

TEST CASE 4: Dual Band Transmit-array

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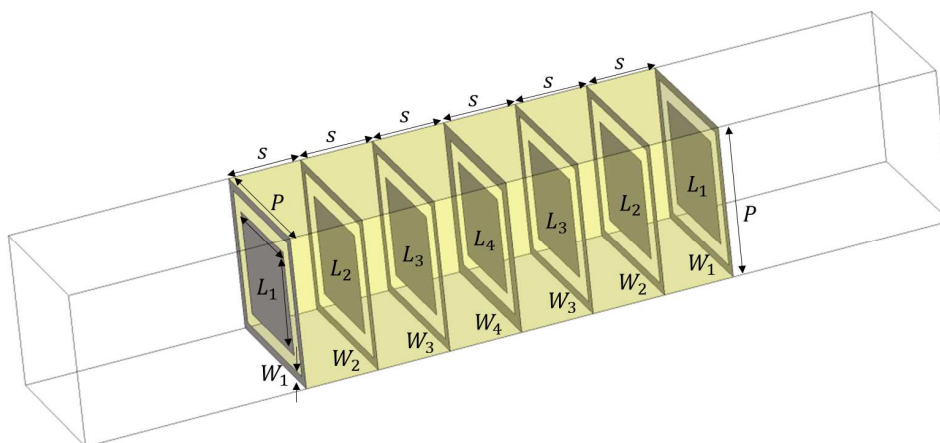
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Abstract:

This test concerns the simulation of a high gain dual band transmit-array (TA) in the Ka-band. This is a particularly challenging problem due to the large computational volume and fine subwavelength details of the proposed antenna.

1. Definition of the Geometry

The dual band TA is composed by a collection of unit cells properly arranged to provide beam collimation. In this test we use the set of 31 dual band unit cells. These unit cells are composed by seven metallized layers of concentric squared patches and strip loops printed on six substrate layers of Rogers Duroid 5880 ($\epsilon_r=2.2$ and $\tan \delta = 0.0009$), according to Figure 1. The metallization can be modelled by a perfect electromagnetic conductor (PEC) with zero thickness. The thickness of each dielectric layer is $s = 1.617$ mm. The in-plane width of the unit cell is $P = 3.5$ mm. The dimensions of the metallization patterns of each layer (in mm) can be found in the file “type_cell_ITlens_DualBand.xls”.



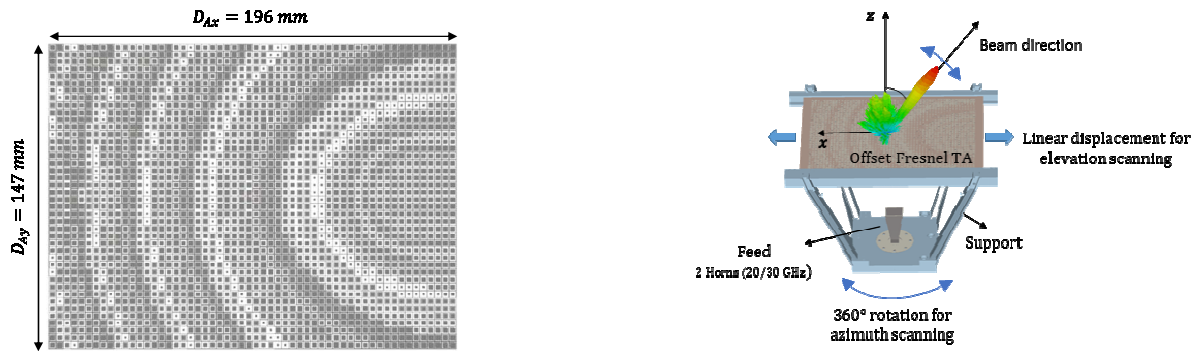
Materials

Dielectric permittivity, ϵ_r	2.2
Dielectric loss tangent, $\tan \delta$	0.0009
Metal	PEC with zero thickness
Unit cell	
In plane dimensions, $(P \times P)$ (mm^2)	3.5x3.5
Thickness of the dielectric layers, s (mm)	1.617
Total height, T (mm)	9.702
Metallization dimensions	
Patches in-plane dimensions (mm^2)	$L_j \times L_j$, $j=1,4$
Strip loops widths (mm)	W_j , $j=1,4$

Figure 1 – Dual band unit cell.

The TA is designed to produce a 40° beam offset for a focal distance $F=100$ mm. The top view of the lens is represented in Figure 2. The aperture size is 196×147 mm², corresponding to a total of 2352 cells. One should note that the lens is symmetric relative to the xz plane. The xy coordinates of the center of the unit cells on the TA (in mm) are given in the file “cell_position_ITlens_DualBand.xls”.

Elevation beam scanning is produced by the linear displacement of the lens (see Figure 2). The lens displacement is given by the parameter a . For this test three lens positions are considered: $a=0$ mm (corresponding to no displacement, the center of the lens is aligned with the feed phase center, as in Figure 2), $a=-15$ mm (lens moves to the right) and $a=44$ mm (lens moves to left). Please note that the supporting structure shown in Figure 2 should not be considered in the simulation.



TA

<i>Focal distance, F (mm)</i>	100
<i>In-plane dimensions (mm²)</i>	196x147
<i>N° of unit cells</i>	2352
Beam direction (°)	
<i>Without lens displacement, a=0 mm</i>	40
<i>Right lens displacement, a=-15 mm</i>	50
<i>Left lens displacement, a=44 mm</i>	15

Figure 2 Dual band TA antenna.

Two 15-dBi standard-gain rectangular horn antennas (Figure 3) are used to illuminate the TA at each band, with their phase centers positioned at 100 mm distance from the bottom face of the TA. For each lens position, one horn orientation should be simulated (y-pol) as shown in Figure 2. The model of the two horns are given in the files “horn_FM20240-15_20GHz.step” and “horn_FM22240-15_30GHz.step”

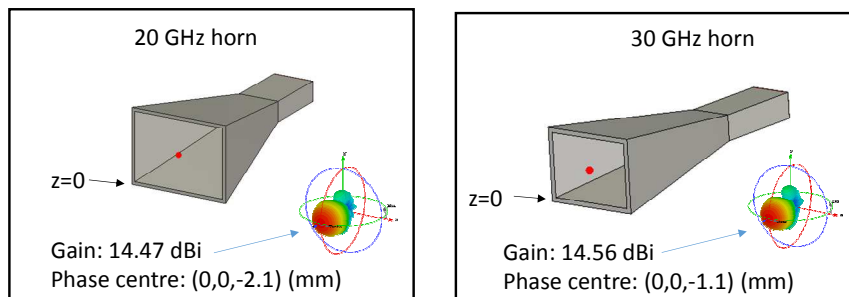


Figure 3 – Models of the horn antennas used as feed for the dual band lens: Flann Microwave N° 20240-15 for 20 GHz and Flann Microwave N° 22240-15 used for 30 GHz

2. Attached files

- “type_cell_ITlens_DualBand.xls”: dimensions of the L_1, L_2, L_3, L_4 patches and W_1, W_2, W_3, W_4 rings for the 31 cells (see Figure 1)
- “cell_position_ITlens_DualBand.xls”: cell location in the grid lens (correspondence $(x_0, y_0) \Rightarrow$ type_cell).
- “horn_FM20240-15_20GHz.stp”: geometry of the 20 GHz horn; The horn phase center (see Figure 3) should be positioned at 100 mm distance from the bottom face of the transmit array.
- “horn_FM22240-15_30GHz.stp”: geometry of the 30 GHz horn; The horn phase center (Figure 3) should be positioned at 100 mm distance from the bottom face of the transmit array.

3. Simulation Parameters

Two frequencies: 20 GHz, 30 GHz

Angular sweep: $-180^\circ < \theta < +180^\circ$, $\delta\theta = 1^\circ$

Horn sources, with phase centers placed at 100 mm from the lower surface of the lens ;

The source is the E-field of the TE₁₀ mode parallel to the shortest dimension of the rectangular waveguide (see Figure 3)

Positions of the lens (beam steering): $a=0$, $a=-15$ mm, $a=+44$ mm (see Figure 2)

Gain_y-pol x 3 positions x 2 frequencies (6 curves)

4. Data formats

The results for each frequency (20 GHz and 30 GHz) will be stored in 6 separated ASCII file containing on each row the data: Theta (degree), Gain (dBi)

1. Gain_frequency_y-pol_a=0 at 20 GHz in the xz plane ($\varphi=0^\circ$)
2. Gain_frequency_y-pol_a=-15 at 20 GHz in the xz plane ($\varphi=0^\circ$)
3. Gain_frequency_y-pol_a=+44 at 20 GHz in the xz plane ($\varphi=0^\circ$)
4. Gain_frequency_y-pol_a=0 at 30 GHz in the xz plane ($\varphi=0^\circ$)
5. Gain_frequency_y-pol_a=-15 at 30 GHz in the xz plane ($\varphi=0^\circ$)
6. Gain_frequency_y-pol_a=+44 at 30 GHz in the xz plane ($\varphi=0^\circ$)

5. Reporting

The numerical method will be presented briefly as well as the characteristics of the computer used for the simulation (type of processors, number of cores, memory) and the elapse simulation time.