A comparison of simple low-power wedge-type X-band waveguide absorbing load implementations

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***Abstract*—Two inexpensive waveguide absorbing loads are constructed and measured, each using a single thin resistive sheet absorber supported by styrofoam walls, and 50mm in length. It is found that a V-cut wedge displays less reflection than a tapered wedge, with -30 dB reflection across a band 8.5 – 12.4 GHz.**

I. Introduction

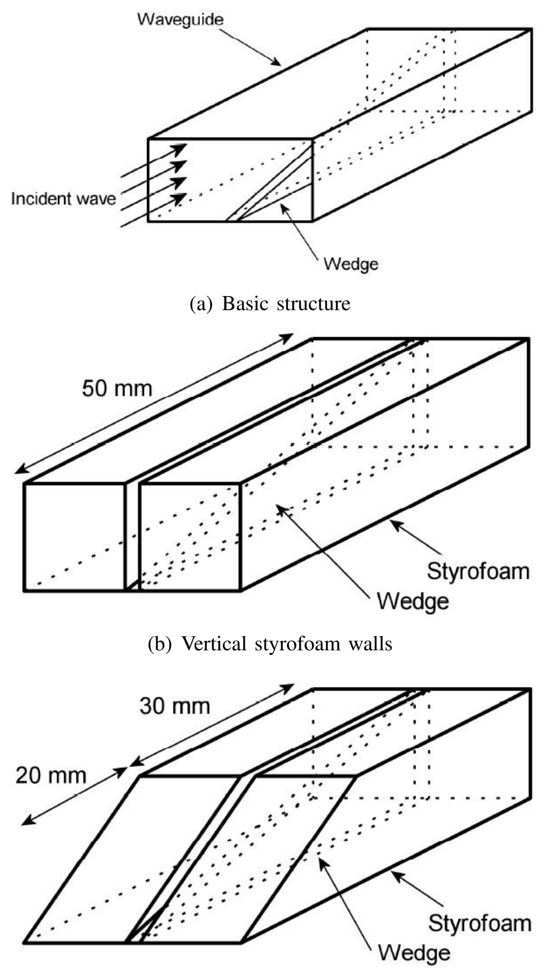
Waveguide loads form an indispensable part of many microwave systems. These loads can be expensive to obtain as well as manufacture, as very low reflection coefficients are normally required over the full guide bandwidth. Designs for these matched loads include radiating loads [1], quartz crystals [2], ferrites [3], carbonyl iron powder filled exoxy [4] and resistive sheets [5] [6] [7].

The implementations in [5], [6] and [7] all require exact design and shaping of the resistive sheets to achieve the required absorption, which increases the development time of the absorber. This paper compares two compact, simple and inexpensive alternatives (suitable for low-power applications) by empirical study, rather than analytic or numerical analysis. In all cases, the absorbing material used was ECCOSORB FGM-40 (a magnetically loaded silicone absorber), shipped in 1 mm thick rubber-like sheets, and the waveguide dimensions that of WR90 (a = 22.86mm, b = 10.16mm). All loads demonstrated have a total length of l = 50mm, and achieved nominal absorption of -20 to -30 dB

II. Tapered-wedge structure

The first structure investigated is the standard tapered-wedge absorber, shown in Fig. 1(a). The effect of this wedge shape is to allow a gradual transition between transmittive (waveguide) and absorbent (ECCOSORB) media. Though most of the energy incident on the ECCOSORB is absorbed, some is still reflected back. This layout, however, ensures that reflected waves (absorbed higher up the slope of the absorber, or further down the waveguide) encounter absorbent material on its way back as well. Because the y-directed E-field the TE_{10} waveguide mode reaches a maximum at $x = \frac{a}{2}$ [8], the wedge is best placed vertically, in the centre of the waveguide, to achieve maximum absorption.

From a mechanical viewpoint, the lone rubber sheet in the waveguide will not be strong enough for any practical application, and support on either side is required. For this purpose, ordinary styrofoam ($\epsilon_r \approx 1.02$ [5]), commonly used for packaging, is quite suited for the task. The low permittivity allows for minimum reflection, whilst the material itself is cheap, readily available, and can easily be fashioned to fit any size waveguide. Two prototypes were constructed, one with vertically-cut styrofoam walls (Fig. 1(b)), the other with



(a) Basic structure

(b) Vertical styrofoam walls

(c) Tapered styrofoam walls

Fig. 1. Tapered-wedge absorber

tapered walls (Fig. 1(c)). The vertically-cut walls provide a plane of discontinuous ϵ_r normal to the incident wave, and is considered a worst-case styrofoam reflection test. The second prototype is expected to have, if anything, a marginally better reflection response, because of the more gradual transition of ϵ_r in the medium.

To investigate the effect of the absorber's length on reflection, a simulation model of Fig. 1(a) was constructed in *CST Microwave Studio 2006B*, with results shown in Fig. 2. In the simulation, the waveguide end at the base of the wedge was set to absorb, to ensure that no backscattering would be recorded. As expected, longer wedges displayed less reflection, due to smoother transition from propagating to absorbing media.

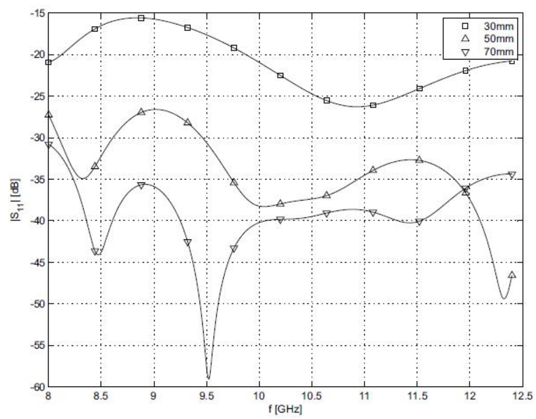


Fig. 2. Simulated reflection of tapered-wedge absorbers, length l = 30, 50 and 70mm

The measured response of these two models are shown in Fig. 3. It features peak reflection of -17 dB at 8 GHz, and -23 dB across the band 8.4 – 12.4 GHz. As expected, the effect of the taper to the styrofoam walls was negligible.

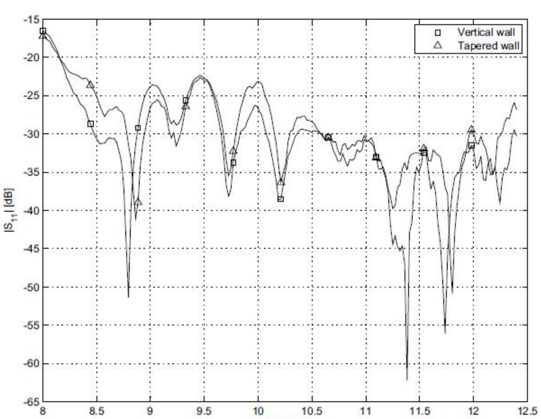
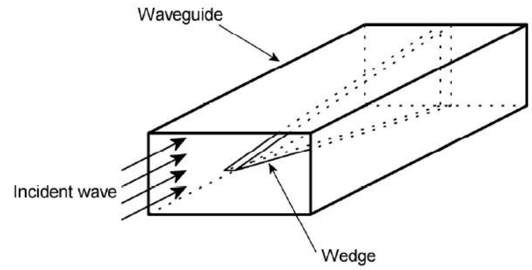


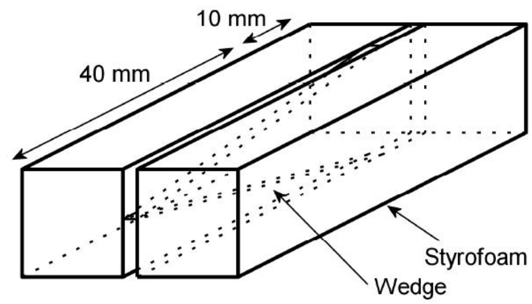
Fig. 3. Measured reflection of tapered-wedge absorbers

III. V-WEDGE STRUCTURE

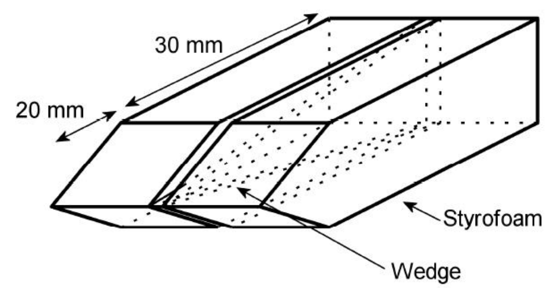
Another structure investigated was a V-shaped wedge, as shown in Fig. 4(a). This shape was previously used in [9], but placed diagonally across the width and height of the waveguide. Here, the incident wave is absorbed by a discontinuity emanating from the centre of the waveguide, not the bottom edge. It is expected that this design would feature less reflection for a fixed l and waveguide height a, due to the sharper wedge angle. Again, two models were constructed.



(a) Basic structure



(b) Vertical styrofoam walls, 40mm taper



(c) Tapered styrofoam walls, 50mm taper

Fig. 4. V-wedge absorber

The first, shown in Fig. 4(b), has a 40mm taper with 10mm deep rectangular base, and vertically cut styrofoam walls. The second (Fig. 4(c)) features a taper over the full 50mm length of the absorber, allowing a sharper angle of incidence with the propagating planewave. Also, the surrounding styrofoam was cut with a 20mm taper itself, though any difference in response between the two V-wedge models would most likely be attributable to the taper of the absorber.

As before, the effect of the load's length on its reflection was investigated by EM simulation, with similar boundary conditions. The model shown in Fig. 4(a) was simulated, with results shown in Fig. 5. Again, the longer loads displayed less reflection.

The measured response of the two V-wedge absorbers are shown in Fig. 6. Clearly, these two models feature less

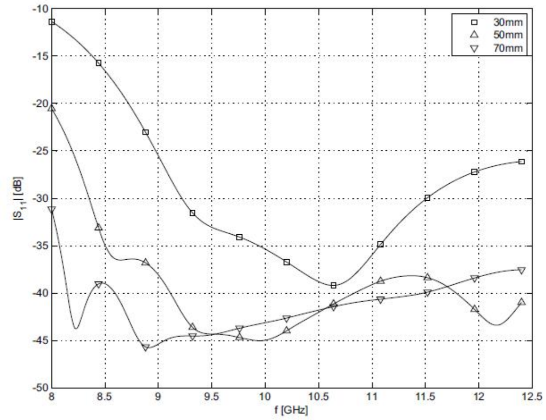


Fig. 5. Simulated reflection of V-wedge absorbers, length l = 30, 50 and 70mm

reflection than the two tapered-wedge structures. The 40mm tapered V-wedge absorber has a peak reflection of -27 dB across a band 8.2 – 12.4 GHz, and the 50mm tapered V-wedge -30 dB across all but the bottom 500 MHz of the X-band. This improvement can be attributed to the sharper taper.

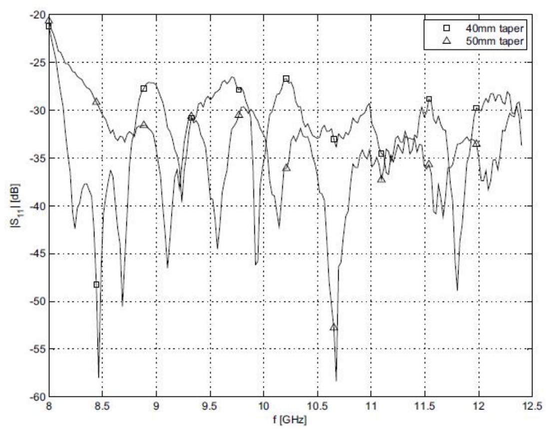


Fig. 6. Measured reflection of V-wedge absorber

IV. Conclusion

Two easily constructible and inexpensive waveguide absorbing loads, each using a single thin resistive sheet absorber, have been demonstrated. It was shown that an absorber 50mm in length could achieve below -30 dB reflection across a band 8.5 – 12.4 GHz, if the absorbing sheet was cut in a V-shape. It was also demonstrated that the supporting styrofoam structure can be cut to arbitrary shapes without significantly affecting the load's reflection response, and that sharper tapers produce less reflection.

Acknowledgment

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