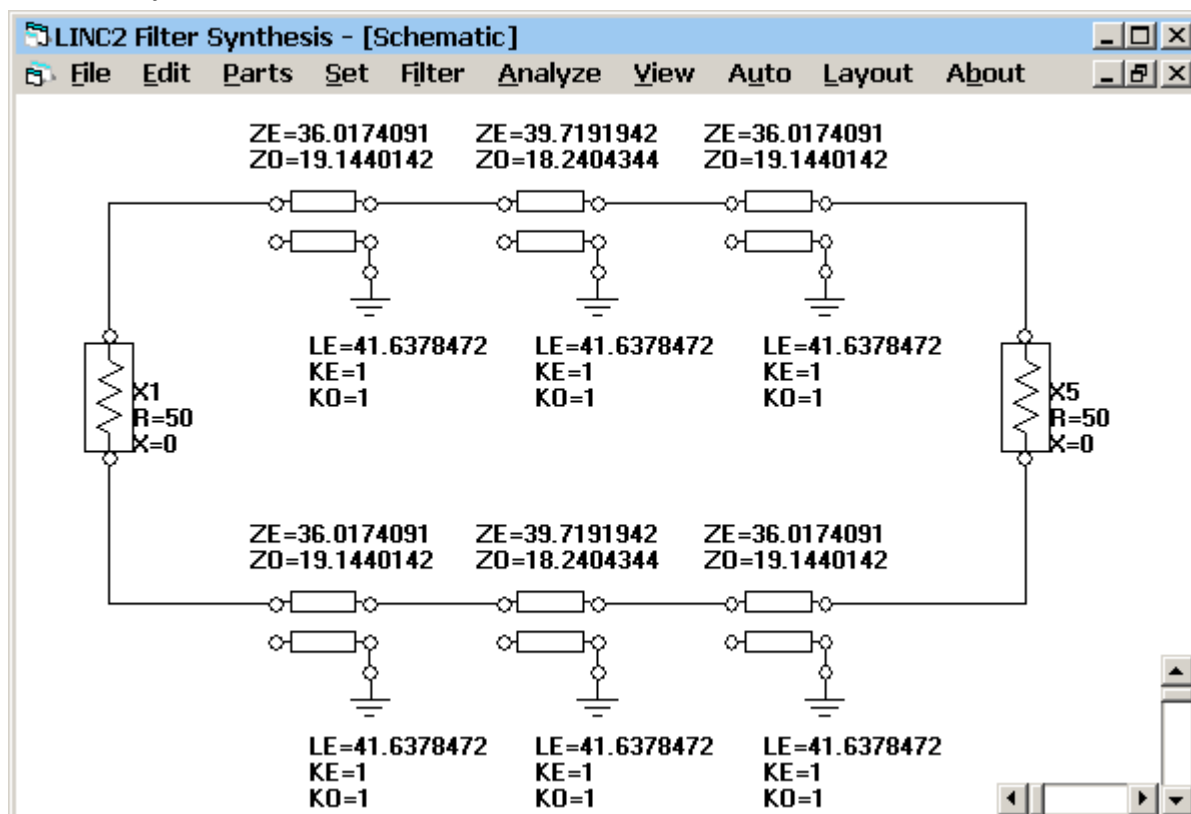Maximum added line length: `30` mils

☑ Use EM edge vias at ground nodes
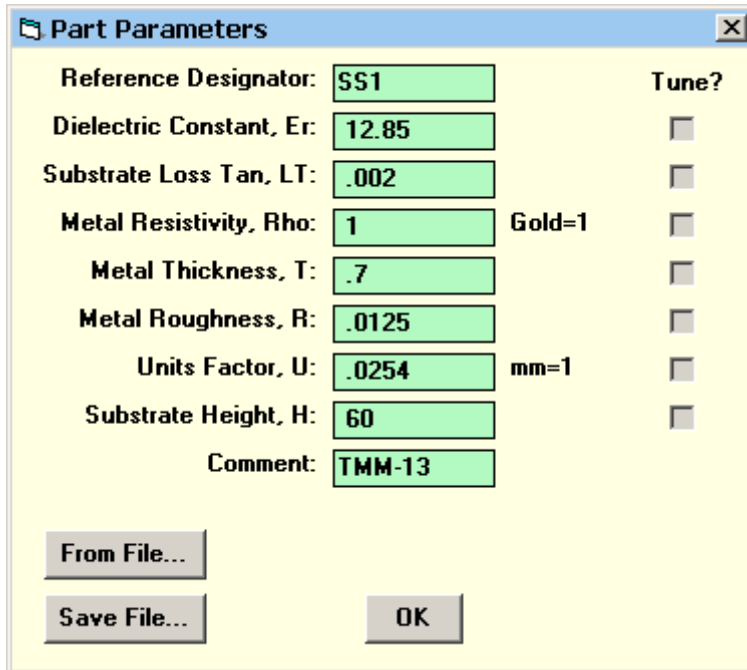
[Synthesize Filter] [EXIT] [CANCEL]

Click the layout tab to review any layout issues. Make sure that all check boxes are checked to address the indicated layout issues. Leave the default values as shown above.
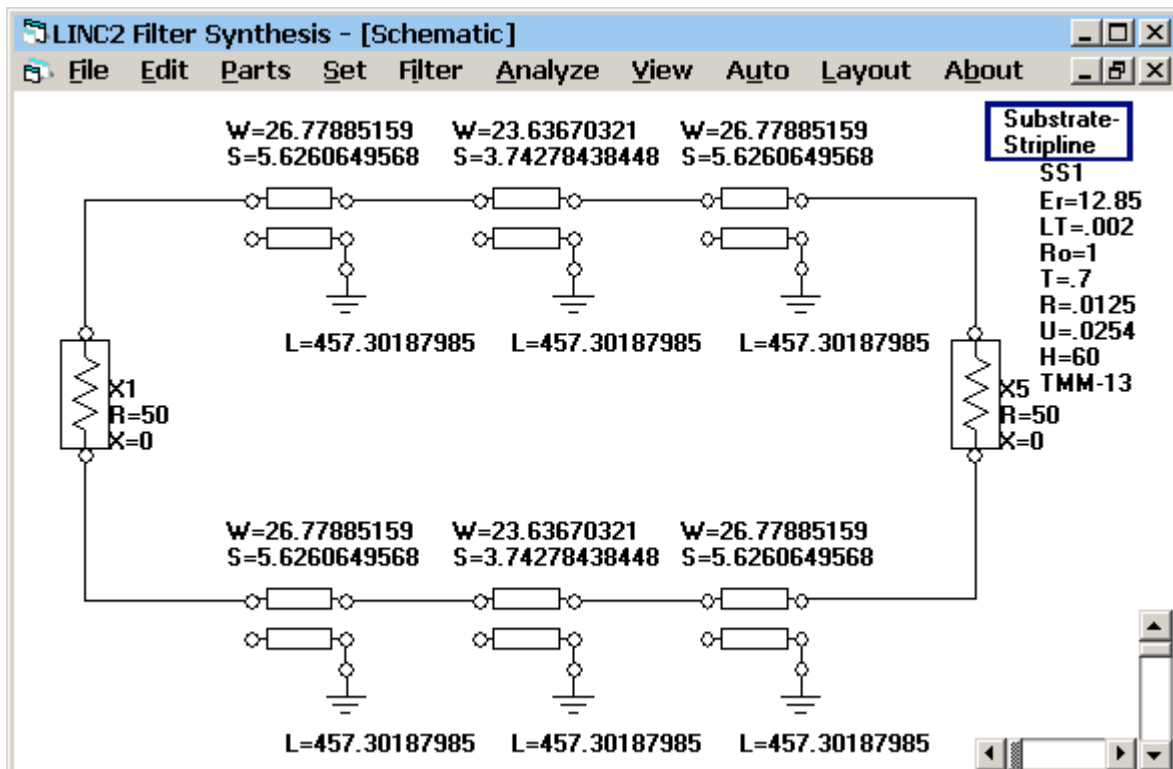
Click the **Synthesize Filter** button and **Exit** to see the filter schematic (below).


LINC2 Filter Synthesis - [Schematic]

File   Edit   Parts   Set   Filter   Analyze   View   Auto   Layout   About

ZE=36.0174091   ZE=39.7191942   ZE=36.0174091
Z0=19.1440142   Z0=18.2404344   Z0=19.1440142

LE=41.6378472   LE=41.6378472   LE=41.6378472
KE=1   KE=1   KE=1
K0=1   K0=1   K0=1

X1
R=50
X=0

X5
R=50
X=0

ZE=36.0174091   ZE=39.7191942   ZE=36.0174091
Z0=19.1440142   Z0=18.2404344   Z0=19.1440142

LE=41.6378472   LE=41.6378472   LE=41.6378472
KE=1   KE=1   KE=1
K0=1   K0=1   K0=1

Part Parameters

Reference Designator:	SS1	Tune?
Dielectric Constant, Er:	12.85	☐
Substrate Loss Tan, LT:	.002	☐
Metal Resistivity, Rho:	1	Gold=1 ☐
Metal Thickness, T:	.7	☐
Metal Roughness, R:	.0125	☐
Units Factor, U:	.0254	mm=1 ☐
Substrate Height, H:	60	☐
Comment:	TMM-13	

From File...

Save File...   OK

Click **Auto | Convert T-Lines to…| Stripline** to convert all transmission lines to striplines. Edit the pop-up stripline substrate parameters for **Er = 12.85**, **LT = 0.002** and a **Substrate Height** of **60** (mils) as shown.

Then click **OK** to covert all lines to physical lines (see schematic below).

LINC2 Filter Synthesis - [Schematic]

File   Edit   Parts   Set   Filter   Analyze   View   Auto   Layout   About

W=26.77885159   W=23.63670321   W=26.77885159
S=5.6260649568   S=3.74278438448   S=5.6260649568

Substrate-Stripline
SS1
Er=12.85
LT=.002
Ro=1
T=.7
R=.0125
U=.0254
H=60
TMM-13

X1
R=50
X=0

X5
R=50
X=0

L=457.30187985   L=457.30187985   L=457.30187985

W=26.77885159   W=23.63670321   W=26.77885159
S=5.6260649568   S=3.74278438448   S=5.6260649568

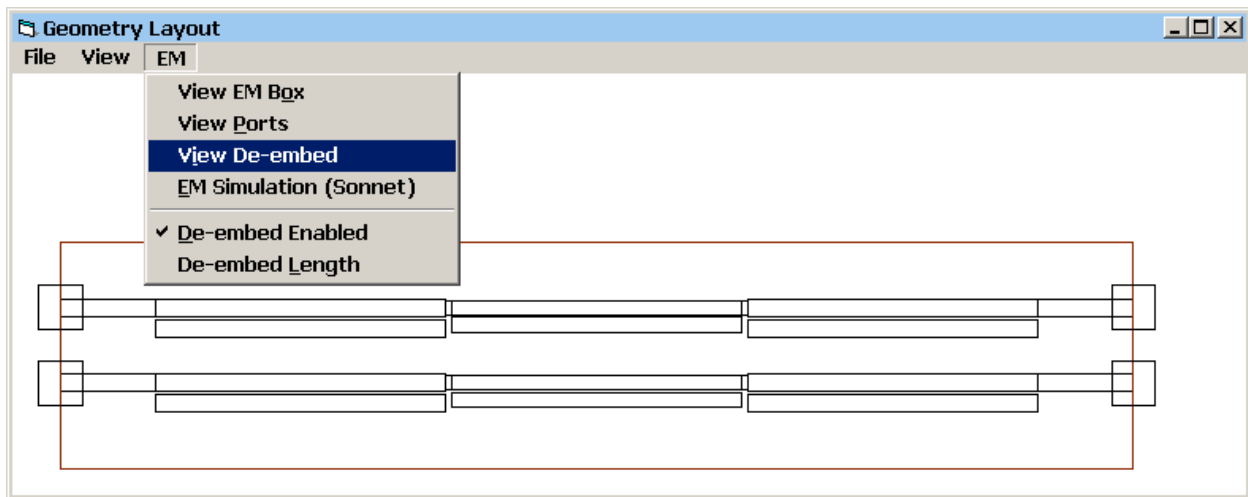L=457.30187985   L=457.30187985   L=457.30187985

The resulting schematic is converted to all physical T-lines with physical dimensions of length (L), width (W), and gap space (S).

Click **Layout** to see the layout geometry (below).
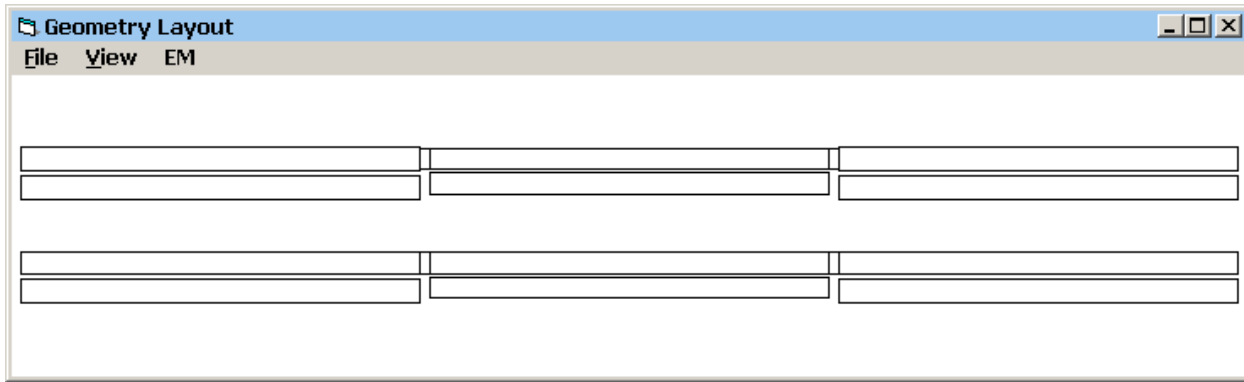
The LINC2 FILTER Geometry Layout

Click **EM | View De-embed** to see the EM simulation box, balanced ports and de-embedding at each port as shown below.

**The LINC2 FILTER Geometry Layout with EM box, ports and de-embedding**

The pair of square boxes drawn at the vertical sides of the EM box represent each port location. These are pairs of differential (or balanced) ports. The differential port numbers will be correctly exported to the Sonnet ® EM simulator as Port 1/-1 and Port 2/-2.

The ground vias are not explicitly shown here but are automatically included in the EM artwork and the EM simulator will correctly include the vias at the edge of the coupled stripline traces.

To run the EM simulation, select **EM Simulation (Sonnet)** from the EM menu.

When EM Simulation (Sonnet) is selected, the file EMTest.SON is created and automatically exported to the Sonnet® xgeom project editor ready for analysis. The EM box, metal and substrate layers and frequency parameters are already loaded.

The layout in Sonnet® is shown below. Notice the black arrows pointing inward from each port. These represent 150 mil de-embedding traces (automatically inserted by default).
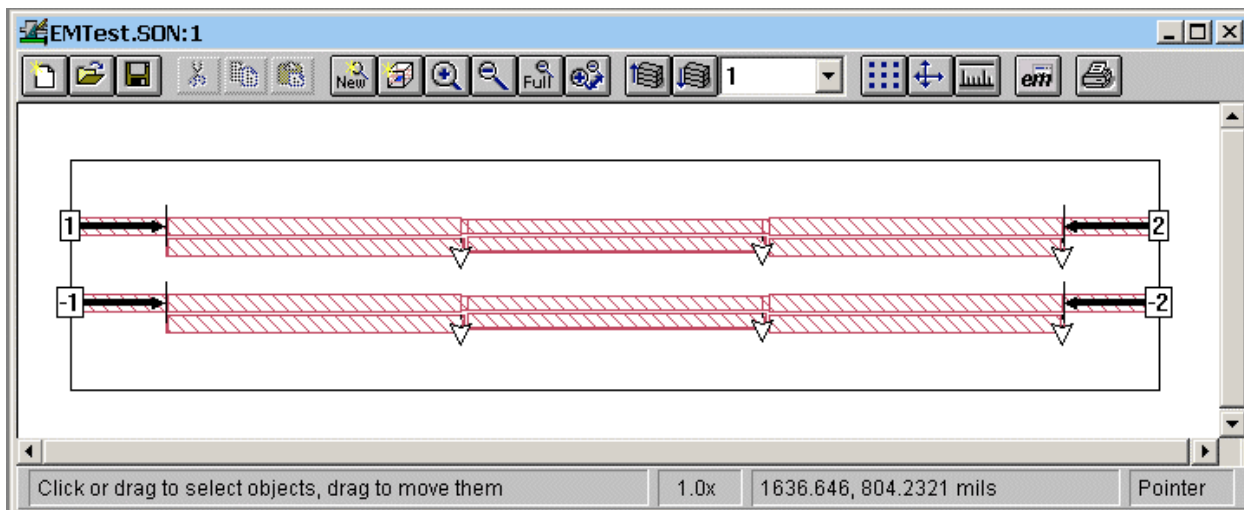
The LINC2 bandstop filter design exported to Sonnet xgeom

Simply select **Analyze** from the Sonnet® project menu to run the simulation. When the simulation is complete, select **Project | View Response | New Graph** to get the response plots shown below.
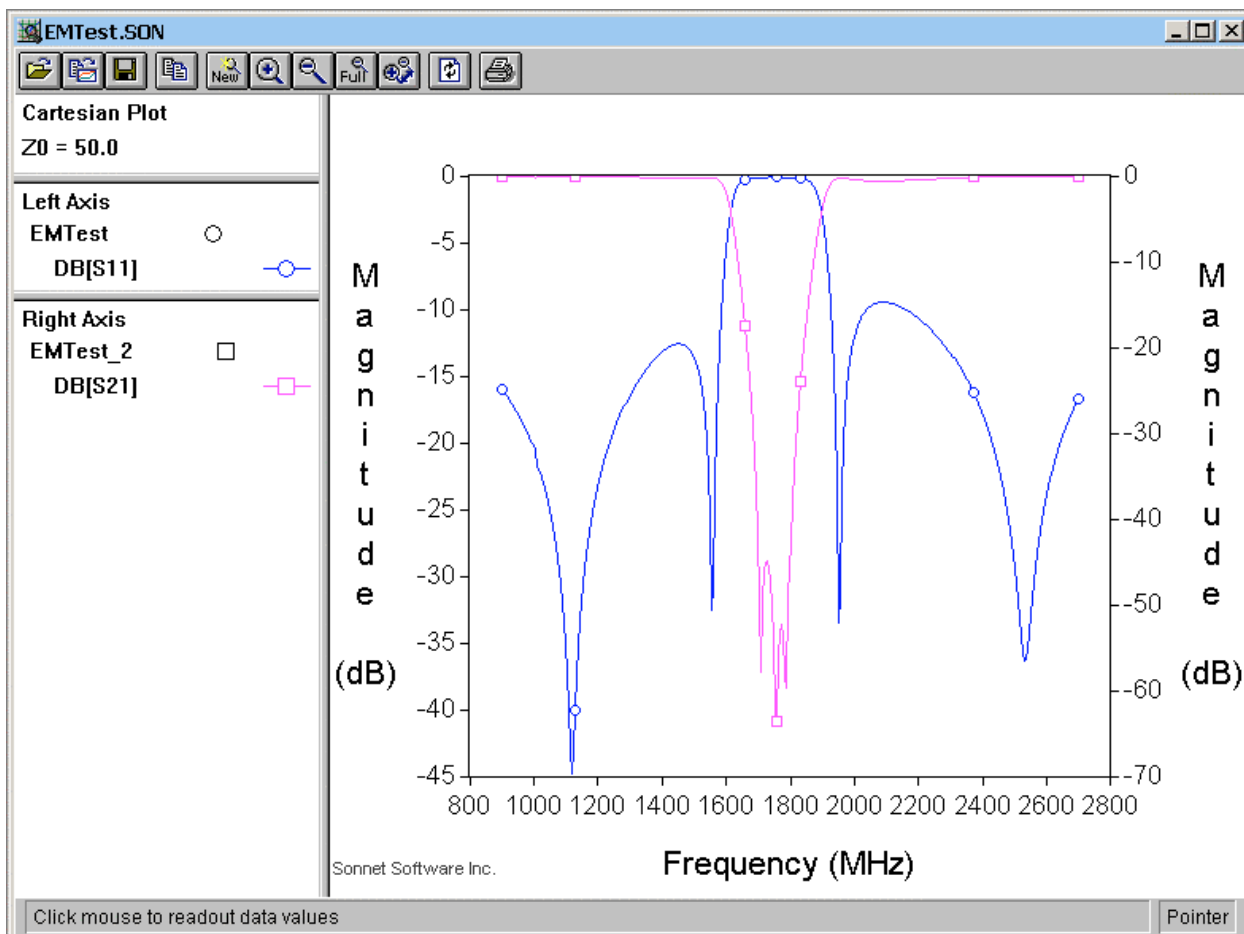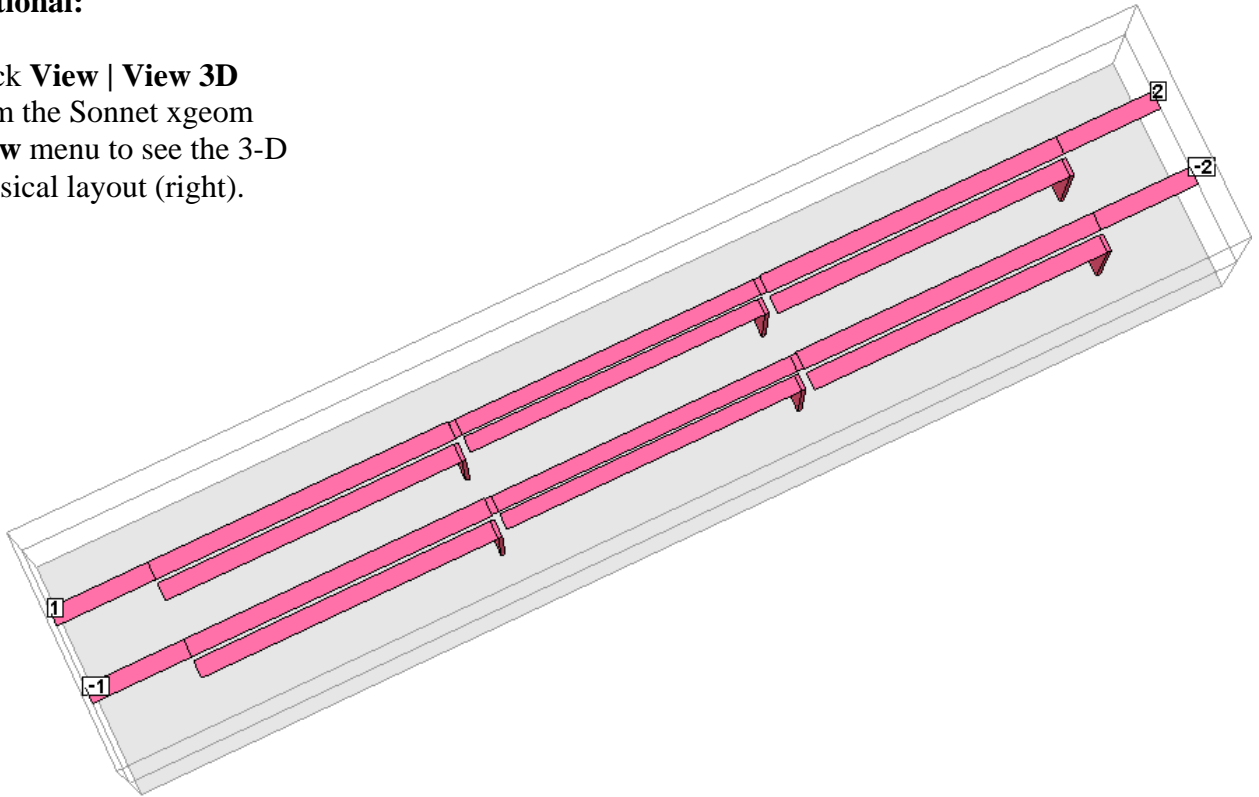

Sonnet EM simulation of the 3rd order differential bandstop filter

The plot of S21 shows that the filter has the correct bandstop response. The rejection band extends from abut 1.6 GHz (slightly lower than the synthesis specification) to 1.9 GHz as designed.

Optional:

Click **View | View 3D** from the Sonnet xgeom **View** menu to see the 3-D physical layout (right).

Optional:

It is interesting to compare the EM simulation results with the electrical (circuit theory) simulation results from the ideal synthesized schematic.

Click **Analyze** and **View | Plot** from the LINC2 filter schematic menu bar to see the differential 3rd order distributed Chebyshev bandstop filter's frequency response as synthesized (before EM geometry simulation): next page →
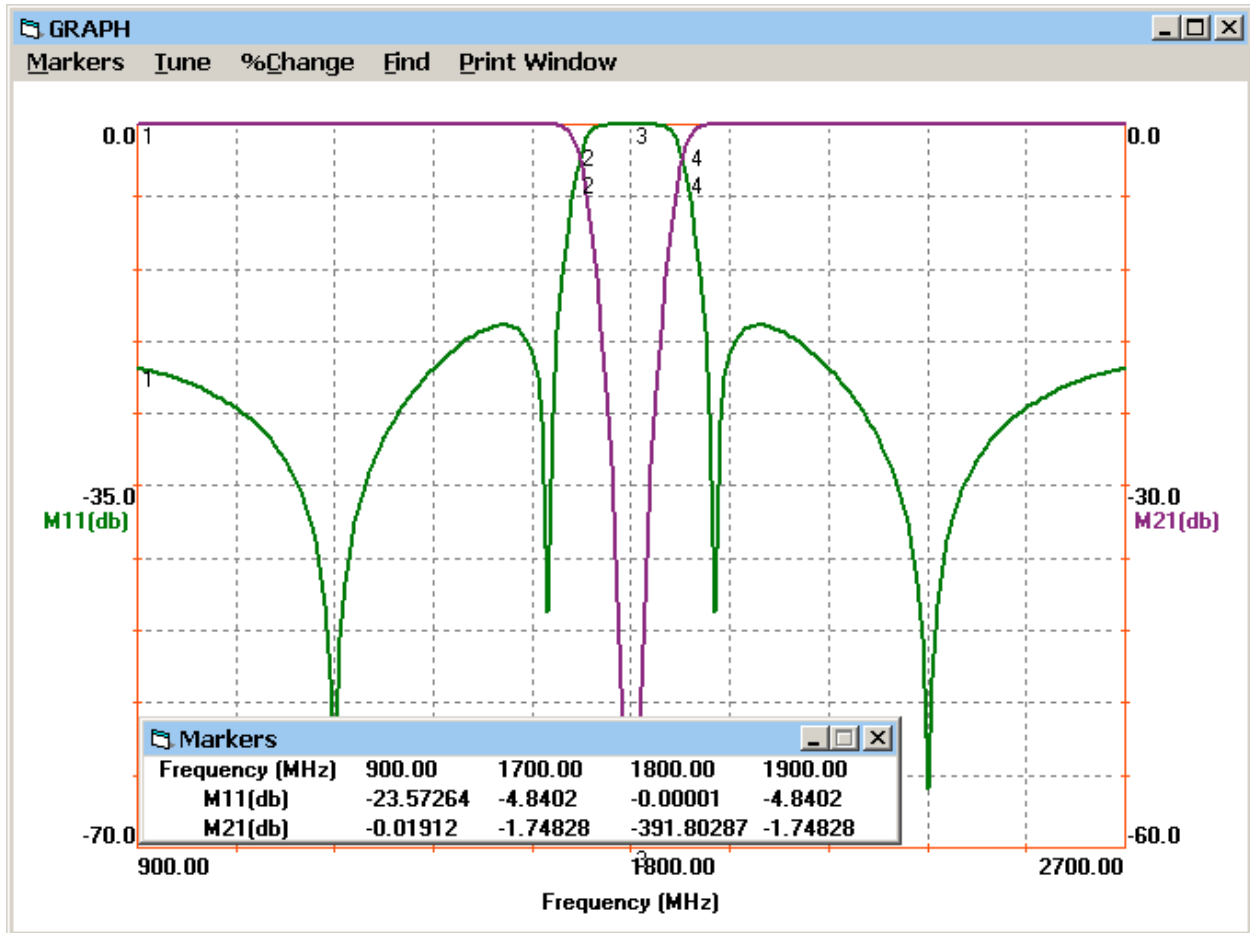
LINC2 synthesized filter response using ideal physical (stripline) coupled line models

Here is the filters frequency response as simulated with the LINC2 simulator (electrical circuit theory simulation of the LINC2 filter schematic) before performing the EM simulation via Sonnet®.

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