NASA TECH BRIEF
NASA Pasadena Office

Analysis of Circuits Including Magnetic Cores (MTRAC)

The problem:

To make possible transient analysis of circuits that include magnetic cores, allowing for complications caused by the nonlinearity of the switching-core model and by the magnetic coupling among the loop currents.

The solution:

In the MTRAC program these difficulties have been overcome by incorporating static and dynamic core models into the automated circuit-analysis computer program. This program is modified to include provisions for successive modes of operation, conditional monitor printout of variable values in different portions of the program, plot and print-plot routines with external or internal specifications for scales, units, and frame sizes, normal and circuit-failure run termination, nonlinear inductor and resistor models, etc. Time variables (voltages, currents, MMFs, fluxes, etc.) of complex magnetic-core circuits (up to 60 nodes) can thus be computed and plotted automatically. All that the user has to supply is the general run-control specifications, the circuit topology, and the values of the circuit-element parameters.

How it's done:

The computation in MTRAC is iterative. It is based on expressing the current through any circuit element connection between Nodes a and b as:

$$i_{ab} = \Delta H (V_a - V_b) - \Delta T,$$

where ΔH and ΔT are constants. Applying this relation to every circuit node yields a matrix equation:

$$T] = [H] \times V],$$

where V] is a matrix whose elements are the unknown nodal voltages. The solution of V] is used to compute the currents through each nonlinear circuit element, and the results are tested for convergence. Expressions are derived for ΔH and ΔT of sources (current or voltage), resistors, capacitors, inductors, zener diodes, diodes, transistors, and magnetic cores.

The MTRAC program consists of two sections, one dealing with initialization and the other with the transient solution. The initialization section will perform the following five tasks: (1) read in and print out general input data; (2) read in and print out the circuit-element data; (3) solve initial conditions (optional); (4) print out and store initial conditions; and (5) read in and print out continued-run data (optional). The transient-solution section will perform the following seven tasks: (1) compute the magnitudes of the time-variable current and voltage sources; (2) until convergence is achieved, compute by iterations (using a routine for solving matrix equations and a modified Newton-Raphson method for solving transcendental equations) all the nodal voltages and all the currents through the nonlinear elements (diodes, transistors, and magnetic-core windings), and if necessary, reset the unknown values and cut the time step, Δt; (3) compute the currents through the linear elements; (4) adjust Δt according to the recent convergence conditions and update the time variables for the next Δt; (5) store (for plots) and print out the resulting time variables; (6) if the run-time limit is about to be exceeded, punch the final results necessary for a future continued run on cards; and (7) print-plot the specified variable wave forms, store the plot data on a tape, begin a new mode, or exit.

Instructions for data entry by the user are provided. These include definitions of special functions and/or auxiliary variables and input-data cards specifying the run control and the circuit-element topology and parameter values. The MTRAC program has been applied successfully to transient analyses of several magnetic core circuits.

(continued overleaf)

Notes:

1. This program was written in FORTRAN IV for use on the UNIVAC-1108 computer.
2. Inquiries concerning this program should be directed to:

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