Computational Investigation of the DTU-ESA 12 GHz VAST12 Validation Standard Antenna to Identify Features Contributing to the Radiated Field

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***Abstract*—In this paper, we present a computational model of the DTU-ESA Standard Validation antenna VAST12, and investigate the impact of how different features on the antenna impact the radiation pattern. It is shown that the termination of the central tube, used to mount the antenna, has a significant impact on the sidelobe level of the antenna.**

***Index Terms*—Reflector antennas, antenna measurements, antenna radiation pattern**

I. Introduction

The DTU-ESA 12 GHz Validation Standard antenna (VAST12) [1]–[6] is one of two Validation Standard antennas developed by the Technical University of Denmark (DTU) under contract from the European Space Agency ESA – the other being the mmVAST antenna [7]. These antennas are intended to be used as tools to benchmark and compare different antenna measurement facilities in Europe [4], [5].

The VAST12 antenna is manufactured to be mechanically stable to ensure that there are no deformations in the antenna due to changing gravitational loads. It is also thermally stable to ensure that changing temperatures in the measurement facilities does not influence the antenna pattern. Therefore, the antenna provides a stable radiation pattern independently of the mounting and scanning methods used in the different measurement facilities.

The VAST12 antenna is still being improved and recently a built-in dual-axis high-precision spirit level has been added to the antenna to allow accurate alignment of both the ϕ-axis of the measurement coordinate system and the roll-axis of the probe positioner (if applicable) [6].

In this work, the VAST12 antenna has been subjected to a mechanical reconstruction using an optical scanner and a three-dimensional simulation model has been created. This simulation model has been used in the TICRA Tools simulation framework to investigate the impact of different features on the radiation pattern of the validation standard antenna. Of special interest is the impact of the support structure of the antenna and the termination of the central tube.

II. Antenna Geometry

A photo of the VAST12 antenna is shown in Fig. 1. The antenna is equipped with a built-in feed and is linearly polarized with the co-polarization being aligned with the offset plane ($\phi = 90°$). The reflector has a circular aperture with a diameter of 20λ and the surface of the reflector has a focal length of 14λ in the offset plane and 21λ in the orthogonal plane [3].

Fig. 1. Photo of the VAST12 validation antenna with the CAD model derived from the mechanical scan in the insert. The reflector has a diameter of 20λ (50 cm) and a focal length in the vertical direction of 14λ and 21λ in the horizontal direction. The central tube through the structure below the reflector is for mounting the antenna during measurements.

The use of a surface with different focal lengths in the two planes implies that the beam from the antenna is broader in the $\phi = 90°$ plane than in the $\phi = 0°$.

III. Simulation Model

The simulation model is based on the CAD model showed in the insert in Fig. 1. The CAD model has been constructed on the basis of an optical scan of the antenna. This allows us to include only parts of the antenna in the electromagnetic model of the antenna. The electromagnetic model is a full-wave MLFMM model made in ESTEAM in TICRA Tools. The analysis of the full antenna model takes just under 10 minutes and uses 2 GB RAM.

IV. Results

The effect of a number of different features on the radiation pattern have been investigated. In this paper we will focus on the effect of the distance from the front of the central tube to the termination of the tube on the mechanical interface of the measurement facility. This distance varies between measurement facilities since the different facilities each use different mechanical interfaces.

In Fig. 2, the measured pattern, a model with a termination depth of 193 mm (”CAD Model”), and a model with a termination depth of 174.5 mm (”Shifted Termination”) are compared. We can see that the shift in termination depth

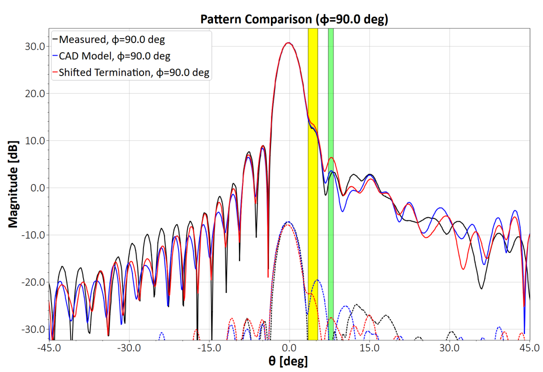

Fig. 2. Comparison of the effect of termination of central tube. Both in the shoulder of the main lobe (yellow region) and the first sidelobe to the right (green region) a clear effect is seen of the depth of the termination of the central tube.

(approxaimtely 3/4 of a wavelength) gives noticeably different results on the shoulder of the main lobe (marked in yellow) and the first sidelobe (marked in green).

In Tables I and II, we have listed the measured and two modeled values of the antenna gain. It is seen that although there is little difference in the peak values, there is more than 2.8 dBi difference in the first sidelobe level. This behavior has also been observed in measurement campaigns and it is now planned to provide a well-defined termination for the central tube [6].

TABLE I
Comparison of measured and modeled results at the peak.

	Measured	Full Model	Shifted Termination
Co Polar	30.71 dBi	30.69 dBi	30.64 dBi
$\Delta_{\mathbf{Co}}$	- - - -	-0.02 dBi	-0.07 dBi
Cx Polar	-7.28 dBi	-7.31 dBi	-8.05 dBi
$\Delta_{\mathbf{Cx}}$	- - - -	-0.03 dBi	-0.77 dBi

TABLE II
Comparison of measured and modeled results at the first sidelobe (marked in green in Fig. 2).

	Measured	Full Model	Shifted Termination
Co Polar	3.23 dBi	3.54 dBi	6.38 dBi
$\Delta_{\mathbf{Co}}$	- - - -	0.31 dBi	3.15 dBi

V. Conclusion

A model suitable for inspecting the effects of different mechanical parts of the VAST12 antenna on its radiation pattern has been developed and results presented.

In this paper, we presented the impact of the termination depth of the central tube on the shoulder of the main lobe and the first sidelobe. This confirmed that the termination of this tube has a noticeable effect on the measured radiation pattern – something that has also been observed in measurements.

The results show that the model of the VAST12 is a powerful tool to understanding the measurement results.

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