A New Coplanar Waveguide/Slotline Double-Balanced Mixer

David Cahana

Avantek, Inc.
Milpitas, CA. 95035

Abstract
A new double-balanced MIC mixer design is presented. Through the use of a diode crossover quad and coplanar waveguide/slotline baluns, the need for via holes and back metalization has been eliminated. A sample mixer with 6-18 GHz RF and 1GHz IF demonstrates a 5.0 to 8.5 dB conversion loss.

Introduction
To achieve the desired electrical orthogonality between the RF and LO, double-balanced microwave mixers have traditionally been designed using three-dimensional topologies[1] or, more recently, thin-film double-sided substrate processing[2]. This paper presents a design of a double-balanced MIC mixer which is realized entirely on one substrate side, with no metalization on or connections to the back side required. This feature alone can significantly reduce the substrate processing complexity and consequently the cost . Thus, from a manufacturing standpoint, the circuit presents a potentially cost-effective solution for a broadband and reliable mixer.

The mixer consists of coplanar waveguide/slotline baluns for the LO and RF and a unique diode crossover quad. An operating bandwidth characterized by a three-to-one frequency ratio has been achieved, at up to 18 GHz, with a conversion loss of 5.0 to 8.5 dB and a 3 dB IF bandwidth from DC to 2 GHz.

Mixer Description
Figure 1 illustrates the mixer layout and the equivalent circuit. It is constructed on a 25-mil thick .325 X .75 inch alumina substrate, which can be reduced to .25 X .60 inches. The substrate metalization consists of 50-ohm coplanar waveguide (cpw) RF, LO and IF interface lines; RF and LO baluns; and 50-ohm slotlines between the baluns and the diode quad. The back side of the substrate is unmetalized, which results in a well-behaved cpw and slotline propagation medium. A four-wire line network performs the same function as the secondary center taps of the conventional transformer baluns[3]. The pair of lines connected to the series capacitors is DC-decoupled from ground and provides the hot IF path, Zif, whereas the second pair is connected to the the LO side and provides the ground return, Zrtn. Although presently implemented with bond wires, these lines can also be realized with printed cpw lines and air-bridges. To minimize LO leakage into the RF and IF, the metalization between the LO and RF baluns is discontinuous. The characteristic impedance, Zd, of the slots created by this discontinuity, and the lengths of the slots are designed to present a high impedance to the diodes across them.

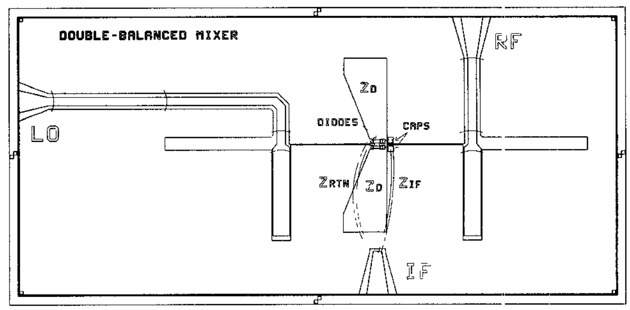

Figure 1a - Mixer Layout

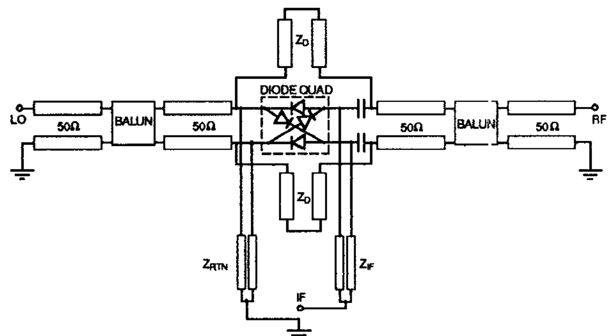

Figure 1b - Mixer Equivalent Circuit

Baluns
Two identical circuits, which are planar realizations of the compensated balun[4,5], feed the RF and LO to the diode quad. As shown in Figure 2, a cpw-to-slotline transition provides the direct path between the balanced and unbalanced lines. The series capacitor and the shunt inductor represent the compensating distributed elements of the transition. They are implemented using, respectively, an open-ended cpw and a shorted slotline, measuring a quarter-wavelength at the center frequency. Although the balun effect can be achieved with a simple cpw-to-slotline transition, the compensated version offers a distinctly broader bandwidth. Figure 3 illustrates the measured back-to-back insertion- and return-losses, including fixture contributions, of two compensated baluns, identical to those used in the mixer. With a design optimized for a 12-GHz center frequency, the insertion loss is 0.8-2.0 dB and the return loss is at least 10 dB, from 4.5 to 18 GHz.

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Diode Quad

The quad of low-barrier beam-lead Schottky diodes uses a unique crossover design[2]. The internal crossover connections make it possible to access the quad from the LO and RF circuits without external crossovers, thus minimizing circuit parasitics.

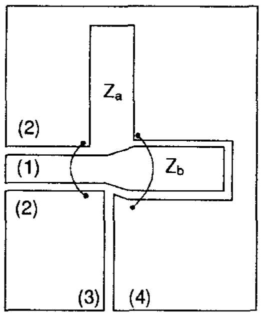

Figure 2a - Balun Layout

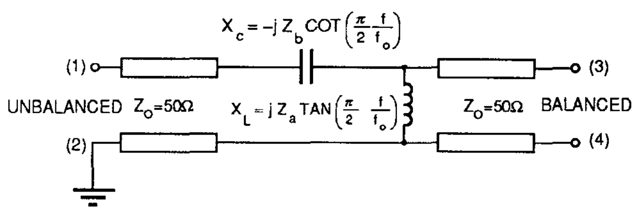

Figure 2b - Balun Equivalent Circuit

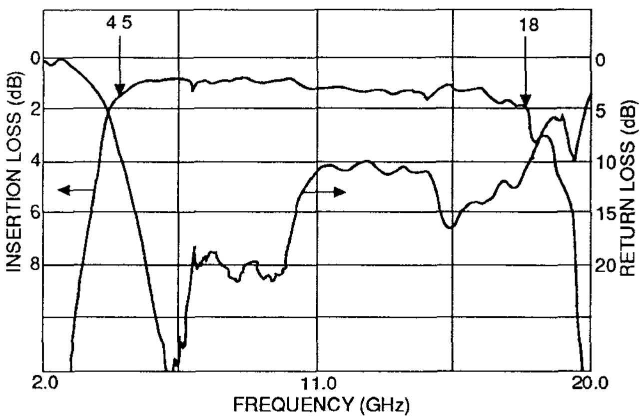

Figure 3 - Measured Back-to-Back Balun Losses

Mixer Performance

As illustrated in Figure 4, the shape of the measured conversion loss curve tracks closely that of the insertion loss of the back-to-back baluns in Figure 3. With a fixed IF of 1 GHz and 10 dBm LO power, the conversion loss is 5.0-8.5 dB from 6 to 18 GHz. In the same range, LO/RF and LO/IF isolation is at least 20 dB, the 1 dB compression point is 6 dBm and the port VSWRs are 3:1 maximum.

Performance can be improved over a more restricted bandwidth by retuning the circuit. As an example, Figure 5 illustrates a 5.0-6.5 dB conversion loss in a 5-12.5 GHz band.

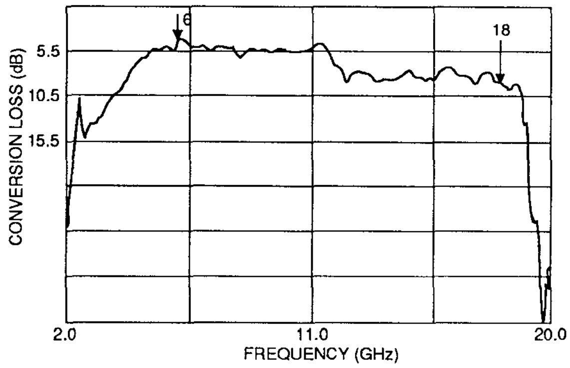

Figure 4 - Conversion Loss, IF=1 GHz

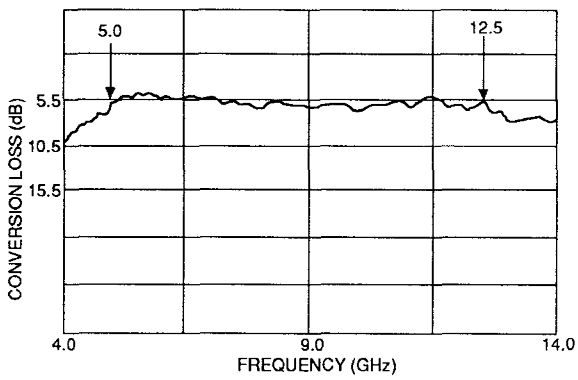

Figure 5 - Conversion Loss, IF=1 GHz

Conclusion

A new design concept for a broadband planar mixer, using single-sided substrate processing, has been presented. The design offers a potential reduction in production costs compared to other mixer types. The planar construction is highly reliable and lends itself to modular MIC applications. Conversion loss in the 6-18 GHz band was found to be similar to that achieved with other double-balanced mixers in the same frequency range.

Acknowledgements

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