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BEAM LEAD DIELECTRIC CROSSBAR MIXERS FROM 60 TO 140 GHz

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Dielectrically loaded crossbar mixers have been developed for operation from 60 to 140 GHz. Using beam lead diodes and a low cost fabrication technique, conversion losses of 5 dB at V band, 5 dB at W band, and 6.5 dB at D band have been measured.

Introduction

High performance millimeter-wave crossbar mixers fabricated with a metal crossbar structure in a waveguide housing have been previously reported.[1,2] However, for ultra high frequency applications, the metal crossbar structure is extremely difficult to fabricate due to physical size limitation of the waveguide. In addition, fabrication of the metal crossbar structure requires precision machined parts and labor intensive assembly. It is therefore not suitable for low cost mass production. This paper reports the continuing development of a new design approach for the fabrication of the crossbar mixer with GaAs beam lead diodes on dielectric substrates[3]. The present approach utilizes the conventional photolithographic techniques by printing the crossbar structure directly on dielectric substrate materials, such as Duroid, quartz, or semi-insulating GaAs. This mixer design has been successfully fabricated and operated through 140 GHz with excellent performance. In this paper, we will present the design details and performance results of the crossbar mixer for millimeter-wave frequencies.

Mixer Design and Configuration

The mechanical configuration of a dielectric loaded crossbar mixer is shown in Figure 1. A dielectric substrate is sandwiched between two waveguide sections; one serves as an RF input port and the other as a backshort housing. The crossbar mixer circuit consists of a pair of GaAs beam lead Schottky barrier mixer diodes, a LO transition and a low pass filter, all fabricated on a common substrate. All of the circuit elements on the substrate are designed with suspended striplines.

In operation, the RF signal and LO power are fed via the waveguide ports. At the LO port, a waveguide-to-stripline transition is provided for supplying the LO power to the diodes. The IF signal is taken off the opposite side of the substrate via the low pass filter through the side wall of the waveguide housing. The advantage of the crossbar mixer configuration is that the two diodes are connected in series with respect to the RF signals and in parallel with the IF output, yielding higher RF and lower IF impedance levels than can be obtained from a conventional mixer. This configuration provides an improved impedance match condition at both the RF and IF terminals, and hence an inherent broadband performance of the mixer design. In the dielectric loaded crossbar mixer, a dielectric substrate is loaded into the RF waveguide section, which artificially lowers the waveguide impedance and further improves the impedance match to the diodes. In addition, the dielectric loaded crossbar mixer design permits the use of a full-height waveguide design which facilitates fabrication and scaling to higher frequencies.

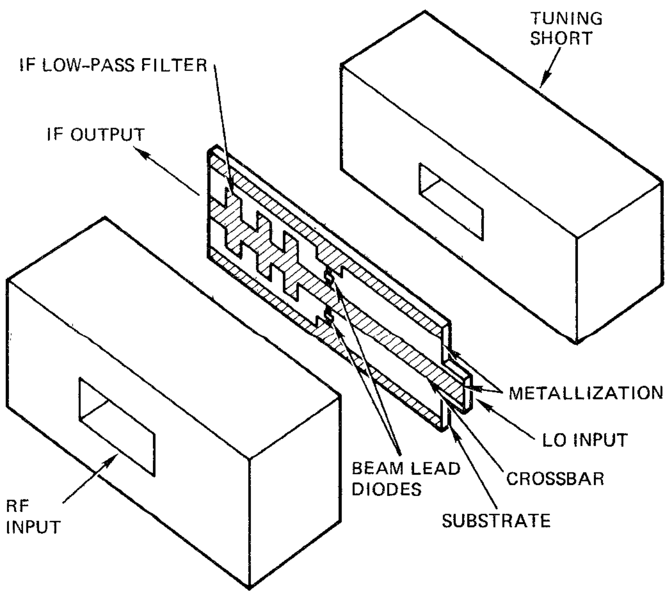

Figure 1. Dielectric loaded crossbar mixer.

Results

Three dielectric loaded crossbar mixers fabricated on Duroid substrates with suspended stripline circuits were evaluated over the V-band (50 to 75 GHz), W-band (75 to 110 GHz), and D-band (110 to 170 GHz) frequencies. Figure 2 shows the mechanical design of the mixers. The design data for the mixers at the three different frequencies are tabulated in Table I.

Table I. Dielectric Loaded Crossbar Mixer Design Data

	60 GHz	94 GHz	140 GHz
LO waveguide	WR-15	WR-10	WR-6
Substrate thickness	10 mils	10 mils	5 mils
Stripline channel	29x74 mils	29x50 mils	15x32 mils
Dielectric substrate	Duroid	Duroid	Duroid

The conversion loss of these three mixers was measured over the three frequency bands. Figure 3 shows the conversion loss of the dielectric loaded mixers measured over V, W, and D band. The typical conversion loss was 5 to 8 dB over an IF range of 0.5 to 8 GHz at V band and 5 to 9 dB over an IF range of 0.1 to 3 GHz at W band. The conversion loss of the D band mixer was typically 6.5 dB over the IF range from 11 to 12.5 GHz and 9 dB over the IF range from 15 to 18 GHz. A maximum conversion loss of 11.5 dB was measured over the IF range from 12.5 to 15 GHz for the D band mixer due to a resonance in the IF circuit. Over a lower IF range, a 7 to 8 dB conversion loss was measured from 0.2 to 2.6 GHz.

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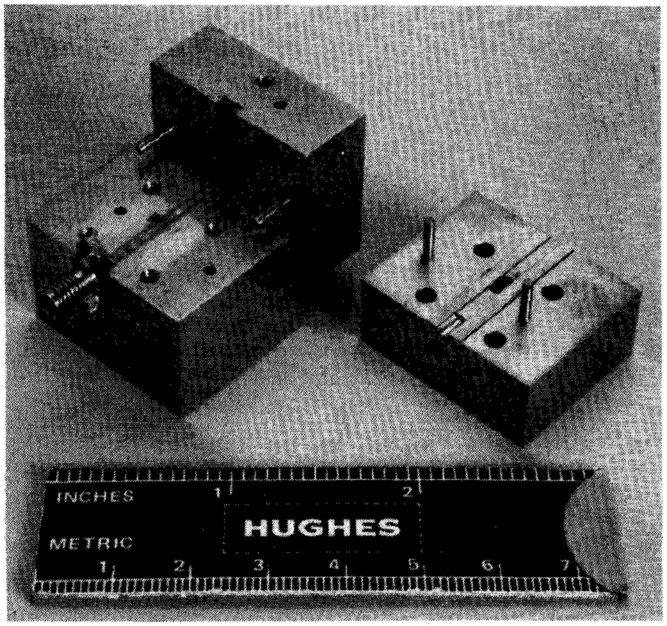

Figure 2. Dielectric loaded crossbar mixer assembly.

Conclusion

Improvements in the design of the dielectric crossbar mixer have reduced its noise figure, increased the IF bandwidth, and extended the frequency of operation. Its simple mechanical design and use of beam lead diodes makes it attractive for low cost, high performance applications. With its inherent wideband properties, it can serve in a wide variety of applications for communications, radar and EW systems.

References

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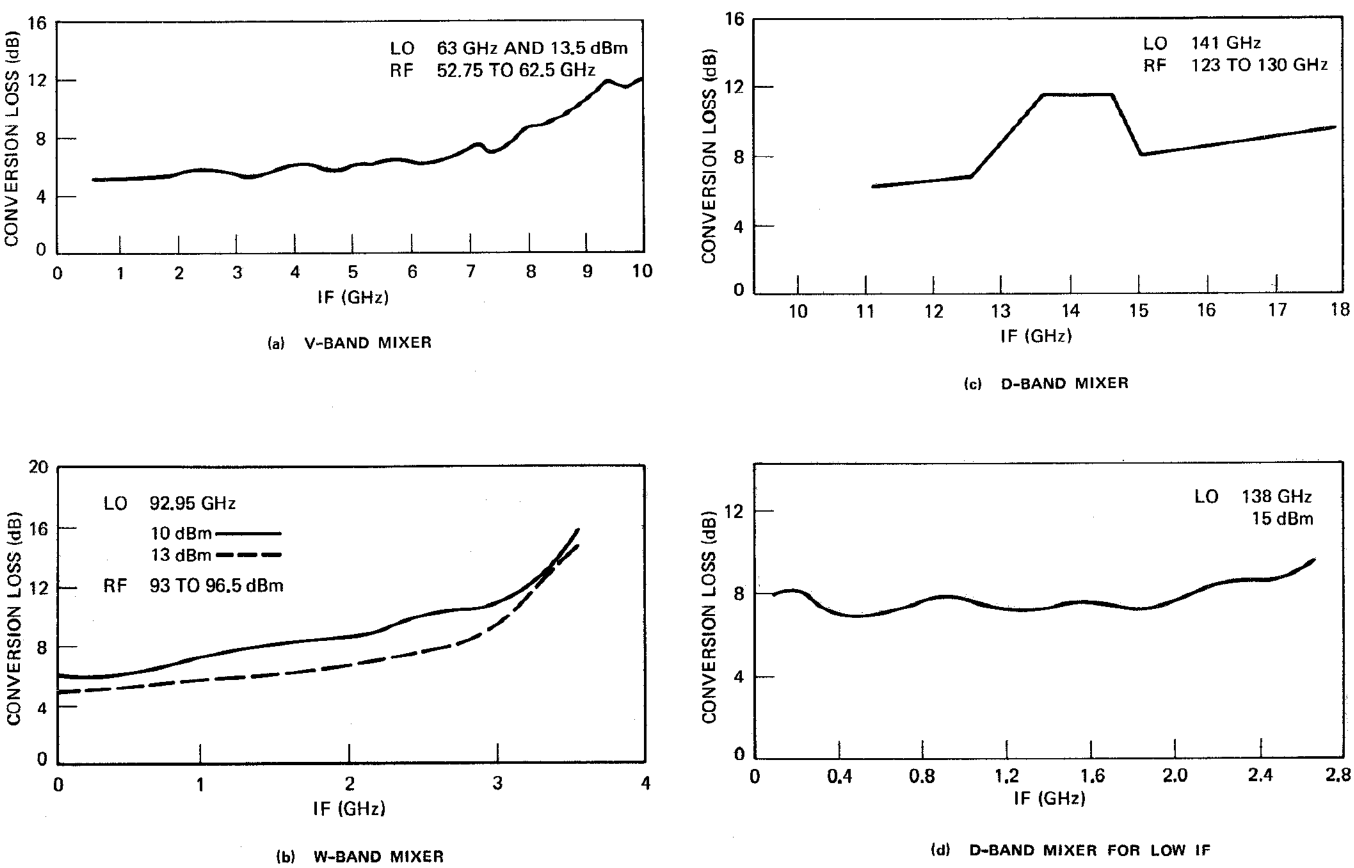

Figure 3. Measured conversion loss of crossbar mixer.