A COMPUTER - AIDED TECHNIQUE FOR THE DESIGN OF PRINTED ANTENNAS

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ABSTRACT

Masks for the realization of printed antennas and associated microstrip circuitry can now be realized in an easy manner with readily available laboratory instruments. The CAD/CAM program MICROS runs on a desktop calculator, and a specially designed micro-knife is used to cut the mask, directly on a standard plotter. Microstrip patches of various shapes can be designed as desired and assembled with a number of available couplers, transformers. The design work can be carried out either on the calculator screen or on the plotter, depending on the available model. The results obtained compare quite well with those obtained when using much more expensive equipment.

INTRODUCTION

In the realization of printed microstrip patch antennas and arrays, drawing the layout and cutting the mask are some of the more delicate and time-consuming steps encountered in the procedure. For some time now, automatic design systems have been available. Most unfortunately, they require rather sophisticated and expensive equipment : a powerful computer, coupled to a specialized drawing machine such as a coordinatograph or photoplotter, and the associated software. In laboratories not provided with such powerful facilities, the only alternative available until now was the design and cutting by hand at a greatly enlarged scale, which is a time consuming and tedious procedure, leading to a limited accuracy.

The technique developed in Lausanne provides an alternate way to design and cut masks for antennas and associated elements for microstrip. It only requires standard informatics equipment, which is already available in many laboratories. The procedure was designed to allow for a large interaction between the operator and the computer, requiring little additional information (it was at first designed for student's projects). The results obtained compare quite well with those obtained when using more sophisticated equipment.

BASIC PRINCIPLE

The computer hardware required consists of a desktop computer, typically of the Hewlett-Packard 200 series, connected to a plotter (for instance the HP 9872C). The procedure leads all the way to the realization of the mask, which is directly cut from a Rubylith sheet (red inactinic material), directly on the plotter itself. A special micro-knife was designed for this purpose, in particular to allow one to cut circles and staight lines at any angle. The knife cuts through the thin soft layer of red material, but not the underlying mylar substrate. The user can design antenna patches as desired, defined by sections of straight lines and of circles. The basic elements are stored in the memory of the computer, and can be reproduced any number of times, for instance when preparing the mask for an array antenna. The radiating elements can then be interconnected, with regular microstrip lines, or more complex feed circuits including couplers, dividers, filters and matching elements. The program MICROS was originally set up for the development of microstrip circuits, and all these elements are available when connecting antenna systems.

POSITIONING AND CONNECTION OF THE ELEMENTS

The antenna patches (designed by the operator) and the basic elements (sections of line, couplers, filters) can be positioned in two different ways :

a) by specifying the coordinates of their center and their orientation,
b) by digitizing one of the access points (at which connection is to be made).

The digitization is made either by positioning an electronic cursor on the screen of the calculator or, with other calculator models, a digitizing sight on the plotter. A search routine ensures connection to the exact coordinates of the access points for the implanted elements : this means that a continuous transition is obtained between elements and interconnecting lines. Any element can be freely positioned and oriented, and then the interconnection process is automated; in this way, the realization of a mask is easy to carry out and does not necessitate any particular drafting skill. The information which the user must provide is limited to the strict minimum : shape and size of the user-defined elements such as patches, dimensions of the circuit, substrate thickness and permittivity, frequency, characteristic impedance of the connecting lines [1].

It must however be noted that the general appearance of the layout must be known beforehand : the program MICROS is specifically dedicated to the tasks of drawing and then cutting masks. It has no provision for the simulation and the optimization of the microstrip systems themselves (other quite sophisticated programs are available for this purpose.

EXAMPLES OF REALIZATIONS

The program MICROS was used to realize a large variety of microstrip circuits and two particular designs involving antennas are presented here.

Figure 1 shows the design of a miniaturized Doppler radar. The rectangular patch antenna is at the same time the radiating element and the resonant circuit, which determines the frequency of oscillation of the generator. It is coupled to the microstrip circuit by means of two coupled lines - on both sides of the patch - which provide the desired feedback to the microstrip MESFET amplifier located next to it. Matching was made with a quarter-wave transformer (wider line) , to the output of the transistor, and with lumped elements at the input. Transistor mounting pads are included in MICROS.

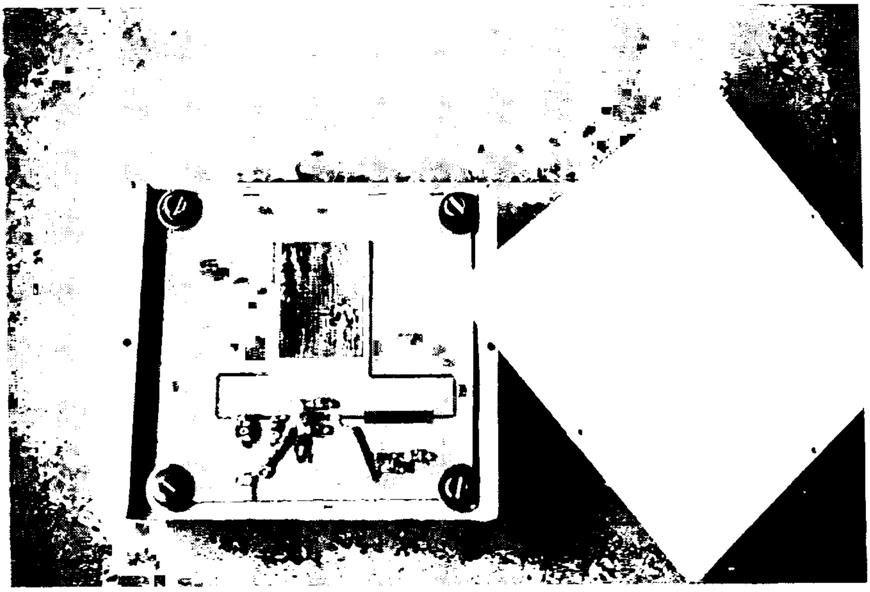

Fig. 1 Miniaturized Doppler radar

Finally, the mask also includes several additional pads for the biasing and interconnecting elements. In this design, the MESFET served as both signal generator and mixer.

Figure 2 illustrates the design of a more complicated antenna shape : the double folded dipole [2] proposed by Dubost. The complete geometry of the element can be specified by the operator : width of lines or slots, radii of the sections of circles, etc. It is possible in this manner to study the effect of any of the parameters. This antenna is provided with a feed coming from underneath (triplate structure), the feed line shown on the left is also realized using the MICROS program.

Fig. 2 Mask of a folded dipole antenna

ACCURACY

The accuracy depends on the reduction factor from the original mask cut on the plotter to the final mask used for photoetching the circuit. The HP plotters have an addressable step of 25 micrometres. On the largest plotters such as the HP7580B and HP7585B, the mechanical steps are of 3 micrometres. This provides a theoretical final resolution ranging from 0.5 to 2.5 micrometers for original masks of about 120 × 90 cm and scale factors ranging from 50 : 1 to 10 : 1.

The accuracy also depends on the repeatibility (repositioning), which is more difficult to estimate. It is felt that the situation there should be fairly similar to the one encountered in coordinatographs.

CONCLUSION

A calculator program for the design and cutting of masks for microstrip patch antennas has been described. It was planned to be as easy as possible to operate, so that the task of its users should be straightforward. The program MICROS runs on several Hewlett-Packard desktop computers. It is complemented by a special microknife for direct cutting of the mask on a standard plotter.

It is planned to continuously update the software, by adding new elements as rules for design become available, and to continuously include new information to keep the program up-to-date.

REFERENCES

[1] J.F. Zürcher, A simple and efficient program for automatizing the design and preparing the masks for microstrip circuits, Mikrowellen Magazin 4/81, pp. 407-409

[2] G. Dubost, Flat radiating dipoles and applications to arrays, Wiley, 1981