94 GHz SUBHARMONIC MIXER USING BEAM LEAD DIODES

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ABSTRACT

As part of a diode and mixer development effort,[1] a low cost subharmonically pumped millimeter-wave mixer design using GaAs beam lead diodes has been developed. It adopts a configuration which incorporates both waveguide and suspended stripline using a low cost Duroid substrate. A DSB noise figure of 8.5 dB has been achieved using a 47 GHz Gunn local oscillator and 5- to 500-MHz IF amplifier with a 1.5-dB noise figure.

Introduction

A 94-GHz subharmonically pumped suspended stripline mixer using GaAs beam lead diodes has been designed and fabricated. Using a local oscillator frequency equal to one half of the signal frequency, the mixer has been developed with an aim for low cost applications with little compromise in performance. The mixer incorporates a low cost Duroid suspended stripline substrate onto which is fabricated the LO and RF probe transitions, as well as two 7-element low-pass filters, as illustrated in Figure 1.

GaAs beam lead diodes were fabricated for the mixer using a mesa etch technique. These diodes have a zero bias capacitance of 35 pF and series resistance of 10 ohms which are mounted in antiparallel fashion on the substrate. The substrate is mounted in a split block stripline channel as shown in Figure 2. Similar mixers have been reported previously in the V-, W-, and Y-band regions.[2,3] In this paper, detailed design consideration and performances will be discussed.

Mixer Configuration

LO and signal ports of the mixer use full-height U-band (WR-19) and W-band (WR-10) waveguides, respectively. Both are terminated with tunable back shorts. The LO and signal waveguide axes are perpendicular to each other and are connected by a section of rectangular channel which serves as the housing for the suspended stripline. Signal is coupled to diodes via an E-field probe of a half-guide height. Two filters are required to multiplex the LO, signal and intermediate frequencies. Design of the LO filter adjacent to the diodes is based upon the 7-element L-C ladder, low-pass prototype approximation with a cutoff frequency of 56 GHz to reject the signal frequency and meanwhile pass the LO frequency and IF. The other one is a high/low impedance quarter-wave IF filter to prevent LO leakage into IF. Diodes are located at approximately a quarter wavelength of signal frequency away from the LO filter so that, looking toward the LO and IF ports, an open circuit at signal is presented to the diodes. Similarly, the position of the IF filter is so chosen that, looking toward the IF port, an open circuit is presented to the LO. The separation between diodes and signal waveguide is approximately a half wavelength of signal frequency, which is experimentally determined for the best conversion loss. Filters and diode mounting pads are realized in suspended stripline. Dimensions of the rectangular stripline channel, shown in Figure 1, are chosen to avoid the propagation of higher order waveguide modes. Stripline circuit is made on 0.010 inch thick Teflon board, and circuit pattern is fabricated by standard photolithographic techniques.

The diodes are connected as an antiparallel pair (as seen from the LO port and signal port) and are thermocompression bonded to the mounting pad. The ground return for the diodes is completed through a compression contact on the side metallization of the Teflon board.

The diodes are of beam lead GaAs type, recently developed at Hughes. The zero bias capacitance is in the range of 0.03 pf to 0.04 pf, the series resistance is about 10 ohms, the reverse breakdown voltage of 6 to 7 V at a current of 10 μA, and an n-factor of 1.18.

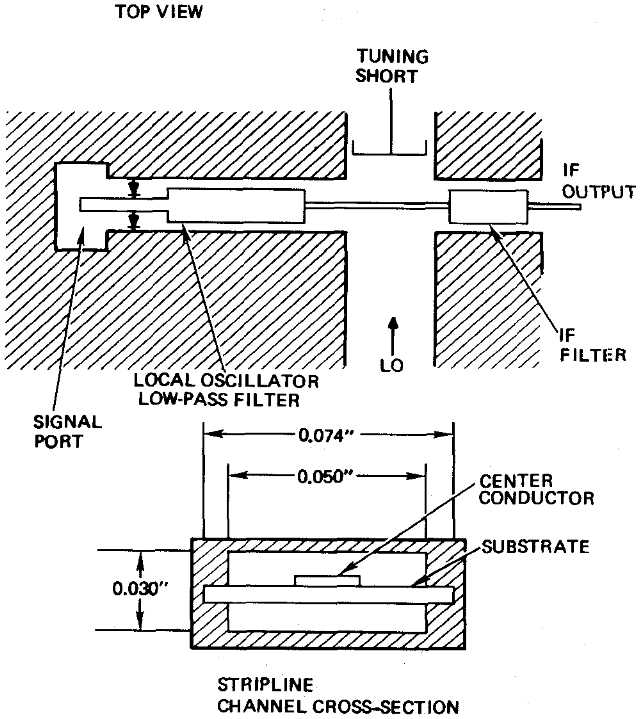

FIGURE 1: CROSS SECTIONAL VIEW OF THE HARMONIC MIXER.

Figure 3 shows the measured I-V characteristics of an antiparallel pair of beam lead diodes. At pumping conditions, the curve will be bent toward the vertical axis and eventually will become a straight line. This observation can be easily used as an indicator of how strongly diodes are being pumped.

Results

A prototype mixer, as shown in Figure 2, has been fabricated and evaluated. Using a Gunn local oscillator at 47 GHz and an IMPATT signal source, conversion loss was measured from IF frequencies of 100 MHz to 1.0 GHz and is given in Figure 4. The data presented is typical for 13-dBm LO power with a fixed tuning short position; some points exhibited lower conversion loss at higher LO power and different tuning conditions. The conversion loss versus LO drive is given in Figure 5. LO VSWR was better than 1.3:1 and signal VSWR was better than 1.4:1 over a 2-GHz band centered at 94 GHz. The noise figure was taken with an argon noise tube and a post IF amplifier chain with a 1.5-dB noise

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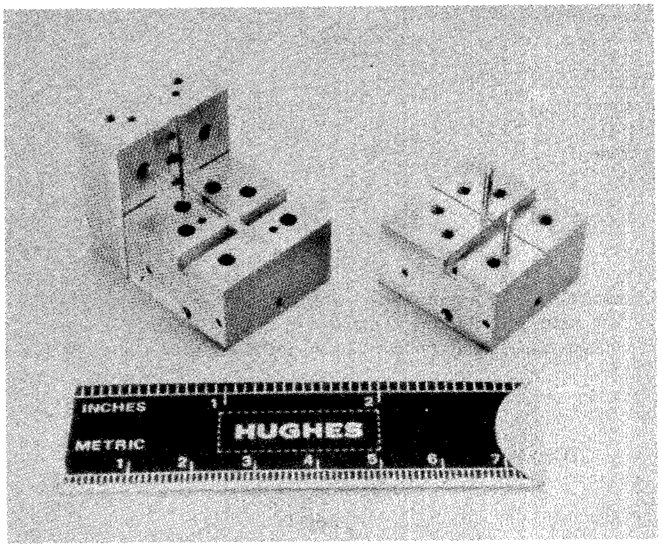
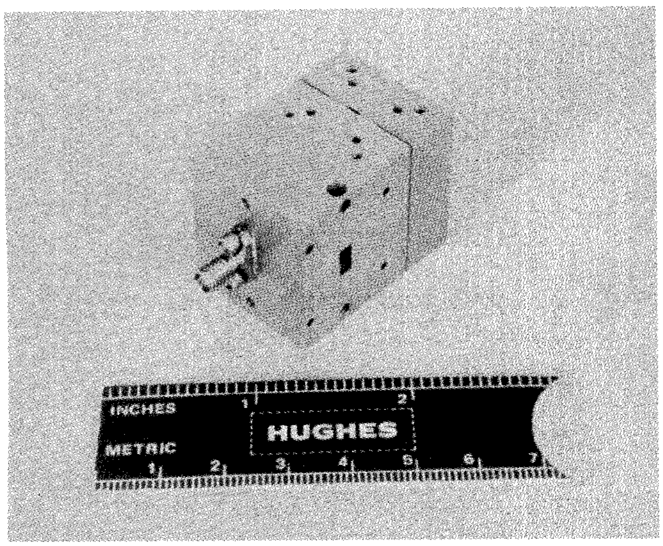


(A) OPEN BODY WITH STRIPLINE



(B) ASSEMBLED BODY

FIGURE 2: HARMONIC MIXER AT 94 GHz.

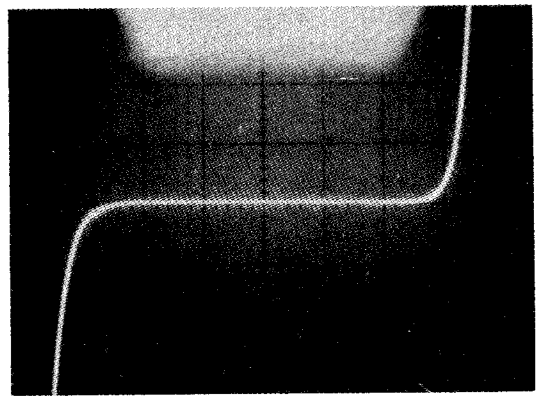


FIGURE 3: ANTISYMMETRIC I-V CHARACTERISTICS ON ANTIPARALLEL DIODE PAIR. HORIZONTAL: 0.2 VOLTS/DIV; VERTICAL: 0.1 mA/DIV

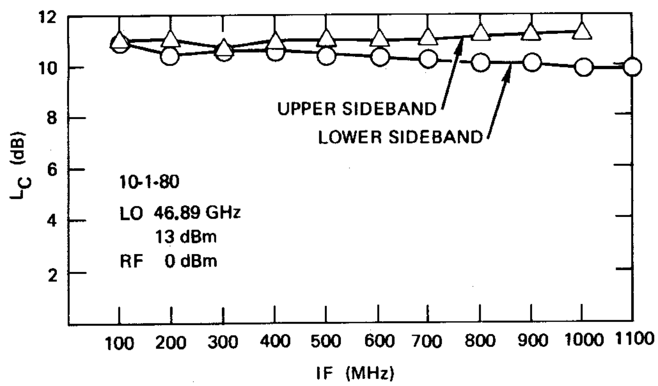


FIGURE 4: CONVERSION LOSS PERFORMANCE.

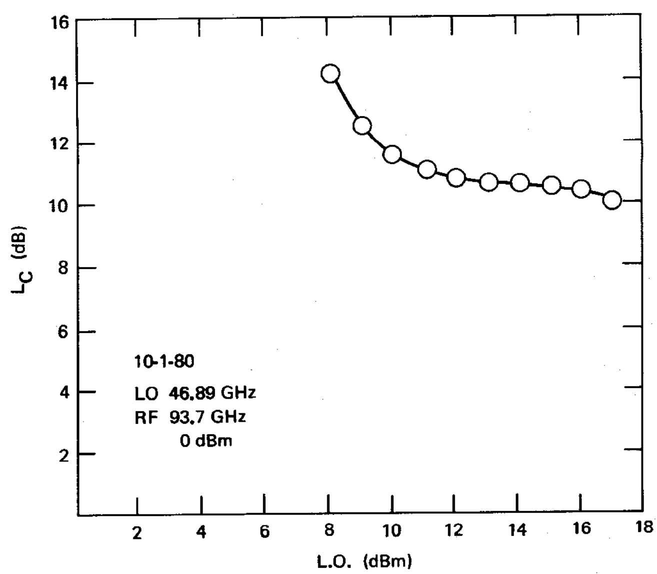


FIGURE 5: CONVERSION LOSS VERSUS LO POWER.

figure and a bandwidth of 500 MHz. A noise figure of 8.5 dB was measured, which includes the IF noise contribution for a fixed tuning short position. The measured second harmonic generation of LO as detected at the signal port is at least 34 dB below the LO input. RF compression is given in Figure 6, and a 0.5 dB compression point is reached at signal input of 7.5 dBm.

Conclusions

A millimeter-wave harmonic mixer incorporating waveguide and stripline has been developed. The mixer design features a low cost approach to high volume production. RF data reveals the possibilities to adapt the mixer for many applications.

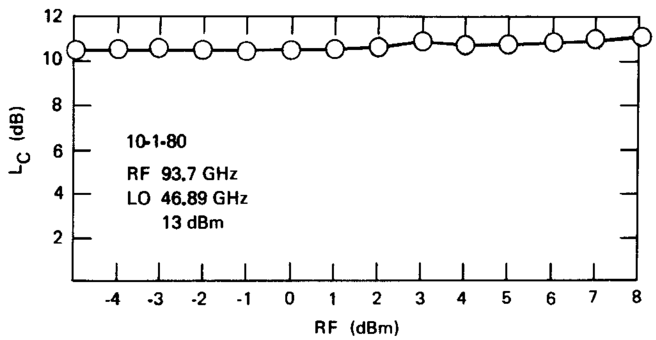


FIGURE 6: RF COMPRESSION.

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