Conductor-Backed Slot Element Surrounded with "Metal Post Cavity": Analysis and Guided-Mode Suppression Effects

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Conductor backing behind a slot antenna or slot-coupled microstrip patch antenna is a useful means to block unwanted back radiation. Conductor backing is also desirable behind slot-based microwave circuits, such as slot-coupled double-sided microstrip circuits and slotline/coplanar waveguide circuits. A metal plane behind the slotted structures may be used to integrate one or more layers of additional circuits stacked underneath (N.K. Das and D.M. Pozar, IEEE Trans., AP-40, 5, 469-491). In this case, the metal offers necessary electrical isolation between neighboring layers, while selective interconnection between layers can be maintained through a few coupling apertures or via-holes.

The above designs, though seemingly attractive and straightforward, unfortunately suffer from some fundamental problems. A coupling aperture excites the parallel-plate mode(s) between two metal planes, which can be prohibitively large for smaller separation between the metal plates. If the above conductor-backed antenna or multilayer circuit concepts were to be successfully implemented, the excitation of any parallel-plate mode(s) must be eliminated or significantly suppressed by novel design modifications. One may use metal shorting posts placed around a coupling aperture, in order to "short-out" the normal electric fields of the dominant parallel-plate mode. If one can achieve significant suppression of the parallel-plate mode, using only a reasonable number of shorting posts optimally placed around an aperture, the method could be practically meaningful.

In this paper we present a new analysis and basic characteristics of such shorting-post structures, and present design data for different parameters of the shorting posts for different levels of modal suppression. The new theory efficiently combines modeling of planar structures with scattering from non-planar surroundings, and is applicable to a broader class of problems (B.L. McCabe, PhD Dissertation, Polytechnic Univ., 2004). The scattering matrix of the shorting posts is modeled by replacing them by thin metal strips of equivalent widths, arranged periodically along a circular boundary. This scattering matrix is then used together with the analysis of the central slot element to derive the impedance and radiation characteristics of the total structure. It is observed that, unless the structure is properly designed, the excitation of the guided mode may actually be enhanced instead of being suppressed as one would usually expect. This is due to possible resonance in a quasi-cavity structure created by the shorting posts. Such resonance effects and suppression characteristics for a rectangular slot as well as a slot-ring element will be discussed.