

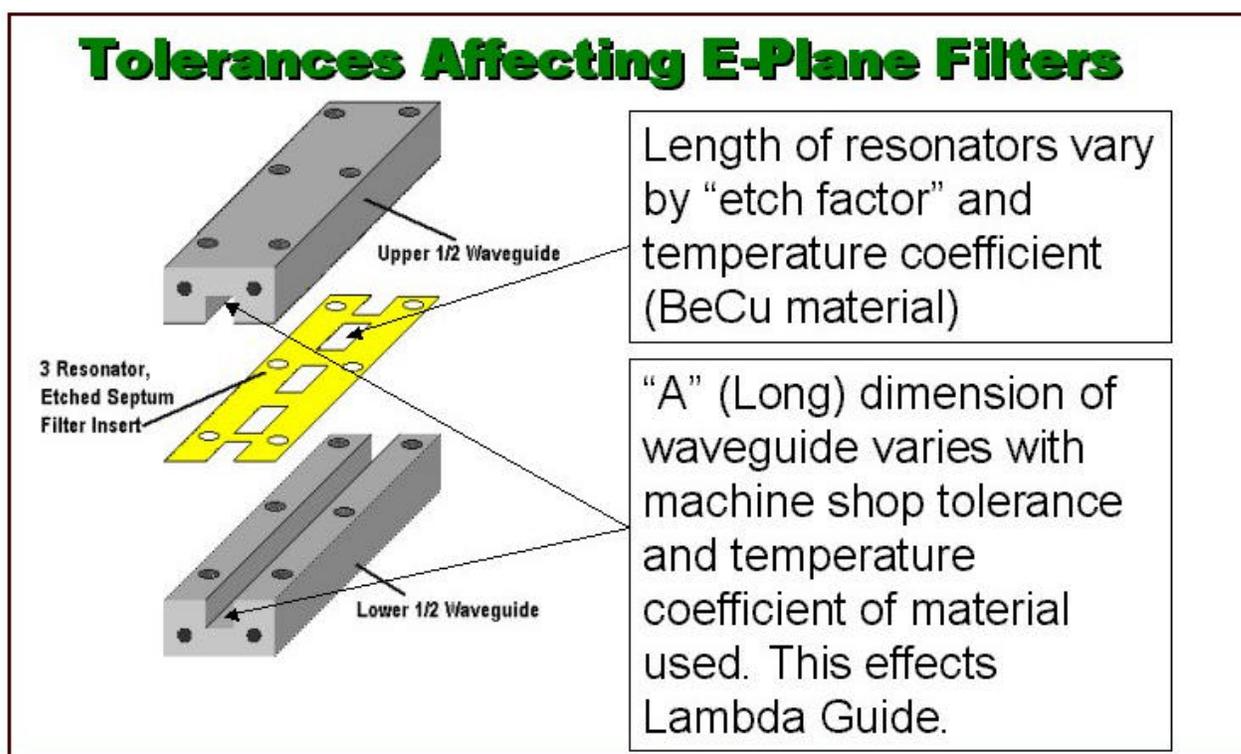
LMDS WAVEGUIDE E-PLANE FILTER DESIGN

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INTRODUCTION:

E-plane filters have been in literature for a couple of decades now. The filters are popular for their low cost and ease of implementation. Filter center frequency and return loss performance are highly dependent on waveguide tolerances, etch factor and temperature coefficient of housing materials used. A software tool (eSeptum©) has been developed that facilitates rapid design and evaluation of e-plane filters. eSeptum© is useful for filter design from 8GHz to well over 100GHz. Bandwidths from 0.7% to 7% can be realized. Tolerance issues are calculated and plotted for waveguide dimensions, etch factor and temperature effects versus material selection. We will use typical LMDS scenario and design an easily manufactured waveguide filter.

Some manufacturing tolerances have a large effect on filter performance (See Figure 1). Waveguide tolerance affects lambda guide, and therefore center frequency of the filter. Etch factor (over or under etch of the filter insert) also affects center frequency and return loss.



(Figure 1)

LMDS DESIGN PROBLEM FOR THIS EXAMPLE

- Receiver passband: 29000 to 29200 MHz, minimum
- Transmitter Frequency: 31000 to 31200 MHz
- Receiver Rejection of Transmitter: 50 dB minimum
- No Spurious Passband: DC to 40000 MHz
- Receiver Ripple: 0.2dB maximum
- Number of Sections: 5 poles
- Temperature range: -30 to +70 degrees centigrade.
- Machine Shop Tolerances: +/- 0.003 inches
- Waveguide Material: Aluminum

FILTER DESIGN:

Screen 1, Data Input – (See figure 2) Software accepts inputs for center frequency, bandwidth, type of filter, and number of poles. (Please note, by a trial run, the bandwidth needed for manufacturing tolerances was found to be 400% wider than actual filter requirement).

Transferring The Requirement to eSeptum®

Simply enter your desired results and press "Next"

Bandwidth has been over-designed by 400% to allow for manufacturing variation

Figure 2

Screen 2, Waveguide selection – (See Figure 3) automatically chosen (in our case WR28 was selected) but this can be over-riden with the "Custom Waveguide" selection.

eSeptum® Solves and Selects Waveguide

- eSeptum gives all needed information on one screen.
- Choose custom or standard guide size by changing pulldown menu and pressing "Refresh"
- When satisfied, press "Next"

Parameter	0.1	1.2	2.3	3.4	4.5	5.6	6.7	?
k Values	0.29	0.077	0.058	0.058	0.077	0.29		
X _{Lp} (ohms)	173.47	42.42	32.25	32.25	42.42	173.47		
L _p (nH)	0.9488	0.232	0.1763	0.1763	0.232	0.9487		
Strip width	22.89	100.13	116.18	116.18	100.13	22.89		
X _{Ls} (ohms)	53.53	148.36	158.47	158.47	148.36	53.53		
L _s (nH)	0.2928	0.8114	0.8667	0.8667	0.8114	0.2928		
Cavity (mils)		229.06	231.89	231.84	231.89	229.06		

Figure 3

Screen 3, *Interactive Display* – Screen allows “real-time” performance plotting versus material types and tolerance issues. The nominal filter performance is displayed (See Figure 4).

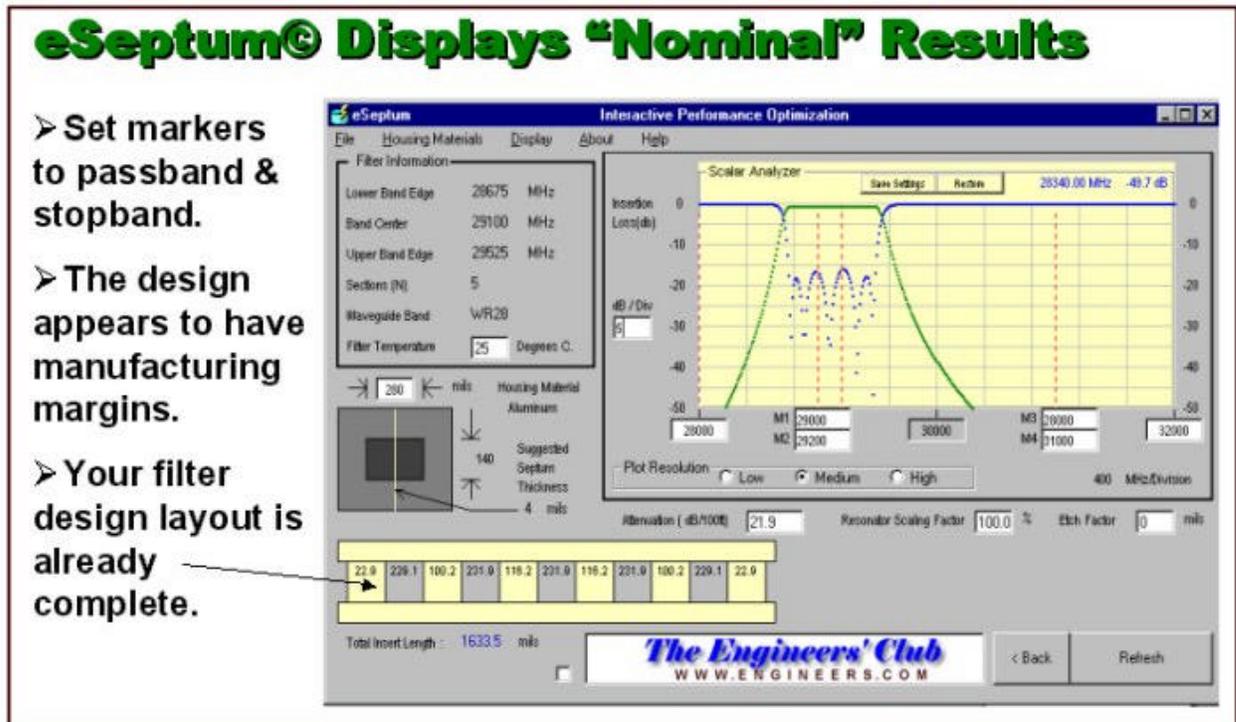


Figure 4

Available software settings/adjustments are:

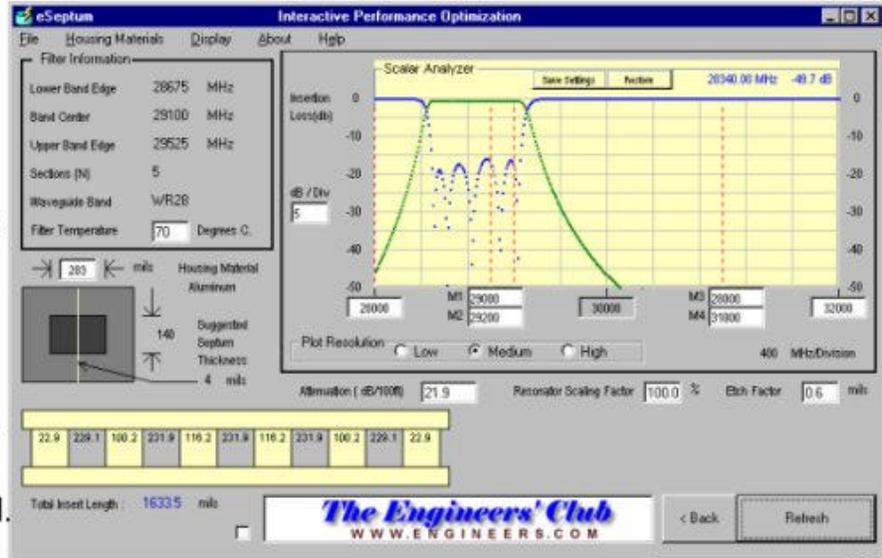
- Housing Materials – Aluminum, Brass, Copper and Kovar
- Temperature Range (any temperatures)
- Etch Factor (amount of over-etch or under-etch of septum foil)
- Waveguide “A” dimension tolerance (machine shop tolerance)
- Resonator Scaling Factor (correlate real world with calculated center frequency)
- Resonator length all independently adjustable
- Septum widths all independently adjustable
- 4 Marker Frequencies
- dB per division scale on plot
- Plot resolution (200, 400 or 700 discrete frequency points)
- Start and Stop Frequency (stop frequency can be set see second or third passbands)

Next, we can change the manufacturing tolerances to all “Plus” variables. Set the waveguide “A” dimension to 0.283 inches (+0.002 inches), the temperature to +70 degrees centigrade, and the etch factor to +0.0006 inches. Press “Refresh” to see the effects of your “Plus” manufacturing variables. Notice the filter has shifted down in frequency to the edge of your required limits. (See Figure 5). Ambient temperature change affects the waveguide “A” dimension by the temperature coefficient of the materials chosen for waveguide housing and the beryllium copper inserts

“PLUS” Manufacturing Tolerance Checkout

- Change waveguide “A” dimension to 283 mils
- Set temperature at +70 degrees
- Set etch factor to +0.6 mils.

Note: materials other than aluminum may be selected if desired.



Plus tolerances show manufacturing margin.

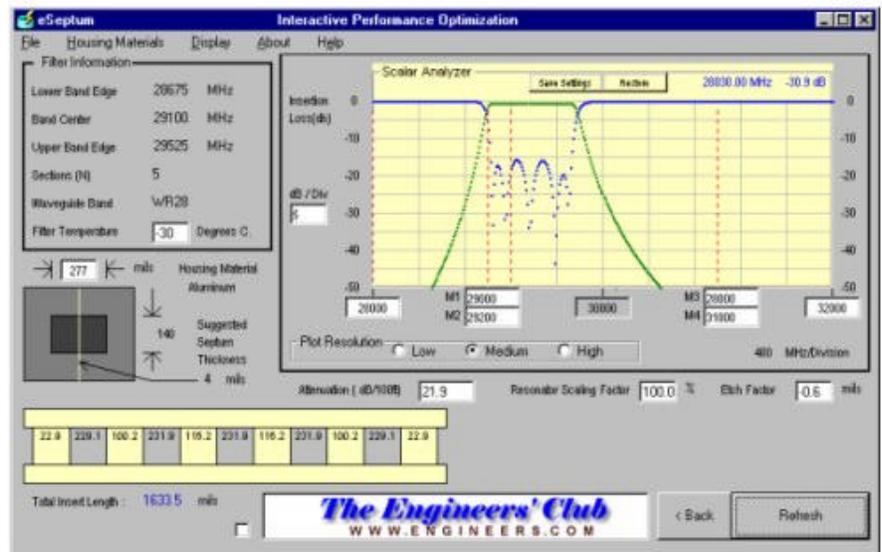
Figure 5

Now move all the manufacturing tolerances to the “Minus” variables. Set the waveguide “A” dimension to 0.277 inches (-0.003 inches), the temperature to -30 degrees centigrade, and the etch factor to -0.0006 inches. You can clearly see the effects of the minus manufacturing tolerances in figure 6. The filter has moved to the lower limit allowed by your requirements.

“Minus” Manufacturing Tolerance Checkout

- Change waveguide “A” dimension to 277 mils
- Set temperature to -30 degrees
- Set etch factor to -0.6 mils.

Note: etch factor is usually about 15% of material thickness. Material is 4 mil BeCu sheet



Minus tolerances still meet requirements.

Figure 6

To check for spurious passband up to 40,000 MHz, reset all the manufacturing tolerances to their nominal values, and set the upper frequency limit on the analyzer display to 40,000 MHz. Press “Refresh” and

observe the filter response up. As can be seen in figure 7, there is a slight second passband response starting just below 40 GHz. This appears to be low enough in power to be ignored. (See Figure 7)

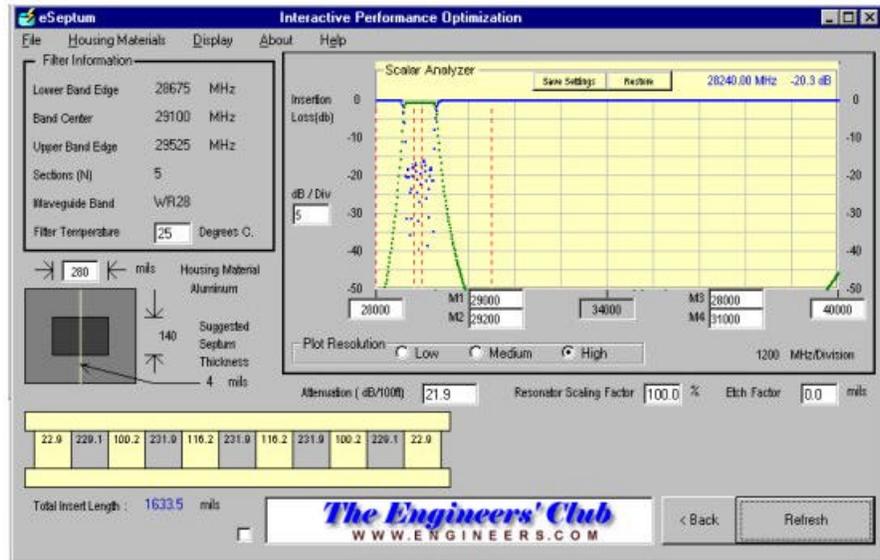
Testing For Spurious Passbands To 40 GHz

➤ Reset all values to nominal value

➤ Set sweep to display up to 40 GHz

➤ Check for spurious filter responses.

Some "fixes" for spurious response would be to use a smaller "custom" waveguide, or add another pole or two to the filter.



A second passband at 40GHz is shown at 45 dBc

Figure 7

A typical test fixture and sheet of filter inserts is shown in figure 8

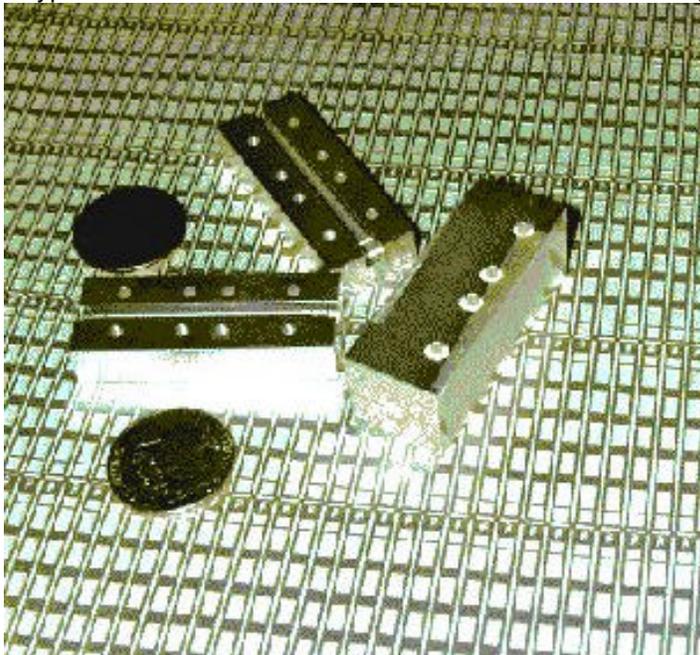


Figure 8

CONCLUSION:

A tool has been developed to aid the design engineer in predicting performance versus manufacturing tolerance for e-plane waveguide filters.

A practical example of a 30 GHz LMDS filter design was shown. The filter was specified, and in a matter of minutes check for all the major manufacturing tolerances that would affect production yields. More data and actual vs. predicted data can be viewed on our website www.engineers.com.

This filter will find wide use in areas where manufacturing cost must be held to a minimum and specifications will allow the extra bandwidth required to accommodate the manufacturing tolerances.