LOW COST MM-WAVE DIELECTRIC LOADED MIXER

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Abstract

A 60 GHz mixer compatible with beam lead diodes using a novel circuit configuration incorporating dielectric loaded waveguide, stripline and coaxial transmission lines has been designed and fabricated. The mixer was developed for low-cost, high volume applications.

Summary

I. Introduction

Under a diode and mixer development program,[1] a new, low-cost millimeter-wave balanced mixer design using beam lead diodes has been developed. It adopts a configuration which incorporates several transmission line media as shown in Figure 1. Similar mixers have been reported previously for their broad band characteristics in the K-band region. With the aid of dielectric loading, the task of RF matching is substantially reduced which simplifies the design of the mixer for higher frequency operation. The mixer was successfully operated in the 60 GHz range with performance competitive with the waveguide mixers.

II. Mixer Configuration

Both signal and L.O. ports use full height V-band waveguides (WR-15) terminated with tunable back shorts. L.O. power is coupled to the diodes via an E-field probe of a half guide height. A low pass filter, made of sections of quarter-wave high/low impedances in cascade, is used in the IF circuit. Spacing the first low impedance section close to an odd multiple number of quarter-wave lengths away from the diodes optimizes the L.O. match of the diodes. Both IF and L.O. circuits are fabricated in coax with an O.D. of 0.034 inches.

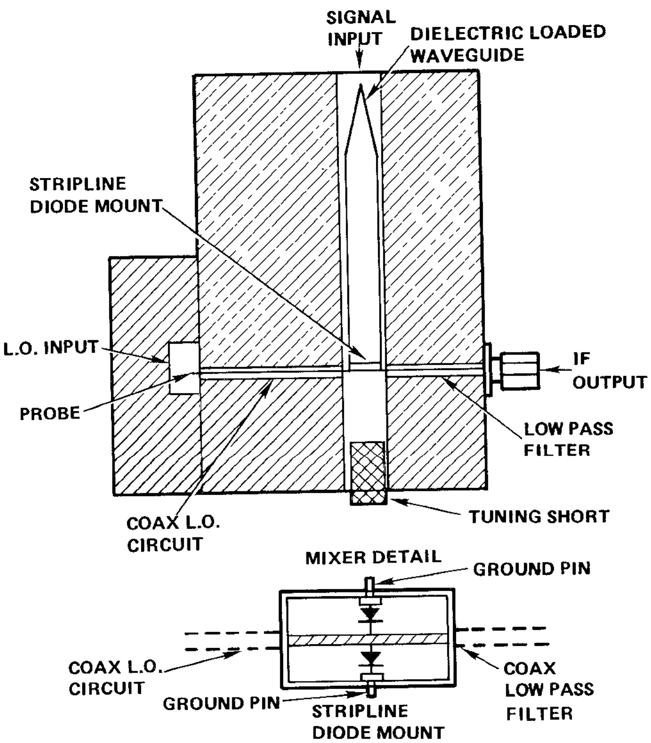

Figure 1 Dielectric loaded mixer.

A pair of beam lead mixer diodes, with polarities oriented as indicated in Figure 1, are thermocompression bonded to the metallization etched on the 0.008" quartz stripline mount. A chrome-copper-gold metallization is sputtered on the polished quartz. The ground return for the diodes is completed through metallic pins which contact gold ribbons to which the diode leads are bonded.

The diodes are of commercial beam lead GaAs type. Under normal L.O. pumping conditions, the diodes have a junction resistance of 125-150 ohms at 2 GHz.[2] The zero bias capacitance is in the range from 0.04 pf to 0.08 pf and the lead inductance is about 0.3 nh. In order to physically accommodate two diodes as shown in Figure 1, the height of the guide has to be kept a minimum of 0.060 inch. Instead of reducing the waveguide height for impedance matching, dielectric loading is used. The transition into the dielectric loaded waveguide is formed by linearly tapering the dielectric. The mixer diode end of the dielectric has a flat surface and contacts the diode mount.

III. Circuit Design Consideration

Excluding the discontinuities, the equivalent signal and L.O. path circuits can be simply represented as shown in Figures 2 and 3. The two diodes appear in series for the signal circuit and in parallel for the L.O. circuit, a condition amenable to broad-band matching of both signal and IF paths. Assuming that the reactive part of diode impedance and circuit discontinuities can be compensated by the back short tuning,

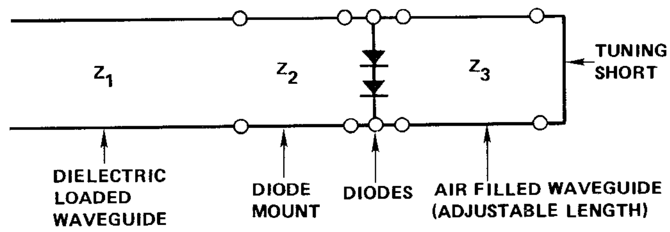

Figure 2 Signal path equivalent circuit.

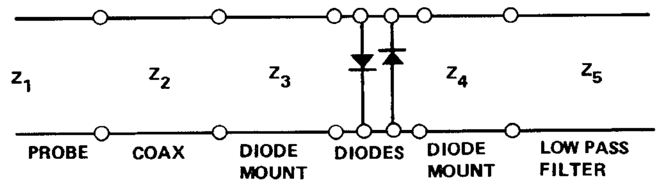

Figure 3 L.O. equivalent circuit.

the transformed diode resistance is the primary loading element to the signal circuit. With two in series, the total transformed diode resistance is on the order of 100 ohms, which suggests the application of dielectric material such as Teflon for matching purposes.

IV. Results

A prototype mixer has been fabricated and tested with various dielectric loading materials, such as air, Teflon and boron nitride. A picture of the mixer fixture is given in Figure 4. Using a klystron local oscillator at 58.2 GHz and an IMPATT signal source, conversion loss was measured from I.F. frequencies of 100 MHz to 1.2 GHz. The best result is obtained with Teflon and is shown in Figure 5. The data presented was typical for 12 dBm local oscillator power, although some points exhibited lower conversion loss at slightly higher L.O. drive. L.O. return loss was 10 dB, which can be caused by unbalanced diodes and discontinuities at the coax/stripline interface. The noise figure of the Teflon-loaded mixer was taken with an Argon noise tube and a post IF amplifier with a 2.5 dB noise figure. The data shown in Figure 6 is given for a fixed tuning short position. A noise figure of 7.6 dB has been measured and a spot noise figure of 6.8 dB was observed with slightly higher L.O. pumping. Results quoted here are comparable to that reported previously using similar diodes in a subharmonically pumped mixer.[3]

V. Conclusions

A new design concept for millimeter-wave mixers incorporating several transmission line media has been developed. The mixer design features a low cost approach to high volume production. The design can be extended toward wider instantaneous bandwidths, lower conversion loss and higher operating frequencies.

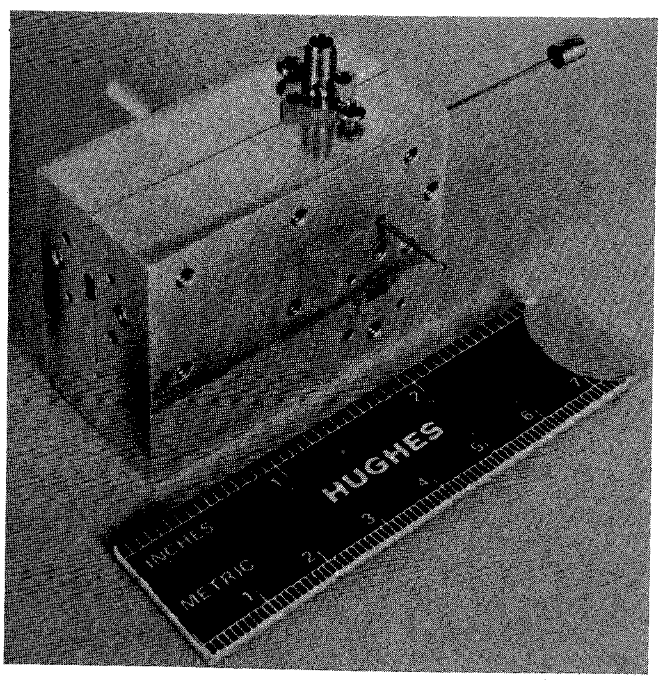

Figure 4 Mixer fixture.

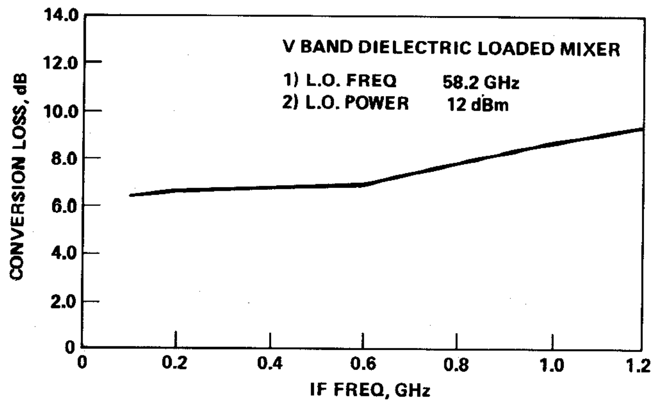

Figure 5 Optimized conversion loss performance.

Acknowledgments

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References

1. This work is supported by U.S. Army Electronics Research and Development Command, Fort Monmouth, New Jersey, under Contract DAAB07-78-C-3002. Samuel Dixon is the Program Monitor.

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3. E. Carlson, M. Schneider, and T. McMaster, "Subharmonically pumped Millimeter-Wave Misers," IEEE. Trans. Microwave Theory Tech., Volume MTT-26, No. 10, pp. 706-715, October 1978.

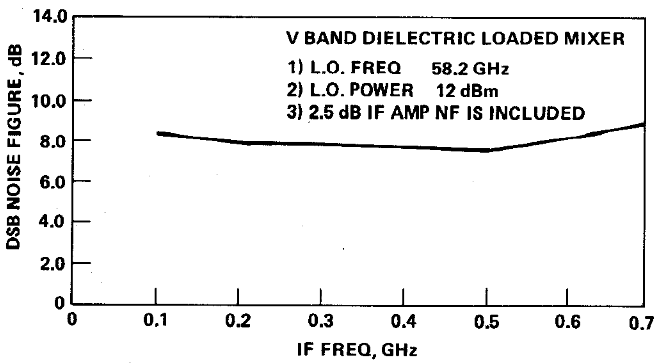

Figure 6 Noise figure performance.