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A Harmonic Mixer for the 20–40-GHz Range

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Abstract —**The design and performance of a wide-band harmonic mixer are described. The circuit is built on a microstrip substrate and uses a single GaAs Schottky-barrier diode.**

I. Introduction

Many of the emerging requirements for millimeter-wave applications involve augmentation of existing systems. Small size, in addition to low cost, is frequently crucial to the success of such an extension program. A wide-band harmonic mixer was designed and fabricated to meet the needs of such a subsystem application and the results are reported in this paper. The LO frequency is 2 GHz, the RF range is 20–40 GHz and the IF frequency is 100 MHz, nominal. The use of stripline circuits for harmonic mixers in the microwave region has been previously reported [1], [2] and similar devices built in waveguide circuits are commercially available. However, the use of hybrid, lumped element, and microstrip techniques shown here should give size and cost advantages while providing comparable performance.

II. Description of the Mixer Circuit and Construction

The circuit is shown in Fig. 1. The diode is a commercial, Alpha type DMK 6606. It is a beam-lead GaAs Schottky-barrier diode. The manufacturer's data sheet gives a capacitance of 0.1 pF and a cutoff frequency of 300 GHz at 0 V. This leads to a series resistance of about 5 Ω. The wide separation of frequencies at the three ports permits the use of simple, mostly lumped element isolation filters. Sections of transmission line are used for impedance matching except at the IF port where some lumped elements are also used.

A photograph of the harmonic mixer is shown in Fig. 2. The circuit is fabricated on a 10-mil RT/Duroid 5880 substrate. The size of the substrate is 0.475 in×0.655 in The diode is grounded on one end by a pair of plated through holes. The RF ground is enhanced by the use of $\lambda/4$ (at 30 GHz) radial sector line. A 0.7-mil-diameter gold wire serves as a grounded inductor at the RF port. The series capacitor at this port has a value of 0.1 pF, which appears small for a coupling capacitor; however, most of

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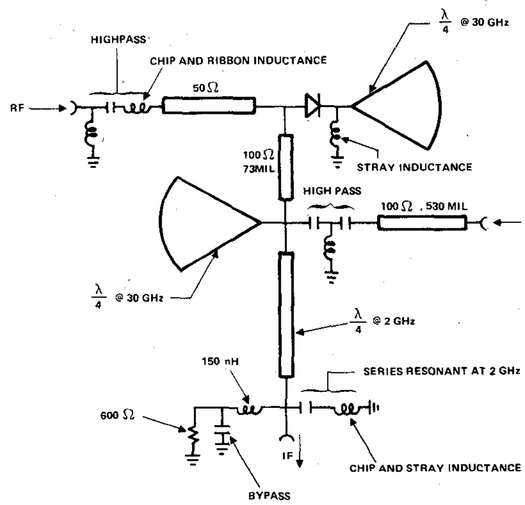

Fig. 1. Circuit diagram of the harmonic mixer.

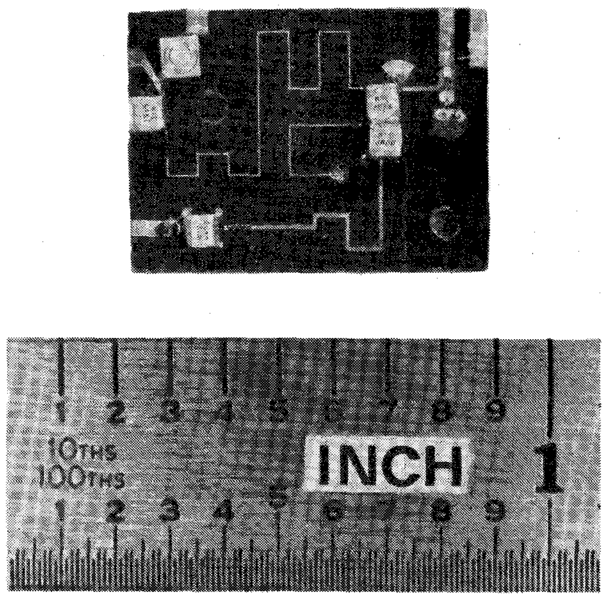

Fig. 2. The harmonic mixer substrate with all the circuit elements attached.

its reactance at RF frequency is cancelled by its "parasitic" inductance and the inductance of a ribbon used to connect it on one end. Its high reactance at 2 GHz helps in rejecting the LO signal. All the capacitors are ceramic chip type. The bias resistor is a fixed value of 600 Ω selected for optimum performance across the band.

III. Performance

The mixer was mounted in a test housing with SSMA connectors at all three ports. A coax to waveguide transition was used at the RF port for tests. All the data reported here is for a fixed LO frequency of 2 GHz and an LO power of +20 dBm. Fig. 3 shows the conversion loss for different harmonic numbers. No adjustments were made to optimize the performance at each frequency. The conversion loss increased somewhat with lower LO power and there was no significant improvement at higher power levels. Fig. 4 shows the LO to RF isolation. A calibrated spectrum

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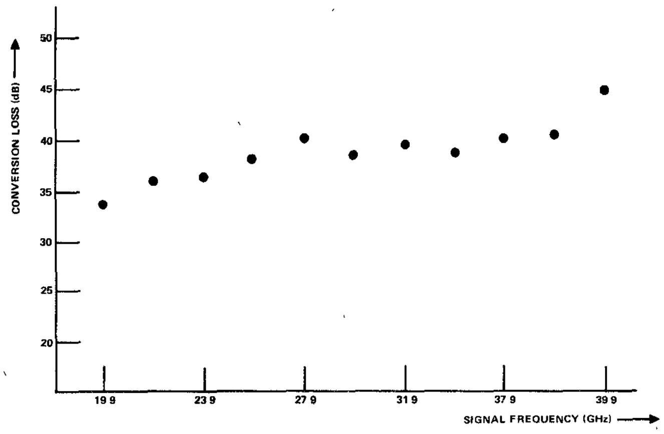

Fig. 3 Conversion loss versus frequency. Each point corresponds to a different harmonic of the 2-GHz LO.

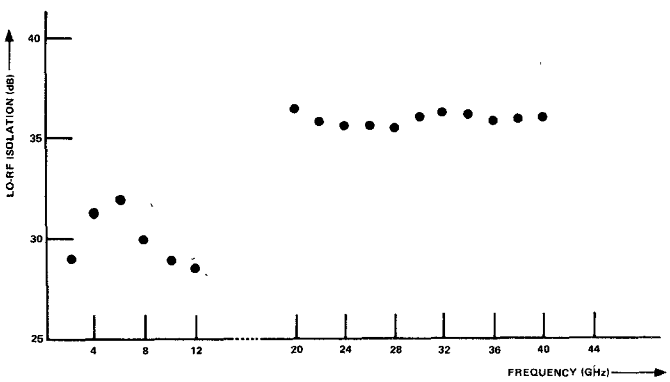

Fig. 4 LO–RF isolation for the LO fundamental and its harmonics.

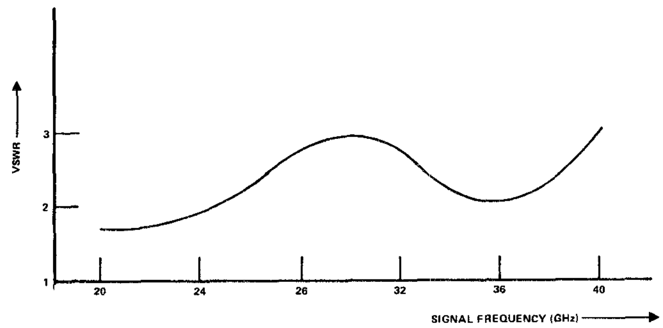

Fig. 5 VSWR at the RF port as a function of frequency.

analyzer was used to measure output at the RF port. Fig. 5 shows VSWR at the RF port. A second unit was built and exhibits similar results. The performance is adequate for most applications.

IV. Conclusion

A wide-band harmonic mixer designed for millimeter-wave applications that offers attractive size, cost, and performance features has been demonstrated.

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