After a discussion of current computer graphics technology in chapter 1, the manipulation of graphic elements represented in matrix form using homogeneous coordinates is described. A discussion follows detailing existing techniques for representing points, lines, curves, and surfaces within a digital computer, as well as computer software procedures for manipulating and displaying computer output in graphic form.

Mathematical techniques for producing axonometric and perspective views are given, along with generalized techniques for rotation, translation, and scaling of geometric figures. Curve definition procedures for both explicit and parametric representations are presented for both two-dimensional and three-dimensional curves. Curve definition techniques include the use of conic sections, circular arc interpolation, cubic splines, parabolic blending, bezier curves and curves based on B-splines. An introduction to the mathematics of surface description is included.

Computer algorithms for most of the fundamental elements in an interactive graphics package are given in an appendix as BASIC language subprograms. However, these algorithms deliberately stop short of the coding necessary to actually display the results. Unfortunately, there are no standard language commands or subroutines available for graphic display. Although some preliminary discussion of graphic primitives and graphic elements is given in Appendix A, each user will, in general, find it necessary to work within the confines of the computer system and graphics devices available to him.

The fundamental ideas in this book are the foundation for an introductory course in computer graphics given to under-graduate students majoring in technical or scientific fields. It is suitable for use at both universities and schools of technology. It is also suitable as a supplementary text in more advanced computer programming courses or as a supplementary text in some advanced mathematics courses. Further, it can be profitably used by individuals engaged in professional programming. Finally, the documented computer programs should be useful to computer users interested in developing computer graphics capability. TEKniques

PLOT 50 Electrical Engineering Software

By Bob Ross

PLOT 50 Electrical Engineering Vol. 1 is a powerful ac circuit analysis program for the 4051. Much of the program is useful for microwave circuits, but it also applies to conventional circuits (e.g., amplifiers, and low-pass filters) that are analyzed at lower frequencies.

The typical system consists of a 4051 with 32K of memory and a Hard Copy Unit to provide copies of the tabular and graphical outputs. (24K of memory can be used with some reduction in speed). The 4662 Digital Plotter can also be used with no software change.

This self-contained system provides several advantages over programs offered through time-sharing services. The primary advantage is that there are no charges accumulating while entering and editing circuits, performing analysis, or presenting results. Neither are there unreliable, noise-prone telephone systems to deal with, nor irritating delays during prime computer time.

You interact with the EE program using the User Definable Keys on the 4051. With the aid of a printed overlay you choose routines to enter your circuit, to run the analysis, and to display the results. The circuit itself is entered using the internal library of components. These components range from resistors, capacitors, inductors, and two-port presentations of devices, to lossy transmission lines, dual networks, gyrators and circulators. An analysis is run over the specified frequencies, and the results are stored on tape. User Definable Keys allow listings and plots of the results.

Internally the computations are done using scattering parameters (S-parameters). However, S-parameters are mathematically related to other two-port parameters (Z, Y, H, G) and to numerous calculated outputs. Some of the outputs provided in graphic or tabular form are stability factor, maximum available power gain, matched source and load gammas, VSWR, return loss, mismatch loss, delay, and stability circles. The two-port parameters Z, Y, G, H and reciprocals 1/Z, 1/Y and 1/S are also provided. With these parameters you have much useful information such as voltage gains, current gains, input and output impedances or admittances, trans-

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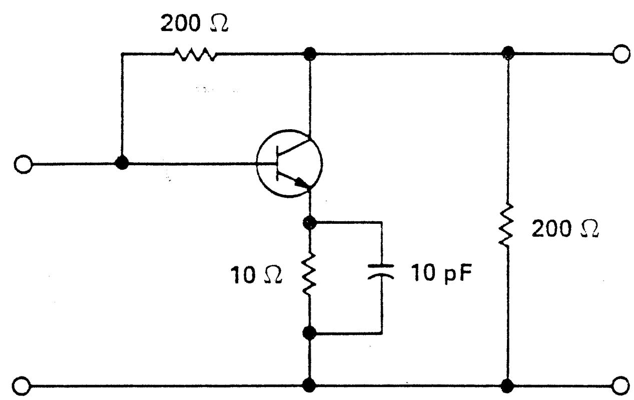
impedances and transadmittances and reflection coefficients. Presentations can be in tabular form or graphed in linear, logarithmic, polar or Smith grids.

Two-port parameters provide useful inforamtion for conventional circuit analysis. For example, Z11 gives input impedance with the output open circuited; 1/Y11 gives input impedance with the output shorted. G21 gives voltage gain, H21 gives current gain. You can pick from a wide selection of parameters, as appropriate for your particular analysis.

A circuit is specified by components and how they are interconnected. Some of the common two-port interconnections available are cascade, series, and parallel. Active devices can be stored on tape in two-port data files (internally as S-parameters) or can be modeled using some gain components in the program. An example illustrates how a simple circuit is coded.

Example



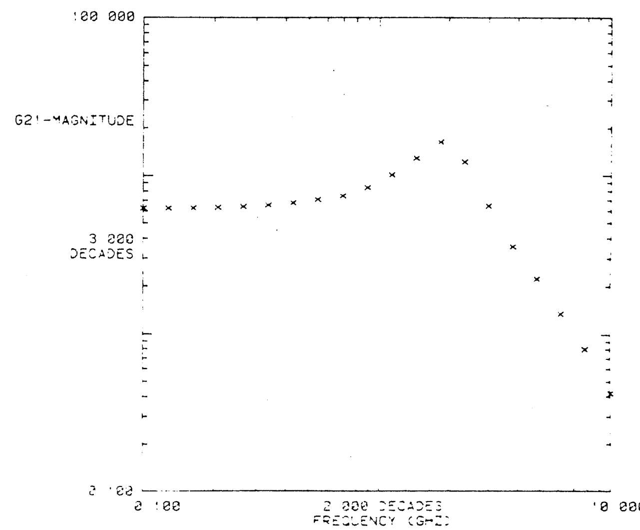

```
1:  FE .1 10 20
2:  RP 10 CA
3:  CP 10 SE
4:  DAT 1 PA
5:  RS 200 CA
6:  RP 200 EQ
7:  NEX
Code length = 63.   Simple diagnostic (Y or N)?
```

Code Listing Description

Line 1 specifies that the analysis is to be done from 0.1 to 10 GHz, in 20 exponentially spaced steps. Lines 2-6 construct the circuit. The emitter RC circuit contains parallel components specified by RP and CP. These are cascaded together by the code step CA in line 2. The combination is taken in series (SE) in line 3 with the transistor specified by DAT 1 in line 4. The transistor two-port parameters are already stored on the tape in data file 1.

The base-collector resistor is a series component (RS) that is combined in parallel with the circuit constructed so far. This combination is cascaded with the parallel output resistor in line 6. The equals step (EQ) in line 6 completes the specification and causes the overall computation to be performed. The NEX step (next) completes the frequency loop specification.

When this program is executed, by pressing RUN on the overlay template, the overall S-parameters for each frequency are stored on tape. Much useful information can be extracted from these parameters. For example, the plot of voltage gain that is given by the two-port parameter G21 is shown below.



Here normal access of the results is illustrated. The question-answer format gives numerous possiblities for plots. Auto scaling is chosen for convenience. Manual scaling can be used to give more flexibility. For example, a portion of a plot can be selected and magnified.

An analysis, including all plots and listings, can be totally automated by entering into the code which results are desired. The Hard Copy Unit can be set up to automatically generate copies of the display as results are presented.

Many advanced features are provided in the PLOT 50 Electrical Engineering Software. Among them are mapping capability to display the effects of imbedded elements on overall S-parameters, "lossless" matching network design, component stripping capability to remove elements or circuit modules rather than add them. Also included is the ability to make any numerical entry in the code variable whose value is requested during execution.

Some typical applications include microwave circuit design and analysis, matching network design, conventional circuit analysis, device characterization using the error stripping capability, and filter analysis.

This is just a glimpse of the capabilities and features in PLOT 50 Electrical Engineering Vol. 1. Much more information, with additional examples, is contained in the manual accompanying the software.