An Open-Boundary Quad-Ridged Guide Horn Antenna for Use as a Source in Antenna Pattern Measurement Anechoic Chambers

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Abstract

The present paper introduces a new antenna design to be used in anechoic chambers. When measuring three-dimensional patterns, the receiving antenna in the anechoic chamber must be able to sense the two orthogonal components of the field that exist in the far field. This can be accomplished by mechanically rotating the source horn in the chamber. A better and faster approach is to use a dual-polarized antenna and to electronically switch between polarizations. This new design is a broadband (2-18 GHz) antenna with dual polarization. The antenna is a ridged guide horn. The novel part is that the sides have been omitted. Numerical analysis and measurements show that this open-sided or open-boundary horn provides a better and more stable pattern behavior for the entire band of operation, as well as good directivity for its compact design. The radiation and input parameters of the antenna are analyzed in this paper for the novel design as well as for some of the early prototypes to show some of the ill effects of bounded quad-ridge horn designs for broadband applications. Mechanically, the antenna is built so that it can be mounted onto the shield of an anechoic room without compromising the shield integrity of the chamber.

Keywords: Horn antennas; ridge waveguides; broadband antenna; dual polarization antenna

1. Introduction

Broadband antennas are the workhorses of field measurement. They allow the engineer and technician to measure different types of sources of electromagnetic radiation without having to stop the test to change the measuring antenna. There are several well-known types of broadband antennas, such as log-periodic dipole arrays (LPDAs), but these are usually limited in gain, and their geometry makes them unsuitable for use in certain chambers, such as tapered anechoic chambers [1]. Ridged horns are another traditional broadband antenna. However, in some cases the pattern behavior of these horns is far from desirable [2]. Additionally, the gain increases with frequency to the point that the amplitude taper across the quiet zone (QZ) in the chamber is very high, along with the problems associated with this [3]. Another drawback of very high gains is that if the antenna is used to illuminate a compact-range reflector, the quite-zone size obtained is also small. In [4], the author introduced a new dual-ridge horn, which corrected the pattern problems of the traditional dual-ridge horn antenna. This new horn, shown in Figure 1, has been tested for compact-range illumination. It has shown good performance in the low end, and a small reduction in the diameter of the quiet zone at the upper end of the range. Figure 2 shows the gain curve for the dual-ridge horn developed in [4]. As can be seen, for most of the range the gain is fairly flat, with less than 1 dB of variation in magnitude.

In the present paper, the concept of this new double-ridged guide horn is taken to a higher level of versatility by creating a dual-polarized antenna. A dual-polarized antenna can measure both orthogonal field components simultaneously, which allows the engineer or technician to measured three-dimensional patterns by

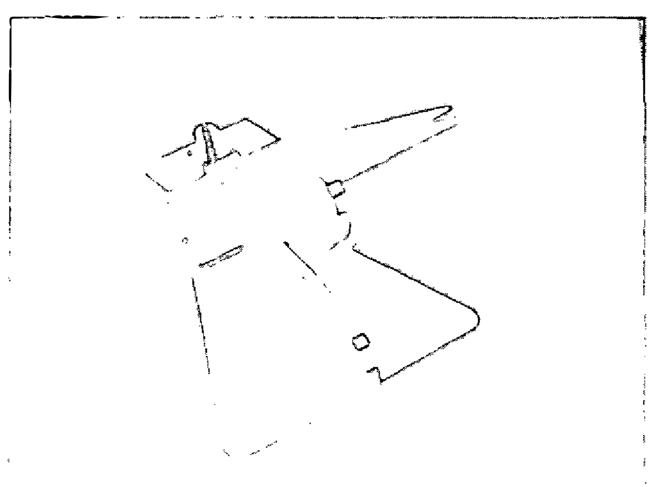

Figure 1. A new double-ridged guide horn.

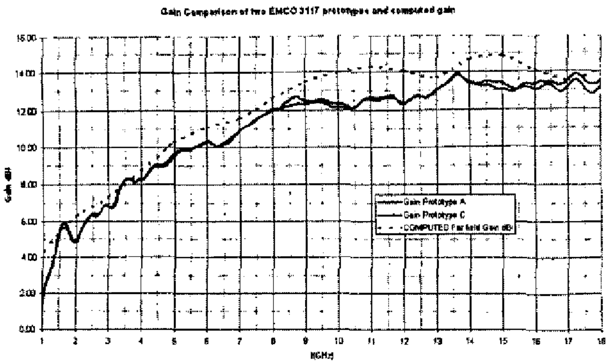

Figure 2. The computed and measured gains for the new double-ridged guide horn.

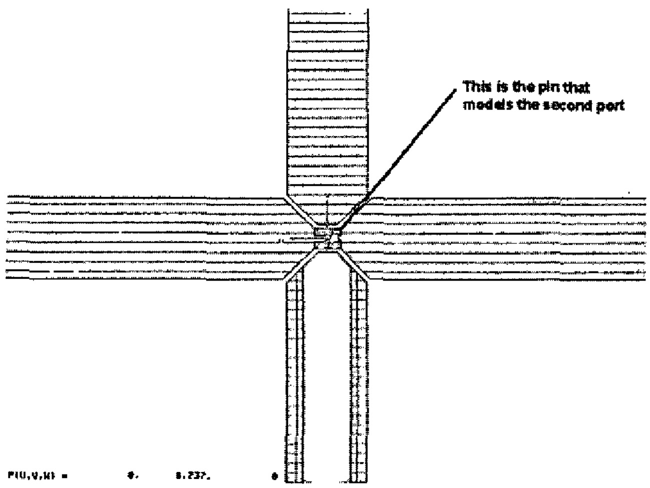

Figure 3. The ridges, with an angle cut so that the four ridges could be fitted together at the feed point.

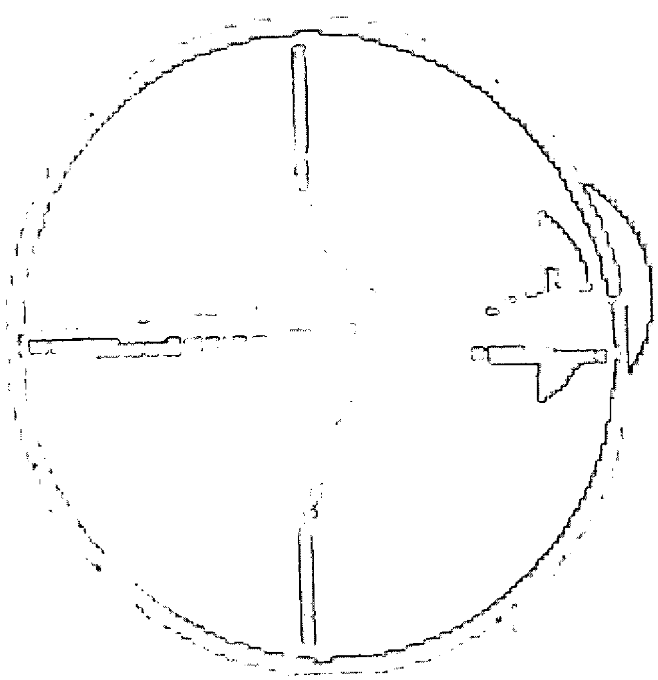

Figure 4. The original born design, with a "closed" boundary.

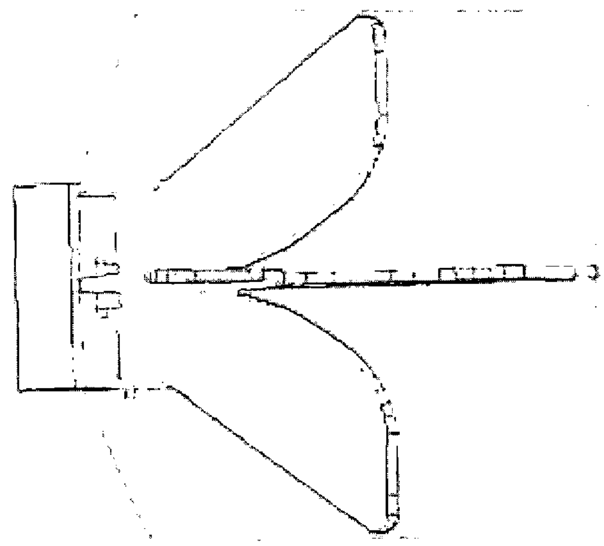

Figure 5. The final design, showing plastic, nonmetallic sides.

rotating the antenna under test (AUT) in both azimuth and elevation. Additionally, the dual-polarized antenna means that there is no need for an expensive rotational positioner to support the source antenna.

2. The Open-Boundary Concept

The design of the new horn started with a conventional look. It preserved the shape of the ridges used in [4] with only slight modification, to be able to add a set of two more ridges in the orthogonal plane, as shown in Figure 3. The original design that was modeled had a cylindrical metal boundary around the ridges, as shown in Figure 4. However, this configuration showed splits of the main beam at several frequencies.

In [4], it was found that the side structure on the original, traditional double-ridged horn affected the pattern by splitting the main beam. The model was modified to have nonmetallic sides with a relative permittivity of 2.5, similar to the manufacturer's claim for polycarbonate plastics. Figure 5 shows the new model with the plastic sides. The final plastic or open-boundary horn showed good gain behavior and a fairly stable pattern for the upper half of the frequency range. The design had overall dimensions of 6 inches by 6 inches in aperture by 6 inches in length.

3. Measured Results

Based on the model results, three prototypes were manufactured. When measuring the pattern, it was discovered that at the upper edge of the range, the polycarbonate sides had an effect on the pattern's behavior. This was not fully predicted by the model, possibly because of memory constrains: only 10 cells per wavelength were used at the highest frequency in the time-domain-method approach. Additionally, the plastic permittivity was an approximation, using a constant value for the 2 to 18 GHz range. The actual material probably had a frequency-dependent permittivity that caused the unpredictable effects at the upper range. Fig-

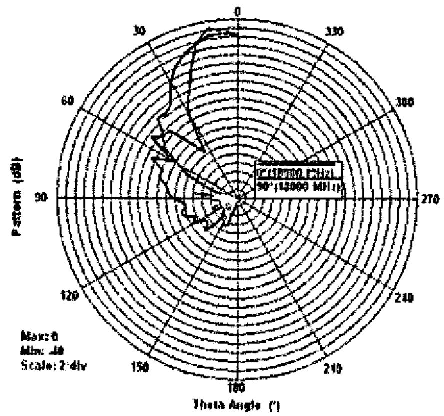

Figure 6. The pattern at 18 GHz with polycarbonate sides. Notice the 2 dB notch on the H plane.

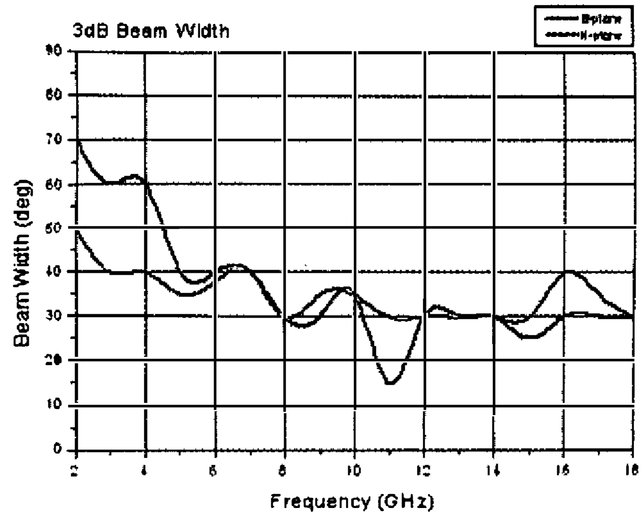

Figure 9. The half-power beamwidth of the open-boundary design.

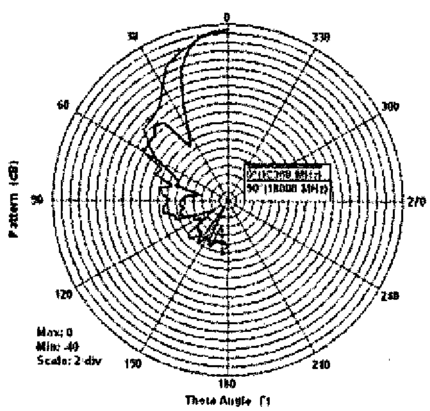

Figure 7. The pattern at 18 GHz without polycarbonate sides. Notice that the 2 dB notch has disappeared from the H plane.

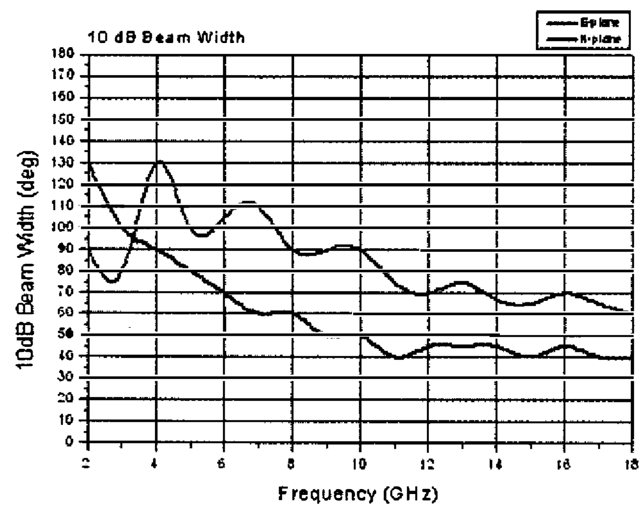

Figure 10. The 10 dB beamwidth of the open-boundary design.

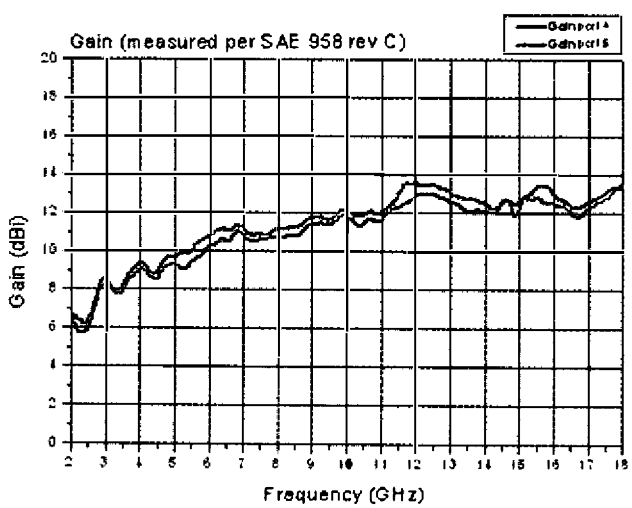

Figure 8. The measured gain of the quad-ridged horn antenna, showing a very small gain variation (0.3 dB) from 7 GHz to 18 GHz.

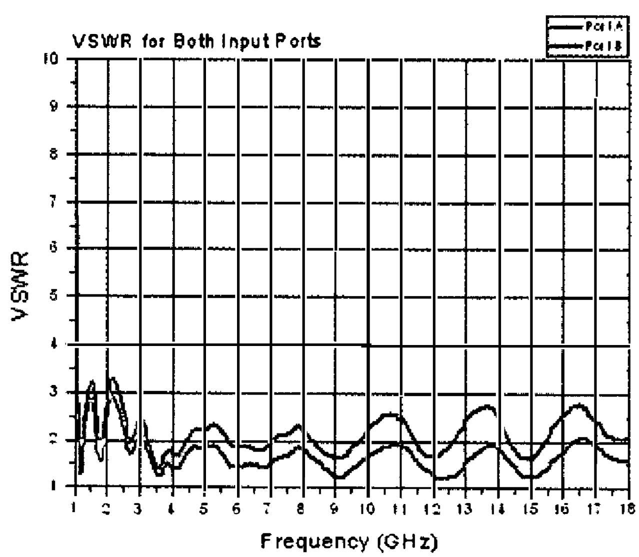

Figure 11. The VSWR of both ports of the prototype of the new design.

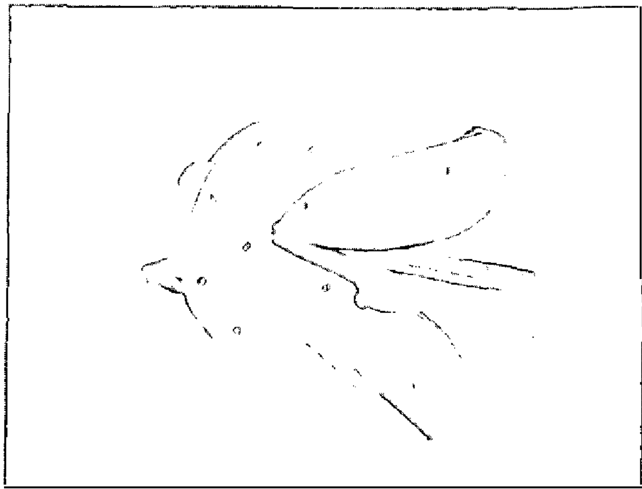

Figure 12. The final configuration of the new horn design.

ures 6 and 7 show the pattern with and without the plastic sides at 18 GHz.

Hence, the final horn design had no sides that could cause perturbations to the pattern. The result was a pattern very similar to the double-ridged guide designed in [4], with a very stable gain from 9 to 18 GHz, as is shown in Figure 8. The illumination properties of the antenna were shown when we looked at the 3 dB beamwidth of the horn. The half-power beamwidth is shown in Figure 9, while the 10 db beamwidth is shown in Figure 10.

The measured input parameters of the antenna are shown in Figure 11, in the form of the VSWR for both ports. We saw a slight difference between the two ports, but this can be calibrated out in the system when performing measurements. The final horn design is shown in Figure 12. As it is shown, it had no dielectric or metallic sides, and only a small plastic trim for aesthetic reasons.

4. Conclusion

The paper has presented a new quad-ridge design without sides. This "open-boundary" horn has been shown to have a stable pattern and gain for the upper half of the frequency range of the antenna. It also has a wider illumination, which can make it suitable for compact-range illumination with a slight reduction of the quiet-zone diameter. Future work must be done on using it as a source in tapered and rectangular chambers to see its capabilities.

5. Acknowledgments

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6. References

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