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August 1965

Westinghouse Astronuclear Laboratory

A DESCRIPTION OF THE DIGITAL ANALYSIS PROGRAMS

USED TO ANALYZE THE WIDE BAND TEST DATA

MASTER

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WANL-TME-1130
August 1965

SUBMITTED BY:

Westinghouse Electric Corporation
Astronuclear Laboratory
Pittsburgh, Pennsylvania 15236

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PREPARED BY:

A. H. Killinger
C. P. Saalbach
W. C. McCune
R. J. Kocur

APPROVED BY:

DW Drawbaugh
D. W. Drawbaugh
Physics & Mathematics

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DW Drawbaugh 9/1/65
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INTRODUCTION

The programs described in this report were written in order that the high frequency (0 to 1000 CPS) aspects of the test data could better be analyzed. The programs are written in Fortran II and FAP to be run on an IBM-7094 computer.

The physical variables to be measured are recorded as voltages on magnetic tape in FM mode. This tape is digitized by the WANL Wide Band Data Converter and recorded on magnetic tape in a packed form. To facilitate analysis, the values should have engineering units.

The SPIT Program unpacks and converts the requested data to values with engineering units. The PLOT Program plots the requested data and the AUTOCT Program prepares the input for the Huntsville Program.

SUMMARY

This report describes the digital computer programs which were written at WANL to process the wide band (0 to 1000 CPS) NEARVA test data. These programs are the SPIT Program, PLOT Program, and the AUTOCT Program.

The input to the SPIT Program is a packed digital tape produced by the WANL Wide Band Data Converter. The SPIT Program performs calibration, tests for linearity of the data recording system, unpacks and converts the voltages from the A-D tape to values with engineering units, calculates interim time values, and generates a magnetic tape containing the time and channel values for the requested time slices.

The Plotting Program uses the data generated above to produce a tape which may be plotted on the Stromberg Carlson 4020 electronic plotter.

The AUTOCT Program generates a tape with the requested data in a form acceptable to the Huntsville Correlation Program.* The Huntsville Program performs spectral analysis of the data.

* Written at the George C. Marshall Space Laboratory at Huntsville, Alabama.

GENERAL DISCUSSION

The systems used to record the test data are shown below in block diagram.

Values representing the variable to be measured are recorded on magnetic tape in the form of voltages. In order to convert these data into values with engineering units, it is necessary to know the relationship of input signal to output signal for both the transducer and the recording system. The relationship is known for the transducer from either the manufacturer or from laboratory tests.

In order to determine the system calibration and also to detect defective recording channels, d.c. voltages are entered into the data recording system both before and after a reactor test. These signals constitute the d.c. calibration data and are transmitted to magnetic tape by the recording system. The system calibration is calculated and combined with the transducer calibration to determine the overall relationship between recorded voltages and the input values to the transducer.

Using the total calibration, the values (with engineering units) which were input to the transducer may be calculated. The corresponding

time values are calculated and both time and variable values are written onto magnetic tape (W-3 tape).

The desired time slice as well as the specific channels to be processed are input variables and hence only the requested data is processed. For each time slice processed, the program will produce a log indicating which channels were processed, the beginning and ending times requested, the first and last times found, the rate at which the A-D tape was sampled (every n^{th} recorded point used), the maximum and minimum value for each channel processed, the W-2 tape number, and the maximum and minimum instrument ranges.

The plotting program uses the W-3 tape to generate a tape which may be plotted on the Stromberg-Carlson 4020 Plotter to produce variable versus time plots. In addition to the SC-4020 plots, a log is produced which gives the number of plots, describes what variable is plotted on each plot, and how many points fell out of the plotting area and hence were not plotted. Some of the input options are:

- a) Any desired time slice from the W-3 tape may be indicated and any part of that slice may be plotted.
- b) From the desired time slice any one or more of the variables present may be selected to be plotted.
- c) The selected data may be sampled at any desired rate (plot every n^{th} point).
- d) The plotted points may be connected by straight lines if desired.

- e) The maximum and minimum value for the ordinate may be input or the values on the W-3 tape may be used.

The AUTOCT Program will select any desired part or parts of the data on the W-3 tape and generate a tape with the data in the form required by the Huntsville Program. Some of the input options are:

- a) Any particular time slice from the W-3 tape may be selected.
- b) For any requested time slice, any channel or channels present on the W-3 tape may be selected to be processed.
- c) The rate at which the data on the W-3 tape will be sampled may be indicated (select every n^{th} point).

WANL WIDE BAND DATA CONVERTER OUTPUT TAPE FORMAT

The A-D tape format is shown in figure (1). The output tape consists of approximately 61 records per second. Each record consists of 102 thirty-six bit words. The first word contains the time value and the second word contains the channel number of the first channel. The remaining 100 words contain scan number and horizontal parity check for each 5 measurements in addition to 50 values for each of the 5 channels or variables being measured. Each of these channel values are represented by 11 bits plus sign. This is therefore a packed tape, and each channel value must be converted to a floating point number which occupies 36 bits before the information can be used. For information on the data conversion equipment, consult reference 1. In some reports the magnetic tape produced by the WANL Wide Band Data Converter is referred to as the W-2 tape, and the tape produced by the SPIT Program is referred to as the W-3 tape. In this report the words channel and variable are used interchangeably.

WANL WIDE BAND DATA CONVERTER SAMPLING RATE

When five variables are being sampled simultaneously, the sampling rate is approximately 3050 points per second per variable. The sampling rate can be increased to $N \times 3050$ where $N = 2, 3, 4, 5$. See reference 1.

ONE PER BLOCK										50 SUCH DATA GROUPS PER BLOCK									
3/4" tape gap	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
	d	d	d	d	d	d	d	d	d	P _h	M ₃₂	S ₁	D ₁	S ₂	D ₂	S ₃	D ₃	S ₄	D ₄
	d	d	d	d	d	d	d	d	d	P _h	M ₁₆	D ₁	D ₁	D ₂	D ₂	D ₃	D ₃	D ₄	D ₄
	T ₈	T ₈	T ₈	T ₈	T ₈	T ₈	T ₈	T ₈	T ₈	P _h	M ₈	D ₁	D ₁	D ₂	D ₂	D ₃	D ₃	D ₄	D ₄
(one per block)	T ₄	T ₄	T ₄	T ₄	T ₄	T ₄	T ₄	T ₄	T ₄	P _h	M ₄	D ₁	D ₁	D ₂	D ₂	D ₃	D ₃	D ₄	D ₄
	T ₂	T ₂	T ₂	T ₂	T ₂	T ₂	T ₂	T ₂	T ₂	P _h	M ₂	D ₁	D ₁	D ₂	D ₂	D ₃	D ₃	D ₄	D ₄
	T ₁	T ₁	T ₁	T ₁	T ₁	T ₁	T ₁	T ₁	T ₁	P _h	M ₁	D ₁	D ₁	D ₂	D ₂	D ₃	D ₃	D ₄	D ₄
	T ₁	T ₁	T ₁	T ₁	T ₁	T ₁	T ₁	T ₁	T ₁	P _h	M ₁	D ₁	D ₁	D ₂	D ₂	D ₃	D ₃	D ₄	D ₄
TIME										CHANNEL NO. OF FIRST CHANNEL IN THIS GROUP									
Tens of Thousands of Seconds										Scan number									
Thousands of Seconds										Data point 1									
Hundreds of Seconds										Data point 2									
Tens of Seconds										Data point 3									
Seconds										Data point 4									
Tenths of Seconds										Data point 5									
100's digit, channel no.										Horizontal parity									
10's digit, channel no.										Scan number									
1's digit, channel no.										Data point 1									

Total block length = 612 characters
 d = dummy bit
 P = vertical parity bit
 P_h = horizontal parity bit

FIGURE 1 DIGITAL TAPE FORMAT (W2)

DESCRIPTION OF SPIT PROGRAM

1. CALIBRATION

One objective of this program is to convert voltages taken from the A-D tape to values with engineering units. In doing this any non-linearity of the transducer as well as the recording system should be taken into account. The transducer characteristic may be found by testing prior to use, and the calibration data allows any non-linearities of the recording system to be determined and accounted for.

The total recording system for one variable could be characterized by the following block diagram.

Figure (2)

The program considers two kinds of calibration:

- a) transducer calibration
- b) system calibration

The transducer calibration should be known at the time the test is performed. This calibration is described to the program by entering polynomial coefficients; the degree of the polynomial may be 5 or less. The system calibration may be determined from the calibration data, or if the system calibration is already known, the coefficients of the overall calibration polynomial may be read in as input data.

The remainder of this section is applicable to each channel. The system d.c. calibration data are generated by inputting to the system (see figure 2) d.c. voltages. Presently, five d.c. step voltages are being used. These voltages are full scale, .6 of full scale, zero, -.6 of full scale, and minus full scale. This is shown by the following diagram.

The program calculates the full scale d.c. voltage by averaging 2500 values (if possible) over the middle 80% of the full scale step. The value of the maximum instrument range (an input value) is divided by the full scale voltage and the units of the result are engineering units per volt. If transducer and system linearity is assumed, this result could be used to multiply each voltage from the A-D tape and produce a value with the desired engineering units. This is one option.

The program will also check the linearity of the system, if desired, in the following manner. The values of the other four levels (0., $\pm .6$ F.S., and - F.S.) are calculated. The average value of each step is now calculated. The set of points (avg. value F.S., F.S.), (avg. value of $.6$ F.S., $.6$ F.S.), ..., (avg. value -F.S., - F.S.) are least squares fitted with a straight line. The standard deviation of this line from the average value is used to indicate the acceptability of the channel.

If the channel is acceptable and there is only system calibration, then the above set of points are least squares fitted with a polynomial of the desired degree (an input value) and the coefficients are then used to correct the data. The output values will have units of volts.

If there are both transducer and system calibration, then the input values to the transducer which would produce output values equal to the 5 d.c. calibration steps are calculated. These input values to the transducer (with engineering units) are found by looking up the d.c. step values on the transducer characteristic curve. The input values to the transducer will be referred to as adjusted d.c. level values. The set of 5 points (avg. values, adjusted d.c. level values) are least squares fitted to the desired degree. Although the program has been written to accommodate up to 15 d.c. calibration steps, the present setup uses only 5 d.c. calibration steps and hence the program allows only second degree least squares fit to determine the overall calibration. The degree may easily be increased if the number of d.c. calibration steps are later increased.

In case the overall calibration is known, the final coefficients may be read as input data. In this case the program will not perform any calibration calculations and the A-D tape will be positioned at the beginning of the run data.

In all of the data processed to this date, it has been found that the zero calibration step (third step) is not zero. The program adjusts the calibration data to account for this drift before the calibration polynomial coefficients are calculated. The data are also adjusted before the calibration is applied to the data.

This program expects that each track (or group of five variables) will have both pre- and post-calibration data on the A-D tape. The channel number of pre-calibration data must be a number between 801 and 899; the channel number for post-calibration data must be between 901 and 999. The channel numbers used for non-calibration data must be between 1 and 799. These numbers are entered into the A-D converter by means of thumb wheels at the time of the data conversion.

2. SELECTION OF DATA TO BE PROCESSED

The SPIT Program is quite flexible in respect to what data to process. Any desired time slices may be processed, and for any given time slice the desired channels to be processed may be indicated as input data. The W-3 sampling rate may change from time slice to time slice, but it must remain the same for each channel being processed within an individual time slice.

A reactor test may produce a very large amount of data. Analog playback of any desired channels and time slice may be performed and the signals recorded on strip charts. The strip charts should help indicate what data should be processed by the SPIT Program.

3. W-3 SAMPLING RATE

The W-3 sampling rate is an input value and is indicated by entering the number of data points to skip between every two recorded points. This allows the minimum amount of data to be selected from the A-D tape to facilitate the desired analysis, be it plotting or spectral analysis. However, in the case where the correct sampling rate is not known, it is suggested that the maximum sampling rate be used and any needed decrease in the sampling be done in the plotting program or the program which prepares the input for the Huntsville Code.

4. ERROR CHECKING WHILE READING THE A-D TAPE

After a record from the A-D tape has been read into core storage, a test is made to ascertain if the record has been read correctly. If a read error has occurred, it is then determined which one or more of the 51 data groups are in error. Indicators are set so that only the good data groups will be unpacked and written on the W-3 tape. The number of records which had redundancy errors is printed on the output log for each time slice which was processed.

When a read error is indicated, the read routine will retry that record 10 times and if the read error persists, then the record is checked to find the faulty data groups. Figure (1) shows that an A-D record is composed of 51 data groups, each with 72 bits. Six bits of each data group are used as parity bits (called horizontal parity in figure (1)). The A-D converter enters in each of the six bits that number (0 to 1) which makes the sum of each row an odd number. (See figure (1)). In order to find which data group or groups are in error, the program sums each row (parity bit included) and checks if the sums are odd or even.

5. BUFFERED INPUT FROM A-D TAPE

There are two kinds of data to be read from the A-D tape; calibration data and non-calibration or run data. When reading calibration data from the A-D tape, no input buffering is used. However, when reading in the run data, two input buffers are used; one buffer is being processed while the other is being filled and then the process is reversed. This can save considerable computer time.

6. TIME DETECTION AND CORRECTION

There are approximately 61 records per second on the A-D tape. Each record contains a time value, and this time value currently is updated once each second. Hence, there are approximately 61 records with the same time value for each second of data. When a record is read from the A-D tape and the time value is different from the time value of the previous record, the time value of the current record is accepted as being correct and is used as the base time until a different time is encountered. The method used to obtain the interim time values will now be described.

For each data group (five channels) within a record which is unpacked and converted to floating point numbers, the correct time is calculated by adding a predetermined increment to the time value for the current record. This predetermined increment is $FN * (IQUN + 1) * (\frac{1}{SAMPRT + 1})$ where IQUN is the number of points to skip between every two recorded points and SAMPRT is the A-D sampling rate. The value of FN is incremented by one each time the channel values are converted to floating point numbers and written out on the W3 tape. In this manner the value of $FN * (IQUN + 1) * (\frac{1}{SAMPRT + 1})$ is added to the time value of the current record. Hence, a time value is available for each data group which is unpacked and converted to floating point.

The time is entered on the analog tape in seconds, and hence the time value can range from 0. to 86400. seconds. For a sampling rate of 3050 each data group occurs $\frac{1}{3050} \approx .000328$ seconds apart. When $IQUAN = 0$ (all points sampled) then $FN*(IQUAN+1)*(\frac{1}{SAMPRT+1}) \approx FN*.000328$ seconds. When $FN*.000328$ is added to a large floating point number, a round-off error will occur. The larger the number to which the fraction is to be added, the larger the round-off error. Of course, as $FN \rightarrow 3050$ the fraction approaches one and the error lessens as compared with $FN \lll 3050$.

In some cases a correctly formatted time code is not available on the analog tape and hence a starting time is entered manually by the thumb wheels, and this time remains the same on the A-D tape for a complete time slice. The method of time correction described above is also adequate for this situation. In this case all records would have the same time values and the program would continue to update time in the above described manner for the complete time slice regardless of the number of seconds of the run.

When manual time is used and more than one time slice is present on the A-D tape for a given track, the program expects that the starting times of the i^{th} time slice is greater than the starting time of the $(i-1)^{th}$ time slice plus the duration of the $(i-1)^{th}$ time slice.

When the A-D sampling rate is 15250 samples/sec., each variable will be digitized separately and all 250 values of the pertinent A-D records will be for this one channel. When processing data with this higher sampling rate, the program calculates the correct time value for each of the 250 values instead of only for the 50 data groups.

7. TREND REMOVAL

Trend removal, if desired, will be performed by calculating the coefficients of a polynomial least squares fitted to selected data points and by using the polynomial to remove the trend from each data point. The degree of the polynomial may be input as a number not greater than 4. If the degree is punched greater than 4, the value of IDEGRE will be set equal to 4. The data without the trend removal are written on tape A-5. The data with the trend removed will be written on tape A-6. For a description of the least squares program used when removing the trend, consult reference 4.

8. SPIT OUTPUT FORMAT

The output format of the W-3 tape for each time slice is as follows: (binary records)

First Record 16 words; W-2 tape no., set no., test designation, experimental plan, date, W-3 sampling rate, W-2 sampling rate, start time for current time slice, stop time for current time slice, SPIT code modification number, and the five wide band channel numbers.

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<u>Second Record</u>	5 words; title information for channel 1.
<u>Third Record</u>	10 words; channel number, band width, transducer location, maximum and minimum instrument ranges, physical units, wide band channel number for channel 1.
<u>Fourth thru Eleventh Record</u>	The fourth through eleventh records are the same as the second and third records repeated for the remaining four channels.
<u>Remaining Records</u>	first word = 0, more records follow for this time slice = 1, last record for this time slice. second word = the number of groups of time plus the values for the channels to be processed that are in this record. remaining words = the groups of time plus the values for the channels to be processed.

The length of the records described above is about 2000 words. The longer record size is used to decrease the percent of tape used for end of record gaps. The record size can be changed easily to suit specific needs.

9. PLOT PROGRAM

The PLOT Program is designed so that unless a specific action is taken, the maximum and minimum instrument ranges will be used as the maximum and minimum ordinate values on the plots. If the Y value for a point exceeds the ordinate range, then this point will not be plotted. In the case where the maximum and/or minimum channel values exceed the instrument ranges, it may be desirable to use the maximum and minimum channel values as the maximum and minimum ordinate values in order that all requested points be plotted. In this case the maximum and minimum channel values should be entered as input data to the PLOT Program.

The plotting program is quite flexible and some of the capabilities are described below:

- a) Any time slice may be selected from SPIT tape.
- b) Any of the variables (channels) may be selected.
- c) Any sampling rate may be used.
- d) The plotted points may be connected by straight lines if desired.

Some samples of plotted data follow.

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NRX-1 376 4 SP172 49/ 305 EP02 JUL-06-64
NOZ MAN INL P.-001.1A 750. 0 300 PSI

3.00000×10^{-02}

2.00000×10^{-02}

1.00000×10^{-02}

2.11000×10^{-04}

2.11000×10^{-04}

2.11100×10^{-04}

2.11120×10^{-04}

TIME IN SECONDS

NR1A-1 SP8 4 SPITZ 49/ 303 EP02 JUL-08-64
NOZ MAN INL P.-001.1A 750. 0 300 PSI

INTERPRETATION OF RESULTS

1. SPIT PROGRAM

A. One Step Calibration Only (see SPIT example 1)

For this case, only the full scale step of the calibration data is used. The number of points used to calculate the average value for each channel over the full scale step is printed out followed by the average value for each channel. These average values (volts) represent the maximum instrument range for the transducers. The values of the maximum instrument range divided by the average value for each channel are printed. The units of these values are (engineering units/volts) and these are the final calibration coefficients used to adjust the run data.

The following assumptions are assumed by this method:

- 1) The transducer characteristic curve passed through (0,0) and has a constant slope of (max. instrument range/full scale avg. value).
- 2) The recording system is linear.

B. One-Step and Five-Step Calibration (see SPIT example 2)

For this case, the one-step calibration is performed as described above and the results printed as before. In addition, the average values for the other four channels are calculated and all the values for each channel and step are printed; the maximum deviation of the values from the average for each channel and step are printed. If

these values are large in relation to the averages, it means that either the recording channel is faulty (noisy) or the A-D converter may not be operating properly.

It has been observed that the average values described above have a d.c. shift in them. This shift is removed by adjusting the values so as to make the third step for each channel zero and these adjusted average values are printed out. The values of the maximum instrument range divided by the adjusted full scale value are calculated and printed.

The linearity of each channel is checked and if the channel is acceptable, a polynomial of the desired degree (≤ 2) is least squares fitted to the following set of points for each channel:

point 1 (adjusted avg. value for full scale, full scale)

point 2 (adjusted avg. value for .6 F.S., .6 F.S.)

point 3 (adjusted avg. value for 0, 0)

point 4 (adjusted avg. value for -.6 F.S., -.6 F.S.)

point 5 (adjusted avg. value for -F.S., -F.S.)

The acceptability of each channel and, if the channel is acceptable, the polynomial coefficients are printed out.

The user may now use either the one-step calibration coefficients (described in part A) or the five-step calibration coefficients by setting an input indicator (IUSE).

If the user has requested a channel which has failed the linearity test, the program will not process that channel.

The log sheet contains the following information:

- a) The number of the A-D tape used.
- b) The start and stop times of the requested time slice.
- c) The set number. This number indicates the relative position of the requested time slices on the W3 tape and is used by the Plotting Program and the W3 tape.
- d) The channel identification of the five channels.
- e) The number of data points which were skipped between every two recorded points.
- f) The minimum and maximum instrument range for each channel which was processed.
- g) The minimum and maximum value for each channel which was processed. All points in the requested time slice were considered when finding the extreme values.
- h) The number of records read from the A-D tape which had redundancy errors. This number should be zero or very small. If this is not the case, the data should be redigitized.
- i) The first and last recorded time values which were written on the W3 tape.

C. No Calibration (See SPIT example 3)

In this case, the final calibration coefficients are read into the computer as data and the A-D tape is positioned to the run data.

The maximum and minimum channel values should not, in general, exceed the maximum and minimum instrument ranges. If they do, it could mean that the instrument ranges were entered incorrectly, or the channel value is a wild point or that the channel value actually exceeded the instrument range.

The first and last recorded time values should, in general, be about the same as the requested start and stop times. It has been found from experience that if the recorded times and requested times are much different, the A-D tape must be dumped on the 1401 and the data checked for any discrepancy. The input times should also be checked with the A-D log.

2. SPIT EXAMPLE PROBLEM #1

A SPIT run with one-step pre-calibration, two time slices, and one-step and five-step post calibration.

SPIT OUTPUT FOR EXAMPLE PROBLEM #1

THE B-6 TAPE NUMBER IS 8C18

THE CHANNEL NUMBER IS 101

ICAL1= 0 ISKIP= 0 IUSE= 0 NORDPS= 0 ITCBPC= 0 ITCAPC= 0

NUMBER OF CALIBRATION STEPS = 5.0 SAMPLING RATE = 3050.00

THE CONSTANT USED TO CHECK THE LINEARITY OF THE RECORDING CHANNELS = 1.00000

CHANNEL	CHANNEL TO BE PROCESSED	CHANNEL IDENTIFICATION	DEGREE OF FINAL LEAST SQUARES FIT	-CALIBRATION- TRANSDUCER, SYSTEM, BOTH, OR NONE	TITLE AND UNITS
1	YES	CHAN NO. 1	1	SYSTEM ONLY	EXAMPLE PROB. GLOBS
2	YES	CHAN NO. 2	1	SYSTEM ONLY	EXAMPLE PROB. GLOBS
3	YES	CHAN NO. 3	1	SYSTEM ONLY	EXAMPLE PROB. GLOBS
4	YES	CHAN NO. 4	1	SYSTEM ONLY	EXAMPLE PROB. GLOBS
5	YES	CHAN NO. 5	1	SYSTEM ONLY	EXAMPLE PROB. GLOBS

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TRANSDUCER CALIBRATION DATA

CHANNEL NO. OF COEFFICIENTS COEFFICIENTS (READ FROM LEFT TO RIGHT)

1 NO COEFFICIENTS WERE ENTERED
 2 NO COEFFICIENTS WERE ENTERED
 3 NO COEFFICIENTS WERE ENTERED
 4 NO COEFFICIENTS WERE ENTERED
 5 NO COEFFICIENTS WERE ENTERED

VALUES OF TIME (SEC.) WHEN CALIBRATION STEPS START

0.45440E 04 0.45640E 04 0.45940E 04 0.46240E 04 0.46440E 04

VALUES OF LENGTH OF CALIBRATION STEP FOLLOW

0.30000E 01 0.30000E 01 0.30000E 01 0.30000E 01 0.30000E 01

START TIME FOR SAMPLING RUN DATA = 0.13791E 05 SEC.

END TIME FOR SAMPLING RUN DATA = 0.13794E 05 SEC.

THE NUMBER OF POINTS USED TO CALCULATE THE AVERAGE VALUE
FOR EACH CHANNEL OF THE FULL SCALE CALIBRATION STEP = 2500

THE AVERAGE VALUES FOR THE FIVE CHANNELS OVER THE FULL SCALE STEP FOLLOW
0.864504E 01 0.876214E 01 0.876241E 01 0.875598E 01 0.875177E 01

THE VALUES OF MAX. INSTRUMENT RANGE DEVIDED BY THE AVG. VALUE FOR THAT CHANNEL FOLLOW
0.115673E 01 0.114127E 01 0.114124E 01 0.114208E 01 0.114263E 01
THE CALIBRATION ON CHANNEL 1 IS SATISFACTORY
THE CALIBRATION ON CHANNEL 2 IS SATISFACTORY
THE CALIBRATION ON CHANNEL 3 IS SATISFACTORY
THE CALIBRATION ON CHANNEL 4 IS SATISFACTORY
THE CALIBRATION ON CHANNEL 5 IS SATISFACTORY

THIS PAGE MAY SERVE AS A PERMENENT LOG

SET NUMBER = 1

A-D TAPE NUMBER = 8C18

A-D SAMPLING RATE = 3050.00

START TIME =13791.000

STOP TIME = 13793.983

CHANNEL NO.	WIDE BAND CHANNEL NO.	CHANNEL IDENTIFICATION	TITLE AND UNITS
1	10	CHAN NO. 1	EXAMPLE PROB. GLOBS
2	17	CHAN NO. 2	EXAMPLE PROB. GLOBS
3	27	CHAN NO. 3	EXAMPLE PROB. GLOBS
4	37	CHAN NO. 4	EXAMPLE PROB. GLOBS
5	47	CHAN NO. 5	EXAMPLE PROB. GLOBS

99 POINTS WERE SKIPPED BETWEEN EVERY TWO RECORDED POINTS

CHAN NO	MIN INSTR RANGE	MAX INSTR RANGE
1	-10.00	10.00
2	-10.00	10.00
3	-10.00	10.00
4	-10.00	10.00
5	-10.00	10.00

	MIN CHANNEL VALUE	MAX CHANNEL VALUE
1	-6.6059	-2.5881
2	5.2631	5.4973
3	-4.6608	-4.4546
4	-11.4208	11.4208
5	-11.4263	11.4263

THERE WERE 0 RECORDS WITH REDUNDANCY ERRORS

THE FIRST RECORDED TIME FOR THIS SLICE IS 0.13791033E 05

THE LAST RECORDED TIME FOR THIS SLICE IS 0.13793950E 05

*** BEGIN THE NEXT TIME SLICE. SET= 2 ***

ANOTHER TIME SLICE FROM THE CURRENT TRACK HAS BEEN REQUESTED
START TIME = 0.13798E 05 SEC. END TIME = 0.13801E 05 SEC.

CHANNEL 1 WAS ASKED FOR

CHANNEL 2 WAS ASKED FOR

CHANNEL 3 SHOULD NOT BE PROCESSED

CHANNEL 4 WAS ASKED FOR

CHANNEL 5 WAS ASKED FOR

THE CALIBRATION ON CHANNEL 1 IS SATISFACTORY

THE CALIBRATION ON CHANNEL 2 IS SATISFACTORY

THE CALIBRATION ON CHANNEL 3 IS SATISFACTORY

THE CALIBRATION ON CHANNEL 4 IS SATISFACTORY

THE CALIBRATION ON CHANNEL 5 IS SATISFACTORY

THIS PAGE MAY SERVE AS A PERMENENT LOG

SET NUMBER = 2

A-D TAPE NUMBER = 8C18

A-D SAMPLING RATE = 3050.00

START TIME =13798.000

STOP TIME = 13800.983

CHANNEL NO.	WIDE BAND CHANNEL NO.	CHANNEL IDENTIFICATION	TITLE AND UNITS
1	10	CHAN NO. 1	EXAMPLE PROB. GLOBS
2	17	CHAN NO. 2	EXAMPLE PROB. GLOBS
4	37	CHAN NO. 4	EXAMPLE PROB. GLOBS
5	47	CHAN NO. 5	EXAMPLE PROB. GLOBS

99 POINTS WERE SKIPPED BETWEEN EVERY TWO RECORDED POINTS

CHAN NO	MIN INSTR RANGE	MAX INSTR RANGE
1	-10.00	10.00
2	-10.00	10.00
4	-10.00	10.00
5	-10.00	10.00

	MIN CHANNEL VALUE	MAX CHANNEL VALUE
1	-7.2953	-2.8141
2	5.2631	5.4806
4	-11.4208	11.4208
5	-11.4263	11.4263

THERE WERE 0 RECORDS WITH REDUNDANCY ERRORS
THE FIRST RECORDED TIME FOR THIS SLICE IS 0.13798033E 05
THE LAST RECORDED TIME FOR THIS SLICE IS 0.13800950E 05

THE CALIBRATION STEPS AT THE END OF THE RUN BEGIN AT THE FOLLOWING TIMES (SEC.)

0.20314E 05 0.20334E 05 0.20364E 05 0.20394E 05 0.20414E 05

THE VALUES OF LENGTH OF THE CALIBRATION STEPS FOLLOW

0.30000E 01 0.30000E 01 0.30000E 01 0.30000E 01 0.30000E 01

THE NUMBER OF POINTS USED TO CALCULATE THE AVERAGE VALUE
FOR EACH CHANNEL OF THE FULL SCALE CALIBRATION STEP = 2500

THE AVERAGE VALUES FOR THE FIVE CHANNELS OVER THE FULL SCALE STEP FOLLOW
0.869313E 01 0.875390E 01 0.876073E 01 0.877501E 01 0.875948E 01

THE VALUES OF MAX. INSTRUMENT RANGE DEVIDED BY THE AVG. VALUE FOR THAT CHANNEL FOLLOW
0.115033E 01 0.114235E 01 0.114146E 01 0.113960E 01 0.114162E 01

THE AVERAGE VALUES USED TO CALCULATE THE SYSTEM CALIBRATION FOLLOW

	CHANNEL 1	CHANNEL 2	CHANNEL 3	CHANNEL 4	CHANNEL 5
STEP 1	0.86733E 01	0.87529E 01	0.87575E 01	0.87742E 01	0.87636E 01
STEP 2	0.51784E 01	0.52206E 01	0.52382E 01	0.52335E 01	0.52213E 01
STEP 3	-0.74263E-01	-0.64076E-01	-0.44005E-01	-0.56426E-01	-0.64416E-01
STEP 4	-0.53128E 01	-0.53778E 01	-0.53399E 01	-0.53651E 01	-0.53461E 01
STEP 5	-0.88233E 01	-0.89221E 01	-0.88531E 01	-0.88815E 01	-0.88783E 01

THE VALUES OF MAX. DEVIATION FROM THE AVERAGES FOLLOW

	CHANNEL 1	CHANNEL 2	CHANNEL 3	CHANNEL 4	CHANNEL 5
STEP 1	0.51387E-01	0.42601E-01	0.66686E-01	0.53361E-01	0.87476E-01
STEP 2	0.58549E-01	0.61839E-01	0.79411E-01	0.74715E-01	0.67406E-01
STEP 3	0.69377E-01	0.59190E-01	0.53775E-01	0.80360E-01	0.91910E-01
STEP 4	0.36770E-01	0.38322E-01	0.49267E-01	0.49986E-01	0.76461E-01
STEP 5	0.33593E-01	0.61806E-01	0.72107E-01	0.97517E-01	0.11910E-00

AVERAGE VALUES ADJUSTED TO MAKE THIRD STEP ZERO

STEP 1	0.87676E 01	0.88170E 01	0.88015E 01	0.88306E 01	0.88280E 01
STEP 2	0.52526E 01	0.52847E 01	0.52822E 01	0.52899E 01	0.52857E 01
STEP 3	-0.	-0.	-0.	-0.	-0.
STEP 4	-0.52385E 01	-0.53138E 01	-0.52959E 01	-0.53087E 01	-0.52817E 01
STEP 5	-0.87490E 01	-0.88580E 01	-0.88091E 01	-0.88250E 01	-0.88138E 01

VALUES OF MAX. INSTRUMENT RANGE DEVIDED BY THE CORRECTED FULL SCALE VALUE FOR THAT CHANNEL FOLLOW
0.114059E 01 0.113405E 01 0.113575E 01 0.113232E 01 0.113329E 01

CHANNEL 1 CALIBRATION WAS SATISFACTORY	SIGMA=	0.608E-02A=	0.347E-01	B1=	0.654E-02	B2=	0.998E 00
CHANNEL NUMBER 1 HAS SYSTEM CALIBRATION ONLY		SIGMA=	0.60830E-02				
THE COEFFICIENTS OF THE FINAL FIT ARE AS FOLLOWS							
0.65364E-02	0.99849E 00						

CHANNEL 2 CALIBRATION WAS SATISFACTORY	SIGMA=	0.769E-02A=	0.436E-01	B1=	-0.140E-01	B2=	0.100E 01
CHANNEL NUMBER 2 HAS SYSTEM CALIBRATION ONLY		SIGMA=	0.76895E-02				
THE COEFFICIENTS OF THE FINAL FIT ARE AS FOLLOWS							
-0.14019E-01	0.10020E 01						

CHANNEL 3 CALIBRATION WAS SATISFACTORY	SIGMA=	0.395E-02A=	0.225E-01	B1=	-0.429E-02	B2=	0.100E 01
CHANNEL NUMBER 3 HAS SYSTEM CALIBRATION ONLY		SIGMA=	0.39548E-02				
THE COEFFICIENTS OF THE FINAL FIT ARE AS FOLLOWS							
-0.42868E-02	0.10004E 01						

CHANNEL 4 CALIBRATION WAS SATISFACTORY	SIGMA=	0.573E-02A=	0.324E-01	B1=	-0.264E-02	B2=	1.000E 00
CHANNEL NUMBER 4 HAS SYSTEM CALIBRATION ONLY		SIGMA=	0.57277E-02				
THE COEFFICIENTS OF THE FINAL FIT ARE AS FOLLOWS							
-0.26357E-02	0.99972E 00						

CHANNEL 5 CALIBRATION WAS SATISFACTORY	SIGMA=	0.552E-02A=	0.313E-01	B1=	0.364E-02	B2=	0.999E 00
CHANNEL NUMBER 5 HAS SYSTEM CALIBRATION ONLY		SIGMA=	0.55243E-02				
THE COEFFICIENTS OF THE FINAL FIT ARE AS FOLLOWS							
0.36356E-02	0.99922E 00						

FILE NO. 000001

A DUMP OF THE W-3 TAPE FOR EXAMPLE PROBLEM #1. THE FIRST 12 RECORDS CONTAIN TITLE INFORMATION WHILE THE NEXT RECORD CONTAINS TIME AND CHANNEL VALUES WITH EXCESS 50 EXPONENTS. THESE 13 RECORDS ARE THEN REPEATED FOR THE NEXT TIME SLICE. EXAMPLE OF EXCESS 50 EXPONENTS 5513791032 = 13791.032.

RECORD NO. 000001

00000 +0000000001 +0000000000

RECORD NO. 000002

00000 +0000000001 +2301006060 +0001000000 -5196043914 -3125476060 -2151400106 -0605606060 +0144000000
00010 -0300050060 +5513791000 +5513793983 -5697036003 +0001000000 +0001000000 +0001000000 +0001000000
00020 +0001000000

RECORD NO. 000003

00000 +0000000001 -5129318325 -2560475146 +3360274346 +6260606060 -6060606060

RECORD NO. 000004

00000 +0000000001 +3021456045 -3360016060 -2266016060 -4346232163 +7362241071 -5210000000 +5210000000
00010 +4346226260 -6060606060 +0012000000

RECORD NO. 000005

00000 +0000000001 -5129318325 -2560475146 +3360274346 +6260606060 -6060606060

RECORD NO. 000006

00000 +0000000001 +3021456045 -3360026060 -2266026060 -4346232163 +7362241071 -5210000000 +5210000000
00010 +4346226260 -6060606060 +0021000000

RECORD NO. 000007

00000 +0000000001 -5129318325 -2560475146 +3360274346 +6260606060 -6060606060

RECORD NO. 000010

00000 +0000000001 +3021456045 -3360036060 -2266036060 -4346232163 +7362241071 -5210000000 +5210000000
00010 +4346226260 -6060606060 +0033000000

RECORD NO. 000011

00000 +0000000001 -5129318325 -2560475146 +3360274346 +6260606060 -6060606060

RECORD NO. 000012

00000 +0000000001 +3021456045 -3360046060 -2266046060 -4346232163 +7362241071 -5210000000 +5210000000
00010 +4346226260 -6060606060 +0045000000

00000 +00000000001 -5129318325 -2560475146 +3360274346 +6260606060 -6060606060

RECORD NO. 000014

00000 +00000000001 +3021456045 -3360056060 -2266056060 -4346232163 +7362241071 -5210000000 +5210000000
00010 +4346226260 -6060606060 +0057000000

RECORD NO. 000015

00000 +00000000001 +0001000000 +0131000000 +5513791032 -5138425879 +5153802123 -5145604954 -5211158537
00010 -5211163907 +5513791065 -5141703380 +5153746369 -5145549203 -5211158537 -5211163907 +5513791098
00020 -5143737692 +5153356095 -5146106721 -5211158537 -5211163907 +5513791131 -5136730619 +5153523356
00030 -5146218225 -5211158537 -5211163907 +5513791163 -5148427909 +5153244588 -5146162473 -5211158537
00040 -5211163907 +5513791196 -5141533854 +5153467602 -5145437699 -5211158537 -5211163907 +5513791229
00050 -5141307819 +5153579109 -5145716458 -5211158537 -5211163907 +5513791262 -5140742733 +5153523356
00060 -5145493451 -5211158537 -5211163907 +5513791295 -5135769972 +5153802123 -5145493451 -5211158537
00070 -5211163907 +5513791327 -5133848678 +5154303905 -5145437699 -5211158537 -5211163907 +5513791360
00100 -5141816397 +5154248151 -5145493451 -5211158537 -5211163907 +5513791393 -5146224071 +5153802123
00110 -5145827962 -5211158537 +5211141579 +5513791426 -5141703380 +5153746369 -5145995217 -5124046648
00120 -5211208562 +5513791458 -5141307819 +5153857877 -5145437699 -5211420763 -5211163907 +5513791491
00130 -5141138294 +5153746369 -5145549203 -5211420763 -5211163907 +5513791524 -5145263424 +5153746369
00140 -5145660706 -5211158537 -5211163907 +5513791557 -5142211958 +5153523356 -5145437699 -5211158537
00150 -5211163907 +5513791590 -5144133252 +5153634863 -5145827962 -5211158537 -5211163907 +5513791622
00160 -5142098940 +5153913630 -5145716458 -5211158537 -5211163907 +5513791655 -5128536866 +5154136644
-36- 00170 -5145493451 -5211158537 +5210750842 +5513791688 -5133961696 +5154080890 -5145437699 -5211158537
00200 +5210773170 +5513791721 -5135882990 +5153467602 -5145270444 -5211158537 +5210806662 +5513791753
00210 -5142437993 +5154025137 -5145493451 -5211158537 -5211163907 +5513791786 -5151874936 +5153523356
00220 -5144768678 -5211158537 -5211426259 +5513791819 -5149784117 +5153746369 -5145437699 -5211158537
00230 -5211163907 +5513791852 -5145715493 +5154303905 -5145493451 -5211158537 -5211163907 +5513791884
00240 -5146958684 +5153690616 -5146050969 -5211158537 +5211409513 +5513791917 -5131475315 +5153857877
00250 -5145549203 -5211158537 -5211186235 +5513791950 -5139330017 +5153802123 -5145437699 -5211158537
00260 -5211163907 +5513791983 -5135600447 +5154192397 -5145549203 -5211158537 -5211163907 +5513792032
00270 -5140234155 +5154415411 -5145437699 -5211158537 -5211163907 +5513792065 -5150066659 +5153690616
00300 -5145214692 -5211158537 -5211163907 +5513792098 -5148088857 +5154303905 -5145326196 -5211158537
00310 +00000000000 +5513792131 -5152496531 +5154080890 -5145493451 -5211158537 -5113396688 +5513792163
00320 -5152948601 +5153411848 -5145772210 -5211158537 -5211163907 +5513792196 -5155491489 +5154471165
00330 -5144824430 -5211158537 -5211163907 +5513792229 -5152609548 +5154080890 -5145493451 +5190216774
00340 -5211163907 +5513792262 -5150744763 +5153802123 -5145214692 +5143127747 -5211163907 +5513792295
00350 -5144980881 +5154248151 -5146050969 +5138999088 -5211163907 +5513792327 -5152892092 +5154359658
00360 -5145493451 -5211314757 -5211163907 +5513792360 -5144754847 +5154025137 -5145437699 -5211158537
00370 +5197293446 +5513792393 -5136391567 +5153913630 -5145549203 -5211158537 +5195563041 +5513792426
00400 -5132322945 +5154248151 -5145493451 -5211158537 -5211163907 +5513792458 -5135374412 +5153857877
00410 -5145995217 -5211158537 +5192883704 +5513792491 -5142437993 +5153411848 -5145437699 -5211158537
00420 -5211163907 +5513792524 -5139838595 +5153913630 -5145437699 -5211158537 -5211426259 +5513792557
00430 -5145489459 +5153634863 -5145214692 -5211158537 -5211163907 +5513792590 -5144698338 +5154248151
00440 -5145437699 -5211158537 +5191376576 +5513792622 -5140290664 +5153857877 -5145493451 -5211158537
00450 -5211163907 +5513792655 -5141929415 +5154248151 -5144657174 -5211158537 -5211163907 +5513792688
00460 -5145941529 +5153913630 -5145437699 -5211158537 -5211163907 +5513792721 -5144472304 +5153857877

00470	-5146106721	-5211158537	-5211163907	+5513792753	-5143059587	+5154303905	-5145437699	-5211158537
00500	-5211163907	+5513792786	-5143568165	+5154025137	-5144824430	-5211158537	-5211163907	+5513792819
00510	-5149558081	+5153690616	-5145437699	-5211158537	-5211163907	+5513792852	-5148314891	+5154248151
00520	-5145493451	-5211158537	-5211163907	+5513792884	-5144754847	+5154080890	-5145716458	-5211158537
00530	-5211314619	+5513792917	-5138312862	+5154080890	-5145716458	-5211158537	+5185682984	+5513792950
00540	-5128706391	+5154192397	-5145437699	-5211158537	-5211163907	+5513792983	-5141985924	+5154136644
00550	-5145549203	-5211158537	-5211426259	+5513793016	-5137352214	+5154136644	-5145493451	-5211158537
00560	-5211163907	+5513793065	-5141703380	+5154192397	-5145270444	-5211158537	-5211426259	+5513793098
00570	-5136448076	+5153913630	-5145326196	-5211158537	+5144599807	+5513793131	-5128875917	+5153523356
00600	-5145270444	-5211158537	+5210689441	+5513793163	-5134357256	+5154303905	-5146106721	-5211158537
00610	-5211163907	+5513793196	-5151705410	+5153356095	-5146106721	-5211158537	-5211163907	+5513793229
00620	-5154022264	+5153523356	-5145493451	-5211158537	-5211426259	+5513793262	-5150518729	+5154136644
00630	-5145493451	-5211158537	-5211426259	+5513793295	-5144585321	+5154136644	-5145437699	-5211158537
00640	+5187804126	+5513793327	-5139556051	+5154415411	-5145716458	-5211158537	-5211163907	+5513793360
00650	-5145998037	+5153523356	-5145995217	-5211158537	-5211163907	+5513793393	-5151761919	+5154025137
00660	-5145326196	-5211158537	-5211163907	+5513793426	-5157017222	+5153802123	-5145716458	-5211158537
00670	+5026235181	+5513793458	-5154135282	+5153690616	-5145493451	-5211158537	-5211275546	+5513793491
00700	-5147580279	+5154136644	-5145270444	-5211158537	-5211186235	+5513793524	-5147636788	+5153579109
00710	-5145326196	-5211158537	+5194390831	+5513793557	-5142833553	+5153857877	-5145604954	-5211158537
00720	-5211426259	+5513793590	-5138764931	+5153634863	-5145493451	-5211158537	-5211163907	+5513793622
00730	-5132435962	+5153746369	-5145660706	-5211158537	-5211163907	+5513793655	-5129271478	+5154025137
00740	-5145326196	-5211158537	-5211163907	+5513793688	-5142777044	+5153523356	-5145437699	-5211158537
00750	+5192883704	+5513793721	-5153344161	+5153857877	-5145437699	-5211158537	+5115127094	+5513793753
00760	-5154982911	+5153857877	-5145326196	-5211158537	+5116020206	+5513793786	-5151931445	+5154136644
00770	-5145493451	-5211158537	-5149958483	+5513793819	-5155378472	+5154136644	-5145437699	-5211158537
01000	-5211163907	+5513793852	-5152722566	+5153857877	-5145047437	-5211158537	+5187245931	+5513793884
01010	-5159390586	+5154136644	-5145995217	-5211158537	-5211426259	+5513793917	-5156000067	+5154192397
01020	-5145493451	-5211158537	-5211163907	+5513793950	-5162894122	+5154248151	-5145995217	-5211158537
01030	-5211426259							

RECORD NO. 000016

00000 +0000000001 +0000000000

RECORD NO. 000017

00000	+0000000001	+2301066060	+0002000000	-5196043914	-3125476060	-2151400106	-0605606060	+0144000000
00010	-0300050060	+5513798000	+5513800983	-5697036003	+0001000000	+0001000000	+0000000000	+0001000000
00020	+0001000000							

RECORD NO. 000020

00000 +0000000001 -5129318325 -2560475146 +3360274346 +6260606060 -6060606060

RECORD NO. 000021

00000	+0000000001	+3021456045	-3360016060	-2266016060	-4346232163	+7362241071	-5210000000	+5210000000
00010	+4346226260	-6060606060	+0012000000					

RECORD NO. 000022

00000 +0000000001 -5129318325 -2560475146 +3360274346 +6260606060 -6060606060

RECORD NO. 000023

00000 +0000000001 +3021456045 -3360026060 -2266026060 -4346232163 +7362241071 -5210000000 +5210000000
00010 +4346226260 -6060606060 +0021000000

RECORD NO. 000024

00000 +0000000001 -5129318325 -2560475146 +3360274346 +6260606060 -6060606060

RECORD NO. 000025

00000 +0000000001 +3021456045 -3360036060 -2266036060 -4346232163 +7362241071 -5210000000 +5210000000
00010 +4346226260 -6060606060 +0033000000

RECORD NO. 000026

00000 +0000000001 -5129318325 -2560475146 +3360274346 +6260606060 -6060606060

RECORD NO. 000027

00000 +0000000001 +3021456045 -3360046060 -2266046060 -4346232163 +7362241071 -5210000000 +5210000000
00010 +4346226260 -6060606060 +0045000000

RECORD NO. 000030

00000 +0000000001 -5129318325 -2560475146 +3360274346 +6260606060 -6060606060

RECORD NO. 000031

00000 +0000000001 +3021456045 -3360056060 -2266056060 -4346232163 +7362241071 -5210000000 +5210000000
00010 +4346226260 -6060606060 +0057000000

RECORD NO. 000032

00000 +0000000001 +0001000000 +0132000000 +5513798032 -5157130240 +5153913630 +5076937453 -5211420763
00010 +5513798065 -5161029337 +5153913630 -5188924085 +5211219909 +5513798098 -5154700368 +5153746369
00020 -5211412389 +5126501526 +5513798131 -5154813385 +5154025137 -5211412389 -5145526832 +5513798163
00030 -5148992995 +5153746369 -5080282560 -5211420763 +5513798196 -5141194802 +5154248151 -5211150356
00040 -5211158537 +5513798229 -5154022264 +5153746369 -5211150356 -5211420763 +5513798262 -5144076743
00050 +5153523356 -5211150356 +5171637810 +5513798295 -5143624674 +5153523356 -5211150356 -5211420763
00060 +5513798327 -5149501573 +5153857877 -5211150356 +5157968602 +5513798360 -5157243257 +5153634863
00070 -5211150356 -5211158537 +5513798393 -5153061617 +5154136644 -5211150356 -5211158537 +5513798426
00100 -5146563124 +5154192397 -5211150356 -5211420763 +5513798458 -5146393598 +5153969384 -5211150356

00110	-5211158537	+5513798491	-5141138294	+5154136644	-5211150356	-5211420763	+5513798524	-5138425879
00120	+5153969384	-5211150356	-5211158537	+5513798557	-5140629716	+5153746369	-5211150356	+5139054881
00130	+5513798590	-5145206916	+5154303905	-5211150356	-5210087318	+5513798622	-5153005109	+5153300342
00140	-5211150356	-5211158537	+5513798655	-5157073731	+5154136644	-5211150356	+5142848784	+5513798688
00150	-5154643860	+5153467602	-5211150356	-5176714944	+5513798721	-5157412783	+5154080890	-5211150356
00160	-5157075918	+5513798753	-5165889080	+5154192397	-5211150356	-5211420763	+5513798786	-5159560112
00170	+5154303905	-5211150356	-5132973478	+5513798819	-5158203904	+5154359658	-5211150356	-5211158537
00200	+5513798852	-5155774032	+5154303905	-5211150356	-5211158537	+5513798884	-5150292694	+5153857877
00210	-5211150356	-5211420763	+5513798917	-5145941529	+5153857877	-5211150356	+5210595031	+5513798950
00220	-5134244239	+5154136644	-5211150356	-5211420763	+5513798983	-5139499543	+5153690616	-5211150356
00230	-5211420763	+5513799016	-5144528812	+5154080890	-5211150356	-5211158537	+5513799065	-5161989984
00240	+5153690616	-5211150356	-5211158537	+5513799098	-5166058606	+5154359658	-5211150356	+5210059422
00250	+5513799131	-5154869894	+5153913630	-5211150356	+5192783238	+5513799163	-5150857780	+5154025137
00260	-5211150356	-5211420763	+5513799196	-5145885020	+5154136644	-5211150356	-5211303598	+5513799229
00270	-5139838595	+5154248151	-5211150356	-5211158537	+5513799262	-5146732650	+5154136644	-5211150356
00300	-5211420763	+5513799295	-5143003079	+5154248151	-5211150356	-5211420763	+5513799327	-5147862822
00310	+5153969384	-5211150356	+5180843603	+5513799360	-5158825500	+5154136644	-5211150356	+5164273175
00320	+5513799393	-5159221060	+5154025137	-5211150356	+5158917078	+5513799426	-5162837614	+5153857877
00330	-5211150356	-5190997872	+5513799458	-5160577268	+5154248151	-5211150356	-5188375615	+5513799491
00340	-5160577268	+5154303905	-5211150356	-5211158537	+5513799524	-5157186748	+5154136644	-5211150356
00350	-5211242226	+5513799557	-5154587351	+5154136644	-5211150356	-5123153965	+5513799590	-5143342131
00360	+5154303905	-5211150356	+5165277444	+5513799622	-5135317903	+5154192397	-5211150356	-5211158537
00370	+5513799655	-5139103982	+5153802123	-5211150356	+5142848784	+5513799688	-5137182689	+5153523356
00400	-5211150356	+5181178359	+5513799721	-5134978852	+5153802123	-5211150356	-5196353970	+5513799753
00410	-5143003079	+5154025137	-5211150356	-5211158537	+5513799786	-5156621662	+5153634863	-5211150356
00420	-5164217382	+5513799819	-5162216018	+5153523356	-5211150356	-5211158537	+5513799852	-5167301795
00430	+5153913630	-5211150356	-5211158537	+5513799884	-5162329036	+5153857877	-5211150356	+5181178359
00440	+5513799917	-5162329036	+5154025137	-5211150356	+5170242993	+5513799950	-5148766961	+5154025137
00450	-5211150356	+5211152958	+5513799983	-5152270496	+5154136644	-5211150356	+5122540246	+5513800016
00460	-5152327005	+5153523356	-5211150356	-5113390245	+5513800032	-5158768991	+5154192397	-5211150356
00470	-5211420763	+5513800065	-5153626704	+5153579109	-5211150356	-5179448786	+5513800098	-5146676141
00500	+5154080890	-5211150356	+5164496346	+5513800131	-5139273508	+5154303905	-5211150356	-5211158537
00510	+5513800163	-5139725577	+5154136644	-5211150356	+5149041772	+5513800196	-5141872906	+5153857877
00520	-5211150356	-5211420763	+5513800229	-5145715493	+5153857877	-5211150356	-5211158537	+5513800262
00530	-5147919331	+5154248151	-5211150356	-5211420763	+5513800295	-5155547998	+5153579109	-5211150356
00540	+5152612504	+5513800327	-5167527830	+5153969384	-5211150356	-5121368599	+5513800360	-5161989984
00550	+5154359658	-5211150356	-5211420763	+5513800393	-5168149425	+5154080890	-5211150356	-5211158537
00560	+5513800426	-5158655974	+5153857877	-5211150356	-5211158537	+5513800458	-5152609548	+5153579109
00570	-5211150356	-5163380492	+5513800491	-5153965756	+5153634863	-5211150356	+5155290552	+5513800524
00600	-5145885020	+5154192397	-5211150356	-5128510063	+5513800557	-5146224071	+5153746369	-5211150356
00610	-5044076223	+5513800590	-5147071702	+5154192397	-5211150356	-5211158537	+5513800622	-5142890062
00620	+5154192397	-5211150356	-5211158537	+5513800655	-5143907217	+5154136644	-5211150356	-5211158537
00630	+5513800688	-5139838595	+5154248151	-5211150356	-5211158537	+5513800721	-5140290664	+5153579109
00640	+515452587	-5211420763	+5513800753	-5151140324	+5153690616	+5121352931	+5210706617	+5513800786
00650	-5158147396	+5153802123	-5211412389	-5211420763	+5513800819	-5165550028	+5153746369	-5211412389
00660	-5211158537	+5513800852	-5171144384	+5153300342	-5211150356	+5124046648	+5513800884	-5168431769
00670	+5154303905	-5211150356	-5211158537	+5513800917	-5167675159	+5153913630	-5211150356	+5166058541
00700	+5513800950	-5163346131	+5154415411	-5211150356	-5062487809			

3. SPIT EXAMPLE PROBLEM #2

A SPIT run with one-step and five-step pre-calibration and post-calibration. The coefficients of the one-step pre-calibration were used as the final calibration coefficients.

SPIT OUTPUT FOR EXAMPLE PROBLEM #2

THE B-6 TAPE NUMBER IS 4D42

THE CHANNEL NUMBER IS 411

ICAL1=-1 ISKIP=-1 IUSE= 0 NORDPS= 0 ITCBPC= 0 ITCAPC= 0

NUMBER OF CALIBRATION STEPS = 5.0 SAMPLING RATE = 3050.00

THE CONSTANT USED TO CHECK THE LINEARITY OF THE RECORDING CHANNELS = 1.00000

CHANNEL	CHANNEL TO BE PROCESSED	CHANNEL IDENTIFICATION	DEGREE OF FINAL LEAST SQUARES FIT	-CALIBRATION- TRANSDUCER, SYSTEM, BOTH, OR NONE	TITLE AND UNITS
1	YES	CHAN NO. 1	1	SYSTEM ONLY	EXAMPLE PROB. GLOBS
2	YES	CHAN NO. 2	1	SYSTEM ONLY	EXAMPLE PROB. GLOBS
3	YES	CHAN NO. 3	1	SYSTEM ONLY	EXAMPLE PROB. GLOBS
4	YES	CHAN NO. 4	1	SYSTEM ONLY	EXAMPLE PROB. GLOBS
5	YES	CHAN NO. 5	1	SYSTEM ONLY	EXAMPLE PROB. GLOBS

TRANSDUCER CALIBRATION DATA

CHANNEL	NO. OF COEFFICIENTS	COEFFICIENTS (READ FROM LEFT TO RIGHT)
1	NO COEFFICIENTS WERE ENTERED	
2	NO COEFFICIENTS WERE ENTERED	
3	NO COEFFICIENTS WERE ENTERED	
4	NO COEFFICIENTS WERE ENTERED	
5	NO COEFFICIENTS WERE ENTERED	

VALUES OF TIME (SEC.) WHEN CALIBRATION STEPS START

0.45440E 04	0.45640E 04	0.45940E 04	0.46240E 04	0.46440E 04
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VALUES OF LENGTH OF CALIBRATION STEP FOLLOW

0.30000E 01	0.30000E 01	0.30000E 01	0.30000E 01	0.30000E 01
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START TIME FOR SAMPLING RUN DATA = 0.13791E 05 SEC.

END TIME FOR SAMPLING RUN DATA = 0.13794E 05 SEC.

THE NUMBER OF POINTS USED TO CALCULATE THE AVERAGE VALUE
FOR EACH CHANNEL OF THE FULL SCALE CALIBRATION STEP = 2500

THE AVERAGE VALUES FOR THE FIVE CHANNELS OVER THE FULL SCALE FOLLOW
0.877350E 01 0.879794E 01 0.87852E 01 0.880984E 01 0.876772E 01

THE VALUES OF MAX. INSTRUMENT RANGE DEVIDED BY THE AVG. VALUE FOR THAT CHANNEL FOLLOW
0.113980E 01 0.113663E 01 0.113785E 01 0.113997E 01 0.114055E 01

THE AVERAGE VALUES USED TO CALCULATE THE SYSTEM CALIBRATION FOLLOW

	CHANNEL 1	CHANNEL 2	CHANNEL 3	CHANNEL 4	CHANNEL 5
STEP 1	0.87648E 01	0.87972E 01	0.87943E 01	0.88078E 01	0.87663E 01
STEP 2	0.51740E 01	0.52119E 01	0.51825E 01	0.52027E 01	0.52027E 01
STEP 3	-0.21778E-00	-0.16757E-00	-0.20610E-00	-0.19541E-00	-0.14167E-00
STEP 4	-0.56273E 01	-0.55464E 01	-0.55981E 01	-0.56209E 01	-0.55046E 01
STEP 5	-0.92342E 01	-0.91308E 01	-0.91867E 01	-0.92164E 01	-0.90750E 01

THE VALUES OF MAX. DEVIATION FROM THE AVERAGES FOLLOW

	CHANNEL 1	CHANNEL 2	CHANNEL 3	CHANNEL 4	CHANNEL 5
STEP 1	0.41175E-02	0.38527E-02	0.39699E-02	0.46985E-02	0.26098E-02
STEP 2	0.43378E-02	0.42581E-02	0.55479E-02	0.29206E-05	0.29206E-05
STEP 3	0.28283E-02	0.63544E-02	0.39669E-02	0.11176E-07	0.74506E-08
STEP 4	0.44069E-02	0.31978E-02	0.45899E-02	0.29364E-02	0.40076E-01
STEP 5	0.37134E-02	0.45557E-02	0.25660E-02	0.28965E-02	0.31928E-02

AVERAGE VALUES ADJUSTED TO MAKE THIRD STEP ZERO

STEP 1	0.89826E 01	0.89648E 01	0.90004E 01	0.90032E 01	0.89080E 01
STEP 2	0.53917E 01	0.53794E 01	0.53886E 01	0.53981E 01	0.53444E 01
STEP 3	-0.	-0.	-0.	-0.	-0.
STEP 4	-0.54095E 01	-0.53788E 01	-0.53920E 01	-0.54255E 01	-0.53630E 01
STEP 5	-0.90164E 01	-0.89632E 01	-0.89806E 01	-0.90210E 01	-0.89333E 01

VALUES OF MAX. INSTRUMENT RANGE DEVIDED BY THE CORRECTED FULL SCALE VALUE FOR THAT CHANNEL FOLLOW
0.111219E 01 0.111539E 01 0.111178E 01 0.111046E 01 0.112241E 01

CHANNEL 1 CALIBRATION WAS SATISFACTORY SIGMA= 0.626828E-02 A= 0.348576E-01 B1= -0.10315E-01 B2= 0.10C
 CHANNEL NUMBER 1 HAS SYSTEM CALIBRATION ONLY SIGMA= 0.62683E-02
 THE COEFFICIENTS OF THE FINAL FIT ARE AS FOLLOWS
 -0.10315E-01 0.10010E 01

*** NEGATIVE ARGUMENT . BLOCK REFERENCE CODE NOT SET .
 ACC -1.5258789E-06 555631463146 MQ -1.5258789E-06 555631463146 PQ 0
 ERROR IN SQRT AT OR BELOW EXTERNAL FORMULA 0 INTERNAL FORMULA 36
 SQRT IN LSF AT OR BELOW EXTERNAL FORMULA 554 INTERNAL FORMULA 63
 ARGUMENT 1 = 5
 ARGUMENT 2 = 1
 ARGUMENT 3 = 8.9655097
 ARGUMENT 4 = 8.9647731
 ARGUMENT 5 = 4.4007301E-04
 ARGUMENT 6 = 6.2682837E-03
 LSF IN CALCHA AT OR BELOW EXTERNAL FORMULA 3 INTERNAL FORMULA 47
 CALCHA IN (MAIN) AT OR BELOW EXTERNAL FORMULA 3721 INTERNAL FORMULA 162

CHANNEL 2 CALIBRATION WAS SATISFACTORY SIGMA= 0. A= 0. B1= 0.44007E-03 B2= 0.995

*** NEGATIVE ARGUMENT . BLOCK REFERENCE CODE NOT SET .
 ACC -1.5258789E-06 555631463146 MQ -1.5258789E-06 555631463146 PQ 0
 ERROR IN SQRT AT OR BELOW EXTERNAL FORMULA 0 INTERNAL FORMULA 36
 SQRT IN LSF AT OR BELOW EXTERNAL FORMULA 554 INTERNAL FORMULA 63
 ARGUMENT 1 = 5
 ARGUMENT 2 = 1
 ARGUMENT 3 = 8.9655097
 ARGUMENT 4 = 8.9647731
 ARGUMENT 5 = 4.4007301E-04
 ARGUMENT 6 = 0
 LSF IN CALCHA AT OR BELOW EXTERNAL FORMULA 11 INTERNAL FORMULA 60
 CALCHA IN (MAIN) AT OR BELOW EXTERNAL FORMULA 3721 INTERNAL FORMULA 162
 CHANNEL NUMBER 2 HAS SYSTEM CALIBRATION ONLY SIGMA= 0.
 THE COEFFICIENTS OF THE FINAL FIT ARE AS FOLLOWS
 0.44007E-03 0.99987E 00

CHANNEL 3 CALIBRATION WAS SATISFACTORY SIGMA= 0.585937E-02 A= 0.325716E-01 B1= 0.32621E-02 B2= 0.995
 CHANNEL NUMBER 3 HAS SYSTEM CALIBRATION ONLY SIGMA= 0.58594E-02
 THE COEFFICIENTS OF THE FINAL FIT ARE AS FOLLOWS
 0.32621E-02 0.99935E 00

CHANNEL 4 CALIBRATION WAS SATISFACTORY SIGMA= 0.538439E-02 A= 0.298959E-01 B1= -0.90208E-02 B2= 0.995

CHANNEL NUMBER 4 HAS SYSTEM CALIBRATION ONLY
THE COEFFICIENTS OF THE FINAL FIT ARE AS FOLLOWS
-0.90208E-02 0.10010E 01

SIGMA= 0.53844E-02

CHANNEL 5 CALIBRATION WAS SATISFACTORY
CHANNEL NUMBER 5 HAS SYSTEM CALIBRATION ONLY
THE COEFFICIENTS OF THE FINAL FIT ARE AS FOLLOWS
-0.87785E-02 0.10013E 01

SIGMA= 0.466302E-02A= 0.261691E-01
SIGMA= 0.46630E-02

B1= -0.87785E-02 B2= 0.100

THE CALIBRATION ON CHANNEL 1 IS SATISFACTORY
THE CALIBRATION ON CHANNEL 2 IS SATISFACTORY
THE CALIBRATION ON CHANNEL 3 IS SATISFACTORY
THE CALIBRATION ON CHANNEL 4 IS SATISFACTORY
THE CALIBRATION ON CHANNEL 5 IS SATISFACTORY

THIS PAGE MAY SERVE AS A PERMENENT LOG

SET NUMBER = 1

A-D TAPE NUMBER = 4042

A-D SAMPLING RATE = 3050.00

START TIME =13791.000

STOP TIME = 13793.983

CHANNEL NO.	WIDE BAND CHANNEL NO.	CHANNEL IDENTIFICATION	TITLE AND UNITS
1	10	CHAN NO. 1	EXAMPLE PROB. GLOBS
2	17	CHAN NO. 2	EXAMPLE PROB. GLOBS
3	27	CHAN NO. 3	EXAMPLE PROB. GLOBS
4	37	CHAN NO. 4	EXAMPLE PROB. GLOBS
5	47	CHAN NO. 5	EXAMPLE PROB. GLOBS

99 POINTS WERE SKIPPED BETWEEN EVERY TWO RECORDED POINTS

CHAN NO	MIN INSTR RANGE	MAX INSTR RANGE
1	-10.00	10.00
2	-10.00	10.00
3	-10.00	10.00
4	-10.00	10.00
5	-10.00	10.00

	MIN CHANNEL VALUE	MAX CHANNEL VALUE
1	-3.5285	8.4627
2	-3.2404	-2.0035
3	-0.0533	-0.0044
4	5.2295	5.2838
5	-0.0274	0.0164

THERE WERE 0 RECORDS WITH REDUNDANCY ERRORS

THE FIRST RECORDED TIME FOR THIS SLICE IS 0.13791033E 05

THE LAST RECORDED TIME FOR THIS SLICE IS 0.13793950E 05

THE CALIBRATION STEPS AT THE END OF THE RUN BEGIN AT THE FOLLOWING TIMES (SEC.)

0.20314E 05 0.20334E 05 0.20364E 05 0.20394E 05 0.20414E 05

THE VALUES OF LENGTH OF THE CALIBRATION STEPS FOLLOW

0.30000E 01 0.30000E 01 0.30000E 01 0.30000E 01 0.30000E 01

THE NUMBER OF POINTS USED TO CALCULATE THE AVERAGE VALUE
FOR EACH CHANNEL OF THE FULL SCALE CALIBRATION STEP = 2500

THE AVERAGE VALUES FOR THE FIVE CHANNELS OVER THE FULL SCALE STEP FOLLOW
0.88142E 01 0.88054E 01 0.88047E 01 0.884474E 01 0.878890E 01

THE VALUES OF MAX. INSTRUMENT RANGE DEVIDED BY THE AVG. VALUE FOR THAT CHANNEL FOLLOW
0.113452E 01 0.113567E 01 0.113575E 01 0.113061E 01 0.113780E 01

THE AVERAGE VALUES USED TO CALCULATE THE SYSTEM CALIBRATION FOLLOW

	CHANNEL 1	CHANNEL 2	CHANNEL 3	CHANNEL 4	CHANNEL 5
STEP 1	0.88142E 01	0.88012E 01	0.88031E 01	0.88422E 01	0.87970E 01
STEP 2	0.52181E 01	0.52363E 01	0.52114E 01	0.52455E 01	0.52277E 01
STEP 3	-0.18077E-00	-0.13925E-00	-0.18212E-00	-0.15144E-00	-0.10800E-00
STEP 4	-0.55887E 01	-0.55110E 01	-0.55556E 01	-0.55706E 01	-0.54625E 01
STEP 5	-0.91890E 01	-0.90894E 01	-0.91440E 01	-0.91617E 01	-0.90234E 01

THE VALUES OF MAX. DEVIATION FROM THE AVERAGES FOLLOW

	CHANNEL 1	CHANNEL 2	CHANNEL 3	CHANNEL 4	CHANNEL 5
STEP 1	0.36024E-02	0.29516E-02	0.21458E-05	0.42915E-05	0.36695E-02
STEP 2	0.42057E-02	0.42404E-02	0.60234E-02	0.37098E-02	0.43576E-02
STEP 3	0.48473E-02	0.24615E-02	0.35219E-02	0.74506E-08	0.38551E-01
STEP 4	0.14305E-05	0.28820E-01	0.37516E-02	0.34105E-02	0.57544E-02
STEP 5	0.56028E-05	0.29129E-02	0.37855E-02	0.29167E-02	0.38667E-01

AVERAGE VALUES ADJUSTED TO MAKE THIRD STEP ZERO

STEP 1	0.89950E 01	0.89404E 01	0.89852E 01	0.89936E 01	0.89050E 01
STEP 2	0.53989E 01	0.53755E 01	0.53935E 01	0.53970E 01	0.53357E 01
STEP 3	-0.	-0.	-0.	-0.	-0.
STEP 4	-0.54079E 01	-0.53717E 01	-0.53735E 01	-0.54192E 01	-0.53545E 01
STEP 5	-0.90083E 01	-0.89501E 01	-0.89619E 01	-0.90103E 01	-0.89154E 01

VALUES OF MAX. INSTRUMENT RANGE DEVIDED BY THE CORRECTED FULL SCALE VALUE FOR THAT CHANNEL FOLLOW
0.111172E 01 0.111799E 01 0.111273E 01 0.111158E 01 0.112399E 01

CHANNEL 1 CALIBRATION WAS SATISFACTORY SIGMA= 0.247053E-02A= 0.137327E-01 B1= -0.44611E-02 B2= 0.100
 CHANNEL NUMBER 1 HAS SYSTEM CALIBRATION ONLY SIGMA= 0.24705E-02
 THE COEFFICIENTS OF THE FINAL FIT ARE AS FOLLOWS
 -0.44611E-02 0.10008E 01

CHANNEL 2 CALIBRATION WAS SATISFACTORY SIGMA= 0.458048E-02A= 0.256046E-01 B1= -0.11813E-02 B2= 0.100
 CHANNEL NUMBER 2 HAS SYSTEM CALIBRATION ONLY SIGMA= 0.45805E-02
 THE COEFFICIENTS OF THE FINAL FIT ARE AS FOLLOWS
 -0.11813E-02 0.10004E 01

CHANNEL 3 CALIBRATION WAS SATISFACTORY SIGMA= 0.427908E-02A= 0.238073E-01 B1= 0.86721E-02 B2= 0.998
 CHANNEL NUMBER 3 HAS SYSTEM CALIBRATION ONLY SIGMA= 0.42791E-02
 THE COEFFICIENTS OF THE FINAL FIT ARE AS FOLLOWS
 0.86721E-02 0.99848E 00

CHANNEL 4 CALIBRATION WAS SATISFACTORY SIGMA= 0.541970E-02A= 0.301222E-01 B1= -0.77638E-02 B2= 0.100
 CHANNEL NUMBER 4 HAS SYSTEM CALIBRATION ONLY SIGMA= 0.54197E-02
 THE COEFFICIENTS OF THE FINAL FIT ARE AS FOLLOWS
 -0.77638E-02 0.10010E 01

CHANNEL 5 CALIBRATION WAS SATISFACTORY SIGMA= 0.365396E-02A= 0.205350E-01 B1= -0.58324E-02 B2= 0.100
 CHANNEL NUMBER 5 HAS SYSTEM CALIBRATION ONLY SIGMA= 0.36540E-02
 THE COEFFICIENTS OF THE FINAL FIT ARE AS FOLLOWS
 -0.58324E-02 0.10014E 01

FILE NO. 000001

A DUMP OF THE W-3 TAPE FOR EXAMPLE PROBLEM #2. THE FIRST 12 RECORDS CONTAIN TITLE INFORMATION WHILE THE REMAINDER OF THE RECORDS CONTAIN TIME AND CHANNEL VALUES WITH EXCESS 50 EXPONENTS. EXAMPLE: 5513791032 = 13791.032.

RECORD NO. 000001

00000 +0000000001 +0000000000

RECORD NO. 000002

00000 +0000000001 +2404026060 +0001000000 -5196043914 -3125476060 -2151400106 -0605606060 +0144000000
00010 -0300050060 +5513791000 +5513793983 -5697036003 +0001000000 +0001000000 +0001000000 +0001000000
00020 +0001000000

RECORD NO. 000003

00000 +0000000001 -5129318325 -2560475146 +3360274346 +6260606060 -6060606060

RECORD NO. 000004

00000 +0000000001 +3021456045 -3360016060 -2266016060 -4346232163 +7362241071 -5210000000 +5210000000
00010 +4346226260 -6060606060 +0012000000

RECORD NO. 000005

00000 +0000000001 -5129318325 -2560475146 +3360274346 +6260606060 -6060606060

RECORD NO. 000006

00000 +0000000001 +3021456045 -3360026060 -2266026060 -4346232163 +7362241071 -5210000000 +5210000000
00010 +4346226260 -6060606060 +0021000000

RECORD NO. 000007

00000 +0000000001 -5129318325 -2560475146 +3360274346 +6260606060 -6060606060

RECORD NO. 000010

00000 +0000000001 +3021456045 -3360036060 -2266036060 -4346232163 +7362241071 -5210000000 +5210000000
00010 +4346226260 -6060606060 +0033000000

RECORD NO. 000011

00000 +0000000001 -5129318325 -2560475146 +3360274346 +6260606060 -6060606060

RECORD NO. 000012

00000 +0000000001 +3021456045 -3360046060 -2266046060 -4346232163 +7362241071 -5210000000 +5210000000
00010 +4346226260 -6060606060 +0045000000

00000 +0000000001 -512931332 -2560475146 +3360274346 +6260606060 -6060606060

RECORD NO. 000014

00000 +0000000001 +3021456745 -3360056760 -2266056060 -4346232163 +7362241071 -5210000000 +5210000000
00010 +4346226260 -6060606060 +0057000000

RECORD NO. 000015

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00020 +5143334558 -5129353065 -4920704081 +5152566640 -4916449603 +5513791131 +5141758913 -5130061419
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00140 -4936997812 +5152566640 -4854832058 +5513791557 +5127849760 -5128535733 -4947860301 +5152566640
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00170 -4931566569 +5152458142 -4910966403 +5513791688 -5010551970 -5125702316 -4931566569 +5152566640
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00220 -4942429057 +5152620888 -4854832058 +5513791819 +5162187980 -5127010047 -4947860301 +5152620888
00230 -4910966403 +5513791852 +5162133647 -5127936357 -4947860301 +5152512391 -4910966403 +5513791884
00240 +5147300840 -5125920272 -4947860301 +5152512391 -4910966403 +5513791917 +5139694273 -5124776007
00250 -4947860301 +5152458142 -4854832058 +5513791950 +5129914400 -5124285608 -4947860301 +5152458142
00260 -4854832058 +5513791983 +5123611815 -5123958675 -4926135325 +5152512391 -4910966403 +5513792016
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00300 -4920704081 +5152566640 -4910966403 +5513792098 +5123611815 -5122868900 -4931566569 +5152620888
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00430 +5140183266 -5123032366 -4926135325 +5152566640 -4916449603 +5513792590 +5131816042 -5122977877
00440 -4931566569 +5152620888 -4921932800 +5513792622 +5128719082 -5121942571 -4936997812 +5152566640
00450 -4910447513 +5513792655 +5126437112 -5121500881 -4931566569 +5152520888 -4916449603 +5513792688
00460 +51248071 -5122551569 -492670031 +5152520888 -4916449603

4. SPIT EXAMPLE PROBLEM #3

No pre-calibration or post-calibration calculations were performed but the final calibration coefficients were read in as input data.

SPIT OUTPUT FOR EXAMPLE PROBLEM #3

THE B-6 TAPE NUMBER IS 1151

THE CHANNEL NUMBER IS 147

ICAL1= 1 ISKIP= 2 IUSE=-0 NCORPS= -0 ITCBPC= 0 ITCAPC= 0

NUMBER OF CALIBRATION STEPS = 0. SAMPLING RATE = 3050.00

THE CONSTANT USED TO CHECK THE LINEARITY OF THE RECORDING CHANNELS = 1.00000

CHANNEL	CHANNEL TO BE PROCESSED	CHANNEL IDENTIFICATION	DEGREE OF FINAL LEAST SQUARES FIT	-CALIBRATION- TRANSDUCER, SYSTEM, BOTH, OR NONE	TITLE AND UNITS
1	THIS CHANNEL WAS NOT REQUESTED				
2	THIS CHANNEL WAS NOT REQUESTED				
3	THIS CHANNEL WAS NOT REQUESTED				
4	THIS CHANNEL WAS NOT REQUESTED				
5	YES	CHAN NO. 5	1	NONE	EXAMPLE PROB. GLOBS

START TIME FOR SAMPLING RUN DATA = 0.12578E 05 SEC.

END TIME FOR SAMPLING RUN DATA = 0.12581E 05 SEC.

THE CALIBRATION COEFFICIENTS WERE INPUT FOR THIS TRACK AND HENCE NO CALIBRATION CALCULATIONS WERE PERFORMED

THE CALIBRATION ON CHANNEL 1 IS SATISFACTORY

THE CALIBRATION ON CHANNEL 2 IS SATISFACTORY

THE CALIBRATION ON CHANNEL 3 IS SATISFACTORY

THE CALIBRATION ON CHANNEL 4 IS SATISFACTORY

THE CALIBRATION ON CHANNEL 5 IS SATISFACTORY

THIS PAGE MAY SERVE AS A PERMENENT LOG

SET NUMBER = 1

A-D TAPE NUMBER = 1E51

A-D SAMPLING RATE = 3050.00

START TIME =12578.000

STOP TIME = 12581.483

CHANNEL NO.	WIDE BAND CHANNEL NO.	CHANNEL IDENTIFICATION	TITLE AND UNITS
5	47	CHAN NO. 5	EXAMPLE PROB. GLOBS

99 POINTS WERE SKIPPED BETWEEN EVERY TWO RECORDED POINTS

CHAN NO	MIN INSTR RANGE	MAX INSTR RANGE
5	-10.00	10.00

	MIN CHANNEL VALUE	MAX CHANNEL VALUE
5	-5.3981	4.0938

THERE WERE 0 RECORDS WITH REDUNDANCY ERRORS
THE FIRST RECORDED TIME FOR THIS SLICE IS 0.12578033E 05
THE LAST RECORDED TIME FOR THIS SLICE IS 0.12581458E 05

FILE NO. 000001

A DUMP OF THE W-3 TAPE. THE FIRST 12 RECORDS CONTAIN TITLE INFORMATION WHILE
THE NEXT RECORD CONTAIN TIME AND CHANNEL VALUES.

RECORD NO. 000001

00000 +0000000001 +0000000000

RECORD NO. 000002

00000 +0000000001 +2505016060 +0001000000 -5196043914 -3125476060 -2151400106 -0605606060 +0144000000
00010 -0300050060 +5512578000 +5512581483 -5697036003 +0000000000 +0000000000 +0000000000 +0000000000
00020 +0001000000

RECORD NO. 000003

00000 +0000000001 -5129318325 -2560475146 +3360274346 +6260606060 -6060606060

RECORD NO. 000004

00000 +0000000001 +3021456045 -3360016060 -2266016060 -4346232163 +7362241071 -5210000000 +5210000000
00010 +4346226260 -6060606060 +0012000000

RECORD NO. 000005

00000 +0000000001 -5129318325 -2560475146 +3360274346 +6260606060 -6060606060

RECORD NO. 000006

00000 +0000000001 +3021456045 -3360026060 -2266026060 -4346232163 +7362241071 -5210000000 +5210000000
00010 +4346226260 -6060606060 +0021000000

RECORD NO. 000007

00000 +0000000001 -5129318325 -2560475146 +3360274346 +6260606060 -6060606060

RECORD NO. 000010

00000 +0000000001 +3021456045 -3360036060 -2266036060 -4346232163 +7362241071 -5210000000 +5210000000
00010 +4346226260 -6060606060 +0033000000

RECORD NO. 000011

00000 +0000000001 -5129318325 -2560475146 +3360274346 +6260606060 -6060606060

RECORD NO. 000012

00000 +0000000001 +3021456045 -3360046060 -2266046060 -4346232163 +7362241071 -5210000000 +5210000000
00010 +4346226260 -6060606060 +0045000000

RECORD NO. 000013

00000 +000000001 +512581229 -2560+5146 +535274346 +6260606060 -6060606060

RECORD NO. 000014

00000 +000000001 +3021456045 -3360056000 -2266056060 -4346232163 +7362241071 -5210000000 +5210000000
00010 +4346226260 -6060606060 +0057000000

RECORD NO. 000015

00000 +00000000001 +00010000000 +01510000000 +5512578032 -5110112358 +5512578065 -5032730819 +5512578098
00010 -5064973119 +5512578131 +5123058129 +5512578163 -5057645324 +5512578196 +5061064961 +5512578229
00020 -5122813870 +5512578262 -5084025387 +5512578295 +5071812394 +5512578327 +5071323874 +5512578360
00030 +5018075229 +5512578393 -5119638492 +5512578426 -5119198824 +5512578458 +5091353182 +5512578491
00040 -5113190032 +5512578524 +5067415717 +5512578557 -5010747433 +5512578590 -5110210062 +5512578622
00050 -4978163151 +5512578655 +5112261844 +5512578688 -5030776740 +5512578721 +5032730819 +5512578753
00060 -5080117229 +5512578786 +5031265260 +5512578819 +5134196378 +5512578852 +5014167071 +5512578884
00070 -5123986317 +5512578917 -5123986317 +5512578950 -5112750364 +5512578983 +5082559828 +5512579016
00100 -5045432332 +5512579065 -5121250607 +5512579098 -5012212992 +5512579131 +5072789433 +5512579163
00110 +5044943812 +5512579196 -5110063506 +5512579229 +5111675621 +5512579262 -5036638977 +5512579295
00120 -5112554956 +5512579327 -5042012694 +5512579360 +5021006347 +5512579393 +5115534926 +5512579426
00130 +5024425985 +5512579458 -5136590125 +5512579491 -5012701512 +5512579524 -5067904237 +5512579557
00140 +5053737166 +5512579590 -5111577917 +5512579622 -4973277954 +5512579655 -5114850999 +5512579688
00150 +5016609670 +5512579721 -5089887623 +5512579753 -5017098189 +5512579786 +5135026862 +5512579819
00160 +5021494866 +5512579852 +5049829009 +5512579884 -5033707859 +5512579917 +5122618462 +5512579950
00170 -5112359548 +5512579983 -4973277954 +5512580016 +5039570095 +5512580032 -5046409371 +5512580065
00200 -5033219339 +5512580098 +0000000000 +5512580131 -5112310696 +5512580163 -5076209072 +5512580196
00210 -5022960426 +5512580229 -5037616017 +5512580262 +5090376143 +5512580295 +5065461639 +5512580327
00220 -5114118219 +5512580360 -5111773325 +5512580393 -5035661937 +5512580426 -5012212992 +5512580458
00230 -5115534926 +5512580491 +5036150457 +5512580524 +5112164140 +5512580557 +5112701512 +5512580590
00240 +5018075229 +5512580622 -5023937465 +5512580655 +5112310696 +5512580688 +5029799701 +5512580721
00250 +5065461639 +5512580753 -5028822662 +5512580786 +4948851970 +5512580819 +5081094269 +5512580852
00260 +5043478253 +5512580884 +5047386410 +5512580917 -5098192458 +5512580950 +5110600877 +5512580983
00270 +5041524174 +5512581016 -5016121150 +5512581065 +5111724473 +5512581098 +5114411331 +5512581131
00300 +5055202725 +5512581163 +5111968732 +5512581196 +5064484600 +5512581229 -5112408400 +5512581262
00310 +4924425985 +5512581295 +0000000000 +5512581327 +5113531996 +5512581360 +5110356618 +5512581393
00320 +5024914504 +5512581426 -5033707859 +5512581458 -5031265260

TRANSFER FUNCTION OF A LINEAR SYSTEM AND
SAMPLE HUNTSVILLE CORRELATION OUTPUT COMPARED WITH OUTPUT OF WANL CODES

A. Calculation of Auto and Cross-Correlation

The cross correlation function $\phi_{xy}(\tau)$ of the random functions $x(t)$ and $y(t)$ is defined by Lee and others to be

$$(1) \quad \phi_{xy}(\tau) = \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T x(t)y(t+\tau)dt$$

while $\phi_{yx}(\tau)$ is similarly defined as

$$(2) \quad \phi_{yx}(\tau) = \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T y(t)x(t+\tau)dt$$

The means of x and y are assumed zero. To find a relationship between $\phi_{xy}(\tau)$ and $\phi_{yx}(\tau)$, consider $\phi_{xy}(-\tau)$.

$$\phi_{xy}(-\tau) = \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T x(t)y(t-\tau)dt$$

Substituting $t' = t - \tau$

$$= \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T-\tau}^{T-\tau} x(t'+\tau)y(t')dt'$$

which could rigorously be proved equal to

$$= \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T x(t' + \tau) y(t') dt'$$

$$= \phi_{yx}(\tau)$$

We therefore have

$$(3) \quad \phi_{xy}(-\tau) = \phi_{yx}(\tau)$$

In the Huntsville program, equations (1) and (2) are approximated by

$$(4) \quad \phi_{xy}(\tau) \approx \frac{1}{N-r} \sum_{i=1}^{N-r} (x_i - \bar{x})(y_{i+r} - \bar{y})$$

and

$$(5) \quad \phi_{yx}(\tau) \approx \frac{1}{N-r} \sum_{i=1}^{N-r} (y_i - \bar{y})(x_{i+r} - \bar{x})$$

where N = total number of points and r is the lag number. Because of (3), they are called the positive and negative cross correlations respectively.

The special case where the functions $x(t)$ and $y(t)$ are both $x(t)$ yields the formula for auto correlation which is used in the Huntsville program. Both (4) and (5) become

$$(6) \quad \phi_{xx}(\tau) = \frac{1}{N-r} \sum_{i=1}^{N-r} (x_i - \bar{x})(x_{i+r} - \bar{x})$$

Continuing to follow Lee, the Cross-Power Density Spectrum is defined (except for the positive constant $\frac{1}{2\pi}$ which is included by some authors in their definition of Fourier integral) to be the Fourier integral of $\phi_{xy}(\tau)$, i.e.

$$(7) \quad \mathbb{I}_{xy}(\omega) = \int_{-\infty}^{\infty} \phi_{xy}(\tau) e^{-j\omega\tau} d\tau$$

$$= \int_{-\infty}^0 \phi_{xy}(\tau) e^{-j\omega\tau} d\tau + \int_0^{\infty} \phi_{xy}(\tau) e^{-j\omega\tau} d\tau$$

Substituting $\tau = -\tau'$ in the first integral

$$= \int_{\infty}^0 \phi_{xy}(-\tau') e^{j\omega\tau'} (-d\tau') + \int_0^{\infty} \phi_{xy}(\tau) e^{-j\omega\tau} d\tau$$

Reversing the order of integration in the first integral and dropping the prime

$$= \int_0^{\infty} \phi_{xy}(-\tau) e^{j\omega\tau} d\tau + \int_0^{\infty} \phi_{xy}(\tau) e^{-j\omega\tau} d\tau$$

Writing the above equation in real and imaginary parts

$$\begin{aligned}
 (8) \quad \bar{\Phi}_{xy}(\omega) &= \int_0^{\infty} \phi_{xy}(-\tau) \left[\cos(\omega\tau) + j \sin(\omega\tau) \right] d\tau \\
 &\quad + \int_0^{\infty} \phi_{xy}(\tau) \left[\cos(\omega\tau) - j \sin(\omega\tau) \right] d\tau \\
 &= \int_0^{\infty} \left[\phi_{xy}(\tau) + \phi_{xy}(-\tau) \right] \cos(\omega\tau) d\tau \\
 &\quad - j \int_0^{\infty} \left[\phi_{xy}(\tau) - \phi_{xy}(-\tau) \right] \sin(\omega\tau) d\tau
 \end{aligned}$$

Substituting (See page 3-85 of Reference 2)

$$\begin{aligned}
 A(\tau) &= \frac{1}{2} \left[\phi_{xy}(\tau) + \phi_{xy}(-\tau) \right] \\
 (9) \quad B(\tau) &= \frac{1}{2} \left[\phi_{xy}(\tau) - \phi_{xy}(-\tau) \right] \\
 \bar{\Phi}_{xy}(\omega) &= 2 \int_0^{\infty} A(\tau) \cos(\omega\tau) d\tau - 2j \int_0^{\infty} B(\tau) \sin(\omega\tau) d\tau
 \end{aligned}$$

If the above integrals are calculated by trapazoidal rule with the substitutions

$$\Delta\tau = \frac{1}{2f_c} = h$$

$$\omega = 2\pi f$$

$$\tau_i = rh = \frac{r}{2f_c}$$

$$\omega\tau_i = \frac{r\pi f}{f_c}$$

$$(10) \quad \bar{\Phi}_{xy}(f) \approx h \left[A(0) + 2 \sum_{r=1}^{M-1} A(rh) \cos \left(\frac{\pi r f}{f_c} \right) + A(Mh) \cos \frac{\pi M f}{f_c} \right] \\ - jh \left[2 \sum_{r=1}^{M-1} B(rh) \sin \left(\frac{\pi r f}{f_c} \right) + B(Mh) \sin \left(\frac{\pi M f}{f_c} \right) \right]$$

Equation (10) is (except for a factor of 2 for positive and negative frequencies) the equation on page 3-86 of Reference 2 which is

$$(11) \quad G_{xy}(f) = C_{xy}(f) - j Q_{xy}(f)$$

where $G_{xy}(f)$ is the cross-power spectral density, $C_{xy}(f)$ is the co-spectrum and $Q_{xy}(f)$ is the quadrature. $C_{xy}(f)$ and $Q_{xy}(f)$ are calculated by the Huntsville program and printed under the headings of co-spectrum and quadrature. The phase ϕ is calculated by

$$(12) \quad \phi = \tan^{-1} \left(\frac{-Q}{C} \right)$$

Before leaving the subject of cross correlation, it is worth considering the relation between $\bar{\Phi}_{xy}(\omega)$ and $\bar{\Phi}_{yx}(\omega)$. From Equation (7)

$$\bar{\Phi}_{yx}(\omega) = \int_{-\infty}^{\infty} \phi_{yx}(\tau) e^{-j\omega\tau} d\tau$$

which because of (3)

$$= \int_{-\infty}^{\infty} \phi_{xy}(-\tau) e^{-j\omega\tau} d\tau$$

Substitution $\tau = -\tau'$

$$\Phi_{yx}(\omega) = \int_{-\infty}^{\infty} \phi_{xy}(\tau') e^{j\omega\tau'} (-d\tau')$$

Reversing the order of integration and dropping the prime

$$\Phi_{yx}(\omega) = \int_{-\infty}^{\infty} \phi_{xy}(\tau) e^{j\omega\tau} d\tau$$

It follows that, since $\phi_{xy}(\tau)$ is real

$$(13) \quad \Phi_{yx}(\omega) = \overline{\Phi_{xy}(\omega)}$$

where $\overline{\Phi_{xy}(\tau)}$ is the conjugate of $\Phi_{xy}(\tau)$. Relation (13) has been observed to be true in the Huntsville code when the functions $x(t)$ and $y(t)$ were reversed.

The Power Spectral Density functions $\Phi_{xx}(\omega)$ and $\Phi_{yy}(\omega)$ are both calculated from equation (10). However, we note from equation (8)

$$(14) \quad \Phi_{xx}(\omega) = \int_0^{\infty} \left[\phi_{xx}(\tau) + \phi_{xx}(-\tau) \right] \cos(\omega\tau) d\tau \\ -j \int_0^{\infty} \left[\phi_{xx}(\tau) - \phi_{xx}(-\tau) \right] \sin(\omega\tau) d\tau$$

and since from equation (3)

$$(15) \quad \phi_{xx}(\tau) = \phi_{xx}(-\tau)$$

the imaginary component of equation (14) is zero (i.e. $\Phi_{xx}(\omega)$ is real). The functions $\Phi_{xx}(\omega)$ and $\Phi_{yy}(\omega)$ are, therefore, calculated from only the cosine terms in equation (10).

Calculation of the Transfer Function for Linear Systems

A linear system may be defined in many ways, but one which is mathematically pleasing is by means of the Convolution or Superposition integral. By means of this integral definition, we are able to derive the following relations for all functions of interest: periodic, aperiodic and random. Given an input function $x(t)$, an output function $y(t)$, and the unit impulse response $h(t)$, a system is linear if

$$(16) \quad y(t) = \int_{-\infty}^{\infty} h(s) x(t-s) ds$$

or equivalently (by substituting $s' = t-s$)

$$(17) \quad y(t) = \int_{-\infty}^{\infty} x(s') h(t-s') ds'$$

The transfer function $H(\omega)$ is defined as the Fourier Transform of $h(t)$ so that

$$(18) \quad H(\omega) = \int_{-\infty}^{\infty} h(t) e^{-j\omega t} dt$$

The transfer function $H(\omega)$ is easily calculated by Fourier transforming the convolution integral if the functions are periodic or aperiodic (see Lee pp. 330-331). The result is that

$$(19) \quad Y(\omega) = H(\omega) X(\omega)$$

or

$$(20) \quad H(\omega) = \frac{Y(\omega)}{X(\omega)}$$

where $X(\omega)$ and $Y(\omega)$ are the Fourier transforms of $x(t)$ and $y(t)$.

But the method fails in the case of random functions, since these functions do not possess Fourier transforms. However, the transfer function for all three types of functions may be obtained in either one of two other ways, namely (1) by means of auto correlation or (2) by means of cross correlation. We begin with the auto correlation method which originates from the definition of auto correlation for random functions. This definition could be replaced by the corresponding definition for periodic or aperiodic functions and the remainder of the proof would be identical. For the random output function $y(t)$ the auto correlation function $\phi_{yy}(\tau)$ is

$$(21) \quad \phi_{yy}(\tau) = \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T y(t) y(t+\tau) dt$$

Using (16)

$$(22) \quad \begin{aligned} y(t) &= \int_{-\infty}^{\infty} h(s) x(t-s) ds \\ y(t+\tau) &= \int_{-\infty}^{\infty} h(s') x(t+\tau-s') ds' \end{aligned}$$

so that (21) becomes

$$(23) \quad \phi_{yy}(\tau) = \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T \left[\int_{-\infty}^{\infty} h(s) x(t-s) ds \int_{-\infty}^{\infty} h(s') x(t+\tau-s') ds' \right] dt$$

By inverting the order of integration and noting that if $X(t-s)$ and $x(t+\tau-s')$ are grouped with the limit integral an auto correlation function is formed, (23) becomes

$$(24) \quad \phi_{yy}(\tau) = \int_{-\infty}^{\infty} h(s)ds \int_{-\infty}^{\infty} h(s')ds' \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T x(t-s) x(t+\tau-s')dt$$

or

$$(25) \quad \phi_{yy}(\tau) = \int_{-\infty}^{\infty} h(s)ds \int_{-\infty}^{\infty} h(s')ds' \phi_{xx}(\tau+s-s')$$

The Fourier transform of $\phi_{yy}(\tau)$ is the output Power Spectral Density function $\Phi_{yy}(\omega)$ and is from (25)

$$(26) \quad \begin{aligned} \Phi_{yy}(\omega) &= \frac{1}{2\pi} \int_{-\infty}^{\infty} \phi_{yy}(\tau) e^{-j\omega\tau} d\tau \\ &= \frac{1}{2\pi} \int_{-\infty}^{\infty} e^{-j\omega\tau} d\tau \int_{-\infty}^{\infty} h(s)ds \int_{-\infty}^{\infty} h(s')ds' \phi_{xx}(\tau+s-s') \end{aligned}$$

Replacing the variable of integration τ with v by making the substitution $\tau = v-s-s'$

$$= \frac{1}{2\pi} \int_{-\infty}^{\infty} e^{-j\omega(v-s-s')} dv \int_{-\infty}^{\infty} h(s)ds \int_{-\infty}^{\infty} h(s')ds' \phi_{xx}(v)$$

and regrouping terms

$$(27) \quad \Phi_{yy}(\omega) = \int_{-\infty}^{\infty} h(s) e^{j\omega s} ds \int_{-\infty}^{\infty} h(s') e^{-j\omega s'} ds' \frac{1}{2\pi} \int_{-\infty}^{\infty} \phi_{xx}(v) e^{-j\omega v} dv$$

Making use of (18) and noting that since $h(t)$ is real

$$\bar{H}(\omega) = \int_{-\infty}^{\infty} h(t) e^{j\omega t} dt$$

equation (27) can be written as

$$(28) \quad \Phi_{yy}(\omega) = \bar{H}(\omega) H(\omega) \Phi_{xx}(\omega) = |H(\omega)|^2 \Phi_{xx}(\omega)$$

or as

$$(29) \quad |H(\omega)|^2 = \frac{\Phi_{yy}(\omega)}{\Phi_{xx}(\omega)}$$

Equation (29) may be used to calculate the magnitude of $H(\omega)$. However, if the phase is also desired, the use of cross correlation is necessary. We begin with the definition of cross correlation for random functions, although this definition could again be replaced by the corresponding definitions for periodic or aperiodic functions and the remainder of the proof would be identical. The cross correlation function $\phi_{xy}(\tau)$ is defined as

$$(30) \quad \phi_{xy}(\tau) = \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T x(t) y(t+\tau) dt$$

which from (16)

$$= \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T x(t) dt \int_{-\infty}^{\infty} h(s) x(t+\tau-s) ds$$

Inverting the order of integration

$$(31) \quad \phi_{xy}(\tau) = \int_{-\infty}^{\infty} h(s) ds \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T x(t) x(t + \tau - s) dt$$

Since

$$\phi_{xx}(\tau - s) = \lim_{T \rightarrow \infty} \frac{1}{2T} \int_{-T}^T x(t) x(t + \tau - s) dt$$

equation (31) becomes

$$(32) \quad \phi_{xy}(\tau) = \int_{-\infty}^{\infty} h(s) \phi_{xx}(\tau - s) ds$$

This relation may be expressed in the frequency domain by Fourier transformation of equation (32). This gives

$$(33) \quad \begin{aligned} \Phi_{xy}(\omega) &= \frac{1}{2\pi} \int_{-\infty}^{\infty} \phi_{xy}(\tau) e^{-j\omega\tau} d\tau \\ &= \frac{1}{2\pi} \int_{-\infty}^{\infty} e^{-j\omega\tau} d\tau \int_{-\infty}^{\infty} h(s) \phi_{xx}(\tau - s) ds \end{aligned}$$

Substituting $v = \tau - s$ in equation (33)

$$(34) \quad \Phi_{xy}(\omega) = \frac{1}{2\pi} \int_{-\infty}^{\infty} e^{-j\omega(v+s)} dv \int_{-\infty}^{\infty} h(s) \phi_{xx}(v) ds$$

Rearranging terms in the integration

$$\Phi_{xy}(\omega) = \frac{1}{2\pi} \int_{-\infty}^{\infty} e^{-j\omega v} \phi_{xx}(v) dv \int_{-\infty}^{\infty} e^{-j\omega s} h(s) ds$$

which from (18) and (26) is

$$(35) \quad \bar{\Phi}_{xy}(\omega) = \bar{\Phi}_{xx}(\omega) H(\omega)$$

The transfer function $H(\omega)$ can therefore be calculated as

$$(36) \quad H(\omega) = \frac{\bar{\Phi}_{xy}(\omega)}{\bar{\Phi}_{xx}(\omega)}$$

Equation (36) can be divided into the two equations of absolute value and phase, and since $\bar{\Phi}_{xx}(\omega)$ is real from the argument following equation (14)

$$(37) \quad |H(\omega)| = \frac{|\bar{\Phi}_{xy}(\omega)|}{\bar{\Phi}_{xx}(\omega)}$$

and

$$(38) \quad \text{phase } H(\omega) = \text{phase } \bar{\Phi}_{xy}(\omega)$$

The quantity $|H(\omega)|$ of equation (37) is calculated in the Huntsville program and listed under TRAN1. The phase of equation (38) is listed under PHASE.

The transfer function $H_1(\omega)$ of the output $y(t)$ to the input $x(t)$ can be calculated in a manner similar to equations (36) to (38).

In particular

$$(39) \quad |H_1(\omega)| = \frac{|\bar{\Phi}_{yx}(\omega)|}{\bar{\Phi}_{yy}(\omega)} = \frac{|\bar{\Phi}_{xy}(\omega)|}{\bar{\Phi}_{yy}(\omega)}$$

where the second part of equation (39) follows from equation (13).

$|H_1(\omega)|$ in equation (39) is calculated in the Huntsville program and listed under the title TRAN2.

Since equations (29) and (37) give two ways of calculating $|H(\omega)|^2$, it is worth considering the ratio of the results of these two methods. This ratio, known as the coherence function γ_{xy}^2 , is defined as

$$\begin{aligned}
 (40) \quad \gamma_{xy}^2 &= \frac{|\bar{\Phi}_{xy}(\omega)|^2}{[\bar{\Phi}_{xx}(\omega)]^2} \div \frac{\bar{\Phi}_{yy}(\omega)}{\bar{\Phi}_{xx}(\omega)} \\
 &= \frac{|\bar{\Phi}_{xy}(\omega)|^2}{[\bar{\Phi}_{xx}(\omega)]^2} \times \frac{\bar{\Phi}_{xx}(\omega)}{\bar{\Phi}_{yy}(\omega)} \\
 &= \frac{|\bar{\Phi}_{xy}(\omega)|^2}{\bar{\Phi}_{xx}(\omega) \bar{\Phi}_{yy}(\omega)}
 \end{aligned}$$

The quantity γ_{xy}^2 is calculated in the Huntsville program and printed under the title COHERENCE. For linear systems, this ratio should be equal to one. The coherence function, therefore, gives a measure of the linearity of the system with $x(t)$ as the input and $y(t)$ as the output.

Some comparisons of the Huntsville Code results and WANL Code results follow.

1. TRANSFER FUNCTION EXAMPLE #1

Extracts from Huntsville correlation code. The input and output waves were entered in the correct order and the desired results were the magnitude and phase representing the transfer function.

The system for which the transfer function is to be calculated is known to be a second order system. It will be noticed that the angle is 180 degrees out of phase. It is thought that one of the waves has a sign reversal which would account for this discrepancy.

CASE IDENTIFICATION-- VAR 1

PLOT OF INPUT DATA

TIME SLICE

+2.016393

+21.327833

TIME	VALUE
0	-3.97166
1	-4.04494
2	-4.43575
3	-4.58231
4	-4.24523
5	-4.08402
6	-3.89350
7	-4.07913
8	-4.47972
9	-4.57254
10	-4.01563
11	-3.54665
12	-3.62970
13	-3.39032
14	-3.17537
15	-3.36101
16	-3.17049
17	-2.77967
18	-2.76013
19	-3.36590
20	-4.02540
21	-4.43575
22	-4.70444
23	-4.87054
24	-4.70933
25	-4.01563
26	-3.34147
27	-2.91157
28	-2.98974
29	-3.59550
30	-4.18172
31	-4.16707
32	-3.57596
33	-3.02882
34	-3.07767
35	-3.29262
36	-3.01905
37	-2.65754
38	-2.41817
39	-2.27161
40	-2.17879
41	-2.10063
42	-2.52076
43	-3.32681
44	-3.49291
45	-3.56619
46	-4.00586
47	-4.44552
48	-4.70444
49	-4.35759

INPUT WAVE

0	0	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DENSITY SCALE

AUTOCORRELATION FUNCTION
CASE IDENTIFICATION-- VAR 1

TIME SLICE

+2.016393

+21.327833

TIME VALUE

0 +0.40840
1 +0.35115
2 +0.24134
3 +0.15581
4 +0.10371
5 +0.06892
6 +0.04250
7 +0.02363
8 +0.01095
9 +0.00135
10 -0.00552
11 -0.00916
12 -0.01069
13 -0.01100
14 -0.00979
15 -0.00748
16 -0.00536
17 -0.00361
18 -0.00258
19 -0.00311
20 -0.00382
21 -0.00311
22 -0.00222
23 -0.00186
24 -0.00146
25 -0.00151
26 -0.00255
27 -0.00372
28 -0.00311
29 -0.00070
30 +0.00157
31 +0.00258
32 +0.00226
33 +0.00091
34 -0.00108
35 -0.00310
36 -0.00454
37 -0.00562
38 -0.00659
39 -0.00712
40 -0.00551
41 -0.00206
42 +0.00107
43 +0.00290
44 +0.00314
45 +0.00279
46 +0.00304
47 +0.00361
48 +0.00420
49 +0.00412

AUTOCORRELATION FUNCTION OF

INPUT WAVE. SEE EQUATION (6)

PAGE 57

0 0 1 1 2 2 3 3 4 4 5 5 6 6 7 7 8 8 9 9 0
0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0

DENSITY SCALE

CASE IDENTIFICATION-- VAR 2

PLOT OF INPUT DATA

TIME SLICE

+2.016393

+21.327833

0	0	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	1
0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0

DENSITY SCALE

AUTOCORRELATION FUNCTION
CASE IDENTIFICATION-- VAR 2

TIME SLICE

+2.016393

+21.327833

TIME VALUE
0 +0.65538
1 +0.65431
2 +0.65085
3 +0.64507
4 +0.63706
5 +0.62698
6 +0.61496
7 +0.60117
8 +0.58576
9 +0.56891
10 +0.55075
11 +0.53146
12 +0.51117
13 +0.49002
14 +0.46815
15 +0.44567
16 +0.42271
17 +0.39940
18 +0.37582
19 +0.35211
20 +0.32835
21 +0.30464
22 +0.28107
23 +0.25770
24 +0.23463
25 +0.21190
26 +0.18957
27 +0.16771
28 +0.14636
29 +0.12557
30 +0.10539
31 +0.08586
32 +0.06702
33 +0.04890
34 +0.03153
35 +0.01493
36 -0.00089
37 -0.01592
38 -0.03015
39 -0.04358
40 -0.05621
41 -0.06804
42 -0.07910
43 -0.08938
44 -0.09889
45 -0.10765
46 -0.11567
47 -0.12296
48 -0.12953
49 -0.13539

AUTOCORRELATION FUNCTION FOR

OUTPUT WAVE. SEE EQUATION (6)

PAGE 57

0 0 1 1 2 2 3 3 4 4 5 5 6 6 7 7 8 8 9 9 10
0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0

DENSITY SCALE

POSITIVE CROSS CORRELATION

CASE IDENTIFICATION-- VAR

1VAR 2

TIME SLICE

+2.016393

+21.327833

TIME VALUE

0	-0.02126
1	-0.03598
2	-0.05378
3	-0.07337
4	-0.09341
5	-0.11313
6	-0.13183
7	-0.14909
8	-0.16500
9	-0.17945
10	-0.19219
11	-0.20320
12	-0.21235
13	-0.21993
14	-0.22619
15	-0.23122
16	-0.23514
17	-0.23793
18	-0.23941
19	-0.23981
20	-0.23944
21	-0.23822
22	-0.23596
23	-0.23261
24	-0.22831
25	-0.22333
26	-0.21781
27	-0.21196
28	-0.20588
29	-0.19948
30	-0.19260
31	-0.18543
32	-0.17805
33	-0.17020
34	-0.16185
35	-0.15317
36	-0.14444
37	-0.13573
38	-0.12682
39	-0.11770
40	-0.10865
41	-0.09971
42	-0.09101
43	-0.08275
44	-0.07505
45	-0.06772
46	-0.06054
47	-0.05338
48	-0.04622
49	-0.03934

SEE EQUATION (4) PAGE 57

0 0 1 1 2 2 3 3 4 4 5 5 6 6 7 7 8 8 9 9 0

0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0

DENSITY SCALE

SPONSOR(S)-HONKA-SEC ORD TEST, 15 CPS FILTER ORIGINATOR- PSEUDO RANDOM INPUT, 1-26-65 01/26/65 SEQ NO = 001 PAGE 286									
CASE IDENTIFICATION--VAR 1VAR 2 TIME SLICE +2.016393 +21.327833									
TIME	FREQUENCY	THETA	TAN	IVAR	ARCTAN	TAU	VAR 1	VAR 2	COHERENCE
0									
1	+0.051783	+176.226124	+0.065962	+3.075726	+881.130623		+0.044823	+0.377330	+1.012894
2	+0.103566	+176.831791	+0.055352	+3.086297	+442.079479		+0.054025	+0.479929	+1.006190
3	+0.155348	+172.269194	+0.135753	+3.006665	+287.115332		+0.047050	+0.420847	+1.004373
4	+0.207131	+169.525452	+0.184880	+2.958777	+211.903681		+0.049379	+0.480096	+1.009574
5	+0.258914	+166.160555	+0.246354	+2.900049	+166.160555		+0.046473	+0.469664	+1.005079
6	+0.310697	+160.393972	+0.356202	+2.799403	+133.661644		+0.044131	+0.421931	+1.007433
7	+0.362479	+156.573210	+0.433294	+2.732718	+111.838007		+0.046597	+0.442756	+1.008529
8	+0.414262	+153.355968	+0.501724	+2.676567	+95.847461		+0.042877	+0.441024	+1.007177
9	+0.466045	+149.131176	+0.597749	+2.602830	+82.950653		+0.038915	+0.429986	+1.009581
10	+0.517828	+142.455423	+0.768564	+2.486316	+71.227712		+0.043601	+0.502188	+1.000978
11	+0.569611	+134.021204	+1.034764	+2.339111	+60.918729		+0.049830	+0.610221	+1.002071
12	+0.621393	+128.852865	+1.241402	+2.248907	+53.688694		+0.051703	+0.622386	+1.009592
13	+0.673176	+125.990724	+1.376851	+2.198953	+48.457971		+0.045602	+0.522397	+1.008344
14	+0.724959	+119.405272	+1.774332	+2.084015	+42.644740		+0.047340	+0.525044	+1.002586
15	+0.776742	+111.014598	+2.603106	+1.937570	+37.904866		+0.064636	+0.776510	+1.002004
16	+0.828524	+103.998336	+4.011277	+1.815113	+32.499460		+0.076651	+0.929862	+0.999945
17	+0.880307	+98.395781	+6.775439	+1.717330	+28.939935		+0.065879	+0.709623	+1.004349
18	+0.932090	+93.115636	+18.371622	+1.625174	+25.865454		+0.047769	+0.454155	+1.005800
19	+0.983873	+84.922282	-11.254212	+1.482173	+22.347969		+0.051525	+0.420340	+0.997276
20	+1.035656	+81.537416	-6.721179	+1.423096	+20.384354		+0.062910	+0.420556	+1.009707
21	+1.087438	+78.785409	-5.043628	+1.375065	+18.758430		+0.052210	+0.307221	+1.008705
22	+1.139221	+71.847697	-3.050073	+1.253979	+16.329022		+0.036827	+0.192259	+1.012760
23	+1.191004	+66.777492	-2.330646	+1.165487	+14.516846		+0.036073	+0.168768	+1.012476
24	+1.242787	+60.325777	-1.755021	+1.052883	+12.567870		+0.039975	+0.161636	+1.009546
25	+1.294569	+53.985532	-1.375651	+0.942225	+10.797106		+0.041606	+0.138890	+1.013040

TRAN 2
The absolute value of the transfer function, $|H_1(\omega)|$, of the second input variable to the first input variable as defined by Equation 39.

TRAN 1
The absolute value of the transfer function, $|H(\omega)|$, of the first input variable to the second input variable as defined by Equation 37.

COHERENCE
The Coherence γ_{xy}^2 as defined by Equation 10.

VAR 2
The Power Spectral Density of the second input variable as defined by Equation 10.

VAR 1
The Power Spectral Density of the first input variable as defined by Equation 10, page 56.

TAU
 $\frac{\phi}{\text{FREQUENCY}}$ x constant. The units of TAU are units of time.

ARCTAN
The phase angle ϕ in radians.

TAN
Tan ϕ .

THETA
The phase angle ϕ in degrees of the Cross Power Spectral Density (Equation 12) and of the transfer function (Equation 38), page 62.

FREQUENCY
Frequency in cycles/second. Frequency is given in increments of $\frac{1}{2f_c}$ where f_c is the cutoff frequency.

SPONSOR(S)-HONKA, SEC ORD	TEST, 15 CPS FILTER	ORIGINATOR- PSEUDO	RANDOM INPUT, 1-26-65	01/26/65 SEQ NO = 001	PAGE 304
FREQ	PSD VAR 1 AMPT VAR 1	PSD VAR 2 AMPT VAR 2	COSPECTRA	QUADRATURE CROSS PSD PHASE (DEG)	COHERENCE
.00000	+0.026201	+0.052092	+0.186278	+0.138896	+0.070890
.05178	+0.044823	+0.068133	+0.377330	+0.197693	-0.008615
.10356	+0.054025	+0.074801	+0.479929	+0.222944	-0.008927
.15334	+0.047050	+0.069805	+0.420847	+0.208771	-0.161273
.20713	+0.049379	+0.071512	+0.480096	+0.222983	-0.141023
.25891	+0.046473	+0.069376	+0.466964	+0.219912	-0.028125
.31069	+0.044131	+0.067605	+0.421931	+0.209039	-0.035327
.36247	+0.046597	+0.069468	+0.442756	+0.214136	-0.045958
.41426	+0.042877	+0.066638	+0.441024	+0.213717	-0.057349
.46604	+0.038915	+0.063484	+0.429986	+0.211026	-0.142856
.51782	+0.043601	+0.067198	+0.502188	+0.228056	-0.061888
.56961	+0.049830	+0.071838	+0.610221	+0.251392	-0.090216
.62139	+0.051703	+0.073176	+0.623486	+0.254110	-0.125521
.67317	+0.045602	+0.068722	+0.522397	+0.232599	-0.140491
.72495	+0.047340	+0.070020	+0.525044	+0.233188	-0.125402
.77674	+0.064636	+0.081817	+0.776510	+0.283584	-0.137523
.82852	+0.076651	+0.090997	+0.929862	+0.310325	-0.209341
.88030	+0.065879	+0.082600	+0.709623	+0.271095	-0.259037
.93208	+0.047769	+0.070337	+0.454155	+0.216875	-0.214363
.98387	+0.051525	+0.073049	+0.420340	+0.208645	-0.147499
1.03565	+0.062910	+0.080717	+0.420556	+0.208699	-0.146389
1.08743	+0.052210	+0.073533	+0.307221	+0.178375	-0.161665
1.13922	+0.036827	+0.061757	+0.199259	+0.143654	-0.124770
1.19100	+0.036073	+0.061122	+0.168768	+0.132207	-0.161665
1.24278	+0.039975	+0.064343	+0.161636	+0.129383	-0.081917
1.29456	+0.041606	+0.065643	+0.138890	+0.119934	-0.072150
					-0.070177
					+0.076511
					+0.061888
					+0.080769
					+0.325777
					+0.009592
					+0.180404
					+0.852865
					+0.009592
					+0.1008344
					+0.154987
					+0.990724
					+0.157861
					+0.119.405272
					+0.224257
					+0.11.014598
					+0.009581
					+0.266965
					+0.998336
					+0.999945
					+0.216685
					+0.98.395781
					+0.147718
					+0.93.115636
					+0.146389
					+0.84.972282
					+0.163444
					+0.81.537416
					+0.127199
					+0.78.785409
					+0.086207
					+0.71.847697
					+0.078511
					+0.66.777492
					+0.012760
					+0.012476
					+0.009646
					+0.013040

COHERENCE

The Coherence $\sqrt{xy}^2$ as defined by Equation 40, page 63.

PHASE

The phase angle ϕ in degrees of the Cross Power Spectral Density (Equation 12) and of the transfer function (Equation 38).

CROSS PSD

The absolute value of the Cross Power Spectral Density, i.e. $|G_{xy}|$ as defined in Equation 11.

QUADRATURE

The Quadrature Q_{xy} as defined by Equation 10 and 11.

COSPECTRA

The Cospectrum C_{xy} as defined by Equations 10 and 11.

AMPT VAR 2

The RMS amplitude of the second input variable = $\sqrt{BW \times PSD}$ where BW is the bandwidth.

PSD VAR 2

The Power Spectral Density of the second input variable as defined by Equation 10.

AMPT VAR 1

The RMS amplitude of the first input variable = $\sqrt{BW \times PSD}$ where BW is the bandwidth.

PSD VAR 1

The Power Spectral Density of the first input variable as defined by Equation 10, page 56.

FREQUENCY

Frequency in cycles/second. Frequency is given in increments of $\frac{1}{2f_c}$ where f_c is the cutoff frequency.

2. TRANSFER FUNCTION EXAMPLE #2

Extracts from Huntsville correlation code. The input and output waves were entered in the reverse order of example #1, and the desired results were the magnitude and phase representing the transfer function.

SPONSOR(S)-HOWKA, SEC DRD TEST, 15 CPS FILTER

ORIGINATOR- PSEUDO RANDOM INPUT, 1-26-65

01/26/65 SEQ NO = 001

PAGE

B

PLOT OF INPUT DATA

CASE IDENTIFICATION-- VAR 1

TIME SLICE

+2.016393

+21.327833

TIME VALUE

0 -7.15192
 1 -7.12261
 2 -7.09330
 3 -7.05422
 4 -7.01025
 5 -6.95652
 6 -6.91255
 7 -6.86370
 8 -6.80996
 9 -6.74645
 10 -6.70249
 11 -6.64386
 12 -6.59501
 13 -6.55593
 14 -6.51685
 15 -6.49731
 16 -6.47777
 17 -6.47777
 18 -6.48754
 19 -6.50708
 20 -6.53639
 21 -6.56570
 22 -6.58036
 23 -6.59013
 24 -6.58524
 25 -6.57547
 26 -6.56570
 27 -6.55104
 28 -6.55593
 29 -6.57547
 30 -6.59013
 31 -6.63409
 32 -6.61455
 33 -6.62432
 34 -6.65363
 35 -6.67806
 36 -6.71226
 37 -6.75134
 38 -6.81973
 39 -6.88312
 40 -6.96629
 41 -7.06399
 42 -7.17146
 43 -7.29359
 44 -7.40595
 45 -7.51343
 46 -7.61602
 47 -7.70395
 48 -7.80654
 49 -7.82608

INPUT WAVE

0 0 1 1 2 2 3 3 4 4 5 5 6 6 7 7 8 8 9 9 1
 .
 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0

DENSITY SCALE

SPONSOR(S)-HONKA, SEC ORD TEST, 15 CPS FILTER ORIGINATOR- PSEUDO RANDOM INPUT, 1-26-65 01/26/65 SEQ NO = 001 PAGE 47

AUTOCORRELATION FUNCTION

CASE IDENTIFICATION-- VAR 1

TIME SLICE

+2.016393

+21.327833

TIME VALUE

0	+0.65538
1	+0.65431
2	+0.65085
3	+0.64507
4	+0.63706
5	+0.62698
6	+0.61496
7	+0.60117
8	+0.58576
9	+0.56891
10	+0.55075
11	+0.53146
12	+0.51117
13	+0.49002
14	+0.46815
15	+0.44567
16	+0.42271
17	+0.39940
18	+0.37582
19	+0.35211
20	+0.32835
21	+0.30464
22	+0.28107
23	+0.25770
24	+0.23463
25	+0.21190
26	+0.18957
27	+0.16771
28	+0.14636
29	+0.12557
30	+0.10539
31	+0.08586
32	+0.06702
33	+0.04890
34	+0.03153
35	+0.01493
36	-0.00089
37	-0.01592
38	-0.03015
39	-0.04358
40	-0.05621
41	-0.06804
42	-0.07910
43	-0.08938
44	-0.09889
45	-0.10765
46	-0.11567
47	-0.12296
48	-0.12953
49	-0.13539

AUTOCORRELATION FUNCTION OF

INPUT WAVE. SEE EQUATION (6)

PAGE 57.

0	0	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	0
0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0

DENSITY SCALE

SPONSOR(S)-HONKA, S-C 030 TEST, 15 CPS FILTER

ORIGINATOR- PSEUDO RANDOM INPUT, 1-26-65

01/26/65 SEQ NO = 001

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CASE IDENTIFICATION-- VAR 2

PLOT OF INPUT DATA

TIME SLICE

+2.016393

+21.327833

TIME VALU

0 -3.97100
 1 -4.04494
 2 -4.43575
 3 -4.58231
 4 -4.24523
 5 -4.08402
 6 -3.99350
 7 -4.07913
 8 -4.47172
 9 -4.57254
 10 -4.01563
 11 -3.54565
 12 -3.62970
 13 -3.39032
 14 -3.17537
 15 -3.36101
 16 -3.17549
 17 -2.77907
 18 -2.76013
 19 -3.36590
 20 -4.02540
 21 -4.43575
 22 -4.70444
 23 -4.87054
 24 -4.70933
 25 -4.01563
 26 -3.34147
 27 -2.91157
 28 -2.99974
 29 -3.59550
 30 -4.18172
 31 -4.16707
 32 -3.57596
 33 -3.02982
 34 -3.07767
 35 -3.29262
 36 -3.01905
 37 -2.65754
 38 -2.41817
 39 -2.27161
 40 -2.17879
 41 -2.10063
 42 -2.52076
 43 -3.32681
 44 -3.49291
 45 -3.56619
 46 -4.00586
 47 -4.44552
 48 -4.70444
 49 -4.35759

OUTPUT WAVE

0 0 1 1 2 2 3 3 4 4 5 5 6 6 7 7 8 8 9 9 1
 0
 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0

DENSITY SCALE

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AUTOCORRELATION FUNCTION
CAS- IDENTIFICATION,-- VAP 2

TIME SLICE

+2.016393

+21.327833

TIME VALUE
0 +.4040
1 +.35115
2 +.24134
3 +.15431
4 +.15571
5 +.0642
6 +.04252
7 +.02363
8 +.0103
9 +0.00135
10 -.00052
11 -.00916
12 -.001069
13 -.01100
14 -.00079
15 -.000746
16 -.00536
17 -.00061
18 -.00258
19 -.00311
20 -.00382
21 -.00311
22 -.00222
23 -.00186
24 -.00146
25 -.00151
26 -.00255
27 -.00372
28 -.00011
29 -.00070
30 +.00157
31 +.00253
32 +0.00226
33 +0.00031
34 -.00108
35 -.00010
36 -.00454
37 -.00062
38 -.00659
39 -.00712
40 -.00551
41 -.00205
42 +0.00107
43 +0.00290
44 +0.00314
45 +0.00279
46 +0.00304
47 +0.00361
48 +0.00420
49 +0.00412

AUTOCORRELATION FUNCTION FOR

OUTPUT WAVE. SEE EQUATION (6)

PAGE 57.

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0 0 1 1 2 2 3 3 4 4 5 5 6 6 7 7 8 8 9 9 0 0
0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 5 0 0

DENSITY SCALE

SPONSOR(S)-HONKA, SEC ORD TEST, 15 CPS FILTER

ORIGINATOR- PSEUDO RANDOM INPUT, 1-26-65

01/26/65 SEQ NO = 001

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POSITIVE CROSS CORRELATION

CASE IDENTIFICATION-- VAR

1VAR 2

TIME SLICE

+2.016393

+21.327833

TIME	VALUE																			
0	-0.02126																			
1	-0.01020																			
2	-0.00279	-																		
3	+0.00203	+																		
4	+0.00514		+																	
5	+0.00698			+																
6	+0.00796				+															
7	+0.00835					+														
8	+0.00846						+													
9	+0.00845							+												
10	+0.00836								+											
11	+0.00821									+										
12	+0.00807										+									
13	+0.00802											+								
14	+0.00806												+							
15	+0.00817													+						
16	+0.00833														+					
17	+0.00850															+				
18	+0.00865																+			
19	+0.00884																	+		
20	+0.00914																		+	
21	+0.00958																			+
22	+0.01010																			
23	+0.01070																			
24	+0.01132																			
25	+0.01181																			
26	+0.01215																			
27	+0.01239																			
28	+0.01264																			
29	+0.01295																			
30	+0.01332																			
31	+0.01367																			
32	+0.01392																			
33	+0.01403																			
34	+0.01401																			
35	+0.01397																			
36	+0.01393																			
37	+0.01386																			
38	+0.01380																			
39	+0.01377																			
40	+0.01375																			
41	+0.01371																			
42	+0.01364																			
43	+0.01364																			
44	+0.01376																			
45	+0.01386																			
46	+0.01385																			
47	+0.01383																			
48	+0.01376																			
49	+0.01356																			
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		0	0	1	1	2	2	3	3	4	4	5	5	6	6	7	8	8	9	9
		0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0

SEE EQUATION (4) PAGE 57

DENSITY SCALE

SPONSOR(S)-HUNKA, SEC JRD TEST, 15 CPS FILTER ORIGINATOR- PSEUDO RANDOM INPUT, 1-26-65 01/26/65 SEQ NO = 001 PAGE 152

NEGATIVE CROSS CORRELATION

CASE IDENTIFICATION-- VAR 1VAR 2 TIME SLICE +2.016393 +21.327833

TIME	VALUE	
0	-0.02126	-
1	-0.03598	-
2	-0.05378	-
3	-0.07337	-
4	-0.09141	-
5	-0.11313	-
6	-0.13183	-
7	-0.14909	-
8	-0.16500	-
9	-0.17945	-
10	-0.19219	-
11	-0.20320	-
12	-0.21235	-
13	-0.21993	-
14	-0.22619	-
15	-0.23122	-
16	-0.23514	-
17	-0.23793	-
18	-0.23941	-
19	-0.23981	-
20	-0.23944	-
21	-0.23822	-
22	-0.23596	-
23	-0.23261	-
24	-0.22831	-
25	-0.22333	-
26	-0.21781	-
27	-0.21196	-
28	-0.20588	-
29	-0.19948	-
30	-0.19260	-
31	-0.18543	-
32	-0.17805	-
33	-0.17020	-
34	-0.16185	-
35	-0.15317	-
36	-0.14444	-
37	-0.13573	-
38	-0.12682	-
39	-0.11770	-
40	-0.10865	-
41	-0.09971	-
42	-0.09101	-
43	-0.08275	-
44	-0.07505	-
45	-0.06772	-
46	-0.06054	-
47	-0.05338	-
48	-0.04622	-
49	-0.03934	-

SEE EQUATION (5) PAGE 57.

0	0	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	9	9	0
0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0	5	0

DENSITY SCALE

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SPONSOR(S)-HONKA, SEC ORD TEST, 15 CPS FILTER ORIGINATOR- PSEUDO RANDOM INPUT, 1-26-65 01/26/65 SEQ NO = 001 PAGE 286									
CASE IDENTIFICATION-- VAR IVAR 2 TIME SLICE VAR 1 VAR 2 COHERENCE									
TIME	FREQUENCY	THETA	TAN	ARCTAN	TAU	VAR 1	VAR 2	COHERENCE	TRAN1
0									TRAN2
1	+0.051783	-176.226124	-0.065962	-3.075726	-881.130623	+0.377330	+0.044823	+1.012894	+0.346872
2	+0.103566	-176.831791	-0.053552	-3.086227	-442.079479	+0.479929	+0.054025	+1.006190	+0.336549
3	+0.155348	-172.269194	-0.135753	-3.006665	-287.115322	+0.420847	+0.047050	+1.004373	+0.335094
4	+0.207131	-169.525452	-0.184880	-2.958777	-211.906816	+0.480096	+0.049379	+1.009574	+0.322239
5	+0.258914	-166.160555	-0.246354	-2.900049	-166.160555	+0.466964	+0.046473	+1.005079	+0.316272
6	+0.310697	-160.393972	-0.356202	-2.799403	-133.661644	+0.421931	+0.044131	+1.007433	+0.326607
7	+0.362479	-156.573210	-0.433294	-2.732718	-111.838007	+0.442756	+0.046597	+1.008529	+0.325792
8	+0.414262	-153.355968	-0.501724	-2.676567	-95.847481	+0.441024	+0.042877	+1.007177	+0.312920
9	+0.466045	-149.131176	-0.597749	-2.602830	-82.850653	+0.429986	+0.038915	+1.009581	+0.302273
10	+0.517828	-142.455423	-0.768564	-2.486316	-71.227712	+0.502188	+0.043601	+1.000978	+0.294801
11	+0.569611	-134.021204	-1.034764	-2.339111	-60.918729	+0.610221	+0.049830	+1.002071	+0.286056
12	+0.621393	-128.852865	-1.241402	-2.248907	-53.688694	+0.623486	+0.051703	+1.009592	+0.289347
13	+0.673176	-125.990724	-1.376851	-2.198953	-48.457971	+0.522397	+0.045602	+1.008344	+0.296684
14	+0.724959	-119.405272	-1.774332	-2.084015	-42.644740	+0.525044	+0.047340	+1.002586	+0.300662
15	+0.776742	-111.014598	-2.603106	-1.937570	-37.004866	+0.776510	+0.064636	+1.002004	+0.288801
16	+0.828524	-103.998336	-4.011277	-1.815113	-32.499480	+0.928862	+0.076651	+0.999945	+0.287102
17	+0.880307	-98.395781	-6.775439	-1.717330	-28.939935	+0.709623	+0.065879	+1.004349	+0.305353
18	+0.932090	-93.115636	-18.371622	-1.625174	-25.865454	+0.454155	+0.047769	+1.005800	+0.325258
19	+0.983873	-84.922282	+11.254212	-1.42173	-22.347969	+0.420340	+0.051325	+0.997276	+0.349636
20	+1.035656	-81.537416	+6.721179	-1.423096	-20.384354	+0.420556	+0.062910	+1.009707	+0.388638
21	+1.087438	-78.785409	+5.043628	-1.375065	-18.758430	+0.307221	+0.052210	+1.008705	+0.414031
22	+1.139221	-71.847697	+3.050073	-1.253979	-16.39022	+0.19259	+0.036827	+1.012760	+0.436538
23	+1.191004	-66.777492	+2.330846	-1.165487	-14.516846	+0.168768	+0.036073	+1.012476	+0.465199
24	+1.242787	-60.325777	+1.755021	-1.052883	-12.567870	+0.161636	+0.039975	+1.009646	+0.499700
25	+1.294569	-53.985532	+1.375651	-0.942225	-10.797106	+0.138890	+0.041606	+1.013040	+0.550879
									+1.838352

TRAN 2

The absolute value of the transfer function, $|H_2(\omega)|$, of the second input variable to the first input variable as defined by Equation 39.

TRAN 1

The absolute value of the transfer function, $|H(\omega)|$, of the first input variable to the second input variable as defined by Equation 37.

COHERENCE

The Coherence γ_{xy}^2 as defined by Equation 10.

VAR 2

The Power Spectral Density of the second input variable as defined by Equation 10.

VAR 1

The Power Spectral Density of the first input variable as defined by Equation 10, page 56.

TAU

$\frac{\phi}{\text{FREQUENCY}}$ x constant. The units of TAU are units of time.

ARCTAN

The phase angle ϕ in radians.

TAN

Tan ϕ .

THETA

The phase angle ϕ in degrees of the Cross Power Spectral Density (Equation 12) and of the transfer function (Equation 38), page 62.

FREQUENCY

Frequency in cycles/second. Frequency is given in increments of $\frac{1}{2f_c}$ where f_c is the cutoff frequency.

SPONSOR(S)-HQ/KA-SEC ORD	TEST, 15 CPS FILTER	ORIGINATOR- PSEUDO RANDOM INPUT, 1-26-65	01/26/65	SEQ NO = 001	PAGE 304	
FREQ	PSD VAR 1 AMPT VAR 1	PSD VAR 2 AMPT VAR 2	COSPECTRA	QUADRATURE CROSS PSD	PHASE (DEG)	COHERENCE
0.0000	+0.186278 +0.138896	+0.026201 +0.052092	-0.070890 +0.000000	+0.070890 -179.999998	-1.134091	
0.0178	+0.377330 +0.197683	+0.044823 +0.068133	-0.130602 +0.008615	+0.130885 -176.226124	+1.012894	
0.0356	+0.479929 +0.222944	+0.054025 +0.074801	-0.161273 +0.003927	+0.161520 -176.831791	+1.006190	
0.0534	+0.420847 +0.208771	+0.047050 +0.069805	-0.139741 +0.018970	+0.141023 -172.269194	+1.004373	
0.0713	+0.480096 +0.222983	+0.049379 +0.071512	-0.152128 +0.028125	+0.154706 -169.525452	+1.009574	
0.0891	+0.466964 +0.219912	+0.046473 +0.069376	-0.143400 +0.035327	+0.147688 -166.160555	+1.005079	
0.1069	+0.421931 +0.209039	+0.044131 +0.067605	-0.129021 +0.045958	+0.136962 -160.393972	+1.007433	
0.1247	+0.442756 +0.214136	+0.046597 +0.069468	-0.132356 +0.057349	+0.144246 -156.573210	+1.008529	
0.1426	+0.441024 +0.213717	+0.042877 +0.066538	-0.123350 +0.051888	+0.138005 -153.355968	+1.007177	
0.1604	+0.429986 +0.211026	+0.038915 +0.063484	-0.111562 +0.066686	+0.129974 -149.131176	+1.009581	
0.1782	+0.502188 +0.228056	+0.043601 +0.067198	-0.117382 +0.090216	+0.148045 -142.455423	+1.000978	
0.1961	+0.610221 +0.251392	+0.049830 +0.071838	-0.121304 +0.125521	+0.174558 -134.021204	+1.002071	
0.2139	+0.623486 +0.254110	+0.051703 +0.073176	-0.113171 +0.140491	+0.180404 -128.852865	+1.009592	
0.2317	+0.522397 +0.232599	+0.045602 +0.068722	-0.091079 +0.125402	+0.154987 -125.990724	+1.008344	
0.2495	+0.525044 +0.233188	+0.047340 +0.070020	-0.077507 +0.137523	+0.157861 -119.405272	+1.002586	
0.2674	+0.776510 +0.283584	+0.064636 +0.081817	-0.080420 +0.209341	+0.224257 -111.014598	+1.002004	
0.2852	+0.929862 +0.310325	+0.076651 +0.089097	-0.064577 +0.259037	+0.266965 -103.998336	+0.999945	
0.3030	+0.709623 +0.271095	+0.065879 +0.082600	-0.031638 +0.214363	+0.216685 -98.395781	+1.004349	
0.3208	+0.454155 +0.216875	+0.047769 +0.070337	-0.008029 +0.147499	+0.147718 -93.115636	+1.005800	
0.3387	+0.420340 +0.208645	+0.051525 +0.073049	-0.013007 +0.146389	+0.146966 -84.922282	+0.997276	
0.3565	+0.420556 +0.208699	+0.062910 +0.080717	+0.024033 +0.161665	+0.163444 -81.537416	+1.009707	
0.3743	+0.307221 +0.178375	+0.052210 +0.073533	+0.024738 +0.124770	+0.127199 -78.785409	+1.008705	
0.3922	+0.199259 +0.143654	+0.036827 +0.061757	+0.026857 +0.081917	+0.086207 -71.847697	+1.012760	
0.4100	+0.168768 +0.132207	+0.036073 +0.061122	+0.030957 +0.072150	+0.078511 -66.777492	+1.012476	
0.4278	+0.161636 +0.129383	+0.039975 +0.064343	+0.039986 +0.070177	+0.080769 -60.325777	+1.009646	

COHERENCE

The Coherence γ_{xy}^2 as defined by Equation 40, page 63.

PHASE

The phase angle ϕ in degrees of the Cross Power Spectral Density (Equation 12) and of the transfer function (Equation 38).

CROSS PSD

The absolute value of the Cross Power Spectral Density, i.e. $|G_{xy}|$ as defined in Equation 11.

QUADRATURE

The Quadrature Q_{xy} as defined by Equation 10 and 11.

COSPECTRA

The Cospectrum C_{xy} as defined by Equations 10 and 11.

AMPT VAR 2

The RMS amplitude of the second input variable = $\sqrt{BW \times PSD}$ where BW is the bandwidth.

PSD VAR 2

The Power Spectral Density of the second input variable as defined by Equation 10.

AMPT VAR 1

The RMS amplitude of the first input variable = $\sqrt{BW \times PSD}$ where BW is the bandwidth.

PSD VAR 1

The Power Spectral Density of the first input variable as defined by Equation 10, page 56.

FREQUENCY

Frequency in cycles/second. Frequency is given in increments of $\frac{1}{2f_c}$ where f_c is the cutoff frequency.

3. TRANSFER FUNCTION EXAMPLE #3

Extracts from WANL correlation codes. The input and output waves were entered in the same order as in example #1. The expanded form of equation (4) and (5) on page 52 were employed to calculate the cross-correlation function. The desired results were the magnitude and phase representing the transfer function.

MOVEX= 100 INPTX= 1800 MOVEY= 100 INPTY= 1800

NO. OF SHIFTS= 900 SAMPLING RATE= 93.21
INPUT DATA

NO.	CURVE 1	CURVE 2
1	-3.971665E 00	-7.151928E 00
2	-4.044943E 00	-7.122617E 00
3	-4.435759E 00	-7.093306E 00
4	-4.582315E 00	-7.054224E 00
5	-4.245236E 00	-7.010258E 00
6	-4.084025E 00	-6.956520E 00
7	-3.893502E 00	-6.912554E 00
8	-4.079139E 00	-6.863702E 00
9	-4.479726E 00	-6.809965E 00
10	-4.572544E 00	-6.746457E 00
11	-4.015632E 00	-6.702490E 00
12	-3.546653E 00	-6.643868E 00
13	-3.629701E 00	-6.595016E 00
14	-3.390327E 00	-6.555934E 00
15	-3.175378E 00	-6.516853E 00
16	-3.361015E 00	-6.497312E 00
17	-3.170493E 00	-6.477771E 00
18	-2.779677E 00	-6.477771E 00
19	-2.760136E 00	-6.487542E 00
20	-3.365901E 00	-6.507082E 00
21	-4.025402E 00	-6.536394E 00
22	-4.435759E 00	-6.565705E 00
23	-4.704445E 00	-6.580360E 00
24	-4.870541E 00	-6.590131E 00
25	-4.709330E 00	-6.585245E 00
26	-4.015632E 00	-6.575475E 00
27	-3.341475E 00	-6.565705E 00
28	-2.911577E 00	-6.551049E 00
29	-2.989741E 00	-6.555934E 00
30	-3.595505E 00	-6.575475E 00
31	-4.181729E 00	-6.590131E 00
32	-4.167073E 00	-6.634097E 00
33	-3.575964E 00	-6.614557E 00
34	-3.028822E 00	-6.624327E 00
35	-3.077674E 00	-6.653638E 00
36	-3.292623E 00	-6.678064E 00

INPUT VALUES

C-VALUES OUTPUT

NO.	C(I)	D(I)
0	-2.113533E-02	-2.113533E-02
1	-3.585458E-02	-1.007676E-02
2	-5.366278E-02	-2.670527E-03
3	-7.324958E-02	2.164841E-03
4	-9.328961E-02	5.269051E-03
5	-1.130064E-01	7.117271E-03
6	-1.317122E-01	8.079529E-03
7	-1.489723E-01	8.476257E-03
8	-1.648777E-01	8.593559E-03
9	-1.793270E-01	8.583784E-03
10	-1.920609E-01	8.489132E-03
11	-2.030799E-01	8.339882E-03
12	-2.122278E-01	8.199453E-03
13	-2.198083E-01	8.144855E-03
14	-2.260668E-01	8.186817E-03
15	-2.310979E-01	8.299351E-03
16	-2.350123E-01	8.460760E-03
17	-2.378089E-01	8.631229E-03
18	-2.392924E-01	8.781195E-03
19	-2.396879E-01	8.969784E-03
20	-2.393174E-01	9.269238E-03
21	-2.381001E-01	9.704113E-03
22	-2.358413E-01	1.023126E-02
23	-2.324889E-01	1.083469E-02
24	-2.281897E-01	1.144958E-02
25	-2.232115E-01	1.193619E-02
26	-2.176914E-01	1.227546E-02
27	-2.118423E-01	1.251960E-02
28	-2.057574E-01	1.276994E-02
29	-1.993620E-01	1.307583E-02
30	-1.924758E-01	1.344538E-02
31	-1.853154E-01	1.379561E-02
32	-1.779335E-01	1.404881E-02
33	-1.700797E-01	1.415253E-02
34	-1.617217E-01	1.413560E-02
35	-1.530480E-01	1.410103E-02
36	-1.443205E-01	1.405454E-02
37	-1.356037E-01	1.398849E-02
38	-1.266990E-01	1.392794E-02
39	-1.175780E-01	1.390171E-02

SEE EQUATIONS (4) and (5) ON PAGE 57

SEC. ORDER SYS. WITH WANL TRANSFER FUNCTION CODE

V-VALUES OUTPUT

NO.	V-REAL	V-IMAG	MODULUS	THETA (DEG.)
0	5.051452E 00	0.	5.051452E 00	0.
1	-1.146020E 01	-3.988757E-01	1.146714E 01	-178.00660
2	-6.254461E 00	-2.015050E-01	6.257706E 00	-178.15469
3	-6.073317E 00	-8.599172E-01	6.133892E 00	-171.94109
4	-7.648163E 00	-1.612193E 00	7.816237E 00	-168.09661
5	-6.985392E 00	-1.155093E 00	7.080250E 00	-170.61062
6	-5.113078E 00	-2.662365E 00	5.764699E 00	-152.49413
7	-6.839201E 00	-2.087708E 00	7.150748E 00	-163.02487
8	-5.880763E 00	-3.852986E 00	7.030567E 00	-146.76780
9	-4.394187E 00	-1.743125E 00	4.727300E 00	-158.36232
10	-6.127319E 00	-5.091633E 00	7.966728E 00	-140.27435
11	-5.232608E 00	-4.891282E 00	7.162738E 00	-136.93099
12	-6.020805E 00	-8.525559E 00	1.043721E 01	-125.22998
13	-3.822844E 00	-4.247578E 00	5.714548E 00	-131.98738
14	-3.312046E 00	-6.356064E 00	7.167231E 00	-117.52332
15	-4.001464E 00	-8.676617E 00	9.554862E 00	-114.75811
16	-3.676241E 00	-1.531482E 01	1.574987E 01	-103.49815
17	-6.842007E-01	-8.982522E 00	9.008542E 00	-94.35582
18	-8.531263E-01	-6.681318E 00	6.735565E 00	-97.27662
19	8.941083E-01	-5.151454E 00	5.228471E 00	-80.15359
20	1.490247E 00	-1.030538E 01	1.041257E 01	-81.77157
21	6.099111E-01	-4.375027E 00	4.417335E 00	-82.06369
22	1.902135E 00	-4.204143E 00	4.614427E 00	-65.65595
23	5.929853E-01	-2.487479E 00	2.557183E 00	-76.59162
24	2.683170E 00	-4.271028E 00	5.043915E 00	-57.86189
25	1.495095E 00	-2.052757E 00	2.539512E 00	-53.93283
26	2.713533E 00	-3.160419E 00	4.165514E 00	-49.35065
27	5.593977E-01	-1.071445E 00	1.208685E 00	-62.43110
28	3.051800E 00	-2.800863E 00	4.142260E 00	-42.54490
29	1.812981E 00	-2.605071E 00	3.173845E 00	-55.16429
30	2.350887E 00	-2.145350E 00	3.182639E 00	-42.38265
31	1.852398E 00	-1.632285E 00	2.468953E 00	-41.38566
32	2.061445E 00	-2.524894E 00	3.259547E 00	-50.77014
33	1.036482E 00	-5.578731E-01	1.177080E 00	-28.29078
34	1.351675E 00	-1.563316E 00	2.066635E 00	-49.15265
35	1.897516E 00	-1.111630E 00	2.199156E 00	-30.36323
36	1.018139E 00	-9.793605E-01	1.412712E 00	-43.88782
37	3.061991E 00	-2.565909E 00	3.994957E 00	-39.96257
38	2.545000E 00	-1.273357E 00	2.845780E 00	-26.58049
39	2.125966E 00	-9.612879E-01	2.333197E 00	-24.33083

SEE EQUATIONS (10), (11),

and (12) ON PAGE 60

U-VALUES OUTPUT

NO.	U-REAL	U-IMAG	MODULUS	THETA (DEG.)
0	-3.204374E 00	-1.994379E-01	3.210575E 00	-176.43854
1	-6.030853E 00	-2.498141E-01	6.036024E 00	-177.62801
2	-7.510610E 00	-4.154507E-01	7.522092E 00	-176.83390
3	-6.512314E 00	-8.833832E-01	6.571956E 00	-172.27508
4	-7.088759E 00	-1.309849E 00	7.208759E 00	-169.53106
5	-6.683006E 00	-1.646186E 00	6.882768E 00	-166.16214
6	-6.012688E 00	-2.141883E 00	6.382795E 00	-160.39272
7	-6.168061E 00	-2.672692E 00	6.722221E 00	-156.57236
8	-5.748729E 00	-2.884201E 00	6.431679E 00	-153.35657
9	-5.199114E 00	-3.107717E 00	6.057119E 00	-149.13156
10	-5.470358E 00	-4.204418E 00	6.899416E 00	-142.45477
11	-5.653335E 00	-5.849939E 00	8.135231E 00	-134.02084
12	-5.274266E 00	-6.547495E 00	8.407589E 00	-128.85281
13	-4.244635E 00	-5.844195E 00	7.222987E 00	-125.99088
14	-3.612100E 00	-6.409081E 00	7.356873E 00	-119.40521
15	-3.747804E 00	-9.756029E 00	1.045113E 01	-111.01441
16	-3.009537E 00	-1.207219E 01	1.244167E 01	-103.99821
17	-1.474442E 00	-9.990295E 00	1.009851E 01	-98.39553
18	-3.740863E-01	-6.874153E 00	6.884324E 00	-93.11492
19	6.063342E-01	-6.822401E 00	6.849292E 00	-84.92123
20	1.121128E 00	-7.534309E 00	7.617266E 00	-81.53631
21	1.153051E 00	-5.814894E 00	5.928112E 00	-78.78415
22	1.251792E 00	-3.817698E 00	4.017686E 00	-71.84611
23	1.442819E 00	-3.362532E 00	3.659009E 00	-66.77645
24	1.863605E 00	-3.270573E 00	3.764262E 00	-60.32507
25	2.096723E 00	-2.884240E 00	3.565822E 00	-53.98440
26	1.870389E 00	-2.361260E 00	3.012292E 00	-51.61673
27	1.721032E 00	-2.026043E 00	2.658346E 00	-49.65360
28	2.118995E 00	-2.319560E 00	3.141735E 00	-47.58727
29	2.257162E 00	-2.539089E 00	3.397315E 00	-48.36401
30	2.091788E 00	-2.132014E 00	2.986814E 00	-45.54565
31	2.029282E 00	-1.983703E 00	2.837792E 00	-44.34928
32	1.752943E 00	-1.809987E 00	2.519694E 00	-45.91725
33	1.371521E 00	-1.300989E 00	1.890408E 00	-43.48822
34	1.409337E 00	-1.199034E 00	1.850382E 00	-40.39043
35	1.541211E 00	-1.191484E 00	1.948067E 00	-37.70699
36	1.748946E 00	-1.409065E 00	2.245947E 00	-38.85718
37	2.421780E 00	-1.846134E 00	3.045198E 00	-37.31843
38	2.569489E 00	-1.518478E 00	2.984636E 00	-30.58159
39	1.975733E 00	-9.129047E-01	2.176446E 00	-24.79971

U-REAL = HANNED V-REALU-IMAG = HANNED V-IMAG

NO.	CURVE 1	CURVE 2
1	-3.971665E 00	-3.971665E 00
2	-4.044943E 00	-4.044943E 00
3	-4.435759E 00	-4.435759E 00
4	-4.582315E 00	-4.582315E 00
5	-4.245236E 00	-4.245236E 00
6	-4.084025E 00	-4.084025E 00
7	-3.893502E 00	-3.893502E 00
8	-4.079139E 00	-4.079139E 00
9	-4.479726E 00	-4.479726E 00
10	-4.572544E 00	-4.572544E 00
11	-4.015632E 00	-4.015632E 00
12	-3.546653E 00	-3.546653E 00
13	-3.629701E 00	-3.629701E 00
14	-3.390327E 00	-3.390327E 00
15	-3.175378E 00	-3.175378E 00
16	-3.361015E 00	-3.361015E 00
17	-3.170493E 00	-3.170493E 00
18	-2.779677E 00	-2.779677E 00
19	-2.760136E 00	-2.760136E 00
20	-3.365901E 00	-3.365901E 00
21	-4.025402E 00	-4.025402E 00
22	-4.435759E 00	-4.435759E 00
23	-4.704445E 00	-4.704445E 00
24	-4.870541E 00	-4.870541E 00
25	-4.709330E 00	-4.709330E 00
26	-4.015632E 00	-4.015632E 00
27	-3.341475E 00	-3.341475E 00
28	-2.911577E 00	-2.911577E 00
29	-2.989741E 00	-2.989741E 00
30	-3.595505E 00	-3.595505E 00
31	-4.181729E 00	-4.181729E 00
32	-4.167073E 00	-4.167073E 00
33	-3.575964E 00	-3.575964E 00
34	-3.028822E 00	-3.028822E 00
35	-3.077674E 00	-3.077674E 00
36	-3.292623E 00	-3.292623E 00
37	-3.019052E 00	-3.019052E 00
38	-2.657547E 00	-2.657547E 00
39	-2.418172E 00	-2.418172E 00
40	-2.271617E 00	-2.271617E 00
41	-2.178798E 00	-2.178798E 00
42	-2.100635E 00	-2.100635E 00
43	-2.520762E 00	-2.520762E 00
44	-3.326819E 00	-3.326819E 00
45	-3.492916E 00	-3.492916E 00
46	-3.566194E 00	-3.566194E 00

INPUT FOR AUTOCORRELATION

SEC. ORDER SYS. WITH WANL TRANSFER FUNCTION CODE

C-VALUES OUTPUT

NO.	C(I)	D(I)
0	4.084668E-01	4.084668E-01
1	3.512163E-01	3.512163E-01
2	2.414027E-01	2.414027E-01
3	1.558739E-01	1.558739E-01
4	1.037744E-01	1.037744E-01
5	6.898308E-02	6.898308E-02
6	4.256642E-02	4.256642E-02
7	2.369547E-02	2.369547E-02
8	1.101029E-02	1.101029E-02
9	1.409292E-03	1.409292E-03
10	-5.470991E-03	-5.470991E-03
11	-9.101391E-03	-9.101391E-03
12	-1.063788E-02	-1.063788E-02
13	-1.094437E-02	-1.094437E-02
14	-9.730458E-03	-9.730458E-03
15	-7.428408E-03	-7.428408E-03
16	-5.306125E-03	-5.306125E-03
17	-3.558278E-03	-3.558278E-03
18	-2.524853E-03	-2.524853E-03
19	-3.055215E-03	-3.055215E-03
20	-3.760695E-03	-3.760695E-03
21	-3.059864E-03	-3.059864E-03
22	-2.164006E-03	-2.164006E-03
23	-1.802087E-03	-1.802087E-03
24	-1.406789E-03	-1.406789E-03
25	-1.452923E-03	-1.452923E-03
26	-2.494693E-03	-2.494693E-03
27	-3.666878E-03	-3.666878E-03
28	-3.058553E-03	-3.058553E-03
29	-6.440878E-04	-6.440878E-04
30	1.632214E-03	1.632214E-03
31	2.642632E-03	2.642632E-03
32	2.321005E-03	2.321005E-03
33	9.785891E-04	9.785891E-04

SEE EQUATION (6) PAGE 57

V-VALUES OUTPUT

NO.	V-REAL	V-IMAG	MODULUS	THETA (DEG.)
0	-1.700078E 00	0.	1.700078E 00	0.
1	4.235979E 00	-0.	4.235979E 00	-0.
2	1.687648E 00	0.	1.687648E 00	0.
3	2.468641E 00	-0.	2.468641E 00	-0.
4	2.146438E 00	0.	2.146438E 00	0.
5	2.446067E 00	-0.	2.446067E 00	-0.
6	1.625487E 00	0.	1.625487E 00	0.
7	2.530284E 00	-0.	2.530284E 00	-0.
8	2.000984E 00	0.	2.000984E 00	0.
9	1.460467E 00	-0.	1.460467E 00	-0.
10	2.332718E 00	0.	2.332718E 00	0.
11	2.002644E 00	-0.	2.002644E 00	-0.
12	2.951540E 00	0.	2.951540E 00	0.
13	1.733109E 00	-0.	1.733109E 00	-0.
14	2.083234E 00	0.	2.083234E 00	0.
15	2.925425E 00	-0.	2.925425E 00	-0.
16	4.115304E 00	0.	4.115303E 00	0.
17	3.133221E 00	-0.	3.133221E 00	-0.
18	1.899522E 00	0.	1.899522E 00	0.
19	1.972950E 00	-0.	1.972950E 00	-0.
20	3.759798E 00	0.	3.759798E 00	0.
21	2.235083E 00	-0.	2.235083E 00	-0.
22	1.502988E 00	0.	1.502988E 00	0.
23	1.624059E 00	-0.	1.624059E 00	-0.
24	1.973493E 00	0.	1.973493E 00	0.
25	1.880850E 00	-0.	1.880850E 00	-0.
26	2.020781E 00	0.	2.020781E 00	0.
27	1.236977E 00	-0.	1.236977E 00	-0.
28	2.533626E 00	0.	2.533626E 00	0.
29	2.657446E 00	-0.	2.657446E 00	-0.
30	1.825256E 00	0.	1.825256E 00	0.
31	2.632240E 00	-0.	2.632240E 00	-0.
32	2.599475E 00	0.	2.599475E 00	0.
33	1.394560E 00	-0.	1.394560E 00	-0.
34	1.732384E 00	0.	1.732384E 00	0.
35	2.371069E 00	-0.	2.371069E 00	-0.
36	1.756440E 00	0.	1.756439E 00	0.
37	4.830451E 00	-0.	4.830451E 00	-0.
38	3.465884E 00	0.	3.465884E 00	0.
39	3.339118E 00	-0.	3.339118E 00	-0.

SEE EQUATIONS (14) and (15)ON PAGE 61

SEC. ORDER SYS. WITH WANL TRANSFER FUNCTION CODE

U-VALUES OUTPUT

NO.	U-REAL	U-IMAG	MODULUS	THETA (DEG.)
0	1.267950E 00	-0.	1.267950E 00	-0.
1	2.114882E 00	0.	2.114882E 00	0.
2	2.519979E 00	-0.	2.519979E 00	-0.
3	2.192842E 00	0.	2.192842E 00	0.
4	2.301896E 00	-0.	2.301896E 00	-0.
5	2.166015E 00	0.	2.166015E 00	0.
6	2.056831E 00	-0.	2.056831E 00	-0.
7	2.171760E 00	0.	2.171760E 00	0.
8	1.998180E 00	-0.	1.998180E 00	-0.
9	1.813659E 00	0.	1.813659E 00	0.
10	2.032137E 00	-0.	2.032137E 00	-0.
11	2.322387E 00	0.	2.322387E 00	0.
12	2.409708E 00	-0.	2.409708E 00	-0.
13	2.125248E 00	0.	2.125248E 00	0.
14	2.206251E 00	-0.	2.206251E 00	-0.
15	3.012347E 00	0.	3.012347E 00	0.
16	3.572313E 00	-0.	3.572313E 00	-0.
17	3.070317E 00	0.	3.070317E 00	0.
18	2.226304E 00	-0.	2.226304E 00	-0.
19	2.401305E 00	0.	2.401305E 00	0.
20	2.931908E 00	-0.	2.931908E 00	-0.
21	2.433238E 00	0.	2.433238E 00	0.
22	1.716279E 00	-0.	1.716279E 00	-0.
23	1.681150E 00	0.	1.681149E 00	0.
24	1.862974E 00	-0.	1.862974E 00	-0.
25	1.938994E 00	0.	1.938994E 00	0.
26	1.789847E 00	-0.	1.789847E 00	-0.
27	1.757090E 00	0.	1.757090E 00	0.
28	2.240419E 00	-0.	2.240419E 00	-0.
29	2.418444E 00	0.	2.418444E 00	0.
30	2.235050E 00	-0.	2.235050E 00	-0.
31	2.422303E 00	0.	2.422303E 00	0.
32	2.306437E 00	-0.	2.306437E 00	-0.
33	1.780245E 00	0.	1.780245E 00	0.
34	1.807599E 00	-0.	1.807599E 00	-0.
35	2.057740E 00	0.	2.057740E 00	0.
36	2.678600E 00	-0.	2.678600E 00	-0.
37	3.720806E 00	0.	3.720806E 00	0.
38	3.775335E 00	-0.	3.775334E 00	-0.
39	2.782234E 00	0.	2.782234E 00	0.

U-REAL = HANNED V-REAL

TRAFER FUNCTION VALUES

NO.	FREQ.	MAGNITUDE	PHASE (DEG.)
0	0.	0.25321E 01	-0.17644E 03
1	0.51733E-01	0.28541E 01	-0.17763E 03
2	0.10357E-00	0.29850E 01	-0.17683E 03
3	0.15535E-00	0.29970E 01	-0.17228E 03
4	0.20713E-00	0.31317E 01	-0.16953E 03
5	0.25891E-00	0.31776E 01	-0.16616E 03
6	0.31070E-00	0.31032E 01	-0.16039E 03
7	0.36248E-00	0.30953E 01	-0.15657E 03
8	0.41426E-00	0.32188E 01	-0.15336E 03
9	0.46604E-00	0.33397E 01	-0.14913E 03
10	0.51783E 00	0.33952E 01	-0.14245E 03
11	0.56961E 00	0.35030E 01	-0.13402E 03
12	0.62139E 00	0.34890E 01	-0.12885E 03
13	0.67318E 00	0.33987E 01	-0.12599E 03
14	0.72496E 00	0.33346E 01	-0.11941E 03
15	0.77674E 00	0.34694E 01	-0.11101E 03
16	0.82852E 00	0.34828E 01	-0.10400E 03
17	0.88031E 00	0.32891E 01	-0.98396E 02
18	0.93209E 00	0.30923E 01	-0.93115E 02
19	0.98387E 00	0.28523E 01	-0.84921E 02
20	0.10357E 01	0.25981E 01	-0.81536E 02
21	0.10874E 01	0.24363E 01	-0.78784E 02
22	0.11392E 01	0.23409E 01	-0.71846E 02
23	0.11910E 01	0.21765E 01	-0.66776E 02
24	0.12428E 01	0.20206E 01	-0.60325E 02
25	0.12946E 01	0.18390E 01	-0.53984E 02
26	0.13464E 01	0.16830E 01	-0.51617E 02
27	0.13981E 01	0.15129E 01	-0.49654E 02
28	0.14499E 01	0.14023E 01	-0.47587E 02
29	0.15017E 01	0.14048E 01	-0.48364E 02
30	0.15535E 01	0.13364E 01	-0.45546E 02
31	0.16053E 01	0.11715E 01	-0.44349E 02
32	0.16570E 01	0.10925E 01	-0.45917E 02
33	0.17088E 01	0.10619E 01	-0.43488E 02
34	0.17606E 01	0.10237E 01	-0.40390E 02
35	0.18124E 01	0.94670E 00	-0.37707E 02
36	0.18642E 01	0.83848E 00	-0.38857E 02
37	0.19160E 01	0.81842E 00	-0.37318E 02
38	0.19677E 01	0.79056E 00	-0.30582E 02
39	0.20195E 01	0.72980E 00	-0.24800E 02
40	0.20713E 01	0.63773E 00	-0.28601E 02
41	0.21231E 01	0.59373E 00	-0.34524E 02
42	0.21749E 01	0.57060E 00	-0.31620E 02
43	0.22267E 01	0.51967E 00	-0.29241E 02

4. TRANSFER FUNCTION EXAMPLE #4

Extracts from WANL correlation codes. The input and output waves were entered in the same order as in example #1. In this example the mean values were removed from the waves before applying equations (4) and (5) on page 57. Again the desired results were the magnitude and phase representing the transfer function.

The meaning of removal of the mean is described below:

$$\text{let } \bar{X} = \frac{1}{N} \sum_{i=1}^N X_i \quad \text{and} \quad \bar{y} = \frac{1}{N} \sum_{i=1}^N y_i$$

$$\text{and let } \widetilde{X}_i = X_i - \bar{X} \quad \text{and} \quad \widetilde{y}_i = y_i - \bar{y}$$

then equations (4) and (5) on page 57 become

$$(4a) \quad \phi_{XY}(\tau) \cong \frac{1}{N-r} \sum_{i=1}^{N-r} \widetilde{X}_i \widetilde{y}_{i+r}$$

$$(5a) \quad \phi_{YX}(\tau) \cong \frac{1}{N-r} \sum_{i=1}^{N-r} \widetilde{y}_i \widetilde{X}_{i+r}$$

MOVEX= 100 INPTX= 1000 MOVFY= 100 INPTY= 1000

NO. OF SHIFTS= 900 SAMPLING RATE= 93.21
INPUT DATA

NO.	CURVE 1	CURVE 2
1	-3.971065E 00	-7.151928E 00
2	-4.044943E 00	-7.122517E 00
3	-4.435759E 00	-7.093306E 00
4	-4.582315E 00	-7.054224E 00
5	-4.245246E 00	-7.010258E 00
6	-4.064025E 00	-6.956520E 00
7	-3.893502E 00	-6.912554E 00
8	-4.079139E 00	-6.863702E 00
9	-4.479726E 00	-6.809965E 00
10	-4.572544E 00	-6.746457E 00
11	-4.015632E 00	-6.702490E 00
12	-3.546653E 00	-6.643868E 00
13	-3.629701E 00	-6.595016E 00
14	-3.390327E 00	-6.555934E 00
15	-3.175378E 00	-6.516853E 00
16	-3.361015E 00	-6.497312E 00
17	-3.170493E 00	-6.477771E 00
18	-2.779677E 00	-6.477771E 00
19	-2.760136E 00	-6.487542E 00
20	-3.365901E 00	-6.507082E 00
21	-4.025402E 00	-6.536394E 00
22	-4.435759E 00	-6.565705E 00
23	-4.704445E 00	-6.580360E 00
24	-4.870541E 00	-6.590131E 00
25	-4.709330E 00	-6.585245E 00
26	-4.015632E 00	-6.575475E 00
27	-3.341475E 00	-6.565705E 00
28	-2.911577E 00	-6.551049E 00
29	-2.989741E 00	-6.555734E 00
30	-3.595505E 00	-6.575475E 00
31	-4.101729E 00	-6.590131E 00
32	-4.167073E 00	-6.634097E 00
33	-3.575964E 00	-6.614557E 00
34	-3.028822E 00	-6.624327E 00
35	-3.077674E 00	-6.653538E 00
36	-3.292623E 00	-6.678064E 00

INPUT VALUES

INPUT VALUES WITH SIGN AND EXPONENT

1	-3.573003E-01	2.216874E-01
2	-4.30553E-01	3.100086E-01
3	-5.21470E-01	3.403097E-01
4	-3.60029E-01	3.793013E-01
5	-6.309013E-01	4.233001E-01
6	-4.507309E-01	4.770003E-01
7	-2.702172E-01	5.210621E-01
	-4.648547E-01	5.609140E-01
	-8.604408E-01	6.236012E-01
10	-3.502000E-01	6.871038E-01
11	-4.013471E-01	7.311255E-01
12	6.763131E-02	7.807479E-01
13	-1.541003E-02	8.385000E-01
14	2.230001E-01	8.776314E-01
15	4.339003E-01	9.167630E-01
16	2.532603E-01	9.363038E-01
17	4.407000E-01	9.558446E-01
18	3.346077E-01	9.558446E-01
19	3.541430E-01	9.460742E-01
20	2.403341E-01	9.205334E-01
21	-4.111175E-01	8.072222E-01
22	-8.214740E-01	8.679110E-01
23	-1.090100E-00	8.532505E-01
24	-1.206207E-00	8.434851E-01
25	-1.005040E-00	8.483703E-01
26	-4.013471E-01	8.581406E-01
27	2.728101E-01	8.679110E-01
28	7.027074E-01	8.825066E-01
29	6.245443E-01	8.776314E-01
30	1.377934E-02	8.581406E-01
31	-5.074433E-01	8.434851E-01
32	-3.527882E-01	7.005193E-01
33	3.002003E-02	8.100001E-01
34	5.304007E-01	8.002337E-01
35	3.306107E-01	7.709775E-01
36	3.216621E-01	7.555510E-01
37	5.952331E-01	7.213551E-01
38	3.507377E-01	6.522736E-01
39	1.106112E-00	6.138895E-01
40	1.342008E-00	5.404381E-01
41	1.405407E-00	4.673240E-01
42	1.513000E-00	3.606200E-01
43	1.003503E-00	2.621406E-01
44	0.0074007E-01	1.400107E-01
45	1.213600E-01	2.760710E-02

U-VALUES OUTPUT

U	U(1)	U(1)
1	-2.126327E-02	-2.126327E-02
2	-3.528185E-02	-1.020207E-02
3	-5.378344E-02	-2.730323E-03
4	-7.33733E-02	2.38599E-03
5	-9.341571E-02	5.143244E-03
6	-1.131321E-01	6.389002E-03
7	-1.313365E-01	7.359446E-03
8	-1.490981E-01	8.352474E-03
9	-1.659051E-01	8.467732E-03
10	-1.794533E-01	8.456711E-03
11	-1.921330E-01	8.361516E-03
12	-2.032055E-01	8.214132E-03
13	-2.123537E-01	8.075791E-03
14	-2.199355E-01	8.021527E-03
15	-2.261962E-01	8.063609E-03
16	-2.312273E-01	8.170729E-03
17	-2.351400E-01	8.335111E-03
18	-2.379356E-01	8.504407E-03
19	-2.394167E-01	8.655876E-03
20	-2.398135E-01	8.844305E-03
21	-2.394477E-01	9.144128E-03
22	-2.382267E-01	9.579620E-03
23	-2.359656E-01	1.010756E-02
24	-2.326148E-01	1.070674E-02
25	-2.283140E-01	1.132545E-02
26	-2.233353E-01	1.181289E-02
27	-2.178130E-01	1.215024E-02
28	-2.119662E-01	1.239795E-02
29	-2.058344E-01	1.264552E-02
30	-1.994857E-01	1.295206E-02
31	-1.926552E-01	1.332245E-02
32	-1.854373E-01	1.367231E-02
33	-1.780331E-01	1.392452E-02
34	-1.702722E-01	1.403242E-02
35	-1.618478E-01	1.401147E-02
36	-1.529172E-01	1.397547E-02
37	-1.444471E-01	1.393400E-02
38	-1.357202E-01	1.386555E-02
39	-1.268225E-01	1.379599E-02
40	-1.177025E-01	1.377336E-02

SEE EQUATIONS (4) and (5) ON PAGE 57

SEC. ORDER SYS. WITH WANL TRANSFER FUNCTION CODE

V-VALUES OUTPUT

NL.	V-REAL	V-IMAG	MODULUS	THETA (DEG.)
0	4.880307E 00	0.	4.880307E 00	0.
1	-1.143319E 01	-3.952713E-01	1.143509E 01	-178.01447
2	-6.250416E 00	-2.007022E-01	6.253637E 00	-178.16085
3	-6.074813E 00	-8.608875E-01	6.135515E 00	-171.93408
4	-7.650007E 00	-1.613109E 00	7.818289E 00	-168.09232
5	-6.984173E 00	-1.155143E 00	7.079055E 00	-170.60862
6	-5.113026E 00	-2.662246E 00	5.765396E 00	-152.49908
7	-6.839766E 00	-2.087939E 00	7.151356E 00	-163.02442
8	-5.879730E 00	-3.852741E 00	7.029736E 00	-146.76574
9	-4.304833E 00	-1.743507E 00	4.728087E 00	-158.36113
10	-6.127260E 00	-5.091727E 00	7.966743E 00	-140.27356
11	-5.232444E 00	-4.891151E 00	7.162536E 00	-136.33080
12	-6.020936E 00	-8.525525E 00	1.043728E 01	-125.23090
13	-3.322393E 00	-4.247592E 00	5.714591E 00	-131.38766
14	-3.312027E 00	-6.356101E 00	7.167252E 00	-117.52300
15	-4.001605E 00	-8.676859E 00	9.555175E 00	-114.75857
16	-3.676152E 00	-1.531482E 01	1.574985E 01	-103.49784
17	-6.843855E-01	-8.782510E 00	9.008544E 00	-94.35700
18	-8.531266E-01	-6.631231E 00	6.735538E 00	-77.27666
19	8.239482E-01	-5.151374E 00	5.228365E 00	-80.15517
20	1.490074E 00	-1.030536E 01	1.041253E 01	-81.77239
21	6.098547E-01	-4.375026E 00	4.417327E 00	-82.06441
22	1.702043E 00	-4.204152E 00	4.614397E 00	-65.65704
23	5.729347E-01	-2.487457E 00	2.557150E 00	-76.53261
24	2.683232E 00	-4.270987E 00	5.043314E 00	-57.86105
25	1.404931E 00	-2.052816E 00	2.539493E 00	-53.93570
26	2.713503E 00	-3.160350E 00	4.165453E 00	-49.35037
27	5.504102E-01	-1.071452E 00	1.208697E 00	-62.43072
28	3.051355E 00	-2.800965E 00	4.142391E 00	-42.54516
29	1.313029E 00	-2.605032E 00	3.173341E 00	-55.16317
30	2.350811E 00	-2.145397E 00	3.182609E 00	-42.38407
31	1.852276E 00	-1.652372E 00	2.468935E 00	-41.38875
32	2.061512E 00	-2.524794E 00	3.259512E 00	-50.76813
33	1.036356E 00	-5.579235E-01	1.176978E 00	-28.29652
34	1.351656E 00	-1.553327E 00	2.066618E 00	-49.15364
35	1.397490E 00	-1.111508E 00	2.109117E 00	-30.36287
36	1.018093E 00	-9.793181E-01	1.412649E 00	-43.88789
37	3.062021E 00	-2.565940E 00	3.994999E 00	-39.96264
38	2.544065E 00	-1.273312E 00	2.945728E 00	-26.58000
39	2.126055E 00	-9.612759E-01	2.333227E 00	-24.33017

SEE EQUATIONS (10), (11),

and (12) ON PAGE 60

U-VALUES OUTPUT

U.	U-REAL	U-IMAG	MODULUS	THETA (DEG.)
1	-3.303894E 00	-1.991357E-01	3.309990E 00	-176.55078
1	-6.036598E 00	-2.493117E-01	6.021702E 00	-177.65443
2	-7.515997E 00	-4.151408E-01	7.527415E 00	-176.83850
3	-6.512535E 00	-8.338965E-01	6.572235E 00	-172.27090
4	-7.069781E 00	-1.310562E 00	7.229894E 00	-169.52696
5	-6.653035E 00	-1.646410E 00	6.882893E 00	-166.16049
6	-6.012948E 00	-2.141893E 00	6.383944E 00	-160.39341
7	-6.168347E 00	-2.672716E 00	6.722493E 00	-156.57314
8	-5.748627E 00	-2.884232E 00	6.431602E 00	-153.35592
9	-5.197239E 00	-3.107570E 00	6.057905E 00	-149.13092
10	-5.470462E 00	-4.204530E 00	6.899567E 00	-142.45456
11	-5.653284E 00	-5.849893E 00	8.135162E 00	-134.02081
12	-5.274327E 00	-6.547451E 00	8.407594E 00	-128.85333
13	-4.244698E 00	-5.844202E 00	7.223030E 00	-125.99125
14	-3.612159E 00	-6.409166E 00	7.356971E 00	-119.40522
15	-3.747876E 00	-9.756165E 00	1.045128E 01	-111.01451
16	-3.009589E 00	-1.207225E 01	1.244174E 01	-103.99838
17	-1.474512E 00	-9.990263E 00	1.009851E 01	-98.39593
18	-3.741726E-01	-6.874116E 00	6.884292E 00	-93.11565
19	6.062160E-01	-6.822349E 00	6.849229E 00	-84.92218
20	1.120998E 00	-7.534278E 00	7.617216E 00	-81.53725
21	1.152962E 00	-5.814890E 00	5.928091E 00	-78.78499
22	1.251719E 00	-3.817697E 00	4.017662E 00	-71.84799
23	1.442786E 00	-3.362513E 00	3.658979E 00	-66.77661
24	1.863595E 00	-3.270562E 00	3.764248E 00	-60.32513
25	2.096676E 00	-2.884245E 00	3.565798E 00	-53.98506
26	1.879352E 00	-2.361247E 00	3.012259E 00	-51.61713
27	1.721053E 00	-2.026057E 00	2.658370E 00	-49.65345
28	2.119052E 00	-2.319603E 00	3.141095E 00	-47.58703
29	2.257158E 00	-2.539104E 00	3.397344E 00	-43.36335
30	2.091757E 00	-2.132045E 00	2.986501E 00	-45.54676
31	2.929229E 00	-1.983732E 00	2.837774E 00	-44.35043
32	1.752914E 00	-1.809972E 00	2.519664E 00	-45.91749
33	1.371455E 00	-1.300994E 00	1.890364E 00	-43.43971
34	1.409275E 00	-1.199945E 00	1.850341E 00	-40.39194
35	1.541177E 00	-1.191460E 00	1.943026E 00	-37.70706
36	1.748974E 00	-1.409044E 00	2.245916E 00	-38.85711
37	2.421775E 00	-1.846127E 00	3.45189E 00	-37.31840
38	2.569459E 00	-1.518460E 00	2.984626E 00	-30.52130
39	1.975722E 00	-9.129085E-01	2.176437E 00	-24.79992

U-REAL = HANNED V-REALU-IMAG = HANNED V-IMAG

IL	CURVE 1	CURVE 2
1	-3.271555E 00	-3.271555E 00
2	-4.544743E 00	-4.544743E 00
3	-4.435759E 00	-4.435759E 00
4	-4.532315E 00	-4.532315E 00
5	-4.245236E 00	-4.245236E 00
6	-4.064025E 00	-4.064025E 00
7	-3.393502E 00	-3.393502E 00
8	-4.079139E 00	-4.079139E 00
9	-4.479726E 00	-4.479726E 00
10	-4.572544E 00	-4.572544E 00
11	-4.015632E 00	-4.015632E 00
12	-3.546653E 00	-3.546653E 00
13	-3.629701E 00	-3.629701E 00
14	-3.390327E 00	-3.390327E 00
15	-3.175378E 00	-3.175378E 00
16	-3.361015E 00	-3.361015E 00
17	-3.170473E 00	-3.170473E 00
18	-2.779577E 00	-2.779577E 00
19	-2.760136E 00	-2.760136E 00
20	-3.365901E 00	-3.365901E 00
21	-4.025402E 00	-4.025402E 00
22	-4.435759E 00	-4.435759E 00
23	-4.704445E 00	-4.704445E 00
24	-4.870541E 00	-4.870541E 00
25	-4.707330E 00	-4.707330E 00
26	-4.015632E 00	-4.015632E 00
27	-3.341475E 00	-3.341475E 00
28	-2.911577E 00	-2.911577E 00
29	-2.969741E 00	-2.969741E 00
30	-3.595505E 00	-3.595505E 00
31	-4.161729E 00	-4.161729E 00
32	-4.167073E 00	-4.167073E 00
33	-3.575764E 00	-3.575764E 00
34	-3.028322E 00	-3.028322E 00
35	-3.077674E 00	-3.077674E 00
36	-3.292623E 00	-3.292623E 00
37	-3.019052E 00	-3.019052E 00
38	-2.657547E 00	-2.657547E 00
39	-2.418172E 00	-2.418172E 00
40	-2.271617E 00	-2.271617E 00
41	-2.178778E 00	-2.178778E 00
42	-2.100635E 00	-2.100635E 00
43	-2.520762E 00	-2.520762E 00
44	-3.326319E 00	-3.326319E 00
45	-3.472916E 00	-3.472916E 00
46	-3.506194E 00	-3.506194E 00

INPUT FOR AUTOCORRELATION

1	-3.573803E-01	-3.573803E-01
2	-4.356583E-01	-4.356583E-01
3	-8.214740E-01	-8.214740E-01
4	-9.650299E-01	-9.650299E-01
5	-6.309513E-01	-6.309513E-01
6	-4.607379E-01	-4.607379E-01
7	-2.702172E-01	-2.702172E-01
	-4.643547E-01	-4.643547E-01
8	-8.654408E-01	-8.654408E-01
10	-9.582595E-01	-9.582595E-01
11	-4.013471E-01	-4.013471E-01
12	6.763181E-02	6.763181E-02
13	-1.541553E-02	-1.541553E-02
14	2.239581E-01	2.239581E-01
15	4.389068E-01	4.389068E-01
16	2.532693E-01	2.532693E-01
17	4.437920E-01	4.437920E-01
18	8.346077E-01	8.346077E-01
19	8.541485E-01	8.541485E-01
20	2.483841E-01	2.483841E-01
21	-4.111175E-01	-4.111175E-01
22	-8.214740E-01	-8.214740E-01
23	-1.090160E-00	-1.090160E-00
24	-1.256257E-00	-1.256257E-00
25	-1.095045E-00	-1.095045E-00
26	-4.013471E-01	-4.013471E-01
27	2.728101E-01	2.728101E-01
28	7.027074E-01	7.027074E-01
29	6.245443E-01	6.245443E-01
30	1.877984E-02	1.877984E-02
31	-5.674438E-01	-5.674438E-01
32	-5.527882E-01	-5.527882E-01
33	3.832063E-02	3.832063E-02
34	5.854627E-01	5.854627E-01
35	5.366107E-01	5.366107E-01
36	3.216621E-01	3.216621E-01
37	5.952331E-01	5.952331E-01
38	9.567377E-01	9.567377E-01
39	1.196112E-00	1.196112E-00
40	1.342608E-00	1.342608E-00
41	1.435407E-00	1.435407E-00
42	1.513550E-00	1.513550E-00
43	1.093523E-00	1.093523E-00
44	2.074557E-01	2.074557E-01
45	1.213590E-01	1.213590E-01

C-VALUES OUTPUT

NO.	C(I)	D(I)
0	4.084058E-01	4.084058E-01
1	3.511558E-01	3.511558E-01
2	2.413439E-01	2.413439E-01
3	1.558144E-01	1.558144E-01
4	1.037147E-01	1.037147E-01
5	6.892463E-02	6.892463E-02
6	4.250872E-02	4.250872E-02
7	2.363708E-02	2.363708E-02
8	1.095186E-02	1.095186E-02
9	1.350463E-03	1.350463E-03
10	-5.529427E-03	-5.529427E-03
11	-9.162015E-03	-9.162015E-03
12	-1.069573E-02	-1.069573E-02
13	-1.100354E-02	-1.100354E-02
14	-9.789561E-03	-9.789561E-03
15	-7.437046E-03	-7.437046E-03
16	-5.366486E-03	-5.366486E-03
17	-3.617961E-03	-3.617961E-03
18	-2.582721E-03	-2.582721E-03
19	-3.113719E-03	-3.113719E-03
20	-3.820739E-03	-3.820739E-03
21	-3.119030E-03	-3.119030E-03
22	-2.223314E-03	-2.223314E-03
23	-1.862592E-03	-1.862592E-03
24	-1.465424E-03	-1.465424E-03
25	-1.511192E-03	-1.511192E-03
26	-2.553261E-03	-2.553261E-03
27	-3.725409E-03	-3.725409E-03
28	-3.118085E-03	-3.118085E-03
29	-7.019975E-04	-7.019975E-04
30	1.573973E-03	1.573973E-03
31	2.585302E-03	2.585302E-03
32	2.263338E-03	2.263338E-03
33	9.193755E-04	9.193755E-04
34	-1.084355E-03	-1.084355E-03
35	-3.105086E-03	-3.105086E-03
36	-4.542978E-03	-4.542978E-03
37	-5.629291E-03	-5.629291E-03
38	-6.598352E-03	-6.598352E-03
39	-7.125863E-03	-7.125863E-03

SEE EQUATION (6) ON PAGE 57

V-VALUES OUTPUT

N.	V-REAL	V-IMAG	MODULUS	THETA (DEG.)
	-1.780122E 00	0.	1.780122E 00	0.
1	4.223302E 00	-0.	4.223302E 00	-0.
2	1.689690E 00	0.	1.689690E 00	0.
3	2.467370E 00	-0.	2.467379E 00	-0.
4	2.145139E 00	0.	2.145139E 00	0.
5	2.446583E 00	-0.	2.446583E 00	-0.
6	1.625218E 00	0.	1.625218E 00	0.
7	2.529919E 00	-0.	2.529919E 00	-0.
8	2.001350E 00	0.	2.001350E 00	0.
9	1.460153E 00	-0.	1.460153E 00	-0.
10	2.332599E 00	0.	2.332599E 00	0.
11	2.002604E 00	-0.	2.002604E 00	-0.
12	2.951330E 00	0.	2.951330E 00	0.
13	1.733128E 00	-0.	1.733128E 00	-0.
14	2.083281E 00	0.	2.083281E 00	0.
15	2.925247E 00	-0.	2.925247E 00	-0.
16	4.115286E 00	0.	4.115286E 00	0.
17	3.133167E 00	-0.	3.133167E 00	-0.
18	1.899490E 00	0.	1.899490E 00	0.
19	1.972926E 00	-0.	1.972926E 00	-0.
20	3.759773E 00	0.	3.759773E 00	0.
21	2.235062E 00	-0.	2.235062E 00	-0.
22	1.502981E 00	0.	1.502981E 00	0.
23	1.624060E 00	-0.	1.624060E 00	-0.
24	1.973543E 00	0.	1.973543E 00	0.
25	1.880855E 00	-0.	1.880855E 00	-0.
26	2.020800E 00	0.	2.020800E 00	0.
27	1.236942E 00	-0.	1.236942E 00	-0.
28	2.533659E 00	0.	2.533659E 00	0.
29	2.657484E 00	-0.	2.657484E 00	-0.
30	1.825298E 00	0.	1.825298E 00	0.
31	2.632194E 00	-0.	2.632194E 00	-0.
32	2.599451E 00	0.	2.599451E 00	0.
33	1.394492E 00	-0.	1.394492E 00	-0.
34	1.732364E 00	0.	1.732364E 00	0.
35	2.371154E 00	-0.	2.371154E 00	-0.
36	1.756391E 00	0.	1.756391E 00	0.
37	4.830416E 00	-0.	4.830416E 00	-0.
38	3.465725E 00	0.	3.465725E 00	0.
39	3.339251E 00	-0.	3.339251E 00	-0.

SEE EQUATIONS (14) and (15)

ON PAGE 61

SEC. ORDER SYS. WITH WAVE TRANSFER FUNCTION CODE

U-VALUES OUTPUT

NO.	U-REAL	U-IMAG	MODULUS	THETA (DEG.)
0	1.221590E 00	-0.	1.221590E 00	-0.
1	2.089043E 00	0.	2.089043E 00	0.
2	2.517640E 00	-0.	2.517640E 00	-0.
3	2.192659E 00	0.	2.192659E 00	0.
4	2.301210E 00	-0.	2.301210E 00	-0.
5	2.165893E 00	0.	2.165893E 00	0.
6	2.056734E 00	-0.	2.056734E 00	-0.
7	2.171602E 00	0.	2.171601E 00	0.
8	1.998193E 00	-0.	1.998193E 00	-0.
9	1.813564E 00	0.	1.813564E 00	0.
10	2.031989E 00	-0.	2.031989E 00	-0.
11	2.322234E 00	0.	2.322284E 00	0.
12	2.409598E 00	-0.	2.409598E 00	-0.
13	2.125217E 00	0.	2.125217E 00	0.
14	2.206234E 00	-0.	2.206234E 00	-0.
15	3.012265E 00	0.	3.012265E 00	0.
16	3.572247E 00	-0.	3.572247E 00	-0.
17	3.070273E 00	0.	3.070278E 00	0.
18	2.226268E 00	-0.	2.226268E 00	-0.
19	2.401279E 00	0.	2.401279E 00	0.
20	2.931833E 00	-0.	2.931833E 00	-0.
21	2.433220E 00	0.	2.433219E 00	0.
22	1.716271E 00	-0.	1.716271E 00	-0.
23	1.681161E 00	0.	1.681161E 00	0.
24	1.863001E 00	-0.	1.863001E 00	-0.
25	1.939013E 00	0.	1.939013E 00	0.
26	1.789849E 00	-0.	1.789849E 00	-0.
27	1.757086E 00	0.	1.757086E 00	0.
28	2.240436E 00	-0.	2.240436E 00	-0.
29	2.418481E 00	0.	2.418481E 00	0.
30	2.235069E 00	-0.	2.235069E 00	-0.
31	2.422284E 00	0.	2.422284E 00	0.
32	2.306397E 00	-0.	2.306397E 00	-0.
33	1.780200E 00	0.	1.780200E 00	0.
34	1.807573E 00	-0.	1.807573E 00	-0.
35	2.057766E 00	0.	2.057766E 00	0.
36	2.678588E 00	-0.	2.678588E 00	-0.
37	3.720787E 00	0.	3.720787E 00	0.
38	3.775379E 00	-0.	3.775379E 00	-0.
39	2.982315E 00	0.	2.982315E 00	0.

U-REAL = HANNED V-REAL

TRANSFER FUNCTION VALUES

NO.	FREQ.	MAGNITUDE	PHASE (DEG.)
0	0.	0.27095E 01	-0.17655E 03
1	0.51783E-01	0.23160E 01	-0.17765E 03
2	0.10357E-00	0.23879E 01	-0.17684E 03
3	0.15535E-00	0.23974E 01	-0.17227E 03
4	0.20713E-00	0.31331E 01	-0.16953E 03
5	0.25891E-00	0.31777E 01	-0.16616E 03
6	0.31075E-00	0.31035E 01	-0.16039E 03
7	0.36248E-00	0.30956E 01	-0.15657E 03
8	0.41420E-00	0.32187E 01	-0.15336E 03
9	0.46604E-00	0.33400E 01	-0.14913E 03
10	0.51783E 00	0.33955E 01	-0.14245E 03
11	0.56961E 00	0.35031E 01	-0.13402E 03
12	0.62139E 00	0.34892E 01	-0.12885E 03
13	0.67318E 00	0.33987E 01	-0.12599E 03
14	0.72496E 00	0.33346E 01	-0.11941E 03
15	0.77674E 00	0.34636E 01	-0.11101E 03
16	0.82852E 00	0.34829E 01	-0.10400E 03
17	0.88031E 00	0.32891E 01	-0.98396E 02
18	0.93209E 00	0.30923E 01	-0.93116E 02
19	0.98387E 00	0.28523E 01	-0.84922E 02
20	0.10357E 01	0.25981E 01	-0.81537E 02
21	0.10874E 01	0.24363E 01	-0.78785E 02
22	0.11392E 01	0.23409E 01	-0.71847E 02
23	0.11910E 01	0.21765E 01	-0.66777E 02
24	0.12428E 01	0.20205E 01	-0.60325E 02
25	0.12946E 01	0.18390E 01	-0.53985E 02
26	0.13464E 01	0.16830E 01	-0.51617E 02
27	0.13981E 01	0.15129E 01	-0.49653E 02
28	0.14499E 01	0.14023E 01	-0.47587E 02
29	0.15017E 01	0.14047E 01	-0.48364E 02
30	0.15535E 01	0.13363E 01	-0.45547E 02
31	0.16053E 01	0.11715E 01	-0.44350E 02
32	0.16570E 01	0.10925E 01	-0.45917E 02
33	0.17088E 01	0.10619E 01	-0.43490E 02
34	0.17606E 01	0.10238E 01	-0.40392E 02
35	0.18124E 01	0.94667E 00	-0.37707E 02
36	0.18642E 01	0.83847E 00	-0.38857E 02
37	0.19160E 01	0.81843E 00	-0.37318E 02
38	0.19677E 01	0.79055E 00	-0.30581E 02
39	0.20195E 01	0.72978E 00	-0.24809E 02
40	0.20713E 01	0.63772E 00	-0.28604E 02
41	0.21231E 01	0.59373E 00	-0.34527E 02
42	0.21749E 01	0.57058E 00	-0.31617E 02
43	0.22267E 01	0.51988E 00	-0.29241E 02

REFERENCES

- 1) Instrumentation Systems and Facilities Support - 706.
- 2) "Analytical Study of Vibration Data Reduction Methods" by Bendat, Enochson, and Piersol.
- 3) " Statistical Theory of Communications" by Y. W. Lee.
- 4) "A Generalized Least Squares Program", WANL-TME-756, C. P. Saalbach, April 1964.

APPENDIX I

This appendix presents a computer flow diagram for the SPIT Program.

MAIN PROGRAM

MAIN PROGRAM

MAIN PROGRAM

INPUT SUBROUTINE

This subroutine reads in and writes out the input data.

SUBROUTINE NUSANE

This subroutine reads in data from the full scale calibration step and computes the average full scale d.c. voltage for each channel.

CAL SUBROUTINE

This subroutine reads into storage, for each step, the desired calibration data to be averaged.

CALERT SUBROUTINE

This subroutine calculates an average value for each of the 5 channels for the current calibration step.

AT

CALCHA SUBROUTINE

This subroutine tests the recording channels for linearity and calculates the final calibration coefficients for those channels which pass the linearity test.

OUT SUBROUTINE

This subroutine writes on the output tape the input information concerning the test in general and each channel in particular.

PIP SUBROUTINE

This subroutine calculates the number of records required on the W-3 tape to process the current time slice and also accumulates the total number of records on the W-3 tape. If this time slice will more than fill a full tape, it will not be processed. If the total will more than fill the current tape, a message is printed to mount another full tape on A-4.

A10

PUTWAY SUBROUTINE

This subroutine adjusts the channel values to take account of the third calibration step not being equal to zero, and converts these values to values with engineering units. These values are then transferred to the output buffer, and when the buffer is full, it is written onto the output tape.

RELENT SUBROUTINE

This subroutine writes onto the W-3 tape any values in the output buffer upon completion of a time slice. The maximum and minimum channel values are converted to floating point numbers and written onto the output tape.

SHIFT SUBROUTINE

This subroutine calculates the number of places to left; shift the AC and IQ registers when unpacking data.

SUBROUTINES HELP AND PITFAL

Subroutine PITFAL unpacks the channel number only of an A-D record and is used to position the A-D tape to the beginning of the run data.

Subroutine HELP unpacks the channel number and returns it to the calling program as an argument.

SUBROUTINES READST, OHMY, SWITCH AND READB6

This subroutine reads a record from the A-D tape into the correct input buffer and checks for redundancy errors and end of files.

SUBROUTINE UNPK

This subroutine unpacks run (non-calibration) data for records with a sampling rate of 3050.

SUBROUTINE UNPACK

This subroutine unpacks calibration data.