Modeling Printed Slot Antenna Properties Versus Slot Thickness Using a Signal Flow Graph Model

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Microstrip antennas are a popular, versatile class of antennas for a variety of reasons. Oft-cited benefits include that they are low profile, low cost, low weight, conformal, and easy to fabricate. The microstrip patch antenna is a common member of this class, with notable characteristics including unidirectional radiation and narrowband operation (generally seen as a detriment, hence the plethora of broadbanding techniques that exist). Another member of the microstrip antenna class is the printed slot (or aperture) antenna, which consists of a slot in a ground plane excited by a planar waveguiding structure such as a microstrip transmission line. In its simplest form, the printed slot antenna exhibits bidirectional radiation and usually a greater bandwidth than its patch counterpart.

Many full-wave analysis methods for microstrip antennas have been created over the years, yielding highly accurate models and simulations of these antennas. One downside common to most of these approaches is the difficulty of predicting changes in antenna behavior with respect to design changes without completely re-analyzing the antenna. Conceptional models, on the other hand, offer a degree of understanding and more easily predict outcomes in these cases. Although these models tend to be less accurate, their results are often sufficient for initial designs; microstrip patch antennas, for example, have the well-known transmission line and cavity models that serve this purpose.

In the realm of printed slot antennas, a design parameter that is frequently ignored for simplicity is the thickness of the slot (that is, of the ground plane conductor). One way to handle this is to model the volume of the slot as a very short waveguide. The slot's fields may then be decomposed into a truncated set of waveguide modes, some or all of which may be evanescent. Changes in the slot thickness may then be easily and intuitively handled using standard waveguide theory. If this approach is combined with information (possibly numerically computed) about modal coupling and reflection at discontinuities, the standard method of modeling a geometry with network theory becomes feasible.

In this presentation, a signal flow graph (SFG) network model for microstrip-fed, printed slot antennas will be developed and explored. This model may be used to facilitate calculation of analytic expressions for some antenna properties, *e.g.*, input reflection coefficient, as a function of both the slot thickness and the length of a microstrip line extension beyond the slot for matching purposes. (Some factors in these expressions may need to be numerically evaluated, however these factors are independent of slot thickness and the microstrip line extension length.) Since multiple waveguide modes in the slot, each coupling power in parallel, would rapidly lead to a complicated network if a usual scalar SFG were used, matrix SFGs will instead be used in this work. To further reduce the tedium of evaluating gain expressions of complicated SFGs, an automated tool for generating these expressions symbolically will be briefly discussed.