Radar Cross Section Engineering Final

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Problem 1:

A wide band scatterometer operating from 0.1 to 10 GHz is used to measure the backscatter RCS of a small metal sphere in a lab project. It is found that the measured RCS shows significant fluctuations over the frequency band, while the highest value occurs exactly at 3 GHz.

(1) What is the radius of the sphere used?

(2) Describe what are the RCS frequency regions this sphere operates from 0.1 to 10 GHz?

To determine the radius of the sphere, we must determine wavelength then we can find the circumference at resonance:

$$\lambda = \frac{c}{f}$$

c = speed of light

f = frequency of 3 GHz

Wavelength = 0.1 meters

Now…

$$r = \frac{\lambda}{2\pi}$$

So, the radius of the sphere is 0.0159 meters.

Since the sweep of the scatterometer is quite large, it encompasses several frequency regions. These being the Raleigh Region, Resonance Region, and Optical Region. The Rayleigh Region which is from less than 1GHz, making the radar return in this region small. The Resonance region, which is around 1 GHz to 3 GHz returns the most energy and thus the highest RCS. The last region operates from 3 GHz and higher. It's radar returns are stable since the sphere cross sectional area is equivalent to the sphere.

Problem 2:

1.8 (From Ref. 15.) The bistatic-monostatic equivalence theorem states that: For perfectly conducting bodies that are sufficiently smooth, in the limit of vanishing wavelength, the bistatic cross section is equal to the monostatic cross section at the bisector of the bistatic angle. Consider a TM z wave incident on the following targets. Use the preceding rule to estimate the bistatic RCS at 0 - 90 deg:

(a) A sphere with ka = 10.

(b) A circular disk in the z = 0 plane for Oi = O. [Hint: Eso (0 = 90 deg) ,~ 0 if the disk is very thin.]

Part (a):

The RCS of the Sphere is:

$$a = \frac{10}{k}$$

$$RCS = \pi \left(\frac{10}{k}\right)^2$$

Part (b):

Since the disk is very thin, the bistatic RCs at 90 degrees is approximated to 0.

Problem 3:

A square plate with edge length a has a square hole with edge length b cut into it. As shown in Fig. P2.3, the hole is centered at (x0, y0) and is rotated an angle 6 with respect to the x axis. Find the monostatic RCS for a TMz-polarized BASIC THEOREMS, CONCEPTS, AND METHODS 89 incident plane wave using the physical optics approximation. Plot the result for q~ -- 45 ° and ~b - 0 °. Verify your result using POFACETS.

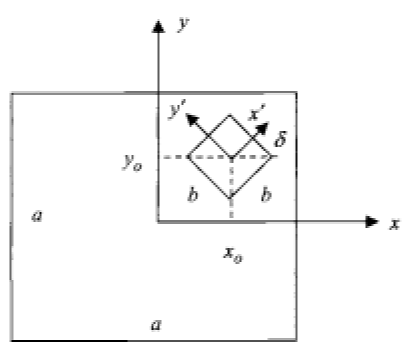

Fig. P2.3

Induced surface currents on a PEC: $J = 2n \times H$

The Scattered Electric Field: $E_S(r) = -j\frac{e^{-jkr}}{2\pi r}\int_s (n \times H)e^{jkr*r'}ds$

$$\text{RCS: } \sigma = \left|\frac{EScattered^2}{E\ Induced^2}\right|$$

Next, the equations are inputted into MATLAB to generate a plot. Several assumptions are made, being the length of the plate and the length of the hole, 1.0 meter and half a meter respectively.

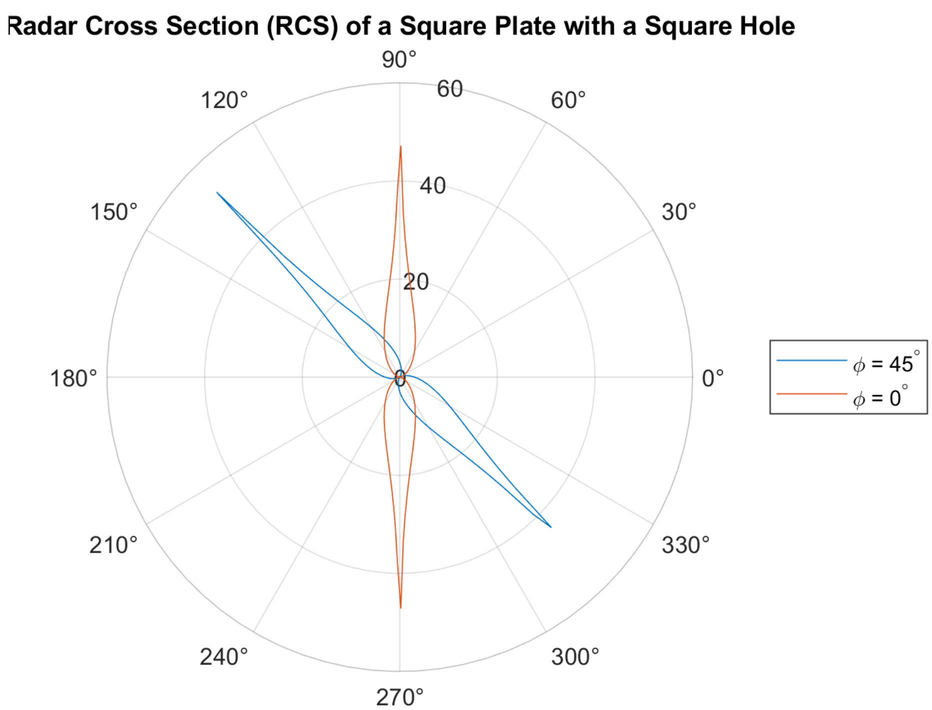

Figure 1: Plot of square plate RCS.

It can be seen in Figure 1, that the RCS at the measured angles is symmetrical and dependent upon the incident angle. Due to simplified processing of the RCS, the model is inaccurate but does provide insight into how the hole or absence of surface area greatly effects the RCS.

Problem 4:

5.3 A "flying wing" appears on the horizon as it approaches a radar (i.e., the wing is viewed directly edge-on). Each half of the leading edge has a length d and makes an angle ot with respect to the centerline.

(a) Estimate the monostatic RCS due to one-half of the leading edge for a horizontally (soft) polarized incident wave using a GTD equivalent edge current. Assume a knife edge, and specify the parameters of the diffraction coefficient DII (£, ~b, ~b', r, fi') in terms of the ray-fixed coordinate system. Express the RCS as a function of o~.

(b) At what angle del will the diffracted ray from the leading edge to the trailing edge (Q1 to Q2) return in the backscatter direction?

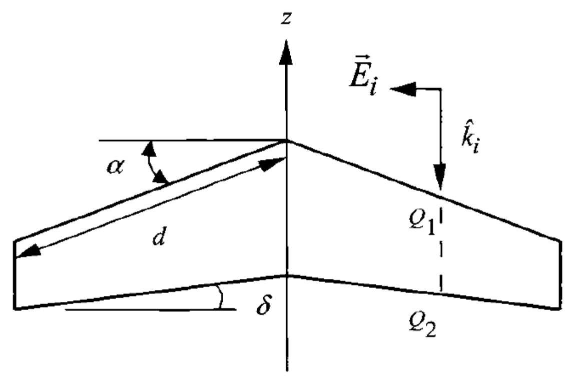

Fig. P5.3

Part (a):

To measure the monostatic RCS of a single wing, the diffraction coefficient and edge currents must be considered. The approximate monostatic RCS of the wing is below:

$$\sigma = \int_{edge} J_{edge} * e^{-jkr} D_{II}(\epsilon, \phi, \phi', r)\, dl$$

Part (b):

In flying wing designs, according to the law of reflection, the angle incident is equal to the angle of reflection. Thus, the maximum reflection would occur when del is (90 degrees – alpha). This allows the reflection of the path from Q1 to Q2 can reflect back to the source. In this case, del would be around 45 degrees, which is typical of stealth aircraft.