December 1968

Brief 68-10448

NASA TECH BRIEF

Performance Analysis of Electrical Circuits (PANE)

The problem:

To develop a method of performing d.c. and a.c. steady stage circuit analyses from a topological description of the circuit components and their interconnections.

The solution:

An automated *statistical* and *worst case* computer program designed to perform d.c. and a.c. steady state circuit analyses. The program determines the *worst case circuit performance* by solving the circuit equations with each input toleranced to produce the minimum and maximum value of each output parameter. The program also performs a Monte Carlo statistical analysis by solving the circuit equations repeatedly, using random selections of the input parameter values, according to user-specified density distributions, thereby producing a statistical variation of each input parameter.

How it's done:

The program is composed of two phases. The first phase accepts the topological description of the circuit components and associated tolerances according to specified density distributions and writes a set of Kirchhoff real (d.c. analysis) or complex (a.c. analysis) circuit equations in matrix form. The second phase of the program performs a nominal, worst case, and Monte Carlo statistical analysis according to the user's specified program control options.

The program is designed to execute *both phases automatically or each phase separately.* Another feature of this program is the ability to determine the effects of component variations on the output parameters. The program automatically computes the statistical sensitivity which determines the changes in each output parameter by taking the input parameters (one at a time) to their statistical limits as specified by the input data, which provides a valuable indication of which input parameters are critical to circuit performance. Also, the information is an aid in determining which input parameters must be considered to correct a marginal circuit condition. The program has a second option which must be specified by the user and it determines the effect on all the output parameters caused by a $\pm 1\%$ change in each input parameter.

The worst case calculation of each output parameter is based on the statistical sensitivity computed. Considering the computed sensitivity, each input parameter is toleranced to its maximum or minimum statistical limit and the circuit equations are solved to maximize and minimize each output parameter. The worst case may be run exclusively or, if the statistical option is specified, the worst case will be computed automatically.

The Monte Carlo statistical analysis is a method of obtaining the performance of a circuit which is comprised of many elements with values varying between tolerance limits. By repeatedly selecting random combinations of these elements and solving the circuit equations, a valuable indication of the circuit's probability of meeting some specific performance criterion can be derived.

The program accepts 200 inputs, each specified with its appropriate tolerances according to density distribution (accepts six different distribution shapes) desired for either a.c. or d.c. analysis. The d.c. analysis program accepts resistors, independent voltage and current sources, voltage dependent current sources, transistors, and diodes. The diodes are described by measured I_D vs V_D characteristics; the transistors use the Ebers–Moll large signal model described by I_e vs V_{BE} and I_s vs V_{BC} measured characteristics supplied by tables.

(continued overleaf)

The program handles 60 dependent nodes (other than ground or those connected to independent voltage sources). The a.c. program accepts resistors, capacitors, inductors, independent voltage and current sources, voltage dependent current sources, any a.c. equivalent transistor model using voltage dependent current sources, and diodes represented by their a.c. equivalent.

A maximum of 50 outputs may be requested indicating worst case performance in tabular form showing the minimum, maximum, and nominal values calculated. Statistical behavior of outputs are given in tabular form and histogram plots. A.C. circuit performance is given in tabular form and histogram plots for statistical analysis. Worst case performance as a function of frequency is given in tabular form with code plots showing the minimum, maximum, and nominal response for each output quantity. The program also outputs sensitivity tables which determine the effect of component statistical variations on the output parameters.

Notes:

1. This program is an IBM System/360 computer program implemented for OS/360 E-level Fortran and Assembler and requires 256,000 bytes of core. The original PANE program was developed by John B. Eggerling and Charles G. Hooks of International Business Machines.
2. Inquiries should be made to:

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Patent status:

No patent action is contemplated by NASA.

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(MFS-15001)