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Design of K-band Bandpass Filter for Satellite Ground Terminal using Substrate Integrated Waveguide

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Abstract: ***In this paper Substrate Integrated Waveguide (SIW) bandpass filter with improved stopband performance and compact size is demonstrated for K-band satellite ground terminal. SIW is a promising and potential technology used for miniaturization of microwave components. K-band bandpass filter are designed using linear array of metalized vias on Rogers RT/Duroid 6002 Substrate and can be fabricated using standard printed circuit board process. The insertion loss at the center frequency of 20.3 GHz is 0.33dB and 3dB bandwidth is from 19.3GHz to 21.3GHz.***

Keywords: Substrate Integrated Waveguide (SIW), satellite ground terminal, Miniaturization

1. Introduction

Laminated waveguide also called as Substrate Integrated Waveguide (SIW) provides all desirable characteristics such as low profile, low cost, low weight with high performance maintenance while waveguide components having high-Q values and capability of high power hence used in many millimeter-wave communication systems but bulky. At high frequency planar technology is prevented due to high transmission losses [1]. This limitation at high frequency can be overcome by using Substrate Integrated Waveguide (SIW) technology. In Substrate Integrated Waveguide (SIW) dielectric substrate is sandwiched between two conducting plates and periodic rows of metallic cylinder slot (vias) are implemented on substrate that is also used to unite both conducting plates [2]. Most key advantage of SIW is that it is viable to incorporate active and passive components on same substrate. SIW having less leakage losses and excellent electromagnetic interference immunity, this shows the suitability of SIW at microwave and millimeter-wave electronics.

One advantage of SIW is that the amount of metal that carries the signal is greater than it would be in microstrip or stripline. Therefore conductor losses are lower. In comparison to classic milled metallic waveguide, SIW are cheap because they can be developed using standard printed circuit board fabrication technique.

2. Design Processs

In this K-band Bandpass filter Finite transmission Zeros (FTZs) are located symmetrically to real axis which can only be produced if two signal paths generate the same magnitude and phase [3]. Because of symmetry of filter two transmission zeros are located very close to each other may be generated through first/last SIW cavity and the second/third SIW cavity. Filter uses 50Ω microstrip line as direct coupled input/output port [4]. K-band bandpass Filter designed on a single layer substrate made up of Rogers RT/Duroid 6002 with relative permittivity of 2.94. Dimension of substrate is 27.02mm × 14.3mm × 0.508mm over which a rectangular metal plate is placed. Array of metalized cylinder also called vias with a diameter of 0.5mm are used to connect metal plate with ground. Spacing between center of two vias are called pitch.

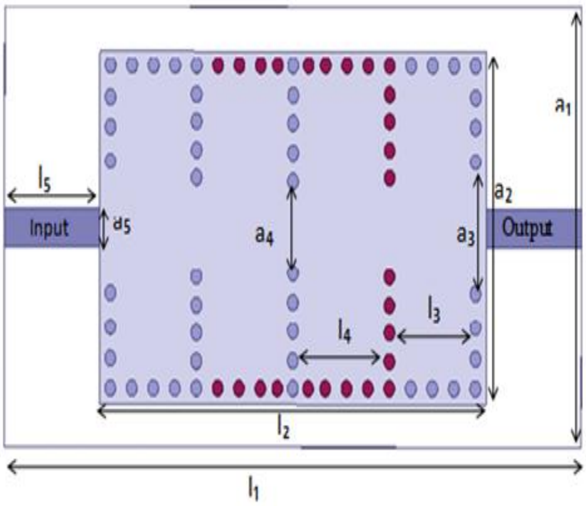

Figure 1: Simulated Structure of K-band Bandpass filter

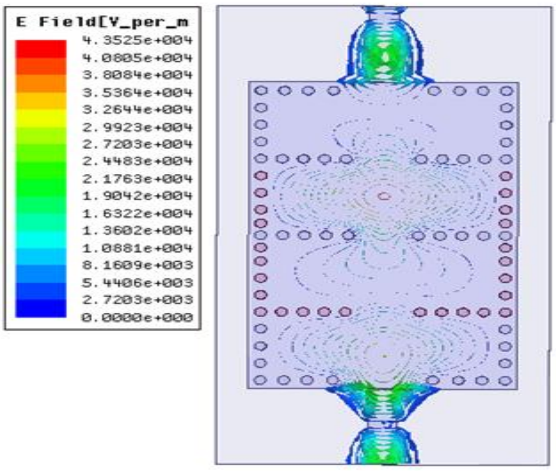

Figure 2: E Field plot of K-band Bandpass filter

3. Design Equations

Initial dimension of SIW cavity are determined by setting the resonant frequency of the TE_{101} mode equal to the center frequency of the desired pass band using formula [4] given below:

$$f_o = \frac{c_o}{2\sqrt{\varepsilon_r}}\sqrt{\left(\frac{1}{a_{eff}}\right)^2 + \left(\frac{1}{l_{eff}}\right)^2}$$

$$a_{eff} = a - \frac{d^2}{0.95p}\ ,\ l_{eff} = l - \frac{d^2}{0.95p}$$

Table 1: Dimensions of Siw Bandpass Filter

Parameter	*Dimensions*
a_1	14.3mm
l_1	27.02mm
a_2	11.5mm
l_2	18.1mm
a_3	2.72mm
l_3	4.03mm
a_4	3.79mm
l_4	4.52mm
a_5	1.28mm
l_5	4.46mm
d	0.5mm
p	1mm

4. Results and Discussions

The Proposed Filter's simulation result shows that, it has insertion loss 0.33dB (approx), return loss is lower than 18dB over the band which shows better impedance matching as shown in fig.3. Group delay shown in figure 4, of the filter is almost constant in the pass band and VSWR is less than 2 over the band shown in figure 5.

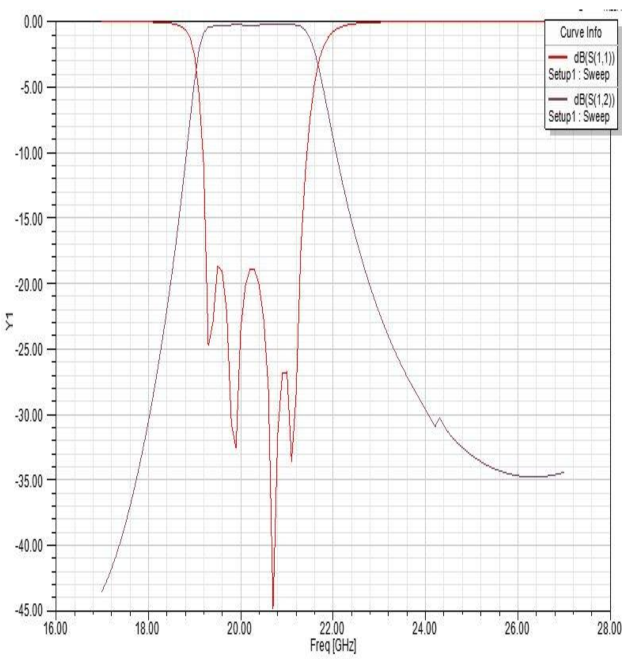

Figure 3: S-parameter plot (insertion loss S_{12} and Return loss S_{11} in dB) of simulated K-band Bandpass Filter.

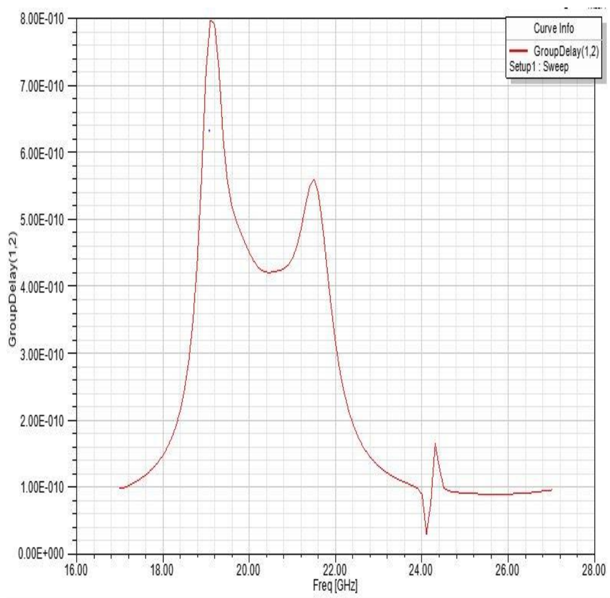

Figure 4: Plot of Group Delay of K-band Bandpass filter

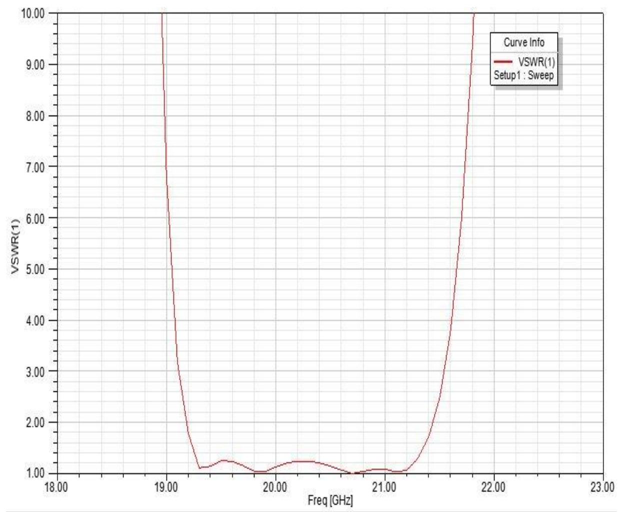

Figure 5: VSWR of simulated K-band Bandpass Filter

5. Conclusion

Proposed K-band bandpass Filter using Substrate Integrated Waveguide Technology (SIW) is easy to fabricate, More Compact and simpler in design. Simulated results shows that the proposed filter has better Frequency Response with insertion loss of 0.33dB at the center frequency, its bandwidth is about 2GHz. Other parameter of filter (such as Group Delay and VSWR) also satisfying the desired criterion of Filter. This Bandpass filter of frequency ranges from 19.3GHz to 21.3 GHz found application for the satellite Ground terminal.

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