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SEMCON: A SEMICONDUCTOR DAMAGE DATA REDUCTION COMPUTER CODE.(U)
DEC 76 J M CLODFELTER
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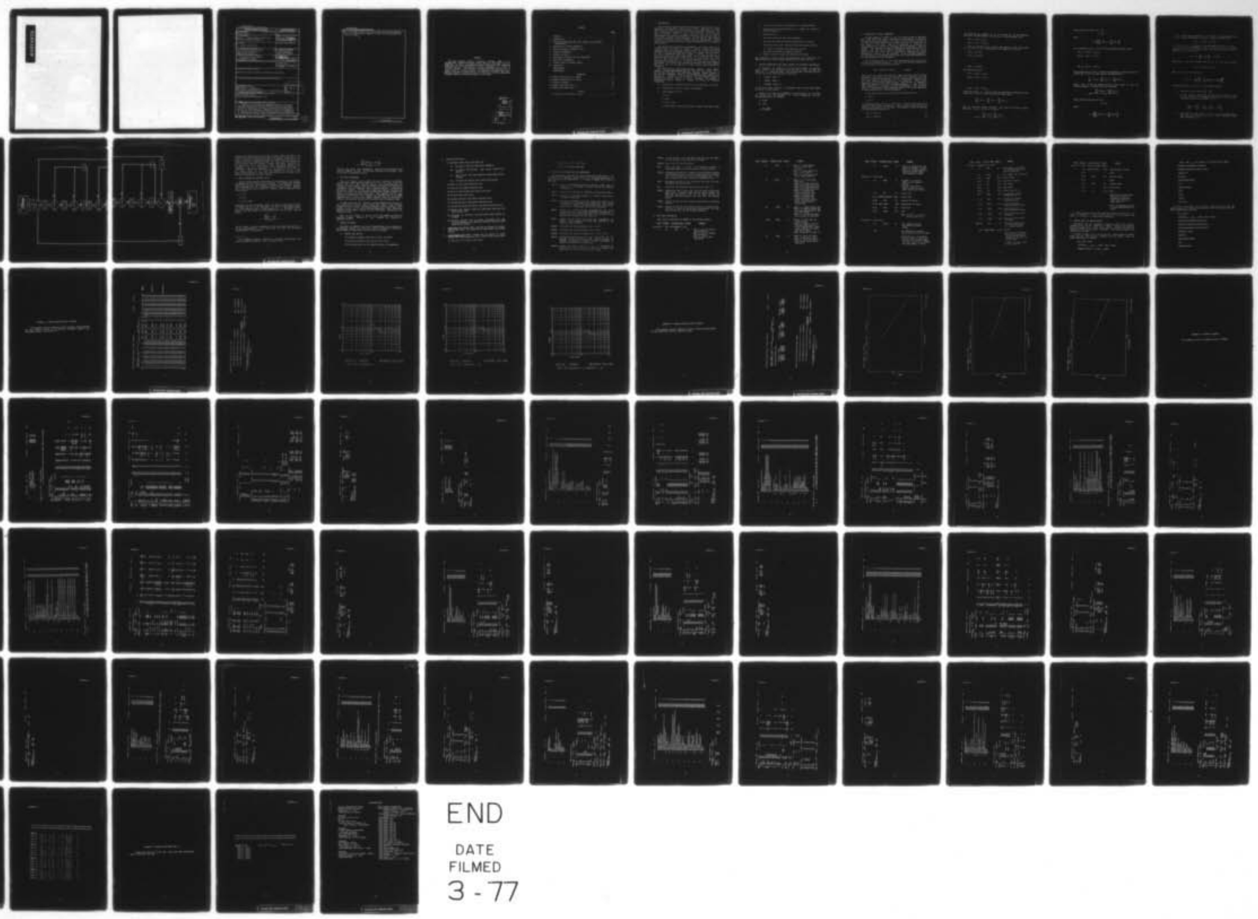

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SEMCON is a semiconductor damage-data-reduction computer code that analyzes various semiconductor devices. The code evaluates semiconductor devices by giving the following information: (1) determination of damage--the failure or nonfailure of a device; (2) calculation of power, energy, and impedance; (3) least-squares fits of specific damage curves to chosen data; (4) selection of the best least-squares fit; and (5) log-log →

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) plots of least-squares fits. This report details the development and capabilities of SEMCON, as well as the procedures for using the code.

FOREWORD

The Army Multiple Systems Evaluation Program (MSEP) is a comprehensive program developing general analytic techniques for the prediction of high electromagnetic-pulse vulnerability and hardening technology and for the application of these techniques to a list of critical systems. The analytic techniques have been verified for a large class of tactical systems. The hardening techniques have been applied to specific systems and are now resulting in product improvement programs leading to hardened equipment in the field.

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APPENDICES

FIGURE

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1. INTRODUCTION

This effort was written under the sponsorship of the Multiple Systems Evaluation Program (MSEP), which has as its main objective to harden Army tactical systems to the electromagnetic pulse (EMP) associated with the exoatmospheric detonation of a nuclear weapon. Along with this major objective, MSEP is tasked also with the aim to develop experimental and analytical evaluation techniques that are applicable to all systems' problems. These objectives are satisfied, since SEMCON provides an analytic method to examine various semiconductor devices used in Army systems and assists in making recommendations for hardening modifications.

When making EMP vulnerability assessments, it is often necessary to perform a circuit analysis on specific circuits driven by a voltage induced by EMP. This analysis often points out a large power value produced on various semiconductor devices that could cause the devices to fail if sufficient power were present. However, to know if a particular device fails and at what power level, a semiconductor device must be analyzed and a damage curve fitted to certain data. This curve gives a good indication as to the vulnerability of the device to particular thresholds of power. Therefore, the main purpose of computer code SEMCON is to provide the necessary information about semiconductor devices so that it is possible to make various EMP vulnerability assessments.

The semiconductor damage-data-reduction computer code, SEMCON, analyzes various semiconductor devices. The code was written for a Control Data Corporation (CDC) 6600 series computer system located at the Mobility Equipment Research and Development Center (MERDC), Fort Belvoir, VA. Written to run employing the FTN compiler, SEMCON is operational using the SCOPE 3.4.3 control language. To evaluate a semiconductor device, SEMCON is capable of giving the following information:

a. Determination of damage--the failure or nonfailure of a device

b. Calculations of power, energy, and impedance

c. Least-squares fits of

$p = at^{-1}$,

$p = bt^{-\frac{1}{2}}$,

$p = at^{-1} + bt^{-\frac{1}{2}}$

to either power versus failure time or power versus pulse width

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d. Selection of the best least-squares fit to specified data

e. Log-log plots of least-squares fits in either the forward or reverse direction

f. Log-log plots of

TD versus Z--failure time versus impedance

TD versus VOC--failure time versus open-circuit voltage

TDOC versus VOC--pulse duration versus open-circuit voltage

TD versus IP--failure time versus peak current

in either the forward or reverse direction

g. Tabular listing of input data and all calculations

The subsequent sections detail the development and capabilities of SEMCON, along with the necessary information to utilize the code.

2. FAILURE DETERMINATION AND POWER, ENERGY, AND IMPEDANCE CALCULATIONS

To determine the damage on a particular pulse number, the specific values used in the calculations are (1) VZBP and VZAP, (2) VZBN and VZAN, and (3) GAINB and GAINA. The criteria used to determine failure are any one of the following three conditions:

a. .8*VZBP - VZAP > 0

b. .8*VZBN - VZAN > 0

c. .8*GAINB - GAINA > 0

If any one of these conditions is satisfied, then for that pulse number the device is said to fail.

Another of the features of SEMCON is the calculations of the power (P), energy (E), and impedance (Z). These computations are very straightforward and are found by

$$P = VP*TD,$$

$$E = P*TD,$$

$$Z = \frac{VP - VZBP}{IP} .$$

3. DERIVATION OF FITTING PARAMETERS

The main purpose of SEMCON is to fit various curves to specified data. They are fit by using the method of least squares to calculate the various fitting parameters. The plots of these curves, as well as the data, are scaled logarithmically, since there can be a wide range in the values of the data. Thus, it is necessary to calculate the least-squares fits in terms of logarithms, which introduces a nonlinear problem. Two methods are used to calculate the least-squares fits in SEMCON. One uses the minimizing conditions known as the normal equations, and the other uses a minimization technique to find the minimum of a function of two variables. In the following paragraphs, the two methods are explained fully along with a detailed derivation of the least-squares fitting parameters.

The first method used to find the least-squares fits involves the solution of the normal equations. This technique involves substituting the n data pairs into the fitting equation.

$$f(x) = a_1\phi_1(x) + a_2\phi_2(x) + \dots + a_k\phi_k(x),$$

where $\phi_i(x)$ are known functions of x, and a_i are the k linear fitting parameters, thus obtaining n linear equations with k unknowns. The next step is to multiply each equation by its corresponding coefficient of the first unknown, which results in n new equations. Adding these equations gives the first normal equation. This process is repeated k times with respect to each of the unknown parameters, so that we end up with k equations in k unknowns (the fitting parameters). The resulting system of simultaneous linear equations, known as the normal equations, is then solved for the k fitting parameters.

In our particular case, we wish to use this method to fit

$$p = at^{-1},$$

$$p = bt^{-1/2}$$

to experimental data, where p is the power, t is the failure time, and a and b are the fitting parameters. Since plots are desired that are scaled logarithmically, we must find the parameters a and b by applying the least-squares technique to

$$\log p = \log at^{-1}, \tag{1}$$

$$\log p = \log bt^{-1/2}. \tag{2}$$

All logarithms are assumed to be to the base 10. By the elementary properties of logarithms, we clearly have a linear problem, since

$$\log p = \log a - \log t,$$

$$\log p = \log b - \tfrac{1}{2} \log t.$$

First, we consider $\log p = \log at^{-1}$ and suppose we have n data pairs (t_i, p_i) for $1 \le i \le n$. Substituting into equation (1), we get

$$\log p_1 = \log at_1^{-1},$$

$$\log p_2 = \log at_2^{-1},$$

$$\vdots$$

$$\log p_n = \log at_n^{-1},$$

and simplifying gives

$$\log p_1 = \log a - \log t_1,$$

$$\log p_2 = \log a - \log t_2,$$

$$\vdots$$

$$\log p_n = \log a - \log t_n.$$

Since this system is linear in terms of logarithms, multiplying by the coefficient of log a in each equation and adding gives

$$\sum_{i=1}^{n} \log p_i = \sum_{i=1}^{n} \log a - \sum_{i=1}^{n} \log t_i.$$

This is the only normal equation, since there is only one fitting parameter. Solving for log a, we obtain

$$\log a = \frac{\sum_{i=1}^{n} \log p_i + \sum_{i=1}^{n} \log t_i}{n},$$

which gives the solution for a as

$$a = 10^x ,$$

where

$$x = \frac{1}{n}\left(\sum_{i=1}^{n} \log p_i + \sum_{i=1}^{n} \log t_i\right).$$

Now, considering $\log p = \log bt^{-\frac{1}{2}}$ and proceeding as above, we get

$$\log p_1 = \log b - \tfrac{1}{2} \log t_1 ,$$

$$\log p_2 = \log b - \tfrac{1}{2} \log t_2 ,$$

$$\vdots$$

$$\log p_n = \log b - \tfrac{1}{2} \log t_n .$$

This system also is linear in terms of logarithms, so multiplying by the coefficient of log b in each equation and adding gives

$$\sum_{i=1}^{n} \log p_i = \sum_{i=1}^{n} \log b - \tfrac{1}{2} \sum_{i=1}^{n} \log t_i .$$

Again, this is the only normal equation, since there is only one fitting parameter. Solving for log b, we obtain

$$\log b = \frac{\sum_{i=1}^{n} \log p_i + \tfrac{1}{2} \sum_{i=1}^{n} \log t_i}{n} ,$$

which gives the solution for b as

$$b = 10^y ,$$

where

$$y = \frac{1}{n}\left(\sum_{i=1}^{n} \log p_i + \tfrac{1}{2} \sum_{i=1}^{n} \log t_i\right) .$$

The second method employed to calculate the least-squares fits involves finding a minimum of a function. Suppose we want to fit

$$f(x) = a_1\phi_1(x) + a_2\phi_2(x)$$

to n data points, where $\phi_1(x)$, $\phi_2(x)$ are known functions of x, and a_1, a_2 are the fitting parameters. Let $\bar{f}_i = \bar{f}(x_i)$ for $1 \le i \le n$ be the experimental data that we wish to fit. Then by the principle of least squares, we want to minimize

$$F(a_1, a_2) = \sum_{i=1}^{n} w(x_i)\left[\bar{f}_i - f(x_i)\right]^2,$$

where $w(x_i)$ is the weight function for each x_i. For our case, we choose

$$w(x_i) = 1 \text{ for } 1 \le i \le n.$$

Thus, we must find the minimum of

$$F(a_1, a_2) = \sum_{i=1}^{n} \left\{\bar{f}_i - \left[a_1\phi_1(x_i) + a_2\phi_2(x_i)\right]\right\}^2 .$$

To find the minimum, we proceed in the following manner:

a. Start with initial values $a_1^{(0)}$, $a_2^{(0)}$.

b. At the ith step, halve $a_1^{(i)}$, and try to step first in the positive and then in the negative x-direction, to see if either resulting value gives a minimum, i.e.,

$$F\left[a_1^{(i)} \pm \frac{a_1^{(i)}}{2^j}, a_2^{(i)}\right] < F\left[a_1^{(i)}, a_2^{(i)}\right] .$$

c. Halve $a_2^{(i)}$, and try to step first in the positive and then in the negative y-direction, to see if either resulting value gives a minimum, i.e.,

$$F\left[a_1^{(i)},\ a_2^{(i)} \pm \frac{a_2^{(i)}}{2^j}\right] < F\left[a_1^{(i)},\ a_2^{(i)}\right].$$

d. If neither (b) nor (c) gives a minimum halve $a_1^{(i)}$ and $a_2^{(i)}$ again, and repeat (b) and (c), i.e., $j = 2$.

e. If a minimum results from either (b) or (c), then let

$$a_1^{(i+1)} = a_1^{(i)} \pm \frac{a_1^{(i)}}{2^j},\quad a_2^{(i+1)} = a_2^{(i)},\ \text{if only (b) holds,}$$

$$a_2^{(i+1)} = a_2^{(i)} \pm \frac{a_2^{(i)}}{2^j},\quad a_1^{(i+1)} = a_1^{(i)},\ \text{if only (c) holds,}$$

$$a_1^{(i+1)} = a_1^{(i)} \pm \frac{a_1^{(i)}}{2^j},\quad a_2^{(i+1)} = a_2^{(i)} \pm \frac{a_2^{(i)}}{2^j},\ \text{if (b) and (c) hold,}$$

and check

$$\left| F\left[a_1^{(i+1)},\ a_2^{(i+1)}\right] - F\left[a_1^{(i)},\ a_2^{(i)}\right] \right| < \varepsilon, \qquad (3)$$

(3)

where ε is a chosen convergence tolerance. If equation (3) holds, then

$$a_1 + a_1^{(i+1)},\quad a_2 = a_2^{(i+1)}$$

are the fitting parameters. If equation (3) does not hold, the process is repeated.

This technique is very simple and always leads to a minimum although it may be only a local minimum. If a local minimum is reached which is not close to the true minimum, then it seems reasonable to assume that the least-squares fit will be poor. Thus, when the fit is bad, it could probably be attributed to this distant local minimum, although there are other occurrences that could cause a bad fit. The only solution to this problem is to try the minimization technique again with different initial values. A repetition of this process leads to the true minimum of the function $F(a_1, a_2)$. The above technique was limited to two fitting parameters, but it is an easy matter to extend this method to k parameters.

For our purpose, we wish to use this method to fit

$$p = at^{-1} + bt^{-\frac{1}{2}} \tag{4}$$

to experimental data $(t_i, \bar{p}_i)$ for $1 \leq i \leq n$, where p is the power, t is the failure time, n is the number of data points, and a and b are the fitting parameters. This poses a nonlinear problem, since log $(at^{-1} + bt^{-\frac{1}{2}})$ cannot be linearized as was log (at^{-1}) and log $(bt^{-\frac{1}{2}})$. This problem is easily overcome by using the minimization technique described above. Let

$$P(t;\ a,b) = \log\ (at^{-1} + bt^{-\frac{1}{2}}),$$

and we want to minimize

$$S(a,b) = \sum_{i=1}^{n} w(t_i) \left[\log \bar{p}_i - P\left(t_i;\ a,b\right)\right]^2 ,$$

where $w(t_i)$ is the weight function for each t_i. Since we choose

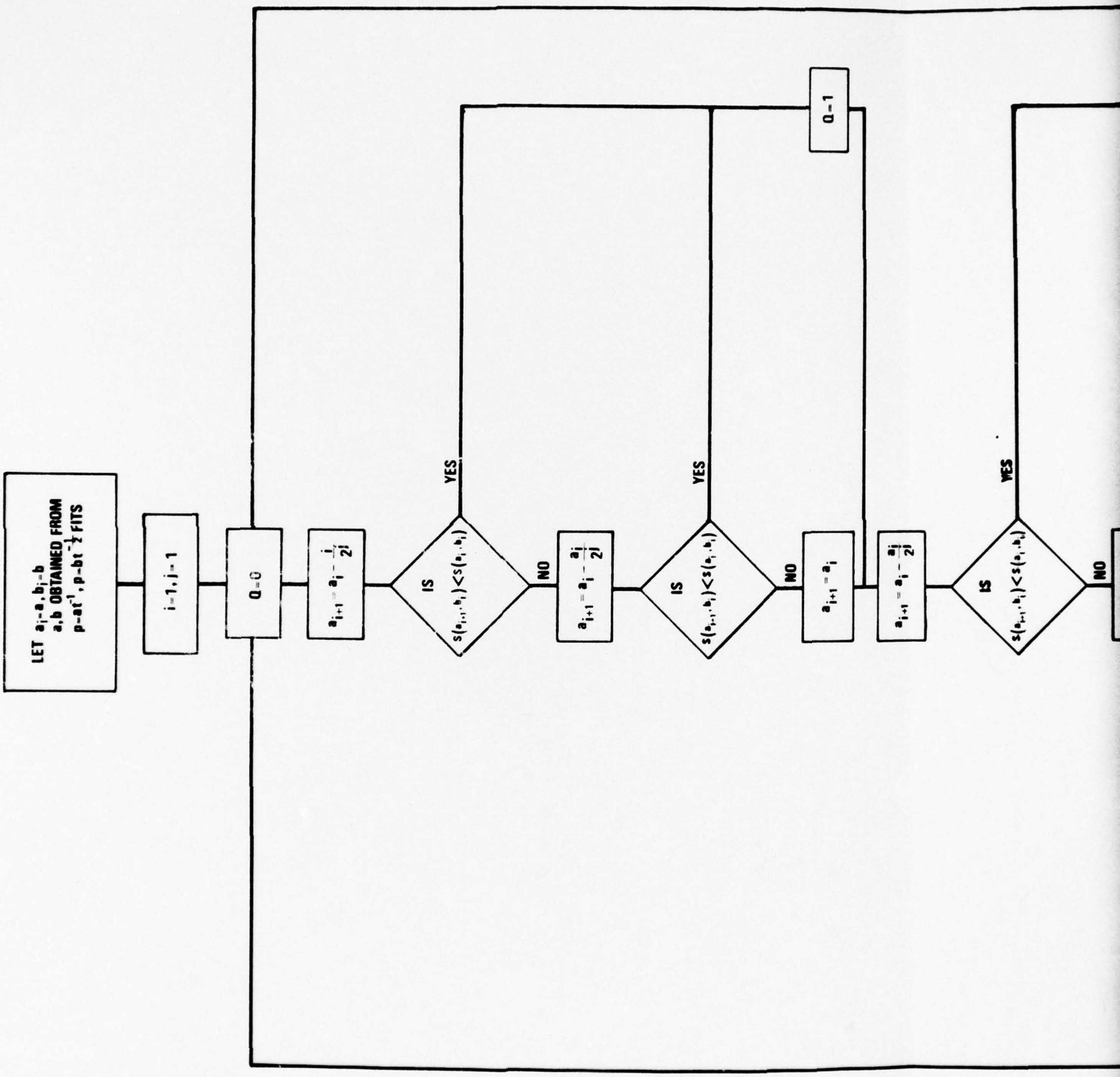
$$w(t_i) = 1 \quad \text{for } i = 1, 2, \ldots n,$$

we must minimize

$$S(a,b) = \sum_{i=1}^{n} \left[\log \bar{p}_i - \log\left(at_i^{-1} + bt_i^{-\frac{1}{2}}\right)\right]^2 .$$

The minimization for S(a,b) is identical to the minimization technique given above. A flow chart for finding the minimum of S(a,b) and thus the fitting parameters a and b is given in figure 1.

Although the techniques outlined above are simple and straightforward, caution should be taken when interpreting the least-squares fits. First, the fits are only as good as the data. Poorly taken and recorded data result in meaningless fits. Probably the major fault with least squares is that a single very wrong measurement greatly distorts the results, because in the squaring process, large



LET a_i=a, b_j=b
a,b OBTAINED FROM
p=at^-1, p=bt^-1/2 FITS
i=1, j=1
Q=0
IS
YES
NO
Q=1

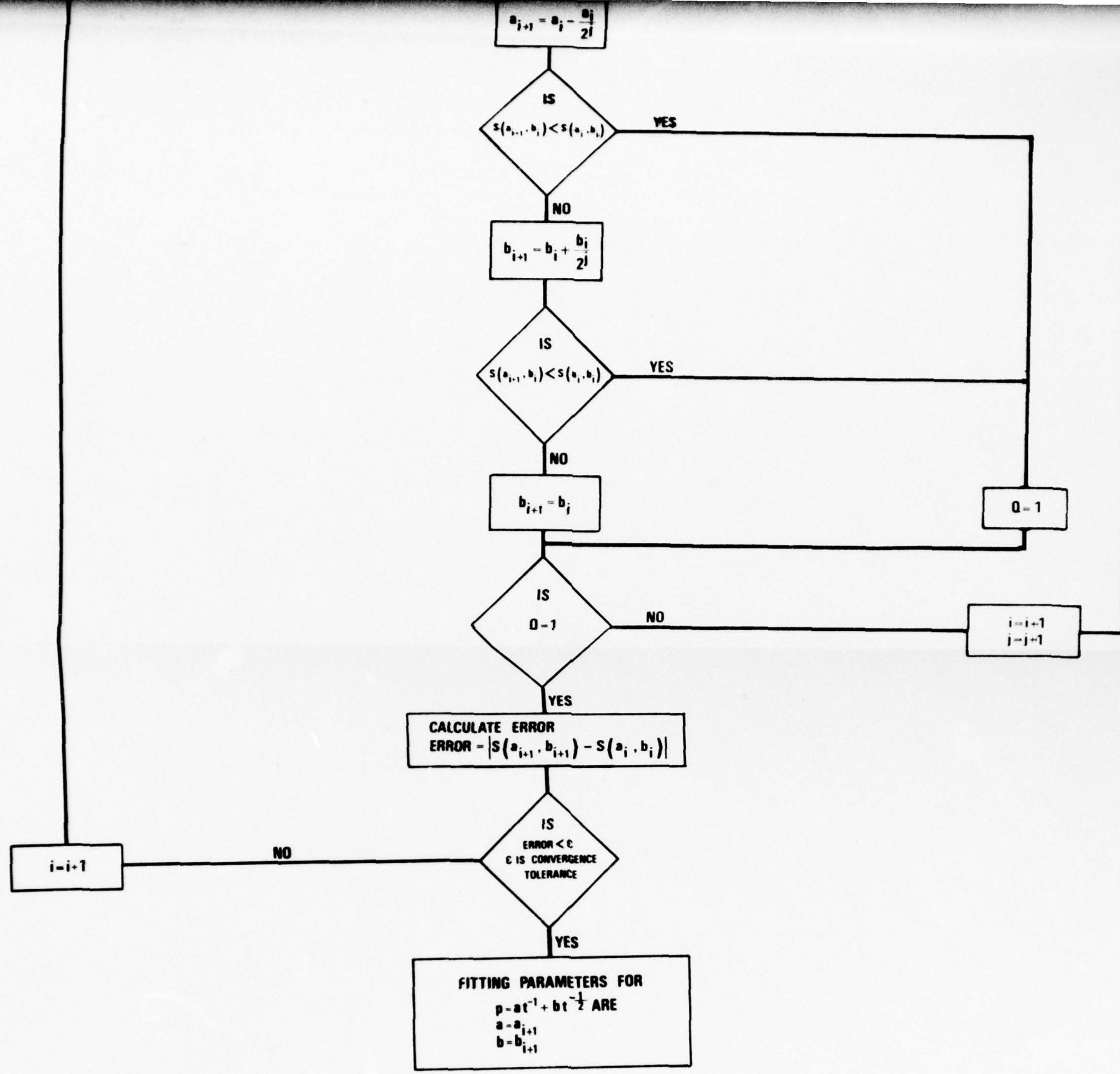


Figure 1. Flow chart for minimizing S(a,b).

residuals are dominant--one gross error 10 times larger than most of the others has the same effect in the sum of the squares as have 100 of the others.[1] Second, a considerable amount of mathematical and statistical sophistication can be employed to give the fits much more reliability when the proper data are involved. Several statistical techniques can be applied to these least-squares fits that would enhance their assurance. One is a statistical test of hypothesis concerning the confidence in the fitting parameters a, b in equations (1),(2), and (4). The other would be to test the goodness of fit by using the χ^2 statistical test. These two techniques can be utilized to make SEMCON's least-squares fits more reliable.

4. GAUSS CRITERION OF GOODNESS OF FIT

One of the main questions pertaining to least-squares fits concerns the goodness of fit of the curve to the data. This problem can be dealt with when using the least-squares technique, and probably the most widely used method is the χ^2 goodness of fit statistical test. Although the χ^2 test has not been utilized in SEMCON, a test to determine which of the curves

$$p = at^{-1}$$

$$p = bt^{-1/2}$$

$$p = at^{-1} + bt^{-1/2}$$

best fits the data is applied. This test, known as the Gauss criterion of goodness of fit, is now explained. Let $\bar{p}_i$ be an experimental value, p_i a value computed from a least-squares fit, n the number of data points, and m the number of fitting parameters in the relation. Then we define

$$\Omega = \frac{\sum_{i=1}^{n}\left(\bar{p}_i - p_i\right)^2}{n - m} ,$$

and the Gauss criterion of goodness of fit states that the best fit is the one that minimizes Ω. Since the plots of these fits are scaled logarithmically, we calculate

[1] *R. W. Hamming, Numerical Methods for Scientists and Engineers, 2nd edition, McGraw-Hill Book Co., Inc., New York (1973).*

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$$\Omega = \frac{\sum_{i=1}^{n} \left(\log \bar{p}_i - \log p_i\right)^2}{n - m}$$

and find the curve that minimizes Ω. Values of Ω are printed in the output of SEMCON, as well as the curve that best fits the data. This can be seen in appendices A and B.

5. PLOTTING INFORMATION

There are several ways to obtain the plots generated by SEMCON. Through MERDC, SEMCON has the capability to use a Cal Comp model 835 cathode ray tube (CRT) plotting system. This system takes plotting information from a magnetic tape and converts the data to be plotted to incremental plotter commands, which produce discrete, electron-beam deflections (relative to the x and y axes) and intensity variations on the face of a CRT. The CRT display is transmitted through a camera lens system and recorded on 35-mm microfilm. The exposed film is then processed, and the plots are recorded on a magnetic tape at the MERDC computer center. A call to the MERDC computer center is necessary to initiate the hard-copy processing of the plots from the magnetic tape.

In addition to the CRT plotting system, SEMCON has the ability to use a Mohawk Data Sciences (MDS) model 2400 remote batch terminal accompanied with a Houston Instruments COMPLOT plotting system. This system, located at the Harry Diamond Laboratories (HDL) Woodbridge Research Facility (WRF), enables all plots and output information to be received on site.

Each of the methods to obtain plots from SEMCON has different plotting software. Examples of this software are contained in appendices A and B.

6. OPTIONS OF SEMCON

The output of SEMCON can be varied substantially, so an analysis of the possible options for outputing various information is essential. The following is a description of the options available.

a. Tabular data options

(1) Listing of tabular data only--no plots are given.

(2) Listings of tabular data and plots are given.

(3) Plots are given, but the tabular listing is suppressed.

b. Plotting selections

(1) Available items versus item plots are

(a) TD versus Z--failure time versus impedance

(b) TD versus VOC--failure time versus open-circuit voltage

(c) TDOC versus VOC--pulse duration versus open-circuit voltage

(d) TD versus IP--failure time versus peak current.

(2) Plots in the reverse direction only

(3) Plots in the forward direction only

(4) Plots in both forward and reverse directions

(5) No item versus item plots

(6) Reverse direction item versus item plots only

(7) Forward direction item versus item plots only

(8) Forward and reverse direction item versus item plots only

(9) Forward and reverse direction item versus item plots and least-squares fits

(10) Plots may be received on the MDS remote batch terminal or at MERDC.

(11) Plotting software may be either the regular Cal Comp plotting software or the software available through the MDS remote batch terminal.

c. Input data--The regular input data may be entered or a simpler form of input data that requires only pulse width versus power entires.

d. Least-squares fits--Three curves may be fitted to either failure time (TD) versus power (P) or pulse width versus power.

(1) Fit to $p = at^{-1}$ and $p = bt^{-\frac{1}{2}}$ only.

(2) Fit to $p = at^{-1} + bt^{-\frac{1}{2}}$ only.

(3) Fit to all three equations.

7. DESCRIPTION OF SEMCON AND ITS SUBROUTINES

The SEMCON code consists of a main program and 19 subroutines. The documentation of SEMCON is detailed by the following analysis of the main program and its subroutines. A listing of SEMCON can be found in appendix C.

SEMCON reads in the data and writes the tabular output seen in appendix A. It also makes the power, energy, and impedance calculations.

FAILUR calculates the failure or nonfailure of each pulse number.

FRFAIL separates the data with respect to failure in the reverse or forward directions.

DIRECT sets up the variables T and PP, which are used in the calculations of the three least-squares fits, with respect to either the forward or reverse direction. Also, DIRECT chooses which least-squares fit will be calculated.

WRITE outputs the various fitting parameters for the chosen least-squares fit. Also, some other useful information is written, such as the curve that best fits the data and the minimum of the function S(a,b) (sect. 4).

PLOTT contains all the plot titles and axes information and labels. This subroutine initiates the plotting of all curves by calling PWRITE.

ALSQAR calculates the fitting parameter for $p = at^{-1}$.

BLSQAR calculates the fitting parameter for $p = bt^{-\frac{1}{2}}$.

ABLSQAR calculates the fitting parameters for $p = at^{-1} + bt^{-\frac{1}{2}}$.

PWRITE performs the plotting using the Cal Comp model 835 CRT plotting system by calling the WRF library routines in TALPLOT. The subroutines SELPLOT, TALGRAF, and TALDATA of TALPLOT are referenced in PWRITE only.

SELPLOT selects the beam intensity of the Cal Comp model 835 microfilm plotter and also enables the user to choose if he wants the plots sent to the MDS system at WRF.

TALGRAF sets up the plot axes and labels and specifies the number of sets of data to be plotted on one graph.

TALDATA plots a set of (x,y) data pairs.

SORT sorts the data in array T of subroutine DIRECT in increasing order so that the plotting is done correctly.

GOODFIT calculates the sum of the squares of the difference between the experimental value and the corresponding value computed from a least-squares fit for each least-squares fit. This sum is used in the Gauss criterion of goodness of fit.

GAUSS Determines the best fit for the data by the Gauss criterion and outputs the correct fit.

SAB calculates the functional values of S(a,b) (sect. 4).

OWNDAT enables the user to enter only data for pulse width versus power input. It outputs these data by calling COLMNS and makes the appropriate calls to the other routines to calculate the least-squares fits and make the desired plots.

COLMNS outputs the data for pulse width versus power in increasing columns.

CHANGE changes the abscissa and ordinate titles to correspond with the use of data for pulse width versus power. It also enters those data into the plotting software.

8. DATA INPUT PREPARATION

Input cards are prepared for SEMCON in the following manner.

Card	Columns	Variable name	Format	Comment
Card set 1: Plot and parameter card				
1	10	IND	I1	IND = 1, plot in reverse direction only IND = 2, plot in forward direction only IND = 3, plot in both directions

Card	Columns	Variable name	Format	Comment
1	20	FLAG	I1	FLAG = 1, least-squares fit to $p = at^{-1}$ and $p = bt^{-1/2}$ FLAG = 2, least-squares fit to $p = at^{-1} + bt^{-1/2}$ FLAG = 3, least-squares fit to all three equations
	30	IPRAM	I1	IPRAM = 0, no item versus item plots IPRAM = 1, reverse direction item versus item plots only IPRAM = 2, forward direction item versus item plots only IPRAM = 3, forward and reverse direction item versus item plots only IPRAM = 4, forward and reverse direction item versus item plots and all curves as specified by IND and FLAG
	40	ISTOP	I1	ISTOP = 1, tabular output only ISTOP = 2, tabular output and all output designated by IND, FLAG, and IPRAM ISTOP = 3, no tabular output, but all plots as indicated
	49-50	IPLOT	I2	IPLOT = 0, plots come out on MDS system IPLOT = K, where 1 < K < 36 indicates beam intensity of Cal Comp plotter; a good value is IPLOT = 18; plots come out at MERDC NOTE: ITYPE must be equal to 0.
	60	ISEM	II	ISEM = 0, enter all input data in card sets 3 and 4 ISEM = 1, enter only pulse width versus power data on card set 5

Card	Columns	Variable name	Format	Comment
1	70	ITYPE	II	ITYPE = 0, regular Cal Comp plotting software is used ITYPE = 1, plotting software available on MDS remote batch terminal is used

Card set 2: Title card

Card	Columns	Variable name	Format	Comment
2	1-3	NUMB	I3	If ISEM = 0 on card 1, NUMB is total number of devices If ISEM = 1 on card 1, NUMB is number of pulse width versus power points
	4-11	DEV	A8	Device name
	12-31	DEVTYP1,DEVTYP2	2A10	Device type
	32-40	JUNC	A9	Junction of device
	41-60	MAN1, MAN2	2A10	Manufacturer of device
	61-70	TECH	A10	Technician
	71-80	DATEE	A10	Date

NOTE: If ISEM = 1 on card 1, skip to card set 5.

Card set 3: Pulse card

Card	Columns	Variable name	Format	Comment
3	1-2	NPULS	I2	Total number of pulses for particular device number
	3-80	-	-	Any comments or notations may be placed in these columns

NOTE: Card set 3 is repeated as many times as indicated on card set 2 for variable NUMB, and thus card set 4 is repeated this same number of times.

Card	Columns	Variable name	Format	Comment
Card set 4: Parameter value cards				
4	1-3	NDEV	I3	Device number; total number of repetitions of this card must not exceed 600
	4-5	PULSE	I2	Pulse number; not to exceed 99
	6-15	TDOC	E10.3	Pulse duration
	16-25	VOC	F10.3	Open-circuit voltage
	26-35	VP	F10.3	Peak voltage
	36-45	IP	F10.3	Peak current
	46-55	TD	E10.3	Failure time (TD ≠ 0)
	56-65	VZBP	F10.3	Voltage before forward breakdown voltage
5	1-10	VZAP	F10.3	Voltage after forward breakdown voltage
	11-20	VZBN	F10.3	Zener voltage before reverse breakdown voltage
	21-30	VZAN	F10.3	Zener voltage after reverse breakdown voltage
	31-40	GAINB	E10.3	Current gain before device was pulsed
	41-50	GAINA	E10.3	Current gain after device was pulsed
	51-52	PIN	A2	Polarity of applied pulse: A+ = forward direction C+ = reverse direction
	53-71	REMAR1,REMAR2	A10,A9	Remarks
				NOTE: Card set 4 represents data for one pulse and is repeated as many times as indicated on card set 3 for variable NPULS.
				If ISEM = 0 on Card 1, data input is complete

Card	Columns	Variable name	Format	Comment
Card set 5: Pulse width and power cards				
6	1-20	IDENT1,IDENT2	2A10	Identification of data
	21-30	-	-	Blank
	31-40	XLAB	A10	Abscissa label
	41-50	-	-	Blank
	51-60	YLAB	A10	Ordinate label
7	1-10	T	E10.3	Pulse width
	11-20	PP	E10.3	Power
				NOTE: Data for pulse width versus power must be arranged in increasing order with respect to pulse width.
				Card 7 is repeated according to value NUMB appearing on Card 2

A sample listing of the input cards when ISEM = 0 on card set 1 is given in appendix D. Also, a sample listing of the input cards when ISEM = 1 on card set 1 is contained in appendix E.

9. CONTROL CARDS FOR RUNNING SEMCON

The SEMCON code is operational using the SCOPE 3.4.3 control language on the CDC 6600 computer at MERDC. Since several different plotting packages can be used, three distinct control card sets are required for the various options available. The following details the operation of the code.

If IPLOT = K where 1 ≤ K ≤ 36 on card set 1 (plots come out at MERDC using the Cal Comp plotting software), then the control cards for running SEMCON are as follows:

```
EM___(MT1, T300)

TASK(TNEM_____,PW_____,TRTS) [user's name]

REQUEST, TAPE50, HI, VSN=____,RING.
```

NOTE: VSN=____is the number of the blank tape at MERDC.

```
ATTACH,AGO,BINSEMCON,ID=EM71606.

ATTACH,F1,TALWYATT,ID=EM71602,MR=1.

LIBRARY(F1)

MAP(PART)

LDSET(PRESET=NGINF)

AGO.

TALPLOT(,TAPE1)

EXIT.

7/8/9

[Data]

0/6/7/8/9
```

If IPLOT = 0 and ITYPE = 0 on card set 1 (plots come out on the MDS system using the Cal Comp plotting software), then the control cards for running SEMCON are as follows:

```
EM___(T300)

TASK(TNEM_____,PW_____,TRTS) [user's name]

ATTACH,AGO,BINSEMCON,ID=EM71606.

ATTACH,F1,TALWYATT,ID=EM71602,MR=1.

ATTACH,LIBA,ANAPAC,ID=EM71605,MR=1.

LIBRARY(F1,LIBA)

MAP(PART)

LDSET(PRESET=NGINF)

AGO.

TALPLOT(,TAPE1)
```

```
EXIT.

7/8/9

[Data]

0/6/7/8/9
```

If IPLOT = 0 and ITYPE = 1 on card set 1 (plots come out on the MDS system using the ANAPAC plotting software), then the control cards for running SEMCON are as follows:

```
EM___(T300)

TASK(TNEM_____,PW_____,TRTS) [user's name]

ATTACH,AGO,BINSEMCON,ID=EM71606.

ATTACH,LIBA,ANAPAC,ID=EM71605,MR=1.

LIBRARY(LIBA)

MAP(PART)

LDSET(PRESET=NGINF)

AGO.

EXIT.

7/8/9

[Data]

0/6/7/8/9
```

10. CONCLUSIONS

The SEMCON code has provided the means to analyze various semiconductor devices and, hence, assist in making EMP vulnerability assessments. The code has accomplished this objective by utilizing very straightforward techniques to calculate the least-squares fits for damage curves of semiconductor devices. For EMP efforts, the fits generated by SEMCON are considered to be reliable when good, accurate data are used. Also, the code has proven to be quite effective in tabulating and reducing numerous amounts of data. Thus, SEMCON is considered to be a useful code in semiconductor damage analysis and is written in such a way as to make it readily adaptable to numerous computer systems.

ABBREVIATIONS

E	Energy
FAIL	Failure
GAINA	Current gain after device was pulsed
GAINB	Current gain before device was pulsed
IP	Peak current
NDEV	Device number
P	Power
PIN	Polarity of applied pulse (i.e., reverse or forward direction)
PULSE	Pulse number
TD	Failure time
TDOC	Pulse duration
VOC	Open-circuit voltage
VP	Peak voltage
VZAN	Zener voltage after reverse breakdown voltage
VZAP	Voltage after forward breakdown voltage
VZBN	Zener voltage before reverse breakdown voltage
VZBP	Voltage before forward breakdown voltage
Z	Impedance

APPENDIX A.--SAMPLE PRODUCTION RUN OF SEMCON

This appendix contains examples of plots available through SEMCON and the computer center at the Mobility Equipment Research and Development Center, Fort Belvoir, VA.

SEMI-CONDUCTOR DAMAGE PROGRAM - VERSION OF JUNE,1975 06/09/76 09.41.28.

DEVICE: IN3600 DEVICE TYPE: DIODE JUNCTION: C-A
MANUFACTURER: FAIRCHILD TECHNICIAN: R.PARSONS DATE: 7-23-73

NO. PT	TDDC	VDC	VP	IP	TD	POWER	ENERGY	IMPEDANCE	VZB+	VZA+	VZB-	VZA-	GAINB	GAINA	PIN	FAIL	REMARKS
1- 1	.10E-04	100.0	100.0	0.0	.10E-04	0.	0.	0.	1.0	1.0	160.0	160.0	0.00	0.0	C+	NO	
1- 2	.10E-04	110.0	105.0	.2	.10E-04	.16E+02	.16E-03	.69E+03	1.0	1.0	160.0	160.0	0.00	0.0	C+	NO	
1- 3	.10E-04	120.0	115.0	.6	.22E-05	.69E+02	.15E-03	.19E+03	1.0	0.0	160.0	0.0	0.00	0.0	C+	YES	
2- 1	.10E-04	60.0	60.0	0.0	.10E-04	0.	0.	0.	.3	.3	92.0	92.0	0.00	0.0	C+	NO	
2- 2	.10E-04	70.0	70.0	0.0	.10E-04	0.	0.	0.	.3	.3	92.0	92.0	0.00	0.0	C+	NO	
2- 3	.10E-04	80.0	80.0	0.0	.10E-04	0.	0.	0.	.3	.3	92.0	92.0	0.00	0.0	C+	NO	
2- 4	.10E-04	90.0	90.0	0.0	.10E-04	0.	0.	0.	.3	.3	92.0	92.0	0.00	0.0	C+	NO	
2- 5	.10E-04	100.0	80.0	1.3	.20E-05	.10E+03	.21E-03	.61E+02	.3	.3	92.0	92.0	0.00	0.0	C+	NO	BRKDWN NO VZ
2- 6	.10E-04	110.0	90.0	2.2	.80E-06	.20E+03	.16E-03	.41E+02	.3	.3	92.0	4.0	0.00	0.0	C+	YES	
3- 1	.10E-04	80.0	80.0	0.0	.10E-04	0.	0.	0.	.3	.3	90.0	90.0	0.00	0.0	C+	NO	
3- 2	.10E-04	90.0	90.0	0.0	.10E-04	0.	0.	0.	.3	.3	90.0	90.0	0.00	0.0	C+	NO	
3- 3	.10E-04	100.0	95.0	.7	.30E-05	.67E+02	.20E-03	.14E+03	.3	0.0	90.0	0.0	0.00	0.0	C+	YES	
4- 1	.10E-04	80.0	80.0	0.0	.10E-04	0.	0.	0.	.3	.3	98.0	98.0	0.00	0.0	C+	NO	
4- 2	.10E-04	90.0	90.0	0.0	.10E-04	0.	0.	0.	.3	.3	98.0	98.0	0.00	0.0	C+	NO	
4- 3	.10E-04	100.0	100.0	0.0	.10E-04	0.	0.	0.	.3	.3	98.0	98.0	0.00	0.0	C+	NO	
4- 4	.10E-04	110.0	105.0	1.0	.19E-05	.11E+03	.20E-03	.10E+03	.3	0.0	98.0	0.0	0.00	0.0	C+	YES	
5- 1	.10E-04	80.0	80.0	0.0	.10E-04	0.	0.	0.	.3	.3	86.0	86.0	0.00	0.0	C+	NO	
5- 2	.10E-04	90.0	85.0	.6	.12E-05	.51E+02	.61E-04	.14E+03	.3	.3	86.0	83.0	0.00	0.0	C+	NO	BRKDWN DEVICE NO
5- 3	.10E-04	100.0	90.0	1.8	.12E-05	.16E+03	.19E-03	.50E+02	.3	.3	86.0	12.0	0.00	0.0	C+	YES	
6- 1	.10E-04	80.0	80.0	0.0	.10E-04	0.	0.	0.	.3	.3	86.0	86.0	0.00	0.0	C+	NO	
6- 2	.10E-04	90.0	90.0	0.0	.10E-04	0.	0.	0.	.3	.3	86.0	86.0	0.00	0.0	C+	NO	
6- 3	.10E-04	100.0	90.0	1.0	.12E-05	.90E+02	.11E-03	.90E+02	.3	0.0	86.0	0.0	0.00	0.0	C+	YES	
7- 1	.10E-04	80.0	80.0	0.0	.10E-04	0.	0.	0.	.3	.3	86.0	86.0	0.00	0.0	C+	NO	
7- 2	.10E-04	90.0	90.0	0.0	.10E-04	0.	0.	0.	.3	.3	86.0	86.0	0.00	0.0	C+	NO	
7- 3	.10E-04	100.0	95.0	.4	.27E-05	.38E+02	.10E-03	.24E+03	.3	.3	86.0	86.0	0.00	0.0	C+	NO	
7- 4	.10E-04	100.0	90.0	1.2	.80E-06	.11E+03	.86E-04	.75E+02	.3	.3	86.0	17.0	0.00	0.0	C+	YES	
8- 1	.10E-04	80.0	80.0	0.0	.10E-04	0.	0.	0.	.3	.3	88.0	88.0	0.00	0.0	C+	NO	
8- 2	.10E-04	90.0	90.0	0.0	.10E-04	0.	0.	0.	.3	.3	88.0	88.0	0.00	0.0	C+	NO	
8- 3	.10E-04	100.0	100.0	0.0	.10E-04	0.	0.	0.	.3	.3	88.0	88.0	0.00	0.0	C+	NO	
8- 4	.10E-04	110.0	110.0	0.0	.10E-04	0.	0.	0.	.3	.3	88.0	88.0	0.00	0.0		NO	
8- 5	.10E-04	118.0	105.0	1.2	.10E-05	.13E+03	.13E-03	.87E+02	.3	.3	88.0	10.0	0.00	0.0	C+	YES	
9- 1	.50E-05	80.0	80.0	0.0	.50E-05	0.	0.	0.	.3	.3	93.0	93.0	0.00	0.0	C+	NO	
9- 2	.50E-05	90.0	90.0	0.0	.50E-05	0.	0.	0.	.3	.3	93.0	93.0	0.00	0.0	C+	NO	
9- 3	.50E-05	100.0	95.0	.6	.28E-05	.57E+02	.16E-03	.16E+03	.3	.3	93.0	93.0	0.00	0.0	C+	NO	
9- 4	.50E-05	112.0	100.0	.9	.90E-06	.90E+02	.81E-04	.11E+03	.3	.2	93.0	0.0	0.00	0.0	C+	YES	
10- 1	.50E-05	80.0	80.0	0.0	.50E-05	0.	0.	0.	.3	.3	93.0	93.0	0.00	0.0	C+	NO	
10- 2	.50E-05	90.0	90.0	0.0	.50E-05	0.	0.	0.	.3	.3	93.0	93.0	0.00	0.0	C+	NO	
10- 3	.50E-05	100.0	97.0	.2	.11E-05	.19E+02	.21E-04	.48E+03	.3	.3	93.0	93.0	0.00	0.0	C+	NO	
10- 4	.50E-05	110.0	103.0	.9	.18E-05	.93E+02	.17E-03	.11E+03	.3	.3	93.0	8.0	0.00	0.0	C+	YES	

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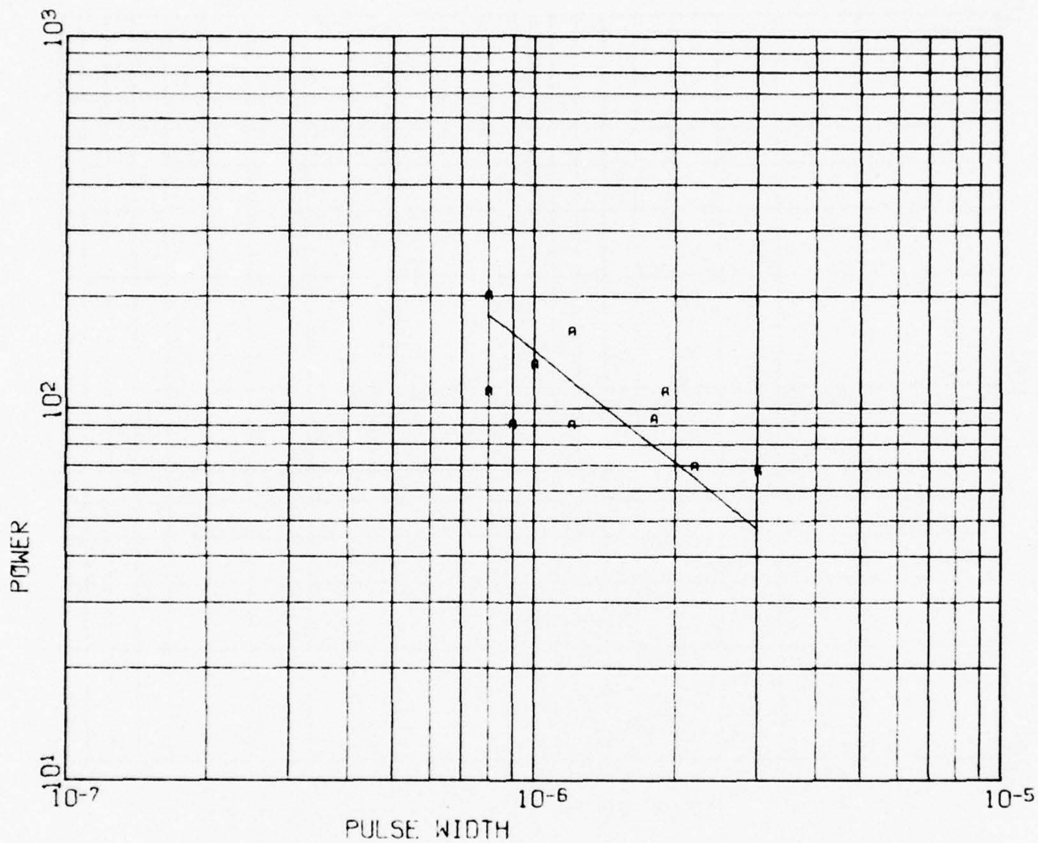
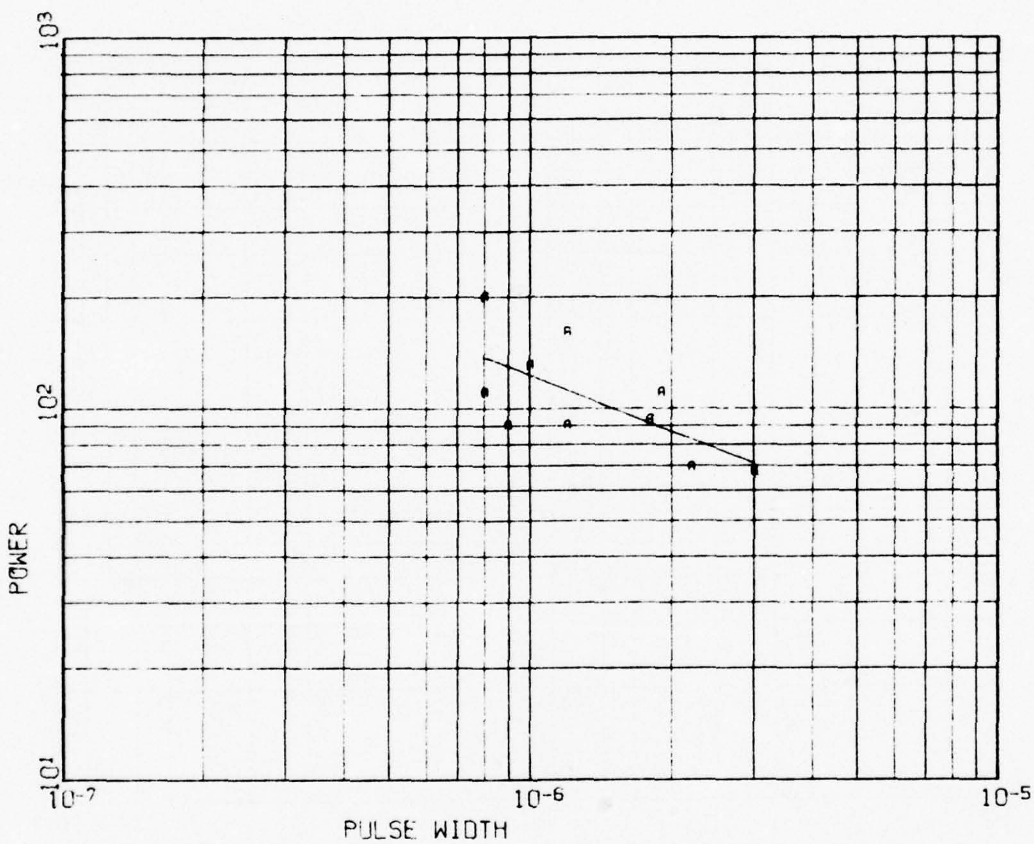
APPENDIX A

```
REVERSE FAILURE CURVES AND DATA FOR DEVICE IN3600

      FITTING PARAMETER FOR P=A*T**(-1) IS:  A=  1.40305738E-04                    OMEGA=  2.14182431E-02

      FITTING PARAMETER FOR P=B*T**(-.5) IS:  B=  1.21187459E-01                   OMEGA=  1.19645338E-02

      FITTING PARAMETERS FOR P=A*T**(-1)+B*T**(-.5) ARE:  A=  3.35628819E-05        OMEGA=  1.40030432E-02
                                                          B=  9.28177482E-02

                     A AND B FOUND IN  24 ITERATIONS        MINIMUM OF S(A,B)=  1.12024345E-01

   GAUSS CRITERION OF GOODNESS OF FIT
      THE EQUATION WHICH BEST FITS THIS DATA IS:

                     P=B*T**(-.5)
```



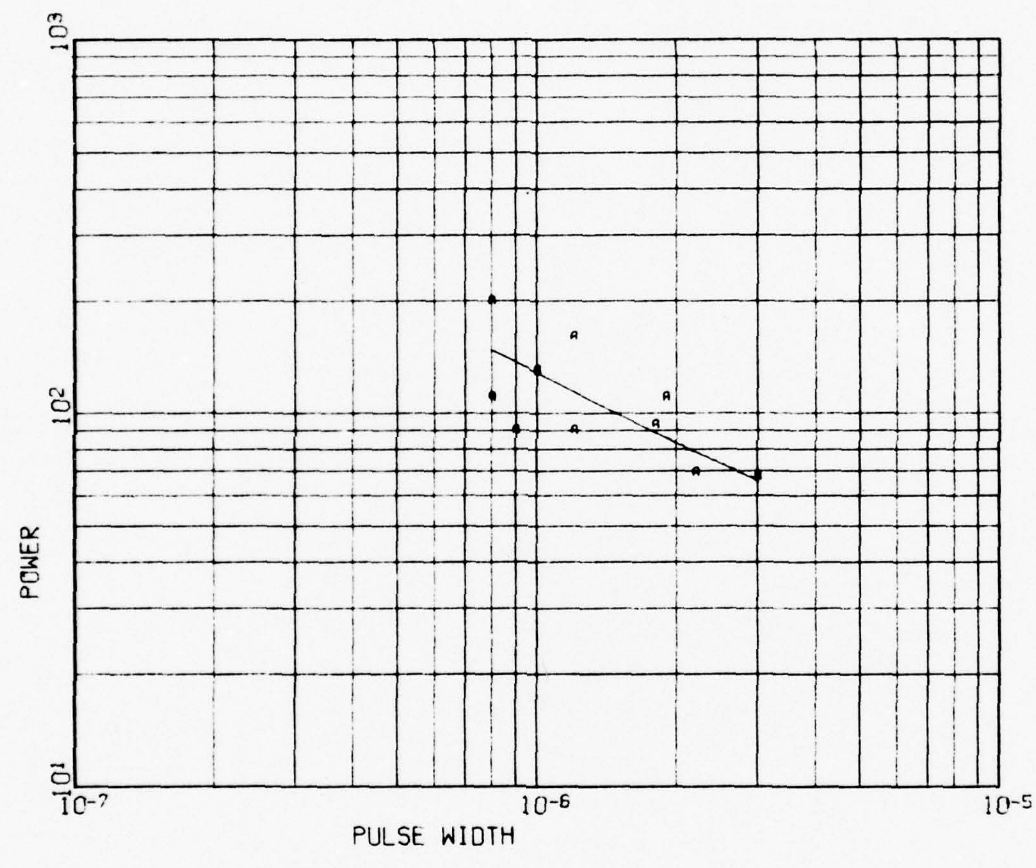
DEVICE: IN3600 REVERSE FAILURE

FIT TO P=A*T**(-1)



DEVICE: IN3600 REVERSE FAILURE

FIT TO P=B*T**(-.5)



DEVICE: IN3600 REVERSE FAILURE

FIT TO P=A*T**(-1)+B*T**(-.5)

APPENDIX B.--SAMPLE PRODUCTION RUN OF SEMCON

This appendix contains examples of plots available through SEMCON and the Mohawk Data Sciences computing system.

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SEMI-CONDUCTOR DAMAGE PROGRAM - VERSION OF JUNE,1975 06/10/76 11.58.41.

DEVICE: IN3600 DEVICE TYPE: DIODE JUNCTION: C-A
MANUFACTURER: FAIRCHILD TECHNICIAN: R.PARSONS DATE: 7-23-73

IDENTIFICATION: REVERSE FAILURE

PULSE WDTH	POWER	PULSE WDTH	POWER	PULSE WDTH	POWER
8.000E-07	1.100E+02	1.200E-06	9.000E+01	1.900E-06	1.100E+02
8.000E-07	2.000E+02	1.200E-06	1.600E+02	2.200E-06	6.900E+01
9.000E-07	9.000E+01	1.800E-06	9.300E+01	3.000E-06	6.700E+01
1.000E-06	1.300E+02				

REVERSE FAILURE CURVES AND DATA FOR DEVICE IN3600

FITTING PARAMETER FOR P=A*T**(-1) IS: A= 1.41779212E-04 OMEGA= 2.16628588E-02

FITTING PARAMETER FOR P=B*T**(-.5) IS: B= 1.22460156E-01 OMEGA= 1.21928344E-02

FITTING PARAMETERS FOR P=A*T**(-1)+B*T**(-.5) ARE: A= 3.39153554E-05 OMEGA= 1.42629648E-02
B= 9.37925093E-02

A AND B FOUND IN 24 ITERATIONS MINIMUM OF S(A,B)= 1.14103719E-01

GAUSS CRITERION OF GOODNESS OF FIT
THE EQUATION WHICH BEST FITS THIS DATA IS:

P=B*T**(-.5)

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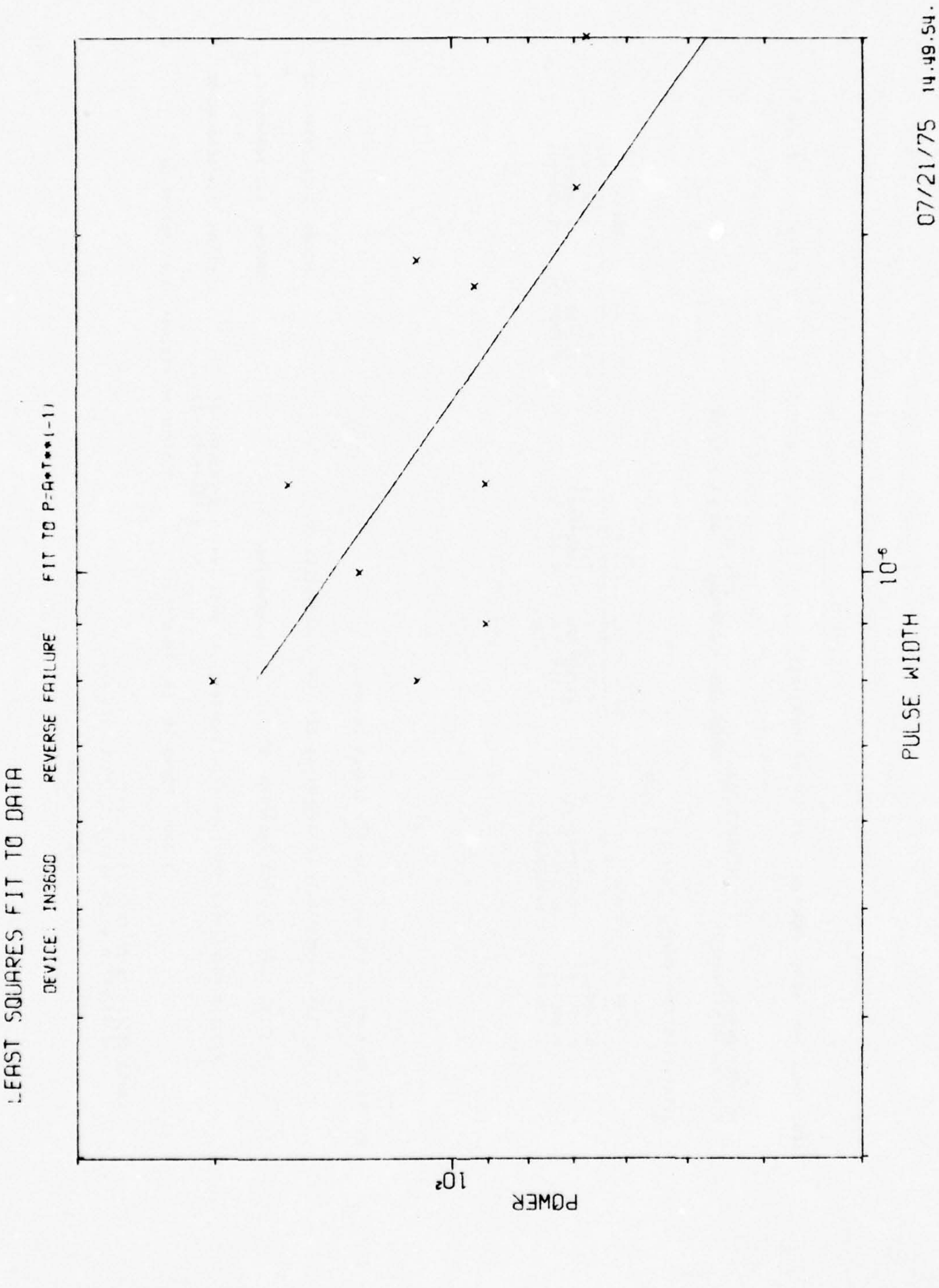
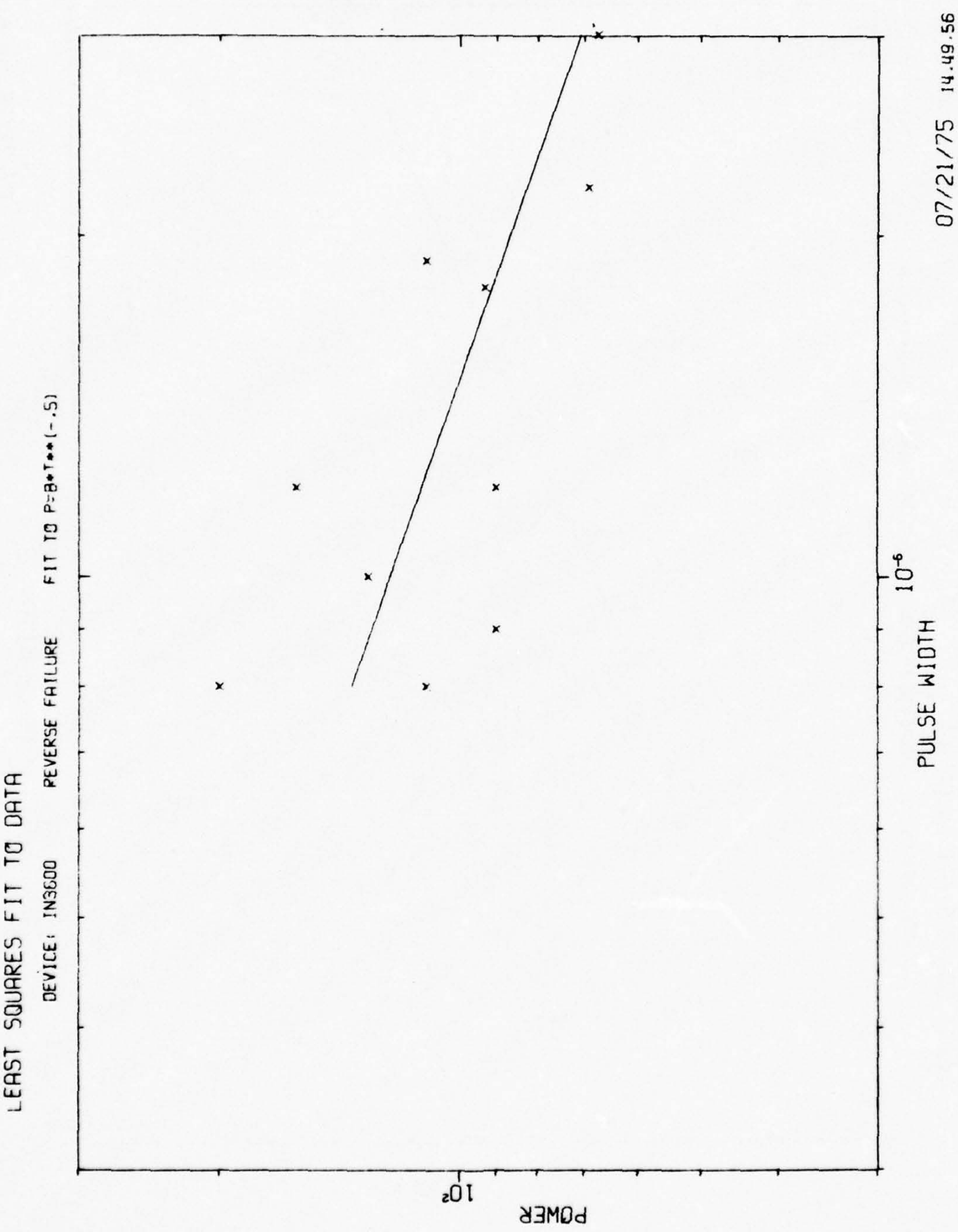
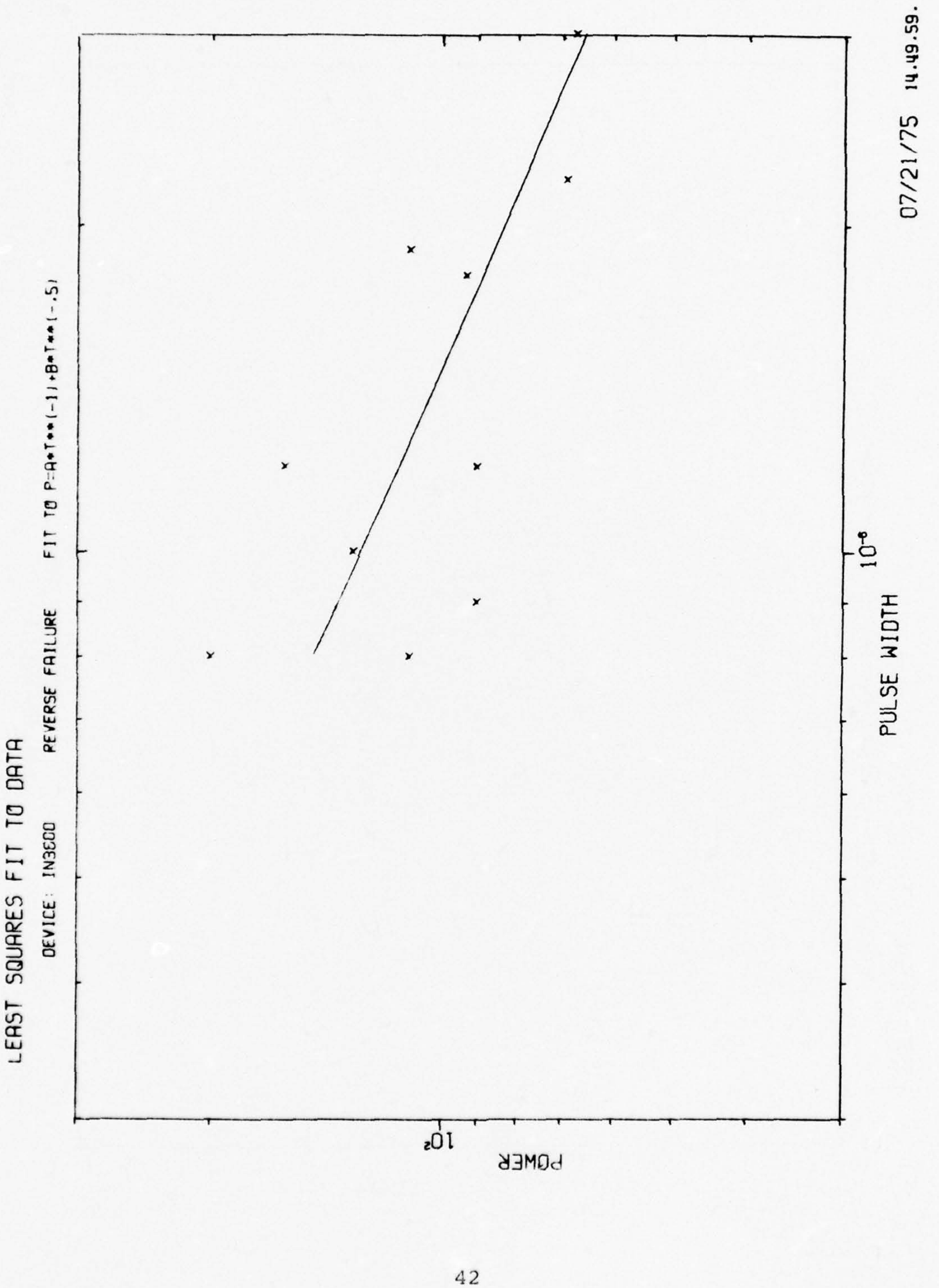
APPENDIX B



LEAST SQUARES FIT TO DATA
DEVICE: IN3600
REVERSE FAILURE
FIT TO P=A*T**(-1)
07/21/75 14.49.54.
PULSE WIDTH
10-6
POWER
10²


LEAST SQUARES FIT TO DATA
DEVICE: IN3600
REVERSE FAILURE
FIT TO P=B*T**(-.5)
07/21/75 14.49.56
PULSE WIDTH
10⁻⁶
POWER
10²

APPENDIX B


LEAST SQUARES FIT TO DATA
DEVICE: IN3600
REVERSE FAILURE
FIT TO P=A*T**(-1)+B*T**(-.5)
07/21/75 14.49.59.
PULSE WIDTH
10-8
POWER
10²

APPENDIX C.--LISTING OF SEMCON

This appendix contains a complete listing of SEMCON.

```
PROGRAM SEMCON      74/74    OPT=1                        FTN 4.5+414        06/01/76  14.04.49        PAGE    1

      PROGRAM SEMCON(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE1,TAPE7)
C
C
C     SEMI-CONDUCTOR DATA REDUCTION PROGRAM
C
C
      INTEGER FLAG,FAIL,PULSE
      REAL IP,JUNC,MAN1,MAN2
      REAL IPRF,IPFF
      COMMON PIN(600),P(600),TD(600),E(600),TDDC(600),Z(600),VDC(600),
     1       IP(600),FAIL(600)
      COMMON/A/IND,FLAG,IPRAM,DEV
      COMMON/B/PRF(600),TDRF(600),ERF(600),TDDCRF(600),ZRF(600),
     1       VDCRF(600),IPRF(600),P1(600),P2(600),P3(600)
      COMMON/C/PFF(600),TDFF(600),EFF(600),TDDCFF(600),ZFF(600),
     1       VDCFF(600),IPFF(600)
      COMMON/D/T(600),PP(600)
      COMMON/E/GAUS(3),S
      COMMON/F/IPLOT,ISEM,ITYPE
      COMMON/G/DEVTYP1,DEVTYP2,JUNC,MAN1,MAN2,TECH,DATEE,ISTOP
      DIMENSION NPULS(300),VP(600),VZBP(600),VZAP(600),VZBN(600),
     1          VZAN(600),REMAR1(600),REMAR2(600),GAINB(600),
     2          GAINA(600),NDEV(600),PULSE(600)
      PRINT 10
   10 FORMAT(1H1)
      CALL DATE(DAT)
      CALL TIME(TIM)
      PRINT 20,DAT,TIM
   20 FORMAT(/,/,1X,44H SEMI-CONDUCTOR DAMAGE PROGRAM - VERSION OF ,
     112HJUNE,1975    ,33X,A10,5X,A10,/,/,/)
      READ(5,25) IND,FLAG,IPRAM,ISTOP,IPLOT,ISEM,ITYPE
   25 FORMAT(4(9X,I1),8X,I2,2(9X,I1))
      READ(5,30) NUMB,DEV,DEVTYP1,DEVTYP2,JUNC,MAN1,MAN2,TECH,DATEE
   30 FORMAT(I3,A8,2A10,A9,4A10)
      IF(ISTOP.NE.1)  WRITE(6,33)
   33 FORMAT(17HPM THIS JOB PLOTS)
      IF(ISEM.EQ.0)  GO TO 35
      CALL OWNDAT(NUMB)
      GO TO 210
   35 L=0
      DO 70 I=1,NUMB
      READ(5,40) NPULS(I)
   40 FORMAT(I2)
      NPUL=NPULS(I)
      DO 70 J=1,NPUL
      L=L+1
      READ(5,50) NDEV(L),PULSE(L),TDDC(L),VDC(L),VP(L),IP(L),
     1TD(L),VZBP(L)
   50 FORMAT(I3,I2,E10.3,F10.3,F10.3,F10.3,E10.3,F10.3)
      READ(5,60) VZAP(L),VZBN(L),VZAN(L),GAINB(L),GAINA(L),PIN(L),
     1REMAR1(L),REMAR2(L)
   60 FORMAT(3F10.3,2(2PE10.2),A2,A10,A9)
   70 CONTINUE
      NUM=L
      DO 90 K=1,NUM
      P(K)=0.
      E(K)=0.
```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APPENDIX C

```
PROGRAM SEMCON      74/74    OPT=1                              FTN 4.5+414         06/01/76  14.04.49        PAGE      2

      Z(K)=0.                                                                 SEMCON    59
      IF(IP(K).LE.0) GO TO 80                                                 SEMCON    60
      IF(VP(K).LE.0) GO TO 80                                                 SEMCON    61
      P(K)=VP(K)*IP(K)                                                        SEMCON    62
      E(K)=P(K)*TD(K)                                                         SEMCON    63
      Z(K)=(VP(K)-VZBP(K))/IP(K)                                              SEMCON    64
      IF(Z(K).LT.0.) Z(K)=0.                                                  SEMCON    65
   80 CALL FAILUR(VZBP(K),VZAP(K),FAIL(K))                                    SEMCON    66
      IF(FAIL(K).EQ.3HYES) GO TO 90                                           SEMCON    67
      CALL FAILUR(VZBN(K),VZAN(K),FAIL(K))                                    SEMCON    68
      IF(FAIL(K).EQ.3HYES) GO TO 90                                           SEMCON    69
      CALL FAILUR(GAINB(K),GAINA(K),FAIL(K))                                  SEMCON    70
   90 CONTINUE                                                                SEMCON    71
      IF(ISTOP.EQ.3)  GO TO 145                                               SEMCON    72
      PRINT 100,DEV,DEVTYP1,DEVTYP2,JUNC,MAN1,MAN2,TECH,DATEE                 SEMCON    73
  100 FORMAT(5X,8HDEVICE: ,A8,3X,13HDEVICE TYPE: ,2A10,3X,                    SEMCON    74
     110HJUNCTION: ,A9,/,5X,14HMANUFACTURER: ,2A10,3X,12HTECHNICIAN: ,        SEMCON    75
     2A10,3X,6HDATE: ,A10,/,/)                                                SEMCON    76
      PRINT 110                                                               SEMCON    77
  110 FORMAT(1X,3HNO.,1X,2HPT,3X,4HTDCC,6X,3HVDC,4X,2HVP,4X,2HIP,5X,          SEMCON    78
     12HTD,6X,5HPOWER,3X,6HENERGY,1X,9HIMPEDANCE,2X,4HVZB+,2X,4HVZA+,         SEMCON    79
     22X,4HVZB-,2X,4HVZA-,2X,5HGAINB,1X,5HGAINA,1X,3HPIN,1X,4HFAIL,5X,        SEMCON    80
     37HREMARKS)                                                              SEMCON    81
      PRINT 120                                                               SEMCON    82
  120 FORMAT(1X,3H---,1X,2H--,3X,4H----,6X,3H---,4X,2H--,4X,2H--,5X,          SEMCON    83
     12H--,6X,5H-----,3X,6H------,1X,9H---------,2X,4H----,2X,4H----,         SEMCON    84
     22X,4H----,2X,4H----,2X,5H-----,1X,5H-----,1X,3H---,1X,4H----,5X,        SEMCON    85
     37H-------)                                                              SEMCON    86
      L=0                                                                     SEMCON    87
      DO 140 I=1,NUMB                                                         SEMCON    88
      NPUL=NPULS(I)                                                           SEMCON    89
      DO 140 J=1,NPUL                                                         SEMCON    90
      L=L+1                                                                   SEMCON    91
      PRINT 130,NDEV(L),PULSE(L),TDCC(L),VDC(L),VP(L),IP(L),TD(L),P(L),       SEMCON    92
     1E(L),Z(L),VZBP(L),VZAP(L),VZBN(L),VZAN(L),GAINB(L),GAINA(L),            SEMCON    93
     2PIN(L),FAIL(L),REMAR1(L),REMAR2(L)                                      SEMCON    94
  130 FORMAT(1H ,I3,1H-,I2,1X,E8.2,1X,F6.1,1X,F6.1,1X,F5.1,1X,E8.2,           SEMCON    95
     11X,E8.2,1X,E8.2,1X,E8.2,1X,F5.1,1X,F5.1,1X,F5.1,1X,F5.1,1X,             SEMCON    96
     2F6.2,1X,F5.1,1X,A2,1X,A3,1X,A10,A9)                                     SEMCON    97
  140 CONTINUE                                                                SEMCON    98
      IF(ISTOP.EQ.1)  GO TO 210                                               SEMCON    99
  145 CONTINUE                                                                SEMCON   100
      PRINT 150                                                               SEMCON   101
  150 FORMAT(1H1)                                                             SEMCON   102
      CALL FRFAIL(NUM,KNUM,JNUM)                                              SEMCON   103
      IF(IPRAM.EQ.4)  GO TO 160                                               SEMCON   104
      IF(IPRAM.NE.0)  GO TO 200                                               SEMCON   105
  160 GO TO (170,180,170),IND                                                 SEMCON   106
  170 CALL DIRECT(KNUM,1,A,B,AE,BE,IT)                                        SEMCON   107
      CALL WRITE(A,B,AE,BE,1,IT)                                              SEMCON   108
      CALL GAUSS                                                              SEMCON   109
      CALL PLOTT(KNUM,JNUM,1)                                                 SEMCON   110
      IF(IND.EQ.1)  GO TO 190                                                 SEMCON   111
  180 IF(JNUM.EQ.0)  GO TO 190                                                SEMCON   112
      CALL DIRECT(JNUM,2,A,B,AE,BE,IT)                                        SEMCON   113
      CALL WRITE(A,B,AE,BE,2,IT)                                              SEMCON   114
      CALL GAUSS                                                              SEMCON   115
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        PROGRAM SEMCON      74/74    OPT=1                          FTN 4.5+414       06/01/76  14.04.49       PAGE     3

  115              CALL PLOTT(KNUM,JNUM,2)                                                 SEMCON     116
               190 CONTINUE                                                                SEMCON     117
                   IF(IPRAM.EQ.0)  GO TO 210                                               SEMCON     118
               200 CALL PLOTT(KNUM,JNUM,3)                                                 SEMCON     119
               210 STOP                                                                    SEMCON     120
  120              END                                                                     SEMCON     121


CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

   105    I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.


        SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
10215  SEMCON        1

VARIABLES       SN  TYPE             RELOCATION
11153  A            REAL                             REFS        106        107        112        113
11155  AE           REAL                             REFS        106        107        112        113
11154  B            REAL                             REFS        106        107        112        113
11156  BE           REAL                             REFS        106        107        112        113
11140  DAT          REAL                             REFS         26         28
    6  DATEE        REAL                 G           REFS         20         72     DEFINED        33
    3  DEV          REAL                 A           REFS         12         72     DEFINED        33
    0  DEVTYP1      REAL                 G           REFS         20         72     DEFINED        33
    1  DEVTYP2      REAL                 G           REFS         20         72     DEFINED        33
 3410  E            REAL        ARRAY   / /          REFS         10         91     DEFINED        57         62
 2260  EFF          REAL        ARRAY    C           REFS         15
 2260  ERF          REAL        ARRAY    B           REFS         13
11300  FAIL         INTEGER     ARRAY   / /          REFS          7         10         65         66         67         68         69
                                                       91
    1  FLAG         INTEGER              A           REFS          7         12     DEFINED        31
24264  GAINA        REAL        ARRAY                REFS         21         69         91     DEFINED        50
23134  GAINB        REAL        ARRAY                REFS         21         69         91     DEFINED        50
    0  GAUS         REAL        ARRAY    E           REFS         18
11144  I            INTEGER                          REFS         42         44         88     DEFINED        41         87
    0  IND          INTEGER              A           REFS         12        105        110     DEFINED        31
10150  IP           REAL        ARRAY   / /          REFS          8         10         59         61         63         91
                                                  DEFINED         47
 7020  IPFF         REAL        ARRAY    C           REFS          9         15
    0  IPLOT        INTEGER              F           REFS         19    DEFINED         31
    2  IPRAM        INTEGER              A           REFS         12        103        104        117     DEFINED        31
 7020  IPRF         REAL        ARRAY    B           REFS          9         13
    1  ISEM         INTEGER              F           REFS         19         37     DEFINED        31
    7  ISTOP        INTEGER              G           REFS         20         35         71         98     DEFINED        31
11157  IT           INTEGER                          REFS        106        107        112        113
    2  ITYPE        INTEGER              F           REFS         19    DEFINED         31
11146  J            INTEGER                       DEFINED         45         89
11152  JNUM         INTEGER                          REFS        102        109        111        112        115        118
    2  JUNC         REAL                 G           REFS          8         20         72     DEFINED        33
```

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         PROGRAM SEMCON      74/74   OPT=1                         FTN 4.5+424       06/01/76  14.04.49       PAGE      4

VARIABLES       SN  TYPE              RELOCATION
11150  K            INTEGER                         REFS       56       57       58       59       60      3*61     3*62
                                                    4*63     2*64     3*65       66     3*67       68      3*69
                                                  DEFINED      55
11151  KNUM         INTEGER                         REFS      102      106      109      115      118
11143  L            INTEGER                         REFS       46     8*47     8*50       54       90     20*91
                                                  DEFINED      40       46       86       90
    3  MAN1         REAL                G           REFS        8       20       72  DEFINED       33
    4  MAN2         REAL                G           REFS        8       20       72  DEFINED       33
25414  NDEV         INTEGER    ARRAY                REFS       21       91  DEFINED       47
11145  NPUL         INTEGER                         REFS       45       89  DEFINED       44       88
12310  NPULS        INTEGER    ARRAY                REFS       21       44       88  DEFINED       42
11147  NUM          INTEGER                         REFS       55      102  DEFINED       54
11142  NUMB         INTEGER                         REFS       38       41       87  DEFINED       33
 1130  P            REAL       ARRAY    / /         REFS       10       62       91  DEFINED       56       61
    0  PFF          REAL       ARRAY    C           REFS       15
    0  PIN          REAL       ARRAY    / /         REFS       10       91  DEFINED       50
 1130  PP           REAL       ARRAY    D           REFS       17
    0  PRF          REAL       ARRAY    B           REFS       13
11160  PULSE        INTEGER    ARRAY                REFS        7       21       91  DEFINED       47
10150  P1           REAL       ARRAY    B           REFS       13
11300  P2           REAL       ARRAY    B           REFS       13
12430  P3           REAL       ARRAY    B           REFS       13
20654  REMAR1       REAL       ARRAY                REFS       21       91  DEFINED       50
22004  REMAR2       REAL       ARRAY                REFS       21       91  DEFINED       50
    3  S            REAL                E           REFS       18
    0  T            REAL       ARRAY    D           REFS       17
 2260  TD           REAL       ARRAY    / /         REFS       10       62       91  DEFINED       47
 1130  TDFF         REAL       ARRAY    C           REFS       15
 4540  TDOC         REAL       ARRAY    / /         REFS       10       91  DEFINED       47
 3410  TDOCFF       REAL       ARRAY    C           REFS       15
 3410  TDOCRF       REAL       ARRAY    B           REFS       13
 1130  TDRF         REAL       ARRAY    B           REFS       13
    5  TECH         REAL                G           REFS       20       72  DEFINED       33
11141  TIM          REAL                            REFS       27       28
 7020  VOC          REAL       ARRAY    / /         REFS       10       91  DEFINED       47
 5670  VOCFF        REAL       ARRAY    C           REFS       15
 5670  VOCRF        REAL       ARRAY    B           REFS       13
12764  VP           REAL       ARRAY                REFS       21       60       61       63       91
                                                  DEFINED      47
17524  VZAN         REAL       ARRAY                REFS       21       67       91  DEFINED       50
15244  VZAP         REAL       ARRAY                REFS       21       65       91  DEFINED       50
16374  VZBN         REAL       ARRAY                REFS       21       67       91  DEFINED       50
14114  VZBP         REAL       ARRAY                REFS       21       63       65       91  DEFINED       47
 5670  Z            REAL       ARRAY    / /         REFS       10       64       91  DEFINED       58       63       64
 4540  ZFF          REAL       ARRAY    C           REFS       15
 4540  ZRF          REAL       ARRAY    B           REFS       13

FILE NAMES          MODE
    0  INPUT
 2041  OUTPUT       FMT                   WRITES       24       28       72       76       81       91      100
 4102  TAPE1
    0  TAPE5        FMT                    READS       31       33       42       47       50
 2041  TAPE6        FMT                   WRITES       35
 6143  TAPE7
```

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          PROGRAM SEMCON      74/74   OPT=1                          FTN 4.5+414        06/01/76  14.04.49       PAGE     5
EXTERNALS           TYPE    ARGS       REFERENCES
          DATE                1             26
          DIRECT              7            106         112
          FAILUR              3             65          67          69
          FRFAIL              3            102
          GAUSS               0            108         114
          OWNDAT              1             38
          PLOTT               3            109         115         118
          TIME                1             27
          WRITE               6            107         113

STATEMENT LABELS                 DEF LINE   REFERENCES
10621   10        FMT               25          24
10630   20        FMT               29          28
10655   25        FMT               32          31
10676   30        FMT               34          33
10704   33        FMT               36          35
10242   35                          40          37
10715   40        FMT               43          42
10733   50        FMT               49          47
10755   60        FMT               52          50
    0   70                          53          41          45
10336   80                          65          59          60
10361   90                          70          55          66          68
10774   100       FMT               73          72
11014   110       FMT               77          76
11040   120       FMT               82          81
11110   130       FMT               94          91
    0   140                         97          87          89
10452   145                         99          71
11131   150       FMT              101         100
10461   160                        105         103
10471   170                        106        2*105
10502   180                        111         105
10512   190                        116         110         111
10513   200                        118         104
10515   210                        119          39          98          117

LOOPS   LABEL    INDEX       FROM-TO      LENGTH     PROPERTIES
10244   70       * I         41 53         55B                   EXT REFS  NOT INNER
10254   70       * J         45 53         43B                   EXT REFS
10324   90       * K         55 70         40B                   EXT REFS
10375   140      * I         87 97         53B                   EXT REFS  NOT INNER
10400   140      * J         89 97         46B                   EXT REFS

COMMON BLOCKS    LENGTH     MEMBERS - BIAS NAME(LENGTH)
      / /         5400            0 PIN      (600)          600 P        (600)          1200 TD       (600)
                               1800 E        (600)         2400 TDOC     (600)          3000 Z        (600)
                               3600 VOC      (600)         4200 IP       (600)          4800 FAIL     (600)
      A              4            0 IND      (1)              1 FLAG     (1)               2 IPRAM    (1)
                                  3 DEV      (1)
      B           6000            0 PRF      (600)          600 TDRF     (600)          1200 ERF      (600)
                               1800 TDOCRF   (600)         2400 ZRF      (600)          3000 VOCRF    (600)
                               3600 IPRF     (600)         4200 P1       (600)          4800 P2       (600)
                               5400 P3       (600)
      C           4200            0 PFF      (600)          600 TOFF     (600)          1200 EFF      (600)
                               1800 TDOCFF   (600)         2400 ZFF      (600)          3000 VOCFF    (600)
                               3600 IPFF     (600)
```

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        PROGRAM SEMCON      74/74   OPT=1                      FTN 4.5+414      06/01/76  14.04.49       PAGE     6

COMMON BLOCKS   LENGTH     MEMBERS - BIAS NAME(LENGTH)
       D          1200               0 T         (600)      600 PP      (600)
       E             4               0 GAUS      (3)          3 S       (1)
       F             3               0 IPLOT     (1)          1 ISEM    (1)        2 ITYPE   (1)
       G             8               0 DEVTYP1(1)             1 DEVTYP2(1)         2 JUNC    (1)
                                     3 MAN1      (1)          4 MAN2    (1)        5 TECH    (1)
                                     6 DATEE     (1)          7 ISTOP   (1)

STATISTICS
  PROGRAM LENGTH               16337B    7391
  BUFFER LENGTH                10205B    4229
  CM LABELED COMMON LENGTH     26233B   11419
  CM BLANK COMMON LENGTH       12430B    5400
```

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SUBROUTINE FAILUR     74/74   OPT=1                      FTN 4.5+414      06/01/76  14.04.49      PAGE     1

                SUBROUTINE FAILUR (R,S,N)                                  FAILUR      2
                REAL N                                                     FAILUR      3
                N=3H NO                                                    FAILUR      4
                IF(R.LE.O.) RETURN                                         FAILUR      5
                IF(.9*R-S.GT.C.) N=3HYES                                   FAILUR      6
                RETURN                                                     FAILUR      7
                END                                                        FAILUR      8


   SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS     DEF LINE     REFERENCES
   3  FAILUR        1            4       6

VARIABLES     SN  TYPE          RELOCATION
   0  N           REAL               F.P.      REFS      2   DEFINED      1        3        5
   0  R           REAL               F.P.      REFS      4         5   DEFINED     1
   0  S           REAL               F.P.      REFS      5   DEFINED      1

STATISTICS
  PROGRAM LENGTH               20B      16
```

APPENDIX C

```
SUBROUTINE FRFAIL      74/74    OPT=1                         FTN 4.5+414        06/01/76  14.04.49       PAGE     1

              SUBROUTINE FRFAIL(NUM,KNUM,JNUM)
              REAL IPRF,IPFF                                                        FRFAIL     2
              REAL IP                                                               FRFAIL     3
              COMMON PIN(600),P(600),TD(600),E(600),TDDC(600),Z(600),VOC(600),      FRFAIL     4
             1       IP(600),FAIL(600)                                              FRFAIL     5
              COMMON/B/PRF(600),TDRF(600),ERF(600),TDDCRF(600),ZRF(600),            FRFAIL     6
             1         VOCRF(600),IPRF(600),P1(600),P2(600),P3(600)                 FRFAIL     7
              COMMON/C/PFF(600),TDFF(600),EFF(600),TDDCFF(600),ZFF(600),            FRFAIL     8
             1         VOCFF(600),IPFF(600)                                         FRFAIL     9
              K=1                                                                   FRFAIL    10
              J=1                                                                   FRFAIL    11
              DO 30 I=1,NUM                                                         FRFAIL    12
              IF(FAIL(I).EQ.3H NO)  GO TO 30                                        FRFAIL    13
              IF(PIN(I).EQ.2HC+)  GO TO 10                                          FRFAIL    14
              IF(PIN(I).EQ.2HA+)  GO TO 20                                          FRFAIL    15
              GO TO 30                                                              FRFAIL    16
           10 TDRF(K)=TD(I)                                                         FRFAIL    17
              PRF(K)=P(I)                                                           FRFAIL    18
              ERF(K)=E(I)                                                           FRFAIL    19
              ZRF(K)=Z(I)                                                           FRFAIL    20
              VOCRF(K)=VOC(I)                                                       FRFAIL    21
              IPRF(K)=IP(I)                                                         FRFAIL    22
              TDDCRF(K)=TDDC(I)                                                     FRFAIL    23
              K=K+1                                                                 FRFAIL    24
              GO TO 30                                                              FRFAIL    25
           20 TDFF(J)=TD(I)                                                         FRFAIL    26
              PFF(J)=P(I)                                                           FRFAIL    27
              EFF(J)=E(I)                                                           FRFAIL    28
              ZFF(J)=Z(I)                                                           FRFAIL    29
              VOCFF(J)=VOC(I)                                                       FRFAIL    30
              IPFF(J)=IP(I)                                                         FRFAIL    31
              TDDCFF(J)=TDDC(I)                                                     FRFAIL    32
              J=J+1                                                                 FRFAIL    33
              GO TO 30                                                              FRFAIL    34
           30 CONTINUE                                                              FRFAIL    35
              KNUM=K-1                                                              FRFAIL    36
              JNUM=J-1                                                              FRFAIL    37
              RETURN                                                                FRFAIL    38
              END                                                                   FRFAIL    39
                                                                                    FRFAIL    40

     SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
    3  FRFAIL        1             38

VARIABLES      SN   TYPE             RELOCATION
  3410  E           REAL         ARRAY    / /        REFS      4        19       28
  2260  EFF         REAL         ARRAY    C          REFS      8    DEFINED      28
  2260  ERF         REAL         ARRAY    B          REFS      6    DEFINED      19
 11300  FAIL        REAL         ARRAY    / /        REFS      4        13
    65  I           INTEGER                          REFS     13        14       15       17       18       19       20
                                                        21    22        23       26       27       28       29       30
                                                        31    32    DEFINED      12
```

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       SUBROUTINE FRFAIL      74/74   OPT=1                               FTN 4.5+414       06/01/76  14.04.49       PAGE     2

VARIABLES      SN  TYPE              RELOCATION
10150  IP          REAL        ARRAY     / /          REFS       3          4        22         31
 7020  IPFF        REAL        ARRAY     C            REFS       2          8   DEFINED         31
 7020  IPRF        REAL        ARRAY     B            REFS       2          6   DEFINED         22
   64  J           INTEGER                            REFS      26         27        28         29        30        31        32
                                                        33      37    DEFINED        11         33
    0  JNUM        INTEGER               F.P.      DEFINED       1         37
   63  K           INTEGER                            REFS      17         18        19         20        21        22        23
                                                        24      36    DEFINED        10         24
    0  KNUM        INTEGER               F.P.      DEFINED       1         36
    0  NUM         INTEGER               F.P.         REFS      12    DEFINED         1
 1130  P           REAL        ARRAY     / /          REFS       4         18        27
    0  PFF         REAL        ARRAY     C            REFS       8    DEFINED        27
    0  PIN         REAL        ARRAY     / /          REFS       4         14        15
    0  PRF         REAL        ARRAY     B            REFS       6    DEFINED        18
10150  P1          REAL        ARRAY     B            REFS       6
11300  P2          REAL        ARRAY     B            REFS       6
12430  P3          REAL        ARRAY     B            REFS       6
 2260  TD          REAL        ARRAY     / /          REFS       4         17        26
 1130  TDFF        REAL        ARRAY     C            REFS       8    DEFINED        26
 4540  TDDC        REAL        ARRAY     / /          REFS       4         23        32
 3410  TDDCFF      REAL        ARRAY     C            REFS       8    DEFINED        32
 3410  TDDCRF      REAL        ARRAY     B            REFS       6    DEFINED        23
 1130  TDRF        REAL        ARRAY     B            REFS       6    DEFINED        17
 7020  VDC         REAL        ARRAY     / /          REFS       4         21        30
 5670  VDCFF       REAL        ARRAY     C            REFS       8    DEFINED        30
 5670  VDCRF       REAL        ARRAY     B            REFS       6    DEFINED        21
 5670  Z           REAL        ARRAY     / /          REFS       4         20        29
 4540  ZFF         REAL        ARRAY     C            REFS       8    DEFINED        29
 4540  ZRF         REAL        ARRAY     B            REFS       6    DEFINED        20

STATEMENT LABELS             DEF LINE    REFERENCES
   22  10                        17         14
   35  20                        26         15
   50  30                        35         12        13        16        25        34

LOOPS  LABEL     INDEX      FROM-TO     LENGTH     PROPERTIES
   14  30        I           12 35        35B         OPT

COMMON BLOCKS     LENGTH     MEMBERS - BIAS NAME(LENGTH)
      / /          5400               0 PIN     (600)          600 P      (600)          1200 TD      (600)
                                   1800 E       (600)         2400 TDDC   (600)          3000 Z       (600)
                                   3600 VDC     (600)         4200 IP     (600)          4800 FAIL    (600)
       B           6000               0 PRF     (600)          600 TDRF   (600)          1200 ERF     (600)
                                   1800 TDDCRF  (600)         2400 ZRF    (600)          3000 VDCRF   (600)
                                   3600 IPRF    (600)         4200 P1     (600)          4800 P2      (600)
                                   5400 P3      (600)
       C           4200               0 PFF     (600)          600 TDFF   (600)          1200 EFF     (600)
                                   1800 TDDCFF  (600)         2400 ZFF    (600)          3000 VDCFF   (600)
                                   3600 IPFF    (600)

STATISTICS
  PROGRAM LENGTH                     66B        54
  CM LABELED COMMON LENGTH        23730B     10200
  CM BLANK COMMON LENGTH          12430B      5400
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SUBROUTINE DIRECT      74/74    OPT=1                         FTN 4.5+414         06/01/76  14.04.49        PAGE      1

 1             SUBROUTINE DIRECT(N,M,A,B,AE,BE,IT)                                   DIRECT      2
               INTEGER FLAG                                                          DIRECT      3
               REAL IPRF,IPFF                                                        DIRECT      4
               COMMON/A/IND,FLAG,IPRAM,DEV                                           DIRECT      5
 5             COMMON/B/PRF(600),TDRF(600),ERF(600),TDOCRF(600),ZRF(600),            DIRECT      6
              1         VOCRF(600),IPRF(600),P1(600),P2(600),P3(600)                 DIRECT      7
               COMMON/C/PFF(600),TDFF(600),EFF(600),TDOCFF(600),ZFF(600),            DIRECT      8
              1         VOCFF(600),IPFF(600)                                         DIRECT      9
               COMMON/D/T(600),PP(600)                                               DIRECT     10
10             J=1                                                                   DIRECT     11
               K=1                                                                   DIRECT     12
               GO TO (10,30,55),M                                                    DIRECT     13
            10 DO 20 I=1,N                                                           DIRECT     14
               IF(PRF(I).EQ.0.)  GO TO 15                                            DIRECT     15
15             T(J)=TDRF(I)                                                          DIRECT     16
               PP(J)=PRF(I)                                                          DIRECT     17
               J=J+1                                                                 DIRECT     18
            15 IF(I.EQ.N.AND.PRF(I).EQ.0.)  J=J+1                                    DIRECT     19
            20 CONTINUE                                                              DIRECT     20
20             N=J-1                                                                 DIRECT     21
               GO TO 50                                                              DIRECT     22
            30 DO 40 I=1,N                                                           DIRECT     23
               IF(PFF(I).EQ.0.)  GO TO 35                                            DIRECT     24
               T(K)=TDFF(I)                                                          DIRECT     25
25             PP(K)=PFF(I)                                                          DIRECT     26
               K=K+1                                                                 DIRECT     27
            35 IF(I.EQ.N.AND.PFF(I).EQ.0.)  K=K+1                                    DIRECT     28
            40 CONTINUE                                                              DIRECT     29
               N=K-1                                                                 DIRECT     30
30          50 CALL SORT(N)                                                          DIRECT     31
            55 GO TO (60,70,60),FLAG                                                 DIRECT     32
            60 CALL ALSQAR(N,A)                                                      DIRECT     33
               CALL GOODFIT(PP,P2,N,1,1)                                             DIRECT     34
               CALL BLSQAR(N,B)                                                      DIRECT     35
35             CALL GOODFIT(PP,P3,N,1,2)                                             DIRECT     36
               IF(FLAG.EQ.1)  GO TO 80                                               DIRECT     37
            70 IF(FLAG.EQ.3)  GO TO 75                                               DIRECT     38
               CALL ALSQAR(N,A)                                                      DIRECT     39
               CALL BLSQAR(N,B)                                                      DIRECT     40
40          75 CALL ABLSQAR(N,A,B,AE,BE,IT)                                          DIRECT     41
               CALL GOODFIT(PP,P1,N,2,3)                                             DIRECT     42
            80 CONTINUE                                                              DIRECT     43
               RETURN                                                                DIRECT     44
               END                                                                   DIRECT     45


CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

   12      I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
   31      I                AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
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      SUBROUTINE DIRECT     74/74   OPT=1                    FTN 4.5+414        06/01/76  14.04.49        PAGE     2

      SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS       DEF LINE      REFERENCES
    3  DIRECT            1           43

VARIABLES        SN   TYPE             RELOCATION
      0  A             REAL                  F.P.     REFS        32        38       40   DEFINED        1
      0  AE            REAL                  F.P.     REFS        40   DEFINED        1
      0  B             REAL                  F.P.     REFS        34        37       40   DEFINED        1
      0  BE            REAL                  F.P.     REFS        40   DEFINED        1
      3  DEV           REAL                A          REFS         4
   2260  EFF           REAL       ARRAY    C          REFS         7
   2260  ERF           REAL       ARRAY    B          REFS         5
      1  FLAG          INTEGER             A          REFS         2         4       31       36       37
    214  I             INTEGER                        REFS        14        15       16     2*18       23       24       25
                                                      2*27   DEFINED        13       22
      0  IND           INTEGER             A          REFS         4
   7020  IPFF          REAL       ARRAY    C          REFS         3         7
      2  IPRAM         INTEGER             A          REFS         4
   7020  IPRF          REAL       ARRAY    B          REFS         3         5
      0  IT            INTEGER               F.P.     REFS        40   DEFINED        1
    212  J             INTEGER                        REFS        15        16       17       18       20
                                                   DEFINED        10        17       18
    213  K             INTEGER                        REFS        24        25       26       27       29
                                                   DEFINED        11        26       27
      0  M             INTEGER               F.P.     REFS        12   DEFINED        1
      0  N             INTEGER               F.P.     REFS        13        18       22       27       30       32       33
                                                        34        35        38       39       40       41
                                                   DEFINED         1        20       29
      0  PFF           REAL       ARRAY    C          REFS         7        23       25       27
   1130  PP            REAL       ARRAY    D          REFS         9        33       35       41   DEFINED       16       25
      0  PRF           REAL       ARRAY    B          REFS         5        14       16       18
  10150  P1            REAL       ARRAY    B          REFS         5        41
  11300  P2            REAL       ARRAY    B          REFS         5        33
  12430  P3            REAL       ARRAY    B          REFS         5        35
      0  T             REAL       ARRAY    D          REFS         9   DEFINED       15       24
   1130  TDFF          REAL       ARRAY    C          REFS         7        24
   3410  TDDCFF        REAL       ARRAY    C          REFS         7
   3410  TDDCRF        REAL       ARRAY    B          REFS         5
   1130  TDRF          REAL       ARRAY    B          REFS         5        15
   5670  VDCFF         REAL       ARRAY    C          REFS         7
   5670  VDCRF         REAL       ARRAY    B          REFS         5
   4540  ZFF           REAL       ARRAY    C          REFS         7
   4540  ZRF           REAL       ARRAY    B          REFS         5

EXTERNALS          TYPE   ARGS        REFERENCES
        ABLSQAR             6              40
        ALSQAR              2              32        38
        BLSQAR              2              34        39
        GOODFIT             5              33        35        41
        SORT                1              30

STATEMENT LABELS          DEF LINE     REFERENCES
     17  10                   13            12
     30  15                   18            14
      0  20                   19            13
     41  30                   22            12
```

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        SUBROUTINE DIRECT      74/74    OPT=1                           FTN 4.5+414       06/01/76  14.04.49         PAGE       3

 STATEMENT LABELS                   DEF LINE    REFERENCES
    52  35                              27          23
     0  40                              28          22
    63  50                              30          21
    66  55                              31          12
    76  60                              32          2*31
   116  70                              37          31
   130  75                              40          37
   145  80                              42          36

 LOOPS  LABEL      INDEX        FROM-TO      LENGTH      PROPERTIES
    24  20         I             13 19         11B            OPT
    46  40         I             22 28         11B            OPT

 COMMON BLOCKS     LENGTH       MEMBERS - BIAS NAME(LENGTH)
        A               4                 0 IND      (1)                1 FLAG    (1)                2 IPRAM   (1)
                                          3 DEV      (1)
        B            6000                 0 PRF      (600)            600 TDRF    (600)           1200 ERF      (600)
                                       1800 TDDCRF   (600)           2400 ZRF     (600)           3000 VDCRF    (600)
                                       3600 IPRF     (600)           4200 P1      (600)           4800 P2       (600)
                                       5400 P3       (600)
        C            4200                 0 PFF      (600)            600 TDFF    (600)           1200 EFF      ( 00
                                       1800 TDDCFF   (600)           2400 ZFF     (600)           3000 VDCFF    (6C
                                       3600 IPFF     (600)
        D            1200                 0 T        (600)            600 PP      (600)

 STATISTICS
   PROGRAM LENGTH                    215B       141
   CM LABELED COMMON LENGTH        26214B     11404
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SUBROUTINE WRITE      74/74    OPT=1                          FTN 4.5+414        06/01/76  14.04.49        PAGE      1

    1             SUBROUTINE WRITE(A,B,AE,BE,M,IT)                                 WRITE        2
                  INTEGER FLAG                                                     WRITE        3
                  COMMON/A/IND,FLAG,IPRAM,DEV                                      WRITE        4
                  COMMON/E/GAUS(3),S                                               WRITE        5
    5             GO TO (10,30),M                                                  WRITE        6
               10 WRITE(6,20) DEV                                                  WRITE        7
               20 FORMAT(/,/,/,1X,43HREVERSE FAILURE CURVES AND DATA FOR DEVICE ,  WRITE        8
                 1A8)                                                              WRITE        9
                  GO TO 50                                                         WRITE       10
   10          30 WRITE(6,40) DEV                                                  WRITE       11
               40 FORMAT(/,/,/,1X,43HFORWARD FAILURE CURVES AND DATA FOR DEVICE ,  WRITE       12
                 1A8)                                                              WRITE       13
               50 GO TO (60,90,60),FLAG                                            WRITE       14
               60 WRITE(6,70) A,GAUS(1)                                            WRITE       15
   15          70 FORMAT(/,/,10X,42HFITTING PARAMETER FOR P=A*T**(-1) IS:  A= ,    WRITE       16
                 11PE15.8,25X,7HOMEGA= ,1PE15.8)                                   WRITE       17
                  WRITE(6,80) B,GAUS(2)                                            WRITE       18
               80 FORMAT(/,/,10X,43HFITTING PARAMETER FOR P=B*T**(-.5) IS:  B= ,   WRITE       19
                 11PE15.8,24X,7HOMEGA= ,1PE15.8)                                   WRITE       20
   20             IF(FLAG.EQ.1)  RETURN                                            WRITE       21
               90 WRITE(6,100) AE,GAUS(3),BE                                       WRITE       22
              100 FORMAT(/,/,10X,46HFITTING PARAMETERS FOR P=A*T**(-1)+B*T**(-.5) ,WRITE       23
                 19HARE:  A= ,1PE15.8,12X,7HOMEGA= ,1PE15.8,/,62X,3HB= ,1PE15.8)   WRITE       24
                  WRITE(6,110) IT,S                                                WRITE       25
   25         110 FORMAT(/,30X,17HA AND B FOUND IN ,I3,11H ITERATIONS,             WRITE       26
                 110X,19HMINIMUM OF S(A,B)= ,1PE15.8)                              WRITE       27
                  RETURN                                                           WRITE       28
                  END                                                              WRITE       29


CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

     5      I              AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
    13      I              AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.


         SYMBOLIC REFERENCE MAP (R=3)

 ENTRY POINTS       DEF LINE     REFERENCES
     3  WRITE            1          20        27

 VARIABLES      SN   TYPE            RELOCATION
     0  A            REAL                 F.P.        REFS        14     DEFINED        1
     0  AE           REAL                 F.P.        REFS        21     DEFINED        1
     0  B            REAL                 F.P.        REFS        17     DEFINED        1
     0  BE           REAL                 F.P.        REFS        21     DEFINED        1
     3  DEV          REAL               A             REFS         3           6       10
     1  FLAG         INTEGER            A             REFS         2           3       13        20
     0  GAUS         REAL       ARRAY   E             REFS         4          14       17        21
     0  IND          INTEGER            A             REFS         3
     2  IPRAM        INTEGER            A             REFS         3
     0  IT           INTEGER              F.P.        REFS        24     DEFINED        1
```

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      SUBROUTINE WRITE        74/74   OPT=1                          FTN 4.5+414       06/01/76  14.04.49       PAGE     2

VARIABLES      SN  TYPE               RELOCATION
    0  M           INTEGER                F.P.        REFS        5   DEFINED        1
    3  S           REAL                  E            REFS        4      24

FILE NAMES         MODE
      TAPE6        FMT                     WRITES        6         10        14        17        21        24

STATEMENT LABELS                DEF LINE    REFERENCES
   14  10                            6          5
   50  20         FMT                7          6
   17  30                           10          5
   63  40         FMT               11         10
   21  50                           13          9
   31  60                           14        2*13
   77  70         FMT               15         14
  115  80         FMT               18         17
   37  90                           21         13
  134  100        FMT               22         21
  156  110        FMT               25         24

COMMON BLOCKS    LENGTH     MEMBERS - BIAS NAME(LENGTH)
      A              4                0 IND     (1)                1 FLAG   (1)                  2 IPRAM  (1)
                                      3 DEV     (1)
      E              4                0 GAUS    (3)                3 S      (1)

STATISTICS
  PROGRAM LENGTH                   167B      119
  CM LABELED COMMON LENGTH          10B        8
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SUBROUTINE PLOTT      74/74    OPT=1                  FTN 4.5+414        06/01/76  14.04.49       PAGE     1

          SUBROUTINE PLOTT(KNUM,JNUM,J)                                          PLOT    2
          INTEGER FLAG                                                           PLOT    3
          REAL IP,IPRF,IPFF                                                      PLOT    4
          COMMON/A/IND,FLAG,IPRAM,DEV                                            PLOT    5
          COMMON/B/PRF(600),TDRF(600),ERF(600),TDDCRF(600),ZRF(600),             PLOT    6
         1        VOCRF(600),IPRF(600),P1(600),P2(600),P3(600)                   PLOT    7
          COMMON/C/PFF(600),TDFF(600),EFF(600),TDDCFF(600),ZFF(600),             PLOT    8
         1        VOCFF(600),IPFF(600)                                           PLOT    9
          COMMON/D/T(600),PP(600)                                                PLOT   10
          COMMON/F/IPLOT,ISEM,ITYPE                                              PLOT   11
          DIMENSION RTITLEA(8),RTITLEB(8),ETITLER(8),RTITLAB(8),                 PLOT   12
         1          FTITLEA(8),FTITLEB(8),ETITLEF(8),FTITLAB(8)                  PLOT   13
          DIMENSION XTITLE(3),YTITLE(3),YTITLEE(3),XTITLEP(3),YTITLEZ(3),        PLOT   14
         1          YTITVOC(3),YTITLEI(3),LEGEN(3),BLANK(3)                      PLOT   15
          DATA RTITLEA/8*1H /,RTITLEB/8*1H /,ETITLER/8*1H /,RTITLAB/8*1H /,      PLOT   16
         1     FTITLEA/8*1H /,FTITLEB/8*1H /,ETITLEF/8*1H /,FTITLAB/8*1H /,      PLOT   17
         2     XTITLE/3*1H /,YTITLE/3*1H /,YTITLEE/3*1H /,XTITLEP/3*1H /,        PLOT   18
         3     YTITLEZ/3*1H /,YTITVOC/3*1H /,YTITLEI/3*1H /,LEGEN/3*1H /,        PLOT   19
         4     BLANK/3*1H /                                                      PLOT   20
          XTITLE(1)=5H                                                           PLOT   21
          XTITLE(2)=10HFAILURE TI                                                PLOT   22
          XTITLE(3)=10HME(TD)                                                    PLOT   23
          YTITLE(1)=10H                                                          PLOT   24
          YTITLE(2)=10HPOWER(P)                                                  PLOT   25
          YTITLEE(1)=10H                                                         PLOT   26
          YTITLEE(2)=10HENERGY(E)                                                PLOT   27
          ETITLER(1)=10H  DEVICE:                                                PLOT   28
          ETITLER(2)=DEV                                                         PLOT   29
          ETITLER(3)=10H   REVERSE                                               PLOT   30
          ETITLER(4)=10H FAILURE                                                 PLOT   31
          XTITLEP(1)=10HPULSE DURA                                               PLOT   32
          XTITLEP(2)=10HTION(TDDC)                                               PLOT   33
          ETITLEF(1)=10H  DEVICE:                                                PLOT   34
          ETITLEF(2)=DEV                                                         PLOT   35
          ETITLEF(3)=10H   FORWARD                                               PLOT   36
          ETITLEF(4)=10H FAILURE                                                 PLOT   37
          YTITLEZ(1)=5H                                                          PLOT   38
          YTITLEZ(2)=10HIMPEDANCE(                                               PLOT   39
          YTITLEZ(3)=10HZ)                                                       PLOT   40
          YTITVOC(1)=10HOPEN CIRCU                                               PLOT   41
          YTITVOC(2)=10HIT VOLTAGE                                               PLOT   42
          YTITVOC(3)=10H(VOC)                                                    PLOT   43
          YTITLEI(1)=5H                                                          PLOT   44
          YTITLEI(2)=10HCURRENT(IP                                               PLOT   45
          YTITLEI(3)=10H)                                                        PLOT   46
          LEGEN(1)=10HLEAST SQUA                                                 PLOT   47
          LEGEN(2)=10HRES FIT TO                                                 PLOT   48
          LEGEN(3)=10H DATA                                                      PLOT   49
          BLANK(1)=10HDATA PAIRS                                                 PLOT   50
          BLANK(2)=10H                                                           PLOT   51
          BLANK(3)=10H                                                           PLOT   52
          IF(J.EQ.2)  GO TO 60                                                   PLOT   53
          IF(J.EQ.3)  GO TO 90                                                   PLOT   54
       20 GO TO (30,40,30),FLAG                                                  PLOT   55
       30 RTITLEA(1)=10H  DEVICE:                                                PLOT   56
          RTITLEA(2)=DEV                                                         PLOT   57
          RTITLEA(3)=10H   REVERSE                                               PLOT   58
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SUBROUTINE PLOTT      74/74   OPT=1                    FTN 4.5+414        06/01/76  14.04.49      PAGE    2

       RTITLEA(4)=10H FAILURE                                              PLOT     59
       RTITLEA(5)=10H   FIT TO                                             PLOT     60
       RTITLEA(6)=10HP=A*T**(-1                                            PLOT     61
       RTITLEA(7)=10H)                                                     PLOT     62
       RTITLEB(1)=10H  DEVICE:                                             PLOT     63
       RTITLEB(2)=DEV                                                      PLOT     64
       RTITLEB(3)=10H   REVERSE                                            PLOT     65
       RTITLEB(4)=10H FAILURE                                              PLOT     66
       RTITLEB(5)=10H   FIT TO                                             PLOT     67
       RTITLEB(6)=10HP=B*T**(-.                                            PLOT     68
       RTITLEB(7)=10H5)                                                    PLOT     69
       IF(ISEM.EQ.0)  GO TO 33                                             PLOT     70
       CALL CHANGE(KNUM,XTITLE,YTITLE,TDRF,PRF)                            PLOT     71
    33 CALL PWRITE(2,RTITLEA,XTITLE,YTITLE,BLANK,LEGEN,KNUM,TDRF,PRF,      PLOT     72
      1T,P2)                                                               PLOT     73
       CALL PWRITE(2,RTITLEB,XTITLE,YTITLE,BLANK,LEGEN,KNUM,TDRF,PRF,      PLOT     74
      1T,P3)                                                               PLOT     75
       IF(ISEM.EQ.1)  GO TO 35                                             PLOT     76
       CALL PWRITE(1,ETITLER,XTITLE,YTITLEE,BLANK,BLANK,KNUM,TDRF,ERF,     PLOT     77
      10.,0.)                                                              PLOT     78
    35 IF(FLAG.EQ.1)  GO TO 50                                             PLOT     79
    40 RTITLAB(1)=10H  DEVICE:                                             PLOT     80
       RTITLAB(2)=DEV                                                      PLOT     81
       RTITLAB(3)=10H   REVERSE                                            PLOT     82
       RTITLAB(4)=10H FAILURE                                              PLOT     83
       RTITLAB(5)=10H   FIT TO                                             PLOT     84
       RTITLAB(6)=10HP=A*T**(-1                                            PLOT     85
       RTITLAB(7)=10H)+B*T**(-.                                            PLOT     86
       RTITLAB(8)=10H5)                                                    PLOT     87
       IF(ISEM.EQ.0)  GO TO 43                                             PLOT     88
       CALL CHANGE(KNUM,XTITLE,YTITLE,TDRF,PRF)                            PLOT     89
    43 CALL PWRITE(2,RTITLAB,XTITLE,YTITLE,BLANK,LEGEN,KNUM,TDRF,PRF,      PLOT     90
      1T,P1)                                                               PLOT     91
       IF(ISEM.EQ.1)  GO TO 50                                             PLOT     92
       IF(FLAG.EQ.3)  GO TO 50                                             PLOT     93
       CALL PWRITE(1,ETITLER,XTITLE,YTITLEE,BLANK,BLANK,KNUM,TDRF,ERF,     PLOT     94
      10.,0.)                                                              PLOT     95
    50 CONTINUE                                                            PLOT     96
       IF(J.EQ.1)  RETURN                                                  PLOT     97
    60 IF(JNUM.EQ.0)  GO TO 130                                            PLOT     98
       GO TO (70,80,70),FLAG                                               PLOT     99
    70 FTITLEA(1)=10H  DEVICE:                                             PLOT    100
       FTITLEA(2)=DEV                                                      PLOT    101
       FTITLEA(3)=10H   FORWARD                                            PLOT    102
       FTITLEA(4)=10H FAILURE                                              PLOT    103
       FTITLEA(5)=10H   FIT TO                                             PLOT    104
       FTITLEA(6)=10HP=A*T**(-1                                            PLOT    105
       FTITLEA(7)=10H)                                                     PLOT    106
       FTITLEB(1)=10H  DEVICE:                                             PLOT    107
       FTITLEB(2)=DEV                                                      PLOT    108
       FTITLEB(3)=10H   FORWARD                                            PLOT    109
       FTITLEB(4)=10H FAILURE                                              PLOT    110
       FTITLEB(5)=10H   FIT TO                                             PLOT    111
       FTITLEB(6)=10HP=B*T**(-.                                            PLOT    112
       FTITLEB(7)=10H5)                                                    PLOT    113
       IF(ISEM.EQ.0)  GO TO 73                                             PLOT    114
       CALL CHANGE(JNUM,XTITLE,YTITLE,TDFF,PFF)                            PLOT    115
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 73 CALL PWRITE(2,FTITLEA,XTITLE,YTITLE,BLANK,LEGEN,JNUM,TDFF,PFF,      PLOT  116
   1T,P2)                                                               PLOT  117
    CALL PWRITE(2,FTITLEB,XTITLE,YTITLE,BLANK,LEGEN,JNUM,TDFF,PFF,      PLOT  118
   1T,P3)                                                               PLOT  119
    IF(ISEM.EQ.1)  GO TO 75                                             PLOT  120
    CALL PWRITE(1,FTITLEF,XTITLE,YTITLEE,BLANK,BLANK,JNUM,TDFF,EFF,     PLOT  121
   10.,0.)                                                              PLOT  122
 75 IF(FLAG.EQ.1)  GO TO 90                                             PLOT  123
 80 FTITLAB(1)=10H  DEVICE:                                             PLOT  124
    FTITLAB(2)=DEV                                                      PLOT  125
    FTITLAB(3)=10H   FORWARD                                            PLOT  126
    FTITLAB(4)=10H FAILURE                                              PLOT  127
    FTITLAB(5)=10H   FIT TO                                             PLOT  128
    FTITLAB(6)=10HP=A*T**(-1                                            PLOT  129
    FTITLAB(7)=10H)+B*T**(-.                                            PLOT  130
    FTITLAB(8)=10H5)                                                    PLOT  131
    IF(ISEM.EQ.0)  GO TO 83                                             PLOT  132
    CALL CHANGE(JNUM,XTITLE,YTITLE,TDFF,PFF)                            PLOT  133
 83 CALL PWRITE(2,FTITLAB,XTITLE,YTITLE,BLANK,LEGEN,JNUM,TDFF,PFF,      PLOT  134
   1T,P1)                                                               PLOT  135
    IF(ISEM.EQ.1)  GO TO 90                                             PLOT  136
    IF(FLAG.EQ.3)  GO TO 90                                             PLOT  137
    CALL PWRITE(1,ETITLEF,XTITLE,YTITLEE,BLANK,BLANK,JNUM,TDFF,EFF,     PLOT  138
   10.,0.)                                                              PLOT  139
 90 CONTINUE                                                            PLOT  140
    IF(JNUM.EQ.0)  GO TO 130                                            PLOT  141
    IF(J.EQ.2)  RETURN                                                  PLOT  142
100 GO TO (110,120,110,110),IPRAM                                       PLOT  143
110 CALL PWRITE(1,ETITLER,XTITLE,YTITLEZ,BLANK,BLANK,KNUM,TDRF,ZRF,     PLOT  144
   10.,0.)                                                              PLOT  145
    CALL PWRITE(1,ETITLER,XTITLE,YTITVOC,BLANK,BLANK,KNUM,TDRF,VOCRF,   PLOT  146
   10.,0.)                                                              PLOT  147
    CALL PWRITE(1,ETITLER,XTITLEP,YTITVOC,BLANK,BLANK,KNUM,TDOCRF,      PLOT  148
   1VOCRF,0.,0.)                                                        PLOT  149
    CALL PWRITE(1,ETITLER,XTITLE,YTITLEI,BLANK,BLANK,KNUM,TDRF,IPRF,    PLOT  150
   10.,0.)                                                              PLOT  151
    IF(IPRAM.EQ.1)  RETURN                                              PLOT  152
120 CALL PWRITE(1,ETITLEF,XTITLE,YTITLEZ,BLANK,BLANK,JNUM,TDFF,ZFF,     PLOT  153
   10.,0.)                                                              PLOT  154
    CALL PWRITE(1,ETITLEF,XTITLE,YTITVOC,BLANK,BLANK,JNUM,TDFF,VOCFF,   PLOT  155
   10.,0.)                                                              PLOT  156
    CALL PWRITE(1,ETITLEF,XTITLEP,YTITVOC,BLANK,BLANK,JNUM,TDOCFF,      PLOT  157
   1VOCFF,0.,0.)                                                        PLOT  158
    CALL PWRITE(1,ETITLEF,XTITLE,YTITLEI,BLANK,BLANK,JNUM,TDFF,IPFF,    PLOT  159
   10.,0.)                                                              PLOT  160
    RETURN                                                              PLOT  161
130 STOP                                                                PLOT  162
    END                                                                 PLOT  163
```

CARD NR.	SEVERITY	DETAILS	DIAGNOSIS OF PROBLEM
54	I		AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.
98	I		AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.

APPENDIX C

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     SUBROUTINE PLOTT        74/74   OPT=1                         FTN 4.5+414        06/01/76  14.04.49        PAGE     4

     SYMBOLIC REFERENCE MAP (R=3)

 ENTRY POINTS      DEF LINE       REFERENCES
     3  PLOTT           1          96        141       151       160

 VARIABLES        SN  TYPE              RELOCATION
  1036  BLANK         REAL        ARRAY             REFS        13       71       73      2*76       89      2*93      115
                                                     117     2*120      133    2*137     2*143    2*145     2*147    2*149
                                                   2*152     2*154    2*156    2*158   DEFINED       15        49       50
                                                      51
     3  DEV           REAL                    A     REFS         4       28       34       56        63        80      100
                                                     107       124
  2260  EFF           REAL        ARRAY       C     REFS         7      120      137
  2260  ERF           REAL        ARRAY       B     REFS         5       76       93
   766  ETITLEF       REAL        ARRAY             REFS        11      120      137      152       154       156      158
                                                 DEFINED        15       33       34       35        36
   726  ETITLER       REAL        ARRAY             REFS        11       76       93      143       145       147      149
                                                 DEFINED        15       27       28       29        30
     1  FLAG          INTEGER                 A     REFS         2        4       54       78        92        98      122
                                                     136
   776  FTITLAB       REAL        ARRAY             REFS        11      133  DEFINED       15       123       124      125
                                                     126       127      128      129      130
   746  FTITLEA       REAL        ARRAY             REFS        11      115  DEFINED       15        99       100      101
                                                     102       103      104      105
   756  FTITLEB       REAL        ARRAY             REFS        11      117  DEFINED       15       106       107      108
                                                     109       110      111      112
     0  IND           INTEGER                 A     REFS         4
   705  IP          * REAL       *UNDEF             REFS         3
  7020  IPFF          REAL        ARRAY       C     REFS         3        7      158
     0  IPLOT         INTEGER                 F     REFS        10
     2  IPRAM         INTEGER                 A     REFS         4      142      151
  7020  IPRF          REAL        ARRAY       B     REFS         3        5      149
     1  ISEM          INTEGER                 F     REFS        10       69       75       87        91       113      119
                                                     131       135
     2  ITYPE         INTEGER                F      REFS        10
     0  J             INTEGER                 F.P.  REFS        52       53       96      141   DEFINED         1
     0  JNUM          INTEGER                 F.P.  REFS        97      114      115      117       120       132      133
                                                     137       140      152      154      156       158
                                                 DEFINED         1
     0  KNUM          INTEGER                 F.P.  REFS        70       71       73       76        88        69       93
                                                     143       145      147      149   DEFINED         1
  1033  LEGEN         INTEGER     ARRAY             REFS        13       71       73       89       115       117      133
                                                 DEFINED        15       46       47       48
     0  PFF           REAL        ARRAY       C     REFS         7      114      115      117       132       133
  1130  PP            REAL        ARRAY       D     REFS         9
     0  PRF           REAL        ARRAY       B     REFS         5       70       71       73        88        89
 10150  P1            REAL        ARRAY       B     REFS         5       89      133
 11300  P2            REAL        ARRAY       B     REFS         5       71      115
 12430  P3            REAL        ARRAY       B     REFS         5       73      117
   736  RTITLAB       REAL        ARRAY             REFS        11       89  DEFINED       15        79        80       81
                                                      82        83       84       85       86
   706  RTITLEA       PEAL        ARRAY             REFS        11       71  DEFINED       15        55        56       57
                                                      58        59       60       61
   716  RTITLEB       REAL        ARRAY             REFS        11       73  DEFINED       15        62        63       64
                                                      65        66       67       68
     0  T             REAL        ARRAY       D     REFS         9       71       73       89       115       117      133
  1130  TDFF          REAL        ARRAY       C     REFS         7      114      115      117       120       132      133
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      SUBROUTINE PLOTT        74/74    OPT=1                       FTN 4.5+414      06/01/76  14.04.49        PAGE     5

VARIABLES       SN  TYPE             RELOCATION
 3410  TDOCFF    REAL      ARRAY    C               137      152      154      158
 3410  TDOCRF    REAL      ARRAY    B              REFS        7      156
 1130  TDRF      REAL      ARRAY    B              REFS        5      147
                                                   REFS        5       70       71       73       76       88       89
 5670  VOCFF     REAL      ARRAY    C                93      143      145      149
 5670  VOCRF     REAL      ARRAY    B              REFS        7      154      156
 1006  XTITLE    REAL      ARRAY                   REFS        5      145      147
                                                   REFS       13       70       71       73       76       88       89
                                                     93      114      115      117      120      132      133      137
                                                    143      145      149      152      154      158
 1017  XTITLEP   REAL      ARRAY                DEFINED       15       20       21       22
 1011  YTITLE    REAL      ARRAY                   REFS       13      147      156  DEFINED       15       31       32
                                                   REFS       13       70       71       73       88       89      114
 1014  YTITLEE   REAL      ARRAY                    115      117      132      133  DEFINED       15       23       24
                                                   REFS       13       76       93      120      137
 1030  YTITLEI   REAL      ARRAY                DEFINED       15       25       26
                                                   REFS       13      149      158  DEFINED       15       43       44
 1022  YTITLEZ   REAL      ARRAY                     45
                                                   REFS       13      143      152  DEFINED       15       37       38
 1025  YTITVDC   REAL      ARRAY                     39
                                                   REFS       13      145      147      154      156
 4540  ZFF       REAL      ARRAY    C           DEFINED       15       40       41       42
 4540  ZRF       REAL      ARRAY    B              REFS        7      152
                                                   REFS        5      143

EXTERNALS              TYPE    ARGS      REFERENCES
        CHANGE                   5            70       88      114      132
        PWRITE                  11            71       73       76       89       93      115      117      120      133
                                             137      143      145      147      149      152      154      156      158

STATEMENT LABELS                      DEF LINE   REFERENCES
    0  20              INACTIVE          54
   66  30                                55        2*54
  111  33                                71          69
  124  35                                78          75
  126  40                                79          54
  145  43                                89          87
  157  50                                95          78       91       92
  161  60                                97          52
  172  70                                99        2*98
  215  73                               115         113
  230  75                               122         119
  232  80                               123          98
  251  83                               133         131
  263  90                               139          53      122      135      136
    0 100              INACTIVE         142
  277 110                               143       3*142
  315 120                               152         142
  332 130                               161          97      140

COMMON BLOCKS    LENGTH      MEMBERS - BIAS NAME(LENGTH)
    A                4                0 IND     (1)              1 FLAG    (1)              2 IPRAM   (1)
                                      3 DEV     (1)
    B             6000                0 PRF     (600)          600 TDRF    (600)         1200 ERF     (600)
                                   1800 TDOCRF  (600)         2400 ZRF     (600)         3000 VOCRF   (600)
                                   3600 IPRF    (600)         4200 P1      (600)         4800 P2      (600)
                                   5400 P3      (600)
```

APPENDIX C

```
      SUBROUTINE PLOTT       74/74    OPT=1                        FTN 4.5+414        06/01/76  14.04.49       PAGE      6

COMMON BLOCKS     LENGTH      MEMBERS - BIAS NAME(LENGTH)
     C             4200                  0 PFF     (600)           600 TDFF    (600)          1200 EFF     (600)
                                      1800 TDDCFF  (600)          2400 ZFF     (600)          3000 VDCFF   (600)
                                      3600 IPFF    (600)
     D             1200                  0 T       (600)           600 PP      (600)
     F                3                  0 IPLOT   (1)               1 ISEM    (1)               2 ITYPE   (1)

STATISTICS
  PROGRAM LENGTH                10418      545
  CM LABELED COMMON LENGTH     262178    11407
```

```
SUBROUTINE ALSQAR      74/74    OPT=1                                FTN 4.5+414        06/01/76  14.04.49        PAGE      1

                 SUBROUTINE ALSQAR(N,A)                                                  ALSQAR       2
                 REAL IPRF                                                               ALSQAR       3
                 COMMON/B/PRF(600),TDRF(600),ERF(600),TDOCRF(600),ZRF(600),              ALSQAR       4
                1        VOCRF(600),IPRF(600),P1(600),P2(600),P3(600)                    ALSQAR       5
                 COMMON/D/T(600),PP(600)                                                 ALSQAR       6
                 SUMTC=0.                                                                ALSQAR       7
                 SUMCP=0.                                                                ALSQAR       8
                 DO 10 I=1,N                                                             ALSQAR       9
                 SUMTC=SUMTC+ALOG10(T(I))                                                ALSQAR      10
                 SUMCP=SUMCP+ALOG10(PP(I))                                               ALSQAR      11
              10 CONTINUE                                                                ALSQAR      12
                 ARG=(SUMTC+SUMCP)/N                                                     ALSQAR      13
                 A=10.**ARG                                                              ALSQAR      14
                 DO 20 I=1,N                                                             ALSQAR      15
              20 P2(I)=A*T(I)**(-1)                                                      ALSQAR      16
                 RETURN                                                                  ALSQAR      17
                 END                                                                     ALSQAR      18


    SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
    3  ALSQAR          1           16

VARIABLES     SN  TYPE              RELOCATION
     0  A         REAL                   F.P.        REFS        15   DEFINED       1        13
    53  ARG       REAL                               REFS        13   DEFINED      12
  2260  ERF       REAL          ARRAY    B           REFS         3
    52  I         INTEGER                            REFS         9        10    2*15   DEFINED        8        14
  7020  IPRF      REAL          ARRAY    B           REFS         2         3
     0  N         INTEGER                F.P.        REFS         8        12      14   DEFINED        1
  1130  PP        REAL          ARRAY    D           REFS         5        10
     0  PRF       REAL          ARRAY    B           REFS         3
 10150  P1        REAL          ARRAY    B           REFS         3
 11300  P2        REAL          ARRAY    B           REFS         3   DEFINED      15
 12430  P3        REAL          ARRAY    B           REFS         3
    51  SUMCP     REAL                               REFS        10        12   DEFINED        7        10
    50  SUMTC     REAL                               REFS         9        12   DEFINED        6         9
     0  T         REAL          ARRAY    D           REFS         5         9      15
  3410  TDOCRF    REAL          ARRAY    B           REFS         3
  1130  TDRF      REAL          ARRAY    B           REFS         3
  5670  VOCRF     REAL          ARRAY    B           REFS         3
  4540  ZRF       REAL          ARRAY    B           REFS         3

EXTERNALS          TYPE     ARGS          REFERENCES
      ALOG10       REAL     1 LIBRARY         9          10

STATEMENT LABELS               DEF LINE     REFERENCES
    0  10                         11             8
    0  20                         15            14

LOOPS  LABEL      INDEX       FROM-TO      LENGTH      PROPERTIES
   20  10       * I             8 11         11B                  EXT REFS
   40  20       * I            14 15          6B                  EXT REFS
```

```
      SUBROUTINE ALSQAR      74/74    OPT=1                          FTN 4.5+414         06/01/76  14.04.49         PAGE      2

COMMON BLOCKS    LENGTH      MEMBERS - BIAS NAME(LENGTH)
      B          6000                 0 PRF      (600)          600 TDRF     (600)          1200 ERF      (600)
                                   1800 TDDCRF  (600)          2400 ZRF      (600)          3000 VDCRF    (600)
                                   3600 IPRF     (600)          4200 P1       (600)          4800 P2       (600)
                                   5400 P3       (600)
      D          1200                 0 T        (600)          600 PP       (600)

STATISTICS
  PROGRAM LENGTH                  61B       49
  CM LABELED COMMON LENGTH     16040B     7200
```

```
SUBROUTINE BLSQAR      74/74    OPT=1                          FTN 4.5+414        06/01/76  14.04.49        PAGE      1

                        SUBROUTINE BLSQAR(N,B)                                            BLSQAR       2
                        REAL IPRF                                                         BLSQAR       3
                        COMMON/B/PRF(600),TDRF(600),ERF(600),TDDCRF(600),ZRF(600),        BLSQAR       4
                       1        VDCRF(600),IPRF(600),P1(600),P2(600),P3(600)              BLSQAR       5
                        COMMON/D/T(600),PP(600)                                           BLSQAR       6
                        SUMTD=0.                                                          BLSQAR       7
                        SUMDP=0.                                                          BLSQAR       8
                        DO 10 I=1,N                                                       BLSQAR       9
                        SUMTD=SUMTD+ALOG10(T(I))                                          BLSQAR      10
                        SUMDP=SUMDP+ALOG10(PP(I))                                         BLSQAR      11
                     10 CONTINUE                                                          BLSQAR      12
                        ARG=(SUMDP+.5*SUMTD)/N                                            BLSQAR      13
                        B=10.**ARG                                                        BLSQAR      14
                        DO 20 I=1,N                                                       BLSQAR      15
                     20 P3(I)=B*T(I)**(-.5)                                               BLSQAR      16
                        RETURN                                                            BLSQAR      17
                        END                                                               BLSQAR      18


      SYMBOLIC REFERENCE MAP (R=3)

 ENTRY POINTS      DEF LINE      REFERENCES
     3  BLSQAR          1            16

 VARIABLES      SN   TYPE            RELOCATION
     55  ARG         REAL                           REFS         13   DEFINED      12
      0  B           REAL                 F.P.      REFS         15   DEFINED       1        13
   2260  ERF         REAL       ARRAY    B          REFS          3
     54  I           INTEGER                        REFS          9        10    2*15   DEFINED        8        14
   7020  IPRF        REAL       ARRAY    B          REFS          2         3
      0  N           INTEGER              F.P.      REFS          8        12      14   DEFINED        1
   1130  PP          REAL       ARRAY    D          REFS          5        10
      0  PRF         REAL       ARRAY    B          REFS          3
  10150  P1          REAL       ARRAY    B          REFS          3
  11300  P2          REAL       ARRAY    B          REFS          3
  12430  P3          REAL       ARRAY    B          REFS          3   DEFINED      15
     53  SUMDP       REAL                           REFS         10        12   DEFINED        7        10
     52  SUMTD       REAL                           REFS          9        12   DEFINED        6         9
      0  T           REAL       ARRAY    D          REFS          5         9      15
   3410  TDDCRF      REAL       ARRAY    B          REFS          3
   1130  TDRF        REAL       ARRAY    B          REFS          3
   5670  VDCRF       REAL       ARRAY    B          REFS          3
   4540  ZRF         REAL       ARRAY    B          REFS          3

 EXTERNALS          TYPE    ARGS         REFERENCES
        ALOG10      REAL       1 LIBRARY       9       10

 STATEMENT LABELS             DEF LINE    REFERENCES
      0  10                       11          8
      0  20                       15         14

 LOOPS  LABEL      INDEX      FROM-TO     LENGTH     PROPERTIES
    20  10       * I            8 11        11B              EXT REFS
    40  20.      * I           14 15         6B              EXT REFS
```

```
      SUBROUTINE BLSQAR      74/74    OPT=1                          FTN 4.5+414        06/01/76  14.04.49        PAGE      2

COMMON BLOCKS   LENGTH      MEMBERS - BIAS NAME(LENGTH)
      B          6000               0 PRF     (600)              600 TDRF    (600)             1200 ERF     (600)
                                 1800 TDDCRF  (600)             2400 ZRF     (600)             3000 VDCRF   (600)
                                 3600 IPRF    (600)             4200 P1      (600)             4800 P2      (600)
                                 5400 P3      (600)
      D          1200               0 T       (600)              600 PP      (600)

STATISTICS
  PROGRAM LENGTH                638B      51
  CM LABELED COMMON LENGTH    16040B    7200
```

```
SUBROUTINE ABLSQAR    74/74    OPT=1                    FTN 4.5+414        06/01/76  14.04.49        PAGE     1

              SUBROUTINE ABLSQAR(N,AI,BI,AE,BE,IT)
              REAL IPRF                                                    ABLSQAR    2
              COMMON/A/IND,FLAG,IPRAM,DEV                                  ABLSQAR    3
              COMMON/B/PRF(600),TDRF(600),ERF(600),TDDCRF(600),ZRF(600),   ABLSQAR    4
             1      VOCRF(600),IPRF(600),P1(600),P2(600),P3(600)           ABLSQAR    5
              COMMON/D/T(600),PP(600)                                      ABLSQAR    6
              COMMON/E/GAUS(3),S                                           ABLSQAR    7
              DIMENSION A(500),B(500)                                      ABLSQAR    8
              I=1                                                          ABLSQAR    9
              J=1                                                          ABLSQAR   10
              EPS=1.E-4                                                    ABLSQAR   11
              A(I)=AI                                                      ABLSQAR   12
              B(I)=BI                                                      ABLSQAR   13
           10 L=0                                                          ABLSQAR   14
              SI=SAB(N,A(I),B(I))                                          ABLSQAR   15
              AI=A(I)/(2.**J)                                              ABLSQAR   16
              A(I+1)=A(I)-AI                                               ABLSQAR   17
              IF(SAB(N,A(I+1),B(I)).LT.SI)  GO TO 20                       ABLSQAR   18
              A(I+1)=A(I)+AI                                               ABLSQAR   19
              IF(SAB(N,A(I+1),B(I)).LT.SI)  GO TO 20                       ABLSQAR   20
              A(I+1)=A(I)                                                  ABLSQAR   21
              GO TO 30                                                     ABLSQAR   22
           20 L=1                                                          ABLSQAR   23
           30 BI=B(I)/(2.**J)                                              ABLSQAR   24
              B(I+1)=B(I)-BI                                               ABLSQAR   25
              IF(SAB(N,A(I+1),B(I+1)).LT.SI)  GO TO 40                     ABLSQAR   26
              B(I+1)=B(I)+BI                                               ABLSQAR   27
              IF(SAB(N,A(I+1),B(I+1)).LT.SI)  GO TO 40                     ABLSQAR   28
              B(I+1)=B(I)                                                  ABLSQAR   29
              GO TO 50                                                     ABLSQAR   30
           40 L=1                                                          ABLSQAR   31
           50 IF(L.EQ.1)  GO TO 60                                         ABLSQAR   32
              I=I+1                                                        ABLSQAR   33
              IF(J.GT.20)  GO TO 90                                        ABLSQAR   34
              J=J+1                                                        ABLSQAR   35
              GO TO 10                                                     ABLSQAR   36
           60 S=SAB(N,A(I+1),B(I+1))                                       ABLSQAR   37
              ERR=ABS(S-SI)                                                ABLSQAR   38
              IF(ERR.LT.EPS)  GO TO 70                                     ABLSQAR   39
              I=I+1                                                        ABLSQAR   40
              GO TO 10                                                     ABLSQAR   41
           70 AE=A(I+1)                                                    ABLSQAR   42
              BE=B(I+1)                                                    ABLSQAR   43
              IT=I                                                         ABLSQAR   44
              DO 80 I=1,N                                                  ABLSQAR   45
           80 P1(I)=AE*T(I)**(-1)+BE*T(I)**(-.5)                           ABLSQAR   46
              GO TO 110                                                    ABLSQAR   47
           90 WRITE(6,100)                                                 ABLSQAR   48
          100 FORMAT(/,/,/,1X,41HNUMBER OF ITERATIONS FOR 2**J EXCEED J=20) ABLSQAR   49
          110 RETURN                                                       ABLSQAR   50
              END                                                          ABLSQAR   51
                                                                           ABLSQAR   52
```

```
      SUBROUTINE ABLSQAR    74/74   OPT=1                          FTN 4.5+414       06/01/76  14.04.49       PAGE     2

      SYMBOLIC REFERENCE MAP (R=3)

  ENTRY POINTS      DEF LINE      REFERENCES
     3  ABLSQAR          1           50

  VARIABLES      SN  TYPE              RELOCATION
    213  A            REAL        ARRAY                   REFS         8        15        16        17        18        19        20
                                                             21        26        28        37        42   DEFINED        12        17
                                                             19        21
      0  AF           REAL                    F.P.        REFS        46   DEFINED         1        42
      0  AI           REAL                    F.P.        REFS        12   DEFINED         1
    210  A1           REAL                                REFS        17        19   DEFINED        16
   1177  B            REAL        ARRAY                   REFS         8        15        18        20        24        25        26
                                                             27        28        29        37        43   DEFINED        13        25
                                                             27        29
      0  BE           REAL                    F.P.        REFS        46   DEFINED         1        43
      0  BI           REAL                    F.P.        REFS        13   DEFINED         1
    211  B1           REAL                                REFS        25        27   DEFINED        24
      3  DEV          REAL                 A              REFS         3
    205  EPS          REAL                                REFS        39   DEFINED        11
   2260  ERF          REAL        ARRAY    B              REFS         4
    212  ERR          REAL                                REFS        39   DEFINED        38
      1  FLAG         REAL                 A              REFS         3
      0  GAUS         REAL        ARRAY    E              REFS         7
    203  I            INTEGER                             REFS        12        13      2*15        16      2*17      2*18      2*19
                                                           2*20      2*21        24      2*25      2*26      2*27      2*28      2*29
                                                             33      2*37        40        42        43        44      3*46
                                                        DEFINED        9        33        40        45
      0  IND          INTEGER              A              REFS         3
      2  IPRAM        INTEGER              A              REFS         3
   7020  IPRF         REAL        ARRAY    B              REFS         2         4
      0  IT           INTEGER                 F.P.     DEFINED         1        44
    204  J            INTEGER                             REFS        16        24        34        35   DEFINED        10        35
    206  L            INTEGER                             REFS        32   DEFINED        14        23        31
      0  N            INTEGER                 F.P.        REFS        15        18        20        26        28        37        45
                                                        DEFINED        1
   1130  PP           REAL        ARRAY    D              REFS         6
      0  PRF          REAL        ARRAY    B              REFS         4
  10150  P1           REAL        ARRAY    B              REFS         4   DEFINED        46
  11300  P2           REAL        ARRAY    B              REFS         4
  12430  P3           REAL        ARRAY    B              REFS         4
      3  S            REAL                 E              REFS         7        38   DEFINED        37
    207  SI           REAL                                REFS        18        20        26        28        38
                                                        DEFINED       15
      0  T            REAL        ARRAY    D              REFS         6      2*46
   3410  TDDCRF       REAL        ARRAY    B              REFS         4
   1130  TDRF         REAL        ARRAY    B              REFS         4
   5670  VDCRF        REAL        ARRAY    B              REFS         4
   4540  ZRF          REAL        ARRAY    B              REFS         4

  FILE NAMES         MODE
       TAPF6         FMT                     WRITES       48

  EXTERNALS           TYPE     ARGS          REFERENCES
       SAB            REAL       3                 15         18        20        26        28        37
```

```
          SUBROUTINE ABLSQAR    74/74   OPT=1                          FTN 4.5+414      06/01/76  14.04.49      PAGE    3

     INLINE FUNCTIONS    TYPE    ARGS          DEF LINE  REFERENCES
           ABS           REAL      1  INTRIN                  38

     STATEMENT LABELS                 DEF LINE    REFERENCES
         23  10                          14          36          41
         60  20                          23          18          20
         61  30                          24          22
        110  40                          31          26          28
        111  50                          32          30
        117  60                          37          32
        133  70                          42          39
          0  80                          46          45
        154  90                          48          34
        170  100      FMT                49          48
        156  110                         50          47

     LOOPS   LABEL      INDEX      FROM-TO     LENGTH     PROPERTIES
       141   80       * I            45 46        13B                 EXT REFS

     COMMON BLOCKS     LENGTH      MEMBERS - BIAS NAME(LENGTH)
             A              4                0 IND      (1)              1 FLAG     (1)              2 IPRAM    (1)
                                             3 DEV      (1)
             B           6000                0 PRF      (600)          600 TDRF     (600)         1200 ERF      (600)
                                          1800 TDDCRF   (600)         2400 ZRF      (600)         3000 VDCRF    (600)
                                          3600 IPRF     (600)         4200 P1       (600)         4800 P2       (600)
                                          5400 P3       (600)
             D           1200                0 T        (600)          600 PP       (600)
             E              4                0 GAUS     (3)              3 S        (1)

     STATISTICS
       PROGRAM LENGTH                 2177B        1151
       CM LABELED COMMON LENGTH      16050B        7208
```

```
SUBROUTINE PWRITE      74/74    OPT=1                         FTN 4.5+414        06/01/76  14.04.49        PAGE      1

  1              SUBROUTINE PWRITE(K,T,XT,YT,GLD,GLL,N,X,Y,XX,YY)                              PWRITE      2
                 COMMON/F/IPLOT,ISEM,ITYPE                                                     PWRITE      3
                 DIMENSION X(600),Y(600),XX(600),YY(600)                                       PWRITE      4
                 DIMENSION T(8),XT(3),YT(3),GLD(3),GLL(3)                                      PWRITE      5
  5              IF(ITYPE.EQ.1)  GO TO 10                                                      PWRITE      6
                 CALL SELPLOT(IPLOT)                                                           PWRITE      7
                 CALL TALGRAF(K,0.,0.,0.,0.,0.,T,XT,YT)                                        PWRITE      8
                 CALL TALDATA(N,X,Y,1,1,2,GLD)                                                 PWRITE      9
                 IF(K.EQ.1)  RETURN                                                            PWRITE     10
 10              CALL TALDATA(N,XX,YY,1,1,1,GLL)                                               PWRITE     11
                 RETURN                                                                        PWRITE     12
           10    CONTINUE                                                                      PWRITE     13
                 CALL DRAW4(1,7,3,3,3,8,XT,YT,GLL,T)                                           PWRITE     14
                 CALL DRAW4(2,7,2,N,-2,10,X,Y,0.,0.)                                           PWRITE     15
 15              IF(K.EQ.1)  GO TO 20                                                          PWRITE     16
                 CALL DRAW4(2,7,2,N,0,10,XX,YY,0.,0.)                                          PWRITE     17
           20    CALL DRAW4(3,7,2,0,2,N,XX,YY,2.,0.)                                           PWRITE     18
                 RETURN                                                                        PWRITE     19
                 END                                                                           PWRITE     20


      SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS     DEF LINE      REFERENCES
   3  PWRITE         1              9          11         18

VARIABLES       SN  TYPE              RELOCATION
   0  GLD           REAL        ARRAY     F.P.       REFS        4         8      DEFINED      1
   0  GLL           REAL        ARRAY     F.P.       REFS        4        10         13     DEFINED       1
   0  IPLOT         INTEGER                F         REFS        2         6
   1  ISEM          INTEGER                F         REFS        2
   2  ITYPE         INTEGER                F         REFS        2         5
   0  K             INTEGER               F.P.       REFS        7         9         15     DEFINED       1
   0  N             INTEGER               F.P.       REFS        8        10         14        16        17
                                                  DEFINED        1
   0  T             REAL        ARRAY     F.P.       REFS        4         7         13     DEFINED       1
   0  X             REAL        ARRAY     F.P.       REFS        3         8         14     DEFINED       1
   0  XT            REAL        ARRAY     F.P.       REFS        4         7         13     DEFINED       1
   0  XX            REAL        ARRAY     F.P.       REFS        3        10         16        17     DEFINED      1
   0  Y             REAL        ARRAY     F.P.       REFS        3         8         14     DEFINED       1
   0  YT            REAL        ARRAY     F.P.       REFS        4         7         13     DEFINED       1
   0  YY            REAL        ARRAY     F.P.       REFS        3        10         16        17     DEFINED      1

EXTERNALS           TYPE    ARGS        REFERENCES
        DRAW4                10             13          14        16        17
        SELPLOT               1              6
        TALDATA               7              8          10
        TALGRAF              10              7

STATEMENT LABELS              DEF LINE    REFERENCES
   41  10                         12          5
   67  20                         17         15
```

```
      SUBROUTINE PWRITE     74/74    OPT=1                         FTN 4.5+414        06/01/76  14.04.49        PAGE     2

COMMON BLOCKS   LENGTH      MEMBERS - BIAS NAME(LENGTH)
     F             3                0 IPLOT  (1)                   1 ISEM    (1)                   2 ITYPE  (1)

STATISTICS
  PROGRAM LENGTH                   220B     144
  CM LABELED COMMON LENGTH           3B       3
```

```
SUBROUTINE SORT        74/74    OPT=1                               FTN 4.5+414        06/01/76  14.04.49        PAGE     1

                  SUBROUTINE SORT(N)                                                      SORT        2
                  COMMON/D/T(600),PP(600)                                                 SORT        3
                  DIMENSION E(600),H(600)                                                 SORT        4
                  I=1                                                                     SORT        5
                  J=0                                                                     SORT        6
           10     TDMIN=1.E300                                                            SORT        7
                  DO 20 L=1,N                                                             SORT        8
                  TDMIN=AMIN1(TDMIN,T(L))                                                 SORT        9
                  IF(TDMIN.EQ.T(L)) J=L                                                   SORT       10
           20     CONTINUE                                                                SORT       11
                  IF(TDMIN.GT.1.E50)  GO TO 40                                            SORT       12
                  E(I)=PP(J)                                                              SORT       13
                  H(I)=TDMIN                                                              SORT       14
                  I=I+1                                                                   SORT       15
                  T(J)=1.E51                                                              SORT       16
                  GO TO 10                                                                SORT       17
           40     CONTINUE                                                                SORT       18
                  DO 50 L=1,N                                                             SORT       19
                  PP(L)=E(L)                                                              SORT       20
                  T(L)=H(L)                                                               SORT       21
           50     CONTINUE                                                                SORT       22
                  RETURN                                                                  SORT       23
                  END                                                                     SORT       24


        SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE     REFERENCES
    3  SORT           1           22

VARIABLES       SN  TYPE            RELOCATION
   51  E            REAL        ARRAY                REFS      3     19   DEFINED     12
 1201  H            REAL        ARRAY                REFS      3     20   DEFINED     13
   45  I            INTEGER                          REFS     12     13        14   DEFINED       4       14
   46  J            INTEGER                          REFS     12     15   DEFINED      5           9
   50  L            INTEGER                          REFS      8    2*9      2*19     2*20   DEFINED       7     18
    0  N            INTEGER                F.P.      REFS      7     18   DEFINED      1
 1130  PP           REAL        ARRAY   D            REFS      2     12   DEFINED     19
    0  T            REAL        ARRAY   D            REFS      2      8         9   DEFINED      15       20
   47  TDMIN        REAL                             REFS      8      9        11        13   DEFINED       6      8

INLINE FUNCTIONS    TYPE    ARGS        DEF LINE   REFERENCES
      AMINI         REAL      0  INTRIN                 8

STATEMENT LABELS              DEF LINE    REFERENCES
    7  10                         6          16
    0  20                        10           7
   32  40                        17          11
    0  50                        21          18

LOOPS  LABEL     INDEX      FROM-TO     LENGTH    PROPERTIES
   13  20        L            7 10         6B      INSTACK
   35  50        L           18 21         4B      INSTACK
```

```
      SUBROUTINE SORT       74/74   OPT=1                        FTN 4.5+414       06/01/76  14.04.49       PAGE     2

COMMON BLOCKS   LENGTH     MEMBERS - BIAS NAME(LENGTH)
      D          1200                0 T       (600)            600 PP     (600)

STATISTICS
  PROGRAM LENGTH                 2331B     1241
  CM LABELED COMMON LENGTH       2260B     1200
```

```
SUBROUTINE GOODFIT    74/74   OPT=1                         FTN 4.5+414     06/01/76  14.04.49      PAGE    1

                SUBROUTINE GOODFIT(Y,YI,N,M,J)
                INTEGER FLAG                                              GOODFIT    2
                COMMON/A/IND,FLAG,IPRAM,DEV                               GOODFIT    3
                COMMON/E/GAUS(3),S                                        GOODFIT    4
                DIMENSION Y(600),YI(600)                                  GOODFIT    5
                IF(FLAG.EQ.2)  RETURN                                     GOODFIT    6
                SUM=0.                                                    GOODFIT    7
                DO 10 I=1,N                                               GOODFIT    8
                YL=ALOG10(Y(I))                                           GOODFIT    9
                YIL=ALOG10(YI(I))                                         GOODFIT   10
                SUM=SUM+(YL-YIL)**2                                       GOODFIT   11
          10    CONTINUE                                                  GOODFIT   12
                GO TO (20,30,40),J                                        GOODFIT   13
          20    GAUS(1)=SUM/(N-M)                                         GOODFIT   14
                RETURN                                                    GOODFIT   15
          30    GAUS(2)=SUM/(N-M)                                         GOODFIT   16
                RETURN                                                    GOODFIT   17
          40    GAUS(3)=SUM/(N-M)                                         GOODFIT   18
                RETURN                                                    GOODFIT   19
                END                                                       GOODFIT   20
                                                                          GOODFIT   21

CARD NR. SEVERITY  DETAILS     DIAGNOSIS OF PROBLEM

    13     I                   AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.


     SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS       DEF LINE      REFERENCES
    3  GOODFIT         1              6          15         17         19

VARIABLES      SN   TYPE               RELOCATION
    3  DEV          REAL                    A          REFS       3
    1  FLAG         INTEGER                 A          REFS       2        3         6
    0  GAUS         REAL         ARRAY      E          REFS       4     DEFINED     14         16         18
   60  I            INTEGER                            REFS       9        10      DEFINED      8
    0  IND          INTEGER                 A          REFS       3
    2  IPRAM        INTEGER                 A          REFS       3
    0  J            INTEGER                  F.P.      REFS      13     DEFINED      1
    0  M            INTEGER                  F.P.      REFS      14        16        18      DEFINED      1
    0  N            INTEGER                  F.P.      REFS       8        14        16         18      DEFINED      1
    3  S            REAL                    E          REFS       4
   57  SUM          REAL                               REFS      11        14        16         18      DEFINED      7       11
    0  Y            REAL         ARRAY       F.P.      REFS       5         9      DEFINED      1
    0  YI           REAL         ARRAY       F.P.      REFS       5        10      DEFINED      1
   62  YIL          REAL                               REFS      11     DEFINED     10
   61  YL           REAL                               REFS      11     DEFINED      9

EXTERNALS          TYPE    ARGS        REFERENCES
      ALOG10       REAL      1 LIBRARY      9          10
```

```
      SUBROUTINE GOODFIT    74/74   OPT=1                          FTN 4.5+414        06/01/76  14.04.49       PAGE     2

STATEMENT LABELS                DEF LINE   REFERENCES
    0  10                           12          8
   42  20                           14         13
   46  30                           16         13
   52  40                           18         13

LOOPS  LABEL     INDEX      FROM-TO     LENGTH     PROPERTIES
   21  10      * I            8 12        12B                  EXT REFS

COMMON BLOCKS    LENGTH      MEMBERS - BIAS NAME(LENGTH)
       A              4                0 IND     (1)                  1 FLAG   (1)                   2 IPRAM  (1)
                                       3 DEV     (1)
       E              4                0 GAUS    (3)                  3 S      (1)

STATISTICS
  PROGRAM LENGTH                  75B       61
  CM LABELED COMMON LENGTH        10B        8
```

```
SUBROUTINE GAUSS       74/74    OPT=1                          FTN 4.5+414        06/01/76  14.04.49        PAGE     1

 1               SUBROUTINE GAUSS
                 INTEGER FLAG                                              GAUSS      2
                 COMMON/A/IND,FLAG,IPRAM,DEV                               GAUSS      3
                 COMMON/E/GAUS(3),S                                        GAUSS      4
 5               J=3                                                       GAUSS      5
                 IF(FLAG.EQ.2)  RETURN                                     GAUSS      6
                 IF(FLAG.EQ.1)  J=2                                        GAUSS      7
                 GMIN=1.E300                                               GAUSS      8
                 DO 10 I=1,J                                               GAUSS      9
10               GMIN=AMIN1(GMIN,GAUS(I))                                  GAUSS     10
              10 CONTINUE                                                  GAUSS     11
                 DO 15 I=1,J                                               GAUSS     12
                 IF(GMIN.EQ.GAUS(I))  L=I                                  GAUSS     13
              15 CONTINUE                                                  GAUSS     14
15               WRITE(6,20)                                               GAUSS     15
              20 FORMAT(/,/,5X,34HGAUSS CRITERION OF GOODNESS OF FIT,/,10X,  GAUSS     16
                143HTHE EQUATION WHICH BEST FITS THIS DATA IS: )            GAUSS     17
                 GO TO (30,50,70),L                                        GAUSS     18
              30 WRITE(6,40)                                               GAUSS     19
20            40 FORMAT(/,30X,11HP=A*T**(-1))                              GAUSS     20
                 RETURN                                                    GAUSS     21
              50 WRITE(6,60)                                               GAUSS     22
              60 FORMAT(/,30X,12HP=B*T**(-.5))                             GAUSS     23
                 RETURN                                                    GAUSS     24
25            70 WRITE(6,80)                                               GAUSS     25
              80 FORMAT(/,30X,22HP=A*T**(-1)+B*T**(-.5))                   GAUSS     26
                 RETURN                                                    GAUSS     27
                 END                                                       GAUSS     28
                                                                           GAUSS     29

CARD NR. SEVERITY  DETAILS    DIAGNOSIS OF PROBLEM

   18      I                  AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.


        SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
   1  GAUSS           1            6         21         24         27

VARIABLES       SN  TYPE             RELOCATION
    3  DEV          REAL                  A          REFS      3
    1  FLAG         INTEGER               A          REFS      2
    0  GAUS         REAL         ARRAY    E          REFS      4        3         6         7
  117  GMIN         REAL                             REFS      4       10        13
  120  I            INTEGER                          REFS     10       13    DEFINED        8        10
    0  IND          INTEGER               A          REFS     10     2*13    DEFINED        9        12
    2  IPRAM        INTEGER               A          REFS      3
  116  J            INTEGER                          REFS      3
  121  L            INTEGER                          REFS      9       12    DEFINED        5         7
    3  S            REAL                  E          REFS     18   DEFINED        13
                                                                   4
```

```
        SUBROUTINE GAUSS       74/74    OPT=1                        FTN 4.5+414       06/01/76  14.04.49       PAGE     2

FILE NAMES        MODE
        TAPE6     FMT                        WRITES       15        19         22         25

INLINE FUNCTIONS    TYPE    ARGS        DEF LINE   REFERENCES
        AMIN1      REAL       0  INTRIN                 10

STATEMENT LABELS                DEF LINE    REFERENCES
     0  10                         11           9
     0  15                         14          12
    55  20       FMT               16          15
    41  30                         19          18
    73  40       FMT               20          19
    44  50                         22          18
   101  60       FMT               23          22
    47  70                         25          18
   110  80       FMT               26          25

LOOPS  LABEL    INDEX      FROM-TO     LENGTH    PROPERTIES
   13  10        I           9 11         4B       INSTACK
   22  15        I          12 14         4B       INSTACK

COMMON BLOCKS    LENGTH      MEMBERS - BIAS NAME(LENGTH)
        A            4                0 IND     (1)                 1 FLAG    (1)                  2 IPRAM   (1)
                                      3 DEV     (1)
        E            4                0 GAUS    (3)                 3 S       (1)

STATISTICS
  PROGRAM LENGTH                  122B       82
  CM LABELED COMMON LENGTH         10B        8
```

APPENDIX C

```
      FUNCTION SAB        74/74    OPT=1                       FTN 4.5+414      06/01/76  14.04.49      PAGE     1

                    FUNCTION SAB(N,A,B)                                              SAB         2
                    COMMON/D/T(600),PP(600)                                          SAB         3
                    SUM=0.                                                           SAB         4
                    NN=N                                                             SAB         5
                    AA=A                                                             SAB         6
                    BB=B                                                             SAB         7
                    DO 10 I=1,NN                                                     SAB         8
                    ARG=AA*(T(I)**(-1))+BB*(T(I)**(-.5))                             SAB         9
                    AL=1.0E+100                                                      SAB        10
                    IF(ARG.GT.0.)  AL=ALOG10(ARG)                                    SAB        11
                    PL=ALOG10(PP(I))                                                 SAB        12
                    SUM=SUM+(PL-AL)**2                                               SAB        13
                 10 CONTINUE                                                         SAB        14
                    SAB=SUM                                                          SAB        15
                    RETURN                                                           SAB        16
                    END                                                              SAB        17


   SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS     DEF LINE     REFERENCES
    4  SAB            1          15

VARIABLES      SN  TYPE              RELOCATION
     0  A           REAL                  F.P.         REFS        5   DEFINED        1
    53  AA          REAL                               REFS        8   DEFINED        5
    57  AL          REAL                               REFS       12   DEFINED        9        10
    56  ARG         REAL                               REFS     2*10   DEFINED        8
     0  B           REAL                  F.P.         REFS        6   DEFINED        1
    54  BB          REAL                               REFS        8   DEFINED        6
    55  I           INTEGER                            REFS      2*8        11  DEFINED        7
     0  N           INTEGER               F.P.         REFS        4   DEFINED        1
    52  NN          INTEGER                            REFS        7   DEFINED        4
    60  PL          REAL                               REFS       12   DEFINED       11
  1130  PP          REAL        ARRAY   D              REFS        2        11
    50  SAB         REAL                            DEFINED       14
    51  SUM         REAL                               REFS       12        14  DEFINED        3        12
     0  T           REAL        ARRAY   D              REFS        2       2*8

EXTERNALS          TYPE     ARGS          REFERENCES
      ALOG10       REAL     1 LIBRARY        10         11

STATEMENT LABELS               DEF LINE    REFERENCES
    0  10                         13           7

LOOPS  LABEL     INDEX     FROM-TO     LENGTH     PROPERTIES
   15  10       * I          7 13        25B                  EXT REFS

COMMON BLOCKS    LENGTH      MEMBERS - BIAS NAME(LENGTH)
      D            1200                0 T       (600)               600 PP     (600)

STATISTICS
  PROGRAM LENGTH                 61B        49
  CM LABELED COMMON LENGTH     2260B      1200
```

```
SUBROUTINE OWNDAT     74/74   OPT=1                      FTN 4.5+414       06/01/76  14.04.49       PAGE     1

                 SUBROUTINE OWNDAT(NUMB)                                         OWNDAT      2
                 REAL JUNC,MAN1,MAN2                                             OWNDAT      3
                 COMMON/A/ IND,FLAG,IPRAM,DEV                                    OWNDAT      4
                 COMMON/D/ T(600),PP(600)                                        OWNDAT      5
                 COMMON/F/IPLOT,ISEM,ITYPE                                       OWNDAT      6
                 COMMON/G/DEVTYP1,DEVTYP2,JUNC,MAN1,MAN2,TECH,DATEE,ISTOP        OWNDAT      7
                 READ(5,10) IDENT1,IDENT2,XLAB,YLAB                              OWNDAT      8
           10    FORMAT(2A10,10X,A10,10X,A10)                                    OWNDAT      9
                 DO 30 I=1,NUMB                                                  OWNDAT     10
                 READ(5,20) T(I),PP(I)                                           OWNDAT     11
           20    FORMAT(2E10.3)                                                  OWNDAT     12
           30    CONTINUE                                                        OWNDAT     13
                 IF(ISTOP.EQ.3)  GO TO 85                                        OWNDAT     14
                 WRITE(6,40) DEV,DEVTYP1,DEVTYP2,JUNC,MAN1,MAN2,TECH,DATEE       OWNDAT     15
           40    FORMAT(5X,8HDEVICE: ,A8,3X,13HDEVICE TYPE: ,2A10,3X,            OWNDAT     16
                1 10HJUNCTION: ,A9,/,5X,14HMANUFACTURER: ,2A10,3X,12HTECHNICIAN: ,  OWNDAT  17
                2A10,3X,6HDATE: ,A10,/,/)                                        OWNDAT     18
                 WRITE(6,50) IDENT1,IDENT2                                       OWNDAT     19
           50    FORMAT(5X,16HIDENTIFICATION: ,2A10,/,/)                         OWNDAT     20
                 WRITE(6,60) XLAB,YLAB,XLAB,YLAB,XLAB,YLAB                       OWNDAT     21
           60    FORMAT(3(11X,A10,5X,A10))                                       OWNDAT     22
                 WRITE(6,70)                                                     OWNDAT     23
           70    FORMAT(3(11X,25(1H-)))                                          OWNDAT     24
                 CALL COLMNS(NUMB,T,PP)                                          OWNDAT     25
                 WRITE(6,80)                                                     OWNDAT     26
           80    FORMAT(1H1)                                                     OWNDAT     27
           85    CONTINUE                                                        OWNDAT     28
                 IF(IND.EQ.2)  GO TO 90                                          OWNDAT     29
                 CALL DIRECT(NUMB,3,A,B,AE,BE,IT)                                OWNDAT     30
                 CALL WRITE(A,B,AE,BE,1,IT)                                      OWNDAT     31
                 CALL GAUSS                                                      OWNDAT     32
                 IF(ISTOP.EQ.1)  GO TO 88                                        OWNDAT     33
                 CALL PLOTT(NUMB,NUMB,1)                                         OWNDAT     34
           88    IF(IND.EQ.1)  GO TO 100                                         OWNDAT     35
           90    CONTINUE                                                        OWNDAT     36
                 CALL DIRECT(NUMB,3,A,B,AE,BE,IT)                                OWNDAT     37
                 CALL WRITE(A,B,AE,BE,2,IT)                                      OWNDAT     38
                 CALL GAUSS                                                      OWNDAT     39
                 IF(ISTOP.EQ.1)  GO TO 100                                       OWNDAT     40
                 CALL PLOTT(NUMB,NUMB,2)                                         OWNDAT     41
          100    CONTINUE                                                        OWNDAT     42
                 RETURN                                                          OWNDAT     43
                 END                                                             OWNDAT     44


     SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS     DEF LINE     REFERENCES
   3 OWNDAT          1            42

VARIABLES      SN   TYPE          RELOCATION
  267  A             REAL                        REFS      29       30       36       37
  271  AE            REAL                        REFS      29       30       36       37
  270  B             REAL                        REFS      29       30       36       37
```

```
      SUBROUTINE OWNDAT     74/74   OPT=1                         FTN 4.5+414      06/01/76  14.04.49       PAGE    2

 VARIABLES       SN  TYPE              RELOCATION
    272  BE            REAL                           REFS       29       30       36       37
      6  DATEE         REAL                   G       REFS        6       14
      3  DEV           REAL                   A       REFS        3       14
      0  DEVTYP1       REAL                   G       REFS        6       14
      1  DEVTYP2       REAL                   G       REFS        6       14
      1  FLAG          REAL                   A       REFS        3
    266  I             INTEGER                        REFS     2*10  DEFINED        9
    262  IDENT1        INTEGER                        REFS       18  DEFINED        7
    263  IDENT2        INTEGER                        REFS       18  DEFINED        7
      0  IND           INTEGER                A       REFS        3       28       34
      0  IPLOT         INTEGER                F       REFS        5
      2  IPRAM         INTEGER                A       REFS        3
      1  ISEM          INTEGER                F       REFS        5
      7  ISTOP         INTEGER                G       REFS        6       13       32       39
    273  IT            INTEGER                        REFS       29       30       36       37
      2  ITYPE         INTEGER                F       REFS        5
      2  JUNC          REAL                   G       REFS        2        6       14
      3  MAN1          REAL                   G       REFS        2        6       14
      4  MAN2          REAL                   G       REFS        2        6       14
      0  NUMB          INTEGER                F.P.    REFS        9       24       29     2*33      36     2*40
                                                   DEFINED        1
   1130  PP            REAL          ARRAY    D       REFS        4       24  DEFINED       10
      0  T             REAL          ARRAY    D       REFS        4       24  DEFINED       10
      5  TECH          REAL                   G       REFS        6       14
    264  XLAB          REAL                           REFS     3*20  DEFINED        7
    265  YLAB          REAL                           REFS     3*20  DEFINED        7

 FILE NAMES          MODE
        TAPE5        FMT                     READS        7       10
        TAPE6        FMT                    WRITES       14       18       20       22       25

 EXTERNALS               TYPE   ARGS        REFERENCES
        COLMNS                    3              24
        DIRECT                    7              29       36
        GAUSS                     0              31       38
        PLOTT                     3              33       40
        WRITE                     6              30       37

 STATEMENT LABELS                     DEF LINE   REFERENCES
    154  10      FMT                       8          7
    165  20      FMT                      11         10
      0  30                               12          9
    202  40      FMT                      15         14
    224  50      FMT                      19         18
    241  60      FMT                      21         20
    247  70      FMT                      23         22
    255  80      FMT                      26         25
     47  85                               27         13
     64  88                               34         32
     66  90                               35         28
    101  100                              41         34       39

 LOOPS   LABEL     INDEX       FROM-TO     LENGTH     PROPERTIES
   20    30       * I            9 12        11B                 EXT REFS
```

```
      SUBROUTINE OWNDAT      74/74    OPT=1                    FTN 4.5+414       06/01/76  14.04.49        PAGE     3

COMMON BLOCKS    LENGTH       MEMBERS - BIAS NAME(LENGTH)
      A               4                  0 IND     (1)              1 FLAG    (1)                 2 IPRAM   (1)
                                         3 DEV     (1)
      D            1200                  0 T       (600)          600 PP      (600)
      F               3                  0 IPLOT   (1)              1 ISEM    (1)                 2 ITYPE   (1)
      G               8                  0 DEVTYP1(1)               1 DEVTYP2(1)                  2 JUNC    (1)
                                         3 MAN1    (1)              4 MAN2    (1)                 5 TECH    (1)
                                         6 DATEE   (1)              7 ISTOP   (1)

STATISTICS
  PROGRAM LENGTH                    276B      190
  CM LABELED COMMON LENGTH         2277B     1215
```

```
SUBROUTINE COLMNS     74/74    OPT=1                    FTN 4.5+414       06/01/76  14.04.49        PAGE     1

                   SUBROUTINE COLMNS(KPTS,X,Y)                                          COLMNS     2
                   DIMENSION X(1),Y(1)                                                  COLMNS     3
             40    INC=KPTS/3                                                           COLMNS     4
                   IK=MOD(KPTS,3)                                                       COLMNS     5
                   ICOL=INC+1                                                           COLMNS     6
                   IF(IK.EQ.0)  GO TO 50                                                COLMNS     7
                   IF(IK.EQ.1)  GO TO 70                                                COLMNS     8
                   IF(IK.EQ.2)  GO TO 80                                                COLMNS     9
             50    WRITE(6,60) (X(I),Y(I),X(I+INC),Y(I+INC),X(I+2*INC),Y(I+2*INC),      COLMNS    10
                  1I=1,INC)                                                             COLMNS    11
             60    FORMAT(3(11X,1PE11.3,3X,1PE11.3))                                    COLMNS    12
                   GO TO 90                                                             COLMNS    13
             70    WRITE(6,60) (X(I),Y(I),X(I+ICOL),Y(I+ICOL),X(I+2*ICOL-1),            COLMNS    14
                  1Y(I+2*ICOL-1),I=1,INC)                                               COLMNS    15
                   WRITE(6,60) X(ICOL),Y(ICOL)                                          COLMNS    16
                   GO TO 90                                                             COLMNS    17
             80    WRITE(6,60) (X(I),Y(I),X(I+ICOL),Y(I+ICOL),X(I+2*ICOL),              COLMNS    18
                  1Y(I+2*ICOL),I=1,INC)                                                 COLMNS    19
                   WRITE(6,60) X(ICOL),Y(ICOL),X(2*ICOL),Y(2*ICOL)                      COLMNS    20
             90    CONTINUE                                                             COLMNS    21
                   RETURN                                                               COLMNS    22
                   END                                                                  COLMNS    23


      SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE     REFERENCES
   3  COLMNS          1           21

VARIABLES      SN  TYPE             RELOCATION
  230  I           INTEGER                         REFS      6*9      6*13     6*17    DEFINED      9        13       17
  227  ICOL        INTEGER                         REFS     4*13      2*15     4*17     4*19     DEFINED      5
  226  IK          INTEGER                         REFS      6         7        8      DEFINED      4
  225  INC         INTEGER                         REFS      5        5*9      13        17      DEFINED      3
    0  KPTS        INTEGER               F.P.      REFS      3         4     DEFINED      1
    0  X           REAL        ARRAY     F.P.      REFS      2        3*9      3*13      15       3*17     2*19
                                                DEFINED      1
    0  Y           REAL        ARRAY     F.P.      REFS      2        3*9      3*13      15       3*17     2*19
                                                DEFINED      1

FILE NAMES         MODE
     TAPE6         FMT                   WRITES      9        13        15        17        19

INLINE FUNCTIONS    TYPE    ARGS        DEF LINE  REFERENCES
     MOD           INTEGER    2  INTRIN                4

STATEMENT LABELS                  DEF LINE    REFERENCES
    0  40            INACTIVE         3
   26  50                             9          6
  157  60        FMT                 11          9        13        15        17        19
   52  70                            13          7
  105  80                            17          8
  142  90                            20         12        16
```

```
      SUBROUTINE COLMNS      74/74    OPT=1                        FTN 4.5+414        06/01/76  14.04.49        PAGE     2

LOOPS  LABEL      INDEX       FROM-TO      LENGTH     PROPERTIES
   31              * I          9 9          17B                EXT REFS
   55              * I         13 13         17B                EXT REFS
  110              * I         17 17         17B                EXT REFS

STATISTICS
  PROGRAM LENGTH                   257B      175
```

APPENDIX C

```
SUBROUTINE CHANGE      74/74    OPT=1                          FTN 4.5+414        06/01/76  14.04.49        PAGE     1

                SUBROUTINE CHANGE(NUMB,XLAB,YLAB,X,Y)
                COMMON/D/ T(600),PP(600)                                        CHANGE      2
                DIMENSION XTITLE(3),YTITLE(3),X(600),Y(600)                     CHANGE      3
                DIMENSION XLAB(3),YLAB(3)                                       CHANGE      4
                DATA XTITLE/3*1H /,YTITLE/3*1H /                                CHANGE      5
                XTITLE(1)=5H                                                    CHANGE      6
                XTITLE(2)=10HPULSE WIDT                                         CHANGE      7
                XTITLE(3)=10HH                                                  CHANGE      8
                YTITLE(1)=10H                                                   CHANGE      9
                YTITLE(2)=10HPOWER                                              CHANGE     10
                DO 5 I=1,3                                                      CHANGE     11
                XLAB(I)=XTITLE(I)                                               CHANGE     12
                YLAB(I)=YTITLE(I)                                               CHANGE     13
            5   CONTINUE                                                        CHANGE     14
                DO 10 I=1,NUMB                                                  CHANGE     15
                X(I)=T(I)                                                       CHANGE     16
                Y(I)=PP(I)                                                      CHANGE     17
           10   CONTINUE                                                        CHANGE     18
                RETURN                                                          CHANGE     19
                END                                                             CHANGE     20
                                                                                CHANGE     21


       SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS      DEF LINE      REFERENCES
   3  CHANGE          1            19

VARIABLES       SN  TYPE           RELOCATION
   42  I            INTEGER                          REFS     2*12      2*13      2*16      2*17    DEFINED     11      15
    0  NUMB         INTEGER               F.P.       REFS       15   DEFINED         1
 1130  PP           REAL         ARRAY    D          REFS        2        17
    0  T            REAL         ARRAY    D          REFS        2        16
    0  X            REAL         ARRAY    F.P.       REFS        3   DEFINED         1        16
    0  XLAB         REAL         ARRAY    F.P.       REFS        4   DEFINED         1        12
   43  XTITLE       REAL         ARRAY               REFS        3        12   DEFINED         5        6        7       8
    0  Y            REAL         ARRAY    F.P.       REFS        3   DEFINED         1        17
    0  YLAB         REAL         ARRAY    F.P.       REFS        4   DEFINED         1        13
   46  YTITLE       REAL         ARRAY               REFS        3        13   DEFINED         5        9       10

STATEMENT LABELS                DEF LINE    REFERENCES
   0  5                            14           11
   0  10                           18           15

LOOPS  LABEL     INDEX     FROM-TO     LENGTH     PROPERTIES
   20  5         I          11 14        38B       INSTACK
   31  10        I          15 18        38B       INSTACK

COMMON BLOCKS    LENGTH     MEMBERS - BIAS NAME(LENGTH)
      D           1200               0 T       (600)          600 PP      (600)

STATISTICS
  PROGRAM LENGTH                   51B      41
  CM LABELED COMMON LENGTH       2260B    1200
```

APPENDIX D.--SAMPLE INPUT WHEN ISEM = 0

Sample input data are listed when all of the data in card sets 3 and 4 are used.

```
*******************************************************************************
         1         2         3         4         5         6         7         8
*******************************************************************************

   1        3                    2                         1          1
10IN3600  DIODE               C-A       FAIRCHILD           R.PARSONS 7-23-73
03IN3600
00101 10.000E-6   100.      100.         0.    10.000E-6     1.0
   1.0      160.      160.      0.00E      0.00E  C+
00102 10.000E-6   110.      105.         .15  10.000E-6     1.0
   1.0      160.      160.      0.00E      0.00E  C+
00103 10.000E-6   120.      115.         .60   2.2  E-6     1.0
   0.       160.        0.      0.00E      0.00E  C+
06IN3600
00201 10.000E-6    60.000    60.         0.000 10.000E-6     .300
    .300     92.       92.      0.00E      0.00E  C+
00202 10.000E-6    70.       70.         0.    10.   E-6     .3
    .3       92.       92.         . E        . E  C+
00203 10.    E-6    80.       80.         0.    10.   E-6     0.3
    .3       92.       92.         . E        . E  C+
00204 10.    E-6    90.       90.         0.    10.   E-6     0.3
   0.3       92.       92.         . E        . E  C+
00205 10.    E-6   100.       80.         1.3    2.0  E-6     .3
    .3       92.       92.         . E        . E  C+   BRKDWN NO VZ CHG
00206 10.    E-6   110.       90.         2.2     .8  E-6     .3
    .3       92.        4.         . E        . E  C+
03IN3600
00301 10.    E-6    80.       80.         0.0   10.   E-6     .3
    .3       90.       90.         . E        . E  C+
00302 10.    E-6    90.       90.         0.    10.   E-6     .3
    .3       90.       90.         . E        . E  C+
00303 10.    E-6   100.       95.         0.7    3.0  E-6     .3
    .0       90.        0.         . E        . E  C+
04IN3600
00401 10.    E-6    80.       80.         0.0   10.0  E-6     .3
    .3       98.       98.         . E        . E  C+
00402 10.    E-6    90.       90.         0.0   10.   E-6     .3
    .3       98.       98.         . E        . E  C+
00403 10.    E-6   100.      100.         0.0   10.   E-6     .3
    .3       98.       98.         . E        . E  C+
00404 10.    E-6   110.      105.         1.0    1.9  E-6     .3
    .0       98.        0.         . E        . E  C+
03IN3600
00501 10.    E-6    80.       80.         0.0   10.0  E-6     .3
    .3       86.       86.         . E        . E  C+
00502 10.    E-6    90.       85.          .6    1.2  E-6     .3
    .3       86.       83.         . E        . E  C+BRKDWN DEVICE NO CG
00503 10.    E-6   100.       90.         1.8    1.2  E-6     .3
    .3       86.       12.         . E        . E  C+
03IN3600
00601 10.    E-6    80.       80.         0.0   10.   E-6     .3
    .3       86.       86.         . E        . E  C+
00602 10.    E-6    90.       90.         0.0   10.   E-6     .3
    .3       86.       86.         . E        . E  C+
00603 10.    E-6   100.       90.         1.0    1.2  E-6     .3
    .0       86.      0.0          . E        . E  C+
```


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APPENDIX D

```
**********************************************************************************
          1         2         3         4         5         6         7         8
**********************************************************************************

041N3600
00701 10.   E-6   80.        80.        0.0  10.   E-6       .3
       .3     86.       86.       . E       . E  C+
00702 10.   E-6   90.        90.        0.0  10.   E-6       .3
       .3     86.       86.       . E       . E  C+
00703 10.   E-6  100.        95.         .4   2.7  E-6       .3
       .3     86.       86.       . E       . E  C+
00704 10.   E-6  100.        90.        1.2    .8  E-6       .3
       .3     86.       17.       . E       . E  C+
051N3600
00801 10.   E-6   80.        80.        0.0  10.   E-6       .3
       .3     88.       88.       . E       . E  C+
00802 10.   E-6   90.        90.        0.0  10.   E-6       .3
       .3     88.       88.       . E       . E  C+
00803 10.   E-6  100.       100.        0.0  10.0  E-6       .3
       .3     88.       88.       . E       . E  C+
00804 10.   E-6  110.       110.        0.0  10.   E-6       .3
       .3     88.       88.       . E       . E
00805 10.   E-6  118.       105.        1.2   1.0  E-6       .3
       .3     88.       10.       . E       . E  C+
041N3600
00901  5.0  E-6   80.        80.        0.0   5.0  E-6       .3
       .3     93.       93.       . E       . E  C+
00902  5.0  E-6   90.        90.        0.0   5.0  E-6       .3
       .3     93.       93.       . E       . E  C+
00903  5.0  E-6  100.        95.         .6   2.8  E-6       .3
       .3     93.       93.       . E       . E  C+
00904  5.0  E-6  112.       100.         .9    .9  E-6       .3
       .2     93.       0.0       . E       . E  C+
041N3600
01001  5.0  E-6   80.        80.        0.0   5.0  E-6       .3
       .3     93.       93.       . E       . E  C+
01002  5.0  E-6   90.        90.        0.0   5.0  E-6       .3
       .3     93.       93.       . E       . E  C+
01003  5.   E-6  100.        97.         .2   1.1  E-6       .3
       .3     93.       93.       . E       . E  C+
01004  5.0  E-6  110.       103.         .9   1.8  E-6       .3
       .3     93.       8.0       . E       . E  C+
```

APPENDIX E.--SAMPLE INPUT WHEN ISEM = 1

Sample input data are listed when only pulse width versus power data on card set 5 are used.

```
********************************************************************************
         1         2         3         4         5         6         7         8
********************************************************************************


         1        2                  2                       1        1
 101N3600  DIODE                 C-A      FAIRCHILD          R.PARSONS 7-23-73
REVERSE FAILURE                 PULSE WDTH          POWER
   .800E-06   .110E+03
   .800E-06   .200E+03
   .900E-06   .900E+02
   .100E-05   .130E+03
   .120E-05   .900E+02
   .120E-05   .160E+03
   .180E-05   .930E+02
   .190E-05   .110E+03
   .220E-05   .690E+02
   .300E-05   .670E+02
```


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