MEASUREMENTS OF A NEW GAUSSIAN PROFILE CORRUGATED HORN ANTENNA FOR MILLIMETER WAVE APPLICATIONS

R. Gonzalo[*,+], J. Martí Canales[+], J. Teniente[*], C. del Río[*] and M. Sorolla[*]
[*]Microwave and Millimeter Wave Group
Public University of Navarra ,Spain
[+]Electromagnetic Division, ESTEC
European Space Agency (E.S.A.), The Netherlands

Abstract

The measurements results of a new design of corrugated horn antennas [1, 2, 3] following the gaussian expansion are presented in this paper. The performance of two corrugated horn antennas of this kind was verified in the ESTEC Compact Antenna Test Range (CATR) [4]. Very high agreement between measured and predicted results is found.

Horn antennas definition

In this section a brief description of the two corrugated horn antennas is given, an in-depth information on the design details can be found in [1], [2] and [3].

In order to distinguish the two antennas, they were denominated A and B. A picture of them can be seen in Figure 1.

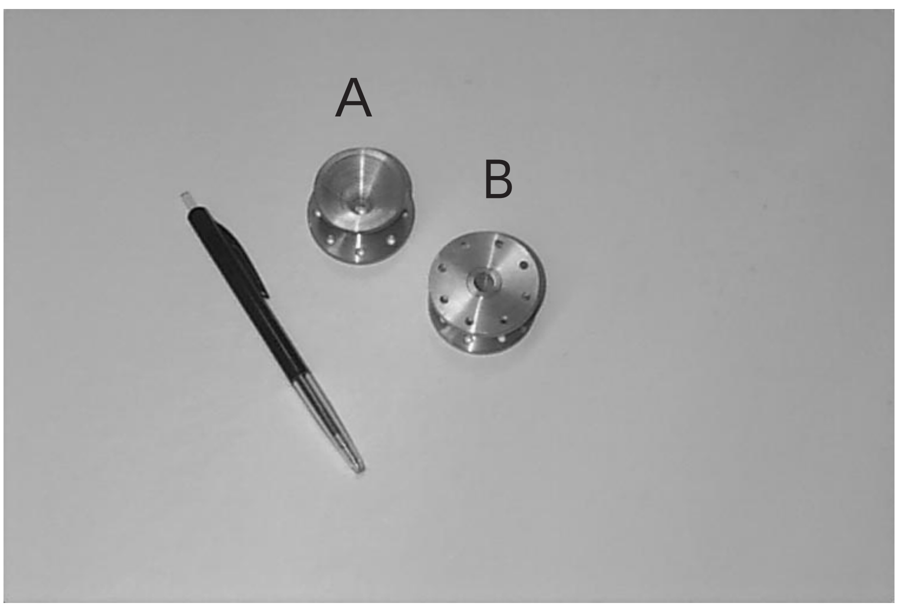


Figure 1: Corrugated Horn Antennas A and B.

Basically, the two antennas were designed following an innovate concept which consists of enlarging the antenna radius in the same way as a gaussian beam is expanding. The gaussian expansion law is defined by the following equation:

$$r(z) = r_0 \cdot \sqrt{1 + \left(\frac{2 \cdot z}{k \cdot \varpi_0^2} \right)^2} \qquad (1)$$

where r_o is the input radius, k is the free space wavenumber and ϖ_o is the beam waist which defines the antenna.

Antenna A was designed to provide a highly efficient fundamental Gaussian beam by feeding the antenna with a TE_{11} mode. A Gaussian beam is the preferred choice in many applications where high sensibilities, high efficiencies, low sidelobes and low crosspolarization are required, i.e., beam waveguide transmission lines, remote sensing, depth space applications and radioastronomy.

Antenna B provides a high purity HE_{11} mode from, again, a TE_{11} mode. This kind of antenna can be used in less restrictive applications, i.e., feeding a reflector antenna system. The radius expansion of this antenna follows a modified expression of (1) in order to allow connectivity with other devices like a waveguide section or another horn antenna. To achieve this, a flange has been placed at the output, as can be seen in Figure 1.

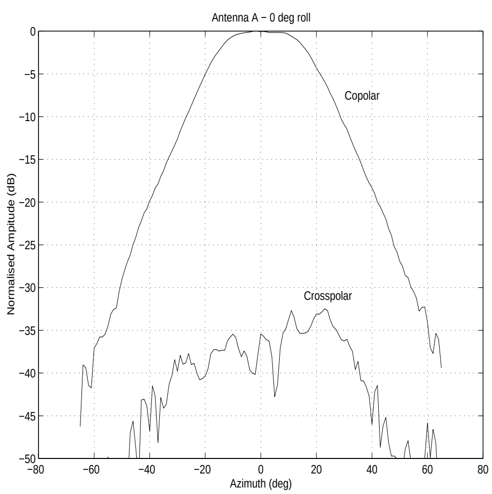
The input mode to both antennas is the TE_{11} mode. An impedance adapter is placed at the input of each horn antenna to provide a good mode matching. Besides, the corrugation parameters were optimized to offer an optimum match for the propagation of gaussian modes. In table 1 can be seen the design parameters.

	Frequency	**Length**	**Rin**	**Rout**
Antenna A	59 GHz	20mm (=4λ)	2.4 mm	15.3 mm
Antenna B	59 GHz	17.7mm (≅4λ)	2.4 mm	4.118 mm

Table 1. Working Parameters of both antennas.

Measured results

The radiation patterns of both antennas were measured in the ESTEC Compact Antenna Test Range [4]. Both co- and cross-polarization patterns from -65º to +65º every 1º in azimuth, and for three roll angles, 0º, 45º and 90º.



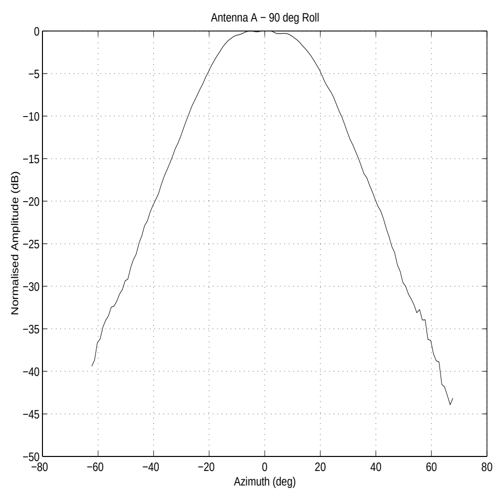


Figure 2 : Antenna A, 0º roll, Co and Crosspolar   Figure 3 : Antenna A, 90º roll.

All cuts obtained from antenna A (Fig. 2 and 3) exhibit good central symmetry and coincidence, which implies also revolution symmetry in roll. This antenna shows a small ripple in the main beam, more visible in the 90º cut, which may be attributed to a possible coupling with the mounting support .

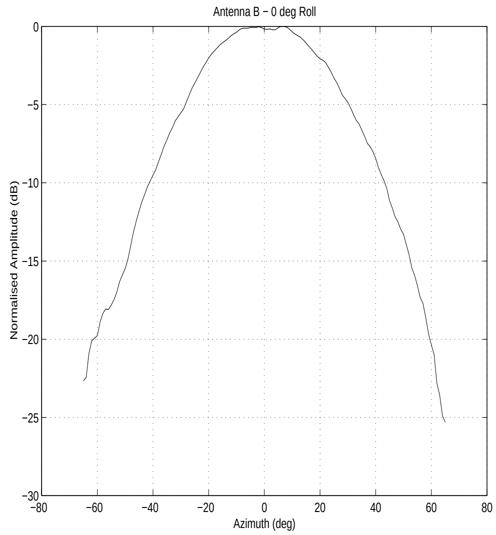


Figure 4 : Antenna B, 0º roll, Co and Crosspolar

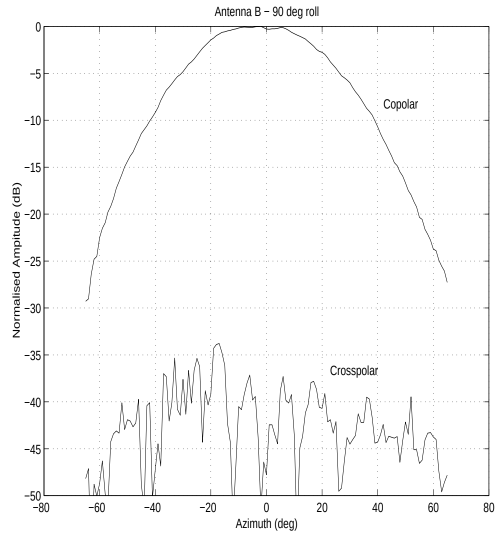


Figure 5 : Antenna B, 90º roll.

Figures 4 and 5 show the results obtained from antenna B, its output connecting flange acts as a finite ground plane in the radiation pattern introducing a small ripple, as it is observed in the measurements of antenna B.

Comparisons with predicted results

In this section a comparison between measured and predicted results is provided. Simulated data were obtained using a modal analysis and generalized scattering matrix software to analyze the antenna and integral equations to calculate the radiation pattern. Only the comparison with the 0º pattern is shown.

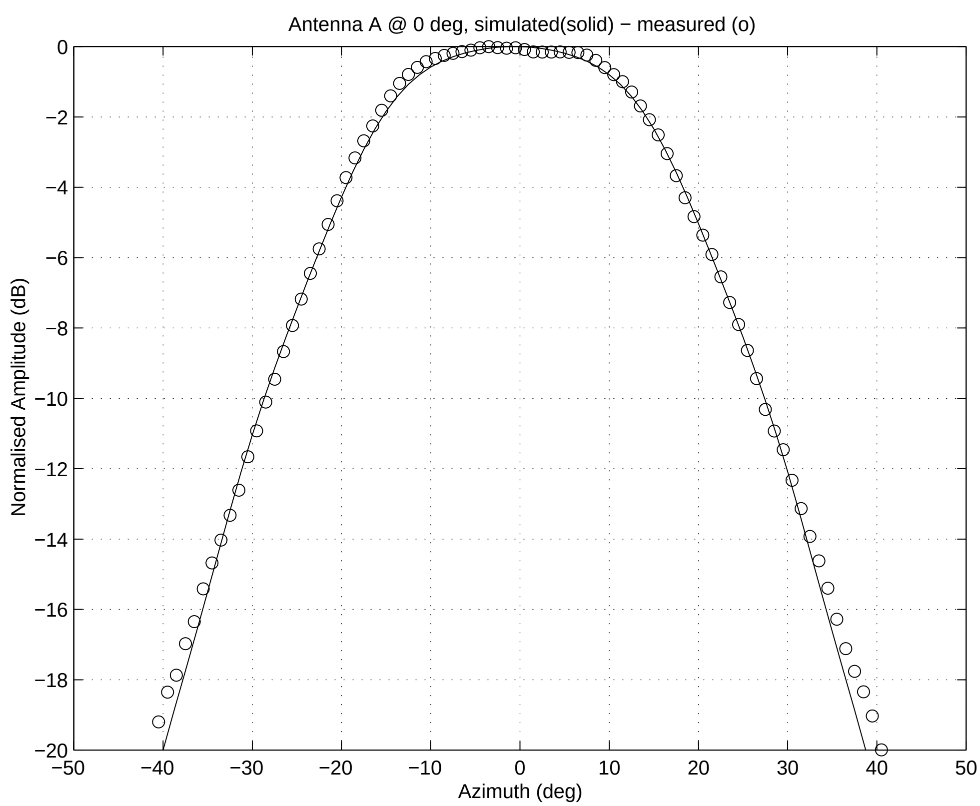


Figure 6: Antenna A, comparison between measured (o) and simulated data (solid) at 0º roll.

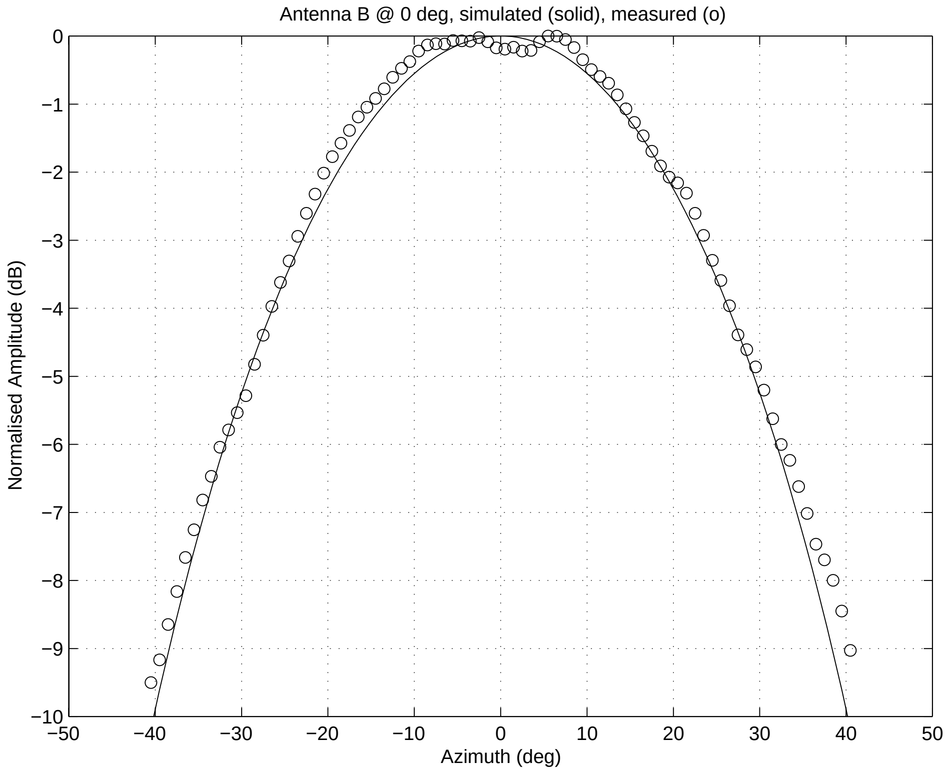


Figure 7: Antenna B, comparison between measured (o) and simulated data (solid) at 0º roll.

Theoretical calculations on antenna A provide a Gaussian of 99%, while a value of 98.8% is finally obtained using the measured far field data. This result shows a very high agreement between measured and theoretical results.

The rest of the pattern cuts measured were compared with their counterpart obtained by simulation. An excellent agreement is also obtained in all of them.

Conclusions

Two different kind of corrugated horn antennas were designed and fabricated. The goal was to verify their proper performance to generate a high pure HE_{11} mode and a highly efficient Gaussian beam.

The two measured antennas show an excellent agreement with their predicted behavior. A highly efficient Gaussian beam (98.8%) has been found at the output of the antenna A. Cross-polarization levels of -35 dB have been obtained.

The measured and the simulated patterns allows to state that the performance of the two antennas is according to the original design, and, therefore, the design has met all expectations.

References

[1] R. Gonzalo, J. Teniente, C. del Río and M. Sorolla "New approach to the design of corrugated horn antennas" 20th ESTEC Antenna Workshop on Millimeter-Wave Antenna Technology and Antenna Measurement, Noorwijk (NL), June 1997.

[2] R.Gonzalo, J.Teniente, and C. del Río "Very Short and Efficient Feeder Design from Monomode Waveguide", 1997 AP-S International Symposium and URSI Radio Meeting, July, Montreal, Canada.

[3] R.Gonzalo, J.Teniente, and C. del Río "A novel and Efficient Corrugated Feeder for Reflector Antennas", 1997 AP-S International Symposium and URSI Radio Meeting, July, Montreal, Canada.

[4] J. Martí Canales and R. Gonzalo "Verification of Performance of Millimeter-Wave Corrugated Horns" Test Report CATR-TR-005.97-JM, Electromagnetic Division, ESTEC, Noorwijk (NL), November 97.