Test case 1 : cone-sphere with a PEC patch

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February 26, 2016.

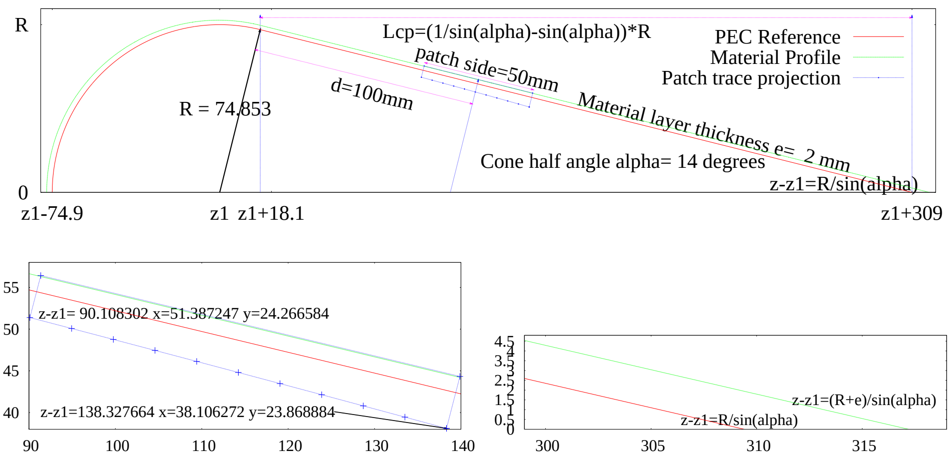
Abstract

We deal with an alumina coated cone bounded by a sphere using a tangential connection. On a generator of the cone we conform a square patch made up of many rectangular pieces in a Perfectly Electric Conductor whose influence on RCS is analyzed through a frequency spectrum.

1 Object definition

We deal with a PEC cone bounded by a PEC sphere using a tangent connection as shown figure 1. The sphere radius is $R = 2.947$ inches (an inch is 25.4 mm), the cone half angle is 14 degrees. The object is covered with $e = 2$ mm of aluminium oxyde ($\varepsilon_r = 9.1$, $\mu_r = 1$) thus defining another cone-sphere of radius $(R + e) = 2.947 * 25.4 + 2 = 76.853$ mm. On a cone generator, at $d = 100$ mm from the tangent connection, we conform a 50 mm square patch made up of rectangular perfectly electric conductor pieces.

Cone angle 14 degrees, sphere radius 2.947 inches, material layer thickness 2 mm :



Zooms of patch projection (left) and top of the cone in (z, x) view (right)
(both relative to z1 $= -1/2(R + e)(1/\sin\alpha - 1)$)

Figure 1: Axisymmetric geometry of the object in (z,x) projected view, dimensions in mm.

1.1 Patch definition

The patch is a square with a side length of 50 mm (zero thickness), 4 different objects are defined from 4 kinds of patch as follows :

1. patch does not exist,
2. patch is totally filled by a perfectly electric conductor,
3. patch is made up of $N = 5$ squares per direction, $f = 80\%$ being made up of PEC per direction,
4. idem with $N = 100$ squares per direction (total PEC surface is the same as above, $f = 80\%$).

Case 2 is $N = 1$ squares, PEC filling ratio per direction is $f = 100\%$.

To fix ideas about what the patch may look like, figure 2, displays a surface mesh of the PEC for a 5 squares per direction patch as in patch 3 above.

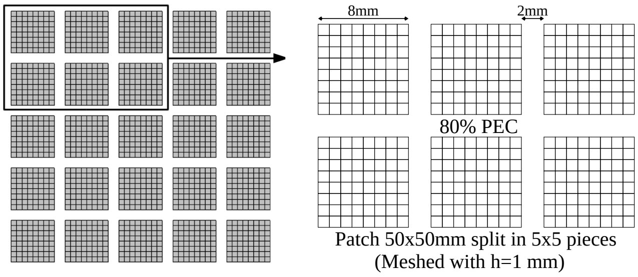


Figure 2: Mesh of a 5x5 patch with 80% PEC on top of a coated square.

1.2 Patch conformation onto the coated cone

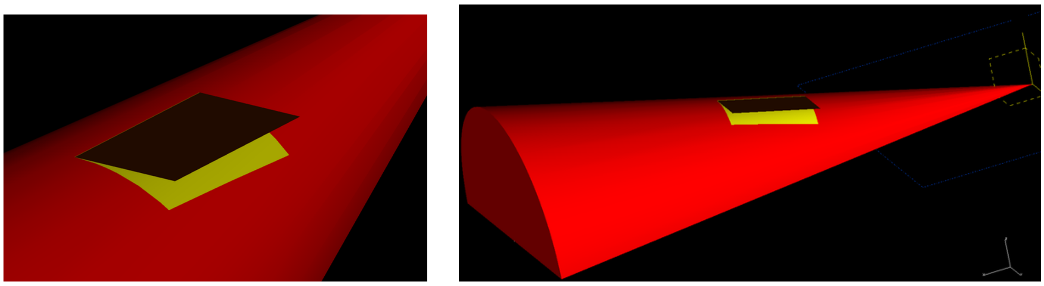


Figure 3: View of a plane patch being normally conformed onto a cone's surface.

The patch is conformed following an industrial like process where we first coincide patch's middle line (in either of its axis) with the cone generator defined by $y = 0$ and $x = -\tan(\alpha)\,(z - z_0)$ where z_O is the coordinate of the top of the cone. Then, we apply the patch tangentially, meaning orthogonal patch lines are the elliptical intersections of the orthogonal plane with the cone.

We compute the curvilinear abscissa along this ellipse to complete the conformation. Figure 3 shows how it looks like in 3D, while figure 1 showed the patch projection in (z, x) coordinates.

Patch center is positioned at $d = 100$ mm from the tangential connection.

Figure 4 shows how it looks like.

Analytical expressions and fortran code for mesh generation are available on request.

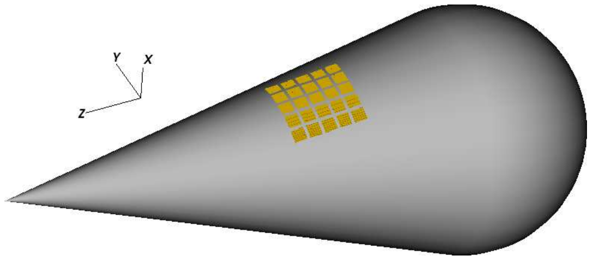


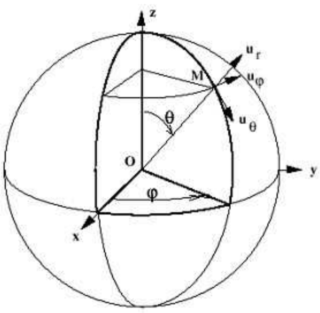
Figure 4: Cartesian mesh of an orthogonally conformed 5x5 patch onto a cone

2 Expected computations to be delivered

2.1 Chairman

Chairman is Olivier Cessenat, CEA, co-chairman is Isabelle Terrasse, ADS-IW.

2.2 Conventions



Monostatic RCS for polarization TM is such that the incident electric is along $u_\theta = \begin{pmatrix} \cos\theta\cos\phi \\ \cos\theta\sin\phi \\ -\sin\theta \end{pmatrix}$ (also called $\theta\theta$ polarization). For instance, $\theta = \phi = 0$ means $E_{inc} = (1, 0, 0)$.
RCS is defined as :

$$10 \log_{10} \lim_{r\to\infty} 4\pi r^2 \frac{|E^{scattered}(r)|^2}{|E_{inc}|^2}$$

2.3 Computations

Incident angles are 0 degrees and 20 degrees (relative to the z axis in the (z, x) plane), polarization is TM mode (incident electric field $E = (1, 0, 0)$), frequency sweeping is between 6 and 10 GHz by 20 MHz step, so 201 frequencies. We expect a monostatic RCS file for all four objects times the two specific incident angles (8 files in total). Format shall be the same for all the files columned as :

$$Frequency(MHz) \quad RCS(dBm^2) \quad phase(degrees)\ .$$

In case your code computes both polarizations TM and TE, accepted file format shall be

$$Frequency(MHz) \quad RCS[TM] \quad phase[TM] \quad RCS[TE] \quad phase[TE]\ .$$

A substraction analysis relative to the no patch axisymmetric case shall be performed by the chairman.