PLANAR FRACTAL FILTER ON DEFECTED GROUND SUBSTRATE

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Abstract: This essay is focus on decrease dimensions of planar filters (microstrip and coplanar waveguide) and design of low-pass filter with reduced fractal defected ground structure (DGS). In this paper, we describe the design of different low-pass filters with DGS and simulations of these filters are compared with simulations of new low-pass filter with reduced fractal DGS. Dimensions of simulated low-pass filters are compared.

Keywords: Defected ground structure, electromagnetic band gap, fractal, low-pass filter

1. INTRODUCTION

Today, the minimum dimensions of the circuit are desirable. This requirement applies even in layout of planar filters. Decrease of dimensions of designed planar filter is possible several ways. The first way, minimum of dimensions can be achieved by increasing the permittivity of substrate. The substrate with high permittivity may by excited the surface waves; this way requiring electromagnetic band gap. [1]

The second way, dimensions of planar filters can be reduced by the fractal theory. Thanks to the fractal theory, we can achieve longer current lines on a smaller area. [2]

The third way, we can used planar filter over the defected ground structure. The DGS is created by etched slots in the ground plane and these etched slots can generate an equivalent parallel resonant circuit. [3]

2. LOW-PASS FILTER WITH REDUCED FRACTAL DGS

The design of low-pass filter with reduced fractal DGS of 11th order is created a pair independently designed filters. The first created filter is convention low-pass filter with stubs separated by transmission lines of 11th order on the top side of substrate with 3 dB bandwidth of 4.6 GHz. The second filter is created by six reduced fractal Minkowski couples DGS on the bottom side of substrate with 3 dB bandwidth of 4.6 GHz. The reduction of dimensions of fractal Minkowski couples is to help values of normalized Chebyshev coefficients. Fractal factor of Minkowski couples is third of main square. Connection two filters, we achieve smaller 3 dB bandwidth from the original 4.6 GHz to new 3.43 GHz. The layout of low-pass filter with reduced fractal DGS of 11th order is shown on Figure 1.

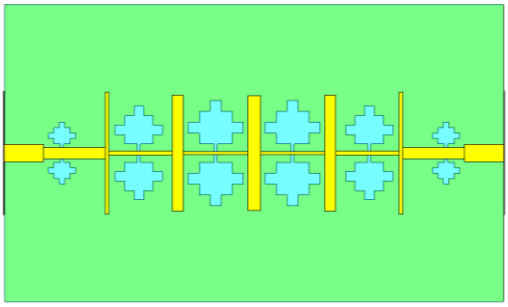

Figure 1: Layout of low-pass filter with reduced fractal DGS

3. FRACTAL LOW-PASS FILTER WITH EBG

The first comparator filter is fractal low-pass filter with EBG of 11th order; this filter was described in [1]. Filter is created by seven transmission lines and six squares on the top side of substrate and five etched squares in the ground plane on the bottom side of substrate. The period *d* of squares on the top side and etched squares in ground plane is half of waveguide wavelength (Bragg´s condition) Dimension of fractal factor is *d* and size of main squares is half of period (fractal factor) *d*. This filter is designed by [1] with 3 dB bandwidth 3.8 GHz. Fractal low-pass filter with EBG was recalculated on frequency of low-pass filter with reduced fractal DGS (3.43 GHz). Layout of fractal low-pass filter with EBG is shown on Figure 2.

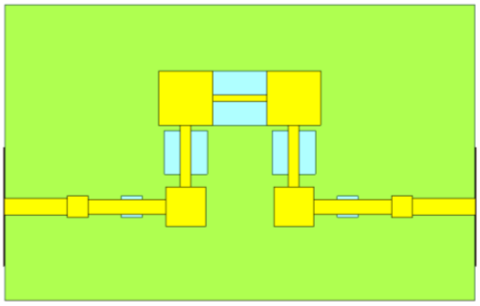

Figure 2: Layout of fractal low-pass filter with EBG

4. FRACTAL CPW EBG LOW-PASS FILTER

The second comparator filter is fractal CPW EBG low-pass filter of 8th order; this filter was described in [2]. Coplanar filter is created by eight Minkowski loops with period *d* is half of waveguide wavelength again and fractal factor of Minkowski loop is third of size of main square *a*. The dimensions of new square (first iteration) are width $a_1 = a/3$ and height $a_2 = 0.83 \cdot a_1$. This filter is designed by [2] with 3 dB bandwidth 12.4 GHz. Fractal CPW EBG low-pass filter was recalculated on frequency of low-pass filter with reduced fractal DGS (3.43 GHz). Layout of fractal CPW EBG low-pass filter is shown on Figure 3.

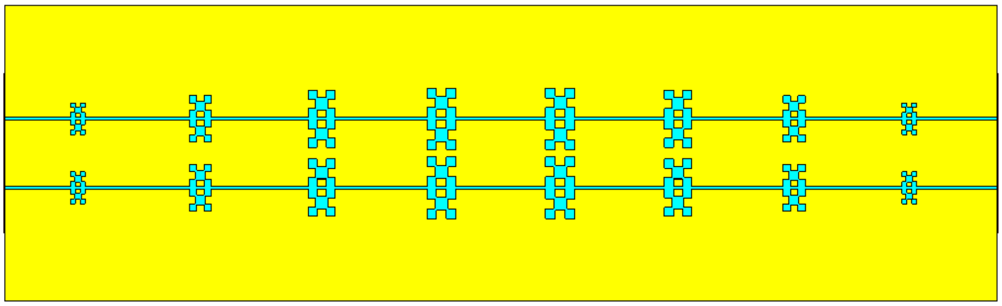

Figure 3: Layout of fractal CPW EBG low-pass filter

5. CONCLUSIONS

As can be seen from Figure 4, all filters are tuned on frequency with 3 dB bandwidth of 3.43 GHz and the best of results was achieved with newly designed low-pass filter with reduced fractal DGS of 11th order. This filter has the biggest attenuation of stopband (68.54 dB) and selectivity 43.69 dB/GHz and while this filter needs one of the smallest area of substrate (50 x 30 mm). Fractal low-pass filter with EBG of 11th order has the worst attenuation of stopband (about 20 dB worse than low-pass filter with reduced fractal DGS) and the worst selectivity, but fractal low-pass filter with EBG needs the smallest dimensions of substrate (44 x 30 mm). Fractal CPW EBG low-pass filter of 8th order is the biggest and needs substrate of dimensions 135 x 40 mm. This filter has worse maximum attenuation of stopband and worse selectivity than designed low-pass filter with reduced fractal DGS.

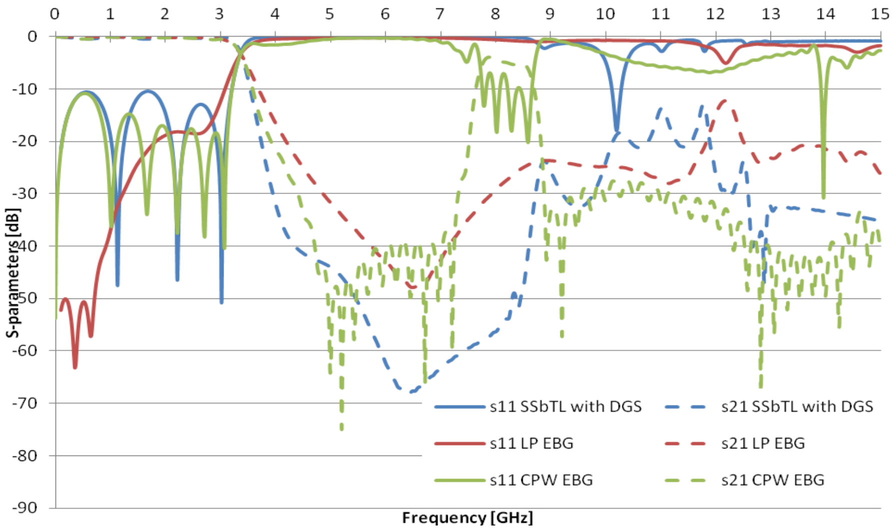

Figure 4: Frequency response of return loss S_{11} and insertion loss S_{21} of low-pass filter with reduced fractal DGS (blue line), low-pass filter with EBD (red line) and fractal CPW EBG low-pass filter (green line). Computed by CST

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