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13. ABSTRACT *(Maximum 200 words)*

An analysis and an experimental study of a stripline-fed slot antenna are reported. A slot in a planar conducting surface is backed by a rectangular waveguide below cutoff. A conducting strip in the short-height waveguide constitutes a stripline transmission line that is fed and terminated via coaxial connectors below the surface and provides a means to excite the slot. A numerical method is developed to solve two "pseudo-mixed" potential integral equations for the electric current on the strip and for the equivalent magnetic current in the slot. The strip in the waveguide and the slot backed by the waveguide are analyzed separately and then the two are combined to form a single antenna element. Green's functions for electric and magnetic current elements in a rectangular waveguide are employed in their spectral and spatial representations, and Shanks' transform is used to speed up the convergence of the doubly infinite series. Numerical and experimental results are presented for the separate analyses of the stripline, the center-fed slot backed by the waveguide, and the stripline-fed slot antenna.

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Problem Studied

The goal of this project is to develop the analytical and numerical tools to design a robust, strip-line fed slot radiating element for use in a phased array antenna. Such an antenna can be made conformal with a surface. The stripline-fed slot antenna has been in use for many years . In general, the stripline feed meanders underneath slots cut in one of the plates that forms the stripline. Unfortunately, parallel plate waveguide modes are excited by the slots and, often, by the stripline feed. These modes can interact with the edges of the finite stripline ground plates and create spurious reflections in the vicinity of the slots. A “curtain” of shorting pins has been used in the past to approximate a cavity whose resonant frequencies are higher than the frequencies of interest in the antenna so that the undesired propagation modes and potential resonances are no longer supported. But the presence of the shorting pins causes the analysis of the element to become very difficult, forcing one to resort to experimental evaluation. If solid walls are used in place of the shorting pins, then analysis of the stripline-fed slot antenna element becomes feasible and allows one to undertake engineering design without depending entirely upon experimental trial and error. In this project the investigators have developed the techniques for analyzing a solid-wall, actually, a waveguide housed, stripline-fed slot element.

Summary

The development has been carried out in three major steps. The steps allowed the investigators to break the overall problem down into less complex problems so that the difficulties that arose in the simplified structures could be addressed and remedied in isolation. The first step was to investigate the problem of a wire or a stripline in a waveguide below cutoff. This structure is the same as the end product except that the slot is not present. The second was to analyze a coax-fed slot, backed by a waveguide below cutoff. This second structure is the same as the final except that the feed system is simpler. After the isolated problems associated with the first two steps were solved, the final structure was address as a third step. With the experience gained in steps 1 and 2, analysis of the final structure fell into place without further difficulties. The analytical work of steps 1 and 2 was supported by experimental corroboration.

In the first step in this analysis, a stripline in a rectangular waveguide below cutoff is examined. The stripline is fed by the center conductor of a coaxial cable through the wall of the waveguide and can be terminated with an arbitrary load through another wall via another coaxial cable. The strip and the center conductor feeds are assumed to be composed of straight segments, each of which is parallel to one or the other pair of waveguide walls. Integral equations for the unknown current on the strip and the feed conductor are formulated and a numerical solution scheme for solving these equations is developed, including an examination of the convergence properties of both the series representations of the rectangular waveguide Green's functions and the convergence properties of the numerical scheme. We employ Shanks' transform to enhance the convergence of the doubly infinite sums that represent the Green's function. As a check of our numerical solution, we obtain data from measurements for a bottom-fed and bottom-loaded stripline in a waveguide and for a monopole fed through the narrow wall of a rectangular waveguide. The work and results of step 1 are documented in a paper which has been accepted for publication in the IEEE Transactions on Antennas and Propagation. See 3 under **Publications.**

In the second step, we investigate a finite-length slot backed by a rectangular waveguide below cutoff. The presence of the waveguide enables one to tune the slot to enhance radiation. As mentioned above, this is a preliminary step in analyzing a stripline-fed slot antenna array in which each stripline feed is enclosed in a rectangular waveguide below cutoff. The longitudinal axis of the slot is parallel to the propagation axis of the waveguide. A numerical method is developed to solve a pseudo mixed potential integral equation for the equivalent magnetic current or electric field in the slot excited by a delta-gap source in the slot. The Green's function for dipole sources in the rectangular waveguide is used in the integral equations, and Shanks' transform is employed to speed up the convergence of the doubly infinite series. Numerical and experimental results are compared to assure the accuracy of the analysis for a center-fed slot in a ground plane and for the center-fed slot backed by the rectangular waveguide. From this we conclude that our computational technique is sufficiently accurate to predict the input impedance of a center-fed slot in the upper wall of a waveguide below cutoff. A manuscript based on the investigation of the second step has been submitted to the IEEE Transactions on Antennas and Propagation. See 4 under **Publications.**

The third and last step is merely a synthesis of the first and second steps. The synthesis involved more work but all of the theoretical and experimental difficulties were addressed in the first and second steps. A third manuscript is being prepared on this last phase but is not yet completed. See 5 under **Publications.**

Publications

1. C. L. Levinson, C. M. Butler, and P. D. Mannikko, "Elimination of unwanted modes in stripline-fed slot antennas," Digest, URSI National Radio Science Meeting, p. 8, Boulder, CO, Jan. 1994.
2. C. L. Levinson and C. M. Butler, "Analysis of slot antennas fed by stripline in rectangular waveguide below cutoff," Digest, URSI Radio Science Meeting, p. 94, Seattle, WA, June 1994.
3. C. L. Freeman* and C. M. Butler, "Analysis of a stripline in a rectangular waveguide," IEEE Trans. Antennas and Propagation (accepted for publication)
4. C. L. Freeman* and C. M. Butler, "Analysis of a center-fed slot backed by a rectangular waveguide below cutoff," IEEE Trans. Antennas and Propagation (submitted)
5. C. L. Freeman* and C. M. Butler, "Analysis of a stripline-fed slot antenna," (in preparation)
6. C. L. Freeman*, "Analysis and design of stripline-fed slot antennas," Ph.D. Thesis, Clemson University, May 1996.

*Formerly, C. L. Levinson.

Inventions

None

Scientific Personnel Employed on Project

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