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PASSIVE COMPONENTS IN INVERTED MICROSTRIP AND SUSPENDED MICROSTRIP CONFIGURATIONS

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ABSTRACT

This paper reports the development and performance characteristics of a number of passive components in the inverted microstrip and the suspended microstrip configurations. These devices are fabricated at frequencies upto X-band. However, using proper scaling, devices at millimeter wave frequencies should be possible in these two configurations.

Introduction

The inverted microstrip (Fig. 1a) and the suspended microstrip (Fig. 1b) have received considerable attention in recent years, in view of their applications at higher microwave and millimeter wave frequencies[1-6]. An extensive analysis and design data on these transmission lines, in isolated and coupled configurations, with isotropic and anisotropic dielectrics, have been reported by the authors[3-6]. Both inverted microstrip and suspended microstrip lines incorporate an air gap between the ground plane and the dielectric substrate, as a consequence of which the effective dielectric constant of the propagating medium is reduced. These configurations therefore permit larger circuit dimensions leading to less stringent dimensional tolerances. The presence of air gap also reduces the conductor loss in the ground plane, since, most of the electromagnetic energy is concentrated in the dielectric substrate.

The development and performance characteristics of a number of passive components in the inverted microstrip and suspended microstrip configurations are reported in this paper. These include: the high directivity directional coupler, balanced mixer and bandpass filter in suspended microstrip configuration, bandpass filter in inverted microstrip configuration, and waveguide to inverted microstrip transition. Besides these. several other components, namely, SPST switch, hybrid rat race coupler, PIN attenuator, branch line coupler, backward wave coupler, in inverted microstrip and suspended microstrip configurations, and waveguide to suspended microstrip transition have been fabricated. All these devices were tried out at frequencies upto X-band. However, with proper scaling, devices at millimeter wave frequencies should be possible in these configurations.

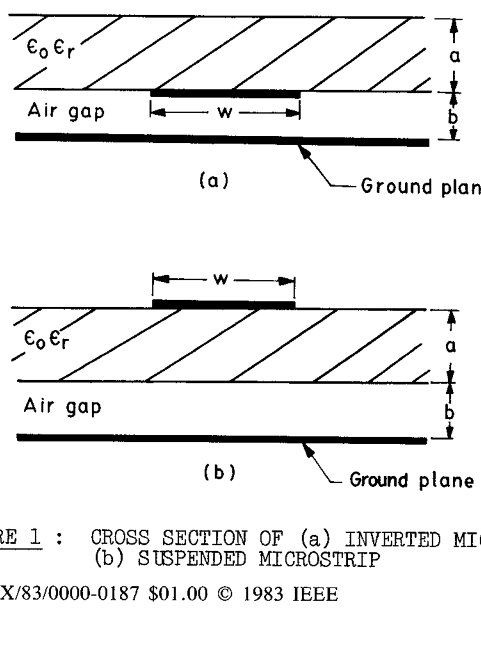

FIGURE 1 : CROSS SECTION OF (a) INVERTED MICROSTRIP (b) SUSPENDED MICROSTRIP

Circuit Configuration and Performance

High directivity coupler

A 15 dB high directivity coupler at 5 GHz was fabricated in edge-coupled suspended microstrip configuration (Fig. 2) using the design data generated by the authors. The air gap height b was optimized for equalising the even-and odd-mode phase velocities. The coupler dimensions for this optimized value of b are:

Coupled line width w = 2.2098 mm
Coupled line spacing s = 0.2515 mm
Air gap height b = 0.2286 mm
Input and output 50 ohm line widths = 2.217 mm

This coupler was photoetched on a duroid substrate (ϵ_r = 2.22) of thickness 0.015 inches. The fabricated coupler showed an isolation of better than 40 dB and coupling of 15 dB i.e. a directivity better than 25 dB at midband (Fig. 2). The return loss at midband was better than 30 dB. A slight shift in the centre frequency was observed. This can be due to the inaccuracy in the air gap height.

Balanced mixer with reactively terminated image

Two different models of the balanced mixer were fabricated. These are of image rejection type designed at 6 GHz. The mixer uses HP Schottky barrier diodes HP 5082-2714 having maximum SSB noise figure of 6 dB. In the first model, a short circuited stub was provided at the diode input terminals. The short circuited stubs provide a short circuit at the diode input terminals at the sum frequency and second harmonic of the local oscillator frequency. In the second model, the short circuited stubs were removed. Fig. 3 shows the conversion loss versus local oscillator frequency at a fixed local oscillator power of +5 dBm and RF power of -20 dBm. It is observed that elimination of short circuited stubs at the diode input terminals deteriorates the conversion loss by 1 dB. Minimum conversion loss obtained in the first model of the mixer is 5 dB at 6.1 GHz. It was also observed that the conversion loss variation is about 1.5 dB when the local oscillator power was varied from 0 dBm to -10 dBm. Fig. 4 shows a photoview of the mixer in suspended microstrip configuration.

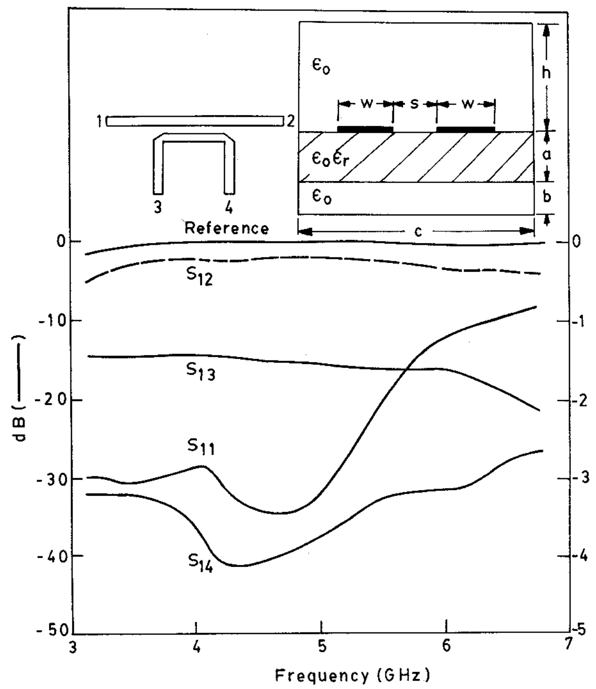

FIGURE 2 : EXPERIMENTAL RESULTS OF HIGH DIRECTIVITY COUPLER IN EDGE-COUPLED SUSPENDED MICROSTRIP CONFIGURATION

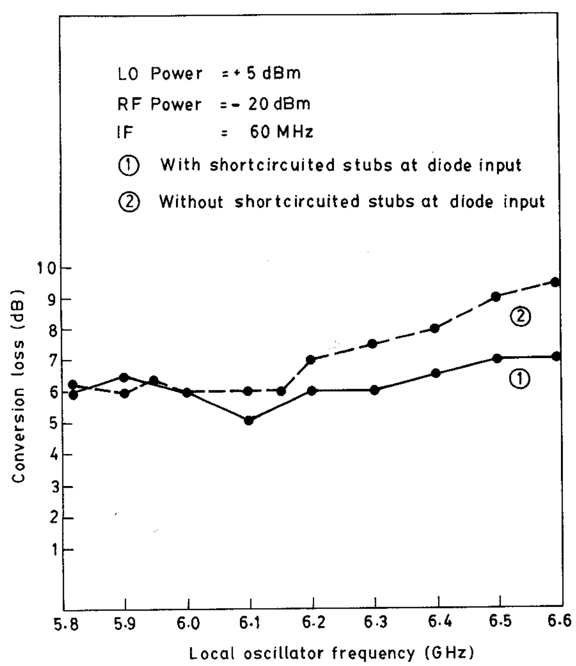

FIGURE 3 : CONVERSION LOSS OF BALANCED MIXER IN SUSPENDED MICROSTRIP CONFIGURATION

Bandpass filters

Five section parallel coupled bandpass filters in the suspended microstrip and the inverted microstrip were fabricated on 25 mil alumina substrates. The air gap b was fixed at 0.5 mm for both the filters. Figs. 5 and 6 show the experimental characteristics of the suspended microstrip and the inverted microstrip bandpass filters, respectively. In both these configurations, the centre frequency of the filter is considerably shifted from the designed value of 7 GHz for the suspended microstrip filter and 9 GHz for the inverted microstrip filter. This shift in frequency could be due to inaccuracies in the air gap height b and the end effects of the resonators which were not taken into account in the design. The higher insertion loss in the passband could be because of the brass material used for the ground planes.

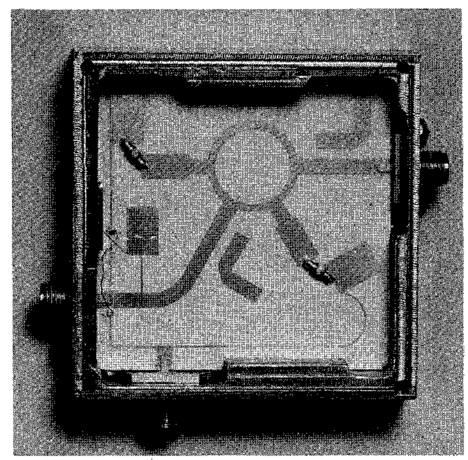

FIGURE 4 : PHOTOVIEW OF THE BALANCED MIXER IN SUSPENDED MICROSTRIP CONFIGURATION

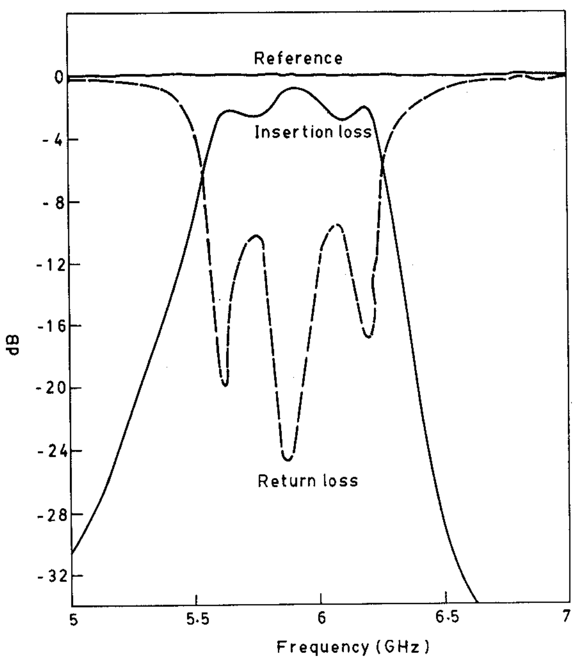

FIGURE 5 : EXPERIMENTAL RESULTS OF BANDPASS FILTER IN SUSPENDED MICROSTRIP CONFIGURATION

Waveguide to inverted microstrip transition

A waveguide to inverted microstrip transition using ridge waveguide transformers has been fabricated. The schematic diagram of this transition and the experimental characteristics are plotted in Fig. 7. The inverted microstrip was fabricated on 25 mil alumina substrate. The air gap was fixed at 1.016 mm. The strip conductor for the inverted microstrip was printed using aluminized sensing tape. For the 50 mm long inverted microstrip line along with two ridge waveguide transformers, the insertion loss was less than 0.8 dB, and the return loss was better than 12 dB over the frequency band 8.2-12 GHz. The characteristics of the transition can be improved by optimizing the contact region between the ridge transformer and the inverted microstrip. Work in this direction is currently in progress.

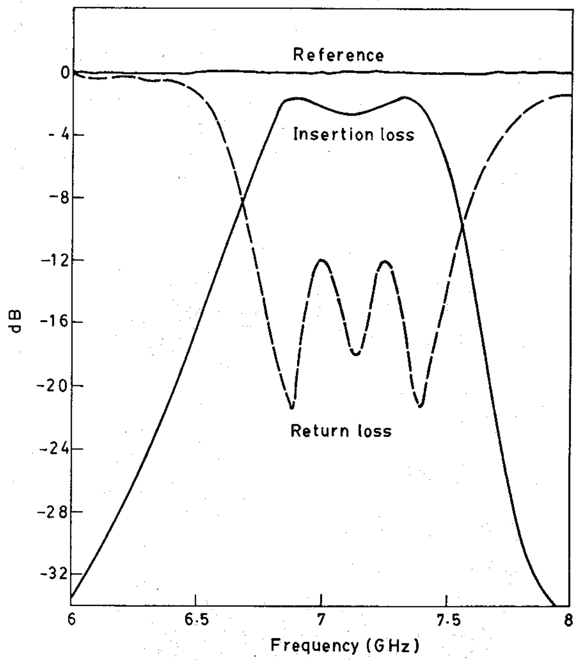

FIGURE 6 : EXPERIMENTAL RESULTS OF BANDPASS FILTER IN INVERTED MICROSTRIP CONFIGURATION

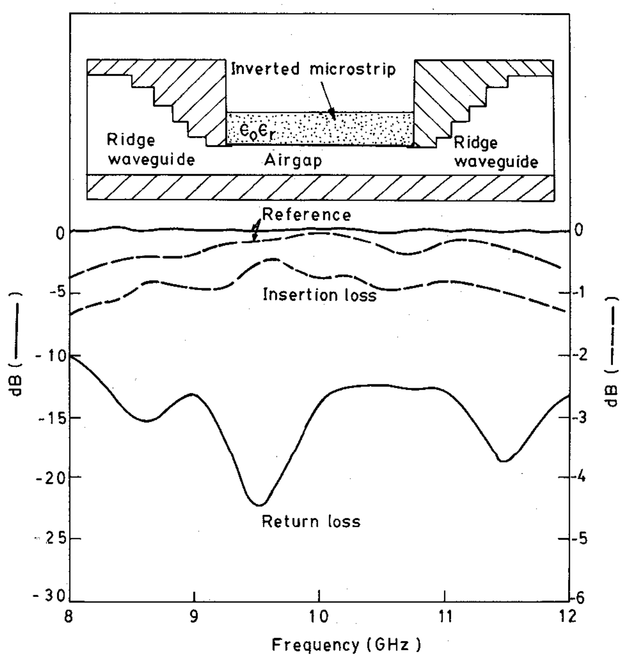

FIGURE 7 : MEASURED RETURN LOSS AND INSERTION LOSS OF WAVEGUIDE TO INVERTED MICROSTRIP TRANSITION

Conclusion

This paper demonstrates the feasibility of developing MIC components in the inverted microstrip and suspended microstrip configurations. Using proper scaling, devices at millimeter wave frequencies should be possible in these two configurations.

Acknowledgement

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References

1. M.V.Schneider,"Microstrip lines for microwave integrated circuits" Bell Syst. Tech. Journal, Vol.48, pp. 1421-1444, May 1969.

2. B.E.Spielman, "Dissipation loss effects in isolated and coupled transmission lines", IEEE Trans. Microwave Theory Tech., Vol.MTT-25, pp. 648-656, August, 1977.

3. S.K.Koul and B.Bhat, "Characteristic impedance of microstrip-like transmission lines for millimeter wave applications", AEU, Vol.35, pp. 253-258, June 1981.

4. ______, "Propagation parameters of coupled microstrip-like transmission lines for millimeter wave applications", IEEE Trans. Microwave Theory Tech., Vol. MTT-29, pp. 1364-1369, December 1981.

5. ______,"Inverted microstrip and suspended microstrip with anisotropic substrates", Proc. IEEE, Vol.70, pp. 1230-1231, October 1982.

6. B.Bhat and S.K.Koul,"Unified approach to solve a class of strip and microstrip-like transmission lines", IEEE Trans. Microwave Theory Tech., Vol. MTT-30, pp. 679-686, May 1982.