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Effects of Misalignment in a Split-Block Waveguide to Suspended-Stripline Transducer

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The effects of misalignment between the two halves of a split-block WR-10 waveguide to suspended-stripline transducer, shown in Fig. 1 [1], have been investigated using the FDTD EM simulator QuickWave. The misalignment was in the direction of the waveguide axis, resulting in the upper substrate channel not aligning with the lower substrate channel, and the semicircular waveguide ends in the upper and lower block halves being staggered.

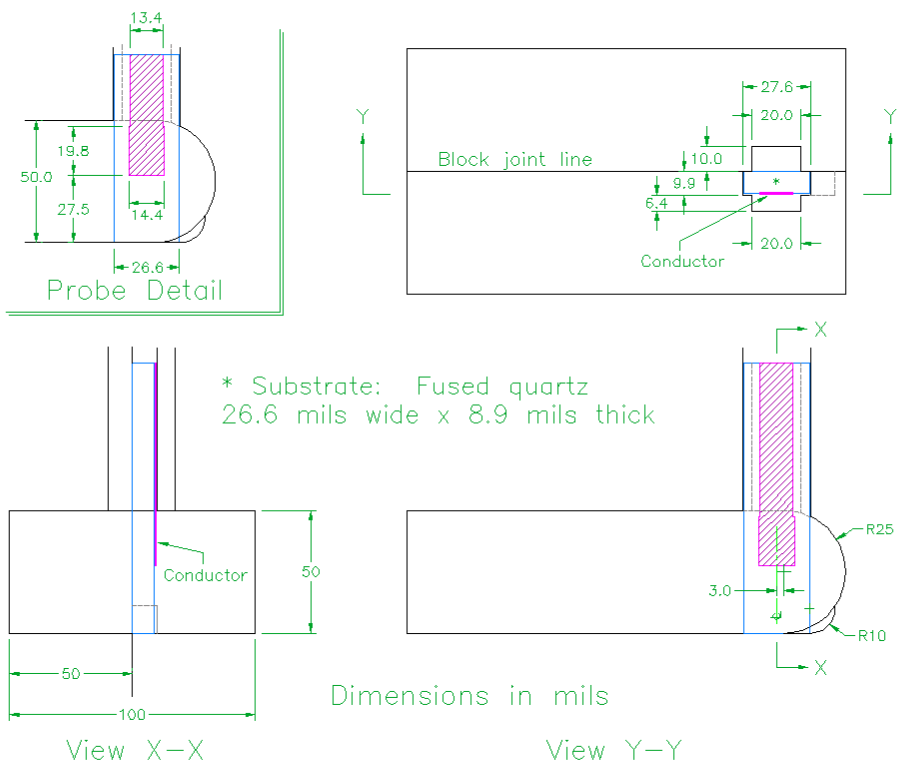

Fig. 1. WR-10 waveguide to suspended-stripline transducer [1]. For the ALMA Band 6 mixers, this WR-10 design is scaled by 0.37.

Figures 2-6 show the effect of different degrees of misalignment on the return loss $|S_{11}|$ (dB) and the transmission phase $\arg(S_{21})$ (degrees) of the transducer. The phase measurements are relative to the transducer with normal alignment (Fig. 4). The markers indicate the nominal WR-10 band edges.

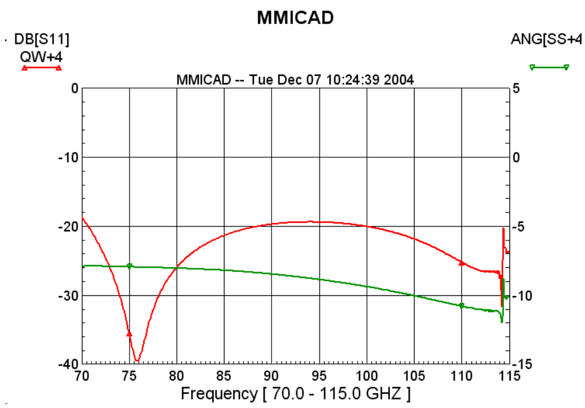

Fig. 2. Bottom block half +4 mils.

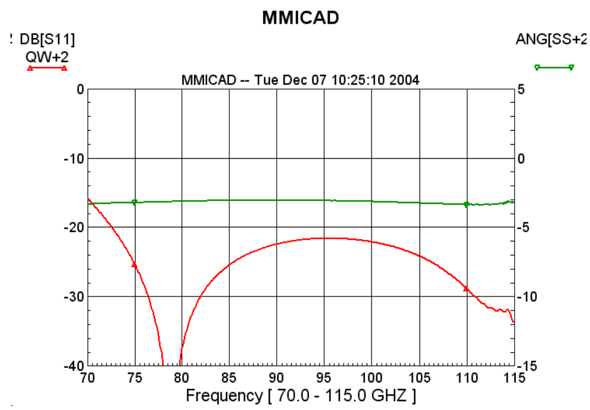

Fig. 3. Bottom block half +2 mils.

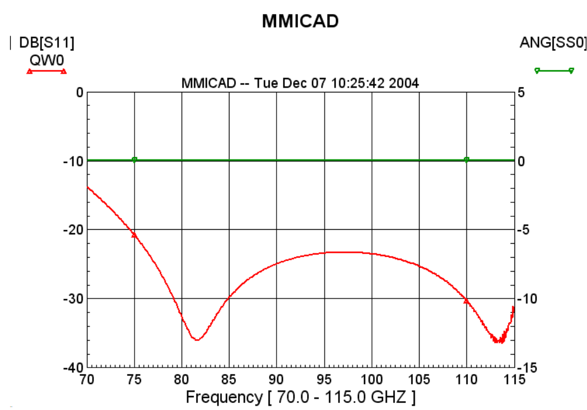

Fig. 4. Normal alignment.

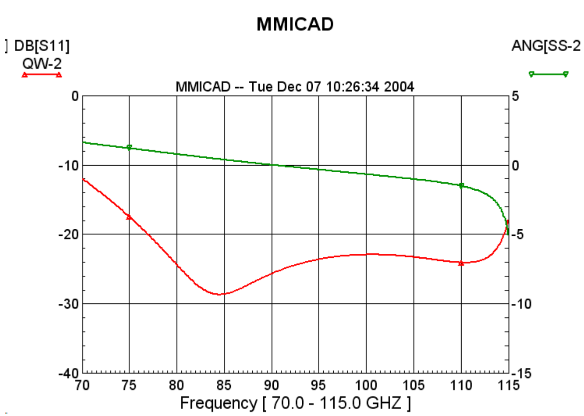

Fig. 5. Bottom block half -2 mils.

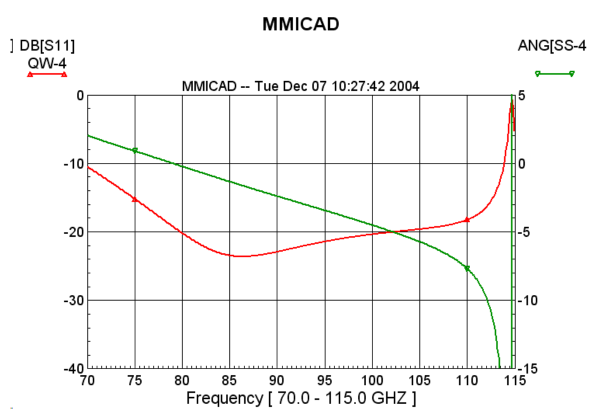

Fig. 6. Bottom block half -4 mils.

Discussion

In applications in which phase is not important, the transducer can be evaluated in terms of its return loss $|S_{11}|$. For the WR-10 transducer, with ± 4 mils (~100 μm) misalignment, $|S_{11}|$ < -15 dB over the full waveguide band and < -19 dB over most of the band. With ± 2 mils (~50 μm) misalignment, $|S_{11}|$ < −18 dB over the full waveguide band and < -22 dB over most of the band.

In circuits using a pair of waveguide to suspended-stripline transducers (e.g., balanced amplifiers, balanced mixers, and sideband-separating mixers), the match of transmission phase between transducers is important. The green curves in Figs. 2-6 show arg(S_{21}) in degrees (right-hand scale) relative to a transducer with normal alignment. For the WR-10 transducer, with ± 4 mils (~100 μm) misalignment, the transmission phase is within +2° to -11° of the normal design. With ± 2 mils (~50 μm) misalignment, the transmission phase is within +2° to -3° of the normal design.

Figure 7 shows the transmission phase mismatch for a pair of transducers with +4 and -4 mils misalignment (red curve), and with +2 and -2 mils misalignment (green curve). It is interesting to observe that, in the upper part of the band, a pair of transducers with +4 and -4 mils misalignment is actually better phase-matched than a pair of transducers, one with +4 or -4 mils misalignment and the other perfectly aligned.

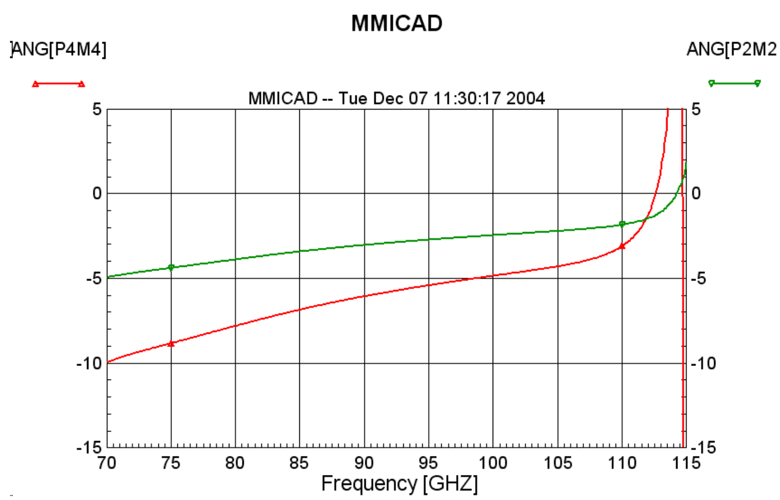

Fig. 7. Transmission phase difference for pairs of WR-10 transducers with +4 and -4 mils misalignment (red curve), and with +2 and -2 mils misalignment (green curve).

The ALMA Band 6 (211-275 GHz) sideband-separating SIS mixers use two waveguide to suspended-stripline transducers scaled from this WR-10 design by the factor 0.37. Acceptable performance is expected from the Band 6 transducers if the alignment tolerance between block halves is no more than 0.74 mils (~19 μm) (this corresponds to ± 2 mil misalignment in the WR-10 design). Then, the return loss > 20 dB and the phase mismatch < 4° across the full ALMA band. If the alignment tolerance is allowed to increase to 1.5 mils (~38 μm), the return loss > 18 dB and the phase mismatch < 9° across the ALMA band. Such a large phase imbalance is likely to combine with other phase imbalances in the sideband-separating mixer to result in unacceptable image rejection at some LO and intermediate frequencies.

Reference

[1] A. R. Kerr, "Elements for E-Plane Split-Block Waveguide Circuits," ALMA Memo 381, 1 July 2001. http://www.alma.nrao.edu/memos/html-memos/alma381/memo381.pdf.