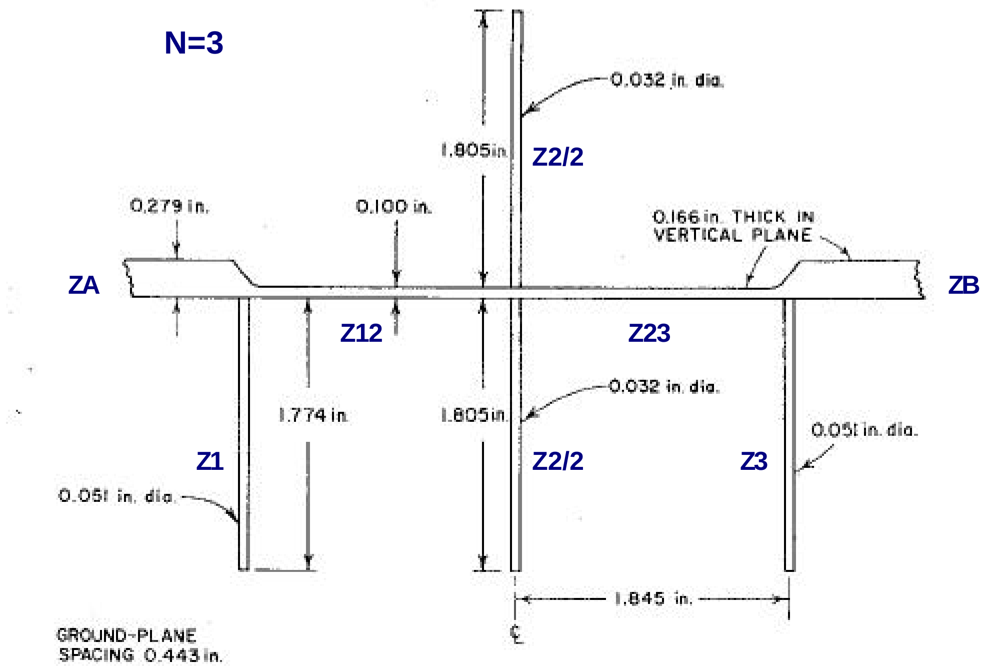
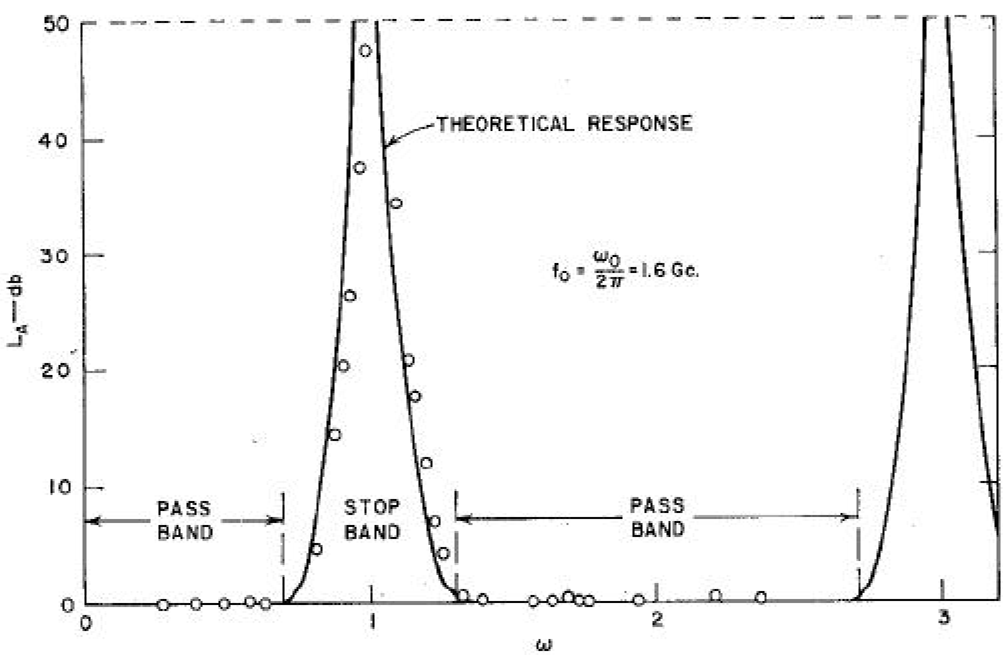
Microwave Notch Filter Design Sheet

Chris Haji-Michael
www.sunshadow.co.uk/chris.htm

This sheet calculates a stop-band filter according to Schiffman and Matthaei, IEEE trans MTT, January 1962. page 6.

N=3





wp

There are three steps to this notch filter:

Step 1, Get the filter g-values, this sheet calculated the g values according to the Chebychev polynomial for a given N, but these can be obtained in a variety of ways from books or from a program freely available from this web page.

Step 2, Calculate Zo for the filter (this sheet stops there). All section are lambda/4

Step 3, Calculate length and width. One method is to use Linecalc which is part of ADS. For microstrip designs I have written a MathCAD sheet which is available from my wepage that works well for thin tracks, less well for thicker tracks. Also you can try **transcalc.sourceforge.net** for a Linecalc equivalent.

Yellow is user input, Green is output

$\mu m := 10^{-6} \cdot m$ $nH := 10^{-9} \cdot henry$

Main user input area:

$L_{ar\_db} := 0.1$ Passband ripple in dB for the chebchev calculations

$N := 5$ Order of the filter 1 to 5, please choose correct section below for the results

$f_0 := 1.6 \cdot GHz$ $f_{bw} := f_0 \cdot 0.6$ $Z_A := 50 \cdot \Omega$ $\omega p := 1.0$

refer to frequency repetition above. If you need to attenuate signal and all harmonics set to 1.5

Calculate Chebychev (g) Polynomials

$k := 1..N$ $\beta := \ln\left(\coth\left(\frac{L_{ar\_db}}{17.37}\right)\right)$ $\gamma := \sinh\left(\frac{\beta}{2 \cdot N}\right)$ $a_k := \sin\left[\frac{(2 \cdot k - 1) \cdot \pi}{2 \cdot N}\right]$

$b_k := \gamma^2 + \left(\sin\left(\frac{k \cdot \pi}{N}\right)\right)^2$

$g_k := 0$

$g_0 := 1$

$g_{N+1} := 1$

g(0) and g(N+1) represent the input/output coupling for odd order filters, these are 1 representing the generator (and equal) load resistance

$$g_k := \begin{cases} \frac{2 \cdot a_1}{\gamma} & \text{if } k = 1 \\ \frac{4 \cdot a_{k-1} \cdot a_k}{b_{k-1} \cdot g_{k-1}} & \text{otherwise} \end{cases}$$

$$g = \begin{pmatrix} 1 \\ 1.147 \\ 1.371 \\ 1.975 \\ 1.371 \\ 1.147 \\ 1 \end{pmatrix}$$

Calculate basic factors

$f_1 := f_0 - \frac{f_{bw}}{2}$ $a := \cot\left(\frac{\pi}{2} \cdot \frac{f_1}{f_0}\right)$ $\Lambda := \omega p \cdot a$

$f_1 = 1.12\,GHz$

$a = 0.509525$ $\Lambda = 0.509525$

For N=1. Note the input and output impedances are different

$$N1\_Z_1 := \frac{Z_A}{\Lambda \cdot g_0 \cdot g_1} \qquad N1\_Z_B := \frac{Z_A \cdot g_2}{g_0}$$

$N1\_Z_1 = 85.566\,ohm$

$N1\_Z_B = 68.56\,ohm$

For N=2

$$N2\_Z_1 := Z_A \cdot \left(1 + \frac{1}{\Lambda \cdot g_0 \cdot g_1}\right) \qquad N2\_Z_{12} := Z_A \cdot \left(1 + \Lambda \cdot g_0 \cdot g_1\right)$$

$$N2\_Z_2 := \frac{Z_A \cdot g_0}{\Lambda \cdot g_2} \qquad N2\_Z_B := Z_A \cdot g_0 \cdot g_3$$

$N2\_Z_1 = 135.566\,ohm$

$N2\_Z_{12} = 79.217\,ohm$

$N2\_Z_2 = 71.565\,ohm$

$N2\_Z_B = 98.751\,ohm$

For N=3

$$N3\_Z_1 := Z_A \cdot \left(1 + \frac{1}{\Lambda \cdot g_0 \cdot g_1}\right) \qquad N3\_Z_{12} := Z_A \cdot \left(1 + \Lambda \cdot g_0 \cdot g_1\right)$$

$$N3\_Z_2 := \frac{Z_A \cdot g_0}{\Lambda \cdot g_2} \qquad N3\_Z_3 := \frac{Z_A \cdot g_0}{g_4} \cdot \left(1 + \frac{1}{\Lambda \cdot g_0 \cdot g_4}\right)$$

$$N3\_Z_{23} := \frac{Z_A \cdot g_0}{g_4} \cdot \left(1 + \Lambda \cdot g_0 \cdot g_1\right) \qquad N3\_Z_B := \frac{Z_A \cdot g_0}{g_4}$$

$N3\_Z_1 = 135.566\,ohm$

$N3\_Z_{12} = 79.217\,ohm$

$N3\_Z_2 = 71.565\,ohm$

$N3\_Z_{23} = 57.772\,ohm$

$N3\_Z_3 = 88.655\,ohm$

$N3\_Z_B = 36.464\,ohm$

For N=4

$$N4\_Z_1 := Z_A \cdot \left(2 + \frac{1}{\Lambda \cdot g_0 \cdot g_1}\right) \qquad N4\_Z_{12} := Z_A \cdot \left(\frac{1 + 2 \cdot \Lambda \cdot g_0 \cdot g_1}{1 + \Lambda \cdot g_0 \cdot g_1}\right)$$

$$N4\_Z_2 := Z_A \cdot \left[\frac{1}{1 + \Lambda \cdot g_0 \cdot g_1} + \frac{g_0}{\Lambda \cdot g_2 \left(1 + \Lambda \cdot g_0 \cdot g_1\right)^2}\right] \qquad N4\_Z_{23} := \frac{Z_A}{g_0} \cdot \left(\Lambda \cdot g_2 + \frac{g_0}{1 + \Lambda \cdot g_0 \cdot g_1}\right)$$

$$N4\_Z_3 := \frac{Z_A}{\Lambda \cdot g_0 \cdot g_3} \qquad N4\_Z_{34} := \frac{Z_A}{g_0 \cdot g_5} \cdot \left(1 + \Lambda \cdot g_4 \cdot g_5\right)$$

$N4\_Z_1 = 185.566\,ohm$

$$N4\_Z_4 := \frac{Z_A}{g_0 g_5} \cdot \left(1 + \frac{1}{\Lambda \cdot g_4 \cdot g_5}\right) \qquad N4\_Z_B := \frac{Z_A}{g_0 g_5}$$

$N4\_Z_{12} = 68.441\,ohm$

$N4\_Z_2 = 60.069\,ohm$

$N4\_Z_{23} = 66.492\,ohm$

$N4\_Z_4 = 98.01\,ohm$ $\quad N4\_Z_3 = 49.686\,ohm$

$N4\_Z_B = 43.598\,ohm$ $\quad N4\_Z_{34} = 78.531\,ohm$

For N=5

$N5\_Z_1 := N4\_Z_1 \quad N5\_Z_{12} := N4\_Z_{12} \quad N5\_Z_2 := N4\_Z_2 \quad N5\_Z_{23} := N4\_Z_{23} \quad N5\_Z_3 := N4\_Z_3$

$$N5\_Z_4 := \frac{Z_A}{g_0} \cdot \left[\frac{1}{1 + \Lambda \cdot g_5 \cdot g_6} + \frac{g_6}{\Lambda \cdot g_4 \left(1 + \Lambda \cdot g_4 \cdot g_5\right)^2}\right] \qquad N5\_Z_{34} := \frac{Z_A}{g_0} \cdot \left(\Lambda \cdot g_4 + \frac{g_6}{1 + \Lambda \cdot g_5 \cdot g_6}\right)$$

$$N5\_Z_5 := \frac{Z_A \cdot g_6}{g_0} \cdot \left(2 + \frac{1}{\Lambda \cdot g_5 \cdot g_6}\right) \qquad N5\_Z_{45} := \frac{Z_A \cdot g_6}{g_0} \cdot \left(\frac{1 + 2 \cdot \Lambda \cdot g_5 \cdot g_6}{1 + \Lambda \cdot g_5 \cdot g_6}\right)$$

$$N5\_Z_B := \frac{Z_A \cdot g_6}{g_0}$$

$N5\_Z_1 = 185.566\,ohm$

$N5\_Z_{12} = 68.441\,ohm$

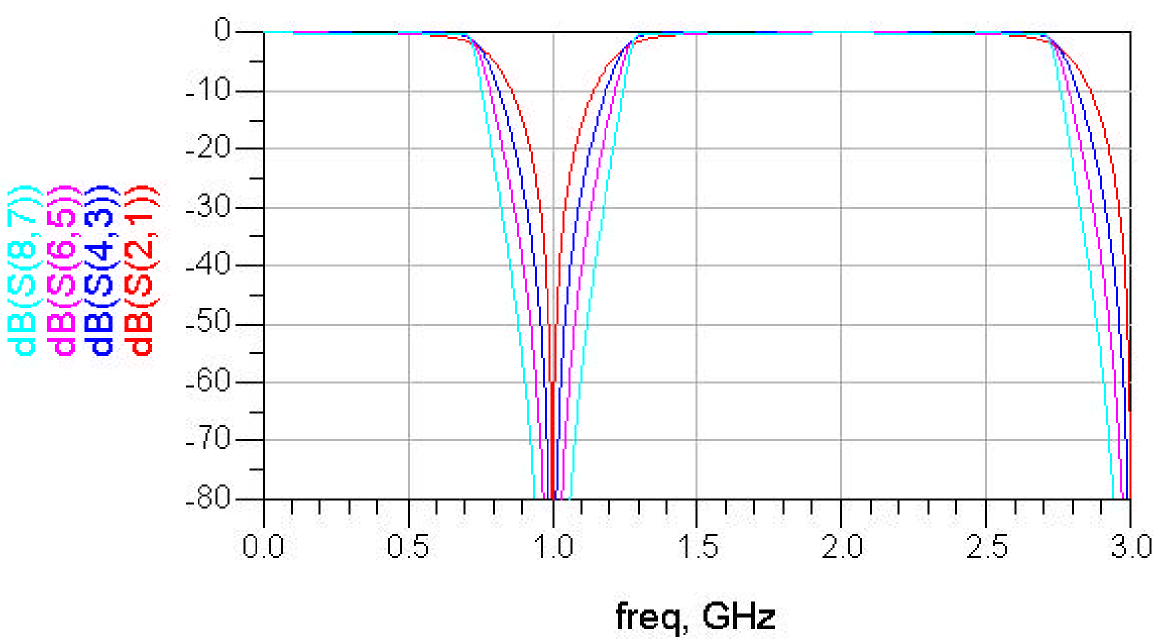
$N5\_Z_4 = 53.616\,ohm$ $\quad N5\_Z_2 = 60.069\,ohm$

$N5\_Z_{45} = 68.441\,ohm$ $\quad N5\_Z_{23} = 66.492\,ohm$

$N5\_Z_5 = 185.566\,ohm$ $\quad N5\_Z_3 = 49.686\,ohm$

$N5\_Z_B = 50\,ohm$ $\quad N5\_Z_{34} = 66.492\,ohm$

Does it work?



The plots above are for four different notch filterss from n=2 to n=5, simulated with ideal transmission lines shown below. Each line is 90 degrees at the wanted frequency, and the results are excellent