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Miniaturized ultra-wideband coplanarwaveguide lowpass filter with extended stop band

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ABSTRACT

In this article, we propose a novel design of large rejected band of miniaturized ultra wide band (UWB) of a planar CPW low pass filter “LPF” based on the use of periodic elements of ‘e’ slots. The goal of this work is to develop a new structure of Low Pass Filter with the following criterion: Miniature, Compact and Easy for Fabrication. The Miniaturization of this structure is achieved by entering the 'e' slot in etching area in the ground of CPW line, to save the standard gap of the adapted coplanar line. The designed coplanar LPF is a compact filter having a large band pass and extended stop band, with the possibility to associate easily with others RF and microwave planar circuits. The entire area of the proposed structure of CPW LPF is 14.3x20 mm2.

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1. INTRODUCTION

Periodic structures of various kinds have been the driving force behind the interest researchers toward miniaturizing of structures. The miniaturized filters with high and low insertion-loss are important requirements in RF and microwave applications [1, 2]. In literature we can find a few approaches address to design such this filter miniaturization, among which are the use of open stubs [3], lumped-element filters [4], stepped impedance [5], high temperature superconducting (HTS) filters, bulk acoustic-wave (BAW) filters, and slow-wave distributed resonator filters [6-8].

Using the two sides of the ground provides additional miniaturization for structure. In both free etched area [9, 10], witch here a rectangle DGS and loaded DGS [11, 12], by entering the 'e' slot in etching area in the ground of CPW line, an electric and magnetic coupling can be implemented, which allows for an intelligible design of simple an miniaturized structures, such as this proposed low pass filter, and many other structures with the same procedure.

In order to reach an accommodation between size and performance, both DGS with different configurations and slot lines, together inserted in coplanar waveguides lines (CPWs) are other important procedure for the realization of resonators and filters for microwave and millimeter-waves circuits [13-15]. Some compact structures based on periodic structures of DGS configuration and other based on periodic slots have been proposed to construct a slow-wave transmission line and has been used in the design of a miniature low-pass filter [16, 17]. This paper translates our efforts to design and develop a miniaturized ultra wide band

(UWB) of a planar CPW LPF and extended stop band with an ideal slow-wave structure, low loss properties, and easy fabrication.

2. FILTER DESIGN AND CONFIGURATION

Figures 1 show the simple proposed ‘e’ slot connected to conductor line of coplanar waveguide with width wc of 1.5 mm and the gap G of 0.4 mm. This topology is placed on the two sides of cpw, and it is excited by 50 Ω line. The proposed structure is coupled to metallic ground plane through a dielectric substrate with εr = 4.4 and thickness h = 1.6 mm. The investigated ‘e’ slot consists of four slices with different length, which are connected to the conductor line. The ‘e’ slot corresponds to an equivalent capacitance and inductance. All the dimensions of the proposed structure are depicted in Table 1.

The filter design is started with a simple CPW line, passing to a rectangular DGS (with dimensions are: Lr=lr=3mm) in the ground, in which we have inserted the ‘e’ slot as shown in Figure 1.

Figure 2 shows the simulation results of the proposed configuration with one unit of ‘e’ slot, as we can conclude, it is clear that the filter provides low pass band behavior, with a cutoff frequency equal to 7 GHz corresponding to a reflection coefficient around -10dB in the whole bandwidth with very low and flat insertion loss less than -0.5dB. From the S-parameter responses, the suppression is inadequate because limit on the separation between the insertion loss and return loss in the game frequency between 6-10 GHz.

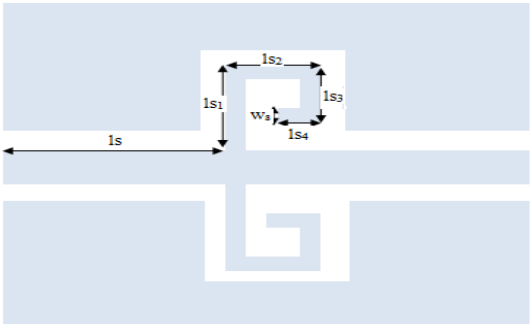

Figure 1. Structure of CPW LPF with one unit of ‘e’ slot

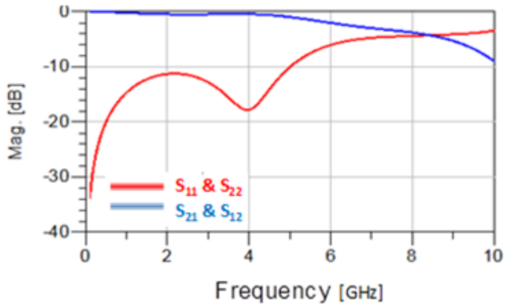

Figure 2. S-parameters versus frequency of the designed LPF filter

Table 1. Values of the different parameters of the bandpass filter

Parameters	Value (mm)
L	20
W	14.3
lr	3
Lr	3
ws	0.5
ls	9
ls1	2.92
ls2	2
ls3	1.5
ls4	1
ds	3.6835
d1	4.3165
d2	1.1835

3. PROPOSED DEVICE OF LPF

In an attempt to improve the performance of S-parameters and the rejection band characteristics, the technique of the periodic cells is a good candidate. In the research, augmentation the number of unit cells and adjusting the distance between cells influence the response of S-parameters characteristics [18-26]. So to adjust the S-parameters in terms of suppression, rejection band and stop band, an optimized ‘e’ slot structure inserted and repeated along the two sides of conductor line. Therefore, the proposed structure of CPW LPF validated into simulation after many optimizations steps using Momentum integrated in ADS. Figure 3 depicts the schematic of the proposed structure with periodic cells.

The parameters of the initial low pass filter with one unit cell are kept unchanged, while two other symmetrical ‘e’slots are introduced and separate with ds=3.6835mm distance as shown in Figure 3. Figure 4 shows the simulated S-parameters of the proposed device of low pass filter with three ‘e’ slots Cells. As a result, the cascaded LPF with just three periodic cells present a good suppression performance and a sharp roll off with improved stop band. The return loss in pass band is greater than 13 dB, with no more than 0.52 dB ripple level in the pass band, while the stop band rejection level going up 50 dB with wide stopband.

By taking the final dimensions of structure, and to ensure the validity of our proposed filter, the simulation result is given by ADS momentum, HFSS and CST Microwave Studio in order to compare the results and to give more credibility for the proposed structure. The s-parameters results show good agreement between ADS momentum, HFSS and CST Microwave Studio in the performance of insertion loss and return loss, and the results with the three simulators are shown in Figure 5.

Figure 6 presents the phase simulation of insertion loss (S21) and return loss (S11). As we shown in Figures, the proposed structure of low pass filter accepted a linear phase for the insertion loss and return loss for the ultra wide band UWB applications from 0.1 GHz to 10 GHz. As results depicts, we can see that the proposed filter with three periodic cells of ‘e’ slot meet the requirement.

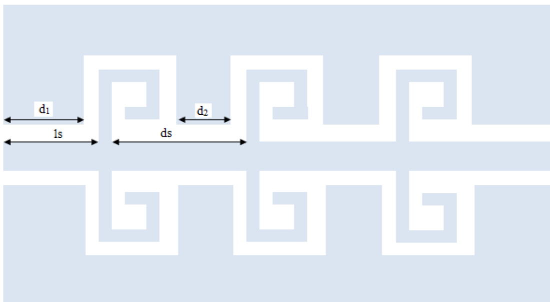

Figure 3. The proposed device of low pass filter with cascaded ‘e’ slots Cells

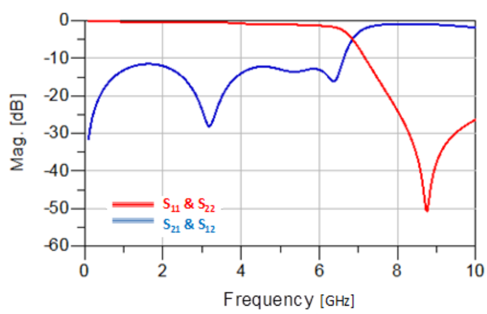

Figure 4. Simulated S-parameter of the proposed LPF with periodic cells device

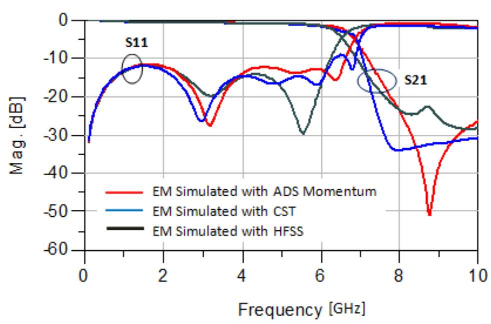

Figure 5. Comparison results between different methods of simulation

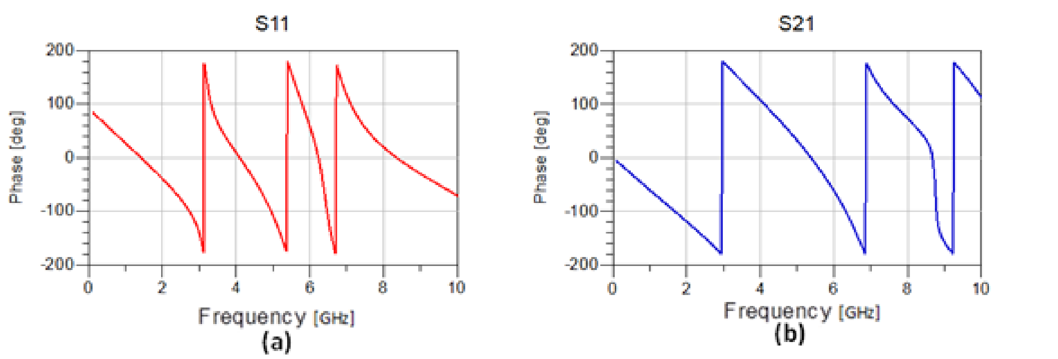

Figure 6. Simulation phase responses of low pass filter designed: (a) of return loss, (b) of insertion loss

4. DISTRIBUTION OF SURFACE CURRENT AT PASS-BAND AND STOP-BAND FREQUENCY RANGES

Figures 7(a) and 7(b) show the current density distributions in the passband and in the stopband, respectively. The power was fully transmitted along the proposed filter, from the input to the output, at the frequency of 3.5 GHz, which means that the filter is in a good passband state. In the other side, in the filter stopband at the 8.5 GHz frequency, there is a high current distribution energies in the first part of structure, while fully attenuated, since no current near to the output port 2, which means that the filter is in strong stopband state. This experiment results demonstrate the relationship and the good reliance between EM-simulation results and the current energies distribution along the proposed structure. All these investigations prove that our proposed low pass filter with just three periodic cells of ‘e’ slot has good performances.

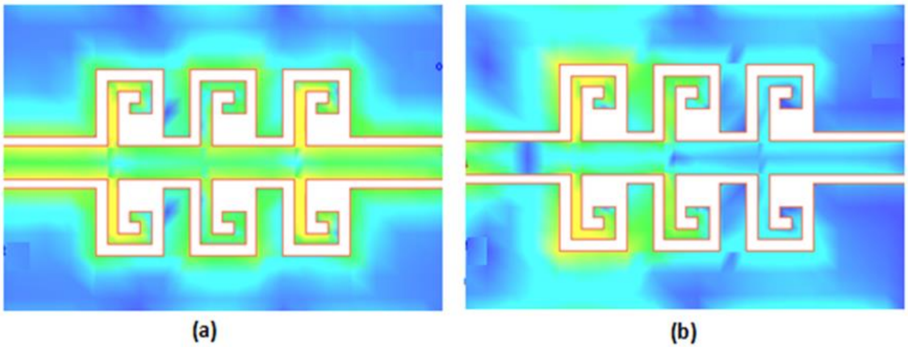

Figure 7. Simulated surface current density. (a) at f = 3.5GHz, (b) at f =8.5GHz.

5. CONCLUSION

This paper comes with a miniaturized and several novel periodic structures for a CPW waveguide. The periodic structures based on three ‘e’ slots series cascade offer very easy fabrication, very low insertion loss, and simple filter synthesis. A periodic series with the proposed configuration results in miniature low-pass filters that offer high attenuation levels in the stopband while reducing filter area size compared with other standard structure. This novel periodic structure is potential to be used in RF and microwave integrated circuits.

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