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High Frequency Compact Microstrip Low Pass Filter

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ABSTRACT: The purpose of this work is to discuss the design and analysis of a low pass filter. The research of a low pass filter with a cut-off frequency of 11.45GHz and an area of 13x6.3mm2 is proposed in this paper. Initially, low pass prototype filter was designed with ground layer. The proposed low pass filter is miniature and low cost because it is mounted on FR4 substrate. The FR4 substrate has thickness of 1.55mm. By using three main stubs that are placed symmetrically around X and Y axis is obtained. The cutoff frequency could be changed by tuning filter's dimensions. The simulations with this design are simulated using Sonnet software and simulation results are reported.

1. INTRODUCTION

Filters have been extensively researched and used as critical components in modern communication systems [1]. This type of circuit, often known as two port devices, is used to suppress undesired signals and segregate signals of different frequencies. Filters of some kinds are required for the operation of most electrical circuits [2]. Filter analysis is a fundamental tool in signal processing research, and it is critical in today's environment. It is employed in a variety of fields, including control systems, circuit analysis, microprocessors, and so on. A filter is nothing more than an electrical network, according to circuit theory. It recasts the phase properties and/or amplitude of a frequency-changing signal [3-5]. From various perspectives, filters can be categories and subcategories. The most common divisions and sub-divisions are active or passive, high-pass, low-pass, band-pass, band-reject/notch, or all-pass; digital or analog, discrete–time or continuous–time; linear or non–linear; infinite impulse response (IIR) or finite impulse response (FIR), and so on. [6-9]. Due to its potential to construct a simple, compact, and inexpensive device, the low pass filter has recently acquired appeal among academics. Planar LPFs are popular because they can be measured using printed circuit technology and are appropriate for commercial use [10-13].

Low pass filters can reject low frequencies that might interfere with the system, allowing only certain frequencies to pass through [14]. On such system, low pass filter open stubs are utilized to distribute and create frequency. Different stub widths are allowed on a single system, and each stub indicates one resonance [15].

In this paper, we are representing three-stub low pass filter , whose cut off frequency is 11.45GHz, and we are comparing it to the other dimensional variations of that same low pass filter. We will be able to see that we don't need stubs with equal dimensions to have quality low pass filter.

2. DESIGN METHODS

Three sections stubs placed along the transmission line are used to build a low pass filter with an 11 GHz cutoff

frequency., with two elements connected to the ports. On figures 1-2 we can see geometry of the proposed filter and 3D view.

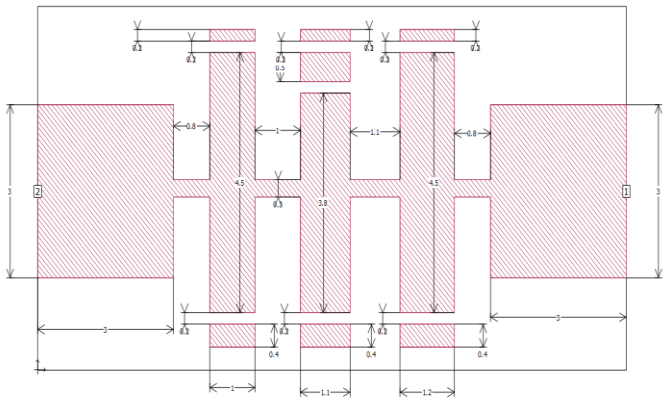

Figure 1:
The top view of the layout for the low pass filter

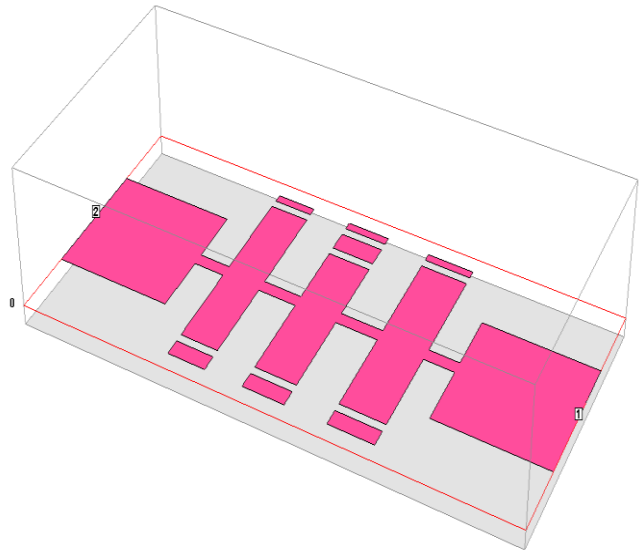

Figure 2:
The 3D view of the low pass filter

3. PARAMETRIC STUDY

We ran a parametric analysis on the dimensions of the three primary stubs that are designed to get a different effect from the low pass filter in tables 1-3. As it could be seen from the tables, cut off frequency is same in most of those cases. S11 curve is successfully kept under -10dB.

Table 1.Parametric study related to dimensions of the three main stubs

dimensions of left center rectangles(mm)	dimensions of the middle center rectangles	dimensions of the right center rectangles	Cut-off freq(GHz)	S11max(dB)	S21(dB)
0.2x1 4.5x1 0.4x1	0.2x1.1 0.5x1.1 3.8x1.1 0.4x1.1	0.2x1.2 4.5x1.2 0.4x1.2	11.4	-12.24	-0.443
0.2x1 4.5x1 0.4x1	0.2x1.1 0.2x1.1 3.8x1.1 0.4x1.1	0.2x1.2 4.5x1.2 0.4x1.2	11.4	-12.19	-0.448
0.2x1.1 4.5x1.1 0.4x1.1	0.2x1.1 0.2x1.1 3.8x1.1 0.4x1.1	0.2x1.2 4.5x1.2 0.4x1.2	11.45	-12.19	-0.449
0.2x1 4.5x1 0.4x1	0.2x1.1 0.3x1.1 3.8x1.1 0.4x1.1	0.2x1.2 4.5x1.2 0.4x1.2	11.45	-12.2	-0.449
0.2x1 4.5x1 0.4x1	0.4x1.1 0.4x1.1 3.8x1.1 0.4x1.1	0.2x1.2 4.5x1.2 0.4x1.2	11.45	-12.23	-0.444

Table 2. Parametric study related to dimensions of the three main stubs

0.2x1 4.5x1 0.4x1	0.5x0.5 0.5x0.5 3.8x1.1 0.4x1.1	0.2x1.2 4.5x1.2 0.4x1.2	11.45	-12.3	-0.436
0.2x1 4.5x1 0.4x1	0.2x1.1 0.7x1.1 4x1.1 0.4x1.1	0.2x1.2 4.5x1.2 0.4x1.2	11.5	-12.71	-0.474
0.3x1 4.5x1 0.5x1	0.3x1.1 0.5x1.1 3.8x1.1 0.5x1.1	0.3x1.2 4.5x1.2 0.5x1.2	11.35	-12.45	-0.46
0.3x1 4.5x1 0.5x1	0.3x1.1 0.5x1.1 3.8x1.1 0.5x1.1	0.3x1.2 4.5x1.2 0.5x1.2	11.4	-12.37	-0.488
0.2x1 4.5x1 0.4x1	0.2x1.1 0.5x1.1 3.8x1.1 0.4x1.1	0.2x1.2 4.5x1.2 0.4x1.2	11.45	-12.16	-0.488

Table 3. Parametric study related to dimensions of the three main stubs

0.3x1 4.5x1 0.5x1	0.3x1.1 0.5x1.1 3.8x1.1 0.5x1.1	0.3x1.2 4.5x1.2 0.5x1.2	11.4	-12.27	-0.466
0.3x1 4.5x1 0.5x1	0.3x1.1 0.5x1.1 3.8x1.1 0.5x1.1	0.3x1.2 4.5x1.2 0.5x1.2	11.4	-12.45	-0.489
0.3x1 4.5x1 0.5x1	0.4x1.1 0.5x1.1 3.8x1.1 0.5x1.1	0.3x1.2 4.5x1.2 0.5x1.2	11.45	-12.43	-0.488
0.3x1 4.5x1 0.5x1	0.4x1.1 0.3x1.1 3.8x1.1 0.5x1.1	0.3x1.2 4.5x1.2 0.5x1.2	11.4	-12.53	-0.499
0.3x1 4.5x1 0.5x1	0.5x1.1 0.3x1.1 3.8x1.1 0.5x1.1	0.3x1.2 4.5x1.2 0.5x1.2	11.4	-12.49	-0.494

As it can be observed from tables 4-5, there is parametric study done related to dielectric thickness and dielectric constant. In Figure 4, dielectric thickness was variated from 1.5 to 1.6 mm and the obtained results were noted in the table below. In Figure 5, the dielectric constant was variated from 4.35 to 4.5 and the obtained results were noted in the table below.

Table 4. Parametric study related to variations with dielectric thickness

Variations with dielectric thickness			
	S11	S21	Cut off
1.6	-12.14	-0.45	11.4
1.52	-12.28	-0.44	11.45
1.55	-12.24	-0.443	11.45
1.53	-12.27	-0.44	11.45
1.5	-12.3	-0.504	11.4

Table 5. Parametric study related to variations with dielectric constant

Variations with dielectric constant			
	S11	S21	Cut off
4.5	-12.35	-0.5	11.35
4.47	-12.32	-0.461	11.35
4.4	-12.24	-0.443	11.45
4.37	-12.2	-0.471	11.45
4.35	-12.17	-0.447	11.45

* S11 and S21 values in the tables are expressed in dB, cut off frequency values are expressed in GHz and dielectric thickness values are expressed in mm

4. RESULTS

Sonnet software is used to generate the simulated and measured findings. One of the requirements of the design was a cut off frequency of 11.4 GHz. As it can be observed from the Figure 3.1, the cut off frequency at -10 dB is 11.4 GHz, exactly as required. The proposed low pass filter with -10 dB cut off frequency of 11 GHz is simulated on a substrate with the thickness of 1.55 mm, and dielectric constant of 4.4. Figure 3 depicts the magnitudes S11 and S21 as a function of frequency. The cutoff frequency of 11.4 GHz determines the entire distance. Because of the initial asymmetry of the filter, the final design is also asymmetric. As we can see from the Figure 3, the maximum value of the red line (S11) before cut off frequency is -12.24 dB. With changing the low pass filter's geometry that value ranged to -12.71, -12.45, -12.53 etc. After cut off frequency, the magnitude of the curve S21 dramatically drops.

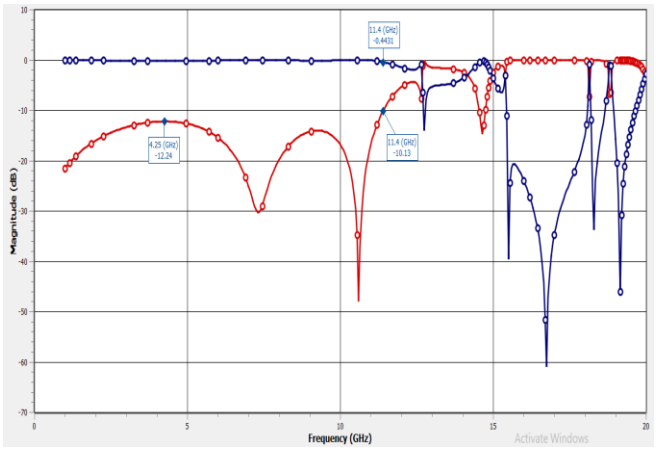

Figure 3: Result of the proposed low pass filter

5. CONCLUSION

In this paper, proposed design of low pass filter with three stubs and two port metals was implemented and analyzed in detail. The overall performance of the final low pass filter met the proposed requirements. When simulated, the final filter design has a cut off frequency of 11.4 GHz.

Respectively, we have constructed low pass filter successfully, and achieved the desired effect.

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