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# DLANET - A DIGITAL COMPUTER PROGRAM FOR THE ANALYSIS OF DISTRIBUTED-LUMPED-ACTIVE NETWORKS

Prepared under Grant NGL-03-002-136 for the
Instrumentation Division of the Ames Research Center
National Aeronautics and Space Administration

by

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Abstract: This report describes DLANET, a digital computer program for the analysis of Distributed-Lumped-Active NETworks, i.e., networks comprised of elements which are distributed, lumped, or active in nature. The program determines the sinusoidal-steady-state response of such a network over a prescribed frequency range. A subprogram is included to provide plots of the resulting magnitude and phase characteristics. A range of options are available to specify the taper of the distributed elements, select linear or logarithmic scales, produce punched card output, etc.

November 1968

Table of Contents

I. Introduction . . . . . 1

II. Theory of Operation . . . . . 1

III. The DLANET Program - General Characteristics . . . . 4

IV. The DLANET Program - Details of Operation . . . . . 6

V. Example. . . . . 10

Acknowledgement. . . . . 10

References . . . . . 10

Input Data Format for DLANET Program . . . . . 11

Flow Chart for DLANET Program. . . . . 16

Flow Chart for DISRP Subroutine. . . . . 21

Flow Chart for XL4 Function. . . . . 23

Flow Chart for YDIST Subroutine. . . . . 24

Flow Chart for CONST Subroutine. . . . . 25

Flow Chart for CMRED Subroutine. . . . . 27

Flow Chart for PLOT Subroutine . . . . . 28

Listing of DLANET Program. . . . . 29

Figures. . . . . 37

# I. INTRODUCTION

This is one of a series of reports concerning the use of digital computational techniques in the analysis and synthesis of DLA (distributed-lumped-active) networks. This class of networks consists of three distinct types of elements, namely, distributed elements (modeled by partial differential equations), lumped elements (modeled by algebraic relations and ordinary differential equations), and active elements (modeled by algebraic relations). Such a characterization is especially applicable to the broad class of circuits referred to as linear integrated circuits, since the fabrication techniques for such circuits readily produce elements which may be referred to as "distributed", as well as producing elements which may be characterized as "lumped" or "active". The DLA class of networks is capable of realizing network functions with a wide range of properties. In addition, such realizations usually have fewer components and superior characteristics to realizations using only lumped elements or realizations using lumped and active elements. The analysis problem for the DLA class of networks, however, is considerably more complex than that for more restricted classes of networks. One of the more fruitful approaches to the analysis problem is that afforded by the digital computer. In this report, the results of such an approach are documented. Specifically, the report will describe the operation and use of the digital computer program DLANET, a program designed to make sinusoidal-steady-state analyses of DLA networks. The distributed elements will be restricted to being resistive and capacitive in behavior, since such elements most closely model those realized by integrated circuit techniques. The program is quite general and is easily extended to other network situations.

# II. THEORY OF OPERATION

One of the major problems encountered in analyzing DLA networks is the problem of adequately modeling the distributed elements. An attractive approach to the modeling of such elements is the use of iterative techniques. Such an approach has the advantage that it is readily adaptable both to the uniform distributed element and to the tapered distributed element. Furthermore, the modeling is independent of the mathematical form of the taper, i.e., the taper need not be simply described. Since solutions to relatively simple tapers can be quite involved mathematically (for example, Bessel functions are required in the solution for linearly tapered distributed elements), this advantage can be of considerable importance.

The model which was chosen for the distributed elements for the program described in this report is a cascade of lumped RC "L" sections. A typical section is shown in Fig. 1. Assuming that this is the "kth" section, it may be considered as a two-port network, and voltage and current variables defined as indicated. Under conditions of sinusoidal steady-state excitation, the equations describing such a section may be written in the form

$$x_k = TD_k x_{k+1} \tag{1}$$

where

$$x_k = \begin{bmatrix} V_k \\ I_k \end{bmatrix} \qquad x_{k+1} = \begin{bmatrix} V_{k+1} \\ I_{k+1} \end{bmatrix}$$

$$TD_k = \begin{bmatrix} 1 + j2\pi f C_k R_k & R_k \\ j2\pi f C_k & 1 \end{bmatrix} \tag{2}$$

and f is the frequency in Hz. The square matrix $TD_k$ gives the transmission parameters of the kth section of the model for the distributed line. The transmission parameters of the overall distributed element may thus be represented as the product of the transmission parameters of the cascaded sections. If there are n such sections and if we let TD be the matrix of transmission parameters with elements $td_{ij}$ for the overall distributed element, we may write

$$TD = \left[ td_{ij} \right] = TD_1 \times TD_2 \ldots TD_n \tag{3}$$

Thus we have obtained a set of two-port parameters which model a distributed RC network.

Since the distributed element, in general, will be combined with lumped and active elements to form a DLA network, a more appropriate set of parameters to describe it is the admittance or y parameters. If we let YD be the 2 x 2 matrix containing the y parameters of the distributed network, we may express YD in terms of the elements $td_{ij}$ of the TD matrix of (3) as

$$YD = \left[ yd_{ij} \right] = \frac{1}{td_{12}} \begin{bmatrix} td_{22} & -1 \\ -1 & td_{11} \end{bmatrix} \tag{4}$$

Finally, to facilitate an even greater generality of interconnection, it is most useful to generate the indefinite admittance parameters of the distributed element. If we let YDI be the 3 x 3 matrix with elements $yd_{ij}$ containing the indefinite admittance parameters of the distributed element, we may express it in terms of the elements $yd_{ij}$ of (4) as

$$YDI = \left[ ydi_{ij} \right]$$

$$= \begin{bmatrix} yd_{11} & yd_{12} & -yd_{11} - yd_{12} \\ yd_{21} & yd_{22} & -yd_{21} - yd_{22} \\ -yd_{11} - yd_{21} & -yd_{12} - yd_{22} & yd_{11} + yd_{12} + yd_{21} + yd_{22} \end{bmatrix} \tag{5}$$

Thus, if we select d quantities $R_i$ and d quantities $C_i$, and a specific frequency f, we can calculate the indefinite admittance matrix for a distributed element under conditions of sinusoidal steady-state excitation at that frequency. The effect of choosing various values of d, i.e., using a model with different numbers of lumped sections has been discussed in a previous report.[1]

The next step in the analysis of the DLA network is to interconnect the distributed element (or elements) with the specified lumped and active elements, and to solve the resulting network for the desired transfer function. The interconnection of the distributed and lumped elements is readily accom-

plished by adding their admittance parameters. The resulting parameters can then be constrained to include the effect of the active elements. Finally, the equations represented by the constrained parameters may be solved by conventional techniques. These steps are now discussed in detail.

We shall begin our discussion by considering the use of an interconnection network consisting of n + 1 nodes. For convenience we shall take node 1 as the input node, node 2 as the output node, and node n + 1 as the reference (ground) node. Thus, we will consider the interconnection network shown in Fig. 2 as the basic framework into which the various distributed, lumped, and active elements are to be imbedded. The (definite) admittance matrix describing an interconnection network of the type shown in Fig. 2 is simply an n x n null matrix. Thus, the effect of connecting a distributed network with admittance parameters as determined by the 3 x 3 matrix YDI to a set of any three terminals of the interconnection network is simply to add the elements of YDI to the appropriate elements of the n x n null matrix representing the interconnection network. Similarly, the effect of any lumped elements may be represented by adding the conductance (for resistors) or the susceptibility (for capacitors) to the appropriate elements of the admittance matrix. The resulting matrix, giving the combined effect of the distributed and lumped elements will be referred to as YT (for Y Total).

The next step in our analysis of the DLA network is to modify the parameters of the network of distributed and lumped elements to take account of the active elements. For simplicity, we shall consider the effect of connecting a VCVS (voltage-controlled voltage source) of gain 1/A from node n to node 2 of the interconnection network as shown in Fig. 3. The effect of such a source is to reduce the n x n array of the matrix YT to a (n - 1) x (n - 1) array, by reason of the constraint equation $V_2 = (1/A)V_n$ imposed on the network variables. Let YC by the (n - 1) x (n - 1) constrained array with elements $yc_{ij}$. It is easily shown that[2]

$$YC = \left[yc_{ij}\right]$$

$$= \begin{bmatrix} yt_{11} & yt_{12} + Ayt_{1n} & yt_{13} & \cdots & yt_{1,n-1} \\ yt_{31} & yt_{32} + Ayt_{3n} & yt_{33} & \cdots & yt_{3,n-1} \\ yt_{41} & yt_{42} + Ayt_{4n} & yt_{43} & \cdots & yt_{4,n-1} \\ \vdots & \vdots & \vdots & & \vdots \\ yt_{n1} & yt_{n2} + Ayt_{nn} & yt_{n3} & \cdots & yt_{n,n-1} \end{bmatrix} \tag{6}$$

The matrix YC interrelates certain of the voltage and current variables of the interconnection network. Thus, we may write

$$\begin{bmatrix} I_1 \\ I_3 \\ I_4 \\ \vdots \\ I_n \end{bmatrix} = \left[yc_{ij}\right] \begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ \vdots \\ V_{n-1} \end{bmatrix} \tag{7}$$

where the quantities $I_i$ represent external excitation currents applied at the nodes of the interconnection network, and the quantities $V_i$ are the nodal voltages. This procedure is easily generalized to include an arbitrary number of sources connected to any desired nodes, thus, the final size of the matrix YC will be n - ng, where ng is the number of VCVSs which are present in the network.

The final step in the analysis of the DLA network is the reduction of the (n - ng) x (n - ng) array YC to a 2 x 2 array from which the voltage transfer function of the network may be computed. To do this, we may note that since node 1 has been selected as the input node, only the current $I_1$ in the column vector on the left of (7) will be non-zero. Therefore, by simple matrix algebraic relations,[3] if we write YC in the form

$$\underset{(n-ng)\times(n-ng)}{YC} = \begin{array}{c} (n\text{-}ng\text{-}1)\ \text{cols} \\ \left[\begin{array}{c|c} Y_{aa} & Y_{ab} \\ \hline Y_{ba} & Y_{bb} \end{array}\right] \end{array} \begin{array}{l} \\ (n\text{-}ng\text{-}1)\ \text{rows} \end{array} \tag{8}$$

Then, we may write

$$\underset{(n-ng-1)\times(n-ng-1)}{YC} = Y_{aa} - Y_{ab}Y_{bb}^{-1}Y_{ba}. \tag{9}$$

Equation (9) is easily programmed for the digital computer and avoids the need for a matrix inversion operation. Successive applications of (9) may be used to reduce the equations of (7) to those defining a two-port. These will be in the form

$$\begin{bmatrix} I_1 \\ 0 \end{bmatrix} = Y \begin{bmatrix} V_1 \\ V_2 \end{bmatrix} \tag{10}$$

where Y is the 2 x 2 matrix with elements $y_{ij}$ defining the two-port network. From the $y_{ij}$ two-port parameters of (10), any desired network transfer function may be specified, for example, for the open-circuit voltage transfer function we obtain

$$\frac{V_2}{V_1} = \frac{-y_{21}}{y_{22}} \tag{11}$$

The algorithms for generating the parameters of the distributed element and for interconnecting the distributed, lumped, and active elements are readily programmed for the digital computer to produce a tabulation (or a plot) of the magnitude and phase of the voltage transfer function of the specified DLA network as a function of frequency. In the following section of this report, the operation of the program DLANET containing these algorithms is described.

## III. THE DLANET PROGRAM - GENERAL CHARACTERISTICS

The DLANET program is a digital computer program written in FORTRAN IV and designed to provide a wide variety of options and features in the sinusoidal steady-state analysis of DLA networks, and in the display of the resulting data. It has been developed for a CDC-6400 computer but it is relatively machine independent. It is suitable for use on a wide range of

medium to large size computers. The program consists of a main program and a series of subprograms. A list of the name and function of each of the subprograms follows:

DISRP - a subroutine designed to read the data defining the distributed networks and to compute the values of the resistors and capacitors used to determine the lumped models for them. Options are provided to permit the specification of uniform, exponential, polynomial, or arbitrary taper.

$XL_4$ - a function designed to provide a sequence of logarithmically spaced numbers. Thus it can be used to generate the values of frequency needed for plots in which the frequency scale is logarithmic rather than linear.

YDIST - a subroutine designed to compute the admittance parameters of the distributed networks, using the values of lumped resistors and capacitors determined by DISRP, and whatever value of frequency is desired. The subroutine also stores the parameters in the appropriate elements of the admittance matrix for the entire DLA network.

CONST - a subroutine designed to constrain the admittance matrix for the DLA network in such a way as to include the effects of the VCVS active elements in a manner similar to that shown in (6).

CMRED - a subroutine designed to reduce the order of the admittance matrix for the DLA network to 2 x 2 size, using the algorithm given in (9), thus, in effect providing a solution to the network equations.

PLOT - a subroutine designed to plot the magnitude and phase values which have been determined for each of the frequencies at which the program has been run.

The main program links the subprograms described above together in such a way as to provide the desired steady-state analysis capability for DLA networks. A flow chart of the main program is given in Fig. 4. This indicates the way in which the various subroutines are incorporated into the logic used in the program. It is readily verified that this flow chart follows the general theory outlined in Sec. II of this report.

The capabilities of the program DLANET are determined mainly by the dimensioning of the various variables. For the dimensioning given in the program listing included with this report, DLANET has the following maximum limits:

Number of network nodes (not including the reference node) - 14
Number of distributed networks - 5
Number of sections permitted for each distributed network - 50
Number of lumped elements - no limit
Number of gain elements of VCVS type - 5

Several options and features are provided to make the program as flexible as possible for the user. These are:

1. A descriptive title is printed at the head of all output data listings and plots.

2. The frequencies at which the DLA network is to be analyzed are determined by specifying the lower and upper frequencies, the number of intermediate frequencies at which computation is desired, whether the frequency scale is to be linear or logarithmic, and whether the frequencies are specified in Hz or rad/sec.

3. The user may choose to suppress all plotting, to plot only the magnitude of the voltage transfer function, or to plot both the magnitude and the phase. To keep the size of the program reasonable, the plotting

subroutine has been simplified so that no internal scaling of data is provided. Thus, the user must select the necessary scale factor to be used in multiplying the magnitude and phase data as well as the maximum value of the ordinate desired on each of the plots.

4. The magnitude of the voltage transfer function is computed and expressed both as an actual magnitude and also in decibels. Either of these values may be used for the plot.

5. Uniform distributed networks may be computed by specifying the total resistance and capacitance, and the desired number of sections.

6. Exponential taper distributed networks may be computed by specifying the number of sections, and the initial values of the resistance and the capacitance and the taper. As an alternative, the taper may be computed by specifying the initial and final values of the capacitance or the resistance.

7. Polynomial taper distributed networks may be modeled by specifying the number of sections, the initial values of the resistance and the capacitance, the length of the lines, and the coefficients of the polynomial determining the taper. Up to 10 polynomial coefficients may be used, and these may be different for each of the distributed networks.

8. Arbitrarily tapered distributed networks may be modeled by reading in the actual values of the resistors and the capacitors for each section of the network.

9. An output listing is provided for each computation giving the values of frequency (in Hz and rad/sec), the magnitude of the voltage transfer function (in linear measure and in decibels) and the phase in degrees (if phase determinations are desired). As a convenience, punched card output of this data may also be requested.

10. Since the modeling of the distributed network parameters may be time consuming if many lumped network sections are used to model the distributed element, a provision is included which makes it possible to make only one computation of the distributed network parameters at a given frequency, and to use this data for all other distributed networks (assuming that they are identical).

11. The program includes a multiple-case option, in which, after the voltage transfer function has been computed for a range of frequencies, values of the parameters may be changed, and the computation repeated for the new parameter values. If desired, the user may choose to read in only selected parameter values rather than repeating all reading and computing operations. The data from these multiple cases may be plotted on the same plot, using the character A to represent the locus for the first set of data, the character B to represent the locus for the second, etc. Up to five simultaneous plots may be displayed.

Details of these and other features and options of the program are described more fully in the following sections of this report.

## IV. THE DLANET PROGRAM - DETAILS OF OPERATION

In this section of the report, the details of the operation of the various portions of the DLANET digital computer program for the sinusoidal steady-state analysis of DLA networks is presented. In studying this material, reference should be made to the flow charts and listings presented in the Appendix of this report.

The main program, and the subroutines DISRP, YDIST, CONST, and CMRED described in the preceding section are linked through the use of commoned variables. A listing and description of these variables and their dimen-

sioning follows:

YR(15,15) - This is a complex array in which are stored the values of the admittance parameters which have been computed at some specific value of frequency for the DLA network. These values are read in ohms, and are converted to mhos before storage in the array.

R(15,15) - A real array in which is stored the admittance parameters of the resistive lumped elements which are used in the DLA network. These values are read in ohms, and are converted to mhos before storage in the array.

C(15,15) - A real array in which is stored the values of the admittance parameters of the capacitive elements (without being multiplied by frequency) of the DLA network. The units are farads.

RD(5,50) - A real array in which are stored the values of the series resistors used in the lumped approximation to the distributed RC networks. These are stored as RD(I,J) where I is the number of the distributed network and J is the number of the lumped section.

CD(5,50) - A real array in which are stored the values of the shunt capacitors used in the lumped approximation for the distrbuted networks. These are stored as CD(I,J) where I is the number of the distributed network and J is the number of the lumped section.

NSECT(5) - The number of sections to be used to approximate distributed networks 1 - 5.

N1(5) - The numbers of the nodes to which the x = 0 end of the resistive layers of distributed networks 1 - 5 are connected.

N2(5) - The numbers of the nodes to which the x ≠ 0 end of the resistive layers of distributed networks 1 - 5 are connected.

N3(5) - The numbers of the nodes to which the capacitive layers of distributed networks 1 - 5 are connected.

NN - The number of nodes in the DLA network (not including the ground node).

ND - The number of distributed networks in the DLA network.

RAD - The value of the frequency variable in rad/sec.

KD - An indicator giving the number of the distributed network whose admittance parameters are currently being computed by YDIST.

NREP - A variable used to specify the repetition of all or certain portions of the main DLANET program so as to provide a multiple case capability.

NGAIN - The number of VCVS gain elements.

NG1(5) - The numbers of the nodes to which the positive polarity end of the source portion of VCVSs 1 - 5 are connected.

NG3(5) - The numbers of the node voltages which control VCVSs 1-5.

JL(5) - The number of the nodes which it is desired to eliminate in applying the constraints imposed by VCVSs 1 - 5.

GA(5) - The value of the gains of VCVSs 1 - 5.

These variables will be referred to in the description of the operation of the various subprograms of the DLANET program which follows:

SUBROUTINE DISRP

This subroutine reads and prints the data for the distributed networks. All input and output variables are in commmon. It goes through ND cycles.

On the Ith cycle it will read the values of NOPT, an indicator which determines the type of taper and must have a value from 1 - 4, NSECT(I), N1(I), N2(I), and N3(I). The values of RD(I,J) and CD(I,J) are computed for values of J from 1 to NSECT(I). If NOPT = 1 (a uniform network), values of RT (the total resistance) and CT (the total capacitance) are read, divided by the number of sections, and stored in RD and CD. If NOPT = 2 (an exponential network), the user may specify RA (the initial resistance), CA (the initial capacitance), and ALFA (the taper coefficient), after which the lumped values of resistance and capacitance are computed to match the relations

$$r(x) = r_a e^{\alpha x/d} \qquad c(x) = c_a e^{-\alpha x/d} \tag{12}$$

where d is the total length of the line, and stored in RD and CD. If ALFA is read in as zero, then it will be computed from the values of RA and RB (the final resistance). If RB is read in as zero, ALFA will be computed using CA and CB (the final capacitance). If NOPT = 3 (a polynomial taper), NP (the number of polynomial coefficients), RI (the initial resistance), CI (the initial capacitance) and XT (the total length of the line) are read in, as are the NP coefficients P(I). The lumped resistors and capacitors are then computed to match the relations

$$r(x) = r_i\ (1 + p_1 x = p_2 x^2 + \ldots) \quad c(x) = c_i/(1 + p_1 x + p_2 x^2 + \ldots) \tag{13}$$

amd stored in RD and CD. If NOPT = 4 (arbitrary taper), the values of RD and CD are read in directly.

FUNCTION XL4 (N, LO, LP)

This function uses a counter N to keep track of the number of logarithmically spaced frequency values which have been generated. This counter is advanced by 1 after each call of the function. It is set to 1 (variable NLG) in the main program before the first call of the function. The function generates LP logarithmically spaced numbers per decade starting with a value (corresponding to N = 0) equal to the antilogarithm of LO. The calling arguments used in the main program for LP and LO are NG and LOG1.

SUBROUTINE YDIST

This subroutine computes the admittance parameters for the distributed networks and stores them in the YR array. All input and output variables are in common. The values stored in RD and CD, and the current value of RAD is used to compute the transmission parameters of each section of the distributed network model. The complex 2 x 2 arrays AR, BR, and CR are used to store the transmission parameters during matrix multiplication. The final values of the transmission parameters are converted to the complex y parameters DR, ER, and GR, and these are entered as appropriate elements of the YR array according to the values specified for N1, N2, and N3. If NSECT(I) = 0, then the previously computed values of DR, ER, and GR are used, thus, the recomputation of the admittance parameters for identical distributed networks is eliminated by specifying NSECT(I) = 0 for any distributed network except the first (I = 1).

SUBROUTINE CONST

This subroutine constrains the YR array to take account of the effect of the VCVSs. All input and output variables are in common. It uses two arrays of indicators NRE(I) and NCE(I) which are initialized to zero, then set to unity for each row and column that is to be eliminated from the YR array. The rows that are eliminated are those corresponding with the nodes

at which VCVSs are connected. The columns that are eliminated are those associated with either the controlling node voltage or the node at which the source is located. Before eliminating the specified columns, the constraining operations are made, i.e., the column to be eliminated is added to the column which is not eliminated after first being multiplied or divided by the gain of the source. It should be noted that the data must not specify that a given column be eliminated more than once. In addition, the order in which the data for the sources is read into the program must be such that no operations are made on a column after it has been eliminated. For example, consider the cascade of sources shown in Fig. 5a. It if is desired to eliminate nodes a and b, then the data for source A must be enetered before the data for source B. On the contrary, if it is desired to eliminate nodes b and c, then the data for source B must be entered before that for source A. If nodes a and c are to be eliminated, the order in which the data is entered is arbitrary. Similar conclusions hold for a parallel connection of sources as shown in Fig. 5b. If nodes a and c are to be eliminated, then the data for source A must be entered before that for source B. If nodes a and b are to be eliminated, then the data for source B must be entered before that for source A. Finally, if nodes b and c are to be eliminated, the order in which the data is entered is arbitrary.

SUBROUTINE CMRED

This subroutine reduces the YR array to a 2 x 2 array using the algorithm described in (9). All input and output variables are in common.

SUBROUTINE PLOT (Y, M, NS, NS)

This subroutine provides a plot of the data stored in the two dimensional Y array. The variable Y(I,J) is used to store the Jth value of the Ith variable that it is desired to plot. The dimensions on the Y array are (5,100), thus, up to 100 values of each of five variables can be plotted. The argument M specifies the number of variables that are to be plotted. This argument must have a value from 1 to 5. The argument NF specifies the number of values of each variable that are to be plotted. This argument is normally set to some multiple of 10 between 10 and 100. If it is desired to contain the plot on a single page, NF should be set to 50. The argument NS determines the maximum value of the ordinate scale that is desired. The minimum value of the scale is automatically set to 100 units lower, thus, the data which is to be plotted must be scaled so as to fit within this range. The arguments listed above are automatically determined by the input data to the main program. In the main program the Y array is used to store the magnitude data and the Z array is used to store the phase data. Thus, if both magnitude and phase plots are desired, the subroutine PLOT is called twice, once to plot the data stored in the Y array, and a second time to plot the data stored in the Z array. A detailed description of the operation of this subroutine may be found in the literature.[4]

MAIN PROGRAM

The operation of the main program follows quite closely the general outline given in Fig. 4. The multiple-case feature provided in DLANET, however, may be better understood by examining the extended flow chart shown in Fig. 6. This chart shows the use of the variable NREP in determining whether or not multiple cases are to be computed. If a blank card (NREP = 0) is used, then the entire program is repeated, and a complete

new set of data must be supplied. The same is true if NREP is read in as 4. If it is desired only to modify the values of the gains of the VCVSs, then NREP is read in as 1. In this case, after reading in the new values of the gains, the original frequency data is used to repeat the computations. If it is desired only to modify the distributed network characteristics, then NREP is read in as 2. In this case after reading in new data for the distributed networks, the original frequency data is used to repeat the computations. If it is desired only to modify the values of the lumped elements, then NREP is read in as 3. In this case, the values read in are superposed on the previous values, thus, to "remove" an element, the negative of the value originally read in must be specified, or, to change the value of an element, only the change should be read in. After all such changes are made, the original frequency data is used to repeat the computations. Finally, if no data dard is provided for NREP, an EOF (end-of-file) is used as an indicator to procede to the plotting portion of the program.

Detailed flow charts and listings of the main program and the subroutines described above may be found in the appendix of this report.

## V. EXAMPLE

As an example of the type of computations performed by this program, consider the network shown in Fig. 7. This network was originally discussed by Kerwin.[5] To make a logarithmic frequency plot from 0.1 to 10 rad/sec of this network using a 5 section model for the distributed network, and to repeat the computation for a 10 section model, the data cards shown in Fig. 8 are required. The resulting computer output is shown in the following sheets, Figs. 9-13.

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Input Data Format for DLANET Program

| Card No. | Variable | Columns | Format | Purpose |
|---|---|---|---|---|
| 1 | LTR | 1-80 | 8A10 | Alphanumeric identification for problem |
| 2 | NN | 1-3 | I3 | Number of nodes (not counting reference node) |
| | ND | 4-6 | I3 | Number of distributed elements |
| | NF | 7-9 | I3 | Number of frequencies at which response is to be calculated |
| | NSY | 10-12 | I3 | Maximum ordinate scale value for plot of magnitude response (minimum is 100 units lower) |
| | NSP | 13-15 | I3 | Maximum ordinate scale for plot of phase response (minimum is 100 units lower) |
| | KRAD | 16 | I1 | Indicator for units of frequency (1 is rad/sec, 0 is Hz) |
| | LMAG | 17 | I1 | Indicator for magnitude units (0 is db, 1 is linear) |
| | LPHS | 18 | I1 | Indicator for phase computation (0 is no, 1 is yes) |
| | KPLT | 19 | I1 | Indicator for whether plot is desired (0 is yes, 1 is no) |
| | LFRQ | 20 | I1 | Indicator for type of frequency scale (0 is linear, 1 is logarithmic) |
| | OLDG | 21-30 | E10.0 | Gain of first voltage-controlled voltage source (used only if NGAIN (cols. 72-74) is set to zero) |
| | FA | 31-40 | E10.0 | Lowest frequency desired |
| | FB | 41-50 | E10.0 | Highest frequency desired |

| | | | |
|---|---|---|---|
| SCALE | 51-60 | E10.0 | Scale factor for magnitude plot |
| SCALP | 61-70 | E10.0 | Scale factor for phase plot |
| KPUN | 71 | I1 | Indicator for punched output (0 is no, 1 is yes) |
| NGAIN | 72-74 | I3 | Number of voltage-controlled voltage sources |

Note: There will be NGAIN of the following cards required. An alternate data input may be used if there is only one VCVS and it is connected from node 3 to node 2. In this case set NGAIN (cols. 72-74) of card 2 to 0, enter the gain of the VCVS in cols. 21-30 (format E10.0) of card 2, and skip the following card (card 3).

| | | | | |
|---|---|---|---|---|
| 3 | NG1(I) | 1-3 | I3 | Node at which the Ith VCVS is located) (the other terminal is assumed to be grounded) |
| | NG3(I) | 7-9 | I3 | Node at which the controlling voltage for the Ith VCVS is located (taken with respect to ground) |
| | JL(I) | 13-15 | I3 | Node (either NG1(I) or NG3(I)) that it is desired to eliminate in taking account of the constraining effect of the Ith VCVS. |
| | GA(I) | 21-30 | E10.0 | Gain of the Ith VCVS |

As many of the following cards may be used as are required:

| | | | | |
|---|---|---|---|---|
| 4 | I | 1-2 | I2 | First node to which lumped element (or elements) is connected |
| | J | 3-4 | I2 | Second node to which lumped element (or elements) is connected (0 if ground node) |
| | RA | 11-20 | E10.0 | Value of resistance of lumped element in ohms connected from node I to node J (zero if no resistor) |
| | CA | 21-30 | E10.0 | Value of capacitance of lumped element in farads connected from node I to node J (zero if no capacitor) |

5 Blank card indicating the end of set of No. 4 cards

Note: There will be ND sets of the following cards Nos. 6-12:

| | | | | |
|---|---|---|---|---|
| 6 | NOPT | 1-3 | I3 | Indicator for type of data describing Ith distributed network (1-linear taper, 2-exponential taper; 3-values of all sections read in; 4-polynomial taper) |
| | NSECT(I) | 4-6 | I3 | Number of sections to be used in Ith distributed network (set to zero if data is same as for (I-1)th distributed network) |
| | N1(I) | 7-9 | I3 | Number of node to which one end of resistive layer of Ith distributed network is connected (use NN+1 if this is the ground node) |
| | N2(I) | 10-12 | I3 | Number of node to which other end of resistive layer of Ith distributed network is connected (use NN+1 if this is the ground node) |
| | N3(I) | 13-15 | I3 | Number of node to which capacitive layer of Ith distributed network is connected (use NN+1 if this is the ground node) |

If NOPT=1, the following card is required:

| | | | | |
|---|---|---|---|---|
| 7 | RT | 1-10 | E10.0 | Total value of resistance of Ith distributed line |
| | CT | 11-20 | E10.0 | Total value of capacitance of Ith distributed line |

If NOPT=2, the following card is required:

| | | | | |
|---|---|---|---|---|
| 8 | ALF | 1-10 | E10.0 | Value of the constant alpha used in exponential taper for Ith distributed line |
| | RA | 11-20 | E10.0 | Resistance per unit length at N1(I) end of exponentially tapered distributed line |

| | | | | |
|---|---|---|---|---|
| | RB | 21-30 | E10.0 | Resistance per unit length at N2(I) end of exponentially Ith tapered distributed line (RB>RA) |
| | CA | 31-40 | E10.0 | Capacitance per unit length at N1(I) end of exponentially tapered Ith distributed line |
| | CB | 41-50 | E10.0 | Capacitance per unit length at N2(I) end of exponentially tapered Ith distributed line (CB<CA) |

Note: If ALF≠0, sectional R and C will be calculated using ALF, RA and CA; if ALF=0, but RB≠0, sectional R and C will be calculated using RA, RB and CA; if ALF=0 and RB=0, sectional R and C will be calculated using RA, CA, and CB.

If NOPT=3, the following cards are required:

| | | | | |
|---|---|---|---|---|
| 9 | RD(I,J) | 1-80 | 8E10.0 | Values of resistance of various sections of Ith distributed line (J=1, NSECT(I)) |
| 10 | CD(I,J) | 1-80 | 8E10.0 | Values of capacitance of various sections of Ith distributed line (J=1, NSECT(I)) |

If NOPT=4, the following cards are required:

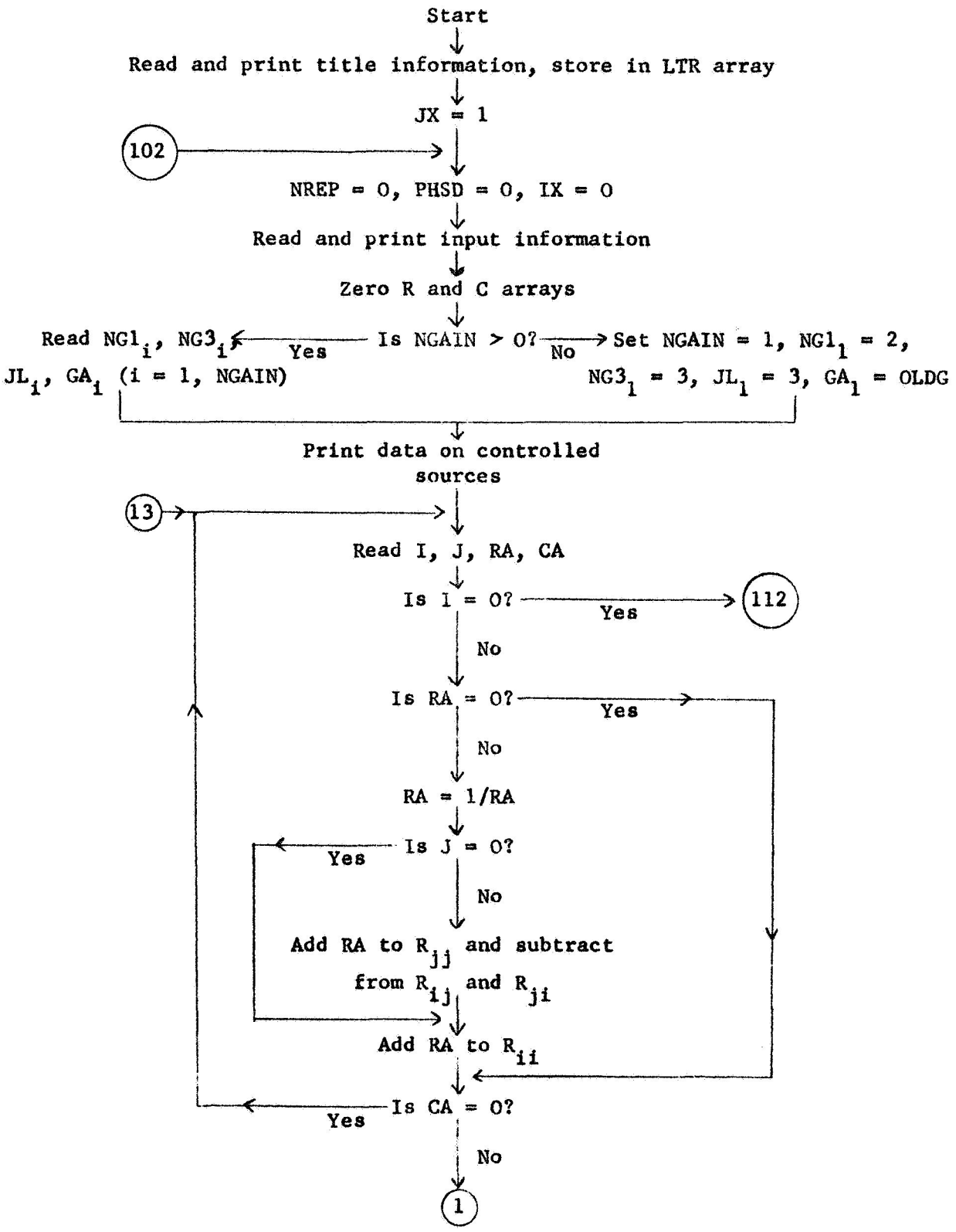
| | | | | |
|---|---|---|---|---|
| 11 | NP | 1-3 | I3 | Degree of polynomial used in approximating taper of Ith distributed line (zero degree coefficient is assumed set to unity) |
| | RI | 11-20 | E10.0 | Multiplier for polynomial expression for r(x), i.e., initial resistance per unit length for Ith distributed line |
| | CI | 21-30 | E10.0 | Multiplier for polynomial expression for c(x), i.e., initial capacitance per unit length for Ith distributed line |
| | XT | 31-40 | E10.0 | Total length of Ith distributed line, i.e., highest value of x |
| 12 | P(I) | 1-80 | 8E10.0 | Values of coefficients of polynomial expression $1 + p_1x + p_2x^2 +$ ... for Ith distributed line (I=1,NP) |

After the ND sets of cards specified above the following card is read:

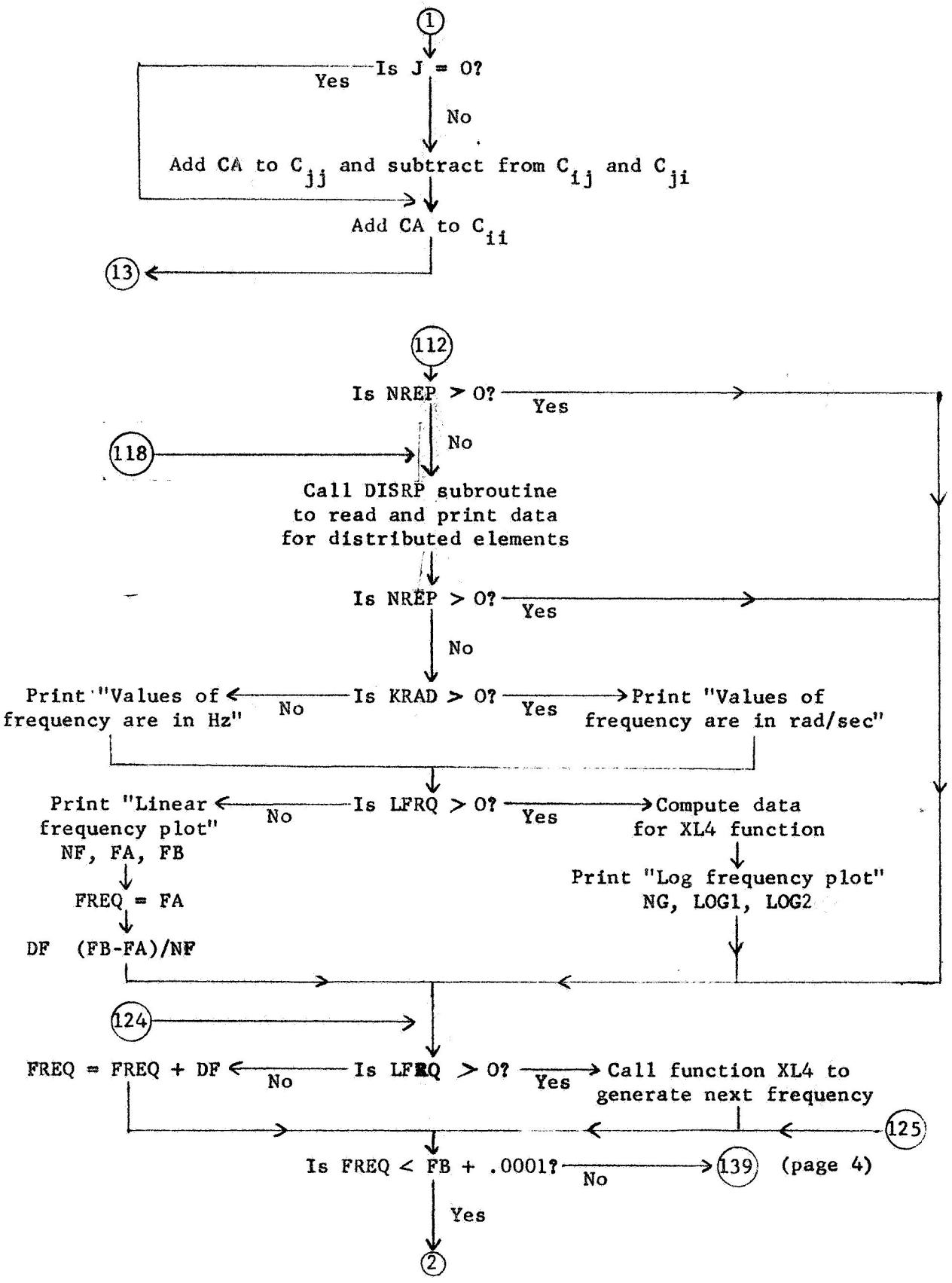
| | | | | |
|---|---|---|---|---|
| 13 | NREP | 1-3 | I3 | Repetition indicator card |

Note: If Card 13 is omitted, the program will plot the data after calculating the values for the first problem. No other data cards must be used in this case. The following other options are available: If NREP=1, the program will read new values of GA(I) (I=1,NGAIN), and repeat the frequency determination. (In this case a single data card is used to read GA(I) in format 8E10.0); if NREP=2, the program will re-read a set of ND groups of card Nos. 6-12 specifying the data for the distributed networks; if NREP=3, the program will read any data cards of type No. 4, until a blank card (No. 5) is encountered (such input will superpose itself upon the input for the lumped elements read on the first cycle of the program); if NREP=4, or if a blank card (NREP=0) is used, the entire read cycle will be repeated starting with card No. 2.

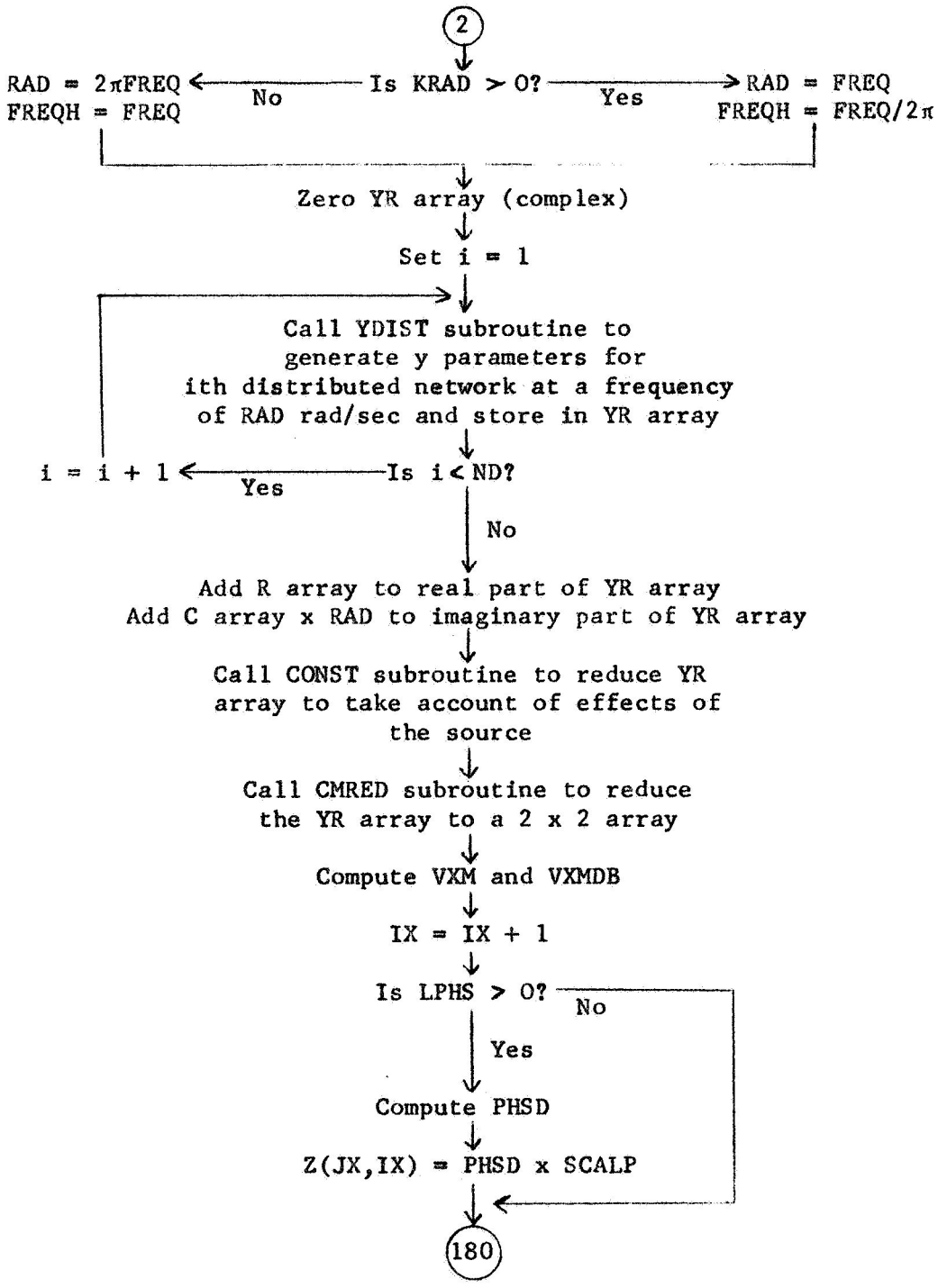
Flow Chart for DLANET Program



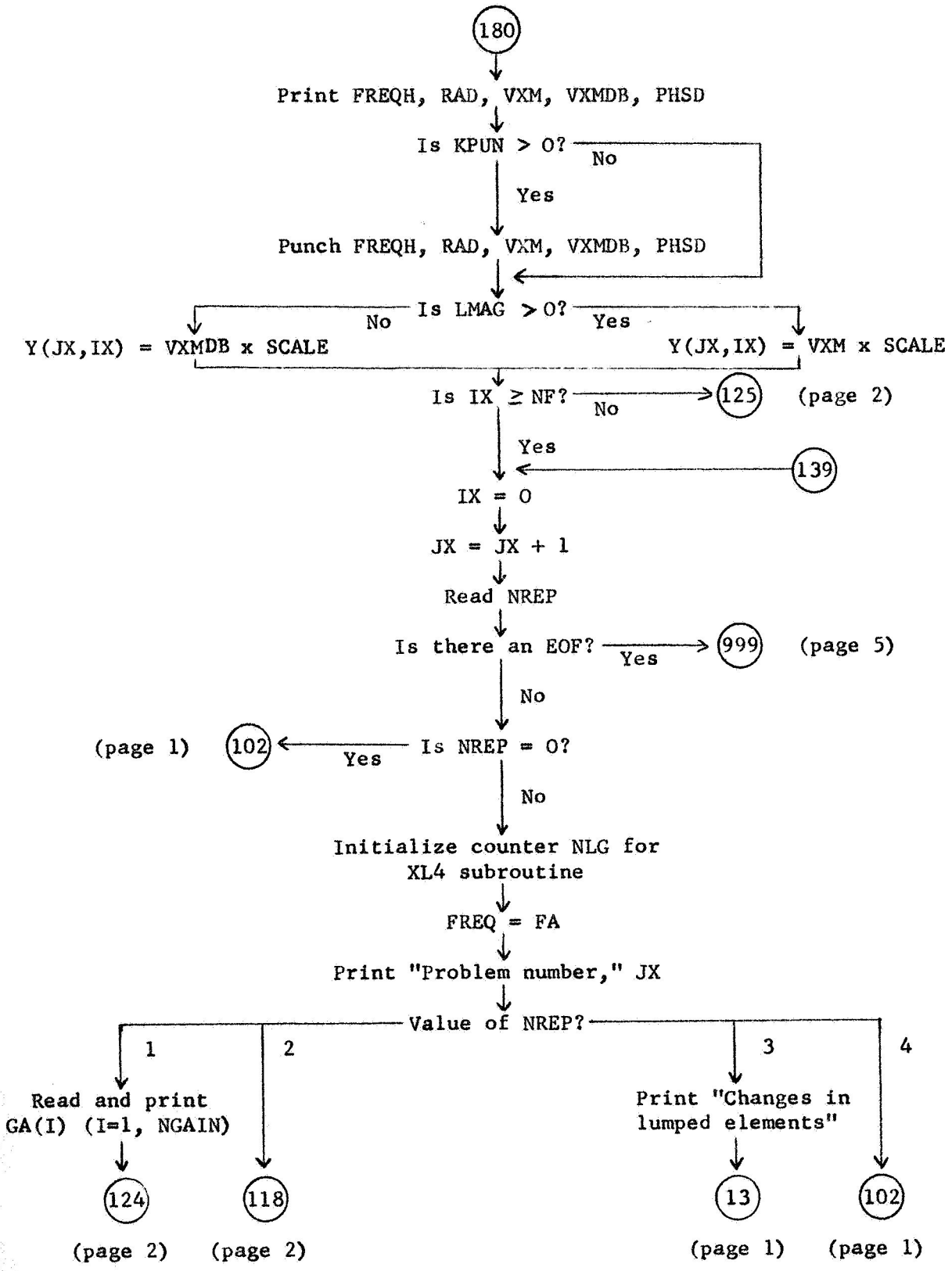
Flow Chart for DLANET Program (page 2)



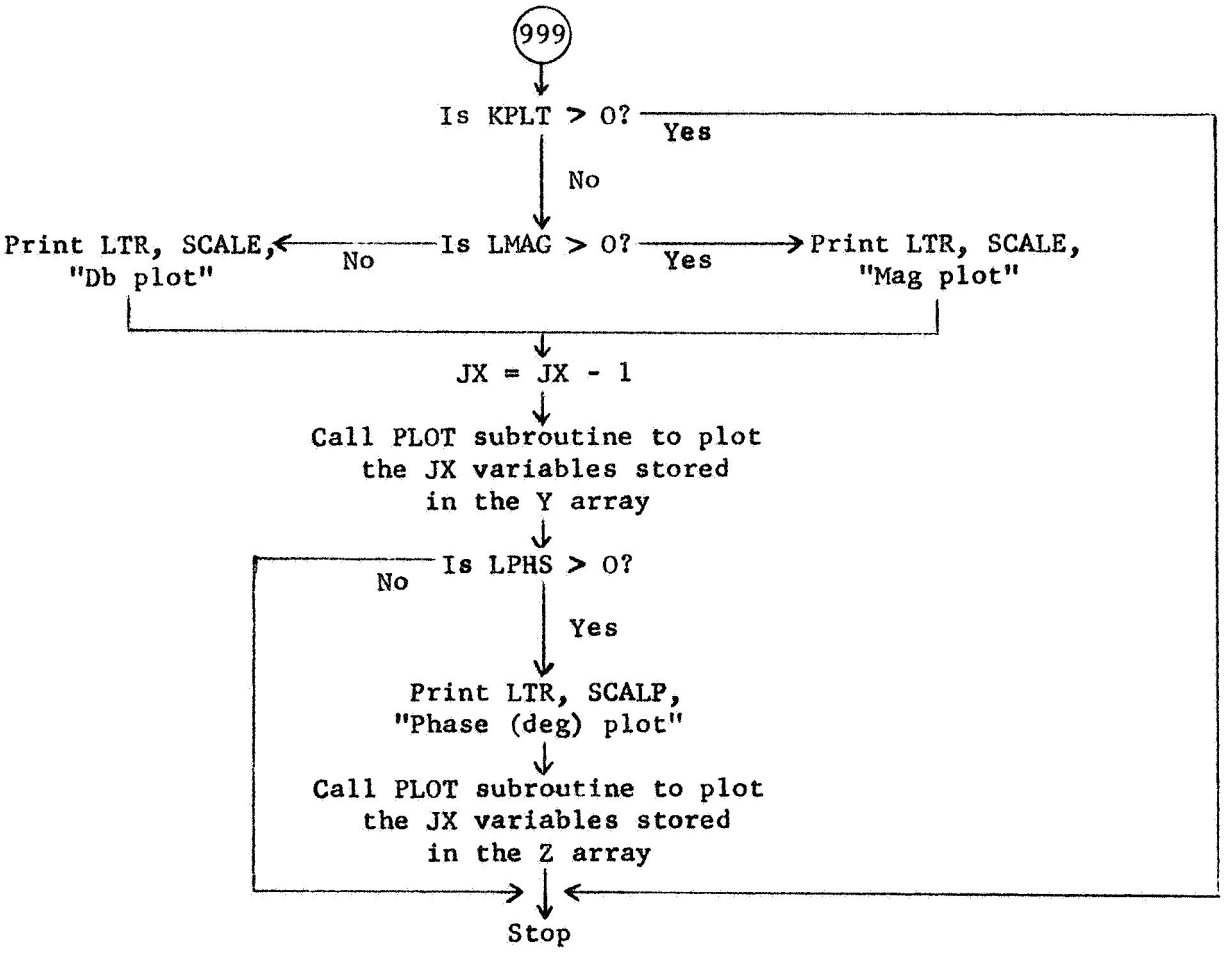
Flow Chart for DLANET Program (page 3)



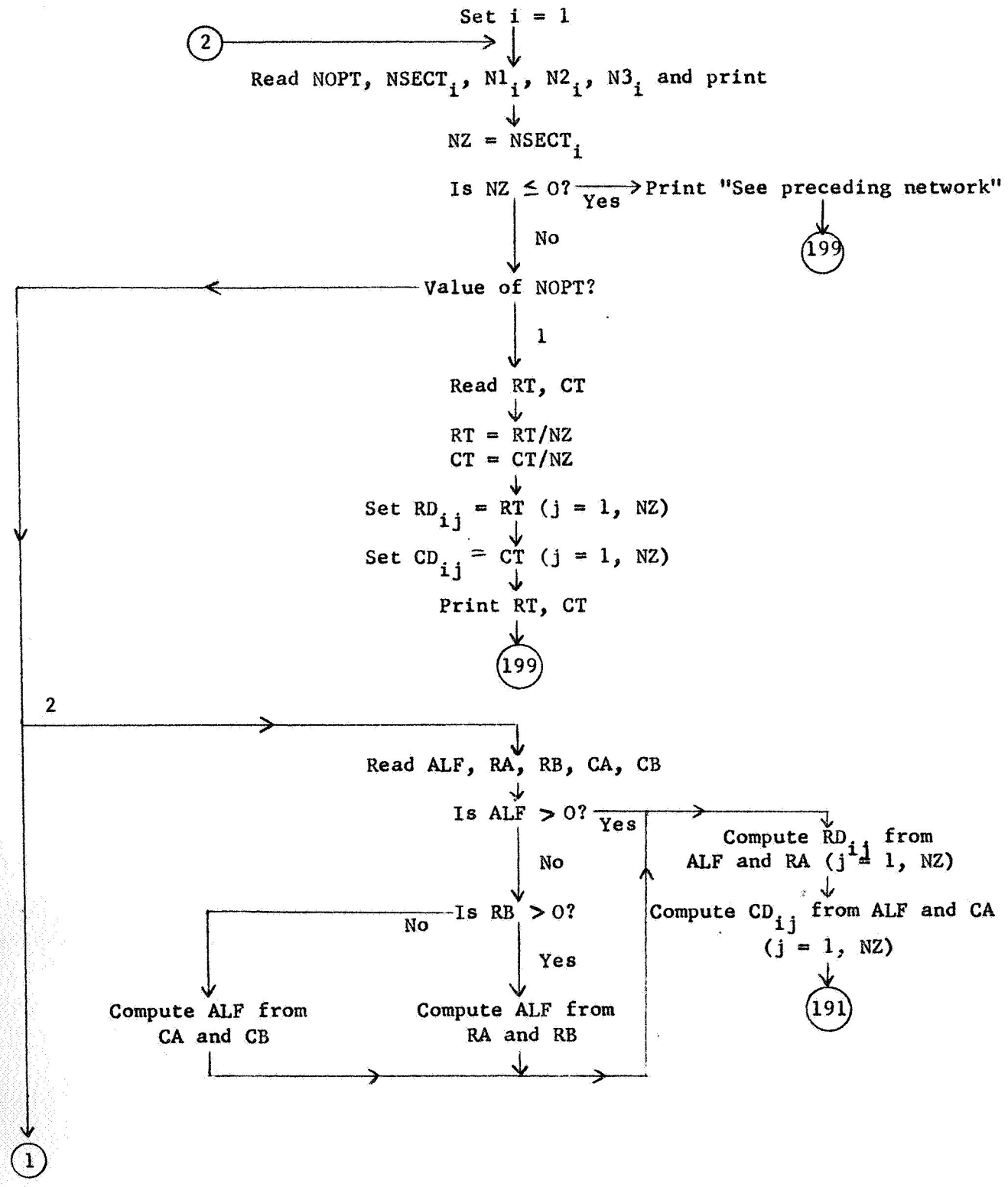
Flow Chart for DLANET Program (page 4)



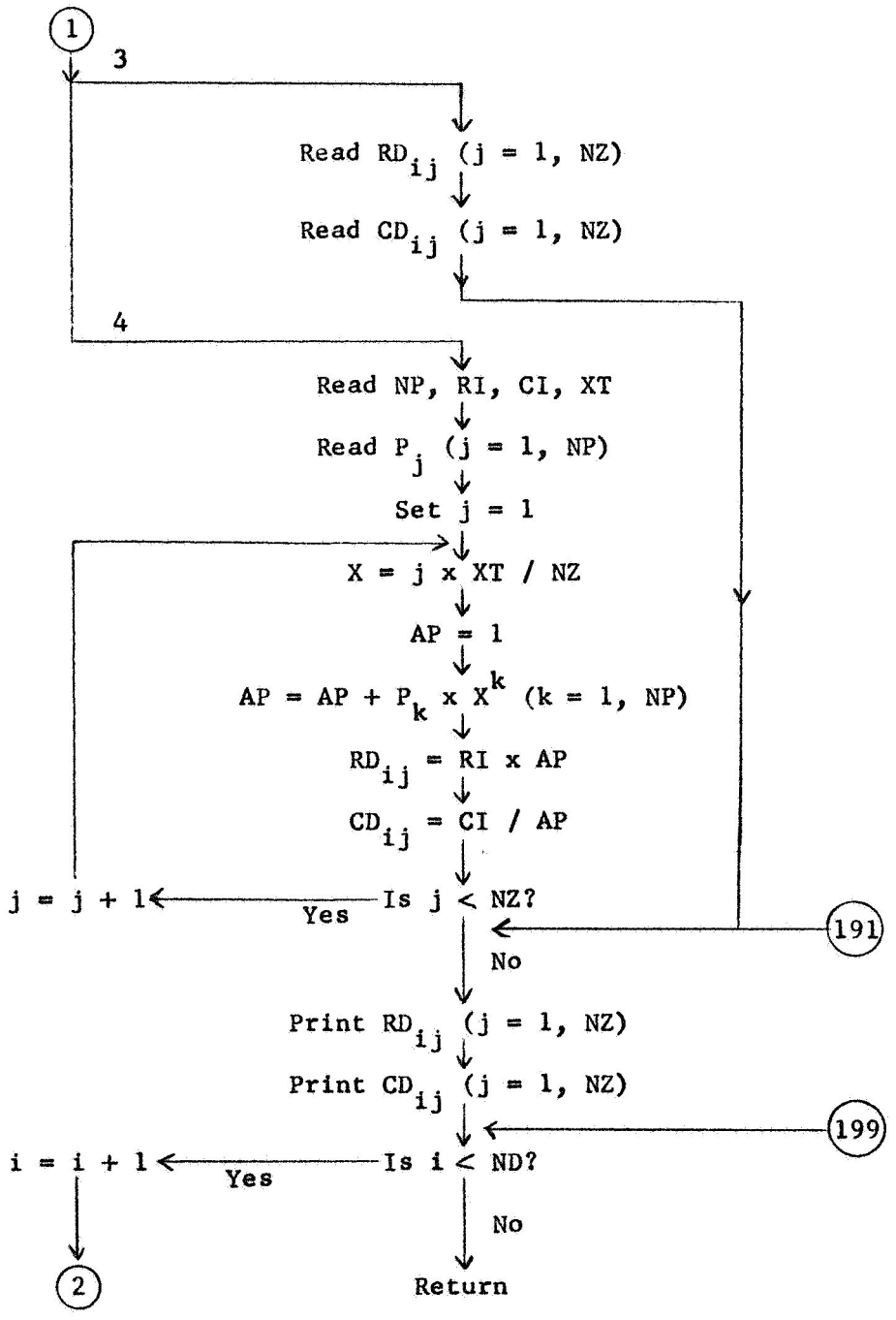
Flow Chart for DLANET Program (page 5)



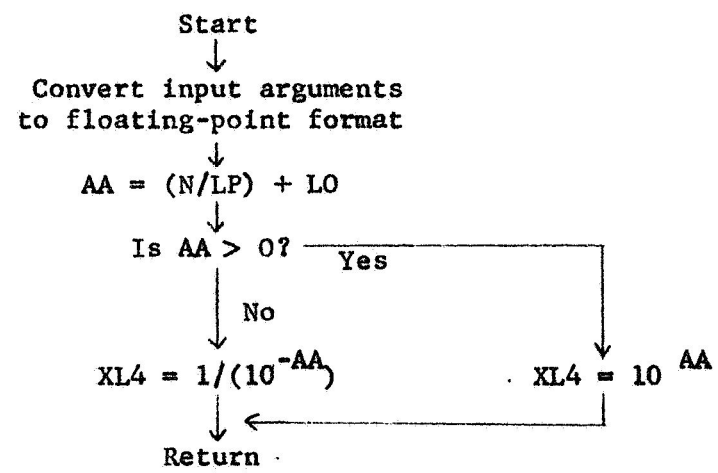
Flow Chart for DISRP subroutine



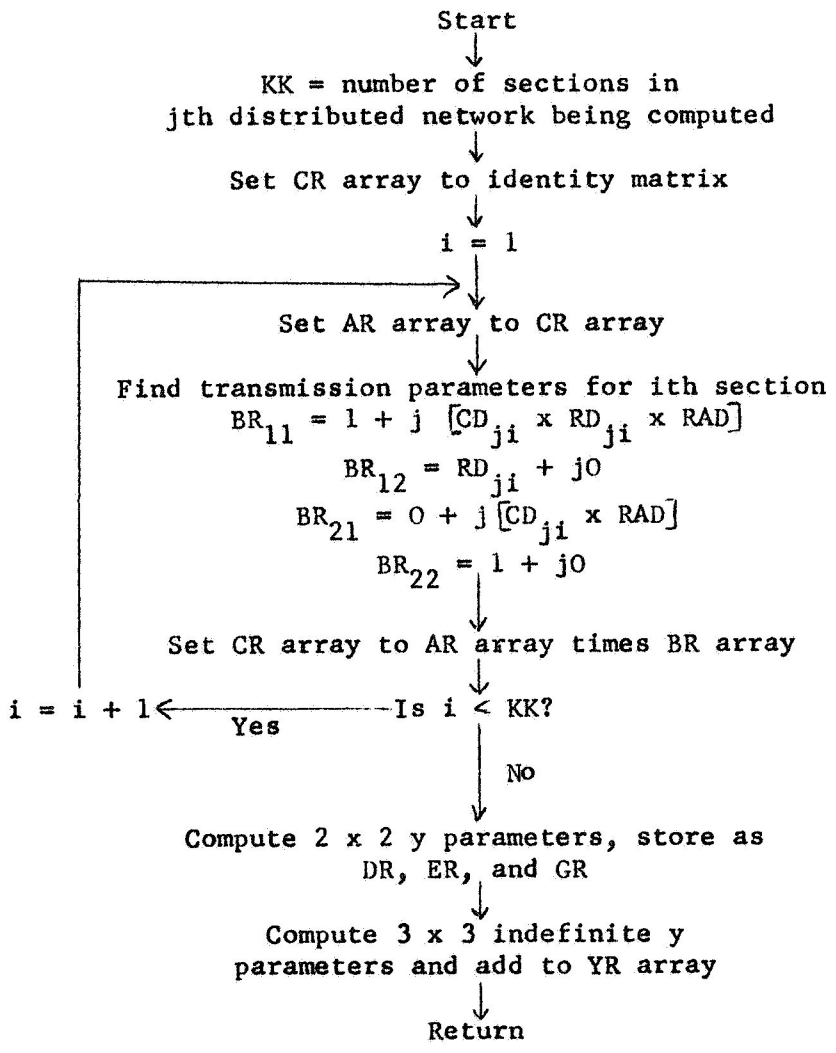
Flow Chart for DISRP subroutine (page 2)



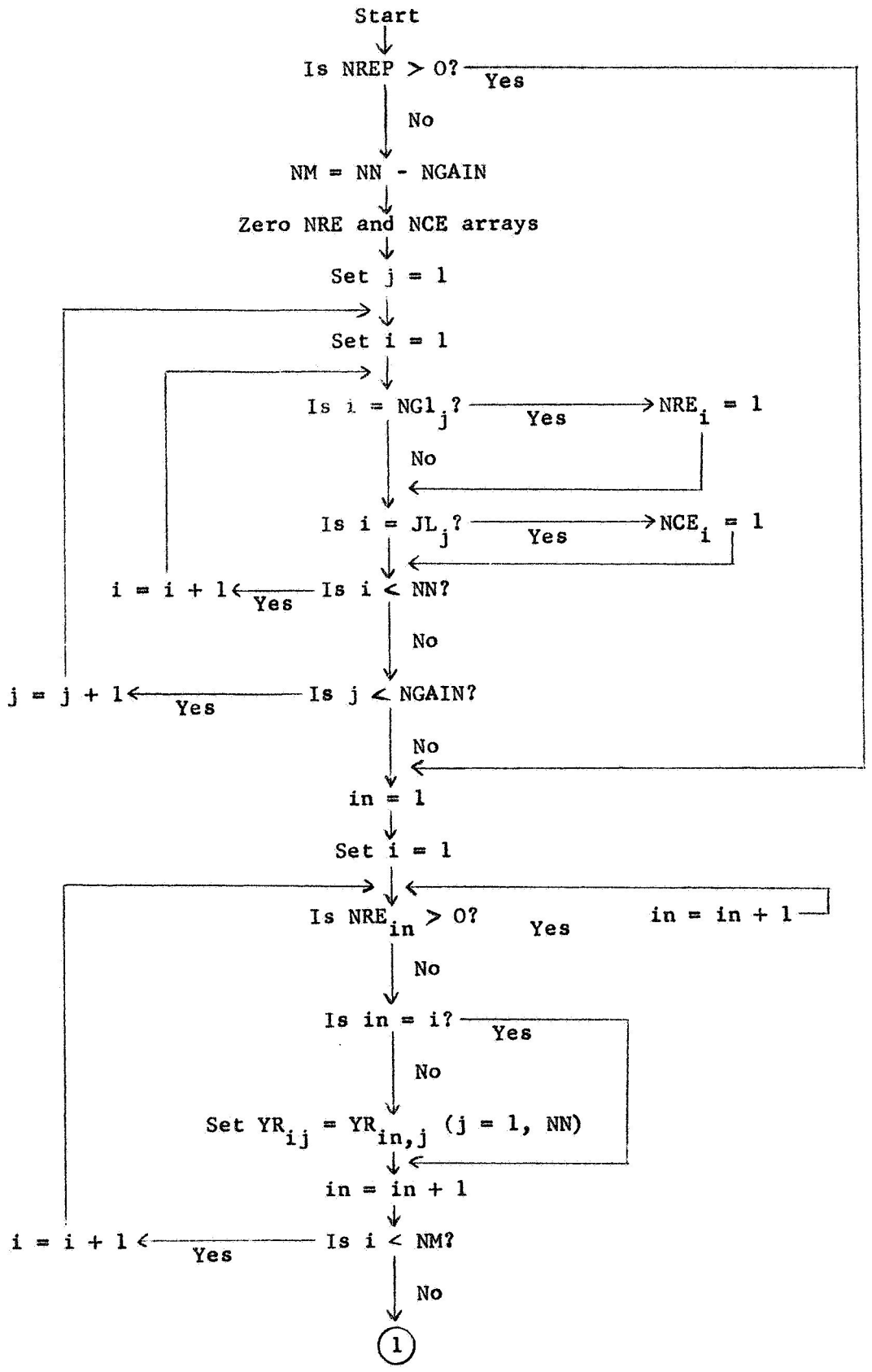
Flow Chart for XL4 Function



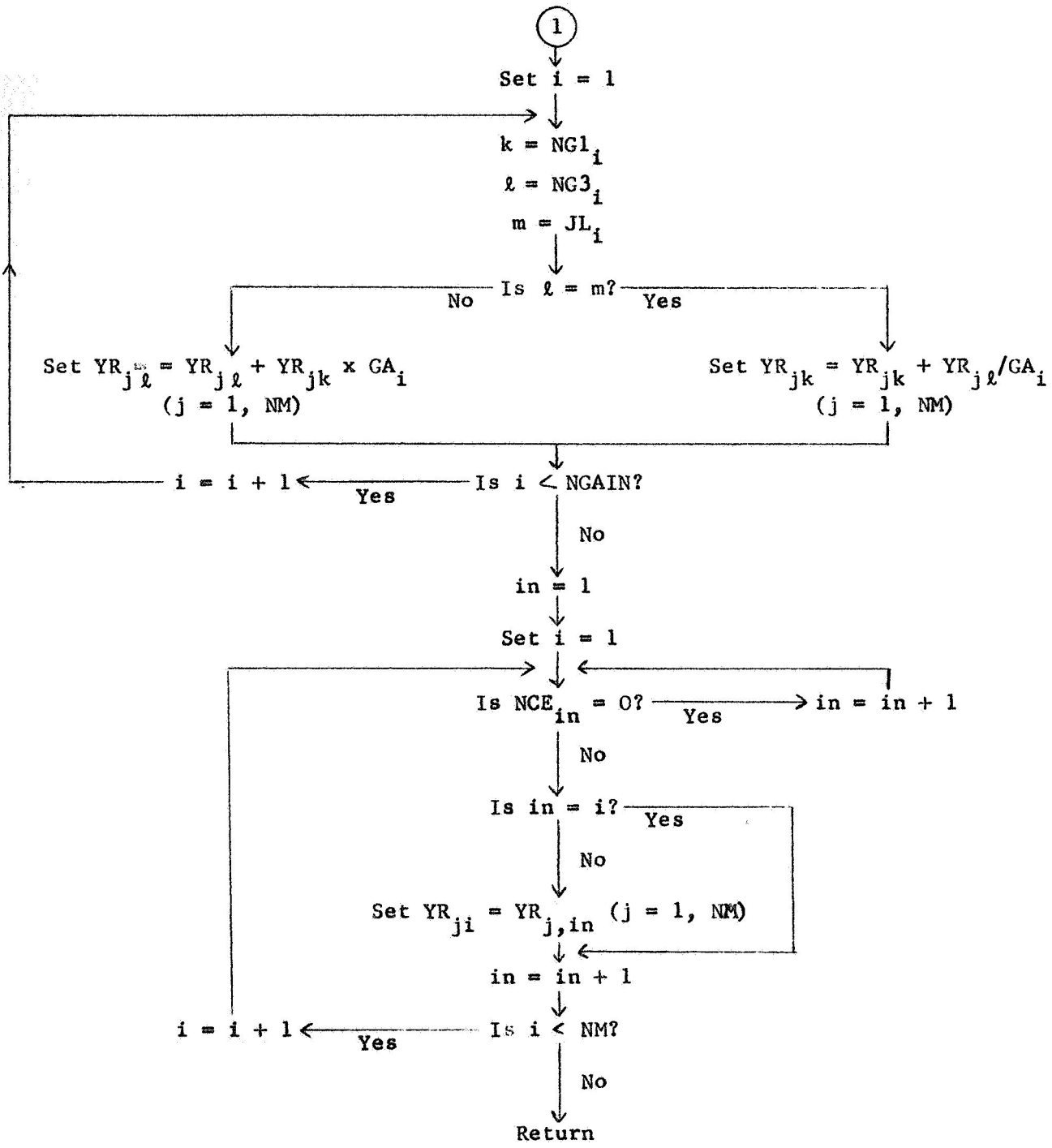
Flow Chart for YDIST subroutine



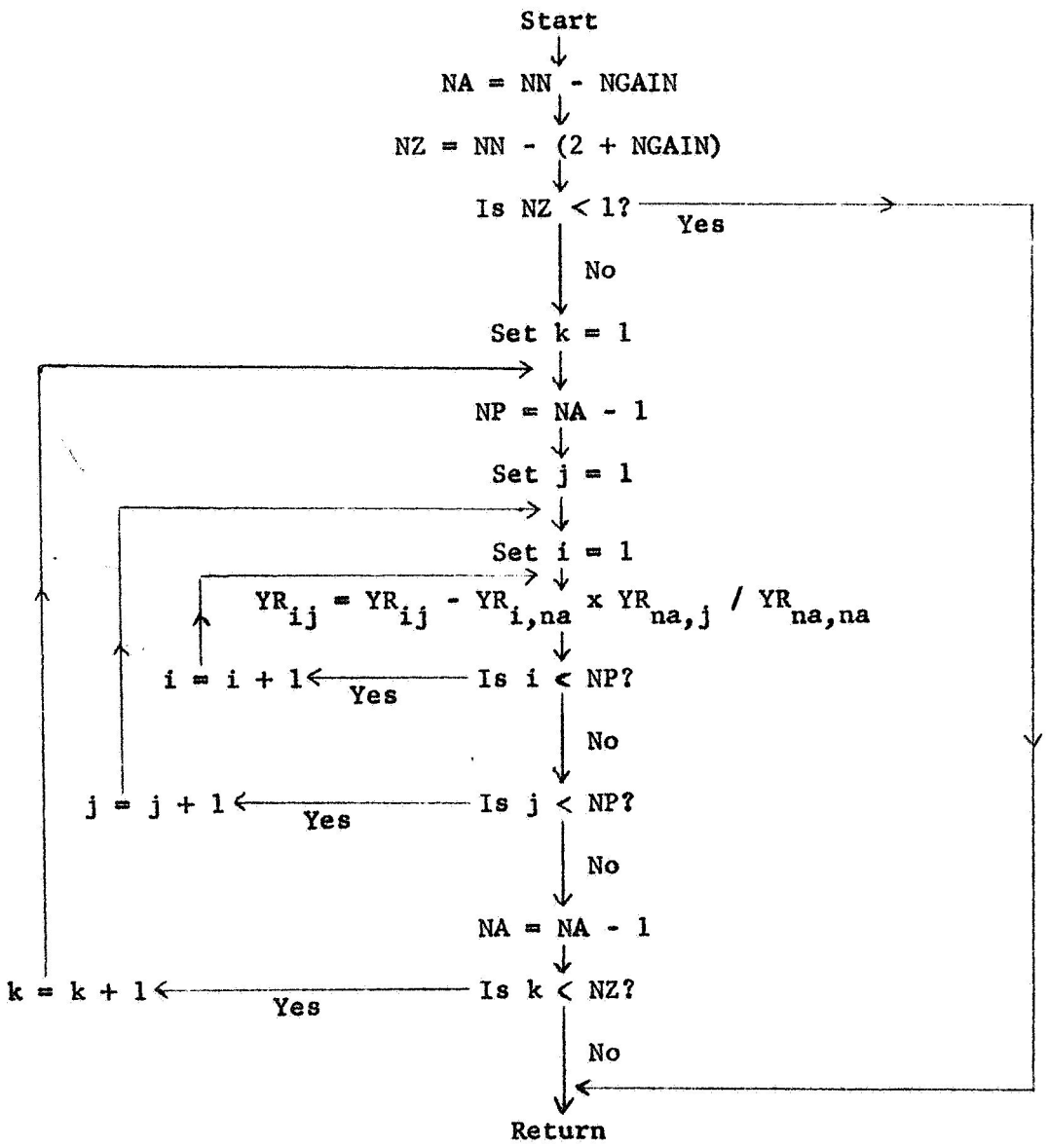
Flow Chart for CONST subroutine



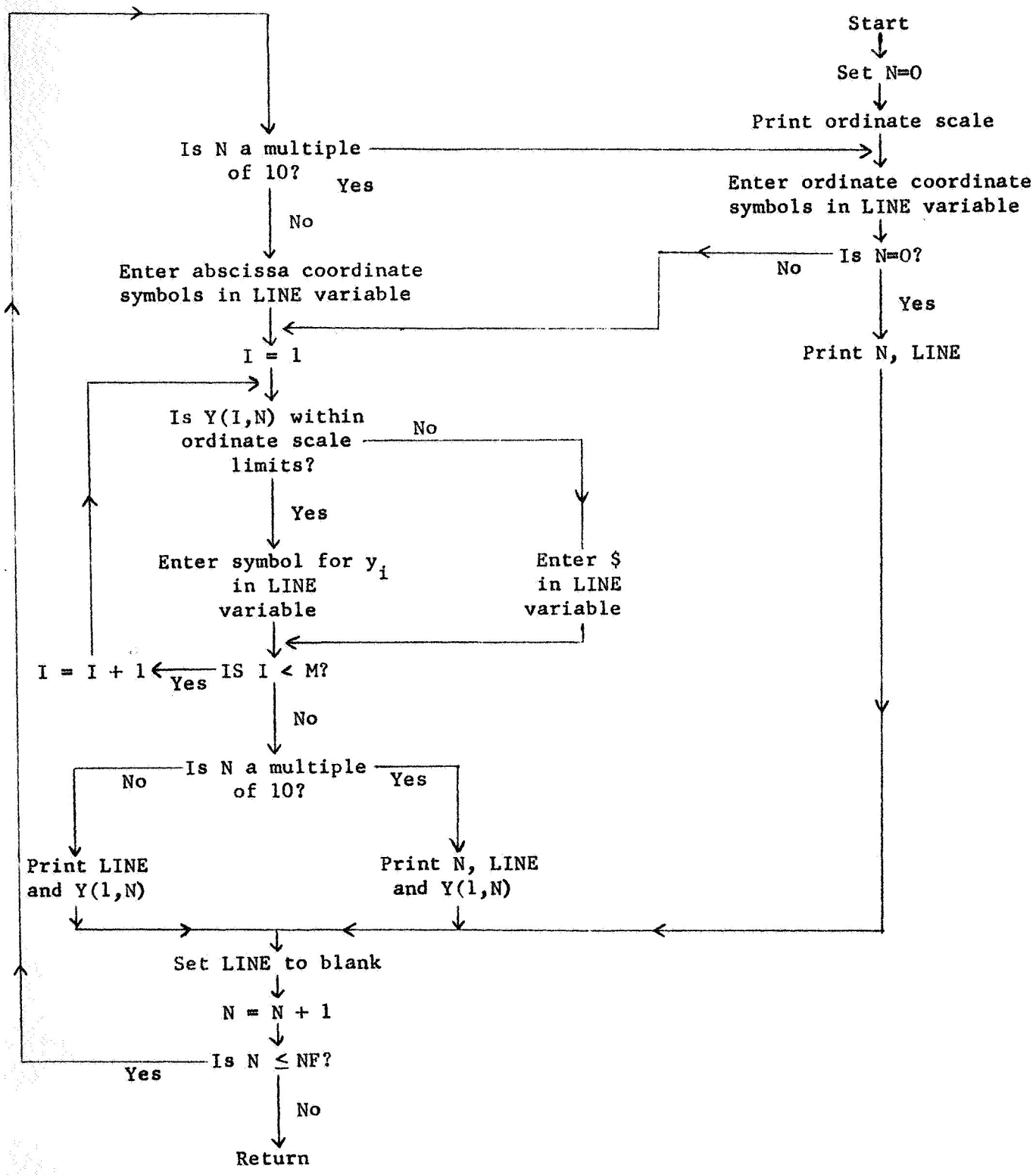
Flow Chart for CONST subroutine (page 2)



Flow Chart for CMRED Subroutine



Flow Chart for PLOT subroutine



```
      FUNCTION XL4(N,LO,LP)                                             HUELSMAN
      AN=N                                                              HUELSMAN
      ALO=LO                                                            HUELSMAN
      ALP=LP                                                            HUELSMAN
      AA=AN/ALP+ALO                                                     HUELSMAN
      IF (AA) 100,100,105                                               HUELSMAN
  100 XL4=1./10.**(-AA)                                                 HUELSMAN
      GO TO 110                                                         HUELSMAN
  105 XL4=10.**AA                                                       HUELSMAN
  110 N=N+1                                                             HUELSMAN
      RETURN                                                            HUELSMAN
      END                                                               HUELSMAN
      SUBROUTINE PLOT (Y,M,NF,NS)                                       HUELSMAN
C     SUBROUTINE FOR PLOTTING 5 X 100 INPUT ARRAY (FORTRAN 4)           HUELSMAN
      DIMENSION Y(5,100), LINE(101),L(11),JL(5)                         HUELSMAN
      DATA (JL(I),I=1,5)/1HA,1HB,1HC,1HD,1HE/,JN,JP,JI,JBLANK,JZ/       HUELSMAN
     11H-,1H+,1HI,1H ,1H$/                                              HUELSMAN
      DO 99 I=1,101                                                     HUELSMAN
      LINE(I)=JBLANK                                                    HUELSMAN
   99 CONTINUE                                                          HUELSMAN
      N=0                                                               HUELSMAN
C     PRINT ORDINATE SCALE                                              HUELSMAN
      DO 101 I=1,11                                                     HUELSMAN
      L(I)=10*I-110+NS                                                  HUELSMAN
  101 CONTINUE                                                          HUELSMAN
      PRINT 105,(L(I),I=1,11)                                           HUELSMAN
  105 FORMAT (3X,11(I4,6X),6HY(1,I))                                    HUELSMAN
      GO TO 115                                                         HUELSMAN
  110 IF (N/10-(N-1)/10) 125,125,115                                    HUELSMAN
C     CONSTRUCT ORDINATE GRAPH LINE                                     HUELSMAN
  115 ND=0                                                              HUELSMAN
      DO 120 I=1,10                                                     HUELSMAN
      ND=ND+1                                                           HUELSMAN
      LINE(ND)=JP                                                       HUELSMAN
      DO 120 J=1,9                                                      HUELSMAN
      ND=ND+1                                                           HUELSMAN
  120 LINE(ND)=JN                                                       HUELSMAN
      LINE(101)=JP                                                      HUELSMAN
      IF (N) 135,121,135                                                HUELSMAN
  121 PRINT 170,N,LINE                                                  HUELSMAN
      GO TO 185                                                         HUELSMAN
C     CONSTRUCT 1 LINE OF ABSCISSA GRAPH LINES                          HUELSMAN
  125 DO 130 I=1,101,10                                                 HUELSMAN
      LINE(I)=JI                                                        HUELSMAN
  130 CONTINUE                                                          HUELSMAN
C     CHANGE NUMERICAL DATA TO LETTERS                                  HUELSMAN
  135 DO 160 I=1,M                                                      HUELSMAN
      XNS=NS                                                            HUELSMAN
      JA=Y(I,N)+101.49999-XNS                                           HUELSMAN
      IF (JA-101) 140,155,145                                           HUELSMAN
  140 IF (JA) 150,150,155                                               HUELSMAN
  145 LINE(101)=JZ                                                      HUELSMAN
      GO TO 160                                                         HUELSMAN
  150 LINE(1)=JZ                                                        HUELSMAN
      GO TO 160                                                         HUELSMAN
  155 LINE(JA)=JL(I)                                                    HUELSMAN
  160 CONTINUE                                                          HUELSMAN
C     PRINT LINE OF DATA                                                HUELSMAN
      IF (N/10-(N-1)/10) 175,175,165                                    HUELSMAN
  165 PRINT 170,N,LINE,Y(1,N)                                           HUELSMAN
```

```
  170 FORMAT (1X,I4,101A1,1X,  E12.5)                                   HUELSMAN
      GO TO 185                                                         HUELSMAN
  175 PRINT 180,LINE,Y(1,N)                                             HUELSMAN
  180 FORMAT (5X,101A1,1X,E12.5)                                        HUELSMAN
C     SET LINE VARIABLES TO ZERO                                        HUELSMAN
  185 DO 190 I=1,101                                                    HUELSMAN
      LINE(I)=JBLANK                                                    HUELSMAN
  190 CONTINUE                                                          HUELSMAN
  195 N=N+1                                                             HUELSMAN
      IF (N-NF) 110,110,200                                             HUELSMAN
  200 RETURN                                                            HUELSMAN
      END                                                               HUELSMAN
      SUBROUTINE CMRED                                                  HUELSMAN
      COMMON YR(15,15),R(15,15),C(15,15),RD(5,50),CD(5,50),             HUELSMAN
     1NSECT(5),N1(5),N2(5),N3(5),NN,ND,RAD,KD,NREP                      HUELSMAN
     2,NGAIN,NG1(5),NG2(5),NG3(5),NG4(5),JL(5),GA(5)                    HUELSMAN
      COMPLEX YR                                                        HUELSMAN
      NA=NN-NGAIN                                                       HUELSMAN
      NZ=NN-(2+NGAIN)                                                   HUELSMAN
      IF (NZ.LT.1) RETURN                                               HUELSMAN
      DO 110 K=1,NZ                                                     HUELSMAN
      NP=NA-1                                                           HUELSMAN
      DO 105 J=1,NP                                                     HUELSMAN
      DO 105 I=1,NP                                                     HUELSMAN
      YR(I,J)=YR(I,J)-YR(I,NA)*YR(NA,J)/YR(NA,NA)                       HUELSMAN
  105 CONTINUE                                                          HUELSMAN
  110 NA=NA-1                                                           HUELSMAN
      RETURN                                                            HUELSMAN
      END                                                               HUELSMAN
      SUBROUTINE YDIST                                                  HUELSMAN
      COMMON YR(15,15),R(15,15),C(15,15),RD(5,50),CD(5,50),             HUELSMAN
     1NSECT(5),N1(5),N2(5),N3(5),NN,ND,RAD,KD,NREP                      HUELSMAN
     2,NGAIN,NG1(5),NG2(5),NG3(5),NG4(5),JL(5),GA(5)                    HUELSMAN
      COMPLEX YR                                                        HUELSMAN
      COMPLEX AR(2,2),BR(2,2),CR(2,2),DR,ER,GR                          HUELSMAN
      KK=NSECT(KD)                                                      HUELSMAN
      IF (KK) 121,121,109                                               HUELSMAN
  109 DO 112 I=1,2                                                      HUELSMAN
      DO 110 J=1,2                                                      HUELSMAN
  110 CR(I,J)=(0.,0.)                                                   HUELSMAN
  112 CR(I,I)=(1.,0.)                                                   HUELSMAN
      DO 120 I=1,KK                                                     HUELSMAN
      DO 115 IA=1,2                                                     HUELSMAN
      DO 115 IB=1,2                                                     HUELSMAN
      AR(IA,IB)=CR(IA,IB)                                               HUELSMAN
  115 CONTINUE                                                          HUELSMAN
      BR(1,1)=CMPLX(1.,CD(KD,I)*RD(KD,I)*RAD)                           HUELSMAN
      BR(1,2)=CMPLX (RD(KD,I),0.)                                       HUELSMAN
      BR(2,1)=CMPLX (0.,CD(KD,I)*RAD)                                   HUELSMAN
      BR(2,2)=(1.,0.)                                                   HUELSMAN
      CR(1,1)=AR(1,1)*BR(1,1)+AR(1,2)*BR(2,1)                           HUELSMAN
      CR(1,2)=AR(1,1)*BR(1,2)+AR(1,2)*BR(2,2)                           HUELSMAN
      CR(2,1)=AR(2,1)*BR(1,1)+AR(2,2)*BR(2,1)                           HUELSMAN
      CR(2,2)=AR(2,1)*BR(1,2)+AR(2,2)*BR(2,2)                           HUELSMAN
  120 CONTINUE                                                          HUELSMAN
      DR=(1.,0.)/CR(1,2)                                                HUELSMAN
      ER=DR*CR(2,2)                                                     HUELSMAN
      GR=DR*CR(1,1)                                                     HUELSMAN
  121 L=N1(KD)                                                          HUELSMAN
      M=N2(KD)                                                          HUELSMAN
```

```
      N=N3(KD)                                                          HUELSMAN
      YR(L,L)=ER+YR(L,L)                                                HUELSMAN
      YR(M,M)=GR+YR(M,M)                                                HUELSMAN
      YR(L,M)=-DR+YR(L,M)                                               HUELSMAN
      YR(M,L)=YR(L,M)                                                   HUELSMAN
      YR(N,L)=DR-ER+YR(N,L)                                             HUELSMAN
      YR(L,N)=YR(N,L)                                                   HUELSMAN
      YR(N,M)=DR-GR+YR(N,M)                                             HUELSMAN
      YR(M,N)=YR(N,M)                                                   HUELSMAN
      YR(N,N)=ER+GR-(2.,0.)*DR+YR(N,N)                                  HUELSMAN
      RETURN                                                            HUELSMAN
      END                                                               HUELSMAN
      SUBROUTINE CONST                                                  HUELSMAN
C     LPH SUBROUTINE 235 REPLACES PERRY 233, JULY 1968                  HUELSMAN
      COMMON YR(15,15),R(15,15),C(15,15),RD(5,50),CD(5,50),             HUELSMAN
     1NSECT(5),N1(5),N2(5),N3(5),NN,ND,RAD,KD,NREP                      HUELSMAN
     2,NGAIN,NG1(5),NG2(5),NG3(5),NG4(5),JL(5),GA(5)                    HUELSMAN
      COMPLEX YR                                                        HUELSMAN
      DIMENSION NRE(15),NCE(15)                                         HUELSMAN
      IF (NREP.GT.0) GO TO 121                                          HUELSMAN
      NM=NN-NGAIN                                                       HUELSMAN
      DO 110 I=1,NN                                                     HUELSMAN
      NRE(I)=0                                                          HUELSMAN
  110 NCE(I)=0                                                          HUELSMAN
      DO 120 J=1,NGAIN                                                  HUELSMAN
      DO 120 I=1,NN                                                     HUELSMAN
      IF (I.EQ.NG1(J)) NRE(I)=1                                         HUELSMAN
      IF (I.EQ.JL(J)) NCE(I)=1                                          HUELSMAN
  120 CONTINUE                                                          HUELSMAN
  121 IN=1                                                              HUELSMAN
      DO 145 I=1,NM                                                     HUELSMAN
  123 IF (NRE(IN)) 130,130,125                                          HUELSMAN
  125 IN=IN+1                                                           HUELSMAN
      GO TO 123                                                         HUELSMAN
  130 IF (IN.EQ.I) GO TO 140                                            HUELSMAN
  132 DO 135 J=1,NN                                                     HUELSMAN
  135 YR(I,J)=YR(IN,J)                                                  HUELSMAN
  140 IN=IN+1                                                           HUELSMAN
  145 CONTINUE                                                          HUELSMAN
      DO 165 I=1,NGAIN                                                  HUELSMAN
      K=NG1(I)                                                          HUELSMAN
      L=NG3(I)                                                          HUELSMAN
      M=JL(I)                                                           HUELSMAN
      IF (L.EQ.M) GO TO 155                                             HUELSMAN
      DO 150 J=1,NM                                                     HUELSMAN
  150 YR(J,L)=YR(J,L)+YR(J,K)*GA(I)                                     HUELSMAN
      GO TO 165                                                         HUELSMAN
  155 DO 160 J=1,NM                                                     HUELSMAN
  160 YR(J,K)=YR(J,K)+YR(J,L)/GA(I)                                     HUELSMAN
  165 CONTINUE                                                          HUELSMAN
      IN=1                                                              HUELSMAN
      DO 190 I=1,NM                                                     HUELSMAN
  172 IF (NCE(IN)) 175,175,170                                          HUELSMAN
  170 IN=IN+1                                                           HUELSMAN
      GO TO 172                                                         HUELSMAN
  175 IF (IN.EQ.I) GO TO 185                                            HUELSMAN
      DO 180 J=1,NM                                                     HUELSMAN
  180 YR(J,I)=YR(J,IN)                                                  HUELSMAN
  185 IN=IN+1                                                           HUELSMAN
  190 CONTINUE                                                          HUELSMAN
```

```
      RETURN                                                            HUELSMAN
      END                                                               HUELSMAN
      SUBROUTINE DISRP                                                  HUELSMAN
      COMMON YR(15,15),R(15,15),C(15,15),RD(5,50),CD(5,50),             HUELSMAN
     1NSECT(5),N1(5),N2(5),N3(5),NN,ND,RAD,KD,NREP                      HUELSMAN
     2,NGAIN,NG1(5),NG2(5),NG3(5),NG4(5),JL(5),GA(5)                    HUELSMAN
      COMPLEX YR                                                        HUELSMAN
      DIMENSION P(10)                                                   HUELSMAN
      DO 199 I=1,ND                                                     HUELSMAN
      READ 150,NOPT,NSECT(I),N1(I),N2(I),N3(I)                          HUELSMAN
  150 FORMAT (5I3)                                                      HUELSMAN
      PRINT 155,I,NSECT(I),N1(I),N2(I),N3(I)                            HUELSMAN
  155 FORMAT (1H0,19HDISTRIBUTED NETWORK,I2,5X,I3,9H SECTIONS,5X,       HUELSMAN
     1  18HCONNECTED TO NODES,3I3)                                      HUELSMAN
      NZ=NSECT(I)                                                       HUELSMAN
      IF (NZ) 156,156,159                                               HUELSMAN
  156 PRINT 157                                                         HUELSMAN
  157 FORMAT (1H0,20X,21HSEE PRECEDING NETWORK)                         HUELSMAN
      GO TO 199                                                         HUELSMAN
  159 DIV=NZ                                                            HUELSMAN
      GO TO (160,180,190,200),NOPT                                      HUELSMAN
  160 READ 165,RT,CT                                                    HUELSMAN
  165 FORMAT (8E10.0)                                                   HUELSMAN
      PRINT 170,RT,CT                                                   HUELSMAN
  170 FORMAT(1H0,17HTOTAL RESISTANCE=,  E15.8,5X,18HTOTAL CAPACITANCE=, HUELSMAN
     1  E15.8)                                                          HUELSMAN
      RT=RT/DIV                                                         HUELSMAN
      CT=CT/DIV                                                         HUELSMAN
      DO 175 IA=1,NZ                                                    HUELSMAN
      RD(I,IA)=RT                                                       HUELSMAN
  175 CD(I,IA)=CT                                                       HUELSMAN
      PRINT 176,RT,CT                                                   HUELSMAN
  176 FORMAT(1H0,17HRESISTANCE/SECT.=,  E15.8,5X,                       HUELSMAN
     1  18HCAPACITANCE/SECT.=,E15.8)                                    HUELSMAN
      GO TO 199                                                         HUELSMAN
  180 READ 165,ALF,RA,RB,CA,CB                                          HUELSMAN
      IF (ALF) 182,182,185                                              HUELSMAN
  182 IF (RB) 184,184,183                                               HUELSMAN
  183 ALF=ALOG  (RB)-ALOG  (RA)                                         HUELSMAN
      GO TO 185                                                         HUELSMAN
  184 ALF=ALOG  (CA)-ALOG  (CB)                                         HUELSMAN
  185 DIV=DIV-1.                                                        HUELSMAN
      DO 188 IA=1,NZ                                                    HUELSMAN
      DIA=IA-1                                                          HUELSMAN
      DB=ALF*DIA/DIV                                                    HUELSMAN
      RD(I,IA)=RA*EXP  (DB)                                             HUELSMAN
  188 CD(I,IA)=CA*EXP  (-DB)                                            HUELSMAN
      PRINT 189,ALF                                                     HUELSMAN
  189 FORMAT (1H0,17HEXPONENTIAL TAPER,1X,7HALPHA =,  E17.8)            HUELSMAN
      GO TO 191                                                         HUELSMAN
  190 READ 165,  (RD(I,IA),IA=1,NZ)                                     HUELSMAN
      READ 165,  (CD(I,IA),IA=1,NZ)                                     HUELSMAN
      GO TO 191                                                         HUELSMAN
  200 PRINT 202                                                         HUELSMAN
  202 FORMAT (1H0,42HPOLYNOMIAL TAPER, R(X)=R*POLY, C(X)=C/POLY    )    HUELSMAN
      READ 201,NP,RI,CI,XT                                              HUELSMAN
  201 FORMAT (I3,7X,7E10.0)                                             HUELSMAN
      READ 165,(P(I),I=1,NP)                                            HUELSMAN
      PRINT 205,NP                                                      HUELSMAN
  205 FORMAT(1H0,I2,47H COEFFICIENTS P(I) OF POLY 1+P(1)X+P(2)X**2+...)HUELSMAN
```

```
      PRINT 193, (P(I),I=1,NP)                                          HUELSMAN
      PRINT 210,XT,RI,CI                                                HUELSMAN
  210 FORMAT (1H0,10HLENGTH  X=,  E10.3,5X,10HINITIAL R=,E10.3,         HUELSMAN
     15X,*INITIAL C=*E10.3)                                             HUELSMAN
      DO 220 IA=1,NZ                                                    HUELSMAN
      PIA=IA                                                            HUELSMAN
      X=PIA*XT/DIV                                                      HUELSMAN
      AP=1.                                                             HUELSMAN
      DO 215 IB=1,NP                                                    HUELSMAN
      AP=AP+P(IB)*X**IB                                                 HUELSMAN
  215 CONTINUE                                                          HUELSMAN
      RD(I,IA)=RI*AP                                                    HUELSMAN
  220 CD(I,IA)=CI/AP                                                    HUELSMAN
  191 PRINT 192                                                         HUELSMAN
  192 FORMAT (1H0,18HRESISTANCE/SECTION)                                HUELSMAN
      PRINT 193, (RD(I,IA),IA=1,NZ)                                     HUELSMAN
  193 FORMAT (1X,  7E17.8)                                              HUELSMAN
      PRINT 194                                                         HUELSMAN
  194 FORMAT (1H0,19HCAPACITANCE/SECTION)                               HUELSMAN
      PRINT 193, (CD(I,IA),IA=1,NZ)                                     HUELSMAN
  199 CONTINUE                                                          HUELSMAN
      RETURN                                                            HUELSMAN
      END                                                               HUELSMAN
      PROGRAM MAIN (INPUT,OUTPUT,PUNCH,TAPE4=INPUT)                     HUELSMAN
C    MAIN PROGRAM, DLA NETWORK ANALYSIS,5VCVS VERSION                   HUELSMAN
      COMMON YR(15,15),R(15,15),C(15,15),RD(5,50),CD(5,50),             HUELSMAN
     1NSECT(5),N1(5),N2(5),N3(5),NN,ND,RAD,KD,NREP                      HUELSMAN
     2,NGAIN,NG1(5),NG2(5),NG3(5),NG4(5),JL(5),GA(5)                    HUELSMAN
      COMPLEX YR                                                        HUELSMAN
      DIMENSION Y(5,100),LTR(8),Z(5,100)                                HUELSMAN
      COMPLEX VD                                                        HUELSMAN
      READ 99,LTR                                                       HUELSMAN
   99 FORMAT (8A10)                                                     HUELSMAN
      JX=1                                                              HUELSMAN
   96 PRINT 98,LTR                                                      HUELSMAN
   98 FORMAT (1H1,8A10)                                                 HUELSMAN
  102 NREP=0                                                            HUELSMAN
      PHSD=0.                                                           HUELSMAN
      IX=0                                                              HUELSMAN
      READ 107,NN,ND,NF,NSY,NSP,KRAD,LMAG,LPHS,KPLT,LFRQ,OLDG,FA,FB,    HUELSMAN
     1SCALE,SCALP,KPUN,NGAIN                                            HUELSMAN
  107 FORMAT (5I3,5I1,5E10.0,I1,I3)                                     HUELSMAN
      PRINT 106,JX                                                      HUELSMAN
  106 FORMAT (/1H0,14HPROBLEM NUMBER,I2)                                HUELSMAN
      PRINT 110,NN,ND                                                   HUELSMAN
  110 FORMAT(1H0,I2,6H NODES,5X,I2,24H DISTRIBUTED SUBNETWORKS)         HUELSMAN
      DO 101 I=1,NN                                                     HUELSMAN
      DO 101 J=1,NN                                                     HUELSMAN
      R(I,J)=0.                                                         HUELSMAN
  101 C(I,J)=0.                                                         HUELSMAN
      IF (NGAIN.GT.0) GO TO 95                                          HUELSMAN
      NGAIN=1                                                           HUELSMAN
      NG1(1)=2                                                          HUELSMAN
      NG2(1)=0                                                          HUELSMAN
      NG3(1)=3                                                          HUELSMAN
      NG4(1)=0                                                          HUELSMAN
      JL(1)=3                                                           HUELSMAN
      GA(1)=OLDG                                                        HUELSMAN
      GO TO 92                                                          HUELSMAN
   95 DO 94 I=1,NGAIN                                                   HUELSMAN
```

```
 94 READ 93,NG1(I),NG2(I),NG3(I),NG4(I),JL(I),GA(I)                HUELSMAN
 93 FORMAT (5I3,5X,E10.0)                                          HUELSMAN
 92 PRINT 91,NGAIN                                                 HUELSMAN
 91 FORMAT (1H0,I2,1X,*GAIN ELEMENTS OF VCVS TYPE*)                HUELSMAN
    PRINT 90,(I,NG1(I),NG2(I),NG3(I),NG4(I),JL(I),GA(I),I=1,NGAIN) HUELSMAN
 90 FORMAT (1X*NO.*I2*, SOURCE AT NODES*I3,2H -,I3                 HUELSMAN
   1*, CONTROL VOLTAGE AT NODES*I3,2H -,I3*, SUPRESS NODE*I3       HUELSMAN
   2*, GAIN=*E12.5)                                                HUELSMAN
    PRINT 115                                                      HUELSMAN
115 FORMAT (1H0,15HLUMPED ELEMENTS)                                HUELSMAN
 13 PRINT 116                                                      HUELSMAN
116 FORMAT (5X,5HNODES,8X,7HR(OHMS),8X,9HC(FARADS))                HUELSMAN
113 READ 105,I,J,RA,CA                                             HUELSMAN
105 FORMAT (2I2,6X,2E10.0)                                         HUELSMAN
    IF (I) 112,112,111                                             HUELSMAN
111 PRINT 114,I,J,RA,CA                                            HUELSMAN
114 FORMAT (1X,2I5,  2E15.3)                                       HUELSMAN
    IF (RA) 104,103,104                                            HUELSMAN
104 RA=1./RA                                                       HUELSMAN
    IF (J.EQ.0) GO TO 14                                           HUELSMAN
    R(J,J)=RA+R(J,J)                                               HUELSMAN
    R(I,J)=-RA+R(I,J)                                              HUELSMAN
    R(J,I)=R(I,J)                                                  HUELSMAN
 14 R(I,I)=RA+R(I,I)                                               HUELSMAN
103 IF (CA.EQ.0.) GO TO 113                                        HUELSMAN
    IF (J.EQ.0) GO TO 15                                           HUELSMAN
    C(J,J)=CA+C(J,J)                                               HUELSMAN
    C(I,J)=-CA+C(I,J)                                              HUELSMAN
    C(J,I)=C(I,J)                                                  HUELSMAN
 15 C(I,I)=CA+C(I,I)                                               HUELSMAN
    GO TO 113                                                      HUELSMAN
112 IF (NREP.GT.0) GO TO 124                                       HUELSMAN
118 CALL DISRP                                                     HUELSMAN
    IF (NREP.GT.0) GO TO 124                                       HUELSMAN
117 IF(KRAD) 160,160,161                                           HUELSMAN
160 PRINT 162                                                      HUELSMAN
162 FORMAT (1H0,40HVALUES OF FREQUENCY ARE IN HERTZ                )HUELSMAN
    GO TO 165                                                      HUELSMAN
161 PRINT 163                                                      HUELSMAN
163 FORMAT (1H0,41HVALUES OF FREQUENCY ARE IN RADIANS/SECOND       )HUELSMAN
165 IF (LFRQ) 120,120,122                                          HUELSMAN
120 PRINT 121,NF,FA,FB                                             HUELSMAN
121 FORMAT( 1H0,16HLINEAR FREQ PLOT,I4,12H POINTS FROM,  E15.8,4H TO ,HUELSMAN
   1  E15.8)                                                       HUELSMAN
    DNF=NF                                                         HUELSMAN
    FREQ=FA                                                        HUELSMAN
    DF=(FB-FA)/DNF                                                 HUELSMAN
    GO TO 124                                                      HUELSMAN
122 IF(FA-1.) 150,151,151                                          HUELSMAN
151 FL=ALOG10 (FA)                                                 HUELSMAN
    GO TO 152                                                      HUELSMAN
150 FL=-ALOG10 (1./(FA-.0001))                                     HUELSMAN
152 LOG1=FL                                                        HUELSMAN
    IF (FB-1.) 153,154,154                                         HUELSMAN
154 FM=ALOG10 (FB)                                                 HUELSMAN
    GO TO 155                                                      HUELSMAN
153 FM=-ALOG10 (1./(FB-.0001))                                     HUELSMAN
155 LOG2=FM                                                        HUELSMAN
    NG=NF/(LOG2-LOG1)                                              HUELSMAN
    PRINT 123,NG,LOG1,LOG2                                         HUELSMAN
```

```
123 FORMAT( 1H0,13HLOG FREQ PLOT,I5,21H POINTS/DEC FROM 10**,I2,      HUELSMAN
   1  9H   TO 10**,I2)                                                HUELSMAN
    NLG=1                                                            HUELSMAN
124 PRINT 144                                                        HUELSMAN
144 FORMAT (1H0,3X,2HJX,3X,2HIX,8X,8HFREQ(HZ),15X,3HRAD,17X,3HVXM,15X,HUELSMAN
   17HVXM(DB),11X,10HPHASE(DEG))                                     HUELSMAN
125 IF (LFRQ) 126,126,127                                            HUELSMAN
126 FREQ=FREQ+DF                                                     HUELSMAN
    GO TO 128                                                        HUELSMAN
127 FREQ=XL4(NLG,LOG1,NG)                                            HUELSMAN
128 IF(FREQ-FB-.0001) 129,129,139                                    HUELSMAN
129 IF (KRAD) 170,170,171                                            HUELSMAN
170 RAD=FREQ*6.283185307                                             HUELSMAN
    FREQH=FREQ                                                       HUELSMAN
    GO TO 130                                                        HUELSMAN
171 RAD=FREQ                                                         HUELSMAN
    FREQH=FREQ/6.283185307                                           HUELSMAN
130 DO 131 I=1,NN                                                    HUELSMAN
    DO 131 J=1,NN                                                    HUELSMAN
131 YR(I,J)=(0.,0.)                                                  HUELSMAN
    DO 132 I=1,ND                                                    HUELSMAN
    KD=I                                                             HUELSMAN
132 CALL YDIST                                                       HUELSMAN
    DO 134 I=1,NN                                                    HUELSMAN
    DO 134 J=1,NN                                                    HUELSMAN
134 YR(I,J)=YR(I,J)+CMPLX(R(I,J),C(I,J)*RAD)                         HUELSMAN
    CALL CONST                                                       HUELSMAN
    CALL CMRED                                                       HUELSMAN
    VD=-YR(2,1)/YR(2,2)                                              HUELSMAN
    VXM=CABS (VD)                                                    HUELSMAN
    VXMDB=20.*ALOG10 (VXM)                                           HUELSMAN
    IX=IX+1                                                          HUELSMAN
    IF (LPHS) 180,180,181                                            HUELSMAN
181 PHSD=ATAN2(AIMAG(VD),REAL(VD))*57.2957795                        HUELSMAN
    Z(JX,IX)=PHSD*SCALP                                              HUELSMAN
180 PRINT 145,JX,IX,FREQH,RAD,VXM,VXMDB,PHSD                         HUELSMAN
145 FORMAT (1X,2I5,5E20.8)                                           HUELSMAN
    IF (KPUN.GT.0) PUNCH 200,IX,FREQH,RAD,VXM,VXMDB,PHSD             HUELSMAN
200 FORMAT (I4,1X,5E15.8)                                            HUELSMAN
    IF (LMAG) 137,137,136                                            HUELSMAN
136 Y(JX,IX)=VXM*SCALE                                               HUELSMAN
    GO TO 135                                                        HUELSMAN
137 Y(JX,IX)=VXMDB*SCALE                                             HUELSMAN
135 IF (IX-NF) 125,139,139                                           HUELSMAN
139 IX=0                                                             HUELSMAN
    JX=JX+1                                                          HUELSMAN
    READ 107,NREP                                                    HUELSMAN
    IF (EOF,4) 999,193                                               HUELSMAN
193 IF (NREP.EQ.0) GO TO 102                                         HUELSMAN
    NLG=1                                                            HUELSMAN
    FREQ=FA                                                          HUELSMAN
    PRINT 106,JX                                                     HUELSMAN
    GO TO (190,118,194,102  ),NREP                                   HUELSMAN
190 READ 191,(GA(I),I=1,NGAIN)                                       HUELSMAN
191 FORMAT (8E10.0)                                                  HUELSMAN
    PRINT 89                                                         HUELSMAN
 89 FORMAT (1H0*CHANGES IN GAIN ELEMENTS*)                           HUELSMAN
    PRINT 90,(I,NG1(I),NG2(I),NG3(I),NG4(I),JL(I),GA(I),I=1,NGAIN)   HUELSMAN
    GO TO 124                                                        HUELSMAN
194 PRINT 195                                                        HUELSMAN
```

```
195 FORMAT (1H0,26HCHANGES IN LUMPED ELEMENTS/)                    HUELSMAN
    GO TO 13                                                       HUELSMAN
999 IF (KPLT.GT.0) STOP                                            HUELSMAN
    IF (LMAG) 172,172,174                                          HUELSMAN
172 PRINT 173,SCALE,LTR                                            HUELSMAN
173 FORMAT (1H1,12HDB SCALED BY, E9.2,5X,8A10/)                    HUELSMAN
    GO TO 179                                                      HUELSMAN
174 PRINT 175,SCALE,LTR                                            HUELSMAN
175 FORMAT (1H1,13HMAG SCALED BY, E9.2,5X,8A10/)                   HUELSMAN
179 JX=JX-1                                                        HUELSMAN
    CALL PLOT (Y,JX,NF,NSY)                                        HUELSMAN
146 IF (LPHS) 183,183,184                                          HUELSMAN
184 PRINT 185,SCALP,LTR                                            HUELSMAN
185 FORMAT (1H1,21HPHASE(DEG), SCALED BY,E9.2,5X,8A10/)            HUELSMAN
    CALL PLOT (Z,JX,NF,NSP)                                        HUELSMAN
183 STOP                                                           HUELSMAN
    END                                                            HUELSMAN
```

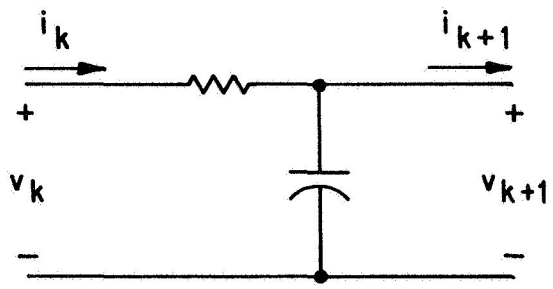



Fig. 1

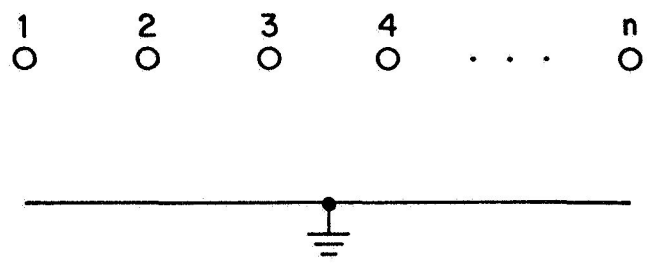



Fig. 2

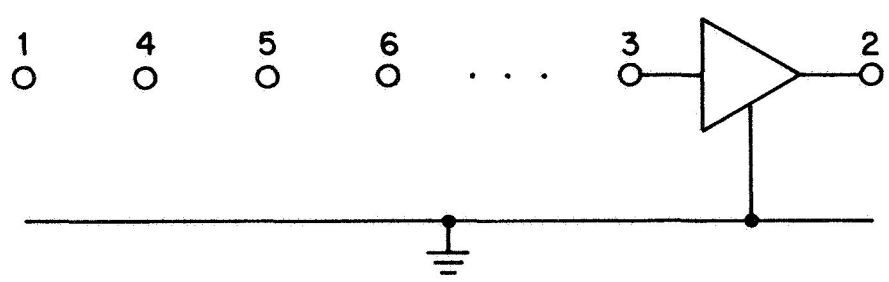



Fig. 3

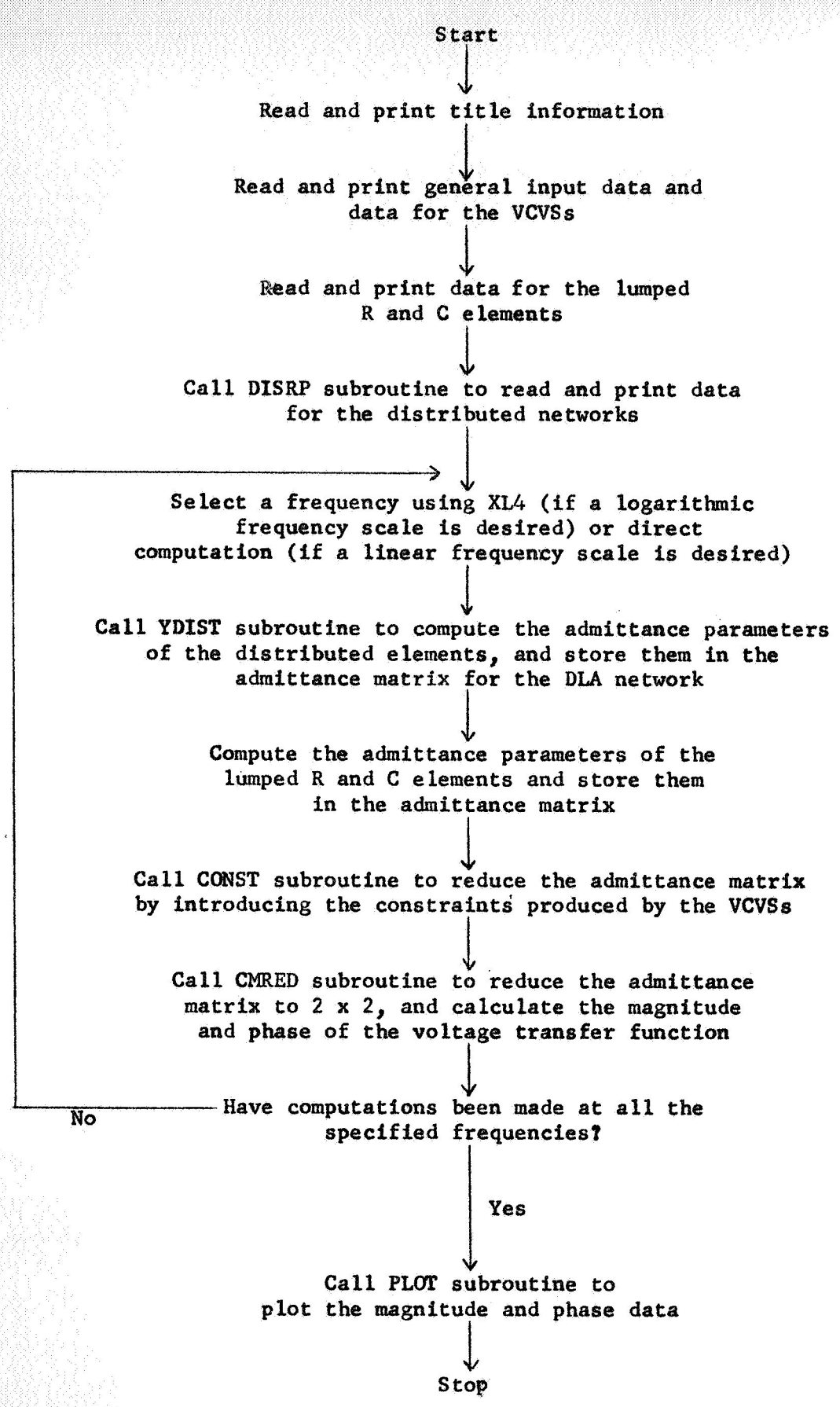



Fig. 4 Flow Chart for the Digital Computer Program DLANET

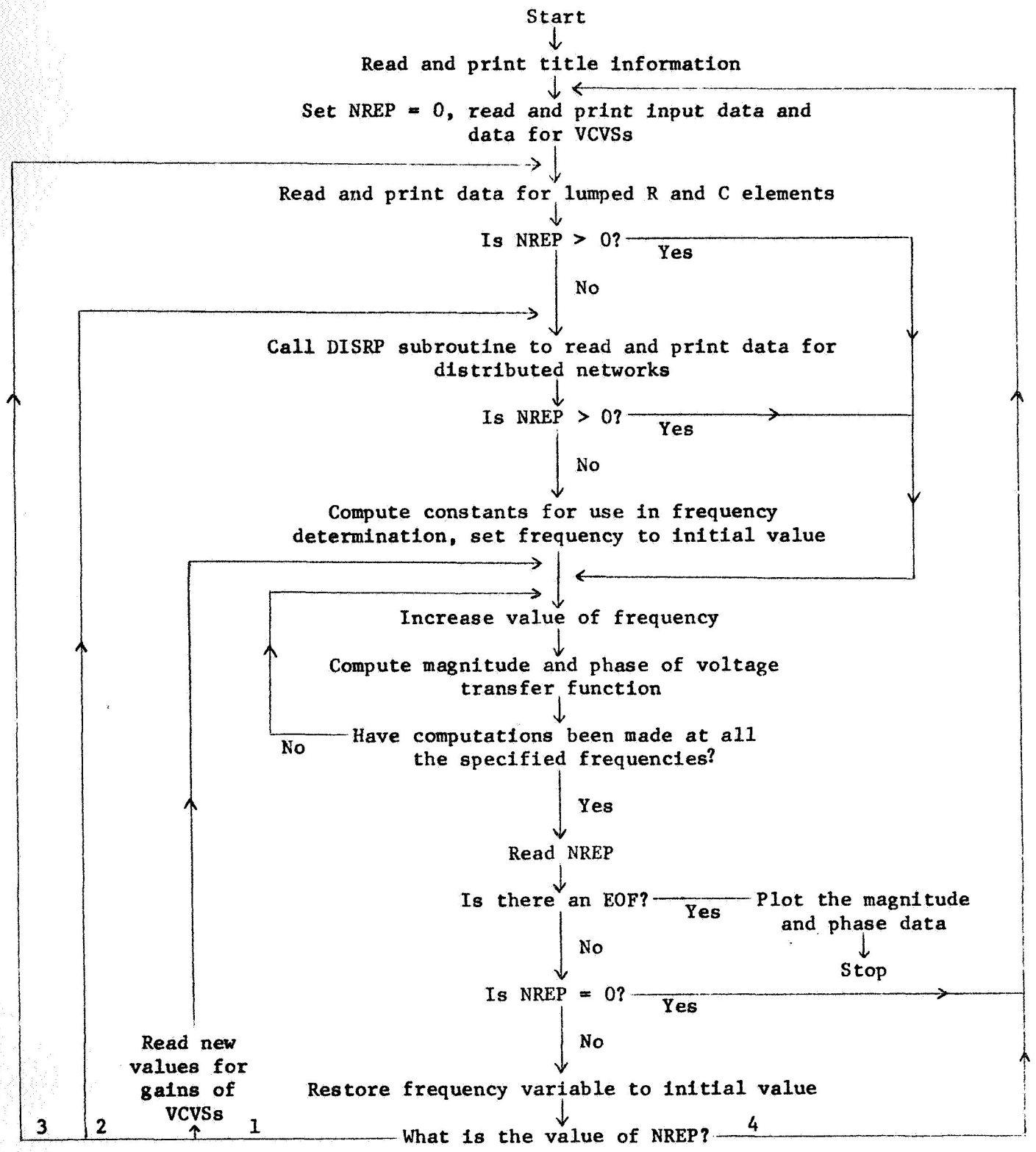



Fig. 6 Flow Chart for Multiple-Case feature of DLANET Program

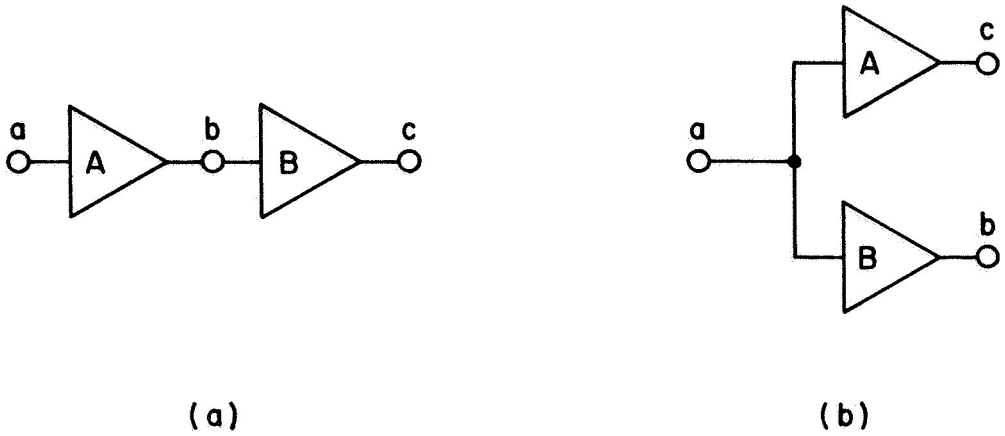



Fig. 5

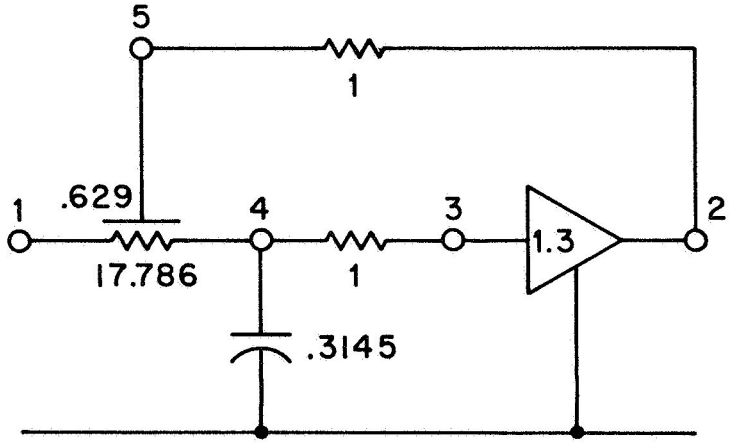



Fig. 7

```
TEST OF KERWIN TEST FOR DLA 5VCVS MOD
  5  1 50 100101 1 1          .1        10.       1.        .5          1
  2  0  3  0  3      1.3
 2 5       1.
 3 4       1.
 4 0                  .3145

  1  5  1  4  5
17.786     .629
  2
  1 10  1  4  5
17.786     .629
```

Fig. 8

TEST OF KERWIN TEST FOR DLA 5VCVS MOD

PROBLEM NUMBER 1

5 NODES 1 DISTRIBUTED SUBNETWORKS

1 GAIN ELEMENTS OF VCVS TYPE
NO. 1, SOURCE AT NODES 2 - 0, CONTROL VOLTAGE AT NODES 3 - 0, SUPRESS NODE 3, GAIN= 1.30000E+00

LUMPED ELEMENTS

| NODES | | R(OHMS) | C(FARADS) |
|---|---|---|---|
| 2 | 5 | 1.000E+00 | -0. |
| 3 | 4 | 1.000E+00 | -0. |
| 4 | 0 | -0. | 3.145E-01 |

DISTRIBUTED NETWORK 1 5 SECTIONS CONNECTED TO NODES 1 4 5

TOTAL RESISTANCE= 1.77860000E+01 TOTAL CAPACITANCE= 6.29000000E-01

RESISTANCE/SECT.= 3.55720000E+00 CAPACITANCE/SECT.= 1.25800000E-01

VALUES OF FREQUENCY ARE IN RADIANS/SECOND

LOG FREQ PLOT 25 POINTS/DEC FROM 10**-1 TO 10**1

| JX | IX | FREQ(HZ) | RAD | VXM | VXM(DB) | PHASE(DEG) |
|---|---|---|---|---|---|---|
| 1 | 1 | 1.74509925E-02 | 1.09647820E-01 | 1.33647759E+00 | 2.51923364E+00 | -2.40335232E+01 |
| 1 | 2 | 1.91346328E-02 | 1.20226443E-01 | 1.34194994E+00 | 2.55472633E+00 | -2.66947552E+01 |
| 1 | 3 | 2.09807076E-02 | 1.31825674E-01 | 1.34755156E+00 | 2.59090784E+00 | -2.97199742E+01 |
| 1 | 4 | 2.30048884E-02 | 1.44543977E-01 | 1.35278907E+00 | 2.62460173E+00 | -3.31756968E+01 |
| 1 | 5 | 2.52243586E-02 | 1.58489319E-01 | 1.35679358E+00 | 2.65027560E+00 | -3.71416328E+01 |
| 1 | 6 | 2.76579592E-02 | 1.73780083E-01 | 1.35811681E+00 | 2.65874247E+00 | -4.17107694E+01 |
| 1 | 7 | 3.03263492E-02 | 1.90546072E-01 | 1.35446450E+00 | 2.63535253E+00 | -4.69860416E+01 |
| 1 | 8 | 3.32521807E-02 | 2.08929613E-01 | 1.34241664E+00 | 2.55774652E+00 | -5.30701449E+01 |
| 1 | 9 | 3.64602911E-02 | 2.29086765E-01 | 1.31729876E+00 | 2.39368567E+00 | -6.00437534E+01 |
| 1 | 10 | 3.99779142E-02 | 2.51188643E-01 | 1.27355079E+00 | 2.10032537E+00 | -6.79285139E+01 |
| 1 | 11 | 4.38349113E-02 | 2.75422870E-01 | 1.20604339E+00 | 1.62725864E+00 | -7.66390264E+01 |
| 1 | 12 | 4.80640244E-02 | 3.01995172E-01 | 1.11241762E+00 | 9.25357211E-01 | -8.59449960E+01 |
| 1 | 13 | 5.27011548E-02 | 3.31131121E-01 | 9.95400869E-01 | -4.00396856E-02 | -9.54793441E+01 |
| 1 | 14 | 5.77856671E-02 | 3.63078055E-01 | 8.63121603E-01 | -1.27856026E+00 | -1.04812461E+02 |
| 1 | 15 | 6.33607241E-02 | 3.98107171E-01 | 7.26538782E-01 | -2.77482397E+00 | -1.13561559E+02 |
| 1 | 16 | 6.94736524E-02 | 4.36515832E-01 | 5.95683250E-01 | -4.49969223E+00 | -1.21470023E+02 |
| 1 | 17 | 7.61763451E-02 | 4.78630092E-01 | 4.77226582E-01 | -6.42550747E+00 | -1.28419692E+02 |
| 1 | 18 | 8.35257015E-02 | 5.24807460E-01 | 3.74180313E-01 | -8.53838132E+00 | -1.34390982E+02 |
| 1 | 19 | 9.15841105E-02 | 5.75439937E-01 | 2.86865236E-01 | -1.08464416E+01 | -1.39404232E+02 |
| 1 | 20 | 1.00419980E-01 | 6.30957344E-01 | 2.14095839E-01 | -1.33878355E+01 | -1.43458583E+02 |
| 1 | 21 | 1.10108319E-01 | 6.91830971E-01 | 1.54070890E-01 | -1.62455882E+01 | -1.46454015E+02 |
| 1 | 22 | 1.20731371E-01 | 7.58577575E-01 | 1.04910203E-01 | -1.95836455E+01 | -1.48024528E+02 |
| 1 | 23 | 1.32379316E-01 | 8.31763771E-01 | 6.49738455E-02 | -2.37452286E+01 | -1.46972163E+02 |
| 1 | 24 | 1.45151033E-01 | 9.12010839E-01 | 3.33345675E-02 | -2.95421035E+01 | -1.38279369E+02 |
| 1 | 25 | 1.59154943E-01 | 1.00000000E+00 | 1.39796901E-02 | -3.70900491E+01 | -8.95850943E+01 |
| 1 | 26 | 1.74509925E-01 | 1.09647820E+00 | 2.29441904E-02 | -3.27865452E+01 | -2.42090268E+01 |
| 1 | 27 | 1.91346328E-01 | 1.20226443E+00 | 3.88059675E-02 | -2.82220297E+01 | -1.10715421E+01 |
| 1 | 28 | 2.09807076E-01 | 1.31825674E+00 | 5.25615936E-02 | -2.55866295E+01 | -8.05015585E+00 |
| 1 | 29 | 2.30048884E-01 | 1.44543977E+00 | 6.38139065E-02 | -2.39016934E+01 | -7.72859185E+00 |
| 1 | 30 | 2.52243586E-01 | 1.58489319E+00 | 7.28248564E-02 | -2.27544073E+01 | -8.45163064E+00 |
| 1 | 31 | 2.76579592E-01 | 1.73780083E+00 | 7.99072823E-02 | -2.19482728E+01 | -9.66495420E+00 |
| 1 | 32 | 3.03263492E-01 | 1.90546072E+00 | 8.53450131E-02 | -2.13764370E+01 | -1.11340995E+01 |
| 1 | 33 | 3.32521807E-01 | 2.08929613E+00 | 8.93830028E-02 | -2.09749012E+01 | -1.27431826E+01 |
| 1 | 34 | 3.64602911E-01 | 2.29086765E+00 | 9.22311657E-02 | -2.07024461E+01 | -1.44277132E+01 |
| 1 | 35 | 3.99779142E-01 | 2.51188643E+00 | 9.40706705E-02 | -2.05309152E+01 | -1.61482447E+01 |
| 1 | 36 | 4.38349113E-01 | 2.75422870E+00 | 9.50597538E-02 | -2.04400663E+01 | -1.78790382E+01 |
| 1 | 37 | 4.80640244E-01 | 3.01995172E+00 | 9.53381659E-02 | -2.04146641E+01 | -1.96030471E+01 |
| 1 | 38 | 5.27011548E-01 | 3.31131121E+00 | [illegible] | [illegible] | [illegible] |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | 39 | 5.77856671E-01 | 3.63078055E+00 | 9.42452582E-02 | -2.05148098E+01 | -2.29945810E+01 |
| 1 | 40 | 6.33607241E-01 | 3.98107171E+00 | 9.30797304E-02 | -2.06228977E+01 | -2.46581462E+01 |
| 1 | 41 | 6.94736524E-01 | 4.36515832E+00 | 9.16149057E-02 | -2.07606772E+01 | -2.63063475E+01 |
| 1 | 42 | 7.61763451E-01 | 4.78630092E+00 | 8.99172150E-02 | -2.09231431E+01 | -2.79495091E+01 |
| 1 | 43 | 8.35257015E-01 | 5.24807460E+00 | 8.80378533E-02 | -2.11066111E+01 | -2.96013660E+01 |
| 1 | 44 | 9.15841105E-01 | 5.75439937E+00 | 8.60132938E-02 | -2.13086884E+01 | -3.12776304E+01 |
| 1 | 45 | 1.00419980E+00 | 6.30957344E+00 | 8.38666847E-02 | -2.15282105E+01 | -3.29943299E+01 |
| 1 | 46 | 1.10108319E+00 | 6.91830971E+00 | 8.16100766E-02 | -2.17651243E+01 | -3.47661236E+01 |
| 1 | 47 | 1.20731371E+00 | 7.58577575E+00 | 7.92472640E-02 | -2.20203145E+01 | -3.66047987E+01 |
| 1 | 48 | 1.32379316E+00 | 8.31763771E+00 | 7.67769368E-02 | -2.22953844E+01 | -3.85181006E+01 |
| 1 | 49 | 1.45151033E+00 | 9.12010839E+00 | 7.41958237E-02 | -2.25924108E+01 | -4.05089839E+01 |
| 1 | 50 | 1.59154943E+00 | 1.00000000E+01 | 7.15015387E-02 | -2.29136922E+01 | -4.25753090E+01 |

PROBLEM NUMBER 2

DISTRIBUTED NETWORK 1 10 SECTIONS CONNECTED TO NODES 1 4 5

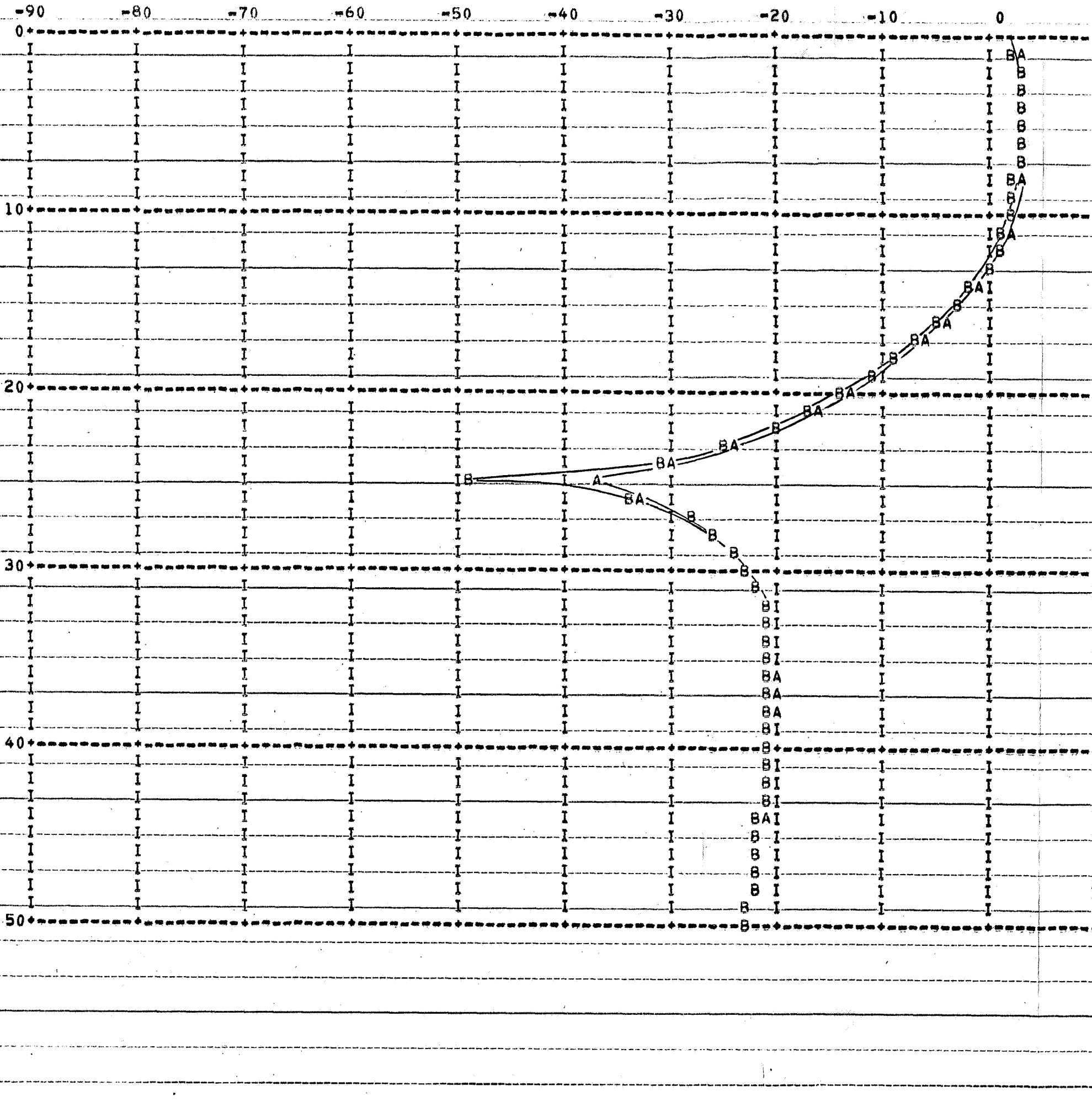
TOTAL RESISTANCE= 1.77860000E+01 TOTAL CAPACITANCE= 6.29000000E-01

RESISTANCE/SECT.= 1.77860000E+00 CAPACITANCE/SECT.= 6.29000000E-02

| JX | IX | FREQ(HZ) | RAD | VXM | VXM(DB) | PHASE(DEG) |
|---|---|---|---|---|---|---|
| 2 | 1 | 1.74509925E-02 | 1.09647820E-01 | 1.33318842E+00 | 2.49783064E+00 | -2.51271051E+01 |
| 2 | 2 | 1.91346328E-02 | 1.20226443E-01 | 1.33781648E+00 | 2.52793082E+00 | -2.79003655E+01 |
| 2 | 3 | 2.09807076E-02 | 1.31825674E-01 | 1.34232689E+00 | 2.55716578E+00 | -3.10492322E+01 |
| 2 | 4 | 2.30048884E-02 | 1.44543977E-01 | 1.34614872E+00 | 2.58186085E+00 | -3.46407311E+01 |
| 2 | 5 | 2.52243586E-02 | 1.58489319E-01 | 1.34831640E+00 | 2.59583634E+00 | -3.87543504E+01 |
| 2 | 6 | 2.76579592E-02 | 1.73780083E-01 | 1.34727104E+00 | 2.58909951E+00 | -4.34814654E+01 |
| 2 | 7 | 3.03263492E-02 | 1.90546072E-01 | 1.34061461E+00 | 2.54607893E+00 | -4.89210167E+01 |
| 2 | 8 | 3.32521807E-02 | 2.08929613E-01 | 1.32488087E+00 | 2.44353658E+00 | -5.51680786E+01 |
| 2 | 9 | 3.64602911E-02 | 2.29086765E-01 | 1.29550157E+00 | 2.24875888E+00 | -6.22911151E+01 |
| 2 | 10 | 3.99779142E-02 | 2.51188643E-01 | 1.24730161E+00 | 1.91942968E+00 | -7.02956578E+01 |
| 2 | 11 | 4.38349113E-02 | 2.75422870E-01 | 1.17588748E+00 | 1.40731531E+00 | -7.90806420E+01 |
| 2 | 12 | 4.80640244E-02 | 3.01995172E-01 | 1.07984151E+00 | 6.67200342E-01 | -8.84092179E+01 |
| 2 | 13 | 5.27011548E-02 | 3.31131121E-01 | 9.62606596E-01 | -3.31023332E-01 | -9.79256562E+01 |
| 2 | 14 | 5.77856671E-02 | 3.63078055E-01 | 8.32356643E-01 | -1.59381100E+00 | -1.07230540E+02 |
| 2 | 15 | 6.33607241E-02 | 3.98107171E-01 | 6.99402140E-01 | -3.10546086E+00 | -1.15980589E+02 |
| 2 | 16 | 6.94736524E-02 | 4.36515832E-01 | 5.72848932E-01 | -4.83919784E+00 | -1.23956213E+02 |
| 2 | 17 | 7.61763451E-02 | 4.78630092E-01 | 4.58607312E-01 | -6.77118051E+00 | -1.31069558E+02 |
| 2 | 18 | 8.35257015E-02 | 5.24807460E-01 | 3.59261078E-01 | -8.89179662E+00 | -1.37329932E+02 |
| 2 | 19 | 9.15841105E-02 | 5.75439937E-01 | 2.74982477E-01 | -1.12138996E+01 | -1.42797367E+02 |
| 2 | 20 | 1.00419980E-01 | 6.30957344E-01 | 2.04594949E-01 | -1.37821018E+01 | -1.47541753E+02 |
| 2 | 21 | 1.10108319E-01 | 6.91830971E-01 | 1.46362749E-01 | -1.66913888E+01 | -1.51606045E+02 |
| 2 | 22 | 1.20731371E-01 | 7.58577575E-01 | 9.84570269E-02 | -2.01350657E+01 | -1.54948820E+02 |
| 2 | 23 | 1.32379316E-01 | 8.31763771E-01 | 5.91889019E-02 | -2.45551943E+01 | -1.57254284E+02 |
| 2 | 24 | 1.45151033E-01 | 9.12010839E-01 | 2.71340510E-02 | -3.13297073E+01 | -1.56673664E+02 |
| 2 | 25 | 1.59154943E-01 | 1.00000000E+00 | 3.44446872E-03 | -4.92575551E+01 | -8.76443857E+01 |
| 2 | 26 | 1.74509925E-01 | 1.09647820E+00 | 2.10499595E-02 | -3.35349747E+01 | 1.00904511E+00 |
| 2 | 27 | 1.91346328E-01 | 1.20226443E+00 | 3.83250832E-02 | -2.83303379E+01 | 2.51627056E+00 |
| 2 | 28 | 2.09807076E-01 | 1.31825674E+00 | 5.23482627E-02 | -2.56219545E+01 | 1.33766078E+00 |
| 2 | 29 | 2.30048884E-01 | 1.44543977E+00 | 6.36108677E-02 | -2.39293736E+01 | -4.25838786E-01 |
| 2 | 30 | 2.52243586E-01 | 1.58489319E+00 | 7.25502474E-02 | -2.27872220E+01 | -2.36983252E+00 |
| 2 | 31 | 2.76579592E-01 | 1.73780083E+00 | 7.95282495E-02 | -2.19895715E+01 | -4.36645036E+00 |
| 2 | 32 | 3.03263492E-01 | 1.90546072E+00 | 8.48426764E-02 | -2.14277128E+01 | -6.36299614E+00 |
| 2 | 33 | 3.32521807E-01 | 2.08929613E+00 | 8.87403757E-02 | -2.10375747E+01 | -8.33210992E+00 |
| 2 | 34 | 3.64602911E-01 | 2.29086765E+00 | 9.14289019E-02 | -2.07783299E+01 | -1.02555157E+01 |
| 2 | 35 | 3.99779142E-01 | 2.51188643E+00 | 9.30863510E-02 | -2.06222799E+01 | -1.21179593E+01 |
| 2 | 36 | 4.38349113E-01 | 2.75422870E+00 | 9.38693272E-02 | -2.05495259E+01 | -1.39050386E+01 |
| 2 | 37 | 4.80640244E-01 | 3.01995172E+00 | 9.39190041E-02 | -2.05449304E+01 | -1.56028612E+01 |
| 2 | 38 | 5.27011548E-01 | 3.31131121E+00 | 9.33652325E-02 | -2.05962963E+01 | -1.71987130E+01 |
| 2 | 39 | 5.77856671E-01 | 3.63078055E+00 | 9.23286992E-02 | -2.06932657E+01 | -1.86823103E+01 |
| 2 | 40 | 6.33607241E-01 | 3.98107171E+00 | 9.09212782E-02 | -2.08266893E+01 | -2.00472954E+01 |
| 2 | 41 | 6.94736524E-01 | 4.36515832E+00 | 8.92449215E-02 | -2.09883298E+01 | -2.12926387E+01 |
| 2 | 42 | 7.61763451E-01 | 4.78630092E+00 | 8.73896475E-02 | -2.11708002E+01 | -2.24236050E+01 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2 | 44 | 9.15841105E-01 | 5.75439937E+00 | 8.34299848E-02 | -2.15735567E+01 | -2.43955575E+01 |
| 2 | 45 | 1.00419980E+00 | 6.30957344E+00 | 8.14291387E-02 | -2.17844032E+01 | -2.52764881E+01 |
| 2 | 46 | 1.10108319E+00 | 6.91830971E+00 | 7.94564939E-02 | -2.19974121E+01 | -2.61194874E+01 |
| 2 | 47 | 1.20731371E+00 | 7.58577575E+00 | 7.75258712E-02 | -2.22110669E+01 | -2.69495426E+01 |
| 2 | 48 | 1.32379316E+00 | 8.31763771E+00 | 7.56400525E-02 | -2.24249636E+01 | -2.77899758E+01 |
| 2 | 49 | 1.45151033E+00 | 9.12010839E+00 | 7.37940278E-02 | -2.26395757E+01 | -2.86610263E+01 |
| 2 | 50 | 1.59154943E+00 | 1.00000000E+01 | 7.19781382E-02 | -2.28559878E+01 | -2.95791238E+01 |

DB SCALED BY 1.00E+00 TEST OF KERWIN TEST FOR DLA 5VCVS MOD




| Y(1,I) |
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| 2.55473E+00 |
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| 2.39369E+00 |
| 2.10033E+00 |
| 1.62726E+00 |
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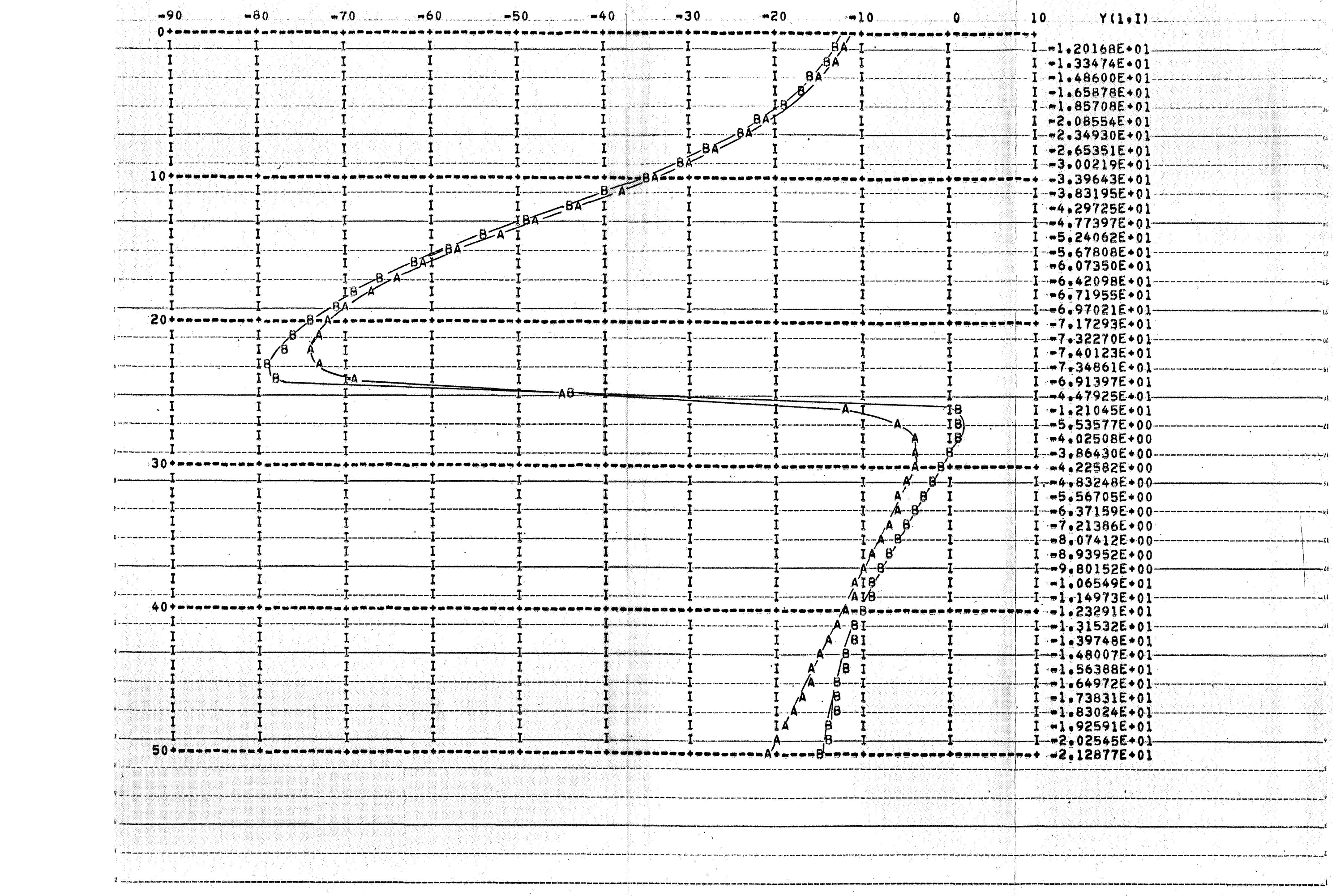
PHASE(DEG), SCALED BY 5.00E-01 TEST OF KERWIN TEST FOR DLA 5VCVS MOD