A Novel Ku-Band Circularly-Polarized Horn Antenna Based on a Ridged Wall

Andoni Marzo[1,2], Fernando Teberio[1], Jorge Teniente[2,3]
[1] Anteral S.L., Pamplona, 31006 Spain, amarzo@anteral.com*
[2] Electrical, Electronic and Communication Eng. Dept., Public University of Navarre, Pamplona, 31006 Spain
[3] Institute of Smart Cities, Public University of Navarre, Pamplona, 31006 Spain

***Abstract*—In this paper, a novel wideband (31.5 % bandwidth) circularly-polarized antenna based on a ridged wall is presented. A pair of ridges on the inner wall of the horn serves as an inbuilt polarizer, which can generate left-hand or right-hand circular polarization without any additional polarizer. The ridged wall is placed at 45º with respect to the input port linearly polarized wave to generate a 90º phase delay and obtain the desired circular polarization at the aperture. The simulated results show that the antenna works great in the whole Ku satellite band (from 10.7 to 14.7 GHz) with more than 20 dB return loss and below 1 dB axial ratio. The antenna can be fabricated using traditional computer numerical control machining techniques or the new 3D metal additive manufacturing processes.**

***Index Terms*—inbuilt polarizer, wideband, circular polarization, 3D metal additive manufacturing, horn antenna**

I. Introduction

The circular-polarized (CP) waves are widely used in satellite communications due to their robust performance under the depolarizing medium and environment interference [1]. Nowadays, there is an increasing demand for CP horn antennas for satellite communications, as well as to be used as reflector feeds.

A CP wave can be easily achieved by combining two perpendicular linearly polarized (LP) waves travelling in the same direction with the same amplitude and a phase difference of 90º. There are several ways to achieve CP, for example through a metasurface polarizer at the output aperture or using a polarizer at the input of the horn [2].

In [3], seven pairs of air holes were used as an embedded polarizer in a circular waveguide, achieving an S_{11} = -15 dB and axial ratio below 1.8 dB from 79.5 GHz to 87.5 GHz. Also, in [4] with an embedded radially opposite rectangular grooves polarizer and corrugated teeth it reached 1 dB axial ratio for the 5G 27.5 GHz – 28.35 GHz communication band. Finally, [5] designed an inbuild polarized based on a grooved wall, obtaining 21 dB return loss and an axial ratio < 2.8 dB from 80 GHz to 110 GHz.

In this paper, a single CP horn antenna with an embedded ridged-wall polarizer for Ku-Band is proposed. This antenna shows a return loss above 20 dB and an axial ratio better than 1 dB from 10.7 GHz to 14.7 GHz. The designed horn can be manufactured using the computer numerical control (CNC) machining or the new 3D metal additive manufacturing process.

II. Inbuilt Ridged Polarizer

A. Antenna Geometry

Fig. 1. shows the geometry of the proposed single CP horn antenna. The horn consists of an input port, a rectangular-to-circular transition, a tapered circular horn and a pair of ridged walls inside the horn.

The input port is a standard WR-75 rectangular waveguide (19.05 mm x 9.525 mm) and the rectangular-to-circular transition allows to excite only the TE_{10} at the input.

The inbuild polarizer consists of two pairs of ridges oriented at 45º with respect to the rectangular port, which generate RHCP or LHCP.

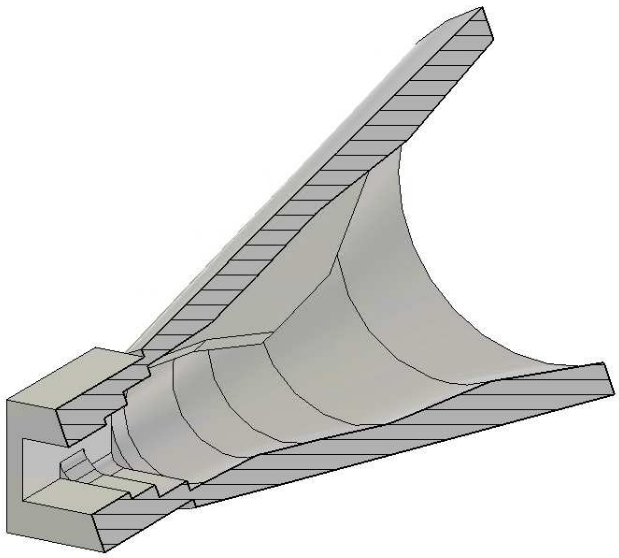

Fig. 1. Section view of the proposed antenna.

B. Principle of Operation

At the input port, the TE_{10} mode is excited and gets transformed into a linearly-polarized TE_{11} mode at the circular waveguide. This linear TE_{11} field can be decomposed into two perpendicular waves E_X and E_Y with the same amplitude and phase as it can be seen in Fig. 2. One of the waves is parallel to the ridge while the other is orthogonal to it.

When both waves E_X and E_Y travel through the horn, they exhibit a phase difference due to the presence of ridges.

At the output port of the horn, the field components E_X and E_Y are similar in amplitude and 90º out-of-phase from each other, generating the expected CP.

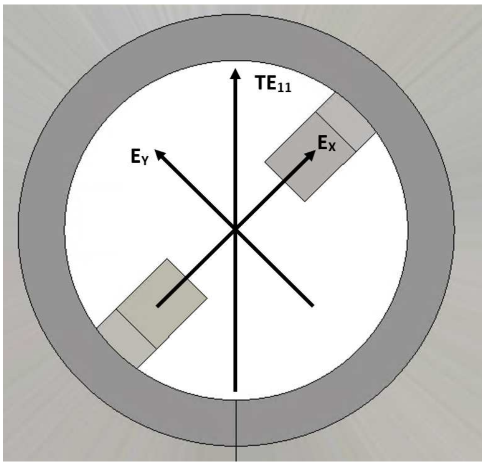

Fig. 2. TE_{11} field distribution.

With the embedded polarizer in the horn antenna body, the use of an orthomode transducer (OMT) or a septum polarizer to generate the circular polarization is avoided. This makes easier the fabrication of the horn, reducing the number of components and therefore the size and mass of the system, which is very beneficial for the aerospace industry. This antenna can also be manufactured using 3D metal additive manufacturing processes, being built in a single piece and reducing the losses.

III. Simulated Results

The simulated matching of the horn antenna works fine from 10.7 to 14.7 GHz as it is shown in Fig. 3. It achieves a return loss above 20 dB at the whole Ku-Band.

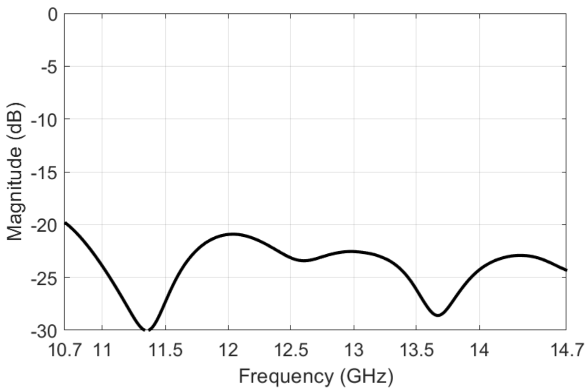

Fig. 3. Simulated S_{11}.

In Fig. 4. the simulated axial ratio is also shown, which is below 1 dB over the entire Ku-Band, from 10.7 GHz to 14.7 GHz, for boresight direction. Axial ratio worsens for wider theta angles, but it maintains always lower than 3 dB for main beam radiation.

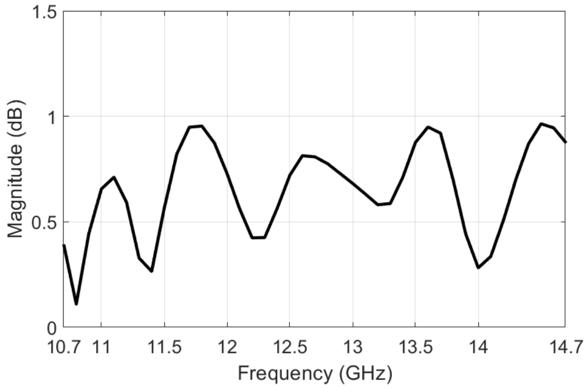

Fig. 4. Simulated axial ratio for boresight direction.

Regarding to the directivity, as it is shown in Fig. 5. is higher than 14.5 dBi in broadside. However, this parameter can be adjusted if needed with a longer and wider aperture horn antenna.

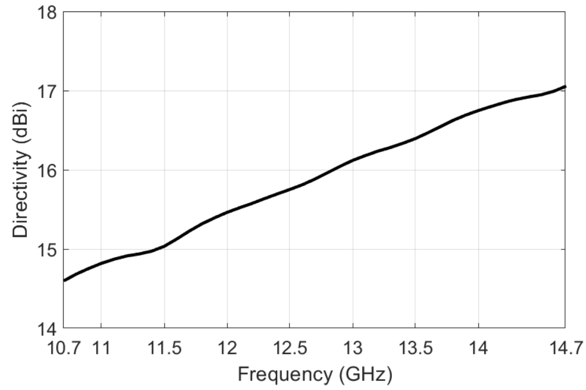

Fig. 5. Simulated directivity.

Figs. 6. and 7. show the radiation patterns of the horn antenna at 11.7 GHz and 14.25 GHz, corresponding to the central frequencies of the selected Ku-Band (10.7-12.7 GHz and 14-14.5 GHz).

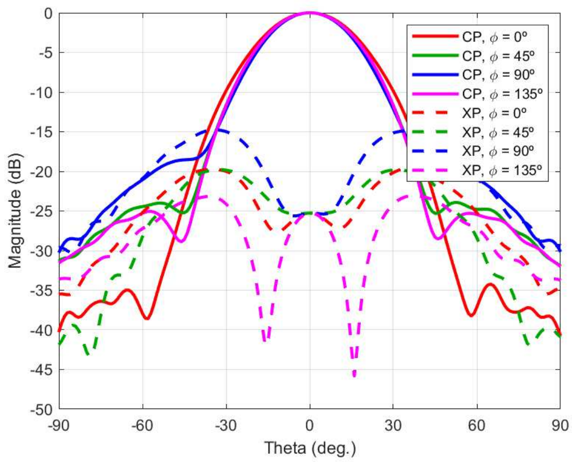

Fig. 6. Radiation pattern at 11.7 GHz.

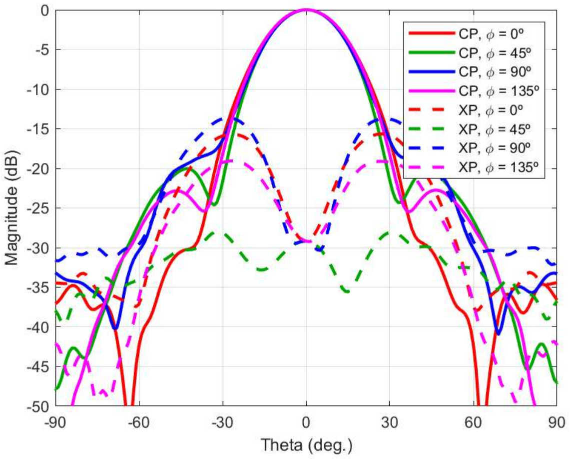

Fig. 7. Radiation pattern at 14.25 GHz.

IV. CONCLUSION

In this paper a novel Ku-Band circularly-polarized horn antenna based on a ridged-wall is presented. This antenna is capable to generate LHCP or RHCP radiation pattern. The simulated results showed very good performance from 10.7 to 14.7 GHz, obtaining return losses of 20 dB and 1 dB axial ratio. At the time of the conference, the fabricated and measured inbuilt polarizer horn antenna will be shown.

ACKNOWLEDGMENT

This research was co-funded by the Navarra Government under project 0011-1408-2021-000004 and project 0011-1365-2021-000220.

REFERENCES

[1] L. Shafai, S. K. Sharma, and S. Rao, *Handbook on Reflector Antennas and Feed Systems, Volume II: Feed Systems.* Norwood, MA, USA: Artech House, 2013.

[2] F. Dubrovka, S. Piltyay, O. Sushko, R. Dubrovka, M. Lytvyn, and S. Lytvyn, "Compact X-band Stepped-Thickness Septum Polarizer," *2020 IEEE Ukr. Microw. Week, UkrMW 2020 - Proc.*, pp. 135–138, 2020, doi: 10.1109/UkrMW49653.2020.9252583.

[3] G. Mishra, A. T. Castro, S. K. Sharma, and J. C. S. Chieh, "W-Band Feed Horn with Polarizer Structure for an Offset Reflector Antenna for CubeSat Applications," *2017 IEEE Antennas Propag. Soc. Int. Symp. Proc.*, vol. 2017-January, pp. 557–558, 2017, doi: 10.1109/APUSNCURSINRSM.2017.8072321.

[4] G. Mishra and S. K. Sharma, "Ka-Band Offset Spherical Reflector Antenna Fed by Dual-CP Horn Array with Switched Multiple-Beams," *IEEE Radio Wirel. Symp. RWS*, vol. 2021-January, pp. 36–38, 2021, doi: 10.1109/RWS50353.2021.9360369.

[5] Y. Y. and X. C. C. Shu, S. Hu, "A W-band Compact Circularly Polarized Horn Antenna," *12th UK-Europe-China Work. Millim. Waves Terahertz Technol. (UCMMT),* pp. 1–2, 2019, doi: 10.1109/UCMMT47867.2019.9008342.