Repositório ISCTE-IUL

Deposited in *Repositório ISCTE-IUL*:
2019-01-10

Deposited version:
Post-print

Peer-review status of attached file:
Peer-reviewed

Citation for published item:
Matos, S., Fernandes, C. & Costa, J. R. (2018). Test Case 4: dual band transmit-array . In Workshop-EM-ISAE-2018.

Further information on publisher's website:
--

Publisher's copyright statement:
This is the peer reviewed version of the following article: Matos, S., Fernandes, C. & Costa, J. R. (2018). Test Case 4: dual band transmit-array . In Workshop-EM-ISAE-2018.. This article may be used for non-commercial purposes in accordance with the Publisher's Terms and Conditions for self-archiving.

Use policy

Creative Commons CC BY 4.0
The full-text may be used and/or reproduced, and given to third parties in any format or medium, without prior permission or charge, for personal research or study, educational, or not-for-profit purposes provided that:

- a full bibliographic reference is made to the original source
- a link is made to the metadata record in the Repository
- the full-text is not changed in any way

The full-text must not be sold in any format or medium without the formal permission of the copyright holders.

Serviços de Informação e Documentação, Instituto Universitário de Lisboa (ISCTE-IUL)
Av. das Forças Armadas, Edifício II, 1649-026 Lisboa Portugal
Phone: +(351) 217 903 024 | e-mail: administrador.repositorio@iscte-iul.pt
https://repositorio.iscte-iul.pt

WORKSHOP EM-ISAE 2018

TEST CASE 4: Dual band Transmit-array

Sérgio MATOS[1,2], Carlos FERNANDES[2], Jorge COSTA[1,2]

[1] Instituto Universitário de Lisboa, (ISCTE-IUL), Lisbon, Portugal
[2] Instituto de Telecomunicações, Instituto Superior Técnico, IT/IST, Lisbon, Portugal

E-mail: sergio.matos@iscte-iul.pt

I. Introduction

In this report a numerical solution for the dual band transmit-array challegenge proposed for the WORKSHOP EM-ISAE 2018 (test case nº 4) is presented. The numerical results are compared with the measurements of the corresponding prototype (see Figure 1). More details about the design and fabrication processes of the dual band TA can be found in [1]. To perform the corresponding full-wave simulations was quite challenging, mainly due to the large volume occupied by the antenna (comprising the feed and lens) and the fine subwavelength details of the unit cells that populate the TA. In fact, we did not had at that time sufficient memory to perform the full-wave simulation of the complete antenna (feed+lens). In this workshop we detailed the developed approach used to conduct the full-wave analysis of the TA within our available computational resources.

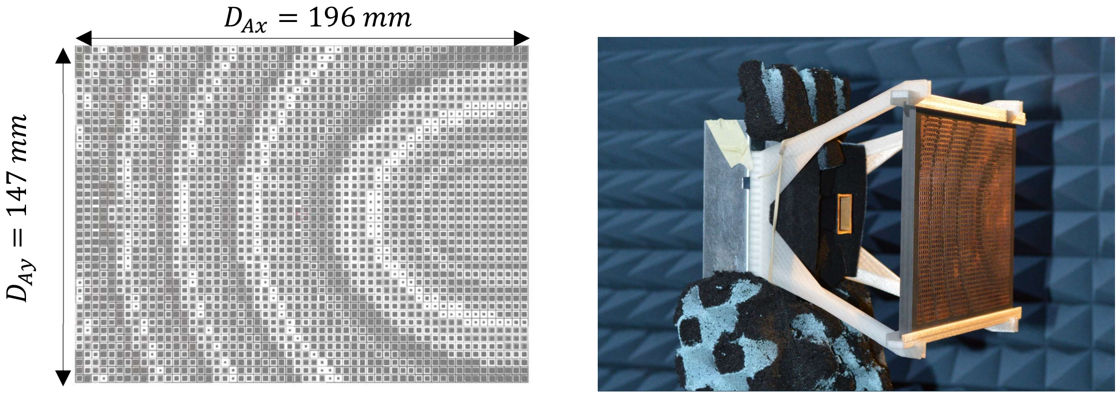


Figure 1 – Fabricated prototype of the dual band lens in Instituto de Telecomunicações, Lisbon, Portugal.

WORKSHOP EM-ISAE 2018

TEST CASE 4: Dual band Transmit-array

Sérgio MATOS[1,2], Carlos FERNANDES[2], Jorge COSTA[1,2]

[1] Instituto Universitário de Lisboa, (ISCTE-IUL), Lisbon, Portugal
[2] Instituto de Telecomunicações, Instituto Superior Técnico, IT/IST, Lisbon, Portugal

E-mail: sergio.matos@iscte-iul.pt

II. Computational method

We use CST Microwave Studio ® Finite-difference time-domain (FDTD) for evaluating the Transmit-array (TA) performance. A high volume mesh density is required to capture the subwavelength details of the unit cells that compose the TA. This problem is computationally difficult even with high end PC workstations. To circuvent this problem a hybrid approach was developed that consist in separating the analysis of the feed from the analysis of the TA. This is a reasonable approximation as the coupling between the feed and the transmit-array is neglectable. The method involves the definition of an equivalent near-field source as a closed parallelepiped region near the transmit-array, as schematized in Figure 2. This near-field source is defined through equivalent electric and magnetic currents at the surface, according to the surface equivalence theorem. The goal is to achieve a near-field distribution that mimics the radiated field distribution of the original feed close to the lens bottom surface. The general procedure of finding the equivalent illumination is describe in Figure 3. Another advantage of this approach, besides the memory reduction, is that with a single simulation is possible to evaluate the transmit-array in both bands, whereas in the real problem two separate simulations would be required, one for each horn.

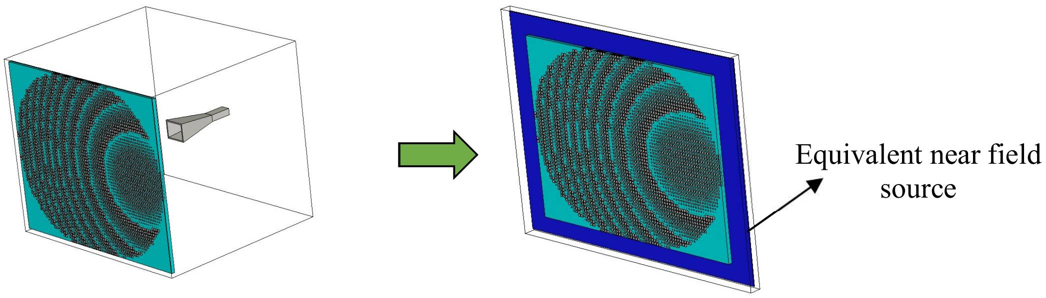
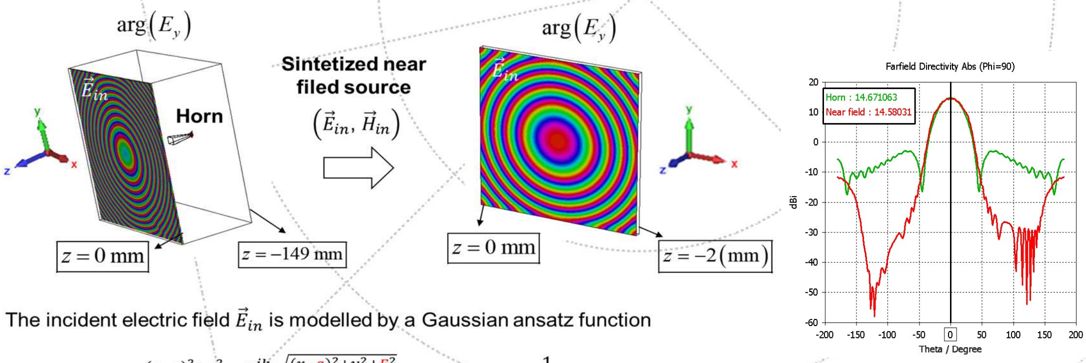


Figure 2 – Schematics of the hybrid approach used to simplify the analysis of TAs.

Sérgio MATOS[1,2], Carlos FERNANDES[2], Jorge COSTA[1,2]

[1] Instituto Universitário de Lisboa, (ISCTE-IUL), Lisbon, Portugal
[2] Instituto de Telecomunicações, Instituto Superior Técnico, IT/IST, Lisbon, Portugal

E-mail: sergio.matos@iscte-iul.pt



The incident electric field $\vec{E}_{in}$ is modelled by a Gaussian ansatz function

$$\vec{E}_{in} = e^{-\frac{(x-a)^2+y^2}{2\sigma^2}} \frac{e^{-jk_0\sqrt{(x-a)^2+y^2+F^2}}}{\sqrt{(x-a)^2+y^2+F^2}} \vec{u}_E \qquad \vec{H}_{in} = \frac{1}{\eta} \vec{u}_z \times \vec{E}_{out} \qquad \boxed{F = 100\ mm, \sigma = 40.4\ mm, \overrightarrow{u_E} = \vec{u}_y}$$

Figure 3 – Definition of the equivalent near field source

A previous single band TA design for Tx Ka-band (30 GHz) [2] is used to validate the accuracy of this method when compared with the complete antenna simulation. The presented results in Figure 4 validate the propose method for the analysis of the dual band TA.

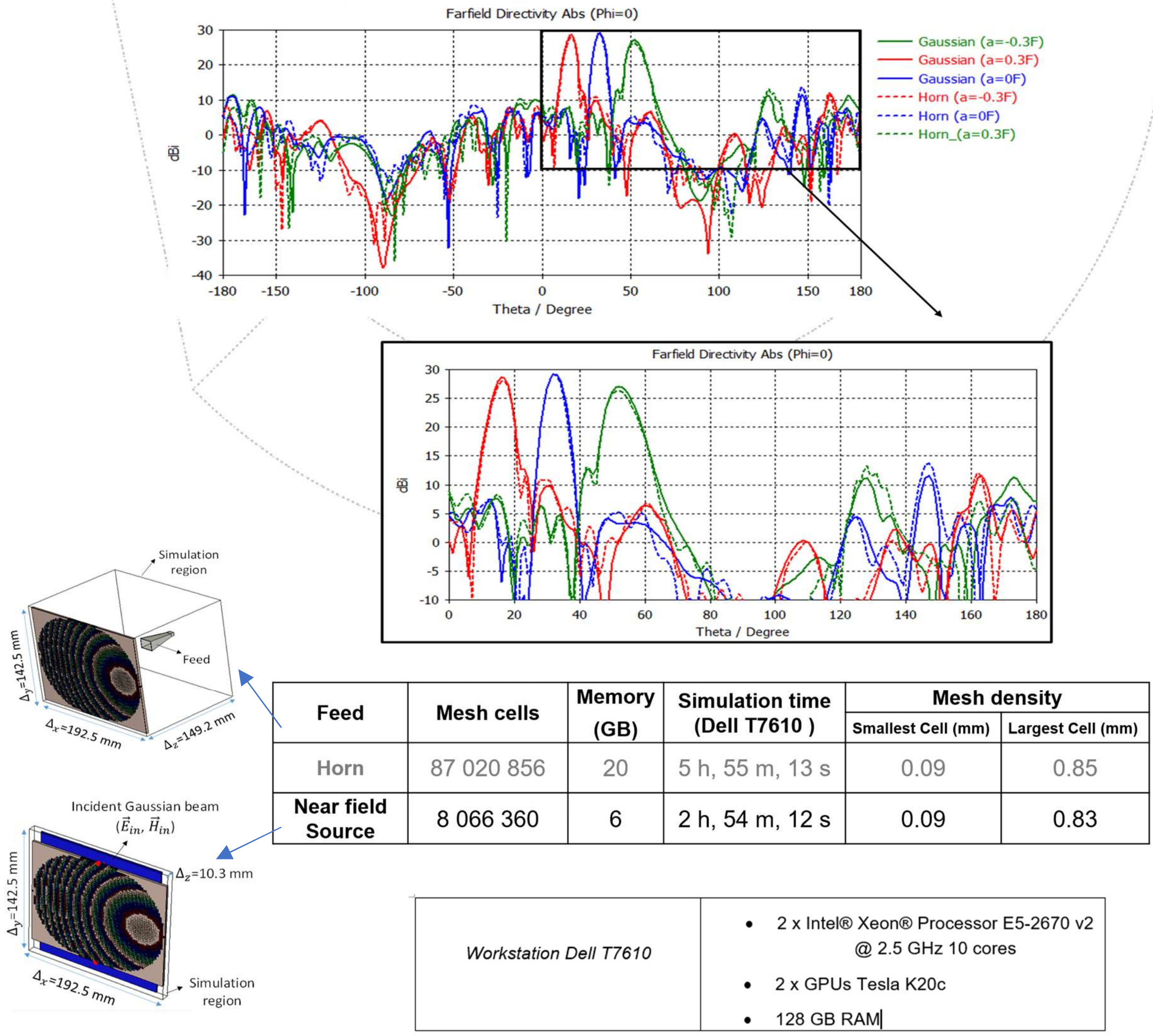
WORKSHOP EM-ISAE 2018

TEST CASE 4: Dual band Transmit-array

Sérgio MATOS[1,2], Carlos FERNANDES[2], Jorge COSTA[1,2]

[1] Instituto Universitário de Lisboa, (ISCTE-IUL), Lisbon, Portugal
[2] Instituto de Telecomunicações, Instituto Superior Técnico, IT/IST, Lisbon, Portugal

E-mail: sergio.matos@iscte-iul.pt



Feed	Mesh cells	Memory (GB)	Simulation time (Dell T7610)	Mesh density	
				Smallest Cell (mm)	Largest Cell (mm)
Horn	87 020 856	20	5 h, 55 m, 13 s	0.09	0.85
Near field Source	8 066 360	6	2 h, 54 m, 12 s	0.09	0.83

Workstation Dell T7610	• 2 x Intel® Xeon® Processor E5-2670 v2 @ 2.5 GHz 10 cores • 2 x GPUs Tesla K20c • 128 GB RAM

Figure 4 – Comparison between the equivalent near field source method and the full-wave simulation of the complete antenna. These simulations where performed using 2 GPUs K20c.

WORKSHOP EM-ISAE 2018

TEST CASE 4: Dual band Transmit-array

Sérgio MATOS[1,2], Carlos FERNANDES[2], Jorge COSTA[1,2]

[1] Instituto Universitário de Lisboa, (ISCTE-IUL), Lisbon, Portugal
[2] Instituto de Telecomunicações, Instituto Superior Técnico, IT/IST, Lisbon, Portugal

E-mail: sergio.matos@iscte-iul.pt

III. Dual band Transmit-array – test case results

In Figure 5 and Figure 6 the comparison between the simulations and measurements is shown for each band, respectively. We should stress that manufacturing process of this TA is also quite challenging. The most demanding elements are the unit cells other rings that can be as small as 0.05 mm, which is in the limit of our manufacturing precision. These elements affect more the unit cell response at 20 GHz than 30 GHz, which may explain why we get a better agreement at 30 GHz.

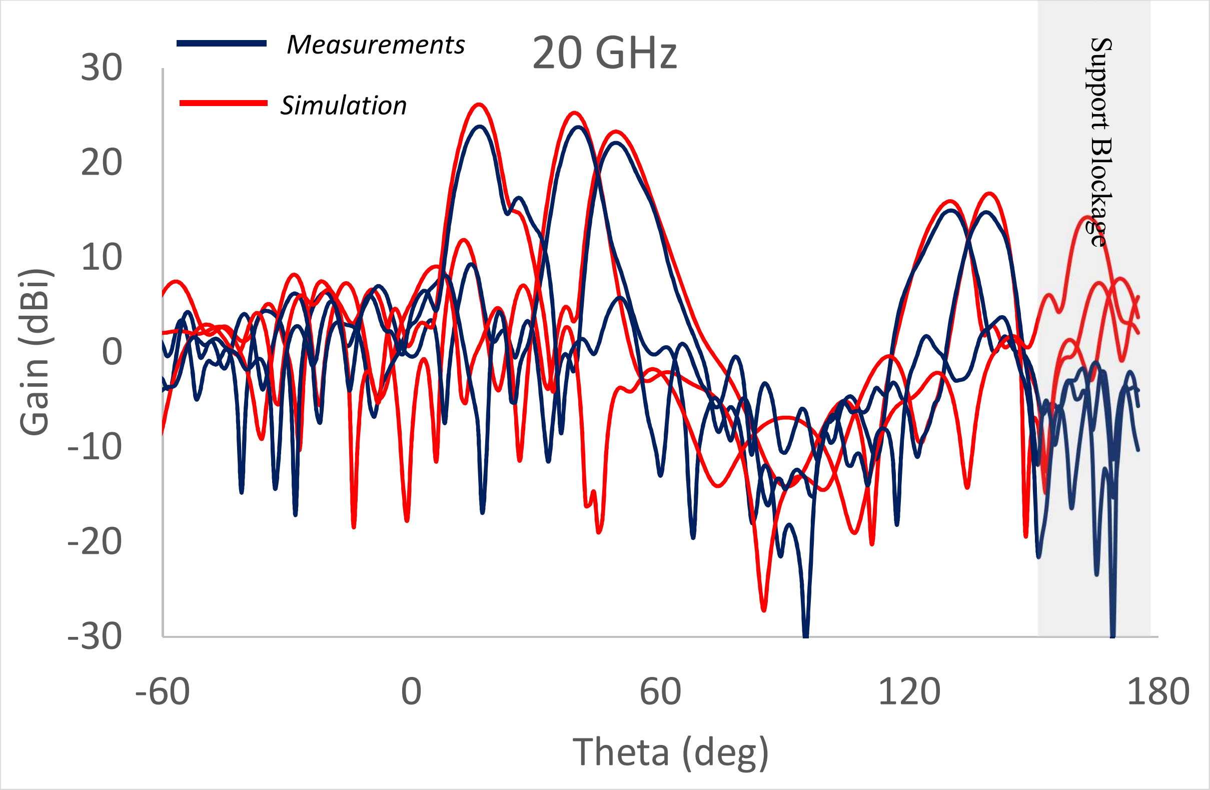


Figure 5 – Comparison between the simulations and measurements for 20 GHz.

WORKSHOP EM-ISAE 2018

TEST CASE 4: Dual band Transmit-array

Sérgio MATOS[1,2], Carlos FERNANDES[2], Jorge COSTA[1,2]

[1] Instituto Universitário de Lisboa, (ISCTE-IUL), Lisbon, Portugal
[2] Instituto de Telecomunicações, Instituto Superior Técnico, IT/IST, Lisbon, Portugal

E-mail: sergio.matos@iscte-iul.pt

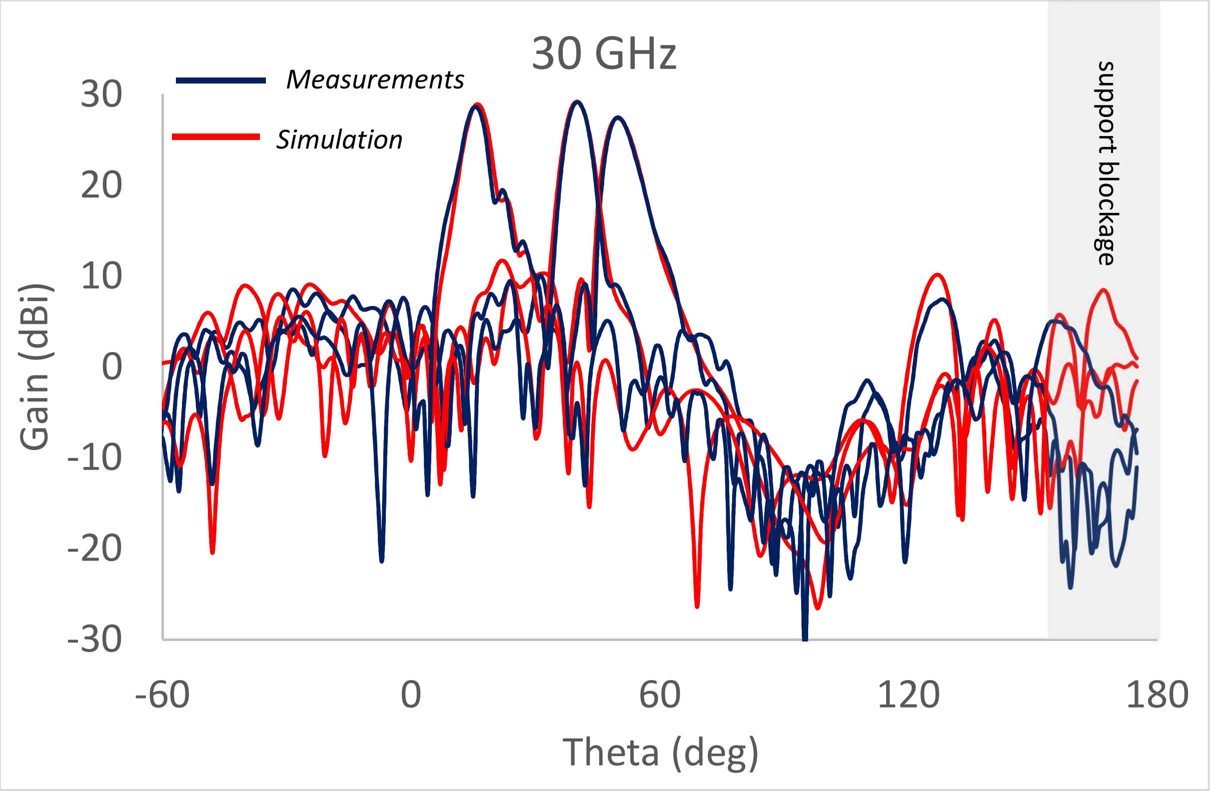


Figure 6 – Comparison between the simulations and measurements for 30 GHz.

WORKSHOP EM-ISAE 2018

TEST CASE 4: Dual band Transmit-array

Sérgio MATOS[1,2], Carlos FERNANDES[2], Jorge COSTA[1,2]

[1] Instituto Universitário de Lisboa, (ISCTE-IUL), Lisbon, Portugal
[2] Instituto de Telecomunicações, Instituto Superior Técnico, IT/IST, Lisbon, Portugal

E-mail: sergio.matos@iscte-iul.pt

Table 1 – Simulation parameters

Workstation Dell T7610	2 x Intel® Xeon® Processor E5-2670 v2 @ 2.5 GHz 10 cores 128 GB RAM
Number of time steps	28 840
Steady state accuracy limit (dB)	-18.6
Smallest cell (mm)	0.0975
Largest cell (mm)	1.29881
Number of Mesh cells	87 357 816
Memory used (GBytes)	24
Elapsed time/ feed position	50h52m54s

IV. References

[1] S. A. Matos, E. B. Lima, J. S. Silva, J. R. Costa, C. A. Fernandes, N. J. G. Fonseca, and J. R. Mosig, “High gain dual-band beam-steering transmit array for satcom terminals at Ka-Band,” IEEE Trans. Antennas Propagat, vol. 65, no. 7, pp. 3528-3539, Jul. 2017.

[2] E. B. Lima, S. A. Matos, J. R. Costa, C. A. Fernandes and N. Fonsenca, “Circular Polarization Wide-angle Beam Steering at Ka-band by In-plane Translation of a Plate Lens Antenna,” IEEE Trans. Antennas and Propag., Vol. 63, No. 12, pp. 5443-5455, Dec. 2015.

V. Acknowledgments

This work was supported in part by the European Space Agency under contract no. 4000109111/13/NL/AD and by the Fundação para a Ciência e Tecnologia under Projects PEst-OE/EEI/LA/0008/2013 and UID/EEA/50008/2013.