# A W-BAND WIDEBAND CROSSBAR MIXER

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Abstract

A broadband mixer using crossbar structure is described. This mixer achieves a fixed tuned instantaneous RF and IF bandwidth of greater than 20 GHz with SSB conversion loss of less than 7.5 dB.

## Introduction

The key element in receiver design is the mixer. Previous EHF mixers have had narrow bandwidth of only a few percent. Present mixer design has both a wide RF bandwidth and a wide IF bandwidth which allows configuration of receiver subsystems with frequency coverage extending into the EHF bands. Consequently, fewer EHF input multiplexers, mixers, and local oscillators are required. The mixer has instantaneous RF and IF bandwidth of greater than 20 GHz. The local oscillator requirement for the unbiased mixer is approximately 20 mW. In this paper, design consideration and performance will be discussed.

## Mixer Design

A well known crossbar configuration[1] shown in Figure 1 was selected for our development because it offers minimum band limiting parasitics. Electrically, the two diodes formed a balanced configuration and are connected in parallel with respect to the IF circuit, and in series with respect to the RF circuit, thus yielding a higher RF and a lower IF impedance level. This provides an improved impedance match condition at both the RF and IF terminals. Local oscillator signal is applied to a separate waveguide oriented orthogonal to the signal waveguide. This arrangement can provide very good RF-LO isolation (generally greater than 25 dB). The IF signal is extracted via the crossbar through a five element low pass filter.

For the best possible performance, Schottky barrier honeycomb diode chips were used.[2,3,4] Typical diode characteristics are listed in Table 1.[5] Because the diode diameter is only 2 μm, a carefully etched contacting whisker with a 1 μm tip radius is used. Diode contact is accomplished by using a differential micrometer and a curve tracer. After contacts are made, a DC verification of diode characteristics is needed to insure proper diode contact. The IF filter is another key component in the mixer design. This filter must be able to provide a good match at IF frequencies, but appears as a short circuit at RF and LO frequencies. Computer aided design was used for the filter optimization. Figure 2 shows a sketch of a microstrip filter on a five mil thick Duroid substrate and its frequency response.

Figure 3 is a photograph of the completed W-band crossbar mixer. This photograph clearly illustrates the compactness of the design (.25" x .75" x 1.25"). RF and LO ports have been filled with low loss foam material to prevent contaminent from entering the waveguide. High frequency OSSM connector is used at the IF port to prevent any higher order mode propagations in the coaxial structure.

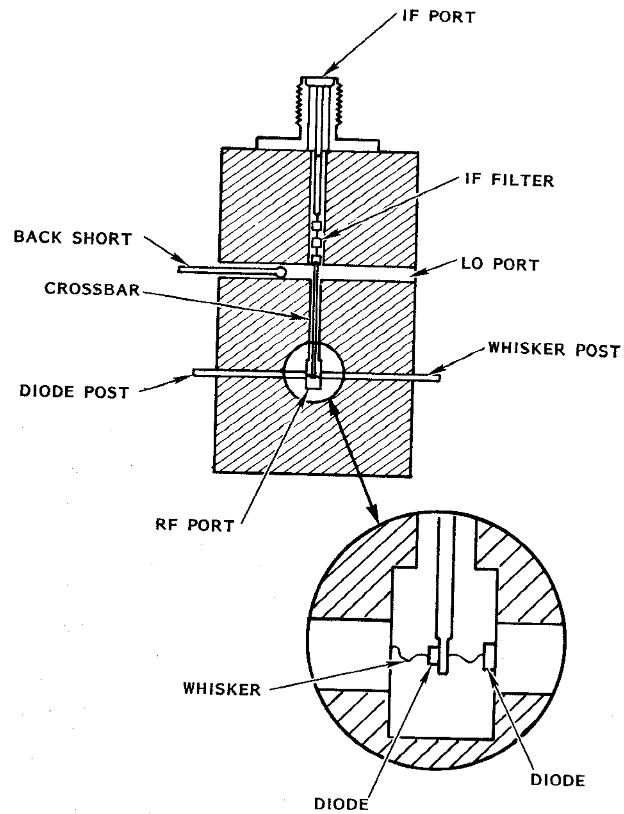


Figure 1. Cross-Sectional View of the Crossbar Mixer

Table 1. Characteristics of Gallium Arsenide Schottky-Barrier Diode at Room Temperature

| PARAMETER | DOPING $3 \times 10^{17}$ $cm^{-3}$ THICKNESS $0.5 \pm 0.25$ um | |
|---|---|---|
| SUBSTRATE | ORIENTATION<br>TYPE<br>DOPING | (1 0 0)<br>n<br>$2\text{-}3 \times 10^{8}$ $cm^{-3}$ |
| DIODE DIAMETER | 2 um | |
| $R_S$ | 5 ohm | |
| $C_{JO}$ | .007 PF | |
| $V_B$ | -8 V | |
| n | 1.2 | |

 

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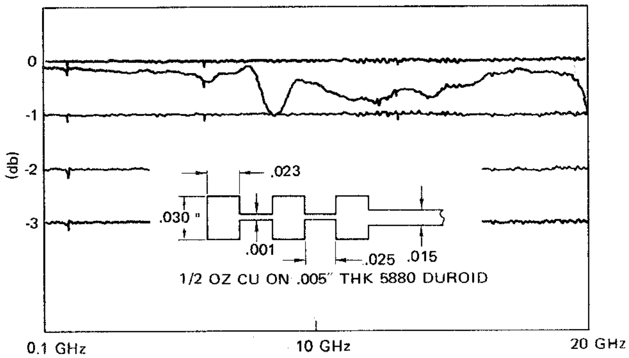


Figure 2. IF Filter Insertion Loss vs. Frequency

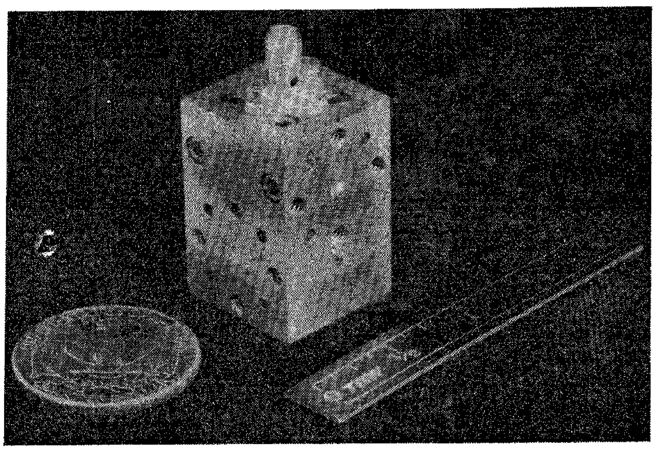

Figure 3. Photograph of W-Band Wideband Mixer

## Results

The completed mixer was initially tested across the 90 to 100 GHz band. The conversion loss measurement data of Figure 4 shows a SSB conversion loss of less than 5.6 dB over 12 GHz RF and IF bandwidths. The noise figure was measured using a calibrated noise tube. Figure 5 shows a plot of the SSB noise figure excluding IF amplifier noise contributions. Notice the measurements were made only up to an IF frequency of 8 GHz due to availability of test equipment. Following these results, the mixer was returned to obtain even wider instantaneous RF and IF bandwidth. The data in Figure 6 shows an instantaneous IF bandwidth extending from 1 GHz to 26 GHz with a corresponding signal bandwidth of 80 to 106 GHz. This bandwidth was obtained with a conversion loss of less than 7 dB over most of the band with 8.7 dB being the worst case.

## Conclusion

A waveguide crossbar mixer was developed which achieves broadband and state-of-the-art performance. The present design can also be used for scaling to other millimeter wave frequencies.

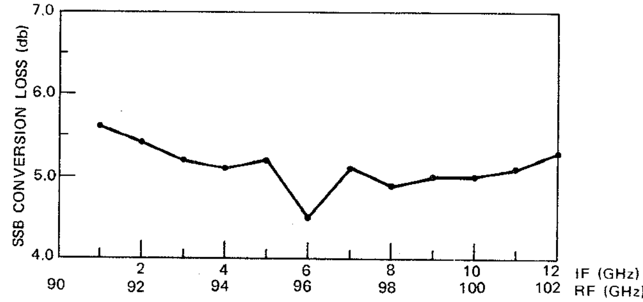


Figure 4. SSB Conversion Loss vs. Frequency

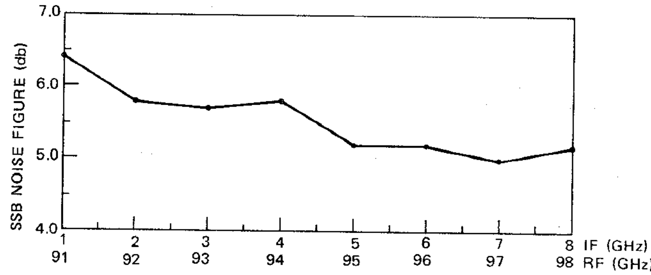


Figure 5. SSB Noise Figure vs. Frequency

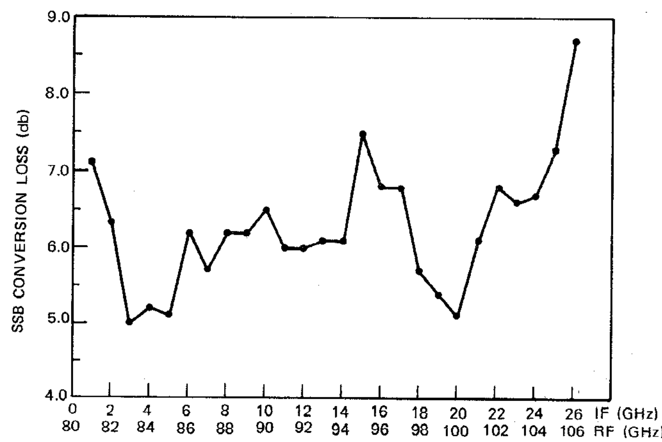


Figure 6. SSB Conversion Loss vs. Frequency

## Acknowledgements

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