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DESIGN OF MILLIMETER-WAVE POWER DIVIDER WITH COUPLED LINE

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Abstract: A novel 35GHz 3dB power divider using coupled transmission line is presented. Unlike conventional Wilkinson divider circuit, only the 50 Ω transmission lines are used in the design. The impedance matching can be achieved by coupled transmission line even-mode characteristic impedance. The predicated and measured performances agree well.
Keywords: power divider, coupled line,even-mode

Introduction: The 3dB power divider plays an important role in microwave and millimeter-wave circuits. Wilkinson bridge is the most popular topology for 3dB power divider, where two parallel quarter-wave length transmission lines are used for impedance transformation. For 50 Ω input and output, the transmission line impedance is about 70 Ω .Usually, at high frequencies, the transmission lines must be separated for some distances in order to reduce parasitic coupling. This increases the total size of the power divider. Some planar and 3D structure are proposed to make the power divider structure more compact [1],[2].

In this paper, the tight coupling between the lines is used intentionally. Based on coupled microstrip line even-mode, the power divider circuit can be realized only by 50 Ω microstrip lines. The lower transmission line impedance helps to reduce the loss due to the wide metal width and the less discontinuities are needed .The coupled transmission line structure determines that the circuit can be more compact than the ordinary Wilkinson 3dB power divider.

In [3], odd-mode impedance variation in tapered line is discussed to analyze the isolation of the power divider. To authors' knowledge, there has been no report of a power divider that utilizes the even mode of coupled transmission line.

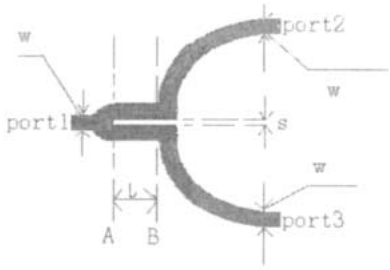

Fig.1 Circuit configuration of 3dB power divider

Design considerations: Fig.1 shows the proposed 3dB power divider . In Fig.1, all the line widths are the same value W. Port1,port2 and port3 are terminated by 50 Ω. As the separation S is very small compared to W , A-B part of the transmission line must be seen as a coupled line.

When the input signal is applied to port1, as the structure is symmetric, quasi-TEM even-mode can be generated in A-B part, resulting in a magnetic wall at the symmetry plane. As shown in Fig.2, the even-mode capacitances may be expressed as:

$$Ce = C_p + C_f + C_{f'} \cdots\cdots (1)$$

where C_p denotes the parallel plate capacitances between the strip and the ground plane, C_f the fringe capacitances like that of the uncoupled single microstrip, and the term $C_{f'}$ represents the fringing capacitances C_f modified by the adjacent single transmission line. An empirical expression for $C_{f'}$ is given below[4]:

$$C_{f'} = \frac{C_f}{1 + A(h/S)\tanh(8S/h)} \cdots\cdots (2)$$

whereA=exp[-0.1exp(2.33-2.353W/h)].

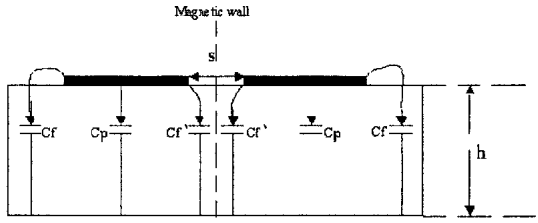

Fig.2 Quasi-TEM even mode of the coupled microstrip line

From (1) and (2), it can be seen that the even-mode capacitance is smaller than that of the uncoupled single microstrip line, therefore, the even-mode impedance is higher than that of the uncoupled single microstrip impedance. The smaller the separation value S, the higher the impedance. For the power divider circuit shown in Fig.1, the impedance transformation from port1 to port2 and port3 can be achieved by even mode's high impedance and the proper A-B part's length L.

Simulated and measured results: A 3dB power divider for center frequency of 35GHz has been realized on 0.254mm RT/D Duriod 5880 substrate with ε_r=2.2, the circuit is simulated by EM simulator Momentum. For50 Ω input and output, W=0. 79 mm, The corresponding values of S and L are 0.16 mm and2.4 mm.. Filter characteristics are measured by HP8510C network analyzer and 2.9mm K adapter. Fig.3 shows the results. In Fig.3,the simulated and measured results are in very good agreement.S_{11} at center frequency is smaller than –26dB. In the view of uncoupled transmission line, by analogy to the parallel connection of the two passive circuit elements, two 50 Ω impedance transmission lines which are connected in parallel yield 25 Ω impedance, then the S_{11} should be greater than –9.5dB. So the simulated and measured results show the validity of the proposed design idea in this paper.

Conclusions: A novel 3 dB power divider using coupled transmission line is proposed, only the 50 Ω transmission lines are used in the design. The impedance transformation can be achieved by coupled transmission line even mode high impedance. The high impedance lines are not needed and the circuits can be more compact. This

technique is successfully demonstrated on HMIC and is very suitable for the design of millimeter-wave MMIC.

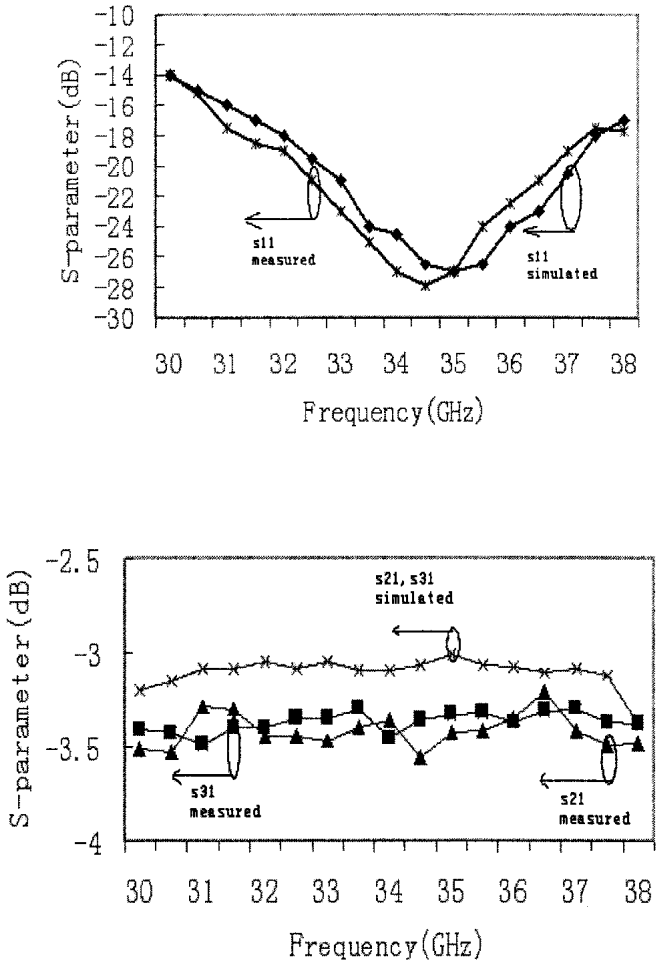

Fig.3 Measured and simulated performances of fabricated power divider

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