MICROS 3 - A CAD/CAM PROGRAM FOR FAST REALIZATION OF MICROSTRIP MASKS

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Abstract

A program for fast realization of microstrip masks is presented. It runs on a desktop computer and allows to directly cut the mask on a plotter. Most elements needed to realize a circuit are directly computed and drawn by the program, and the user can also define his own elements.

Introduction

Drawing the layout and cutting the mask are some of the most delicate and time-consuming operations in designing microstrip circuits. For some time now automatic systems for mask making have been available. Unfortunately, they require expensive equipement : a powerful computer, coupled to a specialized machine for making the mask (automatic coordinatograph or photoplotter) and, last but not least, the associated software.

The technique presented here provides an alternate means to realize masks, using standard informatic equipment - already available in many microwave laboratories [1]. The procedure is easy to use, and the results compare quite well with those obtained using much more expensive methods.

Basic Idea

The hardware consists of a desktop computer and a plotter. The basic idea is to *use the plotter to directly cut the mask on a Rubylith sheet, using a specially designed micro-knife.*

The software - the program MICROS 3 - allows the user to prepare the drawing of the mask very easily, using macro-elements computed according to the various microwave parameters.

Program Description

The program MICROS 3, running on most HP series 200 desktop computers, is interactive and self-documented, and very easy to use.

The initialization comprises the calibration of the plotter, the determination of the scale according to the dimensions of the final circuit, and the presentation of a millimetric grid for easy positioning of elements.

The microwave parameters are then entered : substrate thickness and permittivity, line impedance at the inputs and frequency. All necessary parameters are then computed using formulas yielding the best available approximations and taking into account the effect of dispersion.

Using softkeys, the user can at any time add or delete elements on the drawing, measure a path length, position points, store a drawing into a file for later use, retrieve a stored drawing from a file, make a copy of a drawing, cut the mask, obtain informations on the cutting process or knife adjustment, and so on. When finishing a job the number of elements of each type used is indicated. To add new elements a "menu" is displayed, proposing basic and interconnection elements.

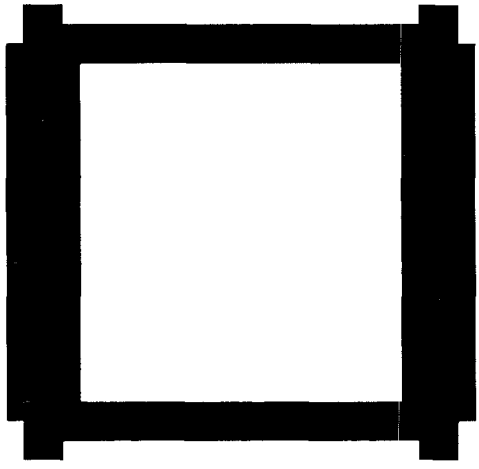
The new elements appear in a separate window and their orientation can be selected directly using the rotary "knob". Then they can be positioned by coordinates or by digitalisation, as will be shown later.

Of course, the general layout of the circuit one wishes to realize must be known beforehand : MICROS 3 is specifically dedicated to the drawing and cutting of masks, but not for their optimization and simulation (other computer programs are available for such purposes).

Available elements

1. Basic elements

1.1 Q-hybrid (standard) : this is the standard geometry Q-hybrid



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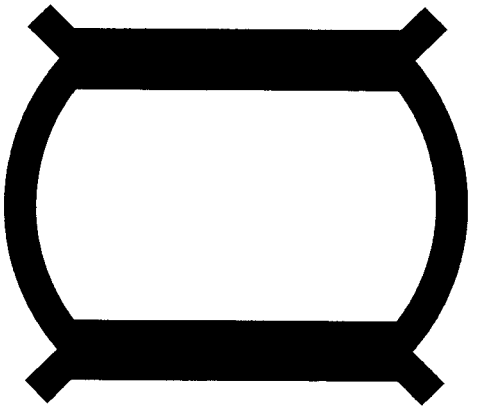
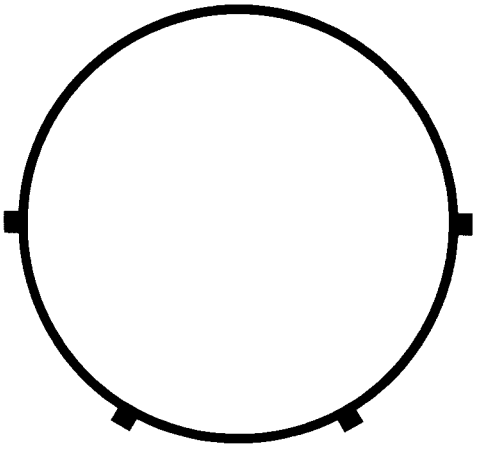
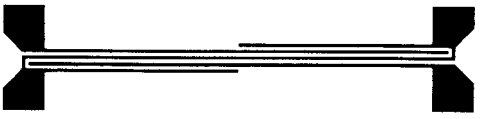
1.2 Q-hybrid (optimized) : this Q-hybrid with a better geometry (due to smaller discontinuities) has better characteristics than the standard one



1.3 H-hybrid : this is the standard Hybrid-ring or "rat race coupler"

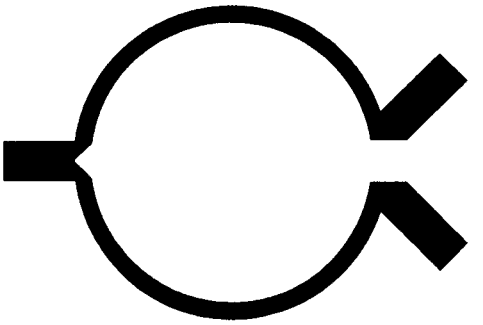


1.4 Lange coupler : this broadband 3 dB coupler is computed using approximate formulas which have been derived from [2]



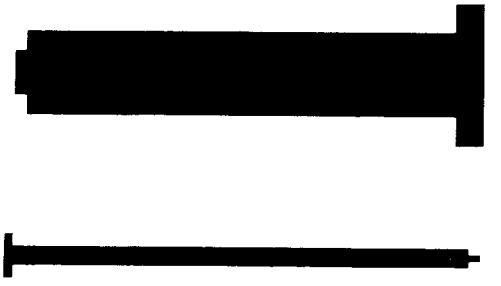
elements 1.1 to 1.3 are also 3 dB couplers.

1.5 Wilkinson power divider : with the geometry chosen the discontinuities are minimized, and the resistor gap is user-definable. This divider is an equal-split divider (3 dB) [3].

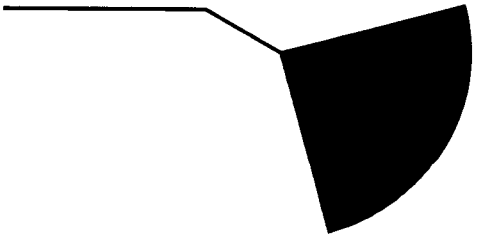


1.6 Directional couplers : their geometry is computed using a very accurate formulation (Kirschning & Jansen [4]) together with a Newton-Raphson optimisation routine. Effects like dispersion and end effect on coupled lines are taken into account. A coupler is typically computed and drawn in less than 30 seconds.

1.7 Quarter-wave transformer : automatically computed from the input and output impedances.



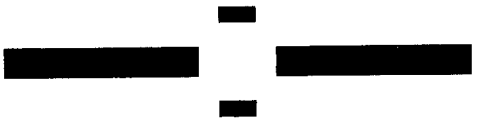
1.8 Decoupling device for DC bias : automatically dimensioned by the program, it is optimized for a large bandwidth, and can be conformed to use a minimum of space on the circuit.



1.9 Bandpass filters with parallel-coupled lines : having up to 8 stages, they are synthesized by the program starting with the filter specifications like passband, ripple within the passband, attenuation at a given frequency. The theoretical response curve is displayed, and

the user can change the specifications and directly see the resulting changes. The filter is then synthesized using [4], taking into account the dispersion and the end effect on coupled lines. Depending on the number of stages, a filter is ready in 1 to 3 minutes.

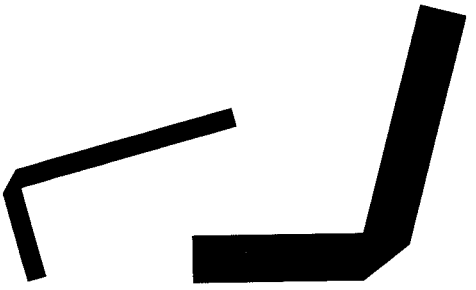
1.10 Transistor pad : it is dimensioned simply by indicating the case type, or can be dimensioned for non-standard cases. This element can also be used to position chip components like resistors or capacitors.



2. Interconnection and terminating elements

2.1 Lines : the impedance can be freely chosen, the length being given in [mm] or in [wavelength]. Lines permit interconnection of elements or realization of stubs. In this case, the end effect is automatically taken into account.

2.2 Mitered bends : their impedance can be freely chosen, the bend aspect is adjustable in 15^0 steps, as well as the bend orientation, so that every possible interconnection can be made.



2.3 Segments : very useful to close lines or join points, they can be digitized or given by their coordinates.

2.4 User-Defined Elements (UDE) : the user can at any time define his own special elements made of segments and arcs of circles, and given by coordinates and pen movements. When defining a UDE, the element is displayed on a millimetric grid and can be corrected interactively until it has the desired shape.
The UDE are stored on a file, and can be used exactly like all other elements. Up to 8 UDE can be present simultaneously. The user can have a display of all UDE present, or inspect in detail a given UDE. Microstrip patch antennas can be defined in this manner.

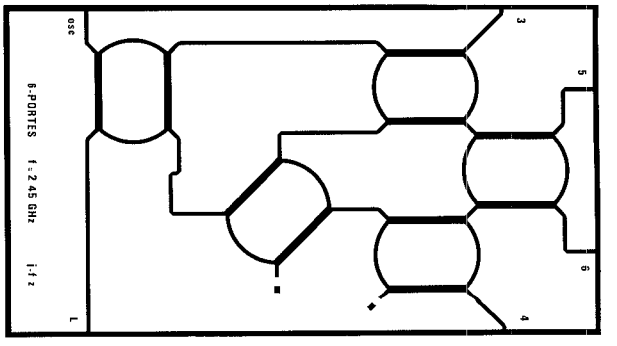
Positioning and connection of the various elements

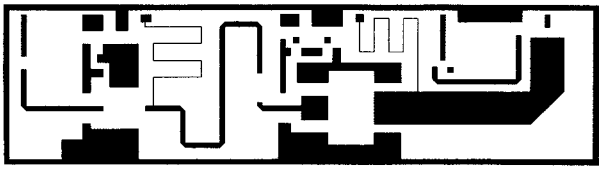
The basic elements and the UDE can be positioned in two ways : a) by specifying the coordinates of their center and their orientation. The orientation is chosen in real time using the "knob" (one can see the element rotating in its separate window when rotating the knob).
b) by digitizing one of their access points. The digitalization is made using an electronic cursor on the screen. To have an adequate resolution and comfortable working conditions is always possible to"zoom" into the part of the circuit drawing where one actually works. A search routine ensures connection to the exact coordinates of the already implanted elements. This warranties a continuous transition between elements witout need for an exact digitalization.

The realization of a mask is easy and fast, since any element can be freely positioned and oriented, and the interconnection process is automated. The information required from the user is limited to a strict minimum, and the graphic part is optimized with respect to speed and efficiency.

Possibilities and advantages of the system

With MICROS 2 almost every possible mask can be realized. Dozens of masks have been made with this program, the circuits realized and tested : six-port junctions, PIN diode attenuators, power amplifiers, low noise amplifiers, miniaturized Doppler radar with integrated antenna, and so on.





Apart from the gain in accuracy and repeatability, the realization of a mask is sped up by a factor of approximately 20 as compared to a manual realization.

Accuracy

The accuracy depends of course on the scale (reduction factor from original to the final mask used for photoetching the circuit). All HP plotters have an adressable step of 25µ. On the largest plotters (HP7580B and HP7585B) the mechanical steps are 3µ. This gives a theoretical final resolution of .5 to 2.5µ for scale factors of 50:1 to 10:1 and original masks of about 120×90 cm.

The accuracy depends also on the repeatibility (repositioning), which is more difficult to estimate. However, this should be fairly similar to the one provided by coordinatographs.

Conclusion

A system for realizing easily and quickly microstrip masks has been presented. It consists of a program - MICROS 3 - and a micro-knife for direct cutting of the Rubylith sheet on a standard plotter.

The program will be continuously updated and extended to new elements.

References

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

[2] Presser, A., "Interdigitated microstrip coupler design", IEEE Trans., MTT-26, No 10, october 1978, pp. 801-805.

[3] Li, C.Q., Li, S.H., Bosisio, R.G., "CAD/CAE Design of an improved, Wideband Wilkinson power divider", Microwave Journal, November 1984, pp. 125-135.

[4] Kirschning, M., Jansen, R.H., "Accurate wide-range design equations for the frequency-dependant characteristics of parallel coupled microstrip lines", IEEE Trans., MTT-23, No 1, January 1984, pp. 83-90.