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Substrate Integrated Waveguide Bandpass Filter for U and V Frequency Band

Palak Pritwani,
Application Engineer,
Keysight Technologies, Delhi, India

Abstract : SIW is a synthesized nonplanar waveguide transformed into planar form, which can then be integrated into any planar dielectric substrate with any planar fabrication or processing technique including printed circuit board (PCB), and low temperature cofired ceramic (LTCC) technologies, among others [1] . This emerging guided-wave structure can be made with a pair of periodic metalized via arrays or slot trenches and it looks like two parallel fences that have a specific spacing in which EM waves are well confined. This paper aims to provide, Two SIW bandpass filter. First, SIW bandpass filter is proposed using u band. Pass band is from 46.25 GHz to 52.08 GHz and the bandwidth of the filter is about 5.83 GHz while the second SIW bandpass filter is proposed using v band. Pass band is from 70.08 GHz to 79.56 GHz and the bandwidth of the filter is about 9.48 GHz.
***IndexTerms* – Substrate Integrated Waveguide ,Printed Circuit board ,Low temperature ceramic coefficient .**

INTRODUCTION

Recently, many millimeter wave systems such as millimeter-wave video transmission, wireless-LANs, automotive radars, and wireless Ethernet, have been proposed and developed. Above 50-GHz band systems are very attractive because of their unlicensed wide frequency bands. A new technique is proposed for millimeter wave application. There is growing interest in a novel planar circuit technique called Substrate Integrated Waveguide (SIW) [2]. The concept of the SIW is to guide the electromagnetic waves by using rows of metallic vias which operate like a metallic wall. So many structures were reported in this technology like antennas, filters, couplers and power dividers. Reduction of the sizes, low costs of fabrication and reduction of losses in the SIW devices are major factors of making this technology a strong alternative of non-planar waveguides. It combines the high performance of the waveguides and the compact size of the planar circuits.
SIW allows only the propagation of traverse electric TEm0 modes. It does not support the propagation of traverse magnetic (TM) modes because the current flow through the sidewalls does not exist [3]. The SIW can be represented by a typical rectangular waveguide filled with a dielectric material.

There are three important parameters while designing SIW structure, i.e. width of SIW W, metalized via diameter d, and distance between two vias p. After considering the effect of dielectric material, the distance between the two rows of periodic metalized vias, i.e. W determines the cutoff frequency .

2. SIW Design Equations

The dominant mode that SIW support is TE10 mode . The relationship between the cut-off frequency, fc, and the dimensions a and b of a SIW are the starting points of a design.

Cut off frequency of an SIW of a mode is given by

$$Filter\ cut\ off\ freq\ f_c = \frac{c}{2\pi}\sqrt{\left(\frac{m\pi}{a}\right)^2 + \left(\frac{n\pi}{b}\right)^2 + \left(\frac{l\pi}{c'}\right)^2} \quad (1)$$

where c is the speed of light in free space, m, n and l are mode numbers, a is the longer and b is the shorter dimensions of the waveguide. As it is TE10 mode, it simplifies to

$$a = \frac{c}{2f_c} \quad (2)$$

(For TE_{10} Mode m=1, n=0 & l=0) a=W=Width of Waveguide

The same fc (i.e., for the dominant TE10 mode) for SIW can be obtained when a is replaced by ad

$$Where\ a_d = \frac{a}{\sqrt{\varepsilon_R}} \quad (3)$$

where ε_R is the relative dielectric constant of the dielectric that fills the waveguide. Making use of these information and aiming to work at the same fc (i.e., the dominant TE10 mode of SIW the first empirical design equation of a SIW is related to its width,

$$Width\ of\ SIW\ W_s = a_d + \frac{d^2}{0 \cdot 95p} \quad (4)$$

where ad is the width of the SIW corresponding to the same fc, d is the diameter of the vias, and p is the center to center separation between the vias along the longitudinal direction [4].

$$Largest\ Via\ dia,\ d < \frac{\lambda_g}{5}$$

$$Largest\ via\ CTC\ spacing,\ pitch,\ p < 2d$$

where λg is the guided wavelength and is given by

$$Guided\ Wavelentgh\ \lambda g = \frac{2\pi}{\sqrt{\varepsilon_R \frac{(2\pi f)^2}{c^2} - \left(\frac{\lambda}{a}\right)^2}} \quad (5)$$

For Microstrip Taper Calculations width and length of taper is given by

$$Width\ of\ Taper\ \omega_{t-v} = \omega_m + 0 \cdot 1547 a_s \quad (6)$$

$$Length\ of\ Taper L_{t-v} = 0.2368\lambda_{(g\ -\ \mathrm{ms})} \quad (7)$$

$$where\ \lambda_{(g\ -\ \mathrm{ms})} = \frac{\lambda g}{\sqrt{\varepsilon_R}} \quad (8)$$

a_s is width of SIW and w_m is width of microstrip line.

50 ohm microstrip line was taken and its length and width were calculated from linecal in ADS.

Note that the thickness of the substrate does not affect these design equations, but it affects the loss of the structure in such a way that the low loss advantage of a high thickness substrate should be considered.

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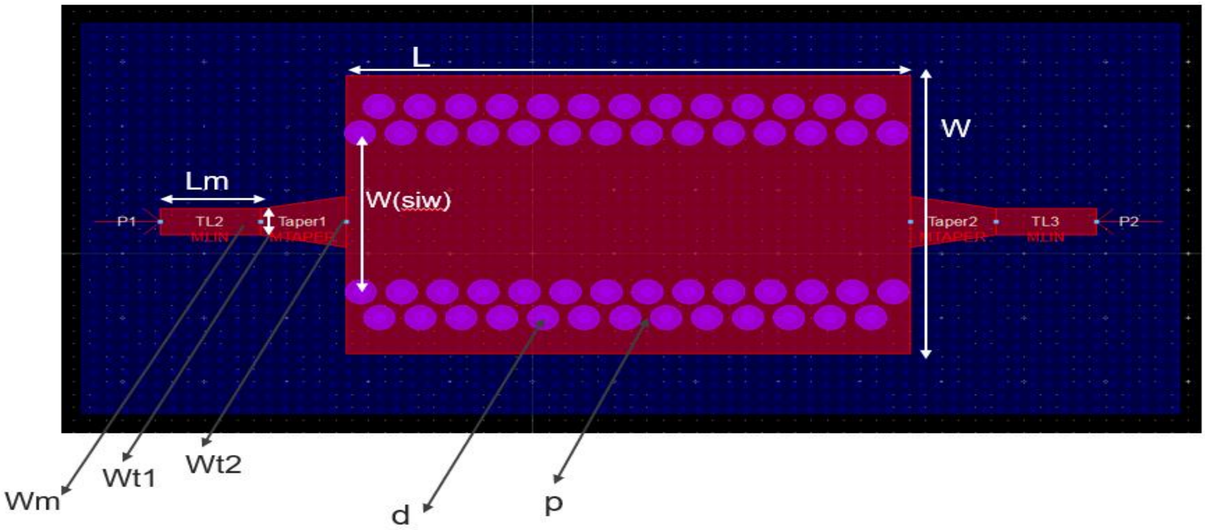

Fig 1. Physical Structure of SIW

3. Simulation and Measurements

3.1 Design of SIW Band Pass filter at 50 GHz

The proposed SIW filter was designed by using the procedure described in the previous section. The initial filter parameters are given in Table 1. The First Filter is designed at 50 GHz, The simulation result of s-parameter for the proposed SIW filter is presented in this work. The results shows good selectivity performance; the band pass is from 46.25 GHz to 52.08 GHz. The filter has approximately 2.577 dB insertion loss(S21) and return loss (S11) is 17.901 dB.

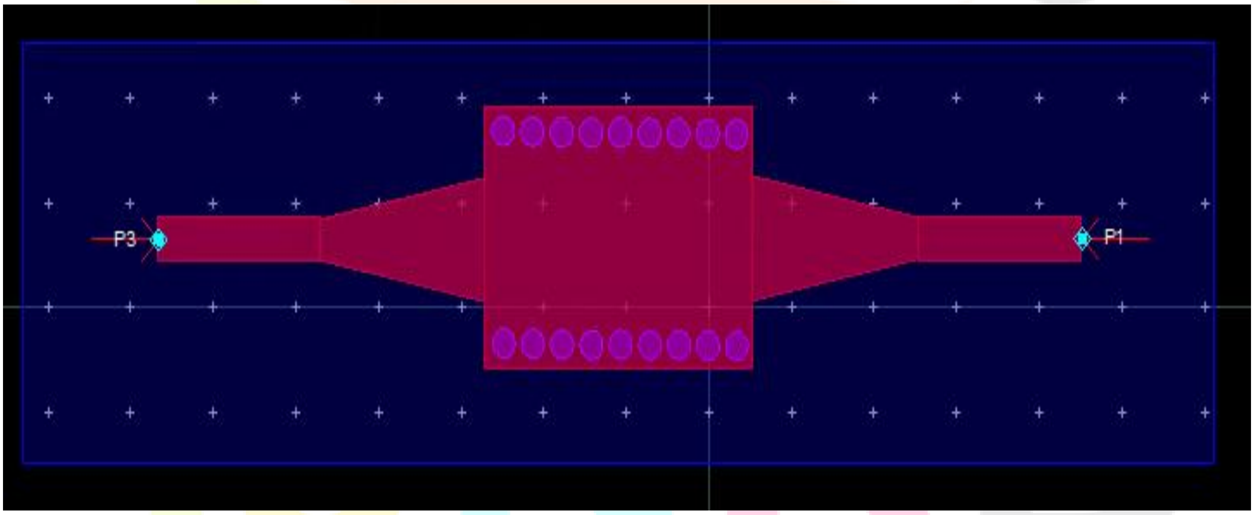

Fig 2. First SIW Filter

Table 1. Design Parameters of First SIW Filter

Parameter	Value
Fc	50 GHz
Er	3.5
Tan delta	0.0015
Height of Substrate	5.813e7
Conductivity	125 mills
W/a	163 mills

L	100.8 mills
Wsiw/asiw	141.2 mills
Lsiw	17.7 mills
P	14 mills
D	0.5 mm
Wt1	1.5 mm
Wt2	0.53 mm
Wm	2.5 mm
Lm	99 mills
W(t-v)	100 mills
L(t-v)	99 mills

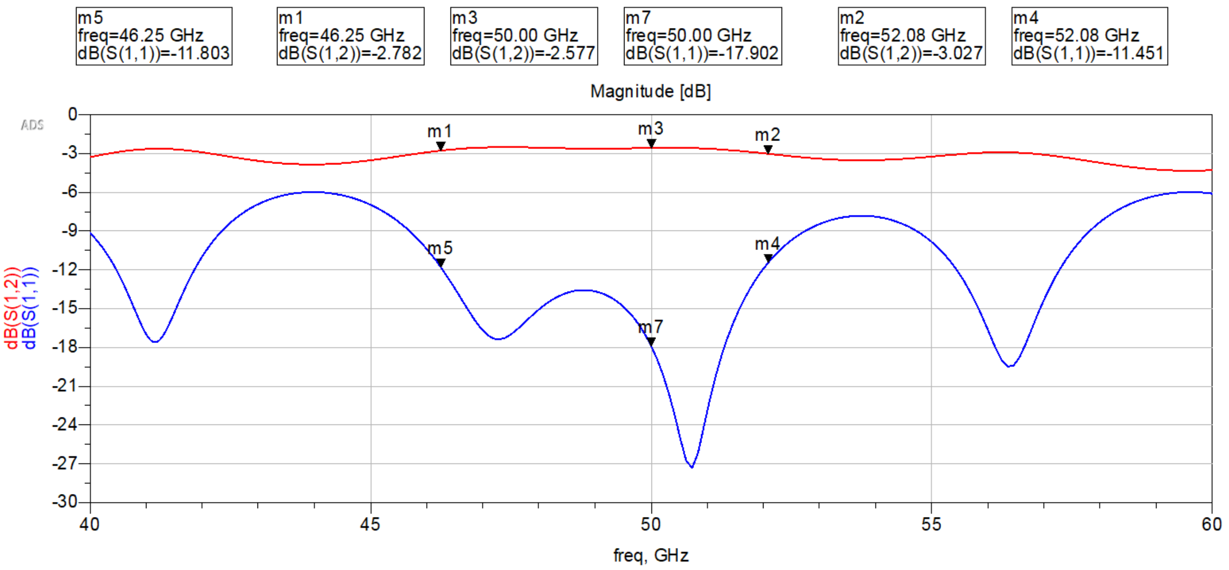

Fig 3. S Parameters of First SIW filter

3.2 .Design of Second SIW Band Pass Filter for 70.08 GHz to 79.56 GHz

The Second Filter is designed from 70.08 GHz to 79.56 GHz , The simulation result of s-parameter for the proposed SIW filter is presented in this work. The results shows good selectivity performance; the band pass is from 70.08 GHz to 79.56 GHz . The filter has two transmission Zeros with first transmission zero at 71.99 GHz with Insertion Loss S21 3 dB as and S11 as 19 dB , The second Transmission zero at 71.99 GHz with Insertion Loss S21 3.2 dB as and S11 as 15.5 dB

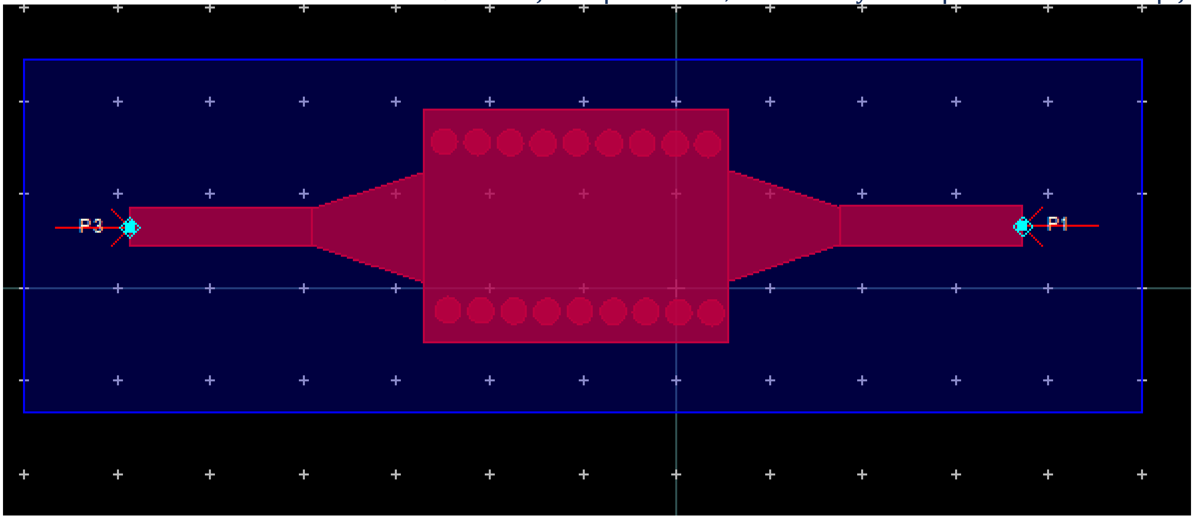

Fig 4. Second SIW Filter

Table 2. Design Parameters of Second SIW Filter

Parameter	Value
Transmission Zero 1	71.99 GHz
Transmission Zero 2	77.47 GHz
Er	3.5
Tan delta	0.0015
Height of Substrate	7 mills
Conductivity	5.813e7
W	125 mills
L	163 mills
Wsiw	100.8 mills
Lsiw	141.2 mills
P	17.7 mills
D	14 mills
Wt1	0.5 mills
Wt2	1.5 mills
Wm	0.53 mm
Lm	96 mills
W(t-v)	60 mills
L(t-v)	60 mills

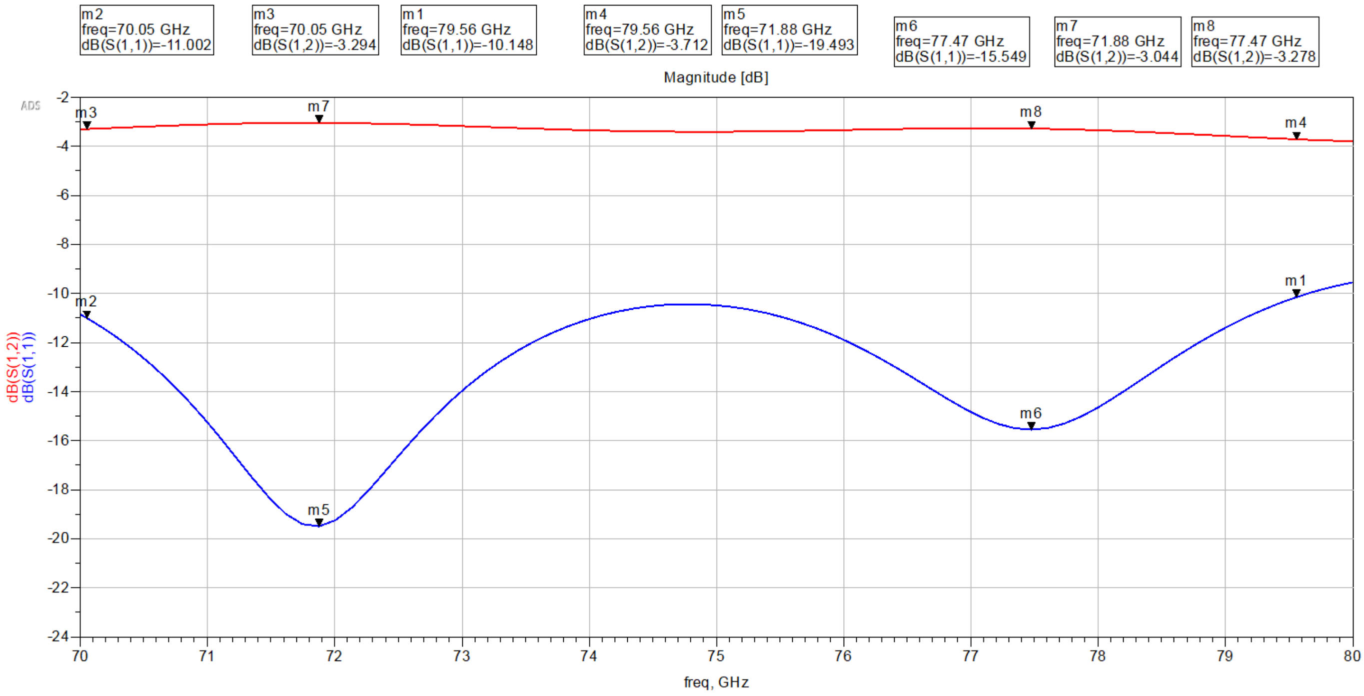

Fig 5. S Parameters of Second SIW Filter

4. Conclusion

This Research paper presents two Band pass Filters using SIW Technology . The proposed Designed Filter is designed using ADS for u and v Frequency bands . The First is a simple SIW Band Pass Filter at with 50 GHz with 5.83 GHz of Bandwidth . The Second filter is designed from 70.08 to 79.56 GHz with transmission zero at 71 and 77 GHz with a bandwidth of 9.51 GHz .

5. References

[1] Y. lahcen, T. Abdelwahed, K. Mohamed, Z. Jamal, M. Angel, Ku-band waveghuide band-pass filter with iris radi International Conference on. IEEE. , 2014, 1435-1438.

[2] K. Wu, Substrate Integrated Circuits (SiCs) – A new paradigm for future GHz and THz electronic and photonic systems. IEEE Circuitsand Systems Society Newsletter. 3.2 (2009).

[3] W. Hong, K. H. Baek, Y. Lee, Y. Kim, and S. T. Ko, “Study and prototyping of practically Large-Scale mmWave Antenna Systems for 5G Cellular Devices, ” IEEE Communications Magazine, vol. 52, pp. 63-69, September 2014.

[4] C. Zhao, C. Fumeaux and C. Lim, "Folded Substrate-IntegratedWaveguide Band-Pass Post Filter," in IEEE Microwave and WirelessComponents Letters, vol. 27, no. 1, pp. 22-24, Jan. 2017.

[5] Athira gopinath and P. Raghul Lal, “Substrate integrated waveguide based hybrid cavity filter for Ku band applications”, International conference on communication and signal processing.,pp.1563-1566, April 6-8,2017.

[6] B. B. Z. Sotoodeh, F. H. Kashani, H Ameri, "A novel bandpass waveguide filter structure on SIW technology," Progress in Electromagnetics Research Letters, vol. 2, p. 8, 2008.

[7] Y. Zhu and Y. Dong, "Stripline resonator loaded compact siw filters with wide suppression and flexible response," IEEE Microw. Wireless Compon. Lett., vol. 30, no. 5, pp. 465-468, May 2020.

[8] Y.C. Lee, C.S. Park, “A fully Embedded 60-GHz Novel BPF for LTCC System-in-Packaging Applications,” IEEE Trans. Advanced Packaging., vol. 29, pp. 804-809, 2006.

[9] A. Coves, G. Torregrosa-Penalva, A. A. San-Blas, M. A. SanchezSoriano, A. Martellosio, E. Bronchalo, and M. Bozzi, “A Novel BandPass Filter Based on a Periodically Drilled SIW Structure,” Radio Science, vol. 51, No. 4, pp. 328–336, Apr. 2016.

[10] WONG, S. W., CHEN, R. S., WANG, K., et al. U-shape slots structure on substrate integrated waveguide for 40-GHz bandpass filter using LTCC technology. IEEE Transactions on Components, Packaging and Manufacturing Technology, 2015, vol. 5, no. 1, p. 128–134. DOI: 10.1109/TCPMT.2014.2367516