A Novel Bandpass Substrate Integrated Waveguide Filter for the Application at K & Ka band

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***Abstract*— This paper presented a novel Substrate Integrated Waveguide (SIW) filter whose aim is to pass K and Ka band frequency signals with high rejection of -43.73 dB. To achieve bandpass filter, two topologies are combined which are iris and the SIW resonators. The CST Microwave studio is used for the simulation of the designed work. The simulated results presented in the paper which have shown that the filter have bandwidth from 20 GHz to 40 GHz. The S-parameter results shown that transmission coefficient is -1.5 dB where return loss is improved than 15 dB for the complete bandwidth frequency range. The structure is designed on a Rogers RO3003 dielctric substrate having dielectric constant 3 and electric tangent 0.001. The purpose of designing this substrate integrated waveguide as bandpass filter to enhance the working quality of the transmission for K and Ka band application.**

Keywords: **Substrate Integrated Waveguide (SIW); Iris bandpass filter; SIW resonator; CST Microwave Studio K and Ka band.**

I. INTRODUCTION

Filters are the backbone of wireless technology. Today, the requirement of modern multifunction communication devices is enlarged which can at the same time manage many applications. A passive SIW filters is electromagnetic devices that can all together works as both bandpass and band reject filters. It can allow the desired frequencies and reject all other unwanted frequencies for reducing interference and safety purpose. SIW filters can boost the working quality of wireless applications. The main task of the designing of any filter is to reduce insertion loss and improve the return loss by deep resonance for the whole bandwidth of the wireless communication systems. A broadband band-pass SIW filter has been proposed by using a technique in which periodic structures of metallic via are combined into the SIW at 20-40 GHz [2].

There are many techniques employed to reduce the size of the substrate integrated waveguides like an four-pole planar and unwavering phase filter recognized on SIW is proposed which demonstrate plane group time delay in the desired allowing band, which has compact size and have low cost. This SIW linear phase filter is designed already for the X-band application [3]. One more technique is invented in which CSRR are combined with SIW and it will give band-pass filter characteristics can also have capability in Low Temperature Co-fired Ceramic (LTCC). Another innovative technique achieved in which SIW cavity is folded by f to achieve bandpass SIW filters which can make compact the size of waveguide resonators [5]. Defected ground structures are also used in filter structures in which at the bottom of filter it consist some design due to which resonance behavior is realized at microwave and millimeter frequency signals for the desired applications. This technique is used as stopband to reduce interference and compact the dimension of circuit [6].

This letter works on the K and Ka band filter using Substrate Integrated Waveguides which has Band-pass filter characteristics with high elimination at unwanted frequency bands. For this two topologies are combined iris metallic vias and the SIW resonators to get such excellent results. The structure is realized on a single substrate of Rogers RO3003. From the simulated results, it is concluded that the proposed work have bandwidth from 20 GHz to 40 GHz. The insertion loss is less than 1.5 dB for the whole bandwidth and return loss in the passband is better than 15 dB, with maximum rejection of -43.73 dB at the resonant frequency 30.83 GHz.

II. DESIGNING OF SIW FILTER

In this letter, the SIW bandpass filter is realized on Rogers RO3003 substrate having dielectric constant $\varepsilon r = 3$, electric tangent = 0.001 and height h = 0.254 mm. The top view and perspective view of a proposed bandpass SIW filter is shown in Figure 1. In the designing of SIW filter, it has a rectangular waveguide structure which has two parallel metallic sheets on the top and bottom. The rectangular waveguide has TE10 dominant mode. The metallic sheets are connected through two metallic methods that are periodically in an insulating substrate which forms an arrow type pattern is created have Pt= 0.5 mm and Lt= 0.65 mm with metallic via. The structure of proposed filter is designed for the K and Ka band applications purpose.

A rectangular SIW dimensions can be calculated by using formulas given in equations 1, 2 and 3 where εr is relative permittivity, D denotes diameter of the metallic via and P denotes period of via holes [2]-[9].

$$f_{c_{101}} = \frac{c}{2\sqrt{\varepsilon_r}}\sqrt{\left(\frac{1}{W_{eff}}\right)^2 + \left(\frac{1}{L_{eff}}\right)^2} \quad (1)$$

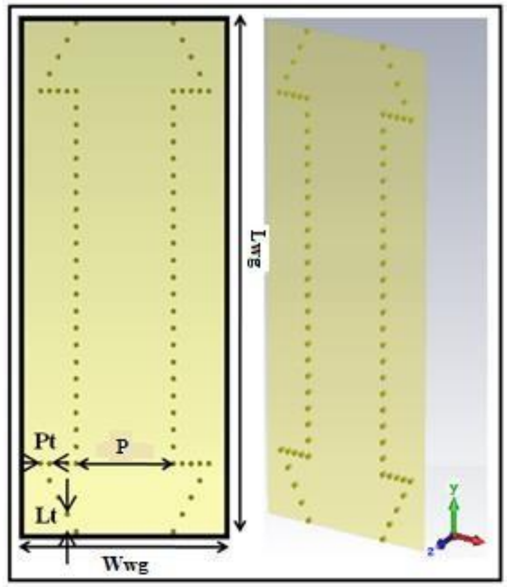
$$W_{eff} = W_{SIW} - \frac{D^2}{0.95P} \quad (2)$$

$$L_{eff} = L_{SIW} - \frac{D^2}{0.95P} \quad (3)$$

The top view and perspective view of proposed SIW bandpass filter in CST Microwave Studio is as shown in Figure 1 and TABLE 1presents dimension.

TABLE 1: Dimension of proposed SIW Filter

Parameter	Dimension (in mm)
Lwg	28.8
D	0.3
Wwg	11.5
Pt	0.5
Lt	0.65
P	5.5
Pitch	0.95



(a) (b)

Figure 1:(a) Top view (b) Perspective view Proposed bandpass SIW filter.

III. RESULTS AND DISCUSSION

The parameters which are calculated for any filter are return loss and insertion loss. To simulate the return loss and insertion loss of the proposed bandpass SIW filter CST Microwave Studio is used. The simulated S-parameters of SIW in the frequency band from 15 GHz to 45 GHz are discussed in this section.

A. Reflection coefficient of proposed SIW Filter

For the analysis of the performance of proposed SIW Filter the CST MW studio microwave software is used. From the Figure 2 , designate that the S11 remains below -15 dB across the entire bandwidth from 20GHz to 40GHz.

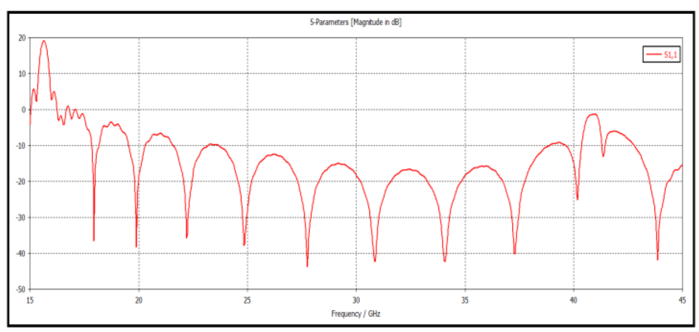


Figure 2: Simulated reflection coefficient of proposed SIW filter using CST Microwave Studio.

B. Transmission Coefficient of proposed SIW Filter

From the results, it is investigated that over the entire bandpass frequency band the transmission coefficient is -1.5 dB which is as shown in Figure 3.

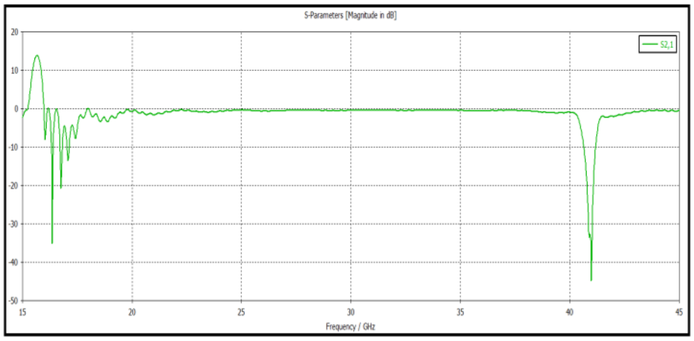


Figure 3: Simulated transmission coefficient of proposed bandpass SIW filter using CST Microwave Studio.

From the Figure 4, the combine response of the proposed bandpass SIW has been presented. In this return loss and insertion has been shown which resulted that proposed SIW is worked as bandpass filter having bandwidth from 20GHz to 40 GHz lie in K and Ka band application.

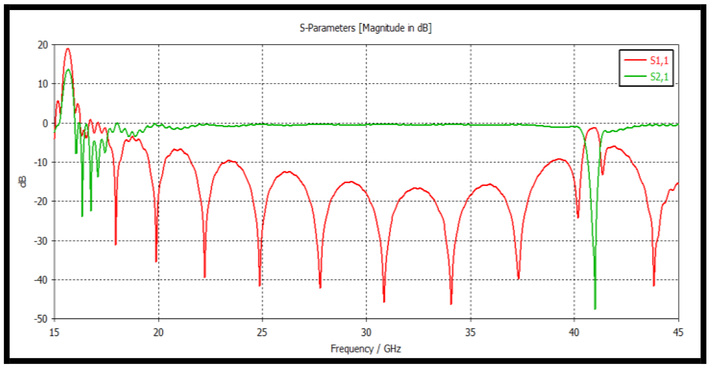


Figure 4: Return loss and insertion loss of proposed bandpass SIW filter.

C. Surface Current

From the results it is investigated that at 24.48 GHz, 30.83 GHz and 37.29 GHz the proposed SIW filter resonates maximum with high rejection. In the Figure 5, the surface current at 24.48 GHz, 30.83 GHz and 37.29 GHz are presented.

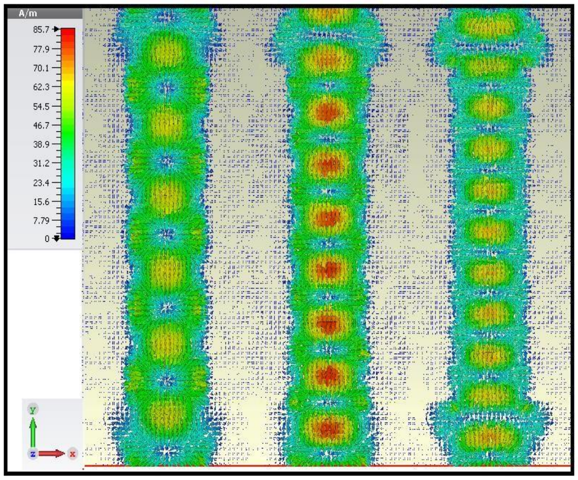


Figure 5: Surface Current at 24.48GHz, 30.83 GHz and 5.5 GHz.

D. Parametric Analysis

Further in this paper parametric analysis has been examined at different parameters like diameter of via, width between and pitch of via which are the most important parameters. On varying these parameters this will help in obtaining the required frequency bandwidth at particular dimensions of the proposed design at desired applications.

From the Figure 6, it is find that on varying diameter of via (dia = D) then there is also shifting in the pass bands. On increasing the diameter of the dia then there will be shifting of pass band towards higher frequencies. Similarly on decreasing the diameter of via then the band shifted towards lower frequencies.

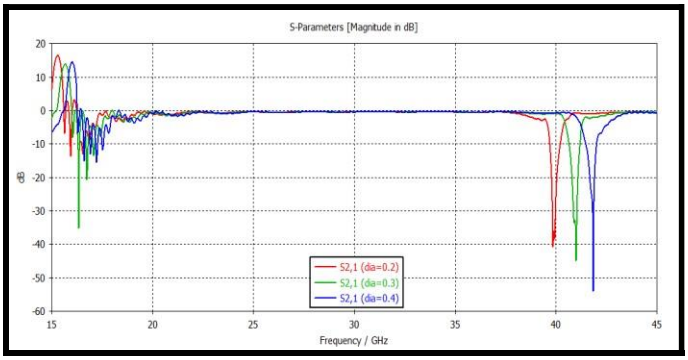


Figure 6: Diameter of via variation.

From the Figure 7, it is noticed that on varying width between the vias then there is also drift in the pass bands. On increasing the width the pass band shifted towards lower frequencies and on decreasing width the pass band shifted towards higher frequencies.

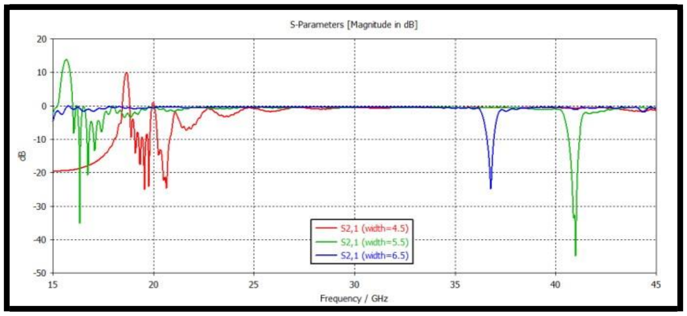


Figure 7: Width between via variation.

From the Figure 8, it is observed that on varying pitch (P) between the vias then there is also drift in the pass bands. On increasing the width the pass band shifted towards lower frequencies and on decreasing width the pass band shifted towards higher frequencies.

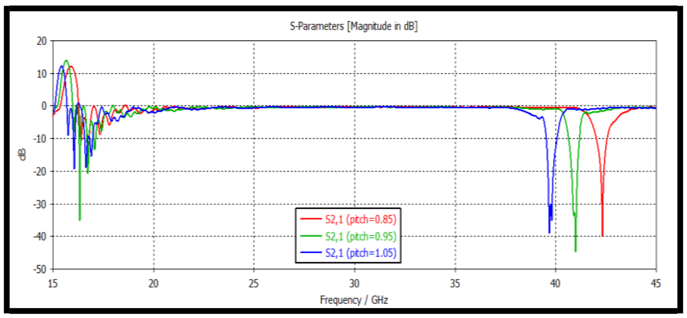


Figure 8: Pitch variation.

IV. CONCLUSION

This letter works on the K and Ka band filter using Substrate Integrated Waveguide which has Band-pass filter characteristics with high elimination at unwanted frequency bands. For this two topologies are combined iris and the SIW resonators. The structure is designed on a Rogers RO3003 dielectric substrate having permittivity εr =3, electric tangent loss= 0.001 and height h = 0.254 mm. From the simulated results, it is concluded that the proposed work have bandwidth from 20 GHz to 40 GHz. The insertion loss is less than 1.5 dB for the complete bandwidth and input return loss for the proposed flter is better than 15 dB, with maximum elimination of -43.738 dB at the resonant frequency 30.83 GHz. Surface current is also represented in the paper at the highest resonating frequencies.

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