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A Novel High-Performance DMS/DGS SIW Band Pass Filter for X-Band Applications

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Abstract: This paper introduces the design of SIW band pass filter for X-band applications. Defective microstrip structure(DMS) consisting of single horizontal slot introduced on the top metal layer. The effect of introducing horizontal slot to create stopband within passband. A simple solution for improving the upper stopband attenuation by using Defected ground structure(DGS) which is etched on the ground plane of the SIW cavity. Microstrip to SIW transition is used to provide smooth transition between the structures. The filter is operated at the center frequency of 9.4GHz with fractional bandwidth of 0.15% and it is developed on the Rogers substrate with dielectric constant of 3.5 and thickness of 0.5mm. Compared to the previous reported SIW filters, the proposed approach provides a low insertion loss of dB with return loss of dB. The filter is simulated using Advanced Design Software (ADS).
Keywords: Substrate Integrated Waveguide (SIW), Bandpass filter (BPF), Defected Microstrip structure (DMS), Defected Ground structure (DGS), X-band application.

I INTRODUCTION

Due to the rapid development of mobile and wireless communication technology, high performance band pass filter are used in communication application to allow a particular range of frequencies to pass through and attenuate all other frequencies lying in some other specific ranges. Nowadays most of the millimeter and microwave bandpass filter are fabricated with low temperature co-fired ceramic(LTCC) and CMOS technology. Compared with the conventional rectangular waveguide, Substrated Integrated waveguide(SIW) is one kind of artificial waveguide constructed into substrates and it has the advantage of rectangular waveguide over high quality factor, low cost and easy connection with planar transmission lines. Realization of microwave bnad pass filter using DGS have drawn great attention due to its advantage in high power handling capability,high selectivity and improved filter performance. DGS is realized by etching slots on the ground plane of the microwave planar circuits to provide capacitive coupling[1-2]. A simple systematic approach for the design of elliptic low pass filter using rectangular slot DGS is designed for critical filter specifications and optimized by reducing parasitic effects induced by DGS[3]. In [4] low pass filter is designed using three different DGS structures get return loss enhancement. Filter performance can be improved with DGS and interdigital resonators are used to provide the better return loss[5]. Another method called defected microstrip structure(DMS) is introduced and analyzed, it has the advantage of easy design, performance control and miniature size[6-7]. Dual frequency operation is obtained by loading two complementary slit ring resonator on the SIW cavity, four transmission zeros are generated to improve selectivity[8]. In [9], half mode SIW filter with single nad multiple slots are introduced to provide stopband within passband. This paper presents the design of SIW based bandpass filter using DGS and DMS technique is designed and analyzed. DGS is made by etching cross slots on the bottom of the SIW cavity to provide better out of band rejection. Furthermore the filter return loss performance can be improved by etching a single rectangular slot on the top layer of the SIW structure. The proposed filter using DGS/DMS technique is used to obtain bandpass filtering response which is usable for X-band applications.

II STRUCTURE OF THE PROPOSED FILTER

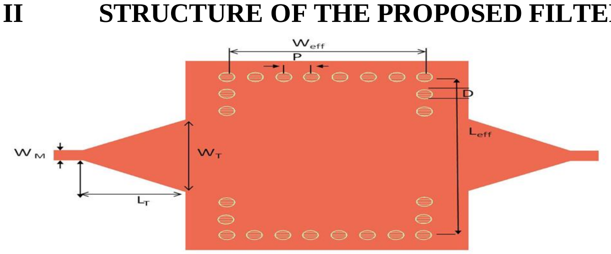


Fig.1 Structure of SIW

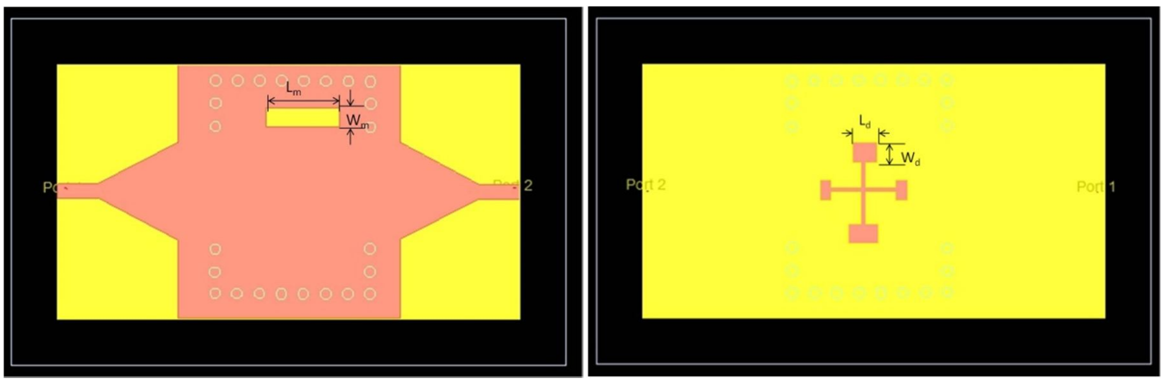
Design of a SIW bandpass filter starts with design of SIW cavity connected to the microstrip structure by tapered transition. The tapering has been done in order to reduce the radiation loss in the structure. SIW cavity is designed using array of metalized via holes connecting upper and lower metal plates of the dielectric substrate. The via holes are separated by post spacing of P, where d is the diameter of the vias, h is the height of the dielectric substrate. The effective width of the SIW can be calculated using the following equation,

$$W_{eff} = W - \frac{d^2}{0.95p}$$

By knowing the value of W_{eff}, the cut off frequency can be obtained as,

$$f_c = \frac{c}{2\epsilon_r W_{eff}}$$

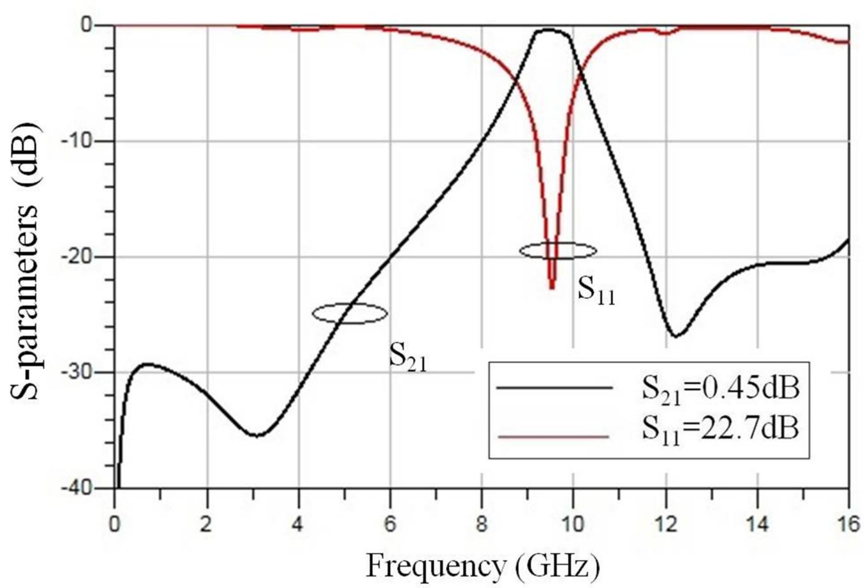
Where C is the velocity of the light, the post spacing should be kept small in order to avoid leakage losses between the vias. According to this, the diameter of the metallic via hole is 0.8mm.



(a) (b)

Fig. 2 Layout of the proposed SIW filter (a). Top view (b). Bottom View (c). Simulated results of the proposed filter

The dimensions of the filter are L_{eff}=15.9mm,W_{eff}=14.1mm,W_d =1.2mm,W_M=0.86mm,L_d=1.8mm, d=0.8mm,P=1.5mm, L_m =3.7mm.



(c)

Figure.2 shows the layout of the proposed SIW BPF filter with DGS and DMS. The DGS is made by etching the cross slot DGS on the ground plane of the SIW cavity. The current distributes along the etched part of the structure. The cross slot DGS with the dimensions of length L_d and width of the slot W_d. The dimensions of the DGS are optimized in order to increase the upper stopband attenuation.

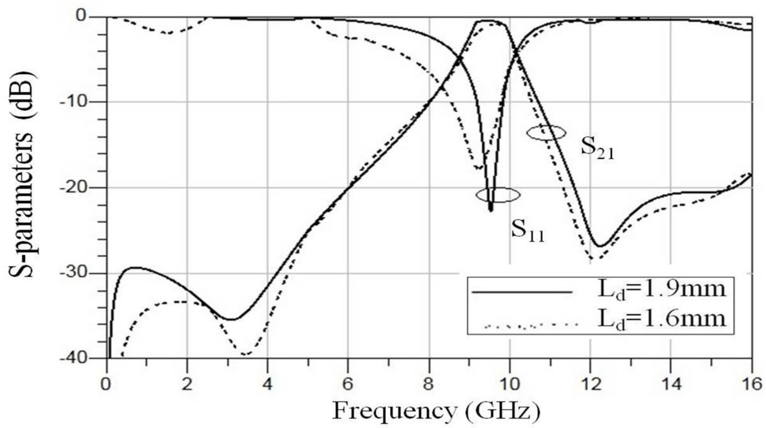


Fig. 3 Simulated results of the proposed filter for different DGS lengths

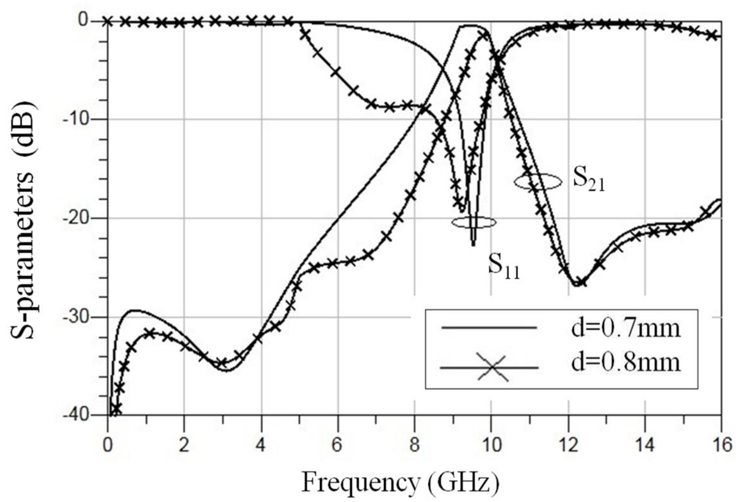


Fig. 4 Frequency response of the filter with different via diameter

Figure.3 shows the simulated results of proposed SIW BPF filter by varying length of the DGS. By reducing the length of the DGS, the resonant frequency of the filter lightly shifts towards its lower frequency side with reduced return loss. In figure. 4 shows frequency response of the filter for different via diameter. The lower attenuation of the filter shifts towards the higher frequency by reducing the via diameter and resonant frequency also shifts on the lower frequency side.

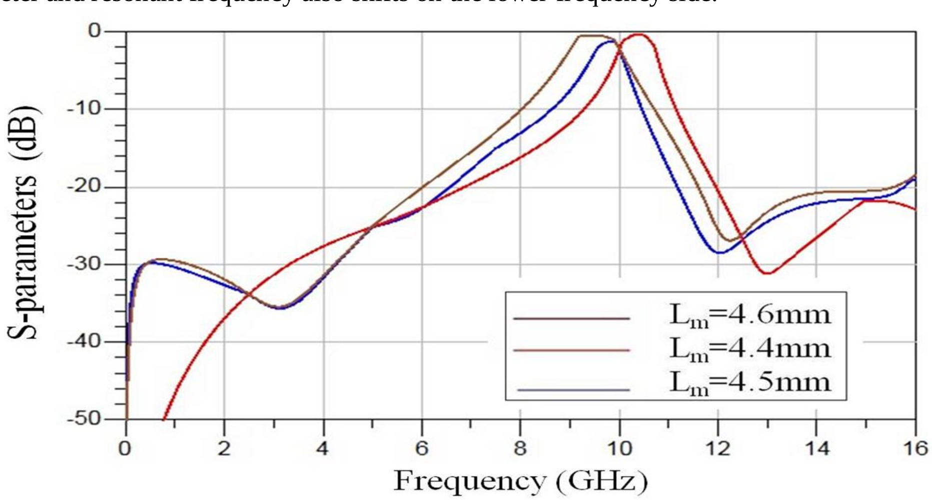


Fig.5 Simulated S_{21}(dB) for various DMS length

The DMS is made by etching the rectangular slot on top metal plate to improve the passband within stopband frequencies. Figure.5 presents the simulated results of S_{21} for various length of DMS structure. By reducing the length of the rectangular slot, the insertion loss moves towards the higher frequency side, ensuring there is a shift in passband frequency.

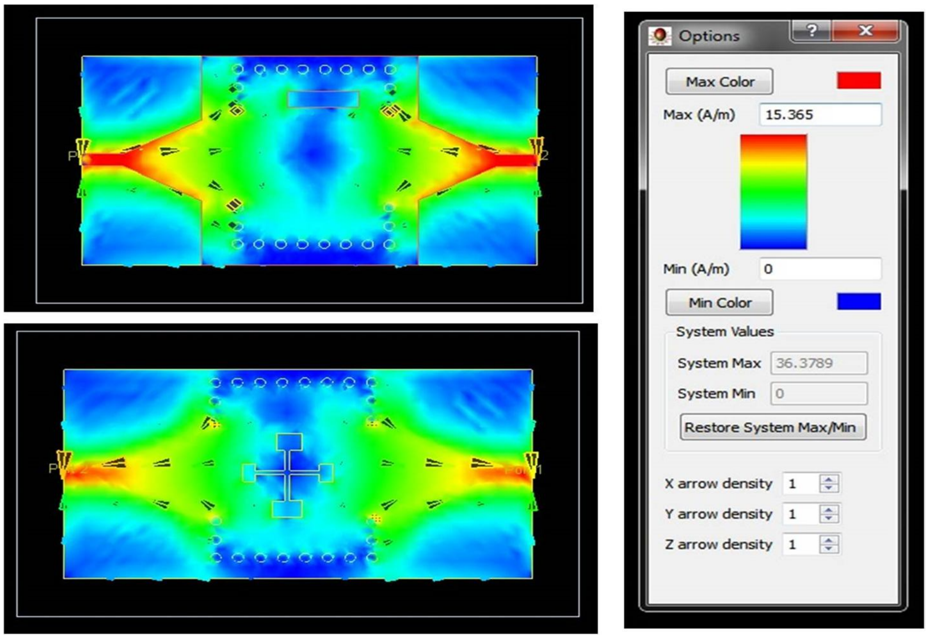


Fig. 6 Surface current distribution of the filter

III SIMULATED RESULTS & DISCUSSIONS

The proposed SIW bandpass filter is realized on the Rogers substrate with dielectric constant of 3.5 and thickness of 0.5mm. The SIW cavity along with the input and output tapered microstrip lines connecting 50Ω microstrip transmission lines to produce narrow bandwidth of the filter. The filter with centre frequency of 9.4GHz, return loss of 22.7dB, insertion loss of 0.45dB with fractional bandwidth of 0.15%. The out 0f band rejection is >20dB.

IV CONCLUSION

A novel high performance SIW bnadpass filter using DGS and DMS is designed and simulated. The SIW filter with center frequency of 9.4GHz and it is applicable for X-band applications. The proposed filter possesses better out of band properties using cross slot DGS. The proposed SIW BPF has the advantage of compact size, good return loss and better stopband attenuation.

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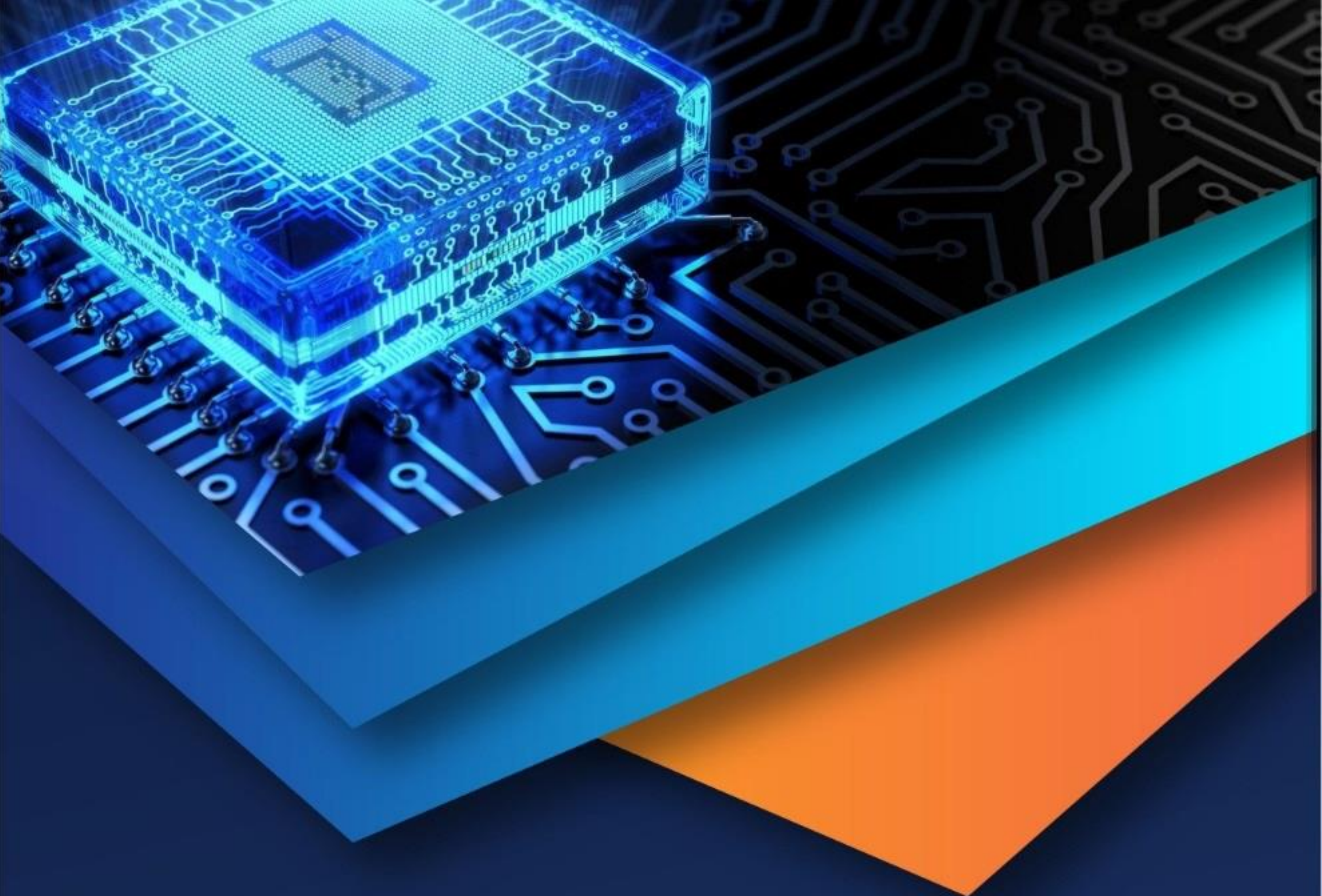

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