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DESIGN AND IMPLEMENTATION OF SUBSTRATE INTEGRATED WAVEGUIDE POWER DIVIDER FOR X- AND KU- BAND APPLICATION

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***Abstract*— In This paper, mainly focused on design and implementation of substrate integrated waveguide (SIW) and its components for X- and Ku- band applications. The components investigated are SIW 1×2 power divider and SIW 1×3 power divider by using commercial simulation tool Ansoft HFSS. The E-field distribution, magnitude and phase response have been studied. Both power dividers exhibit equal amplitude with uniform phase characteristics at the respective output port. The SIW 1×2 power divider has the return loss below -15 dB over the band of 10.8-14.9 GHz and insertion loss is approximately -3.46 dB and that of for 1×3 power divider return loss is below -15 dB over the band ranging from 11.2 - 15 GHz and insertion loss is approximately -4.88 dB is achieved. Moreover, the proposed components are low profile, light weight and can be easily integrated to planar circuits.**

***Keywords*—microwave components, substrate integrated waveguide (SIW) power divider.**

I. INTRODUCTION

Over the years, the conventional metallic waveguides are commonly used in microwave and the millimeter wave communication systems due to their fascinating features such as high-Q, low insertion loss characteristics, high power handling capabilities with self-consistent electrical shielding and resistance to parasitic radiation losses. However, they have relatively high cost, bulky size, inflexibility to integrate with planar technology make unfit for many practical applications.

To overcome these issues, a planar waveguide like structures have been realized by using relatively newly emerging technology so called 'Substrate Integrated Waveguide' (SIW) [1-3] Additionally, SIW structures preserve most of the features of conventional metallic waveguides as mentioned above.

The most versatile significant advantage of SIW technology is the possibility to integrate all the components on the same substrate, including passive components, active elements and even antennas, hence this technology is very suitable to develop a system on substrate (SoS) [4-5]. In the recent years a variety of microwave circuits based on SIW such as such as bends, filters, couplers, duplexer etc. have been developed and studied extensively [6].

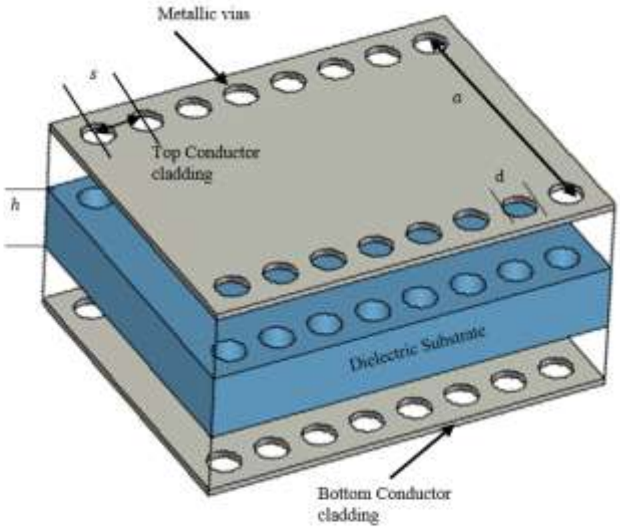


Figure. 1. Typical SIW Configuration [2]

In this paper, a design procedure and study of planar power dividers have been demonstrated using SIW technology for X-band and Ku-band applications.

II. SIW DESIGN

The SIW is framed by using densely arranged metallic posts that realize the bilateral edge walls as shown in Figure 1. The basic parameters of the SIW are the distance between the two parallel metallic vias i.e. the width of the waveguide 'a', diameter of metallic vias 'd' distance between two consecutive vias 's'. The width W_{SIW} of the SIW can be determined by formula in Equation 1.

$$W_{SIW} = a - \frac{d^2}{0.95s} \tag{1}$$

The guided wavelength in the SIW is given by following formula.

$$\lambda_g = \frac{2\pi}{\sqrt{\frac{\varepsilon_r (2\pi f)^2}{c^2} - \left(\frac{\pi}{W_{SIW}}\right)^2}} \tag{2}$$

$$d < \lambda_g /4 \tag{3}$$

$$s \leq 2d \tag{4}$$

The conditions mentioned in (3) and (4) must satisfy in order to minimize the leakage of energy from the gaps between the embedded vias in the dielectric substrate.

In the proposed work, 50 Ω microstrip line (MSL) is used to feed the components and a tapered microstrip transition is used in between the 50 Ω MSL and SIW structure so that signal can be smoothly transmitted [9]. The dimensions of the SIW are chosen in such a way that it can be operated in dominant mode TE_{10}.

The proposed SIW is designed on 0.8 mm thick Rogers RT/Duroid 5880 substrate of relative permittivity of 2.2 and tangent loss is 0.0009. The optimized dimensions for the proposed design are mentioned in Table I.

Table I. Design Parameters of RSIW with Tapper (mm)

Design parameters	*D*	*P*	*L*	*W*	W_T	L_T
Value (mm)	0.5	1.0	40.0	2.41	3.81	2.1

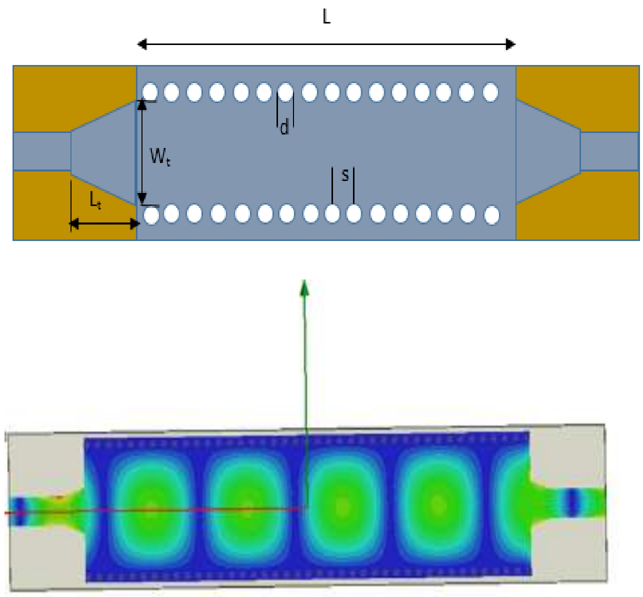


Figure. 2. Proposed SIW schematics and E- field distribution at 12.5 GHz

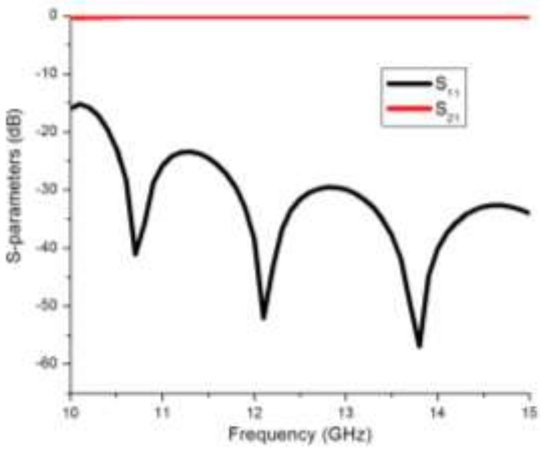


Figure. 3 Transmission coefficients S21 and reflection S11 of the SIW without tapper

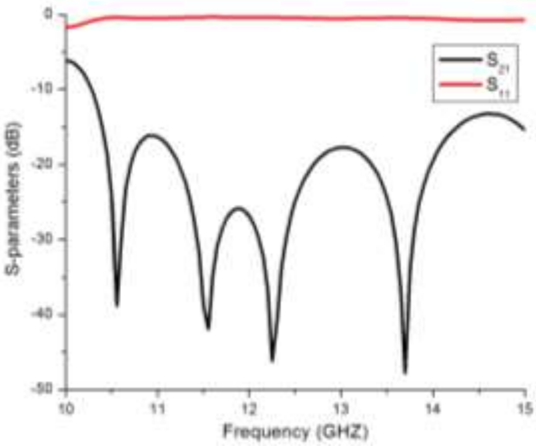


Figure. 4 Transmission coefficients S21 and reflection S11 of matched SIW with tapper

As depicted in Fig. 4, the reflection coefficient S11 below -15 dB ranging from 10-15 GHz frequency and the transmission coefficient S21 is around - 0.37 dB across the entire mentioned frequency range.

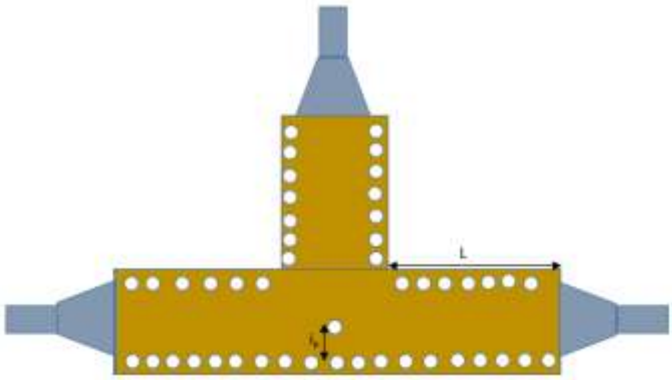
III. Design Of The Power Dividers

The SIW based power dividers have been very popular in recent years due to their compact size, light weight and high isolation compared to conventional waveguide power dividers. They are widely used in antenna feeding networks, amplifier applications, as well as to obtain multiple copies of the same signal with equal magnitude and uniform phase at the output ports [7-8].

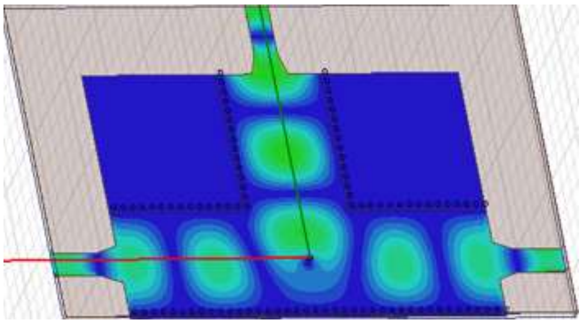
In the proposed work two different power dividers (1×2 and 1×3) based on SIW technology have been designed using full wave simulator ansoft HFSS.

A. SIW 1×2 Power Divider

From table.1 we are realising the SIW 1×2 power divider using three identical SIW each length L=14 mm connected to form a T-junction as show in figure 5. a metal inductive post of radius p=0.25 mm and whose position is i_P=5.5 mm inserted in the junction, utilised to adjust magnitude and phase of the divided power at each output port.



(a)



(b)

Figure. 5 (a) Schematics of proposed SIW based 1×2 power divider (b) E-field distribution proposed SIW based 1×2 power divider at 12.5 GHz

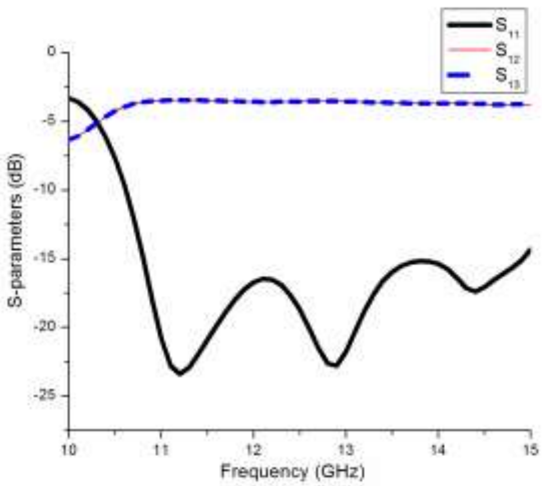


Figure. 6 S-Parameters in the SIW 1×2 power divider with inductive cylinder.

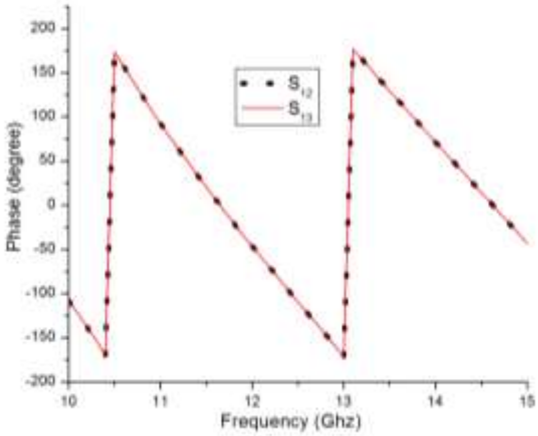
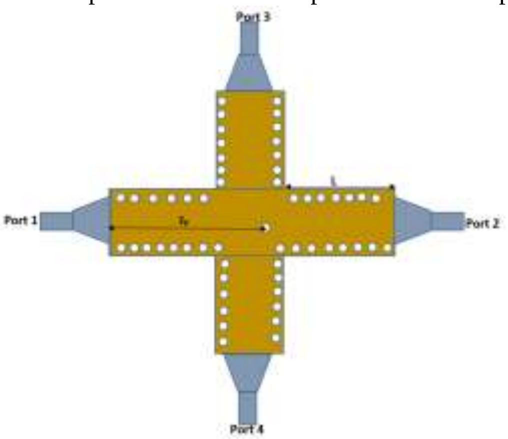


Figure. 7 Phase Results of the SIW 1×2 power divider using EM simulation.

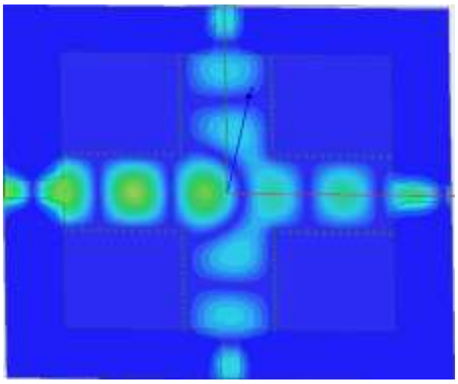
As seen in figure (6, 7), the designed power divider has S_{11} below -15 dB over the bandwidth of [10.8-14.9] GHz, insertion loss (S_{21} and S_{31}) about -3.46 dB with equal phase at design frequency $f = 12.5$ GHz.

B. SIW 1×3 Power Divider

From Table.1 we are realising the SIW 1×3 power divider using four identical SIW structure each length L=14 mm connected to form a '+' junction as show in figure 8. a metal inductive post of radius p=0.25 mm and whose position is Z_P=21.8 mm inserted in the junction, utilised to adjust magnitude and phase of the divided power at each output port.



(a)



(b)

Figure. 8 (a) Schematics of proposed SIW based 1×3 power divider (b) E-field distribution proposed SIW based 1×3 power divider at 12.5 GHz

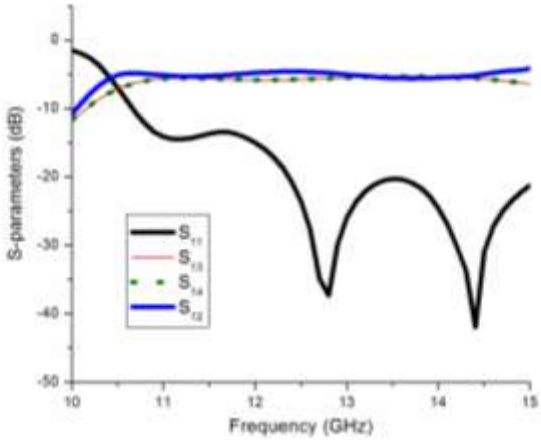


Figure. 9 S-Parameters in the SIW 1×3 power divider with inductive cylinder.

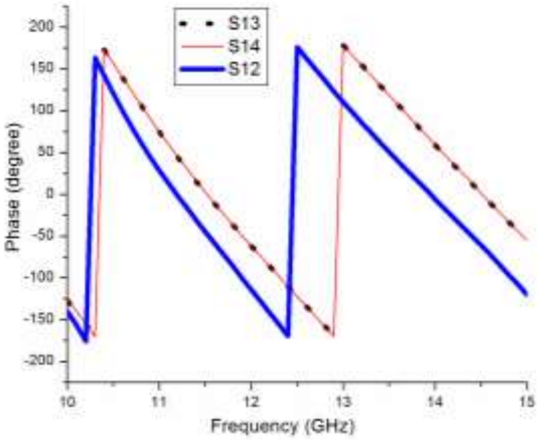


Figure. 10. Phase Results of the 1×3 power divider using EM simulation.

The investigated results as shown in the As seen in figure (9,10), the designed power divider has S_{11} below -15 dB over the bandwidth of [11.2-15] GHz, insertion loss (S_{21}, S_{31},S_{41}) is about -4.88 dB with equal phase.

IV. CONCLUSION

Substrate integrated waveguide passive components have been designed for X- and Ku- band, a commercial simulation tool Ansoft HFSS has been used to analyze the structures. In this paper design and simulation of 1×2 power divider, 1×3 power divider is reported. The simulated results show a very good performance over given band of frequency range. These structures can be used as essential components in the realization of planar microwave and millimeter wave components on the same substrate with microstrip transition.

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