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DECUS NO.	L-40
TITLE	AVERAGER SYSTEM FOR THE CLASSIC LINC
AUTHOR	Dennis J. Nichols
COMPANY	Biomedical Computing Division Medical Center University of Wisconsin
DATE	September 11, 1968
SOURCE LANGUAGE	

AVERAGER SYSTEM FOR THE CLASSIC LINC

DECUS Program Library Write-up

DECUS No. L-40

This set of programs was developed by the Biomedical Computing Division at the University of Wisconsin Medical Center under grant FR00249-03 from the Division of Research Facilities and Resources of the National Institutes of Health.

The averager system consists of three programs filed in the LAP6 file. Each program is described separately on the following pages.

Title: Online AVERAGER Program

Manuscript Names: RESIDENT, FPSP4MOD, QAKBDTTY, SETUP, AVEDISP, CALIBRAT, AVESECT1, AVESECT2, AVEBOTH1, AVEBOTH2, AVEPLOT, AVECALL

Binary Name: AVERAGER

Program Language: LAP6

Computer: LINC

Programmer: Dennis J. Nichols

Contrib. Organ.: Laboratory Computer Facility
University of Wisconsin

1.0 PURPOSE

This program provides a means of computing the average response of some signal-generating device to a series of excitations, e.g., the human evoked cortical response to a train of light flashes. It is also possible to generate a latency histogram of a zero-or-one device, e.g., a discriminated neural firing. The general capabilities of the program include:

A. Simultaneous one-input averaging and latency histogram.

B. Simultaneous two-input averaging.

C. Filing of completed averages.

D. Plotting of filed data.

2.0 USAGE

2.1 Program Implementation

Mount the LINC tape containing LAP6 and the binary program on unit 0. Mount a data tape on unit 1. Set the Left Switches to 0701 and the Right Switches to 7300. Lift the DO lever. When the tape stops, push the START 20 button. Call the program with the LAP6 LOad meta-command as follows:

→LO AVERAGER,0

2.2 Space Required

The binary requires 26_8 blocks and may be filed anywhere in the LAP6 file on unit 0. During execution, AVERAGER uses all 8 quarters of memory.

2.3 Operational Procedure

Upon entry to the program, a 7-way option display is presented. This display will later be referred to as the "main option display." It is to this display that all options return when they are finished. The first three options are normally performed in order followed by option 4 or 5.

```
DO ?

1  SETUP
2  DISPLAY
3  CALIBRATE
4  AVERAGE 1+UNITS
5  AVERAGE 2
6  PLOT
7  CALL PROGRAM
```

To choose the desired option, strike the proper key (1 to 7) followed by End Of Line (EOL). The operation of each option is explained below. For the main option display and within each option, the words "key" and "Keyboard" may be interpreted as referring to either the standard LINC keyboard or the Teletype keyboard. Both keyboards are "live" throughout the program and may be used interchangeably.

2.3.1 SETUP

The SETUP option allows the user to change parameters which are used by options DISPLAY, AVERAGE 1+UNITS, and AVERAGE 2. The parameters entered in this option are retained until modified by subsequent use of this option or until updated by options AVERAGE 1+UNITS or AVERAGE 2.

All questions, in this option only, use the convention that any question answered with all blanks will cause the previous answer to that question to be retained. If the previous answer has been modified, as in the case of RUN NO. or BLOCK NO., then the modified result is retained. A question may be answered with all blanks by simply striking EOL prior to any other key. The questions and their explanations follow.

```
CHANNEL 1 - SAM 1 ?
CHANNEL 2 - SAM 1 ?

NUMBER OF SWEEPS ???
  [1-999]
```

The answers to the first two questions should be digits from 0 to 6. These answers determine which physical analog inputs (SAMs) will be sampled and averaged. AVERAGE 2 uses both CHANNEL 1 and 2, while AVERAGE 1-UNITS uses only CHANNEL 1. The last question of the display determines the number of sweeps (responses) to be averaged.

```
SWEEP TIME =
?? X 50 MS  [1-81]
```

Answer with the multiplier of 50 milliseconds which gives the desired time length for the sweep width.

```
SERIES ID IS ??????
```

Any 6 alphabetic or numeric characters may be used for the series identification which is stored with each data run performed.

```
NEXT RUN NO. ??
```

Data runs will be numbered sequentially starting with the decimal number supplied by the answer to this question. The run numbers, generated by the program, following 99 will be 00, 01, etc.

```
SAVE NEXT RUN IN
BLOCK ??? ON UNIT 1
  [0-774 OCTAL]
```

This answer will specify where on the data tape the next data run will be stored. The block specified must be a multiple of 4. After each data run the block number will automatically be incremented by 4 so that the next data run will be stored in sequence.

2.3.2 DISPLAY

The DISPLAY option causes the LINC to simulate a dual-beam oscilloscope, each beam displaying one analog input. The inputs displayed are those selected in the SETUP option, the upper beam is CHANNEL 1 and the lower is

CHANNEL 2. The sweep speed is also determined by the SETUP option. The first display determines the sweep mode.

```
SWEEP ?
0  FREE RUNNING
1  SYNC TO STIMULUS
```

The analog display will occur after EOL is struck. Strike any key to terminate this option.

2.3.3 CALIBRATE

AVERAGER requires that the input to the LINC be calibrated so that the final averages may be represented as the average voltage occuring at the source. In order to accomplish such a calibration, the user should connect an oscillator with known peak-to-peak amplitude to the input of his first amplifier. The output of the last amplifier then becomes the input to the LINC (such items as a magnetic tape or transmission line may be used between the first and last amplifier). The input to the LINC must not exceed ±1.0 volts. For the purpose of CALIBRATE, this input must have a voltage swing greater than ±0.10 volts and a frequency between 25 and 250 hertz. The first display in this option is:

```
DO ?
0  NEW CALIBRATION
1  CHANGE BY A FACTOR
SAM 1 ?
```

The answer to the second question above determines which analog input (SAM) is to be used. If a NEW CALIBRATION is desired, the user must provide the oscillating signal mentioned above. In this case, the next question will be:

```
??? μV PEAK-TO-PEAK
```

Answer with the amplitude of the oscillator. The voltage levels of evoked potentials usually dictate that the answer will be in micro-volts. The user may adopt any consistent system. After EOL is struck, CALIBRATE will average eight sweeps with a sweep width of 50 milliseconds. The trigger for the

sweep is a positive-going threshold crossing (+0.06v at the LINC input) of the signal to be averaged. The program measures the peak-to-peak average amplitude and computes a calibration value for the desired channel. Each of the 7 channels may have their own calibration values. The average of eight sweeps will be displayed. Terminate by striking any key.

The CHANGE BY A FACTOR allows the user to change the previous calibration value on SAM 1*X* by an integer factor. This is useful when amplifier gain is changed by a calibrated step switch. If this option is chosen, the next display will be:

```
AMPLIFICATION
INCREASED BY ??
DECREASED BY ??
```

Answer the proper question above with the factor by which the amplification was changed. Answer the other question by striking only EOL. The first non-blank or non-zero answer will be used and the other one ignored. After the calculation is made, the main option display will reappear.

2.3.4 AVERAGE 1+UNITS

This option averages one analog input while forming a latency histogram (post-stimulus time histogram). The analog input is CHANNEL 1 as assigned in SETUP. The synchronizing or stimulus input is a -3 volt pulse to be connected to external line 1 (XL 1, see section 2.12). The input for the histogram is a -3 volt level on external line 2 (XL 2, see section 2.12). The program samples 250 points to produce one sweep. Thus, if a sweep width of 50 milliseconds is used, a sample is taken every 200 μseconds.

Before starting sampling, the following display is presented:

```
RUN XX
POINT ??
```

XX is the decimal sequence number of this run. At the completion of this option, the run number will be incremented by 1. The user may answer with

any two alphanumeric characters to further identify this run. When EOL is struck, the program will pause for the synchronizing input and then start sampling. Each sample is compared to the upper and lower limit of the analog-to-digital converter.

If the input ever reaches or exceeds these limits (±1.0 volts), the current sweep will be rejected and not averaged. The number of such rejected sweeps is counted and later referred to as "skips." Sampling continues until the number of acceptable sweeps equals the number of sweeps requested in SETUP. Each acceptable sweep is momentarily displayed before pausing for the next sync signal. Between sweeps the accumulator will display, in octal, the number of remaining sweeps to be averaged. When sweep count is satisfied, the data will be averaged, written onto the data tape, and displayed on the LINC oscilloscope as shown in section 2.4.1. Striking any key interrupts the average waveform display and presents the user with the following options:

```
DO ?
0  NEW SCALE
1  EXPAND DISPLAY
2  COMPRESS DISPLAY
3  EXIT
```

If option 0 is chosen, the user will be asked for a new vertical scale:

```
SCALE ??? [1-510]
```

The user should answer with a decimal number in the indicated range and strike EOL to return to the average waveform display.

The EXPAND and COMPRESS options refer to the horizontal time base. By choosing EXPAND, the display will be enlarged to show only the left half of the display. COMPRESS will return the display to normal. These two options have no effect when the display is already in that state. By choosing EXIT, or simply hitting EOL, control will return to the main option display. If this run resulted in filling the data tape, then that tape is rewound and the following display precedes the return to the main option display.

```
MOUNT NEW DATA TAPE
BEFORE NEXT RUN
```

2.3.5 AVERAGE 2

AVERAGE 2 averages two analog inputs simultaneously. The analog inputs are those assigned in SETUP. The synchronizing input is a -3 volt pulse to be connected to external line 1 (XL 1, see section 2.12). The program samples 250 points on each input to produce one sweep. Thus, if a 50 millisecond sweep is used, a sample is taken on each input every 200 μseconds.

Before starting sampling, the following display is presented:

```
RUN XX
POINT 1 ??
POINT 2 ??
```

XX is the decimal sequence number of this run. At the completion of this option, the run number will be incremented by 1. The user may type any alphanumeric characters to further identify this run (POINT 1 is associated with CHANNEL 1, POINT 2 with CHANNEL 2). When the second EOL is struck, the program will pause for the synchronizing input and then start sampling. Each sample is compared to the upper and lower limit of the analog-to-digital converter. If the input ever reaches or exceeds these limits (±1.0 volts), the current sweep (both channels) will be rejected and not averaged. The number of such rejected sweeps is counted and later referred to as "skips." Sampling continues until the number of acceptable sweeps equals the number of sweeps requested in SETUP. During the pause before the sync signal occurs, the accumulator will display, in octal, the number of remaining sweeps to be averaged. When the sweep count is satisfied, the data will be averaged, written onto the data tape, and displayed on the LINC oscilloscope as shown in section 2.4.2. Striking any key interrupts the average waveform display and presents the user with the following options:

```
DO ?
0  NEW SCALE
1  EXPAND DISPLAY
2  COMPRESS DISPLAY
3  EXIT
```

If option 0 is chosen, the user will be asked for a new vertical scale:

```
SCALE ??? [1-510]
```

The user should answer with a decimal number in the indicated range and strike EOL to return to the average waveform display.

The EXPAND and COMPRESS options refer to the horizontal time base. By choosing EXPAND, the display will be enlarged to show only the left half of the display. COMPRESS will return the display to normal. These two options have no effect when the display is already in that state. By choosing EXIT, or simply hitting EOL, control will return to the main option display. If this run resulted in filling the data tape, then that tape is rewound and the following display precedes the return to the main option display.

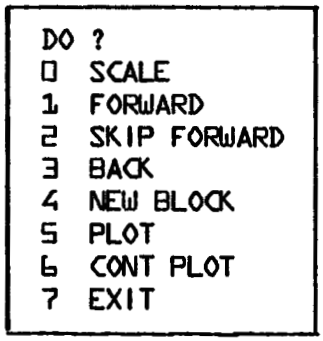
```
MOUNT NEW DATA TAPE
BEFORE NEXT RUN
```

2.3.6 PLOT

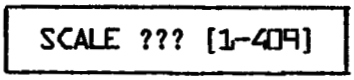
The PLOT option provides a means for retrieving averaged data which has been written on a data tape. PLOT allows the user to display the waveform on the scope face and/or plot it on the Calcomp plotter. If the plotter is to be used, it should be ON previous to entering this option. PLOT begins by initializing the pen position and requesting:

```
BLOCK ???
```

Enter the octal number where the desired data is stored. The block number specified must be either zero or a multiple of 2, i.e., an even number from 0 to 776. After EOL is struck, the program will read the data from unit 1. If the given blocks do not contain averaged data, the program will go directly to the option display shown below. If the data is present, it will be scaled and the waveform display shown in section 2.4.3 will be presented. Striking any key interrupts the waveform display and presents the following options:



The SCALE option allows the user to enter a new vertical scale via the following display:



After entering the new scale and striking EOL, the waveform display is again presented.

Options 1 through 4 change the block number of the data to be displayed. NEW BLOCK returns to the first question in this section to obtain a new block number. The other options modify the block number as shown in the following table.

OPTION NUMBER	NAME	INCREMENT
1	FORWARD	+2
2	SKIP FORWARD	+4
3	BACK	-2

The SKIP FORWARD option is used for going forward thru data produced by AVERAGE 1+UNITS. The FORWARD and BACK options are used for going forward and backward thru data produced by AVERAGE 2. In any case, options 1 thru 4 lead back to the waveform display unless:

a) the blocks referenced do not contain averaged data, in which case the option display reappears;

or b) in the case of FORWARD or SKIP FORWARD, the end of tape is reached, in which case END TAPE will be displayed. By striking EOL, the plot option will terminate and the main option display will reappear.

Option 5 will plot the waveform just displayed. The plotter output is automatically spaced 5 plots per page. The waveform is plotted negative up. A waveform scaled properly for viewing on the scope gives good plotter output. After plotting, the above option display reappears.

Option 6, CONTinuous PLOT, allows the user to plot a series of waveforms which are stored successively on the data tape. The following displays ask for the information necessary to do the plotting:

```
PLOT ??? DEC WITH
INCREMENT ?
```

Answer the first question with the decimal number of plots desired. Answer the second question with 4 if data from AVERAGE 1+UNITS is to be plotted (the increment refers to the spacing of data on the data tape). If plotting data from AVERAGE 2 use an increment of 2 to plot two averages per run or an increment of 4 to plot one average of each run. After striking the second EOL, the user will be asked for the block number of the first waveform to be plotted.

```
BLOCK ???
```

Answer with an even number in the range 0-776. Plotting begins after EOL is struck. It may be stopped only at the end of a plot by striking any key on the LINC keyboard. After all requested plots have been completed, or when plotting has been stopped, CONT PLOT will return to the above option display. CONT PLOT will not plot blocks which do not contain data. However, such blocks are counted towards the number of plots to be done.

```
END TAPE
```

will be displayed if the end of the data tape is reached. Strike EOL to terminate the PLOT option and return to the main option display.

EXIT will return to the main option display. There is no capability for plotting the histograms.

2.3.7 CALL PROGRAM

The CALL PROGRAM option allows the user to exit from the AVERAGER program and load a different program in one step. The new program to be loaded may return automatically to AVERAGER. The program to be loaded must be on unit 0. This option starts with the display:

```
CALL THE PROGRAM
????????
```

Type in the name of the program desired and strike EOL. If the requested program is present, it will be loaded and started. If no such program is found, then:

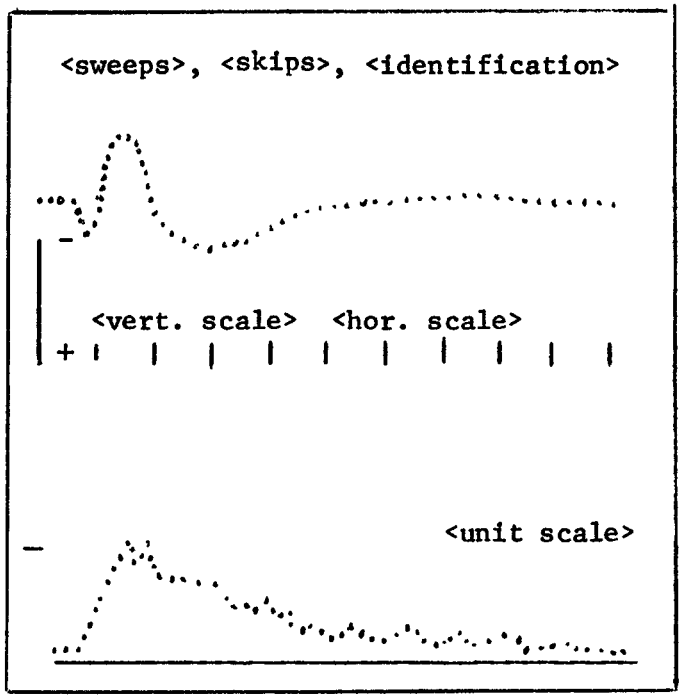
```
NO
```

will be displayed. Strike any key to return to the main option display.

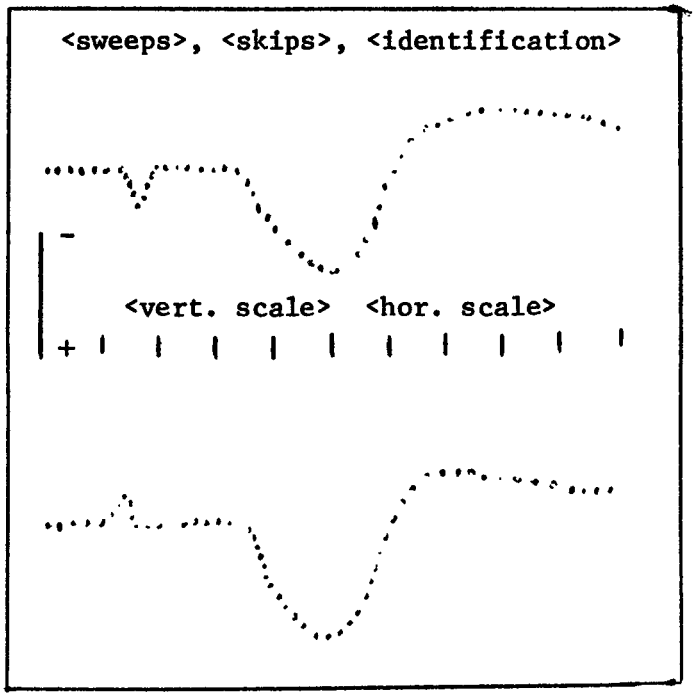
The CALL PROGRAM will allow two other operations. By typing LAP6 for the program name, the user can return to LAP6. AVERAGER will exit and rewind the tape on unit 0 if the requested name is all blanks. AVERAGER may be restarted by pushing START 20.

2.4 Displays

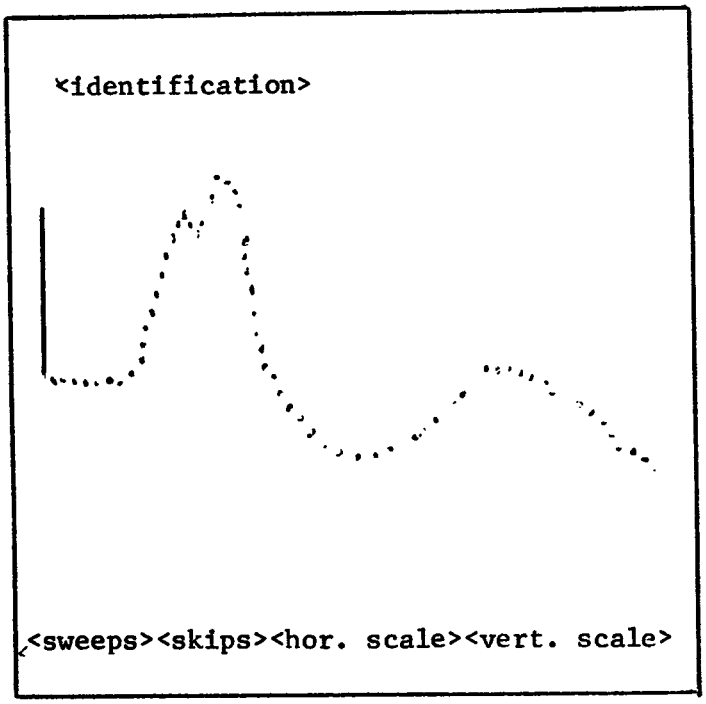
2.4.1 AVERAGE 1+UNITS



2.4.2 AVERAGE 2



2.4.3 PLOT



2.5 Teletype Output

During each data run with AVERAGE 1+UNITS and AVERAGE 2, the run number and block number are printed.

2.6 Error Stops

There are no error stops. None of the console switches are read by the program.

2.7 Input and Output Tape Mountings

The program must be filed on the tape mounted on unit 0. The data tape must be mounted on unit 1. A new data tape should be either freshly marked or remarked.

2.8 Data Tape Format

The averaged data is stored on the LINC tape mounted on unit 1. The averages are expressed as "average μvolts at source" and represented in a floating point format. Each run produces four blocks of data. The first block is always stored in a block whose number is a multiple of 4. If AVERAGE 1+UNITS produced the data, then the tape has this structure:

Loc.	(relative to beginning of group)
0000	exponent
0001	mantissa — 1st averaged point
⋮	
0762	exponent
0763	mantissa — 250th (last) averaged point
0764	sweep speed multiplier (x50ms)
0765	number of sweeps
0766	number of skips
0767 – 0771	series ID
0772	run number in KBD code
0773	point number in KBD
0774 – 0777	unused
1000	first bin of latency histogram
⋮	
1371	250_{10}^{th} (last) bin of latency histogram
1372 – 1763	unused
1764 – 1777	same as 0764 – 0777 except (1773) = 7777

The data structure for AVERAGE 2 is:

0000 – 0777	First channel information in same format as 1+UNITS
1000 – 1777	Second channel information, in same format as 0000-0777

The ID for the first channel is always the same as the second except for point number. In AVERAGE 1+UNITS the point number for the latency histogram is 7777_8 thus distinguishing it from the average data.

2.9 Timing

Sample rate timing is exact. The time between samples can be calculated by dividing the sweep time by 250_{10}. In AVERAGE 1+UNITS, the skew between the analog sample and the histogram input is 64 μsec. In AVERAGE 2, the skew between samples of the two analog inputs is also 64 μsec. with CHANNEL 1 sampled before CHANNEL 2.

After sampling the last point, the program checks the data for limiting on the analog-to-digital converter. If no limited data is found, then the data is added to the previous sweeps. The "dead time" due to this process is about 90 milliseconds in AVERAGE 1+UNITS and 125 milliseconds in AVERAGE 2.

2.11 Cautions to Users

START 20 may be pushed at any time if the user finds that he has proceeded into an option he does not wish to complete.

2.12 Equipment Configuration

On LCF LINC I certain external lines are "anded" with a "Mode" which can be selected under program control. The XL inputs to AVERAGER are assumed to appear when Mode 1 is selected. The program selects Mode 1 as follows:

```
LDA i
  1
OPR 4
```

2.13 Software Configuration

In executing the CALL PROGRAM option, AVERAGER functions much like the LAP6 LO meta-command. There are only two changes to the LAP6 LOading procedure:

a) after NO, control returns to AVERAGER;

b) locations 15 and 16 are modified after quarter 0 is loaded. They will contain

```
0015    RDC i
0016    0/NNN
```

where *NNN* is the first block number of AVERAGER. This allows the called program to automatically return to AVERAGER.

2.14 References

1. Technical Report No. 2 (May 1, 1967), LAP6 HANDBOOK, CRL, Washington University.

3.0 METHOD

3.1 Averaging

As each sample is taken, it is biased by 200_8 thus making the value in the range 0001_8 - 0377_8. These values are stored in a temporary area until the 250_{10} points in one sweep are done. They are checked for limiting of the converter (001_8 or 0377_8). If no limiting values are found, then this sweep will be added, in double precision fixed point arithmetic, to the previous totals. After the required number of sweeps have been added, sampling will stop. The total value of the first point is subtracted each of the 250_{10} points to remove the bias. Each resulting value is converted to floating point, divided by the number of sweeps, and multiplied by the calibration value which is expressed as μvolts per count. The resulting floating point number is stored as the final value for that point and has the dimension of μvolts per sweep. The array of such numbers is written onto the tape in floating point form.

3.2 Histogram Formation

The histogram consists of 250 bins, each representing 0.004 x n milliseconds where n is the sweep width. The input to XL 2 is checked with each sample until a pulse is found. Then proper bin of the histogram is incremented by one. During the next sample, XL 2 will not be checked. Therefore, by

using a pulse which is 1.5 times the inter-sample interval, every pulse will be counted once and only once.

4.0 DESIGN SPECIFICATIONS

AVERAGER consists of 12_{10} separate manuscripts. They are all assembled separately. To produce the binary for AVERAGER, first allocate 26_8 blocks in the file. Begin assembling the manuscripts and copying them into the allocated area.

Manuscript Name	Relative Block	Assembled For Quarter
RESIDENT	0	0
FPSP4MOD	1	3
QAKBDTTY	2-3	2-3
SETUP	4	1
AVEDISP	5	1
CALIBRAT	6	1
AVESECT1	7	1
AVESECT2	10-12	1-3
AVEBOTH2	13	1
AVEBOTH2	14-15	1-2
AVEPLOT	*16-22	0-4
AVECALL	23-25	1-3

*When copying AVEPLOT, copy Q1 into block 16, Q0 into block 17, and Q2-4 into block 20-22.

7.0 OTHER INFORMATION

AVERAGER is written to be used with the standard configuration of LAP6, i.e., a LAP6 at block 300 with an index at block 426. If any other configuration is to be used, the manuscript of AVECALL must be changed.

Title: Latency and Amplitude Measurement

Manuscript Name: LATAMP

Binary Name: LATAMP

Program Language: LAP6

Computer: LINC

Programmer: Dennis J. Nichols

Contri. Organ.: Laboratory Computer Facility
University of Wisconsin

1.0 PURPOSE

LATAMP is a program intended for use with data produced by AVERAGER [1]. Data is retrieved from LINC tape and displayed on the oscilloscope. A cursor is used for selection of the point whose latency and amplitude is measured. These are continuously displayed and may be printed on the Teletype.

2.0 USAGE

2.1 Program Implementation

LATAMP can be started either from LAP6 with the LO meta-command or from AVERAGER with the CALL PROGRAM option.

2.2 Space Required

During execution LATAMP uses all eight quarters of LINC memory. The binary on tape occupies 5 blocks; the manuscript occupies 37_8 blocks.

2.3 Operational Procedure

If any printing is to be done, the Teletype should be turned to LINE before starting LATAMP. A data tape must be mounted on unit 1. The user is first asked:

```
TAPE ID ??????
```

Any six characters may be supplied. Next the user is asked for the block number of the desired data.

```
BLOCK ???
```

The user must type the number in octal. Non-octal characters will cause the program to give unpredictable results. After striking EOL, the data display will appear.

The data display is controlled in the following way:

B	Return to the BLOCK display to obtain a new data block.
F	Move forward two blocks to obtain new data (use only with data produced by the AVERAGE 2 option).
P	Print the latency and amplitude as displayed on the scope.
S	Enter new vertical display scale. The following display appears:

```
SCALE ??? (1-511 DEC.)
```

The scale refers to 2 cm on the scope.

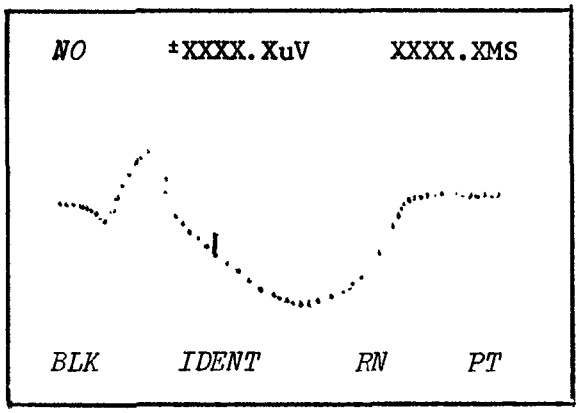
X	Exit. Return to the calling program.
KNOBS 1 and 3	control the horizontal positioning of the cursor.
KNOBS 5 and 7	control the vertical positioning of the trace. AVERAGER assumes the first point sampled to be at 0 amplitude.

2.4 Displays

If the requested block number does not contain data, then the user will be presented this display:

```
NO DATA
```

Striking EOL returns to the BLOCK display. The main data display is as follows:



Where:

NO is the number of the point being measured (incremented only by printing)

BLK is the number of the block being displayed.

IDENT is the six character identifier which is carried along with the data.

RN is the data run number.

PT is the data point number.

2.5 Teletype Output

An example of Teletype output is shown below. The abbreviations are explained in 2.4.

```
DATA 5

NO AMPLITUDE LATENCY  BN  IDENT  RN  PT

01     -.6uV    .0MS 200 CE6708  17  31
02    +5.0uV   8.0MS
03   -10.6uV  14.8MS

01     -2.3uV    .0MS 204 CE6708  18  33
02    +9.5uV  14.4MS
03  +127.7uV  21.6MS
04   -39.1uV  53.2MS
```

2.8 Input Tape Format

The data tape format is found in the documentation for AVERAGER [1].

2.10 Accuracy

The figures given for latency or amplitude are accurate to ±0.05% or an absolute ±0.1, whichever is larger.

2.11 Caution to Users

If striking F causes the end of the tape to be reached, then the data tape will be rewound and the TAPE ID question will appear.

2.14 References

1. AVERAGER, a LINC program by D.J. Nichols.

Title: List Average Data

Manuscript Name: AVELIST

Binary Name: AVELIST

Program Language: LAP6

Computer: LINC

Programmer: Dennis J. Nichols

Contrib. Organ.: Laboratory Computer Facility
University of Wisconsin

1.0 PURPOSE

AVELIST produces a list of blocks containing data from the program AVERAGER [1]. The identification of the data is printed with each block number.

2.0 USAGE

2.1 Program Implementation

Mount the LINC tape containing LAP6 and the binary program on unit 0. Set the switches to 0701 and 7300. DO TOG and START 20. Call the program with the LAP6 LOad meta-command.

→LO AVELIST,0

Alternatively, AVELIST may be called from AVERAGER [1].

2.2 Space Required

The binary program is 4 blocks long and should be filed on the tape to be used on unit 0. The manuscript requires 16_8 blocks in the file.

2.3 Operational Procedure

To use this program, turn the Teletype to LINE. The program begins with the following display:

```
TAPE ID IS
??????

START AT BLOCK
???
```

Enter any six characters for the tape ID. These characters will be printed at the top of each page. Enter the number of the block with which you wish to begin. The block number must be in octal and a multiple of 4. After the final EOL, the program will begin reading the data tape (which must be on unit 1). After each group of 4 blocks is read, the block number and data ID are printed. Printing will continue until either the end of tape is reached or EOL is struck on the LINC keyboard. When the program finishes, the data tape will be rewound and control will return to the program from which it was called.

2.5 Teletype Output

The Teletype output is formatted into pages. A sample is shown in section 6.1. If the data was produced by the AVERAGE 1+UNITS option, then Point 2 (P2) will be listed as **. The legend is:

BN = Block Number, in octal
IDENT = 6 character IDENTifier
RUN = RUN number, in decimal
P1 = Point 1 (first 2 blocks)
P2 = Point 2 (second 2 blocks)
SWP = SWeeps taken, in decimal
SKP = sweeps SKipped, in decimal
WIDTH = sweep WIDTH, in milliseconds

2.7 Input and Output Tape Mountings

There must be a LAP6 tape on unit 0 and a data tape on unit 1.

2.8 Input Tape Format

For the format of the input data tape see [1].

2.13 Software Configuration

AVELIST is written to be called by either AVERAGER or LAP6, both of which enter AVELIST at location 1. The following convention is used in order to allow AVELIST to return to the calling program. AVELIST is written with locations 15 and 16 containing instructions for reading LAP6. These locations are loaded unchanged when the program is called with LAP6 LOad meta-command. Return to LAP6 is accomplished by doing a JMP 15. These locations are modified

(by AVERAGER) when AVELIST is called from AVERAGER. They are changed so that the JMP 15 will read AVERAGER rather than LAP6.

2.14 References

1. AVERAGER, a LINC program by D.J. Nichols

3.0 METHOD

The data tape is scanned, starting at the specified block, for blocks containing data. The identification of each set of blocks is printed as found. A set of blocks with no data is identified as EMPTY. The criteria for establishing that a set of blocks is empty:

a) it has 0011, 0022, in the first 2 locations (which is the MARK pattern)

or b) the first two locations do not contain zero or a normalized floating point number.

If a set of blocks fail to meet either of the above, then it is assumed to contain data.

4.0 DESIGN SPECIFICATIONS

The program is self-contained with a question and answer routine which operates from both the LINC keyboard and the Teletype keyboard. Calling and exiting procedures are described in section 2.13 of this document and in [1]. The source program consists of a single manuscript and may be converted to binary using CV and SB in the usual fashion.

6.1 Sample Output

```
INPUT

 RN    IDENT   MIN   P1   P2  SWP  SKP  WIDTH
413    4C6801   19   15   **   50    0    150
414    4C6801   20   15   **   50    0    150
420    4C6801   21    3   **   50    1    150
424    4C6801   22    3   **   50    0    150
430    4C6801   23    3   **   50    1    150
434 EMPTY
440 EMPTY
444 EMPTY
450 EMPTY
454 EMPTY
```