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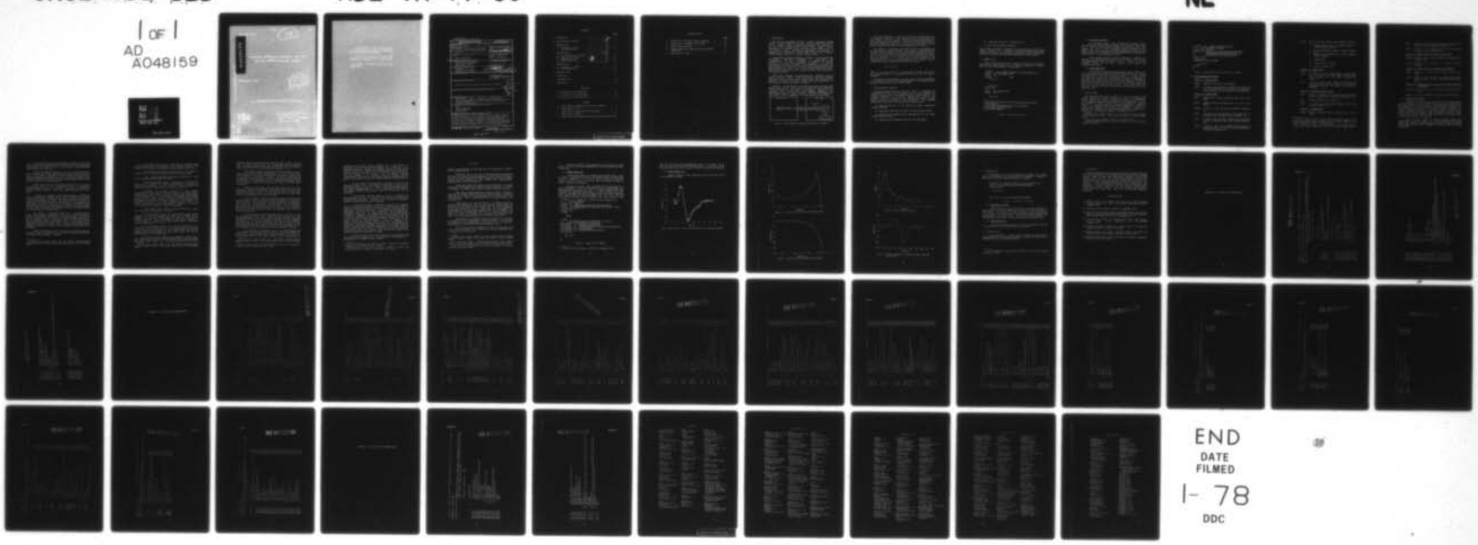

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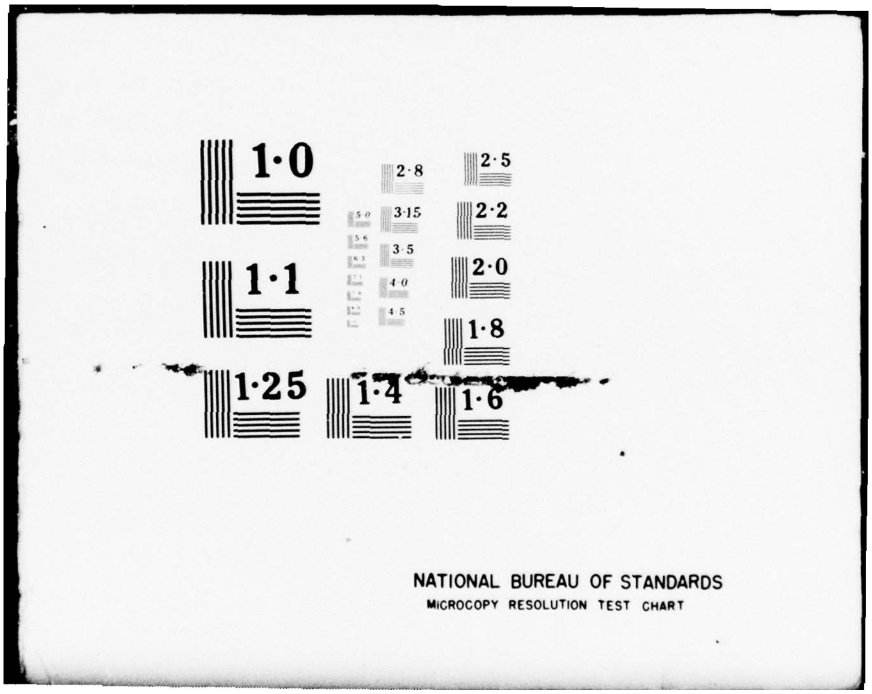
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HDL-TM-77-30

Processing EMP-Related Flash-X-Ray Test Data with the TRANS2 Computer Program

November 1977

This research was sponsored by the Defense Nuclear Agency under Subtask R99QAXEB088, Work Unit 72, EMP Interaction and Coupling Phenomenology.

U.S. Army Materiel Development

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When parameters, such as coupled currents, magnetic fields, Compton currents, etc., are measured at a flash x-ray facility, the measured voltages which represent these parameters are a function of the frequency response of the measuring system. By using a measured response (transfer) function for the measuring systems along with Fourier analysis, the computer program TRANS2 transforms measured voltages into the desired parameters.

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CONTENTS

APPENDICES

FIGURES

FIGURES (Cont'd)

1. INTRODUCTION

The Tactical Environment Multiple Systems Evaluation Program (TEMSEP) is jointly funded by the Army and the Defense Nuclear Agency and is directed toward vulnerability assessments and hardening of tactical military equipment for tactical nuclear threats. TEMSEP complements the Multiple Systems Evaluation Program (MSEP), which is also directed toward vulnerability assessments and hardening of equipment for nuclear threats. Unlike TEMSEP, however, MSEP is directed towards stategic, rather than tactical, nuclear threats.

In the absence of threat-relatable simulation of source-region EMP environments, meaningful assessments of source-region EMP vulnerabilities of tactical equipment are feasible only through theoretical and controlled experimental evaluations of dominant source-region coupling mechanisms. The experimental evaluations are being performed at flash x-ray facilities, such as AURORA and HIFX (the High-Intensity Flash X-Ray), both at Harry Diamond Laboratories (HDL). These facilities are being used as partial simulation tools and as tools for validating theory.

During the experiments at AURORA and HIFX, parameters such as coupled currents, magnetic fields, and Compton currents are measured with sensors such as current probes, Moebius loops, and Rogowski coils. Typically, the sensors are part of a sensor-cable-balun system such as the one shown in the block diagram of figure 1.

Because it is less noisy in a radiation environment than most other cables, twinax cable is normally used to transmit the sensor output from the test cell into the data room. Unfortunately, twinax cable is relatively lossy, and the signal loss is frequency dependent. When twinax cable is used, a balun is needed to match the 78-Ω impedance of this cable to the 50-Ω impedance of the cable used in the data room.

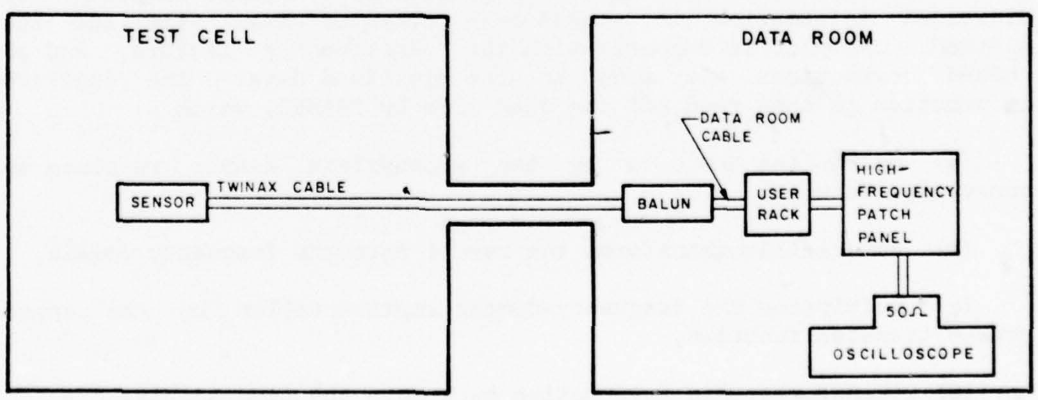

Figure 1. Block diagram of measuring system used at AURORA.

Each sensor exhibits a particular response to a given signal, and this response is degraded by the cables and balun through which the signal passes. Thus, the voltages measured by the oscilloscopes in the data room represent the response of the sensor-cable-balun system to a particular phenomenon occurring in the test cell, and these voltages must be somehow "transformed" into the parameter being measured.

The response of the sensor-cable-balun system to input signals can be measured with a network analyzer. This response, represented by the transfer function measured by the network analyzer, provides the amplitude of the output voltage and the phase difference between this voltage and the input signal for an input signal of unit amplitude over a wide range of frequencies. If a current probe is used to measure it, the transfer function is actually the admittance of the measuring system, and the input signal can be found from the relationship

$$I(\omega) = Y(\omega)V(\omega)$$

where I is the input current, Y is the admittance (transfer function) of the measuring system, V is the measured voltage, and ω is the angular frequency.

The computer program TRANS2 uses this transfer function information to transform oscilloscope voltage measurements into the parameters being measured, even if they are not simply currents.

2. DATA-PROCESSING PROCEDURE

The data-processing procedure which is used to accomplish this transformation is this: The oscilloscope pictures are digitized to provide information which can be manipulated by a digital computer. The digitized information is stored on a computer disk file and then plotted. The plot is compared with the oscilloscope picture, and any needed corrections are made to the digitized data. The digitized information is then read off the disk file by TRANS2, which

(a) multiplies the data by the appropriate sensor response and conversion factors,

(b) numerically transforms the result into the frequency domain,

(c) multiplies the frequency-domain representation by the appropriate transfer function,

(d) transforms this information back into the time domain,

(e) integrates the result, if necessary, and

(f) plots the resultant information.

The plotted information represents the time histories of the actual fields, currents, etc., occurring at the sensor locations during the AURORA or HIFX tests, and not merely the measured voltages. These plots can then be compared with theoretical predictions of test results.

3. PROGRAM DFILE

A listing of the program DFILE, which is used to put the digitized data onto a computer disk file, is presented in appendix A. Figure 2 shows a sample deck needed to run the program.

```
//JFD1ADF1   JOB   (HK3020),'JFWDIETZ',CLASS=A,MSGLEVEL=(2,1)
//STEP1   EXEC TRANS,NAME='&&DATA'
//SYSIN    DD  *
 &OUTPUT                      &END
     data set #1
         o
         o
         o
     data set #n
(7/8/9) CARD
/*
//STEP1   EXEC ANAFORT,OUT=X
//SYSIN    DD  *

     source deck

/*
//GO.FT12F001  DD DSN=*.STEP1.STP.FT12F001,DISP=(OLD,DELETE),
// DCB=(RECFM=VS)
//GO.FT14F001  DD DISP=(NEW,CATLG),VOL=SER=USER02,
// UNIT=SYSDA,SPACE=(TRK,(2,2)),
// DSN=HK3020.CR362022
//
```

Figure 2. Sample deck for DFILE.

3.1 Description of DFILE

The procedure TRANS,* which transforms the digitizer output into usable data, is executed and the data are written to logical unit No. 12. DFILE calls the subroutine READIT, which reads the data from logical unit No. 12. The subroutine CSTOUT, contained in the ANAPAC[1] library and attached by the ANAFORT* procedure, is then called. CSTOUT checks the time ordering of the independent array and casts out those points not in an ascending time order.

DFILE converts the data to double precision to increase the accuracy of the data-processing effort and calls WRITED, which writes the double-precision data to logical unit No. 14 so that it can be cataloged during the GO step. Finally, DFILE prints the double-precision data.

3.2 DFILE Sample Deck

A few comments concerning the sample deck shown in figure 2 are now appropriate. The namelist entitled "OUTPUT" contains two logical variables, LIST and PLOT, which are input to TRANS.* A value of TRUE for either LIST or PLOT turns on either the printing or the plotting of the data sets, respectively. This printing or plotting is performed by TRANS and occurs before CSTOUT corrects the time ordering. Second, the last card in each data set must be a (7/8/9) card, and there must be an extra (7/8/9) card after the last data set. Finally, the name of the data file cataloged by DFILE is given by the DSN parameter on the last executable card.

4. PROGRAM TRANS2

After the digitized data are placed on file and verified to be correct, TRANS2 must be run to transform the data into the measured fields, currents, etc. TRANS2 is currently maintained as an UPDTE[2] file so that temporary changes in the program can be readily made. A sample deck needed to create an UPDTE[2] file containing TRANS2 is shown in figure 3. A listing of TRANS2 is presented in appendix B. Definitions of the input parameters for TRANS2 are presented in section 4.1, followed by a description of how the program works and, finally, by a discussion of the sample deck needed to run TRANS2 (sect. 4.3).

---

[1] *Thomas V. Noon, User's Manual for the Modular Analysis-Package Libraries ANAPAC and TRANL, Harry Diamond Laboratories TR-1782 (November 1976).*

[2] *IBM OS/VS Utilities Manual, GC35-0005-4 (September 1976).*

**From recommendations by Egon Marx and Thomas V. Noon, Harry Diamond Laboratories (1976).*

```
//JFDICTR2   JOB    (HK3020),'JFWDIETZ',CLASS=C
//           EXEC PGM=IEBUPDTE,PARM=NEW
//SYSPRINT DD  SYSOUT=A
//SYSUT2   DD  UNIT=SYSDA,DISP=(NEW,CATLG),VOL=SER=USER02,
//             DSNAME=HK3020.TRANS2,SPACE=(TRK,(25,2)),
//             DCB=(RECFM=FB,LRECL=80,BLKSIZE=4080)
//SYSIN    DD  *
./ ADD LIST=ALL
./ NUMBER NEW1=1000,INCR=1000

      source deck
./ ENDUP
/*
//
```

Figure 3. Sample deck to create UPDTE file for TRANS2.

4.1 Input Parameters for TRANS2

Card No. 1: FORMAT (2I10)

NDSETS — Number of data sets to be processed.

ISAME — If equal to one, the input parameters for the first data set are used for all the data sets; otherwise, input parameters must be provided for each data set.

Card No. 2: FORMAT (7I10)

NOFF — Number of data points removed from the front of the pulse.

NOFFR — Number of data points removed from the rear of the pulse.

INVERT — If equal to one, the pulse is inverted; otherwise, not.

IZERO — If equal to one, the amplitudes of the first and last data points are set equal to zero; otherwise, not.

IPLOT — If equal to one, the input digitized data are plotted after any necessary time shift is made; otherwise, not.

IFILE — If equal to one, the processed data are written to logical unit No. 9 so that they can be cataloged as a disk file; otherwise, not.

ISENSR Denotes the type of sensor used to produce the data:

1 = Current probe used to measure current on truncated cylinder banjo.[3]

2 = Current probe used to measure current on single wire.

3 = Current probe (Rogowski coil) used to measure Compton current.

4 = Moebius loop.

5 = Current probe on pie pan.[3]

6 = One-turn Rogowski coil.

Card No. 3: FORMAT (2I10)

IPLTC If equal to one, coupled-current output from SAPSC[4] is plotted on the same graph as the processed data; otherwise, not. Set equal to one only if ISENSR=1.

NCUR If equal to one, SAPSC output is plotted for the first measurement position; otherwise, for the second measurement position. Set equal to one only if ISENSR=1.

Card No. 4: FORMAT (I10, E10.3, I10)

NSTAR Number of frequency and time points used by the fast Fourier transform (FFT) (must be a multiple of two).

FMAX Maximum frequency used by the FFT.

KPLOT If equal to one, frequency-domain results are plotted; otherwise, not.

Card No. 5: FORMAT (3I10)

NTRANS Number of transfer function amplitude points (25 or less).

---

[3]*John F. W. Dietz, Daniel J. Spohn, and George Merkel, Status of the Tactical Environment Multiple Systems Evaluation Program (TEMSEP), Harry Diamond Laboratories TM-77-23 (September 1977).*

[4]*E. R. Parkinson, SAPSC: A Two-Dimensional Close-in EMP Coupling Analysis Code, Science Applications Inc. SAI-75-506-AQ (October 1975).*

JPLOT If equal to one, the transfer function amplitude and phase (if used) are plotted; otherwise, not.

IPHASE If equal to one, phase is included in the transfer function; if not, amplitude only.

Card No. 6: FORMAT (4(2E10.3)); (one to seven cards)

FTRANS(I) Frequency (Hz) at which transfer function amplitude value is given.

ATRANS(I) Amplitude value (amps/volt) of measured transfer function.

Card No. 7: FORMAT (I10, E10.3) (used only if IPHASE=1)

NPHASE Number of transfer function frequency points (25 or fewer).

TRETRD Amount of time (seconds) by which the input pulse must be retarded if the transfer function includes phase.

Card No. 8: FORMAT (4(2E10.3)) (one to seven cards) (used only if IPHASE=1)

FPHASE(I) Frequency (Hz) at which transfer function phase value is given.

PHASE(I) Phase value (degrees) of measured transfer function.

4.2 Description of TRANS2

TRANS2 was originally written to operate on a CDC 6600 computer and then converted to run on an IBM 370-series computer. Because of the short word length of the IBM computer, it was felt that the precision of the variables and functions within the program should be increased. To avoid the necessity of making a substantial number of changes to the program, the AUTODBL(DBL) option, which automatically doubles the precision of all real and complex variables and library functions, is used. So that the precision of the plot label variables is not doubled, these variables are declared to be integers.

After the plot labels are defined, a number of arrays are equivalenced to reduce storage. If the dimensions of any of these arrays are changed, or the positions of the arrays within the program are changed, the EQUIVALENCE statements must be altered to reflect these changes.

The first data card, containing NDSETS and ISAME, is then read. NDSETS is the number of data sets on file which are to be processed, and the remainder of TRANS2 consists of a DO loop that is executed NDSETS times, once for each data set.

The first statement inside the loop calls subroutine READTP, which reads the time (T) and amplitude (FT) data pairs from logical unit No. 8. If the number of data pairs (NPTS) exceeds 300, the program is terminated because the dimensions of T and FT would be exceeded. Next, the input parameters are read and printed, unless ISAME=1 and other than the first data set is being processed.

NOFFR data points are then removed from the rear of the pulse. This feature is useful if the oscilloscope picture is accidentally digitized beyond the region of interest. The pulse is inverted, if desired, and NOFF extraneous points are removed from the front of the pulse.

If phase is included in the transfer function, the digitized pulse is now retarded by TRETRD seconds. Since it takes a finite amount of time for the sensor to respond to the input signal and for the sensor output to pass through the cables and the balun before it reaches the oscilloscope, the time frame at the oscilloscope is retarded from the time frame at the sensor. Because use of the phase relationship between the sensor input and the cable output would advance the output forward into the sensor time frame, the digitized pulse must be retarded so that it is not advanced into negative time.

The amount of retardation needed for a sensor-cable-balun system can be measured approximately by sending a pulse through the system. Unfortunately, the amount of retardation depends to some extent upon the frequency content of the pulse. Because of this dependence, it may be necessary to make a preliminary run of TRANS2, with TRETRD slightly larger than the expected value. After the processed pulse is examined to determine at what time it actually starts, TRETRD can be adjusted accordingly, and TRANS2 can be run again with the correct value of TRETRD.

Next, the amplitudes of the first and last digitized points are set equal to zero, if desired, and the retarded data are plotted with the DRAW4 plotting routine,[1] if desired.

---

[1] *Thomas V. Noon, User's Manual for the Modular Analysis-Package Libraries ANAPAC and TRANL, Harry Diamond Laboratories TR-1782 (November 1976).*

The digitized data are then multiplied by sensor response functions which are not included in the transfer function. The following list describes the response functions presently being used.

(1) The current probe output is multiplied by the number of resistors (20) in the banjo to provide the total coupled current.

(2) The current probe output is simply multiplied by 1, since the total current is measured by the probe.

(3) The current probe output is divided by the effective area of the coil to provide the Compton current density. At present, an effective coil diameter of 1.875 in. (4.76 cm) has been assumed for the current probe with a center opening of 1.625 in. (4.13 cm).

(4) Because the transfer function of the Moebius loop-cable-balun system cannot be measured directly, the Moebius loop is replaced by a current probe to make the transfer function measurement. If this transfer function is multiplied by the impedance of the current probe, the result is the transfer function of the cable-balun system. Multiplying this result by the sensor response of the Moebius loop $(1 \text{ weber/m}^2\text{s})/(1.14 \times 10^{-3} \text{ V})$ then provides the value of B-dot. At present, the impedance of the current probe is assumed to be simply 2.4 Ω, although it is actually a function of frequency.

(5) The current probe output is simply multiplied by 1, since the total current is measured by the probe.

(6) If the transfer function is measured with a current probe, the output of the one-turn Rogowski coil must be multiplied by the impedance (2.4 Ω) of the current probe. The output of the one-turn Rogowski coil must then be multiplied by the sensor response of $1. \times 10^{-7}$/volume to provide the Compton current density. The volume presently being used is 5×10^{-2} m^3.

Next, the frequency spacing, DF, and the time spacing, DT, are calculated. The frequency spacing is the interval between data points after the data are transformed into the frequency domain, and the time spacing is the interval between the data points after the data are transformed back into the time domain.

The data are then linearly interpolated with CLINTD,[1] which also extends the data array to fulfill the requirement that the maximum time value, TMAX, equals 1/DF. The number of equispaced time points

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[1]*Thomas V. Noon, User's Manual for the Modular Analysis-Package Libraries ANAPAC and TRANL, Harry Diamond Laboratories TR-1782 (November 1976).*

extending across the range of the original data, NTP, is then found so that the proper time interval of the processed data can be plotted later. The equispaced data are then transformed into the frequency domain by FFTD, which is a double-precision version of FFT.[1]

The transfer function amplitude and phase information is available at only a limited number of frequencies. To provide transfer function information at all the frequency values used by FFT, a cubic spline fit to the data is performed. Initially, the spline coefficients are calculated by the subroutine SPLICO, which uses the technique discussed by Pennington.[5] The coefficients for the amplitude and the phase values of the transfer function are stored in the arrays COEF and COEFP, respectively.

Various initializations are performed, and DO loop 30 is then executed to multiply the frequency-domain representation of the data by the transfer function. Since half aliasing[1] is used by the Fourier transform, only the first half of the data array plus one point (NS21 points) is multiplied by the transfer function.

If the frequency value is outside the range of the spline fit to the transfer function amplitude or phase information, the subroutine ENDFIT is called. During the first execution of ENDFIT for any particular fit (KFIT=1), fit coefficients are calculated, and a calculation of the appropriate transfer function value is made. During subsequent executions, these coefficients are not calculated again, but a calculation of the transfer function is made. The following four fits are presently being used:

(1) The transfer function amplitude value is set equal to 1000 if the frequency is below that of the spline fit information. It has been assumed that the user will supply transfer function amplitude information for at least one frequency point below the second frequency value (equal to the frequency spacing $1 \times DF$) used by FFT, so that the only low-frequency value for which an amplitude value is needed is 0 Hz. It was felt that some large value, such as 1000, was appropriate for the 0-Hz frequency point, since the balun should not transmit dc signals.

(2) A decreasing exponential is fit to the high-frequency end of the transfer function amplitude information. Since the Tektronix 556 oscilloscopes used at AURORA have a high-frequency 3-dB cutoff at 50 MHz, it was felt that any energy present in the digitized data at

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[1] *Thomas V. Noon, User's Manual for the Modular Analysis-Package Libraries ANAPAC and TRANL, Harry Diamond Laboratories TR-1782 (November 1976).*

[5] *Ralph H. Pennington, Introductory Computer Methods and Numerical Analysis (2nd ed.), MacMillan, Inc. (1970).*

frequencies much beyond 50 MHz is probably due to the process of digitizing the data and should be filtered out. Therefore, it is suggested that the last value of the measured transfer function which the user provides to TRANS2 be at a frequency of 50 MHz. ENDFIT will then exponentially decrease the value of the transfer function amplitude until it reaches 0 at 100 MHz. Due to sampling theorem considerations,[6] the value of FMAX should always be at least twice the value of the frequency at which the transfer function amplitude drops to 0.

(3) The transfer function phase is set equal to 180 deg if the frequency is below that of the spline fit information. Again, it has been assumed that the user will supply at least one transfer function value below a frequency equal to $1 \times DF$. Examination of the output of the network analyzer indicates that a value of 180 deg at 0 Hz is reasonable.

(4) The transfer function phase is fit to a straight line passing through the last two points if the frequency is above that of the spline fit information. Examination of the output of the network analyzer indicates that this fit is reasonable.

If the frequency value is within the range of the transfer function information provided by the user, the subroutine SPLINE is called to calculate the proper value of the transfer function using the coefficients calculated by SPLICO. The equations used are presented in Pennington's book,[5] but the search technique is not the same as that presented by Pennington. The frequency at which the transfer function is needed is compared with increasing values of the frequency intervals of the cubic splines until the proper frequency interval is found. The transfer function is calculated using the spline coefficients for the proper interval, and a pointer (KSTART) is used to "remember" this interval. During the following call of SPLINE, the search begins with the interval designated by KSTART, rather than with the first interval. KSTART is updated and, during each subsequent call of SPLINE, the first interval used during the search is the interval used for the SPLINE fit during the last call. This process works because the values of the frequency increase with each call of SPLINE.

After the correct values of the transfer function amplitude and phase values are calculated, the frequency-domain representation is multiplied by the transfer function, given by

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[5] *Ralph H. Pennington, Introductory Computer Methods and Numerical Analysis (2nd ed.), MacMillan, Inc. (1970).*

[6] *George R. Cooper, and Clare D. McGillem, Methods of Signal and System Analysis, Holt, Rinehart, and Winston, Inc. (1967).*

$$TF = Ae^{-j\theta}$$

where A is the amplitude (in amps/volt) and θ is the phase (in radians) of the transfer function.

Before the end of DO loop 30, various arrays are filled for plotting. FPLT contains the frequency points, AMPPLT contains values of the transfer function amplitude, PHIPLT contains values of the transfer function phase (in degrees), and FAMP contains the frequency-domain representation of the processed data.

If the user wishes, the transfer function amplitude and phase values and the frequency-domain results are then plotted as a function of frequency. If ISAME=1, the transfer function is plotted only once.

Next, FFTAD, a double-precision version of FFTA,[1] is called to transform the frequency-domain results into the time domain. Because an inverse FFT can cause an overall amplitude shift, the amplitude at the first time point (FTT1) is subtracted from all the other values of the processed data.

The processed data are then plotted. If ISENSR=1 and IPLTC=1, coupled current predictions made by the computer program SAPSC[4] are plotted on the same graph as the processed data. This SAPSC information is read from logical unit No. 10. Since the plot array (CURRNT) is equivalenced to the first SAPSC coupled-current array (CURNT1), the current predicted for measurement position 1 is used unless NCUR is not equal to 1. If NCUR is not equal to 1, the plot array (CURRNT) is set equal to the SAPSC coupled-current array (CURNT2) for position 2.

When Moebius loop (ISENSR=4) data are processed, not only B-dot is plotted, but also the tangential H-field is plotted. H is calculated by dividing B by the permeability of free space (1.26×10^{-6} henry/m), and integrating the result by using the trapezoidal rule.[7]

When one-turn Rogowski (ISENSR=6) coil data are processed, both J and J-dot are plotted. J is calculated by using the trapezoidal rule to integrate the J-dot results.

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[1] *Thomas V. Noon, User's Manual for the Modular Analysis-Package Libraries ANAPAC and TRANL, Harry Diamond Laboratories TR-1782 (November 1976).*

[4] *E. R. Parkinson, SAPSC: A Two-Dimensional Close-in EMP Coupling Analysis Code, Science Applications, Inc. SAI-75-506-AQ (October 1975).*

[7] *Francis Scheid, Schaum's Outline of Theory and Problems of Numerical Analysis, McGraw-Hill (1968).*

Finally, if desired, the processed data are written to logical unit No. 9 so that they can be cataloged as a disk file and used at some future time.

4.3 TRANS2 Sample Deck

A sample deck needed to run TRANS2 from an UPDTE file is shown in figure 4. Information concerning the IEBUPDTE utility has been given by IBM.[2] If TRANS2 is to be run as shown in figure 4, at least one CHANGE card must be present in the deck, even if the change is merely to insert a comment card somewhere.

The data set name (DSN) associated with logical unit No. 8 should correspond to the file containing the data to be processed. The DSN associated with logical unit No. 10 should correspond to the file created by the computer program SAPSC. If SAPSC output is not to be plotted on the same graph as the processed data, the DD cards associated with logical unit No. 10 should be removed from the deck. The DSN associated with logical unit No. 9 should be the user's choice of the

```
//JFD5CTR2   JOB   (HK3020,,5),'JFWDIETZ',CLASS=C,MSGLEVEL=(2,1)
//          EXEC PGM=IEBUPDTE
//SYSPRINT DD   SYSOUT=A
//SYSUT1    DD   DSNAME=HK3020.TRANS2,DISP=(OLD,PASS,CATLG)
//SYSUT2    DD   DSNAME=&&NEWPL,DISP=(NEW,PASS),UNIT=VIO,DCB=*.SYSUT1,
// SPACE=(TRK,(10,10))
//SYSIN     DD   *
./ CHANGE

      changes

./ ENDUP
//          EXEC ANAFORT,PARM.FORT='AUTODBL(DBL)',F1=,OUT=X
//FORT.SYSIN  DD  DSN=&&NEWPL,DISP=(OLD,PASS)
//GO.FT08F001   DD   DSN=HK3020.CR35,DISP=SHR
//GO.FT09F001   DD   DSN=HK3020.TRANSOUT,DISP=(NEW,CATLG),UNIT=SYSDA,
// SPACE=(TRK,(1,1)),VOL=SER=USER02
//GO.FT10F001   DD   DSN=HK3020.SAPSCOUT,DISP=SHR
//GO.SYSIN DD  *

     data cards

/*
//
```

Figure 4. Sample deck for TRANS2.

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[2] *IBM OS/VS Utilities Manual, GC35-0005-4 (September 1976).*

name of a file on which the processed data are to be stored. If the user does not wish to retain the processed data on a disk file, the DD card associated with logical unit No. 9 should be removed from the deck.

4.4 TRANS2 Sample Plots

Figures 5 through 9 contain examples of some of the plots which can be produced by TRANS2.

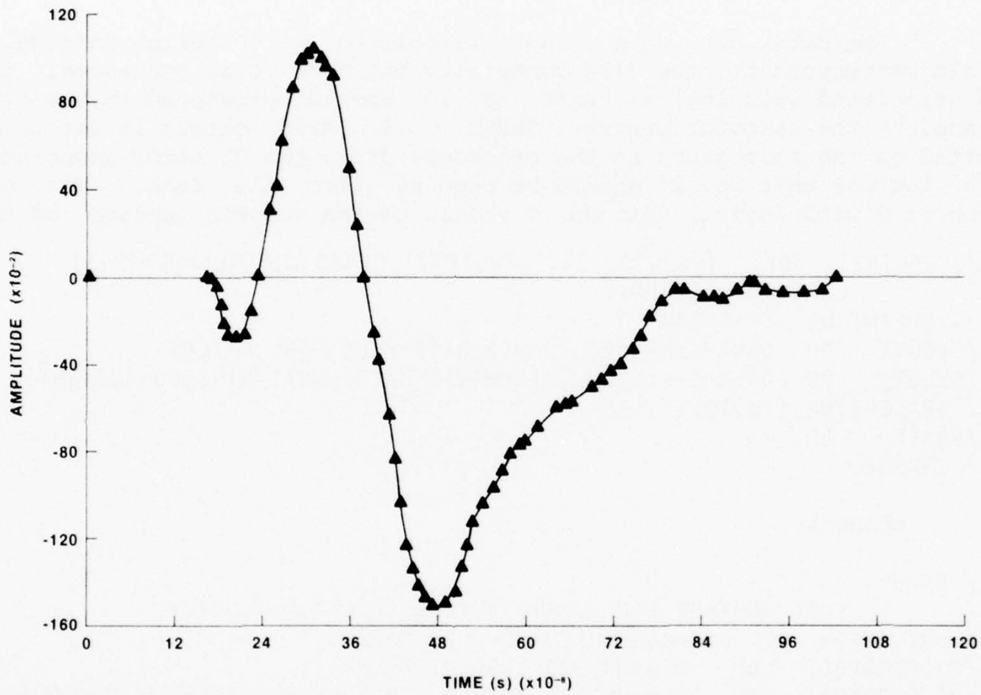

Figure 5. Typical plot of digitized data after they have been shifted.

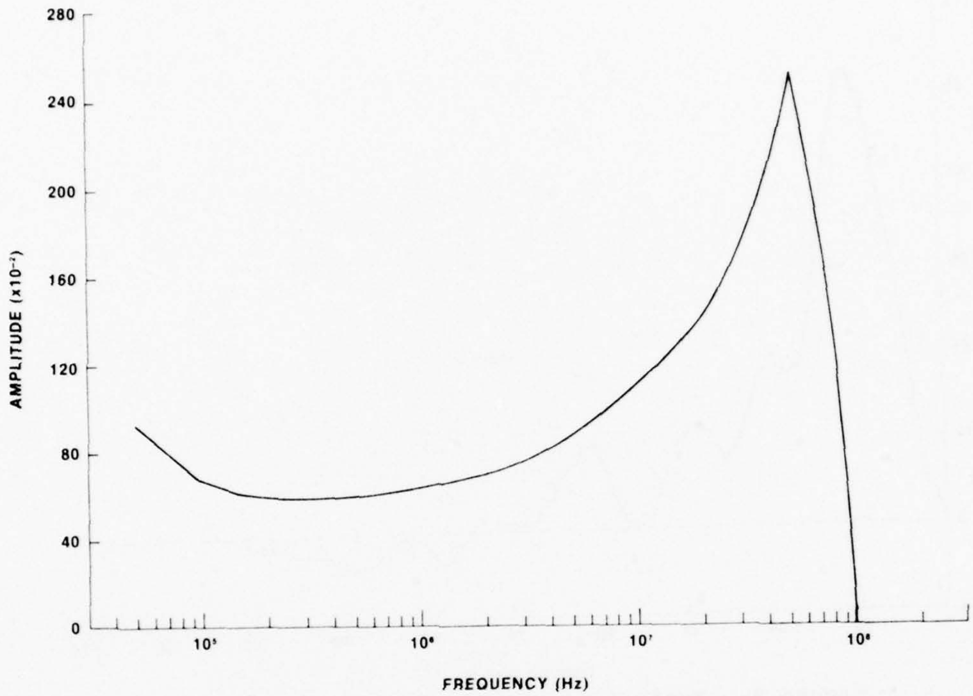

Figure 6. Typical plot of transfer function amplitude.

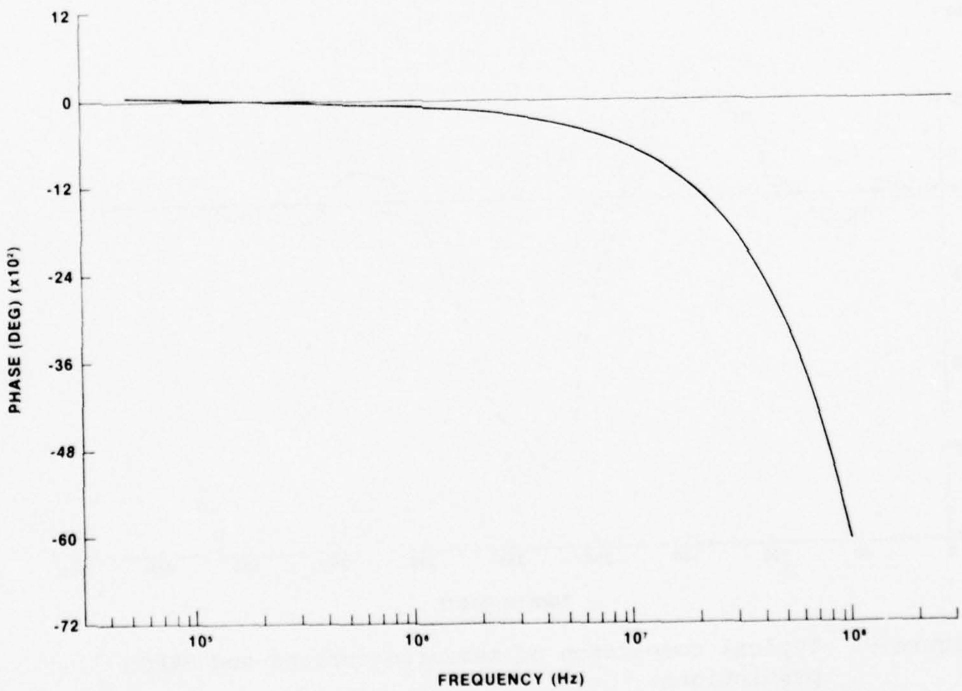

Figure 7. Typical plot of transfer function phase.

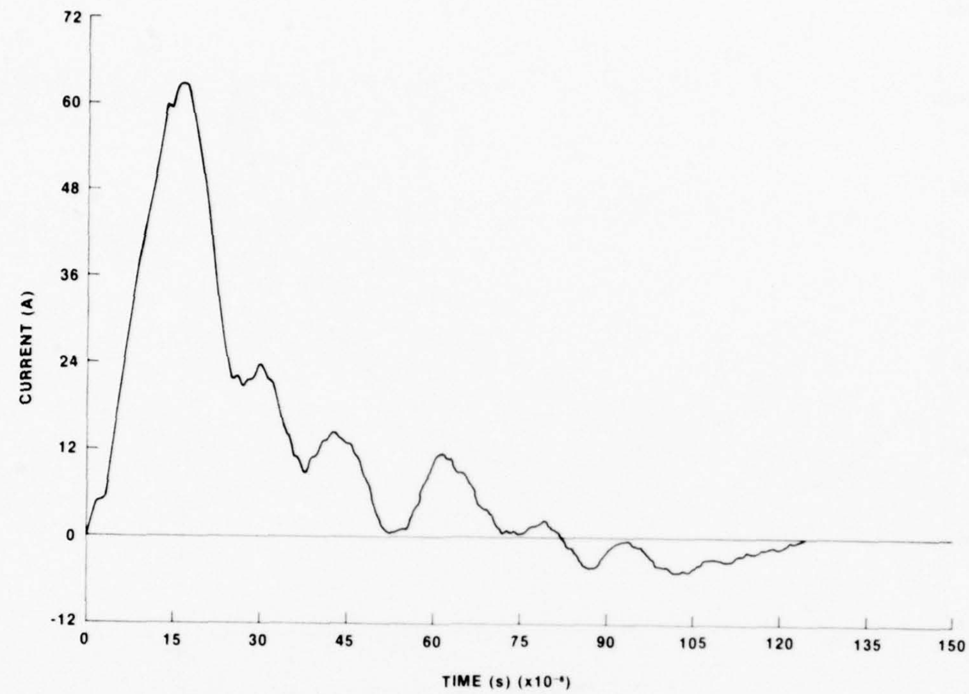

Figure 8. Typical pie-pan response.

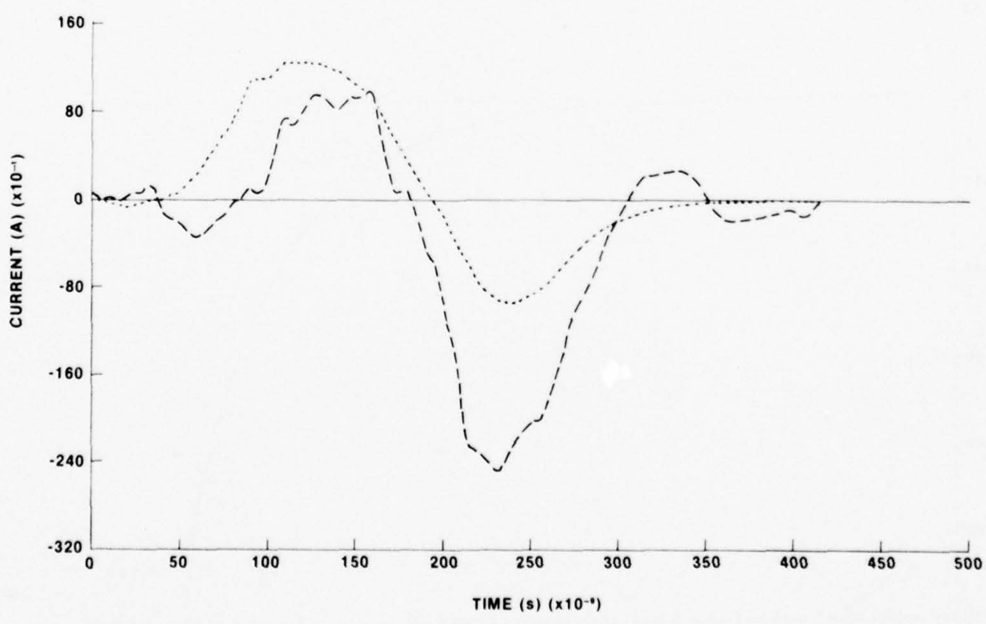

Figure 9. Typical comparison of measured current and SAPSC predictions.

5. PROGRAM PUNCH

If a permanent record of the processed data is needed, the program PUNCH can be executed. A listing of PUNCH is presented in appendix C, and figure 10 shows a sample deck needed to run PUNCH.

```
//JFDIAPUN  JOB  (HK3020),'JFWDIETZ',CLASS=A,MSGLEVEL=(2,0)
//STEP1   EXEC FORTPCLG,PARM.FORT='NOSOURCE,NOMAP'
//FORT.SYSIN DD *

     source deck


/*
//GO.FT10F001  DD  DISP=SHR,DSN=HK3020.TRANSOUT
//
```

Figure 10. Sample deck for PUNCH.

5.1 Description of PUNCH

PUNCH transforms the processed data file created by TRANS2 into punched cards. The first punched card contains the title punched in 20A4 format. The second card contains the number of data pairs punched in I10 format. All subsequent cards contain the time and amplitude data pairs punched in 3(2E12.4) format. At present, PUNCH converts the processed data from double to single precision before punching them.

5.2 PUNCH Sample Deck

The DSN associated with logical unit No. 10 should be the name of the file containing the information to be punched.

6. PROCEDURE PURGE

It is suggested that, to save storage charges, all data files be deleted after the data have been processed. This deletion can be accomplished easily with the PURGE* procedure.

**From recommendations by Egon Marx and Thomas V. Noon, Harry Diamond Laboratories (1976).*

7. CONCLUSIONS

The program TRANS2 has been used successfully to transform digitized data taken at AURORA into the parameters being measured, such as coupled currents, Compton currents, etc. When phase is included in the transfer function, the user may initially have some difficulty choosing the proper time shift to use, but as the user becomes more familiar with the program and the data being processed, this choice should become less difficult. I would suggest that any potential user of TRANS2 have some knowledge of Fourier transforms and the sampling theorem before attempting to use this program. A poor choice of some input parameters, such as NSTAR and FMAX, could result in the data being improperly processed.

LITERATURE CITED

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(3) John F. W. Dietz, Daniel J. Spohn, and George Merkel, Status of the Tactical Environment Multiple Systems Evaluation Program (TEMSEP), Harry Diamond Laboratories TM-77-23 (September 1977).

(4) E. R. Parkinson, SAPSC: A Two-Dimensional Close-in EMP Coupling Analysis Code, Science Applications Inc. SAI-75-506-AQ (October 1975).

(5) Ralph H. Pennington, Introductory Computer Methods and Numerical Analysis (2nd ed.), MacMillan, Inc. (1970).

(6) George R. Cooper, and Clare D. McGillem, Methods of Signal and System Analysis, Holt, Rinehart, and Winston, Inc. (1967).

(7) Francis Scheid, Schaum's Outline of Theory and Problems of Numerical Analysis, McGraw-Hill (1968).

APPENDIX A.--A LISTING OF THE PROGRAM DFILE

APPENDIX A

```
LEVEL 2.1   (JULY 75) OS/360  FORTRAN H EXTENDED PLUS DATE 77.061/15.02.51 PAGE   1

REQUESTED OPTIONS: XL,GOSTMT,XREF,MAP,NODECK

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0500K) AUTODBL(NONE)
                   SOURCE EBCDIC NOLIST NODECK OBJECT MAP NOFORMAT GOSTMT XREF NOALC
                   NOANSF NOTERMINAL FLAG(I) XL

                        FUNCTIONS INLINE ARE:    NONE


                  C       PROGRAM DFILE
                  C
    ISN 0002              REAL*4 TP(400),FTP(400),TITLE(20)
    ISN 0003              REAL*8 TPD(400),FTPD(400)
    ISN 0004              REWIND 12
    ISN 0005              REWIND 14
    ISN 0006            5 CALL READIT(12,TP,FTP,NPTS,TITLE,&10,&20)
                  C
                  C       CAST OUT BAD POINTS
                  C
    ISN 0007              CALL CSTOUT(TP,FTP,NPTS)
    ISN 0008              DO 69 I=1,NPTS
    ISN 0009              TPD(I) = TP(I)
    ISN 0010              FTPD(I) = FTP(I)
    ISN 0011           69 CONTINUE
    ISN 0012              CALL WRITED(14,TPD,FTPD,NPTS,TITLE)
    ISN 0013              WRITE(6,300) (TITLE(I),I=1,20)
    ISN 0014          300 FORMAT(1H1,20A4)
    ISN 0015              WRITE(6,400) NPTS
    ISN 0016          400 FORMAT(//9X,' NO. OF DATA PAIRS',I6//)
    ISN 0017              NROW = NPTS/4
    ISN 0018              NLEFT = MOD(NPTS,4)
    ISN 0019              N1 = 0
```

```
ISN 0020          N2 = 0
ISN 0021          N3 = 0
ISN 0022          IF(NLEFFT.EQ.0) GO TO 4
ISN 0024          IF(NLEFFT-2) 1,2,3
ISN 0025        1 N1 = 1
ISN 0026          GO TO 4
ISN 0027        2 N1 = 1
ISN 0028          N2 = 1
ISN 0029          GO TO 4
ISN 0030        3 N1 = 1
ISN 0031          N2 = 1
ISN 0032          N3 = 1
ISN 0033        4 N1 = N1 + NROW
ISN 0034          N2 = N1 + N2 + NROW
ISN 0035          N3 = N2 + N3 + NROW
ISN 0036          WRITE(6,600)
ISN 0037      600 FORMAT(4(13X,4HTIME,7X,9HAMPLITUDE))
ISN 0038          WRITE(6,500) (TPD(I),FTPD(I),TPD(I+N1),FTPD(I+N1),TPD(I+N2),
                1    FTPD(I+N2),TPD(I+N3),FTPD(I+N3),I=1,NROW)
ISN 0039      500 FORMAT(4(E20.4,E13.4))
ISN 0040          IF(NLEFFT.EQ.0) GO TO 5
ISN 0042          NROW = NROW + 1
ISN 0043          WRITE(6,500) (TPD(I*NROW),FTPD(I*NROW),I=1,NLEFFT)
ISN 0044          GO TO 5
ISN 0045       10 END FILE 14
ISN 0046       20 STOP
ISN 0047          END
```

APPENDIX A


```
ISN 0002          SUBROUTINE READIT(NT,X,Y,N,TITLE,*,*)
ISN 0003          REAL*4 X(N),Y(N),TITLE(20)
ISN 0004          READ(NT,END=69) TITLE
ISN 0005          READ(NT,END=70) N
ISN 0006          READ(NT,END=70) X,Y
ISN 0007          RETURN
ISN 0008       69 RETURN 1
ISN 0009       70 WRITE(6,700)
ISN 0010      700 FORMAT(///' AN EOF HAS BEEN ENCOUNTERED IMPROPERLY, AND THIS PROGR
                 1AM IS TERMINATING')
ISN 0011          RETURN 2
ISN 0012          END


ISN 0002          SUBROUTINE WRITED(NT,X,Y,N,TITLE)
ISN 0003          REAL*8 X(N),Y(N)
ISN 0004          REAL*4 TITLE(20)
ISN 0005          WRITE(NT) TITLE
ISN 0006          WRITE(NT) N
ISN 0007          WRITE(NT) X,Y
ISN 0008          RETURN
ISN 0009          END
```

APPENDIX B.--A LISTING OF THE PROGRAM TRANS2

APPENDIX B

```
LEVEL 2.1  (JULY 74)                    OS/360  FORTRAN H EXTENDED PLUS        DATE 77.3??/09.54.00        PAGE

REQUESTED OPTIONS: AUTODBL(DBL)

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0500K) AUTODBL(DBL)
                   SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT NOGOSTMT NOXREF NOALC NOANSF NOTERMINAL FLAG(I)

                   FUNCTIONS INLINE ARE:  NONE

              C    PROGRAM TRANS.
              C
ISN 0002           DIMENSION T(300),FT(300),TT(301),FTT(4096)
ISN 0003           DIMENSION FPLT(2049),AMPPLT(2049),PHIPLT(2049),FAMP(2049)
ISN 0004           DIMENSION TIME(750),CURNT1(750),CURNT2(750),CURRNT(750)
ISN 0005           DIMENSION FTRANS(25),ATRANS(25),COEFF(4,25)
ISN 0006           DIMENSION FPHASE(25),PHASE(25),COEFP(4,25)
ISN 0007           DIMENSION KFIT(5)
ISN 0008           INTEGER YLAB1(4)/4H  CU,4HRREN,4HT(AM,4HPS) /
                  1        ,PLAB1(7)/4HCURR,4HENT ,4HOF I,4HNTER,4HEST ,4HIMLE,4HR    /
                  2        ,YLAB2(7)/4HCURR,4HENT ,4HDENS,4HITY(,4HA/ME,4HTER*,4H*2) /
                  3        ,PLAB2(7)/4HCURR,4HENT ,4HCURR,4HENT ,4HTIME,4H HIS,4HTORY/
                  4        ,YLAB3(7)/4HLB/D,4HT (W,4HEBER,4HS/ME,4HTER*,4H*2 S,4HEC) /
                  5        ,PLAB3(6)/4HMDOT,4HIUS ,4HDERIV,4H RES,4HPONS,4HE    /
                  6        ,YLAB4(3)/4H  (A,4H/MET,4HER) /
                  7        ,PLAB4(7)/4HMAGN,4HETIC,4H FIE,4HLD T,4HIME ,4HHIST,4HORY /
                  8        ,YLAB5(4)/4H  CU,4HRREN,4HT(AM,4HPS) /
                  9        ,PLAB5(4)/4HFIE ,4HRAN ,4HRESP,4HONSE/
                  1        ,YLAB6(6)/4H  CU,4H/DT ,4H(A/M,4HETER,4H**2 ,4HSEC /
                  2        ,PLAB6(8)/4HONE-,4HTURN,4H RUC,4HEWSK,4HI CO,4HIL R,4HESPO,
                  3         4HNSE /
                  4        ,YLAB7(4)/4H J (,4HA/ME,4HTER*,4H*2) /
                  5        ,PLAB7(7)/4HCOUP,4HTION ,4HCURR,4HENT ,4HTIME,4H HIS,4HTORY/
                  6        ,PLAB8(7)/4HCOUP,4HLED ,4HCURR,4HENT ,4HTIME,4H HIS,4HTORY/
ISN 0009           INTEGER XLABEL(3)/4H  TI,4HME(S,4HEC) /
                  1        ,YLBL(3)/4H  AM,4HPLIT,4HUDE /
                  2        ,XLB(4)/4H FRE,4HQUEN,4HCY (,4HHZ) /
                  3        ,YLP(4)/4HPHAS,4HE (D,4HEGRE,4HES) /
                  4        ,PL1(7)/4HTRAN,4HSFER,4H FUN,4HCTIO,4HN AM,4HPLIT,4HUDE /
                  5        ,PLB2(6)/4HTRAN,4HSFER,4H FUN,4HCTIO,4HN PH,4HASE /
                  6        ,PLB3(7)/4H   F,4HREQU,4HENCY,4H DOM,4HAIN ,4HRESU,4HLTS /
ISN 0010           INTEGER SLABEL(25)/4H  ..,4H CAL,4HCULA,4HTED,,4H   -,4H- ME,
                  1         4HASUR,4HED: ,12*4H    /
ISN 0011           INTEGER TITLE(20)
ISN 0012           COMPLEX JJ,EPHI
ISN 0013           COMPLEX FW(4096)
              C
              C    EQUIVALENCE ARRAYS TO REDUCE MEMORY REQUIREMENTS
              C
ISN 0014           EQUIVALENCE(FW(1),FTT(1))
ISN 0015           EQUIVALENCE (FPLT(1),T(1)),(FPLT(301),FT(1)),(FPLT(601),TT(1))
ISN 0016           EQUIVALENCE (AMPPLT(1),TIME(1)),(AMPPLT(751),CURNT1(1)),CURRNT(1))
ISN 0017           EQUIVALENCE (PHIPLT(1),CURNT2(1))
              C
              C    NDSETS IS THE NUMBER OF DATA SETS TO BE PROCESSED
              C    IF ISAME = 1, THE INPUT PARAMETERS FOR THE FIRST DATA SET ARE USED
              C       FOR ALL THE DATA SETS, OTHERWISE INPUT PARAMETERS MUST BE
              C       PROVIDED FOR ALL THE DATA SETS
              C
ISN 0018           READ(5,500) NDSETS,ISAME
```

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```
ISN 0019           WRITE(6,555) NDSETS,ISAME
ISN 0020       555 FORMAT(//9H NDSETS =,I3,5X,7HISAME =,I2)
ISN 0021           DO 3 IDSETS=1,NDSETS
             C
             C     READ THE DATA FROM LOGICAL UNIT 8
             C
ISN 0022           CALL READTP(8,T,FT,NPTS,TITLE,&9)
             C
ISN 0023        14 IF(NPTS.GT.300) GO TO 5
ISN 0025           WRITE(6,100) (TITLE(I),I=1,8)
ISN 0026       100 FORMAT(1H1,20A4)
ISN 0027           IF(ISAME.EQ.1   .AND.   IDSETS.NE.1)  GO TO 23
             C
             C     NOFF IS THE NUMBER OF DATA POINTS REMOVED FROM THE FRONT OF THE
             C        PULSE
             C     NOFFR IS THE NUMBER OF DATA POINTS REMOVED FROM THE REAR OF THE
             C        PULSE
             C     IF INVERT = 1, THE PULSE IS INVERTED, OTHERWISE IT IS NOT
             C     IF IZERO = 1, THE AMPLITUDES OF THE FIRST AND LAST DATA POINTS ARE
             C        EQUAL TO ZERO
             C     IF IPLOT = 1,THE INPUT DIGITIZED DATA IS PLOTTED
             C     IF IFILE = 1, THE PROCESSED DATA IS WRITTEN ON LOGICAL UNIT 9 SO
             C        THAT IT CAN BE CATALOGED AS A DISK FILE
             C
             C     ISENSR DENOTES THE TYPE OF SENSOR WHICH WAS USED TO PRODUCE THE
             C        DATA
             C        1 = CURRENT PROBE USED TO MEASURE CURRENT ON INNER CYLINDER
             C        2 = CURRENT PROBE USED TO MEASURE CURRENT ON A SINGLE WIRE
             C        3 = CURRENT PROBE USED TO MEASURE COMPTON CURRENT
             C        4 = MOEBIUS LOOP
             C        5 = CURRENT PROBE ON FIR PAN
             C        6 = ONE-TURN ROGOWSKI COIL
             C
ISN 0029           READ(5,500) NOFF,NOFFR,INVERT,IZERO,IPLOT,IFILE,ISENSR
ISN 0030       500 FORMAT(7I10)
             C
             C     IF IPLTC = 1, THE COUPLED CURRENT OUTPUT FROM SAPSC IS PLOTTED ON
             C        SAME GRAPH AS THE PROCESSED DATA
             C     IF NCUR = 1, SAPSC OUTPUT FOR THE FIRST MEASUREMENT POSITION IS
             C        PLOTTED.  OTHERWISE, THE OUTPUT FOR THE SECOND POSITION IS USED
             C
ISN 0031           READ (5,500) IPLTC,NCUR
             C
             C     NSTAR IS THE NUMBER OF FREQUENCY AND TIME POINTS USED BY THE FFT
             C     FMAX IS THE MAXIMUM FREQUENCY USED BY THE FFT
             C     IF KPLOT = 1, FREQUENCY DOMAIN RESULTS ARE PLOTTED
ISN 0032           READ(5,501) NSTAR,FMAX,KPLOT
ISN 0033       501 FORMAT(I10,E10.3,I10)
             C
             C     NTRANS IS THE NUMBER OF TRANSFER FUNCTION AMPLITUDE POINTS TO BE
             C        USED (25 OR LESS)
             C     IF JPLOT = 1, THE TRANSFER FUNCTION AMPLITUDE AND PHASE ARE
             C        PLOTTED
             C     IF IPHASE = 1, PHASE WILL BE INCLUDED IN THE TRANSFER FUNCTION
             C
ISN 0034           READ(5,500) NTRANS,JPLOT,IPHASE
             C
             C     FTRANS IS THE FREQUENCY (HZ), AND ATRANS IS THE AMPLITUDE
```

```
LEVEL 2.1  (JULY 75)          MAIN          OS/360  FORTRAN H EXTENDED PLUS       DATE 77.063/09.04.00        PAGE   5
                C          (AMPS/VOLT) OF THE MEASURED TRANSFER FUNCTION
                C
  ISN 0035            READ(5,510) (FTRANS(I),ATRANS(I),I=1,NTRANS)
  ISN 0036        510 FORMAT(4(2E10.3))
  ISN 0037            TRETRD = 0.
  ISN 0038            IF(IPHASE.NE.1) GO TO 24
                C
                C     NPHASE IS THE NUMBER OF PHASE POINTS TO BE USED (25 OR LESS)
                C     TRETRD IS THE AMOUNT OF TIME (IN SEC) WHICH THE PULSE MUST BE
                C        RETARDED IF THE TRANSFER FUNCTION INCLUDES PHASE
                C
  ISN 0040            READ(5,501) NPHASE,TRETRD
                C
                C     FPHASE IS THE FREQUENCY (HZ), AND APHASE IS THE PHASE ANGLE
                C        (DEGREES) OF THE MEASURED PHASE
                C
  ISN 0041            READ(5,510) (FPHASE(I),PHASE(I),I=1,NPHASE)
                C
                C     WRITE THE INPUT PARAMETERS
                C
  ISN 0042         24 WRITE(6,550) NOFF,NOFFR,INVERT,IZERO,IPLOT,IFILE,ISENSR
  ISN 0043        550 FORMAT(////7H NOFF =,I3,5X,7HNOFFR =,I3,5X,8HINVERT =,I2,5X,
                     1    7HIZERO =,I2,5X,7HIPLOT =,I2,5X,7HIFILE =,I2,5X,8HISENSR =,I2/)
  ISN 0044            WRITE (6,554) IPLTC,NCUR
  ISN 0045        554 FORMAT(8H IPLTC =,I2,5X,6HNCUR =,I2/)
  ISN 0046            WRITE(6,551) NSTAR,FMAX,KPLOT
  ISN 0047        551 FORMAT(8H NSTAR =,I6,5X,6HFMAX =,E10.3,5X,7HKPLOT =,I2/)
  ISN 0048            WRITE(6,570) NTRANS,JPLOT,IPHASE
  ISN 0049        570 FORMAT(9H NTRANS =,I3,5X,7HJPLOT =,I2,5X,8HIPHASE =,I2/)
  ISN 0050            WRITE(6,571)
  ISN 0051        571 FORMAT(7X,6HFTRANS,6X,6HATRANS,4(8X,6HFTRANS,6X,6HATRANS))
  ISN 0052            WRITE(6,602) (FTRANS(I),ATRANS(I),I=1,NTRANS)
  ISN 0053            IF(IPHASE.NE.1) GO TO 23
  ISN 0055            WRITE(6,572) NPHASE,TRETRD
  ISN 0056        572 FORMAT(9HONPHASE =,I3,5X,8HTRETRD =,E10.3/)
  ISN 0057            WRITE(6,573)
  ISN 0058        573 FORMAT(7X,6HFPHASE,6X,5HPHASE,4(9X,6HFPHASE,6X,5HPHASE))
  ISN 0059            WRITE(6,602) (FPHASE(I),PHASE(I),I=1,NPHASE)
                C
                C     REMOVE DATA POINTS FROM REAR OF PULSE
                C
  ISN 0060         23 NPTS = NPTS - NOFFR
                C
  ISN 0061            IF(INVERT.NE.1) GO TO 26
                C
                C     INVERT INPUT DATA
                C
  ISN 0063            DO 25 I=1,NPTS
  ISN 0064         25 FT(I) = -FT(I)
                C
  ISN 0065         26 IF(NOFF.EQ.0) GO TO 27
                C
                C     REMOVE DATA POINTS FROM FRONT OF PULSE
                C
  ISN 0067            NPTS = NPTS - NOFF
  ISN 0068            TN1 = T(NOFF+1)
  ISN 0069            DO 75 I=1,NPTS
  ISN 0070            FT(I) = FT(I+NOFF)
```

```
ISN 0071            T(I) = T(I+NOFF) - TNI
ISN 0072         75 CONTINUE
ISN 0073            NPTS = NOTS
              C
ISN 0074         27 IF(IPHASE.NE.1) GO TO 33
ISN 0076            NN = NPTS + 1
ISN 0077            IF(NN.GT.300) GO TO 5
              C
              C     SINCE THE SIGNAL IS DELAYED BY THE MEASURING SYSTEM, THE PULSE
              C        MUST BE RETARDED IN REAL TIME BEFORE IT CAN BE MULTIPLIED BY
              C        THE PHASE FACTOR OF THE TRANSFER FUNCTION
              C
ISN 0079         95 FT(NN) = FT(NN-1)
ISN 0080            T(NN) = T(NN-1) + TRETRO
ISN 0081            NN = NN - 1
ISN 0082            IF(NN.GT.1) GO TO 95
ISN 0084            NPTS = NPTS + 1
ISN 0085            T(1) = 0.
ISN 0086            FT(1) = 0.
              C
ISN 0087         33 WRITE(6,200) NPTS
ISN 0088        200 FORMAT(1H0,6HNPTS =,I4//)
              C
ISN 0089            IF(IZERO.NE.1) GO TO 28
              C
              C     SET THE AMPLITUDES OF THE FIRST AND LAST POINTS EQUAL TO ZERO
              C
ISN 0091            FT(1) = 0.
ISN 0092            FT(NPTS) = 0.
              C
ISN 0093         28 IF(IPLOT.NE.1) GO TO 83
              C
              C     PLOT THE INPUT DATA
              C
ISN 0095            CALL DRAW41(1,3,3,20,0,XLABEL,YLBL,TITLE,0.)
ISN 0096            CALL DRAW42(1,1,NPTS,2,10,T,FT,0.,0.)
ISN 0097            CALL DRAW43(1,1,0,0,NPTS,T ,FT ,2.,0.)
              C
              C     ASSIGN SENSOR RESPONSE FUNCTIONS
              C
ISN 0098         83 GO TO (49,48,47,46,45,44),ISENSR
              C
              C     CURRENT MUST BE MULTIPLIED BY THE NUMBER OF RESISTORS IN THE BAJ
              C
ISN 0099         49 SENSOR = 20.
ISN 0100            GO TO 21
              C
ISN 0101         48 SENSOR = 1.
ISN 0102            GO TO 21
              C
ISN 0103         47 DIAM = 1.075*.0254
ISN 0104            AREA = 3.14159*(DIAM/2.)**2
              C
              C     CURRENT MUST BE DIVIDED BY AREA OF SENSOR
              C
ISN 0105            SENSOR = 1./AREA
ISN 0106            GO TO 21
              C
```

```
ISN 0107      46 SENSOR = (1./1.14E-[illegible])**2.4                          00225000
ISN 0108         GO TO 21                                                      00226000
            C                                                                  00227000
ISN 0109      45 SENSOR = 1.                                                   00228000
ISN 0110         GO TO 21                                                      00229000
            C                                                                  00230000
ISN 0111      44 VOLUME = 5.E-2                                                00231000
ISN 0112         SENSOR = (1.E-7/VOLUME)**2.4                                  00232000
ISN 0113      21 DO 20 I=1,NPTS                                                00233000
ISN 0114      20 FT(I) = FT(I)*SENSOR                                          00234000
            C                                                                  00235000
            C      CALCULATE FREQUENCY AND TIME SPACING                        00236000
            C                                                                  00237000
ISN 0115           DF = FMAX/(NSTAR-1)                                         00238000
ISN 0116           DT = 1./(NSTAR*DF)                                          00239000
            C                                                                  00240000
            C      LINEARLY INTERPOLATE THE INPUT DATA                         00241000
            C                                                                  00242000
ISN 0117           CALL CLINTD(T,FT,NPTS,NSTAR,DT,FW)                          00243000
            C                                                                  00244000
ISN 0118           TNPTS = T(NPTS)                                             00245000
ISN 0119           NTF = (TNPTS - TRETFD)/DT + 1                               00246000
ISN 0120           IF(NTF.GT.801) GO TO [illegible]                            00247000
            C                                                                  00248000
            C      CALCULATE WHAT POWER OF 2 NSTAR IS                          00249000
            C                                                                  00250000
ISN 0122           NPOW = 0                                                    00251000
ISN 0123           NREM = NSTAR                                                00252000
ISN 0124        22 NREM = NREM/2                                               00253000
ISN 0125           NPOW = NPOW + 1                                             00254000
ISN 0126           IF(NREM.NE.1) GO TO 22                                      00255000
            C                                                                  00256000
            C                                                                  00257000
            C      TRANSFORM DATA INTO FREQUENCY DOMAIN                        00258000
            C                                                                  00259000
ISN 0128           CALL FFTD(FW,NPOW,NSTAR,DT,-1)                              00260000
            C                                                                  00261000
ISN 0129           NS21 = NSTAR/2 + 1                                          00262000
            C                                                                  00263000
            C      CALCULATE SPLINE FUNCTION COEFFICIENTS FOR TRANSFER FUNCTION  00264000
            C         AMPLITUDE DATA                                           00265000
            C                                                                  00266000
ISN 0130           CALL SPLICO(NTRANS,FTRANS,ATRANS,COEF)                      00267000
            C                                                                  00268000
            C      CALCULATE SPLINE FUNCTION COEFFICIENTS FOR PHASE DATA       00269000
            C                                                                  00270000
ISN 0131           IF(IPHASE.EQ.1) CALL SPLICO(NPHASE,FPHASE,PHASE,COEFP)      00271000
            C                                                                  00272000
            C      INITIALIZE STARTING POINT OF SEARCH THROUGH TRANSFER FUNCTION DATA00273000
            C                                                                  00274000
ISN 0133           JSTART = 1                                                  00275000
ISN 0134           KSTART = 1                                                  00276000
            C                                                                  00277000
            C      INITIALIZE FLAG FOR CALCULATION OF PARAMETERS FOR FITS      00278000
            C         TO FRONT AND REAR OF TRANSFER FUNCTION                   00279000
            C                                                                  00280000
ISN 0135           KFIT(1) = 1                                                 00281000
ISN 0136           KFIT(2) = 1                                                 00282000
```

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LEVEL 2.1  (JULY 75)          MAIN          OS/360  FORTRAN H EXTENDED PLUS          DATE 77.163/09.04.00          PAGE   6

ISN 0137            KFIT(3) = 1
ISN 0138            KFIT(4) = 1
              C
ISN 0139            PIRAD = 3.14159/180.
ISN 0140            EPHI = (1.,0.)
ISN 0141            JJ = (0.,1.)
              C
ISN 0142            DO 30 I=1,NS21
ISN 0143            F = DF*(I - 1)
ISN 0144            IF(F.LE.FTRANS(NTRANS)) GO TO 31
              C
              C     PERFORM FIT TO REAR OF TRANSFER FUNCTION AMPLITUDE DATA
              C
ISN 0146            CALL ENDFIT(2,KFIT(2),NTRANS,FTRANS,ATRANS,F,AMP)
ISN 0147            GO TO 34
              C
ISN 0148         31 IF(F.GE.FTRANS(1)) GO TO 32
              C
              C     PERFORM FIT TO FRONT OF TRANSFER FUNCTION AMPLITUDE DATA
              C
ISN 0150            CALL ENDFIT(1,KFIT(1),NTRANS,FTRANS,ATRANS,F,AMP)
ISN 0151            GO TO 34
              C
              C     USE SPLINE FUNCTION TO CALCULATE VALUE OF TRANSFER FUNCTION
              C        AMPLITUDE AT DESIRED FREQUENCY
              C
ISN 0152         32 CALL SPLINE(KSTART,FTRANS,ATRANS,COEF,F,AMP)
              C
ISN 0153         34 IF(IPHASE.NE.1) GO TO 29
ISN 0155            IF(F.LE.FPHASE(NPHASE)) GO TO 35
              C
              C     PERFORM FIT TO REAR OF PHASE DATA
              C
ISN 0157            CALL ENDFIT(4,KFIT(4),NPHASE,FPHASE,PHASE,F,PHI)
              C
ISN 0158            GO TO 36
ISN 0159         35 IF(F.GE.FPHASE(1)) GO TO 37
              C
              C     PERFORM FIT TO FRONT OF PHASE DATA
              C
ISN 0161            CALL ENDFIT(3,KFIT(3),NPHASE,FPHASE,PHASE,F,PHI)
ISN 0162            GO TO 36
              C
              C     USE SPLINE FUNCTION TO CALCULATE VALUE OF PHASE AT DESIRED
              C        FREQUENCY
              C
ISN 0163         37 CALL SPLINE(JSTART,FPHASE,PHASE,COEFP,F,PHI)
              C
              C     CALCULATE TRANSFER FUNCTION PHASE EFFECTS
              C
ISN 0164         36 EPHI = CEXP(-JJ*PHI*PIRAD)
              C
              C     MULTIPLY BY TRANSFER FUNCTION
              C
              C
ISN 0165         29 FX(I) = FX(I)*AMP*EPHI
              C
ISN 0166            FPLT(I) = F
```

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LEVEL 2.1  (JULY 75)          MAIN          OS/360  FORTRAN H EXTENDED PLUS        DATE 77.063/09.04.00        PAGE   7

ISN 0167             AMPPLT(I) = AMP                                                          00341000
ISN 0168             PHIPLT(I) = PHI                                                          00342000
ISN 0169             FAMP(I) = CABS(FW(I))                                                    00343000
ISN 0170          30 CONTINUE                                                                 00344000
               C                                                                              00345000
ISN 0171             IF(JPLOT.NE.1) GO TO 38                                                  00346000
ISN 0173             IF(ISAME.EQ.1   .AND.   IDSETS.NE.1) GO TO 38                            00347000
               C                                                                              00348000
               C     PLOT TRANSFER FUNCTION                                                   00349000
               C                                                                              00350000
ISN 0175             CALL DRAWID(3,4,3,7,0,NS21,2.,0.,XLB,YLBL,PLB,0.,FPLT,AMPPLT)            00351000
               C                                                                              00352000
ISN 0176             IF(IPHASE.NE.1) GO TO 38                                                 00353000
ISN 0178             CALL DRAWID(3,4,4,6,0,NS21,2.,0.,XLB,YLB,PLB2,0.,FPLT,PHIPLT)            00354000
               C                                                                              00355000
ISN 0179          38 IF(KPLOT.NE.1) GO TO 39                                                  00356000
               C                                                                              00357000
               C     PLOT FREQUENCY DOMAIN RESULTS                                            00358000
               C                                                                              00359000
ISN 0181             CALL DRAWID(2,4,3,7,20,NS21,2.,0.,XLF,YLEL,PLB3,TITLE,FPLT,FAMP)         00360000
               C                                                                              00361000
               C     TRANSFORM DATA BACK INTO THE TIME DOMAIN                                 00362000
               C                                                                              00363000
ISN 0182          39 CALL FFTAD(2,FW,NSTAR,DF,1,.FALSE.,FTT)                                  00364000
ISN 0183             FTT1 = FTT(1)                                                            00365000
ISN 0184             WRITE(6,560) FTT1                                                        00366000
ISN 0185         560 FORMAT(7H FTT1 =,E10.3//)                                                00367000
               C                                                                              00368000
               C     REMOVE DC SHIFT FROM PROCESSED DATA                                      00369000
               C                                                                              00370000
ISN 0186             DO 70 I=1,NTP                                                            00371000
ISN 0187             TT(I) = DT*(I-1)                                                         00372000
ISN 0188             FTT(I) = FTT(I) - FTT1                                                   00373000
ISN 0189          70 CONTINUE                                                                 00374000
ISN 0190             WRITE(6,601)                                                             00375000
ISN 0191         601 FORMAT(10X,1HT,10X,2HFT,13X,1HT,10X,2HFT,13X,1HT,10X,2HFT,               00376000
                   1   13X,1HT,10X,2HFT,13X,1HT,10X,2HFT)                                     00377000
ISN 0192             WRITE(6,602) (TT(I),FTT(I),I=1,NTP)                                      00378000
ISN 0193         602 FORMAT(5(E14.3,E12.3))                                                   00379000
               C                                                                              00380000
               C     PLOT PROCESSED DATA                                                      00381000
               C                                                                              00382000
ISN 0194             GO TO (69,68,67,66,65,64),ISENSR                                         00383000
               C                                                                              00384000
ISN 0195          69 IF (IFLTC.NE.1) GO TO 77                                                 00385000
               C                                                                              00386000
               C     READ SAPSC COUPLED CURRENT OUTPUT FROM LOGICAL UNIT 10                   00387000
               C                                                                              00388000
ISN 0197             READ(10) NL                                                              00389000
ISN 0198             READ(10) (TIME(I),CURNT1(I),CURNT2(I),I=1,NL)                            00390000
ISN 0199             DO 72 I=9,20                                                             00391000
ISN 0200          72 SLABEL(I) = TITLE(I-8)                                                   00392000
ISN 0201             NTL = NTP                                                                00393000
ISN 0202             IF (NL.GT.NTP) NTL=NL                                                    00394000
               C                                                                              00395000
               C     CURRNT AND CURNT1 HAVE BEEN EQUIVALENCED                                 00396000
               C                                                                              00397000
ISN 0204             IF (NCUR.EQ.1) GO TO 73                                                  00398000
```

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LEVEL 2.1  (JULY 75)            MAIN            OS/360  FORTRAN H EXTENDED PLUS        DATE 77.063/09.04.00        PAGE   8

ISN 0206              DO 74 I=1,NL
ISN 0207           74 CURRNT(I) = CURNT2(I)
                C
                C     PLOT SAPSC OUTPUT IN SAME GRAPH AS PROCESSED DATA
                C
ISN 0208           73 CALL DRAW41(1,3,4,7,20,XLABEL,YLAB1,PLAB1,SLABEL)
ISN 0209              CALL DRAW42(1,1,NTP,0,  1,TT,FTT,0.,0.)
ISN 0210              CALL DRAW42(1,1,NL,0,  2,TIME,CURRNT,0.,0.)
ISN 0211              CALL DRAW43(1,1,0,0,NTL,TT,FTT,2.,0.)
ISN 0212              GO TO 80
                C
ISN 0213           77 CALL DRAWID(1,3,4,7,20,NTP,2.,0.,XLABEL,YLAB1,PLAB1,TITLE,TT,FTT)
ISN 0214              GO TO 80
                C
ISN 0215           68 CALL DRAWID(1,3,4,7,20,NTP,2.,0.,XLABEL,YLAB5,PLAB8,TITLE,TT,FTT)
ISN 0216              GO TO 80
                C
ISN 0217           67 CALL DRAWID(1,3,7,7,20,NTP,2.,0.,XLABEL,YLAB2,PLAB2,TITLE,TT,FTT)
ISN 0218              GO TO 80
                C
ISN 0219           66 CALL DRAWID(1,3,7,6,20,NTP,2.,0.,XLABEL,YLAB3,PLAB3,TITLE,TT,FTT)
ISN 0220              XMUINV = 1./1.26E-6
                C
                C     INTEGRATE MOEBIUS LOOP DATA TO OBTAIN H FIELD
                C
ISN 0221              AREA = 0.
ISN 0222              FTTI = FTT(1)
ISN 0223              FTT(1) = 0.
ISN 0224              DO 79 I=2,NTP
ISN 0225              FTTI1 = FTTI
ISN 0226              FTTI = FTT(I)
ISN 0227              AREA = AREA + .5*DT*(FTTI + FTTI1)
ISN 0228              FTT(I) = AREA*XMUINV
ISN 0229           79 CONTINUE
ISN 0230              WRITE(6,603)
ISN 0231          603 FORMAT(1H1,8X,1HT,10X,4HH(T),4(11X,1HT,10X,4HH(T))/)
ISN 0232              WRITE(6,602) (TT(I),FTT(I), I=1,NTP)
ISN 0233              CALL DRAWID(1,3,3,7,20,NTP,2.,0.,XLABEL,YLAB4,PLAB4,TITLE,TT,FTT)
ISN 0234              GO TO 80
                C
ISN 0235           65 CALL DRAWID(1,3,4,4,20,NTP,2.,0.,XLABEL,YLAB5,PLAB5,TITLE,TT,FTT)
ISN 0236              GO TO 80
                C
ISN 0237           64 CALL DRAWID(1,3,6,8,20,NTP,2.,0.,XLABEL,YLAB6,PLAB6,TITLE,TT,FTT)
                C
                C     INTEGRATE ONE-TURN ROGOWSKI COIL DATA TO OBTAIN J COMPTON
                C
ISN 0238              AREA = 0.
ISN 0239              FTTI = FTT(1)
ISN 0240              FTT(1) = 0.
ISN 0241              DO 89 I=2,NTP
ISN 0242              FTTI1 = FTTI
ISN 0243              FTTI = FTT(I)
ISN 0244              AREA = AREA + .5*DT*(FTTI + FTTI1)
ISN 0245              FTT(I) = AREA
ISN 0246           89 CONTINUE
ISN 0247              WRITE(6,604)
ISN 0248          604 FORMAT(1H1,8X,1HT,10X,4HJ(T),4(11X,1HT,10X,4HJ(T))/)
```

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LEVEL 2.1  (JULY 75)          MAIN          OS/360  FORTRAN H EXTENDED PLUS        DATE 77.063/09.04.00        PAGE  9

  ISN 0249             WRITE(6,602) (TT(I),FTT(I), I=1,NTP)                                      00457000
  ISN 0250             CALL DRAW1D(1,3,4,6,20,NTP,2.,0.,XLABEL,YLAB7,PLAB7,TITLE,TT,FTT) 00458000
              C                                                                                   00459000
  ISN 0251          80 IF(IFILE.NE.1) GO TO 3                                                     00460000
              C                                                                                   00461000
              C        WRITE PROCESSED DATA ON LOGICAL UNIT 9 SO THAT IT CAN BE CATALOGED00462000
              C                                                                                   00463000
  ISN 0253             CALL WRITTP(9,TT,FTT,NTP,TITLE)                                            00464000
  ISN 0254           3 CONTINUE                                                                   00465000
  ISN 0255             STOP                                                                       00466000
  ISN 0256           6 WRITE(6,302)                                                               00467000
  ISN 0257         302 FORMAT(/////38H THE DIMENSION OF TT HAS BEEN EXCEEDED)                     00468000
  ISN 0258             STOP                                                                       00469000
  ISN 0259           5 WRITE(6,300)                                                               00470000
  ISN 0260         300 FORMAT(/////38H THE DIMENSION OF FT HAS BEEN EXCEEDED)                     00471000
  ISN 0261             STOP                                                                       00472000
  ISN 0262           7 WRITE(6,301)                                                               00473000
  ISN 0263         301 FORMAT(/////37H THE DIMENSION OF H HAS BEEN EXCEEDED)                      00474000
  ISN 0264           9 STOP                                                                       00475000
  ISN 0265             END                                                                        00476000
```

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LEVEL 2.1  (JULY 75)                    OS/360  FORTRAN H EXTENDED PLUS        DATE 77.063/09.04.10        PAGE   1

REQUESTED OPTIONS: AUTODBL(DBL)

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0500K) AUTODBL(DBL)
                   SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT NOGOSTMT NOXREF NOALC NOANSF NOTERMINAL FLAG(I)

                         FUNCTIONS INLINE ARE:    NONE

   ISN 0002          SUBROUTINE WRITTP(NT,X,Y,N,TITLE)                                    00620000
   ISN 0003          REAL*4 X(N),Y(N)                                                     00621000
   ISN 0004          INTEGER TITLE(20)                                                    00622000
   ISN 0005          WRITE(NT) TITLE                                                      00623000
   ISN 0006          WRITE(NT) N                                                          00624000
   ISN 0007          WRITE(NT) X,Y                                                        00625000
   ISN 0008          RETURN                                                               00626000
   ISN 0009          END                                                                  00627000
```

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LEVEL 2.1  (JULY 75)                    OS/360  FORTRAN H EXTENDED PLUS        DATE 77.063/09.04.08        PAGE   1

REQUESTED OPTIONS: AUTODBL(DBL)

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0500K) AUTODBL(DBL)
                   SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT NOGOSTMT NOXREF NOALC NOANSF NOTERMINAL FLAG(I)

                      FUNCTIONS INLINE ARE:   NONE

  ISN 0002            SUBROUTINE READTP(NT,X,Y,N,TITLE,*)                                   00604000
  ISN 0003            REAL*4 X(N),Y(N)                                                      00605000
  ISN 0004            INTEGER TITLE(20)                                                     00606000
  ISN 0005            READ(NT,ERR=11,END=12) TITLE                                          00607000
  ISN 0006            READ(NT,ERR=11,END=12) N                                              00608000
  ISN 0007            READ(NT,ERR=11,END=12) X,Y                                            00609000
  ISN 0008            RETURN                                                                00610000
  ISN 0009         11 WRITE(6,420)                                                          00611000
  ISN 0010        420 FORMAT(//65H **AN ERROR OCCURRED WHEN THE DATA WERE READ FROM THE 00612000
                     1DISK FILE**)                                                          00613000
  ISN 0011            RETURN 1                                                              00614000
  ISN 0012         12 WRITE(6,421)                                                          00615000
  ISN 0013        421 FORMAT(// 88H **AN END OF FILE WAS ENCOUNTERED IMPROPERLY WHEN THE00616000
                     1DATA WERE READ FROM THE DISK FILE**)                                  00617000
  ISN 0014            RETURN 1                                                              00618000
  ISN 0015            END                                                                   00619000
```

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LEVEL 2.1  (JULY 75)          ENDFIT          OS/360  FORTRAN H EXTENDED PLUS       DATE 77.063/09.04.06        PAGE   2
                  C                                                                    00594000
  ISN 0032              BETA = (Y(M) - Y(M-1))/(X(M) - X(M-1))                         00595000
  ISN 0033              B = Y(M)                                                       00596000
  ISN 0034              KF = 2                                                         00597000
                  C                                                                    00598000
                  C     CALCULATE PHASE AT FREQUENCY ABOVE MEASURED PHASE              00599000
                  C                                                                    00600000
  ISN 0035           41 YA = BETA*(XA - X(M)) + B                                      00601000
  ISN 0036              RETURN                                                         00602000
  ISN 0037              END                                                            00603000
```

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LEVEL 2.1  (JULY 75)                OS/360  FORTRAN H EXTENDED PLUS        DATE 77.063/09.04.06        PAGE  1

REQUESTED OPTIONS: AUTODBL(DBL)

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0500K) AUTODBL(DBL)
                   SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT NOGOSTMT NOXREF NOALC NOANSF NOTERMINAL FLAG(I)

                        FUNCTIONS INLINE ARE:   NONE

ISN 0002                SUBROUTINE ENDFIT(LFIT,KF,M,X,Y,XA,YA)
                C
                C       THIS SUBROUTINE CALCULATES THE TRANSFER FUNCTION AMPLITUDE OR
                C          PHASE VALUES OUTSIDE THE BOUNDS OF THE MEASURED VALUES
                C
ISN 0003                DIMENSION X(1),Y(1)
ISN 0004                GO TO (10,20,30,40),LFIT
ISN 0005             10 IF(KF.NE.1) GO TO 11
                C
                C       CALCULATE PARAMETERS FOR FIT TO FRONT OF TRANSFER
                C          FUNCTION AMPLITUDE DATA
                C
ISN 0007                KF = 2
                C
                C       CALCULATE TRANSFER FUNCTION AMPLITUDE BELOW MEASURED DATA
                C
ISN 0008             11 YA = 1000.
ISN 0009                RETURN
ISN 0010             20 IF(KF.NE.1) GO TO 21
                C
                C       CALCULATE PARAMETERS FOR FIT TO REAR OF TRANSFER
                C          FUNCTION AMPLITUDE DATA
                C
ISN 0012                A = Y(M)
ISN 0013                ALPHA = ALOG(2.)/(100.E6 - X(M))
ISN 0014                KF = 2
                C
                C       CALCULATE TRANSFER FUNCTION AMPLITUDE ABOVE MEASURED DATA
                C
ISN 0015             21 IF(XA.LT.100.E6) GO TO 25
ISN 0017                YA = 0.
ISN 0018                RETURN
ISN 0019             25 IF((ALPHA*(XA - X(M))).GT.1.E-6) GO TO 22
ISN 0021                YA = A
ISN 0022                GO TO 23
ISN 0023             22 YA = A*(2. - EXP(ALPHA*(XA - X(M))))
ISN 0024             23 RETURN
ISN 0025             30 IF(KF.NE.1) GO TO 31
                C
                C       CALCULATE PARAMETERS FOR FIT TO FRONT OF PHASE DATA
                C
ISN 0027                KF = 2
                C
                C       CALCULATE PHASE AT FREQUENCY BELOW MEASURED PHASE
                C
ISN 0028             31 YA = 180.
ISN 0029                RETURN
ISN 0030             40 IF(KF.NE.1) GO TO 41
                C
                C       CALCULATE PARAMETERS FOR FIT TO REAR OF PHASE DATA
```

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LEVEL 2.1  (JULY 75)                    OS/360  FORTRAN H EXTENDED PLUS       DATE 77.063/09.04.05       PAGE   1

REQUESTED OPTIONS: AUTODBL(DBL)

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0500K) AUTODBL(DBL)
                   SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT NOGOSTMT NOXREF NOALC NOANSF NOTERMINAL FLAG(I)

                      FUNCTIONS INLINE ARE:   NONE

  ISN 0002              SUBROUTINE SPLINE(K,X,Y,C,XA,YA)
                  C
                  C     THIS SUBROUTINE USES A SPLINE FIT TO CALCULATE THE VALUE OF THE
                  C     TRANSFER FUNCTION AMPLITUDE OR PHASE VALUES AT A GIVEN FREQUENCY
                  C
  ISN 0003              DIMENSION X(1),Y(1),C(4,1)
                  C
                  C     SEARCH FOR PROPER FREQUENCY INTERVAL
                  C
  ISN 0004           29 IF(X(K+1).GE.XA) GO TO 30
  ISN 0006              K = K + 1
  ISN 0007              GO TO 29
  ISN 0008           30 XKI = X(K+1) - XA
                  C
                  C     CALCULATE AMPLITUDE OR PHASE VALUE USING COEFFICIENTS FROM SPLICT
                  C
  ISN 0009              YA = XKI*(C(1,K)*(XKI)**2 + C(3,K))
  ISN 0010              XKI = XA - X(K)
  ISN 0011              YA = YA + XKI*(C(2,K)*(XKI)**2 + C(4,K))
  ISN 0012              RETURN
  ISN 0013              END
```

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LEVEL 2.1  (JULY 75)                  OS/360  FORTRAN H EXTENDED PLUS        DATE 77.063/09.04.03        PAGE   1

REQUESTED OPTIONS: AUTODBL(DBL)

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0500K) AUTODBL(DBL)
                   SOURCE EBCDIC NOLIST NODECK OBJECT NOMAP NOFORMAT NOGOSTMT NOXREF NOALC NOANSF NOTERMINAL FLAG(I)

                      FUNCTIONS INLINE ARE:    NONE

ISN 0002              SUBROUTINE SPLICO(M,X,Y,C)                                        00477000
                C                                                                       00478000
                C     THIS SUBROUTINE CALCULATES COEFFICIENTS FOR A SPLINE FIT TO       00479000
                C     TRANSFER FUNCTION DATA                                            00480000
                C                                                                       00481000
ISN 0003              DIMENSION D(25),P(25),E(25),A(25,3),B(25),Z(25)                   00482000
ISN 0004              DIMENSION X(1),Y(1),C(4,1)                                       00483000
ISN 0005              EQUIVALENCE(E(1),Z(1))                                            00484000
ISN 0006              MM=M-1                                                            00485000
ISN 0007              DO 2  K=1,MM                                                      00486000
ISN 0008              D(K)=X(K+1)-X(K)                                                  00487000
ISN 0009              P(K)=D(K)/6.                                                      00488000
ISN 0010            2 E(K)=(Y(K+1)-Y(K))/D(K)                                           00489000
ISN 0011              DO 3  K=2,MM                                                      00490000
ISN 0012            3 B(K)=E(K)-E(K-1)                                                  00491000
ISN 0013              A(1,3)=D(1)/D(2)                                                  00492000
ISN 0014              A(1,2)=-1.-A(1,3)                                                 00493000
ISN 0015              A(2,2)=2.*(P(1)+P(2))-P(1)*A(1,2)                                 00494000
ISN 0016              A(2,3)=(P(2)-P(1)*A(1,3))/A(2,2)                                  00495000
ISN 0017              B(2)=B(2)/A(2,2)                                                  00496000
ISN 0018              DO 4  K=3,MM                                                      00497000
ISN 0019              A(K,2)=2.*(P(K-1)+P(K))-P(K-1)*A(K-1,3)                           00498000
ISN 0020              B(K)=E(K)-P(K-1)*B(K-1)                                           00499000
ISN 0021              A(K,3)=P(K)/A(K,2)                                                00500000
ISN 0022            4 B(K)=E(K)/A(K,2)                                                  00501000
ISN 0023              Q=D(M-2)/D(M-1)                                                   00502000
ISN 0024              A(M,1)=1.+Q+A(M-2,3)                                              00503000
ISN 0025              A(M,2)=-Q-A(M,1)*A(M-1,3)                                         00504000
ISN 0026              B(M)=E(M-2)-A(M,1)*B(M-1)                                         00505000
ISN 0027              Z(M)=E(M)/A(M,2)                                                  00506000
ISN 0028              MN=M-2                                                            00507000
ISN 0029              DO 6  I=1,MN                                                      00508000
ISN 0030              K=M-I                                                             00509000
ISN 0031            6 Z(K)=E(K)-A(K,3)*Z(K+1)                                           00510000
ISN 0032              Z(1)=-A(1,2)*Z(2)-A(1,3)*Z(3)                                     00511000
ISN 0033              DO 7  K=1,MM                                                      00512000
ISN 0034              G=1./(6.*D(K))                                                    00513000
ISN 0035              C(1,K)=Z(K)*G                                                     00514000
ISN 0036              C(2,K)=Z(K+1)*G                                                   00515000
ISN 0037              C(3,K)=Y(K)/D(K)-Z(K)*P(K)                                        00516000
ISN 0038              C(3,K)=Y(K)/D(K)-Z(K)*P(K)                                        00519000
ISN 0039            7 C(4,K)=Y(K+1)/D(K)-Z(K+1)*P(K)                                    00520000
ISN 0040              RETURN                                                            00521000
ISN 0041              END                                                               00522000
```

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APPENDIX C.--A LISTING OF THE PROGRAM PUNCH

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LEVEL 2.1  (JULY 75) OS/360  FORTRAN H EXTENDED PLUS DATE 77.061/15.07.24 PAGE   1

REQUESTED OPTIONS: MAP

OPTIONS IN EFFECT: NAME(MAIN) NOOPTIMIZE LINECOUNT(60) SIZE(0500K) AUTODBL(NONE)
                   SOURCE EBCDIC NOLIST NODECK OBJECT MAP NOFORMAT NOGOSTMT NOXREF
                   NOALC NOANSF NOTERMINAL FLAG(I)

                   FUNCTIONS INLINE ARE:   NONE


               C       PROGRAM PUNCH
               C
ISN 0002               INTEGER TITLE(20)
ISN 0003               REAL*8 TT(801),FTT(801)
ISN 0004               REAL*4 T(801),FT(801)
ISN 0005             1 CALL READDP(10,TT,FTT,NTP,TITLE,&10)
ISN 0006               DO 69 I=1,NTP
ISN 0007               T(I) = TT(I)
ISN 0008            69 FT(I) = FTT(I)
ISN 0009               PUNCH 100,(TITLE(I),I=1,20)
ISN 0010           100 FORMAT(20A4)
ISN 0011               PUNCH 200,NTP
ISN 0012           200 FORMAT(I10)
ISN 0013               PUNCH 300,(T(I),FT(I),I=1,NTP)
ISN 0014           300 FORMAT(3(2E12.4))
ISN 0015               GO TO 1
ISN 0016            10 STOP
ISN 0017               END
```

```
ISN 0002          SUBROUTINE READDP(NT,X,Y,N,TITLE,*)
ISN 0003          REAL*8 X(N),Y(N)
ISN 0004          INTEGER TITLE(20)
ISN 0005          READ(NT,ERR=11,END=10) TITLE
ISN 0006          READ(NT,ERR=11,END=12) N
ISN 0007          READ(NT,ERR=11,END=12) X,Y
ISN 0008          RETURN
ISN 0009       11 WRITE(6,420)
ISN 0010      420 FORMAT(//64H **AN ERROR OCCURRED WHEN THE DATA WAS READ FROM THE D
                 1ISK FILE**)
ISN 0011          RETURN 1
ISN 0012       12 WRITE(6,421)
ISN 0013      421 FORMAT(// 87H **AN END OF FILE WAS ENCOUNTERED IMPROPERLY WHEN THE
                 1DATA WAS READ FROM THE DISK FILE**)
ISN 0014       10 RETURN 1
ISN 0015          END
```

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