The Cavity Model for Microstrip Antennas Revisited

Constantine A. Balanis*

Department of Electrical Engineering, Telecommunications Research Center
Arizona State University, Tempe, AZ 85287–7206

There are many models that can be used to analyze microstrip antennas. These models span from the simplest, such as the transmission–line model, to the more complex, such as the integral equation model. Advantages and disadvantages are associated with each one of them, including simplicity, physical insight, complexity and accuracy. One model that is simple, accurate and sheds physical insight is the cavity model developed by Prof. Y. T. Lo and his graduate students. This model treats the microstrip antenna as a cavity whose field configurations/modes underneath the patch can be easily obtained by treating it as a boundary–value problem with the appropriate boundary conditions. The boundary conditions proposed by Prof. Y. T. Lo and his students are those that treat the upper and lower sides of the cavity as PEC (perfect electric conducting) and those around the periphery as PMC (perfect magnetic conducting). These boundary conditions lead to very good field configurations for both rectangular and circular cavities, as well as for other canonical geometries. The edges of the cavities are slightly extended to account for fringing. This model has also been used to study microstrip microwave resonators.

The microstrip antenna cavity model leads to very good results in terms of input impedance, when the cavity is fed by a probe, as well as amplitude radiation patterns. To determine the amplitude patterns, the fields around the periphery of the cavity are assumed to be the same as those of the ideal cavity with PMC walls. The equivalent current densities associated with these fields are then formed, which, in turn, are used to determine the patterns. The computed amplitude patterns based on these current densities lead to very good results when compared with measurements as well as with other methods. Because the cavity model assumes that the bottom wall of the cavity is PEC, the predicted patterns for practical microstrip antennas based on this model for the E–plane do not vanish or nearly vanish, as expected, near grazing angles. This shortcoming of the cavity model near grazing angles can be remedied by supplementing the formulation of the cavity model in the E–plane with a reflection coefficient of a lossy surface instead of that of a PEC for the bottom wall. The reflection coefficient used for the E–plane is that of a vertical polarization for a lossy surface. The patterns predicted based on this simple extension of the cavity model lead to very good results for the E–plane. The H–plane patterns based on the cavity model agree quite well with measurements. Therefore, in the H–plane, the formulation for the patterns does not need to be modified because the boundary conditions of the ideal cavity model and those of the actual antenna are very similar.

In the oral presentation of this paper, the cavity model as developed by Prof. Y. T. Lo and his graduate students, and its extension, will be reviewed. Simulations will be presented for both rectangular and circular microstrips, and the results will be compared with measurements and/or other available data.