An Investigation of Radiation from Slot Antennas Etched on Finite Ground Planes using Characteristic Mode Theory

Pallavi Sharma* and Jennifer T. Bernhard,
Electromagnetics Laboratory
University of Illinois at Urbana-Champaign, Urbana, IL 61801
http://antennas.ece.illinois.edu
E-mail: psharma6@illinois.edu, jbernhar@illinois.edu

In planar antenna design, the inclusion of narrow slots is a technique used to improve the bandwidth and reduce the overall size of the antenna. Slot antennas can offer good radiation efficiency and may be used to achieve multi-band characteristics. For a narrow slot etched on a finite ground plane, the operating behavior of the antenna not only depends on the ground plane size but also on the slot geometry. Analytical models such as the transmission line model (J. E. Ruyle and J. T. Bernhard, IEEE Trans. Ant. and Prop., 3, 1407-1410) and the cavity model (M. Himdi, J. P. Daniel and C. Terret, Electronics Letters, 6, 391-392) do not accurately capture the behavior of an arbitrarily shaped slot antenna on a finite ground plane. The theory of characteristic modes is a useful technique which can be used to analyze the radiating behavior and resonances of such arbitrarily shaped structures.

In this study, the bandwidth and radiation characteristics of a narrow slot etched on a finite ground plane is analyzed using the theory of characteristic modes. As a baseline, modal analysis is performed on a finite size ground plane to identify the dominant ground plane resonances. Then, the effect of slot size and geometry on the ground plane modes is studied for different ground plane sizes. Also, the coupling between the ground plane mode and the slot mode is analyzed for different shapes and sizes of the slot. This helps in determining how the ground plane resonances are affected by the shape and size of the narrow slot.

Preliminary results confirm that the ground plane modes are the dominant radiating modes for large ground planes. Also, there is a narrow band slot mode that couples with the ground plane modes resulting in wider slot bandwidth. The coupling between the slot mode and the ground plane mode depends on the slot size relative to the ground plane size and also the geometry of the slot. Comparisons to theoretical analyses with infinite ground plane dimensions will be used to demonstrate the large range of behaviors that may be supported by such finite structures. The analysis presented here can be as a guideline for determining the appropriate slot geometry and slot size for improving the bandwidth and achieving multi-band behavior in a given finite ground plane antenna.