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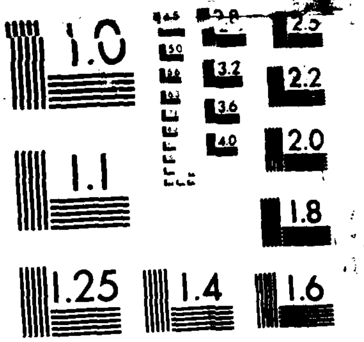

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Millimeter-Wave Range for the Quick Evaluation of Large Reflector Antennas with Complex Feeds

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This technical report has been reviewed and is approved for publication. Publication of this report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

An automated millimeter-wave antenna range capable of measuring primary-feed structure patterns and transferring this data to a mainframe computer for secondary pattern computation is described. Its applicability to the rapid evaluation of complex feed structures as used in a Cassegrain antenna is illustrated. An example of a reflector antenna analysis is compared to a measured pattern.

CONTENTS

FIGURES

I. INTRODUCTION

Radiation patterns of large reflector antennas are often difficult to measure. Even scaled models measured at higher frequencies require large antenna ranges. An alternative method for obtaining reflector antenna patterns is the measurements of primary-feed patterns on a small indoor range and the determination of the secondary patterns by computation. This procedure is described for a Cassegrain reflector system.

The use of the bench-top range for reflector simulation was especially attractive when the effects of a series of small design changes in a complex feed structure on the radiation pattern were needed to be known quickly. For example, this procedure was used in the optimization of a feed structure for low sidelobe levels.

The system consists of the millimeter-wave range, data acquisition instruments and the computational elements. The experiment was performed and recorded using a desktop computer which transmitted the data to a mainframe computer for the reflector antenna simulation. Far-field patterns of the reflector antenna with selected feed structures were conducted on the full-size range to verify the technique, and the results compared favorably with the computed results.

II. DESCRIPTION

The millimeter-wave range was originally developed for quasi-optical millimeter-wave measurement.[1] As shown in Fig. 1, the transmitter consists of a fixed 38 GHz 100 mW Gunn diode oscillator with a precision attenuator placed after the source for gain calibration. The range consists of the feed structure supported on posts on a rotating stage. The mounts were designed to allow for rotation for E and H plane measurements. The posts rest on micrometer driven single axis stages which vary the horn-subreflector spacing and rotation axis relative to the feed structure's phase center. The typical range was 4 ft, and boresight was established using an alignment laser. The rotating stage was mounted on a stepper motor located on the optical rail. Absorber material surrounds the range setup (Fig. 2).

A direct detection system was used with a Schottky diode mixer as detector. The ferrite switch was driven at ~ 200 Hz to maximize detector response with minimum 1/f noise in the correlator. The detected signal, amplified and level shifted using the correlator, was digitized in the data acquisition system. The computer integration of the signal allowed for adaptive averaging to reduce measurement time near the pattern maxima; measurement times were increased in the pattern minima region. The digitized patterns were stored in the desktop computer.

The desktop computer performed averaging and plotting of the measured feed pattern in real time. In addition, the patterns in 1° or 1/2° steps were stored on floppy disk. The patterns chosen for further analysis were uploaded to the mainframe computer for analysis by the Geometrical Theory of Diffraction (GTD) program.[2] The GTD program computes the main-reflector antenna pattern with the measured primary-feed illumination and outputs the listings and plots of the Cassegrain antenna pattern.

Fig. 2. Photograph of Range and Instrumentation

III. EXPERIMENT

The millimeter-wave antenna range was used to measure the effects of numerous modified horn and subreflector combinations as described in Ref. 3. This information was used as a first round analysis to find potentially suitable feed structures to illuminate the reflector. The feed structures found to be most likely to produce acceptable secondary patterns were transmitted from the desktop computer to the mainframe computer.

A reflector antenna with the selected feed structures was measured on the full size far-field antenna range, using a receiver with a 90-95 dB dynamic range.[3] A measured far-field pattern superimposed on a pattern computed by the GTD program using primary-feed data measured on the millimeter-wave range is shown in Fig. 3. There is good agreement between the two patterns in the main lobe and in the average level for angles out to 80°. The greatest discrepancies are in the back lobes. This may be caused by the difference between the mathematical and physical model of the edge of the reflector, namely a knife-edge model in the simulation vs. the actual rounded edge of the dish. In addition, the receiver, which was used in the dish pattern measurement, was mounted on the back of the reflector and was not accounted for in the analysis.

IV. CONCLUSION

The millimeter-wave range was used to quickly eliminate poor horn-subreflector combinations without having to measure the secondary reflector patterns. The true capability of the system was exercised when the millimeter-wave range data was used in conjunction with the GTD reflector program to reduce measurement time and allow quicker modification and analysis turnaround time. Furthermore, with improved correlation between simulated and measured reflector patterns, secondary antenna pattern determinations may in some cases be performed solely by simulation of the reflector with measured primary feed-structure patterns.

REFERENCES

1. F. I. Shimabukuro, S. Lazar, M. R. Chernick, and H. B. Dyson, "A Quasi-Optical Method for Measuring the Complex Dielectric Constant of Materials," IEEE Trans. Microwave Theory & Tech., Vol. MTT-32, pp. 659-665, July 1984.

2. S. H. Lee, R. C. Rudduck, C. A. Klein, and R. G. Kouyoumjian, "A GTD Analysis of the Circular Reflector Antenna Including Feed and Strut Scatter," Ohio State University, Electrical Engineering Dept. TR-4381-1, May 25, 1977.

3. H. E. King, S. Lazar, R. B. Dybdal, D. S. Chang, H. B. Dyson, W. S. Wales, and W. C. Wysock, "Cassegrain Reflector Sidelobe Reduction Study," The Aerospace Corporation, Electronics Research Laboratory, TR-84A (5409-73)-1 (SD TR-85-39), 15 July 1985.

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