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# Design and Analysis of a TEM Coaxial Horn

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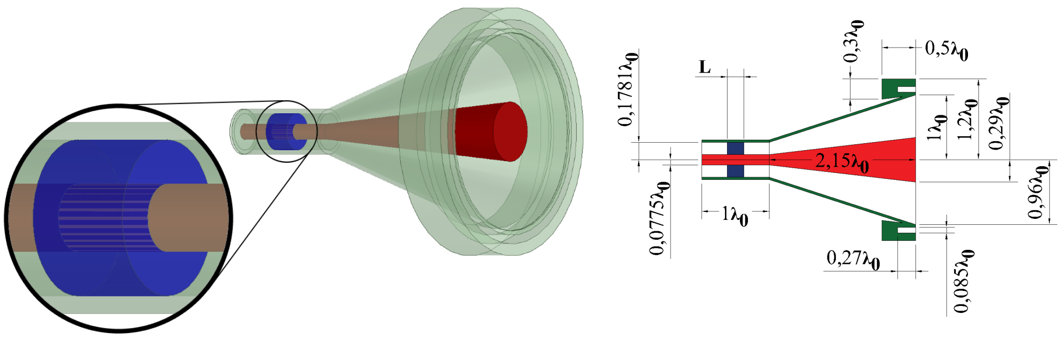
The frequency band between 30GHz and 300GHz, known as millimeter wave (mm-Wave), is an interesting alternative to the development of new mobile data technologies once the spectrum used by almost all mobile communications devices proves insufficient. A solution able to provide the necessary coverage at these frequencies are the omnidirectional dual-reflector antennas fed by a coaxial horn operating in TEM (Transverse Electromagnetic) mode (see Fig. 1(a)) [1], [3].

This study aims to design and analyze a coaxial horn through the $K_a$ frequency band (25GHz–40GHz), expecting a performance consistent with the ones found in referenced literature. Therefore, return loss ($|S_{11}|$) will be used as the benchmark for evaluating the horn's performance. All analysis were done using Ansys High Frequency Structure Simulator (HFSS) implementing the Finite Element Method (FEM) [2].

The three-dimensional geometry of the coaxial horn presented in [1] was reproduced into the CAD environment integrated in the software to be assayed employing FEM. To validate the initial model (non-optimized) and the numerical solution, the results were compared with those in [1] (see Fig. 2(a)), obtaining an acceptable outcome, despite the different numerical techniques employed.

To design a model with a stricter acceptance criterion ($|S_{11}| < -20$ dB) [1], an optimization to the horn's aperture's dimensions was performed through parametric analysis. The $|S_{11}|$ are shown in Fig. 2(a). A significant improvement at the lower (25 to 27GHz) and higher (36 to 40GHz) frequencies was achieved. The 3D model and the cutaway view with optimized dimensions as a function of $\lambda_0 = 10.714$mm ($f_0 = 28$GHz) can be seen in Fig. 1(a) and Fig. 1(b), respectively.




(a) 3D Geometry

(b) Dimensions as a function of $\lambda_0$

Figure 1: Coaxial Horn.

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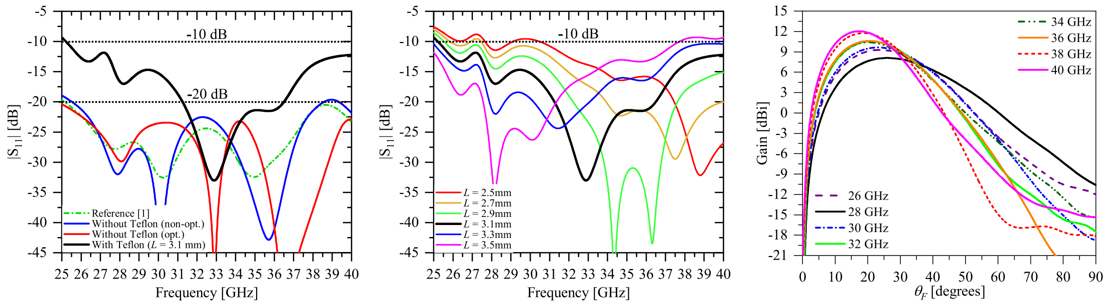
The design modification – with respect to the presented in [3] – proposed in this study changes the mechanical support of the inner conductor, as the reference model leads to a complicated manufacturing process. The novel implementation suggests a dielectric (Teflon with $\epsilon_r = 2.1$) fill close to the feeding port, as illustrated at Fig. 1.

The coaxial horn's model with the mechanical support was simulated in HFSS and a parametric analysis was used to optimize the support length $L$ (Fig. 1(b)). In the result shown in Fig. 2(b), one verifies that increasing the Teflon length leads to better results at lower frequencies, whilst at higher frequencies the best results are achieved decreasing the support's length. Among all variations, $L = 3.1$ mm was chosen as the best result, since it presents better performance throughout the considered frequency band. This result was compared with previously acquired results in Fig. 2(a), which presents the $|S_{11}|$ parameter as a function of the frequency.

Another important parameter to consider is the coaxial horn's radiation pattern, seen at Fig. 2(b). It is desired that the radiation pattern presents itself in a uniform manner throughout the entire band and that no nulls occur before $\theta = 60^o$ [1].




(a) Reflection Coefficient (b) Teflon Length Analysis (c) Radiation Pattern

Figure 2: Analysis' result.

In conclusion: an optimized coaxial horn design without support was presented. The implementation of an inner conductor support degraded the coaxial horn's performance. Nevertheless, for a commercial acceptance criterion ($|S_{11}| < -10$ dB), the proposed technique still leads to a functional antenna.

## Acknowledgments

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