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A Comparison of Analytical Techniques to Teach Students to Model Radiation from Patch Antennas

Steven Weiss
The Johns Hopkins University School for Professionals, Elkridge, MD, 21075, e-mail: sweiss7@jhu.edu

On-line learning has places greater and greater emphasis on developing methods for which students can gain insight into the underlying electromagnetic theory that describes RF devices. A common antenna that is frequently introduced in undergraduate and graduate applied antenna courses is the patch antenna. A description of the radiation can rely on simple models [1] that ignore the air/dielectric boundary or more sophisticated models that take the geometry of the structure into account.

This presentation will compare and contrast two methods that can be used to model radiation by patch antennas. Both approaches use dyadic Green's functions in their formulation and both methods use the cavity model near resonance to approximate the electromagnetic fields underneath the patch antenna itself. The first method then approximates filaments of magnetic current about the perimeter of the patch antenna with the magnetic current located at the air-dielectric interface. The second model presumes electric currents distributed over the extent of the patch itself.

Using these formulations, the far fields for both approaches are found using the method of stationary phase. A comparison of the results helps to emphasize the importance of equivalent currents in the estimate of the electromagnetic fields radiated by the patch. Additionally, the comparison of methods (i.e., magnetic versus electric currents) gives deeper insight into alternative formulations of solutions to the same problem of finding radiated fields and their limitations.

Once the analytical equations are determined, students can then code up the equations (e.g., in Matlab or Mathematica) for comparison of the methods. As such, students can calculate E- and H-plane patterns as well as calculate the directivity of the patch. Such a comparison of formulations has shown to be useful as a teaching technique developing engineering insight into analytical solutions of the fields radiated by the patch antennas as well as the important comparisons to measured data.

1. C. A. Balanis, *Antenna Theory Analysis and Design*, 4th ed. John Wiley & Sons Inc., 2016.