CHAMP – The Dedicated Design Tool for Rotationally Symmetric Horns and Reflector Terminals

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***Abstract*—A fast and accurate approach to designing horns and reflectors is implemented in the CHAMP code. The paper presents examples of designs, including shaped reflectors and a horn with a dielectric lens.**

I. INTRODUCTION

TICRA's commercial program, CHAMP, already renowned for its excellent analysis and design capabilities for circular symmetric corrugated horns, has been extended to accommodate design of entire reflector antenna systems. Since speed and accuracy are pre-requisites for obtaining a usable tool, a highly efficient BoR MoM algorithm based on higher-order expansion functions and curved elements to represent the surface generatrix is implemented. This ensures that even very complex design problems are easily solved on standard laptop computers.

Figure 1 Exploded view of compact reflector terminal. Dielectric shown in green.

Figure 1 shows a typical geometry comprising a waveguide feeding an axially-corrugated horn, a sub-reflector, or splash-plate, supported by a dielectric structure shown in green, and a main dish. The waveguide and internal feed structure are analyzed using mode-matching while the BoR MoM handles the external scattering, including the dielectric. With this approach, a single frequency analysis can be performed in a very short time, as seen in Figure 2.

II. IMPLEMENTED DESIGN FEATURES

CHAMP implements several different optimization engines that can be applied as part of a design process. The program interface enables the user to easily set up goals to the optimization that are commensurate with the antenna designer's needs. These are:

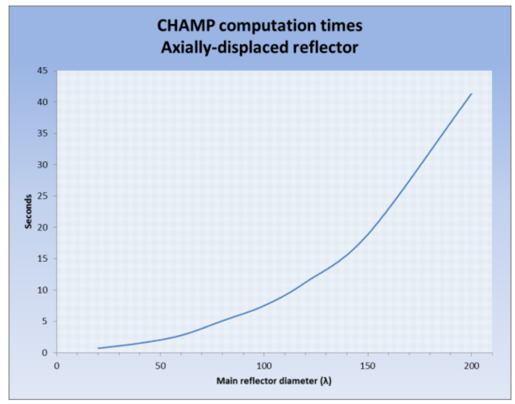

Figure 2 Analysis times per frequency point for different-sized reflector systems of the type in Figure 1, obtained on a standard laptop PC.

- Return loss
- Horn aperture efficiency
- Max cross-polar levels
- Directivity in specific directions, including on-axis
- Phase center location
- Co- and cross-polar patterns relative to templates

To assist the user CHAMP has built-in functionality to easily define templates of the typical form A – Blog(θ), leading to an automatic setup of goals at adequate sampling distances in θ where the co-polar or the cross-polar patterns are suppressed.

Practically all geometric parameters can be optimized. The surfaces are either represented as spline functions where the generatrix' values at the spline knots are the obvious design variable, or as piecewise linear segments. CHAMP contains many different ways of parameterizing different types of horns. Moreover, an ingenious way of using variables in arithmetic expressions provides an efficient tool for expressing preferred geometries and tying various parts of geometries together as required.

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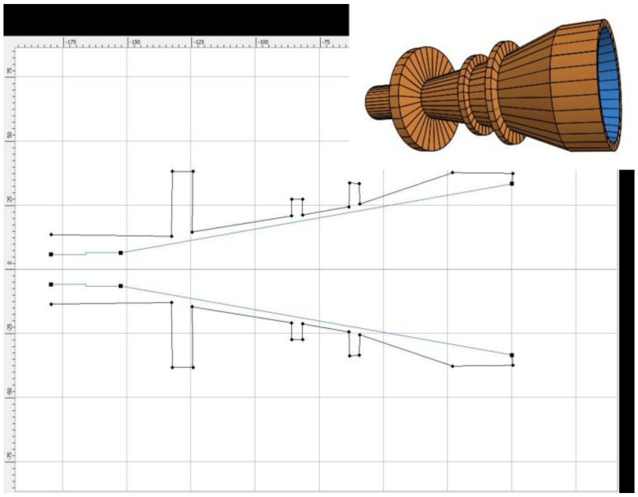

Figure 3 The horn length and aperture size are expressed by means of trigonometric functions involving the flare angle α, which can then be included in an optimization, as can the knot points of the outer structure.

III. Data Presentation

Accurate and fast analysis/design features are supported by easy-to-access graphical presentation of the most important parameters as a function of frequency:

- Return loss
- Radiation patterns
- Efficiency
- Phase center location
- Maximum co- and cross-polar directivity
- Beam width

This is supplemented by more sophisticated color plots of the fields inside a horn, the current distribution on all surfaces, 3D pattern plots, modal spectrum of aperture field, to name but a few.

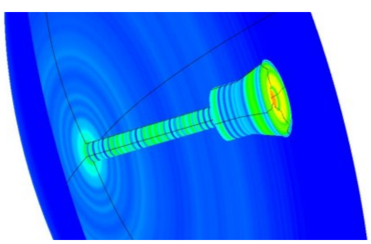

Figure 4 Currents on an optimized "hat-fed" reflector.

IV. A Few Examples

An example of a Ka-band antenna optimized to meet specified sidelobe envelopes for both co- and cross-polar patterns is shown in Figure 5. The main dish is 75 cm in diameter and the sub reflector only 7.5 cm (~5λ).

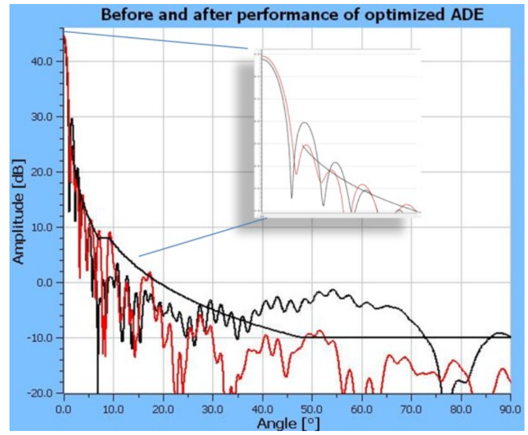

Figure 5 Optimized design to meet the ITU requirements. Black line is before optimization, red after.

The corrugated horn in Figure 5 has been equipped with a dielectric lens cap to increase the gain by more than 7 dB. The grooves ensure that the return loss is as good as for the horn without lens.

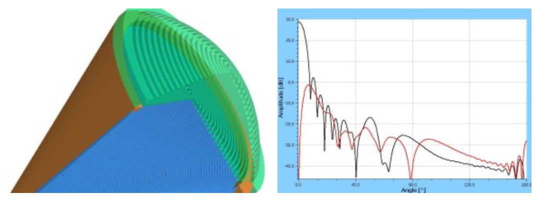

Figure 6 Corrugated horn with grooved lens, designed for the 40-60 GHz frequency range. In spite of the large dielectric surface area, the full analysis is performed in less than 2 minutes per frequency and with very modest memory requirements.

V. Conclusions

A fast and user-friendly tool for the design optimization of rotationally symmetric systems consisting of horns and reflecting surfaces, metallic or dielectric, has been described. By using solvers that are tailored to the particular geometry rather than completely general methods it is possible to perform complex design optimizations with challenging goals within acceptable times on standard PCs.

On-going R&D work at TICRA is now considering further extensions of the capabilities to also include non-symmetric elements, using a domain decomposition technique that ensures efficient computation by applying the fast techniques to the symmetric parts of the antenna.

VI. Acknowledgement

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