A UNI-PLANAR DOUBLE-BALANCED MIXER USING A NEW MINIATURE BEAM LEAD CROSSOVER QUAD

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ABSTRACT

A unique silicon beam lead Schottky diode quad having a crossover configuration and very small size is presented. This rugged, high performance device permits the design of new miniature single-sided double-balanced mixer circuits. They require no backside metal patterning and provide for simple component mounting. The mixers are readily manufacturable and therefore low cost. The uni-planar design has 6.3+-0.5 dB conversion loss over the 8-18 GHz band with a 2 GHz IF.

INTRODUCTION

Conventional double-balanced mixers use a ring quad connected between two back to back balun transformers as shown in Figure 1a. This circuit requires that the two baluns be aligned to each other on two sides of an alumina substrate. In addition to being difficult to manufacture, it also presents difficulties in mounting the diode ring. If, however, the topology of Figure 1a were folded over to obtain that of Figure 1b, the result is a circuit that is more readily realized because it requires no back-plane circuitry.

This folded circuit requires the use of a crossover quad instead of a ring quad. Thus, the crossover quad is key to this whole approach. In this paper an application of the Avantek XLS-05.10 crossover quad is presented and compared with conventional two-sided thin-film double-balanced mixers.

DIODE CHARACTERISTICS

Avantek has developed a fully glass-embedded interdigitated contact silicon beam lead Schottky diode technology. The glass is transparent enough to allow seeing the features on its back side [Fig 2]. This glass creates a structure that is mechanically rugged, making handling and mounting a straightforward procedure with essentially no die cracking. Some other manufacturing techniques result in breakage approaching 25%. The glass "moat" forms a smooth surface between the silicon regions allowing fine geometry

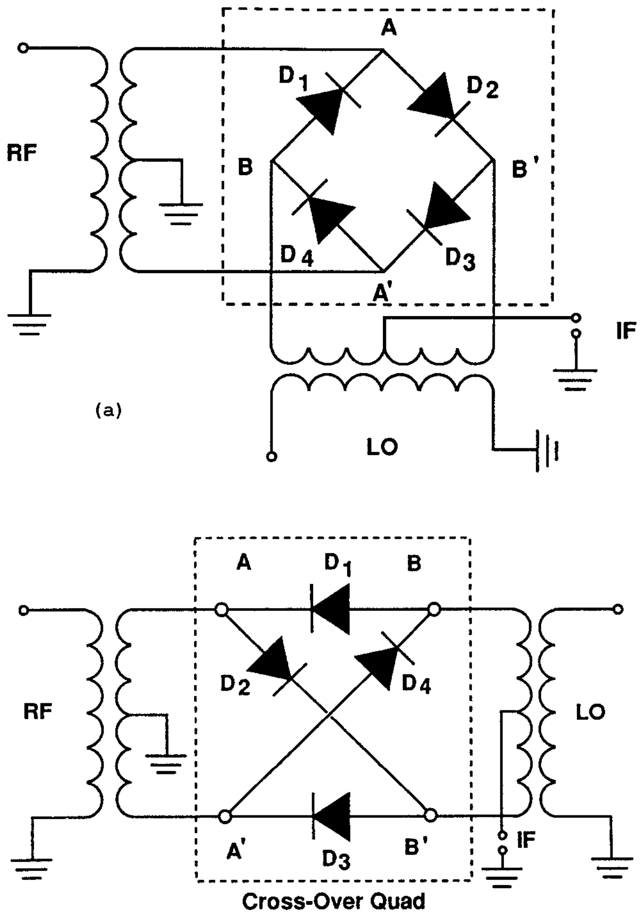

Figure 1 a) conventional double-balanced mixer that would use a ring quad; b) folded circuit of design in (a) illustrates the use of the crossover quad.

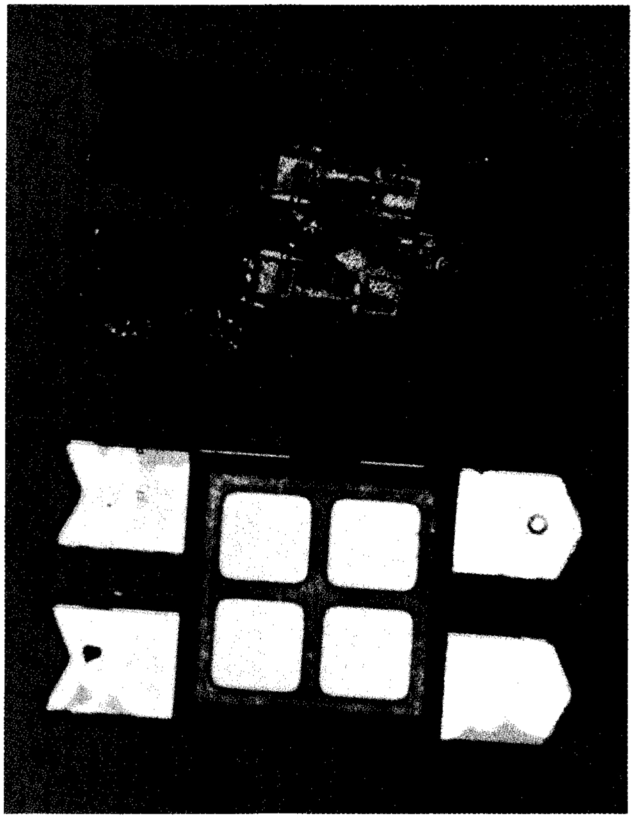

Figure 2 Front and back view of the XLS-05.10.

patterning with 2 um dimensions [Fig 3]. The contact is formed in an interdigitated structure with a large perimeter and a small anode-to-cathode spacing. This is designed to reduce the spreading resistance, resulting in improved high-frequency performance by reducing the RC time constant and conversion loss.

A polyamide layer is used both as scratch protection and as an insulator to allow the crossover bridge structure. The 210 um x 210 um body is markedly smaller than the conventional ring quad shown in Figure 4 along with the tip of a straight pin. Beam pull tests give a minimum strength of 2 grams.

The diode was made with a low barrier. The average DC spot measurements are: Vf(1mA) = 309 mV, Rd(5mA) = 12.4 ohms, C(0) = 0.064 pF, G(0) = 1.10-6S, Vbr(10uA) = 7.5 V, del Vf = 3 mV, del Rd = 1.3 ohms, del C = 0.005 pF. This value of Rd is low for this value of C(0); typically a 0.09 pF device has 14 ohms resistance. The parameters for the standard diode equation are: Is = 1.0E-8A, PhiB = 0.5V, n = 1.05, Rs = 6.7ohms.

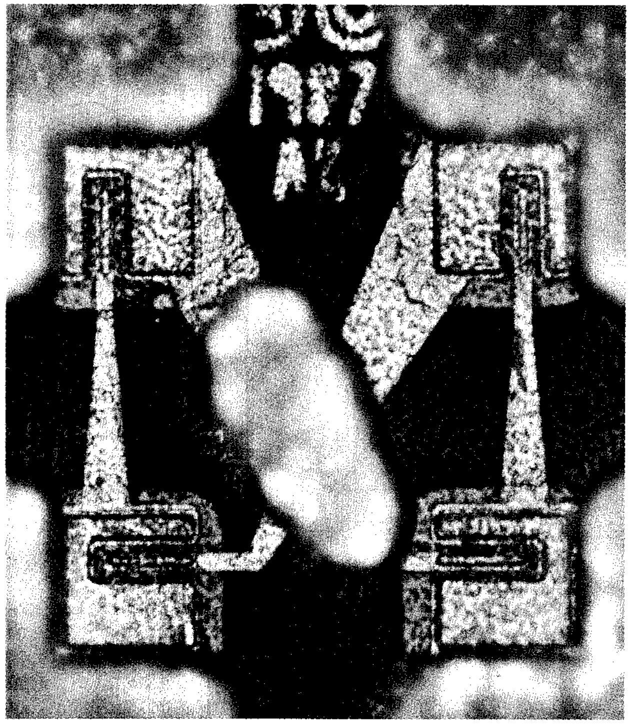

Figure 3 A close-up view of the crossover.

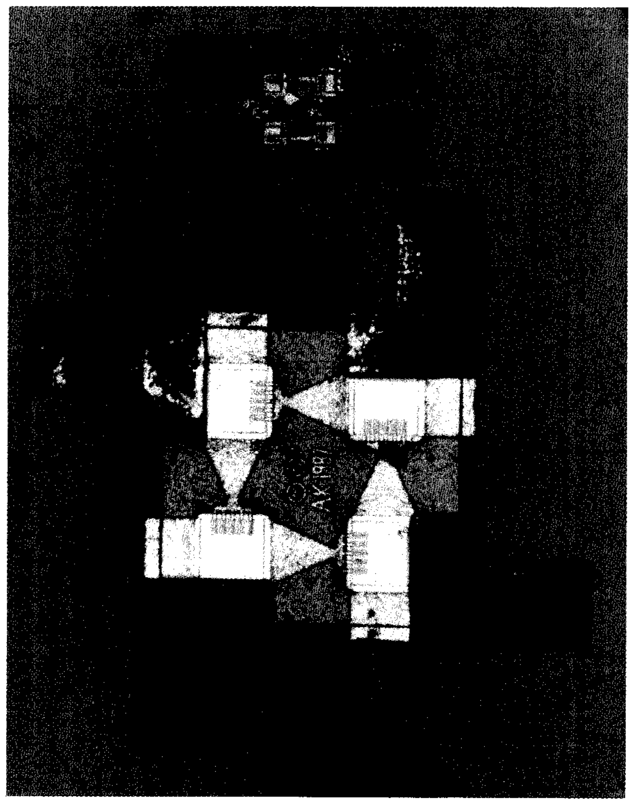

Figure 4 A comparison of a conventional ring quad, the crossover quad, and the tip of a straight pin.

UNI-PLANAR MIXER DESIGN

A unique simple transition from microstrip to coplanar waveguide is used to realize a mixer balun. This configuration is shown in Figure 5. The diode quad is placed between two of these baluns. The diode quad leads sit directly on the points A, A', B, and B'. The IF can be taken from either the LO or RF side. A directional coupler, or preferably, a diplexer is used to access the IF.

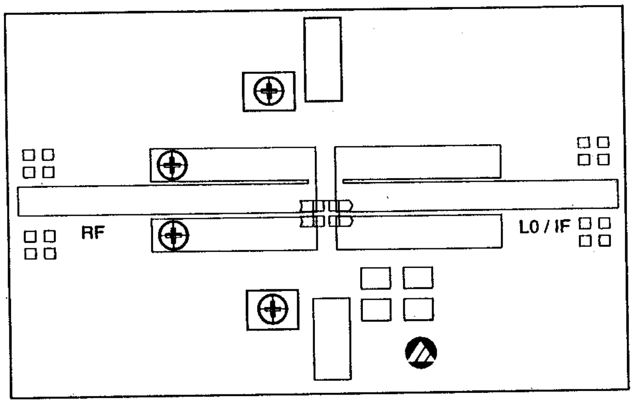

Figure 5 The uni-planar mixer.

The circuit topology of Figure 5 offers many advantages over the two-sided double-balanced mixer which uses the ring quad:

*The balun circuit is uni-planar; only two plated-through-vias are needed to make ground contacts for the microstrip transitions.

* The circuit is very small; it is 10X smaller than conventional designs and lends itself to integration.

* This circuit is very simple to manufacture, there is only one mask and no critical alignment; therefore it offers higher yield and lower production cost.

* This circuit is scalable for use in other frequency ranges.

* This circuit is suitable for monolithic processing for development of MMIC mixers because of its uni-planar construction

MIXER PERFORMANCE AND COMPARISON

The mixer presented above was fabricated on alumina using conventional thin-film technology. A photograph of this mixer is shown in Figure 6. The uni-planar mixer is

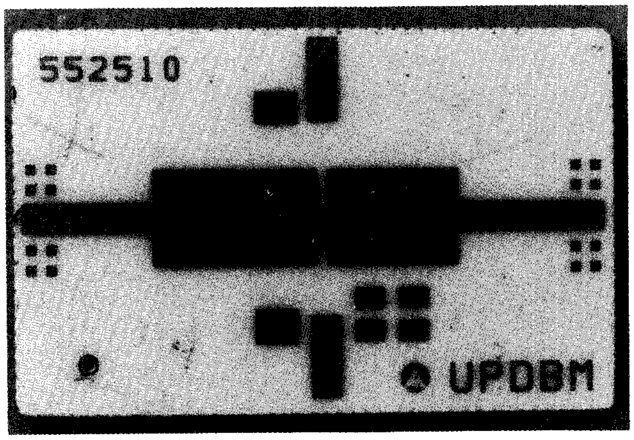

Figure 6 Photograph of the uni-planar mixer.

designed for operation over 8-18 GHz with an IF of 2 GHz. This mixer provides an average of 6.3+-0.5 dB of conversion loss over the band with very good isolation; it has an RF-to-IF isolation of 49 dB, LO-to-IF of 31 dB, and LO-to-RF of 20 dB. A swept LO and RF frequency measurement of the uni-planar mixer for a 2 GHz IF is shown in Figure 7. Figure 7 also shows the performance of a production model two-sided circuit approach using ring quads over a similar frequency range. This is the Avantek TFX-1866 double-double-balanced mixer with 7.0 dB conversion loss over the same band and isolation RF-to-IF of 30 dB, LO-to-IF of 25 dB, and LO-to-RF of 24 dB.

DEDICATION

This work is dedicated to the fond memories of our colleague Steve Taylor, 1959-1987.

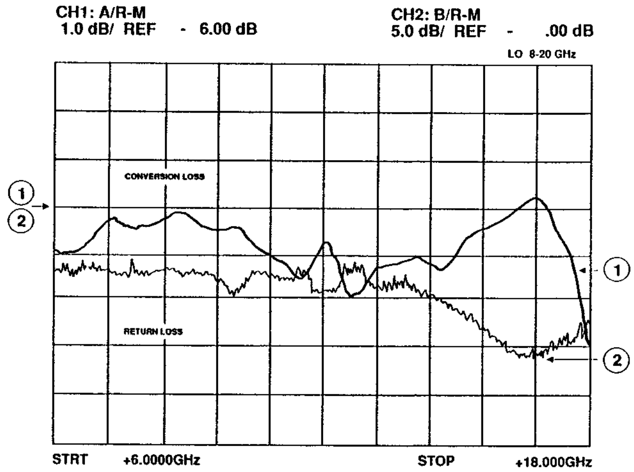

Figure 7a Performance vs. frequency for the double sided double-double-balanced TFX-1866 mixer

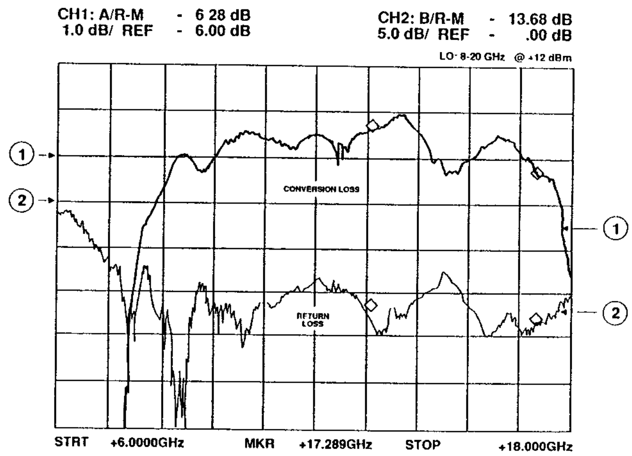

Figure 7b Performance vs. frequency for the uni-planar mixer.