# eSeptum<sup>™</sup>



## Tutorial

eSeptum.doc

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CONCLUSIONS/CAVEATS

This tutorial walks you through a complete filter design. The design is optimized for manufacturability and low cost. Additionally, the tutorial gives you a design methodology easily adapted to your future designs at any frequency band.

### **DEFINE THE FILTER REQUIREMENT:**

A receive filter must be designed for a digital radio transceiver. The transmitter overpowers the receiver by 25 dB. The receiver operates at 44,000 MHz with a bandwidth of +/-500MHz. The transmitter tunes from 41,000 MHz to 42000 MHz. The Local Oscillator leakage from the receiver is at 46GHz and is -35 dBm, There are some receiver spurious at 60 GHz; the level is -40dBm. ETSI specifications requires all out of band transmitted spurious to be -60 dBm. This requires at least 20 dB of filter rejection.

Design Parameter	Design Goals	Comments
Center Frequency	44,000 MHz	
Bandwidth	+/-500 MHz	
Ripple	0.2dB	0.25dB acceptable
Rejection 41 to 42 GHz	30 db (Minimum)	
Rejection 46 GHz	30 dB (Minimum)	ETSI Spec
Rejection 55 to 65 GHz	20 dB (Minimum)	ESTI
Temperature Range	-30, +70 Degrees C.	
Materials	Aluminum Housing	For Low cost
Machining Tolerance	+/-0.001 inches	"A" dim.of guide
Housing Plating	50 uinches Nickel	
Septum	BeCu 0.004" thick	Nickel Flash

🥩 eSeptum 🛛 Version	1.1		Filter Parameters	
PrintScr Registration	About	<u>H</u> elp		
Center Frequency Passband Bandwidth	44000	MHz MHz	Filter Type  C Butterworth (Maxima	ally Flat)
Passband Ripple	0.2	dB	g 0 1 2 3 4	5
Lower Band Edge	43500	MHz	Value 1 1.339472 1.33701 2.166083 1.337014 1	.339507
Upper Band Edge	44500	MHz		
Number of Sections	5	N		]
*Rejection @ 42000	MH2	² <b>-</b> 60	dB Calculate / Refresh	Next >
*Rejection @ 46000	MH2	² <b>-</b> 60		
*Theoretical Rejection	for Butterv	vorth Filter	The Engineers' Club	
Note: Click on descriptiv	ve text for in	stant help	W W W.E N G I N E E R S.C O M	

#### Filter Parameters SCREEN ONE

#### SETTING UP THE FILTERS PARAMETERS

- 1. Default Filter Type:Tchebyscheff2. CENTER FREQUENCY: ENTER44,000 MHz3. Bandwidth : ENTER1,000 MHz4. Ripple: ENTER0.2 dB5. Lower Band Edge: DOUBLE-CLICK forAUTOFIL6. Upper Band Edge: DOUBLE-CLICK forAUTOFIL7. Rejection (1):ENTER42,000 MHz
- 8. <u>Rejection (2):</u> ENTER

46,000 MHz

- Experiment with "N" value to find rejection values of greater than 30dB yield about 36dB). Add 2 more sections (N=5) to increase yields in manufacturing and allow for temperature drift and tolerance. This will result in rejections of 60 dB at BOTH rejection frequencies.
- 10. CLICK <u>Calculate/Refresh</u> to update "g values" to current settings.
- 11. CLICK <u>Next ></u> for the "WAVEGUIDE SELECTION SCREEN"

**Note: CLICK** the <u>CHECK BOX</u> next to the LOGO if you want an area to TITLE your page (useful if printing the screen).

PrintScr   About   Help     Center Frequency (MHz)   44000     Lower Band Edge (MHz)   43500     Upper Band Edge (MHz)   44500     Vaveguide "A" Dimension   188     Waveguide "B" Dimension   94     Vaveguide Cutoff   31412.3     Vaveguide Cutoff   31412.3     MH   Lambda Guide (Fo)   383.341     Lambda Guide (Fo)   383.341   mill     Vaveguide Impedance (Fo)   538.388   0h     Parameter   0.1   1.2   2.3   3.4   4.5   5.6   6.7     k Values   0.233   0.054   0.042   0.042   0.054   0.233     XLp (ohms)   132.73   29.37   23.07   23.07   29.37   132.73     Lp (nH)   0.4801   0.1062   0.0834   0.0834   0.1062   0.4801     Strip width   25.42   83.77   93.52   93.52   83.77   25.43     XLs (ohms)   80.94   165.94   172.26   172.26   165.94   80.97     Ls (nH)   0.2927   0.6002   0.6	
Center Frequency (MHz)   44000   WR19   Band 40.0 To 60.0 GHz     Lower Band Edge (MHz)   43500   Waveguide "A" Dimension   188   mil     Upper Band Edge (MHz)   44500   Waveguide "B" Dimension   94   mil     Vaveguide Cutoff   31412.3   MH   Lambda Guide (Fo)   383.341   mil     Kander Kerresh   Next >   Lambda Guide (Fo)   383.341   mil     Lambda in Air (Fo)   268.43   mil   Lambda in Air (Fo)   268.43   mil     Vaveguide Impedance (Fo)   538.388   Oh   Oh   273   29.37   23.07   23.07   29.37   132.73   29.37   23.07   29.37   132.73   29.37   25.43	
Center Frequency (MHz)   44000   WR19   Band 40.0 To 60.0 GHz     Lower Band Edge (MHz)   43500   Waveguide "A" Dimension   188   mil     Upper Band Edge (MHz)   44500   Waveguide "B" Dimension   94   mil     Vaveguide Cutoff   31412.3   MH   Lambda Guide (Fo)   383.341   mil     K Back   Refresh   Next >   Lambda Guide (Fo)   383.341   mil     Total Filter Insert Length   1152   mils   Waveguide Impedance (Fo)   538.388   Oh     Parameter   0,1   1,2   2,3   3,4   4,5   5,6   6,7     k Values   0.233   0.054   0.042   0.042   0.054   0.233     XLp (ohms)   132.73   29.37   23.07   23.07   29.37   132.73     Lp (nH)   0.4801   0.1062   0.0834   0.0834   0.1062   0.4801     Strip width   25.42   83.77   93.52   93.52   83.77   25.43     KLs (ohms)   80.94   165.94   172.26   172.26   165.94   80.97     Ls (nH)	
Lower Band Edge (MHz)   43500   Waveguide "A" Dimension   188   mil     Upper Band Edge (MHz)   44500   Waveguide "B" Dimension   94   mil     Waveguide Cutoff   31412.3   MHz     Kack   Refresh   Next >   Lambda Guide (Fo)   383.341   mil     Lambda Filter Insert Length   1152   mils   Waveguide Impedance (Fo)   538.388   Oh     Parameter   0,1   1,2   2,3   3,4   4,5   5,6   6,7     K Values   0.233   0.054   0.042   0.042   0.054   0.233     XLp (ohms)   132.73   29.37   23.07   23.07   29.37   132.73     Lp (nH)   0.4801   0.1062   0.0834   0.0834   0.1062   0.4801     Strip width   25.42   83.77   93.52   93.52   83.77   25.43     XLs (ohms)   80.94   165.94   172.26   172.26   165.94   80.97     Ls (nH)   0.2927   0.6002   0.623   0.623   0.6002   0.2928     Cavity (mils)   148.49   149.28 <td></td>	
Upper Band Edge (MHz)   44500   Waveguide 'B'' Dimension   94   mil     Vaveguide 'B'' Dimension   94   mil     Vaveguide Cutoff   31412.3   Mil     Lambda Guide (Fo)   383.341   mil     Lambda Guide (Fo)   383.341   mil     Lambda in Air (Fo)   268.43   mil     Vaveguide Impedance (Fo)   538.388   0h     Parameter   0,1   1,2   2,3   3,4   4,5   5,6   6,7     K Values   0.233   0.054   0.042   0.042   0.054   0.233     XLp (ohms)   132.73   29.37   23.07   23.07   29.37   132.73     Lp (nH)   0.4801   0.1062   0.0834   0.0834   0.1062   0.4801     Strip width   25.42   83.77   93.52   93.52   83.77   25.43     XLs (ohms)   80.94   165.94   172.26   172.26   165.94   80.97     Ls (nH)   0.2927   0.6002   0.623   0.602   0.2928   2.2928     Cavity (mils)   148.49   149.28   149.2	\$
Upper Band Edge (MHz)   44500   Waveguide "B" Dimension   94   mil     Vaveguide Cutoff   31412.3   MHz     Vaveguide Cutoff   383.341   mil     Vaveguide Cutoff   383.341   mil     Lambda Guide (Fo)   383.341   mil     Lambda Guide (Fo)   383.341   mil     Lambda in Air (Fo)   268.43   mil     Vaveguide Impedance (Fo)   538.388   Oh     Parameter   0,1   1,2   2,3   3,4   4,5   5,6   6,7     k Values   0.233   0.054   0.042   0.042   0.054   0.233     XLp (ohms)   132.73   29.37   23.07   23.07   29.37   132.73     Lp (nH)   0.4801   0.1062   0.0834   0.0834   0.1062   0.4801     Strip width   25.42   83.77   93.52   93.52   83.77   25.43     XLs (ohms)   80.94   165.94   172.26   172.26   165.94   80.97     Ls (nH)   0.2927   0.6002   0.623   0.6002   0.2928   149.28   149.28<	·
Kerresh     Next >     Waveguide Cutoff     31412.3     MH       Lambda Guide (Fo)     383.341     mil       Lambda in Air (Fo)     268.43     mil       Lambda in Air (Fo)     268.43     mil       Vaveguide Impedance (Fo)     538.388     0h       Parameter     0,1     1,2     2,3     3,4     4,5     5,6     6,7       k Values     0.233     0.054     0.042     0.042     0.054     0.233       XLp (ohms)     132.73     29.37     23.07     23.07     29.37     132.73       Lp (nH)     0.4801     0.1062     0.0834     0.0834     0.1062     0.4801       Strip width     25.42     83.77     93.52     93.52     83.77     25.43       XLs (ohms)     80.94     165.94     172.26     172.26     165.94     80.97       Ls (nH)     0.2927     0.6002     0.623     0.623     0.6002     0.2928       Cavity (mils)     148.49     149.28     149.26     149.28     149.28     149.28	s
Kerresh   Next>   Lambda Guide (Fo)   383.341   mill     Total Filter Insert Length   1152   mills   Lambda in Air (Fo)   268.43   mill     Parameter   0,1   1,2   2,3   3,4   4,5   5,6   6,7     k Values   0.233   0.054   0.042   0.042   0.054   0.233     XLp (ohms)   132.73   29.37   23.07   23.07   29.37   132.73     Lp (nH)   0.4801   0.1062   0.0834   0.0834   0.1062   0.4801     Strip width   25.42   83.77   93.52   93.52   83.77   25.43     XLs (ohms)   80.94   165.94   172.26   172.26   165.94   80.97     Ls (nH)   0.2927   0.6002   0.623   0.623   0.6002   0.2928     Cavity (mils)   148.49   149.28   149.26   149.28   149.28	Ηz
< Back     Refresh     Next>     Lambda in Air (Fo)     268.43     mil       Total Filter Insert Length     1152     mils     Waveguide Impedance (Fo)     538.388     Or       Parameter     0,1     1,2     2,3     3,4     4,5     5,6     6,7       k Values     0.233     0.054     0.042     0.042     0.054     0.233       XLp (ohms)     132.73     29.37     23.07     23.07     29.37     132.73       Lp (nH)     0.4801     0.1062     0.0834     0.0834     0.1062     0.4801       Strip width     25.42     83.77     93.52     93.52     83.77     25.43       XLs (ohms)     80.94     165.94     172.26     172.26     165.94     80.97       Ls (nH)     0.2927     0.6002     0.623     0.602     0.2928     149.28       Precision     148.49     149.28     149.26     149.28     148.49	s
Total Filter Insert Length   1152   mils   Waveguide Impedance (Fo)   538.388   Oh     Parameter   0,1   1,2   2,3   3,4   4,5   5,6   6,7     k Values   0.233   0.054   0.042   0.042   0.054   0.233     XLp (ohms)   132.73   29.37   23.07   23.07   29.37   132.73     Lp (nH)   0.4801   0.1062   0.0834   0.0834   0.1062   0.4801     Strip width   25.42   83.77   93.52   93.52   83.77   25.43     XLs (ohms)   80.94   165.94   172.26   172.26   165.94   80.97     Ls (nH)   0.2927   0.6002   0.623   0.6002   0.2928     Cavity (mils)   148.49   149.28   149.26   149.28   148.49	s
Parameter     0,1     1,2     2,3     3,4     4,5     5,6     6,7       k Values     0.233     0.054     0.042     0.042     0.054     0.233       XLp (ohms)     132.73     29.37     23.07     23.07     29.37     132.73       Lp (nH)     0.4801     0.1062     0.0834     0.0834     0.1062     0.4801       Strip width     25.42     83.77     93.52     93.52     83.77     25.43       XLs (ohms)     80.94     165.94     172.26     172.26     165.94     80.97       Ls (nH)     0.2927     0.6002     0.623     0.623     0.6002     0.2928       Cavity (mils)     148.49     149.28     149.26     149.28     148.49	-
Parameter     0,1     1,2     2,3     3,4     4,5     5,6     6,7       k Values     0.233     0.054     0.042     0.042     0.054     0.233       XLp (ohms)     132.73     29.37     23.07     23.07     29.37     132.73       Lp (nH)     0.4801     0.1062     0.0834     0.0834     0.1062     0.4801       Strip width     25.42     83.77     93.52     93.52     83.77     25.43       XLs (ohms)     80.94     165.94     172.26     172.26     165.94     80.97       Ls (nH)     0.2927     0.6002     0.623     0.623     0.6002     0.2928       Cavity (mils)     148.49     149.28     149.26     149.28     148.49	ims
k Values   0.233   0.054   0.042   0.042   0.054   0.233     XLp (ohms)   132.73   29.37   23.07   23.07   29.37   132.73     Lp (nH)   0.4801   0.1062   0.0834   0.0834   0.1062   0.4801     Strip width   25.42   83.77   93.52   93.52   83.77   25.43     XLs (ohms)   80.94   165.94   172.26   172.26   165.94   80.97     Ls (nH)   0.2927   0.6002   0.623   0.623   0.6002   0.2928     Cavity (mils)   148.49   149.28   149.26   149.28   148.49	7
XLp (ohms)   132.73   29.37   23.07   23.07   29.37   132.73     Lp (nH)   0.4801   0.1062   0.0834   0.0834   0.1062   0.4801     Strip width   25.42   83.77   93.52   93.52   83.77   25.43     XLs (ohms)   80.94   165.94   172.26   172.26   165.94   80.97     Ls (nH)   0.2927   0.6002   0.623   0.623   0.6002   0.2928     Cavity (mils)   148.49   149.28   149.26   149.28   148.49	
Lp (nH)     0.4801     0.1062     0.0834     0.0834     0.1062     0.4801       Strip width     25.42     83.77     93.52     93.52     83.77     25.43       XLs (ohms)     80.94     165.94     172.26     172.26     165.94     80.97       Ls (nH)     0.2927     0.6002     0.623     0.623     0.6002     0.2928       Cavity (mils)     148.49     149.28     149.26     149.28     148.49	
Strip width     25.42     83.77     93.52     93.52     83.77     25.43       XLs (ohms)     80.94     165.94     172.26     172.26     165.94     80.97       Ls (nH)     0.2927     0.6002     0.623     0.623     0.6002     0.2928       Cavity (mils)     148.49     149.28     149.26     149.28     148.49       Precision     Precision     Precision     Precision     Precision     Precision     Precision	
XLs (ohms)     80.94     165.94     172.26     172.26     165.94     80.97       Ls (nH)     0.2927     0.6002     0.623     0.623     0.6002     0.2928       Cavity (mils)     148.49     149.28     149.26     149.28     148.49       Image: Precision     Example     Image: Precision     Image: Precision     Image: Precision     Image: Precision	
Ls (nH)     0.2927     0.6002     0.623     0.623     0.6002     0.2928       Cavity (mils)     148.49     149.28     149.26     149.28     148.49       Image: Precision     Image: Precision <tht< td=""><td></td></tht<>	
Cavity (mils) 148.49 149.28 149.26 149.28 148.49	
Precision	►
🔿 Low 🔿 Standard 📀 Hi	gh
The Engineers' Club	
W W W.ENGINEERS.COM	

#### Waveguide Selection SCREEN TWO

SELECTING THE APPROPRIATE WAVEGUIDE BAND FOR YOUR DESIGN

As you can see, *eSeptum* has already done the work for you. The waveguide has been selected as WR19 and the k parameters quickly calculated.

The mechanical dimensions of the filter are shown on line 4 of the matrix (Strip Width) and Line 7 of the matrix (Cavity). The total insert length is also shown (in blue) as 1152 mils. The total length is the summation of all the Widths and all the Cavities. Note that you have 5 cavities (resonators) since you requested an N=5 filter design.

The eSeptum **DEMO Version** is **locked to WR19** Waveguide. With the registered version, you could try your design with WR22 or WR28 Waveguide as well. For this case WR19 is, indeed, the best choice for the filter design.

**CLICK** <u>NEXT></u> for "Interactive Performance Optimization, Screen Three.



#### Interactive Performance Optimization SCREEN THREE

FILTER PERFORMANCE BEFORE ANY OPTIMIZATION

**PRESS** <u>"REFRESH"</u> to plot filter performance using data from the "Waveguide Selection", Screen Two.

Let's take a minute to get familiar with the controls available:

**Upper Left Corner** - Filter Requirements from the first screen and test temperature

*Left Center* - End view of WR19 Waveguide showing a 2 mil thick septum "sandwiched" in the center of the waveguide. Data box for changing the "A" dimensions of the selected waveguide (The Demo Version is locked to 188 +/-8 mils).

*Lower Left* - Fully dimensioned layout of your filter insert. All dimensions shown can be changed and the performance effects viewed by pressing <u>"REFRESH"</u>

**Upper Right** - Scalar Analyzer. Preset for you by the frequencies you specified out on the first screen. You can change any scales by entering the new data and pressing <u>"REFRESH"</u>. Please note the <u>"Save Settings"</u> and <u>"Restore"</u> buttons on the Analyzer. When the screen is set the way you want to view your design, press <u>"Save Setting"</u> so that you can <u>"Restore"</u> after you make modifications to your design.

Now verify your design for manufacturing margins and tolerance.

The MOUSEPOINTER TOOL (Crosshair) can be used as a "Delta F" measurement tool;

- 1. **POSITION** the mouse crosshair to the <u>LEFT MOST EQUAL RIPPLE BAND</u> <u>EDGE</u> (The point where return loss passes through -12.5dB on the left edge of the match display)
- 2. **CLICK** the <u>LEFT MOUSE BUTTON</u> to "ZERO" the Delta F Point at the LEFT EQUAL RIPPLE POINT of the filter.
- 3. **MOVE** the MOUSEPOINTER Crosshair to the <u>RIGHT MOST EQUAL RIPPLE</u> <u>BAND EDGE</u> and read the "**EQUAL RIPPLE BANDWIDTH**" of the filter.



#### Interactive Performance Optimization SCREEN THREE

TOTAL FILTER BANDWIDTH MEASUREMENT (Using Mousepointer tool)

The *DELTA F* reading is about 870 MHz, a **130 MHz shortfall** from your design requirement of 1000 MHz.

Make a note, for later use, the **FILTER BANDWIDTH NEEDS TO BE WIDENED BY** <u>130MHz</u> to meet the nominal design at room temperature. Next, check for NEGATIVE FREQUENCY MOVEMENTS due to TEMPERATURE, ETCH FACTOR, and WAVEGUIDE TOLERANCE.

Remember, your MOUSE DELTA F Reading is STILL MARKED FROM THE LEFT MOST EQUAL RIPPLE POINT of your filter.

- 1. **CHANGE** the <u>WAVEGUIDE "A"</u> dimension box to read 189 mils (+1 mil from nominal 188 mils).
- 2. **DOUBLE-CLICK** the <u>ETCH FACTOR</u> box to AUTOFIL a "typical" etch tolerance for this thickness of septum material.
- 3. **CHANGE** the <u>TEMPERATURE</u> box to 70 Degrees Centigrade
- 4. **PRESS** <u>"REFRESH"</u> for the NEGATIVE TOLERANCE PLOT



#### SCREEN THREE

NEGATIVE TOLERANCE FREQUENCY DRIFT

This measurement shows the filter design will drift about 230MHz lower with worst case tolerance. Note this value (230MHz) for future use.

- 1. **CHANGE** the variables back to the NOMINAL Values: <u>Waveguide "A"</u> <u>dimension</u> = 188 mils, <u>Temperature</u> 25 Degrees, and <u>Etch Factor</u> to 0.00
- 2. **PRESS** <u>"REFRESH"</u> to get your nominal filter response back on the screen.
- 3. **LEFT CLICK** the mouse to get into <u>ABSOLUTE FREQUENCY MODE</u>
- 4. **POSITION** the <u>MOUSEPOINTER CROSSHAIR</u> on the RIGHT MOST EQUAL RIPPLE point of the filter return loss response.
- 5. **LEFT CLICK** the mouse to return to <u>"DELTA F"</u> mode.

- 6. **CHANGE** the <u>WAVEGUIDE "A"</u> Dimension to 187mils, the <u>ETCH FACTOR</u> to -0.3 mils, and the <u>TEMPERATURE</u> to -30 Degrees Centigrade.
- 7. **PRESS** <u>REFRESH</u> and move the <u>MOUSEPOINTER</u> Crosshair to the UPPER FREQUENCY TOLERANCE point (the right most equal ripple point).
- 8. **READ** <u>DELTA F</u> to find the filter **POSITIVE tolerance drift.**



#### SCREEN THREE

POSITIVE FILTER DRIFT WITH TOLERANCE AND TEMPERATURE

The POSITIVE tolerance and temperature drift is about 230MHz for this filter.

#### Lets do some housekeeping:

- 1. **CHANGE** the ETCH FACTOR back to 0.00, the temperature back to 25, and the Waveguide "A" dimension to 188 (back to nominal values).
- 2. ENTER 42000MHz in the MARKER3 data box
- 3. **ENTER** 46000MHz in the MARKER4 data box
- 4. **ENTER** 41000MHz in the START FREQUENCY data box
- 5. **ENTER** 47000MHz in the STOP FREQUENCY data box
- 6. **PRESS** <u>REFRESH</u> to get all the markers on the screen.

**PRESS** <u>STORE SETTING</u> to return to these display settings after modifying the filter design requirements accounting for the needed excess bandwidth to compensate temperature and tolerance issues.

The Filter Needs to be redesigned for extra bandwidth:

- 130MHz Shortfall on initial design
- 230MHz Negative tolerance drift
- 230MHz Positive tolerance drift

Add all the above tolerance together to find your TOTAL design shortfall. (130 + 230 + 230 = 590 MHz)

The Total Extra Bandwidth needed = 590 MHz, Round up to 650 MHz.

**PRESS** <u><BACK</u> Twice to return to original design screen (or mouse click on the Parameters screen).

**CHANGE PASSBAND BANDWIDTH by Adding** <u>650MHz to the original</u> <u>1000MHz</u> requirement for a new requirement of <u>1650MHz</u>.

#### **PRESS** <u>REFRESH</u> TO CALCULATE NEW g VALUES

🛃 eSeptum 🛛 Version	1.1		Filter Parame	ters				X
PrintScr Registration	<u>A</u> bout <u>H</u>	<u>l</u> elp						
Center Frequency Passband Bandwidth	44000	MHz Filter MHz ©	r Type Tchebyscheff (Equal Rip	ple)		C But	terworth (Max	imally Flat)
Passband Ripple	0.2	dB	g 0	1	2	3	4	5
Lower Band Edge	43175	MHz \	Value 1	1.339472	1.33701	2.166083	1.337014	1.339507
Upper Band Edge	44825	MHz 🗳						
Number of Sections	5	N						
*Rejection @ 42000	MHz	-38.25 dB				Calculate /	Refresh	Next >
*Rejection @ 46000	MHz	-38.25 dB						
*Theoretical Rejection for Butterworth Filter								
Note: Click on descriptive text for instant help								

#### Filter Parameters SCREEN ONE

MODIFIED VALUES, 1650MHz BANDWIDTH, NEW g VALUES CALCULATED

**PRESS** <u>NEXT></u> to calculate and move on to the WAVEGUIDE SELECTION SCREEN (Screen Two)

🥩 eSeptur		Waveg	uide Selecti	ion			×		
PrintScr Ab	iout <u>H</u> elp								
Center Fr	Center Frequency (MHz) 44000 WR19 Band 40.0 To 60.0 GHz								
Lower Ba	and Edge (MH	z) 43175	43175 Waveguide "A" Dimension 188						
Upper Ba	and Edge (MH	z) 44825		Waveguide '	"B" Dimensior	n 94	mils		
				Waveguide (	Cutoff	31412.3	3 MHz		
	1	1	_	Lambda Guid	de (Fo)	383.34	1 mils		
< Back	Refres	h Nex	t>	Lambda in A	ir ( Fo)	268.43	mils		
Total Filter	Insert Length	1050	mils	Waveguide I	Impedance (F	o) 538.388	3 Ohms		
Parameter	0,1	1,2	2,3	3,4	4,5	5,6	6,7 7		
k Values	0.299	0.089	0.07	0.07	0.089	0.299			
XLp (ohms)	177.12	48.72	48.72 38.19 38.19 48.72 177.11						
Lp (nH)	0.6406	0.1762	0.1762 0.1381 0.1381 0.1762 0.6406						
Strip width	15.55	63.59	63.59 73.25 73.25 63.59 15.55						
XLs (ohms)	54.82	146.94	146.94 157.13 157.13 146.94 54.82						
Ls (nH)	0.1983	0.5315	0.5315 0.5683 0.5683 0.5315 0.1983						
Cavity (mils)		147.62	149.39	149.37	149.39	147.62			
							F		
Precision (	C Low		(	🔿 Standard			High		
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#### Waveguide Selection SCREEN TWO

RECALCULATED VALUES BASED ON NEW "SCREEN ONE" DATA

The work was automatically done for you on the WAVEGUIDE SELECTION SCREEN.

**PRESS** <u>NEXT ></u> to move to SCREEN THREE, Interactive Design Optimization.

**PRESS** <u>RESTORE</u> to get your "Saved" settings for the display back.

**PRESS** <u>REFRESH</u> to display your new "wider band" filter.



Interactive Performance Optimization SCREEN THREE

**DISPLAY OF OUR "WIDER" DESIGN FILTER** 

Looks pretty good, and centered up on the desired band, let's check it for temperature and tolerance performance to see how you did.

- 1. **CHANGE** the <u>TEMPERATURE</u> box to +70 Degrees Centigrade
- 2. **CHANGE** the ETCH FACTOR box to 0.3 mils (or double-click data box)
- 3. CHANGE the WAVEGUIDE "A" dimension to 189 mils
- PRESS <u>REFRESH</u> to see the NEGATIVE tolerance and temperature drift of our new design.



#### Interactive Performance Optimization SCREEN THREE

NEGATIVE TOLERANCE AND TEMPERATURE DRIFT PLOT

Let's check the other tolerance extreme now:

- 1. CHANGE <u>TEMPERATURE</u> box to -30 Degrees Centigrade
- 2. CHANGE ETCH FACTOR box to -0.3 mils
- 3. CHANGE WAVEGUIDE "A" Dimension to 187 mils
- 4. **PRESS** <u>REFRESH</u> to plot positive tolerance and temperature drift.



Interactive Performance Optimization SCREEN THREE

POSITIVE TOLERANCE AND TEMPERATURE DRIFT PLOT

It is seen that the filter now has enough bandwidth but is centered "just a little bit high". This can be easily fixed by lengthening all the resonators by an equal amount on the layout (this will be left as an exercise for the user). Try adding about 2 mils to each resonator length (147.7 to 149.7, 149.4 to 151.4, etc.), that should center the design.

#### Let's check for second pass band responses up to 70GHz or so:

- 1. CHANGE the START FREQUENCY to 40,000mhz on the Scalar Display
- 2. **CHANGE** the <u>STOP FREQUENCY</u> to 70,000mhz on the Scalar Display
- 3. **CHANGE** the "db/Div" box to 10dB/Division on the Scalar Display
- 4. CHANGE the PLOT RESOLUTION to High (we need lots of data points)
- 5. **PRESS** <u>REFRESH</u> to plot filter response up to 70GHz



**SCREEN THREE, Interactive Performance Optimization** 

SPURIOUS RESPONSES, SECOND PASSBAND PLOT

Using the MOUSEPOINTER crosshair, the rejection is measured at about 20dB at 60GHz. This DOESN'T meet our original goal of 20dB loss minimum from 55 to 65 GHz. Also, we have a warning that the waveguide is operating above twice cutoff and possible moding can be present.

For design margin, adding a LOWPASS Filter to the Radio Design would be the safe way to proceed. It could always be removed at a later date if specifications could be met without the Lowpass Filter.

Lastly check Ripple, and then we're ready to give the design to drafting

- 1. **PRESS** <u>RESTORE</u> to bring the original settings back to the display.
- 2. **CHANGE** the <u>"dB/Div"</u> box to 0.2dB/Div.
- 3. **CHANGE** the <u>Temperature</u>, <u>Waveguide "A"</u> dimension and <u>ETCH FACTOR</u> back to nominal values.
- 4. **PRESS** <u>REFRESH</u> to sweep the ripple response of the filter.



Interactive Performance Optimization SCREEN THREE

PASSBAND RIPPLE PLOT

Your filter has a nominal insertion loss of 0.5dB with a ripple of about 0.2 dB.

#### CONCLUSIONS:

We have quickly designed and verified for manufacturing tolerances and temperature a 44GHz Bandpass filter.

This filter should be easily manufactured with inexpensive material and should meet all the requirements (save one) in a production environment.

- The design criteria of 44GHz +/- 500 MHz was easily met
- The Rejection criteria of 30dB at 42 and 46 GHz was met with plenty of margin.
- Bandpass Ripple of 0.2dB was met
- You identified a possible second passband response problem that may need to be corrected by adding a lowpass filter.

#### Some Caveats:

The RESONATOR SCALING FACTOR on Screen Three is used to align the program with "REAL WORLD" measured performance. The septums appear just a little longer than their physical length due to transition effects from waveguide into the septums. A good "Rule of Thumb" value for Resonator Scaling Factor is <u>102%</u>. This gives results closely correlated with measured data on several different frequency bands.

To Adjust For Scaling Factor:

**CHANGE** the <u>Resonator Scaling Factor</u> to <u>102%</u> and <u>SHORTEN</u> all the resonator dimensions by equal values (try, 2 mils each) to bring the filter back to center frequency.

While you will be able to design filters with over 20dB return loss using eSeptum, a practical production value for ease of manufacture would be 15dB. This is primarily due to etch factor variation along the length of the filter insert and slight errors in the algorithms used to predict septum inductance.