Abstract

The goal for this final project is to design and build a 5th order Evanescent Mode (EM) waveguide filter that will successfully be used as a subsystem within a more complicated transmit/receive design. The advantages of the EM filter include a high Q-factor along with a relatively low loss. However, one of the most significant disadvantages of the EM is the large physical size required for success. Although, the final product is susceptible to outside influences, if left untouched the EM filter has a center frequency of 915 MHz and a bandwidth of approximately 200 MHz.

Introduction

The objective for this project is to successfully design and build a 5th order Evanescent Mode (EM) waveguide filter that operates at a center frequency of 915 MHz. The EM waveguide filter will take on the same characteristics as a 5th order Chebyshev band pass filter. The advantages of the EM filter include a high Q-factor along with a relatively low loss. On the other hand, one of the most significant disadvantages of the EM is the large physical size compared with an active filter design. The operation of the EM filter is fairly straightforward. The inductances and capacitances required for an ideal band pass filter are represented in the EM filter by high dielectric posts. In this particular design, 6 steel bolts are used as the variable height dielectric posts. These posts are varied in height in order to fine tune the EM in an attempt to obtain an ideal band pass filter centered at 915 MHz is obtained.

Procedures

The first step in the design includes finding a waveguide that has a cutoff frequency that is between 915 MHz and 2 times 915 MHz. The designed filter will operate at 915 MHz, which is below the cutoff frequency. A coupling curve, which is a relation between the difference of the resonant frequencies and spacing of the tuning screws, will have to be determined through experiment. The desired filter properties are used to calculate the spacing of the screws using published g-values in the following equation:

$$\Delta f_{i,i+1} = \frac{BW}{\sqrt{g_i g_{i+1}}} \qquad (1)$$

Using the values found from the above equation and the coupling curve, the spacing of the tuning screws are found (see Figure 1).

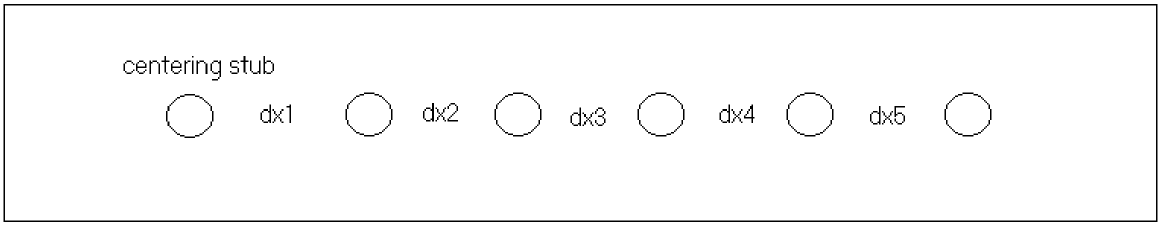

Figure 1. Top view of the EM filter

Once the waveguide is connected to a network analyzer, the centering stub is centered an inch towards the center of the waveguide above the SMA input. This centering stub is used to shift the center frequency to 915 MHz. With the centering screw still in place, an additional screw is inserted into the next hole and the delta f is recorded as was the distance from the centering stub. This process is repeated for the next hole and more data is taken until enough is obtained to create the coupling curve.

Once the correct spacing is determined, the five tuning screws and centering stub are inserted into the waveguide. Tuning is accomplished by adjusting, one by one, the depth each of the screw to be inserted into the waveguide. By observing S11 (the reflection coefficient) on the network analyzer, it can be determined that the filter is centered about 915 MHz.

Data Analysis

The waveguide selected has cross section dimensions of 4” x 2”. Using equation (2) below, the cutoff frequency was determined to be 1.48 GHz which is between fo and 2fo.

$$f_{mn} = \frac{c}{2\pi}\sqrt{\left(\frac{n\pi}{a}\right)^2 + \left(\frac{m\pi}{b}\right)^2} \qquad (2)$$

The experiment to determine the coupling curve generated the data in the table below (Table1):

Table 1:

delta x	trial 1				trial 2			ave delta f	ln delta f
	f1	f2	delta f		f1	f2	delta f		
1	759.9	1084	324.1		740.68	1067	326.32	325.21	5.784471
2.25	846	987.35	141.35		843.3	983.267	139.967	140.6585	4.946335
3.3125	884.5	952.55	68.05		877.89	953.66	75.77	71.91	4.275415
4.3125	897.51	933.13	35.62		892.03	932.32	40.29	37.955	3.636401

Plotting the data above generated the coupling curve of the filter shown in Figure 2.

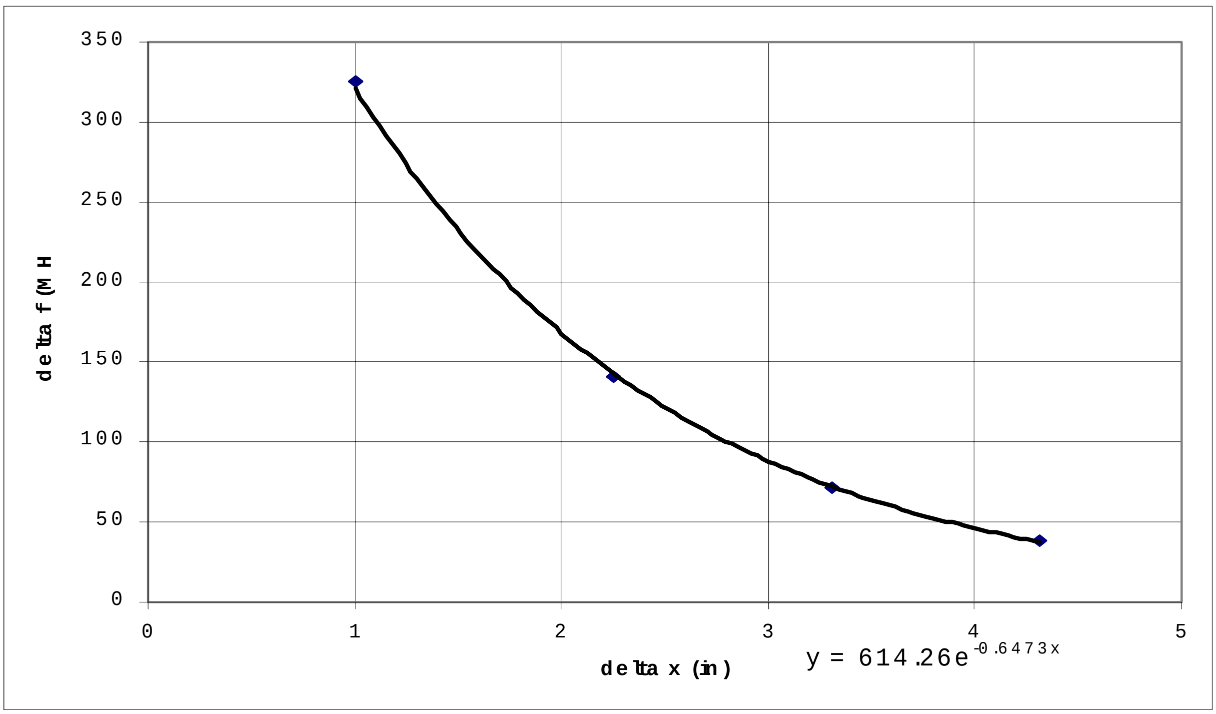

Figure 2. Coupling curve for the EM filter

From the published g-values in table 2 and equation (1) above, delta f is found and listed in table 3, along with values for delta x.

BW =	140	MHz

Table 2: g-values

g1 =	1.14838
g2 =	1.37105
g3 =	1.97655
g4 =	1.37105

Table 3:

	delta f	delta x
12	111.573	2.63516
23	85.04485	3.054595
34	85.04485	3.054595
45	111.573	2.63516

g5 =	1.14838
g6 =	1

total length=	14.37951

Using the network analyzer, the center frequency is found to be at 915 MHz with a S11 of about -20 dB. The bandwidth is measured to be about 200 MHz, which is about 20%. This may seem large, but due to the constraints of our waveguide size, the bandwidth had to be large to accommodate the size of the waveguide. A narrower bandwidth would require a longer waveguide. The results are very sensitive to the outside influences, such as placing pressure on the waveguide or tuning screws. The center frequency would shift a little bit and the reflection coefficient would change. However, untouched, the EM waveguide successfully filters frequencies outside of the specified bandwidth.

Conclusion

In this project, a 5th order Evanescent mode filter was designed using Chebyshev calculations. The final product has a center frequency of 915 MHz and a bandwidth of approximately 200 MHz. The reflection coefficient was measured to be about -20 dB. Unfortunately, the designed filter was not ideal because it was very sensitive to outside influences. By applying pressure to the screws or waveguide, the reflection coefficient and the center frequency slightly shifts. Although the filter has some minor faults, the design successfully filtered frequencies outside of the specified bandwidth centered at 915 MHz.