AN X-BAND MONOLITHIC DOUBLE DOUBLE-BALANCED MIXER FOR HIGH DYNAMIC RECEIVER APPLICATION

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ABSTRACT

An X-Band monolithic double double-balanced mixer utilizing MESFET process is described. This monolithic mixer demonstrates RF performance comparable to that of a hybridized mixer. The mixer achieves a high input IP3 of 20 dBm and 1-dB compression output power of 3.6 dBm at 20 dBm LO drive. The measured conversion loss is less than 10 dB from 7 to 10 GHz with a IF output frequency of 5 GHz. We believed this represents highest IP3 performance among the reported monolithic mixers.

INTRODUCTION

A high IP3 mixer is the key component for the successful development of the high dynamic receivers which are required by many advanced EW and communication systems. Till now these mixers were designed using hybrid implementation [1,2,3]. Though excellent IP3 performances have been reported; these mixers are bulky and suffer performance degradation due to many interconnections between mixer and RF/IF amplifiers. A monolithic receiver based on high IP3 MMIC mixer provides not only significant size and weight reduction but also more superior reliability and RF performance than the hybrid receiver.

In this paper, we present a monolithic X-Band double double-balanced mixer using Schottky barrier diodes. These diodes were fabricated using TRW 0.5 μm MESFET process . Double double-balanced mixer , also known as triple balanced mixer , can handle more power, provide higher dynamic range, better intermodulation suppression, greater port-to-port isolation, and broader IF bandwidth[4] .

Double double-balanced MIMIC mixer was designed and fabricated. With a 20 dBm LO drive and fixed IF 5 GHz the measured conversion loss is less than 10 dB from 7 to 10 GHz of RF bandwidth, with a minumum of 7.5 dB at 10 GHz.

The output power at 1-dB compression is greater than 3.6 dBm and the input IP3 is about 20 dBm. We believed this represents highest IP3 performance among the reported monolithic mixers.

DESIGN

The configuration of the double double-balanced mixer combined two doubly balanced diode mixers as shown in Figure 1. This circuit is composed of three baluns and two Schottky barrier diodes ring quads. The baluns are realized using high-pass "tee" and low-pass "pi" filter structure [5] as shown in Figure 2. The baluns were designed with 50 ohm input and output terminations. The simulation of the baluns are shown in Figure 3. Over a 50% bandwidth, the outputs of the baluns have 175°±10° phrase difference and 4±.5 dB coupling.

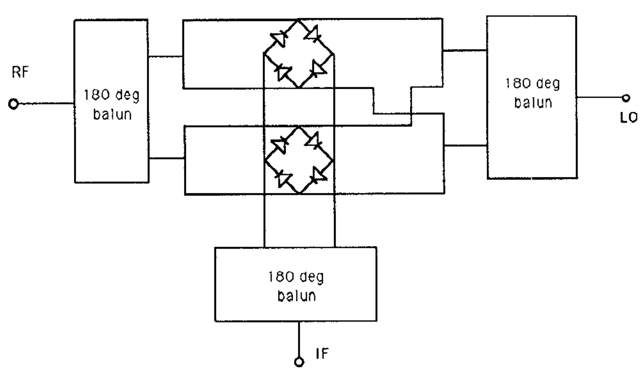

Fig. 1. Block diagram of the double double-balanced mixer.

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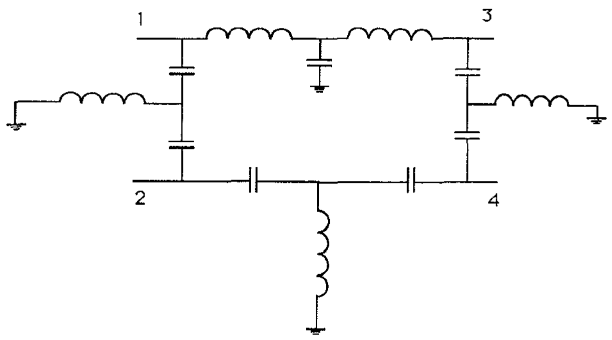

Fig. 2. Schematic diagram of a balun

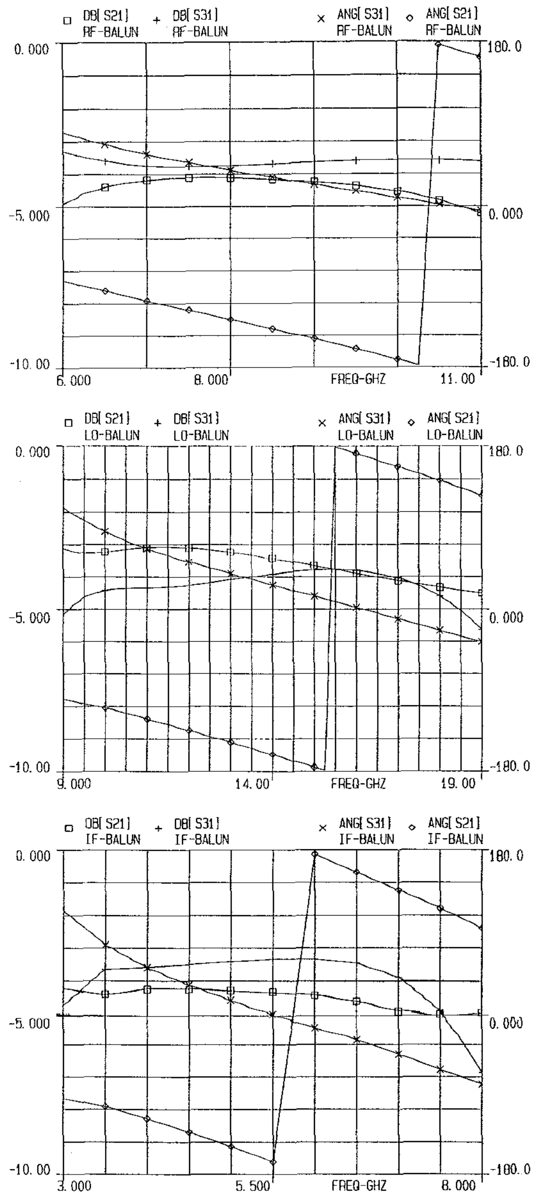

Fig. 3. Simulated performances of the RF, LO, and IF baluns.

The Schottky barrier diodes were fabricated using TRW's baseline MESFET processes [6] . The size of the diode is .5x10 μm. At zero bias, these diodes have a series resistance about 30 ohm , a junction capacitance about 0.04 pf, this corresponds to an f_t of 133 GHz. Process improvement using selective implant process has resulted in substantial cutoff frequency improvement. For the same device structure, the typical f_t is 600 GHz.

To perform impedance matching and interconnection between baluns and diodes, transmission line elements were used. The mixer was analyzed using three different commercially available nonlinear simulation programs: two harmonic balance simulators, Libra and microwave harmonica, and one time domain simulator, Microwave Spice. In general, the agreement between their simulated results is within 1 dB. The simulated conversion loss is less than 10 dB from 7 to 10 GHz of RF bandwidth with a 20 dBm LO drive and fixed IF at 5 GHz, as shown in Figure 4. In addition, we also simulated RF to IF, LO to IF isolation. Figure 5. shows simulated results which predicted more than 26 dB RF-IF isolation and more than 25 dB LO-IF isolation from 7 to 10 GHz. A photograph of the monolithic mixer is shown in Figure 7. The total chip size is 2.5x2.7 mm . Probe pads are included at input/output ports for automatic on-wafer measurements.

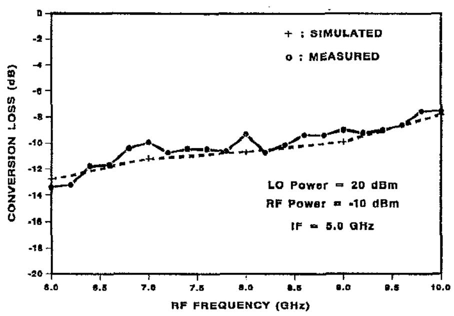

Fig. 4. Measured and simulated conversion loss versus RF frequency.

PERFORMANCE

Monolithic mixer was fabricated using MESFET technology. The measurements were done using automatic on-wafer probe station. Conversion loss and isolations were measured with a fixed IF frequency of 5 GHz. The input power for LO and RF are 20 dBm and -10 dBm respectively. The measured conversion loss is less than 10 dB from 7 to 10 GHz with a minimum of 7.5 dB at 10 GHz. The result is included in Figure 4 to compare with simulations. The agreement is within 1 dB. The measured isolations are shown in Figure 5. The results shows that both RF-IF and LO-IF isolations are better than 25 dB across the band, in good agreement with simulations.

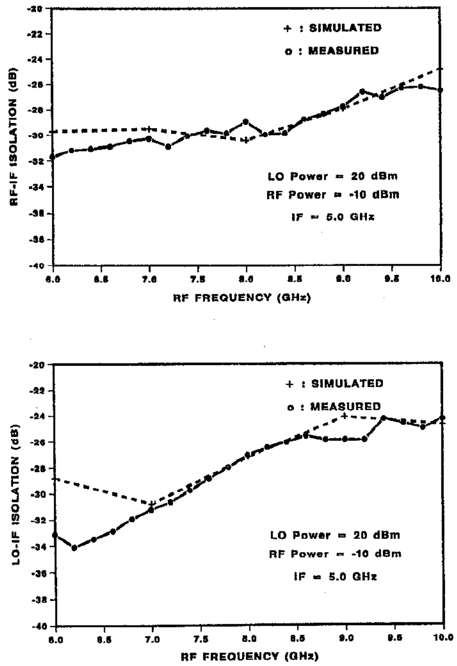

Fig. 5. Measured and simulated isolation.
a) RF to IF isolation versus RF frequency
b) LO to IF isolation versus RF frequency

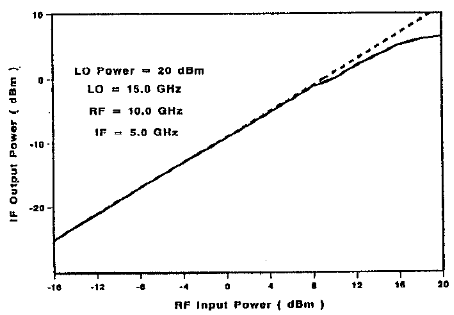

Fig. 6 Measured IF power out versus RF power in

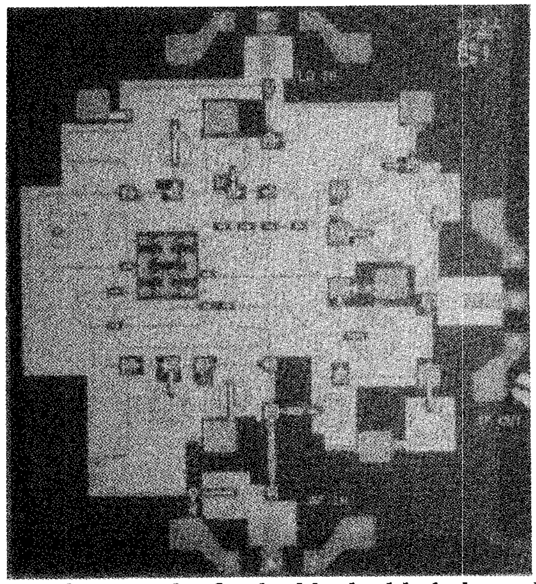

Fig. 7. Photograph of a double double-balanced mixer.

Figure 6 illustrates the power-in-versus-power-out characteristic of the mixer at a RF frequency of 10 GHz. The measured 1-dB compression output power is +3.6 dBm , this corresponds to a RF input power of 14 dBm. The two tone third order intermodulation characteristic of mixer is also measured from 8 to 10 GHz with a LO drive of 20 dBm at 14 GHz. Two frequency separation between the two input RF tones is 5 MHz. The measured input third order intercept points are about 20 dBm, as shown in Figure 8. This result is the highest among the reported monolithic diode mixers and is comparable to the hybrid diode mixers.

CONCLUSION

An X-Band monolithic double double-balanced mixer have been demonstrated. This mixer has exhibited a high input IP3, high 1-dB compression output power, low conversion loss , and good isolations. Further performance improvement is expected with the incorporation of selected implant mixer diodes. Monolithic receivers employ these types of mixer should have significant performance and size advantages over the conventional hybrid receiver.

ACKNOWLEDGEMENT

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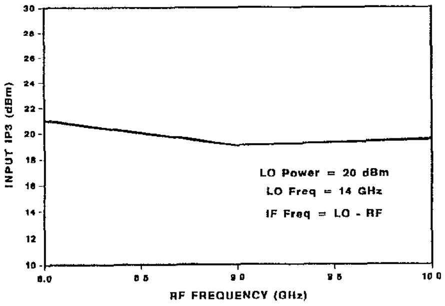

Fig. 8 Measured input IP3 versus RF frequency

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