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EVALUATION OF
METHODS FOR
COMPUTER-AIDED
DESIGN OF TEST
EQUIPMENT

BDX-613-349

July, 1971

Project Leader:
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Department 864

PDO 6984640
Final Report

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Technical Communications

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KANSAS CITY DIVISION
KANSAS CITY, MISSOURI

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Contract Number AT(29-1)-613 USAEC

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ABSTRACT

An evaluation was made of the circuit analysis capabilities that are available to the test equipment engineer through the computer-aided design programs currently in operation at Bendix Kansas City. The advantages, disadvantages, applications, and limitations of the SCEPTRE, ECAP, ECAP (COM-SHARE), and CODED CAP (COM-SHARE) programs are given together with examples of programs formatted for use on the SCEPTRE and ECAP (COM-SHARE) systems.

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SUMMARY

The scope of the project as originally conceived was to develop and evaluate computer-aided design techniques which would facilitate the design of electronic hardware. However, as a result of preliminary surveys both of the state-of-the-art of electronic design and of the advances in computer-aided design (CAD) programs at Bendix Kansas City, test equipment engineering felt that the time and effort required to develop such a system would be too extensive and would parallel too closely current activities in the CAD field to justify such an undertaking. The objective of the project was therefore restated. As modified, the project sought to evaluate the extent to which the existing CAD programs could be used in the design of the interface circuitry required between systems components.

Four CAD systems were evaluated: SCEPTRE, ECAP, ECAP (COM-SHARE), and CODED CAP (COM-SHARE). The factors guiding the engineer in the selection of the system best suited for a particular type of circuit analysis are the size of the problem, the type of analysis required, and the turnaround time required to obtain the solution.

The SCEPTRE system was found to offer the greatest program capacity. It permitted use of subprograms, insertion of mathematic equations for circuit descriptions, and was capable of simulating the effects of radiation on non-linear components such as transistors and diodes. A feature also available only with the SCEPTRE system is the library of model descriptions which are already programmed for the more common transistors and diodes.

An advantage offered by the ECAP and CODED CAP systems, but not by the SCEPTRE system, is direct AC analysis. With the latter, AC analysis must be obtained indirectly by transient analysis.

Still other advantages were found in the direct teletype control offered with the ECAP (COM-SHARE) and CODED CAP (COM-SHARE) systems: the capability to correct errors at any time, the reduced time required for turnaround, and the ease with which modifications can be made to an incorrectly prepared program.

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DISCUSSION

SCOPE AND PURPOSE

The initial objective of this project was to develop and evaluate computer-aided design (CAD) techniques which would be useful at Bendix Kansas City in the design of electronic hardware. The objective was restated, however, following a preliminary survey of the state-of-the-art of electronic design and of new CAD programs which had been introduced at Bendix after the project was already under way. As a result of the new capabilities available to the test equipment engineer, the original purpose was modified to the extent that an evaluation was performed to determine the usefulness of these programs in the design of interface circuitry required between integrated circuits and other system components.

PRIOR WORK

There was no work on this project prior to that reported here.

ACTIVITY

The state-of-the-art survey made at the beginning of this project revealed that current electronics design work makes less use of discrete components (resistors, capacitors, transistors, and circuit boards) and greater use of the integrated circuit (IC), operational amplifiers, and pre-wired assemblies. That is, the tendency is to move away from individual design and toward a systems approach to design problems. The test equipment design engineer is employing the basic circuits available in integrated circuits and using them in combinations to complete the required design. Discrete circuits are used primarily when interfacing IC's with other system components and when designing output drivers.

The CAD programs can assist the test equipment engineer in designing the discrete interface circuitry used between systems components or in designing circuitry that can be discretely modeled. In such an application, the CAD programs also serve to improve budgeting and the cost-effectiveness of the test equipment by optimizing the design. The four programs which would meet the requirements of the test equipment designer are SCEPTRE, ECAP, ECAP (COM-SHARE), and CODED-CAP (COM-SHARE). The SCEPTRE and ECAP programs are stored on the IBM 360 computer located in the Bendix Data Center while the ECAP (COM-SHARE) and CODED-CAP (COM-SHARE) are stored on a computer located in Ann Arbor, Michigan. The latter are connected by telephone lines to teletype terminals located at Bendix.

Since Bendix had only one operational CAD program (ECAP) at the time this project was undertaken, a five-year plan was devised which would utilize services provided by an outside source¹ to provide Bendix engineers with sufficient CAD programs. The plan is outlined below.

First Year

Graphic ECAP utilization;
ACCEL utilization (Automatic Circuit Card Etching Layout);
PAKIT utilization;
Use of network algorithms generated by outside source in design cost estimates; and
Use of logic synthesis programs.

Second Year

Development and utilization of SCEPTRE graphic capability;
Various program refinements;
Plotting refinements; and
Interim use of cost evaluation data generated by outside source in design and development of cost-effective equipment.

Third Year

Refinements to SCEPTRE graphics;
Addition of other analysis programs; and
Application of versatile and modular scheme generated by outside source (for program and data-base manipulation) to many areas of scientific data management.

Fourth Year

Completion of master system (total system utilization);
Continued system refinements.

Fifth Year

Preparation of user's manual and other documentation;
Dissemination of information through seminars and other instructional methods; and
Continuation of system refinements.

Estimates were made in May, 1969, on the cost of implementing the above plan. The cost to purchase the required equipment over the entire schedule was estimated as follows.

First Year

Outside System	70,000
Graphic ECAP	152,000
Engineering	<u>4,000</u>
Total	226,000

Second Year

Outside System	70,000
Engineering	<u>4,000</u>
Total	74,000

Third Year

Outside System	76,000
Engineering	<u>4,000</u>
Total	80,000

Fourth Year

Outside System	76,000
Engineering	<u>4,000</u>
Total	80,000

Fifth Year

Outside System	66,000
Engineering	<u>4,000</u>
Total	70,000

TOTAL PROJECT COST = 530,000

The cost of rental options over the five-year schedule were estimated as follows.

First Year	97,000
Second Year	109,000
Third Year	209,000
Fourth Year	80,000
Fifth Year	70,000

TOTAL PROJECT COST = 565,000

With the addition of several new CAD programs after the start of the above survey and in light of the time and effort that would have been required to implement the system indicated above, it was concluded that a more appropriate approach to the project would be to define the existing CAD capabilities as they relate to test equipment designer. These programs included the ECAP program and the more recent SCEPTRE, ECAP (COM-SHARE), and CODED-CAP (COM-SHARE) programs.

SCEPTRE System

The SCEPTRE system is currently available on the IBM 360 computer located in the Bendix Data Center. Problems to be processed with this system are submitted on a FORTRAN coding form (KCD 1978A). Procedures manuals are available to assist the engineer in his circuit analysis.² Additionally, personnel in the Scientific Programming Department are available to help the engineer working with an unusual problem or circuit.

The SCEPTRE program, a system developed by IBM, has been used at Bendix since September, 1969, when it first became operational. No specialized knowledge of computer programming is required to run a circuit program since the system operates on a free format. Use of the SCEPTRE program assumes only the application of the standard SCEPTRE format and a few rules for defining the circuit.

Both DC steady-state analysis and transient analysis may be performed with SCEPTRE. Among the features available to the engineer, as described in the user's manual for the SCEPTRE program, are the following.

Stored Models

Given any active element or interconnected group of elements that can be described as a combination of sources, passive elements and mutual inductance may be stored on tape by the user and called into the main program at any point in the network.

Automatic Initial Conditions

A special section provides the user the option to determine the initial conditions.

Rerun

Reruns, based on a single master run may be carried out with the user supplying only those changes applicable to the master run.

Linearly Dependent Sources

Voltage and current sources which are linearly dependent upon resistor voltages and currents, respectively, can be executed without delay. This permits extensive use of the family of small-signal, transistor-equivalent circuits.

Subprograms

The user who is familiar with programming may write FORTRAN subprograms and insert them into a conventional SCEPTRE program.

Automatic Termination

Depending upon the behavior of the network, the program can be automatically terminated.

The basic procedure for setting up any circuit to be run with the SCEPTRE program entails the following steps.

1. Draw an equivalent circuit of the problem to be analyzed. Non-linear elements such as transistors and diodes are to be represented in this circuit as resistors, capacitors, inductors, and independent and dependent current and voltage sources. Those resistors, capacitors, and inductors otherwise represented in the problem to be analyzed remain the same in the equivalent circuit. Some of the more common transistors and diodes have already been programmed and may be called into the program using the stored model feature of SCEPTRE.
2. Assign a name, a number, or both a name and number to all nodes in the circuit. A node point is defined as the junction of two or more elements in the circuit. The ground node is identified by GRD, and all other nodes must be numbered or lettered.
3. Assign a name to each element in the circuit. The element name may consist of no more than five numbers or letters; for example, R1A for resistor.
4. Assume the direction of current flow. In most cases a wrong direction results in a negative solution. However, care must be taken when working with dependent sources since the wrong current direction in the independent element will result in the wrong current direction in the dependent element.

The program automatically assumes the current to be flowing from the first node named in the program to the second node named. An example is given below of the program for a particular capacitor element.

where C_x is the element name, 1A and 2A are the node names, and 680 is the value of the element.

5. Indicate the direction of positive current flow in each voltage and current source.
6. Choose a consistent set of element values:

Resistors in kilohms,	Current in milliamperes,
Capacitors in picofarads,	Voltage in volts, and
Inductors in microhenries,	Time in nanoseconds.

Format of SCEPTRE System

Each of the six primary headings in the program format of the SCEPTRE system is given below with its subheadings. The subheadings may or may not apply to a particular program.³

- A. MODEL DESCRIPTION (INITIAL, PRINT) MODEL NAME (permanent or temporary) (NODE-NODE-NODE)
 1. Elements
 2. Defined parameters
 3. Output functions
 4. Functions
- B. CIRCUIT DESCRIPTION
 1. Elements
 2. Defined parameters
 3. Output
 4. Initial conditions
 5. Function
 6. Run control

C. RERUN DESCRIPTION

1. Elements
2. Defined parameters
3. Initial conditions
4. Functions
5. Run control

D. CONTINUE

Run control

E. RE-OUTPUT

F. END

Section A of the SCEPTRE format is used for the stored models to be used in section B. The equivalent circuit of the model is described as a separate circuit; it must be defined only one time after which it can be called into section B as often as necessary. One or more models may be placed in this section and any or all of the subheadings may be used in defining the circuit.

Section B may be used with any or all of its subheadings to define the main circuit to be analyzed. The store models in section A can be used in section B by calling the model's name and the terminal connections. Any other information required by the main circuit, such as initial conditions, defined parameters, and functions (as necessary), is also included.

Section C is used only when a rerun of the program is required. Any changes made to section B are placed in this section, and any or all of the subheadings may be used.

Section D is used to continue computation after the original problem is completed. Only the RUN CONTROL card can be used.

Section E can be used, without additional changes to the program, when additional output copies are required.

Section F is used to terminate the computer program.

Figure 1 shows an example of a program written at Bendix by Mr. W. W. Davis of the Test Equipment Design department. The program illustrates how the different sections of the SCEPTRE format work together to analyze a circuit consisting of two direct-coupled transistors (T1 and T2) and a step-up transformer (T3) to load resistor (R5).

Figure 1. Example of Program Written to SCEPTRE Format

The equivalent circuit for $T3$ is completed (Figure 2) and then placed in section A stored models.

Figure 2. Equivalent Circuit for Step-Up Transformer $T3$

Since section A would already contain programmed model descriptions for transistors T1 and T2 and for diode D1, the engineer would need to record only the model programs in the section. The equivalent circuit and program for transistor T1 is given as an example in Figure 3.

Figure 3. Equivalent Circuit and Program for Transistor T1

With the program given below in the stored model section, the transistor can be inserted at any place in the main program without additional programming.

MODEL DESCRIPTION

MODEL 2N3503 (TEMP) (E-B-C)

ELEMENTS

CET, E-1 = Q1 (0.218E02, 0.163E01, VCET, 0.496, 0.217E03, J1, 0.232E-07)
CCT, 2-1 = Q1 (0.107E02, 0.936 VCCT, 0.361, 0.885E03, J2, 0.234E-07)
J1, E-1 = Diode equation (0.232E-07, 0.272E02)
J2, 2-1 = Diode equation (0.234E-07, 0.278E02)
RBB, 1-B = 0.650E-02
RC, 2-1 = 0.300E07
RCC, C-2 = 0.700E-02
JA, 1-E = 0.883 *J2
JB, 1-2 = 0.995 *J1

FUNCTION

Q1 (A, B, C, D, E, F, G) = ((A/D A B S (B-C)**D) + E* (F + G))

The following would be written into section B for transistor T1 to permit subsequent use of the program without additional programming.

T1, 4-3-5 = MODEL 2N3503

Transistor T1 would then be put into the main program at node points 4, 3, and 5.

Figure 4 shows the circuit of Figure 1 after the six required steps (page 11) have been applied.

The nodes are identified in the figure by circled numbers. Circuit elements are identified by the letters R, L, or C, and voltage sources are identified as E1, E2, and E3. The stored elements are represented by T1, T2, T3. The main program (section B) is given below.

ELEMENTS

E1, GRD-2 = Table 1 (Time)
C1, 2-3 = 680.0
R1, 3-4 = 68.0
L1, 4-6 = 1.0E03
C2, 6-GRD = 2E04
T1, 4-3-5 = MODEL 2N3503
R2, 5-GRD = 1.0
T2, 7-5-9 = MODEL 2N3108
R3, 7-GRD = 1.0
R4, 8-4 = 51.0
E2, GRD-8 = 28.0
E3, GRD-9 = 28.0
T3, 7-GRD-10 = MODEL TRANS

Figure 4. Example of Program Written to SCEPTRE Format
After Application of Six Required Steps (See page 11.)

D1, GRD-10 = MODEL FD700
R5, 10-GRD = 1.0

FUNCTIONS

TABLE 1

0.0, 0.0
5000.0, 0.0
5100.0, - 10.0
9900.0, - 10.0
10000.0, 0.0
15000.0, 0.0

OUTPUTS

IR2, IR3, IL1

RUN CONTROL

```
STOP TIME = 30000, RUN INITIAL CONDITIONS  
INTEGRATION PASSES = TRAP  
MAXIMUM INTEGRATION PASSES = 100000  
MINIMUM STEP SIZE = 0.0001
```

END

In the program above, the outputs requested were the currents in resistors R2 and R3 and in inductor L1. TABLE 1, under the subheading FUNCTION, was used to control the input voltage E1. At zero time E1 was 0.0, and between 5100 and 9900 nanoseconds time E1 was -10.0 VDC. At times greater than 10,000 nanoseconds, time E1 was again 0.0 volts.

With the aid of the manual for the SCEPTRE system, the test equipment design engineer at Bendix can generally program circuits which can be represented by discrete components in a manner similar to that already given. Many circuits can therefore be analyzed for their static or dynamic range of operation under simulated conditions.

A special section in the SCEPTRE manual⁵ deals with evaluation of radiation effects on semiconductor junctions. When subprograms and FORTRAN-type equations are used, SCEPTRE will simulate radiation effects on the circuit under analysis. This feature could be particularly useful to product engineers at Bendix.

ECAP and ECAP (COM-SHARE) Systems

The ECAP and ECAP (COM-SHARE) programs are essentially the same. The basic difference between the two is that ECAP is located on the IBM 360 computer and programs are processed in the same manner as with the SCEPTRE system, while ECAP (COM-SHARE) is located on a computer in Ann Arbor, Michigan, and programs are processed on time sharing terminals at Bendix Kansas City.

AC, DC, and transient analyses can be performed by the ECAP program while ECAP (COM-SHARE) will complete only AC and transient analyses. With each type of analysis, the engineer must perform six steps similar to those outlined under the earlier discussion of the SCEPTRE system.

The user is then ready to write the ECAP program, as with SCEPTRE, for six sections of the program format. Except where noted in the discussion to follow, the headings are the same for both the ECAP (COM-SHARE) programs.

Format of ECAP and ECAP (COM-SHARE) Systems

- A. TYPE OF ANALYSIS TO BE PERFORMED
- B. CIRCUIT DESCRIPTION
- C. TYPE OUTPUT REQUIRED
- D. EXECUTE COMMAND
- E. MODIFICATION
- F. END

Section A would state the type of analysis desired, consistent with the capabilities already stated for the ECAP and ECAP (COM-SHARE) systems.

Section B contains the description of the circuit to be analyzed. Unlike SCEPTRE, ECAP does not contain a stored model section, and non-linear devices must be programmed as equivalent circuits and placed in section B. If more than one transistor or diode exists in the circuit, each must be programmed.

Section C gives the type of output information required of the program. Table 1 gives the types of outputs that may be requested.

Section D directs the computer to start execution of the program.

Section E is used for modifications of the master program to sections B or C. Such modifications require statement of the following.

MODIFY
DESCRIPTION OF MODIFICATION
EXECUTE

The computer will then insert the description of the modification into the main program and execute the program as modified.

Section F is used to terminate the program.

Table 1. Types of Outputs Which May be Requested With ECAP Program

DC Analysis	AC Analysis	Transient Analysis
Node voltage	Node voltage	Node voltage
Element current	Element current	Element current
Element voltage	Element voltage	-----
Branch current	Branch current	-----
Branch voltage	Branch voltage	-----
Element power loss	Element power loss	-----
Sensitivity	-----	-----
Worse case analysis	-----	-----
Standard deviation	-----	-----

Shown in Figure 5 is an exemplary circuit set up for programming and running on ECAP (COM-SHARE).

Figure 5. Example of Circuit Set Up for Use on ECAP (COM-SHARE) Program

The equivalent circuit for transistor T1 is shown in Figure 6. The engineer may add details to the circuit as necessary.

Figure 6. Equivalent Circuit for Transistor T1

Figure 7 shows the circuit resulting after the equivalent circuit of transistor T1 was incorporated in the circuit of Figure 5. In Figure 7 all components, branches, and nodes are identified. The circled numbers identify the nodes; the element branches between the nodes are identified by B-prefix numbers. In ECAP the ground nodes are represented by circled zeros (0). Current direction is selected from the first node to the second node named, as shown in Figure 8.

The program resulting when the circuit shown in Figure 7 was run on ECAP (COM-SHARE) is given in the Appendix. AC analysis was used and the output requested was NODE VOLTAGE and CURRENT.

Although there are some differences between the ECAP and SCEPTRE systems, the basic program format is the same for both. Furthermore, the format was found to be the same in all the CAD programs reviewed. Familiarity with one system therefore is basic to the use of another; only minor peculiarities of the system must be learned to use a new system.

CODED CAP (COM-SHARE) System

The principles governing the use of the SCEPTRE and ECAP programs also apply to circuit analysis by the CODED CAP (COM-SHARE) system. The programs which can be run on the CODED CAP system are more limited, however, in size and variety.

Figure 7. ECAP (COM-SHARE) Program Incorporating Equivalent Circuit for Transistor T1

B1, N(1,2), R = 5E3

B1 = Branch Identification
N(1,2) = Node Identification
R = 5E3 is Element Identification

Figure 8. Current Direction

ACCOMPLISHMENTS

The CAD programs investigated make available to the test equipment design engineer an extended capability to perform various circuit analyses. The following conclusions were drawn about the SCEPTRE, ECAP, ECAP (COM-SHARE), and CODED CAP (COM-SHARE) programs.

- The SCEPTRE system accepts a larger program than do ECAP and CODE-CAP systems. The capacity of the SCEPTRE system is 300 nodes, 300 branches, and 50 mutual inductors. Table 2 provides additional comparison of the four systems.
- The engineer who has some experience in programming can write his own subprograms internal to the main SCEPTRE program. The subprograms may or may not be related to the circuit being analyzed. This advantage is not offered by the ECAP and CODED CAP programs.
- Mathematical equations describing types of circuits can be inserted in the SCEPTRE program. The advantage offered by this feature is demonstrated by the stored model descriptions in which equations more effectively describe a circuit than do the piece-wise equivalent circuits required with the ECAP and CODED CAP systems.
- The SCEPTRE system provides a section for stored models of transistors and diodes, a feature which eliminates the need for programming such discrete components more than once and permits use of the programs as often as necessary. With the SCEPTRE system, the more common transistors and diodes are already programmed in a library and ready for application. The circuit descriptions written for the ECAP and CODED CAP programs must include equivalent circuits for each transistor or diode used.
- The SCEPTRE system will simulate the effects of radiation on non-linear components such as transistors and diodes, a feature not offered by the ECAP and CODED CAP systems.
- A disadvantage of the SCEPTRE system is that it will not perform AC analysis directly; however, AC analysis can be obtained with SCEPTRE by using the transient analysis offered by the SCEPTRE format. Direct AC analysis can be performed with both the ECAP and CODED CAP systems.
- The ECAP (COM-SHARE) and CODED CAP (COM-SHARE) systems offer the following advantages over the sceptre and ECAP systems

Table 2. Comparison of Four CAD Programs

Functions	SCEPTRE	ECAP	ECAP (COM-SHARE)	CODED-CAP
Types of Analysis	DC steady state, transient analysis	DC, AC, transient analysis	AC, transient analysis DC*	DC**, AC, Transient analysis
Elements	Resistors, capacitors, inductors, voltage source, current source, mutual inductance, time	Resistors, capacitors, inductors, voltage source, current source, mutual inductance, frequency, time, power angle	Same as ECAP	Resistor, capacitors, inductors, voltage sources, current source, diodes, open, short
Number of Nodes	300	51	51	25
Number of Branches	300	200	200	60
Number of Mutual Inductors	50	25	25	None
Number of Equations	80	None	None	None
Models (Transistor, Diodes)	Models may be stored either temporarily or permanently	None Equivalent circuit in program	None Same as ECAP	None Same as ECAP
<p>*A DC run may be made if frequency is made very small; that is, frequency = $1\text{E}1 \times 10^{-6}$ Hz.</p> <p>**A DC run may be made if frequency is set to zero.</p>				

- Direct control of the program by the engineer--Programming can be completed from any one of several teletype stations located throughout the Bendix plant. Corrections may be made to the program at any time. Reduced turnaround time--When the program is complete, the off-site computer will transmit the results to the teletype while the engineer waits. The engineer can then terminate the program or continue to work with the computer.
- Ease of making program modifications--If the computer has been programmed incorrectly, errors are indicated so that the proper modifications can be made and the problem resubmitted.

The factors guiding the engineer in the selection of the system best suited for a particular problem are problem size, type of analysis desired, and the time required for obtaining a solution. If the problem is small, the engineer can use a COM-SHARE program, but as the size of the program and non-linear elements increase the user must go to ECAP or SCEPTRE systems.

FUTURE WORK

No further activity is planned for this project at this time.

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REFERENCES

¹Computer-Aided Design of Electronic Products, IITRI Proposal No. 69-302E, January, 1969.

²SCEPTRE User's Manual, International Business Machines Corporation, Contract No. F29601-67C-0049, Technical Report No. AFWL-TR-67-123, pp. 1 - 2.

³Ibid., pp. 7-8.

⁴Transistor and Diode Model Handbook, W. A. Cordell, Technical Report No. AFWL-TR-69-44, Vol. 1.

⁵SCEPTRE User's Manual, pp. 71-75.

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Appendix

Program Run on ECAP (COM-SHARE) System

```

C
C
C   COMMON EMITTER AMPLIFIER ON ECAP (COM-SHARE)
C
C   AC ANALYSIS
C
C
B1 N(0,1),R=1E-6, E=20E-3
B2 N(4,1),C=5E-6
B3 N(1,0),R=1E3
B4 N(1,0),R=6E3
B5 N(2,0),R=2E3
B6 N(3,0),R=500
B7 N(3,0),C=60E-6
B8 N(1,3),R=350
B9 N(2,3),R=11.1E3
B10 N(2,5),C=5E-6
B11 N(5,0),R=10E3
T1 B(8,9),BETA=50
FREQUENCY=1000
PRINT, VOLTAGES, CURRENT
EXECUTE
END

EXECUTE?   YES PLEASE

OPENING FILE 3 FOR OUTPUT, NAME: TEL

EXECUTION

FREQ = .10000000E 4

      NODES          NODE VOLTAGES

MAG   1- 4   .200000E- 1   .391678E 1   .637705E- 2   .200000E- 1
PHA   1- 4   -.493789E- 7   -.161421E 3   -.710870E 2   -.493789E- 7

MAG   5- 5   .391676E 1
PHA   5- 5   -.161238E 3

      BRANCHES        ELEMENT CURRENTS

MAG   1- 4   .766553E- 4   .714315E-14   .200000E- 4   .333333E- 5
PHA   1- 4   .129945E 2   .900000E 2   -.493789E- 7   -.493789E- 7

MAG   5- 8   .195839E- 2   .127541E- 4   .240409E- 2   .540587E- 4
PHA   5- 8   -.161421E 3   -.710870E 2   .189130E 2   .185932E 2

MAG   9-11   .235007E- 2   .391676E- 3   .391676E- 3
PHA   9-11   .186094E 2   -.161238E 3   -.161238E 3

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