Measurements of Losses in EDMed Waveguides and in First W-band Structure

Measurements of the reflection and transmission through the first W-band structure were discussed in ARDB-45. The figure below summaries the situation

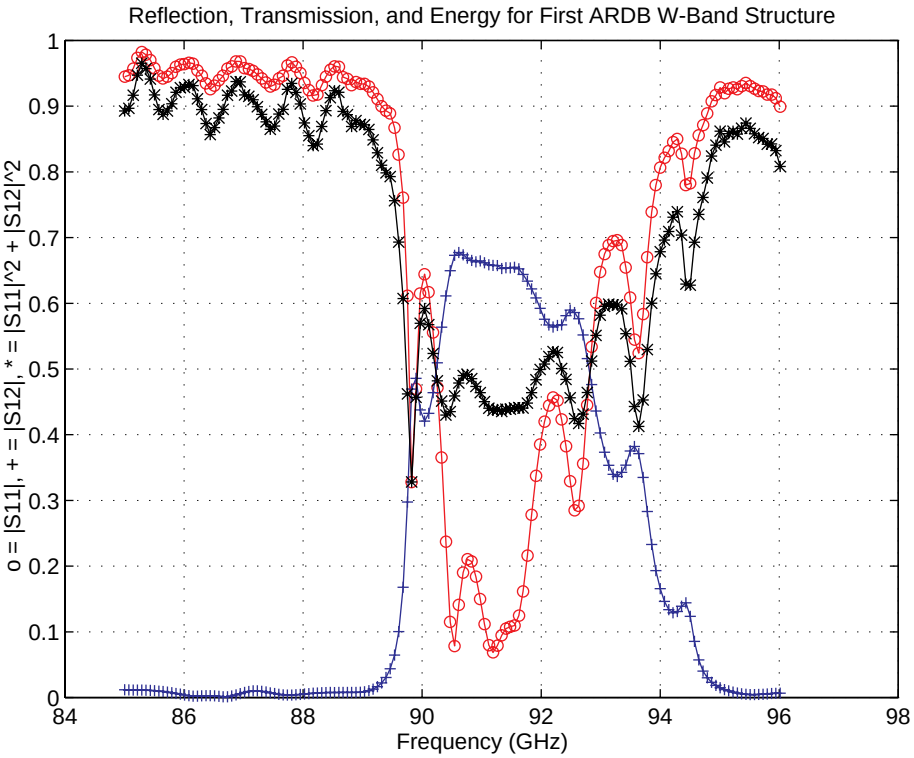

Figure 1: Measurements of $|S_{11}|$, $|S_{12}|$ and $|S_{11}|^2 + |S_{12}|^2$ for the first W-band structure. (Data taken 4/9/97)

The conclusion was that roughly one-half of the energy was lost in the structure.

Resistive losses were thought to be the cause. EDMing could leave the surface in a rough condition that would have losses above those expected for pure copper. Evidence of the surface finish affecting losses has been published.[1] Two 2" long waveguides were machined by RWI. One had the cut made in three passes and is referred in the pictures below as "FINE" cut. The other had the cut made in a single pass and is referred to as the "ROUGH" cut. The W-band structure machining was equivalent to the FINE cut.

Measurements of losses were made in a simple geometry. The W-band apparatus was set up in a reflection geometry. Following that were a 1" long waveguide, the 2" long waveguide under test, and a second 1" long waveguide. The termination was the HP W8486 power sensor. This is shown below. Measurements were performed without the 2" waveguide section to serve as a reference. Several changes had been made to the w-band apparatus since the last calibration,

[1] see for example - F. A. Benson and D. H. Steven, "Rectangular-waveguide attenuation at millimetre wavelengths", PROC. IEE, **110**, 1008 (193)

and this reference measurement removes sensitivity to calibration. Measurements were also made with the W-band structure in the place of the 2" waveguide.

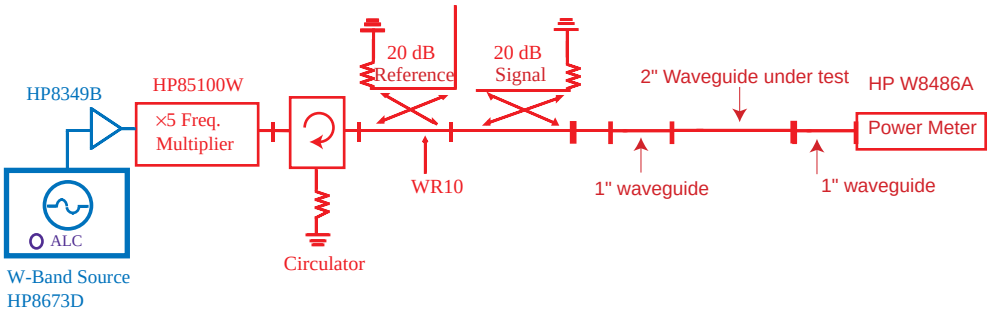

Figure 2: Experimental Apparatus

A typical measurement is shown below for the FINE waveguide. This is raw data without correction for the reference set-up.

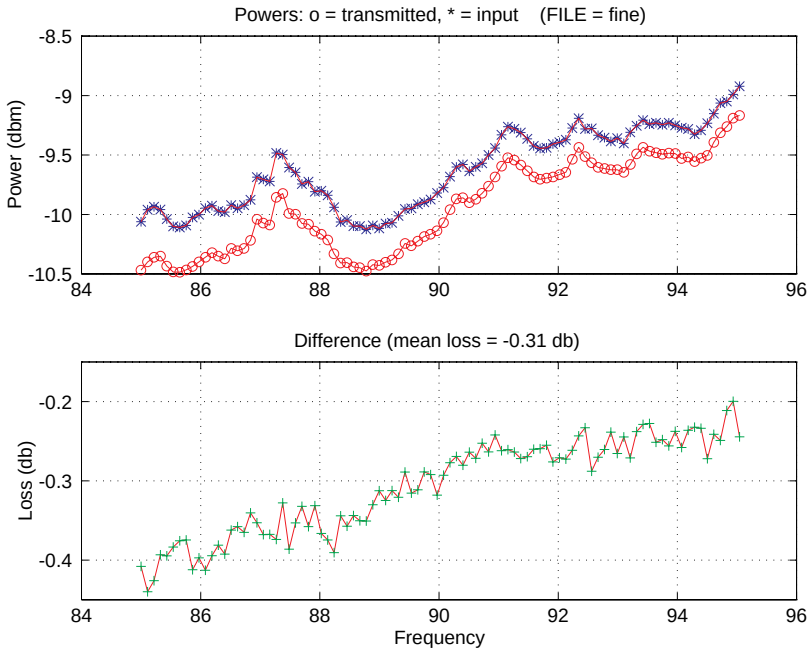

Figure 3: Measurement for the FINE waveguide. Data taken June 16, 1997

A summary of the waveguide data is below. The conclusion is that the FINE waveguide has losses slightly below that of a section of Aerowave waveguide, and the ROUGH guide has substantially more loss. Resistive loss does not seem a likely explanation of the energy loss in the W-band structure.

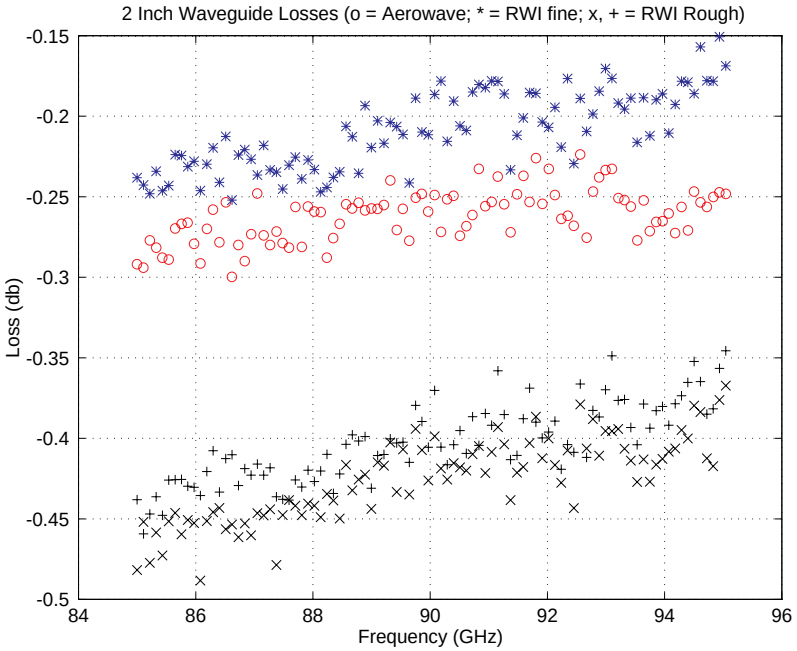

Figure 4: Waveguide losses for 2" long pieces of Aerowave waveguide, the FINE and ROUGH waveguides. The latter was measured twice. For reference the loss of a 2" long waveguide of copper with $\sigma = 5.99\times10^7$ Ω/m is -0.13 db.

The measurements in figure 1 were taken with a set-up of the w-band apparatus for transmission measurement and another set-up for reflection measurement. This is substantially different that the set-up for this measurement. To eliminate the possibility of a systematic error in the two difference techniques, the structure was put in place of the 2" waveguide in figure 2. Since reflected signal was also being measured, the equivalent of figure 1 could be performed. The result of that measurement is shown below. The conclusion is the same. Roughly 50% of the energy is lost.

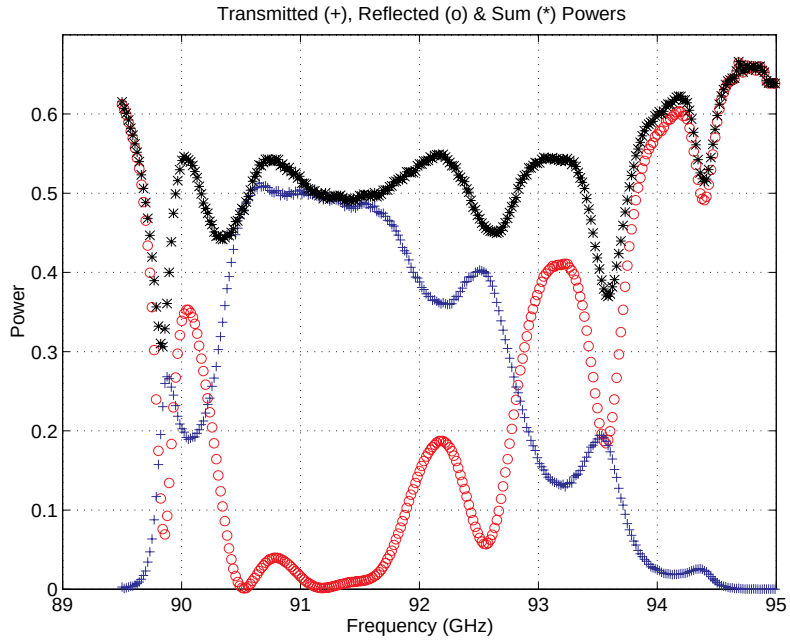

Figure 5: Transmitted, reflected and total power for the first W-band structure.