



# DECUS

## PROGRAM LIBRARY

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## EEG DATA COLLECTION (BNI SERIES)

DECUS Program Library Write-up

DECUS No. 12-1

These programs provide analog data acquisition, manipulation and storage capabilities on the PDP-12. All of the programs are supervised by DIAL, the PDP-12 operating system. Each is loaded from tape by the user as it is required. The programs in the BNI series are:

AVERAGE	accepts analog input at user determined rates and stores it with baseline correction
DATUMPD	manipulates stored data, implements two cursors, and stores modified data on tape
FRQDD	displays power spectrum, synthesized waveform, and sine and cosine components for stored data
DISREALT	accepts data and displays it in real time
PLOTKEY	plots teletype characters on incremental plotter
CORDAT	displays correlation coefficients (correlograms) of stored data
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The data manipulation programs permit plotting of the spectra on a line plotter for hard copy. Refer to the back of this document for the DIAL loading procedure.

### AVERAGE

The program AVERAGE accepts analog input from A/D channels 10-17 at a user determined sampling rate. The incoming data is averaged when more than one trial epoch is requested; the averaged data is displayed and can also be stored on tape unit 1. Data is continually sampled and stored between runs (normalization) in a buffer that accommodates the 20 most recently acquired data points from each channel. The normalization time can be between 0.0 and 0.9 seconds, where 0.0 means no baseline subtraction is occurring. The average of the last 20 points stored between runs is subtracted from each point in the next run; it is this normalized data for the run that is stored on tape. The sampling rate is based on the KW12 real time clock. The minimum interval between samples is 1 msecond. An epoch is the time required to collect 254 data points; thus, the minimum epoch is 254 msec + 2 msec assigned for a 0 value at beginning and end = 256 msec. The trigger pulse for data collection can be a threshold voltage on an analog channel or a pulse on Sense Switch 1.

### Initialization

1. The program is loaded (after DIAL is running) by issuing the command → LO AVERAGE,0 ↓

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\*Additional program (s) as addenda

A series of messages are then printed on the teletype; type the appropriate answer and a carriage return for each reply.

2. The first four messages merely request identifying information for the experiment. The replies are not stored with the collected data, but provide written identification for the rest of the printed parameters. The four messages are:

NAME	(name of this experiment)
TEST NO.	(number of test)
DATE	(date of experiment)
TAPE NO.	(name of tape to be used for data storage)

Type a reply and carriage return after each message.

3. The next message is START AT BLOCK NO. Type the number of the block where data storage, if desired, will start. A reply of just a carriage return implies no data storage is desired.

If an illegal response is typed in reply to any of the following messages, a question mark and the message are printed twice and then the computer waits for a new reply.

4. The message NO. OF CHANNELS requests the number of consecutive analog channels, starting with 1 $\emptyset$ , to be sampled. The reply must be in the range 1 $\emptyset$ -17.

5. NORMALIZATION  $\emptyset.1 X$  is then printed. A value between  $\emptyset$  and 9 is required;  $\emptyset$  implies no normalization and all values are retained with the data. Because the program continually is sampling, less than 1 msecond will elapse between the trigger pulse and the start of the data epoch.

6. The message EPOCH TIME 1 SEC. X specifies the total time for sampling 254 points and requires an answer of  $\emptyset 1-99$  for 1-99 seconds or Q for 1/4 second or H for 1/2 second. (Values between 1 and 9 require a leading zero.)

7. The next parameter is NO. OF TRIALS. Legal replies are only 1, 4, 8, 16, or 32.

8. The answer to THRESHOLD LEVEL determines the trigger for the experiment. A value between  $\emptyset\emptyset 1$  and  $777_8$  can be typed if a threshold voltage on a specified channel is to signal the start of the experiment. A 3-digit number is expected so leading zeros are required for values with less than three digits. A reply in this range causes the message ON ANALOGUE LINE to be printed. Specify the analog channel 1 $\emptyset$ -17 on which the threshold level trigger signal will occur. If  $\emptyset$  is typed in response to THRESHOLD LEVEL, then a Sense Switch can be used as the trigger. The message SENSE LINE NO is printed; type the appropriate switch,  $\emptyset-5$ .

After a reply to the appropriate second message in step 8 , a list of the number of channels requested is printed, as follows for an eight channel experiment:

CH1 CH2 CH3 CH4 CH5 CH6 CH7 CH8

Identifying data may be typed under each channel header after terminating that line, EOL TO START is printed. Press the RETURN key to start the experiment (the computer will wait for the trigger pulse).

### Data Manipulation

After all the requested data has been collected, it is displayed on the scope as follows:

if  $SSW\emptyset=0$ , channels 1, 2, 3 and 4 are displayed

if  $SSW\emptyset=1$ , channels 5, 6, 7 and 8 are displayed

The following keyboard commands can be issued before or between trials:

<u>Key</u>	<u>Action</u>
C	Cancel most recently collected set of data <sup>1</sup> and clear display and wait for trigger pulse .
E	Change epoch .
N	Change number of trials .
T	Change threshold ,
W	Store data on unit 1 .
CTRL/D	Return to DIAL .

### DATUMPD

Data stored on LINCtape is manipulated by the DATUMPD<sup>2</sup> program and can then be stored in the modified form. Two cursors can be implemented to strip out portions of the data and to display a relative position reading. A line plotter may be interfaced to obtain hard copy of the results.

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<sup>1</sup> External Sense line  $\emptyset$  can also be used to cancel the most recent set of data.

<sup>2</sup> DATUMPD is a modification of the DATUM8 program, DECUS No. L-11.

## Usage

Call the program by the DIAL command :

→ LO DATUMPD,Ø ↵

The following message is printed:

SNS3 ZERO WORK ON 1ST BL  
ONE 2ND BL

Two blocks can be current at a time; the value of Sense Switch 3 determines which will be manipulated.

At any time after loading the program, excluding plotting, one or two data blocks may be called from unit 1 for modification. Type R followed by the block number and press RETURN to load in the first block. A three digit block number is required, so leading zero (s) are needed for blocks 0-99. A second block of data is entered by typing the number 2. The computer responds by printing the message:

2ND BLOCK NO

Type the three digit value for the second block to be manipulated and press RETURN. (Rubout may be typed to return to the display.)

The following commands can then be requested to perform the indicated operation:

<u>Key</u>	<u>Action</u>
A	Add the value in the Right Switches to all the data points currently displayed .
-	Subtract the value in the Right Switches from all the data points currently displayed .
C	Display two cursors; A/D knobs 4 and 5 control their movement. The cursors can be positioned on blocks 1 or 2, depending on Sense Switch 3, or on the difference by setting Sense Switch 4=1. Arbitrary amplitude values and relative scope position values are also displayed on the bottom of the scope .
D	Subtract the two sets of data currently displayed and display the difference curve.
E	Erase the data between the cursors. <sup>1</sup>

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<sup>1</sup> Be sure the cursor controlled by knob 4 is to the left of the one controlled by knob 5 before issuing this command.

F	Filter the displayed data.
H	Apply a high pass filter to the displayed area.
I	Integrate data.
J	Display the mean of the data.
K	Erase data outside the cursors. <sup>1</sup>
L	Scale the data up.
M	Multiply the data by the value in the Right Switches. A binary point is assumed between bits 5 and 6.
N	Invert the displayed data.
O	Redisplay original data.
P	Plot the display (refer to PLOTKEY description).
Rn	Load data from block n. (Type R and a three digit block number.)
2	Type 2 and a three digit block number to display a second block of data (must be preceded by Rn).
S	Scale down the data.
T	Draw letters on plotter. Size determined by bits 7-11 of Right Switches (CTRL/E to return to display).
U	Rectify data.
V	Display only the data between the cursors. <sup>2</sup>

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<sup>1</sup>The following A/D knobs control the vertical movement of the three possible displays:

KNOB	Display Controlled
∅	1st block of data
1	2nd block of data
2	difference

<sup>2</sup>When Sense Switch 4 is set to 1, the difference spectrum is displayed.

Wn	Write on tape unit 1 starting at block n.
>	Move right
<	Move left
CTRL/D	Return to DIAL

## FRQDD

FRQDD is a frequency analysis program used to display the sine and cosine components, power spectra and resynthesized waveform of a set of data. Data storage and plotting capabilities are provided.

### Usage

After the program is loaded via DIAL ( $\rightarrow$  LO FRQDD,  $\emptyset$   $\downarrow$ ), it enters display mode. A block of data can be called from unit 1 by typing R followed by the block number and then pressing RETURN. The block number must have three digits; be sure to include leading zeros if needed. If Sense Switch 5 equals  $\emptyset$  at this time, two consecutive blocks of data will be loaded (512 points); if Sense Switch 5 equals 1, the requested block of data will be expanded (with interpolation) from 256 to 512 points.

When the data is displayed, its sine and cosine components and power spectra can be generated using Sense Switches  $\emptyset$  and 2 as follows:

Switch Settings	Display
SSW $\emptyset$ =1, SSW2= $\emptyset$	sine and cosine components
SSW $\emptyset$ =1, SSW2=1	power spectra
SSW $\emptyset$ = $\emptyset$ , SSW2= $\emptyset$	original data and resynthesized waveform

The sine and cosine display is scaled using bits 8-11 of the Left Switches. Bit 2-5 of the Left Switches scale the power spectra.

The following keys can be typed to perform the indicated operations:

<u>Key</u>	<u>Action</u>
D	Return to display (after E or plotting).
E	Erase sine and cosine components. Type the component number after the message ERASE CPT is printed on the teletype.
F	Do a frequency analysis.
L	Double the amplitude of the data.
P	Enter plot mode.
Rn	Enter data from block n, unit 1.

T	Resynthesize the data.
Wn	Store power spectra in block n, unit 1.
Xn	Store resynthesized waveform at block n, unit 1.
CTRL/D	Return to DIAL.

Digital filtering can be achieved by erasing the sine and cosine components of a particular frequency (type E followed by the three digit component number) and then resynthesizing without the erased components (type T).

The W command stores the power spectra at the specified block of unit 1. The X command stores the resynthesized waveform. If one block of data was expanded to 512 points, then only one block of resynthesized data is stored. If two blocks of data were loaded, then two blocks of resynthesized data are stored.

FRQDD provides two types of hard copy graphs for the spectral components:

1. histogram - plotted as seen on scope
2. vector - sine and cosine components are combined to give a vector such that the amplitude and direction represent the selected component.

Plot mode is entered by typing the letter P. The message HISTO or VEC PLOT? H or V is printed. If a histogram plot is desired, type H. The following message is printed: SET SNS TO ZERO TO PLOT, THEN EOL. Set those Sense Switches to  $\emptyset$ , according to the table below, whose spectrum is to be plotted. (Setting the corresponding Sense Switch to 1 will prevent plotting of that spectrum.)

<u>Plot</u>	<u>Sense Switch</u>
original data	$\emptyset$
sine and cosine components	1 (sine above cosine)
power spectra	2
resynthesized waveform	3

Press RETURN when Sense Switches  $\emptyset$ -3 have been properly set to initiate the plot.

If a vector plot is selected, the individual vectors can be plotted by typing the three digit harmonic number. The vector is drawn and the harmonic number printed at the end of the line. The plotter pen then returns to the starting point and additional vectors can be plotted. (Type D to return to the display.)

The RUBOUT key can be pressed when entering a block number (E, R, W and X operations) or a harmonic number to return to the display.

## DISREALT

Data can be displayed and stored during acquisition using the KW12 real time clock. Stored data can also be displayed as though it were being collected in real time. The minimum epoch (256 points) is 1 second.

### Usage

Load the program by typing → LO DISREALT, Ø ↵. The program is now in display mode. Type D to collect and display incoming data on A/D channel 1Ø as a trace across the scope. Typing E and a number from 1 to 9 will alter the scanning time in the range 1-9 seconds. A new scan is started by typing T or generating a pulse on SXL1. If Sense Switch 5=1, data is received from A/D channel 4 and the trace can be deflected with A/D knob 4. If stored data is to be used, type R followed by the three digit block number to load that block of data from unit 1. The data in that block will be scanned at the preset rate. Type E and a number 1-9 to modify the scanning time. A pulse on SXLØ cancels a trigger pulse.

If data has just been collected from an analog channel or called from tape it can be compared with a block of data stored on unit 1 by typing S followed by a three digit block number. A/D knob Ø controls the vertical position of the acquired spectrum and knob 1 controls the position of the stored spectrum. Type T to display the two sets of data together. Type D to cancel the stored block of data and continue with analog input.

C may be typed at any time to cancel the display. CTRL/D causes a return to DIAL.

One block of collected real time data can be stored on unit 1 by typing W block number and pressing RETURN.

These commands are summarized as follows:

C	Cancel display.
D	Collect display data on A/D channel 1Ø.
Em	Alter scan (epoch) time, m = 1-9.
Rn	Retrieve data stored at block n, unit 1.
Sn	Display a second block, n, of data stored on unit 1.
T	Trigger new scan or display 2 sets of data together
Wn	Store data at block n, unit 1.
CTRL/D	Return to DIAL.

### PLOTKEY

When using an interfaced incremental plotter, the PLOTKEY program allows letters, numbers,

and arrows to be drawn on the graph in variable sizes. PLOTKEY can be used in conjunction with the DATUMPD, FRQDD, DISREALT and CORDAT programs.

### Usage

Load the program by typing the command  $\rightarrow$  LO PLOTKEY, $\emptyset$   $\downarrow$ . Any keyboard character typed on the teletype after the program is loaded will be echoed on the plotter.

The size of the characters is controlled by bits 7-11 of the Right Switches. Sense Switches  $\emptyset$  and 1 control the axis of the letters. Initially, when both switches equal  $\emptyset$ , the letters are printed horizontally. The following rotations are possible:

<u>Sense Switch</u>		<u>Setting</u>	<u>Position</u>	
$\emptyset$	=	$\emptyset$	>	Letters are inverted (180°).
1	=	1		
$\emptyset$	=	1	>	Letters are rotated 90° clockwise.
1	=	1		
$\emptyset$	=	1	>	Letters are rotated 90° counterclockwise.
1	=	$\emptyset$		

The following control key commands are available:

<u>CTRL Key and</u>	<u>Action</u>
B	Back up one space.
C	Center pen in X direction.
D	Return to DIAL.
E	Return to display (when using DATUMPD program only).
H	Plot head pattern (  ).
P	Move pen to left.
U	Move up one line.
$\leftarrow$ (Shift/O	Plot right arrow.
$\uparrow$ (Shift/N	Plot down arrow.

### CORDAT

The correlation coefficients are computed at various time leads and lags for cross correlation between two blocks of data or for autocorrelation of one block of data. The data is corrected

for DC level and amplitude so the coefficient lies between  $\pm 1$ . Time shifts of  $\pm 64$  addresses (1/4 block) can be requested. Tail wrapping techniques are used (time shifts greater than  $\pm 32$  addresses may introduce some error).

Usage

Load the program by typing  $\rightarrow$  LO CORDAT,  $\emptyset$   $\downarrow$ . The computer will respond by printing X DATA BLK on the teletype. Type the three digit number of the block on unit 1 where the data is located and press RETURN. Y DATA BLK is then printed. Type that value and press RETURN. (RUBOUT can be typed to request a new block before the calculation starts.) Computation can be accelerated by setting Sense Switch 2=1. (Some loss of accuracy is introduced by this action because the cross product of every other data point is skipped.) The display includes the original Y data (tailwrapped) original X data, and the correlogram with an axis, cursor and X value address. A/D knobs control the movement of these plots as follows:

<u>A/D Knob</u>	<u>Plot</u>
$\emptyset$	Y data vertical movement
1	X data vertical movement
2	Correlogram vertical movement
4	X data and cursor - horizontal position
6	X value of correlogram - horizontal position
7	X value of correlogram - vertical position

The scope channel switch can be set as follows:

<u>Setting</u>	<u>Display</u>
1	X and Y data $\updownarrow$
2	Correlogram $\updownarrow$
1 & 2	X and Y data and Correlogram

CTRL/D may be typed to return to DIAL. Typing the key R causes the program to repeat with new data.

CORDAT also permits use of an interfaced incremental plotter. Type P to enter plot mode. Sense Switches  $\emptyset$ , 1, 4 and 5 control plotting parameters. When the appropriate switch is set to  $\emptyset$ , the program performs the indicated function.

<u>Sense Switch</u>	<u>Action</u>
$\emptyset$	Plot Y data (plus correlogram) .
1	Plot X data (plus correlogram) .
4	Plot scale .
5	Advance paper so correlogram is not overprinted .

Setting the appropriate Sense Switch to 1 prevents the function. Note that when Sense Switches  $\emptyset$  and 1 both equal 1, only the correlogram is plotted.

Setting Sense Switch 5=1 may be particularly useful when Sense Switches 0 and 1 are also equal to 1 so that a second correlogram can superimpose the first.

### DIAL LOADING PROCEDURE

1. Mount a DIAL tape on tape unit 0. (Unit 0 is indicated by setting the tape channel indicator to 8 on TU55 transports.)
2. Mount another tape on unit 1, if required. (Refer to commands, chapter 1.)
3. Set the switches of both tape units to REMOTE and set unit 0 to WRITE ENABLE.
4. Set the mode switch to LINC mode and press I/O PRESET to initialize LINC Instruction Field to 2 and LINC Data Field to 3.
5. Set the Left Switches to 0701 and the Right Switches to 7300 by raising the switches indicated by ↑ and pushing down those indicated by ↓ in the following diagram:



6. Press the DO console switch.
7. When the tape has stopped moving, press the START 20 key.



## DATUMFFT

A program for the manipulation of blocks of data. Ray Cooper and P. V. Popock

Origins

This program has been begotten from many sources including DATAM, PLOTKEY, DATUMPD, FILTERFT. It bears resemblance to all and responsibility to none.

The object of the program is to manipulate either of two blocks of data already stored on Unit 1. These manipulations include larging, smalling, filtering, multiplying, integrating, plotting, etc. The program is loaded through DIAL or by the special load program. The program enters through a typscript routine which tells the user to set SNS 3 to ZERO to manipulate the first block of data or ONE to manipulate the second block. The program then displays a straight line.

Data is loaded from Unit 1 by typing R followed by block number RETURN. Leading zeros must be inserted. Rub out can be used whilst typing to return to display.

A second set of data can be displayed by typing 2 and the block number in answer to the teletype message (leading zeros) then RETURN.

By typing D (difference) a third display is generated which is the difference between the two sets of data (1 minus 2).

These traces can be moved vertically using knobs 0, 1 and 2 respectively.

The second set of data can be changed by typing 2 BN RETURN.

The first set of data can be changed by typing R BN RETURN.

Cursors

Typing C will generate two cursors that can be moved with knobs 4 and 5. The cursors can be positioned on blocks 1 or 2 according to SNS 3 or on the difference by SNS 4.

The positions and amplitude values (decimal) of the cursors are displayed at the bottom of the scope. The amplitude values (upper line) are in arbitrary units (-ve values are up on the scope).

Manipulation of data

The data can be altered in a number of ways by typing the appropriate key on the teletype. If SNS 3 is ZERO the first block will be changed. If SNS 3 is ONE the second block will be changed. The difference is continually generated and will immediately show the change of data.

- A Add contents of RSW (DC shift up)
- Minus contents of RSW (DC shift down)
- C To display cursors
- D** *Difference display*
- E Erase data between cursors
- F Smooth data (a bastard type of filtering)
- I Integrate data
- J Make the mean value of the block of data zero
- K Keep data between cursors
- L Large data (X 2)
- M Multiply data by RSW in which a binary point is assumed between bits 5 and 6.  
(Thus 0200 multiplies data by 2 and 0040 multiplies by 1/2)
- N To invert data
- O This restores data to original state
- P To plot data (see below)
- Q To frequency analyze data (see below)
- R** *read 1 block from drive 1*
- S Small data (divide by 2)
- T To letter on plotter (see below)
- U Rectify data
- V To display data between cursors  
(I will then integrate data between cursors)
- W To store data (see below)
- Z To resynthesize data (see below)

Control D to return to DIAL.

## Fourier Analysis

Typing Q will cause a fast Fourier transform to be done on the data. The power spectrum will be displayed. The frequency range of these 128 points depends upon the sampling rate of the original data. If this data was collected such that the block being manipulated (256 points) was collected in 1 second then the analysis is from DC to 128 Hz in 1 Hz steps. If the original data was collected in 2 seconds the frequency range is DC to 64 Hz in 1/2 Hz steps.

When in the display after analyzing (Q) the addresses of the cursors at the bottom of the display should be divided by two to get the harmonic number.

Whilst displaying the power spectrum any values that overload the scope are brightened. To see spectrum in correctly type S (small) until no bright spots occur.

The power spectrum can be treated like data and manipulated using the teletype.

A scale factor is displayed in the upper left hand corner of scope and is an indication of the absolute amplitude of the power spectrum. If the number is large then the power spectrum is very big.

Typing Z will resynthesize from the sin and cosine components (which are not displayed).

## Filtering

Digital filtering can be achieved by doing the Fourier analysis (Q) and using the cursors (C). By using the erase facility (E) the Fourier components between the cursors can be deleted and the resynthesized waveform (Z) will be formed without these components. Alternatively the keep facility (K) will achieve band-pass filtering.

## Storage of modified data

The modified blocks 1 and 2 or D can be stored on unit 1 by typing W.

If only one block is being displayed W should be followed by the block number, leading zeros if necessary, and RETURN.

If 2 blocks are being displayed W is followed by a question which determines which data block is to be stored.

After answering 1, 2 or D type the block number (leading zeros if necessary) and RETURN. Rubout can be used.

## Plotter

The modified data can be plotted out on an incremental plotter by typing P.

The size of the X axis is set by SNS 0 & 1

If 0 on ONE and 1 on ZERO Quarter scale

If 0 and 1 on ZERO Half scale

If 0 and 1 on ONE Full scale

If SNS 5 is ONE pen will be lifted on return (no baseline)

> and < will move plotter pen right or left

### Lettering on plotter

The program is assembled with PLOTKEY which enables lettering to be performed on the plotter. Whilst in display type T (Type) to enter lettering mode. The size of the letters is set by the RSW (0004 is about 10 mm high). The axis of letters is set by SNS 1 & 0. These SNS are checked after pressing the return key, thus if lettering horizontally change SNS 0 to ONE type return; further characters will be vertical.

SNS 1 ONE inverts characters

SNS 0 ONE rotates 90° anticlockwise

Apart from keys that plot the relevant character the following keys are operative:

Control B back one space

C set pen in middle of plotter paper (this might take a few seconds of apparent inactivity if pen is on left side of paper)

H plot a head diagram

P set plotter pen at left hand side of paper

U move up one space

Left arrow (upper case O) draws arrow pointing to Rt.

Shift O draws arrow pointing to Lt.

Up arrow (upper case N) draws arrow pointing down

Shift N draws arrow pointing up

NOTE Control D to return to DIAL

Control E to return to display