Observations of the Radar Cross Section (RCS) Phenomena of Antennas through the Eyes of Characteristic Modes Theory

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Characteristic Mode Theory is one of the very few analytical/numerical methods that provide a great deal of physical insight because it allows us to determine the natural modes of the radiating/scattering structure. Since these natural current and radiation/scattering pattern modes satisfy certain orthogonally properties, they are referred to as Characteristic Modes. The key feature of these modes is that the total antenna current, input impedance/admittance and radiation pattern can be expressed as a linear weighted combination of individual modes. Using this decomposition method, it is possible to study the behavior of the individual modes, understand them and therefore control the antenna's behavior over a given frequency band.

CM is a suitable tool to analyze the antenna in both radiation and/or scattering modes. In antenna scattering, the field scattered by an antenna contains a component that is the "short-circuit" scattered field, and a second component that is proportional to the radiation field. Using CMs, the CM modes can also be classified based on these two components to yield two different sets of modes. One set is orthogonal to the localized field at the feed point generated by the antenna source and thus is referred as the short-circuited scattered field because it cannot be excited by the antenna source located at the feed point. The other scattered set includes modes that can interact with the load attached to the antenna (internal impedance of antenna source) because they can excite a non-zero voltage at the feed point and is referred to as the "Antenna Mode." This latter mode is proportional to the radiation pattern of the antenna. In this paper, a study of these phenomena from the CM standpoint will be performed aiming to shed some light on the antenna scattering phenomenon. The CM modes will be studied to measure the effect of each set on the overall antenna within these scattering/radiation environments. This analysis is expected to provide additional physical insight that can be used in different antenna applications.