BROADBAND PLANAR BALANCED MIXERS FOR MILLIMETER-WAVE APPLICATIONS

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This paper describes the design and fabrication of broadband millimeter-wave mixers using GaAs beam lead diodes and planar circuit techniques. At Ka band, a conversion loss of less than 9 dB with instantaneous bandwidths of 26 to 40 GHz (RF) and 2 to 16 GHz (IF) has been measured. At W band, the conversion loss was less than 11 dB for an instantaneous RF of 78 to 94 GHz and an IF of 26 to 42 GHz.

Mixer Design and Fabrication

The broadband balanced mixers described herein were fabricated using GaAs beam lead diodes and planar (printed) circuit techniques. The mixers, one at Ka band and the other at W band, utilize fin line and suspended substrate stripline as the principal media. The completed mixer circuit, shown in Figure 1, consists of RF/LO input transitions, a 180° planar hybrid and an IF/LO diplexer.

RF/LO Input Transitions

The RF and LO signals are fed to the diode pair via appropriate transitions from waveguide. The RF waveguide to fin line transition is a fin-line tapered section with a cosine contour. The return loss of two transitions connected back to back was measured to be greater than 20 dB over RF ranges. The LO input to the mixer is coupled through an in-line waveguide to suspended stripline transition. The return loss of two back-to-back transitions is 15 dB.

180° Planar Hybrid

The 180° hybrid is formed by the junction of the balanced RF fin line and the unbalanced LO suspended substrate stripline. The diodes are mounted across the junction as shown in Figure 2. The diode pair appears in series from the RF port and in parallel from the LO port. Therefore, the RF signal is fed to the diodes in phase and the LO signal is fed to the diodes 180° out of phase. The LO circuit is connected to the RF circuit at the virtual ground of the RF input so that it does not affect the RF input impedance. Fin line provides the RF return for the LO signal through the mixer housing.

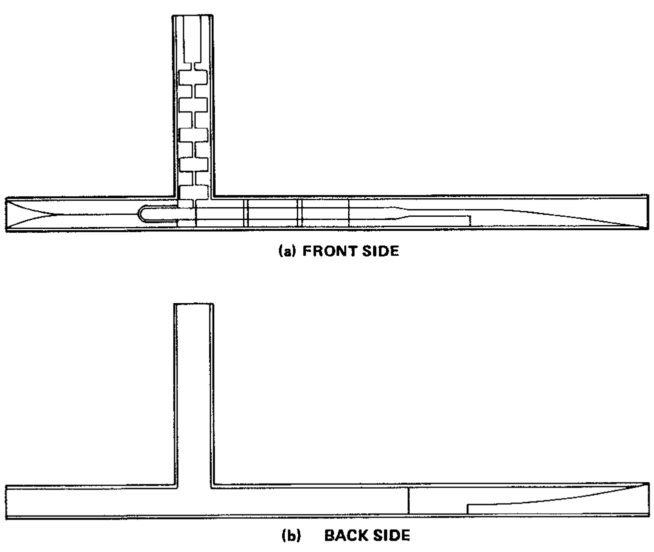

Figure 1. Mixer planar circuit.

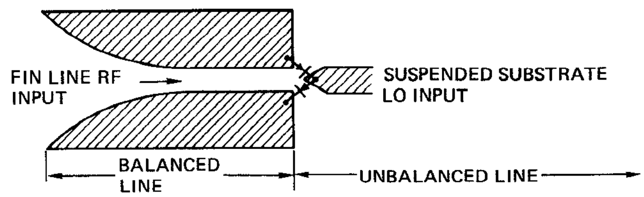

Figure 2. 180° planar hybrid showing location of beam lead diodes.

IF/LO Diplexer

The IF/LO diplexer consists of an IF low pass filter and an LO bandpass filter. Both filters were fabricated on suspended microstripline for minimum losses. The IF low pass filter is a 0.1 dB ripple, 11-section Tchebychev design with a high-low structure. It was designed for 40 dB rejection at the LO frequency. The high impedance lines are 142 ohms and the low impedance lines are 30 ohms. For the high-low structure, analysis shows that the higher the impedance ratio, the better the filter response; however, the range of realizable impedances is constrained in practice by the etching production and the width of the suspended substrate channel. Insertion loss was less than 1.5 dB up to 16 GHz.

The LO bandpass filter is a 0.1 dB ripple, end-coupled, three resonator design. In this design, the gap equivalent circuit was obtained in terms of the even and odd mode fringe capacitances of coupled suspended microstrip. The filter was modeled using a digital computer and optimized for the design frequency response. Typical passband insertion loss was 1 dB.

The W-band version was scaled directly from the Ka-band design with some minor modifications. However, due to the extremely high IF of the W-band mixer (26 to 40 GHz), provisions were made to pick up the IF by either a coaxial connector or by WR-28 waveguide.

Results

The conversion loss of the Ka-band mixer is shown in Figure 3. A conversion loss of less than 9 dB with an instantaneous IF bandwidth of 2 to 16 GHz was measured. When the same mixer is tuned for 4 GHz IF bandwidth, the conversion loss is less than 4 dB.

Figure 4 shows the conversion loss of the W-band mixer. A conversion loss of less than 11 dB was measured for IF up to 42 GHz. This is the highest IF reported for millimeter-wave mixers. The Ka- and W-band mixers are shown in Figures 5 and 6.

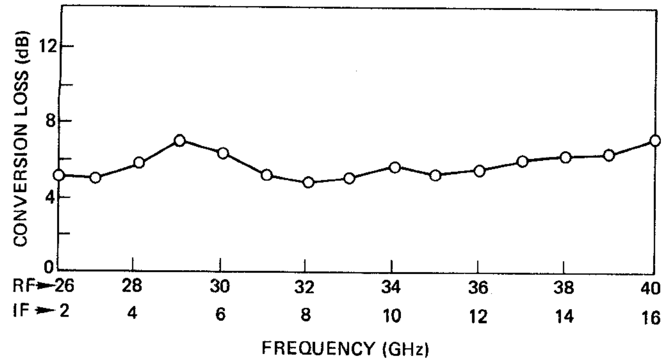

Figure 3. Conversion loss of broadband Ka-band mixer. LO fixed at 24 GHz.

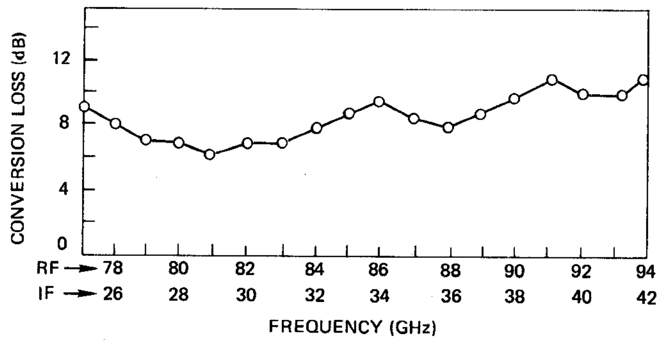

Figure 4. Conversion loss of broadband W-band mixer. LO fixed at 52 GHz.

Conclusion

Broadband planar balanced mixers with low conversion loss over an instantaneous bandwidth of 14 GHz have been designed and fabricated. The use of printed circuit techniques is key to highly reproducible mixer designs which are suitable for EW and other broadband applications.

Acknowledgements

This work was supported by the Naval Ocean System Center, Contract No. N66001-80-C-0565, under the guidance of the program monitor, Mr. J. Reindel.

We would like to thank Dr. Jen Kung for fabricating the beam lead diodes and T. Pham and Y. Weyand for their efforts in fabricating the mixers.

Figure 5. Prototype Ka-band mixer.

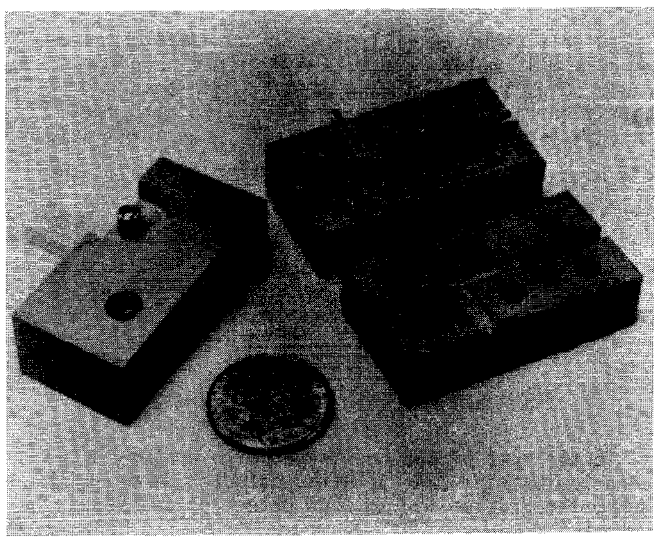

Figure 6. W-band mixer.