AN 18 - 40 GHz DOUBLE BALANCED MICROSTRIP MIXER

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ABSTRACT

An analytical design approach has been used to develop a broadband planar mixer for continuous operation in K- and Ka-bands. The double balanced design, fabricated on fused quartz, exhibits excellent conversion loss and isolation characteristics, and can be used with either coaxial RF connectors (K-Connector) or integrated directly with other planar components.

INTRODUCTION

In nearly all broadband receiver systems the double balanced mixer has become the primary frequency conversion element. At frequencies below 18 GHz, most designs are fabricated using planar circuit techniques which offer advantages of reproducibility, ease of assembly and excellent amplitude/phase tracking. However, at frequencies above 18 GHz, most mixer structures rely on waveguide and finline techniques which tend to be limited to relatively narrowband operation. Some planar mixers operating in this frequency range have been previously developed, but they too tend to be narrowband.

A novel design approach and analytical method, which was used to develop a broadband double balanced mixer for 18 to 40 GHz operation, will be presented. The resulting mixer is completely planar and can be fabricated on a single fused quartz substrate. A combination of transmission line techniques such as parallel plate, microstrip, slotline and suspended coupled strips were incorporated to their best advantages in the balun structures. The simplified transmission line model, shown in Figure 1, helps to illustrate the design concept.

MIXER DESIGN

The mixer uses a parallel plate transmission line balun on the LO port which, through an IF diplexing structure, connects to two nodes of a diode ring. The RF signal is coupled to the remaining nodes of the diode ring through a Marchand- like planar balun [1, 2]. The diode ring is formed by connecting the top surface mounted matched diode pair to the bottom surface mounted pair via plated holes. Thus, the center connections of each pair are odd mode aligned with the tapered balun while the plated holes are odd mode aligned with the coplanar strip output of the RF balun. The resulting structure is orthogonal and exhibits excellent balance.

In order to achieve the desired bandwidth, careful modeling must be conducted. Beam lead GaAs Schottky barrier mixer diodes were characterized by automated network analyzer measurements of shunt mounted diodes in quartz circuits similar to the mixer. A standard diode RF model, fitted to this data, was used in the circuit design.

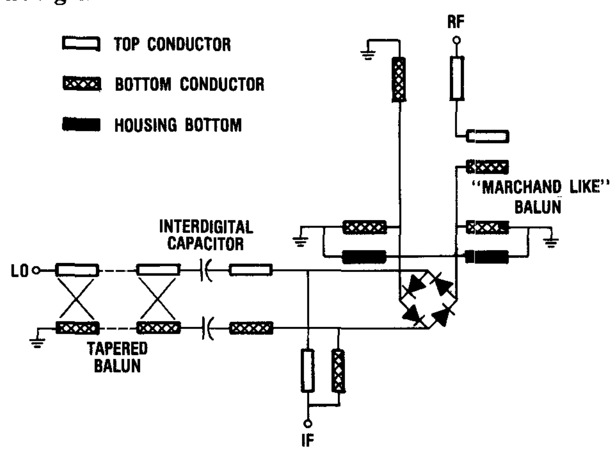

Figure 1 Mixer transmission line model.

Circuit modeling is crucial at the diode/RF balun junction and the diode/IF diplexer junction areas[3]. For example, several modes and spectral components must be accounted for in the design of the RF balun since the transmission lines formed by the bottom strips of the balun and the housing are in series with the IF signal (DC and IF return path). Their width helps define the ground plane for the series matching elements at the RF port. However, if these strips become too wide, the shunt open circuit stub, realized by the slotline- like gap, becomes excessive.

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Conditions are similar on the LO side of the structure. The IF signal (even mode) appears at the LO port of the diode ring and must be effectively decoupled through the IF diplexer. A shunt transmission line stub (parallel plate), which is shorted at the IF port end, is a matching element for the LO signal and appears as a small series inductance at the IF frequency. The IF signal is prevented from propagating on the LO balun by the series blocking capacitors. Key to the mixer's repeatability and performance characteristics is the fact that the blocking capacitors are realized by an interdigitated structure. The structure consists of eighteen 0.9 mm long strips of 0.02 mm width separated by 0.02 mm gaps. Parasitic bond wire inductances and poor placement reproducibility make conventional chip capacitors inferior to interdigitated capacitors at frequencies above 30 GHz. Interdigitated capacitors also aid in mixer assembly since only four beam-lead diodes must be mounted on the substrate.

MIXER PERFORMANCE

Figure 2 is a picture of the mixer in a coaxial test fixture. The 0.25 mm thick substrate was mounted directly into the INVAR housing. The conversion loss of the mixer is shown in Figure 3. Some of the ripple in this conversion loss characteristic is due to the waveguide-to-coaxial transitions that were used in the waveguide test setup. Typical IF bandwidth is 1.8 GHz, and because of the DC response at this port, the mixer can also be used as a phase detector. In Figure 4, the LO to RF isolation characteristics of the mixer are shown.

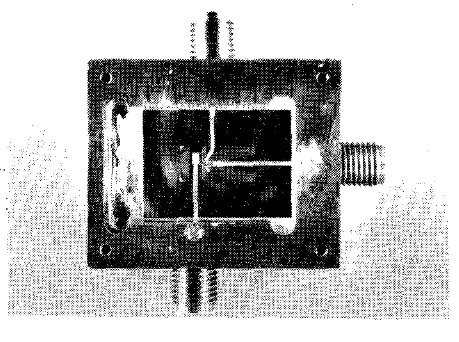

Figure 2 K/Ka band double-balanced mixer.

CONCLUSION

Using the above design approach, a broadband planar microstrip mixer has been developed and demonstrated. The mixer is small and easily integratable since it has no waveguide ports. It is easily assembled and exhibits reproducible K-/Ka-band performance comparable to double balanced 2 to 18 GHz designs.

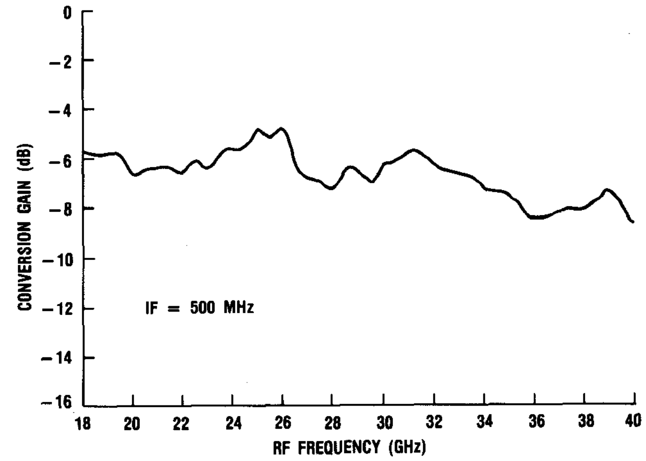

Figure 3 Conversion performance.

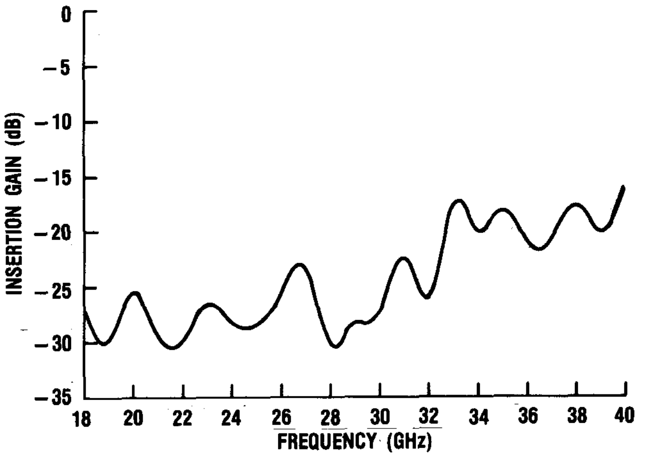

Figure 4 LO to RF isolation.

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[3] R. B. Culbertson and A. M. Pavio, "An Analytic Design Approach for 2 - 18 GHz Planar Mixer Circuits," 1982 IEEE International Microwave Symposium Digest, pp. 425 - 427.