NASA TECH BRIEF
Langley Research Center

A Linear Circuit Analysis Program with Stiff Systems Capability

The problem:

Techniques for the analysis of an electrical network that contains stiff circuits require such a large number of small steps that they are impractical for anything but simple networks.

The solution:

Several existing network analysis programs have been modified and combined to employ a variable topological approach to circuit translation. Efficient numerical integration techniques are used for transient analysis.

How it's done:

This circuit analysis program, called STICAP, is restricted to the analysis of linear time-invariant networks. It represents a merging, with some modifications to each, of Pottle's circuit analysis program, CORNAP, and Gear's program, ALGORITH 407 – DIFSUB, for the automatic integration of ordinary differential equations.

The program package is best viewed as consisting of three separate components or modes of operation: CORNAP, Gear, and Matrix. The characteristics of the particular circuit being analyzed determine which mode should be chosen for use. In each mode, the common method of circuit translation is the topological approach originally employed in CORNAP. The circuit translation yields a set of first-order linear differential equations governing the time evolution of the circuit state variables.

The CORNAP mode selects the program CORNAP with all its previous capabilities. In addition, certain data printing features may be optionally selected. These capabilities include calculation of transfer functions, zeroes of transmission, frequency, and time response of the circuit. CORNAP implements a fourth-order numerical integration algorithm for time-domain analysis. Since it is absolutely stable, the integration may be used for either stiff or non-stiff networks. However, the step size is fixed throughout the duration of computation, a feature which can be uneconomical in some instances. Furthermore, only impulse or step functions and sampled data may be used as circuit input.

The Gear and Matrix modes compute the time-domain transient, impulse, or step responses only. With these, CORNAP subroutines may be called to obtain transfer functions and zeroes of transmission. The Gear mode allows the selection of either Adam's integration method, suitable for non-stiff equations, or the methods of Gear, suitable for stiff equations.

The Gear mode can be used for analysis of the general linear time-invariant network, with forcing functions specified by using the full power of the FORTRAN language or by means of sampled data. In both cases, "automatic" order selection techniques and variations in the step size are employed as the integration proceeds. In this way, the desired level of accuracy is achieved with the minimum number of integration steps. The maximal order truncation error selectable by changing from one algorithm to another through the automatic order selection process is an eighth-order Adam's method of a sixth-order stiff algorithm.

In the matrix mode, a spectral decomposition of the system matrix in terms of its eigenvalues is employed to obtain a closed-form solution which avoids a numerical integration. This method is computationally rapid and may be used for stiff or non-stiff networks. However, it is applicable only where there are no repeated eigenvalues of the system matrix and for systems whose forcing functions are linear combinations of sinusoidal, cosinusoidal, impulse, or step functions.

(continued overleaf)

Notes:

1. This program was written in FORTRAN IV for use on a CDC-6400 computer.
2. Inquiries concerning this program should be directed to:

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