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Broad Band Equal-Length And Equal-Width Substrate Integrated Waveguide Four Channel Power Divider

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Abstract

In this letter a novel broad band substrate integrated waveguide (SIW) power divider is proposed. It consist of four output channels made by SIW with equal length and equal width. Design equations and process are given with mathematical analysis. The propagation constant of the output signals have been adjusted by utilize only four via in the middle of the output arms. As a result a novel equal output power divider, is obtained accordingly. The experimental results of a prototype at 10 GHz shows 3.1 GHz bandwidth in both simulation and measurement results. Return loss and transmission coefficients have good agreement with simulation results in considered band.

Keywords: : Power divider, SIW, compact size

1 INTROCUCTION

The power divider is an essential component for realization of many microwave circuits. It is mainly used as feed network for array antennas and many other communication systems, such as wireless communication systems, radar systems, industrial and biomedical imaging systems. Wave guide power dividers have lower loss or dissipation in comparison to micro strip lines especially in higher frequencies of operation.[1]

Substrate integrated waveguide is a new structure which has become salient in recent decades [2,9] because of its wide impedance band width, compact size, low insertion loss and easily integration with other microwave component. Y and T shape power dividers [4,5], multi-way power dividers which are realized by combining the Y and T junctions have large size and high insertion loss. Radial cavity power dividers are presented as multi-way power dividers with compact dimension and lower insertion loss, however they have a non-planar feed structure [6,7] and narrow band width in resonant structures [6,7]. In this letter a novel four-port T-junction SIW power divider in which output arms have the same length and width has been presented as shown in Fig1. In other works structure have several input channels, however in this structure there is only one input as a feed port.

2 ANALYSIS AND DESIGN

SIW is a quasi-rectangular waveguide formed by two periodic via-hole connections between two metal layers. In the TE₁₀ mode (dominant mode), SIW is equivalent to a conventional rectangular waveguide with negligible leakage losses. Therefore SIW and its equivalent dielectric field waveguide share the same TE₁₀ mode cut-off frequency as follows:

$$f_c = \frac{1}{2a\sqrt{\mu\epsilon}} \quad (1)$$

where a is the width of the rectangular waveguide equivalent of SIW, μ and ϵ are the permittivity and permeability of the

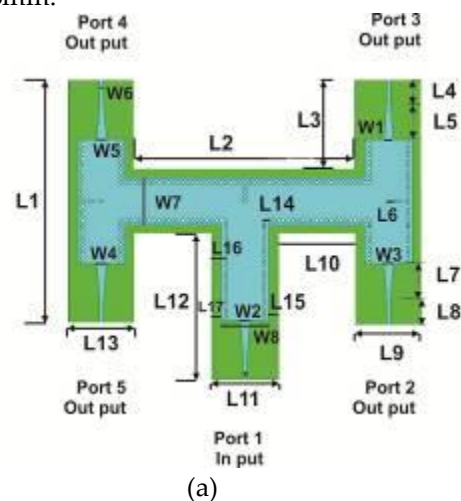
substrate, respectively. The width of the rectangular waveguide equivalent

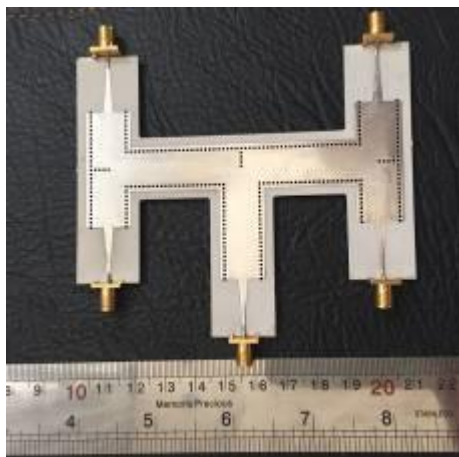
and fundamental properties of SIW are given approximately in [15] as follows:

$$a = A - \frac{D^2}{0.95P} \quad (2)$$

where a is the width of the equivalent rectangular waveguide, A is the width of SIW, D is the diameter of metalized via holes and P is the pitch between adjacent via holes as shown in Fig.2. The dimensions of the proposed power divider in Fig.1 are summarized in Table 1.

Four metalize inductive via have been added for dividing input signal equally between two arms and also matching the input port, for which the values of (P) and (D) are 1.5 mm and 1 mm respectively. Also, Four additional vias (named as middle via) located just in front of each SIW arm are incorporated to improve return loss. Position of this four inductive vias are have important effect in return loss and transition coefficients of outputs. The output arms have same widths and same length. Therefore the propagation constant and the phase of the output signals will be the same. The designed power divider was etched on a piece of Rogers 4003 with $\epsilon_r = 3.55$, $\tan\delta = 0.0027$ and thickness of substrate layer is 0.508mm.





(b)

Fig.1. Geometry of (a) The proposed SIW power divider, (b) The fabricated structure

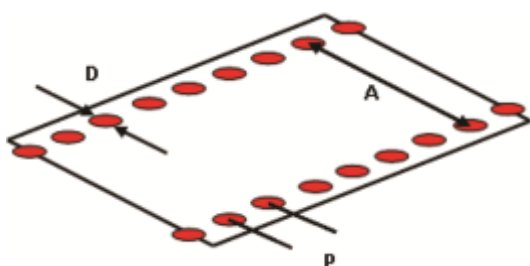


Fig.2. Substrate Integrated Waveguide Geometry

Table 1: Dimensions of the SIW power divider (mm)

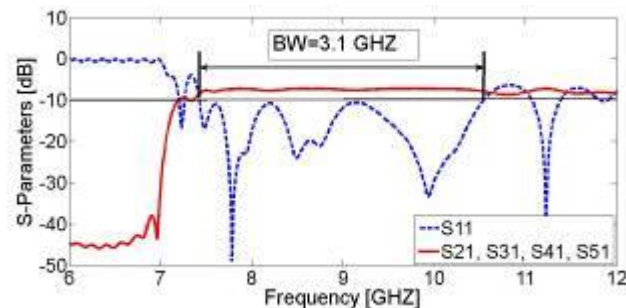
parametr	mm	parametr	mm
L1	77	L2	69
L3	28	L4 - L8	6.5
L5 - L7	12.5	L6	1.5
L9	21	L10	24
L11 - L13	21	L12	46
L14	1.5	L15 - L17	3
L16	4.5	W1 - W2	3
W3	3	W4	3
W5	3	W8	15
W6	1.1	W7	15

3 MEASUREMENT RESULTS

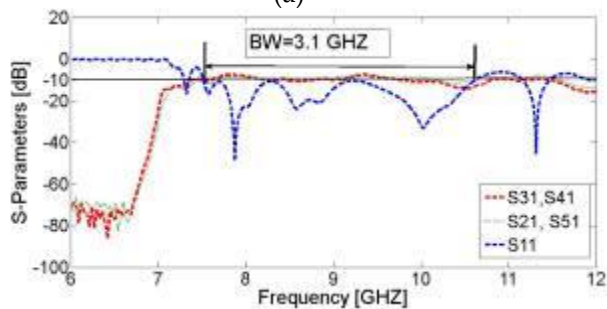
CST MICROWAVE STUDIO software is used for full-wave simulation and optimization. Top view of the fabricated SIW power divider at the frequency of 10 GHz are shown in Fig.1(b). The simulated and measured results of the S-parameters in the SIW power divider shown in Fig.3 (a,b) respectively, as can be seen bandwidth of 3.1 GHz— have been achieved for both simulation and measurement. The comparison between simulation and

measurement results of the return loss are shown in Fig.3(c). The differences between the results of measurement and simulation are due to the effects of the SMA connectors soldered into structure and the fabrication process. Comparison between the measurements results of this work with some references are given in table 2.

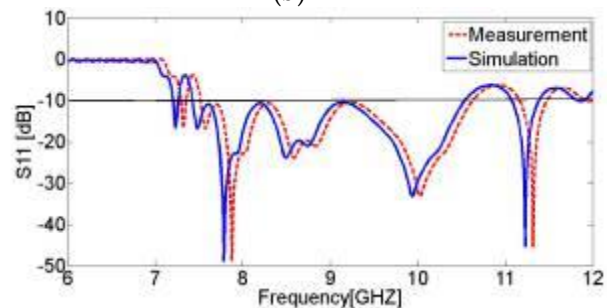
According to simulation and measurement results for transmission coefficients in Fig.4 the output power levels are the same. There are a little difference between simulation and measurement results which may be outcomes from connectors and fabrication process. The output signals are in phase as expected and which are shown in Fig.5



(a)



(b)

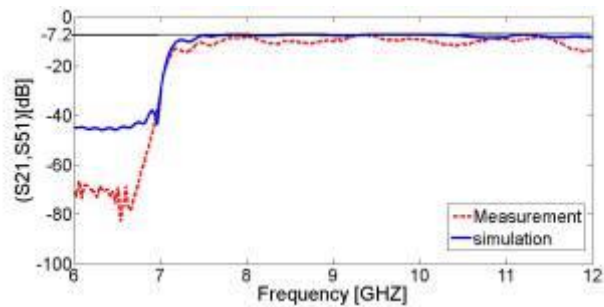


(c)

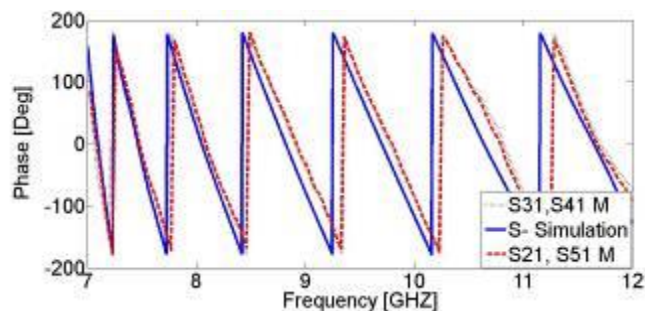
Fig 3. The S-parameters of SIW power divider (a) simulation (b) measurement (c) S₁₁ simulation and measurement

Table 2: Compression between this work and some other works

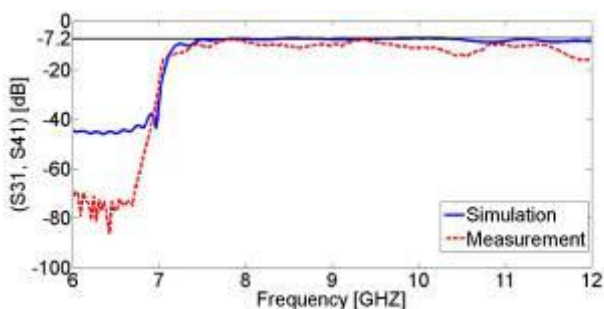
Ref.r	Bandwidth Frequency [GHz]	Fractional bandwidth	Transition [dB]	Size [mm ²]
[10]	7.3 - 13	57	-7.6 tan=0.001	65*65
[11]	4.5 - 6.8	40	-6.7 tan=0.0009	80*140
[12]	8 - 11	27	107*107
[14]	12.3 - 15.5	23	-7.1 tan =0.0009	45*110
[14]	12.3 - 15.5	22	-6.6 tan =0.0009	50*50
[13]	4 - 11	93	165*165
[This work]	7.6 - 10.7	32	-7.2 tan =0.0027	77*111



(a)

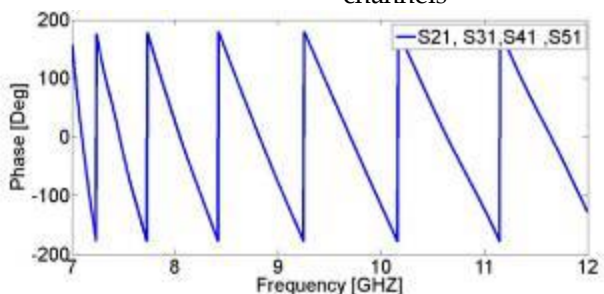


(b)



(b)

Fig.4. Transmission coefficients of Output Channels(a) compression between measurement and simulation results in second and fifth channels (b) compression between measurement and simulation results in third and fourth channels



(a)

Fig.5. Phases of Output Channels(a) simulation (b) compression between measurement and simulation results

4 CONCLUSION

A novel power divider based on SIW technology with the equal length and equal width for output arms is proposed. The proposed SIW power divider has one input and four equal length and width outputs, therefore it has compact size in comparison with available SIW power dividers. Detailed of the design procedure is completely explained. The correctness of the analytical approach is validated by a prototype SIW power divider. Therefore such a SIW power divider is a good candidate for development of a compact size and integrated microwave systems.

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