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**A COMPUTER CODE FOR THE ANALYSIS
OF DIGITIZED SEISMIC SIGNALS**

Barry C. Howard

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A COMPUTER CODE FOR THE ANALYSIS OF DIGITIZED SEISMIC SIGNALS

Abstract

The ADSS code, a multipurpose tool for the reduction of digitized seismic signal data, is presented. The 48 major functions of the code, subroutines identified and called by number, are described. A sample application of the program to digitized seismic data is included. This paper can serve both as an introduction and as a reference manual for the ADSS code.

Introduction

The ADSS computer code is basically a modified version of the A/D 6600 ("SNORTER") code written by David Schreiber and Robert Veilleux.¹ This latter code is a multipurpose program used for the reduction of digitized data produced by the W Division Data Reduction Center at Lawrence Radiation Laboratory, Livermore. The adaptation of the A/D 6600 code to the problem of analyzing digitized seismic signals, with the addition of certain capabilities, has produced the present form of the ADSS code.

The structure of the ADSS program allows much versatility in its application. It is essentially a family of subroutines headed by a main subroutine; specialized subroutines for input, analysis, display, etc., may be added to the code to increase its capabilities. For example, by adding a subroutine which reads data points from cards, any of the operations available in the ADSS code may be applied to a series of discreet amplitudes punched in cards.

The ADSS code is stored on magnetic tape and is operational on both the CDC-6600 and -7600 machines.

Method of Operation

The major operations performed by the ADSS code are identified by number, and any task within the capability of the program must therefore be requested by its assigned number, or "instruction number." Several operations require that additional numbers, besides the appropriate instruction number, must be supplied in the calling of that instruction. For example, the function which reads the label library for plotting is

¹Schreiber, David and R. Vielleux, "A General Computer Code for Environmental Test Data Reduction on the CDC-6600 Computer," unpublished.

assigned instruction No. 1, but must be called by using "1 N1," where N1 is the number of labels to be read for each axis.

The instruction numbers (together with any required supplemental numbers) which correspond to the sequence of operations requested by the user form the "instruction string." Thus, the entries of the instruction string control the logical execution of the code, and must be read by the program first. Each entry is punched in 15 format, with up to 16 entries on a card. A special sentinel, 99999, must be included as the last entry in the instruction string. After reading the string, the main subroutine then interprets each instruction sequentially, executing the simple instructions itself and transferring control to the appropriate subroutines for the more complex operations.

Many of the operations (instructions) of the code require information not supplied by the instruction string in order to be executed. This information is read from supplemental data cards, which must be read in the exact order that the corresponding instruction numbers occur in the instruction string. Hence, if the first instruction of the instruction string is "1 3," then the six label cards (three for each axis) to be read by that instruction must be placed immediately following the set of instruction string cards in the input deck.

Classes of Instructions

INITIALIZATION

Several instructions must be called first to set parameters which control the functioning of various other instructions.

Instruction numbers in this class are:

- 1 - read labels
- 2 - specify X-axis labels
- 3 - specify Y-axis labels
- 4 - channel numbering
- 5 - calibration scaling units
- 6 - ID label
- 7 - time code factor
- 12 - number of channels
- 14 - size of data disk file
- 16 - termination of job
- 21 - input device initialization

Before the first reading of digitized data, several instructions must be called. First, the number of multiplexed channels (NCHANS) on the input device (usually magnetic tape) must be set by using instruction No. 12. The code is capable of processing up to 30 multiplexed data channels. Second, the digital tape unit or input disk file must be initialized by calling Instr. 21. Third, the ID label for diagnostic

messages must be read using Instr. 6. Also, if applicable, the time code factor must be set by Instr. 7, and the size of the data disk file (initially 81000) altered using Instr. 14.

Before scaling the data, the engineering units (ACOR values) which apply to the calibration pulse of each channel must be set by Instr. 5. Any plotting or processing of the data channels requires that the label library be read by Instr. 1, axis labels be designated by use of Instrs. 2 and 3, and the channel numbers (ICOR values) be assigned to each channel by Instr. 4.

The last instruction to be called, immediately before the 99999 sentinel, should be No. 16, which provides the normal termination of the job.

DIGITAL DATA INPUT

The multiplexed data is usually read directly from a magnetic tape. However, if the contents of the tape are transferred to a disk file prior to the use of this code, the data can be read from that input disk file.

Instruction numbers in this class are:

- 22 - rewind input device
- 23 - space over data records
- 24 - space over data files
- 25 - backspace over data files
- 27 - unload data tape
- 28 - destroy input disk file
- 32 - read digital data
- 34 - save data

The digitized data produced by the A/D converter is grouped into data records. Each record consists of 27 scans, 11 words per scan, and 36 binary bits per word. The 11 words of each scan consist of one time word followed by 10 data words. The time word has the following bit pattern:

Ignore	Hours	Minutes	Seconds	Milliseconds	1/10 m.s.
5 bits	5	6	6	10	4 bits

The 36 bits of each data word contain three 12-bit data points. Because two bits are ignored, the number of possible values each data point may assume is $2^{10} = 1024$. When unpacked and converted to 60-bit data points, these values are interpreted decimally as -511 to 511, inclusive.

The data records are grouped by end-of-file (EOF) marks, and the read unit must be positioned at the beginning of the data file to be read. To accomplish this, the input device may be spaced forward over data records (Instr. 23) or data files (Instr. 24), backspaced over data files (Instr. 25) or rewound (Instr. 22). Finally, Instr. 27 unloads the magnetic tape from the read unit, or if the input is from disk, the input disk file is destroyed by Instr. 28.

Instruction 32 searches the scans of successive data records until the initial time word which is greater than or equal to the input begin-read-time is found. The average increment between the 27 time words of the record to which this first time word belongs is computed, and then compared with each of the 26 increments. If fewer than three increments deviate more than 0.001 seconds from the average, the time-per-point (TPP) is computed (in seconds) by dividing the average time word increment by the number of data points sampled from each scan. However, if three or more errant increments are found, the next data record is used to compute TPP. The data points are read, unpacked, sampled, and stored, until the first time word greater than the input end-read-time (or an EOF mark) is encountered. If the EOF has not been reached, the input device is then spaced up to and over the EOF mark.

Each digitized data record produces, after removal of time words, 810 60-bit data points. Memory allocations are sufficient to store 25 records, or 20250 data points in the DATA array. If more than 25 records are to be stored, then the code automatically creates a disk file with a capacity of 81000 points, or 100 records. If created, this disk file will be automatically destroyed when the job is terminated with Instr. 16. For lengthy spans of data, the sampling rate must be used to limit the number of stored points.

Because each use of Instr. 32 destroys the previous contents of the DATA array, Instr. 34 may be used to save the contents of any of the multiplexed channels. A disk file (SAVEFILE) is automatically created to save the desired channels, and automatically destroyed when Instr. 16 is called.

CALIBRATION AND SCALING

Instruction numbers in this class are:

- 35 - read calibration parameters
- 36 }
37 } - calculate calibration parameters
- 38 - scale data

To convert the data points from digital counts to their engineering units, the calibration parameters CALOW and CALPK must be set. This may be done by reading the calibration data file into the DATA array (Instr. 32), and then using Instrs. 36 or 37 to calculate CALOW and CALPK. However, if no calibration signal is available, the parameters may be assigned values using Instr. 35.

Once the parameters CALOW, CALPK, and ACOR (Instr. 5) are set, the test data may be read into the DATA array (Instr. 32) and scaled using Instr. 38.

DATA ANALYSIS AND MANIPULATION

Instruction numbers in this class are:

- 39 - remove mean and/or linear trend
- 44 - cross-correlation
- 45 - Fourier analysis
- 47 - taper data
- 48 - alter data by a constant
- 50 - weight spectral data (filtering)
- 53 - add or subtract channel pairs
- 55 - multiply or divide channel pairs
- 56 - multiply or divide spectral channel pairs

After the data is scaled, it may be necessary to pre-process it before performing any cross-correlation or Fourier analysis. The mean and/or linear trend is removed from the data by Instr. 39, and Instr. 47 tapers the tails of the data. The data can be altered by a constant value using Instr. 48, and pairs of channels are combined arithmetically using Instrs. 53 and 55.

The direct cross-correlation of specified channel pairs is performed by Instr. 44. Instruction 45 Fourier transforms the data, and if desired, the spectral results are saved in disk files, whose names are supplied by the user. If these saved spectral results are then read into the DATA array (Instr. 31), further manipulation is possible. Spectral channel pairs may be multiplied or divided by Instr. 56. This instruction may also be used to form the convolution or cross-correlation product, which when inverse transformed (Instr. 45) gives the indirect convolution or cross-correlation function. Finally, Instr. 50 weights the spectral data of specified channels, and when the weighted data is inverse transformed (Instr. 45), frequency filtering is performed.

DATA DISPLAY

Instruction numbers in this class are:

- 60 - data printing
- 61 - set grid type
- 62 - set max. and min. axis values
- 63-67 - data plotting
- 68 - spectral plotting

At any stage of the data processing, the contents of the DATA array may be printed or plotted. Instruction 60 is used to print the contents of specified channels (those with nonzero ICOR value) on the high speed printer (HSP).

The CRT plotting of data channels is performed by Instrs. 63-67, and if the channels contain spectral data, they may be plotted using Instr. 68. At any time, the type of grid being plotted may be altered by using Instr. 6i, and the maximum and minimum axis values may be set by Instr. 62.

All plots contain a header label consisting of the ID label read by Instr. 6, and the channel number set by Instr. 4.

DISK FILE TRANSPORT

Instruction numbers in this class are:

- 26 - transports files to data tape
- 29 - destroys files
- 30 - demultiplexes channels to files
- 31 - reads files to channels

In addition to those disk files automatically created and named by the code (e.g., Instrs. 32 and 34), others, whose names are supplied by the user, may be needed, and are called "user-named" disk files. These files may be created by Instr. 45, if saving the transformed results is requested, or by Instr. 30, which demultiplexes data channels into disk files. Instruction 30 may also be used to perform progressive interpolation on the contents of any data channel, by specifying the desired new time increment.

User-named spectral disk files may be transported between the disk and the data tape by Instr. 26. This can be used to do additional filtering of the data, without needing to regenerate the spectrums.

The contents of user-named disk files can be read into specified channels using Instr. 31, whereby the previous contents of all data channels are lost. Hence, any disk files to be processed together must be read into channels using a single call to Instr. 31.

The responsibility of destroying all user-named disk files belongs to the user (it is not done automatically), and is performed by Instr. 29.

UTILITY AND DEBUG

Instruction numbers in this class are:

- 13 - repeat instructions
- 17 - non-terminal dump
- 18 - timing routine

The ADSS code is structured for production analysis, and much user time can be saved by writing, whenever possible, instruction loops into the instruction string.

Instruction 13 will execute a specified sub-string of instructions an assigned number of times, and requires the writing of the sub-string only once by the user.

Instruction 18 can be called both before and after a sub-string of instructions to calculate the time required for the execution of that sub-string.

When debugging, Instr. 17 should be used to print a memory dump on the HSP. Control will then be returned to the main subroutine, to continue execution.

Instruction Descriptions

INSTRUCTION NO. 1 N1

Function

Reads N1 X-axis label cards, and N1 Y-axis label cards, in that order, where $N1 \leq 22$.

Format for Data Cards

X-axis labels - N1 cards (6A10):

Columns 1-60 Any label desired;
61-80 blank.

Y-axis labels - N1 cards (6A10):

Columns 1-60 Any label desired;
61-80 blank.

Initialization

The label library is initially blank.

INSTRUCTION NO. 2

Function

Reads a data card specifying which of the X-axis labels read by Instr. 1 are to be used with each channel being plotted. This number is called the IXT value for each channel.

Format for Data Card (3012)

Each channel is allotted 2 columns on the data card in which the number of the X-axis label for that channel is designated.

Example: To assign the 4th, 2nd, and 10th X-axis labels to the 1st, 2nd, and 3rd channels, respectively, Instr. 2 is used with the data card.

Columns	1	2	3	4	5	6	7	...	80
IYT value		4		2	1	0			Blank

Initialization

None required.

INSTRUCTION NO. 3

Function

Reads a data card specifying which of the Y-axis labels read by Instr. 1 are to be used with each channel being plotted. This number is called the IYT value for each channel.

Format for Data Card (3012)

Each channel is allotted 2 columns on the data card in which the number of the Y-axis label for that channel is designated.

Example: To assign the 2nd, 3rd, and 8th Y-axis labels to the 1st, 2nd, and 3rd channels, respectively, Instr. 3 is used with the data card:

Columns	1	2	3	4	5	6	7	...	80
IYT value		2		3		8			Blank

Initialization

None required.

INSTRUCTION NO. 4

Function

Reads a data card specifying the channel number (or ICOR value) to be assigned to each channel. This number appears on the heading of the plots, and also designates to several other instructions (e.g., 36, 45, 63) which channels, by their nonzero ICOR value, are to be processed. Negative ICOR values are not allowed.

Format for Data Card (3012)

Each channel is allotted 2 columns on the data card in which the ICOR value for that channel is assigned.

Example: To assign the channel numbers 1, 2, and 5 to the 1st, 2nd, and 3rd channels, respectively, then Instr. 4 would be used, with the data card:

Columns	1	2	3	4	5	6	7 ... 80
ICOR value	1			2		5	Blank

Initialization

None required.

INSTRUCTION NO. 5

Function

Reads, from one to four data cards, the ACOR value to be assigned to each channel. These values are in engineering units, and are used by Instr. 38 to scale the data.

Format for Data Card(s) (8F10.0)

As many as eight channels may be assigned by each data card, and as many as four data cards may be necessary to assign values to each multiplexed channel (NCHANS in number).

Example: If the three multiplexed channels have ACOR values 2000 g's/pulse, 150.3°F/pulse, and 156 mm/pulse, respectively, then the data card would appear as:

Columns	1 - 10	11 - 20	21 - 30	31 80
ACOR value	2000.	150.3	156.	Blank

Initialization

Instruction 12 must have been called to set the number of multiplexed channels (NCHANS).

INSTRUCTION NO. 6

Function

Reads one data card containing a run identification label. This label appears as the heading for the plots, and in some diagnostics.

Format for Data Card (4A10)

Columns 1-40 Any desired label;
 41-80 blank.

Initialization

The identification label is initially blank.

INSTRUCTION NO. 7 N1 N2

Function

Sets the tape time code correction factor to $(N1/N2)$. The tape time code is multiplied by this factor to correct a record/playback speed discrepancy on the analogue time code.

Initialization

This factor is initially unity.

INSTRUCTION NO. 12 N1

Function

Sets the number of multiplexed channels on the digital input tape or disk (NCHANS) equal to N1.

Initialization

NCHANS = 1 initially.

Note: N1 must be a divisor of 30.

INSTRUCTION NO. 13 N1 N2

Function

The code executes N1 times the N2 instruction values (blanks included) that follow N2 in the instruction string. Nested repeat loops are allowed.

Initialization

None required.

INSTRUCTION NO. 14

Function

Reads a data card containing the length of the data disk file, which is automatically created if ever more than 20,250 data points (after sampling) are read in at one time.

Format for Data Card (I6)

The first 6 columns of the data card contain the disk file length, which must be a multiple of 810, the number of 60-bit words from one A/D record.

Example: The disk file is to have length 105300 words:

Columns	1	2	3	4	5	6	7 ...	80
Entry	1	0	5	3	0	0	Blank	

Initialization

The length is initially 81000 words.

INSTRUCTION NO. 16

Function

This is the normal method of terminating the program.

Operation

The system routine EXIT is called after any disk files automatically created and named by the code are destroyed.

Initialization

None required.

INSTRUCTION NO. 17

Function

An octal dump of memory is made on HSP output, and normal operation is resumed.

Operation

The system routine OCDUMP is called, and is currently available only on the CDC-6600 computer.

Initialization

None required.

INSTRUCTION NO. 18

Function

Prints the elapsed machine time charged (in seconds) since the last call to this instruction, and is used to time the execution of any instruction string.

Operation

The system routine 00TIM is called.

Initialization

The first call to this instruction initializes the timing routine, and the elapsed time is computed on subsequent calls.

INSTRUCTION NO. 21 N1

Function

Loads (assigns) the digital data tape and sets its density, or opens the input data disk file, depending on the value of N1. The vault number of the tape or the name of the disk file is read from a data card.

N1 < 0 for input data disk file.
 N1 = 0 for 200 BPI data tape.
 N1 = 1 for 556 BPI data tape.
 N1 = 2 for 800 BPI data tape.

Format for Data Card (A10)

Whether using an input tape vault number, or disk file name, both must be right justified in the first 10 columns of the data card.

Example: The input data is recorded at 800 BPI on the tape with vault number AC317. Then the instruction 21 2 is used, and the data card appears as:

Columns	1	2	3	4	5	6	7	8	9	10	11	...	80
Entry						A	C	3	1	7			Blank

Initialization

This instruction must be called prior to any data read or tape/disk handling instructions.

INSTRUCTION NO. 22

Function

Rewinds the digital data input device (tape or disk).

Initialization

Instruction 21 must have been called.

INSTRUCTION NO. 23

Function

Reads a data card specifying the number of data records to be skipped, and then skips that number of records on the digital input device.

Format for Data Card (I5)

Columns	1-5	Number of records to be skipped.
	6-80	Blank

Initialization

Instruction 21 must have been called.

INSTRUCTION NO. 24

Function

Reads a data card specifying the number of data files to be skipped, and then skips that number of files on the digital input device.

Format for Data Card (I5)

Columns	1-5	Number of files to be skipped.
	6-80	Blank.

Initialization

Instruction 21 must have been called.

INSTRUCTION NO. 25

Function

Reads a data card specifying the number of data files to be backspaced over, and then backspaces over that number of files on the digital input device.

Format for Data Card (I5)

Columns	1-5	Number of files to be backspaced over.
	6-80	Blank.

Initialization

Instruction 21 must have been called.

INSTRUCTION NO. 26 N1

Function

Transports user-named spectral files between the disk and digital data tape according to N1:

- N1 > 0 Transfers N1 files from disk to data tape.
N1 < 0 Transfers -N1 files from data tape to disk.

In either case, data card(s) are read containing the disk file names.

Format for Data Card(s) (8A10)

Up to 8 file names per card, and up to 25 file names may be used. The names are right justified in successive 10 column fields.

Example: If the spectral file SNORT1 is to be saved on the data tape, then the instruction 26 1 is used with data card:

Columns	1	2	3	4	5	6	7	8	9	10	11	...	80
Entry						S	N	O	R	T	1		Blank

Operation

1. If N1 > 0, the individual disk files are opened, their contents are written, with EOF marks between them, on the data tape, and the files are closed.
2. If N1 < 0, the individual disk files are created, filled with successive files from the data tape, and then closed.

Initialization

Instruction 21 must have been called, and the tape moved to the desired location (beyond digitized data). Only files written by this instruction may be transferred from the data tape in this manner.

INSTRUCTION NO. 27

Function

Unloads the digital input tape from tape reader.

Initialization

Instruction 21 must have been called.

INSTRUCTION NO. 28

Function

Destroys the digital input disk file.

Initialization

Instruction 21 must have been called.

INSTRUCTION NO. 29 N1

Function

Reads data card(s) containing the names of N1 user-named disk files, and then destroys these files. The files should be demultiplexed data or spectral files, whose names the user supplied when they were created.

Format for Data Card(s) (8A10)

Each of the N1 file names should be right justified in a 10 column field; up to 8 names per card, and a maximum of 25 names total.

Example: To destroy the spectral file SNORT1, use Instr. 29 1, with the data card:

Column	1	2	3	4	5	6	7	8	9	10	11	-	80
	S	N	O	R	T					1			Blank

Initialization

None required.

INSTRUCTION NO. 30 N1

Function

Demultiplexes N1 channels and stores each in a separate user-named disk file. The channel numbers and disk file names are read from N1 data cards.

Format for Data Card(s) (A10, A10, 2A10, A6, 4X, I5, I5, F10.0)

N1 data cards required; each has the form:

Columns	1-10	Disk file namc (right adjusted in field).
	11-20	Data type (optional).
	21-40	Event name (optional).
	41-46	Station name (optional).
	47-50	Blank.
	51-55	Channel number.
	56-60	Processing status (must be 10 if spectral data, otherwise optional).
	61-70	Time increment (must be positive to alter increment, otherwise optional).
	71-80	Blank.

Example: To create the disk file SNORT1 and store in it the (non-spectral) contents of channel 3, Instr. 30 1 is used, and the following data card is sufficient:

Columns	1	2	3	4	5	6	7	8	9	10	11-54	55	56-80
Entry					S	N	O	R	T	1	Blank	3	Blank

Operation

Performs the following steps N1 times:

Reads data card, creates the specified disk file, demultiplexes the contents of the specified channel, performs progressive interpolation on the data if a new time increment is requested (and data is non-spectral), stores the data in the disk file, and closes it.

Only one channel may be stored in any one file at a time.

Initialization

None required.

INSTRUCTION NO. 31 N1

Function

Stores specified portions of the contents of N1 user-named disk files into N1 separate multiplexed channels. The N1 file names, channel numbers, read intervals, and sampling rates are read from N1 data card(s).

Format for Data Card(s) (A10, I5, 4I5, 4I5, I5)

N1 data cards required; each has the form:

Columns	1-10	Disk file name (right adjusted in field).
	11-15	Channel number.
	16-35	Begin read mark—four 5-column integers expressing either time in hours, minutes, seconds, and tenths of milliseconds, or frequency in Hertz, and tenths of milli-Hertz (last two fields ignored).
	36-55	End read mark—four 5-column integers expressing either time or frequency as above.
	56-60	Sampling rate.
	61-80	Blank.

Operation

Performs the following process N1 times:

Reads data card containing the name of a file, a read interval, a sampling rate, and the number of a channel to be filled. The file is opened, the contents read over the specified interval at the sampling rate, and stored in the designated channel. The file is then closed.

The previous contents of all channels is lost when this instruction is called.

If the files contain spectral data, the number of points read in is always of the form $2^n + 2$, for some positive integer n.

Initialization

NCHANS must be preset.

INSTRUCTION NO. 32

Function

Reads a data card containing a sampling rate, and the endpoint times of a read interval. Using the corresponding endpoint time words of the digital data file, the data points in that interval are then read, unpacked, sampled, and stored (in multiplex form) in the DATA array. A time per point (in seconds) is computed, and the input and actual time interval endpoints are printed on the HSP.

Format for Data Card (415, 415, 15)

Columns	1-20	Begin read time—four 5-column integers representing hours, minutes, seconds, and tenths of milliseconds.
	21-40	End read time—same format as above.
	41-45	Sampling rate.
	46-80	Blank.

Operation

If more than 20,250 data points are to be stored, then a disk file of length 81,000 (or whatever length set by Instr. 14) is created, and all data points are stored in it. Any excess points to this file are lost.

The sampling rate determines the ratio of the number of data points read to the number that are stored in the DATA array. Thus, if the sampling rate is specified as unity, every data point read will be stored. After completion of the read, the input device is spaced up to and over the next EOF mark.

Initialization

Instruction 21 and, if necessary, Instrs. 12 and 14 must have been called. The input tape or disk must be positioned at the desired file before reading.

INSTRUCTION NO. 34 N1 N2 N3

Function

Manipulates and transfers DATA channels, in multiplex form, between DATA array and a disk file (SAVEFILE). The options for transferring channels are:

N1 = 1	Channel N2 of DATA sent to channel N3 of SAVEFILE.
N1 = 2	Channel N2 of SAVEFILE sent to channel N3 of DATA.
N1 = 3	Channel N2 of DATA and channel N3 of SAVEFILE are switched.
N1 = 4	Channel N2 of DATA sent to channel N3 of DATA.

Operation

On the first call to Instr. 34, unless N1 = 4, the disk file SAVEFILE is automatically created. The number of points in each channel stored there is recorded. Then, when later transferring a SAVEFILE channel to a DATA channel, either the SAVEFILE channel or all DATA channels may be truncated to equalize their lengths.

Initialization

None required.

INSTRUCTION NO. 35

Function

Reads data cards which specify the calibration parameter values (in digital counts) to be used in scaling the data. The parameter names are CALOW and CALPK, and each channel (NCHANS in number) must have values assigned.

Format for Data Cards

CALOW values (8F10.0):

Each channel is allotted 10 columns for its value. Up to eight values per card, and NCHANS total values.

CALPK values (8F10.0):

Same as above.

Initialization

NCHANS must be set.

INSTRUCTION NO. 36 N1 N2 N3

Function

Establishes the calibration parameters (CALOW and CALPK) for those channels N1 through N2 whose ICOR value is nonzero, according to the value of N3:

N1 = 1	Determines CALOW only.
N3 = 2	Determines CALPK only.
N3 = 3	Determines CALOW and CALPK assuming a square wave calibration signal.
N3 = 4	Determines CALOW and CALPK assuming a sine wave calibration signal.

A plot of the calibration signal (in digital counts) for each processed channel is produced.

Operation

For N3 = 1 and N3 = 2, the arithmetic mean of the channel is computed and stored in the appropriate parameter.

For N3 = 3, and N3 = 4, the maximum (AMAX) and minimum (AMIN) data values of the channel are found, then CALPK = AMAX, and CALOW = (AMAX + AMIN)/2.

Initialization

The calibration signals for the appropriate channels must be in the DATA array. ICOR values must be set.

INSTRUCTION NO. 37 N1 N2 N3

This instruction is the same as Instr. 36, except no plots of the calibration signals are produced.

INSTRUCTION NO. 38 N1 N2 N3

Function

Scales, into engineering units, the digital data of those channels N1 through N2 whose ICOR value is nonzero, according to the value of N3:

$$N3 = -1 \quad YSC = \frac{ACOR}{CALPK - CALOW} \times (Y - YAVG) + CONST.$$

$$N3 = 1 \quad YSC = \frac{ACOR}{CALPK - CALOW} \times (Y - YAVG).$$

$$N3 = -2 \quad YSC = \frac{ACOR}{CALPK - CALOW} \times (Y - CALOW) + CONST.$$

$$N3 = 2 \quad YSC = \frac{ACOR}{CALPK - CALOW} \times (Y - CALOW).$$

$$N3 = -3 \quad YSC = \frac{ACOR}{CALPK - CALOW} \times (Y) + CONST.$$

$$N3 = 3 \quad YSC = \frac{ACOR}{CALPK - CALOW} \times (Y).$$

where:

Y = raw data in digital counts,

YSC = scaled data in engineering units,

ACOR = values set by Instr. 5,

CALPK and CALOW = values set by Instrs. 35, 36, or 37,

YAVG = average of first 10 data points, and

CONST = values read from data card(s).

Format for Data Card(s) (8F10.0)

Needed only for N3 negative, in order to set CONST value for each channel. Up to 8 values per card; a total of NCHANS values are required.

Initialization

NCHANS, ACOR, ICOR, CALPK, CALOW values must have been set.

INSTRUCTION NO. 39 N1 N2 N3

Function

Preconditions the data of those channels N1 through N2 whose ICOR value is non-zero, according to the value of N3:

- N3 = 1 Removes (subtracts) the arithmetic mean.
- N3 = 2 Removes the linear trend.
- N3 = 3 Removes both the mean and linear trend.

Operation

For N3 = 1 the mean is computed, and subtracted from the data.

For N3 = 2 and N3 = 3, a linear least squares fit of the data is performed, to determine the values M and B of $Y = MX + B$. Then if

- N3 = 2 $M(X - T/2)$ is subtracted, where T = length of time interval (in seconds) of data, and if
- N3 = 3 $MX + B$ is subtracted from the data.

Initialization

ICOR values must have been assigned.

INSTRUCTION NO. 44 N1 N2

Function

Performs cross-correlation (by the direct method) of N1 channel pairs, with N2 lags in each direction, and plots the N1 resulting functions versus time. A data card specifying the N1 channel pairs is read. If a zero-lag auto-correlation is requested, the result is printed on HSP, but not plotted.

Format for Data Card (3012)

The N1 channel pairs are listed, with each channel in a two column field. A maximum of N1 = 15 pairs is allowed.

Example: To cross-correlate channels 1 and 4 and auto-correlate channel 3, both with 10 lags in each direction, the instruction 44 2 10 is used with data card:

Columns	1	2	3	4	5	6	7	8	9	-	80
Entry		1		4		3		3		Blank	

Operation

If (A, B) is an input channel pair, and N is the number of data points in each channel, then the $2(N2) + 1$ lag products are determined as follows:

$$\text{LAG}(S) = \sum_{t=1}^{N-S} \text{DATA}_A(t) \text{DATA}_B(t+S) \quad \text{for } 0 \leq S \leq N2,$$

$$\text{LAG}(S) = \sum_{t=1}^{N-S} \text{DATA}_A(t+S) \text{DATA}_B(t) \quad \text{for } -N2 \leq S \leq -1.$$

A maximum of N2 = 4999 lags is allowed in each direction.

Initialization

The ICOR, IXT, and IYT values for the first member of each channel pair are used for plotting, and must be preset.

INSTRUCTION NO. 45 N1 N2 N3 N4 N5 N6

Function

Performs Fourier analysis on those channels N1 through N2 whose ICOR value is nonzero, according to the value of N3:

N3 = 1 Forward Fourier transform.

N3 = 2 Forward Fourier transform and results saved in a user-named disk file.

N3 = -1 Inverse Fourier transform.

N3 = -2 Inverse Fourier transform and results saved in a user-named disk file.

The number of complex points transformed is 2^n , for some $n \leq 13$: if $N4 = 0$, n is computed by the code; if $N4 > 0$, then $n = N4$.

That portion of the power spectrum (forward transform) or impulse response (inverse transform) defined over the interval $N5$ to $N6$ units is plotted.

If saving the results is requested ($N3 = 2$ or $N3 = -2$), then for each channel processed, a data card naming a disk file is read (one channel per disk file).

Format for Data Card(s) (A10, A10, 2A10, A6, 4X, I5, I5)

Required only if $N3 = 2$ or $N3 = -2$; then one data card is needed for each channel processed.

Columns	1-10	File name (right adjusted in field).
	11-20	Data type (optional).
	21-40	Event name (optional).
	41-46	Station name (optional).
	47-50	Blank.
	51-55	Channel number.
	56-60	Processing status (must be 10 if spectral results, otherwise optional).
	61-80	Blank.

Operation

Uses the Cooley-Tukey Fast Fourier Transform algorithm (FCOOL).

For the forward transform, enough zeros are added to the data of each processed channel, $X(j)$, to given $N = 2^n$ (complex) points, where $n \leq 13$. The N complex spectral values, $A(m)$, are calculated as follows.

$$A(m) = \sum_{j=0}^{N-1} X(j) W_N^{-mj},$$

where $m = 0, \dots, N-1$, and $W_N = \exp(2\pi i/N)$.

Because the data is real, the power spectrum, $|A|^2$, folds about its midpoint, and only $2^{n-1} + 1$ complex values ($2^n + 2$ array words) are used for plots and saving, in amplitude-phase pairs, on disk. The average energy ($\frac{1}{N} \sum |A|^2 \Delta\omega$), DC and maximum power components, and frequency increment ($\frac{1}{N}$) are printed.

For the inverse transform, the number of amplitude-phase pairs in each processed channel is expected to be of the form $2^{n-1} + 1$ ($2^n + 2$ array words), where $n \leq 13$. The last pair is assumed to correspond to the folding frequency. The $N = 2^n$

complex points of the spectrum, $A(m)$, are then generated by symmetry, and the N real values, $X(j)$, of the inverse transform are computed:

$$X(j) = \frac{1}{N} \sum_{m=0}^{N-1} A(m) W_N^{mj}, \text{ where } j = 0, \dots, N-1.$$

Initialization

IXT, IYT, and ICOR values must be preset.

INSTRUCTION NO. 47 N1 N2 N3 N4

Function

Uses a cosine taper to smooth the tails of those channels N1 through N2 whose ICOR value is nonzero. The first N3% and the last (100-N4)% of the selected channels are tapered.

Operation

If $N\%$ of the left tail of a channel with time interval length T is to be tapered, the point $x(t)$ is weighted by multiplying by

$$c(t) = \frac{1}{2} \left(1 - \cos \left(\frac{t\pi}{NT} \right) \right) = \sin^2 \left(\frac{t\pi}{2NT} \right), \text{ where } 0 \leq t \leq NT.$$

Similarly, the last (100-M)% of the channel is weighted by

$$c(t) = \frac{1}{2} \left(1 - \cos \left(\frac{(T-t)\pi}{(1-M)T} \right) \right) = \sin^2 \left(\frac{(T-t)\pi}{2(1-M)T} \right), \text{ } MT \leq t \leq T.$$

Initialization

ICOR values must be preset.

INSTRUCTION NO. 48 N1 N2 N3

Function

Alters by a constant the data of those channels N1 through N2 whose ICOR value is nonzero, according to the value of N3:

N3 = 1 Multiplies by a constant.

N3 = 2 Adds a constant.

The constants are read from data cards.

Format for Data Card(s) (8F10.0)

Each channel (NCHANS in number) must be assigned a constant, and each is allotted 10 columns on the data card for that purpose. Up to eight channels are assigned values on each data card.

Initialization

ICOR values must be preset.

INSTRUCTION NO. 50 N1 N2

Function

Weights the spectral data of those channels N1 through N2 whose ICOR value is nonzero. The weighting function is generated using the Dolph-Chebyshev (D-C) function, and an ideal filter specified on data cards. The power spectrum and impulse response of the weighting function are plotted.

Format for Data Cards

Parameter Card (15, 15, 5, 15, F10.0)

Columns	1-5	Type of ideal filter (1 - lowpass, 2- highpass, 3 - bandpass, 4 - differentiate).
	6-10	No. of points (NOP) used to define ideal filter.
	11-15	N, where $P = 2^N$ is the number of points to be generated by the Dolph-Chebyshev function.
	16-25	Pass band width of D-C function (Nyquists).
	26-80	Blank.

Ideal Filter Card(s) (3F8.0, 3F8.0, 3F8.0)

The ideal filter is defined by NOP triplets (frequency, amplitude, and phase), each with format 3F8.0, and up to 3 triplets per data card. For standard pass bands, only two triplets are needed, to specify the corners of the pass band.

Note: If the ideal filter type number 4 (differentiator) is specified, this instruction expects columns 6-10 to contain a zero (NOP = 0), and no ideal filter cards are read.

Operation

The weighting function is generated by using the "5-T's" method.² Additional information concerning the use of this instruction is given by Denny.³

Initialization

ICOR values must be preset. Channels must contain spectral data.

INSTRUCTION NO. 53 N1

Function

Sums or subtracts the data of specified channel pairs, according to the value of N1:

N1 > 0 Addition of channel pairs.
N1 < 0 Subtraction of channel pairs.

A data card is read specifying the N1 (or -N1) pairs of data channels. The resulting values replace the data of the first channel of each pair.

Format for Data Card (3012)

Example: To compute the sum of channels 2 and 3 and store it in channel 3, the instruction 53 1 is used, with the data card:

Columns	1	2	3	4	5	-	80
Entry		3		2			Blank

²Helms, Howard D., "Nonrecursive Digital Filters: Design Methods for Achieving Specifications on Frequency Response," IEEE Trans. on Audio and Electronics, AU-16, 336-342 (1968).

³Denny, M. D., "Digitally Filtered Rayleigh Waves as a Yield Indicator," to be published.

Initialization

None required.

INSTRUCTION NO. 55 N1

Function

Multiplies or divides the data of specified channel pairs, according to the value of N1:

N1 > 0 Multiplication of channel pairs.

N1 < 0 Division of channel pairs.

A data card is read, specifying the N1 (or -N1) pairs of data channels. The resulting values replace the data of the first channel of each pair.

Format for Data Card (30I2)

Example: To divide channel 1 by channel 2 (the results to channel 1) and channel 5 by channel 2 (the results to channel 5), Instr. 55 -2 is used, with the following data card:

Columns	1	2	3	4	5	6	7	8	9	-	80
Entry		1		2		5		2		Blank	

Operation

If division by zero is attempted, the result is set equal to the previous quotient (or zero, if the previous result is not available).

Initialization

None required.

INSTRUCTION NO. 56 N1 N2

Function

Multiplies or divides the spectral contents of N1 specified channel pairs, according to the value of N2:

N2 = -1 Division of spectral channel pairs.

N2 = 1 Multiplication of spectral channel pairs.

N2 = 2 Convolution product of spectral channel pairs.
 N2 = 3 Cross-correlation product of spectral channel pairs.

The resulting spectral values replace the data of the first channel of each pair.
 A data card specifying the N1 channel pairs is read.

Format for Data Card (3012)

Example: To multiply channels 3 and 4, and store the results in channel 4, the instruction 56 1 1 is used, with data card:

Columns	1	2	3	4	5	-	80
Entry		4		3		Blank	

A maximum of N1 = 15 pairs is permitted on the card.

Operation

If the spectral contents of channels I and J ($A_I(n)$ and $A_J(n)$), respectively, are to be combined, the following results corresponding to values of N2, are stored in channel I:

N2 = -1	$A_I(n)/A_J(n)$.
N2 = 1	$A_I(n) A_J(n)$.
N2 = 2	$(-1)^n A_I(n) A_J(n)$.
N2 = 3	$(-1)^n \overline{A_I(n)} A_J(n)$,

where the bar indicates the complex conjugate.

If division by zero is attempted (divisor has zero amplitude), the result is set equal to the previous quotient (or zero, if the previous quotient is not available).

Initialization

The channels must contain spectral data.

INSTRUCTION NO. 60

Function

Prints on the HSP the contents of all channels whose ICOR value is nonzero.

Initialization

ICOR values must be preset.

INSTRUCTION NO. 61 N1

Function

Specifies which type of grid is to be used for plots, according to the value of N1:

N1 = 1	No grid lines.	Linear X and Y axis.
2	No grid lines.	Long X and Log Y axis.
3	No grid lines.	Linear X and Log Y axis.
4	No grid lines.	Log X and Linear Y axis.
5	Full grid lines.	Linear X and Y axis.
6	Full grid lines.	Log X and Log Y axis.
7	Full grid lines.	Linear X and Log Y axis.
8	Full grid lines.	Log X and Linear Y axis.
9	Hash marks.	Linear X and Y axis.
10	Hash marks.	Log X and Log Y axis.
11	Hash marks.	Linear X and Log Y axis.
12	Hash marks.	Log X and Linear Y axis.

Operation

The grid parameter can be set and reset only by this instruction, and affects all plot instructions.

Initialization

The grid type is preset to full grid lines and linear X and Y axis (N1 = 5).

INSTRUCTION NO. 62 N1

Function

Determines, according to the value of N1, how the minimum and maximum values for the X and Y axes of the plots are to be defined:

N1 = 0	The min. and max. values for both axes will be determined from the data to be plotted. No. data cards are read.
N1 = 1	Reads the min. and max. values for the X-axis; those for Y-axis are determined from data.
N1 = 2	Reads the min. and max. values for the Y-axis; those for X-axis are determined from data.
N1 = 3	Reads the min. and max. values for both axes.

Format for Data Cards

Required if $N1 = 1$ or $N1 = 3$:

- a. X-axis minimum values (8F10.0);

Each channel (NCHANS in number) must be assigned a value, and has 10 columns of the data card allotted for this purpose. Up to eight channels may be assigned values per card.

- b. X-axis maximum values (8F10.0).

Required if $N1 = 2$ or $N1 = 3$:

- a. Y-axis minimum values (8F10.0);

- b. Y-axis maximum values (8F10.0).

Operation

The minimum and maximum values set by Instr. 62 affect only those plots generated by Instrs. 63-67, and will be used until this instruction is called again. If the minimum and maximum values of a channel are left blank on the data cards, these values will be determined from the data of that channel.

Initialization

The minimum and maximum values are initially determined from the data (i.e., $N1 = 0$). NCHANS must be preset.

INSTRUCTION NO. 63

Function

Plots, against time, the contents of all those channels whose ICOR value is non-zero. A separate plot is generated for each of the selected channels.

Initialization

IXT, IYT, and ICOR values must be preset.

INSTRUCTION NO. 64 N1 N2 N3

Function

Plots, against the contents of channel N3, the contents of those channels N1 through N2 whose ICOR value is nonzero.

Initialization

IXT, IYT, and ICOR values must be preset.

INSTRUCTION NO. 65 N1 N2

Function

The same as Instr. 63, except that only an interval, defined by N1% to N2% of the total time of each channel is plotted.

Initialization

IXT, IYT, and ICOR values must be preset.

INSTRUCTION NO. 66 N1 N2 N3 N4 N5

Function

Plots, against the contents of channel N5, the interval N1% to N2% of the contents of those channels N3 through N4 whose ICOR value is nonzero.

Initialization

IXT, IYT, and ICOR values must be preset.

INSTRUCTION NO. 67 N1

Function

Plots, against time, the contents of N1 specified channels on one CRT frame. A data card specifying the N1 channels is read.

Format for Data Card (3012)

A maximum of 30 channels may be listed, each in a two column field.

Example: To plot both channels 3 and 5 versus time on one frame, instruction 67 2 is used with data card:

Columns	1	2	3	4	5	-	80
Entry			3		5	Blank	

Initialization

The ICOR, DXT, and IYT values for the first channel specified are used, and must be preset.

INSTRUCTION NO. 68

Function

Plots, against frequency, the power spectrum (decibels) and phase shift (degrees) of all those spectral channels whose ICOR value is nonzero. Two plots are generated for each of the selected channels.

Initialization

The channels must contain spectral data. ICOR values must be preset.

Appendix

INDEX TO INSTRUCTIONS

<u>Instr. No.</u>	<u>Function</u>
1	Reads X-axis and Y-axis label library.
2	Specifies X-axis label number (IXT value) for each channel.
3	Specifies Y-axis label number (IYT value) for each channel.
4	Assigns channel number (ICOR value) to each channel.
5	Assigns calibration (ACOR) values to each channel.
6	Reads run identification label.
7	Sets digital tape time (speed-up) factor.
12	Sets number of channels (NCHANS) into which data is multiplexed.
13	Repeats a designated string of instructions an assigned number of times.
14	Sets data disk file length.
16	Call exit instruction.
17	Non-terminal dump of memory.
18	Prints elapsed machine time since last called.
21	Assigns data tape and density, or opens input data disk file.
22	Rewinds data tape or input disk file.
23	Spaces over an assigned number of records on the data tape or disk file.
24	Spaces over an assigned number of files on the data tape or disk file.
25	Backspaces over an assigned number of files on the data tape or disk file.
26	Transports user-named spectral disk files between disk and data tape.
27	Unloads data tape.
28	Destroys input data disk file.
29	Destroys specified user-named disk files.
30	Demultiplexes specified channels and stores them in user-named disk files.
31	Reads contents of specified user-named disk files, and stores in specified multiplexed channels.
32	Reads data from digital tape or input disk file.
34	Transports specified data channel, in multiplexed format, between DATA array and "SAVE" disk file.
35	Reads calibration parameters (CALOW and CALPK) for each channel.

Instr. No.Function

36	Computes calibration parameters (CALOW and CALPK) from calibration data file, and plots calibration signal.
37	Same as Instr. 36, but no plots.
38	Scales data into engineering units by an assigned method.
39	Removes mean and/or linear trend from data.
44	Computes and plots the cross-correlation function for specified channel pairs.
45	Performs Fourier analysis on specified channels, saving the result in user-named disk files if desired.
47	Smooths an assigned percentage of the data, using a cosine taper.
48	Multiplies data by, or adds data to, a specified constant.
50	Weights the contents of specified spectral channels, using the Dolph-Chebyshev function, and a specified ideal filter.
53	Sums or subtracts specified channel pairs.
55	Multiplies or divides specified channel pairs.
56	Multiplies or divides specified spectral channel pairs.
60	Prints contents of specified channels.
61	Sets the type of grid to be used for plots.
62	Reads max. and min. for X- and Y-axis of plots.
63	Plots specified channels versus time.
64	Plots specified channels versus another channel.
65	Same as Instr. 63, except an assigned percentage of each channel is plotted.
66	Same as Instr. 64, except an assigned percentage of each channel is plotted.
67	Plots specified channels versus time on one CRT frame.
68	Plots the power spectrum and phase shift of specified spectral channels versus frequency.

SAMPLE PROGRAM

Tables 1 and 2 describe the contents of the digitized magnetic tape (vault number AC319) to be analyzed. The sample program will read, scale, plot, auto-correlate, Fourier analyze, and filter the A/D channel number 1. The sine wave calibration signal is in data file number 1, and the event signal will be read from the fourth data file of the tape.

Figure 1 shows a numbered listing of the 35 cards of the input deck used to run this job.

Table 1. F. M. tape schedule.

Date: (Julian) <u>310-68</u>		(Calendar) <u>7-30-68</u>	
Recorder <u>FRI300</u>		Record Speed <u>7-1/2</u> ips	Time Code "B" on F. M. Ch. No. <u>13</u>
1) Station Gains: M = <u>100</u> X L = _____ X, K = _____ X, E = _____ X			
2) START TAPE: Original _____ GMT		Duplicate _____ GMT	
3) Bandedges: a) Center Freq. (30 sec) _____ GMT c) LBE (30 sec) _____			
b) UBE (60 sec) _____ d) Center Freq. (30 sec) _____			
4) Calibration a) <u>200</u> μ a p-p <u>0505:32</u> d) _____ μ a p-p			
@2 Hz: b) <u>2000</u> μ a p-p <u>0505:10</u> e) _____ μ a p-p			
c) <u>8000</u> μ a p-p f) _____ μ a p-p			
5) EVENT TIMES Mina Landers Kanah Elko			
1st Arrival <u>0500:36.7</u> pst _____ pst _____ pst _____ pst			
After 2 Cycles <u>0500:37.5</u> pst _____ pst _____ pst _____ pst			
6) STOP TAPE: Original _____ GMT		Duplicate _____ GMT	

STATION CENTER FREQ.	F. M. CH.	A/D NO.	DIGITIZE?	CALIB. ?	ACOR or NCOR	REMARKS: Time Clipped or % full scale, etc.
Hg Mina	3	1	Yes	Yes	.003075	100% full scale
Mg Mina	5	2	Yes	Yes	.03075	<50% full scale
Short	7	3	Yes	Yes	.123	
Time Code (B)	13		Yes	—	—	

Table 2. Digital tape (Vault AC319).

DATE: (Julian) <u>310-68</u> ; (Calendar) <u>7-30-68</u>				
F. M. Playback Spd: <u>30</u> ips; Basic A/D Rate: <u>24</u> kc; Aliasing Freq.: <u>1000</u> Hz.				
DATA DESCRIPTION	TSTART	TEND	FILE #	# of RECORDS
Mina High Gain Calibration	0505:32	0505:37	1	38
Ignore			2	892
Ignore			3	38
Mina High Gain Event	0500:36.7	0505:00	4	1958

Explanation of Input Cards

The input deck has three sections: the control cards (Nos. 1-4), the instruction string cards (Nos. 5-10), and the supplemental data cards (Nos. 11-35).

```

1*ID 143HKB TORORUN1 HOWAPO BOXE31 001
2*T AC319=68=AC319
3*T AC323=5A=AC323
4* LOAD(1,5)
5 12 3 21 2 1 2 5 6 32 4
6 36 1 1 4 24 6 32 39 1 1 3
7 34 1 1 3 2 3 63 44 1 0 2
8 3 45 1 1 2 0 15 31 1 50 1
9 2 3 6 45 1 1 -1 0 0 300 27
10 29 1 16 99999
11 AC319
12 TIME IN SECONDS
13 FREQUENCY IN HERTZ
14 MM/SEC
15 POWER SPECTRUM IN DECIBELS
16.007075 .03075 .123
17CALIBRATION FOR 7-30-68 MINA
18 5 5 32 0 5 5 33 0 1
19 1
20 2
21EVENT FOR 7-30-68 MINA
22 5 0 36 0 5 5 36 0 80
23 1
24 1
25 1 1
26 2
27 2
28 TOR01 1 0 0 15 0 1 10
29 TOR01 1 2 11 0.004
30 1 1. 0. 0.1 1. 0.
31. 1
32 1
33 1
34FILTERED EVENT FOR 7-30-68 MINA
35 TOR01

```

Fig. 1. Listing of the 35-card deck used in the sample run.

Control Cards

Card No. 1	Identifies the user account, problem name, user name, and box number.
2	Specifies the vault number of the data tape.
3	Specifies the vault number of the tape on which the ADSS code is stored.
4	Reads the ADSS code into memory from the specified tape.

Instruction String and Supplemental Data Cards

Each of the instructions has been space delimited to assist in its identification. The CRT output produced by this job is shown on the pages following the instruction descriptions.

<u>Instruction</u>	<u>Operation Performed and Supplemental Data Cards Required</u>
12 3	Sets the number of multiplexed channels to 3.
21 2	Reads the vault number (card No. 11) of the data tape, loads the tape, and assigns its density as 800 bpi.
1 2	Reads 2 X-axis labels (card Nos. 12 and 13), and 2 Y-axis labels (card Nos. 14 and 15).
5	Reads ACOR values (card No. 16) for the 3 channels.
6	Reads run ID (card No. 17).
32	Reads and stores data (calibration signal), using the read interval (1 sec) and sampling rate (1) (card No. 18).
4	Sets the ICOR values (card No. 19)—only channel 1 is to be processed.
36 1 1 4	Sets CALOW and CALPK values for channel 1, and plots calibration signal (Fig. 2).
24	Spaces tape to data file number 4 (card No. 20).
6	Reads ID (card No. 21).
32	Reads and stores data (event signal), using the read interval (5 min) and sampling rate (80) (card No. 22).
39 1 1 3	Removes mean and linear trend from channel 1.
38 1 1 3	Scales channel 1.
2	Designates X-axis label No. 1 for channel 1 (card No. 23).
3	Designates Y-axis label No. 1 for channel 1 (card No. 24).
63	Plots channel 1 versus time (Fig. 3).
44 1 0	Auto-correlates channel 1, with zero lags (card No. 25).
2	Resets DXT values (card No. 26).
3	Resets IYT values (card No. 27).
45 1 1 2 0 0 15	Fourier transforms channel 1, plots its power spectrum (Fig. 4), and saves the spectrum in a disk file named TORO1 (card No. 28).
31 1	Reads the entire spectrum in the disk file TORO1 into channel 1 (card No. 29).
50 1 1	Weights channel 1 using a low-pass ideal filter (0, .1), with zero phase shift (card Nos. 30 and 31), and plots the impulse response and power spectrum of the weighting function (Figs. 5 and 6).
2	Resets DXT values (card No. 32).
3	Resets IYT values (card No. 33).
6	Reads ID (card No. 34)
45 1 1 -1 0 0 300	Inverse Fourier transforms channel 1, and plots the resulting (filtered) signal (Fig. 7).
27	Unloads input tape.
29 1	Destroys the disk file TORO1 (card No. 35).
16	Terminates job.
99999	Terminates instruction string.

Fig. 2. Plot of calibration signal; instruction is "36 1 1 4."

Fig. 3. Plot of channel 1 vs time; instruction is "63."

Fig. 6. Power spectrum of the weighting function; instruction is "50 1 1."

Fig. 7. Filtered signal resulting from Fourier transform of channel 1; instruction is "45 1 1 -1 0 0 300."

DICTIONARY OF VARIABLES

The variables defined below are those contained in the COMMON blocks. These variables serve as the only means of communication among most of the subroutines in the code. All other variables appearing in the main subroutine and the other subroutines are only temporary working variables, and will not be discussed here.

ACOR	Array of calibration pulse levels. Set by Instr. 5.
ALPHUN	Array of units (seconds or Hertz) corresponding to the first data point of each channel.
AMIN	Array of minimum data values.
AMAX	Array of maximum data values.
CALOW	Array of calibration pulse low values. Set by Instrs. 35, 36, or 37.
CALPK	Array of calibration pulse peak values. Set by Instrs. 35, 36, or 37.
DATA	Data storage array.
DATAFILE	Contains the name of the data disk file automatically created if the DATA array cannot accommodate all the data.
FINC	Frequency increment (Hertz).
IAPLOT	Parameter whose value determines type of grid to be plotted. Set by Instr. 61.
ICNT	Counter containing the location within the INSTR array of the instruction currently being executed by the code.
ICOR	Array of channel numbers. Set by Instr. 4.
IDADSK	Sentinel indicating the status of the data disk file: IDADSK = 0, no data disk file; IDADSK = 1, data disk file created, but not currently used; IDADSK = 2, data disk file contains data for current run.
INST	Current instruction being executed.
INSTR	Array containing the instruction string.
IPLSET	Determines how the max. and min. axis values are defined for plotting. Set by Instr. 62.
ISADSK	Sentinel indicating the status of the save disk file (SAVEFILE). Same values as IDADSK.
IXT	Array of X-axis label numbers. Set by Instr. 2.
IYT	Array of Y-axis label numbers. Set by Instr. 3.
NIPER	Sampling rate specified when reading data.
NBRPTS	Length of DATA array.
NCHANS	Number of multiplexed channels. Set by Instr. 12.
NDADSK	Number of data points stored in data disk file; used only when IDADSK = 2.
NLENGTH	Size of data disk file. Set by Instr. 14.
NMBR	Number of data points in DATA array; not used if IDADSK = 2.
NOUT	Logical unit number of device for printed output.
NSAMPAT	Array of sampling rates.
NWORK	Length of WORK array.
OMEGUN	Array of units (seconds or Hertz) corresponding to the last data point of each channel.

SAVEFILE	Contains the name of the save disk file automatically created if data is saved by using Instr. 34.
TPP	Time per point (seconds).
WORK	Array which provides temporary working space.
XID	Array containing the run ID label. Set by Instr. 6.
XLAB	Array containing the X-axis labels. Set by Instr. 1.
XSCALE	Time code scaling factor. Set by Instr. 7.
YLAB	Array containing the Y-axis labels. Set by Instr. 1.

SUBROUTINES

The subroutines which comprise the ADSS code are of two types: utility and specialized.

Utility Subroutines

Certain operations which are common to more than one subroutine have been converted into separate subroutines.

ADDSKIO	Transfers data points between the DATA array and either the data disk file or the save disk file.
AMIMX	Finds the min. and max. values of any specified array.
FCOOL	Performs the Cooley-Tukey algorithm (Fast Fourier Transform) on any specified array.
MSTRPT	Performs the plotting on the CRT.

Specialized Subroutines

The remaining subroutines each perform a specific task, and are not used by more than one other subroutine. All, except those listed below, have names of the form SUBXX, where XX is the number of the corresponding instruction. (For instance, Instr. 39 calls the subroutine SUB39).

CALAD	Calculates calibration parameter values (Instrs. 36 and 37).
CATWDS	Used by TADATA to unpack the digital time words.
DCWIND	Used by SUB50 to generate spectral weights by the "5-T's" method.
GRANGE	Used by DCWIND to generate the ideal filter using Lagrangian interpolation. (E1.1-002).
PLTPT	Sets parameters for call to MSTRPT, to plot data.
PRINT	Outputs data on the HSP (Instr. 60).
SAVDAT	Saves DATA channels (Instr. 34).
SCALE	Scales data (Instr. 38).
TADATA	Reads digitized data (Instr. 32).

FORMAT FOR USER-NAMED DISK FILES

Each of the disk files created by Instrs. 30 and 45 requires the user to supply information, including the file name, to the code. These data, along with parameter values kept by the code, are then written as a "Header" record of the disk file. This Header record is used to identify the contents of the user-named disk file, and is written in a format which allows the user to display the Header information on a teletype machine.

The first ten characters of the Header record form an inter-record word (IRW) used by the system, and the following 120 characters contain the Header information.

Character	1-10	Inter-record word
	11-20	Data type (A10)
	21-23	Blank
	24-41	Event name (A10, A8)
	42-44	Blank
	45-50	Station name (A6)
	51-55	Channel number (I5)
	56-60	Processing status (I5)
	61-68	Number of data points (I8)
	69-70	Skip
	71-82	Begin unit (F12,4)
	83-97	End unit (F15,4)
	98-103	Sampling rate (I6)
	104-117	Unit increment (E14,5)
	118-130	Skip

To display and, if desired, to alter the contents of the Header record, the user may call the NAB utility routine from the teletype. The Header information is listed in the same order as it is stored in the disk file: data type, event name, station name, channel number, processing status, number of data points, begin unit, end unit, sampling rate, and unit increment. An end-of-file sentinel denotes the end of the Header record.

An example is shown in Fig. 8. The data points are written into the disk file using a 2-argument buffer operation, and are stored in 10,000-word blocks.

```

FILES / 1 .1
2031 TOROI
600 TOROTEST

```

```

ALL DONE
NAB TOROI / 1 .1
L= 14
OK

```

```

T 0 3
00000000 ! ,GEOLOGIC TANYA MINA 1 10
          1026
00000007 0. 12.5096 1 2.44329E-02
00000014 END OF FILE

```

```

OK
R 1 2
GEOLOGIC
SEISMIC!
OK

```

```

T 0 3
00000000 ! ,SEISMIC TANYA MINA 1 10
          1026
00000007 0. 12.5096 1 2.44329E-02
00000014 END OF FILE

```

```

OK
END

```

```

ALL DONE

```

Fig. 8. Altering the contents of the Header record using the NAB utility routine.

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