URSI AP-RASC 2019, New Delhi, India, 09 - 15 March 2019

Analytical Method of Radiation Mode Radar Cross Section (RCS) of Low Profile Phased Arrays

Avinash Singh, Deepa K. Sasidharan, and Hema Singh
Centre for Electromagnetics, CSIR- National Aerospace Laboratories, Kodihalli, Bengaluru-560017, India,
avi.23110@gmail.com, deepasasidharan10@gmail.com, hemasingh@nal.res.in

The Radar Cross Section (RCS) of a phased array comprises of two scattering modes, the antenna (or the radiation mode), and the structural mode [1]. The antenna mode RCS depends on the radiation behavior of the antenna array. The structural mode arises from the currents induced on the antenna and the platform. In case of phased array, the structural RCS also signifies the case when the antenna array is matched with the feed network. However, it is not practically possible to achieve such perfectly matched antenna array. The feed structure of the phased array itself contributes to most of the impedance mismatches and hence scattering. When the incident energy strikes the phased array, it traverses through the components of feed network, viz. phase shifters, couplers, and load impedances. Each feedline of a certain feed width acts as a transmission line having finite input and characteristic impedance. At every junction of impedance mismatch, a portion of incident wave is reflected and rest is transmitted further in to the feed network. The coherent sum of all these reflections within the array and its feed structure contributes to the total radiation mode RCS [2], which is significantly higher than the structural mode RCS. This makes the study of radiation mode RCS most important especially for a radiating phased array. This paper proposes a novel analytical method to estimate the radiation mode RCS of a low profile patch array. The incident wave is traced as it travels from the array aperture into the feed network. The scattered field contribution from each component of feed network is expressed in terms of the reflection and transmission coefficients. The individual contributions are then coherently superimposed to arrive at total array RCS, given by

$$\sigma(\theta,\phi)=\frac{4\pi}{\lambda^2}\left(\left|\sigma_r(\theta,\phi)\right|^2+\left|\sigma_p(\theta,\phi)\right|^2+\left|\sigma_c(\theta,\phi)\right|^2+\left|\sigma_s(\theta,\phi)\right|^2+\left|\sigma_d(\theta,\phi)\right|^2\right) \quad (1)$$

where, σ_r, σ_p, σ_c, σ_s and σ_d correspond to RCS due to reflections from patch antennas, phase shifters, coupler inputs, sum and difference ports of couplers.

The proposed method can be used to obtain the radiation mode RCS of conventional patch array, and the array with high impedance surface (HIS)-based substrate or superstrate. This involves the accurate estimation of antenna impedance either with conventional substrate or HIS-based substrate/superstrate. Figure 1 shows a typical result of computed radiation mode RCS of a conventional 4-element patch array and a 4-element patch array with HIS-based substrate.

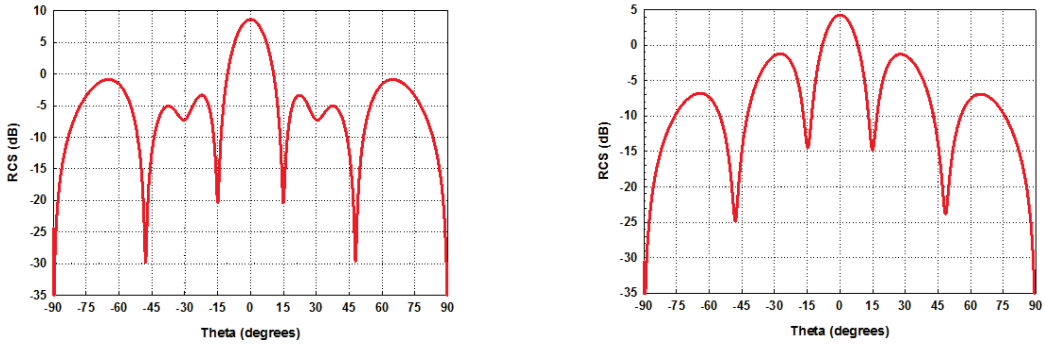

Figure 1. Radiation mode RCS of a 4-element patch array. (a) conventional (b) patch array with HIS substrate.

1. D.C. Jenn, Radar and Laser Cross Section Engineering. AIAA Education Series, Washington, DC, ISBN: 1-56347-105-1, 476p., 1995.
2. H. Singh and R.M. Jha, Active Radar Cross Section Reduction: Theory and Applications. Cambridge University Press, Cambridge, UK, ISBN: 978-1-107-092617, 325 p., 2015.