CPW fed Substrate Integrated Waveguide based Band Pass Filter in K Band

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Abstract-In this paper Substrate Integrated Waveguide based band pass filter is developed in K band for satellite communication applications. A compact iris coupled fourth order band pass filter having a flat pass band from 22.2GHz to 24.76GHz is designed using Rogers RT/Duroid 5880 substrate. The filter has a maximum insertion loss of 0.8dB and a maximum return loss of 17.6dB in the pass band of operation. The filter is highly miniaturized and measures a size of 15mm×28mm×.508mm.

Key Words: Filter; SIW; wide band; post wall iris.

I. INTRODUCTION

Traditional rectangular waveguide structures find extensive applications in millimeter and microwave communication systems due to their high Q factors, high power handling capabilities and low insertion loss. However, for rectangular waveguides circuit level integration is difficult because of their non planar bulky structure.

A novel technology named Substrate Integrated Waveguide (SIW) has been of great interest in recent times due to their light weight, low loss and planar characteristics [1, 2]. SIW is made up of a single layer dielectric substrate where the vertical walls of the rectangular waveguide are emulated by two rows of metallic via embedded in the dielectric substrate. This paper reports the design of a fourth order band pass filter in K band for satellite applications. The proposed structure is based on iris couplings in the waveguide. Coplanar waveguide feeding technique is used to decrease the amount of losses in the structure. By optimizing the width of the iris and the length of the resonators the filter response is achieved in K band.

The paper is organized as follows Section II discusses about the design procedure of the K band filter, Section III discusses about experimental results and Section IV concludes the present paper.

II. DESIGN PROCEDURE

A. Design of the Substrate Integrated Waveguide

The basic design equations for Substrate Integrated Waveguide[3] constructed using top and bottom metallic planes and two arrays of via in place of both side walls as shown in Figure 1 is given below.

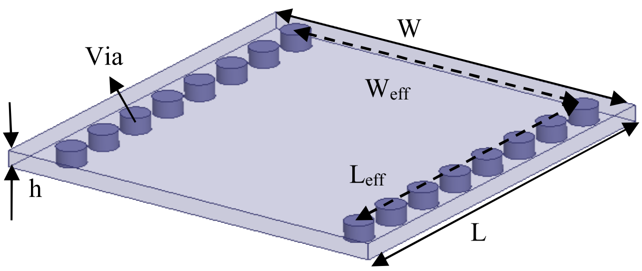

Figure 1. Structure if SIW

$$W_{eff} = W - \left(d^2 / .95 \times p \right) \tag{1}$$

$$L_{eff} = L - \left(d^2 / .95 \times p \right) \tag{2}$$

$$d < \lambda_g / 5 \tag{3}$$

$$p = 2 \times d \tag{4}$$

Where,
W is broad wall dimension of the SIW, L is length of SIW, d is diameter of via, p is pitch of the via array.

B. Design of Band Pass Filter in K band

The proposed wide band pass filter is designed with the following specifications.

Electrical Specifications
Frequency band: 22.2GHz to 24.76GHz
Insertion loss: < 0.8dB
Return loss: better than 17dB
Substrate Parameters:
Substrate permittivity ε_r : 2.2
Substrate thickness (h): 20 mils

By using the equivalence resonance condition for TE_{101} mode the size of the SIW cavity is determined as:

$$f_{101} = \frac{c}{2\pi\sqrt{\mu_r \varepsilon_r}} \sqrt{\left(\frac{\pi}{W_{eff}}\right)^2 + \left(\frac{\pi}{L_{eff}}\right)^2} \qquad (5)$$

Initially the inter resonator coupling and external quality factor is obtained from the classical equations [4, 5].

$$K_{i,i+1} = FBW \Big/ \sqrt{g_i \times g_{i+1}} \qquad (6)$$

$$Q_e = (g_0 \times g_1) \Big/ FBW \qquad (7)$$

FBW=Fractional Bandwidth of the band pass filter
Secondly, the cavity dimensions are optimized to meet the frequency specifications. Thirdly, width of the post wall iris is adjusted to realize the coupling coefficient obtained from the classical process. Finally, slight tuning and adjustment is made in the entire filter for best performance.
The proposed filter structure and dimensions are shown below in Figure 2 and Table 1 respectively.

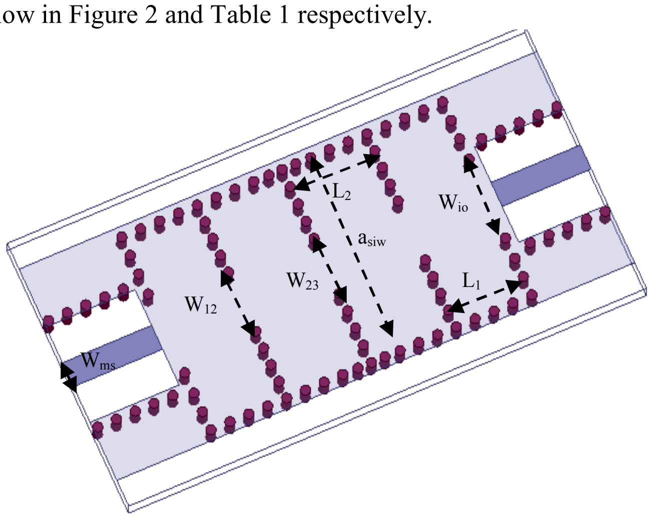

Figure 2. Proposed band pass filter structure in K band

Table 1 Physical parameters of the filter

Parameters	Values(mm)
W_{ms}	1.3
a_{siw}	10.5
W_{12}	3.22
W_{23}	2.99
W_{io}	4.3
L_1	4
L_2	4.52

III. EXPERIMENTAL RESULTS

The filter is designed based on the procedure given in Section II and is manufactured using standard printed circuit board fabrication method. Full Wave EM simulations of the proposed structure are carried out using standard Ansys HFSS [6]. The filter response is plotted in Figure 3.

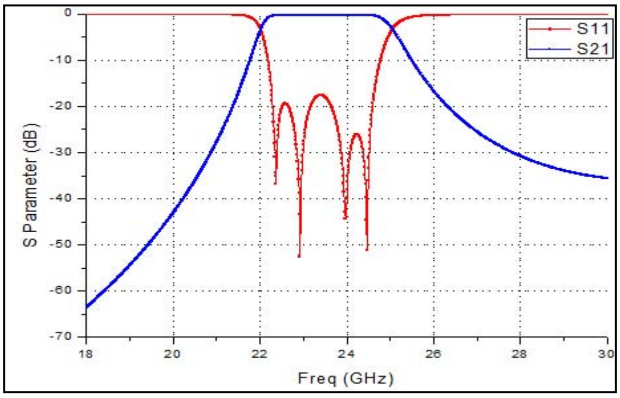

Figure 3. Simulated S parameter plot for the designed Band Pass Filter

IV. CONCLUSIONS

This paper has proposed a novel substrate integrated waveguide based band pass filter in K band. The compact band pass filter is working over pass band of 22.2GHz to 24.76GHz. Insertion loss in the pass band is less than .8dB and Return Loss is better than 17dB. The filter is compact has a size of 15mm×28mm×0.508mm. The filter can be used in any traditional satellite communication system.

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