ARO 17446.4-EL

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO.	2.	3. Recipient's Accession No.
4. Title and Subtitle MICROSTRIP ANALYSIS TECHNIQUES			5. Report Date 11/1/80 - 10/31/83
AD A137972			
7. Author(s) E.H. Newman			8. Performing Organization Rept. No. ESL 713402-7
9. Performing Organization Name and Address The Ohio State University ElectroScience Laboratory Department of Electrical Engineering Columbus, Ohio 43212			10. Project/Task/Work Unit No.
			11. Contract(C) or Grant(G) No (C) DAAG29-81-K-0020 (G)
12. Sponsoring Organization Name and Address Department of the Army U.S. Army Research Office Research Triangle Park, North Carolina 27709			13. Type of Report & Period Covered Final Report
			14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

This report will describe three computational techniques applicable to microstrip antennas and arrays. The first is an analysis of the self and mutual impedance between microstrip antennas on a flat grounded dielectric slab. The second is an analysis of a microstrip array plus it's microstrip transmission line feed network. The third is an analysis of the self and mutual impedance between microstrip antennas on a dielectric coated cylinder.

grounded

17. Document Analysis   a. Descriptors

Microstrip Antennas   Impedance
Antennas   Transmission Lines
Dielectric Materials
Computation

18. Availability Statement	19. Security Class (This Report) Unclassified	21. No. of Pages 7
Approved for public release; distribution unlimited.	20. Security Class (This Page) Unclassified	22. Price

(See ANSI-Z39.18)

OPTIONAL FORM 272 (4-7
(Formerly NTIS-35)
Department of Commerce

DTIC FILE COPY 84 02 16 103

PROGRESS REPORT

1. ARO PROPOSAL NUMBER: 10290-55-00

2. PERIOD COVERED BY REPORT: November 1, 1980 - October 31, 1983

3. TITLE OF PROPOSAL: "Microstrip Analysis Techniques"

4. CONTRACT OR GRANT NUMBER: DAAG29-81-K-0020

5. NAME OF INSTITUTION: The Ohio State University
    Department of Electrical Engineering
    ElectroScience Laboratory
    Columbus, Ohio 43212

6. AUTHOR(S) OF REPORT: E.H. Newman

7. LIST OF MANUSCRIPTS:

    E.H. Newman, J.H. Richmond and B.W. Kwan, "Mutual Impedance
    Computation Between Microstrip Antennas", IEEE Trans. Microwave
    Theory and Techniques, Vol. MTT-31, Nov., 1983, pp. 941-945.

    E.H. Newman and J.E. Tehan, "Analysis of a Microstrip Array Plus
    It's Feed Network", submitted for publication to the IEEE Trans. on
    Antennas and Propagation.

    J.E. Tehan, "Analysis of a Microstrip Array Plus It's Feed
    Network", M.Sc. Thesis in preparation, The Ohio State University,
    Department of Electrical Engineering.

8. SCIENTIFIC PERSONNEL: E.H. Newman
                           B.W. Kwan
                           J.E. Tehan

1

BRIEF OUTLINE OF RESEARCH FINDINGS

This report summarizes the research on ARO Grant DAAG-80-0020. It is a final report and covers the three year period November 1, 1980 to October 31, 1983. The purpose of this grant, entitled "Microstrip Analysis Techniques", was to develop computational techniques applicable to the microstrip antenna. A microstrip antenna is a metallic patch printed on a grounded dielectric slab. They can be fed by an extension of the center conductor of a coaxial transmission line, which passes through the ground plane and the dielectric slab, and contacts the patch. Alternatively, they can be fed by a microstrip transmission line which contacts an edge of the patch. Microstrip antennas are finding increased application because they are lightweight, essentially flush mounted, and simple and inexpensive to fabricate. Entire arrays, together with their feed lines, can be etched or deposited on a single substrate.

Since their invention in the late 1960's, various techniques for the analysis or design of microstrip antennas have been developed. Much of the early work dealt with relatively simple transmission line or cavity models of microstrip antennas. Although these models are very useful in the design of a single microstrip antenna, their application to arrays is limited in that they do not include mutual coupling between antenna elements. Mutual coupling effects are often not very strong and can be ignored. However, one important case where mutual coupling must be included is in the design of low sidelobe arrays. Another limitation of the simple transmission line or cavity models is that they require

2

the dielectric substrate to be very electrically thin. Further, the early techniques did not include any curvature effects of the ground plane. The purpose of this work was to develop techniques to remove these restrictions of the earlier work. In particular, solutions have been obtained for the following three problems:

1. computation of the self and mutual impedance between microstrip antennas on a ground dielectric slab;

2. analysis of a microstrip array plus its microstrip transmission line feed network;

3. computation of the self and mutual impedance between microstrip antennas on a coated dielectric cylinder.

These three solutions will now be briefly described.

The computation of the self or mutual impedance between microstrip antennas on a grounded dielectric slab is begun by obtaining the exact Green's function for a horizontal current element on the dielectric slab. This Green's function, commonly referred to as a Sommerfeld integral, is in the form of a double integral of traveling waves. The Green's function must be integrated four times to obtain an expression for the mutual impedance between two rectangular microstrip antennas. However, these four integrations are done in closed form, leaving the original two integrations to be done numerically. Computations based upon this method are in close agreement with measurements of the input

3

impedance of a single microstrip antenna or the mutual impedance between microstrip antennas. The results of this study have been published [1].

The elements in a practical microstrip array are coupled by "electromagnetic" coupling and by the microstrip (or other) transmission lines or feed network. The techniques described above are suitable for evaluating the "electromagnetic" coupling. The coupling effects of the feed network are included by using a generalized N-port Thevenin theorem. Basically, the solution proceeds as follows. First, one obtains the N-port open-circuit impedance matrix for the microstrip array, referenced to it's N feed ports. For rectangular microstrip arrays on a grounded dielectric slab, this can be done using the results from the first study described above. Next one obtains the N-port open-circuit impedance matrix for the feed network, again referenced to the N feed ports. This matrix is usually straight-forward to compute, using transmission line equations. The two matrices are then addeed to form the Thevenin equivalent impedance matrix for the array plus it's feed network. Then following the recipe of the Thevenin theorem, one can obtain the currents, voltages, and impedances on the array plus the feed network. One may then also find the far-zone pattern of the array, including radiation from the feed lines. The method was applied to find the input impedance of the series fed microstrip array. The results of this study have been submitted for journal publication [2]. They are also the subject of a masters thesis now in preparation.

The above two problems dealt with microstrip antennas on flat grounded dielectric slabs. However, often microstrips are placed on the curved surface of an aircraft, a missile, etc. Thus, we have developed the solution for the self or mutual impedance between microstrip antennas on a singly curved surface, in particular, a dielectric coated cylinder. To solve this problem, we first obtained the exact dyadic Green's function for the coated dielectric cylinder. This Green's function must be integrated four times to obtain the self or mutual impedance between microstrip antennas. Again, these four integrals were done in closed form. The final expression for the self or mutual impedance is in the form of an infinite summation and an infinite integral. These expressions have been coded for the digital computer, and are believed to be correct. Work continues to asymptotically evaluate these expressions for cylinders of large radius. At the conclusion of this study, the results will comprise a Ph.D. dissertation, and will also be submitted for journal publication.

REFERENCES

1. E.H. Newman, J.H. Richmond and B.W. Kwan, "Mutual Impedance Computation Between Microstrip Antennas", IEEE Trans. Microwave Theory and Techniques, Vol. MTT-31, November 1983, pp. 941-945.

2. E.H. Newman and J.E. Tehan, "Analysis of a Microstrip Array Plus It's Feed Network", submitted for publication to the IEEE Trans. on Antennas and Propagation.