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W-BAND CROSSBAR MIXERS INTEGRATED ENTIRELY ON A SINGLE-SIDED SUBSTRATE YIELDING 15 GHz INSTANTANEOUS BANDWIDTH

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Abstract

Broadband millimeter-wave crossbar mixers using commercially available GaAs beamlead diodes and integrated circuit technology are described. The entire integrated mixer circuit is printed on the same substrate surface allowing for future extension to MMIC form. Measured performance of a compact single balanced mixer at 100 GHz shows an instantaneous 15 GHz RF and IF bandwidth and a conversion loss of 7 dB. This design is most suitable for future ESM receivers.

Introduction

Due to the increasing interest in millimeter-wave hardware, a need has arisen for high performance broadband mm-wave mixers for receivers used in electronic warfare, surveillance, meteorology, radiometry, and communication systems. Recently, state-of-the-art performance W-band broadband integrated circuit mixers have been developed [1,2]. The crossbar mixers employed in [1,2] use a broadside coupler to serve as the dc block between the LO and IF and to provide IF-to-LO isolation. However, the IF-to-LO isolation provided by a broadside coupler is not sufficient if large IF bandwidths are required. An alternative to the broadside coupler is an end-coupled bandpass filter as reported in [3]. The advantages of using an end-coupled bandpass filter is that the IF-to-LO isolation can be set by the order of the bandpass filter and the entire integrated mixer circuit can be printed on the same side of the substrate. With a broadside coupler, the underside metallization requires careful alignment.

This paper reports on two W-band broadband crossbar single balanced mixers which have been developed incorporating 2-section end-coupled bandpass filters, these are believed to be the only W-band mixers published that use end-coupled bandpass filters. An unbiased crossbar mixer has been developed which has a conversion loss of less than 7.0 dB over a 15 GHz instantaneous RF and IF bandwidth with RF swept from 85 to 100 GHz and +12 dBm LO power.

The performance of this mixer rivals that presented in [1] which uses a broadside coupler.

A second mixer with dc bias has a conversion loss of less than 9.0 dB over a 10 GHz instantaneous RF and IF bandwidth with the RF swept from 80 to 90 GHz and only +8 dBm LO power.

Circuit Design

The crossbar mixer circuit, shown in Figure 1, consists of a pair of GaAs beamlead mixer diodes, a probe transition, a bandpass and a lowpass filter all integrated on a soft substrate. The RF signal is applied directly to the diodes from a waveguide orthogonal to the mixer circuit. The LO is coupled into the diodes via a probe transition and a bandpass filter. The end-coupled bandpass filter is designed following the procedure outlined in [4]. The location from the diodes' plane and selection of the end-coupled bandpass filter type is an important factor in ensuring the integrity of the IF response continuously over the full IF bandwidth.

The IF network consists of a lowpass filter and a matching circuit which presents a match to the diodes at IF frequencies and an open circuit at the diodes' plane to LO and RF frequencies.

The integrated mixer circuit was then optimized using a microwave synthesis program. Final empirical optimization of the circuit parameters was done to achieve best mixer performance.

Mixer Performance

Two W-band crossbar mixers with and without dc bias have been fabricated on a 5 mil duroid substrate, their performances are as follows:

- an unbiased mixer with less than 7.0 dB conversion loss
- 15 GHz instantaneous RF and IF bandwidth
- RF swept from 85 to 100 GHz
- +12 dBm LO power

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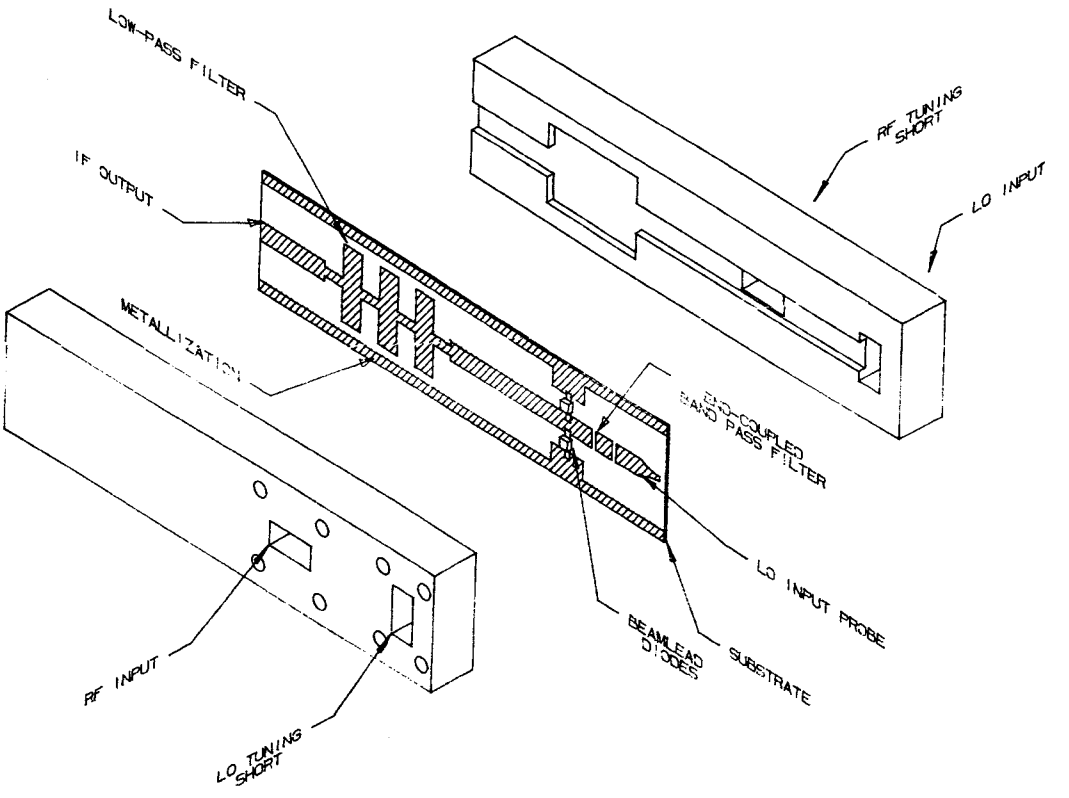

FIGURE 1 : Crossbar Mixer with an End-Coupled Bandpass Filter

- a dc biased mixer with less than 9.0 dB conversion loss
- only +8 dBm LO power
- 10 GHz instantaneous RF and IF bandwidth
- RF swept from 80 to 90 GHz.

The results are presented in Figures 2 and 3.

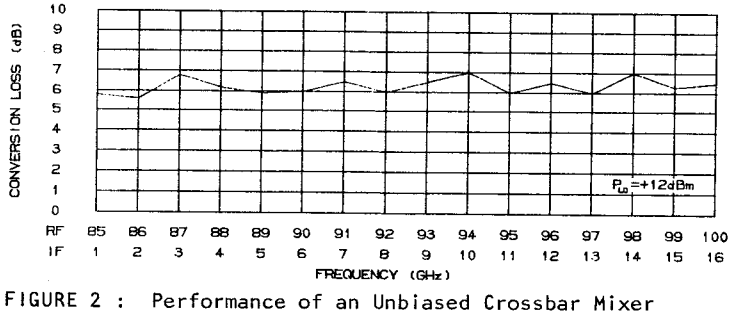

FIGURE 2 : Performance of an Unbiased Crossbar Mixer

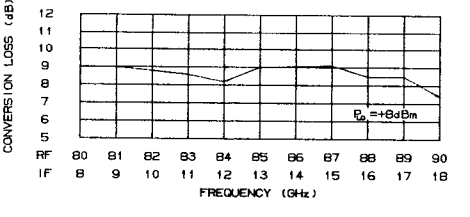

FIGURE 3 : Performance of a DC Biased Crossbar Mixer

Conclusion

W-Band crossbar suspended substrate mixers with low conversion loss have been developed with over 15 GHz instantaneous RF and IF bandwidths, these mixers have complete integrity over the entire IF bandwidth. End-coupled bandpass filters were used to provide the necessary IF to LO isolation, the entire integrated mixer circuit can be printed on the same side of the substrate, thus reducing fabrication and assembly problems to a minimum. The use of the simple crossbar configuration, and beamlead diodes combined with printed-circuit techniques, offer the advantages of millimeter-wave mixers which are, light weight, small size have improved reproducibility, and low-cost manufacturing techniques.

Acknowledgements

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References

[1] R.S. Tahim, G.M. Hayashibara and K. Chang, "Design and Performance of W-Band Broad-Band Integrated Circuit Mixers", IEEE Trans. Microwave Theory Tech., Vol. MTT-31, No. 3, March 1983.

[2] R.S. Tahim, T. Pham, and K. Chang, "W-band Low Noise Integrated Circuit Crossbar and Finline Mixers with Over 20 GHz Instantaneous RF Bandwidth", IEEE 1983 MTT-S International Microwave Symposium Digest, pp. 290-293.

[3] C. Nguyen and K. Chang, "140 GHz Broadband Crossbar Stripline Mixers With Over 20 GHz Instantaneous RF Bandwidth", Electronic Letters, Vol. 20, No. 11, 24 May, 1984.

[4] R.M. Dougherty, "Mm-Wave Filter Design with Suspended Stripline", Microwave Journal, July 1986.