A LOW NOISE BROADBAND Ka-BAND WAVEGUIDE MIXER

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Abstract

A Ka-band waveguide double-balanced mixer is described which has low noise and broadband performance. A double sideband noise figure of 5.9 dB was achieved. The mixer is capable of operation over a frequency range from 26 to 40 GHz. A unique mixer configuration for achieving double-balanced mixer operation is described. The new mixer configuration simplifies the problems encountered in fabricating a double-balanced waveguide mixer at Ka-band

Summary

This paper describes a new concept for the fabrication of a Ka-band double-balanced waveguide mixer which has low noise and broadband performance. The design combines the attributes of conventional waveguide balanced mixer designs together with crossbar, back-to-back diodes, and waveguide mixer mounts as described by Dickens.[1] He utilized a crossbar structure with two back-to-back diodes connected across the broad walls of a single waveguide to achieve broadband impedance matching. The disadvantage of the crossbar mixer is that the mixer operates basically as a single ended mixer. In the present design, two back-to-back diode pairs of opposite polarities connected in a double-crossbar structure are housed in a dual waveguide mount as illustrated schematically in Figure 1. The transformers schematically represent the technique to apply RF signal and local oscillator power to the individual diodes. It should be noted that the orientation and connection of the four diodes provide the required symmetry for a double-balanced mixer operation.

In actual operation, RF signal and local oscillator power are fed to the individual waveguide ports via either a folded hybrid tee or a short slot hybrid coupler. The IF signal is taken out from the center of the diode pairs through the common waveguide wall. The operation principle of the present mixer design is basically the same as that of a double-balanced star mixer/modulator.[2] The design possesses the same advantage as the four-diode star mixer/modulator by having a single node for the IF output, which permits either dc or capacitively coupled connections. No RF choke is required at the IF port. A novel feature of the design is the special configuration of the mixer diode arrangement in the waveguide mount which replaces the design of a four-port waveguide hybrid junction required for the star mixer/modulator described by Mouw.[2]

Figure 2 shows the mechanical configuration of the waveguide mixer at Ka-band. It consists of a folded hybrid tee coupler, a sidewall panty adapter, two diode wafer mounts, and a back short housing (back shorts not shown). The wafer mounts were fabricated with four Si Schottky barrier diodes. The back short housing also serves as a mounting block for the wafer mounts. RF signal and local oscillator power are fed to the corresponding waveguide ports of the folded hybrid tee coupler. IF output is taken out via a coaxial line between the two wafer mounts. The special double crossbar arrangement of the mixer diodes, as shown in Figure 3, provides not only the symmetry required for a double-balanced mixer, but also a broadband impedance match condition for matching the diodes to the waveguide and the IF coaxial line impedances. This is possible because the two diodes in the waveguide are connected in series with respect to the RF signals and in parallel with the IF output, thus yielding a higher RF and a lower IF impedance level than that of a single diode mixer.[1] The improved impedance match condition at both the RF and IF terminals results in broadband performance of the mixer design. Another outstanding feature is that the IF output of the mixer is taken out from the sidewall of the waveguide, which is at the minimum of the RF fields. This, plus the symmetrical arrangement of the diodes, virtually eliminates RF signal and local oscillator power leakages. As a result, no RF chokes are required for the IF output port. Therefore, broadband performance of the mixer is further enhanced since the RF choke that imposes severe band-limiting performance at both the RF and the IF terminals is eliminated. The major bandwidth limiting elements are, therefore, those of the hybrid coupler and the parasitic reactances of the mixer diodes.

The working principle of the design concept has been demonstrated by the performance of a Ka-band double-balanced mixer fabricated in the double crossbar waveguide structure as shown in Figure 2. RF measurements were performed by directly integrating the mixer with a 600 MHz IF amplifier having a 1.5 dB noise figure. A double sideband (DSB) noise figure of 5.9 dB was measured at a fixed tuned frequency of 38 GHz. An instantaneous RF bandwidth of 6 GHz with VSWR less than 2:1 was achieved. The bandwidth limiting performance was primarily due to the bandwidth limitation of the folded hybrid tee coupler used. A broadband noise figure measurement was performed by using two hybrid couplers to cover an RF bandwidth from 26.5 to 40 GHz. Figure 4 shows the measured noise figure vs frequency with the mixer fixed tuned at 38 GHz, and the LO drive power to the mixer at different frequencies. Figure 5 shows a plot of VSWR of the mixer over a 6 GHz bandwidth.

In conclusion, the performance of the dual guide double-crossbar mixer has demonstrated the working principle of the design concept. The DSB noise figure can be improved by selecting matched high quality mixer diodes. In addition, an interface impedance match between the mixer and the IF amplifier can be performed to improve the noise figure.

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References

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2. R. B. Mouw, "A Broadband Hybrid Junction and Application to the Star Modulator," IEEE Trans., Vol. MTT-16, No. 11, November 1968.

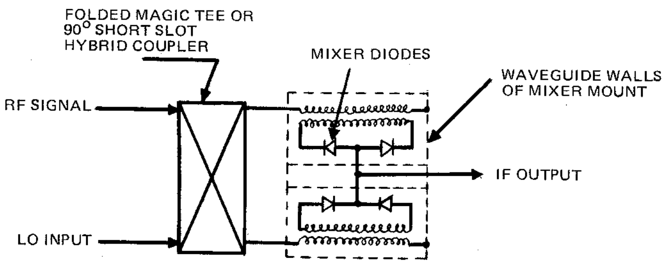

Figure 1. Schematic Diagram of the Double-Crossbar Waveguide Mixer

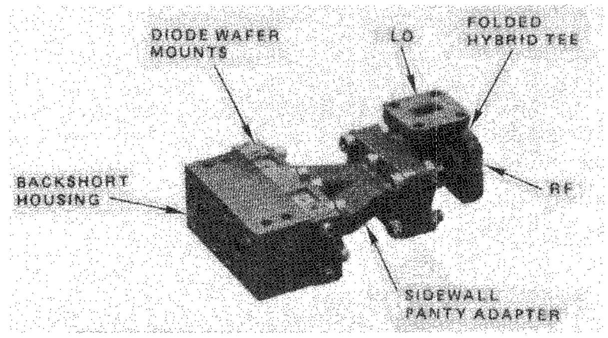

Figure 2. Mechanical Configuration of the Double-Crossbar Ka-Band Mixer

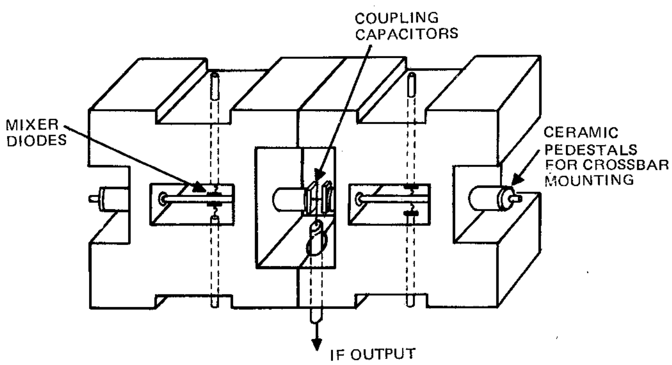

Figure 3. Double-Crossbar Mixer Assembly

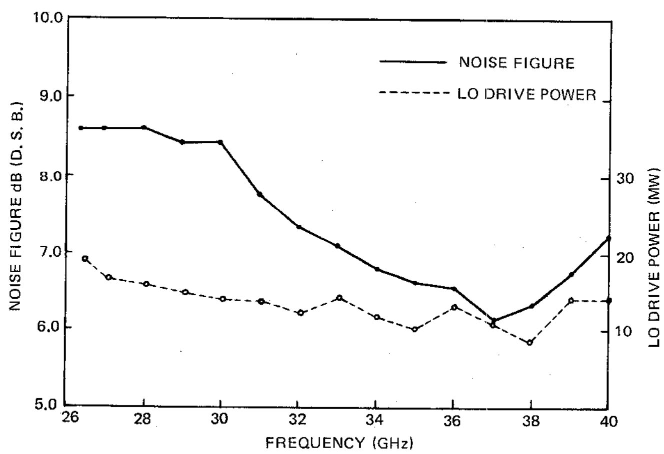

Figure 4. Noise Figure vs Frequency

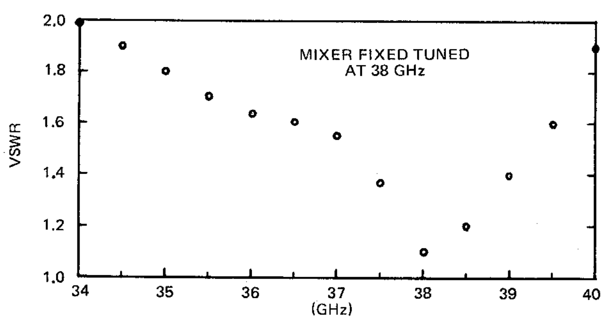

Figure 5. VSWR vs Frequency