International Journal of Modern Engineering Research (IJMER)
www.ijmer.com Vol.3, Issue.1, Jan-Feb. 2013 pp-86-88 ISSN: 2249-6645

Waveguide to Suspended Stripline Transition Techniques at 94 GHz

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Abstract: *This paper describes the techniques for waveguide to suspended stripline transition as well as suspended stripline to waveguide transition. These transitions are used to realize crossbar mixers and band pass filters at 94 GHz. Back to back transitions with input/output waveguide WR-10 have been fabricated to measure insertion loss and return loss of the transition. Transitions have been simulated and tested for different orientations of excitation and probe shapes. Agilent's "Advanced Design System" and CST Microwave Studio have been used for simulation of the circuits.*

Index Terms: *waveguide, Suspended stripline, transition, millimeter wave.*

I. Introduction

Suspended stripline is among the principal transmission media used in upper microwave and lower millimeter wave bands. It consists of a dielectric substrates placed between two ground planes. Efficient SSLIN to waveguide transitions with low insertion loss and good VSWR are required for proper LO feed in case of a mixer and low insertion loss in a band pass filter. SSLIN to waveguide transitions can be realized with different types of techniques as ridge, Van Heuven and probe methods [1] & [2]. Effective dielectric constant of the line can be made close to that of air by selecting sufficiently thin substrate, thus allowing higher frequency of operation in the dominant mode which leads to nearly TEM. Practically entire circuit is placed in rectangular metallic enclosures, which has grooves to suspend the substrate. The inner dimension of the enclosure (called channel dimension) and groove depth are carefully selected to avoid the propagation of undesired modes. The basic difference between various techniques is in the orientation of the mode coupling where the transition is made from Quasi-TEM mode in suspended stripline to dominant TE_{10} mode in waveguide. Probe type transition is well suited for suspended stripline to waveguide transition.

In this design probe type transition has been used. Fig.1 shows the conversion of TE_{10} mode in waveguide to TEM mode in suspended stripline.

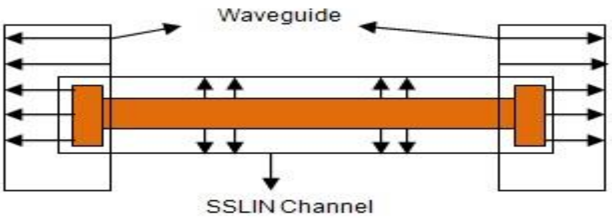

Fig.1. Field configuration of suspended stripline to waveguide transition

The suspended stripline channel cross-section is shown in Fig.2, which is basically a dielectric substrate sandwiched between two ground planes. Channel cross-sectional dimensions are carefully chosen to avoid higher order mode propagation. The cut-off frequency of the suspended stripline for the dominant waveguide mode LSM_{11} is related to the dimension of the structure and is given by [3].

$$f_c = \frac{c}{2a}\sqrt{1-\frac{d}{b}\left(\frac{\varepsilon_r - 1}{\varepsilon_r}\right)} \qquad (1)$$

Where a is the width of the channel, b is the height of the channel, d is the thickness of the substrate, ε_r is relative dielectric constant and c is the speed of light in a vacuum.

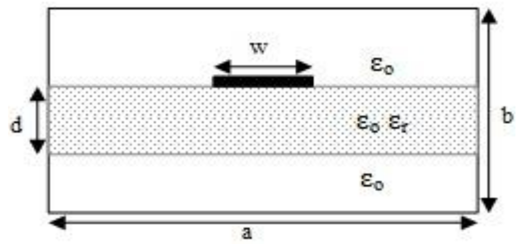

Fig.2. Suspended stripline channel cross-section

The above formula is empirical and not valid for such high frequencies, so actual channel cut off is determined using EM softwares.

The suspended strip line parameters are H_u (upper channel height) = 0. 2 mm, H_l (lower channel height) = 0.2 mm, a (Channel width) = 1.27 mm & grove length = 0.1 mm and the channel cut-off frequency calculated from CST microwave studio for 5 mil RT Duroid substrate is 101 GHz for 50-ohm impedance line. The waveguide cross-sectional dimensions are a= 2.54 mm and b = 1.27 mm.

II. SSLIN to Waveguide Transition

The suspended stripline to waveguide transition consists of an electric probe inserted into the broad wall of the waveguide. The probe is an extension of a suspended stripline into the waveguide. When a probe is inserted into the waveguide it radiates and in certain position desired mode is excited or vice versa fields set up in the waveguide can be picked up. At one end of waveguide input is given and at other end tuning short is provided to provide optimum matching. Most critical parameters for the transition are probe shape and insertion distance of suspended stripline into the waveguide.

Many types of transitions are simulated to get maximum coupling from waveguide field over a minimum of 20 GHz bandwidth. Optimization of probe shape, probe depth and position of shorting plane has been carried out with the help CST microwave studio.

Although, analytical formula to calculate width of an impedance line are available in the literature [4], but they are not accurate at such high frequencies. Hence actual simulation of the structure is done and port solution is obtained with EM software to calculate the effective dielectric constant, propagation constant and the characteristic impedance of the transmission line. Four types of transitions have been designed on RT Duroid (ε_r=2.22) substrate for 50 ohm transmission line by varying the orientation of excitation and probe shapes. These are shown in Table1. In this paper simulation results for both of them are presented.

TABLE 1

TWO DIFFERENT TYPES OF TRANSITION

Type	Substrate	Excitation	Probe shape
I	5 mil RT Duroid	Top	Rectangular
II	5 mil RT Duroid	Side	Rectangular

III. Simulated Results

Both types of transition were simulated and optimized in CST software.3D view of back to back transition , it's simulated S-Parameter results and dimensions for type-I are given in Fig.3,4 & 5 respectively. Fig.6, 7 & 8 represents corresponding parameters for type-II.

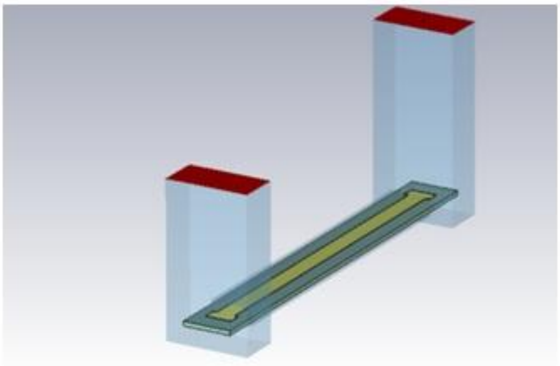

Fig.3. 3D view of transition for type-I

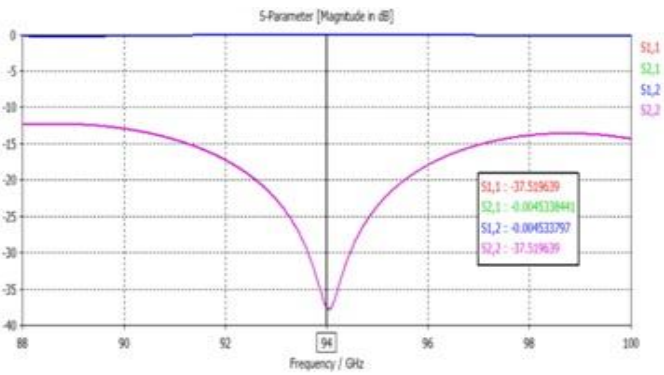

Fig.4. S-Parameter results of transition for type-I

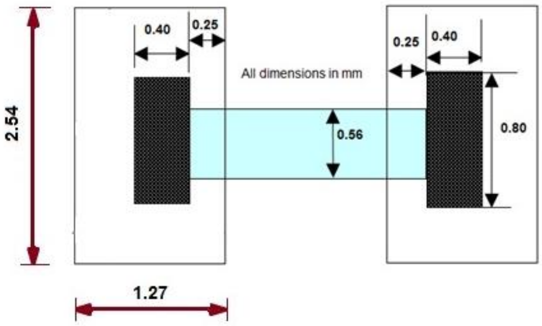

Fig.5. Dimensions of transitions for type-I

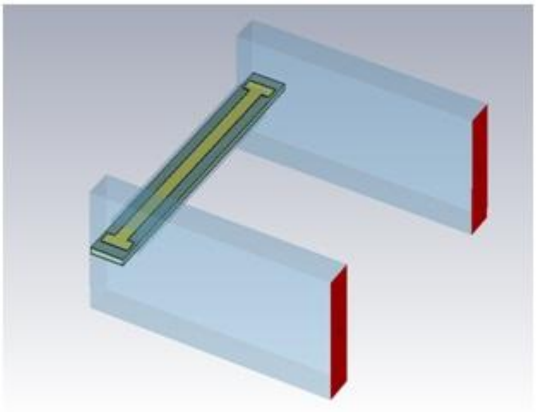

Fig.6. 3D view of transition for type-II

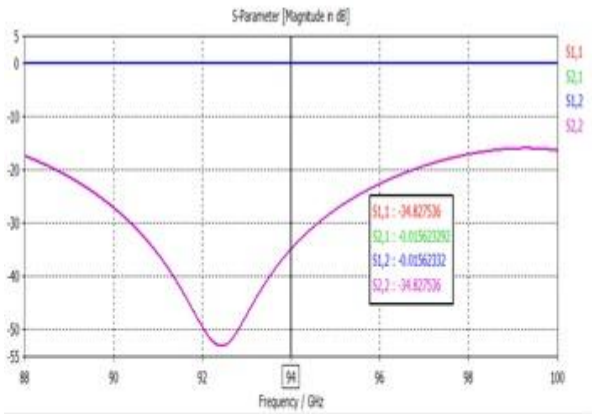

Fig.7. S- Parameter results of transition for type-II

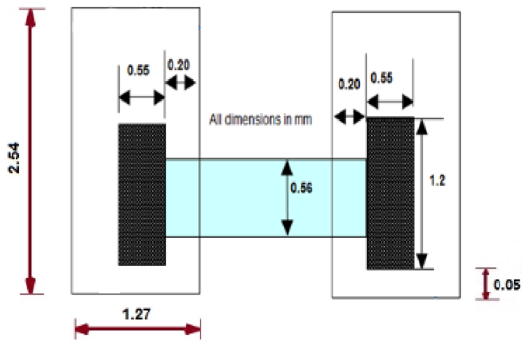

Fig 8. Dimensions of transitions for type-II

IV. Conclusion

Two probe type transitions were designed, optimized, fabricated and tested. The best results were achieved with side excitation on RT Duroid substrate using rectangular probe. These transitions have been used to realize band pass filters, couplers and crossbar mixers at 94 GHz.

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