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W-BAND LOW NOISE INTEGRATED CIRCUIT CROSSBAR AND FINLINE MIXERS WITH OVER 20 GHz INSTANTANEOUS RF BANDWIDTH

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ABSTRACT

W-band integrated circuit mixers with state-of-the-art performance over wide IF and RF bandwidths have been developed. A conversion loss of less than 7.2 dB over 20 GHz instantaneous RF bandwidth has been achieved in a crossbar stripline structure and less than 7.6 dB over 28 GHz in a finline structure. Commercially available beamlead diodes are used in both structures. Major features include mechanical ruggedness, light weight, small size, and ease of low cost manufacturing. Areas of application include advanced electronic warfare, surveillance, and communication systems.

Introduction

High performance broadband millimeter wave mixers are required in many electronic warfare, surveillance, and communication system applications. Waveguide mixers using honeycomb diodes have been used for many years. However, the fabrication of such mixers is very expensive because of the requirements for precision machining and labor-intensive assembly. Furthermore, the mechanical contacts in whisker-contacted honeycomb diodes are unable to withstand the high vibration and shock levels experienced in military applications. The integrated circuit mixers, on the other hand, are mechanically rugged since beamlead diodes eliminate the need for mechanical contacts. The use of integrated circuit technologies and beamlead diodes thus provides the advantages of low cost, light weight, and small size. The circuit patterns generated by high precision photolithographic methods also enhance their reliability and reproducibility.

W-band integrated circuit crossbar and finline mixers have been reported for narrowband operation in references 1 through 4 and for wideband operation in references 5 and 6. This paper describes mixer design improvements resulting in much better performance. In a crossbar stripline mixer, a conversion loss of less than 7.2 dB was achieved over 20 GHz instantaneous RF and IF bandwidths. In a finline mixer, less than 7.6 dB conversion loss was achieved over 28 GHz instantaneous RF and IF bandwidths. These results represent state-of-the-art performance in integrated circuit mixers. Compared to the best results of waveguide mixers using honeycomb diodes,[7] this performance is equivalent or better.

Circuit Design

Figure 1 shows the circuit layout of the crossbar stripline mixer and Figure 2 the finline mixer. In the crossbar stripline mixer, the RF is applied to the mixer diodes from a waveguide perpendicular to the circuit board and the LO is applied via a probe in the waveguide and is coupled to the diodes through a broadside coupler. The crossbar configuration is formed by two mixer diodes with opposite polarity connected across the broadwall of the waveguide. RF matching is achieved by a reduced-height waveguide transformer and a backshort behind the diodes. The RF waveguide port and LO port are orthogonal to each other and thus present inherent RF to LO isolation. The details of each component design can be found in reference 6. Improvements in bandwidth have been obtained by placing the broadside coupler closer to the mixer diodes and the lowpass filter away from the diodes. Instead of using a double open stub, a two-section matching circuit was placed between the diodes and the IF filter to achieve the wider IF matching.

Our new finline design is considerably different from that previously reported in references 5 and 6. As shown in Figure 2, the RF is fed to the diodes via a finline cosine taper; the length of the taper is minimized for low loss and the gap between the lines is optimized for RF matching. The LO is coupled through a broadside coupler as in the case of the crossbar stripline mixer. This eliminates the use of a high loss and narrowband bandpass filter which is difficult to fabricate with accurate dimensions. Good isolation between the LO and RF port is achieved because the electric fields of the finline and suspended stripline are perpendicular to each other. The use of a broadside coupler also gives the flexibility that the LO frequency can be varied over a wide range without changing the circuits. Two beamlead diodes with opposite polarity are connected between the LO and RF. The IF signal is extracted via a lowpass filter perpendicular to the LO and RF circuits.

Performance

Crossbar and finline mixers are fabricated on a 5 mil thick Duroid substrate. For the crossbar stripline mixer, a conversion loss of less than 7.2 dB over a 20 GHz instantaneous RF and IF bandwidth has been achieved. The LO was fixed at 85 GHz as the RF was swept from 86 to 106 GHz. The results are shown in Figure 3. In the case of a finline mixer, a conversion loss of less than 7.6 dB has been achieved over 28 GHz instantaneous RF and IF bandwidths with the LO at 82 GHz and the RF swept from 82 to 110 GHz. The results are given in Figure 4. Since the broadside coupler is quite broadband, the LO frequency can be varied without the need of changing the circuit. The performance of the same circuit with the LO at 87 GHz is also shown in Figure 4. These results represent state-of-the-art performance for both integrated circuit and waveguide type mixers.

Conclusions

W-band integrated circuit crossbar and finline mixers have been developed using beamlead diodes with state-of-the-art performance. These integrated circuit mixers, compared to waveguide mixers, provide the advantages of immunity to shock and vibration, low cost production, and better reproducibility.

0149-645X/83/0000-0187 $01.00 © 1983 IEEE

Acknowledgements

The authors wish to thank Dr. C. Sun for his useful suggestions. They would also like to thank Ms. T. Cazares for her technical assistance.

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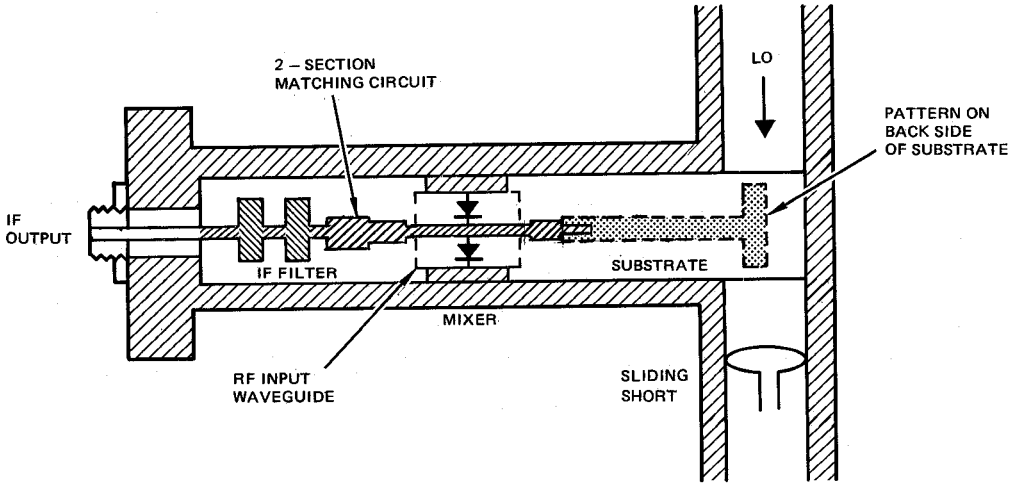

Figure 1. Crossbar Stripline Mixer

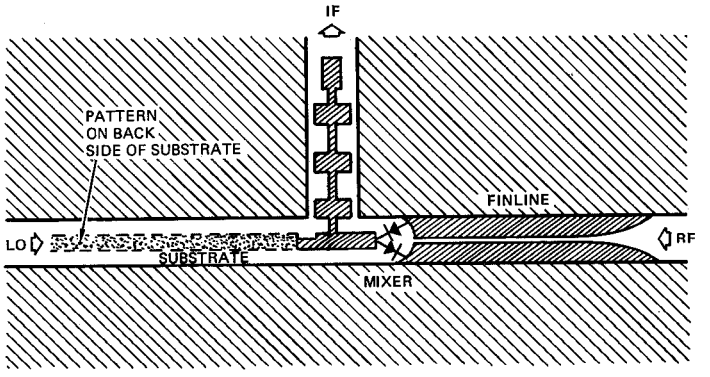

Figure 2. Finline Mixer

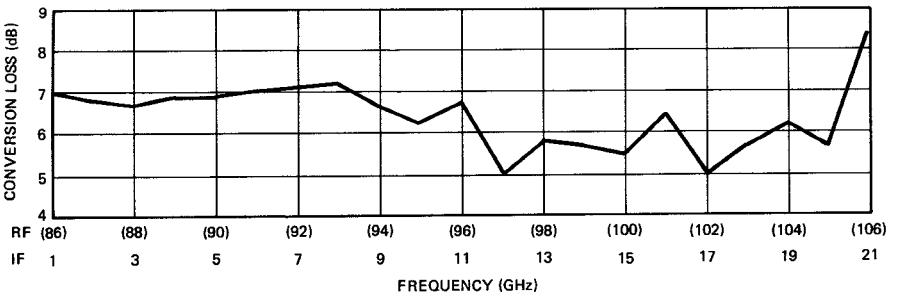

Figure 3. Performance of Crossbar Stripline Mixer (LO at 85 GHz)

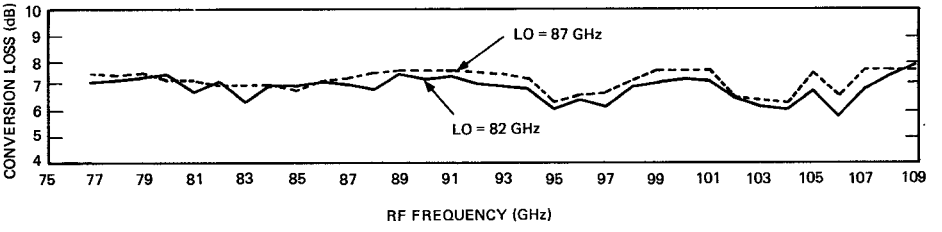

Figure 4. Finline Mixer Performance