Second lab: Radar cross section (RCS) analysis

First experiment: RCS of a wing

Let us consider an aircraft wing illuminated by a bi-static radar as represented in the Figure below.

The antenna gains of the radar are 15 dBi over the frequency band [18:26.5] GHz. This frequency range will also be the frequency band of interest.

The objective is to measure the radar cross section (RCS) of the wing. For that purpose, a VNA will be used to measure the transmittance (S12) between the two antenna ports. To maintain the received reflected signal at a power level higher than the noise, a power amplifier is used as represented in Figure 1.

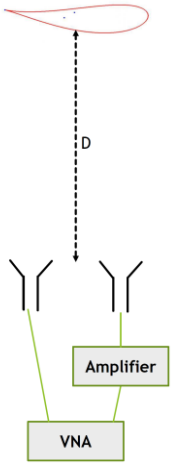

Figure 1: Measurement configuration

The amplifier gain is 21 dB in the frequency band of interest.

In the course theory, it has been proven that the RCS of a cylinder is given by $\sigma = \pi R D$ where D is the distance between the radar and the cylinder, and R is the cylinder radius. Based on this formula, it is reasonable to say that the RCS of the wing being equal to $\sigma = \pi r D$, with r being the curvature radius at the specular reflection point.

The geometry of the cylinder will be given in the form of the x-y coordinates (in millimeters) of some points around the wing. At each point, the local curvature radius (in millimeter) will also be given.

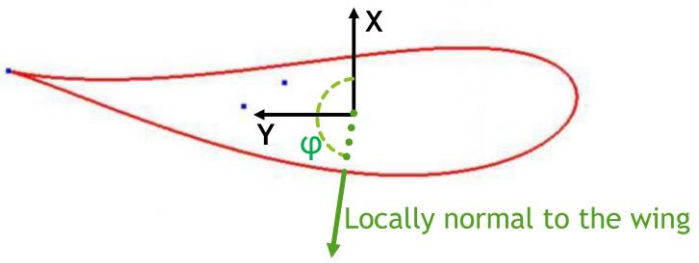

Figure 2: Convention for the definition of the locally normal to the wing

Finally, at each point, the angle phi (in radian) between the normal to the cylinder and the X-axis will also be provided (see Figure 2 for the conventions).

Those data allow for finding for each wing orientation, the specular reflection point (point for which the normal to the wing is approximately in the same direction with the radar direction) and the corresponding curvature radius.

Tasks:

1-Measure the transmittance (S12) for different orientations of the wing.

2-Considering that the measured RCS is related to the transmittance (S21), and based on the expected frequency dependence of the RCS, what can you conclude about the accuracy of the measured RCS?

3-What is the origin of the frequency oscillation of the S21?

4-Propose a solution to solve this issue.

5-Deduce a more accurate measure of the radar cross section of the wing as a function of its orientation.

6-Based on the provided numerical data of the wing, compute the radar cross section of the wing as a function of the wing orientation. Compare the obtained prediction with the measured one.

7- Same exercise for a large sphere available in the lab.